Nor Azizah Yacob · Nur Asmaliza Mohd Noor
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Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)

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ISBN 978-981-13-0073-8 ISBN 978-981-13-0074-5 (eBook)
https://doi.org/10.1007/978-981-13-0074-5

Library of Congress Control Number: 2018938378

Printed on acid-free paper

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

This book reports the proceedings of the *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*, bringing forth more than 250 papers, selected from various disciplines in sciences, technology and social sciences. In the event organized by Universiti Teknologi MARA Pahang in Cameron Highland, Pahang from 4th to 6th December 2016, RCSTSS 2016 has published 104 science and technology papers from the fields of architecture, computer science, engineering, environmental and management, furniture, forestry, health and medicine, material science, mathematics, plantation and agrotechnology, sport science and statistics in this book.

This collection of research and review papers conducted by academicians locally, regionally and globally have undergone peer reviewing and been edited to give clear illustrations, tables, figures and diagrams. These papers from various universities form a platform which contributes towards the enhancement of the learning and sharing environment. It is hoped that RCSTSS 2016 can be the impetus towards future research and development in Malaysia and even at global level.

Pahang, Malaysia

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Acknowledgements

In the name of ALLAH, the Most Gracious, the Most Merciful. Praise be to Him for giving the editorial team courage, strength, patience and resilience in completing the proceedings of *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*.

Our sincerest gratitude goes to all RCSTSS 2016 committee members, participants and reviewers for their contributions and support. Gracious appreciation to the Editorial Committee: Mohd Zahari Abdullah@Rafie, Aiza Harun, Zurhana Mat Hussin, Duratul Ain Tholibon, Wan Mohd Norsyam Wan Norman, Siti Suhaila Harith, Muzamil Mustafa and Roger Canda for the tireless and enormous effort towards completing this book.

We are especially indebted to the current Rector of Universiti Teknologi MARA Pahang, Prof. Dr. Nazip Suratman; former Rector, Prof. Dr. Jamaludin Kasim; and the RCSTSS 2016 Chair, Associate Professor Dr. Azhan Hashim for the moral support and encouragement given. Last but not least, thank you to Universiti Teknologi MARA, Pahang, Malaysia for the technical and financial support which ensures the successful continuation of RCSTSS from 2014 to 2016 and insha'Allah, for years more to come.

Alhamdulillah.

Contents

Part I
Architecture

Chapter 1
A Review on Indoor Environmental Quality (IEQ) Attributes for Malaysian Post occupancy Evaluation (POE) in Green Office Building

Asniza Hamimi Abdul Tharim, Muna Hanim Abdul Samad and Mazran Ismail

Abstract Green buildings represent sustainable design and construction that require a holistic interaction between all components of a building that are environmentally responsible throughout a building's life cycle from the beginning until the completion. A green building should deliver its occupants with a comfortable indoor environment that will satisfy their comfort needs and enhance the productivity while working in the building. Among the numerous efforts in the emerging green building is the establishment of green building certification systems worldwide that is considered as one of the most prominent and systematic approaches to the continuous effort in promoting outdoor and indoor environmental sustainability. The benefits of these tools are they can guide the development of construction industry towards its best practice and improve the quality of building for tenants and occupants. Previous literature revealed that Indoor Environmental Quality (IEQ) assessment in green rating standards such as the LEED United State and BREEAM United Kingdom does play a significant role in the certification process of green building. Thus, the IEQ comprises several main aspects such as temperatures, humidity, noise, lighting, space design, structural systems and last but not least the building envelope design. Therefore, the main objective of this paper is to review the aspects of IEQ in Post-Occupancy Evaluation (POE) study previously conducted by researchers around the world. The paper will focus on the development of IEQ assessment attributes that can be used in POE for an office building in a hot and humid climate. It will also provide an emphasis on the relationship

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_1

between IEQ and Post-Occupancy Evaluation (POE) in determining post occupant's satisfaction. It is hoped that these research findings will bring benefit to green certification bodies in Malaysia such as the Green Building Index (GBI) and GreenRE Malaysia in evaluating office building in post-occupancy stage.

Keywords Indoor environmental quality (IEQ) · Green building index (GBI) Office building · Post-occupancy evaluation (POE)

1 Introduction

The momentum of green building is striking and is driven partly by widening awareness of the environmental impact of the built environment to the health implications of occupants in indoor spaces. Green building is also known as green construction or sustainable building in construction industry worldwide. It often encompasses from the planning stage through to the ultimate end of building life cycle, which comprises the design, construction, operations and renewal of the building structures. The green building brings together a huge range of knowledge, practices, techniques and skills to reduce and eradicate the negative impacts of buildings on the environment and human health. Hence, this reduction and eradication of negative impacts requires close collaboration and understanding between the design team, client and developers at all stages of a project. Various researchers believed that green buildings have been shaped to lower the impacts on the environment and improve the health quality of the building occupants (Woo 2010). According to Erica (2008), green building is sexy in their design and ambition, and with proper design and executions, a green building does more than just conserve energy and resources. The green building is also getting an enhancement from agencies around the world to set standards for sustainable building and also helps in educating the public, industry and policymakers on the benefits of sustainability for future life. Green buildings could be considered as a technological innovation because it encapsulates a system that uses environmentally aware approaches to modifying conventional construction practices (Ofori-Boadu et al. 2012). It also means protecting natural resources and improving the built environment so that people, communities and ecosystems can thrive and prosper (John and Michael 2007). The development of green building has vast benefits such as it is built for long term (build durable, efficient homes and liveable communities), and the green building is also built for life and humans where it makes homes, communities and environment safe for current and future generations. Last but not least, the green building is also built for the planet and world environment with a wise use of natural resources and recycled materials (John and Michael 2007). However, besides their enormous advantages, green buildings are not yet perceived as attractive projects by most of the clients and developers. It is mainly because most builders associate green features and construction with expensive technologies that add cost to the overall budget allocation of the building (Metthiessen and Morris

2007; Sherwin 2006). Nevertheless, careful design process and a comprehensive materials selection method of the green building may result in desired environmental goals for the building, and save the energy consumption for a long term. Hence, there are numerous other potential benefits of green building including the environmental, economic and social benefits. The environmental benefits include protecting, conserving and restoring the biodiversity and the natural resources. In addition, the economic benefits comprise reducing the life cycle cost of the building and enhancing profit and rental value. As for the social benefits, the implementation of green building can improve the occupants' comfort and health thus improving the overall quality of life. Other benefits of green building include the improvement of Indoor Environmental Quality (IEQ), reduction in health costs, increase in employees' productivity as well as increased occupant's satisfaction on the aspects of indoor comfort conditions (Edwards 2003; Kats 2003; Ross et al. 2006) and significantly improved indoor air quality with access to lighting and windows that serve to promote physical and mental well-being (Heerwagen 2001). Previous study done by USGBC had proven that the green building does increase performance by 6–26%, decreases absenteeism by 15% (compared to conventional buildings), and improves health conditions (LEED 2002). Moreover, a study by Gabay et al. (2014) indicated that numerous benefits of the green building include minimal energy use; minimum requirement for water, material and energy resources throughout its life cycle; conducive to occupant's health productivity; and minimal waste, pollution or environmental degradation. With the blooming of the green building concept, the sustainable building standard or tools for green buildings have been developed worldwide to promote the construction of green buildings in the industry. According to Liang et al. (2014), among the numerous efforts in the emerging green building is the establishment of green building certification systems as one of the most prominent and systematic approaches towards promoting sustainability in construction. This sustainable building standard is believed to be able to provide an efficient framework for assessing building environmental performance, and integrating sustainable development into building and construction processes while assisting in determining performance measures to guide the sustainable design and decision-making processes (DEWA 2003).

2 The Sustainable Building Rating System (SBRS)

The Sustainable Building Rating System (SBRS) is a concept of sustainable practice and environmental responsibility which normally is an elective standard as opposed to a mandated regulation involving multiple constituents (building owner, design professionals, construction professionals and code officials). It is a crucial tool to measure and evaluate green building in most of the countries worldwide including Malaysia, and it can thus provide further enhance the frameworks for building performance criteria which enable building construction to be more accurate and precise about the movement towards sustainable working process. There are many

great building certification tools globally to assess the environmental performance of building and its sustainability (Todd et al. 2001) such as BREEAM in the United Kingdom, and the Leadership in Energy and Environmental Design Standard (LEED) in the United State of America are assessments made by awarding credits, points or marks according to the building performance in order to determine the green rating given at the end of the building's assessment process. The benefits of these tools are they can guide the development of construction industry towards the best practice and improving the quality of building for tenants and occupants. To date, the USGBC-US Green Building Council and LEED-Leadership in Energy and Environmental Design green building rating system is a certification programme that has been widely accepted as a benchmark for the design, construction and operation of green and sustainable built environment in the United State and many other countries worldwide. The LEED green building rating system concerns mostly with the design of green building which requires less energy for operation, and with the processes to implement the design properly. The rating system provides a list of credits, measuring the environmental performance of construction processes in terms of sustainable development, energy efficiency and selection of material (USGBC 2009). Apart from the LEED, there are other sustainable rating tools available such as BREEAM United Kingdom, HK BEAM Hong Kong, GREEN STAR Australia (2011), GREEN MARK Singapore and last but not least our own sustainable rating tools the Green Building Index (GBI) (2015) Malaysia. As at December 2015, according to the information published by the World Green Building Council (2015), there are a total of sixty-three (63) rating systems to date with the total of nineteen (19) Sustainable Building Rating Systems (SBRS) in the Americas, twenty-three (23) in the continent of Europe, fourteen (14) in the Asia-Pacific region, and as for continents of Africa and Middle East & North Africa (MENA), there are a total of seven (7) and ten (10) numbers of Sustainable Building Rating Systems (SBRS), respectively. Thus out of the sixty-three (63) available Sustainable Building Rating Systems (SBRS), the most commonly mentioned and analysed by researchers are the United Stated LEED, United Kingdom BREEAM, Australia GREENSTAR, Hong Kong HK BEAM and our neighbour rating system the Singaporean GREENMARK. Nevertheless, two of the most common and similar criteria that are being assessed by all the sustainable rating tools are the energy efficiency and IEQ. Both criteria are closely related with the end users and the end use of the rated green building. Pioneer research by Lebowitz et al. (1985) found that people in developed world spent almost 75–90% of their time inside a building. Similar findings were obtained by Singh (1996) and Klepeis et al. (2001) by which their research also suggested that people tend to spend 80–90% of their time indoors. These facts highlighted the importance of building indoor environment quality improvements, and the need for validating the related well-being and productivity from which the benefits are available in rated green buildings (Singh et al. 2011).

3 Indoor Environmental Quality (IEQ)

IEQ can be defined as 'the measurement of the key parameters affecting the comfort and well-being of occupants' or 'the elements to provide an environment that is physically and psychologically healthy for its occupants' (Garnys 2007). The IEQ which includes the integrated physiological and psychological influences of thermal, acoustic and luminous environments and air quality on occupants (Li et al. 2013). Clements-Croome and Baizhan (2000) stated that the IEQ comprises a range of components such as humidity, indoor air quality, temperature and ventilation, lighting, noise and work space density. Sarbu and Sebarchievici (2013) believed that the main environmental factors that define the IEQ are the thermal comfort, indoor air quality, acoustic comfort and visual comfort. It is supported by Hodgson (2008) as cited in Rao and Aminuddin (2012) who highlighted that the four major criteria emphasised in green building rating tools are (1) indoor air quality, (2) acoustics, (3) visual comfort (lighting) and (4) thermal comfort. However, many believed that even though the fact that acoustics is one of the main criteria for IEQ, it is often overlooked and neglected. Similarly, Chandratilake and Dias (2015) stated that the main IEQ parameter includes the occupants' health and safety, thermal comfort, daylight, visual quality, acoustic and indoor air quality. Other researchers such as Woo (2010) and Prakash (2005) added ergonomics as one of the factors that need to be taken into account in providing a comfortable indoor environment to the end users.

Apart from that, IEQ also comprises a few other aspects such as the spectrum of the paints (Prakash 2005), electric lighting, daylight, views, individual control and indoor contaminants by materials and tenants as the components of the IEQ in a building (GBCA 2009). Subsequently, Frontczak and Wargocki (2011), from the results in their research, recommended that in developing systems for governing the indoor environment, the type of building and outdoor climate including seasons should be taken into account. Findings from their research indicated that thermal comfort is ranked by building occupants to be of greater importance compared with visual, acoustic and air quality. However, the ranking was different in different countries and depended on the building whether it is private or public. They also pointed out that women and men ranked environmental conditions differently. A longitudinal study by Lai and Yik (2007, 2009), on commercial spaces in Hong Kong, showed fairly dissimilar results. This indicated that thermal comfort had the highest impact on overall IEQ acceptance followed by indoor air quality, acoustic and visual quality. Subsequently, a study by Frontczak et al. (2012) showed that thermal comfort, air quality and visual quality are positively correlated with overall IEQ. This outcome was also supported by Lai et al. (2009) whose study was based on an indoor evaluation of occupants living in Hong Kong apartments which indicated that thermal comfort has the highest importance impact on overall IEQ. Flores-Colen and De Brito (2010) also concluded that the thermal comfort and indoor air quality are the most significant factors in determining occupants' comfort and satisfaction of the IEQ in a building.

4 Green Building Index (GBI)

Driven by environmental needs, the GBI was founded and developed by the Pertubuhan Akitek Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM) in 2009 as one of the accelerators in Malaysia's sustainable development. The Malaysian GBI is envisioned to promote sustainability in the built environment and enhance awareness among developers, architects, engineers, planners, designers, contractors and the public about environmental issues. The GBI is Malaysia's initial comprehensive rating system for assessing the design and performance of Malaysian buildings based on the six criteria, which are 'Energy Efficiency', 'IEQ', 'Sustainable Site Planning & Management', 'Materials and Resources', 'Water Efficiency' and 'Innovation' with four categories of rating given which are the 'Platinum', 'Gold', 'Silver' and 'Certified' ascertained by the marks obtained by the assessed building. There are 15 areas of assessment for IEQ item in the Non-Residential New Construction (NRNC) Tool. Each of these 15 areas contributes certain mentioned point for total score of the (IEQ) item. These 15 areas are divided into four main variables, namely, Variable 1: Air Quality; Variable 2: Thermal Comfort; Variable 3: Lighting, Visual and Acoustic Comfort; and Variable 4: Verification that can be measured by using the objective measurement on site excluding the Post-Occupancy Evaluation (POE) that falls under Verification. In conjunction with the POE requirement, it is a must for building occupants to meet at least 80% of the satisfaction level. If the building fails to comply with this requirement, corrective plans need to be developed in order for the building to obtain final certification from the Malaysian GBI. In the current practice by the Malaysian GBI, the POE in the Completion and Verification Assessment stage is conducted by appointing independent GBI Commissioning Specialist to carry out the POE for building occupants after the Design Assessment stage is completed. The POE must be carried out within 12 months of occupancy or completion in order for the building to obtain GBI Final Certification. However, there is no specific or systematic POE available for implementation used in Malaysia currently. Therefore, the need to develop a comprehensive and systematic POE survey and database such as Building User Survey (BUS) Methodology, Centre for the Built Environment (CBE) survey and the Building Occupants Survey System Australia (BOSSA 2015) is considerably important. This can be done through evaluating and recognising the requirement for POE that matches with the requirement stipulated by the Malaysian GBI. It is also crucial to consider the aspects of climate, environment, regulations and public's perception in developing the Malaysian POE on IEQ item. It is hoped that the comprehensive survey and database can help in motivating the Provisional Certification GBI buildings to obtain its Final Certification, and drive more future research in this field. Thus, it is optimism that the framework of POE measurement model can be used in the evaluation of IEQ at any office building in Malaysia.

5 Post-occupancy Evaluation (POE) Database

According to Preiser (2002), the POE is very different from other evaluation methods available because of its emphasis on building occupant's needs and requirements. It also has the capacity to apply the knowledge of sustainable environment for occupants in post-occupancy stage through all the feedback obtained from the evaluation. One of the available POE is IEQ assessments that evaluate the needs and collect feedback from building occupants in the post-occupancy stage in relation with the indoor environment of a building. Thus, as discussed previously in this paper, there are a number of POE methods on IEQ assessment available worldwide. However, for the proposed research, only four (4) types of IEQ assessments were analysed; namely, the BUS Methodology, CBE survey, Building Occupants Survey System Australia (BOSSA) and Post-Occupancy Evaluation Survey (Scan SPOES) in determining the dimension of the study's independent variable. Later, based on these assessments, an adopted questionnaire was constructed with several adjustments related to the country's climate and human aspects. Research reviewed by Mastor and Ibrahim (2010) indicated that the earlier protocol of POE in the aspect of IEQ was the PROBE (Post-Occupancy Review of Buildings and their Engineering). The protocol was developed in 1995 in the United Kingdom to examine the workplace. Heinzerling et al. (2013) also explored existing literature on IEQ assessment model and found out that the most used occupant's surveys were the BUS Methodology and CBE assessment. Another literature analysis on the IEQ assessment was also conducted by Galatioto et al. (2013) that briefly compare different post-occupancy methods available worldwide. Table 1 summarised four (4) types of IEQ assessment that can be assessed online by building occupants in evaluating their building indoor performance, namely, the pioneer POE available until today, the BUS Methodology of United Kingdom, the most well-known survey worldwide, the CBE, followed by recently developed office building survey, the BOSSA from Australia and last but not least the Sustainable Post-Occupancy Evaluation Survey (Scan SPOES).

The CBE, BOSSA and Scan SPOES were focusing their assessments in an office building. However, the BUS did not specifically mention office building as one of its building assessment categories. However, the BUS, CBE and Scan SPOES do cover a wider range of building categories in comparing with Australia's BOSSA. All the surveys were available to be assessed as an online survey tool and using the similar scale of seven (7) in judging occupant's perception and satisfaction. Hence, Table 2 shows the cross tabulation of IEQ assessment by these selected survey database that will be used later as guidance in determining the proposed study dimension or the attributes.

From Table 2, it can be concluded that the IEQ assessment can be divided into two (2) categories, namely, the major and subsidiary attributes that are used in measuring occupant's satisfaction in a building. The attributes were selected based

Table 1 Indoor Environmental Quality (IEQ) assessment

Centre for the Built Environment (CBE)	Building User Survey (BUS) methodology	Building Occupants Survey System Australia (BOSSA)	Sustainable Post-Occupancy Evaluation Survey (Scan SPOES)
Occupant Indoor Environmental Quality (IEQ) survey by US Green Building Council	Occupant satisfaction evaluation surveys using the BUS Methodology are an excellent tool for use in academic research projects. UK Green Building Council	BOSSA Time Lapse is a web-based survey tool to assess occupants' satisfaction with the IEQ performance of their office building	B3 Post-Occupancy Evaluation (POE) developed by University of Minnesota
Using a 7-point satisfaction scale	Using a 7-point Likert scale	Using a 7-point Likert scale	Using a 7-point satisfaction scale
Online survey tools	Online survey tools	Online survey tools	Online survey tools

Table 2 Indoor Environmental Quality (IEQ) assessment attributes

IEQ evaluation criteria	(CBE)	(BUS)	(BOSSA)	(Scan SPOES)
Acoustic	✓	✓	✓	✓
Thermal comfort	✓	✓	✓	✓
Visual/lighting	✓	✓	✓	✓
Air quality	✓	✓	✓	✓
Maintenance and cleanliness	✓		✓	✓
Appearance/design/space	✓	✓	✓	✓
Personal control		✓	✓	✓
Privacy			✓	✓
Technology				✓
Spatial comfort			✓	
General comments	✓			
Health and productivity			✓	
Connection to outdoor environment			✓	
Vibration and movement				✓
Electric lighting conditions				✓
Function				✓

on the reference that the stated attributes were mentioned and measured by more than one of the above-mentioned survey databases. Whereas subsidiary attributes refer to the attributes that appear in one of the survey databases. Table 3 indicates the major and subsidiary attributes generated from Table 2.

Table 3 Indoor Environmental Quality (IEQ) major and subsidiary assessment attributes

Major attributes	Subsidiary attributes
Acoustic	Technology
Thermal comfort	Spatial comfort
Visual/lighting	General comments
Air quality	Health and productivity
Maintenance and cleanliness	Connection to outdoor environment
Appearance/design	Vibration and movement
Space	Electric lighting conditions
Personal control	Function

6 Conclusion

Thus, for this proposed research model, the list of attributes that were selected in evaluating the performance level of the indoor space of the building is as follows (Fig. 1).

6.1 Independent Variable

The selection of these attributes as the independent variables of the proposed research model is derived from the above compilation tables (Tables 1, 2 and 3). An additional variable was added based on the previous study. The intention of this additional variable was to integrate the objective and subjective outcomes of the proposed research. Hence, it is hoped that all the nine (9) variables are valid precedents for the study's dependent variable. A pilot study had been conducted by

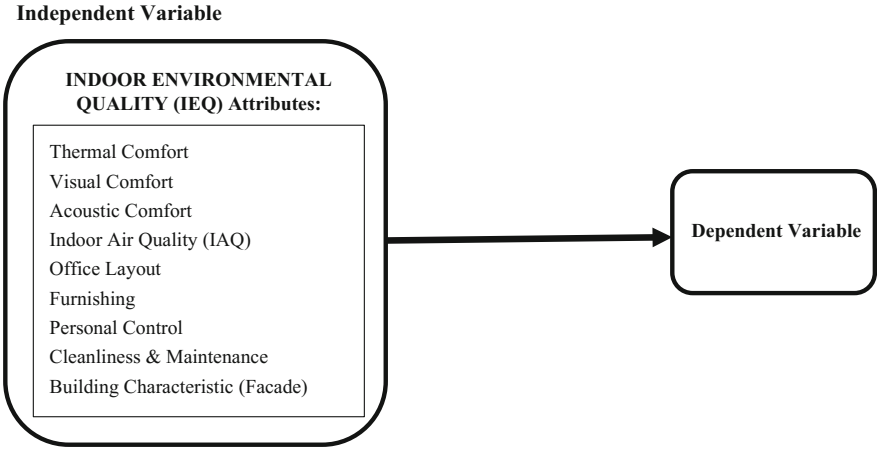

Fig. 1 Proposed conceptual research model

the author in identifying the roles of selected independent variable, and the results are presented in the following paper STSS079 titled 'Relationship between IEQ And Occupant's Satisfaction in Malaysian Rated Office Building: A Pilot Study'.

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Chapter 2
Relationship Between Indoor Environmental Quality (IEQ) and Occupant's Satisfaction in Malaysian Rated Office Building: A Pilot Study

Asniza Hamimi Abdul Tharim, Muna Hanim Abdul Samad and Mazran Ismail

Abstract Green building development is an upcoming topic and is driven mostly by the growing awareness of the environment impact of construction on the satisfaction, health, performance, well-being and productivity of its occupants. Therefore, the purpose of this study is to identify the relationship between Indoor Environmental Quality (IEQ) and occupant's satisfaction in a Platinum rated GBI's office building located in the heart of Kuala Lumpur, Malaysia. Data were collected through self-administered questionnaire from the building occupants and analysed using Statistical Package of Social Science (SPSS) and Structural Equation Modelling (SEM) Smart PLS. This analysis was conducted in obtaining the level of reliability and validity of the data in measuring occupant's productivity in relation with the IEQ. Subsequently, the result of the Variance Inflation Factor (VIF) for each of the variables shows that there are no collinearity issues in between the attributes.

Keywords Indoor environmental quality (IEQ) · Green building index (GBI) Office building · Self-Evaluated productivity

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_2

1 Introduction

The Green Building Index (GBI) founded and developed by the Pertubuhan Akitek Malaysia (PAM) and the Association of Consulting Engineers Malaysia (ACEM) in 2009 was one of the advocates for Malaysia sustainable development. The Malaysian GBI is envisioned to promote sustainability in built environment and enhance awareness among developers, architects, engineers, planners, designers, contractors and the public about environmental issues. Malaysian (GBI) will be one of the rating tools developed for the tropical zones other than Singapore Government's Green Mark that customised to suit the Malaysian climate and also the current state of the country's development and existing resources. The GBI is always dynamic, constantly adapted and adopted from other rating systems. GBI is closely adopted from the Leadership in Energy and Environmental Design Standard (LEED) rating award and its criteria, although both are used in a different geographical zone and under different climatic conditions. The GBI rating tool provides an opportunity for developers and building owners to design and construct green, sustainable buildings that can provide energy savings, water savings, a healthier indoor environment, better connectivity to public transport and the adoption of recycling and greenery for their projects and reduce our impact on the environment (GBI 2015). It is developed specifically for the Malaysian tropical weather, environmental and cultural, social and development needs. Malaysian GBI comprises two foremost types of buildings in its assessment which are the residential and non-residential buildings with several categories and tools.

The Green Building Index is Malaysia's initial comprehensive rating system for assessing the design and performance of Malaysian buildings which are based on six criteria, which are 'Energy Efficiency', 'Indoor Environment Quality', 'Sustainable Site Planning & Management', 'Materials and Resources', 'Water Efficiency' and 'Innovation' with four categories of rating which are 'Platinum', 'Gold', 'Silver' and 'Certified' that are given based on the marks obtained by the assessed building. To be certified as a green building under the GBI association, registered buildings must complete the assessment process as stipulated by the Malaysian GBI Tools. The assessment process of the Malaysian GBI comprises three (3) stages which are obtained from the Malaysian GBI website: (1) Stage 1: Application and Registration, (2) Stage 2: Design Assessment and (3) Stage 3: Completion and Verification Assessment.

Therefore, for a building to be fully certified with Final Certification, it must go through the final certification process known as the Completion and Verification Assessment (CVA) stage. Provisional Certification will be granted for buildings that do not accomplish the third stage of the certification process. The third stage of GBI certification includes the Post-Occupancy Evaluation (POE) which should be conducted by the owner within 12 months of completion or 50% of occupancy for

the building to be fully certified by Malaysia GBI. However, to sustain its quality and standard, these rated GBI buildings must be reassessed every 3 years to maintain its given ratings. As of December 2015, 664 buildings were registered with GBI. Out of these 664 registered buildings, 335 buildings in Malaysia have been certified as a green building in various categories through GBI ratings whereas 15 buildings have been awarded Platinum, 79 buildings were awarded Gold, 38 buildings achieved Silver 34 and 203 buildings were awarded Certified green buildings.

There are 15 areas of assessment for Indoor Environmental Quality (IEQ) item in the Non-Residential New Construction (NRNC) Tool. Each of the 15 areas contributes certainly mentioned point for a total score of the IEQ item. These 15 areas are divided into four main variables, namely, Variable 1: Air Quality; Variable 2: Thermal Comfort; Variable 3: Lighting, Visual and Acoustic Comfort; and Variable 4: Verification that can be measured by using the objective measurement on-site excluding the POE that falls under Verification. In conjunction with the POE requirement, it is a must for building occupants to meet at least 80% of the satisfaction level. If the building fails to comply with this requirement, a corrective plan needs to be developed for the building to obtain Final Certification from Malaysian GBI. As per information published on the GBI Malaysia site, to date, there are a huge number of buildings (283 buildings counted as per December 2015) that did not manage to obtain Final Certification from the GBI and must settle with only the Provisional Certification (not passing the requirement of the CVA stage). Therefore, it is crucial to take into great consideration of these particular buildings focusing on the aspect of CVA that includes the measurement of occupant's perception on POE of the IEQ item in the building. In correlation, to verify the POE of these Provisional Certification buildings, the IEQ assessment of these building must also assess and meet the standard according to MS 1525.

In current practice by the Malaysian GBI, the POE in the CVA stage is conducted by appointing an independent GBI Commissioning Specialist to carry out the POE for building occupants after the Design Assessment stage is completed. The POE must be carried out within 12 months of occupancy or completion for the building to obtain GBI Final Certification. However, there is no specific or systematic POE available for the implementation or used in Malaysia currently. Therefore, the need to develop a comprehensive and systematic POE survey and databases such as Building User Survey (BUS) Methodology, Centre for the Built Environment (CBE) survey and the Building Occupants Survey System Australia (BOSSA) is considerably important. This survey can be done through evaluating and recognising the requirement for POE that matches with the requirement stipulated by the Malaysian GBI. It is also crucial to consider the aspects of climate, environment, regulations and public's perception in developing the Malaysia POE on IEQ item. It is hoped that the comprehensive survey and database can help in

motivating the Provisional Certification GBI buildings to obtain its Final Certification and drive more future research in this field. Thus, it is hoped that the framework of POE measurement model can be used in the evaluation of IEQ at any office building in Malaysia.

2 Hypothesis and Research Model

Figure 1 portrays the conceptual research model of the IEQ and POE for this study. It is hypothesised that nine factors that may influence occupants in perceiving of their indoor environmental satisfaction in an office building.

Subsequently, this study has nine (9) hypotheses that are tested in this initial study which is as follows:

H1. IEQ has a positive relationship with occupant's satisfaction.

H1a. Thermal comfort has a positive relationship with occupant's satisfaction.
H1b. Visual comfort has a positive relationship with occupant's satisfaction.
H1c. Acoustic comfort has a positive relationship with occupant's satisfaction.
H1d. Indoor Air Quality (IAQ) has a positive relationship with occupant's satisfaction.
H1e. Office layout has a positive relationship with occupant's satisfaction.
H1f. Furnishing has a positive relationship with occupant's satisfaction.
H1g. Personal control has a positive relationship with occupant's satisfaction.
H1h. Cleanliness and maintenance has a positive relationship with occupant's satisfaction.
H1i. Building characteristic (façade) has a positive relationship with occupant's satisfaction.

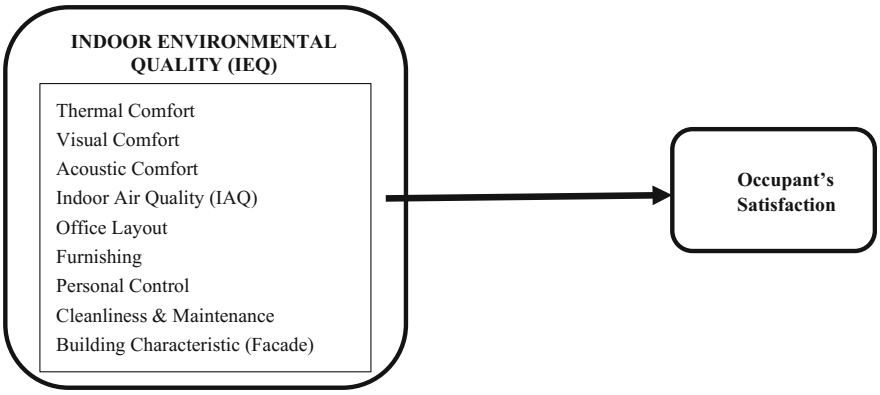

Fig. 1 Conceptual research model

3 Methodology

The criteria for selection in this pilot study are within the research scope of the main data collection study where the building must be rated by the GBI Malaysia. It must be an office building (full or semi-government) and is located in the city of Kuala Lumpur or Putrajaya, Malaysia. Therefore, a Platinum rated office building was chosen to be the location of this pilot study. The selected building is a government building located in the heart of Kuala Lumpur Malaysia with over 700 occupants and had been occupied and fully operated for less than 2 years. The outcomes presented are based on the data collected for the purpose of this pilot study. Therefore, the initial stage of this study is to test the reliability and validity of the instruments (subjective measurement) by conducting a hands-on survey of the building occupants. The unit analysis of this study is the occupants in the rated GBI office building in Malaysia that includes the administrative, technical person, professional and others that work on a daily basis at this selected building. Hence, this study employs a non-probability purposive sampling since it is not possible to acquire the list of all the elements of the building population due to its private and confidential policy.

The non-probability purposive sampling facilitates in choosing the right respondents for the survey and eliminates those who did not fix the criteria from the sample. Subsequently, as for the initial study, the sample size acceptable for this pilot study as mentioned by Isaac and Micheal (1995) and Hills (1998) who suggested 10–30 respondents for the pilot in survey research. Conversely, Julious (2005) and Van Belle (2002) suggested 12 respondents in the medical field. Therefore, as for this study, a total of one hundred questionnaires were distributed among the occupants in the selected GBI office building by hand and 81 questionnaires were returned which represents approximately 81% of response rate for this pilot study. Thus, the main data collection of this research will be measured using two instruments, namely, the objective and subjective measurement. The objective measurement of the student refers to the data collected using fieldwork while the subjective measurement is the collection of data by using questionnaire. However, for this pilot study, only subjective measurement is taken into account to identify the reliability and validity of the instrument for the use of main data collection.

The survey questionnaires used in this study are divided into three sections. The first section of the questionnaire focuses on the independent variable (IV) of the study which is the IEQ that comprises nine dimensions: (1) thermal comfort, (2) acoustic comfort, (3) visual comfort, (4) Indoor Air Quality (IAQ), (5) office layout, (6) furnishing, (7) personal control, (8) cleanliness and maintenance, and (9) building characteristic (façade). All 37 items in the first section are adapted and edited from the CBE and BOSSA POE as well as from the literature review (CBE, BOSSA). The second section of the survey is focused on the aspect of occupant's satisfaction as the dependent variable of the proposed study. The items in this

section are taken from various satisfaction literatures. These items in both sections were measured using a 7-item scale. Hence, the last section of the survey focused on the demographic variables of the respondent as listed in Table 1.

4 Analysis and Findings

SPSS 22 and Smart PLS 3.2 were employed to assess the reliability and validity of the survey questionnaires data and conduct preliminary testing on the research hypothesis. The demographic profile of the respondents is analysed using the SPSS version 22 while the measurement and structural model of the research framework were analysed using the Smart PLS 3.2. The significant advantage of using the Smart PLS 3.2 in determining study reliability and validity is that this method delivers latent variable score thus avoiding the problem of small sample size and efficiently handling complex models with many variables (Henseler et al. 2009).

Based on Table 1, there is a quite balanced percentage between female and male respondent, respectively, as the female group score is 51.9% and while 48.1% is the male respondent's score. Ages of respondent's majority were occupants between the ages of 31–50 years old. Table 1 also shows that majority of the respondents were working in the administration field and most of them worked in the building between 1 and 2 years. This finding was equal to the duration of building occupancy of fewer than two (2) years. Subsequently, Table 1 also portrays that a majority of the respondents' work area or sitting location is near to the external glass wall or windows thus exposing them more to the external heat through the building façade.

Table 2 summarises the results of the measurement model of the study conceptual framework. The model was analysed using Smart PLS 3.2 algorithm

Table 1 Demographic profile

Item	Valid percentage	Item	Valid percentage
Gender		*Posting*	
Female	51.9	Administrative	43.2
Male	48.1	Technical	11.1
Age		Professional	28.4
Under 30 years	27.2	Managerial	14.8
31–50 years old	61.7	Other	2.5
Over 50 years old	11.1	*Years working in the building*	
Work area proximity to		Less than 6 months	29.6
External glass wall/window	66.6	7–12 months	18.5
Atrium	2.5	1–2 years	51.9
Courtyard	1.2	2–5 years	0
Not applicable	29.6	More than 5 years	0

Table 2 Measurement model analysis result

Construct	Item	Convergent validity		Internal consistency reliability		Discriminant validity	
		Cross loading	AVE[a]	Cronbach's alpha	Composite reliability	HTMT	VIF
		>0.50	>0.50	0.60–0.90	0.60–0.90	>1	<5.00
Thermal comfort	4	0.539–0.828	0.534	0.698	0.817	Yes	1.721
Visual comfort	4	0.779–0.876	0.666	0.835	0.888	Yes	1.211
Acoustic comfort	4	0.817–0.915	0.767	0.898	0.929	Yes	2.342
Indoor Air Quality (IAQ)	4	0.774–0.866	0.690	0.850	0.899	Yes	2.298
Office layout	4	0.748–0.910	0.667	0.833	0.888	Yes	3.111
Furnishing	4	0.723–0.931	0.721	0.869	0.911	Yes	3.155
Personal control	4	0.866–0.949	0.838	0.935	0.954	Yes	1.566
Cleanliness and maintenance	4	0.852–0.926	0.802	0.918	0.942	Yes	2.218
Building characteristic (façade)	5	0.600–0.859	0.599	0.828	0.880	Yes	2.514
Occupant's satisfaction	4	0.822–0.902	0.759	0.894	0.926	Yes	–

Table adapted from Hair et al. (2014)

[a]*AVE* Average Variance Extracted; *HTMT* Heterotrait-Monotrait Ratio; *VIF* Collinearity Statistic

function with a total of nine (9) independent variables and one dependent variable that comprises 41 items. Results of the model are presented as illustrated in Table 2. To test the goodness of the proposed conceptual model and further rectify its validity as an instrument for real study data collection, there are few test and figures that need to be finalised within its acceptable range of measurement. Two of the significant test that needs to be taken into consideration in determining the goodness of measure for a model is the reliability and validity test. According to Sekaran and Bougie (2013), reliability is a test of measuring the consistency of the instruments while validity is a test that indicates the wellness of the developed instrument in measuring a particular concept of the study.

Reliability of the measurement model can be accessed using two values which are the Cronbach's alpha coefficient of above 0.6 in assessing the inter-item consistency and through composite reliability where value ranged from 0.7 or greater is considered as acceptable (Fornell and Larcker 1981). As for this study, Table 2 indicates that the composite reliability of the model measurement values ranged

from 0.698 to 0.935 for Cronbach's alpha value and range of 0.817–0.954 for composite reliability as portrayed in Table 2. Thus, the values prove that it is acceptable to measure the instruments consistently. Subsequently, to measure the goodness of this survey, it must also be valid apart from its reliability as the study instruments. Therefore, the main purpose of validity test is to measure the theories fitness of the designed test (Sekaran and Bougie 2013). It can be divided into two tests which are convergent validity and discriminant validity. Convergent validity can be assessed by looking at the results of measurement model's factor loading, composite reliability and also its average variance extracted (AVE) (Hair et al. 2014). Table 2 shows that the factor loading of each item in the construct exceeded the endorsed value of 0.5 as stated by Hair et al. (2014). Although the cross loading value of items in the first construct (thermal comfort) was quite low, it still passes the minimum requirement value of 0.50. This low loading value may be due to the small sample size of the respondents in the pilot study. Subsequently, Table 2 also further confirms the validity of the model by indicating the value of composite reliability of the model that ranged from 0.816 to 0.954, which surpassed the recommended value of 0.7 (Hair et al. 2012). The model's AVE values also exceed the expected value of 0.5 (Fornell and Larcker 1981; Barclay et al. 1995; Hair et al. 2014) with the range of 0.534–0.838 that reflects the overall amount of variance in the items for the latent construct. Thus, the result of convergent validity is acceptable for this model.

The subsequent test that needs to be taken into deliberation is the discriminant validity test that explores the degree to which definite measure of one variable is not a reflection of another variable in the proposed conceptual model. The discriminant validity test can be indicated by the low correlation between items in a different construct. This test can be identified by looking at the collinearity statistic of the Varian Inflation Factor (VIF) value of the constructs. Table 2 rectifies that all constructs in the model obtain VIF values of less than five (5). Therefore, it can be concluded that there are no collinearity issues between the constructs in the proposed conceptual model. An alternative type of construct validity test that is included in the PLS measurement analysis is the discriminant validity. According to Hulland (1999) and Hair et al. (2007), the discriminant validity refers to the concept on which the construct in the model does not correlate with each other. Fornell–Larcker criterion can be used in confirming the discriminant validity of the constructs where AVE of each construct must obtain higher value than its correlation with another construct as highlighted in Table 3. It is also a necessity for the diagonal elements to be larger value than the off-diagonal elements in the parallel rows and columns Hulland (1999). Table 3 further confirmed that the discriminant validity is achieved by showing its diagonal value (in *bold) are greater than the off-diagonal value.

Based on the above discussion of the model measurement findings, it can be concluded that all the nine constructs of the IEQ which are the thermal comfort, acoustic comfort, visual comfort, indoor air quality, office layout, furnishing, personal control, cleanliness and maintenance, and building characteristic are all valid measures of their individual constructs based on their factor estimations and

Table 3 Discriminant validity (AVE and Fornell–Larcker criterion)

Construct	TC	VC	AC	IAQ	OL	FUR	PC	CM	BC	SAT
Thermal Comfort (TC)	**0.731**									
Visual Comfort (VC)	0.136	**0.816**								
Acoustic Comfort (AC)	0.400	0.193	**0.876**							
Indoor Air Quality (IAQ)	0.603	0.228	0.491	**0.830**						
Office Layout (OL)	0.478	0.203	0.521	0.554	**0.817**					
Furnishing (FUR)	0.336	−0.014	0.255	0.500	0.720	**0.849**				
Personal Control (PC)	0.206	0.225	0.369	0.388	0.456	0.506	**0.916**			
Cleanliness and Maintenance (C&M)	0.402	0.075	0.458	0.577	0.555	0.584	0.359	**0.896**		
Building Characteristic (BC)	0.448	0.158	0.680	0.503	0.556	0.423	0.338	0.621	**0.774**	
Occupant's satisfaction (SAT)	0.607	0.292	0.544	0.593	0.640	0.575	0.477	0.693	0.727	**0.871**

statistical significance. It can also be summarised as the proposed measurement model established adequate reliability and validity standard that can be used in the actual data collection stage.

5 Discussion

This study emphasises the importance of the IEQ aspect in providing office occupants with indoor space satisfaction. From the findings of the pilot study, it is noted that IEQ does play a significant role in determining occupant's satisfaction in a green office building. Therefore, this initial study is an attempted to highlight the interaction between the nine (9) independent variables with one (1) dependent variable of the proposed research conceptual model. The result from this pilot study indicated that the selected independent variables are a valid measurement of perceiving occupant's satisfaction in a rated Malaysian GBI green building. It also indicates that the questionnaire survey is reliable and valid in measuring the relationship between the independent and dependent variables of the proposed study. Subsequently, currently, the main data collection of this study has collected a large number of respondents which hoped to encourage and contribute to research findings that are more substantial.

6 Conclusion

This pilot study tested a proposed conceptual model based on the indoor environmental and occupant's satisfaction literature. The instrument used in this study fulfil the acceptable requirements of the reliability and validity analyses. The outcome of the path model analysis has confirmed that IEQ is significantly correlated with Occupant's Satisfaction in rated green office building. At present, the main data collection was conducted in several Green Building Index (GBI) rated office buildings in Malaysia, and the results are expected to be published in the near future.

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Chapter 3
Performance Measurement of Industrialised Building System (IBS) Towards Achieving Green Construction and Sustainability in Construction Project in Malaysia

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Abstract The Malaysian Government is committed to change significantly through embracing sustainable practices and meeting its target and obligations towards sustainable development. In response to these desires, Industrial Building System (IBS) and their design procedures are considered as an opportunity to introduce sustainable features to the construction process and enhance construction sustainability into a more socially responsible, environmentally sustainable and economically viable to meet the current demand of the construction market. This research mainly studies the fundamental connotation of IBS that has the potential contributing to green construction and sustainability, and illustrates the significance and meaning of green construction principles based on IBS perspectives. The establishment of effective methods to evaluate the performance of different approaches in which IBS contributes to green construction and sustainability is crucial for construction organisation at present in deliberate whether returns have been attained on their investment in implementing IBS in construction project. The nature of this research was partly exploratory and tried to identify the major issues by examining

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_3

the viewpoints of experts in the construction industry. The research method for this study encompasses qualitative data gathering via semi-structured interviews and quantitative data gathering via structured questionnaires.

Keywords Construction project · Green construction · Industrialised building system (IBS) · Performance and sustainability

1 Introduction

Construction industry in Malaysia plays a crucial role in generating wealth for the nation and also helps in facilitating the development of social and economic of the country. The Eleventh Malaysian Plan report (2015) provides a critical platform for the Malaysia country to make vital policy shifts and invent new approaches to address new and existing challenges in construction industry which include time overrun, cost overrun, construction waste, imposing negative impacts to the environment and excessive construction resources consumption (Abdullah et al. 2009; Endut et al. 2009). In addition, the growing awareness on environmental protection due to the depletion of non-renewable resources, global warming and extremity of destruction to ecology and biodiversity impact has gained wider attention by the construction practitioners worldwide (Abidin 2009). It is crucial a reinforced commitment by the Government to pursue development in a more sustainable manner, that is, resource-efficient, clean and resilient to ensure that Malaysia's precious environment and natural endowment are conserved and protected for present and future generations.

In response to these aspirations, Prefabrication, Industrial Building System (IBS) and their design procedures are considered as an opportunity to introduce sustainable features to the construction process and enhance construction sustainability. In Malaysia, IBS is the dominant conceptualisation and terminology used for pre-fabricated construction (Jelodar et al. 2013). The general principles of sustainability within construction industry are showing concern for people by ensuring they live in a healthy, safe and productive built environment and in harmony with nature. Other than that is safeguarding the interest of future generations while at the same time, meeting today's needs, evaluating the benefits and costs of the project to society and environment (Abidin 2010). Thus, the issues of sustainability and green construction have been duly highlighted in the Construction Industry Master Plan (2005–2015) as being of significant importance for the Malaysian construction industry (Kamar et al. 2010a, b).

1.1 Problem Statement

Key stakeholders in the industry are demanding that organisations demonstrate their ability to improve their operations, processes and products into a more socially responsible, environmentally sustainable and economically viable to meet current demand of the construction market (Mohammad 2013), and the optimal use of available resources has become an absolute necessity (Abidin and Pasquire 2007). This is where the Malaysian construction industry players and stakeholders believed that IBS could play its role in materialising full integration in the core business strategies, management systems and construction processes factors in meeting the needs of clients and stakeholders.

In Malaysia, CIDB had launched IBS Strategic Plan since 1999 to promote the usage of IBS in construction industry. The IBS Roadmap 1999 and 2003 had outlines several well-thought strategies and aggressive steps to promote the usage of IBS in Malaysia (CIDB 2003). In measuring the performance of IBS construction project, CIDB (2010) had been establish the Key Performance Indicators (KPIs) in their IBS Roadmap 2011–2015. Whereby these KPIs were focused on quality, time, competency and productivity, and financial sustainability. Unfortunately, the performance of construction project remains a prominent issue in delivering construction projects all over the world (Bassioni et al. 2004). This is because construction projects involve defined objectives and goals that must be achieved and large resources which need to be utilised optimally and efficiently in achieving sustainable development. Nevertheless, the study on project performance specifically in IBS construction project in achieving sustainability is rarely conducted and still limited. A study done by Kadir et al. (2006) on construction performance comparison between conventional building and IBS was mainly focused on actual labour productivity, structural cost, crew size and cycle time. Meanwhile, a study done by Amlus et al. (2014) defined that cost, training and construction policies play an important role in determining the performance of IBS project. There are no dedicated assessment and certification systems for IBS products, manufacturers and installers in the Malaysian construction industry (Kamar et al. 2009). This assessment system is very important to identify the current performance in order to promote further improvement of IBS implementation (Amlus et al. 2014). The traditional view of performance measurement in construction project only concerned on cost variance, time variance, design and quality of workmanship in order to measure the performance of the construction projects (Jabar et al. 2013).

In order to achieve sustainability in IBS construction project, the KPIs need to comply with the sustainable development requirement. As discussed, the concept of sustainable construction governs three main pillars: environmental protection, social well-being and economic prosperity (Abidin 2010). Deficiency of effective methods to measure the performance for IBS in green construction and sustainability towards achieving sustainable development lead to many construction organisations at present have no way knowing whether returns have been attained on their investment in implementing IBS. Therefore, this study attempts to fulfil this gap.

1.2 Research Aim and Objectives

In line with this consideration, the overall aim for this research is to develop a framework which can measure the performance of IBS construction project effectively and continuously throughout the construction project life cycle in achieving green construction and sustainability in construction project in Malaysia. In line with this aim, the research objectives suggested are as follows:

- To identify the level of consideration given to green construction and sustainability issues in IBS construction project in Malaysia.
- To explore the drivers and barriers to green construction and sustainability through IBS perspectives in Malaysia.
- To determine the Key Performance Indicators (KPIs) in implementation of IBS in construction project in achieving green construction and sustainability.

1.3 Significance of Study

This study will be anticipated to contribute towards a better knowledge and understanding the different ways of IBS contribution to green construction and sustainability in construction project in Malaysia. Exploring the implementation of IBS construction project towards the enrichment of green construction and sustainability for all project in achieving sustainable issues is likely to improve the implementation of the IBS and enhance the confidence of clients about their investment in IBS components, beneficial to the IBS manufactures and IBS contractors for a better construction industry performance by maximising project's value. The results will be increase in productivity indirectly, increase in the value of investment and decrease in the maintenance cost of the building in the future.

2 Literature Review

2.1 Sustainable Development and Green Construction

According to Bordeau (1999), the World Commission on Environment and Development (WCED) defined sustainable development as development which meets the need of the present without compromising the ability of future generation to meet their own needs. Hamid et al. (2011) state that construction industry is a major consumer of non-renewable resources, a massive producer of waste and the operation of buildings also contribute to CO_2 emissions. Further stated by Zhiwei

et al. (2014), the implementation of sustainable development strategy in construction industry not only concerned during the planning, design and decision-making stage but also reflected in the whole process of construction whereby at this stage, it will have a serious impact on the environment and resources. Thus, sustainable construction includes the responsibility of the construction players to design, develop, construct and manage a project in a way that reduces the bad impacts towards environment as well as society. This has challenged the industry players to propose and produce better buildings and infrastructure. Malaysia as a developing country and an active participant to this global process has endeavoured since 1970s, to introduce a variety of regulatory measures to balance the goals of socio-economic development with the maintenance of sound environmental conditions (Foo 2013).

According to Kamar et al. (2010a, b), green building or sustainable building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle. Green building has now become a forefront of sustainable development in this century that takes the responsibility for balancing long-term economic, environmental and social health (Zhiwei et al. 2014). Construction has been accused of causing environmental problems ranging from excessive consumption of global resources both in terms of construction and building operation to the pollution of the surrounding environment, and research on green building design and using building materials to minimise environmental impact is already increasing (Ding 2008). Green construction can reduce the environmental pollution and negative effects of the construction project and improve the economic and social benefits, especially the environmental benefits. Therefore, it is necessary to perfect the green construction technology, improve the green construction level and build economic, environmental and green construction for society (Zhiwei et al. 2014). The land and space occupied by building, building materials production and transportation and the waste treatment and disposal generated from construction have a great impact on the ecological environment (Tan et al. 2011).

According to Zhiwei et al. (2014), in the whole process of design, construction and repair, the utilisation efficiency and environmental impact of resource are supposed to be comprehensively considered. Utilisation efficiency and waste discharge should be well controlled in all activities in green construction. And finally, the target of resource saving, environment-friendly and quality assurance will be realised.

Based on Fig. 1, the implementation of the green construction is to reduce the influence to the environment and the resource. Green construction is the application of sustainable development idea in the whole construction process and the comprehensive application of green construction technology. The green construction is not only to implement closed construction with no dust and noise, but the protection of ecology and environment, the utilisation of resource and energy and the development of social economy as well.

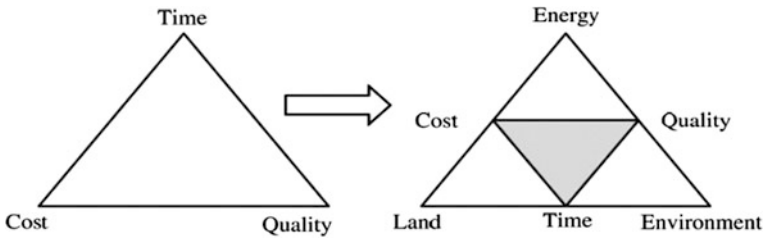

Fig. 1 Conversion process of traditional construction method. *Source* Zhiwei et al. (2014)

The traditional construction method is to achieve the project quality, schedule and cost as the basic goal. The resource conservation and the environmental protection has rarely considered in the construction. When the construction meets the requirements of the project quality, schedule and cost, it will cause the resource waste and the environmental damage. However, green construction emphasises the efficient use of resources as the core and the environmental conservation as the priority principle in order to pursue the integrated construction method with the high efficiency, low consumption and environmental protection (Kamar et al. 2010a). Figure 2 illustrated the three major principles of sustainability and their respective area.

Further state by Abidin (2009), environmental protection concerns on the built environment and the natural environment. The built environment refers to the activities within the construction project itself and if not handled effectively will have a serious adverse impact on the environment. Social well-being concerns with the benefits of the workers and the future users. Basically, this aspect is concerned with human feelings: security, satisfaction, safety and comfort (Lombardi 2001); and human contributions: skills, health, knowledge and motivation (Parkin 2009). Finally, the economic sustainability is concerned with the micro- and macroeconomic benefit. Micro-economic focuses on the factors or activities which could lead to monetary gains from the construction while macro-economic relates to the advantages gained by the public and government from the project success.

Thus, with the growth of complexities in construction activities, it has become imperative that design tools be provided which can give acumens into the sustainability of a building during the design stage itself, and helps the design team incorporate the sustainable solutions in the design process. IBS can be a potential solution to achieve greatness in the area of green construction and sustainability with the growing prominence of off-site construction and having a luxury of manufacturing buildings in a controlled environment, where issues of sustainability can be addressed faster and more efficient way.

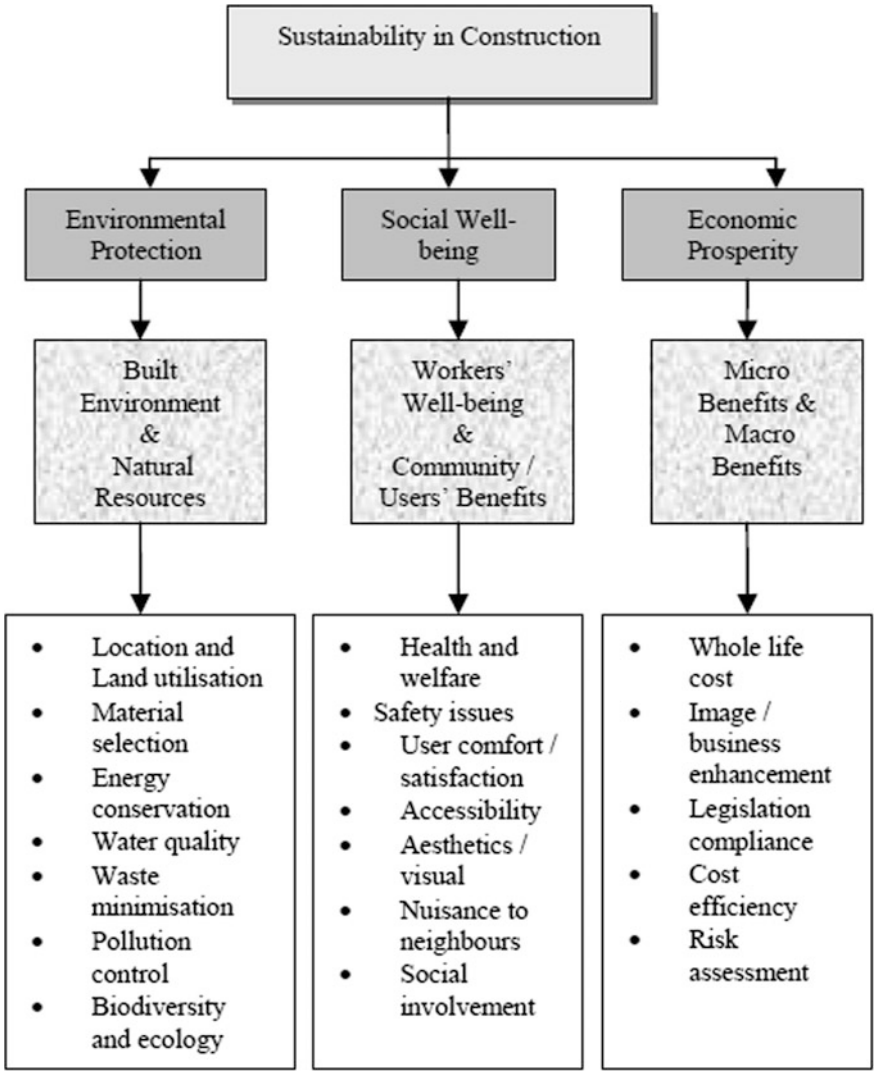

Fig. 2 Sustainability in construction diagram. *Source* Abidin (2009)

2.2 Industrialised Building System (IBS) in Malaysia

In the earliest literature, IBS can be defined as a total integration of all subsystem and components into overall process fully utilising industrialised production, transportation and construction methods (Dietz 1992). Meanwhile, Warszawski (2003) stated that industrialised process is an investment in equipment, facilities and technology with the objectives of maximising production output, minimising

labour resources and improving quality while a building system is a set of interconnected elements that joint together to enable the designated performance of a building. Further definition was developed by Kamar et al. (2009), an innovative process of building construction using the concept of mass production of industrialised systems, produced at the factory or onsite within controlled environments; it includes the logistic and installation aspect of it, done in proper coordination with systematic planning and integration. In a nutshell, most of the definitions of IBS mentioned on prefabrication, off-site production and mass production of building components as the main characteristic of IBS (CIDB 2003).

In Malaysia, IBS has started in the early 1960s when the officers of the Ministry of Housing and Local Government of Malaysia visited a number of European countries and evaluated their housing development programmes (Thanoon et al. 2003). Therefore, after their successful visit in 1964, the Malaysian Government had started constructed the construction project using IBS which targeting to speed up the delivery time and to build affordable and quality houses. Today, the use of IBS as a method of construction in Malaysia is evolving. Many private companies in Malaysia have teamed up with foreign expert to offer precast solution to their project (CIDB 2003). In Malaysia, CIDB had classified IBS into six categories which are precast concrete framing, panel and box systems, steel formwork systems, steel framing systems, pre-fabricated timber framing systems, block work systems and innovation system.

IBS also provides the opportunity for the players in the construction industry to project a new image of the industry to be at par with other manufacturing-based industry. The adoption of IBS promises to elevate every level of the construction industry to a new height and image of professionalism (Rahman and Omar 2006; Sadafi et al. 2012). Furthermore, Kamar et al. (2010a, b) highlight that IBS is a potential method to improve overall construction performance in terms of quality, cost-effectiveness, occupational safety and health, waste reduction, image and productivity. In addition, many construction players and researchers stated that IBS offers cost and financial advantages such as earlier completion time (Kamar et al. 2010a, b), repetitive use of formwork system made up of steel, aluminium, etc.; provides considerable cost savings (Thanoon et al. 2003), less wastage (Idrus et al. 2008; Kadir et al. 2006); reduces labour at site because prefabrication takes place at a centralised factory with high degree of mechanisation involved; and allows flexibility in architectural design in order to minimise the monotony of repetitive facades (Warszawski 2003; Kamar et al. 2010a, b). IBS also contributes in reducing wastage, less site materials, cleaner and neater environment, and improves the site safety (Tam et al. 2007; Rahman and Omar 2006). In addition, IBS will help the construction phase towards greater concentration on achieving a better construction which meets the client needs, potential solution in sustainable development and provide highest quality affordable building (Warszawski 2003; Thanoon et al. 2003; CIDB 2003). However, the realisation of these benefits depends very much on the performance of IBS construction project throughout project development.

2.3 *Developing the Key Performance Indicators (KPIs) in IBS in Achieving Sustainable Construction*

In a time of globalisation and an increasingly competitive environment, measuring performance has become critical to business success. Mullins (2005) described the performance as relating to such factors as increasing profitability, improved service delivery or obtaining the best results in important areas of organisation activities. Broadly, in construction industry, performance relates to the achievement to meet or exceed the client's expectation from the project. A considerable amount of literature has been dominated that time, cost and quality as the basic criteria of performance measurement in construction project. However, different ideas have emerged in the last decade (Zhiwei et al. 2014; Toor and Ogulana 2010). For instance, if low energy use, low maintenance costs and low transport costs are given a high value by the client, then higher costs at the design and construction phase can often be justified economically as well as environmentally (Parkin et al. 2000). Thus, the Malaysian Government has defined the needs for construction industry to intensify mechanisation; new construction methods and technology; prefabrication to improve the contractors' performance and productivity in construction project (Kamar et al. 2011).

Any improvement to existing practices cannot be properly considered until the existing conditions and problems surrounding them are fully understood. Therefore, a comprehensive review of Key Performance Indicators (KPIs) in measuring the success of IBS construction project is essential. Cox et al. (cited in Toor and Ogulana 2010) observe that the KPIs are helpful to compare the actual and estimated performance in terms of effectiveness, efficiency and quality of both workmanship and product. However, it seems difficult as every project has certain unique features and limitations. Hence, observation greatly complements the literature review as it yields some understanding of how a process is conducted. Thus, generalising the nomenclature of KPIs for all kinds of projects looks fairly impractical because different types of projects are carried out from different contexts (Toor and Ogulana 2010). Therefore, regardless of these limitations, it is important to comprehend the perception of KPIs on IBS projects based on Malaysian context.

3 Methodology

The nature of this research was exploratory and tried to identify the major issues by examining the viewpoints of experts in the construction industry. The mix method research strategy would be used in this study. In order to achieve the objectives formulated, this research will be divided into three main phases.

3.1 Phase 1: Literature Review and Preliminary Questionnaire Survey

This phase aims to get an overview of the study by referring to the past studies done by other researchers relating to this research. The literature search is focused on identifying the level of consideration given to green construction and sustainability issues in the current implementation of IBS construction project in Malaysia. Furthermore, this search will extend to explore the drivers and barriers to green construction and sustainability through IBS perspectives in Malaysia. A literature review seeks to describe, summarise, evaluate, clarify or integrate the content of information. Completing a literature review is usually a significant intellectual achievement in its own right, requiring the analysis and synthesis of previous work in such a manner that new understandings of that work are uncovered, and the way is opened for new research. Most of the reading materials are published in journal, articles, textbook and other relevant reading material. On the other hand, the purpose of the preliminary questionnaire is to refine the theoretical framework and validate the variables gained from the literature reviews.

3.2 Phase 2: Semi-structured Interview and Case Studies

The semi-structured interview is important to explain the case studies and comparison studies to validate various aspects of the performance measurement frameworks because it permits an informal setting of data collection that reflects the reality of what is happening in the real settings. This approach also allows the researcher to probe each argument in detail and obtain rich and more complex data in terms of tacit knowledge, perception and human experience which may not be measured using a quantitative approach (Yin 2003).

3.3 Phase 3: Interview with Expertise in IBS

The final data collection method is interview with expert people involved in IBS project. The final interview is undertaken as the most appropriate manner in which to gain the views of expert stakeholders involved in construction project that enables an evaluation of different approaches in which IBS contributes to green construction and sustainability in construction project in Malaysia.

4 Conclusion

The present conventional methods of construction often associated with many unprofessional practices. The adoption of IBS promises to elevate every level of the industry to a new height and image of professionalism. In addition, IBS has a potential usage to promote green construction and sustainability from controlled production environment, minimise waste generation, usage of energy efficient building material, promote effective logistics and encourage economic stability and sustainability. The development of this research enables the improvement of IBS construction project in the future in refining construction practices and modernises the construction industry towards achieving sustainable development. From this paper, the authors hope to receive any feedback, comment and recommendation for improvement.

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Part II
Computer Science

Chapter 4
Mobile Calorie Burned Estimation Based on Pedometer Steps

Suhailah Mohd Yusof, Jasmin Ilyani Ahmad and Noor Hasnita Abdul Talib

Abstract A rapid exchange of mobile technologies has offered many features and functions that are useful to build application for various environments. This creates new opportunities for integration of mobile and e-health application into mobile health application (m-health). Due to this opportunity, many applications are developed to cater some issues like health awareness and patient monitoring. With the use of m-health, users can keep track and monitor their health progress from time to time no matter where they are. Therefore, this paper aims to expose the use of m-health application in people living life ideally by developing a mobile calorie burned estimation application. The proposed application can keep track and monitor user weight loss by using their smartphone without using traditional method like paper and pen. The proposed application used several formulas and techniques in developing this mobile application such as three-axis accelerometer for pedometer step, BMI, BMR, and body fat percentage formula. However, this paper does not aim to cover the techniques used in the proposed application but this paper only focuses on m-health application that can assist people toward healthy living lifestyle.

Keywords Body fat · Calorie · m-health · Pedometer

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_4

1 Introduction

In recent years, mobile devices have been used as a platform for delivery of health interventions. Increasingly, there are a lot of mobile phone health applications which are developed in order to fulfill the human need. The new m-health applications are specifically targeted to help people track their own health and wellness. This widespread of m-health is due to the power of technical capabilities of mobile devices such as high processing speed and high battery consumption (Pew Internet and American Life Project 2010). In addition, people have more tendencies to bring and to be attached to their mobile devices at anywhere (Ventä et al. 2008). According to Klasnja and Pratt (2012), the fundamental of many m-health applications is to track and self-monitor the symptoms, behaviors, physiological states, and other factors that are related to health. Due to several reasons, the proposed application is developed.

The proposed application will ease the user to estimate the calorie burned and monitor the total weight loss. By using smartphone and its technology, it can be used to calculate how many gross calories in the body and how many are needed to be burned off. By walking, the calorie burned can be calculated using the Android accelerometer, global positioning system, and gyroscope. Therefore, people are aware of their calorie in the body and how many are needed to get rid of it. A healthy lifestyle can be nurtured and people can enjoy life much longer.

The rest of the paper is organized as follows. Section II reviews some of the preliminary works which include mobile health application, body mass index (BMI) versus basal metabolic rate (BMR), calorie overview, body fat percentage, and smartphone pedometer overview. Section III presents the proposed approach application that consists of several modules. Section IV presents the testing results of the proposed application and the final section concludes the paper with future works.

2 Literature Review

2.1 Mobile Health Application

Mobile health application or also known as m-health nowadays is needed in order to assist people in supporting self-management, lifestyle changes, and also educating them especially in facing their diseases. The application can be easily used by people with their mobile device such as tablet or smartphone within the Internet or Bluetooth coverage. According to Arsand et al. (2012), the acceptance of mobile health application among the diabetes patients and nurses was found positive. More than that, by using this application, the way nurses manage their work also becomes more easy as they can refer to the result produced by the application such as using

pie chart and graph. Referring to Williams et al. (2014), most of their respondents were confident in using the technology, even they were not in computer background as it was designed user-friendly to all levels of users.

2.2 Body Mass Index (BMI) Versus Basal Metabolic Rate (BMR)

Body mass index (BMI) is the measurement method to calculate the amount of tissue mass of an individual and categorized that person as underweight, normal weight, overweight, or obese. The calculation is based on an individual weight and height. BMI is one of the accurate methods to measure an individual weight, especially among obese (Dessinioti and Zouboulis 2014). Basal metabolic rate (BMR) is the minimum rate of energy used by an individual at rest. BMR is measured in calories needed by a person in order to make sure the body keeps functioning even in sleep.

2.3 Calorie Overview

Calories are units of energy in food that will produce in the human body. Knowing the calories in the food will help people in balancing their calories needed by their body. The calculation of the calories will assist people in maintaining or losing their weight to the have an ideal weight. According to Hemmingsson et al. (2012), weight loss program can be effective with calorie diet done by a person. It also depends on an individual's weight and height, and it can be very low-calorie diet, low-calorie diet, or restricted normal food.

2.4 Body Fat Percentage

An excessive amount of body fat is associated with numerous comorbidities including hypertension, insulin resistance, dyslipidemia, and systemic inflammation (Shea et al. 2012). Body fat percentage is the fat percentage contains in the body. Body fat includes essential body fat and storage body fat. Several approaches to estimate the body fat percentage include the use of calipers to measure skinfold thickness, bioelectrical impedance (BIA), or underwater (hydrostatic) weighing. A person is considered obese when body fat content equals or exceeds 25% of body weight (Al-Hazzaa 2007).

2.5 *Smartphone Pedometer Overview*

Many exercise equipment or gadgets have been used for tracking, enhancing, or facilitating physiological state, which include smartphone, laptop, television, and other screens such as pedometer and weight scale (Liao and Deng 2014). Fong et al. (2016) reported that smartphone pedometer application-based walking intervention was well accepted by community-dwelling older adults due to its convenience and minimization risk of losing. Smartphone processing is using a sophisticated real-time sensor data that provide the functions of a pedometer using the accelerator (Oshin and Poslad 2013). Pedometer is widely used for walking behavior measurement (Bassett and Cureton 2000).

3 The Proposed Application

3.1 *Overview of Application Module*

There are several modules for the proposed application, which are BMI/BMR calculation, pedometer, step records, and fitness tips. Figure 1 shows the division of the modules. When a user enters the application menu, the user will see those modules.

3.2 *Implementation and Development*

The application is implemented using three-axis accelerometer technique for pedometer module and several formulas are used in order to calculate the weight

Fig. 1 Application module

loss. Some of the formulas had been mentioned in the previous section. For development tools, Eclipse Android System Development Kit (SDK) is used. The proposed application is developed in English since English has become the universal language among people around the world.

Figure 2 shows the interfaces of the main menu of the proposed application, which are Home, BMR Calculation, Steps Record, Pedometer, Fitness Tips, and About. This navigation menu is available through swiping gesture from left to right or touching through an icon in the top menu. Figure 3 shows the BMR and the BMI calculation which used to calculate BMI index of user and body fat. The user needs to input their weight in kg or lbs., height in cm or inch, and specify their gender. The unit to choose will be accessible with drop-down list beside the input box. To access the input box, the user needs to touch the input box to display the keypad. Then, the user needs to press the Calculate Body Fat button to display the result.

Figure 4 shows the interface when the user navigates to the pedometer menu. Two options will be available whether a user can access the pedometer setting and straightly start the pedometer. So as to start the pedometer, the user simply touches the red region to start. On the other hand, to access pedometer setting, the user needs to touch the green region to open setting. Figure 5 shows the pedometer interface when started. When mobile phone starts shaking indicates that user has

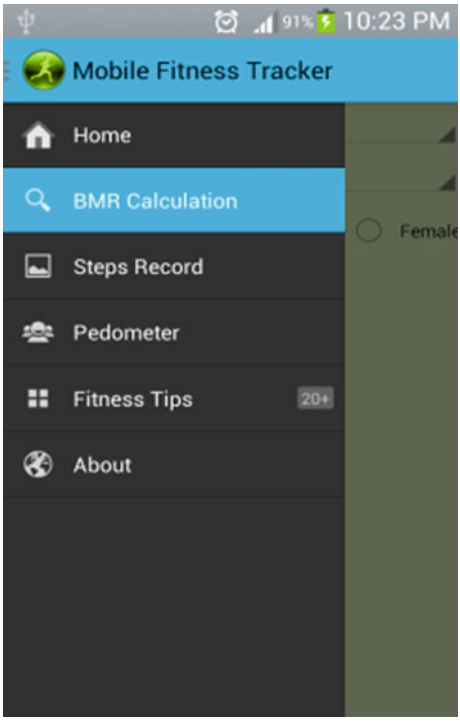

Fig. 2 Application module

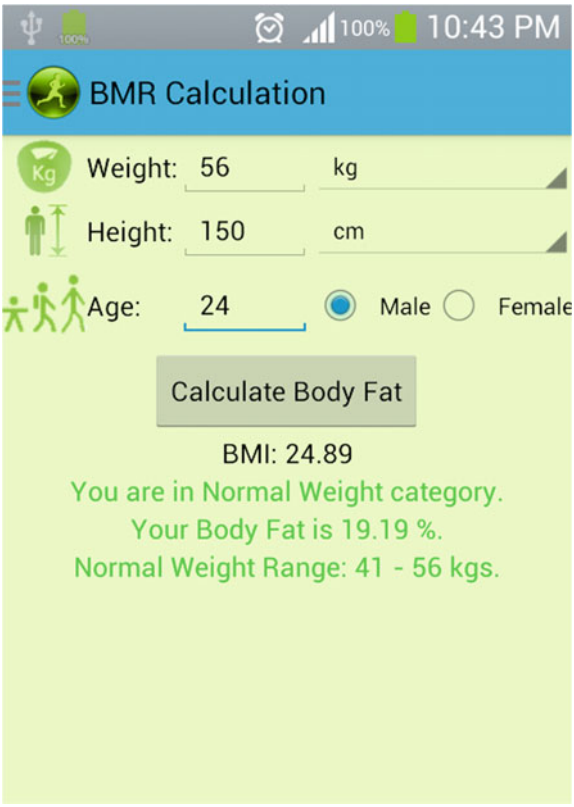

Fig. 3 BMR calculation

started walking, the steps will be increased accordingly. This pedometer will display the steps counted, distance of user had walked, count the steps per minute, kilometer per hours, and the total calories burned.

3.3 Laboratory Testing

The proposed application has been tested in several lab testings. The purpose of lab testing for each type is described as follows.

Mobile Device Compatibility Testing: The purpose of this test is to check the compatibility of several types of mobile devices that are commonly used by the user. The feature of application running smoothly on the mobile device is figured out. In this lab scenario, the smoothness means whether the application can display image inappropriate way or vice versa. However, only three types of mobile devices are tested, which are tablet, smartphone, and phablet.

Fig. 4 Pedometer menu

Navigation and Event Handler Testing: The navigation and event handler testing are based on the gesture movement of the mobile device whether it is able to navigate from current page to the next page or not.

Featured Testing: This test is a crucial part of the proposed application. This test is implemented to evaluate the efficiency of several techniques involved in counting the steps and check whether the formulas like BMI, BMR, body fat percentage, and calorie burner equation are working appropriately in real-life scenario.

However, the proposed application has several limitations which it cannot support some posture inference scheme and fitness activities like bicycling, tennis, and swimming. The proposed application considers the user to maintain a good nutritional intake and at least 300 steps are required to see changes in calories decrease.

4 Results

This section presents the achieved results of the proposed application based on laboratory testing.

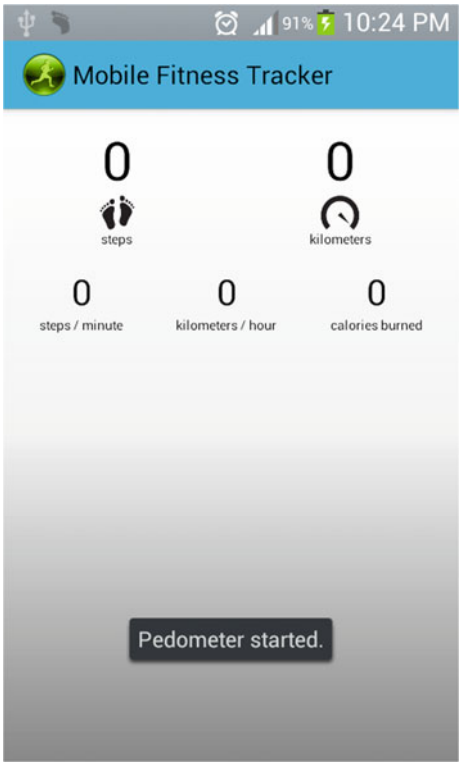

Fig. 5 Pedometer menu

4.1 Mobile Device Compatibility Testing

Table 1 shows the result of compatibility for different types of mobile devices. Based on the result, the proposed application can be installed in all mobile devices with no compatibility issues. In terms of smoothness, only tablet device has distorted image in a certain module due to the large size of screen size.

Table 1 Different mobile device types

Mobile device type	Smoothness	Compatibility
Tablet	Distorted image in certain module	Yes
Candy bar smartphone	Excellent smoothness	Yes
Phablet	Excellent smoothness	Yes

4.2 Navigation and Event Handler Testing

Table 2 shows the possible navigation of the proposed application. There is slow loading when starting or quitting the application. This is due to the large size of the application.

Based on Table 3, all event handlers of the proposed application are well functioning. This means no error or bug occurs during the testing phase.

4.3 Featured Testing

The sample population taken to accomplish this test is 100 respondents who are aged from 20 years and above. The respondents are agreed to use the proposed application for a period of no more than 7 days. The respondents are then grouped into 10 groups and their early average weight and total steps were calculated. The final average weight is calculated at the end of 7 days. The nutrition intake for each day restricted to daily eating order, which is breakfast, lunch, and dinner. The following details were requested for each of the 7 days:

Table 2 Result of navigation testing

Navigation gesture	Smoothness
Sliding to the left	
Sliding to the right	
Sliding up	Excellent
Sliding down	
Scrolling	
Starting	
Quitting	A bit slow

Table 3 Result of event handler testing

Event handler	Functionality	Result
BMR calculation	Calculate BMI and body fat percentage of users	Successful
Pedometer starting	Start the pedometer	
Step counting	Start the counting of steps	
Pedometer setting	Setting a different variable to the pedometer	
Interface switching	Switching module. Example, from pedometer to BMR calculation	

Table 4 Result of featured testing

Group	∑ Early weight	∑ Day 1–3 walk distance	∑ Day 4–7 walk distance	∑ Final weight	Weight different	% Weight different	Average weight loss per respondent
1	742	48000	56010	731	11	0.75	1.1
2	648	45020	47770	640	8	0.62	0.8
3	775	49000	54086	771	4	0.26	0.4
4	779	47096	52000	775	4	0.26	0.4
5	720	46322	51245	715	5	0.35	0.5
6	689	42065	48056	686	3	0.22	0.3
7	650	41222	43602	640	10	0.78	1
8	680	44090	41365	674	6	0.44	0.6
9	702	47702	56520	695	7	0.50	0.7
10	661	48023	45788	651	10	0.76	1

- Whether the application had been used that day.
- The number of steps taken that day.
- Weight on each day.
- Distance walked in each day.
- Food intake each day.
- Calories burned in days as displays on the application.

Table 4 shows the result of the featured test in which all participants gained a weight loss minimum with 0.3 kg per week and with maximum 1.1 kg. This means that the proposed application can be applied in a real-world environment to control body weight if certain rules are obeyed.

5 Conclusion

This paper proposes calorie burned estimation for mobile health application that can be used among mobile device users. The purpose of this paper is achieved by providing user to monitor calories loss thus encouraging a user to maintain a healthy lifestyle. This suggests that the proposed solution can be applied in health monitoring system environment. Nevertheless, the proposed application only can count the steps. For future work, other techniques like global positioning system (GPS) can be applied. Other than that, the proposed application can be enhanced by integrating a method to keep track of user intake calorie can be applied in order to enhance the proposed approach. In brief, the proposed application can assists users especially for those who want to control their calorie intake. Lastly, this paper provides the mobile device users to monitor their calorie and weight loss at anytime and anywhere.

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Chapter 5
Improved Feature Subset Selection Based on Hybrid Correlation for Disease Diagnosis

Wannoraini Abdul Latif and Fatihah Mohd

Abstract One of the important research issues in disease diagnosis is the selection of a subset of attributes that can produce the preferred output with a satisfactory level of accuracy. Therefore, the aim of this study is to improve accuracy the presence of oral cancer primary stage with elimination of the attributes that are strictly correlated with other already selected attributes. This study propose a hybrid features selection method based on a correlation evaluator and linear forward selection to address feature selection. Originally, 25 attributes from an oral cancer data set have been reduced to 14 features using proposed method feature selection in order to diagnose the oral cancer staging. Subsequently, seven classifiers: updatable Naïve Bayes, multilayer perceptron, K-nearest neighbors, support vector machine, Rules-DTNB, Tree-J48, and Tree-Simple Chart are used in order to evaluate the efficiency of the features selection methods. All the evaluations are conducted in Waikato Environment Knowledge Explorer (WEKA) with tenfold cross validation. The empirical comparison shows that the subset of features generated from the proposed features selection methods with over-sampling techniques at preprocessing phases significantly improved the accuracy of the entire classifier algorithm used for the oral cancer data set with a mean accuracy of 96.53%. The implication of the study supports the suitable subset of variables in oral cancer diagnosis. Therefore, the future direction includes the consideration of using proposed feature subset to classify and generate the differential probabilities for stage diagnosis among oral cancer patients.

Keywords Correlation · Diagnosis · Features subset selection
Oral cancer · Over-sampling

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_5

1 Introduction

Oral cancer (OC) or mouth cancer is any cancerous tissue growth located in the mouth (Scully and Porter 2000). It may arise as a primary lesion originating in any of the oral tissues, by metastasis from a distant site of origin, or by extension from a neighboring anatomic structure. Most common OC is oral squamous cell carcinoma (SCC). It may occur on tongue, the buccal mucosa, palate, floor of mouth, maxilla, lip, cheek, mandible, tonsil, parotid gland, oropharynx, and other unspecified parts (Scully and Porter 2000). Risk of OC, it can go unseen in its early stages. It can be painless, and little physical changes may be ignored or missed by patients, healthcare professionals (Neville and Day 2002; Lingen et al. 2008).

An early diagnosis of cancer problems will increase patients' survival rate (Sankaranarayanan et al. 2005; Waal et al. 2011). In the OC diagnosis, all the clinical features and numerous clinical subsets, personal history, and social habits from the records of the cancer registries, outpatient department (OPD) data sheet, radiology report, and histopathology report of the hospitals are considered as valuable information for decision-making (Neville et al. 2009). However, the patient's records are a collection of features and data, which could be lead to problems in the diagnosis (Zhang et al. 2012). So that, the process removing bad data, data preparation, identifying sources of data, and determining which columns are the most appropriate for use in the analysis are current challenges for developing and improving the performance of clinical diagnosis (Guillén et al. 2013). Then, the study concentrates on the selection features to reduce the unrelated data that involves the diagnosis of OC. Features selection (FS) performs a set of process automatically, whose aim is to discover and extract relevant and valuable features from data set.

Another issue is an imbalanced data set. Data set is imbalanced when at least one class is represented by only a small number of training examples (called the minority class) while other classes make up the majority (Ramentol et al. 2012). In this scenario, classifiers can have good accuracy on the majority class but very poor accuracy on the minority class(es) due to the influence that the larger majority class has on traditional training criteria. Most classification algorithms pursue to minimize the error rate and the percentage of the incorrect prediction of class labels. They ignore the difference between types of misclassification errors. To overcome this problem, we propose a preprocessing of imbalanced data set before the features selection stage. In this study, we integrate the Synthetic Minority Over-sampling Technique (SMOTE) algorithm into our diagnostic model to resolve the problem of imbalanced data set.

This study aims to produce an efficient predicting diagnosis with deducted number of features that contribute more to the use of OC using correlation FS with classification. In this paper, an integrated diagnostic model for selection of the optimum features is proposed. The model is based on the integrated a preprocessing phase and hybrid FS which is used to select of features used in the diagnosis process. We also suggested our new hybrid feature selection method is evaluated using seven classification techniques: Naïve Bayes (NB), multilayer perceptron

(MLP), support vector machine (SVM), K-nearest neighbors classifier (KNN), Rules-DTNB (DTNB), decision trees (J48), and BFTree (TC). This paper is organized into four sections. Section 2 outlines the materials and methods used. The proposed an integrated diagnostic model is presented in section three. The discussion on simulation results of experimental works is elaborated in Section 4. Conclusions are drawn in Section 5.

2 Materials and Methods

The main purpose of the study was to produce the optimum relevant number of features that contribute more accuracy of OC diagnosis using FS method. The development of the integrated diagnostic model is also presented in this section together with a propose hybrid FS method for the diagnosis primary stage of OC. Waikato Environment Knowledge Explorer (WEKA) open source data mining software was used for the experimental works. The data set and FS methods used are described below.

2.1 Oral Cancer (OC) Data Set (Bakar et al. 2013; Mohd et al. 2013)

OC data set consists of 25 variables or features and 82 instances or records. The 25 features of OC are divided into four categories:

i. demographic features are assigned as number 1–6 (age, sex, race, smoke, quid, and alcohol),
ii. clinical signs and symptoms features are assigned as number 7–20 (swallow, ulcer, neck lump, loss of appetite, loss of weight, hoarseness of voice, bleeding, burning sensation in the mouth, painful, swelling, numbness, site, size, and lymph node),
iii. histopathological features are assigned as number 21–25 (histological type, differentiation of squamous cell carcinoma (SCC), primary tumor (T), regional lymph nodes (N), and distant metastasis (M), and
iv. feature of the primary stage is a class label of disease's diagnosis (one, two, three, and four).

2.2 Synthetic Minority Over-Sampling Technique (SMOTE)

In this study, SMOTE algorithm is applied to resolve the problem of imbalanced data set during the preprocessing stage. SMOTE is running in a WEKA software

environment under the supervised filter function. The original OC data set with imbalanced data must fit entirely in WEKA memory. The minority class is over-sampled by creating synthetic examples rather than by over-sampling with replacement. This approach is inspired by a technique that proved successful in handwritten character recognition (Ha and Bunke 1997). Chawla et al. (2002) generated synthetic examples in a less application-specific manner, by operating in feature space rather than data space.

2.3 *Features Selection (FS) Algorithms*

FS is a process to produce the most relevant variables (features) from a data set. It includes reduced dimensionality, removing irrelevant data, and noise, in order to improve result comprehensibility (Aruna et al. 2012; Xie et al. 2012). The main idea of FS functions is used for finding the most significant variables (optimal subset) by removing the features with little or no predictive information. In this study, FS for OC data set is conducted in WEKA with tenfold cross validation. The FS algorithms used for feature evaluation within this study are outlined below:

- Correlation-based feature subset selection (CfsSubsetEval). This method evaluates the worth of a subset of variables by considering the individual predictive ability of each feature along with the degree of redundancy between them.
- Correlation variable evaluation (CorrelationVarEval). This FS method evaluates the worth of a variable by measuring the correlation between it and the class. Nominal variables are considered on a value by value basis by treating each value as an indicator. An overall correlation for a nominal variable is arrived at via a weighted average.
- InfoGain (IG) variable evaluation method (InfoGainVarEval). It evaluates the worth of variable by measuring the information gain with respect to the class.

All the features were searched using these algorithms:

- Best first forward/sequential forward FS (SFFS). This algorithm searches the space of variable subsets by greedy hill climbing augmented with a backtracking facility.
- Ranker. The variables are rank by their individual evaluations.
- Linear forward selection with floating forward selection or known as sequential backward selection (SBFS). It is an extension of best first. The search direction can be forward or floating forward selection (with optional backward search steps).

We then run the following feature selection methods against the OC data set to select feature subsets from the full set of 25 features set:

i. It started with all selected features (FS0).
ii. CfsSubSetEval with best first forward (FS1) (Selvakuberan et al. 2008).
iii. InfoGain variable evaluator combined sequential backward selection or known as linear forward selection with floating forward selection (IGSBFS) (FS2) (Aruna et al. 2012).
iv. Correlation variable evaluator with ranker (FS3).
v. Hybrid FS3 with CfsSubset evaluator with linear forward selection (FS4).

2.4 An Integrated Diagnostic Model

In this study, the integrated diagnostic model is proposed to OC data set. It integrates the preprocessing phases, over-sampling technique (SMOTE), and FS methods (see Fig. 1). The collected OC data is first introduced, as well as the case study with a number of instances and features. Then, the data proceed by scaling or standardizing to reduce the level of distribution between the variables in the data set. The preprocessing phase included data integration, data consistency, data transformation, and data cleaning process. Data integration enables merging of data from multiple sources into a coherent data source. To resolve ambiguity between clinical terms, the variable and value will be given a same name or term in data consistency. Data transformation generates the data into a suitable form for a knowledge base. Data cleaning activity reduces the noise present in the data set. The result of data preprocessing phases is a free noisy data, no inconsistency, and missing values are filled.

After over-sampling OC data set, the process proceeds to FS to find the most relevant variables in the OC data set. At this phase, FS methods are used to select most relevant features model. Seven machine learning classifiers are used at this stage to evaluate the performance measure accuracy of FS model. Finally, the result of the proposed integrated diagnostic model gives the best subset of features that particular type of data set.

2.5 Hybrid Correlation Evaluator and Linear Forward Selection (HCELFS)

There are six stages in our proposed hybrid FS method. The method is called HCELFS, where it combines hybrid correlation attribute evaluator (CAE) with ranker and correlation-based feature subset (CFS) evaluator with linear forward selection (LFS), to select the optimal features subset from the original feature set. In this diagnostic model, we applied the correlation attribute evaluator method to filter the relevant features which resulted in reduced features subset. From this subset, a CFS subset evaluator with LFS searched for the most relevant features resulting in

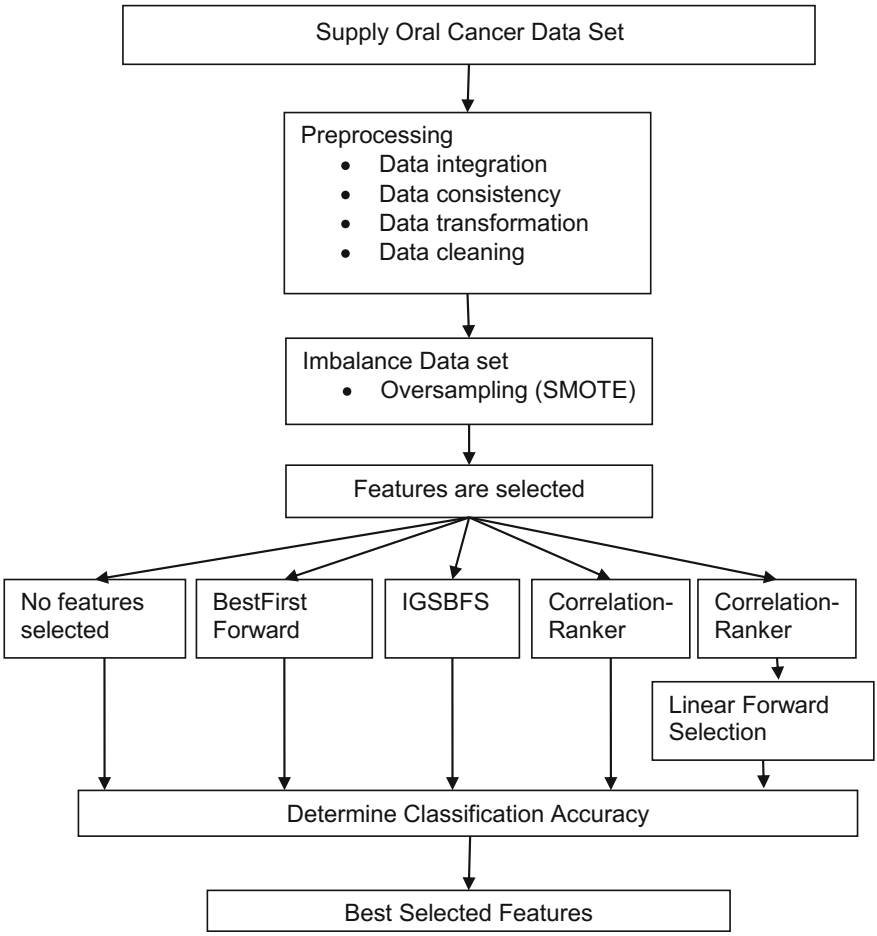

Fig. 1 An integrated diagnostic model for OC data set

optimum feature set used for OC data set. Our HCELFS algorithm selected the optimum features as follows:

Input: Data set with all features.
Output: Data set with optimum features.
Step 1: Rank the relevant features from highest to lowest using correlation attributes evaluator method.
Step 2: Remove 1/3rd of the features from the feature set which has lowest ranking rate.
Step 3: Add the remaining 2/3rd feature set in the queue to the next steps.
Step 4: Reduce the features subset to remove redundant and irrelevant features.

Step 5: Select the most relevant features using linear forward selection.
Step 6: The features in the queue is the required optimum feature subset necessary for the diagnostic model.

3 Results and Discussion

This section presented and described the finding of experiments in this study.

3.1 Balance Data Set

The original imbalanced OC data set is categorized into four classes. There are 58 instances of the majority class (stage four), 16 for stage three and stage one, and two fall under the category of minority class with the number of instances less than 10. In this study, for the training set tenfold cross validation is used. The minority class is over-sampled at 100, 200, 300, and 400% of its original size. Table 1 shows the result of resample an imbalanced OC data set using SMOTE. The result after over-sampling presented the number of instances is resample to 210 instead of 82 instances. The result of Table 1 also shows the class distribution of each minority class of OC data set, stage one (22.86%) and two (19.05%), is almost balance as majority class, stage three (30.48%) and four (27.62%).

3.2 Optimum Features Selected

Features selection started with all features selected (FS0), cfsSubSetEval with best first forward (FS1), InfoGain variable evaluator combined sequential backward selection or known as linear forward selection with floating forward selection (IGSBFS) (FS2), correlation variable evaluator with ranker (FS3), and hybrid FS3

Table 1 Balance class distribution for OCDS by applying SMOTE

Class label	Original data set (R_0)	After resampling (R_x)
One	3 (3.6585%)	48 (22.8571%)
Two	5 (6.0975%)	40 (19.0476%)
Three	16 (19.5121%)	64 (30.4761%)
Four	58 (70.7317%)	58 (27.6190%)
Total instances	82	210

Table 2 Selected attributes with FS methods

FS	Selected features
FS0	All features (25 features)
FS1	14 features (2, 3, 8, 9, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24)
FS2	14 features (23, 21, 19, 24, 20, 18, 22, 16, 8, 15, 3, 2, 17, 9)
FS3	i. Ranked features: 20, 23, 21, 22, 16, 19, 24, 8, 2, 15, 7, 17, 3, 18, 5, 1, 13, 9, 11, 6, 25, 10, 14, 4, 12 (25 features) ii. Remove ranting value = 0 (feature 12)
FS4	14 features (20, 23, 21, 22, 16, 19, 24, 8, 2, 15, 17, 3, 18, 9)

with CfsSubset evaluator with linear forward selection (FS4). All experiments of FS are done in WEKA began with FS0 with 25 features and ended with optimal features at FS4.

The process of the proposed FS method, HCELFS algorithm with six stages started with 25 of OC data set features and 210 instances. With Correlation Ranking Filter, the algorithm ranked 25 features, namely, 20, 23, 21, 22, 16, 19, 24, 8, 2, 15, 7, 17, 3, 18, 5, 1, 13, 9, 11, 6, 25, 10, 14, 4, and 12 with correlation value (0.4602, 0.4319, 0.3715, 0.3611, 0.3561, 0.3558, 0.3349, 0.3203, 0.2751, 0.266, 0.2644, 0.2345, 0.2323, 0.2297, 0.1966, 0.1884, 0.181, 0.1496, 0.1465, 0.1042, 0.1042, 0.0905, 0.0599, 0.0455, 0).

Then, it removed one feature, namely, 12 with ranking rate 0. With the resultant 24 features, subset method removes the redundant and irrelevant 10 features, namely, 7, 5, 1, 13, 11, 6, 25, 10, 14, and 4. This algorithm ended with 14 features, namely, 20, 23, 21, 22, 16, 19, 24, 8, 2, 15, 17, 3, 18, and 9 (sex, ethnicity, ulceration, neck lump, painful, swelling, numbness, site, size, lymph node, histopathology, SCC types, primary tumor, and regional lymph nodes) as an optimum features set. Table 2 shows the details of results for each FS method.

3.3 Accuracy Classification Performance

The effectiveness of the proposed integrated diagnostic model combined with SMOTE and FS algorithm was investigated using real imbalanced OC data sets and balanced OC data set. The accuracy performance is tested with classification accuracy metric (ACC) where four (4) outcomes are labeled as true positive (TP), false positive (FP), true negative (TN), and false negative (FN), ACC = (TP + TN)/(TP + FP + FN +TN) (Mohd et al. 2015; Vaghela et al. 2015). Seven different machine learning algorithms are used to classify the OC data set with five FS methods and optimum features selected by proposed hybrid FS method: Naïve

Table 3 Accuracy performance for three selected FS on OC data set without SMOTE

Classification accuracy without SMOTE (%)			
MLA	FS0	FS2	FS3
NB	85.37 14.63	75.61 24.39	87.80 12.20
MLP	76.83 23.17	79.27 20.73	90.24 9.76
SVM	62.20 37.80	62.20 37.80	86.59 13.41
KNN	75.61 24.39	75.61 24.39	76.83 23.17

Bayes (NB), multilayer perceptron (MLP), SMO-Poly Kernel (E-1.0) (SVM), K-nearest neighbors (KNN), Rules-DTNB (DTNB), decision trees (J48), and BFTree (TC).

Table 3 shows the result for the four classifiers without over-sampling method, SMOTE. It started with selecting all the features of OC data set, 25 features. Next phase is FS2, also carrying on with 25 features. Finally, classifiers with 14 selected features from FS3 are generated. Using over-sampling technique (SMOTE), the results for three FS methods (FS0, FS2, and FS3) with four classifiers show that the features selected by the integrated diagnostic model contributed to improve the accuracy of the entire classification algorithms used for the OC data sets.

Table 4 presents overall accuracy performance of feature subset evaluators and their respective machine learning algorithms. Applying over-sampling method (SMOTE), the results for five FS methods (F0–F4) with seven classifiers show that the features selected contributed to the improved accuracy of the entire classification algorithm used for the OC data set. The accuracy of OC data set from original

Table 4 Performance accuracy for five FS on OC data set

MLA	Raw (25F)	FS0 (25F)	FS1 (14F)	FS2 (25F)	FS3 (14F)	FS4 (14F)
NB	85.37 14.63	91.91 8.10	94.77 5.53	94.76 5.24	91.91 8.10	94.76 5.24
MLP	89.02 10.98	94.29 5.71	94.76 5.24	94.76 5.24	93.81 6.19	95.24 4.76
SVM	80.45 19.51	93.33 6.67	92.38 7.62	92.38 7.61	93.33 6.67	96.19 3.81
KNN	67.07 32.93	86.19 13.81	90.95 9.05	90.95 9.05	86.19 13.81	91.43 8.57
DTNB	79.27 20.73	98.10 1.91	99.52 0.48	100.0 0.0	100.0 0.0	100.0 0.0
J48	91.46 8.54	98.57 1.43	98.57 1.43	98.57 1.43	98.57 1.43	98.57 1.43
TC	90.24 9.76	99.52 0.48	99.52 0.48	99.52 0.48	99.52 0.48	99.52 0.48
Mean	83.27	94.56	95.78	95.85	94.76	96.53

unbalanced OC data set with 25 features (Raw) to FS4 is improved from 85.36 to 94.76% (NB), 89.02 to 95.23% (MLP), 80.48 to 96.19% (SVM), 67.03 to 91.42% (KNN), 79.26 to 100% (DTNB), and 91.46 to 98.57% (J4.8) and 90.24 to 99.52% (TC). Findings from Table 4 are also shown that the highest classification accuracy for entire classifier is well performed with 14 optimal features selection, namely, 2, 3, 8, 9,15, 16, 17, 18, 19, 20, 21, 22, 23, and 24. It presents the optimal features set from FS4 contributes the highest accuracy performance for all classifiers.

The empirical comparison between fives FS methods and original imbalanced data set (Raw) for the entire classifier algorithms as shown in Table 4 is also presented as graph comparison (see Fig. 2). It illustrates that the accuracy performance for all classifier is increased by applying the FS method compared to original imbalanced data set without features selection. Generally, FS4 gave the highest accuracy with mean 96.53% than original OC data set (Raw), 83.27% (see Fig. 3).

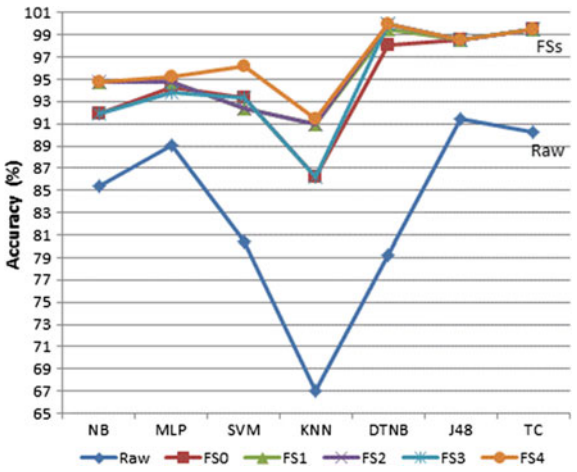

Fig. 2 Graphical representation of FS methods according to accuracy performance

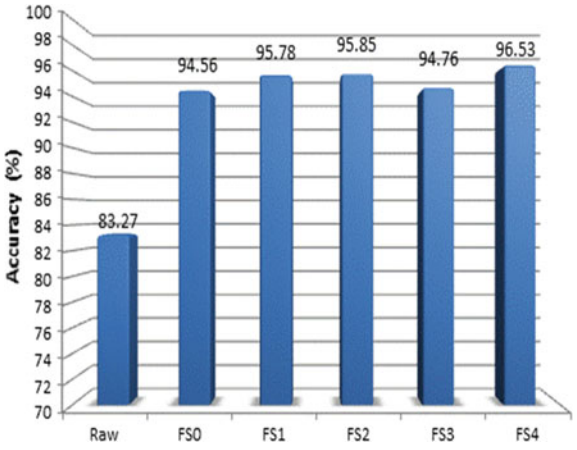

Fig. 3 Graphical representation of FS methods according to mean accuracy performance

4 Conclusion

Acceptability level of the accuracy looks as a main issue of the research. Thus, the subset of the selected attributes that could produce the optimal relevant attributes is investigated. Five FS methods with OC data set were demonstrated using WEKA software in order to improve the accuracy of OC diagnosis. It is noted that the integrated preprocessing phases with a proposed hybrid FS method to diagnose the stage of OC showed an increase in classification accuracy. The hybrid FS method, named HCELFS, combines the correlation attribute evaluator which acts as a filter and SBFS which acts as the wrapper to select the ideal feature subset from the remaining features. 14 optimal feature subsets (sex, ethnicity, ulceration, neck lump, painful, swelling, numbness, site, size, lymph node, histopathology, SCC types, primary tumor, and regional lymph nodes) from 25 features obtained were then trained with seven machine learning algorithms, including Naïve Bayes, multilayer perceptron, K-nearest neighbors, SVM, Rules-DTNB, Tree-J48, and Tree-Simple Chart. The empirical comparison shows that the proposed hybrid FS algorithms in this study gave the accuracy improvement of the entire classifier algorithms used for the OC data set with a mean accuracy of 96.53%. These results clearly demonstrate the great potential of the proposed model for the diagnostic of clinical data. The future direction includes the consideration of using proposed feature subset to classify and generate the differential probabilities for stage diagnosis among oral cancer patients.

Acknowledgements The authors would like to acknowledge all contributors who have provided their assistance in the completion of the study and anonymous reviewers of this paper. Their useful comments have played a significant role in improving the quality of this work.

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Chapter 6
Multiple Types of Semi-structured Data Extraction Using Wrapper for Extraction of Image Using DOM (WEID)

Ily Amalina Sabri Ahmad and Mustafa Man

Abstract The amount of all kinds of data that available electronically has increased dramatically in recent years. The data resides in different types, either in structured (SD), semi-structured (SSD) or unstructured data (USD). Data integration for multiple types of data can be defined as the problem of combining data from heterogeneous sources to one unified structure. A user is unable to view it as a single entity irrespective of the origination or its data type. It involves combining data coming from different sources and providing users with a unified view of these data. In this paper, we propose a diagrammatic representation of a wrapper for multiple types of SSD data extraction using Document Object Model (DOM). We have implemented the automated web extractor, Wrapper for Extraction of Image using DOM (WEID) using the PHP programming language that can extract images from a web page. Experimental results on a web page are encouraging and confirm the feasibility of the approach in extracting images successfully. Our approach is less labour-intensive, and we believe via our technique that automatic extraction of images can be done fast and effectively.

Keywords Data integration · Data extraction · Document object model (DOM) Semi-structured data (SSD) · Wrapper for extraction of image using DOM (WEID)

1 Introduction

The World Wide Web (WWW) has become large information store that is growing very fast. Many web pages are generated online for website multi-purposes. A huge amount of data is available on the web and it continues to increase dramatically in

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_6

recent years. The data resides in different forms, ranging from unstructured data (USD) in file systems to highly structured in relational database systems. Data is accessible through a variety of interfaces including web browsers, database query languages, application-specific interfaces, or data exchange formats. Some of this data is raw data such as images or sound. Some of it has structure even if the structure is often implicit, and not as rigid or regular as that found in standard database systems. Sometimes, the structure exists but has to be extracted from the data but we prefer to ignore it for certain purposes such as browsing. We need to consider three types of data such as SD, USD and SSD as shown in Fig. 1 (Ronk 2014).

Data integration is considered as one of the hot issues to be solved especially in integrating unstructured data with multiple types and formats and stored in different locations (Man et al. 2015). The integration between the structured and unstructured data is concerned by certain organizations in terms of their benefits to retrieve valuable information and knowledge. Scheuermann (1990) not suggest imposing a single global schema for users in data integration. This is because it can seriously interfere with their individual work, as the autonomy of information receivers is disrupted. The autonomy of information receivers implies that integrated information used must be non-intrusive so that users should not be forced to adapt to any standard concerning the structure and meaning of the data they request. The desired kind of data integration can thus be characterized by the optimal fitness of the supplied information for a certain purpose, concerning the organization, presentation and semantics. The integrated information that is provided has all the relative qualities required by a particular user in a specific task.

Data integration has become a very challenging task with the consequently growing volume of the data especially in integrating data from distributed, heterogeneous and large volume of data sources (Ziegler and Dittrich 2007).

Fig. 1 Types of data

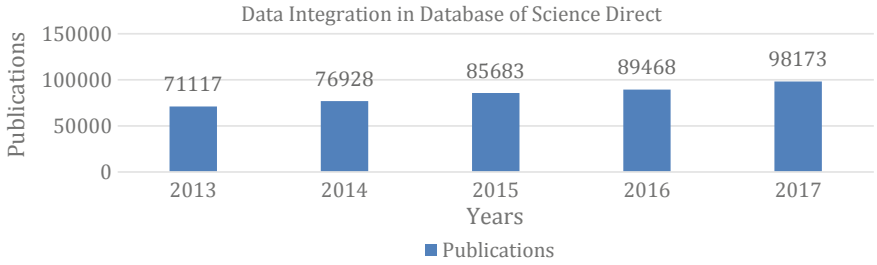

Fig. 2 Data integration in database of science direct

Figure 2 shows publications for data integration in Science Direct (2017). In practical applications, information is often vague or ambiguous. Traditional databases allow for the storage and retrieval of large amounts of data but do not make any concessions for imprecision and uncertainty in the data (Nierman and Jagadish 2002).

The unifying idea in SSD is the representation of data as some kind of graph-like or tree-like structure (Buneman 1997). Abiteboul (1997) suggested that the choice of a model should consider richness, complex, simple and lightweight. Imprecise and uncertain data in those domains are generally caused by data randomness and incompleteness, limitations of measuring equipment, delayed data updates, etc. Due to the promptly increasing amount of imprecise and uncertain data collected and accumulated, it is important to investigate the combination of XML and imprecision/uncertainty (Liu and Zhang 2014). The adoption of the Extensible Markup Language (XML) as the standard for data representation and exchange has led to an increasing number of XML data sources. XML provides two enormous advantages as a data representation language because it is text-based and position-independent. Unfortunately, XML is not well suited to data interchange because it is hard to understand by a human.

The JavaScript Object Notation (JSON) format is usually used the presentation of such data structures (Izquierdo and Cabot 2014). JSON is a binary and typed data model which supports the data types list, map, date, Boolean as well as numbers of different precisions. We apply an intuitive notation coming out from the example and only reminding JSON. JSON is an open, text-based data exchange format. Like XML, it is human-readable, platform-independent, and enjoys a wide availability of implementations (Nurseitov et al. 2009). Data formatted according to the JSON standard is lightweight and can be parsed by JavaScript implementations with incredible ease, making it an ideal data exchange format for Ajax web applications.

Since it is primarily a data format, JSON is not limited to just Ajax web applications and can be used in virtually any scenario where applications need to exchange or store structured information as text. Table 1 shows the comparison between XML and JSON.

Table 1 The comparison between XML and JSON

Characteristics	XML	JSON
Simplicity	Simpler than Standard Generalized Markup Language (SGML)	Simpler than XML
Extensibility	It is a document markup language so it is necessary to define new tags or attributes to represent data in it	Not extensible because it is not a document markup language
Openness	Wide implementation	Wide implementation
Interoperability	Comparable	Comparable

Abiteboul (1997) discussed that there are two approaches that need and probably more feasible than all proposed model for semi-structured data. There are maximalist approach and a minimalist approach. After consider and choose a model, the query language has to be more flexible than in conventional database systems. There are two general approaches have been recognized to devising query languages for semi-structured data, SQL and OQL (Buneman 1997). The semi-structured data is the information that does not fit well into relational databases or tables. The management of semi-structured data is recognized as one of the major problems in the information technology industry as the variety and quantity of semi-structured data found on World Wide Web has been increased dramatically in last few decades (Chakraborty and Chaki 2011).

1.1 Semi-structured Data (SSD)

SSD is also called as 'self-describing'. The information in SSD is normally associated with a schema is contained within the data (Buneman 1997). Some data is really unstructured. The motivation comes from the need to bring new forms of data into the ambit of conventional database technology. The term semi-structured data has been defined in different ways related to the World Wide Web. Semi-structured web pages are those that may contain tuples with missing attributes, exceptions and attributes with multiple values. The contents of a web page are usually semi-structured data.

The web also provides numerous popular examples of SSD by applications in the various domains (Gupta et al. 2017; Rawat et al. 2016). SSD arises under a variety of forms for a wide range of applications such as genome databases, scientific databases, libraries of programs and more generally, digital libraries, online documentation and electronic commerce. It is thus essential to better understand the issue of querying SSD. Web data extractions are applications that used to extract semi-structured data from web page. Usually, the extraction process involved web data extraction system and web source. The system will interact with the web page and extract semi-structured data. The extracted contents may contain various elements of multimedia data such as audio, video, text and image. After extraction

process, the data will be stored in a temporary folder or directly store into database. These systems have been developed to assist human in wide range applications. The advantages of web data extraction systems are it can collect meaningful data efficiently and decrease human effort in a structured way. There are many discussions from different perspectives about scientific methods and techniques. The design and implementation come from various disciplines such as machine learning, natural language processing and logic. Web data extraction system is a software application that can extract data from web sources (Laender et al. 2002). This application usually interacts with a web source and extracts data stored in it. The extracted content could consist of elements in the HTML Web page. Finally, the extracted data might be post-processed, converted in the most appropriate structured format and stored for further usage.

Multimedia data such as images, video clips, animations, graphics and audio have increased rapidly over the past several years. Users have begun to expect that multimedia contents should be easy to access. They want to find relevant photo images that appear in a web page, see video clip related to text articles they read and listen to the audio. It is important to provide integrated access to diverse types of multimedia semi-structured data stored in disparate data sources. Many web data extractors today deal with multimedia data.

Classification of data patterns is important for data extraction from the web page. There are four classes that have been identified; image, text, audio and video. These multimedia data will be identified when the parser found the word 'src=' in the data structure during the extraction process as shown in Table 2. This is a keyword for multimedia data source reference to locate the source data that has been used.

This study is intended to develop data integration system for biodiversity data related to Setiu Wetland areas. Data integration architecture has to be developed before data integration processing is done. First, this paper will only discuss about data extraction model for semi-structured.

2 Methods and Material

A wrapper is a set of extraction rules that applied to extract information from a web page. The following section discussed the proposed method of implementation of the wrapper, WEID. The various phases of extraction are also further elaborated. The next stage gives the overview of WEID.

Table 2 Data source for media

Type	'src'-source reference
Text	<a><p> <font><size>
Image	'src=*.jpg,gif,png,bmp'
Audio	'src=*.wav,mp3,raw,midi'
Video	'src=*.flv,wmx,mp4,avi'

2.1 Overview of WEID

WEID is developed to assist a user in extracting semi-structured data from a web page. A web page can be represented by a tree structure Document Object Model (DOM) (Man et al. 2016). It converts and stores a given *url* of the web page from a search engine into a DOM tree. Recently, the extraction process is focused on image. When the user inputs the uniform resource locator (*url*) and the query is submitted to a search engine, the search engine will dynamically generate a result page containing the result records. The results consist a link path for each element of image, image, size of image and time processing to load each image.

The wrapper is divided into two main parts. The first part involves the first step starting input the *url* of web page. It involves the parsing of the HTML web page and storing them as Document Object Model (DOM) tree. The conversion is important in order to understand the structure of HTML pages in a tree environment. This method is useful in measuring the structure of data either it is structured, semi-structured or unstructured data. The second part is about extracting technique. The wrapper applied the extraction technique. The entire flow is depicted in Fig. 3.

2.2 Information Extraction Using DOM Tree

In the beginning, the user needs to insert the path of the selected web page. When a page is crawled, we first extract the tree structure of a page based on DOM. Basically, HTML DOM defines a standard way to access and manipulate HTML documents. HTML page represents as a tree-like structure known as a node tree.

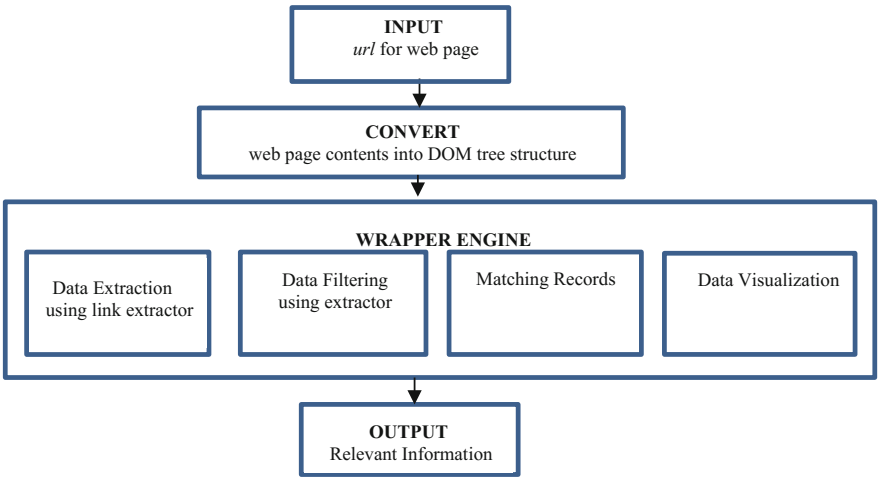

Fig. 3 Diagrammatic representation of WEID wrapper

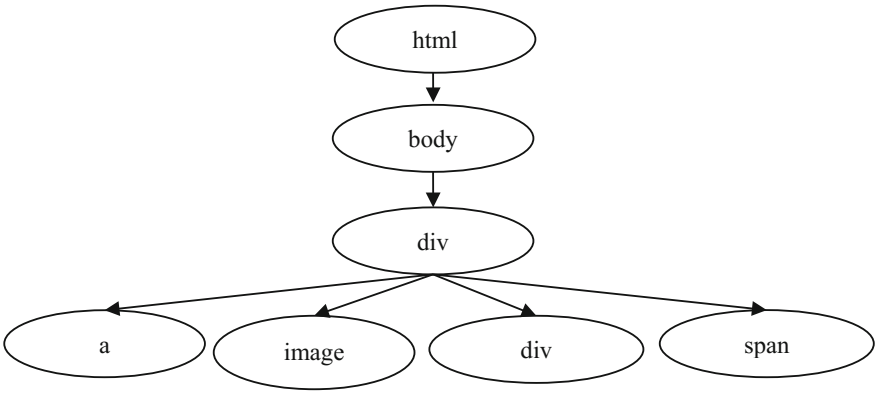

Fig. 4 DOM tree structure

Table 3 HTML tag descriptions

No	HTML tags	Descriptions
1	<body></body>	The content of the document
2		Defines a division or a section in an HTML document
3	<a>	Defines a hyperlink, which is used to link from one page to another
4		Provides a way to add a hook to a part of a text or a part of a document
5	<img>	Defines an image in an HTML page

Everything in a web page contains HTML tags called as a node. Figure 4 shows an example of an HTML document and its node tree. Table 3 shows HTML tags description for Fig. 4.

2.3 Multiple Types of Semi-structured Data Extraction Algorithm

Our algorithm relies on the DOM tree representation of a web page. The algorithm that has been discussed in this research is for extracting semi-structured data focusing on the image that works on each web page automatically. This algorithm will delete unnecessary HTML tags to reduce the processing time. This algorithm also indicted the block-level tags contain a significant amount of useful information and display. The summary of techniques are as follows:

i. Retrieve all data from web page
   - Compute the page pattern and identify the list on each page.

- Compute a set of features (tags and html attributes).

ii. Identify classification of data

- Identify the list of image.

iii. Display the extracted data

We present in this section the experimental results for our targeted extraction algorithm. The experiments were conducted on a workstation equipped with a 2.59 GHz CPU and 12 GB of RAM. The prototype tool built using PHP was designed and developed. Extraction and classification is a process to extract multimedia data from web page. Classification is the main process before extraction. We need to classify the multimedia data either in text, image, video and audio format. In Setiu Wetland, they have a lot of information related to the women activities conducted by World Wildlife Fund Organization (WWF) could be accessed via web pages in an image format.

The user interface of the testing algorithm using DOM is illustrated in Fig. 5. This process allows users to search multimedia elements by retrieving uniform resource locator (*url*) contents of semi-structured data (image) from any web page using this tool. List of *urls*, the image, size and time performance for extracting images were displayed in Fig. 5. The results from this process were done to validate whether the semi-structured data (image) can be retrieved using DOM algorithm.

After the extraction process, the user has to select certain images. Then, those images will be stored in temporary storage. Figure 6 shows the path for temporary storage. This prototype system can be viewed as a tool for extracting and gathering multimedia data of semi-structured for systematic data management.

Fig. 5 Output of the testing algorithm using DOM

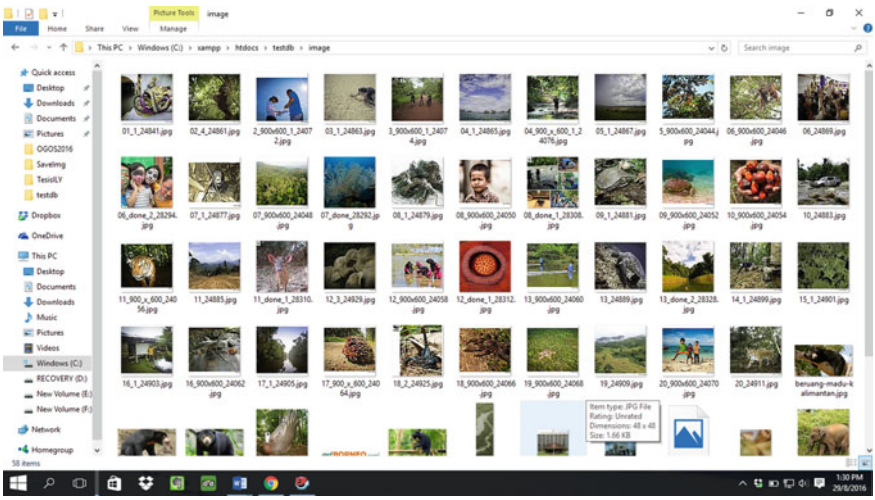

Fig. 6 Temporary storage for images

3 Conclusion

This paper proposed a wrapper, namely, WEID that can be applied in the multimedia database management system. The design of this wrapper is not just focusing on the system that handling the integration process for varieties of multimedia data but only focus on images that related to semi-structured data. It is also capable of handling and transforming semi-structured data into a useful information that can be managed as a valued enterprise asset. The transformation from unstructured information into structured data has been successfully performed using DOM parse tree. Our algorithm is based on extracting images from web page done automatically. The limitation of this research is time-consuming for image retrieving. In future work, we are expecting to fetch image automatically from web page by using JSON for reducing the processing time (Sabri and Man 2017).

Acknowledgements This research is supported by Scholarship of Universiti Malaysia Terengganu (BUMT).

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Chapter 7
Android Application to Test for Nicotine Dependence

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Abstract Nicotine dependence is categorized as tobacco addiction where the smokers are unable to stop taking cigarettes even though it causes harm. It is estimated that tobacco use has increased the death rate of smokers, that is, 5.4 million. It kills up with an average of one person in every 6 seconds. Many smokers do not realize that smoking is dangerous until they have suffered from health problems. If there is no prevention, the smoking habit will lead to cardiovascular disease. Therefore, the aim of this project to design an application to measure the addictive level of nicotine dependence using Fagerstrom test for Nicotine Dependence Therapy (NRT) product with appropriate dosage based on the nicotine level. Thus, by using mobile application, the smokers can interact with this application to monitor their nicotine level. From the tests that had been conducted, this application has been accepted by the experts and also target user who is a smoker.

Keywords Android application · Fagerstrom test · Nicotine dependence

1 Introduction

The smoking habit nowadays has become a trend. These trends are no longer dominated by men but have been spread among women. It also had become a virus among adolescence and even influenced the child as early as 10 years old. If the

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https://doi.org/10.1007/978-981-13-0074-5_7

trend is not overcome, the number of death will increase due to various health problems, which are the effects of smoking.

According to research by Pasupathi et al. (2009), cigarette smoking leads to atherosclerotic disease, which is the major contribution to coronary heart disease. Arteriosclerosis occurs when arteries are hardening and narrowing as a result of plaque formation made up of fat, cholesterol, calcium and other substances. Over time, it will harden and limit the flow of oxygen to the organs and other parts of the body. If there is no prevention, this disease will lead to other cardiovascular diseases which are harmful to health, such as stroke and heart failure.

The cigarette smoking is maintained primarily by dependency on nicotine where this substance is a chemical compound that exists in tobacco. Nicotine is very addictive and poisonous where it can act in the brain within 10 s after entering the human body. The brain will then release adrenaline that creates a buzz of pleasure and energy. As the buzz fades, it makes the body become tired and creates a desire to smoke again. As a result, it will build up a higher tolerance to nicotine that triggers crave for smoking in order to obtain the nicotine's pleasurable effects. With the high nicotine level, the smokers become addicted where it makes them continue to smoke even though they try to quit. This might be the concrete reason why most of the smokers are not succeed in quitting and getting back to their old habits although 70% of them expressed their willingness to quit, and 41% have an attempt to quit for at least a day (William and Diederich 2008).

Therefore, besides campaign like 'Stop Smoking', restrict some area to smoking and display the warning on the cigarette' packet, it seems that we need other tools to help the smokers to quit smoking gradually and eventually stop their habits permanently. The tool must capable of helping smokers decrease their nicotine level since it is important in order to identify the effectiveness of smoking prevention (Lim et al. 2012). The level of nicotine can be measured using Fagerstrom test where the users need to answer a sheet of questions. However, this test is not exposed intensively to the smokers especially those who have the intention to quit because of it only available at the clinic or hospital. Going to a clinic or a hospital is burdensome; thus, some smokers prefer to evaluate themselves by taking the test personally rather than taking the test at the clinic or hospital.

Therefore, with the massive development of mobile applications, it is the best platform not only to spread about the Fagerstrom test to the smokers but also enable them to monitor their nicotine dependence digitally. Thus, this research aims to develop a mobile application to test for nicotine dependence using the Fagerstrom test.

2 Literature Review

2.1 Nicotine Dependence

The level of addiction, low dependence, moderate dependence or high dependence, is determined by the nicotine dependence (Difranza et al. 2012). Table 1 shows the factors that decide the level of addiction.

Table 1 Level of addiction

Factor	Level		
	Low dependence on nicotine	Moderate dependence on nicotine	High dependence on nicotine
Number of cigarettes in a day	Less than 10	20–30	More than 31
Smoking time after waking up	31–60 min	30 min	5 min
Difficulty of quitting	Not difficult to stop smoking in restricted area	Need to find ways to break the smoking habit and arrange daily routine	Tend to smoke even unwell and hard to refrain from smoking in restricted area
Nicotine Replacement Therapy (NRT)	May not need NRT, but still need to monitor withdrawal symptoms	May not need NRT, try to handle the emotions like stress, sadness or frustrations, as these situations will probably lead to smoking	Recommended use patches

2.2 Fagerstrom Test

The Fagerstrom Test for Nicotine Dependence (FTND) is designed to evaluate the strength of nicotine dependence of smokers. This test is related to a number of variables that associated with the dependency such as levels of nicotine, cotinine (major metabolite) and withdrawal symptoms that will occur to most smokers. Besides, this test will also predict the ability to stop smoking consistently (Fagerstrom et al. 1990).

Most of the Smoking Clinic in Malaysia implement Fagerstrom test as a tool to measure the nicotine level of smokers (Ministry of Health 2010). According to Fagerstrom et al. (1990), the use of Fagerstrom test has been questioned as is it not accurate and not valid. However, Verification (2002) mentioned that findings from the population-based study have shown that there is a high consistency between self-reports in Fagerstrom test for nicotine dependence and biochemical measures or clinical test among the respondents.

Fagerstrom test consists of six questions to evaluate the smoking behaviour of smokers. The result of this test can be obtained by adding all the points that were answered by the user. Then, by referring the score result, the smokers can identify their level of nicotine dependence. Table 2 shows the Fagerstrom test for nicotine dependence.

Table 2 Fagerstrom test for nicotine dependence

No	Question	Answer	Score
1	How soon you smoke after you wake up from sleep?	5 min	3
		6–30 min	2
		31–60 min	1
2	Do you think it is difficult to stop you from smoking at public places?	Yes	3
		Depends on surrounding	2
		No, I can stop myself from smoking	1
3	Which time you find that it is difficult to avoid smoking?	Early in the morning	3
		Any other	2
		I am not smoking at all	1
4	Do you smoke frequently early in the morning	Yes	3
		Sometimes	2
		I am not smoking for whole day	1
5	Do you smoke at the time you are sick?	Yes	3
		Depends on health condition	2
		No	1
6	How many cigarettes do you smoke in a day?	Less than 10	3
		21–30	2
		31 or more	1

Scores
0–6 = Low nicotine level
7–12 = Medium nicotine level
13–18 = High nicotine level

2.3 Nicotine Replacement Therapy

Nicotine Replacement Therapy (NRT) has contributed to the increase of success rates in quitting. According to Zhu et al. (2000), the use of assistance such as nicotine replacement therapy for smoking cessation has increased over recent years from 7.9% in 1986 to 19.9% in 1996. Based on Division (2008), in order to encourage and motivate smokers to maintain the non-smoking status, the Ministry of Health has recommended smokers to use NRT product. There are three types of NRT products that available in the markets which are nicotine gum, nicotine patch and nicotine lozenge. However, according to Ministry of Health (2010), nicotine gum and nicotine lozenge are no longer used in Malaysia since the smokers will depend on these products if they are not taking cigarettes.

2.4 Android Application

Rapid development of mobile devices into clinical practise has encouraged the rising availability and quality of the medical applications. According to Ventola (2014), the use of mobile devices by healthcare professionals has transformed many aspects of the clinical device. Also, the mobile phones have shown some opportunity in helping people to reduce smoking addiction, thus stop their smoking habit (Abroms et al. 2011).

Each mobile phone has its own operating system in order to run its applications. Android application is a mobile software application that is powered by Google's Android platform. Besides, the Android application uses Java programming language, and it is an open source. Android is unique because Google is actively developing the platform but giving it away free to hardware manufacturer and phone carriers who want to use Android on their device.

2.5 Related Study

Tables 3 and 4 show the similarities and differences between the existing application named Last System and Smoke Free developed by Finkelstein and Wood (2013) and Crane (2017), respectively, with the proposed application. From the study, the proposed application is significant to developed because it has its own strength compared to the existing application.

Table 3 Comparisons between last system and proposed application

	Last system	Proposed application
Similarities	The smokers will be evaluated based on the series of questions that related to smoking behaviour	
Differences	Providing tips for smokers to quit smoking based on current stage of smoking cessation For example, • Preparation state—smokers ready to quit smoking • Action state—smokers undergo the process of quitting	Calculate the score of Fagerstrom test to identify the dependency level of the smokers
	Review smokers quit date and calculate the duration of quit smoking	User needs to enter the number of day they quit smoking to allow the application display their health improvement

Table 4 Comparisons between Smoke Free and proposed application

	Smoke Free	Proposed application
Similarities	Both of the application will provide the user with the information of their health improvement and money savings	
Differences	Smokers able to review how many days they have been smoke free	Smokers able to know what type of nicotine replacement therapy product that is most suitable
	Enable the smokers to see how their health is improving after quit smoking	Smokers only can see their health improvement from day one to day thirty after they quit smoking
	Calculate savings daily, monthly and yearly, but in dollar currency	Calculate savings daily, monthly and yearly, but in Ringgit Malaysia currency

3 Research Methodology

In this section, the research workflow that was designed and referred throughout the project is elaborated based on Fig. 1. The workflow was divided into three main phases, namely, analysis phase, design and construction phase, and testing and evaluation phase. Each of the phases has its own activities that need to be completed in order to proceed with next activity.

3.1 Analysis Phase

In order to gather information and obtain project requirement, the questionnaire was randomly distributed to 20 male respondents among students and staffs in UiTM

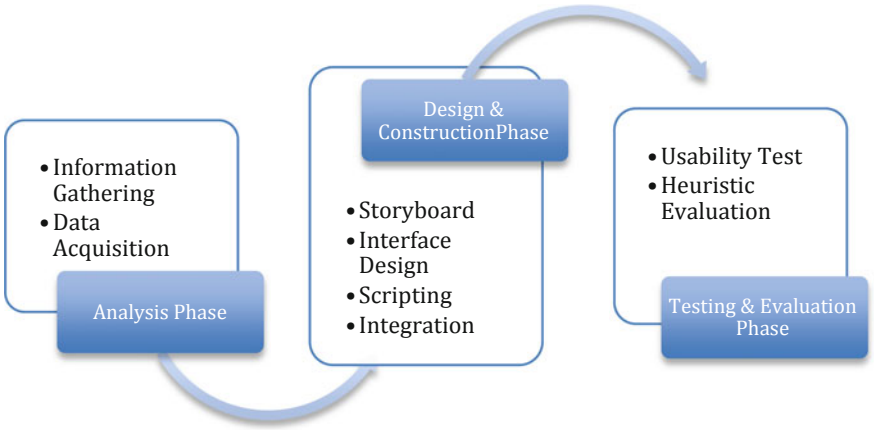

Fig. 1 Research workflow

Perlis. The purpose of the questionnaire was to collect the information regarding the type of smokers, the age they start smoking and factors of they keep smoking.

3.2 Design and Construction Phase

In design and construction phase, the activities involved are storyboard, interface design, scripting and integration. The storyboard was sketched based on the requirement obtained from the previous phase. The storyboard describes the flow of the applications comprehensively to make sure the applications running smoothly during the implementation phase. Figure 2 describes the sample of storyboard while Fig. 3 illustrates the sample of interface design.

In each application, interfaces play an important role since it is a connector between the application and the end user. Thus, in designing the interface, the criteria such as the type of fonts, theme colour and the quality of graphic must be taken into account. This was to ensure the applications is interactive, attractive and user-friendly. The interface design later on was translated into an Android application where the scripting was written using Java language in Android Studio software. The integration activity was accomplished by an Android application prototype named as 'Start2Quit'.

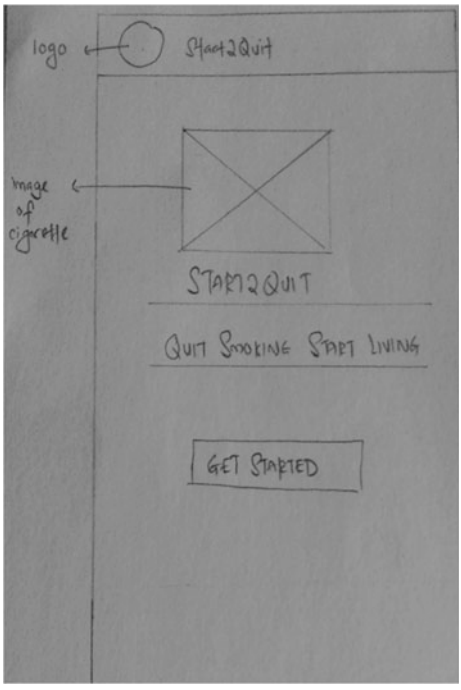

Fig. 2 Storyboard

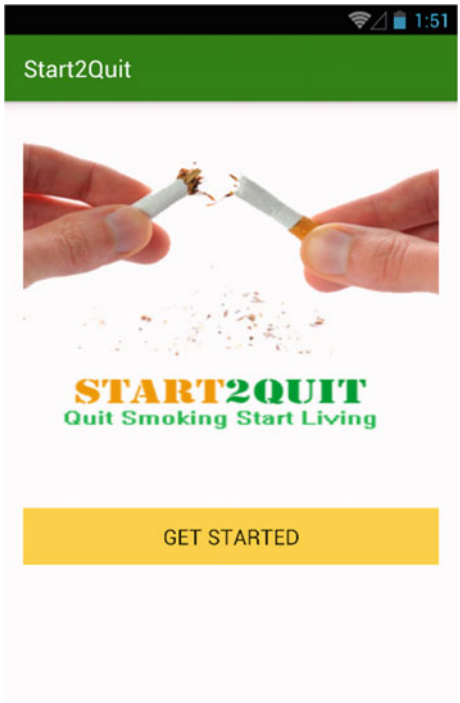

Fig. 3 Interface design

3.3 Testing and Evaluation Phase

For this project, usability test and heuristic evaluation were used as the measurement tools to test for accuracy, effectiveness and efficiency of the applications. There are 20 respondents were involved in the usability test while two experts had conducted the heuristic evaluation. The respondents are the staffs and students from UiTM Perlis while the experts are the medical officer and pharmacist from Klinik Kesihatan Manjoi, Ipoh and Aries Pharmacy, respectively.

4 Findings and Discussion

From the analysis, almost half of the respondents were categorized as heavy smoker because they smoke between 10 and 20 cigarettes in a day. Out of 20 respondents, 17 of them start smoking at a young age in the range of 12–17 years old. Besides friend's influence, the main reason they fail to quit smoking is depression. The respondents are also asked about their knowledge of nicotine replacement therapy and their feedback on the proposed applications. Based on the analysis, only four respondents know about the nicotine replacement therapy while 15 respondents agree with the proposed applications developed.

Table 5 Usability test

Task	Description
1	Respondents successful click the 'Get Started' button to access the applications
2	Respondents successful click the 'Overview' button to know the details of applications
3	Respondents successful click the 'Nicotine Level' button to answer all questions
4	Respondents successful click the 'View Results' button to view their scores
5	Respondents successful click the 'Savings' button to calculate the estimated savings after they quit smoking
6	Respondents successful click the 'Health Progress' button to know their health improvement after not smoking on certain days within 30 days

4.1 Usability Test

A usability test is one of the suitable ways to understand and observe users experience in using the applications. The aims of this test are to identify usability problems and to evaluate users satisfaction. For this test, users need to complete six tasks as shown in Table 5, and also they need to give their comments and feedback on the applications.

From the observation, it can be said that the applications are usable since all respondents successfully complete all the given tasks. Meanwhile, based on users feedbacks, the applications had undergone few refinements. The language used in the application was reviewed so that users can easily understand and get a clear explanation especially regarding the description of nicotine level and instruction of nicotine therapy dosage. Other than that, the image in the applications also upgraded with high resolution, and the type of colours used also reduced to three colours only.

4.2 Heuristic Evaluation

In a heuristic evaluation, the experts review the interface and the accuracy of the contents of the applications. For this project, experts need to evaluate six criteria using Likert scale in range 1–5. The criteria are listed as follows (Table 6).

Table 6 Heuristic evaluation

Criteria	Description
1	The applications generate low nicotine level result for scores 0–6
2	The applications generate medium nicotine level result for scores 7–12
3	The applications generate high nicotine level result for scores 13–18
4	The applications suggest an accurate dosage for patch
5	The applications suggest an accurate health progress
6	The applications use a clear and understandable term

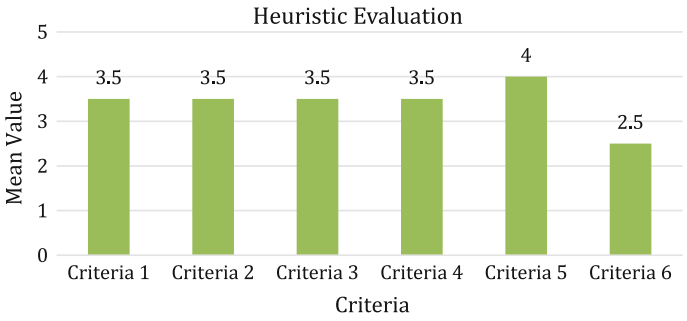

Fig. 4 Heuristic evaluation bar chart

Based on the bar chart in Fig. 4, the fifth criterion yield the highest mean value while the sixth criterion got the lowest value, and the rest score an average value. This is because both experts agree the applications should provide health progress to encourage smokers to quit their smoking habit. The experts also approved the accuracy of the health progress information is correct, and it is accordance with Ministry of Health. However, the experts suggested changing the terms used in the applications because for the user who not in the field, it is hard to understand. Based on the evaluation, it can be said most of the criteria yielded an acceptable score, which indicates that the application is capable of providing an accurate result of the nicotine dependence level and recommends a suitable therapy.

5 Conclusion

In this research, an Android application to test for nicotine dependence is had been successfully developed. The experts had proved that the application is reliable because it generates an accurate result. Apart from that, the user who has tested the applications expressed that they will use the applications as a tool to guide them through the process to quit smoking. In addition, the users also felt Saving menu which also provided in the applications is a bonus for them to calculate their estimate savings if they did not spend their money on cigarettes.

However, there are some improvements that are noteworthy in a future work such as the applications should be upgraded with a database to save users' past information that eases the user to keep track their progress. Other than that, it is advisable that the applications have some visual aid that can help users in understanding the use of the recommended therapy. In addition, in order to provide a variety of access to the application, it is recommended to develop the application on other platforms such iOS. In a nutshell, the applications are acceptable for the time being, and it is hoped that the applications are capable of reducing the numbers of smokers among us.

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Chapter 8
Embedding Teaching Plan into E-learning System

Amran Ahmad and Nik Nurhafzan Mat Yaacob

Abstract Teaching plan (TP) or scheme of work (SOW) is a document used to plan a layout of the teaching process in an educational environment. Meanwhile, an e-learning can be used to bridge between student and teacher at anytime and anywhere to support the TP. Unfortunately, both TP and e-learning activities are prepared separately. There is a need to embed TP into e-learning to gain less effort and less time spent on preparing TP and e-learning activities singly. Moreover, the TP activities can be reused in e-learning by this embedding mechanism. The mechanism consists of TP structure which is comprising weekly activities and arranged into e-learning structure. This is achieved through setting up the Moodle environment to hold a plugin which is hosting the embedded mechanism. This paper highlights an integration between TP structure's weekly activities like quiz and assignment to be pasted into e-learning activities automatically through the plugin. As a result, educators do prepare TP once, then embedding into e-learning without having to double their efforts and reduce time spent. The mechanism is fully supporting the TP activities to be embedded into the e-learning structure and comply with reusability concept. This will ensure the acceptability of e-learning to educators is achievable.

Keywords E-learning · Plugin · Scheme of work · Teaching plan

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_8

1 Introduction

The arrival of e-learning has contributed to more flexible ways of delivering knowledge between educators and students (Alian and AL-Akhras 2010; DePAN 2011; Embi and Adun 2010). The learning and teaching are done in online mode and happened anywhere and anytime supporting by Internet technology. This learning concept is called blended learning where teachers will prepare an activity like assignments and quizzes and upload to the e-learning system (Shen et al. 2014). The e-learning can help students to access the online sources for their own needs and time. However, to make this happen, each educator or teacher must have a proper Teaching Plan (TP) before it can be transferred to e-learning activities.

It is normal to have a plan for a teaching activity (Surgenor 2010). This plan is called TP or lesson plan (LP). Somehow, at higher educational level, it is named as SOW. TP is a teacher's teaching structure describing a detail about a course objective, learning outcome, teaching method and course activities. The course activities used to measure a student's knowledge and understanding through course assessment prepared on a weekly basis. Lately, student-centred learning is embarking on the curriculum rather than teacher-centred learning. The student can have their own time to get through a lesson and doing activities which are prepared by their instructor (Li and Long 2013).

Generally, TP or SOW is a structured document listing a weekly activity of teaching and learning either in conventional (traditional) or e-learning approach. In a higher learning institution, each course needs to have SOW, to helping lecturer planning their movement along a semester in 14 weeks. Each week contains a main topic and subtopic, an objective of support topics and a learning outcome. This learning outcome can be assessed through learning activities. SOW also shows a time is spent while a student having or doing their activities. Moreover, a method of teaching which is prepared in SOW will guide a lecturer to execute the activities in the given time (Yusoff et al. 2011).

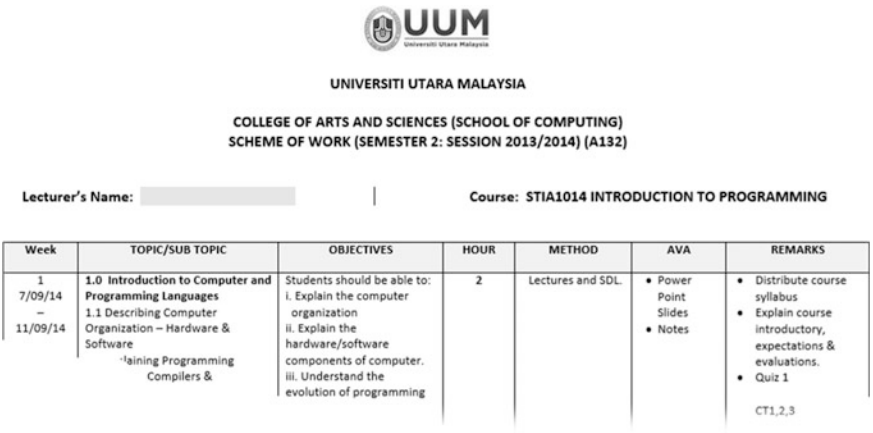
There are a few activities that students can involve in teaching and learning session like an assignment, quiz, discussion, exam, etc. The most common activities being prepared in SOW is an assignment and quiz. As stated previously, the existence of e-learning has been widened an access not in a classroom only but also outside the classroom. Wherever there is an Internet, e-learning can play the best media for supporting teaching and learning process. In normal practice, teacher or lecturer at school or at college or universities must start their learning and teaching process by strategically plan it in TP or SOW. In Malaysia, it is already accepted by MQA to enforce building TP or SOW in a higher learning institution (HLI). At the same time, educators are encouraged to use e-learning as a medium to spread a knowledge. Because implementing both TP and preparing e-learning activities consumes more time and efforts, some educators tend to choose to implement TP rather than building up e-learning activities (Yusoff et al. 2011).

Even though TP is prepared in softcopy, the activities that have been planned are built separately in learning management system (LMS). There is no specific integration between both TP and e-learning activities by a popular LMS such as Moodle. Perhaps teacher or educators must prepare the e-learning content and TP separately. As a result, this will contribute to doubling a time spent in preparing both contents. There is a need to create a mechanism that can embed TP activities into e-learning without sacrificing time and efforts.

1.1 Teaching Plan Structure

There are various types of TP being used in HLI. One of the TP that we used is shown in Fig. 1. The header and sub-header show an information about the institution, department and current semester. Instead of that, a lecturer or educator name and course are stated. The most important section for our works is stated inside the table which contains a various information regarding the subject matter.

Normally, the LP is arranged into weekly basis, and the first and last dates are recorded and then followed by a topic and subtopic which are extracted from a course syllabus. The objective section is the next information that shows what to be achieved by the students when they finish the topic and subtopic within the weeks. Each topic has been given a specific time frame to be covered, and the way it handles is mentioned by LP method and audiovisual aids. Last but not least, section is remarked where it can record anything that related to the activities conducted inside and outside the classroom. At this point, an activity like an assignment, quiz, project and other assessment activities are going to be stated. In this paper, we choose two common activities which are an assignment and quiz to be included in embedding mechanism process.



UNIVERSITI UTARA MALAYSIA

COLLEGE OF ARTS AND SCIENCES (SCHOOL OF COMPUTING)
SCHEME OF WORK (SEMESTER 2: SESSION 2013/2014) (A132)

Lecturer's Name: | Course: STIA1014 INTRODUCTION TO PROGRAMMING

Week	TOPIC/SUB TOPIC	OBJECTIVES	HOUR	METHOD	AVA	REMARKS
1 7/09/14 – 11/09/14	**1.0 Introduction to Computer and Programming Languages** 1.1 Describing Computer Organization – Hardware & Software -laining Programming Compilers &	Students should be able to: i. Explain the computer organization ii. Explain the hardware/software components of computer. iii. Understand the evolution of programming	2	Lectures and SDL.	• Power Point Slides • Notes	• Distribute course syllabus • Explain course introductory, expectations & evaluations. • Quiz 1 CT1,2,3

Fig. 1 Teaching plan structure

1.2 E-learning Structure

We choose Moodle as an e-learning tool to be injected with an assignment and quiz from TP. It is an open-source software that easily to be enhanced with a new module which is called plugin or as an external tool (Bär et al. 2007; Kumar et al. 2011). Figure 2 shows the e-learning front-page consisting of activities.

This is a common interface of the Moodle e-learning in a weekly topical format. The SOW weekly activities can be easily embedded into e-learning using this format. The embedding mechanism will scan for the week that having an assignment and quiz activities than feed into an e-learning database through SQL. Figure 3 shows a series of database tables involve in embedding the activities into e-learning.

Based on our observation, tables *mdl_assing* and *mdl_quiz* which are representing the assignment and quiz activities to be projected inside e-learning whereas *mdl_couse_module* used to gain information about the modules (assignment, quiz, etc.) being inserted and *mdl_course_sections* help in placing the activities into the specific week on e-learning.

Both *mdl_assing* and *mdl_quiz* have a relationship to *mdl_couse_module* through *id* to *instance* keys. While *mdl_couse_module* connected to *mdl_course_sections* by *id* and *sequence* keys. The *mdl_course_sections* id key is pointing to a weekly format where the activities are embedded in e-learning. This database structure is then used to strengthen the embedding mechanism which is discussed in next topic.

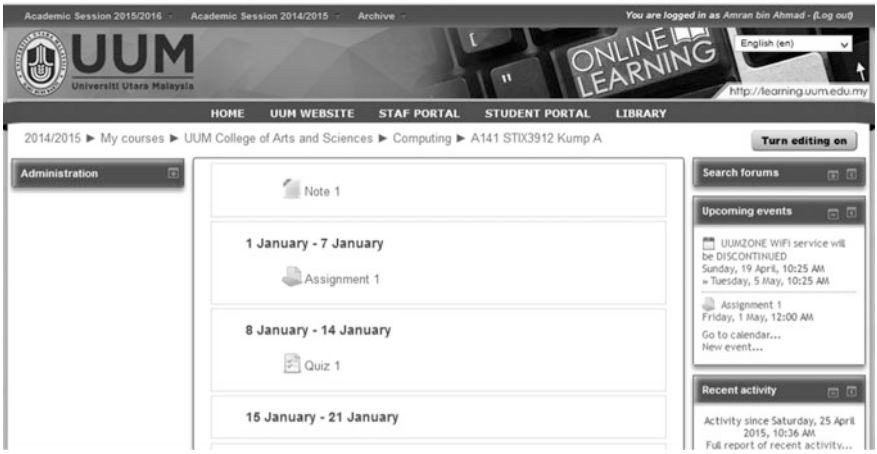


Fig. 2 E-learning structure

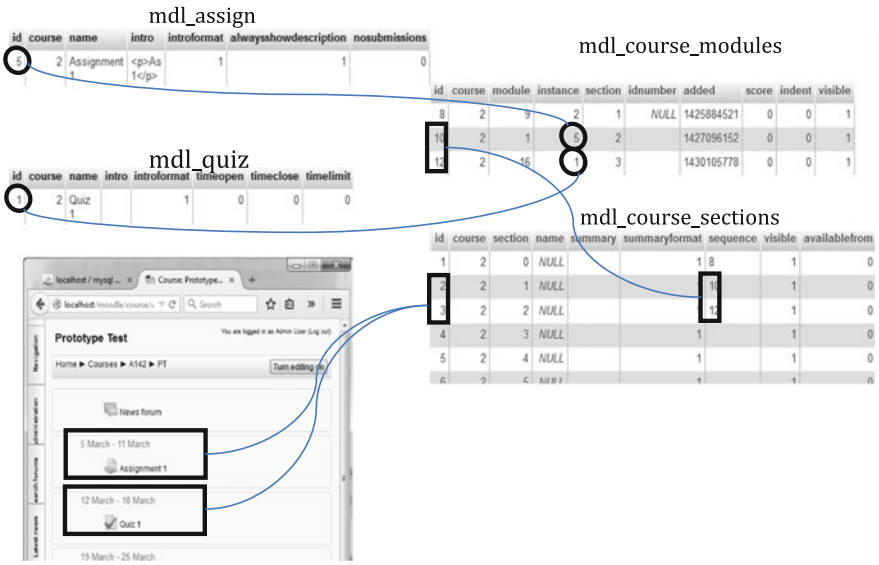


Fig. 3 Database structure

1.3 *Embedding Mechanism Process*

After the database structure is known, then the overall embedding mechanism can be prepared. It is consisting of four processes (see Fig. 4). Each process is presented by their respective component.

The embedding mechanism can be classified into four components: SOW structure, embedding mechanism, database structure and e-learning tools.

1.4 *SOW Structure*

In this structure, SOW source file is converted into a flat file with selected items such as weeks and activities information. The conversion is only done for the week that consists of activities. Other information are not considered.

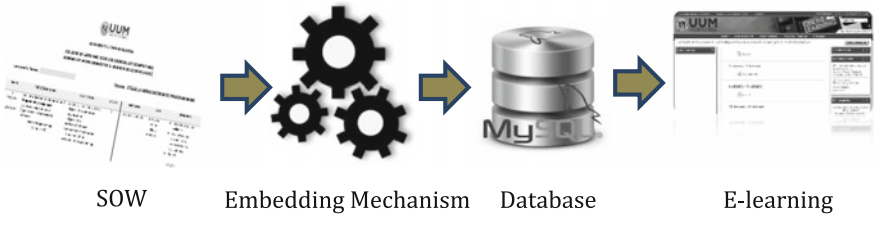


Fig. 4 Embedding mechanism process

1.5 Embedding Mechanism

The SOW structure that consisting of the chosen week and activities in the flat file is read by this process and prepared for injecting or updating a database structure that holding e-learning information. The updating process can happen in four steps which are reading data from flat file, open connection to database, send SQL updating to database and close database connection.

1.6 Database Structure

Database is where the e-learning information is kept and organized. Accessing this database is done through authentication and authorization from embedding mechanism and e-learning. The database structure in Fig. 3 is manipulated for accessing by next tool which is e-learning. This database is updated by embedding mechanism and then the web server refreshes its state which is affecting the e-learning course structure. The detail on e-learning structure is discussed in next section.

1.7 E-learning Tools

This is our objective to bring in SOW into e-learning. Starting from SOW flat file, read into database structure contributed by embedding mechanism which is designed and built to support e-learning tools. Each course is automatically embedded with all activities being planned in SOW.

2 Results and Discussion

The working mechanism was evaluated through usability study which involved 15 candidates. The candidates were given a task to migrate SOW in softcopy into Moodle using embedding mechanism. Their feedback then recorded which is focused on six questions listed in Fig. 5.

All candidates are familiar and having experiences using Moodle. Majority of them used Moodle one to five times a week. Moodle is said to be easy and with the help of embedding mechanism, many believe it is going to save time spent for preparing activities that are previously assume hard to create. Preparing SOW and online learning become tedious and need efforts if it is prepared separately.

Majority agree that with the support of the embedding mechanism, SOW can easily be embedded into e-learning with one single movement or task and single

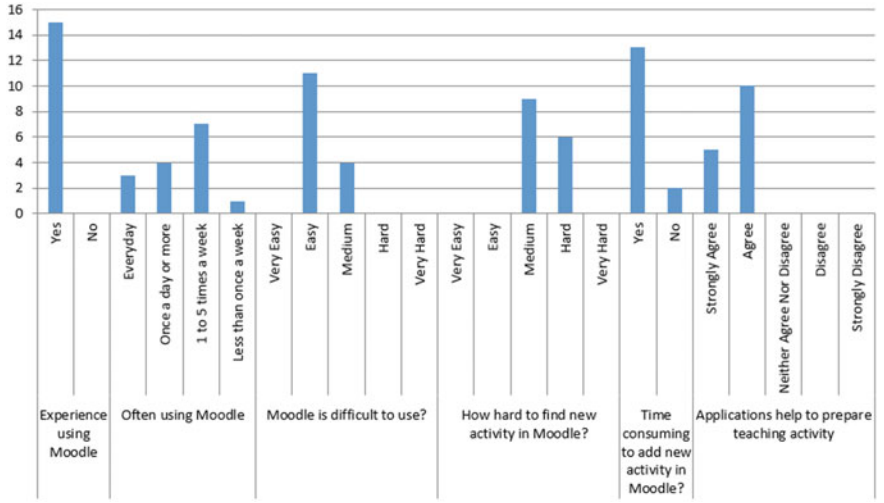


Fig. 5 Results of the survey

efforts. The process of planning and executing teaching and learning becomes easier and simpler.

3 Conclusion

This paper highlighted an integration between TP or SOW activities and e-learning which is automatically processed through the plugin called embedding mechanism. Using this mechanism, educators do not have to prepare TP and e-learning activities separately. Both are completed once covering both, SOW and the e-learning activities. This embedding mechanism reduces efforts and time spend while preparing both SOW and e-learning activities which are complying with reusability concept. Because of these benefits, it will ensure the highest acceptability of e-learning among educators.

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Chapter 9
Geovisualization of Nonresident Students' Tabulation Using Line Clustering

Zainura Idrus, Zanariah Idrus, Siti Zaleha Zainal Abidin, Nasiroh Omar and Nur Syamimi Aziah Mohamat Sofee

Abstract Today, we are abundance with a huge amount of space-related data. Hidden within this data is rich knowledge which can be discovered through geovisualization method. This method supports interactive simulation on data via its visual form. The data is plotted on a map to create density population where it forms patterns and through exploration of the patterns, the hidden knowledge is extracted. However, during the plotting process, overlapping of dots occurs, and it distorts the density. Thus, the overlapped dots need to be repositioned. The overlap is the main issue in mapping University Teknologi MARA nonresident student tabulation that complicates the analysis process. The overlap cannot be avoided since students are centered in three main towns, and they stay close to each other. Most of the dot replacement methods are centered on neighboring clustering where these dots are relocated to a location closer to their original locations. Thus, this research introduces a new relocation method where line clustering is used instead of neighboring clustering as a mean to distribute density. The line clustering method was tested, and results indicate that line clustering is capable to portray a better data density.

The original version of this chapter was revised: Second author name "Zanariah Idrus" has been included. An erratum to this chapter is available at https://doi.org/10.1007/978-981-13-0074-5_105

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_9

Keywords Data analytics · Data visualization · Dot replacement
Geovisualization · Nonresident student

1 Introduction

Technological advancement in data collection and big data processing enabled data to be viewed from inside. However, it is difficult to extract the inside knowledge from the huge data. One of the extraction methods is data visualization where data are converted into visual form. The process of extracting is commonly known as visual analytics. For effective analysis, the visual form must be selected carefully since not every visual is suitable for every set of data. For instance, space-related data are suitable to be tabulated on geographic map. Thus, geovisualization is mandated to visualize such geographic data and provides theory, method, and tool to support a human in analyzing and reasoning (MacEachren and Kraak 2001). The big challenge in visual analysis of data related to geography is the conflict between readability and details of the data (Zhang et al. 2016). Therefore, visual analytics need to use opportunities to identify better solutions for old problems and identify solutions to new problems (Andrienko et al. 2017).

In geovisualization, data is generally represented on maps by dots of same size and color. Each dot represents a phenomenon or a group of phenomena and their combination create phenomena density. The tabulation of the density reveals patterns and these patterns are the hidden knowledge (Raghupathi and Raghupathi 2014). Figure 1 depicts the process flow of geovisualization. Similarly, according to Coulson (1990), the power of dot map lies in the overall pattern of the distribution as his famous quote,

> It is not the dot size, or value, or even placement, that give the real power to the dot map-assuming some reasonable decisions have been made. Rather, the power of the dot map is in the overall pattern of the distribution that is revealed.

The density patterns are the one that needs to be harnessed. Thus, it is important to map the data to reveal the true density patterns through dot shape, dot size (Dent 1999) and dot placement (Gao 2015). They play a vital role in shaping the density pattern. Too small dots generate an overly sparse density pattern which leads to accuracy issues. On the other hand, dots that are too large generate an overpopulated dense pattern which exaggerates the true knowledge.

Fig. 1 Geovisualization process flow

Besides dot size, dot placement is also vital in revealing the density. A true density distribution can only be achieved if there are no overlapping dots. However, this is not always true since a few dots consistently ended on the same spot which distorted the true density. Thus, the true pattern cannot be revealed. These dots have to be relocated to new locations which are to be as close as possible to its real location. In addition, selecting relevant patterns is a challenge (Sallaberry et al. 2011). Choosing the right placement algorithm is not a straightforward process. It is highly dependent on the dataset and topographic background map such as map border, river, and other features (De Berg et al. 2004). Thus, experience and experimentation are required in deciding the right placement algorithm (Aggarwal 2013).

Similarly, Universiti Teknologi MARA (UiTM), Jasin Melaka is facing a problem of analyzing their nonresident students' tabulation in an attempt to provide better facilities to students. Such facilities are transportation, placement of events, security, and support. Due to the lack of effective analysis measurement, the managements are faced with various issues which became obstacles for them to support students' need effectively. For instance, bus transportation fails to satisfy students' need, and activity centers for students are stationed far away from students' populated areas. Moreover, resident staffs who manage students' welfare and well-being are not located within student's main population. Thus, geovisualization is one of the suitable analysis methods to support such analysis. However, since most of these students stay closer to each other and mostly ended up renting the same house, overlapping of dot placement occur. Such situations distort the true density pattern. Since the technique of mapping data is unique to each dataset, there is a need to find a suitable algorithm to redistribute these overlapping dots to reveal the accurate pattern of students' distribution. Thus, this research is intended to discover the suitable dot placement algorithm for nonresident dataset.

Hence, this paper is organized by first introducing geovisualization and the dot placement issue in mapping the data of UiTM nonresident students. The discussion continues with related works in the area of geovisualization. Then, the focus moves on to dot replacement algorithm where various algorithms are analyzed. Finally, the discussion is on a newly introduced algorithm before concluding the paper.

1.1 Related Works

Today, we are surrounded by abundant of data, and the amount continues to grow rapidly. The growth can easily reach terabytes due to advance technology in data collection, storage, communication, and processing (Keim et al. 2006). These data emerge from medical, engineering, climate, nuclear, and science field (Kehrer and Hauser 2013; Keim et al. 2006). However, this big data is to no avail if the true knowledge behind it is not discovered. To gain inside this big data is a challenging task due to its huge volume, varying velocity, complex, and heterogeneous. One of the proven methods to analyze the big data is through data visualization where the

data is converted into their visualized form prior to analysis (Fekete et al. 2008). The process of analyzing visual-based data is commonly known as visual analytics. It is a method that supports interactive exploration through analytic techniques such as brushing, binning, linking, ranging, zooming, filtering, and rotating. The process of exploration involves analysis and synthesis of visual-based data and the main purpose is to uncover valuable knowledge through data pattern (Raghupathi and Raghupathi 2014). Thus, both visualization and visual analytics play a vital role and become powerful drill-down mechanisms to uncover knowledge hidden behind big data. Visual analytics has become a science of analytical reasoning through interactive visual interfaces (Rhyne et al. 2004).

Data that is relative to geographic location are suitable to be tabulated on the map which is commonly known as geovisualization. There are various ways to visualize this data. Sacco et al. (2013) in their research have classified data visualization into three groups which are urban characterization, spatial discovery, and expectation alerting. Urban characterization functions like a snapshot of certain phenomena at a point in time. Data changes are analyzed and compared with time. One of the applications is to predict social ties and urban structure. Spatial discover, on the other hand, is more focusing on user interaction with data through analytical processing tool such as filtering, comparing, slicing, dicing, drill down, and correlating data to forecast, model, and predict. Expectation alerting conversely is highly involving real-time data. It is responsible to notify users of any important changes in data which demand immediate user attention. It is used to detect disease, disaster, and unexpected crowds.

Geovisualization concisely coupled with dot density technique to tabulate data relative to location. The dot density technique was first discovered in nineteenth century and is widely used in tabulating geographic phenomena (Moore and Carpenter 1999) such as transportation records, land use categories, highway segments, health statistics by treatment addresses, tax and property records Rhyne et al. (2004), population, and crop productivity. Dots are spatial proxy where they represent the geographic phenomena that occur somewhere in that area. The dots do not represent the exact spot of the phenomena (Goodchild and Mark 1987). Too often, these dots ended up on top of each other thus distort the true density information. This incident occurs when a group of phenomena have the same geography coordinate and must be mapped on the same spot. One of the methods to solve this problem is to redistribute these dots. Hey (2012) in his research designed a redistribution method called dot cluster where logarithmic spirals and concentric circles design are adopted. A few central dots are identified to become reference dots where other dots tightly circled around them. These dots are placed as such that they are not tangent to each other. Figure 2 depicts the clustering technique in visualizing data.

Another widely used clustering method is Density-Based Spatial Clustering of Applications with Noise (DBSCAN). It is a clustering method that can tolerate noise where some data are independent and not assigned to any cluster (Villatoro et al. 2013). Spectral clustering methods, on the other hand, are popular due to their quality cluster production and their easy implication. Moreover, the methods are

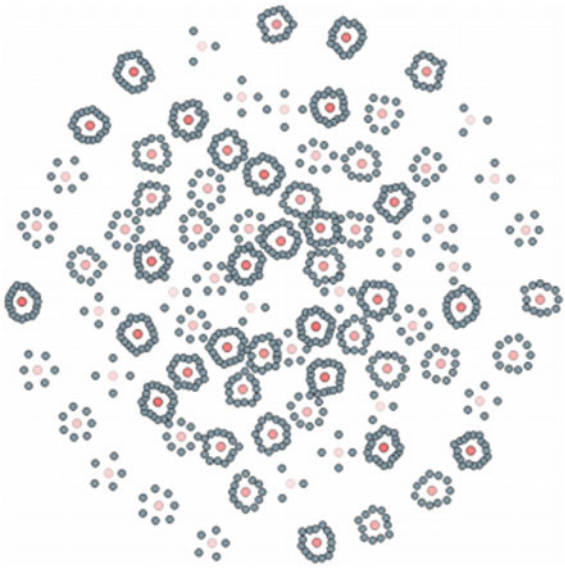

Fig. 2 Clustering technique

designed as such that they can seek for arbitrarily shaped clusters without posting any constraints on the cluster. However, the number of clusters must be defined prior to implementation (Rösler and Liebig 2013).

Mean shift is another clustering method which is a nonparametric clustering. It detects the probability of distribution from a set of discrete samples. Thus, it can be used both to identify local maxima and also area associated to the maxima (Frias-Martinez et al. 2012). Kernel density estimation is another cluster detection which is suitable for various dataset in various fields (Xie and Yan 2008). In addition, Keim (2000) discussed three different methods to redistribute overlapped dots using pixel-oriented visualization technique. The first method is called nearest-neighbor algorithm where the overlapped point is shifted to the nearest unoccupied position. Then, his discussion continues to curve-based algorithm where the overlapped points are shifted to unoccupied position in the direction of screen-filling curve which is similar to Hilbert curve and Z-curve. Finally, his discussion ended with the gridfit algorithm. The basic idea of gridfit algorithm is to create a partition in the data space hierarchically. The algorithm adopts the concept of quadtree data structure. Every layer has its own data space where it is further divided into four subregions. The process of partitioning ensures that the area for subregion is larger than the number of pixels that fit into it.

Besides relocation of dots, density accuracy can be increased through dot size. The size influences the understanding and impression on the density pattern (Kimerling 2009). In most cases, the accuracy of dot distribution increases as the dot get smaller relative to the overall map size. This is because smaller dots take small territory, thus, reducing chances of location error (He et al. 2006). The suitable size of the dots highly depends on the map scale and the available space on

the distributed area to place these dots (Hey 2012). Distributed areas are area where the phenomena occur. However, dots that are too small fail to reveal the true pattern relative to a big map. They do not always stand out as proper figures relative to the rest of the map. On the other hand, a small dataset looks crude when mapping with too big dots (Keim et al. 2004).

However, the dot size alone will not solve the density problem when they end up on the same spot. Thus, both dot size and distributive mechanism must be utilized together in the process of redistributing these dots and map them as closer as possible to each other. This is still a challenging task as stated by pixel-based visualization research community that the limited number of screen pixels will eventually limit the quantity of information that can be presented simultaneously (Andrews et al. 2011; Keim 2000; Keim et al. 2004).

1.2 Dot Replacement Method

Most of the dot placement methods locate the dot closer to each other in a neighboring cluster manner. However, this research seeks the feasibility of using line as the mean to portray density. Figure 3 displays four different line algorithms to portray the density.

(a) Intersection (b) Line

(c) Cross (d) Star

Fig. 3 Four line algorithms to display data density

Intersection in Fig. 3a leads to a very long line. The central of clustering is clear. *Line*, Fig. 3b, on the other hand, has no clear central point; thus, the base of the density is not clear. *Cross*, Fig. 3c, has a clear central point but since only two lines are allowed to cross, the lines lead to long lines which are difficult to capture the density. *Star*, Fig. 3d, is the improved version of cross where six lines are allowed to intersect to form a density. Thus, cross is selected since it can directly reveal the density. The intersection becomes the center point of clustering. The longer the line the higher the density is.

2 Analysis

Few steps have been taken before the formulation of the replacement algorithm. The first step was data collection process where a total of 2377 nonresident students' data has been collected. This data is in the form of *.xlsx* format. They were collected from Non-Resident Unit of UiTM Melaka Kampus Jasin.

The data has gone through two steps of parsing process. The first parse was to convert the data into tab delimited file (.txt). Then, the *.txt* data was parsed again into the desired format where a comma was used as the separator between the fields. In the second parse, filtering process has the responsibility to correct the addresses. The corrections have been made to address repetitive notation (postcode, city, and state), short form, and wrong postal code. The filtering process removed any data that was outside the acceptable range. As the result, 287 data that did not fit the area scopes has been removed. The filtered data was grouped into its respective areas which are Merlimau, Jasin, and Bemban. Both parsing and grouping processes are performed by the dedicated custom-made program.

The next step was to retrieve coordinates which were latitudes and longitudes that formed the respective addresses. The coordinates were then appended to the dataset. Before mapping can be performed, the datasets were clustered into their similar coordinate called key coordinates. By using the key coordinates, these clusters of coordinates were ready to be plotted.

The plotting process starts by first identifying the quantity member in each cluster. They were then organized into six different directions. The key coordinates for each group become the center for the six directions division. Next was to plot the graph. Prior to that, the dot size and shape must first be determined. After conduction a few simulations on the graph, the dot point of 1.8 and circle shape were found to be suitable.

Finally, the test has been conducted to four Student Affairs (HEP) staffs at the management level. The feedbacks received shown that the density was easy to be seen and read.

3 Conclusion

In geovisualization, mapping techniques such as dot shape, dot size, and dot replacement method are not universal to all datasets. A technique that is suitable for one dataset might not be transferable to another dataset. Thus, experiment and exploration are required. Even though most of dot relocation technique is focused on various neighboring techniques, this research has proven that line can also be used to portray density.

Acknowledgements The authors would like to thank Universiti Teknologi MARA and Ministry of Higher Education Malaysia for the financial support under the national grant 600-RMI/RAGS 5/3 (20/2012).

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Chapter 10
Measuring Helpful Aspect of User Experience: The Development of Q-iCalH

Siti Zulaiha Ahmad and Ariffin Abdul Mutalib

Abstract This paper enlightens the development of an instrument to measure helpful aspect of user experience in interactive computer-assisted learning for low achieving children courseware, namely, iCAL4LA-*Bijak Matematik*. The iCAL4LA-Bijak Matematik is a working prototype that has been developed based on the conceptual design model of interactive computer-assisted learning for low achieving children in primary school. The instrument was developed in the context of children-tailored questionnaire, named as questionnaire of interactive computer-assisted learning helpfulness (Q-iCalH), which presented in two versions (for the low achieving (LA) children and the facilitator). It contains 11 measuring items that elicited from 12 previous works. This study engaged with 11 experts for content and face validity tests. This study manages to test the instrument, n = with 64 low achieving children from year one to year three. Having conducted the validity and reliability tests, this study found that the instrument is consistent and reliable ($\alpha = 0.816$) in measuring helpful aspect of user experience.

Keywords Children questionnaires · Helpful · Low achieving children User experience · Computer-Assisted learning

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_10

1 Introduction

Helpful indicates that users are supported with assistance features that facilitate their activities in using any product. Merriam-Webster online dictionary defines helpful/helpfulness as "making it easier to do a job" or "giving help", which relates to the ability of giving assistance. Park et al. (2011) define helpfulness as "*user's perception that a product/service communicates in a helpful way*", where it is one of the constructs to evaluate the user experience of mobile phone and services.

In order to evaluate whether the developed product such as interactive software is beneficial to the users or not, it is important to measure its helpfulness. In line with that, Birch et al. (2010) and Brecht (2012) both have investigated helpfulness based on the content presentation (content features) provided in the learning tool. Meanwhile, Yamada et al. (2014), Ferdiansyah and Nakagawa (2013), and Gurung (2003) in their studies measure the helpfulness of the multimedia assistance features such as entity linking (interactivity feature), video captioning, and pedagogical aiding (instruction features) that were embedded in the learning material.

In addition, Software Usability Measurement Inventory (SUMI) is an instrument developed by Kirakowski and Corbett (1993) to evaluate users' perception toward quality of the software, in which it includes helpfulness as one the measurement constructs. In SUMI, helpfulness is used to measure the ability of software to assist users in terms of the quality of help messages or dialogues as well as labels and instructions given (van Veenendaal 2002). Accordingly, the property of providing assistance for the users in investigating user experience of helpfulness toward the interactive software in this study can be based on interaction, instruction, and content features support.

This study intends to investigate the helpful aspect embedded in the iCAL4LA prototype using a set of questionnaire instrument. The use of questionnaire instrument in extracting children experience, after engaged with a technological tool, has been conducted in many studies (Othman and Leng 2011; Saine et al. 2011; Dalle 2017).

The implementation of this method is reasonable because most children have an ability to choose an appropriate option that reflects their perception (Bell 2007). Besides that, it is also important for this study to extract the helpful aspect of user experience directly from the children without relying on the proxy such as teachers to answer the questions on behalf of the children. However, these children require assistance to explain and answer the questions (Ibrahim et al. 2015; Shaw et al. 2011) in order to ensure the children understand the measured item.

Inevitably, the development of the instrument is challenging because the participants are LA children. As discussed in previous studies (Siti Zulaiha and Ariffin 2015a, b), most of the LA children have to confront with reading problem and lack of focus. In this study, LA children refer to the children that confronted with learning difficulties especially in core subjects (literacy and arithmetic) of primary education. Therefore, the characteristic of LA children must also be considered in designing the questions. For that reason, this study applies the guidelines of

Table 1 Summary of questionnaires guideline for children

No	Rules
1	The length of questions should be short
2	Direct or straightforward questions avoid ambiguity question
3	Positive type of questions avoid negative question structure (contrary to adult questionnaires)
4	Number of option should be between 3 and 4 options and 2 options (Yes/No), must avoid ambiguity options
5	Scale labels
6	Verbal scales are better than numeric and visual image (pictorial scales) and are also better than others (i.e., smiley faces—smileyometer)
7	Avoid using unsure/unknown/don't know as one of the choices or options

children's questionnaire by Bell (2007), Borgers and Hox (2001) and Read (2008) to develop the instrument as listed in Table 1.

Additionally, this study also considers the suggestions and advises from the LA class teachers and LINUS Coordinator for the instrument development. Unfortunately, due to limitation of literatures that contain specific instrument to measure the helpful aspect featured in a CAL, this study requires a new instrument for this purpose. The following sections discuss the method of the development of Q-iCalH.

2 Methodology

This study adapts the systematic approach of instrument development (Ariffin et al. 2009) to measure the helpful aspect of user experience. The process began with an elicitation on the previous works to determine the measuring item. It continued with activities to ensure the wellness of the item constructed through content validity and face validity. Finally, the instrument was piloted to ensure its reliability. Figure 1 illustrates the summary of the instrument development process, which is described in subsequence sections.

2.1 Elicitation Works

In this study, the instrument was developed based on the helpful measurement item of CAL extracted from an elicitation work involving 12 previous research works that are labeled with indicators detailed in Table 2. Those studies were selected because the instrument used in each study contains items that measure helpful aspects of a learning tool, which share similar nature with this study as shown in Table 3.

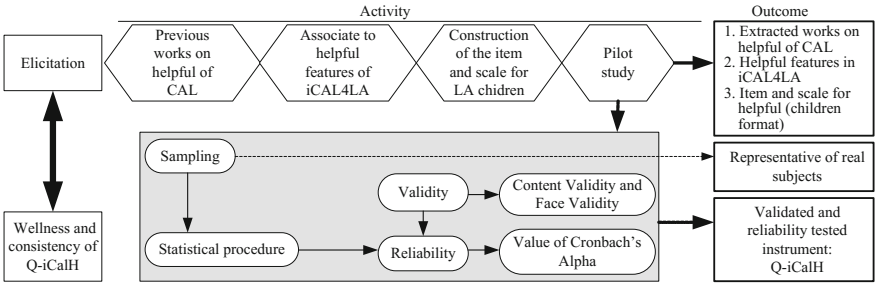


Fig. 1 Summary of instrument development

Table 2 Previous research works

Indicator	Authors
A	Bishop and Santoro (2006)
B	Brecht (2012)
C	Chiew and Salim (2003)
D	Gurung (2003)
E	Kay and Knaack (2008)
F	Kay and Knaack (2009)
G	Lewis (1995)
H	Gibbs and Graves (2000)
I	Cheong (2006)
J	Goyne et al. (2000)
K	Yoag et al. (2012)
L	Abas et al. (2007)

The items in Table 3 were then mapped to the most crucial of helpful features that designed specifically for iCAL4LA. Based on the details in Table 3, the helpful features of iCAL4LA are designated to (i) the multimedia design that contains video, animation, graphics, audio, and text; (ii) the navigational design consists of its instruction, tool, and structure; and (iii) the object interaction design that refers to direct manipulation behavior, feedback, and cues. However, some of the helpful features of iCAL4LA are combined to minimize the constructed item as advised by the teachers of LA children. According to them, LA children could easily lose focus and get tired of answering too many questions that consume a long time. Having considered that, this study limits the number of items in the questionnaire as listed in Table 4.

Besides that, this study includes a sample of the courseware screenshots for each of the constructed items. It is purposely to facilitate the LA children to answer the questions, in which they are able to recall the example of the measured items. This format is adapted from a study by Read (2008). In addition, the items are written in dual language, which are English and Malay for better understanding of the measured elements. Having constructed the items, the instrument was labeled to four

Table 3 The measuring item of helpful from the previous works

Items	Previous works
Video content	A, B, E, F, J, L
Step-by-step animation	A, E, F, I, J, L
Text size/color	C, D, E, F, H, I, J, L
Voice over	A, G, I, J, L
Textual instruction	A, C, D, E, F, G, H, K, L
Button tips	E, G, H, J, L
Icon	E, H, J, L
Button behavior change	E
Menu position	A, C, E, G, H, J, L
Tooltip features	E, L
Overall—helpful to be used	F, G, H, I, K, L
Overall—helpful to be understood	F, G, H, I, L
Overall—helpful to be memorized	H, I

Note A is an indicator of work by author A

Table 4 Proposed item for the first draft of the instrument

No	Items
1	Video content helps me understand addition operation
2	Step-by-step animation helps me understand the learning content
3	On-screen text size and color help me to read
4	Voice over helps me understand the instruction
5	On-screen text instruction helps me in doing activities
6	Tooltip on the button helps me in understanding the button function
7	The use of icon helps me memorize the function
8	Button behavior changes help me to recognize the clickable button
9	Menu position helps me to navigate the _____
10	Tooltip feature given on-screen helps me to interact with the _____
11	Overall reaction: _____ is helpful to be used
12	Overall reaction: _____ is helpful to be understood
13	Overall reaction: _____ is helpful to be memorized

measurement scales (Bell 2007) using pictorial or image-based Likert scale (Reynolds-keefer et al. 2011; Ghilain et al. 2017) that appropriate for children as it can be utilized using suitable representations such as smiley face, sun image, cat face, and real image. As illustrated in Fig. 2, this study adapts the 4-point Likert smileyometer scale ranging from 1-very unhelpful (denoted by big-frown face) to 4-very helpful (denoted by big-smile face) using different colors for each scale to highlight the difference.

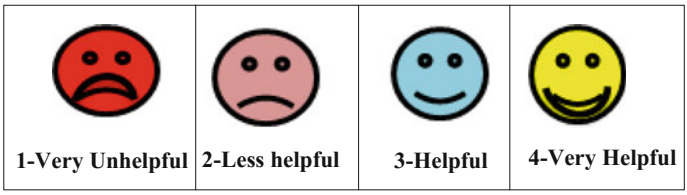


Fig. 2 The smileyometer measurement scales

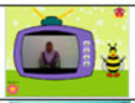
Item	Sample of screen shot	1-Very Unhelpful	2-Less helpful	3- Helpful	4-Very Helpful
1. Video content helps me understand addition operation					
2. Step-by-step animation helps me understand the learning content					

Fig. 3 First version of the Q-iCalH

Based on the proposed items in Table 4, the format and the scale for the instrument, this study drafted the instrument in measuring helpful aspect. It was named questionnaire of interactive computer-assisted learning helpfulness (Q-iCalH). The first version of Q-iCalH, as illustrated in Fig. 3 (only part of the instrument), is ready for validity and reliability test, which uses a sample of screenshots of an existing prototype (Ahmad et al. 2014).

2.2 *Ensuring Wellness and Consistency of Q-iCalH*

In ensuring the wellness and consistency of Q-iCalH, validity and reliability procedures have been conducted. They are elaborated in the following subsections.

2.3 *Validity of Q-iCalH*

The instrument was validated through expert review for content validity. It is intended to ensure that the measure contains a relevant and representative set of items of intended concept (Sekaran and Bougie 2010). Meanwhile, face validity was conducted involving teachers in order to ensure the measuring instrument is clear and easy to understand on its surface. In order to conduct the validity test, this

study managed to engage six experts for content validity and five experts for face validity. They are from various fields of expertise: human–computer interaction, software engineering, children computer interaction, multimedia, special education, remedial education, and language academician. As suggested by Yaghmaie (2003), having at least five experts is sufficient and useful to validate the instrument. Therefore, this study modified and restructured the Q-iCalH to ensure its consistency as recommended by the experts.

2.4 Reliability of Q-iCalH

This study determines the consistency of Q-iCalH through a pilot study. The representative subjects are important for the pilot study of Q-iCalH. In order to get reliable results in statistical test, 30 datasets are sufficient (Sekaran and Bougie 2010). Therefore, this study managed to engage 64 LA children as respondents using purposive sampling. They were selected based on their low achievement in the common test for core subjects in literacy and numeracy by the LINUS teachers from six primary schools in Perlis. A mathematical courseware was installed on each computer, and the LA children were given 30 min to explore the courseware. After the exploring session, the children then answered the Q-iCalH instrument. At this point, the teacher involved in assisting the children to answer each of the items. In average, they took 20–30 min to complete the instrument.

3 Findings and Discussion

The results of this study are divided into two parts: the validity and the reliability of Q-iCalH contribute to the wellness and consistency of Q-iCalH.

3.1 Validity of Q-iCalH

Result of content and face validity obtained from the experts are illustrated in Table 5.

Table 5 Agreement of experts for content validity of Q-iCalH

Questions	Yes (%)	No (%)
Do all items for "content features support" ask appropriate questions?	100	0
Do all items for "instructions support" ask appropriate questions?	81.8	18.2
Do all items for "interactivity support" ask appropriate questions?	72.7	27.3
Do all items sound mutually exclusive?	90.9	9.1
Do measurement scale used is appropriate?	90.9	9.1

Based on the reviews for content validity, this study found that the instrument needs the following modification:

i. The instrument should include measuring items for graphics as part of multimedia element.
ii. The colored scales are not appropriate as it could lead to misunderstanding about the meaning and bias.
iii. Some of the items require modifications in terms of reposition the order and reword. Some of the items were recommended to be deleted.
iv. The sample of screenshots must be made clear and marked with specific label such as a circle.

Further, based on the discussions of face validity, the expert informed that this study must highly consider the reading ability of the LA children in answering the measuring items. Therefore, a simplified version for the LA children (the full version is only for the facilitator) is prepared for the actual testing session. This is important to ensure the LA children focus on the items being measured. The inclusions of appropriate keywords and explanation from the facilitator are sufficient for them to answer the questionnaire. After some modifications based on the findings, Q-iCalH contains 11 validated items to measure the helpful aspect of user experience for an interactive CAL courseware as listed in Table 6.

Based on validated items, this study provided two versions of Q-iCalH, which are designed for (i) the facilitator who conduct the testing and (ii) the LA children who answer the questionnaires. The facilitator's version contains complete measuring items, the sample of screenshots, and the 4-point pictorial Likert scales for measurement. The simplified version for LA children contains keywords of the measuring items, enlarged sample of screenshots, and label of measurement scales for each item with the space to tick the option. This format is essential in facilitating the LA children to go through each of the items clearly and easily.

Table 6 Items of Q-iCalH

No	Items
1	The graphics design helps me understand the lesson content
2	The step-by-step animation helps me understand the lesson content
3	The video element helps me understand the lesson content
4	The text color helps me read well
5	Voice over helps me understand the instruction
6	On-screen text instruction is clear for me
7	Tooltips (graphic) on the button helps me to understand the button function
8	The use of icon (graphical button) helps me memorize the function
9	The visual cue feature helps me recognize buttons
10	The audio cue feature helps me interact with the *{name of prototype}**
11	The button position helps me to navigate the *{name of prototype}**

Note *{name of prototype}** → can be changed based on the prototype name

3.2 Findings for Q-iCalH Reliability Test

This study ran the reliability analysis to ensure the Q-iCalH is highly consistent in measuring helpful aspect. It is crucial as some items have been recoded and reworded. From the result, this study found that the instrument (number of item = 11) is reliable ($\alpha = 0.816$). The result shows that the measurement is consistent. Therefore, it is proven that Q-iCalH is ready to collect data on helpful aspect of iCAL4LA in the actual user experience testing. However, the strategy of conducting the questionnaire answering session must be done in a very small group or individually (if possible) as the LA children are unable to follow instruction naturally.

4 Conclusion

This study focuses on the development of Q-iCalH to measure the helpful aspect of user experience for iCAL4LA, which specifically designed for LA children. Based on the elicitation of 12 previous works, 13 items were extracted. The pictorial smileyometer with 4-point Likert scale was adapted for the instrument. The proposed instrument went through the validity and reliability test in order to ensure its wellness and consistency. The result of content and face validity shows that the instrument requires recoding, rewording, and eliminating some of the items. Therefore, some modifications have been made to Q-iCalH prior piloting it with the representative subjects, and only 11 items are found valid to be included. This is to ensure the LA children were able to respond to each item. Meanwhile, the Q-iCalH is found reliable with Cronbach's alpha = 0.816 and ready for the actual user experience testing as the subsequent activity of this study. However, the inclusion of other interface design aspect should be considered to improve the instrument for future, as this study only focuses on the helpful interaction of a courseware.

Acknowledgements The authors would like to thank UiTM Malaysia, UUM, MOHE of Malaysia, and all participants for supporting this study. Also, special appreciation to Ministry of Education and principal of primary schools for the approval in conducting this study.

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Chapter 11
Persuasive Multimedia Application for Children Readiness Towards Circumcision

Raudzatul Fathiyah Mohd Said, Norzilah Musa, Norzehan Sakamat and Noorazida Mohd Idris

Abstract Nowadays, there are many educational software products that have incorporated motivational factors for assisting parents and teachers in persuading, convincing and motivating children to change their existing perception or behaviour. Different combinations of persuasive approaches work with different children, as verbal persuasive alone is not sufficient in changing children's behaviour. The lack of existing applications to assist parents in persuading boys to undertake the circumcision procedure has motivated this study. A survey was conducted in order to determine the factors that might influence children to undergo circumcision. Rasch Measurement Model is used for validating and analysing the collected data. Results from this analysis are used for designing a knowledge management framework, which in turn will be used as a base for developing a multimedia prototype called *BraveBoy*. The strength of this framework is in its combination of different knowledge sources on circumcision procedures for boys, blended with various persuasive techniques to form an effective strategy.

Keywords Circumcision · Knowledge management · Rasch · Multimedia application · Persuasive

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_11

1 Introduction

Circumcision is a surgical procedure for removing a part of the penile foreskin (Frisch and Earp 2016a, b). In Malaysia, circumcision is the most frequent surgical procedure performed on Muslim boys. Nevertheless, circumcision is also widely being practised by others due to religious belief as well as health benefits. According to some studies conducted, circumcision is a means of protection against sexually transmitted disease (STD) and some form of cancer such as penile and cervical malignancies. However, this procedure has been blamed for causing psychological trauma for children who refused to be circumcised (Sancar et al. 2016).

Overcoming fear and encouraging children is a difficult and challenging task for parents as well as teachers and relatives. Using verbal persuasion alone is not inspiring enough for children to adjust their behaviour. Hence, proper and adequate information and good persuasive techniques are essential to convince them for undergoing this surgical procedure. In line with that, researchers have developed various computer application embedded with persuasive techniques to change children behaviour towards their setting goals (Chang et al. 2008; Chiu et al. 2009; Thompson et al. 2010; Bin Ismail et al. 2012a, b; Almonani et al. 2014).

The goal of this study is to propose a knowledge management framework in designing a multimedia prototype, called *BraveBoy,* as a persuasive tool for helping children to get appropriate knowledge on circumcision. Knowledge Management (KM) has been widely used in various domains such as businesses, banks, retails (Gonzalez and Martins 2014), library and information sciences and health. KM has been adopted by several health organisations in contributing for better health systems: to discover important information, identify specific knowledge and facilitate knowledge exchange. When it is implemented, KM will make health information delivered efficiently and effectively. Hence, *BraveBoy* may help children to view circumcision as a fearless health procedure and they will voluntarily undergo circumcision without being forced by parents, teachers or relatives.

1.1 Related Works

As defined by Fogg (2009), persuasive technology is about learning to automate behaviour change. In order to change behaviour, the factors that drive human behaviours should be understood specifically. Without it, a solution of it may rely only on guessing. Persuasive technology has been used in the health field to persuade people on health practices and awareness of preventive actions. It provides the required support to better cope with personal health such as lifestyle change (Blanson Henkemans et al. 2015). The advantage of using persuasive technology in multimedia application is that it can be used as an intervention tool which helps to promote better health practices.

In this study, multimedia application will be used as a medium for promoting circumcision because it may give exciting experiences for children. There are six (6) principles of persuasive technology in multimedia application (Bin Ismail et al. 2012a, b):

i. Praise—people can be persuaded by praises in form of words, images or sounds.
ii. Cause and effect—people tend to change their behaviour when they can observe immediately the link between cause and effect.
iii. Attractiveness—appealing visual interfaces and images may lead to higher persuasiveness.
iv. Convenience—easy to access (click on or swipe on devices) is likely to be more persuasive.
v. Simplicity—ease of use may have higher persuasive influence.
vi. Information quality—current, relevant and trustworthy information has better potential to create attitude or behaviour change.

As shown in Table 1, the persuasive technology principles have been used in various multimedia applications between years 2010 to 2014, specifically in the health domain.

2 Research Design and Methodology

Since most children are emotionally dependent on their parents in overcoming their fears and anxieties, a questionnaire survey was conducted on parents in order to determine the factors that might influence their children to undergo circumcision.

Table 1 Persuasive technology principles in multimedia application

Focus group	Principles
Children (Bin Ismail et al. 2012a, b, Almonani et al. 2014)	Attractiveness Cause and effect Convenience Information quality Mobile simplicity Praise Similarity
Teenager (Thompson et al. 2010, Yahaya et al. 2012)	Cause and effect Similarity
Adult (Grimes et al. 2010, Orji et al. 2012, Karppinen et al. 2016)	Simplicity Information quality Attractiveness Praise Cause and effect Similarity

100 questionnaires have been distributed in June 2016 to several selected clinics that provide circumcision services in Selangor, Malaysia. Out of this, 65% were completed and returned.

There are three (3) sections in the questionnaire: demographic of the respondent, circumcision purpose and persuasion used. In the demographic section, the age of boys to be circumcised are gathered. The parents are also required to state the ideal age that they believe suitable for circumcision. In the second section, the parents were asked about their knowledge and attitude towards circumcision. Questions pertaining how parents persuade their children were also investigated. They were questioned on whether they make an effort to search for circumcision information; where they get the information from; are the information is a great help in persuading their children to change their perception; factors that they believe can help them in persuading their children and what type of persuasive methods that are suitable. Rasch Measurement Model was chosen for data validation and analysis purpose. Subsequently, qualitative data were transcribed, coded, arranged and transformed to charts in order to effectively present the important points derived from the analysis results

3 Analysis of Data

Data were gathered and analysed in Winsteps 3.74 to produce the Rasch output. In order to portray respondent's agreement and acceptability of the assigned persuasive techniques (item), the Person-Item Distribution Map (PIDM) as shown in Fig. 1 is used. The items comprise knowledge, technical terms, circumcision experiences, cartoon illustration, praise, monetary rewards and educational game. This map is linking item difficulties to the respondent's endorsement ability of the questionnaires across the four Likert scale (strongly disagree, disagree, neutral, agree and strongly agree). In PIDM, the mean item serves as a threshold and it is set to zero on the logit scale. The most agreed item is located at the lowest location from the mean item. Same goes to person distribution, where the most parents or guardians who brought their boys for circumcision were located at the bottom of the map. Therefore, the level of a person's ability can be identified from PIDM by looking at the separation between the person and item on the map. The bigger the separation means the likelihood of the person to apply the item is high.

It was found that all respondents agree with all the persuasive techniques items with person mean 1.60 logits. From the nine items in the survey, respondents strongly agreed that item 'knowledge' is very useful in persuasion, with logits measure of −0.07. While using 'technical terms' in persuasion is strongly disagreed with logits measure of 1.18. This means, most respondents disagree with using technical terms as one way to persuade children to circumcise.

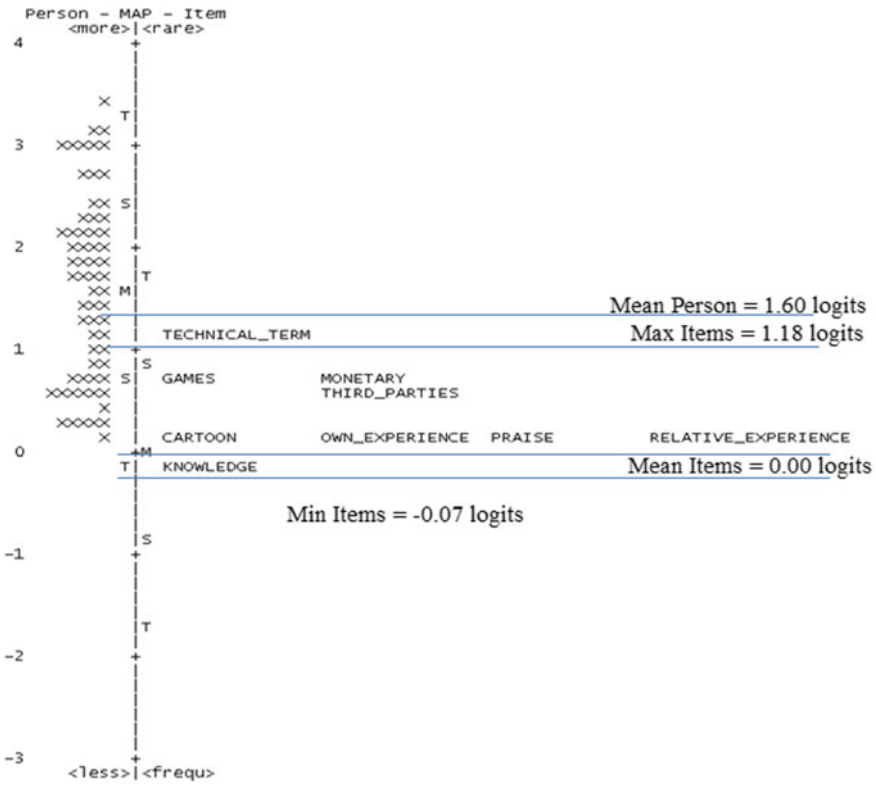

Fig. 1 Person-item distribution map relating to persuasive techniques

Therefore, based on these findings, out of nine persuasive techniques, eight are incorporated into the design of *BraveBoy* knowledge management framework, namely, knowledge, circumcision experience of the guardians, circumcision experience of the relatives, cartoon illustration, praises, monetary rewards, third person persuasion and educational game.

Figure 2 illustrates the outcome regarding the means of acquiring information pertaining to circumcision. 27% respondents obtained the information from the Internet, 18% from health talks attended and 17% from relatives via informal communications, 11% from newspaper and 10% from books. The remaining 6% obtained the information from TV programmes.

Parents were enquired regarding factors they thought might assist them in persuading their children. The result of Fig. 3 indicates that 29% parents believed that religious knowledge is the most important factor, 21% considered conveying circumcision techniques knowledge, 17% believe through reading and storytelling and 15% post-circumcision procedure care management. Others believe that the place and pre-circumcision preparation are the factors.

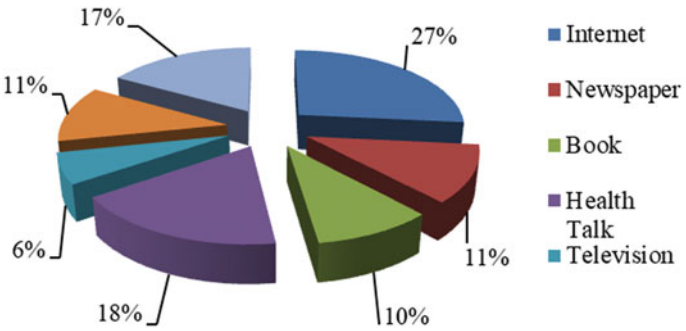

Fig. 2 Acquired information about circumcision

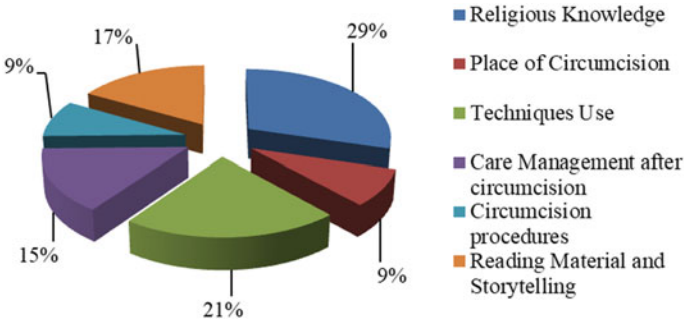

Fig. 3 Factors that help parents to persuade

3.1 Knowledge Management Approach in Designing BraveBoy

BraveBoy is a persuasive tool that may help parents to get comprehensive knowledge of circumcision. The prototype to be developed mainly comprising multimedia application and knowledge storage. As illustrated in Fig. 3, 17% of the parents agreed that storytelling is an important factor in persuading their children. Hence, multimedia application is suitable to be used for this purpose, as it may contain text, graphics, videos and animations. As for gathering the knowledge, knowledge management approach (Fig. 4), namely, acquisition, storage, dissemination and application, are adopted. Knowledge acquisition is the process of gathering tacit and explicit knowledge from the various domain experts and literature, respectively. Based on the survey conducted, the source of knowledge to be acquired from has been identified as the following:

Fig. 4 Knowledge management process

- *Religious scholars*. Based on the response to the purpose of circumcision, 45% of those who underwent this procedure are due to religious practices. Respondents also have agreed that religious knowledge is a significant factor in persuading their children, as illustrated in Fig. 3.
- *Medical doctors and traditional practitioners*. In Malaysia, circumcision is performed by medical doctors and traditional practitioners. Knowledge extracted from them may give insights to children on the techniques being used and help them to decide which practitioner they would opt for. The techniques being used for the circumcision procedure are seen as the second important factor that is 21%, in persuading the children as illustrated in Fig. 3.
- *Individual personal experience*. Experience from those who had undergone the circumcision procedure, especially close family members may be gathered as well.
- *Literature*. Circumcision is not limited to religious practices and cultural only. There are other purposes why people underwent circumcision, for example, health reason (Hewlett et al. 2011).

Once knowledge has been gathered, they need to be stored in a storage medium that can be easily retrieved by the multimedia application. The storage medium and its design should cater for structured and unstructured data, while providing efficient data retrieval. In order to reach out to a large number of users and whenever it is needed, *BraveBoy* will be disseminated via the Internet. Furthermore, based on Fig. 2, 27% of the information pertaining to circumcision was retrieved from the Internet. An offline version, in a form of desktop application, will also be made available.

Therefore, the proposed knowledge management framework emphasises on how the required data, information and knowledge are linked together to come up with the design of *BraveBoy*. Figure 5 shows the knowledge flow diagram of *BraveBoy*. The flow of knowledge begins with the identification of boys' negative perceptions towards circumcision which will be mapped with persuasive elements acquired from multidisciplinary areas (religious scholars, medical and traditional practitioners, individual personal experience and literature). The result of the mapping process is a personalised persuasive technique in the form of computer representation to change the boy's perceptions and behaviour towards circumcision.

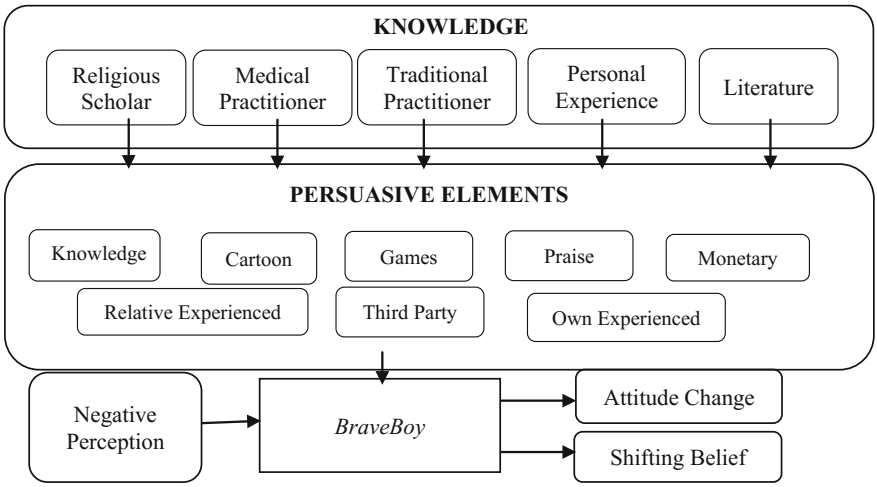

Fig. 5 Knowledge flow diagram

4 Conclusion

Circumcision is commonly performed surgical procedure on young boys which can cause castration anxiety, depression and anger in the children. Overcoming fear and to minimise the circumcision anxiety on children is a demanding task for parents. Hence, it is important for parents to know and equipped with appropriate children persuasive techniques which can assist them in convincing their children to undertake the surgical process. This study emphasises on designing a KM framework to manage knowledge among different knowledge expert disciplines before the development of a persuasive multimedia application called *Braveboy*. The KM framework incorporates a distinctive type of expert's knowledge to form effective eight persuasive techniques for children, to change the child's perception and behaviour towards circumcision. Hence, the knowledge framework is expected to be beneficial to other multidisciplinary researchers. With the potential of the persuasive multimedia application, *Braveboy* can be improved to cater for more children medical cases. Hence, based on the *Braveboy* KM framework, further research can be explored for developing various medical expert systems that specialised in diagnosis and treatment for children.

Acknowledgements The authors would like to thank Universiti Teknologi MARA and Ministry of Education, Malaysia [600-RMI/DANA5/3/LESTARI(76/2015)] for the financial support.

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Chapter 12
The Development of E-Research Engine System for Final Year Project (FYP)

Maslina Abdul Aziz, Fatin Jalillah Kamaruzaman and Anis Hasliza Abu Hashim

Abstract Selecting a topic is possibly the most difficult part of final year project (FYP). The FYP must be completed by final year students with the aim to train the students to do their work independently while being monitored closely by their supervisors. Usually, the FYP topics chosen can either be from the students or new topic suggested by the supervisor in any computing area. There are some cases where the topics are not suitable for the students and vice versa. Based on this problem, we proposed a recommender system that will help to ease this process. The main objective of this study is to develop E-Research Engine System that could help to match between student and supervisor for the FYP project. A survey was conducted with 50 students from Faculty of Computer and Mathematical Sciences (FSKM), Universiti Teknologi MARA. Results show that the majority of students used a search engine to find their research topic, and most of the students expressed their difficulties to find a suitable research topic that matches with the supervisor's area of interest. In summary, the proposed E-Research Engine System will help students to save time and effort in finding the best match supervisor with a good quality final year research project topic.

Keywords Final year project (FYP) · FSKM · E-Research engine system

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_12

1 Introduction

All final year undergraduate students undertake an independent project called final year project (FYP) as a compulsory module and graduation requirement. It is a two-semester course of the degree programme offered in every faculty at Universiti Teknologi MARA (UiTM). Students able to choose from a range of research topic chosen by them as it related to their area of interest with support provided by supervisors. Abdullah (2010) remarks that throughout completing the FYP, most of the time, students are expected to do their work independently. However, their current progress will be monitored closely by their supervisors. Students find it very challenging in undertaking FYP because it is done individually with high difficulties and high expectations (Tien and Lim 2016).

FYP can be considered as a course that affords an opportunity for students to graduate from their programmes by combining and putting together all the knowledge that they have gain throughout the years of studies. It is expected that students will benefit from FYP in terms of building their self-confidence, developing the skill of problem-solving, teamwork, professional responsibility as well as the skill to write complete technical report writing. FYP is a course that requires a tremendous amount of time and effort. Students need to be independent and work together with their supervisor. Moreover, it was proven that FYP strengthens the collaboration between university and industry in the long run (Alhamrouni et al. 2016).

As part of the degree programme offered in Faculty of Computer and Mathematical Sciences (FSKM), students must successfully complete the FYP. Data collected in this research focused on Department of Science System (SS) students who enrolled in four major courses including Bachelor of Science Information Technology (CS220), Bachelor of Science Intelligent System (CS223), Bachelor of Science Business Computing (CS224) and Bachelor of Science Information System Engineering (CS226). Students need to take an Information Technology Project Formulation (ITS600) course during the first semester of final year studies and Information Technology Project (ITS690) during the final semester. ITS600 is a course that must be taken by FYP students, as they need to complete their proposal phase. After the proposal has been approved, they are required to continue with their FYP until it is completed at the end of the final semester.

The success of FYP is measured by the success of student's planning and managing their time effectively. The research topic should be well rounded with skills and deep knowledge together with a good supervision from a supervisor that expert in the field of student's research topic (Arisó et al. 2016). Vaman (2008) noted that students must make a judicious decision on the selection of a supervisor since the supervisor will assist the student in selecting the research topic that matches with the area of interest. Through the year, the supervisor will be a team member with the students to ensure the successful completion of the FYP.

Inevitably, the research topic proposed also must provide values to the community and benefits for both supervisor and students in long term. During the selection of topic, students must consider the concept of topic significance. It means the topic should at least have an impact on a greater number of the community and not merely for personal satisfaction (Dissertation: Good Research Topic 2008). In choosing the right dissertation topic, Sanders et al. (2008) claim that students often thinking too broad when they approach their topic to a supervisor. As many supervisors agreed upon, student's topic needs to be related to the academic field, related to the course that students are attending as well as the area of expertise that the supervisors enrolled. The author concedes that students surely are heading in the wrong direction if the research topics are too broad or off-topic. This is where the supervisor can test student's understanding whether students have the background knowledge and potential to see the research through.

Connell (1985) stressed that research supervision is the most advanced level of teaching in the educational system. This supervisory process is crucial in order for the students to graduate successfully. Zhao (2001) maintained that the roles of research supervision can be interpreted in the views of students and supervisor. For students, the ideal supervisor is the one who helps them to learn and conduct research against the quality standard of the system whereas for supervisor, they are able to contribute towards the advancement of knowledge by building a creative research situation among students. Most of the students agreed that programmes should provide detailed information regarding the implementation of the final year project, such as guidelines to selecting scope of research, assessment of the project, project writing format as well as the important dates related to the project (Din et al. 2010; Thambyah 2011).

Overall, based on the research conducted, it was found out that the main issue faced by students taking FYP is trying to find suitable research topic and supervisor. Among the impacts faced by students are mismatch student's topic with supervisor's expertise area, incompetent to get research topic that captures the interest of supervisor and unable to get research topic or/and supervisor. Therefore, a faster and efficient way that find and match conveniently the research topic and expert area between supervisor and students are required. The main objective of this research is to develop a web-based system called E-Research Engine System that helps students who are enrolled in the final year project to find a suitable research topic and supervisor. By just entering a keyword, the system will use expertise matching technique to match the topic with supervisor's research area.

2 Methodology

This project was developed using the systems development life cycle (SDLC). The first stage is the planning phase, where problems and opportunities are identified in the system development processes. During this stage, problems statements along with the objectives, scope and the significance of the new proposed system were

identified. A survey was conducted with 50 students from Faculty of Computer and Mathematical Sciences (FSKM). The students are given a set of questionnaire with 15 questions regarding their FYP process. The questions in the survey represent the student's experience regarding the process of choosing a research topic and supervisors who are willing to supervise them throughout a year of completing FYP. Based on the survey, the majority of students who have a research topic at the beginning of FYP are using a search engine to find their research topic and most of the students agree that it is hard for them to find a suitable research topic that matches with the supervisor's area of interest.

Based on the findings from the survey, the problems and opportunities were described and analysed in detail. Interview method was conducted with the lecturers of FSKM. The requirements were gathered. User involvement plays a vital role as the first step for designer to design a system that is usable and meet the requirements of the user.

In the last phase, the requirements gathered were analysed and transformed into a logical model. The E-Research Engine System is designed based and tested to validate its usability.

3 Results and Analysis

Through this preliminary study, it was found that 41% of respondents find their research topic through search engine, 27% continues the topic from the seniors and 32% find their topic from the Internet (the students surfs other university's web page to look for topics) as shown in Fig. 1. If a student has a topic, he or she will try to find a supervisor that would like to supervise their propose topics. Among them, 13% of respondents got rejected from 8 to 10 times. It is because they just choose the supervisors randomly without knowing the supervisor's area. Thus, when they propose the topics to a particular supervisor, they do not aware that the topics do not match supervisor's field of expertise and do not capture supervisor's interest.

Besides that, 36% respondents prefer to do research on supervisor's topic while 64% of the respondent prefers to do their own research topic as shown in Fig. 2.

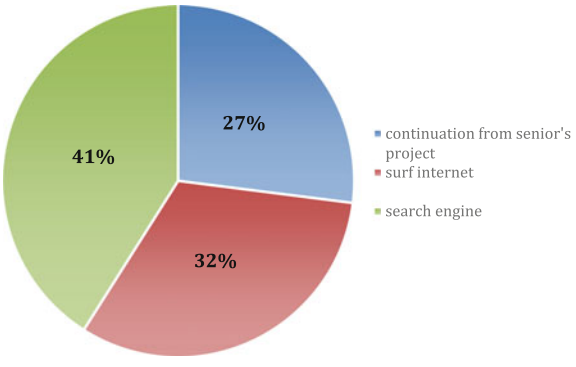

Fig. 1 Finding a research topic

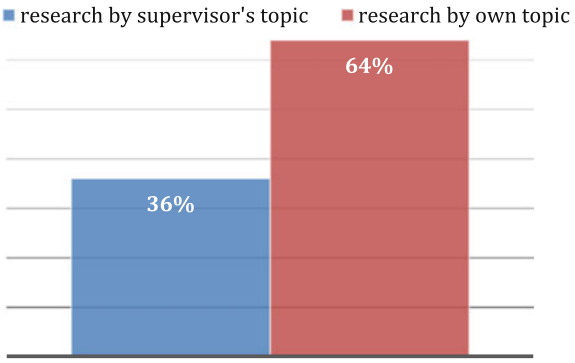

Fig. 2 Choosing a research topic

Those respondents who prefer to do the research on supervisor's topic basically do not have both topic and supervisor at the beginning of FYP whereas those who prefer their own topic cannot find a suitable supervisor that have interest in supervising their research topic. While 50% respondents agree that the main problems faced by students are there is no topic to be proposed and no supervisor would like to supervise them.

The combination of finding and matching research topics with supervisor's area is expressed in the relationship between research topic and the existence of supervisor. The relationships are as follows:

i. Students have a research topic and a potential supervisor to supervise their research.
ii. Students do have a proposed research topic but do not have a supervisor to supervise their topic.
iii. Students do not have a research topic but do have a supervisor that proposes some topics and willing to supervise them.
iv. Students do not have both, research topic and supervisor to supervise them.

These findings can be summarized in Table 1.

For the first situation in Table 1, there is no problem since the students do have their proposed topics and that topic does capture supervisor's area of interest. Students do not have difficulties since the topic is suitable and match with supervisor's field of expertise.

For the second situation in Table 2, the students have their proposed topic but the supervisor's area is not matched with the topic they proposed. Based on the survey conducted, some of these students agree that their proposed topic does match with supervisor's area; however, the topic does not capture the supervisor's interest.

Table 1 Matching matrix I

	Have supervisor	No supervisor
Have topic	X	
No topic		

Table 2 Matching matrix II

	Have supervisor	No supervisor
Have topic		X
No topic		

Table 3 Matching matrix III

	Have supervisor	No supervisor
Have topic		
No topic	X	

Table 4 Matching matrix IV

	Have supervisor	No supervisor
Have topic		
No topic		X

The third situation in Table 3 occurs when students do not have topics but they just come and propose the lecturers to be their supervisor. This situation results in students do have a supervisor that proposed a topic for them. However, the topic does not capture their interest. The fourth situation as depicted in Table 4 happens when students do not have topics and supervisor. This situation needs them to find for both supervisor and research topic. It is difficult for them since they do not have proper guidelines to find a supervisor and how to choose a good research topic that can capture both their supervisor's interest as well as themselves.

Based on the matching matrix mentioned above, 77% students agree that this situation could be improved by having a computerized database system. The system could help students to find a list of topics that match with supervisor's area of interest. This shows how important is to build the relationship among supervisor and the students they supervise. Students will not only facing hardest time in finding a good supervisor, but selecting research topic could be possibly the most difficult part of doing research (UC Santa Cruz 2010). Sanders et al. (2008) suggested that the topics that students will choose should need to be related to the academic arena, the course enrolled and the supervisor's expertise area. The author believed that if the students choose a topic that is too broad, they are usually heading in the wrong direction.

Due to this, by having the E-Research Engine System, students are able to find a suitable research topic that matches with supervisor's research area. Students are able to minimize their difficulties in finding a topic or prospective supervisor and maximizes the chances of completing their FYP. They are more aware of the availability of supervisor and a suitable research topic that matches supervisor's expert area. Through this matching process, students do not need to worry if the potential supervisor has interest in the topic that students choose.

E-Research Engine System

Screenshots of this system are presented in four different views of general users, students, supervisors and coordinator. In the general user views, the whole

complete interface of the system is displayed whereas for the students, supervisors and coordinator views, only the main function is highlighted in the screenshot's section. The homepage shows a brief explanation of a Department of Systems Science at FSKM where the general user might want to get to know further. Based on the research, the significant of E-Research Engine System is undeniable as it helps students to find a suitable supervisor that matches student's research topic.

As shown in Fig. 3 is the main homepage. The main tab includes 'FYP' where students are able to view supervisor's research area together with their proposed research topic in the form of matching matrix method. The 'Library' tab provides the front page of previous research or development done by final year students whereas the 'Search' tab enables the user to search for available supervisor along with their proposed research topic. At the left corner of the website, there are three mini tabs that available to help user ease their process of browsing the E-Research Engine System. The first mini tab is for user login, the second mini tab is for the user who seeks for help in terms of understanding the E-Research Engine System. The last mini tab provides useful links that has a link to UiTM Official Website and FSKM Official Website.

Figure 4 is the matching matrix table. It consists of the 'FYP' tab, which allows the user to view available supervisor and proposed topic based on the matching matrix technique. This matching process enables the user to view and select a topic that interests them, viewing a list of available supervisor together with their expertise area as well as viewing available supervisor with their suggested topic. This matching technique helps to ease the process of finding and matching supervisor's area with student's research topic. By having this, the final year students just need to identify they fall on which category, and enable them to select the topic or supervisors that interest them most. When coordinators click the 'FYP' tab, they will be directed to Matching Matrix page where they can check the status of their students by click on the link 'View Student's Status'. This student's status will be

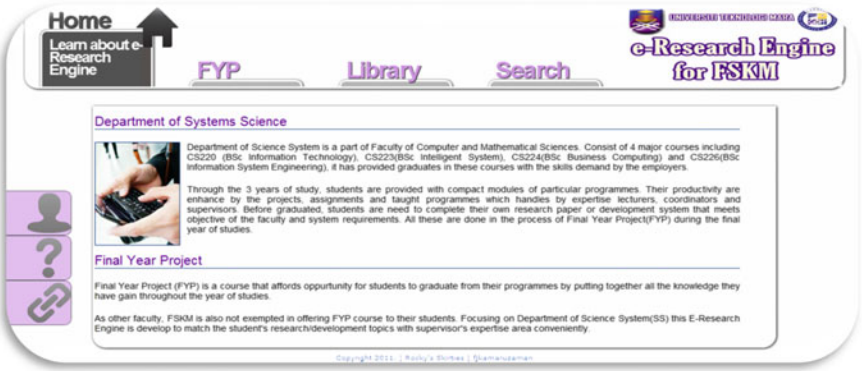

Fig. 3 Main homepage

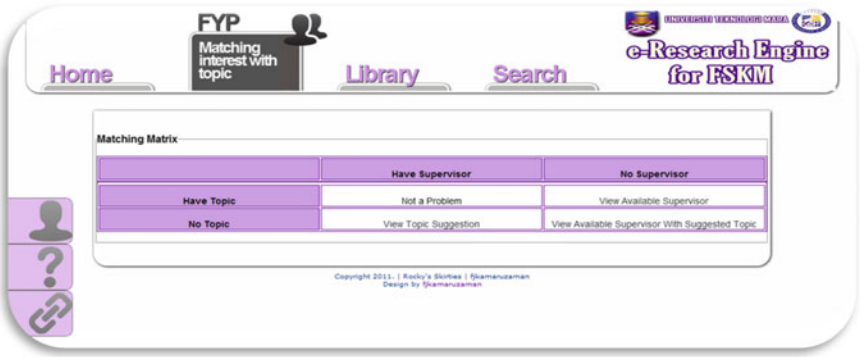

Fig. 4 Research topic-supervisor matching matrix

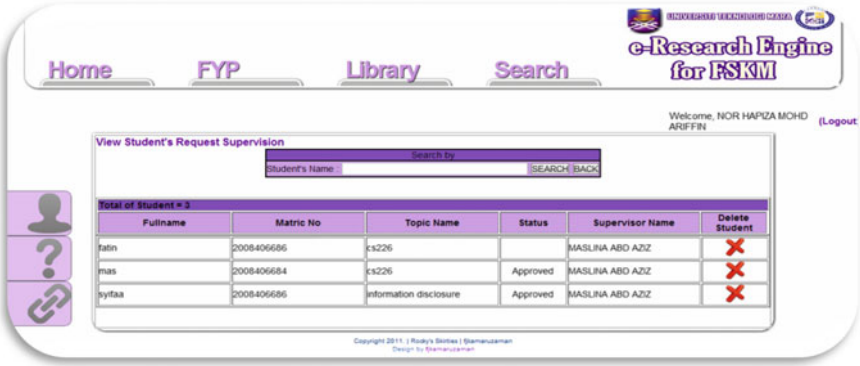

Fig. 5 Student's status page

updated by the supervisor where they request supervision at. As shown in Fig. 5, the coordinator can view student's status along with their proposed supervisor and topic name.

4 Conclusion

Taken as a whole, E-Research Engine System can be defined as a faster and efficient web-based system that finds and matches conveniently the research topic and expert area between supervisor and students. By having this system, students are more aware of the availability of supervisor as well as a suitable research topic that the supervisor is expert in. Based on the preliminary study conducted at FSKM, 50% of respondents agree that the main problem faced by students is they do not

have a topic to propose, and there is no supervisor available to supervise them. By summarizing the combination of finding and matching research topic with supervisor's area into a matching matrix, a complete figure of this situation can be seen clearly. 77% agree that this situation could be improved by having a computerized database system where students can find a list of topics that match with supervisor's area of interest. This research will benefit not only the students but also the supervisors and FYP Coordinator since the process of finding and matching research topic with supervisor's expertise area can be done throughout a web-based system. It saves all the hassle at the beginning of the FYP process especially in matching topics and finding a potential supervisor. As a result, it is hoped that E-Research Engine System will benefit and help both students and supervisor by saving time, cost and effort as this system able to find and matches conveniently the research topic and expert area between supervisor and students.

5 Limitation and Recommendation

Though the system was completed and successful, there were several limitations that were found and several new ideas that cannot be fully implemented. As a result, several recommendations are proposed here as it can be applied in the future for further improvements and enhancements. This system was expected to be used by Faculty of Computer and Mathematical Sciences (FSKM). However, due to the time constraints, this system only mainly focuses on the Department of Systems Science. By undergoing more testing such as usability testing and integration testing across several departments, this system can be enhanced and used by all students from other different departments in FSKM. Besides that, the implementation of this system can be improved by integrating it with Student Portal, ISIS as well student's registration course. By having this system it is much hoped that it can help to solve the problems such as the mismatched of student's topic with supervisor's area, the incompetency to get research topic that captures the interest of supervisor as well as the students unable to get research topic or supervisor at the beginning of their final year project. Hopefully, it will benefit all users including students, supervisor and coordinator as it provides a better solution in finding suitable research topic and supervisor.

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Chapter 13
WMH Detection Using Improved AIR-AHE-Based Algorithm for Two-Tier Segmentation Technique

Iza Sazanita Isa, Siti Noraini Sulaiman and Noor Khairiah A. Karim

Abstract The segmentation of magnetic resonance imaging (MRI) brain images could be implemented using any technique, either automatic or manual. The different methods commonly show different results because their performance relies on the segmentation precision and accuracy. In this paper, a new image segmentation algorithm is proposed based on k-means and AIR-AHE clustering algorithm to automatically segment and classify WMH severity in brain white matter region. The objective of this new segmentation algorithm is to minimize the false positive (FP) in white matter hyper-intensity (WMH) detection and hence will increase the WMH detection accuracy in MRI images. The proposed algorithm is implemented on two-tier segmentation system by identifying the edge of WMH and WM boundary for image mapping purpose. T2-weighed imaging (T2-WI) and fluid-attenuated inversion recovery (FLAIR) MRI sequences are used for mapping most precise WMH region of interest (ROI). From the experimental results, the proposed algorithm produces significant improvement in terms of correct WMH localization and reduces the false WMH detection. Based on the accuracy and capabilities of the proposed algorithm, this algorithm is suitable to be implemented to aid radiologist in the image analysing.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_13

Keywords Algorithm · Image processing · MRI · Segmentation
WMH

1 Introduction

In the clinical image processing, image segmentation is one of the clustering methods used to classify pixels that have similarity in terms of its intensity into the same groups. This approach has been applied to segment MRI image for many purposes including disease analysis or clinical diagnostic. It is important to implement such reliable techniques in image segmentation to ensure better results, especially for MRI brain segmentation. In the brain image, the anatomy of complex structure and tissue could be revealed through the MRI scan. Thus, the brain lesions or abnormalities are able to be identified by processing the regions in the brain.

Most researchers are focused on segregation of three main brain tissues that are white matter (WM), grey matter (GM) and cerebrospinal fluid (CSF) (Cercignani et al. 2001). There are many proposed techniques and segmentation algorithm recommended by researchers to segregate these brain tissue images depending on their clinical requirement. The purpose is including for brain quantitative information (Cercignani et al. 2001), brain lesions detection (Zhan et al. 2015), differentiating normal and abnormal WM (West et al. 2014) and also for method validation (Samaille et al. 2012).

Among all MRI modalities, specifically in T2-WI image, the intensities of WMH and GM are most likely which may contribute to a higher tendency of false classification. Despite any event of segmentation, researchers found that it is difficult to detect an exact boundary between WM and GM due to brain inter-variability (Strumia et al. 2016). As a consequence, the detected WM may include areas of GM that might be segmented as lesion. On the other hand, the fluid-attenuated inversion recovery (FLAIR) image produced a high number of false positives at grey matter boundaries (Klöppel et al. 2011). Therefore, a reliable brain segmentation algorithm is crucial to provide a good result in WMH detection in terms of lower false positive (FP) and higher in true positive (TP).

In order to produce a better result, an efficient segmentation algorithm is required in the WMH detection system. Therefore, in this study, a new segmentation algorithm for WMH identification based on AIR-AHE algorithm (Isa et al. 2016) and k-means algorithm is proposed. With the combination of both algorithms, this research not only aims to minimize the number of false tissues which are classified as WMH region but also intends to preserve the accuracy of correct WMH classification.

2 Method

This work is implemented using MRI images obtained from the 1.5T MRI scanner (General Electric, Wisconsin, USA). The acquisition protocols for MRI sequences used are as follows: three-dimensional T2-weighted gradient echo planar imaging (GRE T2* AX and FLAIR T2 PROPELLER). The experimental work was conducted on four healthy subjects that containing sets of 19, 22, 21 and 19 images slices from each subject, respectively. So, there are 81 slices of overall images from T2-WI and FLAIR are executed in this study. However, from the execution of images, there were only 48 selected T2-WI and FLAIR images applicable to be extracted further after excluding the corrupt images, unmatched image sequences and absent WMH. The main criteria of image sharpness and sequence matching between T2-WI and FLAIR are used for selecting the images.

2.1 Two-Tier Segmentation

This work is proposing an automatic WMH detection system based on two-tier segmentation that contains two of segmentation tasks as shown in Fig. 1. The first segmentation phase is used to cluster the image into four classes which are WM, GM, CSF and non-tissue brain or background. In this part, k-means was implemented as the clustering algorithm with initial centroid was selected based on previous experimental work on brain greyscale intensities, which are 0, 68, 100 and 110 (Isa et al. 2016). The k-means replaced new centroid by iteration step until it converged where all pixels are located in the closest centroid for each class.

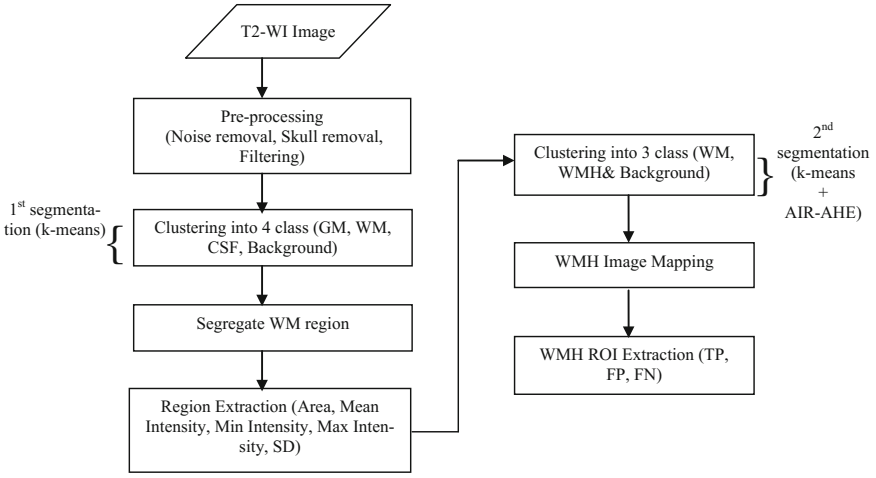


Fig. 1 Two-tier segmentation system for automated WMH detection

Next, the segregated WM region was executed to retain image information on WM parameters of area, intensities and standard deviation (SD). The processed WM image was further continued with second segmentation to identify the region of interest (ROI) WMH. In this phase, the new segmentation algorithm is applied to cluster the image into three classes that are WM, WMH and background with initial centres of 0, 68 and 79. Finally, the potential WMH region is mapped with FLAIR image to validate most precise region of WMH. The evaluation is made by calculating the percentage accuracy based on the number of TP, FP and false negative (FN).

2.2 *Proposed Segmentation Algorithm*

With the objective to improve TP detection as well as to minimize the FP in WMH quantification, the AIR-AHE segmentation technique is proposed to be implemented with k-means algorithm on the second image segmentation phase as shown in Fig. 2. The AIR-AHE algorithm has been proposed by (Isa et al. 2016) to enhance MRI FLAIR image by replacing the new calculated average pixels intensity. In this event, the proposed algorithm is used to mask WM and WMH region so that further segmentation phase is capable to differentiate those regions precisely.

For details on the implementation of the proposed segmentation algorithm, consider a T2-WI image with data set of $\{x_i\}$ where x represents the i-th pixel's intensity of the image. The intensity of each pixel is determined by using nx n sliding neighbourhood operation, where n is number of window tile (3 by 3). The new pixel's intensity of the image, $\{x_i'\}$, is calculated using (1). The process is repeated until all pixels' intensity has been replaced.

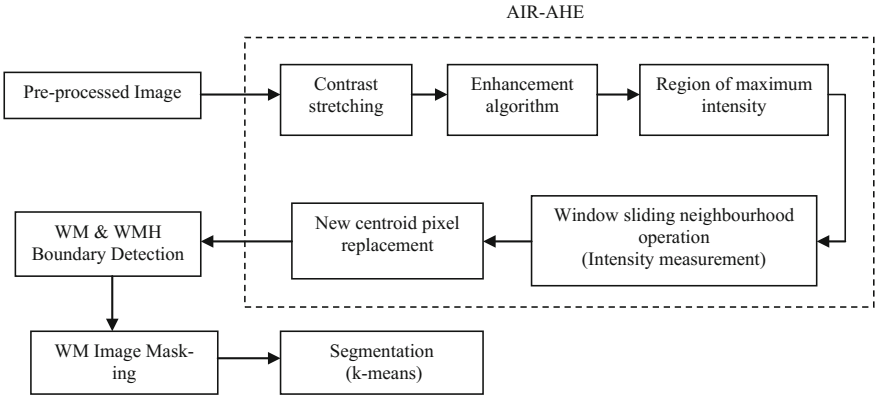


Fig. 2 Proposed segmentation technique combining AIR-AHE and k-means algorithm

$$\{x_i'\} = \sum_{i=1}^{x} \sum_{j=1}^{y} \frac{\{x_i\}}{n} \tag{1}$$

The new pixel's intensity is then clustered into v_j regions or clusters. The conventional k-means objective function of grouping the data set of new pixel's intensity is given as in (2). The fitness of each cluster is calculated based on Euclidean distance between x_i' and v_j. C_v denotes the number of data points in v-th cluster, and C is number of cluster centres.

$$f(v_j) = \sum_{i=1}^{Cv} \sum_{j=1}^{C} \left(\left\| x_i' - v_j \right\| \right)^2 \tag{2}$$

Then, the new position of each centre is calculated based on (3) and finally, the process is repeated until the value of all centres no longer change

$$v_j = \frac{1}{C_{v_j}} \sum_{i \in v_j} x_i' \tag{3}$$

Upon completion the AIR-AHE execution, the image produces two regions of WM and WMH which then detects the boundary of each region for mapping purpose. Based on boundaries of WM and WMH, the image was masking on the original T2-WI image provided only the real WM and WMH to be segmented by k-means in the AIR-AHE second segmentation phase. In this phase, the remaining WM region is segmented into three clusters to represent WM, WMH and background.

3 Results and Discussion

The experimental result shows the proposed algorithm has improved the processing technique by minimizing the FP region in WM. To evaluate the performance of this work, three evaluation methods were used. The methods were; percentage of correct detection, branching factor (measurement on the over-detection pixels) and percentage of the quality for WMH ROI detection as stated in Eqs. (1), (2) and (3), respectively. Each segmented WMH was classified based on the number of pixels on the overlapped area. The true positive (TP) was denoted as the segmented WMH region that was proven to be WMH. False negative (FN) represents the WMH region that was predicted as other brain tissues while false positive (FP) represents other brain tissues that were predicted to be the WMH region.

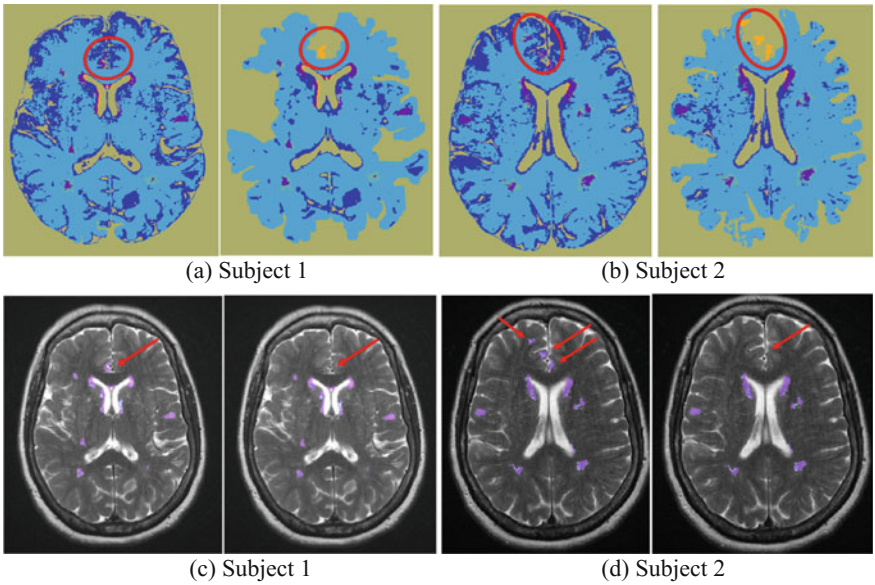
$$\text{Detection}, \quad \mathrm{D} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}} \times 100 \tag{1}$$

$$\text{Branching factor}, \quad \mathrm{f} = \frac{\mathrm{FP}}{\mathrm{TP}} \tag{2}$$

$$\text{Quality percentage}, \quad \mathrm{Q} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FP} + \mathrm{FN}} \times 100 \tag{3}$$

3.1 Qualitative

The qualitative result shows that the proposed algorithm was capable to minimize the false detection of ROI WMH in the WM region. The system has been improved in terms of the percentage of WMH correct detection. Figure 3 shows the comparison results after implementation of proposed algorithm for segmentation the brain image of Subject 1 and Subject 2. The segmented images shown in Fig. 3a and b remark the eliminated WMH region as in the circle and while in Fig. 3c, d represent as arrow marks. As the system proposed two-tier segmentation approach, the GM region has been eliminated on first segmentation phase and second segmentation able to concentrate on clustering the WM and WMH regions only.



(a) Subject 1 (b) Subject 2

(c) Subject 1 (d) Subject 2

Fig. 3 Before (left) and after (right) implementation of the proposed algorithm

Therefore, the probability of segmented GM as WMH region has been reduced and increased in correct WMH detection.

3.2 Quantitative

In terms of quantitative results, the proposed segmentation algorithm shows significant improvement for each subject. Since the initial MRI slices have no WM content, only selected MRI slices have been considered for execution due to WM appearance. As an example, Table 1 shows comparison result of applying k-means segmentation algorithm and proposed algorithm for executed image slices 6 to 17 from overall images 19. The result shows that the performance using the proposed algorithm for automated segmentation of Subject 1 has improved 16.43% compared to commonly used k-means segmentation algorithm. Meanwhile, the branching factor (measurement on the over-detection pixels) also shows significant improvement which had been minimized from 26.93 to 8.49. The image quality was also showing an improvement after applying proposed segmentation algorithm from 78.97 to 92.56%.

In terms of ground truth comparison between radiologist manual delineation and automated WMH detection, the results show a slight difference in correct detection of WMH region. However, since the comparison by evaluating directly

Table 1 Comparison results of applying proposed algorithm on MRI images (Subject 1)

Subject 1								
Image slices	k-means (%)			k-means + AIR-AHE (%)			Improvement (%)	Manual delineation
	D	*f*	*Q*	*D*	*f*	*Q*		
6	96.6	3.5	96.3	84.7	18	84.7	-12.32	No WMH detected
7	83.4	19.9	80.75	95.7	4.55	95.7	14.75	
8	92	8.6	91.73	100	0	100	8.70	
9	76.3	31.1	76.1	No WMH detected			NA	
10	61.86	61.6	59	74.46	34.3	71.35	20.37	Yes
11	62.66	59.6	61.5	96	4.08	96	53.21	Yes
12	Image damage						NA	Yes
13	82.1	21.75	81.98	92	8.64	92	12.06	Yes
14	94.2	6.16	91.2	99	0.85	99	5.10	Yes
15	76.2	31.3	75.93	94.3	6.02	94.3	23.75	Yes
16	76.6	30.5	74	No WMH detected			NA	No WMH detected
17	81.8	22.2	80.16	100	0	100	22.25	
Average	80.34	26.93	78.97	92.91	8.49	92.56	16.43	

D correct detection, *f* branching factor, *Q* image quality

Table 2 Comparison results of applying proposed algorithm on MRI images (Subject 2)

Subject 2								
Image slice	k-means (%)			k-means + AIR-AHE (%)			Improvement (%)	Manual delineation
	D	*f*	*Q*	*D*	*f*	*Q*		
8	88.6	12.87	87.1	No WMH detected			NA	No WMH detected
9	No WMH detected			No WMH detected			NA	
10	90.5	10.4	89.3	No WMH detected			NA	
11	94.4	5.88	92.2	93.9	6.46	91.1	−0.53	Yes
12	89.4	11.88	89.4	No WMH detected			NA	No WMH detected
13	98	2.04	98	98.6	1.44	98.6	0.61	Yes
14	92.1	8.55	90.9	99.5	0.5	99.5	8.03	Yes
15	92.2	11.15	89.3	98	2.09	97.6	6.29	Yes
16	83.7	19.5	80.1	No WMH detected			NA	No WMH detected
17	77	35.9	70.5	93.2	7.25	89.6	21.04	Yes
18	100	0	100	No WMH detected			NA	No WMH detected
Average	90.59	11.817	88.68	96.64	3.548	95.28	7.09	

D correct detection, *f* branching factor, *Q* image quality

voxels-by-voxels was not acceptable in most cases (Ong et al. 2012), the results are acceptable.

Table 2 shows comparison result for Subject 2 which has been testing using k-means segmentation algorithm and proposed algorithm for executed image slices 8 to 18 from overall images of 22. The result shows that the proposed segmentation algorithm was capable to minimize the FP and thus improved correct detection of WMH region by 7.09%. In terms of ground truth and automated method comparison, the proposed algorithm result was more consistent with the manual delineation provided by radiologists.

Table 3 shows result of Subject 3 which is also the highest improvement of correct detection in WMH region among all subjects. The proposed segmentation technique has produced an average of 30.7% improvement after applying the technique. The branching factor also shows better performance and the image quality as well. Table 4 shows comparison result of applying proposed segmentation technique for Subject 4. The result shows a slight improvement that was average of 1.13% from 86.6 to 87.2%. All slices were improved after applying the proposed segmentation technique except only 2 slices were not performed. The event may occur due to several factors including the WMH load and brightness of the WMH region.

Table 3 Comparison results of applying proposed algorithm on MRI images (Subject 3)

Subject 3								
Image slice	k-means (%)			k-means + AIR-AHE (%)			Improvement (%)	Manual delineation
	D	*f*	*Q*	*D*	*f*	*Q*		
6	73.91	35.30	73.27	90.91	10.00	90.91	23.00	No WMH detected
7	54.55	83.33	51.98	100.00	0.00	100.00	83.33	
8	52.37	90.95	50.54	100.00	0.00	100.00	90.95	
9	67.01	49.24	66.00	81.46	22.76	77.96	21.57	
10	63.55	57.36	61.95	74.58	34.08	72.76	17.37	
11	75.33	32.75	74.06	92.70	7.88	91.79	23.05	Yes
12	80.25	24.61	77.66	89.57	11.65	88.07	11.62	Yes
13	79.96	25.06	78.01	92.72	7.85	91.87	15.96	Yes
14	83.24	20.14	72.82	88.98	12.39	87.60	6.90	Yes
15	82.15	21.73	81.54	94.92	5.35	94.55	15.55	No WMH detected
16	66.16	51.14	65.57	91.15	9.71	90.35	37.77	Yes
17	69.15	44.60	64.95	100.00	0.00	100.00	44.60	No WMH detected
18	70.97	40.91	61.68	76.23	31.18	59.62	7.41	Yes
Average	70.66	44.40	67.70	90.25	11.76	88.11	30.70	

D correct detection, *f* branching factor, *Q* image quality

Table 4 Comparison results of applying proposed algorithm on MRI images (Subject 4)

Subject 4								
Image slice	k-means (%)			k-means + AIR-AHE (%)			Improvement (%)	Manual delineation
	D	*f*	*Q*	*D*	*f*	*Q*		
6	No WMH detected			No WMH detected				No WMH detected
7								
8								
9								
10								Yes
11	88.7	10.4	88.7	91.5	9.3	88.6	3.16	Yes
12	86.8	15.2	86.04	92.3	8.3	91.44	6.34	Yes
13	88.2	13.4	87.7	89.2	12.1	88.8	1.13	Yes
14	96.3	3.8	95.6	96.6	3.5	96.1	0.31	Yes
15	88.9	12.5	88	68.9	45.2	68.9	−22.50	Yes
16	82.3	21.5	79	81.25	23.1	81.25	−1.28	Yes
17	75.1	33.1	66	90.7	10.3	90.7	20.77	Yes
Average	86.6	15.7	84.4	87.2	16	86.5	1.13	

D correct detection, *f* branching factor, *Q* image quality

4 Conclusion

This paper has introduced a new two-tier segmentation technique for WMH detection based on a novel average intensity replacement algorithm. The proposed technique has been applied to 48 MRI standard images of four subjects. Furthermore, the performance of the proposed technique was compared with common K-means clustering algorithm, and the results shown a significant improvement. The proposed technique was also successfully minimizing the FP of WMH region and increased the correct detection of WMH lesions. The approach was capable to efficiently detect WMH lesion without requiring any image registration or atlas modelling or complicated training procedures. In addition, it was proven to be robust to successfully segment various sizes and shapes of the lesions in MRIs which were acquired from different subjects. This work has been experimented only on small data set of few subjects and therefore for future development, it is recommended to conduct the study on large data set for further work including the training, testing and validation of overall works.

Acknowledgements The authors wish to thank the other members of the Imaging Department, Advanced Medical and Dental Institute (AMDI), Kepala Batas, Universiti Sains Malaysia and Hospital Universiti Sains Malaysia (HUSM), Kubang Kerian, Kelantan, for providing the assistance and guidance for the field works. Special thanks to the Research Management Institute (RMI) and the Ministry of Higher Education (MOHE), Malaysia for their administrative and financial support. A special thanks to Prof. Dr Ibrahim Lutfi Shuaib, Suzana Mat Isa, Che Mohd Nasril Che Mohd Nassir and all supportive staffs for their help and guidance in completing this work.

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Chapter 14
Development of Social Presence Requirements Artefacts for E-Learning Using Multiphase Approach

Noorihan Abdul Rahman and Shamsul Sahibuddin

Abstract E-learning is an application which facilitates learners' activities throughout the learning process. An E-learning plays a role in attracting learners to sustain learners' connectedness while they are sharing knowledge. To address the issue of lack of connectedness in E-learning, the authors have introduced multiphase approach whereby it is able to assist in providing a set of social presence requirements for E-learning development. This paper reveals four social presence elements for developing connectedness in E-learning. In requirements elicitation, the authors prioritize social presence elements via MoSCoW prioritization method. Delphi method is carried out to obtain experts' consensus as the evaluation for all the artefacts related to social presence requirements development. The evaluation discusses results on Delphi round one and Delphi round two regarding social presence requirements. Three requirements elicitation products are Technical Guide to Requirements Elicitation for Social Presence Support (Artefact One), Social Presence Requirements Template (Artefact Two) and Social Presence Requirements (Artefact Three).

Keywords Artefacts · E-learning · Learner · Requirements elicitation
Social presence

1 Introduction

In virtual communications, social presence is needed in order to gain a sense of connectedness albeit through an interface. In a computer-mediated communication environment, social presence refers to the user's degree of feelings, perceptions or

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_14

reactions being connected to another intellectual entity, involving a subjective quality of the communication medium related to the concepts of intimacy and immediacy (Short et al. 1976). Social presence is important in order to reduce the sociotechnical gaps in a particular system development and therefore increase the interaction and collaboration among the users (Bani-Salameh and Jeffery 2011; Bilandzic and Foth 2013; Frankl and Bitter 2013; Ghosh et al. 2012; Howe and Schnabel 2012; Keengwe et al. 2013; Kreijns et al. 2003; Medeiros et al. 2013). In motivating students to actively use E-learning, the social-technical gaps must be analysed in order to create an environment that can be understood by all of the stakeholders. Requirement elicitation process can be an option that allows the developer to simultaneously understand and elicit social presence requirements as well as the technical requirements. Developing user requirements for human activity in collaborative applications may address requirements elicitation for social presence and thus may increase social interaction in collaborative applications (Lowenthal 2010). Therefore, besides having technical solutions for developing collaborative applications, the stakeholders should also consider requirements from the human perspective (Hayat et al. 2010). This study envisions the potential to work with requirements elicitation issues by examining as to whether a new requirements elicitation process is possible for gathering the necessary requirements for social presence, especially in the context of collaboration in E-learning. This study also seizes upon the opportunity to suggest possible requirements elicitation processes which might accommodate the processes needed to extract social presence and transform it into software requirements.

2 Methodology

2.1 Refining Social Presence Requirements Using Requirements Prioritization

The MoSCoW prioritization method was used in this study to statistically categorize social presence factors which were reported in Abdul Rahman and Sahibuddin (2016). The authors chose MoSCoW prioritization method according to the types of requirements gathered during the elicitation, as well as the suitability of extracting social presence elements. MoSCoW is a technique used to categorize the requirements into priority groups (Brodie and Woodman 2011; Mead et al. 2008; Messenger 2013; Ramsin and Paige 2008). Other prioritization methods that are considered in this study are, namely, Analytic Hierarchy Process (AHP), Simple Ranking and Hundred Dollar method. The Analytic Hierarchy Process (AHP) is used for the decision-making process (Ertuğrul and Karakaşoğlu 2009; Ishizaka and Labib 2009; Lee et al. 2009), Simple Ranking (Berander and Andrews 2005) is

used for doing simple requirements ranking, for instance, *n* requirements are ranked from 1 to *n*, and the Hundred Dollar method (Aasem et al. 2010; Ahmad et al. 2011; Fitsilis et al. 2010; Thakurta 2013) is used to quickly help choose ideas from multiple ideas created in order to carry those ideas forward to next stage of development. In order to prioritize social presence requirements, the author used the MoSCoW prioritization method to categorize requirements into 'Must Have', 'Should Have', 'Could Have' and 'Won't Have' priority groups. The acceptance of the main components of social presence such as Perceived Attention, Perceived Confidence, Perceived Relevancy and Perceived Satisfaction was confirmed and accepted using the SEM analysis.

2.2 *Expert Consensus for Artefact One*

Study Two, which was the second stage in the multiphase method, was carried out qualitatively in Round One of the Delphi's survey. The objective of Study Two was to seek opinions from a panel of experts regarding the technical guide based on the analysis which was done in Study One, whereas Study Three establishes the experts' consensus to improve the artefact to become more meaningful and clearer to support social presence. The guide clarifies the steps needed for extracting social presence for the E-learning domain. The requirements for supporting social presence were documented in the artefact and evaluated by 11 experts such as the Director of the UTM Centre of Teaching and Learning, the Director of iLearn Centre UiTM, a Senior Software Developer, a Business Analyst, an IT Manager, an IT Officer, an IT Executive, a PMO Specialist, a System Analyst, a Lecturer and an Assistant Director and Manager Network Engineer. From the experts' consensus, the authors were able to obtain their recommendations and opinions in order to highlight social presence criteria. It was also important to translate the elements of social presence into requirements for E-learning to improve the collaborative activities among students as well as to enhance knowledge sharing among the students. Figure 2 illustrates experts' consensus that has been contributed to the Artefact One as the initial product of requirements elicitation for extracting social presence requirements. The need to create this artefact corresponds with the need to enhance the requirements elicitation process for developing collaborative applications since requirements elicitation is an initial process in RE (Fig. 1).

The authors' contribution towards the supporting document, known as a 'Technical Guide to Support Social Presence', may offer some recommendations to the developers and related experts in having a clearer picture to the understanding of social presence.

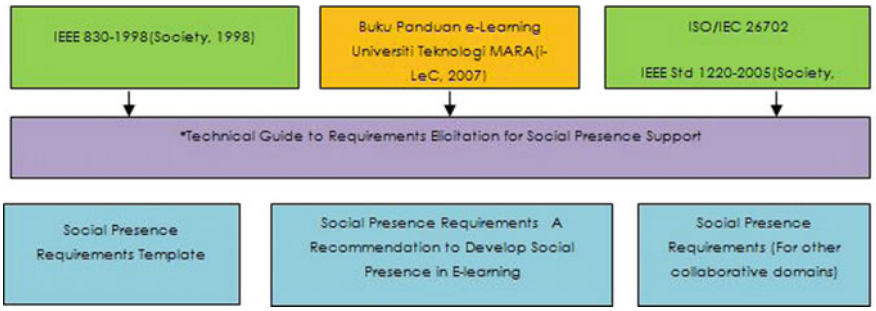


Fig. 1 The relationship of 'Technical Guide to Requirements Elicitation for Social Presence Support' to documentation standards

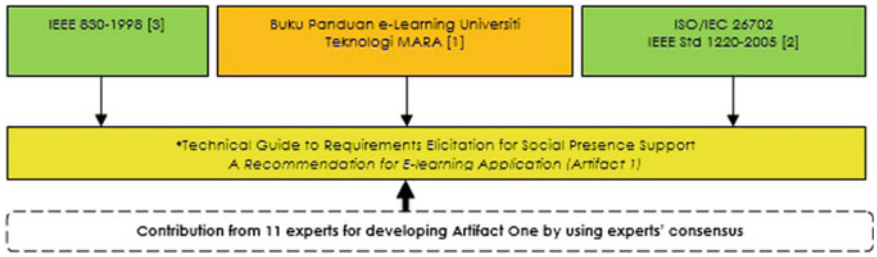


Fig. 2 The contribution of the 11 experts for Artefact One

3 Results and Discussion

3.1 Social Presence Requirements Analysis

Based on AMOS analysis presented in Abdul Rahman and Sahibuddin (2016) as Study One of multiphase approach, the structural model was tested in this study to prove the underlying hypotheses, which have been depicted in Table 1. The hypotheses were tested by determining the statistical significance of the path coefficients. The findings in Table 1 show that all of the hypotheses were significant. In Table 1, Perceived Satisfaction ($\beta = 0.45$, p -value< 0.001) had the greatest effect, followed by Perceived Relevancy ($\beta = 0.35$, p-value < 0.001) and Perceived Attention (slope, $\beta = 0.17$, p-value $= 0.006$) while Perceived Confidence (slope, $\beta = 0.16$, p-value $= 0.043$) had less effect. From Table 1, the authors also learned that Perceived Satisfaction, Perceived Relevancy, Perceived Attention and Perceived Confidence had a positive effect on Social Presence in the E-learning domain. In order to use the analysis for requirement elicitation, the authors used the requirements prioritization method for organizing social presence factors in artefacts which could be used for assisting the stakeholders in capturing social presence

Table 1 Path analysis for social presence variables (elements) in the model

Variable	Path	Variable	Unstandardized estimate	*p*-value	Result
Perceived relevancy	→	Social presence	0.35	0.043	Significant
Perceived confidence	→	Social presence	0.16	0.006	Significant
Perceived attention	→	Social presence	0.17	<0.001	Highly significant
Perceived satisfaction	→	Social presence	0.45	<0.001	Highly significant

elements. Therefore, the next section elaborates on the prioritization method and why this method is useful in organizing social presence during elicitation.

3.2 Prioritizing Factors Using the Actual Beta Estimate and the MoSCoW Method

In order to manage the requirements in social presence, the authors have selected the MoSCoW method for requirements prioritization. It categorizes requirements by using 'Must Have', 'Should Have', 'Could Have' and 'Won't Have' (Brodie and Woodman 2011; Mead et al. 2008; Messenger 2013; Ramsin and Paige 2008). The technical guide to elicit requirements in social presence is explained in the artefact draft known as a 'Technical Guide to Requirements Elicitation for Social Presence Support'. The authors used the SEM analysis of social presence factors based on the users' feedback to analyse the relationships among the four factors of social presence. In the SEM analysis, it analysed factors such as Perceived Satisfaction (PS), Perceived Confidence (PC), Perceived Relevancy (PR) and Perceived Attention (PA) and produced an Actual Beta Estimate value to prioritize social presence elements accordingly. The value of the Actual Beta Estimate for each variable is depicted in Table 2. The higher the value of the Actual Beta Estimate of the factor means the higher is its effect on social presence element. The lower the

Table 2 Requirements grouping using the Actual Beta Estimate and the MoSCoW prioritization method

Social presence element	Actual Beta Estimate	Requirements grouping
Perceived Satisfaction (PS)	0.45	Must Have
Perceived Relevancy (PR)	0.35	Should Have
Perceived Attention (PA)	0.17	Could Have
Perceived Confidence (PC)	0.16	Could Have
Irrelevant	None	Won't Have

value of the Actual Beta Estimate of the factor means the less effect it has on social presence element.

According to Table 2, the authors used MoSCoW method (Brodie and Woodman 2011; _ENREF_14 Mead et al. 2008; Messenger 2013; Ramsin and Paige 2008) to prioritize four types of requirements grouping, which consisted of 'Must Have', 'Should Have', 'Could Have' and 'Won't Have' with the ordinal value from the Actual Beta Estimate produced earlier in the SEM analysis. From that analysis, the value for PS is 0.45 whereas PR, PA and PC held a value of 0.35, 0.17 and 0.16, respectively. Table 2 also illustrates how prioritization was done for PS, PR, PA and PC elements by using requirements grouping. It also shows that the highest value of user feedback falls into the 'Must Have' category, while the lower value of user feedback falls into less prioritized groups such as 'Should Have', 'Could Have' and irrelevant requirements into 'Won't Have'.

The author advances the elicitation process by developing sufficient information and documenting it in the 'Technical Guide to Requirements Elicitation for Social Presence Support' artefact, which is known as the initial draft of Artefact One. A detailed description of this elicitation process suggests how to execute the requirements elicitation process by referring to prioritization groupings for social presence in E-learning. To summarize, the authors prioritized social presence factors according to the values of the Actual Beta Estimates obtained from the AMOS analysis in Study One.

The most critical requirements for social presence in this research belong to 'Perceived Satisfaction' since it held the highest value of the Actual Beta Estimate, whereas 'Perceived Confidence' was considered to be the least critical requirement of social presence in this research. There is a need to provide an artefact to support social presence (Pereira et al. 2011). In this research, the authors named the artefact as 'Technical Guide to Support Social Presence' in order to better focus and perform as a supplementary documentation to support social presence elements in E-learning or related collaborative applications. The purpose of this artefact is to allow developers or requirements engineers, or any intended audience, to extract information related to social presence and as well as information which was provided voluntarily by E-learning users. Figure 1 depicts the relationships of the 'Technical Guide to Requirements Elicitation for Social Presence Support' to Documentation Standards. In the technical guide, a set of requirements specification was recorded and social presence requirements were classified and prioritized using the constructs of Perceived Attention, Perceived Relevancy, Perceived Confidence and Perceived Satisfaction, which were identified earlier in Abdul Rahman and Sahibuddin (2016).

3.3 Delphi Result—Round One

In the initial round of Delphi, the panel of experts was given details by the researcher regarding the information which was relevant to the study. The 11

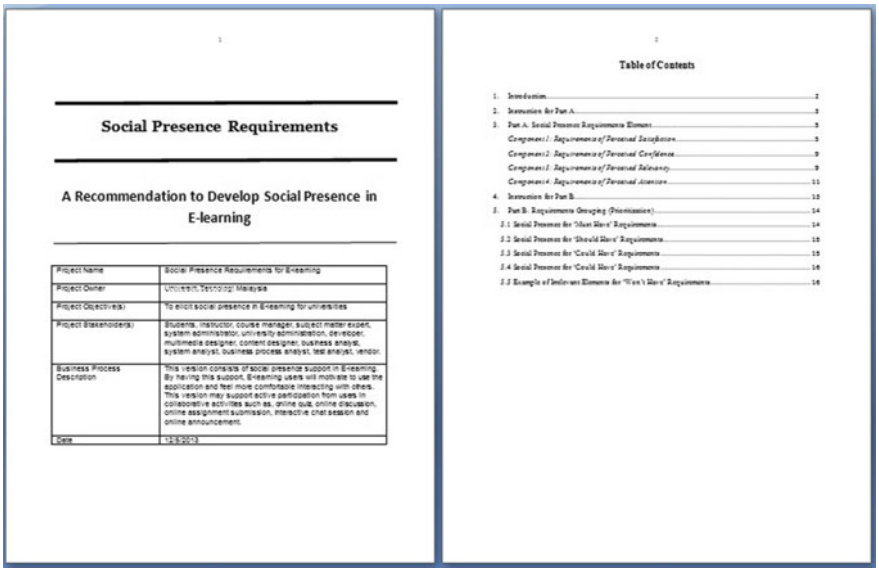
experts were selected to evaluate the technical guide. During the first round, the experts were informed about the title of the research and the title of the elicitation output which was the technical guide. After the information was understood by them, the authors described the details of the technical guide, such as the objective of doing the requirements elicitation, the objective of the technical guide for supporting social presence in E-learning and how social presence contributes to the E-learning domain, especially in collaborative activities as well as the technical references of Artefact One.

After having a mutual understanding of how social presence plays its role in E-learning, the authors further explained the research work that contributed to the technical guide. According to the technical guide, there are four main components that are recommended for Social Presence (SP) such as Perceived Satisfaction (PS), Perceived Relevancy (PR), Perceived Attention (PA) and Perceived Confidence (PC). Therefore, the authors provided an explanation for each component to ensure that those experts understood the terminology for each component according to the research work. It was also essential for the authors to explain how the four components came up with the prioritization matrix. In addition, the authors also offered some explanation on the technical aspects of the prioritization matrix, and how the MoSCoW plays a part in prioritizing the requirements for the ease of reading for the stakeholders. From the discussion with the panel of experts, the authors also elucidated on how their roles and job descriptions could help the researcher to produce the requirements elicitation product and thus improve the quality of the requirements elicitation process by adding value to support social presence as the requirements for a collaborative application. In order to obtain the expert consensus on Artefact One, a qualitative study was carried out in the Delphi's Round Two.

3.4 Delphi Result—Round Two

The results of Round Two were collected based on the feedback from the panel of experts. From the survey, the author analysed their consensus and recorded it in a document in order to proceed to Round Three of the survey. All of the suggestions were useful to help improve the technical guide, as it is a supporting document to support related stakeholders in implementing a collaborative application that has social presence features. There were four (36.4%) males experts and seven (63.6%) females experts who were involved in Delphi Round Two (Study Two), and Delphi Round Three (Study Three). From these 11 experts, seven were from the software documentation domain and four of them were from the E-learning domain. Six were from the academic field, four of them were from the IT industry and only one was from both fields. The consensus of the experts was recorded based on their comments and opinions on the three semi-structured questions.

After analysing their consensus in Round Two, the authors concluded that 'Artefact One' should be subdivided into two other artefacts in order to produce more structured and meaningful documents. Besides a 'Technical Guide to Requirements Elicitation for Social Presence Support' (Artefact One), the other two artefacts are the 'Social Presence Requirements Template' (Artefact Two) and 'Social Presence Requirements: A Recommendation to Develop Social Presence in E-learning' (Artefact Three). After obtaining the consensus and modifying Artefact One, the authors finalized Artefact One as a supporting document to provide a description of the objective to elicit social presence support. The artefact also contains information on which factors should be considered by the stakeholders in order to elicit social presence voluntarily in the E-learning domain, which is an example of a collaborative application. The authors believe that the technical guide can be a supporting document to elicit social presence elements for other collaborative applications besides E-learning. Figure 3 shows the summary of contents contained in Artefact Two. This artefact supports the implantation of social presence requirements by recommending a template for social presence requirements. By utilizing this template, the template user manages to organize the requirements related to social presence elements. Examples and instructions are given in the template to assist the user in following the template. Figure 3 consists of template instruction on how to manage social presence elements. Figure 4 shows a summary of contents contained in Artefact Three. Artefact Three offers recommendations on how to develop social presence in E-learning, which was the focus of this research. The Artefact Three document was produced based on Artefact Two's template.



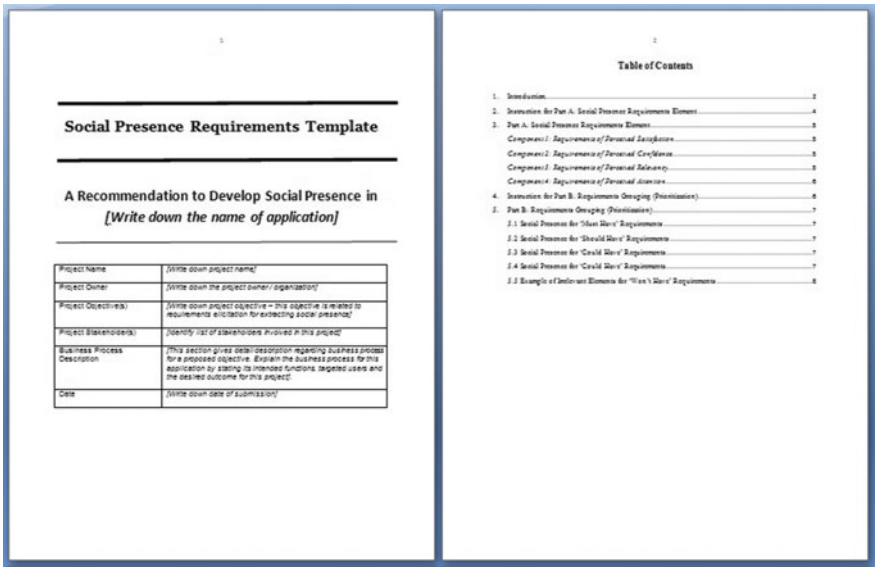
Social Presence Requirements

A Recommendation to Develop Social Presence in E-learning

Project Name	Social Presence Requirements for E-learning
Project Owner	University, Technology Malaysia
Project Objective(s)	To elicit social presence in E-learning for universities
Project Stakeholder(s)	Students, instructor, course manager, subject matter expert, system administrator, university administration, developer, multimedia designer, content designer, business analyst, system analyst, business process analyst, test analyst, vendor.
Business Process Description	This version consists of social presence support in E-learning. By having this support, E-learning users will motivate to use the application and feel more comfortable interacting with others. This version may support active participation from users in collaborative activities such as, online quiz, online discussion, online assignment submission, interactive chat session and online announcement.
Date	12/8/2013

Table of Contents

Fig. 3 Screen shot of Artefact Two—summary of contents



Social Presence Requirements Template

A Recommendation to Develop Social Presence in
[Write down the name of application]

Project Name	*[Write down project name]*
Project Owner	*[Write down the project owner/ organization]*
Project Objective(s)	*[Write down project objective – this objective is related to requirements elicitation for extracting social presence]*
Project Stakeholder(s)	*[Identify list of stakeholders involved in this project]*
Business Process Description	*[This section gives detail description regarding business process for a proposed objective. Explain the business process for this application by stating its intended functions, targeted users and the desired outcome for this project]*
Date	*[Write down date of submission]*

Table of Contents

Fig. 4 Screen shot of Artefact Three—summary of contents

The generation of social presence requirements in this research was to demonstrate how social presence can be gathered by the stakeholders using these supporting documents.

4 Conclusion

E-learning is a collaborative application that acquires an element of motivation in order to maintain learners' interaction in the platform. The element of motivation, known as social presence needs to be elicited during Requirements Engineering phase for reducing social-technical gaps. There is an opportunity to improve requirements elicitation process for addressing the issue of lack of connectedness among the learners. Therefore, this paper elaborates multiphase approach in requirements elicitation process by conducting three studies. The knowledge of Requirements Engineering is expanded by introducing the requirements elicitation process to address non-technical requirements for developing collaborative application.

Acknowledgements The work reported herein was fully supported by the Research University Grant (RUG), Universiti Teknologi Malaysia (UTM), Malaysia, under Vote Number 02H40. The authors would also like to thank the Ministry of Higher Education (MOHE), Malaysia and Universiti Teknologi MARA (UiTM), Malaysia for supporting the research.

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Chapter 15
Facial Expression Recognition in the Presence of Partially Occluded Images Using Higher Order Spectra

Hasimah Ali, Muthusamy Hariharan, Siti Khadijah Zaaba and Mohamed Elshaikh

Abstract Facial expression recognition (FER) still be ongoing research and considered as a challenging task largely because of uncontrolled environmental conditions, for example, the presence of partially occluded images (masks or sunglasses) on the human face. To address the issue, this paper proposed a new approach of using higher order spectra (HOS) to improve recognition performance of FER under partial occlusions. HOS or second-order statistics the so-called bispectrum is used to reconstruct the occluded texture feature based on the configuration and visual properties of the human face. The bispectrum could capture a contour (shape) and texture information of the facial emotion whose enable the effective implementation algorithm in FER. In this framework, first the 2D facial spatial images are projected into 1D signal by means of Radon transform. The Radon transform has properties of rotation and translational invariants; thus, it can preserve any variation in pixel intensities. Then, the projected 1D signal was analysed using HOS to obtain bispectrum magnitude plot whose exhibit the behaviour of different emotions. A set of bispectral statistic features were extracted from the bispectrum plot and used as informative features to recognize the emotions. Linear discriminant analysis (LDA) was adopted to reduce the data features before fed as input to Support Vector Machines. A series of experiments have been conducted on CK database. The obtained results show that the recognition rates of occlusion of the upper face give the accuracy of 93.1%; thus, it is promising.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_15

Keywords Bispectral · Facial emotion · HOS · Partial occlusion SVM

1 Introduction

Facial expression recognition (FER) has received great interest over the last three decades due to sizable impacts in various applications such as robotics, augmented reality, healthcare monitoring and surveillances. The recognition of FER remains a challenging task, due to unpredictable exterior environment such as the presence of partial occlusion images and noise corrupted images. In real situations, the occlusions may occur from hand movements, sunglasses, or wear scarves in front of face. Existing FER studies on handling facial occlusion images try to improve the accuracy by using various methods (Li et al. 2015; Zhang et al. 2014; Owusu et al. 2014; Kotsia et al. 2008; Fayaa and Toygar 2008; Buciu et al. 2005). For example, Liu et al. (2013) introduced Weber local descriptor (WLD) histogram and decision fusion in FER that missed under partial occlusion. At first, they divided the images into non-overlapping rectangular regions and used the WLD to extract the WLD features on that region. The histogram of WLD features was further computed and concatenated to form the feature vector before fed to SVM classifier. All the outputs of SVM classifier of the segmented region were fused together by decision rule. They simulated four types of occlusion (Li et al. 2015) except for upper and lower face occlusions. They found that the WLD histogram reserves well on the local description ability, in turn, give poor global description ability of WLD. Further, their claim decision rule can reduce the negative influence of poor quality of local regions in FER under partially occluded images.

Liu et al. (2013), on the other hand, have proposed the fusion technique of Gabor filter multi-orientation features with so-called local Gabor binary pattern histogram sequence (LGBPHS) to improve the recognition rates of facial expression under partial occlusion. The Gabor magnitudes pictures were extracted by using Gabor filter at specified scales and orientations before subjected to fusion rule. The fusion images then further encoded using local Gabor binary pattern (LGBP) by dividing non-overlapping block region to further process using a histogram. They evaluated four modes of occlusion, which are an upper face, lower face, right face and left face occlusion. They found the fusion technique can effectively reduce the data redundancy of original Gabor filter. In similar work, Li et al. (2015) combined the Gabor filter with texture analysis based on grey level co-occurrence matrix (GLCM) in recognizing seven facial expressions under facial occlusion images. In their framework, multi-scales and multi-orientation of Gabor filter of partial occlusion images were used to extract the block Gabor feature statistics on the spatial distributions. In parallel, the GLCM was used to extract the texture features. Both

inputs were then concatenated and linearly superimposed before fed to the Gaussian normalization. Five different modes of occlusions were tested such as occlusion of the upper face, lower face, right face, left faces, both eyes and mouth region.

It is desirable that the feature should be robust to intra-class variation such as a small amount of translation, rotation, spatial scale and additive noise. HOS features are suitable for these perspectives. HOS or third-order spectra, namely, bispectrum, are used to reconstruct the occluded texture feature based on the configuration and visual properties of the human face. Due to the advantages of bispectrum having capability in capturing a contour (shape) and extracting texture information of the facial emotion, thus it enables the effective implementation algorithm in recognizing the facial emotion. Thus, this paper proposed a new set of bispectral-based features for recognizing facial expression under partial occlusion images.

The outline of the paper as follows: Sect. 2 explains the database and methods used in the experiments, feature extraction, Radon transform and HOS and facial classification using SVM. In Sect. 3, the results of the proposed method are presented and discussed. Finally, Sect. 4 concludes the paper.

2 Materials and Methods

First, the partial occlusion image is projected into 1D function signal using successful projection via Radon transform at specified angles. The two-dimensional image is reduced to a one-dimensional Radon transform projections in order to apply a one-dimensional version of bispectral invariants (Chandran et al. 1997). The projected signal is then subjected to third-order spectra of HOS, namely, bispectrum which bispectrum plot of bi-frequency plane will exhibit the distinctive pattern of different emotions. A set of bispectral features are derived from the bispectrum plot to extract the informative features. To reduce the data dimensional features, LDA is used as reduction technique before is fed as input to the SVM classifier. The block diagram of the proposed method is depicted in Fig. 1.

2.1 Facial Expression Database

The public available database, namely, Cohn-Kanade Facial Expression database (CK database) (Kanade et al. 2000) was employed in this work. It consists of 500 image sequences from 100 university students, between 18 and 30 years of age, in which 65% were female, 15% were African American and 3% were Asian. The subjects were instructed to express six basic emotions that are *angry*, *disgust*, *fear*, *happy*, *sad* and *surprise*. The image sequences begin with the *neutral* face and slightly increase the *peak* emotion. The size of the original image is 640 by

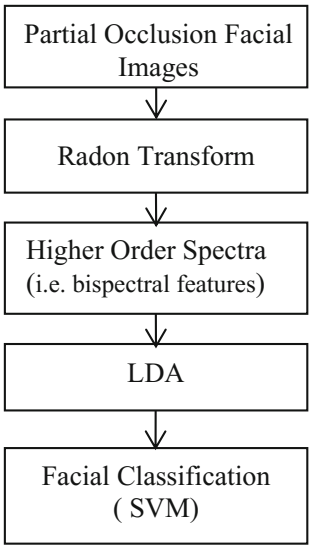

Fig. 1 Description of the proposed method

490 pixels. In this work, we selected 404 images (38 anger, 59 disgust, 52 fear, 75 happiness, 54 sadness, 46 surprise and 80 neutral). As there is no real partial occlusion database, the facial images are simulated with partial occlusion similar to Kotsia et al. (2008) using four different modes as shown in Fig. 2.

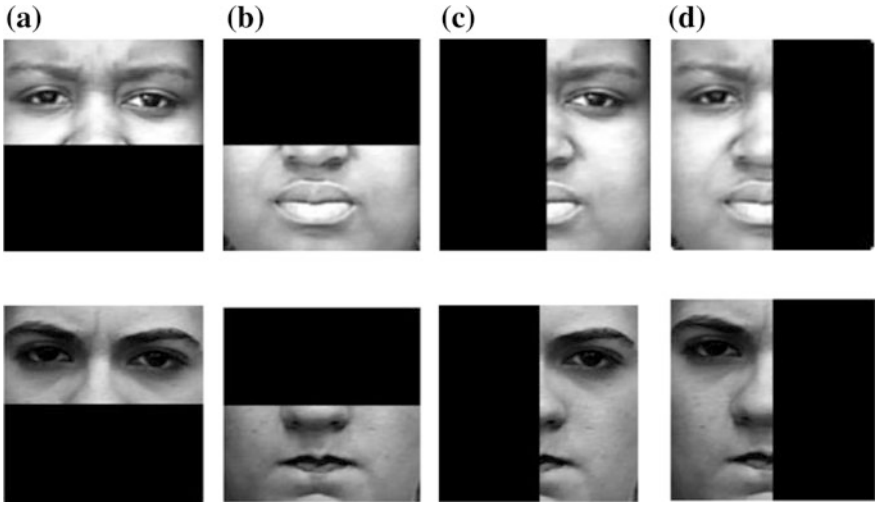

Fig. 2 Four types of occlusion modes: **a** lower part, **b** upper part, **c** left part and **d** right part of face region

2.2 Radon Transform

The Radon transform is widely used in medical imaging such as CT scans, MRI, PET, etc. The Radon transform can also be used for line detection. Mathematically, it is defined as

$$\rho = x\cos\theta + y\sin\theta \tag{1}$$

in which the Radon transform:

$$R(\rho,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(\rho - x\cos\theta - y\sin\theta)\mathrm{d}x\mathrm{d}y \tag{2}$$

where $\delta(.)$ is Dirac delta function. In 2D images, the Radon transform computes the projection of the image along the specified angle (Hoilund 2007). The resulting projection is the sum of the intensities of the pixels in each direction, i.e. line integral. The concept of Radon transform is depicted in Fig. 3. While Fig. 4 illustrates the result of a Radon transform with θ = 70°.

2.3 Higher Order Spectra

Higher order spectra (HOS) or known as polyspectra is a spectral representation of higher order moments or cumulants for deterministic signal or random process. The HOS analysis is very useful in the extraction of shape-dependent phase information and the identification of nonlinearity and non-Gaussianity in the deterministic signals as well as a random process (Chandran and Elgar 1993). The third-order statistics or cumulants of the signal are referred as *bispectrum*

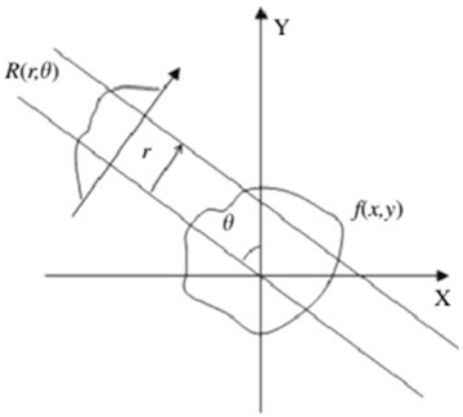

Fig. 3 Radon transform

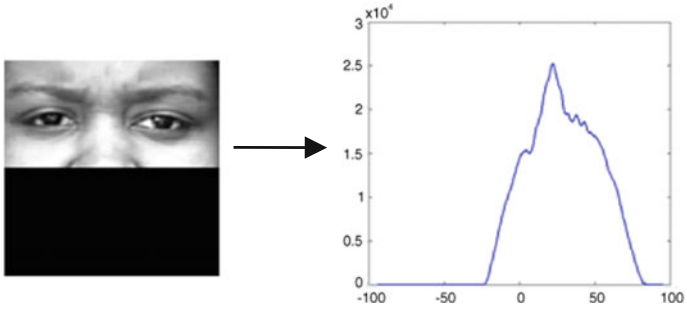

Fig. 4 The result of a Radon transform with $\theta = 70°$

(Chandran and Elgar 1993; Chandran et al. 1997) and fourth-order statistic is referred as *trispectrum* and so on. Bispectrum for a given random signal $x(n)$ is defined in the frequency domain as

$$B(f_1, f_2) = E[X(f_1)X(f_2)X*(f_1 + f_2)] \tag{3}$$

where $X(f)$ is the discrete-time Fourier transform of $x[n]$, f is the normalized frequency (divided by one half of the sampling frequency) that is between 0 and 1, * denotes the complex conjugate and $E[.]$ denotes the expectation operator over an ensemble of possible realizations of the signal. For a deterministic signal, there is no need for expectation. Bispectrum is a function of two frequencies, and because of symmetry properties (Chandran and Elgar 1993) for a real-valued and discrete-time signal, it needs to be computed only over a triangular region in bi-frequency plane.

In this work, the HOS feature generation method can be illustrated as follows. For each model image, $I(x, y)$ is first reduced into a set of 1D function $R(\rho,\theta)$ by the Radon transform using Eq. (1). It is assumed that the origin is set at the centre of the image plane. Figure 10 illustrates the example of bispectrum magnitude plot using an indirect estimate of a simulated partial occlusion image at an inclined angle of 70° for emotion *disgu*st. The non-redundant region referred to as the 'principal domain' is marked by the red triangle in $f_1 - f_2$ plane. A set of bispectral entropies (normalized bispectral entropy (NBE), normalized bispectral squared entropy (NBSE), normalized bispectral cubic entropy (NBCE), sum of logarithmic amplitude (A) and the mean magnitude (M_{ave})) are derived within this region and used as features to recognize the facial emotions (Ali et al. 2015).

2.4 Linear Discriminant Analysis

Linear discriminant analysis (LDA) or Fisher's linear discriminant (Belhumeur et al. 1997) is an example of a *class-specific method*, tries to 'shape' the scatter of the data. The framework of LDA is to select W, which maximizes the ratio

between-class scatter and the within-class scatter. Consider the between-class scatter matrix, S_B and the within-class scatter matrix, S_W given as

$$S_B = \sum_{i=1}^{n} N_i(\mu_i - \mu)(\mu_i - \mu)^{\mathrm{T}} \tag{4}$$

$$S_W = \sum_{i=1}^{c} \sum_{x_k \in X_i} (x_k - \mu_i)(x_k - \mu_i)^{\mathrm{T}} \tag{5}$$

where μ_i is the mean of class X_i, μ is the mean of all classes, x_k is the kth sample of class X_i and N_i is the number of samples in class X_i. If S_W is *non-singular*, the optimal projection can be calculated as

$$W_{\text{opt}} = \arg\max \frac{|W^{\mathrm{T}} S_B W|}{|W^{\mathrm{T}} S_W W|} = [\, w_1 \quad w_2 \quad \cdots \quad w_m \,] \tag{6}$$

where $\{w_i | i = 1, 2, \cdots m\}$ is the set of generalized eigenvectors of S_B and S_W corresponding to the largest generalized eigenvalues $\{\lambda_i | i = 1, 2, \cdots m\}$, such as

$$S_B w_i = \lambda_i S_W w_i, \quad i = 1, 2, \cdots m \tag{7}$$

Note that there are at most $c - 1$ non-zero generalized eigenvalues, and the upper bound of m is $c - 1$, where c is the number of classes (Belhumeur et al. 1997).

2.5 Support Vector Machines

SVM has been introduced by Vapnik (1998) and successfully applied in various applications such as face recognition, bioinformatics, text, speaker identification and image recognition due to attractive features and empirically good performance. SVM is based on the idea of finding the hyperplane that best divides a dataset into two classes such as class 1 or class 2 for linear separable case. In other words, the aim of an SVM is to find the optimal separating hyperplane, which maximizes the margin of the training data. The margin is defined as the distance between the closest data points to the hyperplane (Burges 1998). Support vectors are the points closest to the hyperplane. Removal of this point will alter the location of separating hyperplane. Further, in the case of nonlinearly separable problem, a kernel function is used to map the feature space into higher dimensional feature space so as to make the problem become linearly separable.

3 Results and Discussion

In this work, the simulated facial occlusion images are projected into 1D facial signal using Radon transform. For each image, the angle (theta) is varied from 0 to 179 at an interval of 5 to generate a facial signal. Thus, the resultant of 36 projection of facial signal will be produced for each image. This facial signal is subjected to bispectrum plot to observe the behaviour of the emotions. A set of bispectral features are derived from the bispectrum plot at the principal region. The extracted features are then reduced using LDA technique before subjected to SVM classifier. In this work, tenfold cross-validation is adopted in which the whole data is randomly divided into 10 sets equally distributed. At each process, nine sets are used as a training and the one remaining set used for testing. Each process is repeated for each fold and the final average is calculated.

Table 1 shows the confusion matrix for left part face occlusion based on reduced bispectral features using SVM classifier. It can be seen from Table 1 that the average recognition rate for the occluded upper face region is 91.34%. Emotion sadness contributes the lowest recognition rate which is 12/38 (12 out of 38 images) are misclassified. This emotion mostly confused with emotion fear, neutral and happiness. On the other hand, emotion surprise gives perfect recognition of 100% accuracy. This can be inferred that, although in the presence of left part occlusion, the information contains in another half of the face is sufficient to classify the emotion surprise correctly.

Confusion matrix in the presence of right face occlusion is illustrated in Table 2. As observed from Table 2 that the average recognition rate is 90.35% which seems to be comparable with the previous result as in Table 1. Also, emotion anger contributes the lowest recognition rate which is 10/38 are misclassified and followed by emotion sadness which is the second lowest recognition rate of 10/54 are misclassified. In contrast, the recognition rate of surprise has achieved the highest recognition rate which is only 1/46 are misclassified.

Table 1 Confusion matrix for left part occlusion based on reduced bispectral features using SVM classifier

	An	Dis	Fe	Ha	Neu	Sad	Sur	Average
An	**28**	0	0	0	1	1	0	
Dis	2	**52**	1	0	1	0	0	
Fe	0	1	**48**	2	0	1	0	
Ha	0	1	1	**73**	0	0	0	
Neu	7	4	1	0	**77**	6	0	
Sad	1	1	1	0	1	**45**	0	
Sur	0	0	0	0	0	1	**46**	91.34%
Total	38	59	52	75	80	54	46	**404**

Note An (Anger), Dis (Disgust), Fe (Fear), Ha (Happiness), Neu (Neutral), Sad (Sadness), Sur (Surprise)

Table 2 Confusion matrix for right part occlusion based on reduced bispectral features using SVM classifier

	An	Dis	Fe	Ha	Neu	Sad	Sur	Average
An	**28**	0	0	1	0	0	0	
Dis	1	**55**	1	0	1	2	0	
Fe	0	0	**44**	0	2	0	0	
Ha	0	1	5	**74**	0	1	1	
Neu	8	1	1	0	**75**	7	0	
Sad	1	2	1	0	2	**44**	0	
Sur	0	0	0	0	0	0	**45**	90.35%
Total	38	59	52	75	80	54	46	**404**

Note An (Anger), Dis (Disgust), Fe (Fear), Ha (Happiness), Neu (Neutral), Sad (Sadness), Sur (Surprise)

Table 3 presents the confusion matrix for lower part occlusion. As observed from Table 3 that the average recognition rate for lower part occlusion is 84.41%. Emotion surprise has achieved perfect recognition rate, which is 100% accuracy. This implies that there no error in identifying the emotion surprise in the presence of lower part region. However, emotion anger shows the lowest recognition rate which is 12/38 are misclassified (highly degraded the performance). This means that the information contains at the upper region is insufficient to recognize the anger as compared with the most discriminative region of lower part of the face. Table 4 shows the confusion matrix for upper face occlusion. One can observe from Table 4 that the average recognition rate is 93.07%, where emotion happy achieved the highest recognition rate which is 74/75 are successfully classified. In contrast, the emotion anger has revealed the lowest recognition rate which is 5/38 are misclassified.

Table 3 Confusion matrix for lower face occlusion based on reduced bispectral features and SVM classifier

	An	Dis	Fe	Ha	Neu	Sad	Sur	Average
An	**26**	0	1	0	1	1	0	
Dis	1	**54**	0	0	2	1	0	
Fe	5	1	**35**	0	1	0	0	
Ha	2	1	5	**66**	3	3	0	
Neu	3	2	8	9	**69**	3	0	
Sad	1	1	2	0	4	**45**	0	
Sur	0	0	1	0	0	1	**46**	84.41%
Total	38	59	52	75	80	54	46	**404**

Note An (Anger), Dis (Disgust), Fe (Fear), Ha (Happiness), Neu (Neutral), Sad (Sadness), Sur (Surprise)

Table 4 Confusion matrix for upper face occlusion based on reduced bispectral features using SVM classifier

	An	Dis	Fe	Ha	Neu	Sad	Sur	Average
An	**33**	0	0	0	0	0	0	
Dis	1	**55**	0	0	2	0	0	
Fe	0	0	**47**	1	0	0	0	
Ha	0	3	3	**74**	0	2	0	
Neu	4	1	2	0	**76**	5	2	
Sad	0	0	0	0	2	**47**	0	
Sur	0	0	0	0	0	0	**44**	93.07%
Total	38	59	52	75	80	54	46	**404**

Note An (Anger), Dis (Disgust), Fe (Fear), Ha (Happiness), Neu (Neutral), Sad (Sadness), Sur (Surprise)

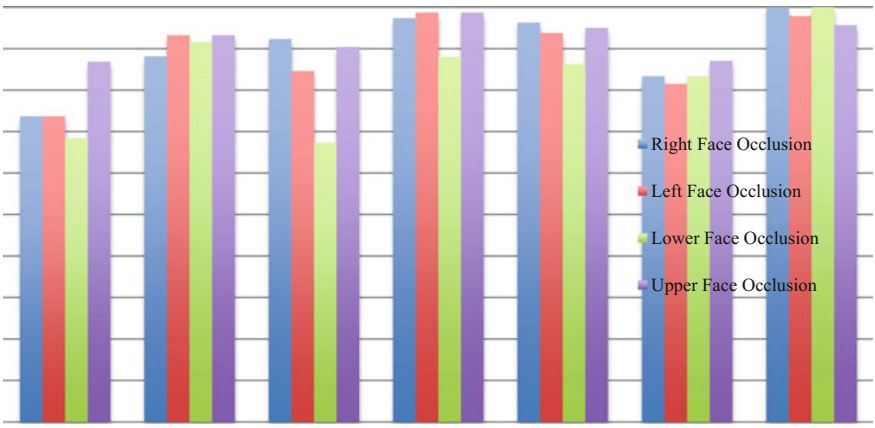

Fig. 5 Partial occlusion across emotions

Figure 5 shows the summary of emotion across the occlusion. It can be observed in Fig. 5 that for:

i. *Anger*. Emotion anger has the lowest recognition rates in the presence of right/left, upper and lower part face occlusion.
ii. *Disgust*. The recognition rates of emotion disgust have degraded due to the occlusion of left/right face region.
iii. *Fear*. The recognition rates of fear mostly affected by the occlusion in lower face region and followed by left face region.
iv. *Happy*. The recognition rates are affected due to occlusion of lower face region.
v. *Neutral*. The recognition rate is affected due to occlusion of lower face region.

vi. *Sad*. The recognition rates are affected by arising from occlusion of left face region.
vii. *Surprise*. The recognition rates of emotion surprise are not shown its consistency in accuracy but also less affected despite the presence of partial occlusion.

4 Conclusion

This paper has presented FER under partial occlusion images of upper, lower, left and right region using HOS method. A new set of bispectral features, LDA and SVM classifier have been used to achieve the recognition. The results showed that left and right region occlusion does not affect the recognition rate, indicating that both left/right regions occlusion possesses similar discriminate information. The results of lower region occlusion have degraded the recognition rate of FER since most the information contains in the lower region such as mouth region which gives the most discriminative information as compare to eyes. Analysis across the emotions under different modes of occlusion have shown that the accuracy of emotion fear is the most affected while the accuracy of emotion surprise is not only provided its consistency but also less affected despite in the presence of partial occlusion. In future, further study should be conducted on a different scale of occlusion with optimal feature selection method.

Acknowledgements This research work is supported by Fundamental Research Grant Scheme (FRGS: 9003-00526).

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Chapter 16
A Preliminary Study: Mobile Application for Shuttle Bus Service

Thong Chee Ling, Bilal A. Soomro, Chit Su Mon, Lee Chiw Yi and Chaw Lee Yen

Abstract Nowadays, software packages designed to run on smartphones are expanding fast. Mobile applications such as Grab for car and taxi booking have eased the life of users, as it is able to engage car and taxi service and also tracking the location of taxi using Global Positioning System (GPS). The objectives of this paper are twofold. The first objective of this study is to conduct a preliminary study to find out the difficulties encountered by users without the use of smartphone in engaging transport service. The second objective is to gather user requirements including desired features of the proposed mobile application which is developed in future study. The results of the preliminary study, which are collected using survey, show that users encountered difficulties when engaging shuttle bus service within the campus such as bus delay. Furthermore, users also indicate their most desired features of the proposed mobile application, that is, tracking the location of shuttle bus using smartphones. The results obtained in this study can be used for future mobile application development, which enables users to plan their journey effectively.

Keywords Global positioning system · Mobile application · Smartphones

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_16

1 Introduction

As information communication technology (ICT) grows rapidly, smartphones have become a must-have device in the modern world. In the modern world today, smartphones are not only used for communication, they are also being used for internet surfing, taking photos, playing games and many more. Furthermore, smartphone applications or mobile application (in short 'App') is expanding fast. Grab is an example of mobile App which provides services for car and taxi booking. Services provided by Grab have eased the life of users by enabling them to engage car and taxi services as well as tracking the location of taxi using Global Positioning System (GPS). As a result, it has helped the users in reducing waiting time and efforts when engaging public transport services.

Public transport plays an important role in our daily life. People use it to get to work and travel anywhere in the area. It is also reasonable in terms of cost and time in saving the hassle of looking for a parking when driving. Zhou et al. (2012) stipulated that public transport especially bus transport has been well developed in many parts of the world. The bus transport services reduce the private car usage and fuel consumption and alleviate traffic congestion.

As public transport passengers (or known as users), it is more efficient if users know the accurate schedule of the public transport such as bus arrival time. Oftentimes, long waiting time at bus stops drives away the anxious travellers and makes them reluctant to engage bus service. Nowadays, most bus operating companies have been providing their bus schedules on the web which are freely available for the users. However, the bus schedules are only provided with limited information such as operating hours and time intervals. Moreover, this information may not be updated timely. Due to the rapid growth of mobile technology, smartphones are able to be used to track the location of the buses. One of the technologies used is Google Maps which offers useful information such as traffic conditions or weather situations (Zhou et al. 2012). The issue of long waiting time at bus stop without the use of ICT has triggered the idea of initiating this study. Hence, the objectives of this paper are to conduct a preliminary study which includes identifying difficulties encountered by users without the use of smartphone in engaging transport service; and gather user requirements including desired features of the proposed mobile App for shuttle bus service. This paper serves as preliminary study, and the results obtained are used for a mobile App future development, which is able to address the difficulties encountered by the users by running it their smartphone and plan their journey effectively.

2 Methodology

This section presents research methodology used to achieve the objectives of this study. The research methodology consists of two phases: (i) literature review and (ii) preliminary study through survey. First, literature review phase provides

analysis of the review of current relevant literature, their strengths and limitations are analysed through current relevant journals and articles. Second, the preliminary study is conducted to identify difficulties faced by shuttle bus riders in UCSI University, Malaysia and the desired features of mobile App for the riders. Survey method is used in the preliminary study. The questionnaire consists of three sections. Section 1 consists of demographic related questions, section B consists of information related to usage of UCSI University shuttle bus service and section C focuses shuttle bus usage including difficulties faced by bus riders in engaging bus service and desired features of the proposed mobile App. The target respondents are students at UCSI University who are engaging shuttle bus service provided by the university at least once a week. Convenience sampling is used for the survey method. The survey is pilot tested by a group of ten students to gather feedback on the questions asked and clarity of the questions. Subsequently, the survey is distributed to 75 respondents using online mode. At the end, 66 respondents are participated in the survey, yielded 88% response rate. The results are presented in the next section.

3 Literature Review

Transportation information has evolved over the years. From being printed on paper and posted around bus and train stations, they are now becoming available remotely on the internet. Biagioni et al. (2011) noted that today, in the developed country virtually every transit service makes their schedule available on the web in one form or another regardless of size. More advanced services such as integration with Google maps, automatic transit directions or real-time tracking and arrival time prediction are typically reserved for large transit agencies that have the necessary expertise in-house or can afford to have it done for them. Through the advanced services, transits agencies can dramatically improve the transit user experience and mitigate their anxiety (Zhou et al. 2012). Particularly real-time tracking and arrival time prediction are very powerful. The transit users (or riders) who can now adjust their travel plans to reduce waiting time. Even though buses typically punctual, real-time tracking can improve riders' confidence in the transit service, allowing users to schedule closer connections with less built-in margin of errors (Biagioni et al. 2011).

With the use of smartphones or mobile phones, the transit information can be accessed remotely via the internet. Mobile phones are ubiquitous and they are carried by people throughout the day. They have computation, sensing and communication capabilities. Many of these devices can already record audio, take photos and communicate over different radio channels. Furthermore, these mobile phones are being equipped with sensors that are able to capture location and measure acceleration. According to several practical systems have been implemented by using these features on the mobile phones, which have enabled applications in regards to sharing sensor derived status information in online social

networks, capturing the characteristics and dynamics of everyday activities. Some of these activities are enabling queries associated with physical space.

In developing countries such as Malaysia, there are many transportation companies provide various public transportation services such as RapidKL, Cityliner and Mini Bus service. While in campuses or universities, shuttle bus services are provided for the students. They offer an alternative way to save on transportation cost compared to driving own vehicles. UCSI University which is located in the capital city of Malaysia, Kuala Lumpur, also offers a free shuttle bus service for its students, and a bus schedule is provided on the university website. However, there is no method available for students to find out the current location of the buses and estimate the arriving time of the shuttle bus. This triggers the idea of initiating this research work by conducting a preliminary study identifying the difficulties encountered by the students who are shuttle bus riders or users, and gather user requirements such as desired features of mobile App in the study.

3.1 Global Positioning System

GPS sensor is one of the prestigious features of smartphones which is required for the mobile application. GPS is a satellite-based navigation system developed by U. S. Department of Defense in the 1970s for military and civilian applications. It consists of 31 satellites on six orbital planets about 20,000 km above the earth's surface. This constellation enables accurate location information to be computed at any place, anytime on earth using trilateration with range measurements between the observer and a few vehicle satellites (Hedgecock et al. 2013). With the embedded GPS receivers in modern phones, mobile App can easily collect users' locations and accurately locate users' positions at any given point in time. Location-based services have become a reality. Mobile phones users now only have to instal a tracking application to their phone and the application runs quietly in the background while regularly sending GPS locations to a remote server via cell phone networks. One apparent use of a tracking application is to locate the user in real time (Khoa 2013).

3.2 Google Maps

Google Maps is a desktop and mobile web mapping service application. It is created and supported by Google and offers features such as street maps, street view, satellite imagery and route planners. Google also provides Google Maps API for various platforms such as Web, Android and iOS to enable developers to embed Google Maps into their applications (Google Maps API 2014). Google Distant Matrix API is a web service that provides travel distance and time for a matrix of origins and destinations. The information returned is based on the recommended

route between start and end points as calculated by the Google Maps API, and consists of rows containing duration and distance values for each pair. Google allows extra parameters such as mode of transport, language, places to avoid and so forth. It is also free to use, however, it has some limitations to how many elements can be used per query and how many queries can be made in a certain time period.

3.3 Existing Mobile Applications or Information Systems Applications

There are numerous existing mobile Apps in other studies focusing on phone-based transit tracking. These systems include mobile-based vehicle tracking systems (Sedhuraman and Kavitha 2015), mobile-based participatory sensing bus arrival prediction system (Zhou et al. 2012) and bus arrival time prediction system using RBF neural networks (Wang et al. 2014). Others transit tracking methods such as Celltower sequence matching or participatory sensing are not covered in this study. This subsection presents the selected existing commercial bus tracking mobile App or information system application related to transportation services.

3.4 NextBus

NextBus is one of the main vendors' commercial bus tracking providers that provide real-time transit tracking service. It is available for Android mobile devices and it is a free application on Google Play. Some of the features include: find real-time arrival predictions for nearby stops instantly, find the location of stops and vehicles on a live map and send feedback to NextBus or the applicable transit agency (NextBus Real-time Passenger Information 2013).

3.5 EasyTracker

Since NextBus is one of the main vendors' commercial providers that providing real-time transit tracking service which incurs substantial initial and recurring fees, therefore EasyTracker is proposed to reduce cost and complexity. EasyTracker is an automatic system for low-cost, real-time transit tracking, mapping and arrival time prediction using GPS traces collected by in-vehicle smartphones (Biagioni et al. 2011). This application collects GPS traces from the transit vehicles to determine routes served, locate shops and infer schedules. Using online algorithms calculate the arrival time at upcoming stops using information collected by the servers. It is

found that real-time transit tracking is the most desired features for this mobile application.

3.6 Star-Bus System (or *Bus)

Star-Bus system is a transportation information system that uses GPS and SMS technologies. It is developed in response to transportation challenges experienced in Kyrgyzstan, a developing region with poor infrastructure and limited resources. Kyrgyzstan is a small and mountainous country in Central Asia with a population of about 5.5 million and shared transportation often happen outside the realm of a national or metropolitan transit authority. At the end, there is also no central body coordinating or allocating resources to ensure that the system is efficient and meets citizen's needs. Under such circumstances, this system might aggregate and disseminate information about transportation options to make it more efficient and effective for both riders and drivers. However, ICT usage in Kyrgyzstan remains relatively low and has seen slow growth over the years. Statistics show from 11% in 2006 to 15% in 2008. While mobile phone usage is growing from 21% in 2006 to 71% in 2008 (Anderson et al. 2010). Mobile phone users use their phone much more frequently, with 89% reporting using mobile phones at least once a day. Moreover, Kyrgyzstan uses SMS more regularly (about one-third of mobile use is on SMS) (Anderson et al. 2009). According to the statistics provided by a statistical portal (Statista 2017), the number of smartphone users in top 15 countries worldwide are China (717.31 millions), India (300.12 million), Brazil (79.58 million), Russian Federation (78.36 million), Japan (63.09 million), Germany (55.49 million), Indonesia (54.49) and so forth. Kyrgyzstan which belongs to Russian Federation is placed in fourth place among the fifteen countries, which has 78.36 million of smartphone users as of April 2017. It is believed that the number of smartphone users in this country is still increasing.

3.7 CTA Bus Tracker

Chicago Transit Authority (CTA) Bus Tracker operates the nation's largest public transportation system and covers the City of Chicago in the United States and 35 surrounding suburbs. CTA uses GPS devices to report bus location data (and more) back to the servers. In real time, it shows where buses are on a map and performs time estimation of bus arrival (CTA Bus Tracker 2016).

The summary of strengths and limitations of the selected existing mobile App are presented in Table 1.

Table 1 Summary of strengths and limitations of existing mobile App

Existing mobile App	Strengths	Limitations
EasyTracker	Able to calculate arrival time at upcoming stops using an online algorithm and information collected from the servers Collect GPS traces from the transit vehicles to determine routes served, locate shops and infer schedules	Collect own GPS where not needed
NextBus	Provide arrival times of chosen buses and routes Allow users to locate bus stops near them using GPS Users can query using SMS and be alerted of bus arrival via SMS	Only provide transit information specific fixed location
Star-Bus System	Allow queries by SMS such as predicting bus arrival time given the route number Able to generate geo-codes using crowd mapping with the help of users providing information about buses and routes they are travelling on	SIM card from different providers may have different timing requirements If messages are frequently delayed or dropped between *boxes and the server, the accuracy of the prediction may be adversely affected
CTA Bus Tracker	GPS real-time countdown Vehicles on map Live service announcement	Only provide transit information specific fixed location

4 Results and Discussion

This section presents the results and discussion. Once the respondents answer the survey, the data is collected and the responses are tabulated. A summary of responses is then generated from collected data. This data is then presented for better understanding and discussion.

The respondents are spread out from eight faculties in the university and the highest number of respondents (47%) coming from Faculty of Business and Information Science. 9% of the respondents are year one students, 33% of the respondents are year two students and 45% of them are in year 3. The remaining respondents have been studying at the university for more than 3 years. These students are the shuttle bus riders who engage in bus service at least one time per week. From the results, it is noted that majority (64%) only engage shuttle bus service from 1 to 4 times per week. One of the reasons given is the uncertain bus schedule. Based on the reason given, 49% of the respondents indicated that they spend around 20–30 min waiting for the shuttle bus and 5% of respondents spend more than 40 min waiting time for bus arrival. From the survey, it is discovered that the major issues faced by shuttle bus riders are bus schedules are unclear (28%), long waiting time (34%), bus departure is delayed (17%), not enough seats provided in

bus (12%) and limited bus stop (9%). In summary, long waiting time for buses become the major issues or difficulties faced by the respondents and follow the unclear bus schedule. Summary of the above statistics is presented in Table 2.

Table 2 Summary of demographics and usage of shuttle bus service

Profile	Frequency	Percentage (%)
1. Gender		
Male	42	64
Female	24	36
2. Years spent at UCSI University		
Less than 1 year	6	9
1–2 years	22	33
2–3 years	30	45
More than 3 years	8	12
3. Faculty		
Faculty of Applied Science	3	5
Faculty of Business and Information Science	31	47
Faculty of Engineering, Technology and Built Environment	19	29
Faculty of Hospitality and Tourism Management	0	0
Faculty of Medicine and Health Sciences	0	0
Faculty of Pharmaceutical Sciences	1	2
Faculty of Social Science and Liberal Arts	8	12
De Institute of Creative Arts and Design	4	6
Others	0	0
4. Programme		
Respondents specified their respective programmes	66	100
5. Number of time (per week) use bus service		
1–4	36	64
5–8	20	36
9–12	0	0
>13	0	0
6. Time spend waiting for the shuttle bus		
1–10 min	1	2
10–20 min	14	25
20–30 min	27	49
30–40 min	10	18
>40 min	3	5
7. Difficulties faced using shuttle bus service		
Bus timings unclear	44	28
Long waiting time	55	34
Delays in leaving	27	17
Not enough seats	19	12
Limited bus stops	15	9
Others	0	0

Table 3 Summary of time prediction features

No.	Item	Mean
1.	The mobile application should display real-time estimated arrival time of the shuttle buses	4.75
2.	The mobile application should allow querying of arrival time for shuttle buses to bus stop	4.69
3.	The mobile application should display expected journey time to each bus stop	4.50
4.	The mobile application should display real-time departure time of the shuttle bus from all bus stops	4.41

Pertaining to using technology (mobile application) to address the issue of long waiting time for buses, over 90% of the respondents show their support. These respondents feel that there is a strong need for the university to use the mobile application to overcome the long waiting time for buses daily. Over 80% of the respondents pointed out that having a mobile application in predicting bus arrival time (or in other words, reducing waiting time) encourages them to engage shuttle bus service more often. The results are encouraging as earlier mentioned respondents only take bus 1–4 times per week due to the long waiting time. It shows that mobile application with bus arrival time prediction is one of the desired features. Other features include location tracking and timely notification. Table 3 shows the mean scores on time prediction feature for the proposed mobile application.

As shown in Table 3, all of the listed features have achieved mean score more than 4. It shows that it is scaled towards 'strongly agreed' through the survey (using 5-point Likert Scale—'1' Strongly Disagree to '5' Strongly Agree'). These results have shown the most desired feature is displaying real-time estimated arrival time of the shuttle buses. Based on a literature study, if bus riders are able to predict bus arrival time, the waiting time is significantly reduced. In other words, the efficiency is increased. This shows that while waiting for bus arrival, bus riders can go to university library borrow or return a book or meet up with lecturers for a short discussion or even buy a cup of coffee or drinks. Other useful and preferred features such as allowing querying arrival time of buses and displaying journey time as well as display departure time at the bus stop.

The twofold objectives of this study have been achieved. By reviewing and analysing related literature, strengths and limitations of the existing systems are identified. Through the survey, the difficulties and desired features of the bus users are identified and gathered.

5 Conclusion

The results show that users encountered difficulties in locating shuttle buses as well as predicting the arrival time. Without the support of ICT, engaging shuttle bus service is really time-consuming. Since most of the respondents are smartphone

users, allowing them to instal mobile application on their smartphone and tracking the bus arrival time help them to overcome waiting time issues. User requirements are gathered in this study. These requirements include mobile App display real-time estimated arrival time of the shuttle buses, allow users to query of arrival time of shuttle buses at bus stop, display expected journey time at each bus stop and display real-time departure time of the shuttle bus at all bus stops. In future work, a mobile application can be developed based on the requirements gathered in this study.

Acknowledgements This work is supported by UCSI University under the University Pioneer Scientist Incentive Fund (PSIF).

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Chapter 17
Constructing Dynamic Infrastructure as a Service Model (DIAAS) According to User Preferences

Yazeed Al Moaiad, Zainab Abu Bakar and Najeeb Abbas Al-Sammarraie

Abstract Cloud computing has forced providers to give satisfying services to users. Unfortunately, there is no model that integrates user preferences with services offered by providers. The services provided are subject to change and thus this information must be reflected in the proposed dynamic model so the user can make an up-to-date decision in choosing the provider based on his preferences. In order to construct and evaluate this dynamic infrastructure as a service (DIAAS) model, the services considered are the speed of central processing unit (CPU), the size of random-access memory (RAM), the size solid-state drive (SSD), the bandwidth in bits per second (bit/s), and the cost of service. The DIAAS uses intelligent tool (ITOOL) for grabbing current provider functional services and stores user preferences. ITOOL retrieves the values of services either by using Web Services or JSON. The services are weighted using linear equations and ranked using average sum of the weighted services. DIAAS will display the list of providers according to user preferences after performing weighting and ranking procedures. There are changes in the value of services by providers, and this implies that user has to be aware of these changes. DIAAS can also be used by providers to improve their services. The findings of DIAAS model will be provided based on three levels (Low, Medium, High). Low = 33.33%, Medium = 6.66%, High = 100%. In DIAAS model, the low percentage will be given to the lower weight of the service and the high percentage of highest weight. Except for cost, the low percentage will be given to highest weight and the high percentage of lower weight. After that, we calculate the weight of each service for each provider by the linear equation formula. Finally, the rank value for each provider is the average of the summation of weights for all the services.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_17

Keywords Dynamic model · Infrastructure as a service · User preferences Web services

1 Introduction

The cloud computing has resources and systems across the Internet that allows user to employ services such as software and systems. Cloud computing model consists of Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Mell and Grance 2009). Large competitive companies provide these services are DropBox, Google Docs, Pixlr Editor and Jaycut (Whaiduzzaman et al. 2014). Well-known established companies have large high-capacity servers for cloud computing applications. They are Google, Amazon, Microsoft and IBM (Antoniou 2012). There is an increasing number of providers and their services. In addition, the cost of their services has increased and changeable. User has to adapt to these changes based on his original requirement, for instance, if there is an increase of load on the server, then the storage and CPU will automatically scalable.

User can request any service required with certain budget whenever and from anywhere (Malik and Nazir 2012). Examples of widely known providers are Google Compute Engine (GCE), Microsoft Azure (Azure), Amazon Web Services (AWS) and Rackspace Cloud (Rackspace). The offer for high-quality services provided is very useful for the user to analyse costs incurred. Providers are always seeking to challenge, compete and develop their services timely. Thus, user will face difficulties and challenges when there are many options to seek appropriate services needed (Gui et al. 2014; Jahani et al. 2014).

If user is not an expert, he/she will have difficulty and spend longer time to find his/her preferred services (Cao et al. 2009). Even though the providers show features, benefits and deployment, the user still faces obstacles to select and identify Quality of Service (QoS) (Zheng et al. 2013; Garg et al. 2013). Users have to be familiar with the providers and their services (Saravanan and Kantham 2013). However, there is a difficulty of the user's ability to make a decision to choose the best cloud services based on their requirements (Wang et al. 2011).

These services are what the user depends on according to the requirements. Example of research conducted on functional services are solid-state drive (SSD), CPU, RAM, bandwidth, performance, availability, elasticity, security, application update frequency, response time, throughput, efficiency and capacity. Most research focus on cost (Liu et al. 2004; Fujiwara 2011; Qu et al. 2013; Mamoun and Ibrahim 2014; Saravanan and Kantham 2013; KPMG International 2014; Bibi et al. 2010; Armbrust et al. 2010; Iosup et al. 2011a, b; Kondo et al. 2009). Example of non-functional services includes reputation (Zheng et al. 2013; Kumar and Agarwal 2014; Itani et al. 2014; Salama et al. 2012; Fujiwara 2011), age of company (Antoniou 2012; Cloud Computing 2016; Raderbauer 2011); and, availability (Salama et al. 2012).

There are many systems that employ linear models in making decisions (Shaw et al. 2012; Yuan and Lin 2012; Hall and Miller 2012). Linear models are used to aid the decision maker, contrast with the decision maker in the clinical versus statistical controversy, represent the changes in decision-making and initiate the decision maker (Rezaei 2015).

Currently, there is no tool that assists user to choose the right provider with regard to the required services (Sun et al. 2014) and QoS (Garg et al. 2013). Therefore, the first objective of this research is to construct an intelligent tool, ITOOL, in grabbing services needed by the user dynamically from various sites of Cloud Computing providers. Finally, to present the list of providers that are weighted and ranked according to user preference. The user then can decide whether to accept the top ranked provider proposed by DIAAS or select other provider from the list.

2 Method

Figure 1 shows the construction of DIASS Model. When a user submits his preferences, DIAAS will use web services for grabbing current provider functional services. The list of providers and their services will be displayed after performing weighting and ranking procedures using linear equation. The experiments were in the DIASS model on ten users with experience, and feedback was given rate from 1 to 5 based on comparing between the traditional method and the dynamic method to rank and get the result of who is the best provider according to user preferences. The construction of DIAAS is further discussed in the following subsection.

2.1 Providers Services

The construction of DIAAS requires two inputs: providers with their dynamic services and user preferences. Four best providers are chosen based on ranking by CloudHarmony (2014). They are AWS, Azure, GCE and Rackspace. The functional services that are essential such as SSD, central processing unit (CPU), random-access memory (RAM), bandwidth and cost are selected as shown in Table 1.

Table 2 illustrates the data values that were grabbed dynamically from the service provider (SP) sites for weighting and ranking procedures (Amazon EC2 Pricing 2014; GCE Pricing 2014; Rackspace Public Cloud 2014; Virtual Machines Pricing 2014). The weights of the services SSD, RAM, CPU and bandwidth are calculated by identifying the maximum and minimum volume according to the preferred service of users. The cost is an important service that is mostly concerned by the user. Unfortunately, at the same time of grabbing the cost, there is the possibility of price increasing or decreasing based on the competition and the provider's reputation.

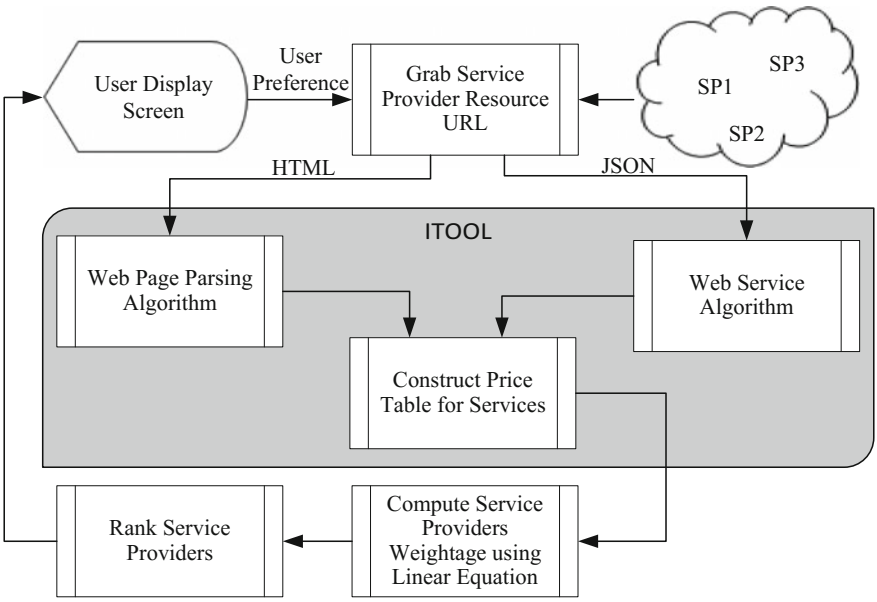

Fig. 1 Dynamic infrastructure as a service model (DIAAS)

Table 1 Functional services of cloud computing providers

Services	Description
SSD	A solid-state drive (SSD) is a data storage device, typically used in a computer and measured in bytes
RAM	A random-access memory device that allows data items to be read and written in the same amount of time and measured in bytes
CPU	A central processing unit (CPU) is an important part of almost every computer and measured in hertz
Bandwidth	The rate of data transfer in bits per second (bit/s)
Cost	The fee of the services

Table 2 Cloud computing provider services

VPS	AWS	Azure	GCE	Rackspace
SSD (GB)	640	800	1500	320
RAM (GB)	60	112	120	60
CPU core	32 cores	20 cores	32 cores	32 cores
Bandwidth (MB/S)	2000	2000	1000	5000
Cost/month	$1209.6	$1110.24	$1152	$921.6

2.2 User Preferences

The users are usually comprised of researchers and computing personnel that are from universities and customer service companies. These users are involved heavily in developing or using applications, information, runtime, middleware and operating system. The score values of 1–3 indicate the essential degree of requirement. Score value of 1 indicates user requires high level of the service; value 2 implies medium level; whereas the value 3 indicates low level.

2.3 Grabbing Provider Functional Services

Some providers do not have standard data or web services. To get these data values from these providers, an intelligent tool, ITOOL is developed. It has the features and abilities to measure the preferred service automatically. The ITOOL will browse the data page of the provider, perform searching for the highest value and convert to the standard form. This standard data can now be processed. This tool examines and makes parsing of the values for each row on the table when there is an update in the providers' sites. Table 3 summarises the steps taken for providers that do not have standard data or web services. Providers that have web service, then the ITOOL will invoke the cloud provider web service to retrieve and store the services data values.

Table 3 Grabbing provider services without web service

Step	Process
1	Fetch the pricing web page and detect all the tables in that page to get data values of cloud service providers
2	Detect the needed pricing tables using regular expressions to find the needed data
3	Loop over all of the tables and data sets until the highest values in CPU, RAM, SSD, bandwidth and cost are found
4	Store the highest value in a new variable that will be populated using standard way JSON
5	Process all the HTML tags by using special libraries. Import the data in text format and keep track the location of the table and the cell

2.4 Weighting and Ranking Procedures

The weight of each service is calculated by the linear equation formula as shown in Eq. (1). The steps for calculating the weights are illustrated in Fig. 2.

$$y + mx = b \tag{1}$$

After calculating the weight of each service for each provider (x_i), the rank value for each provider is the average of the summation of weights for all the services. The summation formula is shown in Eq. 2.

$$\sum_{i=1}^{5} x_i = x_1 + x_2 + x_3 + x_4 + x_5 \tag{2}$$

Fig. 2 Weight calculation for a service

For each service
Get the values of the service from each provider
Sort these values
Get the max and min service values
Get user preference (low, medium or high)
Calculate the upper and lower % from user preference
Let m = (max-min service values)/upper-lower %)

For provider with highest service value
Let y_1 be the service value of provider
Let x_1 be upper percentage value of user preference
Get value of b from $b = y_1 - mx_1$

For the rest of the provider
Let y be the service value of provider
Use m and b calculated from Step 6 and 9 respectively
Determine x_j
Plot y_i vs x_j for each service value and provider.

3 Results and Discussion

In the following subsections, the result of weighting and ranking of SPs and the performance of DIASS are discussed.

3.1 Weighting and Ranking of Service Providers

Results that are presented in this section are based on a selected user preference. The user decides the lowest level for SSD service, medium level for the RAM service, medium level for the CPU service, medium level for the bandwidth service and the highest level of cost service. Table 4 summarises the user requirements for each service.

Table 5 displays the results of weighted and ranked providers according to user preference. This result is displayed to the user and after analysing and the optimal choice which meets his requirements and application need.

The highest percentage of preference and evaluation in preference has been given GCE provider which is 63.44% base to the user preference the lowest level for SSD service, medium level for the RAM service, medium level for the CPU service, medium level for the bandwidth service and the highest level for cost service. GCE also obtains highest weightage for SSD (34.0%) and CPU (7.0%), Rackspace obtains highest weightage for RAM (67.0%) and cost (100.0%). Three providers, GCE, Rackspace and AWS have the same weight for CPU (67.0%). The user can consider GCE as the best provider as the cost difference between GCE (99.8%) and Rackspace (100.0%) is only 0.2% and the difference of the rank value of GCE (63.44%) and Rackspace (55.94%) is 7.5%. Rackspace can also be reconsidered by the user if he insists on the highest level of preference is cost. In contrast, AWS is in the last rank which has the lowest rank value 14.2% although the score for CPU (67.0%) is the same for GCE and Rackspace. Figure 3 shows the ranking of four providers according to user preference.

Table 4 Requirement level of service needs of user

SSD	RAM	CPU	Bandwidth	Cost/month
3	2	2	2	1

1 high, *2* medium, *3* low

Table 5 Rank value (%) of providers based on user requirement

Providers	SSD	RAM	CPU	Bandwidth	Cost/month	Rank value
GCE	34.0	49.4	67.0	67.0	99.8	63.44
Rackspace	19.9	67.0	67.0	25.8	100.0	55.94
Azure	1.0	58.2	1.0	1.0	61.8	24.40
AWS	1.0	1.0	67.0	1.0	1.0	14.20

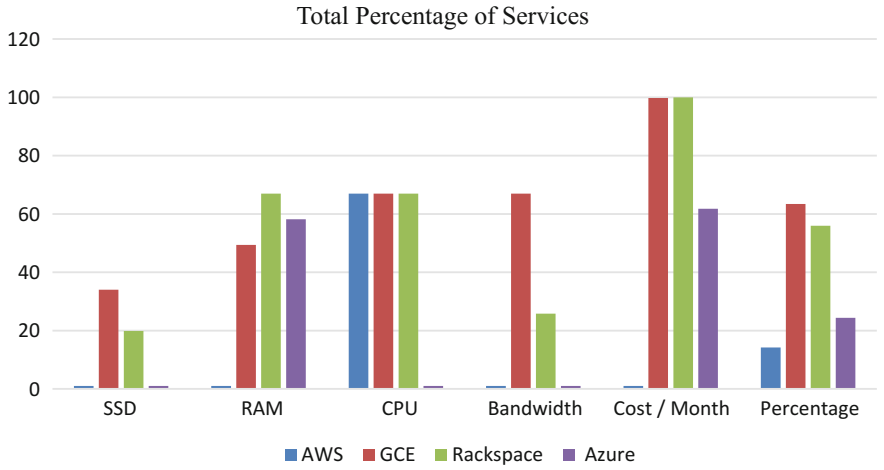

Fig. 3 Rank of providers services

4 Conclusion

In this research, the proposed DIAAS model called DIAAS is constructed to enable user to make an up-to-date decision in choosing the SP based on his preferences. The construction of DIAAS considers the speed of CPU, the size of RAM, the size SSD, the bandwidth in bits per second (bit/s) and the cost of service. DIAAS uses an intelligent tool (ITOOL) for grabbing current provider functional services, give weights by employing linear equation and rank the SPs by averaging the summation of the weights for all services for SPs. From the results, DIASS presented the ranked list according to user preference. The user has the choice to accept or choose other SP from the ranked list.

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Chapter 18
A Preliminary Study on Real-Time Mobile-Aided Shuttle Bus Service

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Abstract Due to the severe traffic congestion and the exponential rising number of vehicles on the road, public transport delays is a common and routine issue suffered by every citizen in a high-density city such as Kuala Lumpur. The delay becomes worse a day before and after school holidays or if there is accident happened on the road. Transit riders are unaware of the current traffic condition but have to keep on waiting until buses or trains arrive. As consequences, transit riders could be late to class or work. This paper studied on the needs of having a real-time bus location tracking system for UCSI University in Kuala Lumpur and proposed to develop a mobile-aided Bus Locator which embedded Global Positioning System (GPS) that aids bus riders to trace and track the current location of the University shuttle bus. Literature study on existing location tracking systems, tools and technologies embedded in application development are carried out to apprehend how existing systems work and how real-time location data is collected, processed and displayed to users. This paper also covers hardware and software components needed across various operating systems platforms to facilitate real-time location tracking.

Keywords GPS · Mobile application · Real time · Smartphones

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_18

1 Introduction

Kuala Lumpur is the federal capital of Malaysia with an estimated population of 1.7 million in year 2016. It covers an area of 243 km^2 and hence contributes to a high population density of 17,310 people per square mile (Kuala Lumpur Population 2016 August 06). As the result of this high population density, it creates a high demand for efficient transportation infrastructure as people hope to travel from one location to their destination in a short period of time. The demand goes high with the exponentially growing number of private vehicles driving on the road which brings to severe traffic congestion during peak working hour especially in the morning and late evening. In order to avoid the delay and lateness due to heavy traffic congestion, people who drive own vehicles have decided to become transit riders for public transportation such as trains and buses as their best alternate solution.

In order to alleviate the traffic congestions in Klang Valley area, Malaysia government developed an integrated public transport system which connects and links various cities together by integrating several transits and transportation services such as bus, Light Railway Transit (LRT), Mono Railway Transit (MRT), Komuter train (KTM) and metered-taxi. Among these services, bus service caters for the most number of passengers and covers the broadest area within Klang Valley. This is mainly due to bus service is cheaper and it provides the most frequent routines compared to the other public transportations.

Students are the main crowds who heavily depend on shuttle bus services provided by their institutes or universities as most of them are not affordable to own private vehicles or it could be due to their age are yet to be eligible to own a driving license. Students might travel from their home via various public transits which could not send them directly to the university and hence most of the universities' shuttle buses are stationed at bus terminal which is located near interchange point of different public transits. It could sounds like it helps a lot to students who do not have their own transport, however, they are still some controversial issues especially on bus arrival time and time spent waiting at the bus stand. Sometimes, buses reach later than expected time due to some unavoidable reasons such as accidents along the road or during peak working hour. Without a proper notification of the delay, it may cause students feel uncomfortable and inconvenient keep on waiting for bus without knowing the arrival time of the bus.

University provides free shuttle bus service to cater the need of students without personal own transport. Its main purpose is to bring convenience to students who wish to travel from UCSI University to the external public transit hub such as Terminal Bersepadu Selatan (TBS) or vice versa. However, excessive long waiting time at the bus stand decreases and hinders students from utilizing the shuttle bus service. Due to the uncertain bus arrival time, University received negative feedback from students who were eventually reluctant to continue using the shuttle bus service and choose to travel with their own transport or even call for cab service.

This paper studied the needs of having a bus location tracking system for a private university in Kuala Lumpur by providing real-time location tracking to university students through a mobile-aided application. Besides, this study is also carried out to review existing real-time location tracking system and identify required software (technologies) and hardware (tools) components in mobile platform and are presented as result of the preliminary study of the project.

2 Background and Related Works

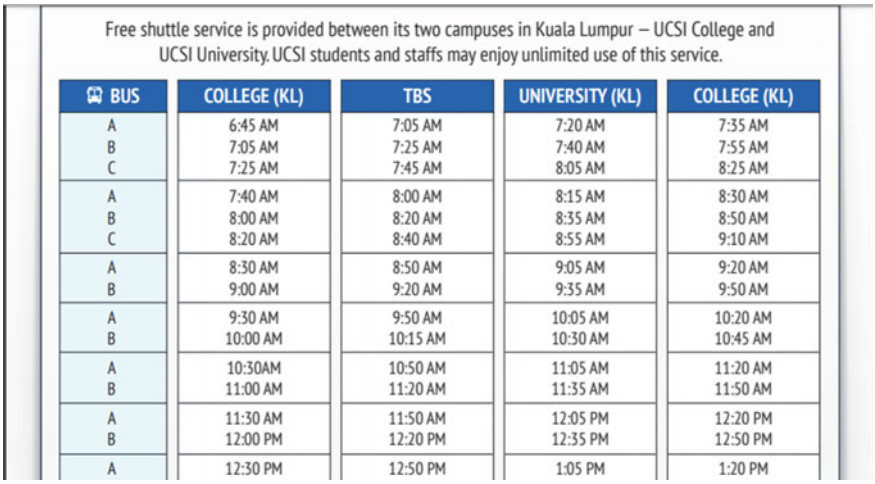
2.1 Traditional Bus Schedule

Buses travelled within Klang Valley area are normally cater for workers and students who travel a short distance to their workplace or school daily. Transit riders may find transits information on a piece of printed paper which sticks on the bus stands' notice board or counter. This kind of traditional bus schedule provides information such as bus routes, destination, bus number and estimated arrival time. Riders may estimate bus arrival time and get ready to approach the bus stand 10 to 20 minutes before the estimated time. However, the bus might not reach the bus stand exactly at the stipulated time due to some unforeseen reasons. Passengers might end up queueing at the bus stand longer than expected time.

Figure 1 shows an example of printed bus schedule with estimated arrival time and bus number. The schedule does not provide complete information or timely updated bus arrival time. Passengers have to wait at the bus stand until the bus arrives. Any unexpected car accidents along the road may cause a delay even more than an hour and eventually, transit riders have to find another solution to reach their destination. However, in most of the time, they are unaware of the current traffic conditions that may bring to the delay of bus arrival time. They have to keep on waiting until the very last minutes and only find out that the bus will not come on time and this might cause them late to the office or school. Therefore, it makes traditional bus schedule unreliable.

2.2 Passive and Active Location Tracking System

The demand for location tracking was first started in shipping industry where location information is stored in an internal storage and only accessible within the vehicle itself. Servers are unplugged from the ship and data are downloaded to a computer for analysis. However, the initial passive tracking system does not support real-time tracking (Muruganandham and Mukesh 2010). In order to solve the constraints faced by the passive tracking system, there is a need to develop an active tracking system which is able to transmit real-time location tracking to the server anytime anywhere.



Free shuttle service is provided between its two campuses in Kuala Lumpur – UCSI College and UCSI University. UCSI students and staffs may enjoy unlimited use of this service.

BUS	COLLEGE (KL)	TBS	UNIVERSITY (KL)	COLLEGE (KL)
A	6:45 AM	7:05 AM	7:20 AM	7:35 AM
B	7:05 AM	7:25 AM	7:40 AM	7:55 AM
C	7:25 AM	7:45 AM	8:05 AM	8:25 AM
A	7:40 AM	8:00 AM	8:15 AM	8:30 AM
B	8:00 AM	8:20 AM	8:35 AM	8:50 AM
C	8:20 AM	8:40 AM	8:55 AM	9:10 AM
A	8:30 AM	8:50 AM	9:05 AM	9:20 AM
B	9:00 AM	9:20 AM	9:35 AM	9:50 AM
A	9:30 AM	9:50 AM	10:05 AM	10:20 AM
B	10:00 AM	10:15 AM	10:30 AM	10:45 AM
A	10:30AM	10:50 AM	11:05 AM	11:20 AM
B	11:00 AM	11:20 AM	11:35 AM	11:50 AM
A	11:30 AM	11:50 AM	12:05 PM	12:20 PM
B	12:00 PM	12:20 PM	12:35 PM	12:50 PM
A	12:30 PM	12:50 PM	1:05 PM	1:20 PM

Fig. 1 Traditional printed bus schedule

An active web-based location tracking system is a software which displays updated and timely location information to their users. Google maps are used for location mapping while the GSM modem fetches the GPS location and send it to the server using GPRS. The information from in-time vehicle unit is transmitted to tracking server using GSM/GPRS modem on GSM network through SMS or direct TCP/IP connection to tracking server (Muruganandham and Mukesh 2010). The system comprises of vehicle-mounted tracking devices, a central server system and a web-based application which reads and displays transmitted location information from tracking devices to the server (Salim and Idrees 2013). Information is displayed on computer desktop or mobile device through a web browser.

2.3 Web-Based Location Tracking System

UD Shuttle (University of Delaware 2010) is a web-based application which provides Live Bus Map and estimated bus arrival time to students in University of Delaware. The webpage provides users with real-time bus routes, estimated bus arrival time (which is still under construction), current bus location tracking and even mobile alert for specified subscribers (refer to Fig. 2). Students who subscribe mobile alerts will receive notification via text message and a reminder of bus arrival time on daily basis.

Rice Shuttle (Rice University 2013) provides convenient shuttle bus tracking system by displaying updated information of each shuttle bus traveling on each route and their location in real time. Google map is embedded with bus icons which will be updated in two seconds interval time while the bus is moving (refer to Fig. 3). Riders can identify the bus based on different color-coded bus icon shown on the map.

Fig. 2 UD Shuttle: real time shuttle bus information

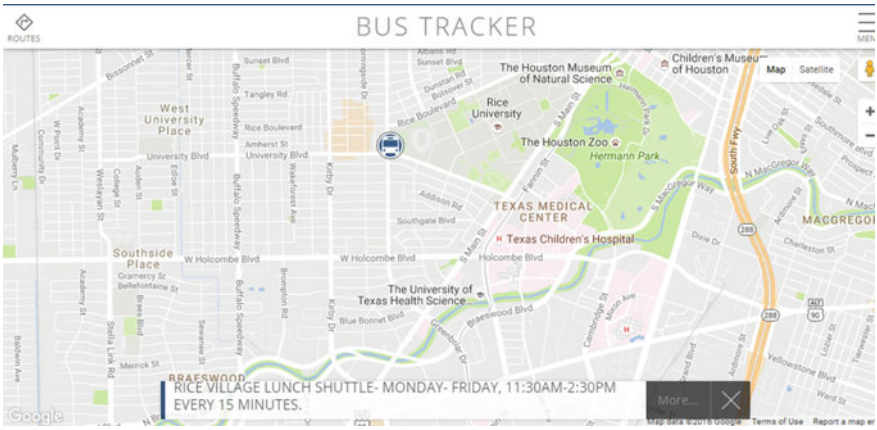


Fig. 3 Rice shuttle: real time bus location on map

However, the web-based system might react slower than naïve mobile applications (Power 2011). It is also less portable and restricts the accessibility from any places where users are not provided with laptop or desktop especially when massive information is not accessible through a handheld device due to space constraints.

2.4 Mobile-Aided Location Tracking System

Mobile apps are applications which are downloaded and installed on the mobile devices, rather than being rendered within a browser (Compuware: the Technology

Performance Company 2012). The definition differentiates between web-based applications from mobile apps as users are required to visit device-specific portals such as Google Play Store or Apple Apps Store to download and install the application on their mobile device as the first step. The shift from Web-based applications to Mobile-aided application is again proven with statistic result which shows the usage of Internet usage on mobile had exceeded PC usage in year 2014 (SearchEngine Watch 2016).

Mobile-based vehicle tracking system uses smartphones which supports GPS function to pin point real-time location coordinate accurately and update the information to the server (Punjabi et al. 2014). Many vehicle systems that are in use today are some form of Automatic Vehicle Location (AVL) (Muruganandham and Mukesh 2010). AVL technology records the coordinates on the ground of any vehicle and its actual real-time location is calculated and transmitted to a control center. It uses GPS signals and calculates from a known position, odometer and compass reading (RACCA 2004).

KATSANA is a modern, intuitive vehicle tracking system which allows users to check real-time location of own vehicle on mobile device (KATSANA 2013). Its main purpose is to track vehicle's location at the very first time once it was found stolen in order to increase the chances to recover the stolen vehicle. Location information is stored securely in cloud storage and users manage to retrieve the data through web tracking platform via mobile phone. KATSANA shuttle is the first interactive public bus tracking system in Malaysia. It provides with a bunch of functionalities such as live bus location tracking, geographic location of bus stand, current user's location display, routes information, estimated arrival times as well as custom and interactive landmarks (KATSANA Shuttle 2013). GPS tracking device is attached to the bus in order to transmit timely location to the server. Movement of buses is tracked every 5 s and viewable on a public tracking page.

Ride system was initially available as web-based shuttle tracker and had evolved to a mobile-aided shuttle tracker which is supported by both Android and IOS platforms. Google map is used to display real-time location of buses on different routes. Users are able to access the location of multiple bus stands, live location of buses, route details, bus schedules as well as the estimated arrival time. Besides, users also receive a text message as a reminder of bus arrival time (Ride systems 2016).

3 Results and Discussion

The preliminary study of the project was based on three parts: (i) literature review; (ii) survey; and (iii) interview. The literature review provides a basic understanding of the current approaches being used for bus scheduler; from traditional approach to active location tracking either through a web browser or mobile apps. Different approaches were studied and technologies and tools used were reviewed. The summary of existing bus scheduler using different approaches across various platforms is presented in Table 1.

Table 1 Summary of bus scheduler using different approaches across various platforms

Bus scheduler	Location tracking	Real time location tracking	Hardware requirement	Software requirement	Supported platforms	Limitation
Traditional bus schedule	–	–	Printer to printed bus schedule	–	–	Information is not updated and reliable
Passive location tracking system	√	–	Vehicle internal storage	PC Application	PC	Do not support real time location tracking
Active location tracking system						
Web-based	√	√	Vehicle-mounted tracking device Server	Web-based application and Google Map	PC	React slower than mobile apps and less portable
			Vehicle-mounted tracking device			–
Mobile-aided	√	√	Server	Mobile apps with GPS functions	GPS-enabled phone	

While the survey had been carried out among 38 students in order to gather the satisfaction level of the shuttle bus service provided by UCSI University and the tendency or preference of using mobile apps. The survey covers three major areas: (i) demographic information; (ii) mobile and Internet usage of candidates; (iii) perception and suggestion on the current and proposed system. All respondents are shuttle bus riders and mainly are locals. Results show that high Internet usage is mobile users (81%) rather than computer users and 97.4% of them are using smartphone. Furthermore, more than 90% have experienced using GPS-enabled application. While for the perception on current shuttle bus service, 50% of the respondents only take shuttle bus at most twice a month due to the uncertain bus arrival time and excessively long waiting time at the bus stand. From the result, 80.6% of respondents are not satisfied with the service provided as more than 50% of them spend at least 20 min or even more to wait for the bus. When respondents are presented with the proposed system, 84.2% of students agree to have a mobile-aided real-time bus locator system.

Interview was conducted with several frequent shuttle bus users and non-frequent shuttle bus users to analyze the preferences and reasons of not using University shuttle bus services. All interviewers stated that the average waiting time during rush hour takes 30–40 min with the condition of clear traffic on road and most of the time it takes approximately 10–20 min to catch another bus once they miss the bus. Furthermore, they feel worried about uncertain bus arrival time and always have very hard time struggling whether to switch to alternate transportation such as taxi or keep waiting at the bus stand. When the proposed system was presented to them, they strongly agree with the mobile-aided real-time bus locater will definitely save a lot of their time.

4 Conclusion

The result shows a high tendency of utilizing mobile-aided real-time bus locator in the university. Riders with GPS-enabled mobile phone are able to track live location of the shuttle bus and plan ahead for their journey effectively and furthermore save a lot of time. With the result generated from the survey, the team believes that the development of a mobile-aided real-time bus locator is needed.

Acknowledgements This work is supported by UCSI University under the University Pioneer Scientist Incentive Fund (PSIF).

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Chapter 19
A Preliminary Investigation on Managing Volatile Requirements in E-Learning Web Service

Noorihan Abdul Rahman, Shamsul Sahibuddin, Azlena Haron and Syarifah Adilah Mohamed Yusoff

Abstract Web service is an URL-addressable set of functionality exposed over a network or hosted on the Internet. The service helps organization to interact by using various programming languages and machine platform. Web service requirements are evolving according to requirements' volatility introduced by business demands and computer technology. In developing E-learning web service, developer needs to cater challenges in business requirements as well as web service issue. E-Learning web service must be managed properly to cater changing requirements of syllabus and courses contents. Therefore, changing requirements can be identified in order to meet requirements corresponding to requirements' priority. There is a challenge for developer to develop changing requirements in e-Learning Web service since business demands and technical needs always change. For that reason, volatile requirements should be prioritized by imposing prioritization method in order to allow developers execute more critical task. This paper reveals a preliminary investigation to manage volatile requirements in Web service. This paper also depicts on possible requirements elicitation techniques for analyzing volatile requirements for E-learning web service.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_19

Keywords Developer · E-learning · Learners · Volatile requirements
Web service

1 Introduction

In education, Learning Management System (LMS) is a collaborative tool for knowledge sharing such as blogging, commenting, instant messaging, wiki and XML RSS (Rahman and Sahibuddin 2016; Hon 2004). E-Learning is a powerful tool for knowledge sharing especially in universities. Web application has fundamentally changed the nature of how work and the nature of how people learn. People are more and more encouraged to learn by themselves and to only learn what they really need to know to perform their task optimally. According to the results of the Euro Barometer Survey (2002), the majority of teachers uses computers and accesses the WWW at home and believes that the WWW has changed or soon will change their teaching methods (Uzunboylu 2006). Due to this situation, requirements are flexible and 'scope creep' might arise and lead developer to produce ambiguous requirements for system implementation. Having time and cost as constraints to develop the web application, developer should find a way to accomplish the project that satisfies business requirements as well as volatile requirements within time and budget. To reduce the complexity of requirements in e-Learning web service, Goal-Oriented Requirements Engineering (GORE) will be used for eliciting, elaborating, structuring, specifying, analyzing, negotiating, documenting, and modifying requirements. Analytic Hierarchy Process (AHP) and Dynamic Systems Development Method (DSDM) are tools for managing volatile requirements in e-Learning Web Service.

In developing E-learning web service, developer needs to cater challenges in business requirements as well as web service issue. Web service is developed so that it is accessible by kinds of computers with different platforms. Web service requirements will change according to the features introduced by business demands and computer technology. Regards to this, web service features and requirements will eventually change according to business requirements and policy.

2 Literature Review

The literatures cover issues related with learning online, web-based application, e-learning as a web service, GORE and prioritization methods in order to relate with research proposal.

2.1 Learning Using Web-Based Application

The study stated that the majority of teachers uses computers and accesses the WWW at home and believes that the WWW has changed or soon will change their teaching methods (Larson et al. 2017; Uzunboylu 2006). Web services allow applications to communicate across platforms and programming languages using standard protocols based on XML. The mainframe of e-Learning Service quality includes ability to promised service dependably of users and offer individualized service (Zhang et al. 2004).

2.2 E-Learning as a Web Service

E-learning is a LMS that stores and manages content, an authoring system that helps creating content, and a run-time system that interacts with learners. E-learning also is perceived as a group effort where learners, administrators, trainers and authors work with one another to serve a community of learners (Rahman and Sahibuddin 2017; Vossen and Westerkamp 2003). Therefore, there is a need for having effective communication between service providers and service consumers regardless of platform that learners are using. The study has reported that various kinds of supporting tool and services need to be provided, including authoring tools, testing and examination services, certification and accreditation, simulation environments, etc. Selection of learning service offerings must be made as easy as surfing the Web, which might require the development of ontologies or markup languages through which learning content can be adequately classified, grouped, annotated and registered. This study also emphasizes challenge in e-learning system is concerning the presentation of the learning material on the client side. Madjarov and Boucelma (2006) stated that e-Learning as a web service can help to provide interoperability between heterogeneous systems. The study uses Learning Content Management System (LCMS) in order to integrate the components that user and provider need from the system. Therefore, a new Web service-based client has been proposed in this study in order to increase interoperability and reusability for learning data and applications. It uses (Asynchronous JavaScript and XML) AJAX technique (Chusing et al. 2017) to send requests to the Web server-engine to retrieve only the data that is needed using Simple Object Access Protocol (SOAP) or some other XML-based Web service dialect.

2.3 Managing Web Requirements

Web services allow applications to communicate across platforms and programming languages using standard protocols based on XML (Bahill and Madni 2017;

Kumar et al. 2002). Therefore, there are some factors that need to be considered in order to gather requirements for web service. The factors are value to business, cost to deliver, time to deliver, complexity to deliver, risks, relation to other requirements and when the requirements is needed for certain operations in Web Service (Ambler 2007). For this research, agile methodology will take part in analyzing volatile factors and hence prioritize the factors based on requirements needed by stakeholders in e-Learning. Poor requirements increase the risk of missing the opportunity of meeting customers' needs and enhancing the user experience (Fernández et al. 2017; Bahill and Madni 2017; Brinck et al. 2001). In fact, in order to be successful on the market, a web application has to be stakeholder-centred. On one hand, it has to offer content and interaction capabilities which best meet the goals of the users.

2.4 Goal-Oriented Requirements Engineering

GORE is concerned with the use of goals for eliciting, elaborating, specifying, analyzing, negotiating, documenting and modifying requirements (Horkoff et al. 2017). Such use is based on a multi-view model showing how goals, objects, agents, scenarios, operations, and domain properties are inter-related in the system-as-is and the system-to-be. Goal-agent-scenario that was introduced in GORE has proven to be effective in analyzing requirements since goal model provides an ideal communication interface between business managers and software engineers. It turned out to be helpful in producing more robust requirements, through obstacle analysis (Van Lamsweerde 2000) and identifying and resolving conflicting reasons (Van Lamsweerde et al. 1998).

Second feature of GORE models was their built-in vertical traceability from strategic business objectives to technical requirements to precise specifications to architectural design choices. The ability to capture multiple system versions within the same model through multiple paths of the goal AND/OR graph to see the system-as-is, to-be and likely-to-be-next was very helpful in some cases (Van Lamsweerde et al. 1998).

3 Goal-Oriented Methods for Changing Requirements

The possible methods might be applicable to deal with volatile requirements for E-learning Web Service since these methods can analyze, current goals, changing goals and future goals.

3.1 Goal-Driven Change Methods (GDC)

Overall goal-driven change (GDC) objective is to assist organizational stakeholders to consciously develop schemes for introducing changes. It is based on the premise that understanding change issues depends on the knowledge shared by organizational stakeholders about existing situation as well as the need for change using this knowledge, organizational change plans are systematically devised by analyzing the impact of change goals on the existing situation (Kavakli 2002). According to the strategy, models of the current enterprise processes are developed with the help of business experts and are consequently analyzed in order to identify current enterprise objectives.

3.2 ISAC Change Analysis

The objective of ISAC change analysis is to ensure that the business problems to be solved are identified and that these problems are diagnosed correctly. Current business problems will be analyzed and hence come out with possible solutions follow by one solution chosen. This method involves participation and cooperation from stakeholders in brainstorming sessions in order to achieve organizational change goals as well as alternative ways to act in order to resolve current enterprise problems and reach future goals (Kavakli 2002).

3.3 i* Strategic Rationale Modelling

*i** strategic rationale modelling follows three steps; identifying and modelling the existing processes, analyzing the model for deficiencies and proposing new processes that resolve the identified deficiencies. *i** begins with actor modelling strategy. Using this strategy, knowledge about the current enterprise state is developed by means of modelling current enterprise actors and their rationale. The importance of actor's roles can be seen from the collaboration activities among other actors (Kavakli 2002).

3.4 NFR Framework

NFR framework is suitable for developing quality requirements in terms of its non-functional such as performance, security, reliability and so on. First task is to develop an initial model of the existing situation which will reach As-Is state using quality goal graphs. NFR framework will address change issues based on

incremental strategy which reveals change needs are reflected in the existing quality goal graph, resulting in a revised quality goal graph that will eventually reach To-Be state (Kavakli 2002).

3.5 Goal-Scenario Coupling

The goal-scenario coupling approach assists the identification of future solutions that satisfy the organization's needs for change. This method uses scenarios in order to elicit future organizational goals and to operationalize them in terms of system components. According to the goal-scenario coupling strategy, identification of alternative solutions is addressed through analysis of possible future scenarios by business experts. For each future goal a scenario is described as a possible realization of the goal. The scenario is subsequently explored to yield additional future goals. The same process may be repeated for each of the discovered goals and so on (Kavakli 2002).

3.6 Prioritizing Software Requirements

Karlsson et al. (1997) described a method for prioritizing software requirements. The study emphasizes the importance to allow developers to focus more easily to guarantee quality requirements. The study has concluded that AHP is the most promising approach in for decision-making process compared to minimal spanning tree, bubblesort and binary search tree. AHP (Yu et al. 2017; Sadiq et al. 2017) is used for prioritizing software requirements where it involves three stages; as preparation, as execution and as presentation. Preparation stage outlines all unique pairs of requirements. Execution phase compares all outlined pairs of requirements and presentation stage estimates relative priority of each requirement. For this proposed research, AHP will be applied in Web service requirement management to see whether it is applicable to be used with Web-based information system.

3.7 UWA Project: A Model for Analyzing Web Requirements

UWA Project is a web-based credit-card-service of Banca121 (B121) in Italy. This study allows to assess and refine the model requirements analysis known as UWA Requirements (Bolchini and Paolini 2002). It uses goal-oriented analysis to determine goal and sub-goals of the web requirements. During requirements analysis, activities involved are as follows; define stakeholders, goal, sub-goal, requirements

and refinement process. During B121 requirement analysis, business and communication goals have been defined clearly and there were no assumptions made to the requirements. This presents a success to produce Web service standards.

3.8 *Dynamic Systems Development Method (DSDM)*

DSDM is one of agile techniques that is suitable to develop an application that is responsive to changing requirements. DSDM was developed in the 1990s by the DSDM Consortium of vendors and experts in the field of Information System development by combining their best-practice experiences. The main idea of DSDM is to involve users in requirements gathering to deliver customer-oriented product and services. In designing web service, user will give feedback corresponding to the web service framework. DSDM will utilize prioritization technique MoSCoW (Ramsin and Paige 2008; Serral et al. 2017) during requirement elicitation of e-Learning Web Service. It is to organize requirements by categorizing all types of requirements in 'Must Do', 'Should Do', 'Could Do', or 'Won't Do' (Ramsin and Paige 2008).

Table 1 Flow chart of research methodology

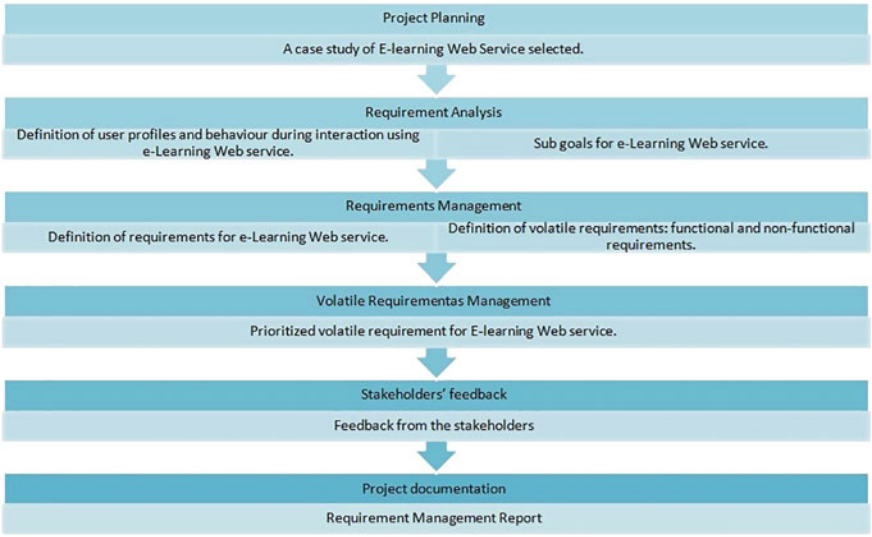

Table 2 Phases, activities, techniques and deliverables for each phase in managing volatile requirements

Phase	Activities	Techniques	Deliverables
Project planning	– Selection of e-learning web service	– Survey on e-learning web services	– A case study of E-learning Web service selected
Requirement analysis	– Determine goals for e-learning web service	Goal-based analysis and scenario-based technique – Elicitation technique—brainstorming (ISAC change analysis), questionnaires	– Definition of user profiles and behaviour during interaction using e-learning web service – Sub-goals for e-learning Web service
Requirement management	– Determine conflicting goals – Determine volatile requirements	– AND/OR graphs – Forward traceability, GDC, NFR Framework, *I strategic rational modelling, UML	– Definition of requirements for e-learning web service – Definition of volatile requirements: functional and non-functional requirements
Volatile requirement management	– Prioritize volatile requirements	AHP MoSCoW technique	– Prioritized volatile requirement for E-learning web service
Stakeholders' feedback	– Get feedback from stakeholders	User acceptance test (learner), interview (developer)	
Project documentation	Writing report		– Requirement management report

4 Description of Methodology

This research will manage volatile requirements for e-Learning Web service. Referring to Schön et al. (2017), methodology can be defined as a strategy and approach to identify user perspectives by conducting certain processes in order to achieve research objectives. Table 1 explicates flow chart of research methodology. The proposed methodology has been adapted from UWA Requirement model of UWA project (Bolchini and Paolini 2002) and GORE (Kavakli 2002) in order to emerge a process to manage volatile requirements for e-Learning Web service.

To begin with the proposed research, an e-Learning Web service will be identified in order to indicate requirements needed from stakeholders like learners and developers. Sample size of stakeholders will be determined later once e-Learning Web service has been selected for this research Next step will be requirements analysis which is to capture goals and sub-goals for the Web service. Sub-goals are then operationalized into requirements using AND/OR graph.

Volatile requirements will then be identified in resulted list of requirement the GDC method with the adaptation of NFR framework to identify non-functional volatile requirements whereas UML to identify volatile functional requirements. AHP and MoSCoW approach will be used in this research to prioritize requirements from top priority to low priority requirements. From there, Web service developer is able to justify which requirements are needed to be implemented first and which requirements are implemented next. User Acceptance Test to stakeholders will be carried out to determine e-Learning Web Service quality.

Table 2 depicts description of research methodology of this study by elaborating activities, techniques and deliverables involved in each phase. Phases of accomplishing this study comprised of project planning, requirement analysis, requirement management, volatile requirement management, stakeholders' feedback and project documentation. The list of deliverables produced for each phase are; a case study of E-learning web service, definition of user profiles and behaviour, definition of requirements, sub-goals for e-Learning web service and prioritized volatile requirements for E-learning web service.

5 Conclusion

E-Learning is a powerful tool for knowledge sharing especially in universities. Web application has fundamentally changed the nature of how work and the nature of how people learn. People are more and more encouraged to learn by themselves and to only learn what they really need to know to perform their task optimally. Due to this situation, requirements are flexible and 'scope creep' might arise and lead developer to produce ambiguous requirements for system implementation. Having time and cost as constraints to develop the web application, the developer should find a way to accomplish the project that satisfies business requirements as well as

volatile requirements within time and budget. In order to reduce the complexity of requirements in e-Learning web service, GORE will be used for eliciting, elaborating, structuring, specifying, analyzing, negotiating, documenting, and modifying requirements whereas AHP and DSDM are tools for managing volatile requirements in e-Learning Web Service.

Acknowledgements The authors would like to thank Universiti Teknologi MARA (UiTM) and Ministry of Higher Education (MOHE) for supporting the research activities towards conducting the preliminary investigation on E-learning web services.

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Chapter 20
Analysis of Private Browsing Activities

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Abstract Private browsing has been used by many users because of increasing awareness to browse the Internet in a private manner. The user can avoid someone to find the browsing histories and ensure no evidence of the visited sites. However, many users are not aware that the private browsing features do not meet with what it claimed to the users. Many users presume that the private browsings are secured, however, there are still flaws that can be identified. This study is conducted to examine the information obtained from the browser activities and analyze the evidence of data flows from some of private browsers. It focuses on retrieving the evidence of private browsing in RAM and hard disk as data usually are stored in local storage on user's computer. Some tools are used to retrieve private browsing data activities and several websites tasks and parameters has been set and identified for analyzing activities. In conclusion, although using private browsers, the evidence of private browsing data activities in RAM which are important and confidential for the user can be easily retrieved using RAM imaging. For the hard disk, different private browsers save the private browsing data in the different file but most of the data are store in C:\ partition. Although all evidences of private browsing data are different due to the different development algorithm of each private browsing, some parameters such as downloaded files and bookmarks can be easily retrieved from the browsers.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_20

Keywords Computer artifacts · Digital evidence · Internet forensics
Private browsing · RAM analysis · Hard disk analysis

1 Introduction

Web browsers are the essential platforms for users to access, share information, and perform all their activities over the Internet. The major browsers are Firefox, Internet Explorer, Google Chrome, Opera, and Safari (Mrinal and Kaushik 2013; Tsalis et al. 2017). In addition, a web browser is also used as a portable operating system (Hsu et al. 2014; Tsalis et al. 2015; Alan et al. 2017).

Users usually use web browsers in accessing their social networking media, and doing online banking and office management. However, some unethical users are constantly trying to steal others' personal data. As users become more aware of protecting their privacy while browsing the Internet, many developers add a new feature to tackle this privacy issue. Each browser refers to each private mode, namely "InPrivate" in Internet Explorer, "Incognito" in Google Chrome, and simply "Private Browsing" in Safari, Opera, and Firefox (Tsalis et al. 2017).

The main objective of private browsing is to disable some data while browsing and to make the users browse the Internet without leaving any traces in their computers. By using this privacy mode in web browser, it can prevent accidental saving of log-in credentials to accounts (Alan et al. 2017).

However, there are trails that can be traceable using some tools (Chivers 2013). Among the flaws can be retrieved from the private browsing are browsing history, bookmarks, downloaded files, caches, and cookies (Oh and Lee 2011; Kiavash et al. 2014; Tsalis et al. 2017).

According to Ohana and Shashidhar (2013), artifacts from private and portable browsing sessions such as usernames, browsing history, and images may contain significant evidence to a computer investigator. Forensic examinations of private and portable web browsing artifacts are extremely valuable only if prior research gained lack significant findings or does not provide sufficient answers (Oh and Lee 2011; Ruiz et al. 2015). Digital forensic examination helps to prove any activity involved in the past and also the person that may have been using the machine (Saidi et al. 2013).

The data that are related to pages visited during private browsing sessions are possibly archived from local storage. According to Montasari and Peltola (2015) data activities of private browsing can be found in the physical memory in the RAM. By using memory parser, it is able to scan the processes. Some of the private browsing data activities are also stored in the hard disk (Alan et al. 2017). Most common data found in the hard disk are texts and images from visited web browsers. Some artifacts from private browsing session still remain after the browser was closed (Kiavash et al. 2014).

Based on the brief introduction, private browsing, RAM, and hard disk are very popular subject pertaining to tracking ones' browsing history. To date the information related to forensic analysis perusals are very few. This study investigates the evidence from RAM and hard disk from the private browsing activities. Next sections provide explanation regarding the analysis environment, result and discussion, and the conclusion.

1.1 Analysis Environment

All the aforementioned browsers used in private mode were analyzed whether the browser leaving traces after the session had been closed. Difference researchers use difference techniques and tools to retrieve the data as much as possible (Oh and Lee 2011; Malmström and Teveldal 2013; Kiavash et al. 2014). Table 1 shows the tools used to retrieve private browsing data activities.

In order to setup the experiment, there are several websites and tasks that have been identified to retrieve data from different activities. Table 2 shows the websites and tasks to perform the testing activities.

During the processes of retrieving evidence, the searching processes are focused on RAM and hard disk. To ensure the evidences remain in the RAM and hard disk, the imaging processes need to be done. The imaging process happened as; live memory captured as the memory imaging for RAM image while disk imaging captured as hard disk image. It is the process of making bit-by-bit copy of the memory and disk, to prevent any changes that will occur in the RAM and hard disk. The results are stored in image files without altering any data.

RAM imaging should be done right after the user's finished surfing the Internet. The destination of the image is saved at the specific folder at the computer desktop. Hard disk imaging also prevents the temporary data from being deleted. During the analysis, the C:\ partition of the hard disk is being imaged because it contains all the folder of the browsers and the hidden folders related to this analysis.

Table 1 Software specifications

Type	Function
FTK Imager Lite 3.1.1	RAM and hard disk imaging
WinHex	Retrieved data from RAM image file
Autopsy	Retrieved data from hard disk image file
Encase	Retrieved data from hard disk image file
Cacheview	Retrieved cache file in the hard disk
CookiesView	Retrieved cookies file in the hard disk
SqliteBrowser	Retrieved database file

Table 2 Website and task activities

Websites	Task
YouTube	Enter the URL youtube.com in the browser. Search keyword Marron 5 in YouTube search Played the Maroon 5-Sugar video
Google mail	Enter the URL gmail.com in the browser Enter email address of the user Enter user's email password Send an email to another user of the Internet
Facebook	Enter Facebook in the browser search Select facebook.com URL from the search result Log in the Facebook using email address and password Click to the user profile and upload a picture from the computer
Zalora	Enter zalora.my in the URL Log in into Zalora account using email address and password Click to women and Muslims wear to view the items Bookmark the Baju Kurung webpages in the Muslim wear category Add to cart the Mango bag that is in shoulder bag category
Maybank2u	Enter Maybank in the browser search Select maybank2u.com.my from the URL search result Log in into maybank2u by entering the username and password Click to the transfer button to make money transaction Transfer RM50 to another user account

2 Results and Discussion

The following section provides explanation regarding the experiment.

2.1 Evidence Found in RAM

Private browsing data activities in RAM can be retrieved through the image file saved in.mem format and can be open by using WinHex tool. All the RAM information that store in image file can be viewed in hexadecimal and ASCII format. The evidence of private browsing data activities in RAM will be shown in the following subtopics.

2.2 Email Evidence

Figure 1 shows that the user has signed in into Google account using the opera browser in Windows operating system. By using WinHex, user's email account can be retrieved. As shown below, the user has sign in the Google account using fatinfarhanah93@gmail.com email.

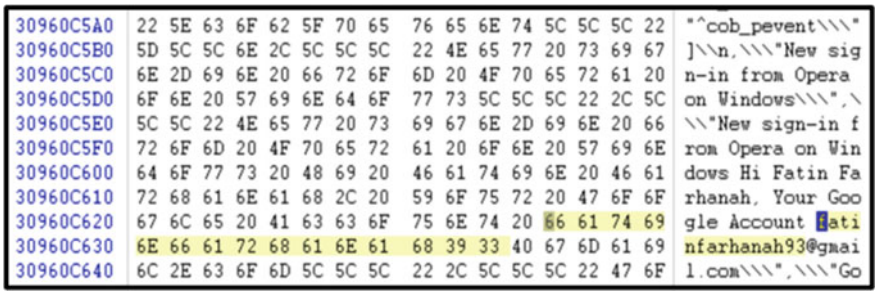

Fig. 1 Email address

2.3 URL Evidence

Figure 2 shows the user has browsed www.youtube.com. It also shows that a user performs keyword search to search `Maroon 5` in the YouTube website. While searching the evidence in the RAM image file, WinHex enables to retrieve all the URL histories including the directories visited by a user.

2.4 Bank Information Evidence

This information obtains from the user online transaction activities using a private browser. As shown in Fig. 3, the information are found in the RAM image file. It shows that the user has transferred RM50, the user account number "`from account = 114302158890`" and the recipient account number "`to account = 158435054563`", with the recipient's email address farah.aina.husin@gmail.com, transfer's purpose and description. All information are important and confidential for the user.

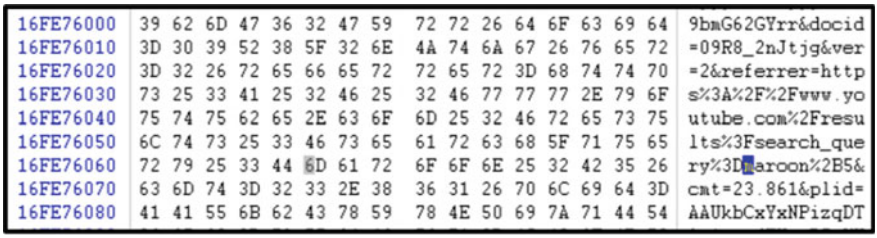

Fig. 2 URL address and the search keyword

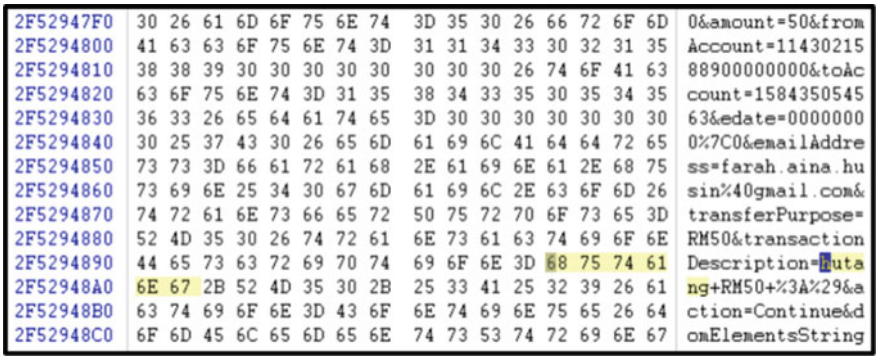

Fig. 3 Money transfer information

2.5 *Evidence Found in Hard Disk*

There are some hidden folders that stores web browsers information that are virtually unnoticed by the user. These hidden folders are usually stored at `C:\Users\User\AppData`. Therefore, the evidence searches are conducted extensively in the `C:\` partition including the web browsers hidden folders.

2.6 *Bookmarks Evidence*

Web browsers claim that the bookmarks are not deleted even in the private browsing mode. These bookmarks are not confidential information, but there are valuable to others. Although the user bookmarks the website using the private browsing mode, it remains and can be viewed in a normal mode as shows in Fig. 4.

2.7 *Downloads Evidence*

The downloaded files, such as image, document, video, audio, and application by default are saved at `C:\Users\User\Downloads`. Figure 5 shows the evidence that a user downloaded the image from the website while browsing the Internet. This image remains in downloads folder until the user manually deletes.

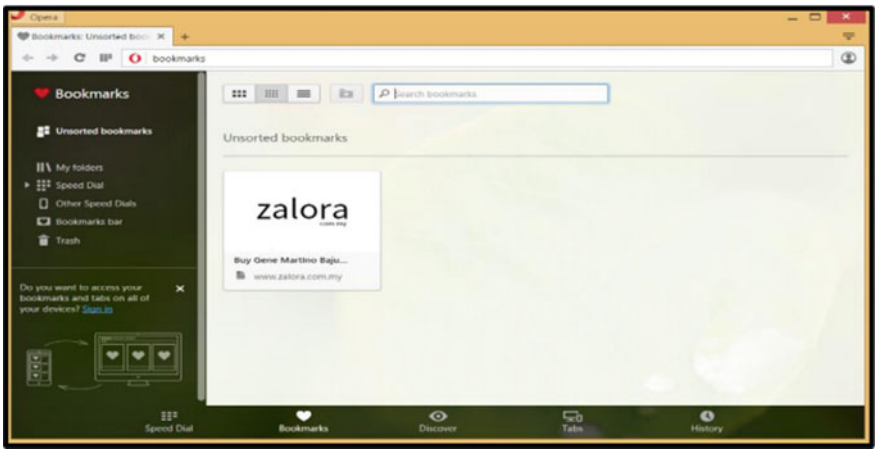

Fig. 4 Bookmark from Opera private browser

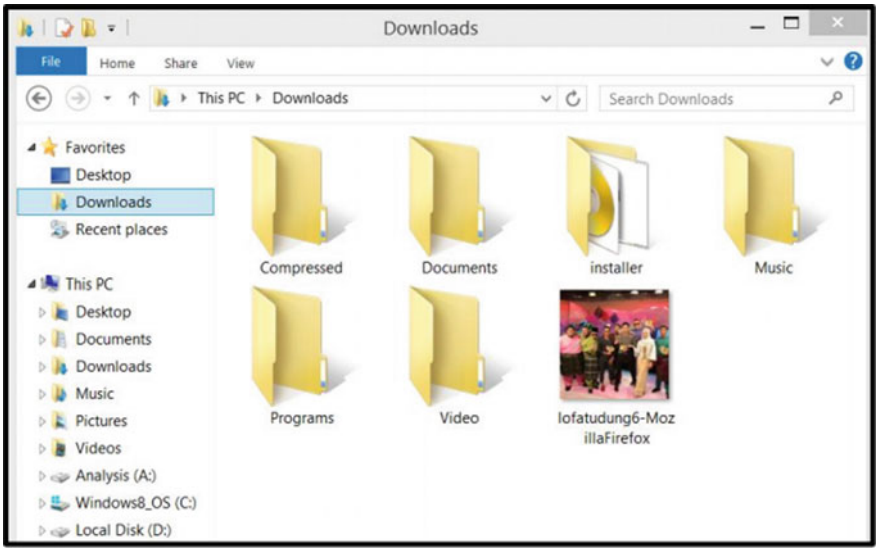

Fig. 5 Downloads evidence from Mozilla Firefox private browser

2.8 *URL and Browsing History Evidence*

A file, `webpageIcons.db` can be found at `C:\Users\User\AppData\Local\Apple Computer\Safari`. This file is a safari database file that saves the browser database and URL that user has entered. Figure 6 shows the `webpageIcons.db` file that has been opened using sqlitebrowser.

Database Structure | Browse Data | Edit Pragmas | Execute SQL

Table: PageURL

	url	iconID
	Filter	Filter
1	http://www.apple.com/	1
2	http://www.apple.com/safari/welcome/	1
3	http://www.apple.com/startpage/	1
4	http://www.youtube.com/	2
5	http://penmerah.com/hiburan/gambar-neelofa-yang-semakin-menawan-bertudung/	3
6	https://www.facebook.com/	4
7	https://www.facebook.com/login.php?login_attempt=1&lwv=110	4
8	http://zalora.my/	5
9	http://r.criteo.com/r/d5b2a7c8d473859f8ef34d64e82b690dfb4542c4?t=aHR0cDovL3d3dy56YWxvcmEuY29tL...	6
10	http://www.zalora.com.my/cart/	5
11	http://zalora.com.my/Asymmetric-Mini-Dress-330922.html	5
12	http://www.zalora.com.my/Asymmetric-Mini-Dress-330922.html	5
13	http://www.zalora.com.my/women/	5
14	http://www.zalora.com.my/women/pakaian-tradisional/baju-kurungs/	5
15	http://www.zalora.com.my/Baju-Kurung-Modern-425525.html	5
16	http://www.zalora.com.my/Trendy-Casual-Tote-Bag-369438.html	5
17	http://www.zalora.com.my/checkout/index/	6

Fig. 6 URL Evidence found from `WebpageIcons.db` file

CacheView uses to trace the entire URL and browsing histories from the private browsing session including the temporary files. Figure 7 shows the user has browsed the Google email account by using http://mail.google.com. These evidences also indicate that an unauthorized user could obtain the URLs that even the user have stopped browsing using the private browser.

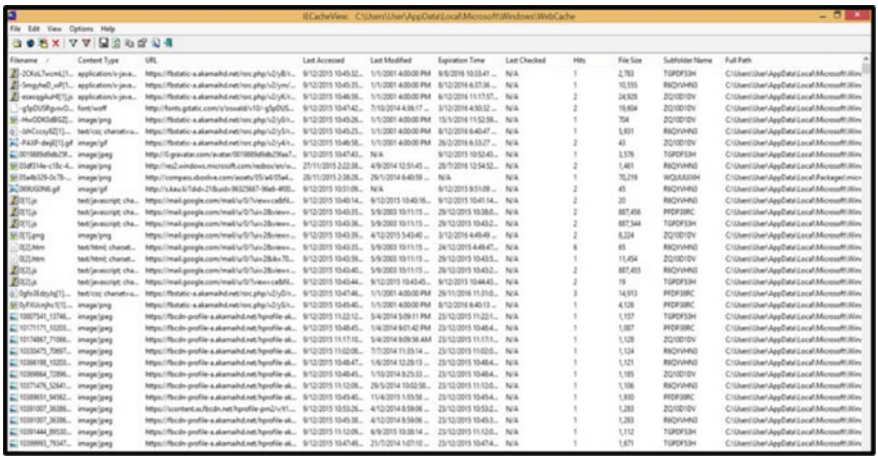

Fig. 7 URL and History Evidence found using CacheView

2.9 Image Evidence

Figure 8 shows the image properties found using CacheView. The details of the image are filename, content type, date and time of last accessed, last modified file, and file size. Furthermore, the CacheView enables to find the image's URL and from specific website. There are also a full paths of the image stored in the hard disk at `C:\Users\User\AppData\Local\Microsoft\Windows\INetCache\Low\IE\PFDP38RC\`. This is a proof that the private browsing images are stored in the hard disk and are able to be retrieved.

A. Analysis of private browsing in different private browsers

Table 3 shows the result of the analysis in using different private browsers. This is to differentiate the result of the private browsing data activities among these browsers. Five different parameters are browsing history, bookmarks, downloads,

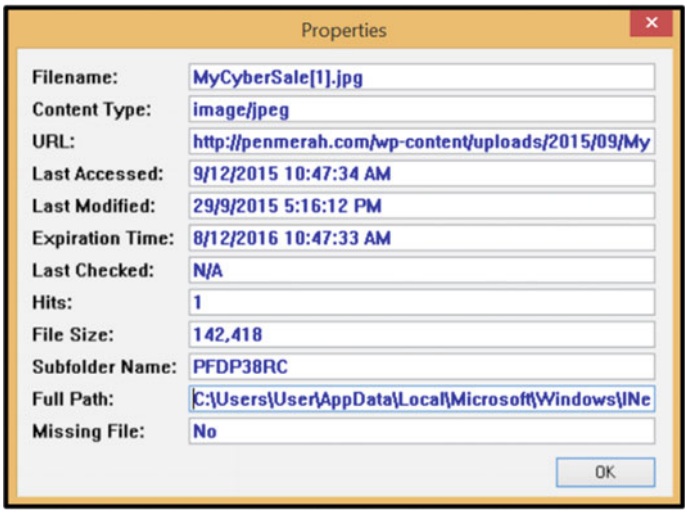

Fig. 8 Image properties found using CacheView

Table 3 Analysis of different private browsers

Browser parameters	Google chrome	Internet explorer	Mozilla firefox	Opera	Safari
Browsing history	√	√	√	√	√
Bookmarks	√	√	√	√	√
Downloads	√	√	√	√	√
Cookies	x	√	X	√	√
Cache	x	√	X	√	√

cookies, and cache. Evidences based on five parameters are found in Internet Explorer, Opera, and Safari. This means Internet Explorer, Opera, and Safari private browsers are not secured as claimed to the users.

B. Analysis of private browsing in RAM and hard disk

As shows in Table 4, browsing history, URL, email address, keyword search, and bank information can be found in RAM for all browsers except any evidence related to username, password, download, website content, and bookmarks. It is because RAM captures and temporarily stored all activities. These data are the result from the imaging process after the users finished surfing the Internet using private browsers.

Table 5 shows the result of the analysis of private browsing from the hard disk in C:\ partition on user's computer. Only the downloaded files and Bookmarks parameters can be found from these five private browsers.

The analysis of the private browsing activities were done by investigating the evidences on RAM and hard disk, that indicates a forensic value to support the user activities simulated in the experiments. It shows that there are footprints made

Table 4 Analysis on RAM

Browser parameters	Google chrome	Internet explorer	Mozilla firefox	Opera	Safari
Username/password	x	X	x	x	X
Browsing history/URL	√	√	√	√	√
Email address	√	√	√	√	√
Pictures	x	X	x	x	x
Download files	x	X	x	x	x
Keyword search	√	√ √	√	√	√
Website content	x	X	x	x	x
Bookmarks	x	X	x	x	X
Bank information	√	√	√	√	√

Table 5 Analysis on hard disk

Browser parameters	Google chrome	Internet explorer	Mozilla firefox	Opera	Safari
Username/password	x	X	x	x	X
Browsing history/URL	x	√	x	√	√
Email address	x	X	x	x	X
Pictures	x	√	x	√	X
Download files	√	√	√	√	√
Keyword search	x	X	x	x	x
Website content	x	√	x	√	√
Bookmarks	√	√	√	√	√
Bank information	x	X	x	x	x

within the private browsing. The different result of findings in this analysis is due to different development structure of each private browser. In this analysis, it can be concluded that Google Chrome, Mozilla Firefox, and Opera has the least-traced evidence relating to this study.

3 Conclusion

The analysis of private browsing data activities focus on searching the evidence from RAM and hard disk. All evidences of private browsing data are different due to the different development algorithm of each private browsing. The analysis also focuses on retrieving the evidence of private browsing in RAM and hard disk. Although private browsing data in RAM are the temporary data, data in the RAM are able to be retrieved and saved using RAM imaging. For the hard disk, different private browser saves the private browsing data in the different files. Most of the data are stored in C:\ partition in the hard disk. Moreover, some of the files may be hidden and it needs some skills and knowledge about the specific private browsers and the knowledge on method to retrieve the evidence.

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Chapter 21
Information Security Requirement: The Relationship Between Cybersecurity Risk Confidentiality, Integrity and Availability in Digital Social Media

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Abstract Digital Social Media as a part of the eco-system in today's global cyberspace business environment. It provides an excellent communication and marketing channel for knowledge societies in the world. The popularity of Digital Social Media has also influenced the personal lifestyle and encouraged the digital culture development among cyber community around the globe. Unfortunately, sharing their ideas, activities, statuses, and real-time location could cause them to several critical cybersecurity risks. These categories of risk caused severe impacts to the entire cyber community eco-system associated in digital social media that need to be managed and mitigated seriously. Recent empirical findings underlined the core information security requirement (confidentiality, integrity, and availability) contributes to the severity level of cybersecurity risks in digital social media.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_21

Therefore, the aim of this study is to determine the relationship between cybersecurity risks confidentiality, integrity, and availability in Digital Social Media. Questionnaires were distributed to the various active cyber communities and knowledge societies. The results of the mean score indicate that, more cybersecurity awareness program should be implemented in digital knowledge societies. Furthermore, the results of the correlation coefficient (r) values between >0.4 and <0.7 verifies that a moderate positive relationship exists between cybersecurity risks, confidentiality, integrity, and availability of information in Digital Social Media. Findings reveal that the highest moderate cybersecurity risk relationship between integrity and availability. This empirical evidence indicates how the core information security requirement influences each other's on the cybersecurity risk severity. Through the findings, cyber communities and knowledge societies would be able to determine the direction and strength of the relationship among information security requirement and plan the appropriate cybersecurity awareness program to Digital Social Media users as a preventive approach to mitigate critical cybersecurity risks.

Keywords Cybersecurity risk · Digital social media · Human factor
Information security requirement · Social engineering

1 Introduction

Digital Social Media provides an excellent communication platform through uncountable application such as online forums, chatting channels, video streamings, blogs, etc. Unfortunately, digital social media could enable threats and vulnerabilities that lead to cybersecurity risks to the cyber communities and organizations. Thus, it is crucial to manage the confidentiality and integrity of information in Digital Social Media. To this end, the relationship between confidentiality and integrity security requirements were measured and analyzed. The empirical findings point to the significant relationship between information confidentiality, integrity and availability in digital social media. This suggests that organizations should carefully determine and evaluate cybersecurity risks' confidentiality and integrity in their mitigation plan.

A generic definition for the term "social media" is given as "… the set of Web-based broadcast technologies that enable the democratization of content, giving people the ability to emerge from consumers of content to publishers (Jacka and Scott 2011). With the ability to achieve massive scalability in real time, these technologies empower people to connect with each other to create (or co-create) value through online conversation and collaboration" (Jacka and Scott 2011).

Cybersecurity is beyond securing a perimeter the individual digital or virtual assets (Carpinella 2015). It entails a comprehensive understanding of every element that might enable penetration, interaction and compromise, and that could lead to catastrophic events or risks. Cybersecurity is becoming increasingly important as

more information and technology are being uploaded into cyberspace. This has led to new terms such as cyberwarfare, cybercrime, and cyberterrorism.

Digital Social Media is gaining fast popularity among Internet users globally. Unfortunately, Digital Social Media could become the main information sources from most of the social engineers to harvest required data and information to plan cyberattacks. The larger possibility of cybersecurity risks happening could cause serious impacts to the organization and cyber community, such Phishing Ponds, Privacy Violation, Risk of Losing the legal battle, Corporate Espionage, Viruses and Malware, Productivity Loss (Social Networking Sites 2011). Cybersecurity risks are currently becoming serious issues in digital social media due to the increasing number of social media population globally. Cybersecurity risks are caused by common risk factors, which are threats and vulnerabilities of information in social media. Social media allows social engineer to use the psychological manipulation of people into performing actions of confidential information for the purpose of information gathering, fraud, or system access (Anderson 2008; Valerică and Oana 2014; Wikipedia 2016a, b). Digital Social Media becomes the source of information for social engineer to capture and harvest useful information for the purpose of the cyberattack.

Information Security Requirements adopted the core principles of information confidentiality, integrity and availability (Vorster and Labuschagne 2005; Parker 2002; Wikipedia 2016a, b) and broadly used in various fields of studies (Khidzir et al. 2010). Confidentiality refers to the limitations on the use and retention of different kinds of information (Vorster and Labuschagne 2005; Parker 2002; Code of Practice for Information Security Management 2005; Canal 2005). Integrity is the guarantee that information has not been manipulated (Vorster and Labuschagne 2005; Parker 2002; Code of Practice for Information Security Management 2005; Canal 2005) while availability is ensuring that authorized users have access to information and associated assets when required (Vorster and Labuschagne 2005; Parker 2002; Code of Practice for Information Security Management 2005; Canal 2005). Information in Digital Social Media might be improperly disclosed due to its confidentiality being exposed, modified in an inappropriate way, if its integrity is jeopardized, and destroyed or lost because its availability is threatened (Blakley et al. 2001).

Therefore, for the purpose of this study, the exploration focused on investigating the relationship of information security requirement between information confidentiality, integrity and availability in Digital Social Media. The results were measured and statistically analyzed to investigate the relationship between them.

2 Methodology

An empirical study was conducted to determine the relationship between confidentiality, integrity and availability of cybersecurity risk in Digital Social Media. Five-Point Likert-Scale was used to measure the severity level of online social media cybersecurity risks. Primary data were collected using questionnaires as the

data collection tool for the study. Analysis of primary data was supported by the application of appropriate statistical techniques such mean score analysis and Bivariate Pearson Correlation test.

3 Research Model

A research model illustrated in Fig. 1 was developed focusing on the confidentiality, integrity and availability core component which has contributed to cybersecurity risk in digital social media.

Based from a research model in Fig. 1, three hypotheses have been developed to test the relationship between each core element of information security requirements, confidentiality, integrity and availability levels. The hypotheses are

H1 There is a positive relationship between confidentiality and integrity for cybersecurity risk in Digital Social Media.
H2 There is a positive relationship between confidentiality and availability for cybersecurity risk in Digital Social Media.
H3 There is a positive relationship between integrity and availability for cybersecurity risk in Digital Social Media.

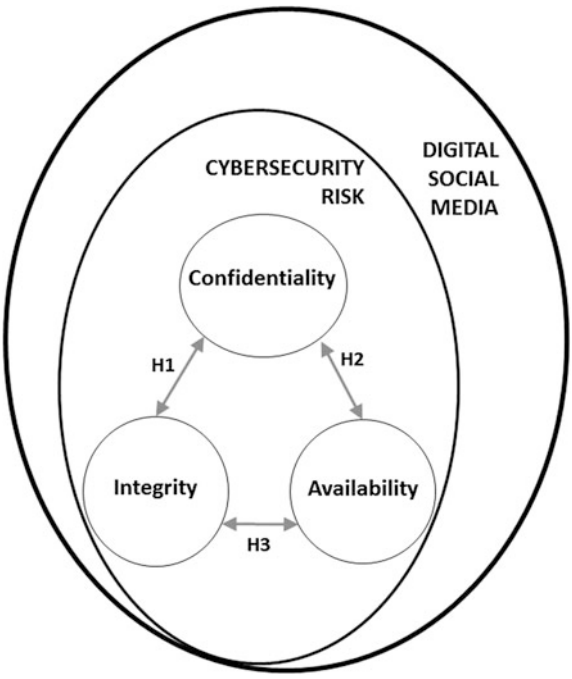

Fig. 1 Research model for relationship between cybersecurity risk on confidentiality, integrity and availability in digital social media

4 Results and Analysis

There are three sections discussing the results and analysis of demographic profiles and information security risk mean score for each core component information security requirement.

4.1 Demographic Profiles and Analysis

Respondents' demographic profiles examined were respondents' gender, age, professional experiences, organizational sectors and their industrial involvements. Most of them are the professional and senior executives from various organizations and institutions in Malaysia. Therefore, the analysis shows that most of the respondents were considered as appropriate professionals that possess sufficient experience to respond to the entire question trustfully and accurately. Table 1 summarized the demographic profiles of respondents involved in the study.

In terms of respondents' years of ICT Security Experiences, majority of 42.4% had experience between 1–3 years. Only 15.2% respondents had ICT Security Experience between 4–6 years. About 21.2% of those had less than 1 year as well as more than 6 years' experience.

4.2 Information Security Requirement Mean Score Analysis (Confidentiality, Integrity, Availability)

Information security requirement (Confidentiality, Integrity and Availability) mean score for cybersecurity risk in Digital Social Media were measured to determine each severity level.

As summarized in Table 2, the highest mean score on availability (3.6510) of information in Digital Social Media indicates most of the cyber community alert on the availability aspect towards the cybersecurity risk severity level. The highest mean score of availability signifies the respondents really care about the availability aspects. The second highest mean score on confidentiality (3.6094) of information indicates the level of cyber community awareness on the confidentiality issues in Digital Social Media. Therefore, the confidentiality issues awareness among cyber community could also significant to severity level of cybersecurity risk. The results prove that integrity (3.6042) of information stored, processed, and transferred through Digital Social Media platform is also given an attention among cyber communities. They also realize that the integrity of information should give priority in managing the cybersecurity risk impact.

Table 1 Demographic analysis

Respondent's gender	Percentage (%)
Male	54.5
Female	42.4
Respondent's age	Percentage (%)
>50 years	9.1
46–50 years	6.1
41–45 years	18.2
36–40 years	18.2
31–35 years	24.2
26–30 years	21.2
Years of working experience	Percentage (%)
>20 years	18.2
15–20 years	33.3
11–14 years	6.1
6–10 years	15.2
<= 5 years	27.2
Years of ICT security experience	Percentage (%)
>6 years	21.2
4–6 years	15.2
1–3 years	42.4
<1 year	21.2
Organizational sectors	Percentage (%)
Private company	6.1
Government agencies	84.9
Government-link-company (GLC)	9.1
Industrial cluster	Percentage (%)
Healthcare private	6.0
Healthcare government	3.0
Creative technology	6.0
Higher education	69.7
Information communication technology	6.0
Services	9.1

4.3 Analysis of Relationship between Confidentiality, Integrity and Availability in Digital Social Media

The Bivariate Pearson Correlation test was then conducted on the formulated research hypotheses to determine the significant relationship, strength, and direction between three core component of information security requirement (confidentiality, integrity and availability). The correlation coefficient values, (r) were derived to explain the relationship strength between them. A result of p-value <0.01 is

Table 2 Mean score cybersecurity risk confidentiality, integrity and availability

Information security requirement	Digital social media cybersecurity risk severity		
	Mean	Std. Dev.	N
Confidentiality	3.6094	0.78713	32
Integrity	3.6042	0.63700	32
Availability	3.6510	0.79239	32

considered significant. A weak relationship is indicated by a (r) value of less than 0.4, values between 0.4 and 0.7 indicate moderate relationship and a strong relationship has a value higher than 0.7.

5 Discussion

The analysis of mean score results discovers the empirical evidence on how the cyber communities concerned on the core element of information security requirement in Digital Social Media that could cause the cybersecurity risks. Generally, the mean score results demonstrate the moderate level of cyber communities concerned on the confidentiality, integrity and availability of information when using Digital Social Media. Therefore, cybersecurity awareness program should be in place to educate cyber communities how to use, communicate and interact through Digital Social Media in order to minimize the frequency of cybersecurity incident and mitigate the associated risks more effectively.

A specific target group and generation gap for cybersecurity awareness program also being identified based on the demographic analysis results for more effective outcome of the program. Specific awareness content focuses on information security requirement and cybersecurity risks issues also being identified through the findings.

As revealed in Table 3, the results of the hypothesis tests indicate positive correlations for the three hypotheses. H1, H2, and H3 were accepted and the null was rejected based on significant *p-value* < 0.001. The correlation coefficient (r) values were 0.627 for H1, 0.591 for H2, and 0.631 for H3. All the significant

Table 3 Hypotheses test results for the significant relationship between cybersecurity risk confidentiality, integrity and availability

Hyp.	Correlation coefficient (r)	Sig. (p-value)	Decision	Results
H1	0.627	0.000*	Significant	Moderate +ve
H2	0.591	0.000*	Significant	Moderate +ve
H3	0.631	0.000*	Significant	Moderate +ve

hypotheses described moderate relationship strength among information security requirement (Confidentiality, Integrity and Availability) in Digital Social Media.

The strongest moderate positive relationship level integrity and availability of information will cause the cybersecurity risk in Digital Social Media. Thus, the level of moderate influences between integrity and availability of information in Digital Social Media. Information integrity does not influence much to the information availability that could cause the cybersecurity risk in Digital Social Media. Meanwhile, the weakest moderate relationship was between information confidentiality and availability for cybersecurity risk in Digital Social Media. Last but not least, the others moderate positive relationship between confidentiality and integrity for cybersecurity risk in Digital Social Media.

The moderate level of relationships among three core elements of information security requirement stored, transferred, and shared in Digital Social Media still contributes to the cybersecurity risks incident that could cause a catastrophic impact to human and the entire structure of cyberspace.

6 Conclusion

This study has empirically established the significant relationship between confidentiality, integrity and availability of information in Digital Social Media private and public agencies in Malaysia. However, the moderate level of relationship influences between each of information security requirement contributed to the cybersecurity risks incident in Digital Social Media. Other findings explore the level of cybersecurity risk awareness among cyber communities. The empirical evidences show the need the comprehensive cybersecurity risk awareness program for digital societies. By identifying the relationship between these cores component of information security requirement will assist the technologist, cybersecurity expert, and practitioners to mitigate the possible impact of the risk. Additionally, cyber community will gain the full benefit from Digital Social Media platform.

Acknowledgements This work was supported in part by Malaysian Ministry of Higher Education under RAGS Grant. Special thanks also to Faculty of Creative Technology and Heritage; Universiti Malaysia Kelantan; and Global Entrepreneurships Research and Innovation Centre (GERIC) for facilities support for this research.

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Part III
Engineering

Chapter 22
Calibration Assessment of the Distributed Hydrologic Model Using SWAT-CUP

Khairi Khalid, Mohd Fozi Ali, Nor Faiza Abd Rahman, Zulhafizal Othman and Mohd Fairuz Bachok

Abstract The idea of distributed hydrologic modeling is embedded in the interrelationships of geospatial and hydro-meteorological data and represented by mathematical abstractions. The behavior of each process is controlled by its attributes as well as by its interaction with other processes active in the catchment. Model calibration is the process of estimating model parameters by comparing model predictions to a given set of assumed conditions with observed data under the same circumstances. The Soil Water Assessment Tool-Calibration Uncertainties Program (SWAT-CUP) is a computer model for calibrations of SWAT model is utilized in the study for the simulation of the daily streamflow. For Langat River Basin, the coefficient of determination (R^2), Nash–Sutcliffe efficiency (NSE) and PBIAS for the calibration period were found as 0.75, 0.70, and 0.15, respectively, which confirms the satisfactory performance of the model.

Keywords Daily streamflow · Langat River Basin · SWAT model

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_22

1 Introduction

Hydrology is a subject of great importance to human and the environment, which deals with all phases of the earth's water. The discipline has many practical uses such as in the design and operation of the hydraulic structures, water supply, wastewater, irrigation, flood control, erosion and sediment control, pollution abatement, recreational, and many mores application (Shaw et al. 2010). In Malaysia, Liew and Selamat (2011) highlighted the Info Works Collection System (CS) and Stormwater Management Model (SWMM) are among the most broadly utilized programming to model drainage systems. Nevertheless, many more hydrological models were found in the literature have been utilized for the watershed modeling study in the nation. These included a Hydrologic Engineering Centre-The Hydrologic Modeling System (HEC-HMS) software (Alaghmand et al. 2012; Mustafa et al. 2011; Julien et al. 2010); followed was the MIKE SHE models (Rahim et al. 2012) and finally the most current model is the Soil Water Assessment Tools (SWAT) software (Khalid et al. 2016a; Ali et al. 2014a; Lai and Arniza 2011). SWAT model is a continuous-time, spatially distributed simulator developed to assist water resource managers in predicting impacts of land management practices on water, sediment, and agricultural chemical yields (ASCE 1999). The model has been successfully used by researchers around the world for watershed modeling and management of water resources in watersheds with various climate and terrain characteristics. A comprehensive review of SWAT model applications, calibration, and validation are given by many researchers (Arnold et al. 2012; Gassman et al. 2007; Moriasi et al. 2007).

SWAT-CUP is a SWAT Calibration Uncertainties Program, which was developed by Swiss Federal Institute (EAWAG), and is used to analyze the prediction uncertainty of SWAT model calibration and validation results. SWAT-CUP is an interface that was developed for SWAT. It is a public domain program that links Sequential Uncertainty Fitting ver.2 (SUFI-2), Particle Swarm Optimization (PSO), Generalized Likelihood Uncertainty Estimation (GLUE), Parameter Solution (ParaSol), and Markov Chain Monte Carlo (MCMC) procedures to SWAT. Using the generic interface, SWAT-CUP enables sensitivity analysis, calibration, validation, and uncertainty analysis of SWAT models. The main objectives of SWAT-CUP are to integrate various calibration and uncertainty analysis procedures for SWAT in one user interface and providing a faster way to do the time-consuming calibration operations and standardize calibration steps. The study attempted to highlight the calibration processes of the SWAT model using the SUFI-2 Algorithm procedure in the tropical river basin. The second section gives some basic explanation of the SUFI-2 Algorithm. It followed by the explanation of the study area. The following section discussed on the SWAT-CUP model calibration setup. The fifth section discusses on the calibration output with focusing on the annually and monthly calibration time steps. Finally, the paper concludes by identifying key issues and gives some directions for future research.

1.1 Sequential Uncertainty Fitting Ver.2 (SUFI-2) Algorithm

The Sequential Uncertainty Fitting ver.2, SUFI-2 Algorithm was developed by Abbaspour et al. (2007), operated with the parameter uncertainty accounts for all sources of uncertainties such as uncertainty in driving variables, conceptual model, parameters, and measured data. In SUFI-2, the degree to which all uncertainties are accounted is quantified by a measure referred to as the P-factor, which is the percentage of measured data bracketed by the 95% prediction uncertainty (95PPU). Another measure quantifying the strength of a calibration/uncertainty analysis is the R-factor, which is the average thickness of the 95PPU band divided by the standard deviation of the measured data. SUFI-2 hence seeks to bracket most of the measured data with the smallest possible uncertainty band. The 95PPU is calculated at the 2.5 and 97.5% levels of the cumulative distribution of an output variable obtained through Latin hypercube sampling, disallowing 5% of the very bad simulations. Theoretically, the value of the P-factor ranges between 0 and 100%, while that of R-factor ranges between 0 and infinity. A P-factor of 1 and R-factor of zero is a simulation that exactly corresponds to the measured data.

The further goodness of fit can be quantified by the Coefficient of the determination (R^2) or Nash–Sutcliff (NSE) coefficient and the Percent bias (PBIAS) between the observations and the final "best" simulation. In this study, SWAT model calibration performance is measured by assessing the value of R^2, NSE, and PBIAS.

1.2 Study Area

Langat River Basin occupies the south and southeastern parts of Selangor and a small portion of Negeri Sembilan and Wilayah Persekutuan. The study area has compensated the virtue of "spill-over" development from Klang Valley. It is undergoing rapid development that is influenced by some fast growing new centers, such as the Kuala Lumpur International Airport (KLIA), Cyberjaya, Putrajaya, and other manufacturing zones. The study area is included in a Greater Kuala Lumpur projects which cover Kajang town areas as a southern boundary of the project.

The mainstream, Langat River stretches for 180 km and has a total catchment area of 2271 km^2. The major tributaries are the Semenyih River and Labu River. The average rainfall is about 2400 mm, and the highest months (April and November) show rainfall amount above 250 mm, while the lowest is in June, about the average of 100 mm. The study only focused on the upper part of Langat River Basin with a catchment area of 331 km^2. The main streamflow station of the study area is located in Kajang town, in the District of Hulu Langat as shown in Fig. 1. There are a numbers of the previous hydrologic research in the river basin including Khalid et al. (2015), Ali et al. (2014b), and Ayub et al. (2009), which reflect the importance and a need of widespread sustainable water resources management in the Langat River Basin.

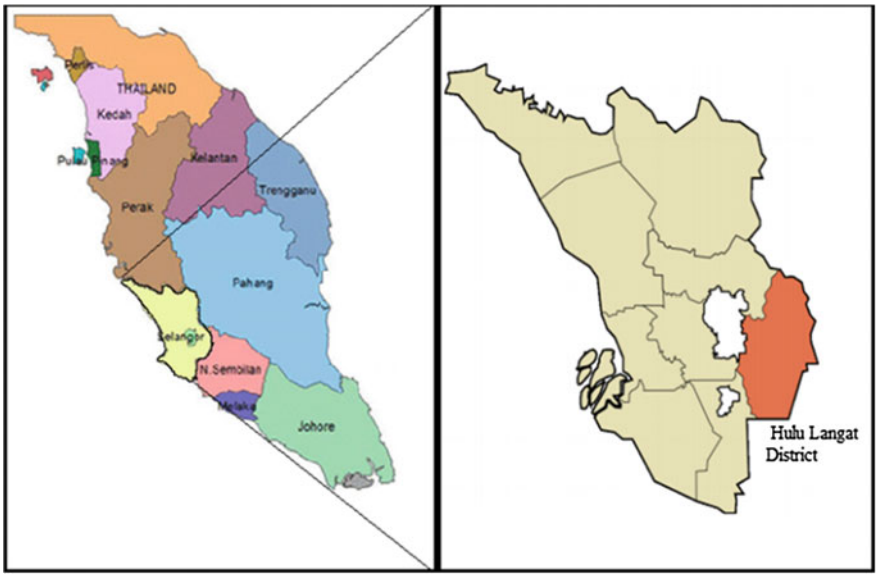

Fig. 1 Langat River Basin in the Hulu Langat district of the Selangor map

2 Methods of the Study

The major geospatial input data for the SWAT model includes Digital Elevation Model (DEM), soil data, land use, and stream network layers. The daily weather variables used in this study are daily precipitation, minimum, and maximum air temperature for the period 1976–1992. Daily river discharge values for Kajang streamflow station were obtained from the Department of Irrigation and Drainage (DID), Malaysia. The sub-basin discretization only focused on the 331.36 km^2 upper part of the Langat River Basin. The watershed was divided into 17 sub-basins and 142 numbers of Hydrologic Response Unit (HRU). After setting up the model, the default simulation of streamflow was conducted in the Langat River Basin for the calibration period and, after that, compared with the observed streamflow. About 17 years (1976–1992) of daily rainfall data was utilized in the calibration periods with the first 4 years used for the model initial setup. The sensitivity analysis of the study also was based on this calibration period.

A complex watershed model includes many parameters that represent hydrologic processes in the watersheds. There are a few methods available in assessing input parameters in hydrological models. In SWAT model, input parameters can be either manually adjusted in the SWAT model or can be accessed in the SWAT-CUP. SWAT-CUP includes automated as well as semi-automatic procedures for model calibration. The calibration procedures only embarked once the sensitivity analysis

was completed. The selected SWAT sensitive input parameters for the study are based on the SWAT-CUP user manual, Abbaspour (2012) and the previous studies for the Langat River Basin. Khalid et al. (2016b) were analyzing the 21 SWAT input parameters using the SWAT-CUP in the tropical river basin. For Langat River Basin, five SWAT input parameters show the most sensitive for both of the local and global sensitivity procedures, including of SCS runoff curve number (CN2.mgt), groundwater delay (GW_Delay.gw), average slope steepness (SLOPE.hru), available water capacity of the soil layer (SOL_AWC.sol), and the saturated hydraulic conductivity (SOL_K.sol). The following steps as in Fig. 2 are applied in a calibration exercise of the study. The objective functions of the calibration assessments are quantified by the Coefficient of the determination (R^2), Nash–Sutcliffe (NSE) coefficient and the Percent bias (PBIAS) between the observations and the final "best" simulation.

SWAT-CUP parallel processing currently allows the SUFI-2 algorithm to perform faster using Parallel Computing Technology. The SWAT-CUP parallel processing technology was fastened the simulation processes by allowing eight parallels simulation processing at one time. In the study, it observed that only 60 minutes time was taken for 2000 simulations instead of 8 h in a normal single processing procedure.

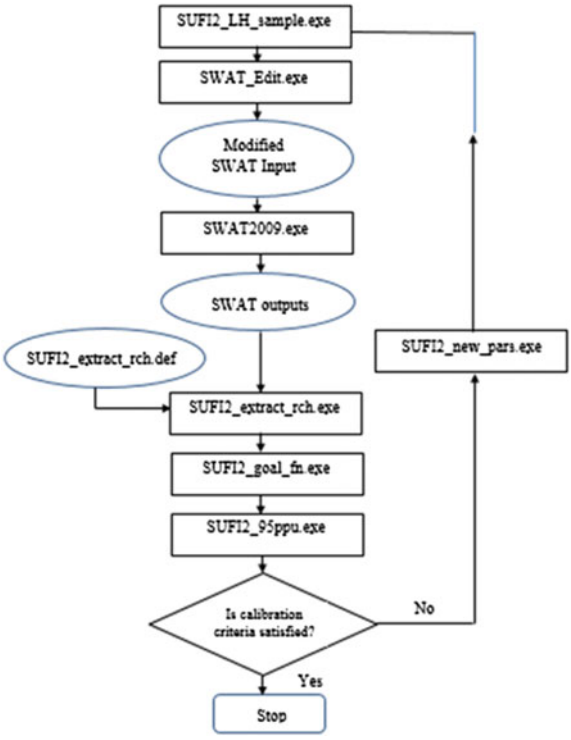

Fig. 2 SWAT-CUP Exercises using the SUFI-2 algorithm (Abbaspour 2012)

3 Results and Discussion

SWAT was calibrated using observed streamflow data recorded at Kajang gaging station within the Langat River Basin. Model calibration was conducted using SUFI-2 Algorithm in obtaining the best possible match between the observed and simulated streamflow. The following sections discussed the annually and monthly time step calibration.

3.1 Annual Time-Step Calibration

Annual calibration of the SWAT model was performed by minimizing the relative error between observed and simulated annual mean streamflow. Figure 3 shows the plots of observed versus simulated annual mean flows at the Kajang gaging station, and corresponding weighted average annual precipitation for the drainage area. It depicts that the simulated annual average flows match well with the corresponding observed flows, and the relative errors as in Table 1 are within the reasonable limit. For Langat River Basin, the average simulated annual mean streamflow was calculated to be at 6.249 m^3/s, which is comparatively lower compared to observed streamflow.

It was detected that the results of 8 years or 61.5% of simulated annual mean streamflow are measured lower compared to the measured streamflow. The highest relative errors were recorded at 11.1% for the mean annual streamflow in 1986. Annual precipitation of 2015.2 mm during 1986 reveals that it was an average year, in which simulated flow was found as 5.525 m^3/s that corresponds with the simulated average streamflow for the entire calibration period.

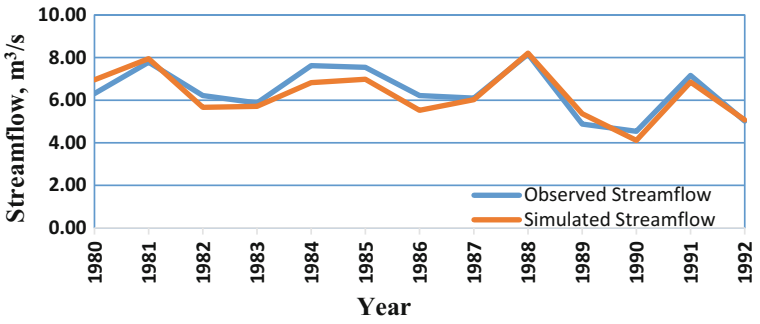

Fig. 3 Annual observed and simulated streamflow for the calibration period

Table 1 Annual calibration results for the period 1980–1992

Year	Streamflow (m^3/s)		Relative error (%)
	Observed	Simulated	
1980	6.310	6.954	10.2
1981	7.782	7.952	2.2
1982	6.218	5.664	−8.9
1983	5.872	5.711	−2.7
1984	7.624	6.824	−10.5
1985	7.543	6.980	−7.5
1986	6.218	5.525	−11.1
1987	6.097	6.024	−1.2
1988	8.165	8.206	0.5
1989	4.879	5.364	9.9
1990	4.537	4.108	−9.5
1991	7.160	6.850	−4.3
1992	5.015	5.074	1.2
Average	6.417	6.249	−2.6

3.2 Monthly Time-Step Calibration

Calibration of the model for monthly streamflow prediction was conducted using time series plots for qualitative evaluation, and three-model efficiency criteria were used for quantitative assessment of the model performance. Figure 4 shows the plots of observed versus simulated monthly flow along with corresponding monthly total precipitation during the calibration period. It was noticed that a good agreement between observed and simulated flow except for few months.

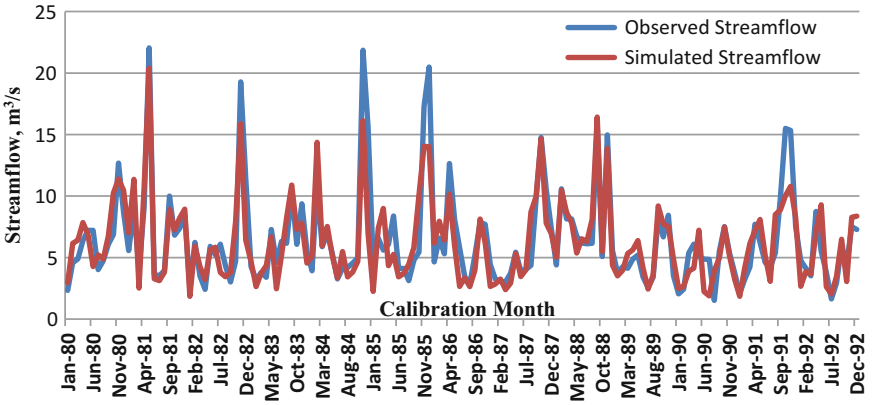

Fig. 4 Monthly observed and simulated streamflow for the calibration period

Table 2 Selected monthly observed and simulated streamflow during the calibration periods

No.	Month	Streamflow (m^3/s)		Percentage
		Observed	Simulated	Different (%)
1	Nov-80	12.69	11.39	10.24
2	May-81	22.05	20.39	7.53
3	Nov-82	19.28	15.88	17.63
4	Nov-83	9.373	7.79	16.89
5	Jan-85	4.56	2.249	50.68
6	Dec-85	20.48	14.04	31.45
7	Apr-86	14.64	10.17	30.53
8	Nov-91	15.33	10.79	29.62

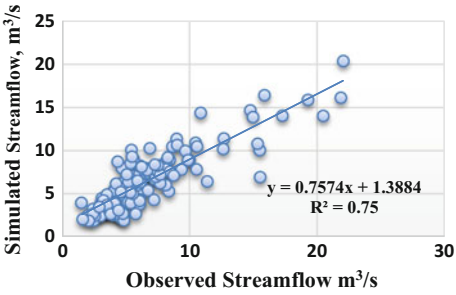

Fig. 5 Scatter plot of observed and simulated streamflow during model calibration

For Langat River Basin, it was noted the SWAT model was predicted lower flow for some months. About eight months of the peak simulated streamflow as in Table 2 were observed lower compared to the observed values. The monthly simulation different was measured and ranging from 7.53% to the highest of 50.68%, which was measured in January 1985.

Generally, the scatter plot of observed versus simulated flow as in Fig. 5 depicts that the model moderate predicted during low flow conditions (>10 m^3/s) and under predicted for the high flow condition (<10 m^3/s). However, the coefficient of determination (R^2), Nash-Sutcliffe efficiency (NSE), and PBIAS of the model were found as 0.75, 0.70, and 0.15 respectively that reveal a good performance of the model.

4 Conclusion

A watershed of the upper part of the Langat River Basin was successful been modeled by SWAT2009 model and capable of predicting the streamflow at Kajang streamflow station. The selected SWAT input parameters are recommended to utilize for the similar spatial pattern of other tropical watersheds. Since the model performance during calibration largely depends on the quality the observation data, the results might be further better if there were not many estimated values in the

observed streamflow records. The future works will investigate the integration of the ANN model streamflow outputs with the SWAT model in order to reduce the predicted streamflow different with the measured streamflow data.

Acknowledgements The project was supported by the Fundamental Research Grant Scheme (FRGS), Ministry of Education, Universiti Teknologi MARA (UiTM), Malaysia, and SWAT Network of Malaysia.

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Chapter 23
Compressive Behaviour of Sustainable Hair Fibre-Reinforced Concrete

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Abstract Concrete provides versatility, durability and is a very cost-effective material in construction project. However, when compared to other binding materials, the tensile strength of this concrete is relatively low and the weight to strength ratio is high. This study focuses on the effect of human natural hair mixture with plain cement concrete with regards to its compressive strength in which the main purpose is to economize the mass concrete production for non-load bearing structure and indirectly helps to reduce the deterioration of environment. A set of experiment was conducted to 27 samples of concrete cube with varied percentage of human hair fibre as part of the mixture. It is found that there is a better compressive strength performance for concrete grade M25 which is 20.22% increment compared to concrete grade M15 and M20 at the same portion of HF. This study shows that grade of concrete and percentage of Hair Fibre added into concrete mixture influenced the compressive strength of concrete.

Keywords Hair fibre · Reinforced concrete · Cube test · Sustainable Construction

1 Introduction

Concrete is a material which is widely used in construction works regardless of the scale of the project. Commonly, the processing of concrete mixture in current practice is much more preferred compared to other conventional method as it

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_23

produces a higher compressive strength in which is able to resist high pressure or loading that is acting on it. In contrast to this characteristic of concrete, it also has a lower tensile strength when compared with other construction binding materials such as reinforcement steel bar and building mortar. Hence, alternative measures are required to provide options and overcome this deficiency.

Fibre-Reinforced Concrete (FRC) is a concrete containing dispersed randomly oriented fibres. In early 1960s, the earliest findings have brought attention from the academics and scientist to study more on FRC. Since then, thousands of scientific papers have been published on improving and improvising the subject (Zollo 1997).

The use of fibre as material to increase the strength of man-made structure dated back to the Egyptian and Babylonian eras. During that time, straws were used to reinforce sun-baked bricks and mud-hut wall, horse hair was used to reinforce plaster, and asbestos fibres have been used to reinforce Portland cement mortars (Nawy 1997). After the scientific breakthrough findings in early 1960s, steel-fibre-reinforced concrete began to be used in engineering practice, particularly in pavements construction. From 1970s to the present, the use of steel-fibres has been well established as a complementary reinforcement to increase cracking resistance, flexural and shear strength, and also the impact resistance of reinforced concrete elements both in situ cast and precast concrete. Among the other type of fibres that have been studied and applied since then includes asbestos, cotton, glass, nylon, polyester and many more.

Now, the concept of using fibres to enhance the characteristics of construction materials is quite common (Wafa 1990). The use of continuous reinforcement in concrete does increase its strength and ductility but it also requires careful placement and labour skill. When the concrete cracks, the randomly oriented fibres start functioning, arrest the crack formation and propagation, and thus improve its strength and ductility in achieving significant deformations without marked increase of stresses beyond the yield strength of the steel.

The common failure modes of FRC are either bond failure between fibre and matrix or material failure. Deep understanding on how the fibre reacts to bond with the concrete is crucial as it will help to decide the arrangement details of the concrete. Table 1 shows the reviews on recent studies that have been conducted on the utilization of human hair as reinforced fibre in concrete.

In this study, Hair Fibre (HF) has been introduced as an additional material in concrete mixture. Human hair is known to be strong and is able to act as a natural fibre to increase the tension strength in the concrete mixture. Due to its non-degradable nature, human hair may also create environmental problem for its lengthy decomposition characteristics. The utilization of this material as concrete mixture will benefit both to the environment and human health (Suhendro 2014). This HF can be considered as an alternate non-degradable matter and it is also available in abundance at an extremely lower cost.

Table 1 Reviews on previous studies

Author	Description
Jain and Kothari (2012)	The effects of hair fibre to the tensile strength in concrete have been investigated. This is to determine the improvement in the concrete properties of concrete based on the percentage of HF mixture. The compressive strength increase ranging from 10% to 22% compared to plain cement concrete.
Batebi et al. (2013)	This experimental investigation focus on the impact of using nano hair fibre to the shrinkage problem in the concrete mixtures. The result shows that considerable amount of HF is able to reduce the shrinkage in the hair reinforced concrete.
Nila et al. (2015)	The research intention is more on the usage of hair fibre in real application. Among the usage suggested includes crack resistant structures, seismic resistant structures, road and pavement construction and water proof construction.

1.1 Mechanical Properties of Concrete

The mechanical property of concrete that is focused in this research is the compressive properties as it is the most significant and it gives an overall idea about all the characteristics of concrete. Compressive strength depends on various factors including water–cement ratio, cement strength, and quality control during production of concrete. During compression, the stresses in concrete samples will concentrate either in aggregates, which have higher elastic modulus value or around holes and cracks (Panasyuk et al. 2014). To determine the compressive strength of the concrete, cube strength test was conducted. Cube samples will break under uniaxial compression by the concrete cracking in planes parallel to the compression axis and the results will be recorded.

1.2 Experimental Setup

The methodology used to investigate the compressive strength of the concrete reinforced with HF is the Compressive Strength Test. Materials that are used for this experiment are cement, aggregate, water and hair fibre. The hair needed for the preparation of concrete cubes was collected from salons. It needs treatment before being added into the concrete mixture. The treatment process includes various stages in which the hair needs to be separated from other wastes followed by washing it, drying and sorting.

A total of 27 samples of concrete cubes have been prepared and tested to examine the effect of HF in the concrete mixture, which is known as Sustainable Fibre-Reinforced Concrete (SFRC). The percentage of HF used is varied ranging

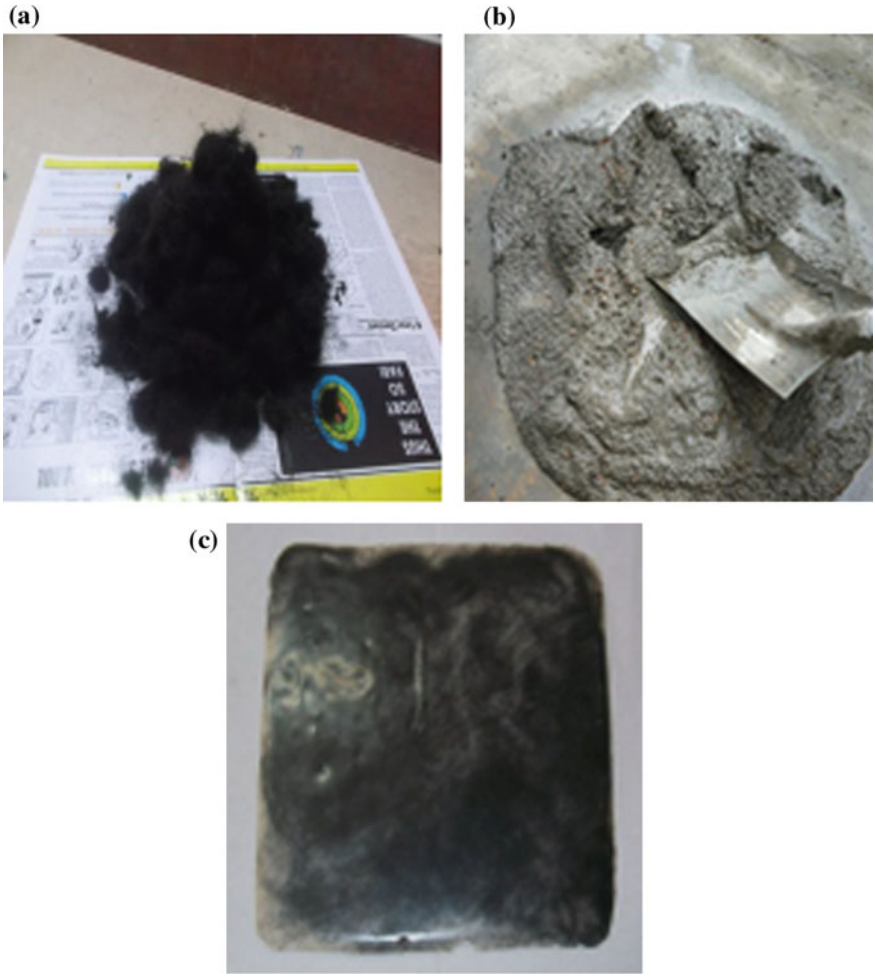

Fig. 1 Experimental setup. **a** Human hair fibre; **b** concrete mixture; and **c** HF concrete cube

from 0, 1.0, and 1.5% and they are added to the cement of grades M15, M20, and M25 with three samples are prepared for each concrete grade selected. In this laboratory work, concrete cubes with standard size of 150 mm × 150 mm × 150 mm were used in the experimental setup. Figure 1 shows the pictures taken during experimental setup.

The quantity of mixture for HF is calculated and added manually. Then, the results from the compression test will be obtained in the form of the maximum load that the cube is able to withstand before it ultimately fails. The compressive strength is then determined (Fig. 2).

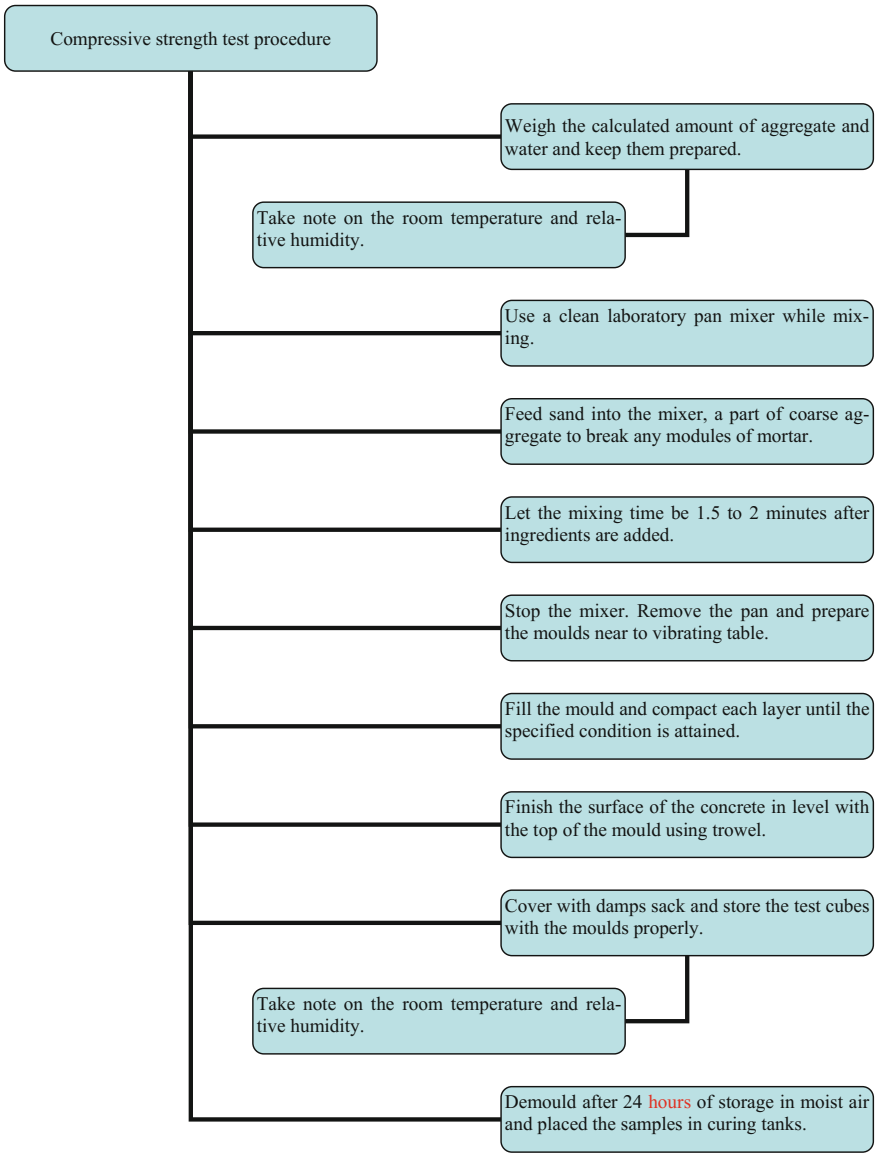

Fig. 2 Summary of experimental procedures

2 Results and Discussion

Table 2 shows the results of the tests performed on the concrete cubes to determine its compressive strength with various percentage of HF (0, 1, and 1.5%) by weight of cement.

Table 2 Compression test and the compressive strength obtained

Specimen	Mix	% Hair	Maximum load (kN)			Compressive strength (N/mm^2)		
			C1	C2	C3	C1	C2	C3
1	M-15	0	330.50	343.70	358.60	14.69	15.28	15.94
	M-20	0	450.00	461.30	472.70	20.00	20.50	21.01
	M-25	0	562.50	581.30	590.10	25.00	25.84	26.23
2	M-15	1	363.55	378.07	398.05	16.16	16.80	17.69
	M-20	1	508.50	524.50	534.20	22.60	23.30	23.74
	M-25	1	652.50	680.12	699.27	29.00	30.23	31.00
3	M-15	1.5	380.08	398.00	419.57	16.89	17.69	18.65
	M-20	1.5	540.00	560.48	562.51	24.00	24.91	25.00
	M-25	1.5	675.00	703.34	705.17	30.00	31.20	31.30

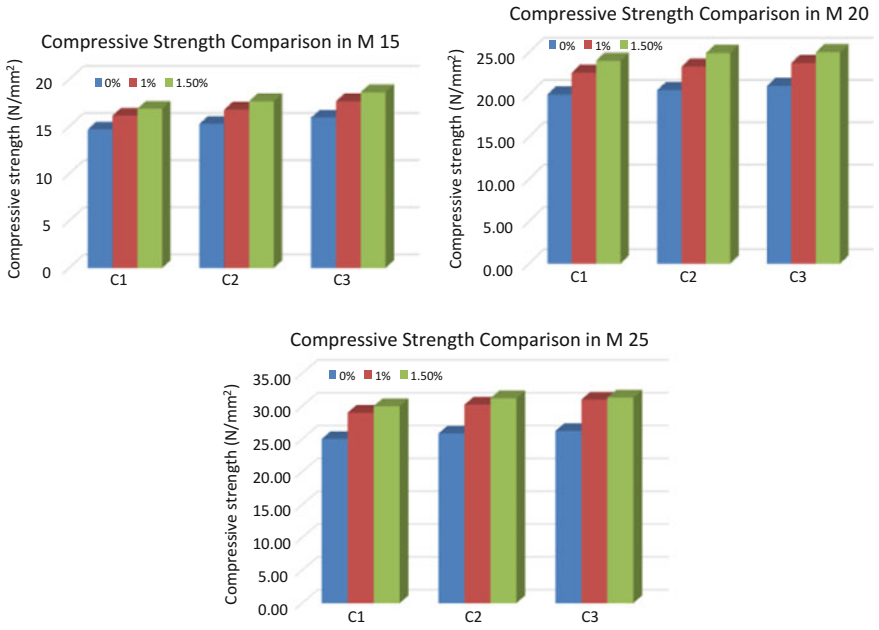

Fig. 3 Charts showing the comparison of compressive strength for each concrete grade and various percentage of hair fibre

After the compression tests are performed, it is observed that there is a remarkable increment in the compressive strength of the samples with the increment of percentage of hair fibre mixture. The plain concrete with zero percent (0%) hair becomes the control mixture. Based on the result obtained, it can be seen that there are better performance in terms of the compressive strength after adding the hair fibre with 10% increment after 1% of HF being mixed to the M15 grade of concrete.

Meanwhile for 1.5% of HF added to the same concrete grade, there is 16% increment of compressive strength when compared to the plain concrete or control mixture.

As for M20 concrete grade with 1% hair added, there is an increment of 13.2% to its compressive strength. For M20 concrete grade with 1.5% HF mixture, there is an increment of 20.2% of the compressive strength. Also, there is 17.08% increment for M25 concrete grade with 1% HF mixture by weight of cement compared to the control mixture. Finally, there is approximately 20% increment recorded after 1.5% HF added in M25 concrete grade. Based on the result obtained, it can be concluded that there is a better performance in terms of the compressive strength of concrete with more HF added into the concrete mixture (Fig. 3).

3 Conclusion

According to the test performed in this study, it is observed that overall, there is an increment in terms of the compressive strength of the HF concrete where higher percentages of hairs by weight of cement added into the concrete mixture will increase its compressive strength. However during the laboratory work, the main challenges will be to uniformly distribute the HF within concrete mixture due to its light in weight. Future study may as well focus on the way to distribute the HF effectively and efficiently and also the effect of animal hairs in concrete. With more research and findings from this area, the waste from human hair can also be fully utilized as HF especially for simple structures in construction projects.

Acknowledgements The authors wish to thanks the Ministry of Education, Malaysia for funding the research project through the i-RAGS, Research Acculturation Grant Scheme [Ref. No. 600-RMI/IRAGS 5/3 (40/2015)] and, the Research Management Unit (RMU), Universiti Teknologi MARA (UiTM) for the administrative support. Grateful acknowledgment also goes to all who are involved direct and indirectly in this project for their kindly supports.

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Chapter 24
Placement of SVC and Transformer Tap Setting for Minimum Loss Using Evolutionary Programming

Nur Ashida Salim, Aiman Safian, Zuhaila Mat Yassin and Norzulaily Mohamed

Abstract This research paper presents an application of Fast Voltage Stability Index (FVSI) power flow based technique and Evolutionary Programming (EP) technique to determine the placement and sizing of Static VAR Compensator (SVC) for installation at transmission system. SVC which is one of the Flexible AC Transmission System (FACTS) available in the market is used in this research for reducing the power losses in the system as well as monitoring the minimum voltage. The system will be stressed out by increasing the loadability of certain buses until it is near to its maximum loadability. The determination of the placement of Static VAR Compensator (SVC) was determined by using power flow based approach of Fast Voltage Stability Index (FVSI) to detect the weakest line which consequently will lead to the weakest bus. The Evolutionary Programming (EP) technique is used to look for the best sizing of Static VAR Compensator (SVC). The Evolutionary Programming (EP) technique and Fast Voltage Stability Index (FVSI) is tested with IEEE 14 bus test system to prove the effectiveness of the proposed technique. Further, the comparison between installation of SVC and transformer tap setting in order to identify which one is more effective in minimizing the power losses.

Keywords Evolutionary programming · Flexible AC transmission system
Fast voltage stability index · Maximum loadability · Static VAR compensator

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_24

1 Introduction

Power system security performs a vital role in power system. Poor network security will lead to a significant problem in power system. As an example, overload in certain area or any contingency disturbances will stress the power system. Thus, it will lead to unsecure power system. In this case, if it happens for a long period without any action taken to secure the system, the system will be prone to unstable condition (Ghanaati et al. 2011). Flexible Alternating Current Transmission System (FACTS) devices have been proposed to be installed to stabilize the system.

Recent technological advancement in power electronics have contributed to development of electronic equipment that can stand for a large amount of power. Due to this improvement, the use and application of power electronics in electrical power system has been significantly increased. These electronics devices are called Flexible AC Transmission System (FACTS). FACTS devices are based on the electronic power converters and they provide the ability to make an adjustment in a short period of time in order to control the power system. FACTS devices can be connected in series or parallel, or it can be connected in both connection. FACTS devices has many beneficial in power system which include improvement of the stability of the grid, control the active and reactive power flow in the system, loss minimization and increase on power system efficiency. In this research, Static VAR Compensator will be used as the FACTS device. According to the IEEE definition, a Static VAR Compensator (SVC) is a parallel connected static VAR generator or absorber whose output is adjusted to exchange the capacitive or inductive current to maintain or control specific parameters of the electrical power system which is usually the bus voltage (Hingorani and Gyugyi 2000).

The placement of FACTS devices has been figured out through different ways (Mínguez et al. 2007). An index of sensitivity studies has been proposed to find the best place to install two types of FACTS devices which are thyristor-controlled series capacitor (TCSC) and unified power flow controller (UPFC) in order to increase the power transfer capability (Orfanogianni and Bacher 2003). In Chang and Saha (2010), the most suitable placement of SVC to increase the system loadability was searched using the mixed integer linear programming (MILP) and the line flow based equation were used for the formulation. Besides looking for the placement, this technique can be used to find the best setting of SVC as well as decrease the value of compensation (Chang and Saha 2010). Apparently, in order to obtain better results, researchers tends to use Artificial Intelligence (AI) technique to perform their works in pursuing their objectives. Differential Evolution (DE), which is one of the AI technique was used to find the optimal placement of SVC for the purpose of voltage security enhancement in power system (Udgir et al. 2014). Besides, in the same paper, the researchers used voltage performance index (VPI) to locate the contingencies happen in the system which is due to the line outage in the system (Udgir et al. 2014). By considering the critical contingencies, authors in

Dixit et al. (2014) proposed a Genetic Algorithm (GA) technique to find the most suitable place to install SVC for decreasing the power losses and voltage deviation. In Balachennaiah et al. (2015), Artificial Bee Colony (ABC) technique was used to optimize the rating of SVC for the purposes of voltage stability amplification in power system and the three multi-objective functions are, loss minimization, voltage profile and stability enhancement. Next, Static Synchronous Compensator (STATCOM) and SVC was chosen as the FACTS devices for enhancement of the power system performance such as real power losses and voltage stability improvement. The technique that has been used is the Heuristic Optimization technique (Dubey et al. 2014).

In Panda and Padhy (2008), comparison between Particle Swamp Optimization (PSO) and Genetic Algorithm (GA) has been made for a FACTS-based controller design in which the objective is to enhance the power system stability. According to this paper, both PSO and GA algorithm can be used as an optimization technique but it can be seen that PSO is better than GA because the PSO get their results in fewer generation compared to GA (Panda and Padhy 2008). In Jumaat et al. (2012), PSO and EP techniques was used to find the best placement to install and sizing of FACTS devices including SVC to minimize the transmission losses in the power system. According to this paper, outcomes from PSO have decreased the transmission losses and increase the voltage profile of the power system. Nevertheless, EP still can be used as an optimization technique. The placement of the FACTS devices were usually was on the most unstable point in the system.

Therefore, in order to look for the most unstable place in the system, paper (Musirin and Rahman 2002b) and Musirin and Rahman (2002a) proposed a new voltage stability index which refers to a transmission line which is called Fast Voltage Stability Index (FVSI). This technique will rank the line stability index for each line. Thus, the most unstable transmission line can be detected for the installation of FACTS devices.

In this paper, EP technique will be used as an artificial intelligence computation technique in order to optimize the sizing of SVC and FVSI technique will be used for finding the best location to install the SVC. To ascertain validity of the proposed technique, an experiment was carried out with the IEEE 14 bus system.

1.1 Facts Device (Static VAR Compensator)

In this paper, SVC was used as the FACTS device which will be modeled as reactive power injection model. SVC can compensate the system both in inductive and capacitive. SVC will be injecting reactive power at certain bus as in the block diagram in Fig. 1. SVC consists of Thyristor-Controlled Reactor (TCR) and parallel with a capacitor bank (Jumaat et al. 2012).

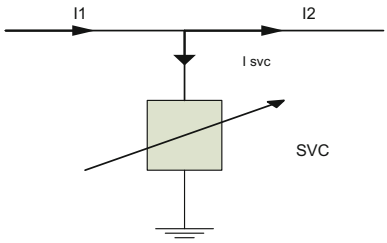

Fig. 1 Block diagram of SVC

2 Methodology

2.1 Fast Voltage Stability Index

One of the best ways to analyze the voltage stability in the system is by calculating the index of voltage stability referred to the transmission line. It can be a tool for a voltage stability indicator, the weakest line in the transmission system will has the highest FVSI value (Ramasamy et al. 2009). Equation (1) below represents the FVSI mathematical formulation.

$$\mathrm{FVSI}_{ij} = \frac{4Z^2 Q_j}{V_{\mathrm{i}}^2 X}, \tag{1}$$

where

Z line impedance
X line reactance
Q_j reactive power at the receiving end
V_i sending end voltage.

According to Musirin and Rahman (2002a) and Ramasamy et al. (2009), if the FVSI of the line is near to 1.00, it shows that the line is approaching to its unstable condition. Thus, one of the buses connected to the line will have a sudden voltage collapse and affect the stability of the system.

2.2 Evolutionary Programming

Evolutionary Programming is one of the main evolutionary algorithm techniques which was first used by Lawrence J. Fogel in early 1960s due to the use of simulated evolution as a learning process aiming to generate artificial intelligence (Aziz et al. 2013). Figure 2 shows Evolutionary Programming general flowcharts.

Generally, there are seven main steps in EP which are the generation of initial population, fitness for the parents, mutation which will be the generation of off-spring, fitness for the offspring, combination of parents and offspring, selection of

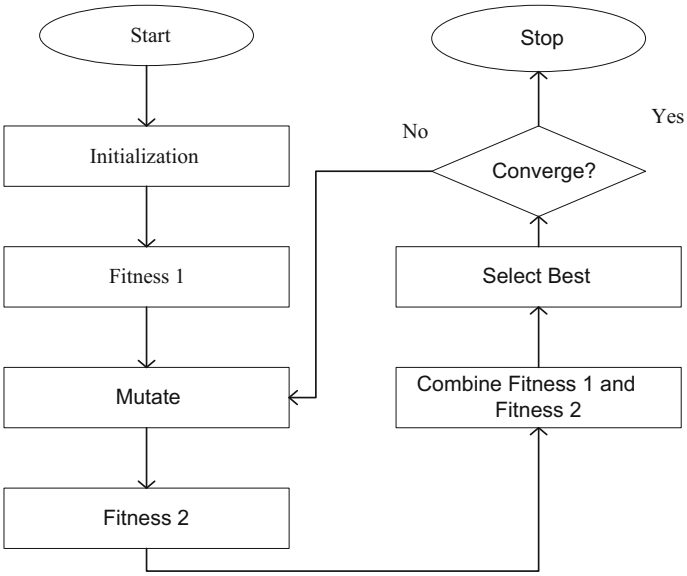

Fig. 2 Evolutionary programming flowcharts

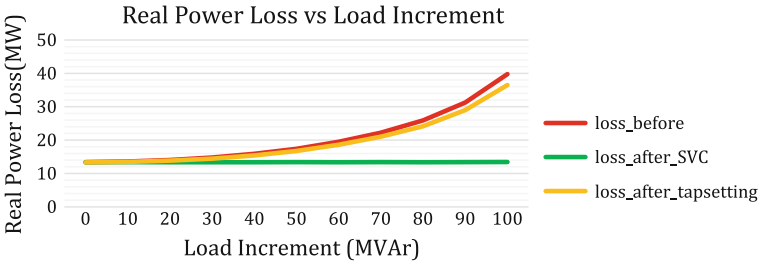

Fig. 3 Graph of real power loss versus load increment

the data from the combination of parents and offspring, and the last step which is the convergence test of the data. Evolutionary programming has been generally utilized with accomplishment in the scope of optimization. There are three different types of EP used which are, Classical Evolutionary Programming (CEP), Fast Evolutionary Programming (FEP), and Improved Fast Evolutionary Programming (IFEP). These three models of EP were different in term of search operator which are Gaussian, Cauchy, and mixed Gaussian–Cauchy through mutation process. Based on this paper, it can be decided that FEP is the best among them in terms of computation time and fitness solution.

For a start, groups of random number will be produced and it represents the variable to control the objective function (Aziz et al. 2013). The random number that will be generated is in the range of our own setting. Fitness is computed based

on its objective function. A short mathematical equation can be a fitness function. Parents data will be generated before fitness and then they will be evaluated. During mutation, a set of data which can be called offspring is produced which is also a random number. The offspring was produced using the Gaussian mutation technique or the classical evolutionary programming (CEP) (Aziz et al. 2013). The general formulation of Gaussian mutation is in Eq. (2).

$$x_{i+m.j} = x_{i.j} + N\left(0, B(x_{j\,\max} - x_{j\min})\left(\frac{f_i}{f_{\max}}\right)\right), \tag{2}$$

where

$x_{i+m.j}$	offspring
$X_{i.j}$	parents
B	search step
$X_{j\ \max}$	max parents
$X_{j\ \min}$	min parents
f_i	fitness "ith"
$f_{\max}$	max fitness.

After that, both of parents and offspring will be combined together. A selection of the best data will be collected from the combination of both parents and offspring. The convergence test is to determine the stopping criterion of the program whether to minimize or maximize the fitness.

2.3 *Placement of SVC*

The technique used in order to get the best placement for SVC is FVSI. Due to the stable condition in the base case, load increment has been done to stress the system. A certain bus will be stressed until it nearly reaches its maximum loadability. The steps taken are as followed:

- The load will be increased by setting the reactive power demand to a certain value in the unit of MVAr at the load bus. The increment of load will be at 1 bus at a time and it will be only at the load bus.
- Run load flow.
- The unit increase per step will be 10 MVAr. Until certain amount of load increment has been done, the load flow will started to have a problem to converge. This is a sign where that bus which was increased in load has reached its maximum reactive power load.
- The FVSI cannot be calculated if the load flow did not converge. Therefore, the value of reactive power which has been set should be decrease a bit to ensure that the FVSI can be calculated.

- After FVSI has been calculated, the most unstable line can be detected by searching for the FVSI of the line which is near to 1.00 or more than 1.00.
- The first bus to reach maximum reactive power load will be the weakest bus. Therefore, the weakest bus will be the suitable bus to install SVC.

2.4 Size of SVC

According to Wu et al. (2008), SVC has both characteristics of capacitive and inductive which made it to have an ability to absorbs and injects reactive power in the system. Therefore, the value of reactive power of SVC, Q_{SVC} will be limited between

$$-100\,\text{MVAr} < Q_{\text{SVC}} < 100\,\text{MVAr} \tag{3}$$

In order to have the optimal size of SVC, EP technique will be used as the optimization technique. The steps taken are as followed:

- Stress the system the same steps as searching for the placement for SVC.
- Run load flow.
- Generation of initial population. The limit of reactive power of SVC to be installed will be the constraint in generating random number due to its minimum and maximum value of reactive power.
- Calculate fitness.
- Mutation from the offspring.
- Combine the parents and offspring.
- Selection of data.
- Convergence test. This is where the total loss of the system before and after SVC has been install will be compared. The data will be converged if the loss of the system after the installation of SVC is lower than the loss of the system before the installation of SVC.

2.5 Tap Changer Setting

Usually, tap changer was in the range of 90–110% of its nominal voltage, V_N (El-Fergany and El-Arini 2012). Therefore the range of tap changer will be set in the source code is in the range below:

$$0.9 < \text{Tap Changer} < 1.1 \tag{4}$$

According to the IEEE 14-bus system, the transformer will be between bus 4–7, 4–9, and 5–6.

3 Results and Discussion

The objective of this paper is to find the best location to install SVC and to have the best configuration of range of the tap changer setting in order to decrease the transmission loss in the system using FVSI and EP. Besides, the minimum voltage in the system was also monitored other than the transmission loss. In addition, Newton–Raphson method was used for the load flow calculation.

FVSI was used as the technique to find the best location to install SVC and EP was used as the optimization technique for minimizing the transmission loss of the system, as well as to look for the size of capacitor to be installed and the best configuration for tap changer at the transformer. MATLAB R2014b was used to write the programming.

In order to prove the effectiveness of these techniques IEEE 14-bus test system is used. After the program of FVSI technique has been run, the results shows that the best place to install SVC is at bus 14. Table 1 shows that the ranking of the bus from the weakest to the strongest bus based on its maximum reactive power loadability. Bus 14 with its maximum reactive power loadability is 100 MVAr is assumed to be the weakest bus, while bus 4 with its maximum reactive power loadability is 390 MVAr assumed to be the strongest bus in the system. The line which has the highest FVSI during the maximum reactive power loadability of the bus was also included in Table 1, and it indicates that the line between bus 13 and 14 is the most unstable during maximum reactive power loadability of bus 14 which the index is 0.9619.

Table 1 Bus ranking of maximum reactive power loadability

Bus	Max Reactive Power Load (MVAr)	Line	FVSI
14	100	13–14	0.9619
12	160	12–13	5.5844
10	160	5–6	2.1091
11	170	6–11	1.1191
9	220	7–8	1.5811
13	250	13–14	1.4166
7	290	7–8	5.1302
5	270	5–6	0.9700
4	390	5–6	0.9486

The best size for the SVC to be installed in the system was determined after the optimization process in EP. Table 2 shows the suitable size of SVC to be installed due to the load variation at bus 14. Based on the results, the most suitable size of SVC to be installed at bus 14 will be 98.21 MVAr, for the system to minimize its losses until bus 14 reaches its maximum loadability.

Table 3 shows the optimum percentage of tap changing configuration due to the reactive power loading at bus 14. The configuration of transformer tap varies from 90 to 110%. The transformer tap setting has to be varied due to the reactive power loading of bus 14.

Table 4 shows the total real loss of the system before any installation of SVC and transformer setting, loss after installation of SVC and loss after setting the transformer tap.

Table 5 shows the minimum voltage in the system before any installation of SVC and transformer setting, as well as the minimum voltage after installation of SVC and minimum voltage after setting the transformer tap.

Figure 3 shows the graphically interpretation of relationship between total real power loss of the system and load increment at bus 14. Based on the graph in Fig. 3, it can be seen that installation of SVC has significantly decrease the total loss of the system compared to the total loss of the system before the installation of SVC. In addition, there is only small decrease of loss after configuration of transformer tap compared to the loss before configuration of transformer tap.

Figure 4 shows the graphically interpretation of relationship between voltage minimum of the system and load increment at bus 14. Based on the graph in Fig. 4, the difference between minimum voltage before and after the installation of SVC is larger than the difference between minimum voltage before and after the configuration of transformer tap. The minimum voltage after installing SVC is stable although the load was increased until the maximum loadability of bus 14.

Table 2 Size of SVC

Reactive power loading (MVAr)	Size of SVC (MVAr)
0	5.22
10	17.44
20	26.32
30	35.77
40	47.21
50	52.44
60	66.18
70	69.23
80	86.08
90	98.20
100	98.21

Table 3 Transformer tap changing configuration

Reactive power loading (MVAr)	Transformer 1	Transformer 2	Transformer 3
0	1.0379	0.9087	1.0527
10	1.0112	0.9296	1.0966
20	0.9853	0.9284	1.0895
30	0.9333	0.9973	1.0795
40	0.9333	0.9973	1.0795
50	0.9031	1.0377	1.0736
60	0.9053	1.0419	1.0875
70	0.9069	0.9107	1.0059
80	0.9069	0.9107	1.0059
90	0.9069	0.9106	1.0059
100	0.9069	0.9106	1.0059

Table 4 Total real loss of the system

Reactive power loading (MVAr)	Loss before (MW)	Loss after installing SVC (MW)	Loss after tap configuration (MW)
0	13.4049	13.3681	13.3379
10	13.5887	13.3787	13.4881
20	14.0122	13.3722	13.8459
30	14.7730	13.3698	14.4549
40	15.9046	13.3772	15.4210
50	17.3878	13.3928	16.7393
60	19.5016	13.3716	18.6013
70	22.2151	13.4100	21.044
80	25.9176	13.3711	24.1656
90	31.2534	13.3845	29.0008
100	39.7761	13.4218	36.5059

4 Conclusion

The application FVSI and EP technique for finding the suitable place to install SVC and as an optimization technique to minimize loss for installing SVC and transformer tap configuration has been presented in this paper. The optimal sizing of SVC and the transformer tap setting configuration was also achieved for minimizing the loss in the transmission system. It is proven that the installation of SVC is more effective than the tap setting configuration in order to minimize loss of the transmission system. For a further research, both of SVC installation and tap changing configuration can be combined together in order to minimize the loss in the transmission system.

Table 5 Minimum voltage of the system

Reactive power loading (MVAr)	V_{MIN} before (V)	V_{MIN} after installing SVC (V)	V_{MIN} after tap configuration (V)
0	0.9900	1.0078	0.9944
10	0.9679	1.0091	0.9851
20	0.9447	1.0084	0.9627
30	0.9180	1.0080	0.9493
40	0.8893	0.9905	0.9122
50	0.8609	0.9927	0.8823
60	0.8284	1.0099	0.8523
70	0.7937	1.0100	0.8166
80	0.7541	1.0086	0.7789
90	0.7053	0.9833	0.7451
100	0.6412	0.9610	0.6819

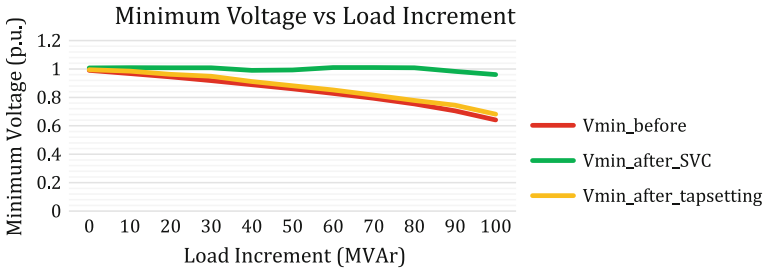

Fig. 4 Graph of minimum voltage versus load increment

Acknowledgements The authors would like to thank the Research Management Institute (RMI), Universiti Teknologi MARA, Malaysia and the Ministry of Higher Education (MOHE), Malaysia through research grant 600-RMI/DANA 5/3/LESTARI (77/2015) for the financial support of this research.

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Chapter 25
Optimization of Flocculation Process for a New Myco-Coagulant to Reduce Water Turbidity

N. Jebun, Abdullah Al-Mamun, Md. Zahangir Alam and Raha Ahmad Raus

Abstract The flocculation process of a new myco-coagulant, isolated from River Water Fungus (RWF5) was optimized to reduce turbidity from kaolin suspension. The results indicated that turbidity removal of 94% (from 650 NTU to 38 NTU within 5 min settling time) could be achieved by a combination of rapid and slow mixing process. A sequential optimization strategy, based on a statistical experimental design, was used to determine the suitable agitation and mixing time. Four process parameters were optimized by the response surface methodology (RSM), based on the face-centered central composite design (FCCCD). The optimum agitation speed and mixing time were found as 250 rpm and 7 min for rapid mixing stage and 90 rpm and 22 min for slow mixing process, respectively. Analysis of variance (ANOVA) showed a good regression coefficient (R^2) of 0.95, which indicated satisfactory fit of the model data with the experimental results. The findings were statistically significant at confidence level of $p < 0.05$.

Keywords Coagulation · Flocculation · Myco-coagulant · Optimization Turbidity

1 Introduction

The coagulation–flocculation process is applied in water and wastewater treatment to remove solids, turbidity, color, and natural organic matter (Chang et al. 2009). Inorganic coagulants (e.g., aluminum sulfate, ferric chloride and calcium carbonate) and synthetic organic polymers (e.g., Poly aluminum chloride (PAC) and polyethylene imine) are common coagulants used in such treatment. This process highlights a water treatment mechanism that stimulates the aggregation of sus-

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_25

pended particles to settleable flocs by the destabilization of the charged colloids thus, neutralizing the forces that keep them apart.

Water treatment is essential to the health and welfare of a community and water from all sources must have some form of purification before consumption. Various methods are used to make water safe and attractive to the consumer. The method employed depends on the character of the raw water. One of the problems with treatment of surface water is the large seasonal variation in turbidity (McConnachie et al. 1999). Nowadays, with a variety of coagulants and uneven water quality in different water sources, poses a great challenge and difficulty in the suitable selection of coagulants for certain raw water. In conventional water treatment process, in the presence of a suitable coagulant and proper dosage, we can achieve a better removal result of particulate matters. Many water treatment processes have been developed and used for decades, such as coagulation–flocculation units, sedimentation basins, slow sand filtration, rapid sand filtration, and disinfection units (Bauer et al. 2011; Konieczny et al. 2009; Ebeling et al. 2003; Davis and Cornwell 1998; Peavey et al. 1985).

In wastewater treatment, coagulation/flocculation followed by sedimentation process is considered as easy and effective method of removing suspended solids (SS). Several studies have been carried out by many researchers to improve the efficiency of sedimentation processes either by the use of gravity or by means of the coagulation and flocculation process (Geng 2005; Lancine et al. 2008; Noushin et al. 2013; Prakash et al. 2014). Koohestanian et al. (2008) aimed at developing a treatment system that can effectively reduce the concentration of colloidal particles in raw water which can greatly reduce the cost of treatment and improve the subsequent steps of treatment. In recent decades, some other methods have been used for wastewater treatment plant. Some researchers have investigated the use of electro-dewatering to remove water from different materials, such as clay (Vijh 1995, 1997, 1999; Rabie et al. 1994; Yamaguchi et al. 1992), kaolin suspension (Dussour et al. 2000; Addai-Mensah and Ralston 2005; Aziz et al. 2006).

This chapter reports the optimisation process for the maximum removal of colloidal particles by using newly discovered myco-coagulant. The present work was intended to understand the influence of various factors that may impact the efficiency of coagulation–flocculation process of a new myco-coagulant by using jar apparatus.

2 Materials and Methods

2.1 Microorganisms and Growth Conditions

Six strains of filamentous fungi, RWF1 to RWF6, were isolated from river water samples collected from the Pusu River at IIUM campus, Gombak. Among the six

strains, RWF5 produced the best potential myco-coagulant by reducing the turbidity of kaolin suspension and real river water (Jebun et al. 2016).

RWF5 was grown on Potato Dextrose Agar (PDA) mixed with sawdust and initial pH of 5.8 ± 0.2. Distilled water was used to prepare the media which was sterilized at 121 °C for 15 min. The culture plates were incubated at 32 ± 2 °C for 10 days. Subculture was conducted twice in a month and the plates were stored at 25 °C for further use.

2.2 Production of Myco-Coagulant

The suitable medium was screened to enhance myco-coagulant production of RWF5. The malt extract was (1%w/v) mixed with 1 L distilled water and the media was sterilized by autoclaving it at 121 °C for 15 min. The sterilized media was inoculated with (3%v/v) fungal inoculum strength (dried mycelia 340 mg/L). Ten days old culture plates were used to prepare fungal inoculum and culture was incubated in a rotary shaker at 150 rpm at 30 ± 2 °C for 6 days. Initial pH of the culture was adjusted to 7.0 ± 0.1 using 1 M NaOH or 2 M HCl.

The cultures were harvested after 6 days of cultivation and centrifuged (10^3 rpm for 10 min at 25 °C) to separate the biomass from supernatant. The supernatant was used as myco-coagulants and stored at room temperature at 28 ± 2 °C and at 4 °C for further use.

2.3 Preparation of Synthetic Turbid Water

Kaolin suspension was used to determine the turbidity removal ability of the new myco-coagulant. About 0.7 g kaolin powder (R&M chemicals, UK) was mixed in 1 L of tap water. The initial turbidity was recorded at 600 ± 50 NTU and pH was adjusted to 7.0 ± 0.1. Each jar was filled with 500 mL kaolin suspension for flocculation process.

2.4 Optimization of Agitation Speed and Mixing Time

Coagulation/flocculation process was performed in two stages: first, the coagulated water was rapidly mixed and flocculation was enhanced by slow mixing. Four factors were optimized–Rapid agitation (low–150 rpm, medium–200 rpm and high–250 rpm), mixing time (low–2 min, medium–5 min and high–8 min), Slow agitation (low–50 rpm, medium–75 rpm and high–100 rpm), mixing time (low–14 min, medium–22 min high–30 min). The myco-coagulant dose was induced at 1% (v/v) in the kaolin suspension. After the coagulation-flocculation process, the

water was allowed to settle for 5 min. Then the top layer of water from each jar was collected with a micropipette and flocculation efficiency was calculated based on % reduction in turbidity. All the experiments were conducted in triplicate. In the case of sample for the control, 1% (v/v) of the supernatant was replaced with 1% (v/v) of nutrient broth.

The turbidity removal was calculated as follows:

$$\text{Turbidity removal efficiency}\ (\%) = (A - B)/A \times 100, \tag{1}$$

where A is the initial turbidity value and B is the turbidity value after flocculation.

2.5 Faced-Centered Central Composite Design (FCCCD)

Optimization was calculated using response surface methodology (RSM) in the form of FCCCD to obtain the optimum flocculation conditions for maximum turbidity removal from kaolin suspension. In the FCCCD, rapid mixing speed, mixing time, slow mixing speed and mixing time were fixed. A set of 30 experimental runs with six center points were generated (Table 1). Each factor was studied in three levels: low (−1), medium (0) and high (+1).

2.6 Data Analysis

Design Expert 10 (Stat-Ease Inc., USA) software was used to design the experiments for the optimization as well as validation of the experiments. The develop regression model was evaluated by analyzing the values of regression coefficients, analysis of variance (ANOVA), Fisher's F-test (overall model significance), R^2. Furthermore, the fitted polynomial equation expressed in the form of contour and surface plots describing the relationship between the responses and the experimental levels of each of the variables utilized in this study.

3 Results and Discussion

3.1 Optimization of Rapid and Slow Mixing

One of the most useful experimental statistical techniques in optimizing process is response surface methodology (RSM). It has been widely used for the optimization of various processes in food chemistry, chemical engineering, and biotechnology (Granato et al. 2010; Hong et al. 2011; Liu et al. 2010). The main objective for optimization process was to develop and evaluate the statistical approach to obtain

better understanding of the relationship between factors involved in the flocculation process, also to reduce the number and cost of experiments. Mixing speed and time are significant factors in flocculation process; it encounters between particles and flocculating agents (Chen et al. 1998). Table 1 listed the experimental and predicted

Table 1 Faced-centered central composite design (FCCCD) experimental design for flocculation process for turbidity reduction

Run No.	Factor 1	Factor 2	Factor 3	Factor 4	Response	
	A: Rapid agitation (rpm)	B: Rapid mixing time (min)	C: Slow agitation (rpm)	D: Slow mixing time (min)	Actual turbidity removal (%)	Predicted turbidity removal (%)
1	150	8	50	30	93	93
2	150	5	75	22	93	93
3	250	8	50	30	94	94
4	250	2	50	14	88	88
5	250	8	100	30	95	95
6	150	2	100	30	93	93
7	150	2	50	14	87	87
8	200	5	75	30	93	94
9	250	8	100	14	93	93
10	**200**	**5**	**75**	**22**	**93**	**93**
11	**200**	**5**	**75**	**22**	**93**	**93**
12	200	2	75	22	92	91
13	150	8	100	14	93	93
14	150	2	100	14	91	91
15	**200**	**5**	**75**	**22**	**93**	**93**
16	200	5	75	14	92	91
17	200	5	100	22	94	94
18	200	5	50	22	91	92
19	250	8	50	14	92	92
20	**200**	**5**	**75**	**22**	**93**	**93**
21	150	8	100	30	94	94
22	250	2	50	30	92	92
23	250	5	75	22	94	94
24	200	8	75	22	93	94
25	150	8	50	14	91	91
26	150	2	50	30	91	91
27	250	2	100	14	90	91
28	250	2	100	30	94	94
29	**200**	**5**	**75**	**22**	**93**	**93**
30	**200**	**5**	**75**	**22**	**94**	**93**

*Bold indicates center points

response of the turbidity removal for each experimental run, taken from the regression equation of 30 runs. The highest turbidity removal of 95% was achieved for run 5, and the lowest activity turbidity removal 87% was for run 7.

Several regression analyses of the experimental data were employed to calculate the regression coefficients of the equation and the fitted equation was used to predict the turbidity removal (%). The quadratic polynomial equation provided levels of turbidity removal as a function of rapid agitation, mixing time (rapid), slow agitation and mixing time (slow), which can be presented in terms of coded factors as shown in Eq. 2.

$$\begin{aligned} Y = {} & 93.11 + 0.33A + 1.11B + 1.00C + 1.22D \\ & + 0.063AB - 0.19AC + 0.19AD - 0.31BC - 0.44BD \\ & - 0.19CD + 0.46A^2 - 0.54B^2 - 0.54C^2 - 0.54D^2, \end{aligned} \tag{2}$$

where, Y is the turbidity removal (%) produced as a function of the coded levels of rapid agitation (A) rapid mixing time (B), slow agitation (C) and slow mixing time (D) respectively.

Analysis of variance (ANOVA) was used to assess the adequacy of the statistical model, which are summarized in Table 2. The F-value of 20.96 and p-value of <0.0001 of the model indicated that the selected quadratic model was significant. P-value was also used to determine the significance of each coefficient and used as an indication to examine the interaction strength between each coefficient that was independent. P-value of less than 0.05 implies that model terms are significant, while values greater than 0.1 means insignificant. In this case, the terms A, B, C, D, BC, and BD were found to be significant and influenced the coagulation–flocculation process. Meanwhile, based on the F-values of the main factors studied, the mixing time showed the highest value, indicating that it presented the strongest influence on the turbidity removal, while the rapid mixing showed the least effect. The F-value of 2.10 also implied that the lack of fit was not significant relative to the pure error. Non-significant lack of fit indicates that the model fits adequately.

In addition, the efficiency of the model was demonstrated by the high value of R^2 (0.95) and adjusted R^2 (0.91), which indicated better correlation between the actual and predicted values. The signal-to-noise ratio was measured by the adequate precision, in which a ratio greater than 4 is considered a requirement for desirable models and the model showed a ratio of 19.28. Meanwhile, coefficient of variation (CV) is a measure expressing standard deviation as a percentage of the mean; the small values of CV give better reproducibility (Liyana-Pathirana and Shahidi 2005). The CV for the turbidity removal was 0.58%, which was within the acceptable range. The 3D response surface curve for interaction between factors (rapid and slow agitation, rapid and slow mixing time) is shown in Fig. 1.

Figure 1a, b showed the effect of rapid mixing and slow mixing on turbidity removal rate at central point of mixing time for rapid and slow agitation. The shape of the response surface curves showed a good interaction between these tested

Table 2 Analysis of variance (ANOVA) for turbidity reduction

Item source	Sum of squares	df	Mean square	*F*-value	*p*-value Prob > *F*	Comment
Model	84.86	14	6.06	20.96	<0.0001	Significant
A–Rapid agitation	2.00	1	2.00	6.91	0.0189	
B–Rapid mixing time	22.22	1	22.22	76.83	<0.0001	
C–Slow agitation	18.00	1	18.00	62.23	<0.0001	
D–Slow mixing time	26.89	1	26.89	92.97	<0.0001	
AB	0.063	1	0.063	0.22	0.6487	
AC	0.56	1	0.56	1.94	0.1835	
AD	0.56	1	0.56	1.94	0.1835	
BC	1.56	1	1.56	5.40	0.0346	
BD	3.06	1	3.06	10.59	0.0053	
CD	0.56	1	0.56	1.94	0.1835	
A^2	0.54	1	0.54	1.86	0.1923	
B^2	0.77	1	0.77	2.65	0.1244	
C^2	0.77	1	0.77	2.65	0.1244	
D^2	0.77	1	0.77	2.65	0.1244	
Residual	4.34	15	0.29			
Lack of fit	3.51	10	0.35	2.10	0.2131	Not significant
Pure error	0.83	5	0.17			
Cor. total	89.20	29				

R^2 = 0.95, Adjusted R^2 = 0.91, C.V% = 0.58, Predicted R^2 = 0.78, Adequate precision = 19.28

variables. The response surface indicated that the optimal conditions were exactly located at the design boundary (Fig. 1a, b). Rapid and slow agitation exhibited quadratic effects on the response were turbidity reduction rate increased only 2% (from 92 to 94%) central point to high level.

Figure 1c, d showed the interaction between rapid mixing time and slow agitation on turbidity removal when rapid mixing and slow mixing time was set at the center point. Rapid mixing time exhibited quadratic effect on the response, while the effect of slow agitation was linear. Figures 1e, f depicted the interaction between rapid mixing time and slow mixing time on turbidity reduction when rapid and slow agitation speed was set at the central point. The 3D graph indicated that optimal turbidity removal was achieved while rapid and slow mixing time was at high level. Wang et al. (2005) reported that adequate time must have been provided to make large size flocs for efficient removal of particles in sedimentation process. A similar finding was reported by Aljuboori et al. (2015), for the optimization of flocculation process, where maximum flocculating rate observed at 80 rpm was

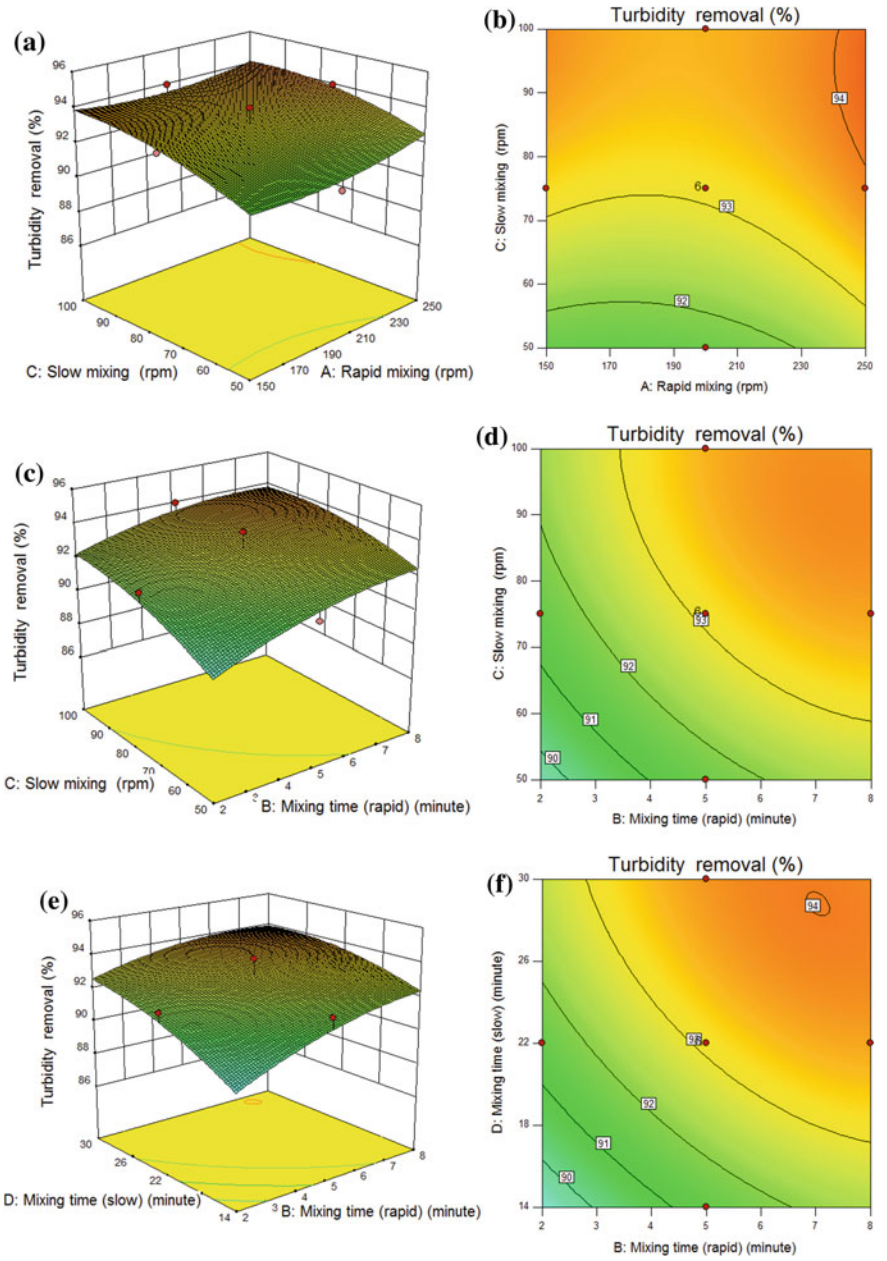

Fig. 1 3D response surface curve (left) and contour plot (right) of the interaction effects of: **a**, **b** rapid mixing and slow mixing; **c**, **d** rapid mixing time and slow mixing; **e**, **f** rapid and slow mixing time on turbidity removal (%)

94.6% while mixing time was from 3 to 7 min. The time of macro-flow formation is one of the operating parameters that are given great consideration in any water treatment plant that involves coagulation–flocculation operations.

3.2 Validation of the Statistical Model

The statistical model was checked for the adequacy of the model equation. A few sets of experiments were carried out within the design space based on the optimum conditions established using the FCCCD for the flocculation process. To confirm the validity of the statistical experimental strategies and gain a better understanding of the flocculation for the novel myco-coagulant, experiments were performed within the design space. Experiments predicted by the point prediction feature of the Design Expert software were used in determining optimal conditions. The results were compared with the predicted values, as shown in Table 3. It was observed that the experimental response was in good agreement with the predicted values (percentage error <10%), confirming the validity and accuracy of the models.

The results demonstrated that highest turbidity removal of 95% (from 650 NTU to 30 NTU) was achieved in run 5 while the lowest result was observed in run 7 at 85% (83 NTU). The method of FCCCD improved the flocculation process where turbidity removal was 95% (agitation–120 rpm, mixing time–40 min and settling time–30 min) before optimization (Jebun et al. 2016) and turbidity removal of 95% (250 rpm for 7 min and 90 rpm for 22 min, settling time–5 min) was achieved by optimization. The resulting enhancement indicated that statistics based experimental design is a valuable tool in optimizing the coagulation/flocculation process factors.

Table 3 Validation of experimental model for optimization of turbidity removal

Exp. No.	Rapid agitation (rpm)	Rapid mixing time (min)	Slow agitation (rpm)	Slow mixing time (min)	Turbidity removal % (Predicted)	Turbidity removal % (Actual)	Error (%)
1	250	7	90	22	95	94	1.05
2	250	7	80	25	95	93	2.10
3	180	8	70	25	94	93	1.06
4	160	8	80	20	94	93	1.06
5	150	8	70	30	94	94	0.00
6	150	2	50	14	87	85	2.29

4 Conclusions

The coagulation–flocculation process with a new myco-coagulant was used to reduce turbidity from kaolin suspension by jar tests. Faced Centered Central Composite Design (FCCCD) and Response Surface Methodology (RSM) was employed to optimize the levels of rapid agitation speed and mixing time, slow agitation speed, and mixing time. Results revealed that the optimum conditions for the minimum residual turbidity (from 650 NTU to 30 NTU) were rapid mixing at 250 rpm for 7 min and slow mixing at 90 rpm for 22 min. Maximum turbidity removal of 95% could be achieved by the new bio-coagulant extracted from fungus. Species of the fungus RWF5 was determined to be *Lentinus squarrosulus*. The verification experiments demonstrated that the RSM approach was an acceptable technique for optimizing the coagulation–flocculation process.

Acknowledgements The authors would like to express their gratitude to the Ministry of Education (MOE) Malaysia for granting a Fundamental Research Grant Scheme (FRGS), project No. FRGS-14-109-0350 for the financial support. Thanks also due to IIUM through the research management center (RMC) for financial management and monitoring progress of the project.

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Chapter 26
Durability Analysis of Natural Lime Concrete

Yeong Yu Tan, Shu Ing Doh and Siew Choo Chin

Abstract Concrete is known to be durable and dependable material since it is resistance to weathering action and chemical attacks while maintaining its engineering properties. However, carbon dioxide produced by the cement industries had caused severe environmental pollution. To minimize carbon dioxide emission into the atmosphere, eggshell wastes are treated as partial cement replacement in this study. The eggshell was oven-dried at 105.5 °C for 24 h before grinding it into powder passing through sieve size 45 μm. Eggshell powder was used as partial cement replacement at 5, 10, 15 and 20%. The performance of the concrete mix was evaluated against control concrete mix. The specimens were tested on acid attack and sulphate attack. The concrete specimens were prepared in the form of cubes and then subjected to water curing for 28 days before immersed in sulphuric acid solution for 1800 h and sodium sulphate for 50 weeks respectively. From the analysis, it is observed that reduction of compressive strength of the concrete cubes for the acid attack and sulphate attack reduce gradually when the eggshell powder increase.

Keywords Acid attack · Cement replacement · Eggshell powder
Sulphate attack · Compressive strength

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_26

1 Introduction

Concrete is extensively used in the building and construction sector. One of the main ingredients is ordinary Portland cement. However, production of ordinary Portland cement will consume a lot of energy in the manufacturing process and generate high amount of carbon dioxide that is approximately 1 tonnes of cement will generate 1 tonnes of carbon dioxide (Pliya and Cree 2015). Social and environment issue of sustainability and energy conservation are assisting in changing the cement industry by lowering and partially replacing its cement production with supplementary cementing materials.

The physical nature of the eggshell waste and the foul-rotten egg odours produced when the materials degrade, reduce the lime value, and renders the waste difficult to recycle to land (Amu et al. 2005). Ideally, the eggshell waste should be dried at source transported to a site where it would be finely ground immediately and used as source of lime to agriculture and other applications. In the ever-increasing efforts to convert waste to wealth, the efficacy of converting eggshells waste to beneficial use becomes a knowledge that worth embracing. It is scientifically known that the eggshell is mainly composed of compounds of calcium which is similar to the cement (Neville 2011).

In this investigation, eggshell was selected as the source of the partial cement replacement. Eggshells are known as the agricultural waste that generated from hatcheries, bakeries, fast food restaurants which is traditionally useless and treated as landfilling (Sivakumar and Mahendran 2014). Eggshell consists of several mutually growing layers of $CaCO_3$, the innermost layer-maxillary three layer grows on the outermost egg membrane and creates the base on which palisade layer vertical layer covered by the organic cuticle. The primary chemical content that is available in the eggshell was mainly calcium (Raji and Samuel 2015). Thus, the quality of the calcium in the eggshell is greatly influenced by the extent of exposure of sunlight, raw water and harsh weather condition. In this study, various percentage of eggshell powder had been used as the partial cement replacement to produce concrete and tested the durability of it with sulphuric acid solution and sodium sulphate solution.

2 Method

Materials used on this investigation consisted of ordinary Portland cement, river sand, granite aggregate, eggshell powder and tap water. A single batch of ordinary Portland cement that fulfil the requirement of BS EN part 1 (2011) was used as the binder to produce all the concrete cube specimens Fine aggregate used was taken from the local river sand with the fineness modulus of 1.64. Granite aggregate was obtained from Bukit Rangin quarry. Eggshell was obtained from Eggtech Manufacturing Sdn Bhd.

Concrete cube (100 mm × 100 mm × 100 mm) was selected for this study. Initial, plain concrete of Grade 30 was prepared using Department of Environment (DOE) method. The plain concrete was act as the control specimens which produced 100% of ordinary Portland cement as cement binder. After that, eggshell concrete specimens were prepared by integrating a range of eggshell powder as partial cement replacement used from 5 to 20% with 5% interval by weight. All the concrete cubes were demolded after 24 h before subjected to full water curing for 28 days prior to immersing them into 5% of sodium sulphuric acid solution for 1800 h and 5% of sodium sulphate solution for 50 weeks respectively. The durability of the both plain concrete and eggshell concrete mixes was determined by measuring the mass loss and reduction of compressive strength.

3 Results and Discussion

3.1 Acid Attack

The durability of the concrete towards acid attack decreases as the percentage of the eggshell powder increases. Mass loss and compressive strength loss can be observed in the Figs. 1 and 2. Plain concrete cube specimen exhibit the lowest total mass loss and compressive strength reduction compared to other eggshell concrete mixes. The specimens experienced gradual mass loss and strength as the eggshell powder increases. However, when the eggshell powder increases up to 20%, the concrete significant drop in mass and compressive strength up to 0.76 and 31.1% respectively.

Mass loss occurs as a result of leaching out of the calcium chloride from the concrete due to the reaction between calcium hydroxide in concrete with sulphuric acid (Goyal et al. 2009). This is because of acid attacks mainly calcium hydroxide and then the hydration products in the cement matrix which leads to hydrolytic decomposition of hydration cement products followed by degradation of the

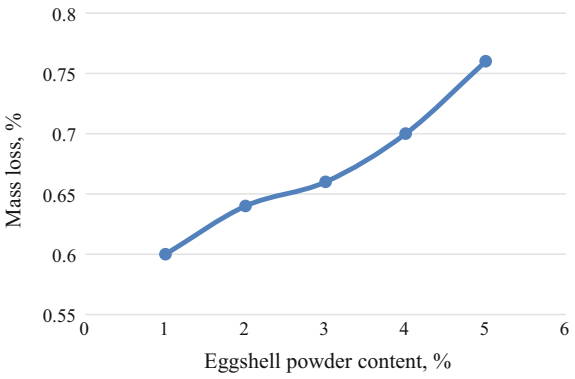

Fig. 1 Total mass loss of concrete consisting various percentage of eggshell powder after submerged in sulphuric acid solution

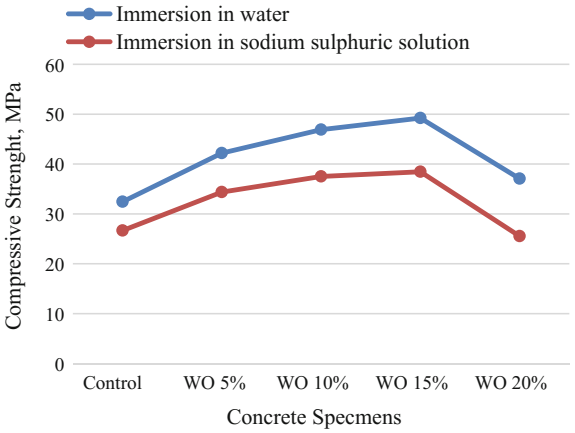

Fig. 2 Compressive strength of concrete consisting various percentage of eggshell powder after submerged in tap water and sodium sulphuric acid solution

mechanical properties of the cement based material (Hussin et al. 2008). It was found that the decomposition of larger amount of hydration product of cement matrix in eggshell concrete specimen loss of adhesion between the aggregate particles on the concrete surface to be higher thus resulting in more corner and edges losses as shown in Fig. 3.

As the immersion become longer, the sulphuric acid solution attack progresses from the concrete surface to the internal part, thus resulting in larger percentage of strength loss. Eggshell concrete (Water-cured Oven-dried, WO 20%) had the severe condition among all the concrete specimens. The percentage of calcium hydroxide is much greater than the other specimens which it is more vulnerable to the acid attack (Khairunisa et al. 2015). Evidently, strength reduction and severity of physical

Fig. 3 Eggshell concrete after submerged in sulphuric acid

damages is higher for the specimens using eggshell powder as partial cement more than 20%. This deterioration process observed on the specimen is in line with the findings by Zivica and Bajza (2001) who highlighted that the reduction of the compressive strength and degradation process of concrete when it exposed to acid attack. Principally, from the study of Zivica and Bajza the gradual reduction of the compressive strength due to increase in the amount of the lateric aggregate integrated in the mix also diminished the concrete durability. Generally, the gradual reduction in the concrete compressive strength is due to the addition of the eggshell powder which had increase the amount calcium hydroxide that vulnerable to acid attack.

Care need to be taken, not to use the eggshell powder as partial cement replacement more than 20% due to adverse effect to the resistance of concrete to acid attack. When the amount of the eggshell powder increases, the amount of the ordinary Portland cement in the mixer is lower which is directly less silicon dioxide to react with calcium hydroxide to form secondary C–S–H gel during the pozzolanic reaction and hydration process. As the result, there is left unreacted eggshell powder left in the concrete which readily reacts with the acid solution (Karthik and Gandhimathi 2015).

3.2 Resistance to Sulphate Attack

The concrete cube specimens were submerged in the 5% of sodium sulphate solution to analyse the sulphate resistance of the specimens. At the end of 50 weeks of immersion period, the specimens were tested for the compression strength test. This is to determine the residual compressive strength after the subjected to sulphate environment. The result of the compressive strength was illustrated at Figs. 4 and 5. The reduction of the compressive strength increases when the eggshell powder increases. The WO 20 shows significant reduction of compressive strength at 32% different from 37 to 25 MPa. Generally, the reduction of the strength of the concrete was related to the weight loss. Since the concrete matrix was disturbed during the immersion period, the bonding between the ingredients inside was affected. This situation happened was due to the disintegration of the specimens owing the formation of the ettringite and gypsum (Alam et al. 2012). Thus, the loss of compressive strength of the concrete specimens during the sulphate attack is due to the loss of cohesion in the hydrated cement paste and of adhesion between it and the aggregate particles (Sumer 2012).

Since sodium sulphate is known as the salt with strong base with relatively high pH of 7.7. The formation of the gypsum from the portlandite under the attack of Na_2SO_4 is an exchange that present in the Eq. (1). As the result the formation of the calcium sulphate which precipitates and crystallizes in the cement paste microstructure had contributing to expansion process. As the immersion continues, the sulphate ion concentration in the solution increases, it will be close to gypsum and monosulphate, the precipitation of ettringite and expansion is showed in the Eqs. (2) and (3). Thus the ultimate disintegration of the C–S–H phase had delayed.

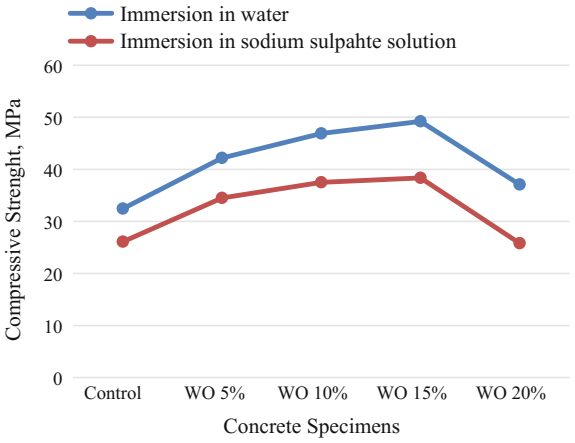

Fig. 4 Compressive strength of concrete consisting various percentage of eggshell powder after submerged in tap water and sodium sulphate solution. *Source* Piasta et al. (2014)

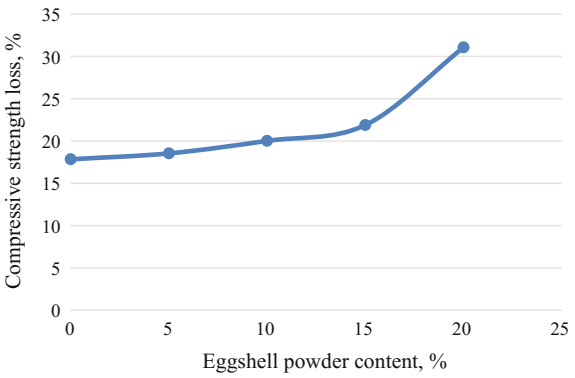

Fig. 5 Changes of compressive strength of concrete specimens with different percentage of eggshell

As the result, numerous of micro-cracking occurs followed by the expansion that illustrated in the Fig. 6.

The compressive strength of the eggshell concrete drops gradually when immersed in the sodium sulphate solution. This is because eggshell powder had provided extra calcium hydroxide and left less silicon dioxide in the ordinary Portland cement to react during the hydration process and pozzolanic activity (Ho 2003). As the result, there is abundant availability of free calcium hydroxide in the concrete allows the sulphate ion to react and transform into ettringite especially when the replacement up to 20%.

$$Ca(OH)_2 + Na_2SO_4.H_2O \rightarrow CaSO_4.H_2O + 2NaOH \quad (1)$$

$$C_3A.Ca(OH)_2.12H_2O + 3Na_2SO_4 + 2Ca(OH)_2 + 20H_2O \rightarrow C_3A.3CaSO_4.32H_2O + 6NaOH \quad (2)$$

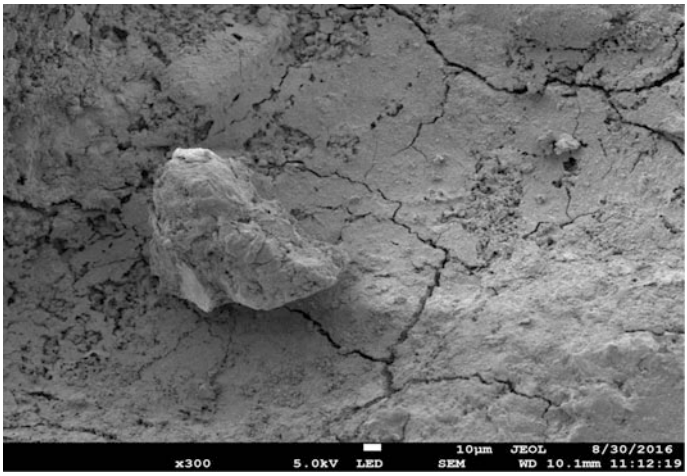

Fig. 6 Micro-cracking occur in the concrete cube after submerged in sodium sulphate solution

$$C_3A.CaSO_4.12H_2O + 2NaSO_4 + 2Ca(OH)_2 + 20H_2O \rightarrow C_3A.3CaSO_4.32H_2O + 4NaOH \quad (3)$$

4 Conclusion

The small difference in total weight loss and compressive strength for the eggshell concrete in the sulphuric acid solution and sodium sulphate solution when the eggshell powder replaces up to 15% which is comparable to normal plain concrete. However, when the eggshell powder replaces up to 20% of the partial cement replacement, it shows a significant drop of mass and compressive strength after immersed in the sulphuric acid solution. Thus, WO 20% showed a multiple of micro-cracks that available in the concrete specimens after immersed in the sodium sulphate solution for 50 weeks. As the result, eggshell powder was recommended to be used as partial cement replacement up to 15%. More research needs to be conducted to investigate the potential of using eggshell powder as the partial cement replacement.

Acknowledgements The author would like to express special thanks to Eggtech Manufacturing Sdn Bhd for contribution is providing eggshell for the whole research.

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Chapter 27
Material Properties of Porous Concrete Using Recycled Coarse Aggregates

Ilya Joohari, Mohd Izzat Joohari and Ang Ai Leen

Abstract This paper presents the properties of porous concrete with different amounts of recycled coarse aggregate (RCA) obtained from a demolished building and comparing the results with normal porous concrete containing 100% natural coarse aggregate (NCA). The RCA that was used is crushed clay brick (CCB), which was partially replacing NCA by an amount of 25, 50 and 75%. Laboratory testing was carried out to identify the physical and mechanical properties of the respected concrete. Slump test was studied at fresh state, whereas compressive strength test and water absorption test was studied at hardened test. The experimental results indicate that the compressive strength for the porous concrete using RCA with CCB is less than the porous concrete using 100% NCA. The strength of porous concrete decreases with an increase in RCA replacement ratios. On the contrary, the percentage of water absorption of porous concrete increases as the RCA replacement ratios is increased. The present study recommends porous concrete marginally achieves the required compressive strength up 25% replacement of RCA for the CCB.

Keywords Natural aggregate · Porous concrete · Recycled aggregate

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_27

1 Introduction

As we know, concrete has emerged as an important construction material for infrastructure. According to Gambhir (2004), when the mixture is placed in the moulds and allowed to dry, it will harden into a rock-like mass known as concrete. The concrete excellent behaviour in fire protection and high density, make it suitable for building components such as wall, column, foundation and slab (Maguesvari and Narasimha 2013). However, the challenge for the civil engineering community in the near future is to apply the concept of sustainable development by using high-performance materials and products manufactured at reasonable cost with the lowest possible environmental impact (Muhammad et al. 2013). This is because the use of conventional concrete has been claimed to be non-environmentally friendly, manifested by frequently voiced negative concerns (Shivakumar et al. 2014).

In this study, concrete was made with the demolition waste which in respond to the Construction Industry Development Board (CIDB) who recommended the use of part-recycles construction materials. For that reason, crushed clay brick is chosen for this study in order to produce lightweight porous concrete. Lightweight concrete is concrete which densities vary from the range 300 to 1850 kg/m^3 (Stephen et al. 2014). The use of lightweight aggregate concrete has been found as early as 3000 BC, when the famous towns of Mohenjo-Daro and Harappa were built during the Indus Valley civilization (Neithalath 2004). Porous concrete is a form of lightweight concrete obtained when fine aggregate is omitted and this concrete is made up of only coarse aggregate, cement and water having uniformly distributed voids (Wang et al. 2006). Porous concrete is also known as no—fines, pervious or open-textured concrete.

In this study, lightweight aggregate is being used to produce no fines concrete. Normal concrete density is in the range between 2200 to 2600 kg/m^3, but for lightweight concrete it is defined by BS EN 206-1, density not less than 800 kg/m^3 and not more than 2000 kg/m^3. According to Newman and Choo (2003), the production of no fines concrete mix consists of cement, water and coarse aggregate with fines aggregate omitted. As a result, no fines concrete contains a multitude of voids and reduces the density.

Zhang (2011) defined lightweight concrete as concrete of which the density is less than 1950 kg/m^3, including lightweight aggregate concrete, aerated concrete and porous concrete. The strength of the aggregates mainly determines the strength of the concrete. As a result, Newman and Choo (2003) states that the strength of lightweight concrete approximately from 1 to over 60 N/mm^2. In addition, Collings (2013) points out that lightweight concrete may be used as composite structure, particularly long-span bridges, which eventually reduce the overall dead weight of span.

According to Newman and Choo (2003), lightweight concrete principal techniques used can be summarized based on the method of production. In contrast, according to ACI (2004), lightweight concrete can be classified into six classes based on the density of the concrete.

2 Methodology

This study was set out to investigate the usefulness of crushed clay bricks as the replacement of coarse aggregate in porous concrete. After obtaining the best mix design, cube samples of size 100 mm × 100 mm × 100 mm have been produced to determine the maximum design strength under different proportions. The primary objective of this study is to determine the optimum proportion of crushed clay bricks to be used as coarse aggregate replacement in order to develop porous concrete. The results are used to determine the mechanical properties under investigation with respect to different proportion of crushed clay brick in the porous concrete.

2.1 Materials and Design Mix of No Fines Concrete

In this research, the common materials for concrete such as Ordinary Portland cement, coarse aggregate and tap water was used for the normal porous concrete sample. However, replacement of crushed clay brick for coarse aggregate and admixture (superplasticizer) was used for the other three samples. Crushed clay brick was collected from a demolition waste of house in Perak. All the crushed clay brick collected from the demolition waste must be crushed into smaller size manually using hammer into an about fist before the sized being grinded mechanically by using laboratory jaw crusher. The crushed clay brick was then sieved accordance to BS 410 in order to be used as coarse aggregate substitution. Aggregates was crushed again which larger than 19 mm, while smaller than 9.5 mm was discarded. The crushed clay brick must first pre-soaked for around 24 h before adding them into the concrete mix. Meanwhile, superplasticizer was used to suit the requirements for producing porous concrete.

2.2 Experimental Work for Mix Design

This prospective study was designed to investigate the use of crushed clay bricks as the replacement of coarse aggregate in porous concrete. Four types of concrete mixture were analysed in this study. Cube moulds with the dimension size of 100 mm × 100 mm × 100 mm are used for this study. There are two types of state are tested in this study. Compressive strength test and water absorption test are tested for hardened state of concrete while slump test for fresh state.

3 Results and Discussion

3.1 Slump Test

Slump test was conducted on the fresh concrete for every batch of mixes accordance to American Concrete Institute (ACI) standard. Complementary to this, there were four type of mixes observed for the slump tests which were normal porous concrete, 25, 50 and 75% of crushed clay bricks replacement of no fines concrete. Table 1 showed the result of slump for this study. After examining all the mixes, the workability of the mixes was almost the same as to ACI standard value for slump. Thus, the workability of the concrete mix was good because the slump was in the range of ACI standard. In addition, the four mixtures were consistent and show the type of true slump for all the mixes.

3.2 Density

As shown in Table 2, the density was increased slightly from 7 to 28 days. The density measured in this study was in the range of 1500 to 2000 kg/m^3 which accordance with the range of ACI. The highest density between the samples was normal porous concrete with 1911 kg/m^3 followed by 25% replacement and 50% replacement. 75% replacement of crushed clay brick had the lowest density among all the samples with 1591 kg/m^3. It was apparent that crushed clay brick was a lightweight concrete due to the density was less than 2000 kg/m^3. As well as fine aggregate was omitted being reason of a lightweight concrete result.

Table 1 Properties of concrete at fresh state

Type of concrete	Slump (mm)
Normal No fines concrete	10
25% Crushed clay bricks replacement	14
50% Crushed clay bricks replacement	17
75% Crushed clay bricks replacement	18

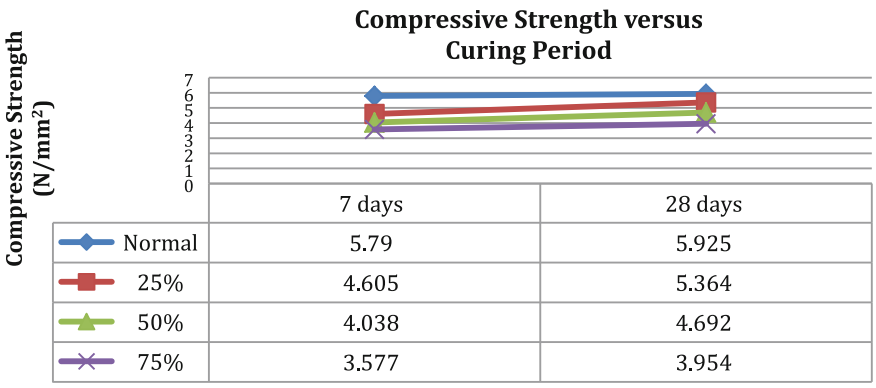
Table 2 Density of concrete along with curing period

Type of concrete	Density (kg/m^3)	
	7 days	28 days
Normal No fines concrete	1895	1911
25% Crushed clay bricks replacement	1724	1757
50% Crushed clay bricks replacement	1575	1645
75% Crushed clay bricks replacement	1541	1591

3.3 Compressive Strength Test

Based on Fig. 1, the result of compressive strength was increased steadily from 7 to 28 days. On the other hand, the result for normal no fines concrete showed highest strength compared to other samples. Normal no fines concrete had the strength of 5.925 N/mm^2 at 28 days. Whereas the strength of 25% had the second highest with 5.364 N/mm^2 compared to 50 and 75%. The result indicates the replacement of crushed clay bricks attribute to the lower strength of concrete. This may be due to the weak porous structure of crushed clay brick that affects the mode of failure under compression. The higher the replacement levels, the lower the compressive strength of the concrete. The result pointed out that 25% replacement was the optimum replacement for the crushed clay brick as coarse aggregate as the strength of concrete was the higher compare to other samples. Besides, the difference between the normal and 25% replacement of crushed clay brick for the strength at 28 days was only 0.561 N/mm^2 which was 9.5% and it could conclude that the strength was almost the same.

At the same time when compressive strength test was carried out, the crack behaviour of the samples were observed. All four exposed faces of samples were cracked approximately the same with little damage to faces in contact with the platens. First, the samples start to crack when the loading was added at the top of the samples. As the loading increase, the aggregate would slide with each other. Eventually the sample would start to shattered. Based on the crack pattern observed, it was found that the crash would be shattered more on the samples using crushed clay brick as coarse aggregate compare to normal concrete. For the normal concrete, the concrete would crumble but it do not shattered much compare to 75% replacement of crushed clay brick. 75% replacement of crushed clay brick showed the crack pattern that would shatter until the cube reached failure. Once the samples had reached the failure, the shape of the cube samples had been altered due to the compression.



	7 days	28 days
Normal	5.79	5.925
25%	4.605	5.364
50%	4.038	4.692
75%	3.577	3.954

Fig. 1 Relationship between compressive strength and curing period

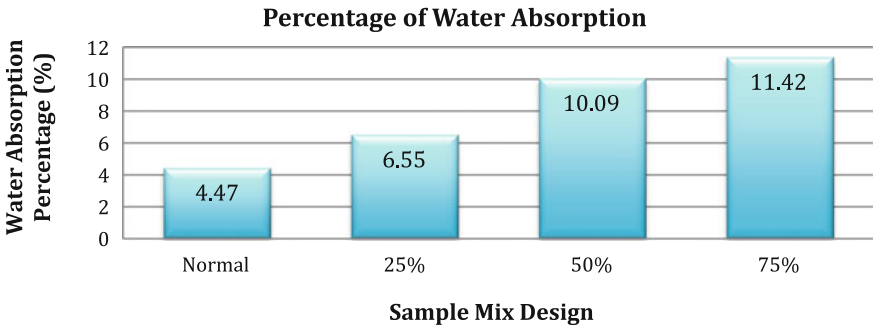


Fig. 2 Water absorption percentage result

3.4 Water Absorption Test

Figure 2 showed the percentage of water absorption for all the concrete mixes. There was an increase approximately three times in the percentage of water absorption from normal porous concrete to 75% replacement of crushed clay brick. For normal porous concrete, the percentage was only 4.47% which was the smallest compare to other samples. Whereas the percentage for the replacement of crushed clay brick was notably higher, 25% replacement with 6.55, 50% with 10.09 and 75% which had the highest water absorption with 11.42%. It could be seen that the 75% replacement of crushed clay brick absorb more water compare to other. Crushed clay brick had the characteristics of absorbing more water compare to natural gravel coarse aggregate. 75% replacement of crushed clay brick had the highest percentage of water absorption due to the amount of crushed clay brick was more compare to 25 and 50% replacement. Subsequently, the water was absorbed more in this sample. For normal no fines concrete, the percentage was lower compared to other samples due to coarse aggregate absorb less water compare to crushed clay brick.

4 Conclusion

By exploring the literature reviews thoroughly and the results obtained in this study, conclusions can be made for this research.

i. Demolition waste has the potential to be reused in the concrete mix. However, the proportions need to be examined for the desired strength.
ii. The most optimum proportion of crushed clay brick to be used as coarse aggregate replacement in order to develop no fines concrete is 25%.

iii. The workability of the lightweight concrete increase as the crushed clay brick is used in the lightweight concrete mix. But, the higher the proportions of crushed clay brick in the concrete, the lower is the compressive strength of the concrete.
iv. Crushed clay brick has high ability for water absorption and as a result it will lower the strength of the concrete. 75% of crushed clay brick replacement shown high water absorption percentage, but it has the lowest compressive strength compare to others.
v. Crushed clay brick has lower density compare to coarse aggregate. Complementary to this the compressive strength of concrete is increased as the density is increased.

Acknowledgements We would like to take this opportunity to acknowledge the Universiti of Malaysia Perlis for the financial support in undergoing this research.

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Chapter 28
Bed Load and River Bed Pattern at Lebir River After Extreme Flood Event in 2014

Nadiatul Adilah Ahmad Abdul Ghani and Nur Insyirah Izzati Omar

Abstract Lebir River is the main river that joins Sungai Galas to form Sungai Kelantan at Kuala Krai. In December 2014, it had faced extreme flood event. The situation has led to the introduction of changes and movement of sediment along Lebir River. This study was done to determine a bed load discharge and deposition of bed load at river bed after this flooding. Five locations have been identified to be used as the sampling location. Three different methods were used to determine the bed load discharge; Meyer Peter Muller, Schoklitsch, and Duboys. Results of the study shows, the size of the sediment in Lebir River is between 0.75 to 5.0 mm and an average velocity is 0.224 up to 0.599 m/s. From the analysis, it shows that Meyer Peter Muller is suitable to predict bed load in Lebir River. The Meyer Peter and Muller formula obtained from experiments with relatively sediment and formula has been used frequently to estimate rates of bed load discharge. It is suitable for uniform sediments with specific gravity that are varying from 1.25 to 4. The particle size range for the Meyer Peter and Muller is between 0.4 and 28.65 mm. This method gives better prediction compared to other two methods and it is suitable for coarse sands and gravel. The river profile in selected point was identified to determine the river bed pattern cause by deposition of sediment at Lebir River after facing an extreme flood event in 2014.

Keywords Bed load · Extreme flood · Lebir River · Meyer Peter Muller River pattern

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_28

1 Introduction

Each year, usually flood is often to occur in Kelantan. In year 2014, it can be considered as one of the worst flood and Lebir River is one of the most affected areas in Kelantan by flood. Erosion of sediment is one of main cause that begins the process of sediment transport which also can cause bed load in the river to increase.

Sediment can be transported by a flow of water. Sediment transport can be in the form of bed load and suspended load, which are depending on the size of the bed material particles and the flow conditions. Some factors which influence the sediment transport are flow conditions, sediment size, and sediment density. Usually, the greater the flow of water, the more sediment will be transported while the movement of sediment will control the size and shape of bed forms. The most important property of the sediment particle or grain is its size (Arman and Mohammad 2013).

This study was done to determine a bed load discharge of Lebir River using selected method and deposition of bed load at Lebir River bed after 2014 flood. The study will focus at five points at Lebir River. Figure 1 shows the location of five sampling points at Lebir River since there are five hydrological stations near the Lebir River. The amount of sediment that is carried by a stream will be past the gaging station that will be as reference point.

1.1 Study Area

Lebir River is located in Kelantan, Malaysia. The river is located at the latitude and longitude coordinates of 5.516667 and 102.2. Lebir River is the main river that

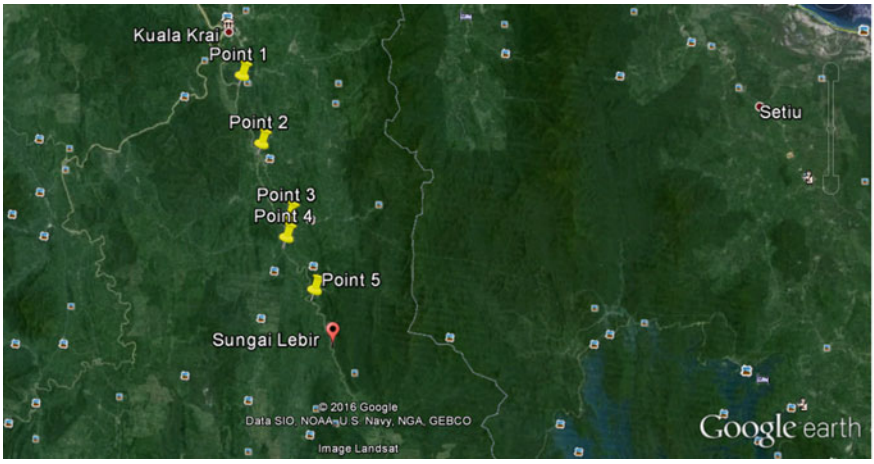

Fig. 1 Locations of points at Lebir River

joins Sungai Galas to form Sungai Kelantan at Kuala Krai. Records from the Kelantan Department of Irrigation and Drainage (JPS) indicated heavy rainfall in Ulu Kelantan from December 16 to 24, 2014 and the amount of rain recorded within the period at the Gunung Gagau Station was almost half of the state's annual rainfall (Hoong 2007).

Each year, flood is often occurring in Kelantan. In year 2014, it can be considered as one of the worst flood and Lebir River is one of the most affected areas in Kelantan. Erosion of sediment is one of main causes that begin the process of sediment transport which also can cause bed load in river to increase. Through this study, bed load pattern through the sedimentation process at Lebir River can be determined.

2 Methodology

According to Martin (2003), The Meyer Peter and Muller formula has been used frequently to estimate rates of bed load discharge. Wang et al. (2015) stated that, The Meyer Peter and Muller formula obtained from experiments with relatively sediment.

Schoklitsch was pioneer that used discharge for the estimation of bed load. He obtained the data with his own to purpose bed load transport rate formula for particle size of sediment ranging from 0.3 to 6 mm.

Duboys is one the first successful development of sediment discharge formula. Although the model of sediment transport was incomplete, the proposed relationship

Fig. 2 Sieve analysis equipment used

for bed load transport rate has been proven to be in good agreement with a large amount of experimental measurements.

There are two methods to get the data of sediment transport which are on site and in soil laboratory. Bed characteristics can be determined from field test while the tests that are conducted in soil laboratory are Sieve Analysis to obtain the grain size for the sediment and Particle Density Analysis for the determination of the average density of individual particles that comprises a soil sample.

Particle density information is required in order to determine the volume of solids in a soil in contact with water. Figures 2, 3 and 4 show the laboratory process done to analysis the sediment data for Lebir River.

Fig. 3 Sample at 5 point before oven and after oven

Fig. 4 Equipment and sample used for particle density analysis

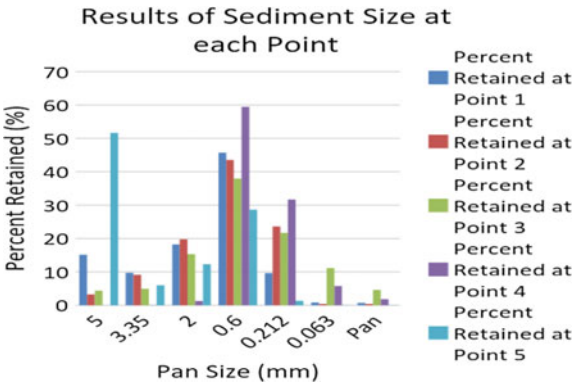

Fig. 5 Results of sediment size at each point

3 Results and Discussions

3.1 Properties of Sediment (Size)

The particle size distributions were obtained for each point. The particle size distribution is one of the important factors that affect the sediment transport in river.

According to Fig. 5, by using Udden Wentworth scale, soil distribution was most retained at 0.600 mm except for Point 5. Most of the distributions of soil at each point were dominated by Coarse Sands except for Point 5. At Point 5, soil distribution most retained at 5 mm which is Fine Gravel type. Average of particles size, (d50) recorded between 0.75 and 5.00 mm.

Grain size distribution is one of the most important characteristics of sediment. Grain size allows investigator to interpret the speed of fluid, from which a sample of particles was deposited (Nadiatul Adilah et al. 2013).

3.2 Bed Load Equations (Discharge)

There were three different bed load equations used in this study to evaluate bed load transport which were Meyer Peter Muller, Schoklitsch and Duboys.

According to Table 1, it shows the limitation of each equation used in this study. Table 2 tabulate results of bed load discharge at each point using these three methods.

Meyer Peter Muller gives more consistent result of bed load discharge. Comparison between these method shows that results of bed load discharge using Meyer Peter Muller method give better prediction of bed load which is the function is suitable for coarse sands and gravel. For Schoklitsch method, based from the characteristic of sediment at each point, it shows Schoklitsch equation is not suitable to use because Lebir River is the sand-bed river. Duboys equation, it is one of the bed load formula that is not applicable for sand-bed streams that carry suspended load.

Table 1 Description of bed load equations used in this study

Function name	Type	Particle size (mm)	Type of data and description
Meyer Peter Muller	Bed load	0.40–30.0	Uniform sediments with varying specific gravity from 1.25 to 4
Schoklitsch	Bed load	0.30–5.0	Well sorted and graded sediment in small flumes. Not applicable for hyper-concentrate sand based river
Duboys	Bed load	0.01–0.4	Not applicable for sand-bed stream carrying suspended load

Table 2 Results of bed load discharge at each point using three different methods

Method used/ point	Meyer Peter Muller (MPM) (lb/ sec-ft)	Schoklitsch (lb/ sec-ft)	Duboys (lb/ sec-ft)
Point 1	0.0027	0.0173	0.2463
Point 2	0.0014	0.0188	0.995
Point 3	0.0005	0.0186	0.7039
Point 4	0.0003	0.5797	0.3514
Point 5	0.0031	0.0024	0.0925

According to Allison (1995), the process of sediment deposition is also dependent on river discharge and speed of river flow. As such, a higher discharge values and water velocity would result in higher amounts of sediment. In addition, time is a factor whereby the longer the sediment deposition process, the higher the sediment loads.

3.3 River Bed Pattern at Point 1

Figure 6 shows the river bed pattern at Point 1. It shows most the deposition of bed load starting from left river bank. The maximum depth at Point 1 is about 3.029 m. Velocity at the at the left bank is 0.833 m/s and suddenly drop about 0.344 m/s at the middle of the bank then increase about 0.621 m/s at the right bank. From the Fig. 6, it shows that the river bed pattern is not uniformly distributed at the left and right bank of the river and the shapes are irregular at Point 1.

3.4 River Bed Pattern at Point 2

The depth of river at Point 2 increased gradually until it decreasing to zero at end of the Point 2. The maximum depth at Point 2 is about 5.238 m. Velocity at the left bank is 0.524 m/s and then drops about 0.452 m/s at the middle of the bank then

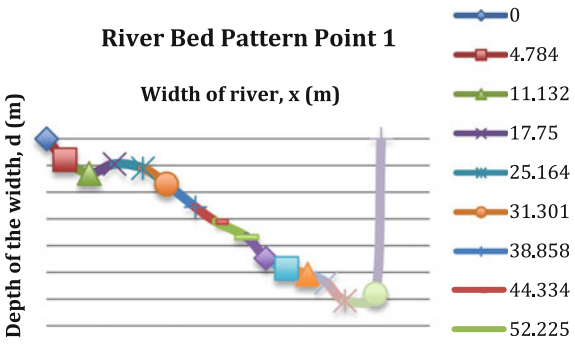

Fig. 6 River bed pattern at Point 1

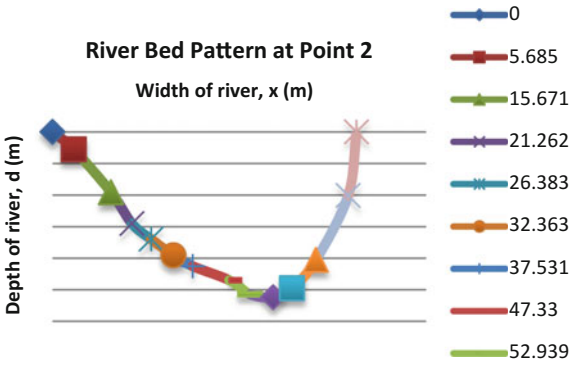

Fig. 7 River bed pattern at Point 2

decreases about 0.264 m/s at the right bank. From Fig. 7, it is seen that the river bed pattern is uniformly distributed at the left and right bank of river and the shape is symmetrical at Point 2.

3.5 River Bed Pattern at Point 3

The depth of river at Point 3 increased gradually until it decreasing to zero at end of the Point 3. The maximum depth at Point 3 is about 3.976 m. Velocity at the left bank is 0.442 m/s and suddenly drops about 0.188 m/s at the middle of the bank then decreases about 0.165 m/s at the right bank. From Fig. 8, it is seen that the river bed pattern increase drastically and then drop suddenly at the left bank of the river.

3.6 River Bed Pattern at Point 4

The depth of river at Point 4 increased gradually until it decreasing to zero at right of the Point 4. The maximum depth at Point 4 is about 3.571 m. Velocity at the left

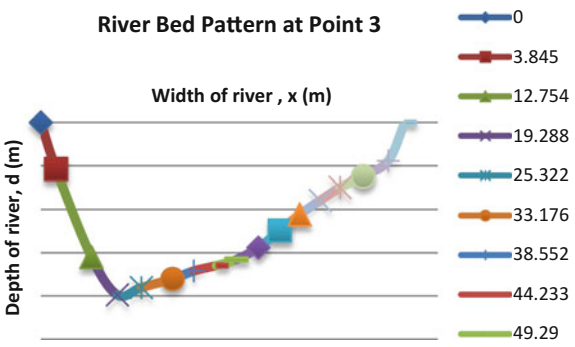

Fig. 8 River bed pattern at Point 3

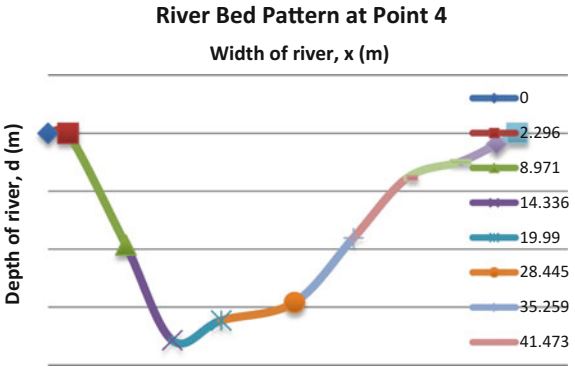

Fig. 9 River Bed Pattern at Point 4

bank is 0.241 m/s and then decreases about 0.222 m/s at the middle of the bank then decreases again about 0.210 m/s at the right bank. From Fig. 9, it is seen that the river bed pattern increase drastically and then drop suddenly at the right bank of the river. One of the factors that might affect the pattern is due to the erosion process that occurred at Lebir River after 2014 flood.

3.7 River Bed Pattern at Point 5

The depth of river at Point 5 increased gradually until it drops at 8 m at the right bank of the river at Point 5. The maximum depth at Point 5 is about 9.0595 m. Velocity at the left bank is 0.281 m/s and then decreases about 0.211 m/s at the middle of the bank then increases again about 0.244 m/s at the right bank. From Fig. 10, it is seen that the river bed pattern at the Point 5 is dispersed due to steep gradient of the river at upstream.

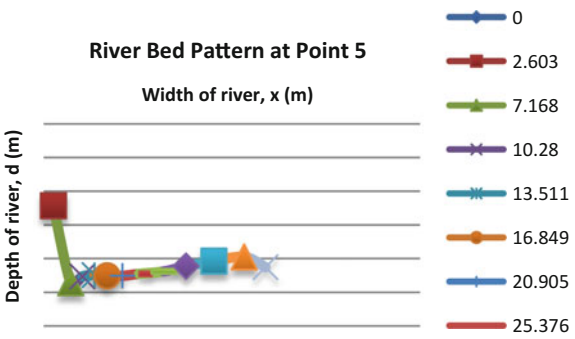

Fig. 10 River bed pattern at Point 5

3.8 Discussion on Rainfall Event and Sediment Transport

The sediment carried by river is high especially when the heavy rainfall occurred. Heavy rainfall will lead to surface runoff and erosion to happen. This would result to high amount of sediment concentration in river as the eroded soil goes in the river. Other than that, grain size of sediment and flow rate will affect sediment discharge in river (Nadiatul Adilah et al. 2013).

Over the 5 months period, the highest rainfall event was recorded in December 2014 which is about 182 mm during the monsoon period. The rainfall precipitation in December 2014 showed that the maximum rainfall event will cause the high amount of rainfall precipitation and will increase the movement of bed load discharge. The surface erosion also contributes to sedimentation process and becomes as one of main problems at Lebir River after flood in December 2014.

4 Conclusions

The particle size distributions were obtained for each point. The bed load discharge was evaluated using three different formulas which were Meyer Peter and Muller, Schoklitsch and Duboys method. From the results, it shows Meyer Peter and Muller can be used to predict bed load discharge for Lebir River as it is suitable for particle size range between 0.4 and 30.0 mm. The bed load pattern at each point was identified through the sedimentation process. The bed load pattern gave the variation of sediment transport modes at Lebir River. Sediment transport did not occur in the upstream of the river which is located at Point 5 because of the steep topography in the upstream compare to other Points which are Point 1, Point 2, Point 3, and Point 4.

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Chapter 29
Development of Self-compacting Concrete Using Palm Oil Clinker as Lightweight Aggregate

Ilya Joohari, Roslli Noor Mohamed and Mohd Izzat Joohari

Abstract This chapter reports the study of development of self-compacting lightweight concrete using lightweight aggregate. In this study, palm oil clinker (POC) is used to replace normal gravel as course aggregate in concrete. There are two types of mix designs in this project, which are the normal self-compacting concrete as the control mix and the POC mix with 100% POC replacement for course aggregate. Slump flow test is carried out to measure the workability of the concrete. Compressive strength test is conducted using cubes for these two types of concrete mix at the age of 7 and 28 days. Splitting tensile and flexural strength test were also conducted using cylinders and prism, respectively, at the age of 28 days and were also wet-cured. The result shows that by using POC as lightweight aggregate, lightweight self-compacting concrete with high workability and strength almost similar to normal self-compacting concrete can be produced. This study also analyzes characteristics of 500 mm × 500 mm wall with thickness 125 mm under vertical load using both types of mix design. Throughout the test, data such as load capacity, behavior of cracks, and failure mode were observed. The test results showed that specimens with POC achieved almost similar performance in terms of ultimate load capacity with only 14.3% difference.

Keywords Aggregate replacement · Lightweight aggregate · Palm oil clinker Self-compacting concrete

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_29

1 Introduction

Palm oil industry in Malaysia is one of the leading industries contributing so much for the nation's development. However, despite its generous contribution, the palm oil industry is producing too much waste disposal, which in the long run can definitely harm our environment. One of the main by-products of palm oil is clinker. Palm oil clinker (POC) is the by-product from burning of fibers and husks inside the boiler under very high temperature in order to generate the steam engine for oil extracting process (Boon et al. 2005). Substituting POC in the concrete mix as course aggregate could produce lightweight concrete due to its low density. According to the British Standard, BS 8110: Part 2: 1985, concrete having the density of 2000 kg/m^3 or less is classified as lightweight concrete.

Lightweight concrete can be defined as the concrete with substantially lower unit weight than that made from gravel or crushed stone (Sulaiman et al. 2004). The decrease in concrete weight reduces dead load on structure, thus making the construction less expensive (Mustapure and Eramma 2014). This study focused on using POC as a replacement for course aggregate in the concrete mix. Ahmad et al. (2004), stated that POC has the specific gravity of 2.17 compared to conventional aggregates, which is 2.6.

A relatively new technology is the self-compacting concrete (SCC), which is regarded as a high-performance composite, that flow under its own weight over a long distance without segregation and without the use of vibrators (Maghsoudi et al. 2010). SCC poses several benefits including improved constructability, labour reduction, increase bond to reinforcing steel, accelerate project schedules, and many more (Sachdeva et al. 2013). According to Nascimento et al. (2013), to be classified as SCC, the concrete should have three basic properties, which are filling ability, passing ability, and segregation resistance.

Since the use of lightweight concrete in construction posses many advantages, this research is carried out to study the development of SCC using POC as the lightweight aggregate. This chapter reports the result of experimental study on the replacement of POC as course aggregate in the lightweight self-compacting concrete mixture with a small percentage use of superplasticizer as the admixture.

2 Scope of Study

For this research, focuses were on the material properties of different concrete design mix using palm oil clinker (POC) as course aggregate replacement, becoming lightweight self-compacting concrete (SCC). POC of size 10 mm will be used as course aggregate replacement in this study. Important material properties such as compressive strength, tensile strength, and flexural strength were the main focus. In order to fully understand the development of lightweight self-compacting concrete using POC, a series of tests were conducted.

The test conducted was at fresh state and hardened state. The concrete mix involves normal self-compacting concrete as the control mix and the POC mix with 100% POC replacement for course aggregate. Slump test was conducted at fresh state to ensure the concrete mix meets the requirement of 150 mm slump for it to be considered as SCC. At hardened state, compressive strength test is conducted on the cubes of these two types of concrete mix at the age of 7 and 28 days. The test cubes are 100 mm × 100 mm × 100 mm size and wet-cured. Splitting tensile and flexural strength test were also conducted at the age of 28 days and were also wet-cured. The splitting tensile test consists of cylinders of size 150 mm × 300 mm, while flexural test involves prism of size 100 mm × 100 mm × 500 mm.

The comparison of both concrete mixes were to be observed throughout the experiment. Apart from obtaining material properties, two smaller scale wall of size 500 mm × 500 mm with thickness 125 mm was constructed for the testing under vertical load. Both of the walls were wet-cured for 28 days before tested. The test involves two-point vertical load on top of the wall. Important results such as load capacity, deflection, cracking pattern, and failure modes were noted.

3 Methodology

To investigate use palm oil clinker (POC) as course aggregate to fulfill the requirement for lightweight self-compacting concrete, laboratory testing was conducted to determine the strength POC as a suitable substitution for course aggregate. After obtaining the best mix design, two wall samples of size 500 mm × 500 mm × 125 mm have been fabricated to determine the maximum design strength under vertical loading. The primary objective of this study is to obtain reliable experimental data of the vertical load—displacement response of the structure until total collapse. The results are used to access the strength of the wall under investigation with respect to different type of course aggregate used in the SCC.

3.1 Materials and Design Mix of Lightweight Self-compacting Concrete (LWSCC)

In this research, the common materials for concrete such as tap water, Ordinary Portland cement, sand and natural gravel was used for the control sample. However, a substitution of palm oil clinker (POC) for gravel, fly ash, and admixture (superplasticiser) was used for the second sample. POC was collected from a local palm oil mill in Kulaijaya, Johor. All the clinkers collected from the boiler must be crushed into smaller size manually using hammer into an about fist-sized before being ground mechanically. The clinkers are then sieved using BS 410 sieve in order to be used as course aggregate substitution of size 10 mm. Aggregates larger

than 10 mm were crushed again, while smaller than 5 mm were discarded. The POC must first be left to cool at room temperature for around 24 h before adding them into the concrete mix. Meanwhile, superplasticizer is used to suit the requirements for producing SCC.

3.2 Experimental Work for Mix Design

The evaluation on development of lightweight self-compacting concrete (LWSCC) will be conducted during fresh state and hardened state. The mechanical properties test was conducted for both normal SCC and lightweight SCC. Slump flow test is the only test conducted during fresh state. It is done to observe the workability of the concrete. At hardened state, strength performance test such as compression test, flexural test, and splitting tensile test were done.

3.3 Experimental Work for Wall Samples

The current study involves two wall samples with different type of material for course aggregate. The strength and crack pattern for both samples are observed and recorded. Both samples have the same dimensions of 500 mm × 500 mm with thickness of 125 mm. Tables 1 and 2 show the material properties of both samples.

Table 1 Material properties

Properties	
Type of cement	Portland
Size of sand	2.36 μm
Size of aggregates	10 mm
Grade concrete	30 N/mm^2

Table 2 Constituent material composition for SCC and LWSCC

Type of mixes	Normal self-compacting concrete	Lightweight self-compacting concrete
Free-water/cement ratio	0.57	0.57
Free-water content (kg/m^3)	200	200
Cement content (kg/m^3)	348.57	348.57
Fine aggregate content (kg/m^3)	716.31	716.31
Course aggregate content (kg/m^3)	675	430

3.4 Testing of Samples

Once the samples are cured for 28 days, it is set up for testing. Prior to loading, the slabs were painted white to facilitate crack detection and marking of crack patterns. The samples are loaded onto a flat surface on the frame as in Fig. 1. Two concrete strain gauges are installed on the surface of the samples as shown. The function of the strain gauges is to measure the amount of stresses generated. Two LVDT's are used to measure the deflections of the slab. The two LVDT's are placed on both sides, exactly in the middle, respectively to measure horizontal displacement. Load increment of 0.3 kN/s is subjected on top of the wall acting as vertical load. The samples are loaded continuously until failure. Each crack formed on the slab surface is marked.

4 Results and Discussion

4.1 Slump Flow Test

Table 3 shows the result for both types of concrete mix. Both mixes passed the requirement of self-compacting concrete which is having diameter of more than 650 mm. The presence of superplasticizer has produced high workability for the concrete.

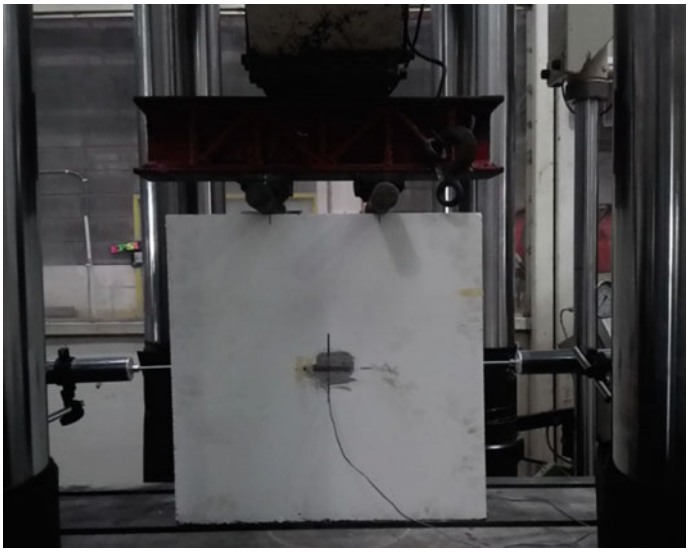

Fig. 1 The set up of testing

Table 3 Properties of SCC and LWSCC (fresh concrete)

	Normal self-compacting Concrete	Lightweight self-compacting concrete
Slump diameter (mm)	660	650

4.2 Compressive Strength Test

Referring to Table 4, the compressive strength at 7 days for normal SCC is 28.373 N/mm^2, while lightweight SCC is 27.16 N/mm^2. The difference between the strength at 7 days is only 4.3%, whereas for 28 days, the compressive strength of normal SCC is 46.936 N/mm^2 and lightweight SCC is 44.080 N/mm^2. The difference between the strength at 28 days is only about 6%. Both mixes exceed the design grade of 30 and show good compressive strength.

4.3 Splitting Tensile Test

As shown in Table 5, the split tensile strength of normal SCC is slightly higher than lightweight SCC, which is 3.435 and 3.292 N/mm^2, respectively. The difference between these two concrete mixes is 4.2%. It can be said that lightweight SCC posses almost similar tensile strength as normal SCC due to the slight difference.

4.4 Flexural Strength Test

Table 6 shows the result for flexural tensile strength test. From the table, we can conclude that lightweight SCC has almost similar value for flexural strength as compared to normal SCC. The value of flexural strength of normal SCC and lightweight SCC are 4.678 and 4.549 N/mm^2, respectively, with a difference of only 2.8%.

Table 4 Compressive strength of normal self-compacting concrete

Type of concrete	Day	Mean cube strength (kg/m^3)
SCC	7	28.373
	28	46.936
LWSCC	7	27.160
	28	44.080

Table 5 Splitting tensile strength

Type of concrete	Average split tensile strength (N/mm^2)
SCC	3.435
LWSCC	3.292

Table 6 Flexural tensile strength

Type of concrete	Average modulus of rupture (N/mm^2)
SCC	4.678
LWSCC	4.549

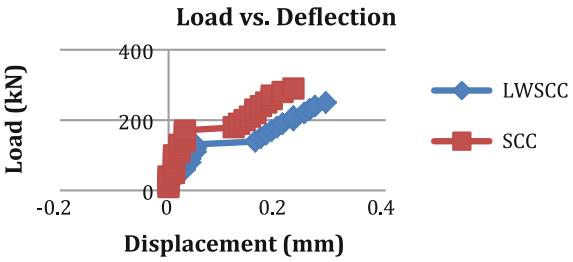

Fig. 2 Load versus deflection

4.5 Load Deflection Result

Figure 2 shows the result for load vs. displacement. The maximum load recorded for normal SCC is 293 kN, which occurred at displacement of 0.23 mm before collapse. On the other hand, it can be observed that the maximum load recorded for lightweight SCC is 251 kN, which occurred at a displacement of 0.29 mm. In comparison, by using POC as course aggregate, the maximum load difference recorded was 42 kN, which is 14.3% lower compared to using normal gravel as course aggregate. Because the difference is not much, using POC is still considered reliable.

5 Conclusion

Based on the result of the study, the following conclusions can be made.

The average density for the lightweight concrete mix is 2128 kg/m^3, which is 11.3% lower than the normal weight concrete mix.

i. The lightweight self-compacting concrete has good workability due to the use of supersplasticizer. The slump flow diameter is 650 mm × 670 mm.
ii. The results from material properties tests indicate that POC clinker posses slightly lower strength in comparison with normal course aggregate, however, still higher than standard requirement.
iii. The load carrying capacity of lightweight wall sample is slightly lower, which is 251 kN compared to normal weight wall sample which is 293 kN with a difference of 14.3%.

Acknowledgements We would like to take this opportunity to acknowledge the Universiti of Malaysia Perlis for the financial support to implement this research.

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Chapter 30
The Potential of Blended Cement Mortar Brick Using Sewage Sludge and Eggshell Waste

Shu Ing Doh, Yeong Yu Tan, Siew Choo Chin and Su Kong Ngien

Abstract Sewage sludge is one of the largest contributors toward solid waste in Malaysia. The amount of sewage generated is expected to increase every year, which is in line with the population growth in Malaysia. Landfilling has been identified to be the most widely used method to dispose of sewage sludge in Malaysia. This high amount of solid waste resulted in shortage of landfilling area, which has indirectly increased the cost of waste management in Malaysia. Hence, the aim of this chapter is to identify the potential use of solid wastes; namely sewage sludge and eggshell as partial cement replacement in mortar bricks. The sewage sludge and eggshell wastes were obtained from Indah Water Konsortium (IWK) and Eggtech Manufacturing, respectively. Both sewage sludge and eggshell powder were treated prior to mixing. The organic materials in the sewage sludge were removed through incineration process at a temperature of 800 °C for 3 h in which Incinerated Sewage Sludge Ash (ISSA) was produced. Meanwhile, the eggshell waste was dried under the sun before being ground into powder form. The treated ISSA and eggshell powder were then mixed with Ordinary Portland Cement, fine aggregates, and water to produce mortar bricks. Tests including compressive strength, flexural strength, and water absorption were conducted on bricks formed from four different percentages of eggshell powder (5–20%) with 10% ISSA. Findings showed that 10% ISSA as partial cement replacement with 5% eggshell as additive has increased the strength of the mortar bricks tested to 72% higher than the strength of the control bricks.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_30

Keywords Absorption · Compressive strength · Eggshell · Flexural strength
Sewage sludge · Wastewater management

1 Introduction

Sewage sludge is a semisolid material, also referred to as biosolids, that is, the by-product of sewage treatment plants. It contains mineral, organic, and biological impurities in soluble, insoluble, and colloidal form. Indah Water Konsortium (2010) estimated the population of Malaysia to be 32.4 million in 2020 and 36 million by 2030. The increase of population will directly increase the generation of sewage sludge. An annual estimate of 7 million cubic metres of sewage sludge will be produced in the year 2020 and this is recorded by Indah Water Konsortium (2010). It is estimated that approximately 1.7 million tonnes of incinerated sewage sludge is produced annually worldwide and the amount is likely to increase in the future. The best way to recycle the nutrients and organic matters contained in sewage sludge is through the utilization of land (Sanchez-Monedero et al. 2004).

In the past, sewage sludge has been used as fertilizer in agriculture. Unfortunately, Hsiau and Lo (1998) and, more recently, Herzel et al. (2016) discovered the occurrence of high heavy metal in sewage. Concerns had been increased toward the exposure of emerging pollutants such as metals, organic contaminants and pathogenic bacteria in sewage sludge as these might threaten human health through crops cultivated in sewage or compost-amended soils (Zuloaga et al. 2012).

Eggshell is rich in calcium carbonate, $CaCO_3$, which makes up about 94% of the shell (Murakami et al. 2007). Eggshell is known to have potential to be mixed with cement-based material for strength and properties improvement. Tsai et al. (2007) suggested that eggshell is traditionally useless and is usually disposed in landfills without any pretreatment. Calcium carbonate, namely limestone, which contains calcite, is used as additive in concrete (Matschei et al. 2007). The presence of reactive calcite alters the mineralogy of hydrated cement paste.

Current research shows that the use of incinerated sewage sludge is very minimal, up to only 8% as cement replacement and 20% as cement additive. One of the methods which can be used to increase the use of incinerated sewage sludge is to include calcium carbonate. The typical calcium carbonate source used in the construction industry is limestone, which is a type of nonrenewable material obtained from quarrying. In this investigation, eggshell containing 95% calcium carbonate is used as additive to optimize the use of sewage sludge as cement replacement in concrete.

2 Materials and Methods

The materials used in the investigation were incinerated sewage sludge ash (ISSA), eggshell powder, ordinary Portland cement, fine aggregates, and water. The preparation of material such as ISSA and eggshell powder is further discussed in

this section. Besides that, the standards used for all the experiments were also clearly defined.

2.1 Incinerated Sewage Sludge Ash (ISSA)

The sewage sludge used in this research was collected from an IWK sewage treatment plant (Fig. 1) located in Kuantan which caters to a commercial area. At the sewage treatment plant, the sewage sludge was sun-dried at the sludge bed. Once collected from the sewage treatment plant, the sewage sludge was oven-dried at 105 °C for 24 h to lower the moisture content of the sample before being sent for incineration at 800 °C for 3 h and 30 min. The product from the incineration process is known as ISSA. The ISSA is then cooled down to room temperature before being packed into sealable bags. Prior to mixing, the ISSA has to be ground into fine particles and sieved as only particles passing through 150 μm sieve were used in this research. Figure 2 shows the sample of ground ISSA.

2.2 Eggshell Powder

The eggshells used in this research were collected from Eggtech Manufacturing Sdn Bhd in Kuala Selangor. The eggshells were spread onto trays to be dried under the sun. The dried eggshells were then ground into powder using a grinder. The color of the ground eggshells is barley white as shown in Fig. 3.

Fig. 1 Sewage sludge dried at the sludge bed under sun

Fig. 2 Incinerated sewage sludge ash (ISSA)

Fig. 3 Eggshell powder

2.3 Ordinary Portland Cement

The cement used in this research is YTL ORANG KUAT Ordinary Portland Cement (OPC). YTL ORANG KUAT is certified to MS 522-1: 2007 (EN 197-1: 2000), CEM I 42.5 N/52.5 N, and MS 522: Part 1:2003. This cement is widely used in Malaysia for construction work particularly in bricklaying, concreting, plastering, screeding, and tiling. In this research, only cement from the same batch was used to ensure the accuracy and consistency of the research.

2.4 Fine Aggregate

The fine aggregates used in this research are natural fine sand sourced from Panching, Kuantan. The sand need to pass through a sieve of 4.75 mm in order for it to be considered as fine aggregate, according to ASTM standard. In this research, the sand was sieved and stored in air dry condition as excess moisture in the sand will affect the strength and properties of the mortar paste.

2.5 Water

The water to cement ratio (W/C) used in this research was 0.6. Water plays an important role in mortar mixing as it causes the hardening of mortar through the hydration process. In addition, water also provides good workability to the cement mortar. The water used in this research was taken from a normal water reticulation system that is free of impurities in order to prevent any side reaction during the hydration process.

2.6 Preparation of Mix Design

The mortar mix was designed according to the standard ASTM C1329-05, a type N mortar, where the proportion of sand to cement to water is 2.75:1:0.6. The main ingredients in the mortar were cement, sand, water, incinerated sewage sludge ash and eggshell powder. Two types of mould were used during specimen preparation. The mould with dimensions of 50 mm × 50 mm × 50 mm is used for compressive strength and total porosity test, while the brick mould, measuring 210 mm 100 mm × 65 mm, is used in flexural test. Table 1 lists the mix design of different combinations of blended cement used as partial cement replacement.

After the mortar paste was evenly mixed, it was placed on a tray before being poured into the mould. A layer of grease was applied on the mould surface prior to

Table 1 Summary of mix design

Type of mortar bricks	Composition
Control	0% of ISSA + 0% of eggshell powder
SE 0	10% of ISSA + 0% of eggshell powder
SE 5	10% of ISSA + 5% of eggshell powder
SE 10	10% of ISSA + 10% of eggshell powder
SE 15	10% of ISSA + 15% of eggshell powder
SE 20	10% of ISSA + 20% of eggshell powder

mortar casting. The mortar samples were cured for 24 h before being demoulded for water curing. The specimens were tested at 1, 7, and 28 days.

3 Results and Discussion

Results from the experiments were recorded and discussed according to compressive strength, flexural strength, and water absorption. The results were based on the average of three specimens.

3.1 Compressive Strength

The compressive strength test was conducted according to BS1881: Part 116:1983. The mortar bricks were cured using water curing and its compressive strength was tested at the ages of 1, 7, and 28 days. The relationship between compressive strength versus age of concrete for different mix design is plotted in Fig. 4. From the figure, it is observed that the early compressive strength of the blended cement is relatively low compared to the 28 days compressive strength. This can be explained by the findings of Cyr et al. (2007) whereby the occurrence of sewage sludge could have retarded the development of concrete strength since there is a delay in the early hydration process. Meanwhile, at 7 days, it was found that the compressive strength of different mix design of the mortar ranged from 14.01 to 25.35 MPa. It is observed that the 7 days compressive strength of the blended mortar brick is more than doubled than that of its one-day compressive strength. From the result, SE 5 achieved the highest compressive strength of more than 25 MPa. This implies that it is suitable to be used as structural brick instead of non-loading brick.

For 28 days compressive strength, all the other specimens attained a higher compressive strength compared to the control bricks except for SE 20. SE 5 exhibited the highest compressive strength of 38.02 MPa, followed by SE 15 and SE 10 with approximately 28.51 and 28.27 MPa, respectively. SE 20 portrayed the lowest compressive strength of approximately 17.58 MPa.

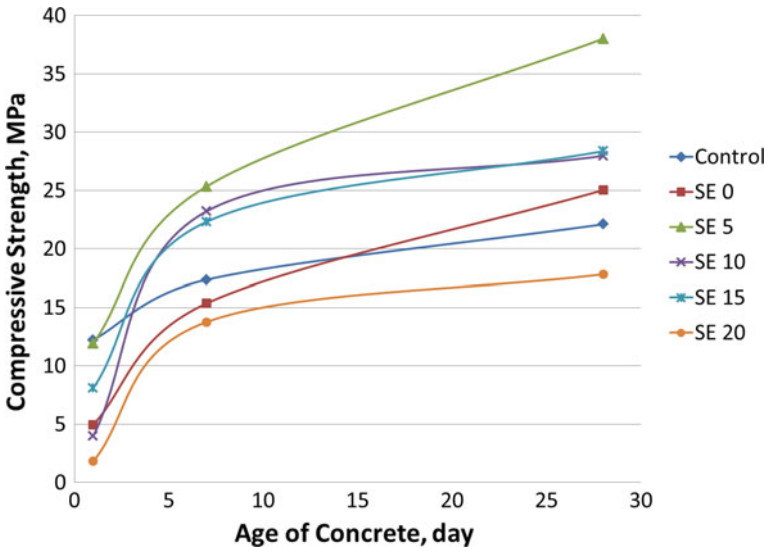

Fig. 4 Relationship of compressive strength with age of concrete

3.2 *Flexural Strength*

Flexural strength test was carried out according to the standard for compressive strength (ASTM C78/C78 M-15a). Flexural strength test was conducted at 1, 7, and 28 days. The relationship between the flexural behavior of various types of blended cement is depicted in Fig. 5. At the early stage, it was found that the flexural strength of the control mortar brick, 3.25 MPa, is the highest among the mortar bricks. The mortar bricks of SE 0, SE 5, SE 10, and SE 15 achieved a flexural strength of 2.43, 3.25, 2.76, and 2.23 MPa, respectively. The flexural strengths of the control bricks were higher than the other bricks by 15.08–38.15%. At 28 days, similar to that obtained in the compressive strength test, SE 5 achieved the highest flexural strength at 7.50 MPa, which is approximately 16.64% higher than the control brick. In general, cement replacement with sewage sludge may delay the early hydration process, thus retarding the strength development of mortar (Lynn et al. 2015).

3.3 *Water Absorption Test*

Castro et al. (2011) suggested that the water absorption test is an important laboratory analysis or important factor in determining the durability of cementitious systems. Hence, this test is only conducted on concrete of 7 and 28 days. Figure 6 illustrates the water absorption with different mix design. From the figure, it was

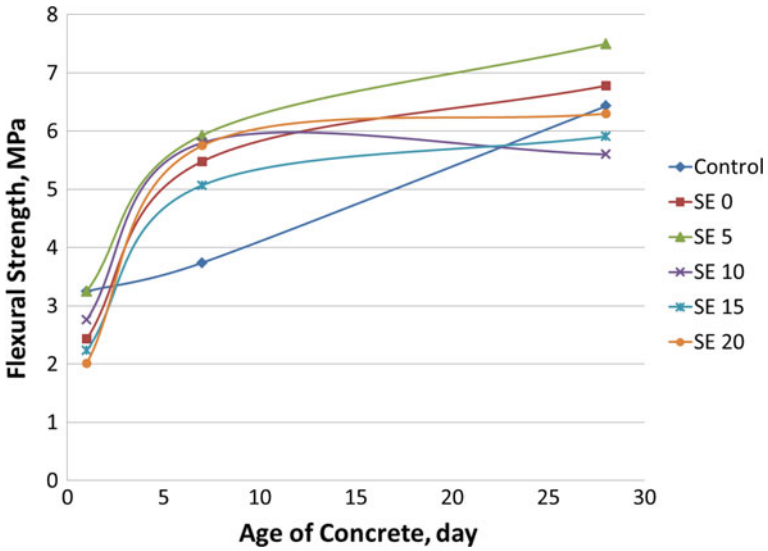

Fig. 5 Relationship of flexural strength with age of concrete

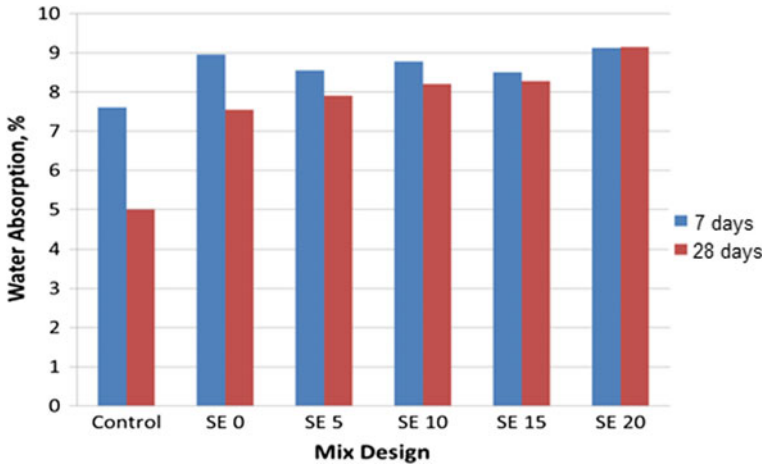

Fig. 6 Water absorption of different mix design

found that in general the rate of water absorption at 28 days is lower compared to the same sample at 7 days. The water absorption for blended cement is relatively higher than the control mix. Hence, it can be summarized that the replacement of sewage sludge and eggshell powder has increased the pore size of the mortar which resulted in higher water absorption in cement mortar (Lynn et al. 2015).

4 Conclusion

This research had demonstrated the utilization of ISSA as a partial replacement for cement in mortar bricks and eggshell powder as an additive. Based on the analysis, several conclusions can be drawn, which are given as follows:

1. In general, utilization of ISSA as partial cement replacement and raw eggshell powder as additive in mortar bricks has increased the strength of the bricks. SE 5 had achieved the highest compressive strength of 38.02 MPa at 28 days, which is 72.04% higher than the control specimen. With the addition of 20% of eggshell powder, SE 20 has shown reduction in the compressive strength of the mortar brick. The strength reduction was about 24% and >100% compared to the control and SE 5 sample, respectively.

With the addition of 5% eggshell powder, SE 5 achieved the highest flexural strength, 7.50 MPa, which is about 14% higher than the control mix. It was found that the flexural strength decreases as the percentage of the eggshell powder increases. The flexural strength against compressive strength range from 19.73 to 29.10%.

The water absorption of blended cement increases as the amount of eggshell powder increases. However, the percentage of water absorption of blended cement is still within the acceptable range.

Acknowledgements The author would like to express special thanks to Indah Water Konsortium Sdn Bhd and Eggtech Manufacturing Sdn Bhd for their contribution in providing sewage sludge and eggshell, respectively throughout the research as well as to Universiti Malaysia Pahang for the research facilities.

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Chapter 31
Strength Development of Pervious Concrete Embedded with Latex and Polypropylene Fiber

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Abstract Nowadays, in Malaysia, there is flooding issue during heavy rainfall. This is caused by an increase in infrastructure and construction. So, the surface of the water that infiltrates into the earth is very limited. However, to overcome this situation, pervious concrete is the best alternative solution. Pervious concrete has been increasingly used to reduce the amount of runoff water to the drainage system and sidewalks. However, the mechanical properties of pervious concrete are lower in compressive strength and has limited usage of application. These investigations will be carried out to determine the strength of pervious concrete with different percentages of polypropylene fibers. In this study, a series of volume polypropylene fiber and SBX latex, which is fixed to 0, 0.5, and 1.0% will be used in pervious concrete. The result will indicate the effect of polypropylene fibers and inclusion of SBR latex as admixture and modify concrete properties for the strength development of pervious concrete. Polypropylene fiber existence incorporates with SBR latex effect in the permeability of pervious concrete. While SBR latex also helping in strengthen the bonding of pervious specimens since it is high in tension.

Keywords Compressive strength · Latex · Pervious concrete · Polypropylene Tensile strength

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_31

1 Introduction

Pervious concrete is a porous concrete paving material which allows precipitation and stormwater runoff to flow through it rather than flood surrounding areas or storm drains. Pervious concrete also called Porous concrete or Enhanced Porosity Concrete (EPC) is a macro-porous concrete that is gaining rapid popularity in many parts of the world because of its applications in sustainable construction (Kuennen 2003; Huffman 2005). Besides, pervious concrete is a concrete mixture contained cement, coarse aggregates, water, and in some cases admixtures. Pervious concrete is a special type of concrete with a high porosity used for concrete flatwork applications (Obla 2007). It allows water from precipitation and other sources to pass through it, thus reducing the surface runoff and recharging groundwater levels. Currently, pervious concrete is used in parking areas, areas with non-heavy traffic, pedestrian walkways, and greenhouses. According to Advanced Concrete Pavement Technology (ACPT) (2012), pervious concrete contributes to credits in the Leadership in Energy and Environment Design LEED® rating system for sustainable building construction. One of the benefits provided by pervious concrete is best practice in stormwater management tool. The stormwater unable to be managed by conventional concrete that is impervious, thus will disturb the surface and groundwater circulation that can lead to flood and erosion (Aoki et al. 2008). This situation happened when the surface runoffs on a conventional concrete are higher than the infiltration process.

The primary benefit offered by pervious concretes is their ability to infiltrate large volumes of water through the material structure, thus reducing or eliminating problems associated with stormwater runoff (Powell and Morgenstern 1985). The Environmental Protection Agency (EPA) recognized the use of pervious concretes as one of the best management practices for reducing stormwater runoff. It is designed with an open-graded aggregate structure, resulting in a high interconnected air void content that allows water to penetrate through the pavement (Obla 2007; Martin et al. 2014).

Pervious concrete is an alternative material to conventional pavements, particularly in low volume traffic and parking applications. The properties of pervious concrete were evaluated through air void test, permeability test, compressive strength test, and split tensile strength test. The number of pervious concrete installations has been consistently increasing not only for the traditional uses of stormwater volume reduction and quality improvements but also for nontraditional uses such as quiet pavements and urban heat island mitigation (Bury and Mawby 2006). Pervious concrete also possess other major benefits including reduction in heat island effects, standing water on pavements and tire-pavement noise emissions (ACI 2010). The process of reduction in heat island effects when the water is percolating through the pavement which exerts a cooling effect by evaporation and convective airflow that also will help to reduce the heat 2009). Meanwhile, the standing water on pavements is important to be eliminated, since its existence on pavement may reduce skid resistance of vehicles. Last but not least, tire–pavement

noise emissions may be reduced since the open structure of pervious concrete contribute in absorbing noise at tire–pavement interface (ACI 2010).

There are many advantages of pervious concrete such as the rainwater were quickly filtered into ground; the groundwater resources can renew in no time. The pervious concrete pavement is able to absorb the noise of vehicles, which creates quiet and comfortable environment. In rainy days, the pervious concrete pavement has no plash on the surface and does not glisten at night. This improves the comfort and safety of driver. Besides that, the pervious concrete pavement materials consist of pores that can cumulate heat.

2 Methodology

The mix proportion for this study was designed and modified based on previous research. The alteration to this study was seen by the inclusion of latex and also polypropylene. The aggregate was granite and fixed to 20 mm passing. The latex used was SBR Latex provided by SIKA Kimia. The polypropylene used was fibrillated polypropylene fibers. The procedure of mixing pervious concrete started by pouring the coarse aggregates into the mixer. After that, cement can be added to the mixer together with aggregates. Then, the mixer will be turned on and the cement will be mixed and aggregated for 1 min. Water is then added in the mixer and the mixer will mix for 3 min. Next, polypropylene fiber is added in the mixer. SBR latex is added after the polypropylene fiber in the mixer is mixed. The content of water in the mixture will affect the structure of pervious concrete. After the mixture was mixed thoroughly, it was cast inside the cube size 100 × 100 × 100 mm and cylinder of size 100 Ø × 200, respectively. The entire cast specimen compacted using mechanical vibrated machine. Last, the specimen was applied on the vibrator to ensure the mixture is cast properly. Table 1 shows the mix proportion of pervious concrete used in this study.

Table 1 Mix proportion for pervious concrete used in this study

Specimen	Aggregates (mm)	Percentage of fiber (%)	Cement (kg/m^3)	Latex (kg/m^3)	Coarse aggregates (kg/m^3)	Water (kg/m^3)	Fiber (kg/m^3)
OPC	20	0	333.60	0.00	1501.40	116.70	–
0.5P		0.5	330.75	0.00	1492.62	116.00	4.75
1.0P		1.0	330.75	0.00	1481.58	116.00	9.50
L		0	330.75	41.70	1501.40	116.70	–
0.5PL		0.5	330.75	41.82	1492.62	116.00	4.75
1.0PL		1.0	330.75	41.82	1481.58	116.00	9.50

3 Results and Discussion

Figure 1 charted the compressive strength of pervious concrete incorporated with latex and polypropylene fiber. It is proved that the inclusion of latex and polypropylene shows enhancement in compressive strength as compared to the plain pervious sample (OPC). On day 7, the highest compressive strength is recorded by latex sample (L) and followed by 0.5PL, 0.5P, OPC, 1PL, and 1P samples with 20.97, 18.91, 18.74, 15.16, 14.69, and 10.37 MPa, respectively. This shows that the pervious concrete performs better compressive strength with the inclusion of cement and latex only. On contrary, with the addition of polypropylene, the compressive strength of pervious concrete shows a similar strength enhancement when paired with or without latex. The optimum strength enhancement for pervious concrete incorporated with polypropylene was obtained at 0.5% only. This proves that at 0.5% inclusion is enough to improve the bonding and integration between the pervious microstructure as compared to the plain pervious sample. However, at higher inclusion of polypropylene, the compressive strength is reduced. This is marked by 1.0P which represent polypropylene and 1.0PL, which represent polypropylene and latex. The reduction in compressive strength occurred due to the disintegration of high volume of fiber in the pervious microstructure, which provides loose bonding between cement and aggregates region. In addition, high compressive strength for latex mix (L) was obtained due to the better dispersion of cement and aggregate which makes the binding of cement with aggregates is uniform.

The compressive strength for day 28 is charted in Fig. 1. The strength development at day 28 shows a similar strength enhancement shows on day 7. The highest compressive strength was marked by latex sample (L) and followed by

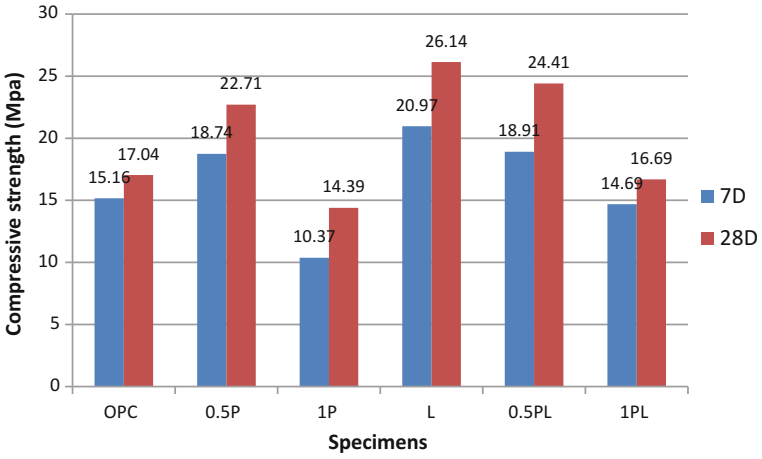

Fig. 1 Compressive strength for day 7 and 28 for pervious concrete

0.5PL, 0.5P, OPC, 1PL, and 1P samples with 26.14, 24.41, 22.71, 17.04, 16.69, and 14.39 MPa, respectively. This proves that the enhancement of pervious concrete is contributed by the latex and also polypropylene. The addition of latex in the pervious concrete shows better dispersion effect at age 7 and continue on day 28, which provides uniformity in the pervious concrete. Due to the uniformity, the hydration or binding gel (C–S–H) gel was uniformly formed and resulting in higher compressive strength. The disintegration of polypropylene in the pervious concrete looks continue on day 7 and on day 28. Due to this effect, at higher inclusion of polypropylene, the compressive strength is showing a decrease pattern as compared to the plain pervious and latex pervious concrete.

Based on Fig. 1, another discussion on the strength development from day 7 to day 28 can be monitored. Based on percentage, OPC mix recorded 12% development from day 7 to day 28, inclusion of 0.5% polypropylene (0.5P) marked a strength development at 21, 1% inclusion of polypropylene (1.0P) recorded strength development at 38%. This is followed by latex pervious concrete (L) with strength development at 24, 0.5% inclusion of polypropylene and latex (0.5PL) with 29 and 1% polypropylene with latex (1.0PL), which recorded strength development at 13%. Although 1.0P mix shows low compressive strength at every age of testing, the strength development to achieve the strength on day 28 was the highest as compared to the pervious mix. Despite the disintegration effect of polypropylene, with the addition of fiber, increase the tendency of those pervious samples to improve the compressive strength. It was suspected that increased in the percentage of fibers, will result in low compressive strength but high strength development due to the tailored effect of polypropylene fiber in the microstructure of pervious concrete.

4 Conclusion

The inclusion of latex and polypropylene in the pervious concrete proves to enhance the compressive strength, respectively. Apart from that, enhancement effect for compressive strength is contributed by dispersion effect between uniformity structure of aggregates. In addition, this research contributes to the new design and alternative or conventional design for rigid pavement.

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Chapter 32
Effect of Inflow and Infiltration in Sewerage System of Residential Area, Kuantan, Pahang

Hiew Thong Yap, Su Kong Ngien, Norasman Othman, Norhan Abd Rahman and Chee Ming Choo

Abstract Inflow and infiltration is a phenomenon in sewerage systems that give negative effects on the environment and human health if not addressed properly. Collaboration has been made between Universiti Malaysia Pahang and Indah Water Konsortium Sdn. Bhd., where the purpose is to evaluate the amount of inflow infiltration happening in sewerage systems of residential areas in Kuantan. For this part of the study, one sewer pipeline was selected at the residential area of Bandar Putra, having a population equivalent of 1694. The method used in this research was the Flowrate method to tabulate data. ISCO 2150 and 4250 Area Velocity Flowmeters were used to measure flow rate data in the sewer pipeline, whereas ISCO 674 Rain Gauge was used to collect rainfall intensity data. The data were collected for 41 days with each measurement separated by an interval of five minutes. The result shows that the average percentage infiltration rate of Q_{peak} and Q_{ave} in this residential catchment were 6.0 and 19.4%, respectively. Inflow and

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_32

infiltration is a real concern, more study is required to determine whether revision of the infiltration rate recommended in the Malaysian Standard is needed.

Keywords Inflow · Infiltration · Rainfall · Sewerage system

1 Introduction

Integrated urban sewerage system allows for high density of population and imperviousness associated with urbanization. Its role is to transfer wastewater to natural waters through urbanization (Kaushal and Belt 2012). Functional efficiency of sewer systems includes conveyance of wastewater from urban and industrial areas to sewerage treatment plants without inflow and infiltration (Rehan et al. 2014). Inflow and infiltration is a phenomenon in sewerage systems that bring negative effects to the environment, human health, and the sewerage system itself (Beheshti et al. 2015). According to EPA (2014), inflow is defined as sources of water that enters the sewerage system from manhole covers, area drain, and roof leaders, whereas infiltration is defined as water from the subsurface that enters into sewerage system through defective pipes and loose joints.

Malaysia is a tropical country and the separate sanitary sewer system is commonly applied which only transport sanitary wastewater to sewerage treatment plant. The allowable infiltration rate should be incorporated into the sewerage system design. Based on Malaysian Sewerage Industry Guideline (MSIG) Volume III, maximum allowable infiltration rate is stated as 0.05 m^3/mm/km/day (MSIG 2009). Besides that, according to Hammer and Hammer, the maximum allowable infiltration rate of peak hourly sanitary flow and average flow is 3–5 and 10%, respectively. The purpose of this research is to evaluate the amount of inflow infiltration happening in the sewerage system of Bandar Putra, Kuantan by comparing to allowable infiltration rate of peak hourly sanitary flow and average flow mentioned in Hammer and Hammer (2012).

According to previous studies in Norway, it was demonstrated that extraneous sources entering into sewer systems would overload the capacity of the sewer pipeline and increase the cost of maintenance required (Beheshti et al. 2015). Another case study was done in Columbus, where 116 private houses were investigated. The result showed that 68% of the sewer pipeline was tested and inflow and infiltration occurred in the residential area (Pawlowski et al. 2014). A report investigating quantification of inflow from surface water and infiltration from groundwater was done by Karpf and Krebs (2011). The method used was inflow infiltration modeling combined in a quasilinear model. The finding showed that a 79% rate of inflow infiltration was expected in 3% of total sewer length monitored.

There are a few studies done locally by Rahman et al. (2003, 2007). By comparing between the infiltration rate calculated from site and the one recommended in MS 1228:1991, the studies showed that the infiltration rate was higher than MS

1228:1991 in Skudai, Johor. Another similar research was done in Kuantan Pahang and the result also showed the infiltration rate from site was higher than MS 1228:1991 (Yap and Ngien 2015).

2 Fundamental of Inflow and Infiltration Measurement

Flowrate method was used to investigate inflow and infiltration rate based on the analysis of daily hydrograph (Benedittis and Bertrand-Krajewski 2005). This method is the most commonly used method to calculate mean hourly, daily or annual inflow and infiltration. Dry weather period measurement is necessary to estimate the total flow of wastewater in a sewer pipeline. Based on Eq. (1), total flow of wastewater in sewer pipeline, Q_T is the combination of sanitary wastewater flow, Q_{sw} and wastewater flow except for sanitary flow which means infiltration flow, Q_{inf}.

$$Q_T = Q_{sw} + Q_{inf} \tag{1}$$

Infiltration rate is frequently expressed as the infiltration flow divided by the length of sewer pipe and divided again by the diameter of the sewer pipe as shown in Eq. (2).

$$\text{Infiltration rate} = \frac{Q_{inf}}{\left(L_{pipe} x \emptyset_{pipe}\right)} \tag{2}$$

The unit of Q_T, Q_{sw}, and Q_{inf} is m^3/day. L_{pipe} has a unit of km and $\emptyset_{pipe}$ has a unit of mm. As mentioned previously by Hammer and Hammer (2012), estimation of infiltration rate percentage of peak hourly sanitary flow is from the range of 3–5% or 10% of the average.

3 Methodology

In this inflow infiltration study, Universiti Malaysia Pahang (UMP) is collaborating with Indah Water Konsortium Sdn. Bhd. (IWK), Pahang branch. This study is divided into several stages such as information gathering, site survey, and data collection. During the information gathering stage, meeting with authorized staff was done at IWK office to discuss suitability as well as to collect more information on the selected site location. Once the site location was selected, site survey started after that. During the site survey, site visit to the area as well as a population equivalent (PE) survey was done. The data was collected in terms of flow rate, water level, and velocity of wastewater in the sewer pipeline. Data analysis began as soon as the data was extracted from the equipment.

3.1 Site study

The residential catchment, Bandar Putra was selected in this study. This residential area has a coordinate of 3.765650, 103.320367 on the map and is 520 m away from Sungai Kempadang. Besides that, there is one pond with an invert level of 0.9 m near the selected sewer pipeline. The selected sewer pipeline is between manhole MH 92a and MH 92b. The sewer pipeline is located outside a sewerage treatment plant that has the code number KUN 285. The length and diameter of the sewer pipeline selected were 25.7 and 0.4 m, respectively. PE surveyed in the residential catchment was 1694 PE. Figure 1 shows a close-up of the sewer reticulation layout of Bandar Putra.

3.2 Equipment and Materials

The main equipment consists of ISCO 2150 and 4250 Area Velocity Flowmeters as shown in Fig. 2 and was installed separately in MH 92a and MH 92b. Both flowmeters functioned to collect data at interval of every 5 min. Low profile sensor attached to the flowmeters was fixed in the sewer pipeline using mounting ring to measure flow rate data. Calibration of flowmeters was done at the Hydrology and Hydraulic Laboratory of UMP. Calibrated error percentage for the flowmeters was incorporated into the inflow and infiltration measurement (Yap et al. 2017). Rainfall data was also collected at intervals of every five minutes using the ISCO 674 Rain Gauge installed inside the sewerage treatment plant area. Flowlink 5.1 was used to extract and analyze data from both flowmeters.

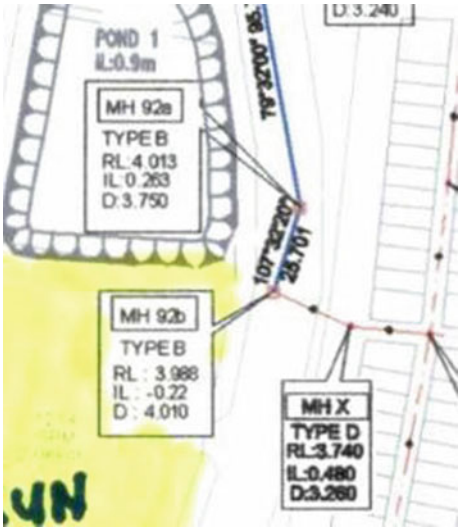

Fig. 1 Sewer reticulation layout of Bandar Putra

Fig. 2 ISCO 2150 and 4250 area velocity flowmeters

4 Results and Discussion

In this research, 41 days worth of data was collected from Bandar Putra. It was divided into three phases, which were 26 February 2016–9 March 2016, 11 March 2016–23 March 2016, and 25 March 2016–8 April 2016. Data was analyzed separately for dry and wet periods. Tables 1, 2 and 3 shows the tabulated result of each phase of data collection. Infiltration rate (I) was the difference of Downstream Infiltration Rate (D) and Upstream Infiltration Rate (U). The ratio indicated the ratio of Downstream Infiltration Rate (D) to Upstream Infiltration Rate (U) obtained from the monitored sewer pipeline. Meanwhile, Peak Hourly Flow (P) refers to the peak flow value from each hour in a day. Infiltration Rate of Q_{peak} was calculated as the percentage of Infiltration Rate (I) to Peak Hourly Flow (P). Infiltration Rate of Q_{ave} was calculated as the percentage of Infiltration Rate (I) to Upstream Infiltration Rate (U).

Table 1 shows the tabulated percentage result of infiltration rate from 26 February 2016 to 9 March 2016. There were only four days of rainfall recorded during this phase. On 28 February 2016, the result shows a negative infiltration rate value with a magnitude of 0.95 m^3/mm/km/d. This was because the Upstream Infiltration Rate was higher than Downstream Infiltration Rate. From Table 1 the highest Peak Hourly Flow was located on 5 March 2016 with the amount of 233.25 m^3/mm/km/d. This likely happened due to rainfall that occurred on that day.

Similar calculations for the second phase and third phase are shown in Tables 2 and 3. Table 2 shows the second phase from 11 March 2016 to 23 March 2016.

Table 1 Infiltration rate data from 26 February 2016 to 9 March 2016

Date (year 2016)	Total rainfall (mm)	Downstream infiltration Rate (D) (m^3/mm/km/d)	Upstream infiltration rate (U) (m^3/mm/km/d)	Infiltration rate (I) (m^3/mm/km/d)	Ratio = (m^3/mm/km/d)	Peak hourly flow (P) (m^3/mm/km/d)	Infiltration rate (%)	
							(Q_{peak}) $\left[\frac{I}{P}\right]$	(Q_{ave}) $\left[\frac{I}{U}\right]$
26 Feb	0	50.95	49.32	1.63	1.2	80.50	2.03	3.31
27 Feb	0.51	55.70	47.69	8.01		123.34	6.49	16.79
28 Feb	38.61	70.69	71.64	−0.95		226.22	−0.42	−1.32
29 Feb	1.02	66.93	65.59	1.34		133.25	1.00	2.04
1 Mar	0	63.44	58.78	4.66		120.45	3.87	7.92
2 Mar	0	60.31	50.77	9.54		123.81	7.71	18.80
3 Mar	0	61.01	50.30	10.70		154.78	6.92	21.28
4 Mar	0	53.13	49.67	3.46		117.57	2.94	6.96
5 Mar	7	62.49	44.56	17.93		233.25	7.69	40.24
6 Mar	0	57.73	38.75	18.98		102.34	18.55	48.99
7 Mar	0	57.10	38.57	18.52		108.55	17.07	48.03
8 Mar	0	56.57	39.34	17.23		114.49	15.05	43.81
9 Mar	0	56.03	36.62	19.41		111.30	17.44	53.01

Table 2 Infiltration rate results in the second phase

Date (year 2016)	Total rainfall (mm)	Downstream infiltration rate (D) (m^3/mm/km/d)	Upstream infiltration rate (U) (m^3/mm/km/d)	Infiltration rate (I) (m^3/mm/km/d)	Ratio = $\left[\frac{\sum D}{\sum U}\right]$	Peak hourly flow (P) (m^3/mm/km/d)	Infiltration rate (%)	
							$(Q_{peak})\left[\frac{I}{P}\right]$	$(Q_{ave})\left[\frac{I}{U}\right]$
11 Mar	0	56.96	49.52	7.44	1.14	120.27	6.19	15.03
12 Mar	0	47.50	42.24	5.26		110.61	4.76	12.46
13 Mar	0	48.80	43.51	5.29		109.54	4.83	12.15
14 Mar	0	60.02	53.57	6.45		102.57	6.29	12.05
15 Mar	0	51.88	43.47	8.41		103.48	8.13	19.35
16 Mar	0	41.51	36.72	4.78		110.96	4.31	13.02
17 Mar	0	47.69	39.51	8.18		92.85	8.81	20.70
18 Mar	0	39.70	37.57	2.13		89.59	2.38	5.67
19 Mar	0	49.92	46.07	3.85		92.17	4.18	8.36
20 Mar	0	45.52	40.44	5.09		91.47	5.56	12.58
21 Mar	0	51.41	42.98	8.43		101.06	8.34	19.62
22 Mar	0	49.02	41.42	7.60		92.17	8.24	18.34
23 Mar	0	42.52	38.92	3.60		89.44	4.02	9.25

Table 3 Infiltration rate result from 25 March 2016 to 8 April 2016

Date (year 2016)	Total rainfall (mm)	Downstream infiltration rate (D) (m^3/mm/km/d)	Upstream infiltration rate (U) (m^3/mm/km/d)	Infiltration rate (I) (m^3/mm/km/d)	Ratio = $\left[\frac{\sum D}{\sum U}\right]$	Peak hourly flow (P) (m^3/mm/km/d)	Infiltration rate (%)	
							(Q_{peak}) $\left[\frac{I}{P}\right]$	(Q_{ave}) $\left[\frac{I}{U}\right]$
25 Mar	0.51	52.85	42.55	10.3	1.18	185.42	5.55	24.2
26 Mar	0	47.63	43.5	4.14		212.48	1.95	9.52
27 Mar	0	50.36	42.67	7.69		212.2	3.62	18.03
28 Mar	37.59	56.18	43.5	12.69		231.22	5.49	29.17
29 Mar	0	52.13	42.77	9.35		239.06	3.91	21.86
30 Mar	0	51.05	46.67	4.38		218.58	2	9.39
31 Mar	0	50.88	43.29	7.59		218.65	3.47	17.54
1 Apr	0	51.29	42.95	8.34		198.21	4.21	19.41
2 Apr	0	52.02	42.77	9.24		222.92	4.15	21.61
3 Apr	0	55.12	46.67	8.45		237.68	3.56	18.11
4 Apr	0	47.73	42.55	5.18		264.01	1.96	12.17
5 Apr	0	48.45	41.93	6.52		251.06	2.6	15.56
6 Apr	0	46.76	39.65	7.11		234.77	3.03	17.93

Due to dry season during that period, low amount of rainfall was encountered. The analysis was for dry weather in this phase. The average value of Peak Hourly Flow was 100.48 m^3/mm/km/d, relatively lower than the first phase value of 134.60 m^3/mm/km/d. The ratio of Downstream Infiltration Rate to Upstream Infiltration Rate was 1.13, which was also lower than the wet weather phase. During the second phase, the value of Infiltration Rate on each day was within the range of 2.13–8.43 m^3/mm/km/d.

Table 3 shows the analysis for the third phase in this research. The rainfall intensity was recorded on the days of 25 March 2016 and 28 March 2016. The total amount of rainfall that occurred in this phase was 38.1 mm. When rainfall occurred, the infiltration rate was relatively higher at 10.30 and 12.69 m^3/mm/km/d on 25 March 2016 and 28 March 2016, respectively. The ratio of Downstream Infiltration Rate to Upstream Infiltration Rate was 1.18.

Figure 3 shows the hydrograph of rainfall, Infiltration rate of Q_{peak} and Q_{ave}. According to Hammer and Hammer (2012), the percentage of Infiltration Rate of Q_{peak} is in between 3 and 5%. Meanwhile, percentage of Infiltration Rate of Q_{ave} was 10% as mentioned previously. During the first phase on 28 February 2016, negative value of infiltration rate was found. That day was not included into the average percentage of Infiltration Rate. Thus, the result shows the average Infiltration Rate of Q_{peak} and Q_{ave} was 8.9 and 25.9% in the first phase. The percentage infiltration rate of both parameters gradually increased due to the value of Infiltration Rate which increased at the end of this phase.

In the second phase, the percentage of average Infiltration Rate of Q_{peak} and Q_{ave} were 5.9 and 13.7%, respectively. The percentages in this phase was quite consistent. During the third phase, the percentage average Infiltration Rate of Q_{peak} and Q_{ave} were 3.34 and 18.45%. Overall for all, the phases, the average percentage Infiltration Rate of Q_{peak} and Q_{ave} were 6.0 and 19.4%. Both parameters were slightly higher than the values mentioned in Hammer and Hammer (2012).

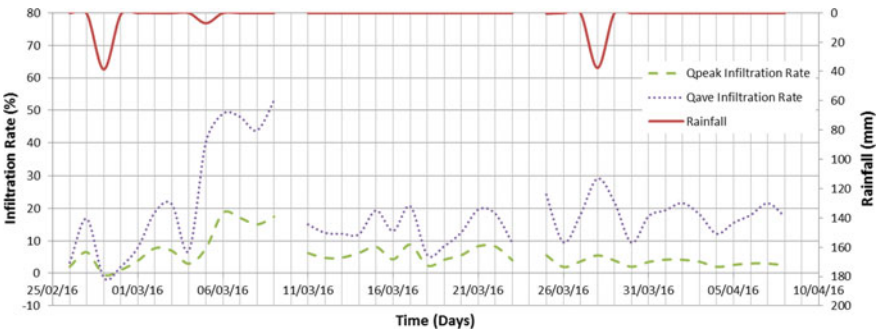

Fig. 3 Several phases of infiltration rate

5 Conclusion

In this study, inflow and infiltration of the sewerage system in the residential area Bandar Putra has been determined. The purpose of this research is to evaluate the amount of inflow and infiltration. The result shows that the average percentage Infiltration Rate of Q_{peak} and Q_{ave} in this residential catchment were 6.0 and 19.4% which is higher than the corresponding values mentioned in Hammer and Hammer (2012). Inflow and infiltration in sewerage systems is a concern. It would decrease the efficiency of sewerage treatment plant which in turn will affect public health and water quality. In terms of cost, it is very expensive to rehabilitate and maintain defected sewer pipeline. There are limitations and advantages of using this method. Wastewater flow in sewerage system is unpredictable, long-term investigation is required as well as groundwater level monitoring.

Acknowledgements This study was financially supported by the Malaysian Ministry of Education in the form of RACE research grant RDU 141302. The authors gratefully acknowledge the support given by the staff of Indah Water Konsortium Sdn. Bhd. The authors also want to thank lab assistants who assisted in the data collection.

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Chapter 33
The Effect of Rice Husk Ash (RHA) Mixtures on Geotechnical Properties of Soil

Juhaizad Ahmad, Mohd Ikmal Fazlan Rosli and Abdul Samad Abdul Rahman

Abstract Nowadays, a major issue in construction industry is about soil stability. RHA is one of the potential stabilizers and can be easily found in Malaysia. RHA can create a negative effect on the environment if it is being dumped as a waste since it can cause air pollution from its fine grains when blown by the wind. Therefore, this study will utilize this waste and it hopefully can reduce the above-mentioned hazard. The samples were prepared with different proportions of RHA which are 4, 8, and 12% of the soil mass. On top of that, the samples were added with Ordinary Portland Cement (OPC) to ignite the pozzolonic reaction between the soil particles and the additives. The amount of cement used in every sample is 2% of the soil mass. Unconfined Compression Test (UCT) was conducted to determine the maximum strength that can be sustained by the modified samples. The higher strength can be gained with addition of RHA together with OPC. It is recommended that 8% of RHA content with 2% cement is the optimum amount for practical purposes. In conclusion, RHA and OPC are suitable to be used for soil stabilization.

Keywords Maximum dry density · Optimum moisture content
Ordinary portland cement · Rice husk ash · Uniaxial compression test

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_33

1 Introduction

Determination of the strength of the soil is very important during the planning stage of the construction project. For engineers, encountering a soil stability problem at their project site is like facing a nightmare. The cost of the project increases dramatically if the problematic soil is not handled properly. Also, the construction will face settlement problem after the construction is completed. The defects of the building and roads are normally the biggest problem happened after the construction due to soil settlement. The causes of settlement problem are low soil strength, wrong use of geotechnical parameters, and improper method of construction. Ground improvement is the common application to stabilize the soil in order to increase the strength or stability of the soil. The application will change the characteristic of the soil by using chemical or physical methods. Usually, the improvement can be seen in the shear strength, stiffness, durability, and permeability. There are many techniques for ground improvements, but this study will focus on the chemical stabilization technique. The soil was mixed with the local additives that are vastly available which is Rice Husk Ash (RHA).

On top of the soil stability problem, there is another major problem that should be solved as well. The problem is about waste disposal. In Malaysia, there are a lot of paddy fields, in Kedah alone, the paddy field covers over 100,000 ha (MADA 2016). It is a major staple food supply for the nation and that is only 80% of the actual national needs (Nations Encyclopedia 2016). However, the paddy harvesting process will create agricultural waste which is known as rice husk. This waste is dumped everywhere. It is noted that the proper waste disposal of this waste costs about US$ 2183 per year (FFTC 2001). In worst case, it is dumped at the roadside and it is burned if the space to store is insufficient. This has caused major health issue due to air pollution and creates haze. Therefore, this study will try to incorporate this organic waste for the soil strength improvement. Hopefully, this will help to minimize the health risk. Moreover, the farmers will benefit the waste as a source of income due to the commercial application of this agricultural waste. This study will help to promote the use of rice husk on the ground improvement, besides it is already known for potential use in biomass industry (Parnphumeesup and Kerr 2011), cement industry (Roy 2014), and heavy metals removal method (Yin et al. 2006). On the other hand, RHA is not a new material in soil improvement. In fact, the application has shown dramatic success in many types of soils around the world. It is capable of solving the expansive soil problem (Muntohar and Hashim 2002), reducing the compressible soft marine clay problem (Chan and Muntohar 2012) and improving the residual soil properties (Basha et al. 2005; Rahman et al. 2014).

The soil that supports the load must have enough strength to prevent the settlement problem. In order to achieve this, the soil was mixed with RHA and cement as the additives to improve the strength of the soil. Cement is selected as the supplementary materials because the effectiveness on bonding the soil particle is

much better than RHA alone. The main purposes of this study are to determine the basic properties of soil, assess the strength development of soil-RHA-cement mixture, and evaluate the potential of the rice husk ash for soil stabilization.

2 Materials and Methods

The experiment was conducted by using soil, RHA and OPC. There were 12 samples prepared for this study. Each sample has different amount of soil and RHA but constant amount of cement (2% of soil sample weight). The control sample of soil does not contain any additive so that it can be compared with modified samples. Then, the samples were tested using Unconfined Compression Test (UCT) at different curing days which are on 0th, 7th, and 14th day to assess the strength development over time. Table 1 shows the preparation of the samples.

2.1 Soil

The soil sample used for this study has been collected from a paddy field at Baling, Kedah. The soil was first oven-dried for 24 h before the test. The total weight of the soil is kept constant at 2.5 kg. For the modified soil samples preparation, the weight of the soil is varied depending on the percentages of the additives.

Table 1 Preparation of samples

Sample number	% of soil mass	% of RHA (by weight of soil)	% of OPC (by weight of soil)
1A 1B 1C	100	0	0
2A 2B 2C	96	4	2
3A 3B 3C	92	8	2
4A 4B 4C	88	12	2

2.2 Rice Husk Ash

The rice husk ash was obtained from burning the rice husk and the amount of RHA are 4, 8, and 12% by the mass of the soil. The RHA was first oven-dried for 24 h before being used for the test. Then, the RHA was ground and sieved through 0.0045 mm before mixing with the soil samples.

2.3 Cement

The type of cement is Ordinary Portland Cement (OPC). The amount of cement is kept constant at 2% of the amount of the soil in every sample. The cement was mixed with the modified samples to increase the strength of the soil. Also, cement is responsible for pozzolonic reaction that eventually promotes the bonding between soil particles.

2.4 Methods Used

The tests consisted of physical and engineering properties tests. The first process in physical properties test is sieve analysis. After the material was oven-dried for 24 h, 500 g of soil sample was weighed. The pan and the sieves were weighed separately. The soil was sieved through 0.063 mm and the material that retained on that sieve was rejected. Second, the soil undergone Specific Gravity (SG) test. In soils, SG refers to the mass of solid matter of a given soil sample as compared to an equal volume of water. The method used in this test is density bottle method. The result is used to compare between the control sample and modified samples. Then, the soil is used for engineering properties tests. For this study, standard proctor compaction and unconfined compression tests are selected. Standard Proctor Compaction test was used to determine the Optimum Moisture Content (OMC) of the soil sample. After the sample was prepared as shown in Table 1, the value of OMC from the compaction test was used to prepare the samples. The Standard Proctor Compaction Test was used to standardize the compaction effort on the samples. Then, a cylinder mould is used to shape the cylinder triaxial samples. The size of the mould used is 76 mm height and 38 mm diameter. The sample was compacted with 27 number of blows for each layer. After that, the samples were tested using UCT to determine the strength of the soil sample. The rate of the machine was 1% per minute. The interval time to record the reading was set to 10 s. All standards test listed above is in accordance to BS1377 (BSI 1990).

3 Results and Discussion

3.1 Effect on Specific Gravity

From the calculation of sieve analysis, the soil is classified as poorly graded sand since the value of Cu and Cc are 3.87 and 0.81, respectively. Figure 1 shows the result of the specific gravity test. The value of specific gravity is disproportionate with RHA amounts. The specific gravity of the control sample that is not mixed with any additive was 2.63. For sample 2, the value decreases by 0.04, which is 2.59. The values keep decreasing for sample 3 and sample 4, which is 2.53 and 2.45, respectively.

3.2 Effect on Optimum Moisture Content

Figure 2 illustrates the Optimum Moisture Content (OMC) in every sample. The OMC is proportionated with RHA from 10 to 15.5%. The maximum dry density from each sample decreased with increasing RHA from 2016.39 to 1785.37 g/m^3. This is due to the increase in fines from the RHA with larger surface area that required more water for hydration (Eberemu et al. 2001). This trend is also reported by Alhassan (2008), where the laterite soil stabilized by RHA showed the same response on these compaction characteristics.

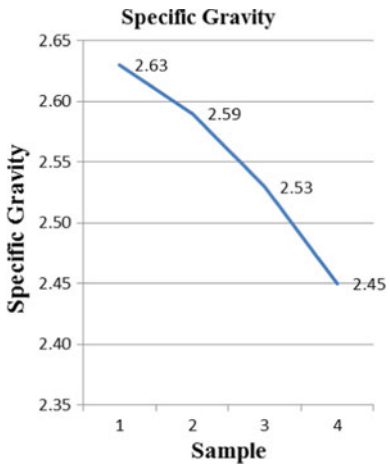

Fig. 1 Specific gravity of each soil sample

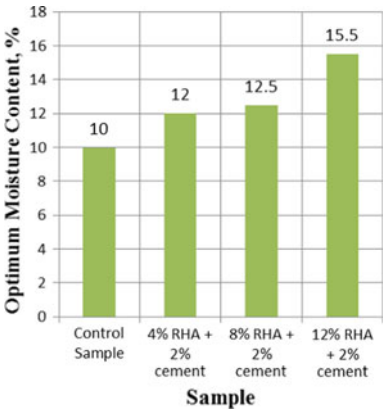

Fig. 2 Optimum moisture content

3.3 Effect on Compressive Strength

In general, the compressive strength will increase with the increase of curing time and stabilizer content (Hossain 2011). The strength development over time for zero days, 7 days and 14 days curing period is shown in Fig. 3. There is decreasing pattern in the stress value with addition of RHA and cement to the natural soil when compared to the stress value recorded for the control sample. The decrease is denoted by the excess RHA that was not mobilized in the reaction, which consequently occupies spaces within the sample, and therefore reducing bond in the soil —RHA mixtures. However, the strength increases to its maximum at 8% RHA. The strength dropped to its lowest value for 12% RHA. The maximum strength recorded was 532 kPa at 8% after 14 days curing period. These values are slightly higher than the control sample strength of 525 kPa. From the result, ironically, the strength of the control sample is increasing and the maximum strength value of the sample is almost the same as the sample that has been added to 8% of RHA. The first reason for this anomaly is because the soil sample is sand. The soil itself may have enough strength to cater the load. If the soil is clay, the result may show a lower strength compared to modified soil. Secondly, the drying effect of sand sample had contributed to strength development of the sample although no chemical added. As sand is a free draining material, the drying effect took place almost instantly. This is not happened on clay, because clay tends to retain the moisture and the soil structure will be softer.

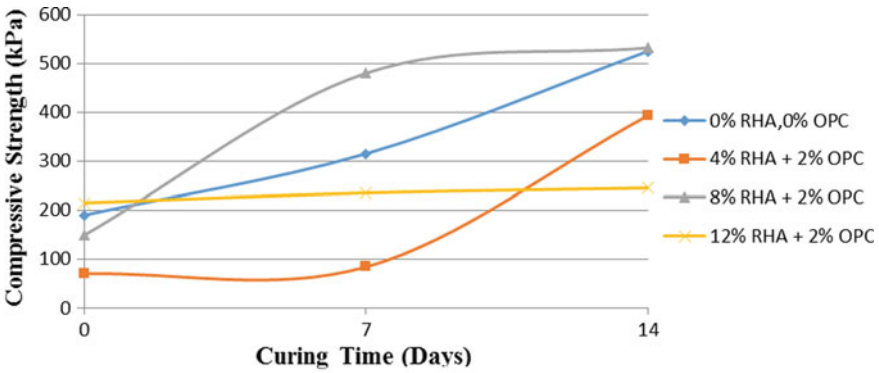

Fig. 3 Strength development over time

4 Conclusion

The soil is identified as poorly graded sand according to Unified Soil Classification System. Moreover, the specific gravity is 2.63. The optimum moisture content of control sample is 10%. The maximum dry density of the soil is 2016.39 g/m^3. After the soil was stabilized with RHA and cement, the properties of the soil have changed dramatically. The specific gravity of the modified soil is decreasing with the increasing amount of RHA. The maximum dry density of the modified soil also showed the same pattern. After stabilization, the strength of the modified sample is higher than control sample. The maximum strength of the modified samples can be gained with 8% RHA addition in 14 days curing period. This results proved that RHA can be accepted for soil stabilization. RHA will reduce the amount of cement to achieve the expected strength as compared to cement alone stabilized soils (Basha et al. 2005). Cement is costlier compared to RHA, which can incur higher construction cost. Therefore, it can be concluded that RHA can be a potential stabilizer for the soil.

Acknowledgements The authors would like to express their sincere gratitude to Ministry of Higher Education Malaysia (MOHE) for the funding under FRGS scheme [600-RMI/FRGS 5/3 (100/2013)] and fellow assistant researcher Zulaikha Maseri and Fazliana Musa for the hard work and scarifies along the completion of this study. Also, the author would like to thank UiTM Permatang Pauh for providing the equipment and resources for this research. The kind commitment of the assistant engineers in the laboratories is really highly appreciated.

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Chapter 34
Blended Binder System Containing Palm Oil Fuel Ash (POFA) for Solidification/Stabilization (S/S) Method in Treating Ceramic Sludge

Mazni Mat Zin, Mohd Fadzil Arshad, Nadia Zalikha Saifullizam, Adrina Rosseira and Nurliyana Ismail

Abstract Ordinary Portland cement (OPC) was the major binder used in solidification/stabilization (S/S) method in treating hazardous waste. The problems created by cement industry in producing OPC such as emission of carbon dioxide (CO_2) to the environment and high energy used cause new alternative introduced through this research to replace OPC with other material to act as a binder in S/S method. An experimental study of the use of an industrial by-product as a binder in (S/S) in treating Ceramic sludge (CS) has been performed. The influence of the variable mixes composition of Palm Oil Fuel Ash (POFA) in producing blended binder system has been studied. The compressive strength and Toxicity Characteristic Leaching Procedure (TCLP) was used to evaluate the effect of POFA on the solidified/stabilize ceramic sludge after 28 days of water curing. The results indicated the optimum ceramic sludge to be treated achieved by M2 containing 30% OPC: 60% CS: 10% POFA. The sufficient compressive strength and significant reduction in heavy metal Cr, Pb, Ni, and Cu show the potentiality of using POFA in producing blended binder system significantly reduce the amount of OPC usage to

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_34

control environmental problem. New system will be developed when optimum binary blended cement (BBC) produce binder system in treating ceramic sludge.

Keywords Blended binder · Ceramic sludge · Leachability · POFA Solidification/stabilization

1 Introduction

Booming industrial activities in Malaysia has led to production of large quantities of industrial sludge. Sludge is a residual or final product in term of settled suspension produced through chemical processes in industrial downstream activity (Jewaratnam 2006). As reported by Yin et al. (2008), usually sludge can be formed as semisolid and contains about 40–60% of 'interstitial' water. Sludge that contains heavy metal is the second largest waste generated in Malaysia (Jewaratnam 2006). Approximately 60,200 tonnes (17%)/year were produced in year 2002 as reported by Malaysian Environmental Quality (2002) and only 3% of the wastes were exported for treatment and recovery. The rest of it was treated and either disposed at the Kualiti Alam Treatment Disposal Facility or stored on-site at the waste generators' premises. As found by Netpradit et al. (2002), the sludge usually contains insoluble metal hydroxides, $M(OH)CaSO_4$, $CaCO_3$, NaCl, $NaHCO_3$ and other salts that is know as heavy metal sludge that can harm the environment and human's health. One of heavy metal sludge identified is ceramic sludge.

As reported by Senthamarai and Manoharan (2005), about 30% of the production in ceramic industry goes to waste. Elias et al. (2013) found that ceramic sludge contains heavy metals such as Cadmium (Cd), Chromium (Cr), Copper (Cu), Zinc (Zn), Manganese (Mn), Iron (Fe), (Fe), and Boron (B). It is classified as hazardous waste because containing toxic heavy metals and serious threats to the environment and ecology if it is improperly treated. High in cost and not applicable treatment cause new alternative to properly handle and manage the increasing of ceramic sludge should be explored. Through this research, the introduction to Solidification/Stabilization method (S/S method) was used as innovative method to treat ceramic sludge.

Solidification/stabilization (S/S) method is a low cost and an easy apply technology to treat hazardous industrial sludge by alters the physical form of hazardous waste by immobilizing the contaminant through chemical reaction, decrease the surface area, and solubility of hazardous waste (Barnet et al. 2009). The effects of S/S are mainly influent by the binder and waste used. Andres et al. (1998) found that the binder and the waste must interact chemically to create chemical bonding. Therefore, a binder becomes main contributor to develop S/S product.

For the time being, Ordinary Portland cement (OPC) was used as the main binder in S/S method, where OPC is used as solidifying agent to treat hazardous waste (Hills et al. 1993). The demand of OPC by industry has risen up the price of the material and at the same time released CO_2 to environment from production of

cement leads to increasing the concern for global warming (Yin et al. 2008). According to the research, approximately 0.97 tone of CO_2 is produced for each tone of clinker produced, and the cement production process is classified as the second biggest industry that is responsible for 6.97% of CO_2 emission in the world (Bamaga et al. 2013).

In order to diminish a demand of OPC, the combination of two types of materials act as binder in the system knows as blended binder cement system containing mineral waste POFA was introduced. The objectives of this research are to identify the optimum mixes composition of POFA in producing blended binder system in treating ceramic sludge as well to analyze the potential of POFA as blended binder. The effect of POFA to the properties of ceramic sludge after been treated with the system then evaluated by Compressive strength test and also leaching test carried out based on US EPA method 1311 TCLP (Toxicity characteristic leaching procedure). New system will be developed when optimum binary blended cement (BBC) produce binder system in treating ceramic sludge.

2 Materials and Methods

2.1 Materials

The material used in this research divided into two (2) groups named as ceramic sludge and industrial mineral waste to develop blended binder system. Ceramic sludge was selected as industrial sludge collected at John Ceramic Berhad Senawang Industrial Estate, Malaysia. The sludge stored in air tight container and humidity control room to control the quality of sludge until the date of test. The industrial mineral waste selected to be used in this study was scope to POFA. POFA was collected at palm oil mill factory at Jengka Pahang, Malaysia. Chemical composition in the materials as shows in Table 1.

2.2 Binder Formulation and Development

The formulation of blended binder system start with determines the optimum mix proportion of OPC with ceramic sludge. For this research, five (5) mixtures were prepared with a ratio OPC: Sludge at an interval 20%. A1 was a control sample containing 100% OPC. The rest of mixtures containing 20, 40, 60 and 80% ceramic sludge added to OPC. All the samples were blend together with water/binder ratio of 0.5 was used. All of the mixtures are as presented in Table 2. The mixtures were casted in cube steel mould size of 50 mm × 50 mm × 50 mm, de-mould after 24 h. The cube was left to the ambient temperature and cured for 28 days before tested. The compressive strength test was carried out as accordance to BS 1881:Part

Table 1 Chemical compositions of binder and ceramic sludge

Element	Ceramic sludge	OPC	POFA
CaO	11.4066	63.0	3.0563
SiO_2	53.3547	20.0	43.492
Al_2O_3	7.8676	5.70	3.188
MgO	<LOD	0.99	<LOD
Fe_2O_3	0.472	2.90	11.413
SO_3	<LOD	3.50	0.0389
Zn	3.2322	0.005	0.006
Cu	<LOD	0.003	0.02
Cd	<LOD	<LOD	<LOD
Ni	0.0367	0.011	0.0086
Pb	0.1857	0.001	<LOD
Zr	1.7947	0.0737	0.0069
Rb	0.0282	0.0041	0.0092
Sr	0.0523	0.2192	0.0056
Nb	<LOD	0.0027	<LOD
Mo	0.0051	<LOD	<LOD
Ba	0.4066	0.1629	<LOD
Ag	<LOD	<LOD	<LOD
Sr	0.0523	0.2192	0.0056
Th	0.0124	<LOD	<LOD

Note Less off detection (LOD)

Table 2 Mixes proportion to obtain optimum sludge

Mixes	OPC (%)	Ceramic sludge (%)	Strength N/mm^2
A1	100	0	18.25
A2	80	20	11.48
A3	60	40	15.50
A4	40	60	8.50
A5	20	80	0

1:1983. The optimum mixes proportion was determine based on the mix that have the highest sludge content that satisfied solidification requirement as required in S/S method specification. A sludge only consider as solidified if compressive strength value of sludge cube is achieve a minimum strength of 0.34 N/mm^2 as stated by regulatory waste disposal limit at a disposal site in UK (Yin et al. 2008).

From Fig. 1, it is clearly shows that A4 is the optimum mixes. A4 is a cube of sludge added with OPC at a ratio 60:40 where its compressive strength recorded is 8.50 N/mm^2. A4 contain the highest sludge content that satisfied solidification requirement. For mixes A5, there no compressive strength recorded with replacement 80% ceramic sludge. The result support by Ismail et al. (2015) reported that the highest amount of sludge added the lowest compressive strength achieve.

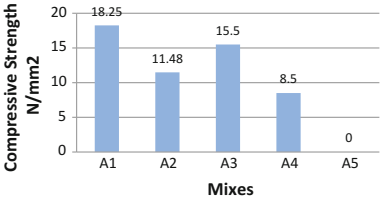

Fig. 1 Compressive strength of OPC with different proportion of ceramic sludge

Table 3 Mixes proportion of binder

Mixes	OPC	Sludge	POFA
M1	40	60	–
M2	30	60	10
M3	20	60	20
M4	10	60	30
M5	–	60	40

The optimum mix proportion of POFA in performing binder characteristic in bonding sludge particles were investigated after obtained optimum sludge. Table 3 present mixes proportion of binder and in producing blended binder system in treating ceramic sludge. All mixes then cast in a steel mould 50 mm × 50 mm 50 mm and cured at ambient temperature for 24 h before de-mould. All prepared sample then left for water curing and test at interval of 1, 3, 7, and 28 days.

The mixes proportion of POFA is prepared at interval of 10% it is because according to previous research conducted by Karim et al. (2011), the replacement of OPC by 10, 20, and 30% of POFA will produce high strength concrete but exceed that value will reduce the strength of concrete.

3 Result and Discussion

3.1 Effect of POFA to the Solidification of Ceramic Sludge

The sludge with POFA label as M2 and M3 have higher compressive strength as compare to M1. A compressive strength of M2 and M3 found to be 19.55 and 16.99 N/mm^2 higher than M1 respectively. M4 and M5 which contained 30% and 40% POFA found to being lower than M1 (Fig. 2).

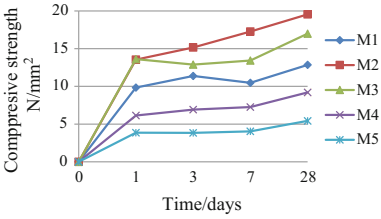

Fig. 2 Effect of binder containing POFA to the solidification of ceramic sludge at different curing time

The results obtained ware support by research conducted by Awal and Abubakar (2011), stated that the strength of POFA concrete produce more C–S–H gel and at the same time reduce the amount of calcium hydroxide $Ca(OH)_2$. Tangchirapat et al. (2007), also found that the utilization of ground POFA as supplementary cementitious materials has improved the compressive strength of concrete.

The optimum percentage of POFA being used that has higher compressive strength than OPC is around 10–20%. As the replacement level of POFA increased, the compressive strength is decreasing. Lower in compressive strength will effect to the properties of concrete has its maximum strength against compression.

3.2 *The Effect of POFA to the Stabilization of Ceramic Sludge*

The stabilization of ceramic sludge that have been treated with POFA as a binder was tested through chemical properties Leaching Test carried out based on US EPA method 1311 TCLP (Toxicity characteristic leaching procedure) (Figs. 3 and 4).

There are four (4) types of heavy metal ware been highlighted through this research which are Cadmium (Cd), Lead (PB), Copper (Cu), and Nickel (Ni). The result obtained was been compared with standard required as stated by Malaysia Environmental Quality Act 1974, Environmental Quality Sewage and Effluent Regulation, 1979, Standard B limit. From the result obtained shows that the heavy metals in ceramic sludge in satisfy with the standard stated after been treated with the blended binder system containing POFA. From the data analysis shows that some of heavy metal in ceramic sludge increased after been treated with the system as shown by Fig. 5. The concentration of Cu in ceramic sludge is obviously increased compare to the concentration of Cu before the sludge treated but instead

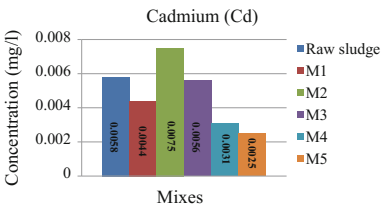

Fig. 3 Concentration of cadmium (Cd) in ceramic sludge

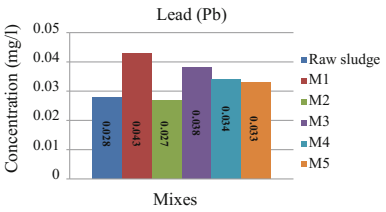

Fig. 4 Concentration of lead (Pb) in ceramic sludge

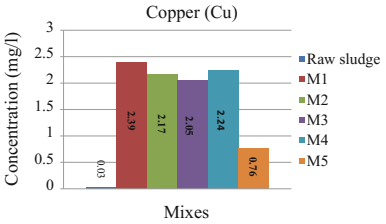

Fig. 5 Concentration of copper (Cu) in ceramic sludge

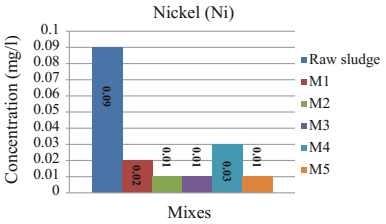

Fig. 6 Concentration of nickel (Ni) in ceramic sludge

happen with the concentration of Ni in ceramic sludge that show the system develop have higher potential to treat Ni in ceramic sludge (Fig. 6).

As reported by Malviya and Chaudhary (2006), different waste metals have different effects individually and in combination with binders in a solidified/stabilized matrix. Wiles and Barth (1992) also reported that waste characteristics also are among the most important factors affecting waste solidification/stabilization. The increasing of heavy metal in stabilizes sludge after been treated with POFA as a binder is because of some of other factor. One of that are the presence of heavy metal in different composition of POFA and heavy metal presence in OPC as well as ceramic sludge itself. Even though occur increasing of heavy metal concentration in stabilizes sludge, but it is still satisfying the standard requirement.

4 Conclusion

For the particular objectives examined in this study, the following conclusions are drawn:

(i). The optimum mix composition of POFA in producing blended binder system in treating ceramic sludge through S/S method is 20% with 60% ceramic sludge with the compressive strength of solidified ceramic sludge is 5.43 N/mm^2.

(ii). POFA is highly potential to be a binder in S/S method when replace OPC. Higher percentage of Silica and Alumina in POFA shows its can act as bonding material and produce pozzolanic reaction to develop strength for S/S product.

(iii). The effect of POFA to the properties of ceramic sludge can be evaluated by analysis stabilize sludge. POFA have a potential to stabilize the heavy metal concentration in ceramic sludge since the concentration of heavy metal is satisfied the standard requirement.

Acknowledgements The authors wish to acknowledge the help and cooperation received from the related industries, technical staff of the Structure and Environmental Laboratory of the Universiti Teknologi Mara (UiTM) Shah Alam and Pasir Gudang in conducting the experimental work. The financial support received from the university is also gratefully acknowledged.

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Chapter 35
Harmonic Formulation of Prestressed Concrete Sleeper Subjected to Freight Train

Mohd Ikmal Fazlan Rozli, Juhaizad Ahmad, Sharul Nizam Alias, Kay Dora Abd. Ghani, Afidah Abu Bakar and Siti Hawa Hamzah

Abstract In Malaysia, rail transportation has become an integral part of the society. It can be seen by the effort of the Malaysia Government to improve the rail system by laying new route, provide new type of trains and others. For transporting goods, Malaysian rail authorities (Keretapi Tanah Melayu Berhad) used 22 coaches so-called freight train becoming one of the most popular transportation in delivery goods. In the past, wood is commonly used as a material in sleeper's manufacturing but nowadays, prestressed concrete sleeper starts to capture their name in the industry in producing more quality sleeper as one of railway track components. This study will be focusing on determination of constant amplitude for 22 coaches, cyclic counting strain and calculation of frequency of strain on prestressed sleeper subjected to freight train. Rainflow cyclic counting method is used to determine the constant amplitude, cycle and frequency for each parts of train body. By using rainflow method and formulas, average number of cycle and frequency is obtained. From the obtained results, the individual PCS have to endure a maximum frequency and number of cycles of 11.91 Hz and 1.39 s, respectively. The outcome of this study will have a formulation of the freight train that is currently being used in Malaysia.

Keywords Concrete sleeper · Constant amplitude · Cyclic counting

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_35

1 Introduction

Over the past few years, ballasted track is the traditional railway system used in transporting population, goods and many more. This typical railway track consists of superstructure that includes rails, fastenings and sleepers while substructure comprised of ballast, subballast and formation including subgrade and substructure (Kaewunruen and Remennikov 2009). Increase in the number of passengers of using trains and the rise of loads in freight train over the years has become one the factor that contributes to the deterioration of the railway track. Before the introduction of prestressed concrete sleepers, wooden sleepers are widely used in the past. However, in modern railway track, prestressed concrete sleepers have been adopted because of their durability and long service of life.

As of now, millions of these blocks manufactured and distributed to satisfy demand for network expansion and upgrades. Timber has been historically dominant material used for sleepers. Wooden sleepers are cheap, light and easy to transport, quicker and easier to install and maintain and cost saving too. However, most of these sleepers will deteriorate and become less capable of meeting performance requirements.

In recent years, the environmental protection issue is a major concern, where purchasing of wooden sleeper becomes more difficult. Furthermore, due to heavy load and humid climate significantly decreases the life of the wooden sleeper. Hence, it might increase life cycle cost and operational risk. Therefore, it is necessary to find a heavy duty and low life cycle cost sleeper to replace wooden sleeper. The important functions of sleepers are to uniformly transfer and distribute loads from the rail foot to the underlying ballast bed, to provide an anchorage for the fastening system that holds the rails at their correct gauge and preserves inclination (Hwang et al. 2011). Thus, the strength and reliability of sleeper is related to the track safety as it is very important component of the railway track. Thus, the design of sleeper is the main factor in track safety. Type of sleeper that is widely used recently is prestressed concrete sleeper. In this study, the performance of prestressed concrete sleeper will focus more on freight train track. Prestressed concrete sleeper is designed with long service life compared to timber sleeper that have the capabilities to serve high-speed routes more efficiently and lower maintenance is required compared to timber.

Current practice shows that PCS is designed based on an international code (AS1085.14). Apart from that, PCS can also be designed based on EN 13230 and local railway authority specification (Keretapi Tanah Melayu Berhad, KTMB). KTMB is a company that manages railway system in Malaysia (Mohd Ikmal Fazlan et al. 2015). Prestressed Concrete Sleepers is subjected to repeatedly applied loads and unloading due to train that passes on it. Behaviour of prestressed concrete sleeper is determined under impact load, performance of prestressed concrete sleepers was investigated under constant amplitude load and cyclic loading subjected to freight train.

1.1 Functions of Prestressed Concrete Sleeper

In the historic past, sleepers for railway track consisted of slabs of stones or longitudinal timbers laid continuously under the rails. In 1835, the adoption of cross sleepers was introduced in Britain (Coombs 1971). The natures of placing sleepers are shown in Fig. 1. The functions of sleepers were to hold the track to gauge, transmit and distribute the oncoming loads to the ballast underneath, to hold the rails in proper level or transverse tilt level in turn outs and crossovers, to interpose an elastic medium in between the ballast and the rails, and supporting wheels and or jacks direct.

1.2 Freight Trains of Keretapi Tanah Melayu Berhad

Freight transportation has been the second most profitable service for KTMB through time. According to its latest annual report in 2013, freight services alone contribute RM 127.4 million to its income. The freight train is used to transport a heavy material such as cement, maritime equipment and others as shown in Table 1.

Furthermore on 28th January 2016, a new freight was launched that claims to be the longest freight train services in South East Asia (Harian 2016). According to report, the train is equipped with 120 coaches that carry various items. Thus, one can imagine the impact that the individual PCS have to endure in coming years. If any structural failure occurs especially PCS, KTMB will have to bare not only losses in revenue but also loss of human life.

2 Methodology

In order to obtain the required data, a real-time train freight data must be established. After much deliberation and suggestion from Kertapi Tanah Melayu Berhad (KTMB), a high traffic train site was determined. The site is located around Kajang

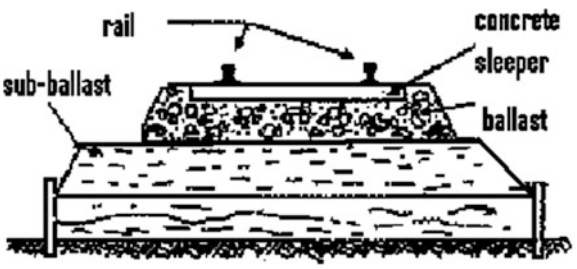

Fig. 1 Structural parts of railway track (Rozli 2007)

Table 1 Freight train traffic (Malaysia 2013)

Jenis Kargo *Type of Cargo*	(000)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Simen and Llinker	Tonne	942	1026	1220	1355	4654	1704	1814	2224	2353	2594
Cement and Clinker	t km	227,924	293,139	308,121	356,299	390,869	531,335	605,926	732,170	800,581	926,262
Kontena Perkapalan	Tonne	2887	1876	2074	2222	2272	2603	2588	2702	2691	2864
Maritime Container	t km	343,462	394,193	597,355	507,900	490,127	455,843	408,893	383,866	390,327	406,723
Landbridge	Tonne	216	184	164	122	105	55	39	26	19	19
Landbridge	t km	54,689	114,199	22,516	56,701	72,286	15,710	17,189	22,954	25,724	30,512
Petrol and Minyak Gallan	Tonne	72	57	62	75	45	–	–	–	–	–
Petrol and Mineral Oil	t km	22,894	17,763	19,714	23,964	13,935	–	–	–	–	–
Makanan and Minuman Proses	Tonne	288	358	363	421	433	476	487	459	417	413
Processed Food and Drink	t km	214,539	267,898	278,419	323,857	315,429	319,811	308,923	221,428	168,725	169,418
Beras, Padi and Bran	Tonne	–	–	–	–	–	–	–	–	–	–
Rice, Paddy and Bran	t km	–	–	–	–	–	–	–	–	–	–
Getah	Tonne	–	–	–	–	–	–	–	–	–	–
Rubber	t km	22	–	–	–	–	–	–	–	–	–
Getah Cecair	Tonne	–	–	–	–	–	–	–	–	–	–
Latex	t km	12	1	1	–	–	–	–	–	–	–
Kayu Balak	Tonne	–	–		–	–	–	–	–	–	–
Logs	t km	–	–	–	–	–	–	–	–	–	–
Kayu Gergaji	Tonne	–	–	–	–	–	–	–	–	–	–

(continued)

Table 1 (continued)

Jenis Kargo *Type of Cargo*	(000)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Swan Timber	t km	–	–	–	–	–	–	–	–	–	–
Bijih and Lain-Lain Gallan	Tonne	90	58	21	10	11	6	2	0	–	–
Ore and other Minerals	t km	21,929	12,654	1133	182	1573	102	38	2	–	–
Kimla	Tonne	346	309	370	386	347	259	298	287	337	341
Chemicals	t km	20,986	20,682	22,602	23,611	21,935	18,390	22,422	19,770	19,774	21,047
Minyak makan	Tonne	–	–	–	–	–	–	–	–	–	–
Edible Oil	t km	–	–	–	–	–	–	–	–	–	–
Lain-Lain	Tonne	121	204	174	166	138	130	204	216	279	390
Others	t km	60,618	57,082	68,107	62,723	44,244	42,916	119,294	155,294	159,253	205,671
Jumlah	Tonne	4962	4072	4448	4757	8005	5233	5432	5915	6096	6621
Total	t km	967,075	1,177,611	1,317,968	1,355,237	1,350,398	1,384,107	1,482,685	1,535,474	1,564,294	1,759,633

Sumber Keretapitanah Melayu Berhad (KTMB)
Source Malayan Railways Limited

train route. At site, a sleeper was chosen to be equipped with necessary gadgets at certain location in order to capture the much-needed data. The process can be seen in Figs. 2 and 3. For this study, the researcher was able to capture at least six (6) readings of 22 freight trains. Thus, the researcher will analyse data, which give a maximum reading to further study.

3 Analysis and Results

3.1 On-site Data

Raw data is analyzed by plotting irregular strain versus time graph representing strain characteristic, times of cyclic loading subjected to concrete sleeper and velocity of the freight train. Cycle counting method is the first step to interpret the data. The cycles are identified from a random series of loading conditions. Normally, the cycles are characterized by mean and maximum stress or amplitude stress and mean stress. Rainflow cycle counting method is the best procedure to determine the events in a complex loading history. Train body is separated into four different *N*. Maximum and minimum strain is determined from the actual graph sample and from that strain ratio is calculated. Then, mean value strain and strain amplitude are calculated. From these, constant amplitude is obtained. Fourier analysis concept is used to obtain constant amplitude for further analysis. Figure 4 shows the variable amplitude from raw data.

Fig. 2 Specimen was equipped with necessary gadgets

Fig. 3 Capturing the speed of train

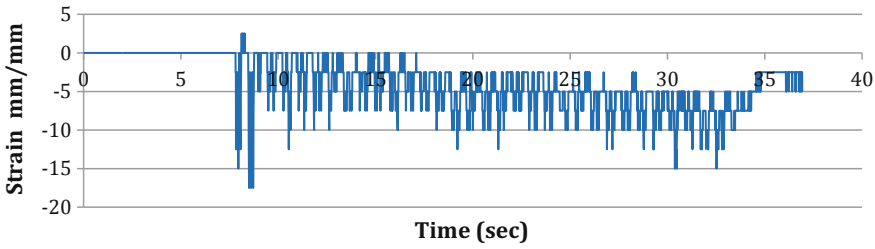

Fig. 4 Raw data for 22 freight trains

3.2 *Interpretation of Data*

As shown in Fig. 4, it is impossible for researcher to simulate this data in laboratory. There is so much variable to be taken care of and it will consume a lot of time to conduct the test with this set of data. Thus, rainflow method was used to make this variable data to a constant data so that the data obtained can be used to simulate in laboratory (Sharul et al. 2015).

3.3 *Constant Amplitude*

By using rainflow method, a constant graph for the whole freight train has been established. From 22 coaches of freight train, the researcher can determine what the maximum and minimum loading that imposed to individual PCS. Thus, the result as shown in Fig. 5 shows the comparison between variable amplitude and constant amplitude of graph. The blue line in the graph shows the variable amplitude while the red line is the constant amplitude. Since freight train consists of 22 and each

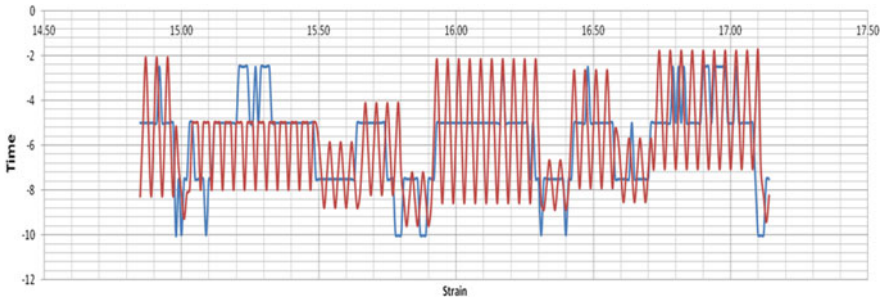

Fig. 5 Variable amplitude and constant amplitude

Table 2 Average value of Coach

Constant amplitude average			
Coaches	Loading, P	Cycle, N	Frequency, F
n1	-42.47	1.39	11.91
n1	-32.44	1.39	11.91
n1	-22.25	1.39	11.91
n1	-32.44	1.39	11.91
n2	-28.45	4.11	2.48
n2	-16.57	4.11	2.48
n2	-5.39	4.11	2.48
n2	-16.57	4.11	2.48
n3	-42.66	1.39	11.23
n3	-33.22	1.39	11.23
n3	-22.37	1.39	11.23
n3	-33.22	1.39	11.23
n4	-36.24	1.74	6.10
n4	-22.59	1.74	6.10
n4	-8.95	1.74	6.10
n4	-22.59	1.74	6.10

N1 =
N2 =
N3 =
N4 =

coach have four portions, average for each coach is calculated. Table 2 depicts the data that is needed to be averaged, which include loading, the number of cycle and the frequency.

Real structures seldom experience constant amplitude of loading. Therefore, certain types of cycle counting method must be used to reduce the irregular loading into a constant loading. Rainflow method that was proposed by Matsuishi and Endo is more convenient compared to other method (Bai et al. 2014).

4 Conclusion and Discussion

The results shown in Table 2 give a more reasonable value for researcher to simulate this data in laboratory and finite element experiment. Based on the results and observations, the constant amplitude, cyclic counting and load for 22 coaches of

train is determined by using rainflow method. Thus, the first objective in this study is successfully achieved. It showed that the maximum value of each sleeper has to endure for 0.08 s is around 42 kN. The individual PCS also have to withstand a maximum frequency of 11.91 Hz and repeated cycle of 1.39 s.

Acknowledgements The authors would like to express their sincere gratitude to Ministry of Higher Education Malaysia (MOHE) for the funding under FRGS scheme [600-RMI/FRGS 5/3 (100/2013)] and Keretapi Tanah Melayu Berhad (KTMB) for providing the much-needed onsite data capturing. Special thanks to Research Management Institute (RMI) and Faculty of Civil Engineering, UiTM Pulau Pinang and Shah Alam for providing facilities and guidance that helped this research to be completed.

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Chapter 36
Development of Telerehabilitation Monitoring System for Arm Recovery

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Abstract This chapter presents on the development of arm telerehabilitation system to detect fatigue of patient with affected arm due to accident, diseases or injury by using the application of ADXL335 accelerometer and Arduino Uno microcontroller. Arm rehabilitation requires repetitive movement which can be tiring and might worsen the condition of the affected arm if forced to proceed. The GUI of the system was developed by using Microsoft Visual Basic, which automatically stores the data in the Microsoft Access and MySQL to be displayed in the developed website. The system can display approximate values as the goniometer which can be used to monitor the recovery improvement of the patient. The fatigue status depends on the speed and time taken to raise up the affected arm. Decrease in speed or longer time taken to raise arm the affected arm shows that the patient is tired.

Keywords Arduino · Three-axis accelerometer · Arm telerehabilitation

1 Introduction

Arm pain can occur as a result of sports injuries, work injuries or simply because of everyday arm use. It can be caused by local muscle, tendon or joint injury which can cause shoulder pain, wrist pain, and elbow pain. Loss of voluntary arm movement is also prevalent after stroke and traumatic brain injury. According to

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_36

Reinkensmayer et al. (2000), Natarajan (2003), Skilbeck et al. (1983), approximately 85% of the stroke patients incurr acute arm impairment and 40% of chronic impairment. With early treatment, most patients with arm injuries respond quickly to physiotherapists who allow the patients to resume their normal pain-free arm movement. The major challenge involved in arm rehabilitation is the repetitiveness of the rehabilitation exercises, such as wrist, elbow, and shoulder range of motion which can be tiring and might cause muscle injury and fatigue if forced to proceed (Aini et al. 2015; Al-Mulla et al. 2009). As stated by von Koch et al. (2000) and Reinkensmeyer et al. (2000), the physiotherapist is the first step to help the patient to resume their normal movement in the recovery period.

The development of monitoring system for arm rehabilitation which detects on fatigue and recover is presented. An appropriate range of motion was set to low, medium, and high range of motion. The bending of the arm will indicate the recovery improvement of the patient. For instance, initially the patient is able to bend the arm in the lower range of motion and after a long time of rehabilitation exercise, the patient is able to bend the affected arm in the high range of motion. Thus, it indicates that the patient is recovering from the arm injury which allows the patient to bend the arm further. This system involves the patients to test their range of motion as guidance to choose the mode of exercise, whether they are in low, medium or high mode of exercise. The time to raise up the arm was set according to the level of difficulty. If the patient takes greater time to raise up the affected arm than the time that was set, it indicates that the patient is tired, however, when the time to raise up the arm takes less than the time that was set, it indicates that the patient is in a good condition.

2 Methodology

The system consists of three main units, which are the input, process and last, the output as shown in Fig. 1. An Arduino microcontroller reads the data collected from the wearable sensors, processes the data received and transmit it to the personal computer (PC) to be displayed in the GUI of the Microsoft Visual Basic in which the data are stored in the database of the Microsoft Access and send to MySQL to be displayed in the developed website.

Figure 2 shows the overall flowchart of the system, where the patient needs to check and test their range of motion first before they can select the appropriate modes of exercises either for shoulder or elbow exercise. The fatigue status and range of motion will be displayed in both the GUI of Microsoft Visual Basic and the developed website to be evaluated by the physiotherapist.

When an accelerometer sensor is attached to the human limbs, a single-axis accelerometer will provide kinematic information based on measurements of acceleration and position with respect to the gravity along on a sensitive axis. In order to detect human motion, three planes of motion are needed. The ADXL335 accelerometer is a complete three-axis acceleration measurement system with a

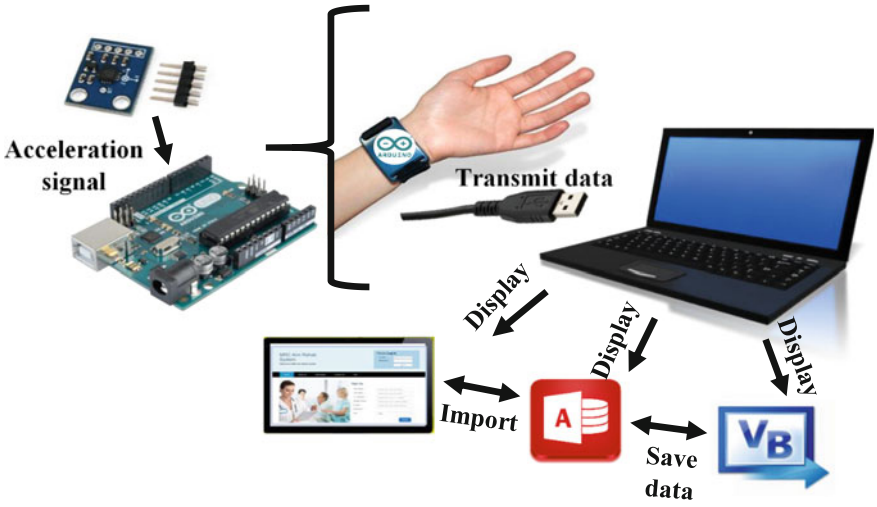

Fig. 1 The system architecture of the arm rehabilitation system for fatigue and recovery monitoring

range of ±3 g. It measures both dynamic acceleration resulting from motion or shock as well as static acceleration. The ADXL335 was chosen because of its small, thin, and low power characteristics. The range of the acceleration signal is important to be able to set the angle of the range of motion for arm and shoulder rehabilitation exercise which is as shown in Fig. 3. The analog pin 0, 1, and 2 of the Arduino Uno were connected to the *x*, *y*, and *z*-axis of the ADXL335 accelerometer, respectively.

3 Results and Analysis

Figure 4 shows the complete prototype of the arm rehabilitation monitoring system. The Arduino Uno was covered with Perspex and a strap was added to hold the device on the patient's wrist. The data transmitted by the Arduino Uno microcontroller were displayed in the Microsoft Visual Basic as shown in Fig. 5a. The system includes the description of the guidelines about the rehabilitation system, selection of the types of exercise either elbow or shoulder, range of motion and modes of exercise. The patient needs to test or check their range of motion in order to choose the level of difficulty for the exercise. The exercises were divided into two types of arm rehabilitation exercises, elbow and shoulder. Each of the exercise is divided into three levels, which are low, medium, and high level. After the patient is done checking and testing their range of motion, the textbox will show message to tell the patient to proceed with the rehabilitation exercise by choosing the mode of

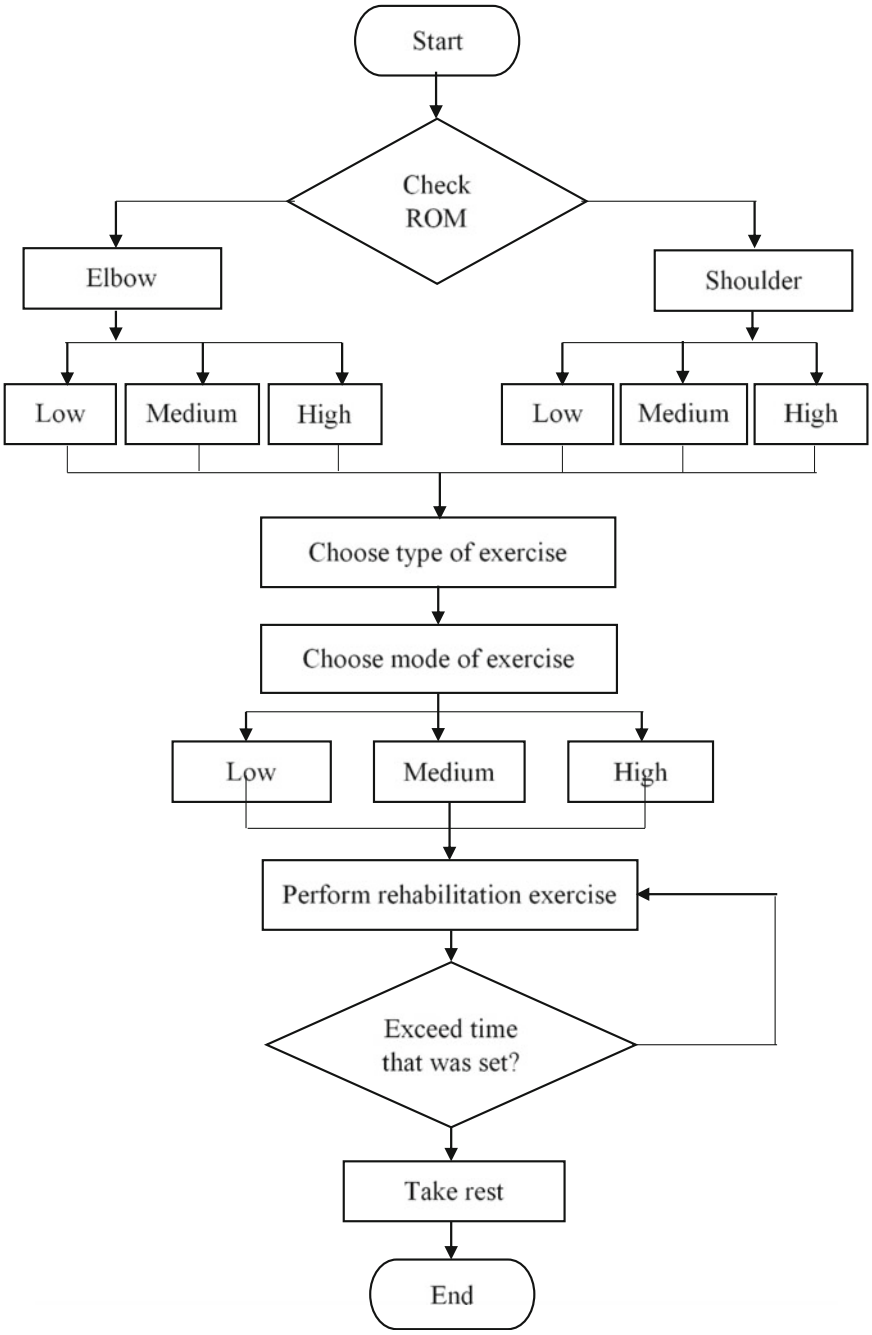

Fig. 2 Flowchart of actions and decisions needed for using the arm rehabilitation system for fatigue and recovery monitoring

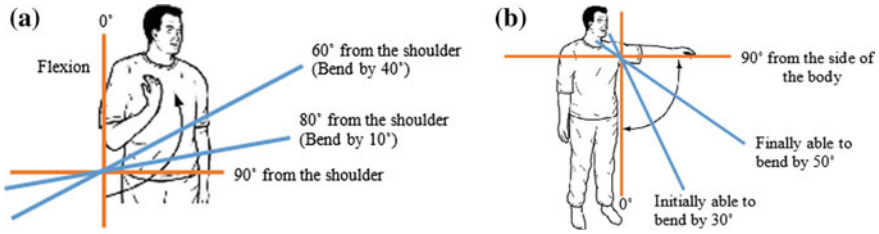

Fig. 3 Exercises sets for low, medium, and high range of motion of **a** elbow, and **b** shoulder

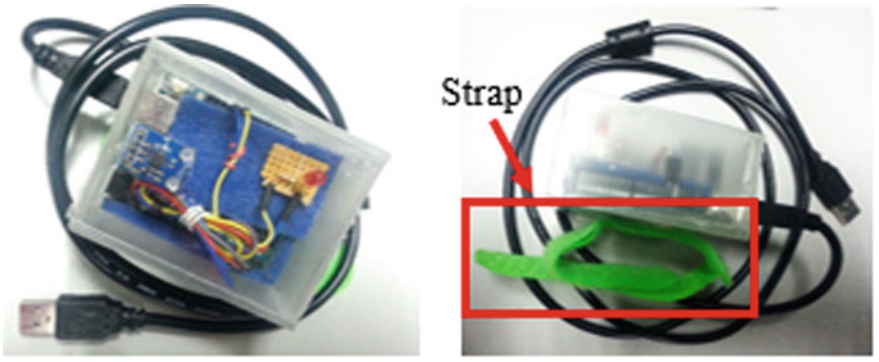

Fig. 4 The complete prototype of the arm rehabilitation monitoring system

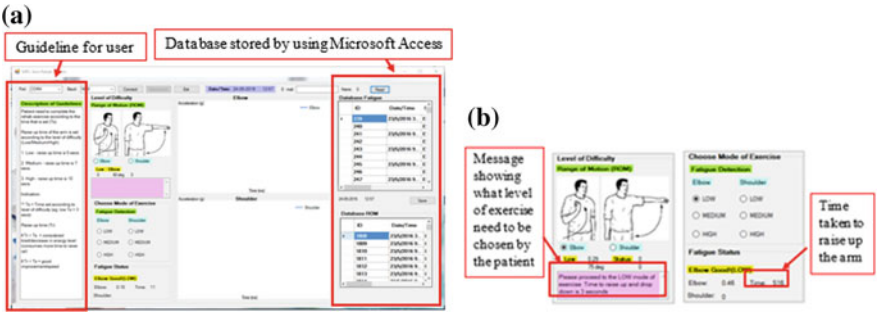

Fig. 5 **a** GUI of the arm rehabilitation system, and **b** The selection mode and level of difficulty for either elbow or shoulder exercise

exercise, according to the types of exercise they want and the level of difficulty as shown in Fig. 5b.

The recovery improvement can be monitored first by the range of motion of the arm. The exercise for the elbow is done 90° from the shoulder. The signal for the elbow range of motion was set in the x-axis direction with the sensor positioned in the positive z-axis. The range of the acceleration signal for each mode was obtained

by comparing the value obtained by using a goniometer. The range of motion is important in determining the recovery improvement of the patient. For instance, initially, the patient is only capable of bending the arm by 10° (80° from the shoulder). After the rehabilitation period, the patient is able to bend the arm by 40° (60° from the shoulder). Hence, the result obtained shows improvement in the range of motion by 30° in which the patient is capable of bending their arm as a result of the rehabilitation exercise.

The recovery improvement also can be determined by the pattern of the time taken to raise up the arm. For instance, if initially the patient can raise up the arm in 4000 ms (4 s) and the time taken to start up the exercise for the next exercise is lesser and lesser, hence, it indicates that the patient is also recovering from the rehabilitation exercise. The recovery improvement by the range of motion will show the patient can bend their arm. If the patient can bend their arm more than the previous exercise, thus, the patient has improved from the rehabilitation exercise. The graph of the acceleration signal (g) versus time (ms) is also displayed on the GUI. High speed to raise up the arm shows narrow gap, while slower speed shows wider gap between raise and drop down the arm as shown in Fig. 6. If the patient takes greater time to complete the rehabilitation exercise than the time that was set, it indicates that the patient is tired and if the patient completed the rehabilitation exercise less than the time that was set, hence, the patient will still have energy to raise up the arm.

From a survey conducted with a few physiotherapists, it is suggested that the starting position to be 0° instead of 90° as the elbow movement for biceps exercises is more effective at starting point of 0°, depicted in Fig. 7. The developed system is more to the strength exercise as it involves the repetitive movement of the exercise. The physiotherapist rate the results from the system are quite reliable and relevant to be used as the pattern of the fatigue status and the initial condition has a different pattern when displayed in the graph. The physiotherapist agreed that the results can be displayed in almost real-time monitoring, which is very useful to continuously monitor the recovery improvement and the fatigue of the patient.

Figure 8 shows the home page of the telerehabilitation website that has been developed by using Laravel 5.2 and Sublime Text. The home page of the website displays brief introduction about the website and sign up form for the patient to register for the rehabilitation services. The patient and doctor can log into the system at the top of the homepage. The patients can also review their rehabilitation

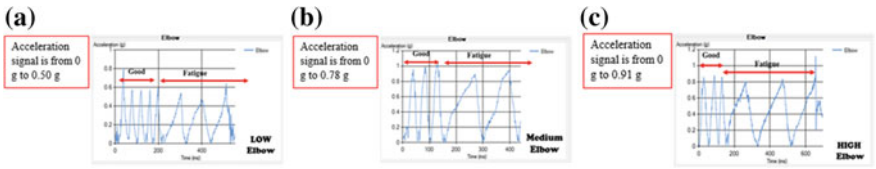

Fig. 6 Graph of g acceleration versus time for **a** low, **b** medium, and **c** high, with referred to the range of acceleration signal

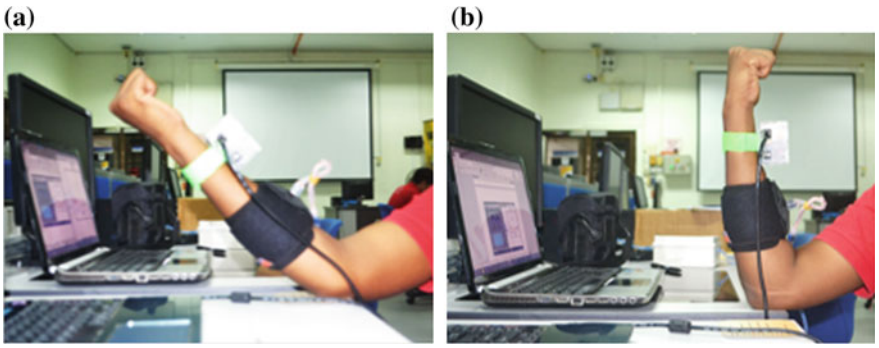

Fig. 7 The position of the sensor, where **a** 90° from the shoulder, **b** 75° from the shoulder, **c** 45° from the shoulder, and **d** parallel with the shoulder

Fig. 8 The home page of the telerehabilitation website with sign up and log in function

history in table and graphical view as shown in Fig. 9. The doctor or physiotherapist can view the patient rehabilitation history and can give response or reply to the patient by using the feedback and response function provided in the developed website as shown in Fig. 9. The doctor or physiotherapist also can assign an appointment to the patient if the patient wants to meet them. The patient will be

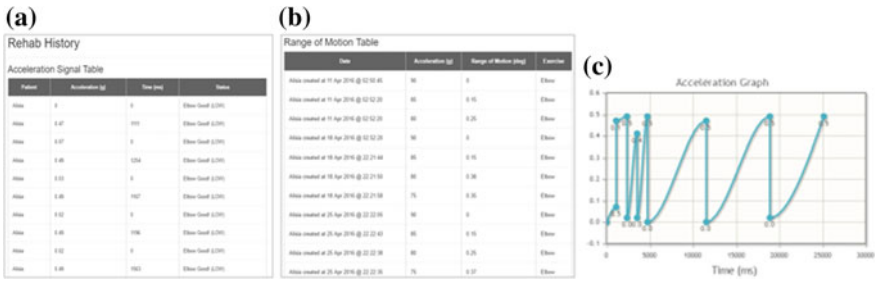

Fig. 9 The rehabilitation history of patients, where **a** acceleration signal for fatigue detection, **b** range of motion table for recovery monitoring, and **c** graph of acceleration signal versus time taken to raise up the arm

notified if there is feedback or response from the physiotherapist. Similarly, the physiotherapist will also be notified if there are feedbacks and responses from the patient.

4 Conclusions

The development of arm rehabilitation monitoring system for arm injury patient has been designed and developed. The system was designed as wearable in which the strap will hold on to the patient wrist when performing the rehabilitation exercises. The recovery and fatigue can be determined by the time to raise up and the range of motion while performing the elbow or shoulder exercises. The GUI displayed and stored the related data in the database system which is used to display the rehabilitation history and can be further stored in the developed website.

Acknowledgements This work was financially supported by Faculty of Electrical and Electronics Engineering Universiti Tun Hussein Onn Malaysia (UTHM) and Centre for Diploma Studies, and the author would like to thank researchers of Biomedical Engineering Modelling and Simulation (BioMEMS) Focus Group for technical support.

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Chapter 37
Applying MagPI to Determine Adhesiveness in Matured Biofilm

Ainamardia Nazarudin, Sabine U. Gerbersdorf, Duratul Ain Tholibon and Nur 'Ain Mat Yusof

Abstract The development of biofilm on sediment surface can enhance the adhesion of substratum as well as improve sediment stability. Extracellular polymer substances (EPS) produced during the formation of biofilm act as a glue to bind sediment particles together, thus increasing their stability. The adhesiveness of biofilm throughout their development on the artificial sediments has been investigated in the laboratory using magnetic particle induction (MagPI), which is a device based on the magnetic attraction of magnetic particles that sits on the biofilm surface. Flumes experiment under two different flow treatments has been prepared to be compared with each other. The data of MagPI readings have been taken during the biofilm growth. The results show a continuous increase from the beginning of experiment until they reached matured state between day 25 and day 40. The biofilm under low flow treatment reached matured state quicker compared to the biofilm growth under high flow. After they reach maturity, there are consistent readings and very small increment in the MagPI readings during plateau state. This result shows that matured biofilm may become thicker due to EPS generation, but it will not contribute to the increase of adhesiveness on the surface of biofilm.

Keywords Adhesiveness · Matured biofilm · MagPI · Sediment stability

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_37

1 Introduction

Sediments play an important role in elemental cycling in the aquatic environment. They are responsible for transporting a significant proportion of many nutrients and contaminants. They also mediate their uptake, storage, release, and transfer between environmental compartments (Ongley 1996). The instability of rivers caused by excess deposition of sediment can severely impact aquatic life including the food chain, producing and raising habitat, water temperature extremes, and other structural and functional components. In addition, adverse sediment impacts also include harmful effects on recreation, navigation, conveyance, water treatment systems, and water storage.

Biofilm matrix that formed when benthic bacteria, microalgae, and macrofauna secrete extracellular polymeric substances (EPS) can bind mineral grains together in a sticky matrix, hence increasing the sediment stability (Paterson 1997). The presence of biofilm could also allow suspended sediments particles that flow through it to be attached on it despite its adhesiveness. This method is very practical to prevent erosion from happening, which furthermore improves the sediment stability. Generally, EPS are composed of polysaccharides, but may also contain proteins, nucleic acids, and polymeric lipophilic compounds (Kolari 2003).

Magnetic Particle Induction (MagPI) system has been developed to measure the adhesive capacity of sediment surfaces below the point of bed failure or incipient erosion. For example, the changes in adhesion during early stages of biofilm formation (Anderson et al. 2011). By using this device, the adhesiveness of biofilm can be measured over a period of time without interfering the growth of biofilm. This study has been conducted to measure the adhesiveness of matured biofilm using MagPI method throughout the growth of biofilm. The measurements of biofilm adhesives are taken twice per week in 14 weeks of the total period of biofilm growth. In addition, two different flumes have been setup in this experiment, which are high flow and low flow treatments. The biofilm that grows in flume 1, 2, and 3 is treated under high flow treatment, while biofilm in flume 4, 5, and 6 grows under low flow treatment. The results from MagPI measurements under both treatments were also compared with each other to achieve this objective.

2 Method

2.1 Preparation for Biofilm Growth

In this study, the biofilm was developed on the artificial sediment which was placed in the flume with recirculation fresh water. Because of the complex heterogeneous composition (organic content, size, and form of single grains) of natural cohesive sediment, artificial sediment (glass beads) is chosen to account for the geometrical characteristics (Thom et al. 2012). Fresh water is taken from the nearby river, which

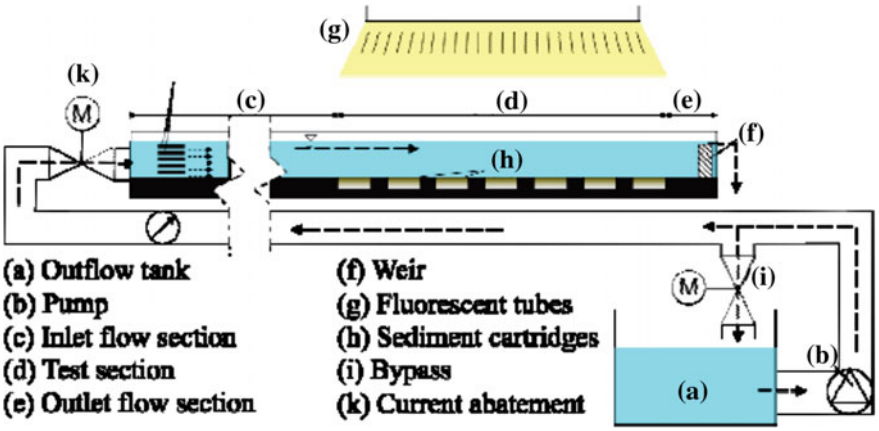

Fig. 1 Schematic view of a testing flume (Thom et al. 2012)

is River Enz. The Enz is a river flowing north from the Black Forest to the Neckar in Baden-Württemberg. In order to reproduce the same condition as the river flow, the flow of freshwater over the cartridges filled with artificial sediment is prepared. The scheme is prepared as shown in Fig. 1.

The outflow tank (a) provides the pumping system (b) with 200 l of circulating water flow. The flumes ($L \times W \times H = 2.00 \times 0.15 \times 0.15$ m) are made of float glass, suitable for Laser Doppler Anemometry (LDA) measurements of the bottom shear stress and monitoring of the biofilm growth. The test section (d) has a length of 0.90 m and holds the cartridges (h) for biofilm growth. The length of the inlet flow section ($L = 1.90$ m) (c) is dimensioned to avoid undesired turbulence in the test section and to accomplish a regular distribution of bottom shear stresses. The outlet flow section (e), which ends in a weir (f), has a length of 0.20 m. The light regime is applied with fluorescent tubes (g), which produce a constant intensity, with wavelengths in the range of 480–665 nm, important for biofilm growth. The intensity is regulated by adjusting the height of the tubes (Thom et al. 2012). Figure 2 shows one of the flumes which contained 14 cartridges filled with artificial sediment for biofilm growth. There are three flumes with low discharge located in one container, while the other three flumes with high discharge in another container.

2.2 *Measurement of Biofilm's Adhesiveness*

In order to measure the adhesiveness of biofilm throughout its growth, MagPI device and magnetic particles are used. The measurement is taken twice for a week for several cartridges during the biofilm development. MagPI device consists of an electromagnet, voltage and current variable power supply, glassed box, camera, and computer (shown in Fig. 3). This device has been equipped with camera, where

Fig. 2 Flume for biofilm growth

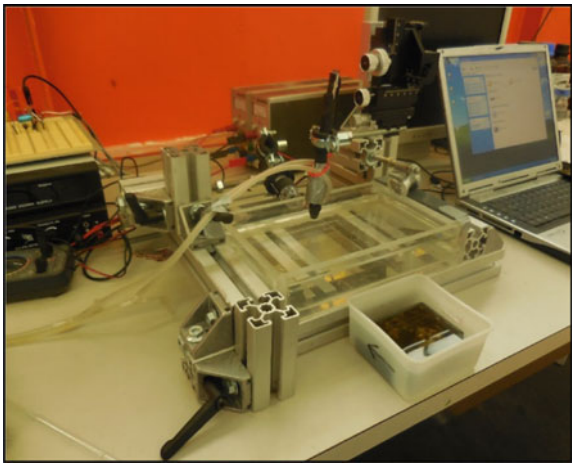

Fig. 3 MagPI device

images can be taken throughout the measurement and saved in the computer. This device can also be operated automatically, where the current increases when the switch is on and stops when its turned off.

Magnetic particles used in this experiment have a magnetic force where they can be attracted to the magnet. The magnetic particles are known as ferrous test particles, which consist of an amalgam of ferrous material to provide a magnetic response in the inside, and covered with fluorescent pigment to increase their visibility. The test particles were then sieved into different size classes. The size range selected for the trials was 180–250 μm, similar to fine/medium beach sand.

There are few important steps that should be considered during the measurement of biofilm's adhesiveness. The cartridge filled with sediment is taken from the flume with care to ensure the biofilm growth is not disturbed. After that, the cartridge is located under the magnet as shown in Fig. 4. The magnetic particle that has been

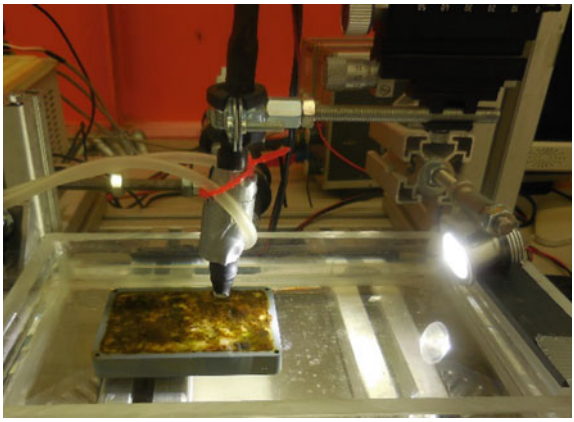

Fig. 4 Lamp is turned on to provide clear observation

mixed with water is then drawn into a pipette and ejected as a single drop in the media above the biofilm's surface below the magnet probe. Once the device is turned on, the magnetic force acting on particles also will increase. The picture of the response of magnetic particles to magnet probe is taken as well as the increasing of the current. Any difference and remark during the measurement are monitored and noted.

There were four thresholds of particles have been observed being responded to the increase of magnetic field. The first threshold ($T1$) happened when the first particle is 108 orientated; the second threshold ($T2$) happened when the first particles is attracted to the 109 magnets, the third threshold ($T3$) happened when half of the particles attracted to the magnet 110 and the last threshold ($T4$) happened when the whole particles are attracted to the magnet. Three measurements are taken at different places in every cartridge to get average reading before the cartridges are placed into their positions into the flume back.

2.3 Measurement of Extracellular Polymeric Substances (EPS)

In order to prepare biological analysis, the samples of biofilm are taken from the cartridge every week starting from week 4. These samples are taken to measure EPS protein and EPS carbohydrate. The sample is mixed together before inserted into two separated safety-lock Eppendorfs with 0.2 ml for each Eppendorf. The Eppendorf with the mixture of biofilm and sediment is filled with 1 ml of milli-Q water and rotated for 1 h by a horizontal mixer at room temperature. The Eppendorfs are then placed on centrifugation for 15 min before the supernatant was analysed for protein and carbohydrate following the modified Lowry procedure.

Protein concentration was measured by spectrophotometer at 750 nm wavelength, while carbohydrate concentration at 488 nm wavelength (BUCK Scientific,

CECIL CE3021, UK). Both concentrations were calculated according to BSA standard (Albumin from bovine serum: Sigma, cat no A 4503-10 g) with results reported in μg ml-1.

3 Results and Discussion

The electric currents are used to attract magnetic particles from the biofilm surfaces by electromagnet in order to measure the adhesive force on the biofilm surface. The electric current indicates the level of adhesiveness of biofilm in this method. The MagPI was applied twice per week in triplicate measurement in order to monitor the development of biofilm over time. Figures 5, 6, and 7 show the results of adhesive capacity for *T*1, *T*2, *T*3, and *T*4 by MagPI in high flow.

From the graphs, the adhesiveness of biofilm for the flumes under high flow showed almost the same pattern throughout the experiment, except flume 1 whose measurements could not be taken after day 42 due to some problems with eroded cartridges. The minimum readings for *T*3 in flume 1, flume 2, and flume 2 are 217, 219, and 223 mA, respectively, whereas the maximum reading for *T*3 in flume 1, flume 2, and flume 3 were 816, 1870, and 1565 mA, respectively. While, Fig. 8, 9, and 10 show the results of MagPI measurement in flume 4, flume 5, and flume 6 under low flow. The results show that the growth of biofilm after day 25 for flume 4 and 5 and after day 32 for flume 6 did not increase the adhesiveness of biofilm under low flow. The minimum readings for *T*3 in flume 1, flume 2, and flume 2 were 224, 221, and 222 mA, respectively, whereas the maximum reading for *T*3 in flume 1, flume 2, and flume 3 are 1346, 1177, and 1117 mA, respectively.

The measurements were taken from day 5 until day 49 of biofilm growth. Over this period, the results show an increase of biofilm adhesiveness under high flow and low flow. This trend continues until they become matured biofilm between day 25 and day 49 shown in the reading of threshold three (*T*3) and threshold four (*T*4).

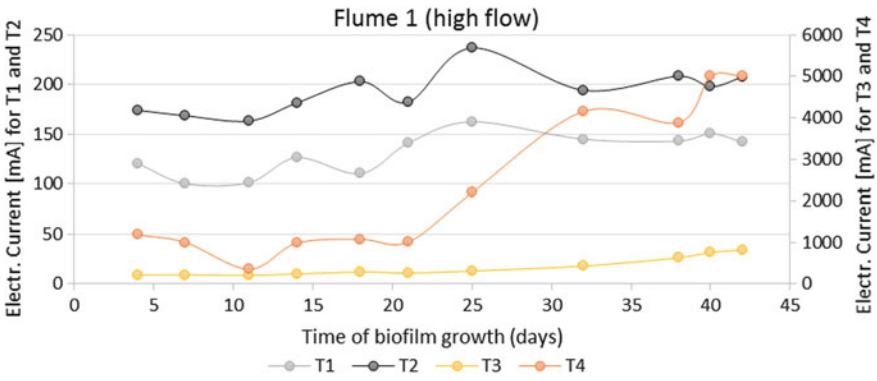

Fig. 5 MagPI measurement for flume 1 (high flow)

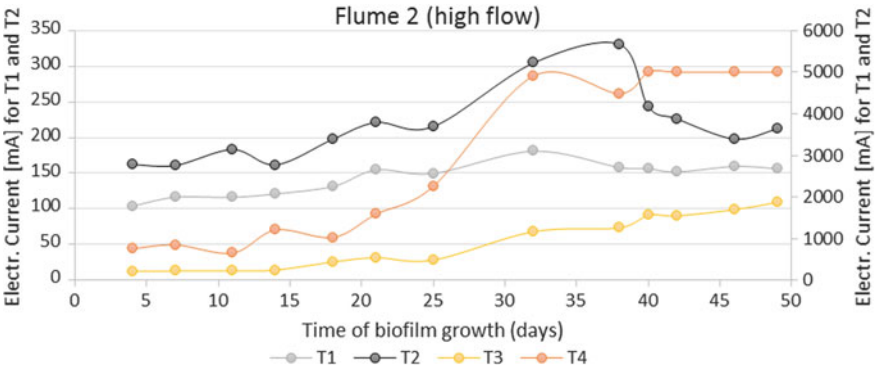

Fig. 6 MagPI measurement for flume 2 (high flow)

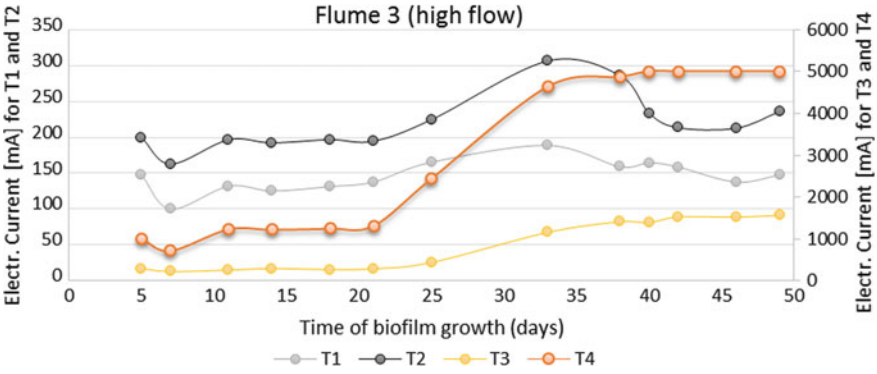

Fig. 7 MagPI measurement for flume 3 (high flow)

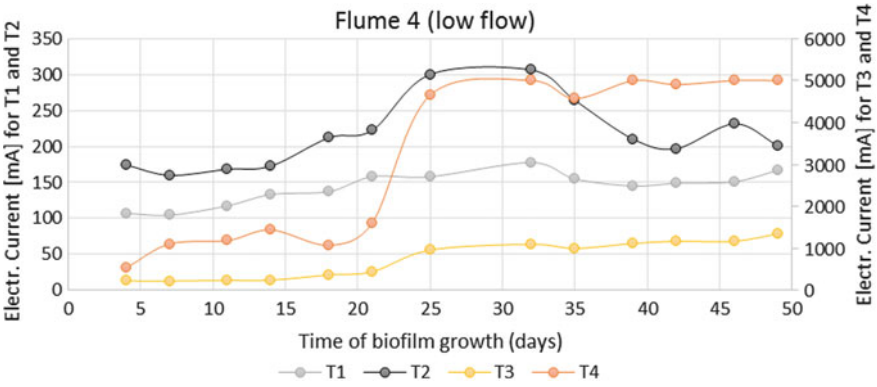

Fig. 8 MagPI measurement for flume 4(low flow)

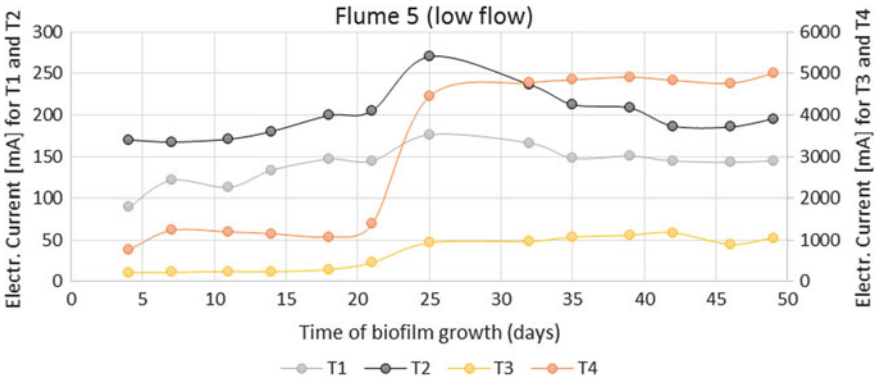

Fig. 9 MagPI measurement for flume 5(low flow)

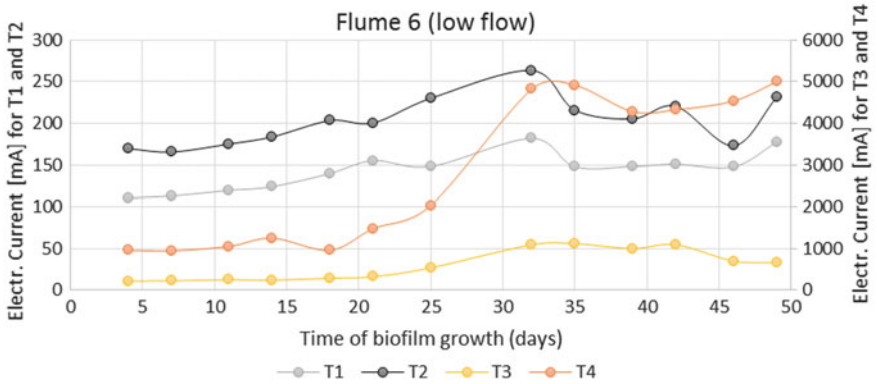

Fig. 10 MagPI measurement for flume 6 (low flow)

At the end of experiment, there are still increasing readings in *T*3 under high flow, while under low flow treatment, the readings show consistent pattern. The adhesive capacity results from *T*3 to *T*4 in this experiment supports the previous study that showed the ability of the MagPI System to determine the changes in surface adhesion as a result of biofilm formation and confirmed that the development of biofilm has increased the biofilm adhesiveness (Anderson et al. 2011).

On the other hand, threshold one (*T*1) and threshold two (*T*2) show no major changes throughout the experiment under both treatments. As the readings for *T*1 were taken when first magnetic particle orientated and *T*2 was taken when first magnetic particle was attracted to the magnet, there are possibilities that some of the particles may not be placed on the biofilm but rather on the pure sediment due to uneven growth of biofilm on the sediment surface, which can cause the particle to

be easily attracted to the magnet. As the substratum was composed of artificial sediment, the binding force must have been entirely due to biofilm attachment and secretion of polymeric matrix (Gerbersdorf et al. 2008).

The data for the adhesiveness of biofilm from threshold three (*T*3) were related to EPS proteins and carbohydrates. Both conditions showed a good regression between biofilm adhesion and EPS proteins as well as EPS carbohydrates as shown in Figs. 11 and 12, respectively. While Figs. 13 and 14 show the correlation of *T*3 in MagPI measurement with both EPS measurements under low flow.

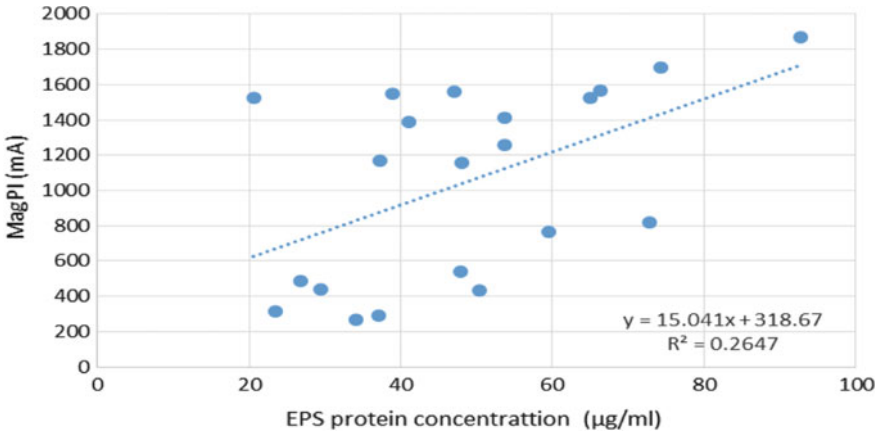

Fig. 11 Correlation between MagPI measurement (*T*3) and EPS proteins concentration under high flow

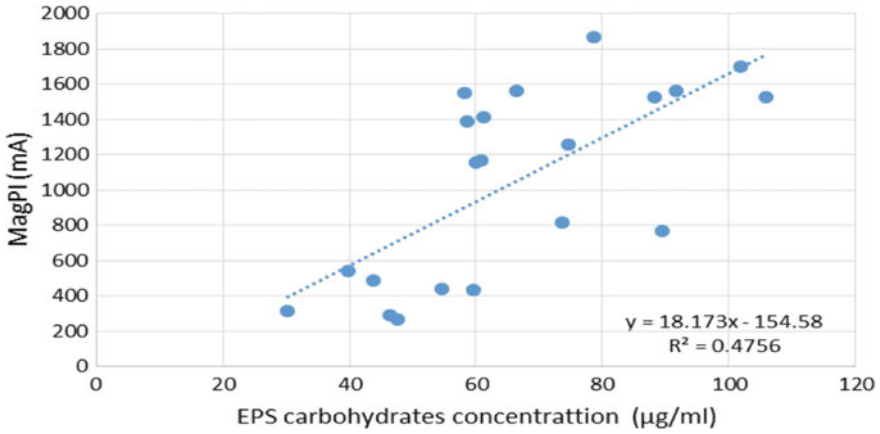

Fig. 12 Correlation between MagPI measurement (*T*3) and EPS carbohydrates concentration under high flow

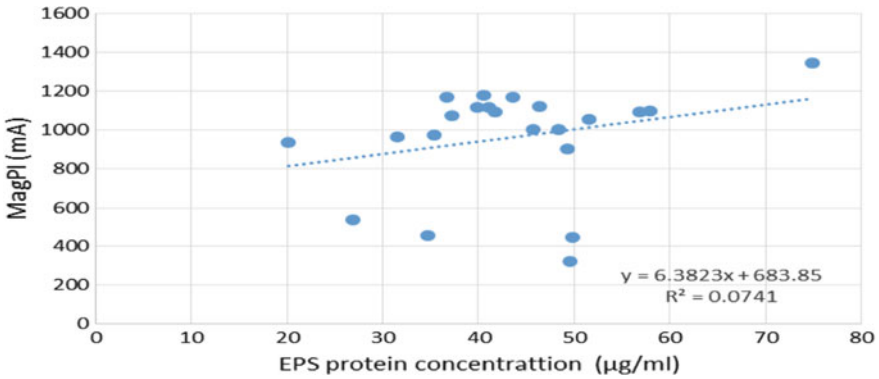

Fig. 13 Correlation between MagPI measurement (*T*3) and EPS proteins concentration under low flow

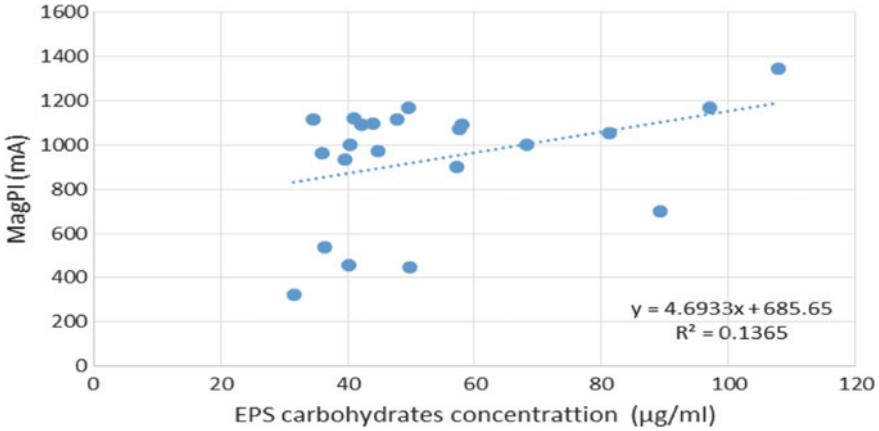

Fig. 14 Correlation between MagPI measurement (*T*3) and EPS carbohydrates concentration under low flow

In this study, the relationship between biofilm adhesiveness and EPS concentration show a positive relationship, where both EPS concentrations increased as MagPI readings increased. There are positive relationships under both treatments, while under high flow treatment, the relationships are rather more positive. This result also shows that the EPS concentration profile, in terms of protein and carbohydrate are correlated with the biofilm adhesiveness measured by MagPI method, which is consistent with previous study that found that EPS affected biofilm adhesion (Ahimou et al. 2007).

The experimental results of the formation of biofilm under different flow were helpful to better understand the effects of flow on the growth rate and EPS composition produced within biofilm. In this study, there are two types of treatments

applied during the growth of biofilm, which are high flow and low flow treatments. It seems that the growth of biofilm under high flow and low flow shows the similar pattern throughout the experiment. However, the biofilm under high flow treatment seems to grow denser compared to under low flow treatment at the end of experiment, which are shown in the pictures and verified by MagPI measurement. In addition, the reading of threshold two ($T2$), threshold three ($T3$), and threshold four ($T4$) from MagPI measurements also showed that most of the readings under high flow treatment were higher compared to low flow except during the middle of experiment. This result could indicate that high flow contributes to the diffusion of nutrient into biofilm, which might stimulate metabolism and respiration, and accelerates the production of attached cell that are concluded in the previous study (Wang et al. 2014).

Nevertheless, the result also exhibits that the biofilm under low flow has quicker establishment of matured biofilm compare to under high flow treatment. It seems like if there are low flow, the bacteria can attach better and grow quicker. This result supports the previous study by Mcclaine and Ford (2002) that confirmed higher flow velocities prevent the attachment of non-motile bacteria; thus, the surface is reached only by active movements. In contrast, bacteria under high flow could not easily attach themselves to the sediment due to the high velocity and would immediately be washed away. Conversely, these results show inconsistency with result from the previous study, where it had been found that the attachment rate is a function of laminar flow velocity, i.e., delivery of cells to the interface (Zhenga et al. 1994).

Flow conditions influenced also the distribution and composition of EPS in the biofilms as proved in the previous study (Wang et al. 2014). Based on the results, it is concluded that biofilm under high flow treatment produced more EPS protein in the time frame of experiment compared to under low flow treatment. The same pattern is discovered in carbohydrate concentration. Indeed, the EPS production depends on the wide range of variables such as flow of the river as proved in this study. The results show that the higher flow rate can stimulate biofilm to secrete more EPS, in response to the stronger hydrodynamics, creating a better stability of biofilm.

4 Conclusion

The main objective of this study is to investigate the adhesiveness of biofilm throughout the experiment and the influence of different flows on the development of biofilm. Based on experimental data, the following specific conclusions are arrived at:

1. There is increasing biofilm adhesiveness throughout the experiment, which is measured by MagPI method and adhesion force is enhanced by the production of EPS. A positive relationship has been observed between MagPI measurements and EPS measurements during biofilm growth.

Flow conditions influence the development and maturation of biofilm as well as the composition of EPS in the biofilms. Biofilm under low flow reached maturity earlier compared to biofilm under low flow treatment. However, the biofilm adhesiveness under high flow is higher at the beginning and the end of experiment.

Matured biofilm under high flow keeps growing until the end of experiment, which is hard to observe whether they have already reached plateau state or not. While under low treatment, in plateau state, we can conclude that matured biofilm at plateau state may become thicker with no more adhesion.

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Chapter 38
Numerical Analysis on the Effect of Geometry Parameter on the Behaviour of the T-Shaped Cantilever Retaining Wall

Noraida Mohd Saim and Anuar Kasa

Abstract The design of T-shaped cantilever retaining wall and support system requires careful analysis especially the geometry of the wall. The design starts by proportioning the wall dimension for which stability is checked for. Commonly, limit equilibrium method (LEM) is used to analyse the performance, however, the LEM analysis unable to predict the displacement of the wall. Thus, the numerical analysis using finite element method (FEM) incorporated in Plaxis software computer program was adopted to analyse the behaviour of the T-shaped cantilever retaining wall. This chapter describes the performance of a cantilever wall with different geometry parameter to predict the displacement pattern of the wall and the distribution of lateral earth pressure. Plain strain condition with 15 nodded triangular elements have been chosen in modelling the wall using Plaxis 2D. The result of the analysis indicates the lateral earth pressure distribution depended on the height of the wall. While the displacement of the retaining wall system showed the reasonable agreement with the recommended design of the geometry ratio.

Keywords Cantilever wall · Displacement · Finite element · Numerical analysis Plaxis

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_38

1 Introduction

The utilisation of the numerical analysis is very well known in geotechnical practices for more accurate and economical design compared to the conventional method. It is because of the powerful tools of the numerical technique such as finite element method (FEM) solved the complicated and advanced analysis like deformation behaviour of the substructures and slopes.

In conjunction with the evolution of computer hardware, the finite element code was incorporated in the Plaxis computer software programs that enable the geotechnical engineers to perform the complicated analysis even they are not a specialist in that numerical analysis. Plaxis have become popular in optimising engineering tasks (Wulandari and Tjandra 2015; Tang and Zheng 2008; Damians et al. 2014) and its performance has been validated by numerous analyses of a problem with known analytical solutions (Binkgreve and Vermeer 2002). The development of PLAXIS that began in the 1970s at the Technical University of Delft, Netherland has provided the calculations of forces, displacement and stresses, which lead to the prediction of the overall behaviour of geotechnical engineering structures such as a dam, pile foundation, retaining wall, slope stability, etc. (Brinkgreve 2002).

The inverted T-shaped cantilever retaining wall is the commonly used of retaining structure because cantilever walls do not require the installation of tie-backs below adjacent properties and offer a simpler construction procedure as the construction staging is much simpler. To start the design process, engineers need to make an assumption of the wall dimension called proportioning to check the walls for stability. Normally, the limit equilibrium method (LEM) is used to analyse such wall. However, prediction of displacement of the wall and backfill soil is not possible by using LEM. Therefore, in order to foresee the performance of the wall, FEM analysis is preferred. The focus of this study was to investigate at a fundamental level the effect of geometry parameter in term of the ratio between the lengths of the base and the wall stem on the generation of earth pressure and pattern of displacements by developing a numerical model using the Plaxis code.

2 Methodology

2.1 Wall Geometry

To study the effects of the stem height (H) and horizontal length of the base (B) on the displacement pattern and the lateral pressure acting on it, the different values of H were considered; a 4, 5 and 6 m height wall. Meanwhile, for the length of the base (B), there are five (5) different ratios that were investigated to account the effect on the lateral pressure. The ratios are $0.4H$, $0.5H$, $0.6H$, $0.7H$ and $0.8H$ to consider for the lower bound and upper bound behaviours. The details designated

Table 1 Designation of wall geometry

H (m)	*B* (m)				
4	0.4*H*	0.5*H*	0.6*H*	0.7*H*	0.8*H*
5	0.4*H*	0.5*H*	0.6*H*	0.7*H*	0.8*H*
6	0.4*H*	0.5*H*	0.6*H*	0.7*H*	0.8*H*

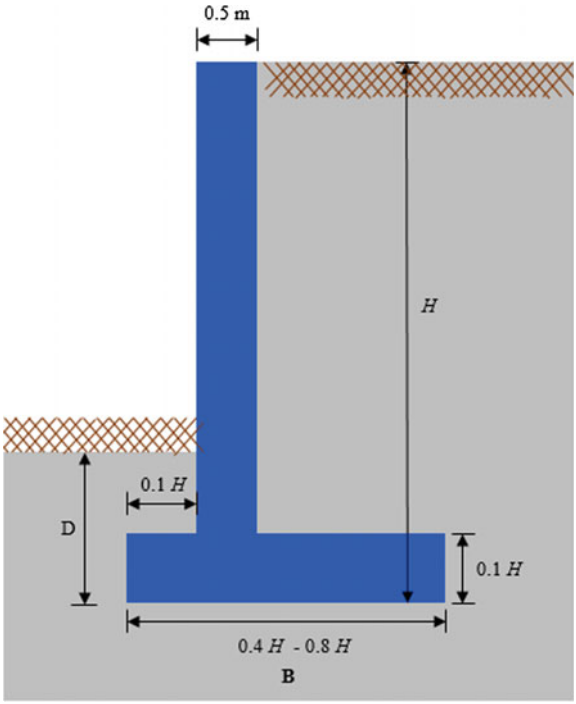

Fig. 1 T-shaped retaining wall

parameter used is presented in Table 1. The total of 15 different T-shaped retaining walls were analysed using numerical approach. Moreover, the length and thickness of toe were designed with 0.1*H* for each case as well as for heel thickness. The schematic diagram of the wall is shown in Fig. 1.

2.2 Soil Modelling

The retaining wall is constructed over gravelly sand soil, similar to the backfill material and the front fill. In addition, the water table is assumed to be located below the superstructure, therefore it is in drained condition. In this study, the soil material behaviour was analysed using Mohr–Coulomb model that required a total of five basic parameters that are common in the geotechnical area. The values of the modelling soil parameters used are presented in Table 2.

Table 2 Soil parameter

Parameter	
Modulus Young, E	80,000 kN/m^2
Unit weight, γ_{unsat}	17 kN/m^3
Angle of friction, φ	35°
Cohesion, c	2 kN/m^2
Poisson ratio, v	0.3
Dilatancy angle, ψ	0.0

2.3 Numerical Analysis

Numerical analysis using Plaxis 2D program was carried out separately for each case. The cantilever wall was modelled as plate element with the value of Young's modulus, $E = 20$ Mpa for reinforced concrete. The most important parameters of plate's inputs are the bending stiffness, $EI = 2.083 \times 10^5$ kNm^2/m and axial stiffness, $EA = 1 \times 10^7$ kN/m. From these, the equivalent thickness, d was determined to equal to 0.5 m. The plain strain condition is considered and 15 nodded triangular elements have been chosen for higher accuracy in assessing the displacements and stresses. These due to the capability of the 15-node triangular element that provides a fourth-order interpolation for displacement and the numerical integration involves twelve Gauss points (stress points) compare with 6-node triangular elements as shown in Fig. 2.

To simulate the full interaction between the plate and surrounding soil, an interface was created in the geometry model and it appears as a dashed line with plus sign (+) and minus (−) sign at which side of soil and plate interaction takes place. This sign has no effect on the calculation result and it just for identification purposes only. It can be seen in Fig. 3. Then, the strength reduction factor in the interface (R_{inter}) was set at 0.8, which indicates the roughness of the interaction between the wall and the soil.

In order to perform the finite element calculation, mesh generation was done first after the geometry model was well defined and material properties are assigned to all clusters and structural objects. Therefore, the mesh coarseness was designated *Fine* for the mesh generation to inspect the occurrence of deformations. The example of finite element mesh is shown in Fig. 4 for $H = 6$ m and $B = 0.5H$ m.

The calculation process of stresses and displacements in the model starts with initial condition and followed by another four phases; placement of foundation, construction of the wall, backfilling process and finally the front fill as resistance to the wall. All the phases mentioned were run as *staged construction* in loading input. The calculation completed when the prescribed ultimate state is fully reached and the Plaxis output generates the computed results. The presented results show the prediction of the displacements and lateral earth pressures computations.

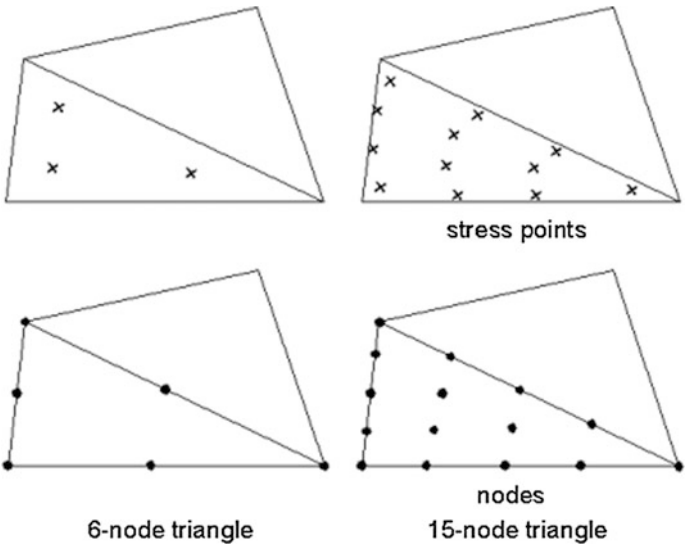

Fig. 2 Position of nodes and stress points in soil elements, Brinkgreve (2002)

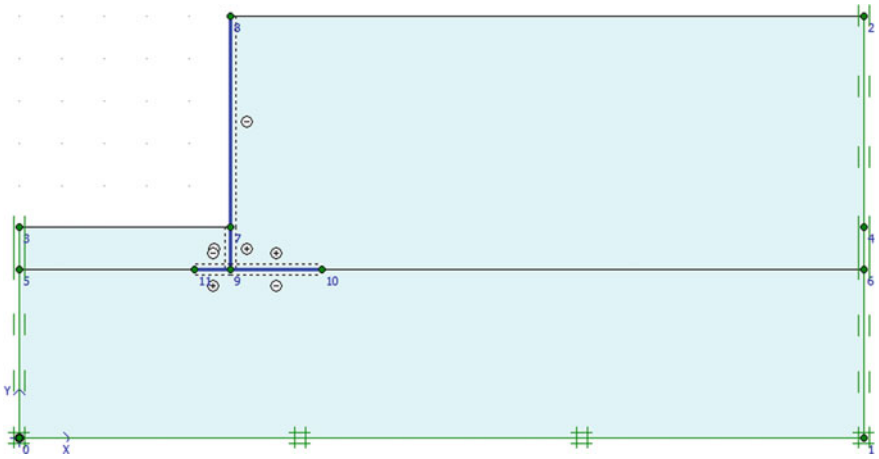

Fig. 3 Employment of interface in the model

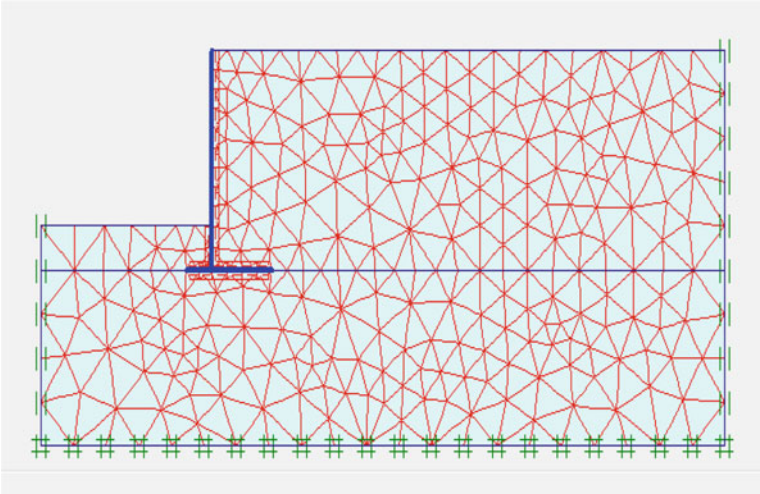

Fig. 4 Finite element mesh

3 Numerical Results

3.1 Wall and Soil Displacements

Figure 5 shows the post typical numerical element mesh predictions for the wall $H = 6$ m and $B = 0.4H$ m at the end of backfilling stage. The figure highlights the displacements pattern of the wall and the soil mass. It could be noticed that the movement of the wall stem is tilted forward away from the original backfill and moving downward slightly rotating anticlockwise at the toe as the centre of rotation. This is due to the load given by the soil mass during the backfilling process of the wall and the soil is moving together when it can't stand the load. The lower part of

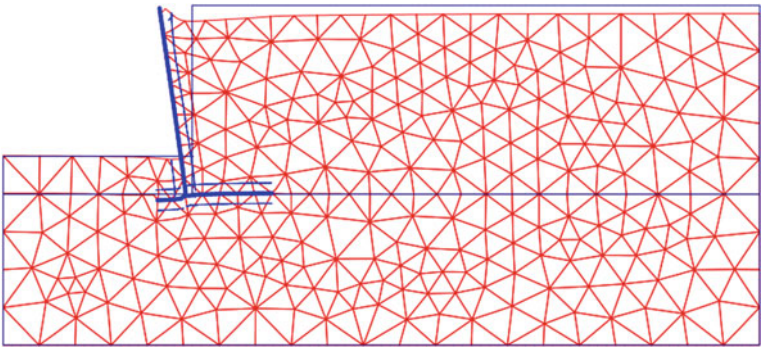

Fig. 5 Deformed mesh

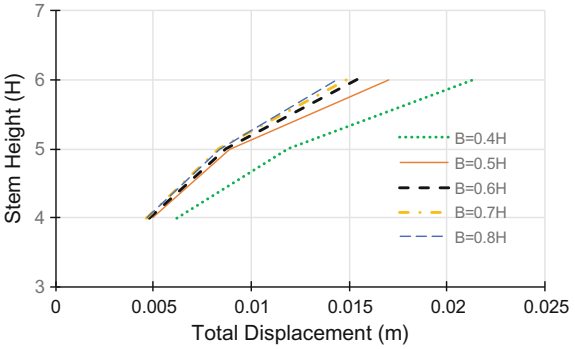

Fig. 6 Total displacement for all cases

the stem was contradicted by the soil in front of the wall that resists from major displacement. In overall, the computed results produced the similar outline of the wall displacement and soil movement. However, the amount of displacement differs for different geometry parameter of the wall. The total displacements for all cases are summarised in Fig. 6. As can be seen in this figure, the length of the base given by the ratio 0.4*H* for all height of stem produced the higher deformation. While for 0.5*H*, 0.6*H*, 0.7*H* and 0.8*H* have shown fairly small displacement and the value is close amongst each other.

Figure 7 shows the predicted displacement vectors of the various retaining wall with a different height of stem and different length of the wall base. Besides the displacement of the wall stem, it is clear that the base of the wall also has slightly rotating downward at the toe. In addition, as illustrated in this figure, for the values of *B* that is more than 0.6*H*, the heel of base does not seem to have displacement compared to *B* values of 0.4*H*, 0.5*H* and 0.6*H* that have very minimum displacement. The computed wall movement indicates rotation is dominant displacement and the centre of rotation is usually fixed at the toe of the wall which is in agreement with previous studies (Pot 1991; Rouili et al. 2005; Rouili 2013).

3.2 Lateral Earth Pressure

Figure 8 shows the lateral pressures profile for varying height, *H*, and ratio of the length of the base, *B*. It can be clearly seen that the lateral earth pressure are typically smallest at the top of the wall and increase accordingly towards the bottom part of the base due to the weight of backfill soil. According to the wall movement, the wall structure moves away from the supporting soil, indicating that the soil mass was in an active state. It indicates that the wall cannot maintain large stresses in the horizontal plane, so the major principles will have to be the vertical one. This figure

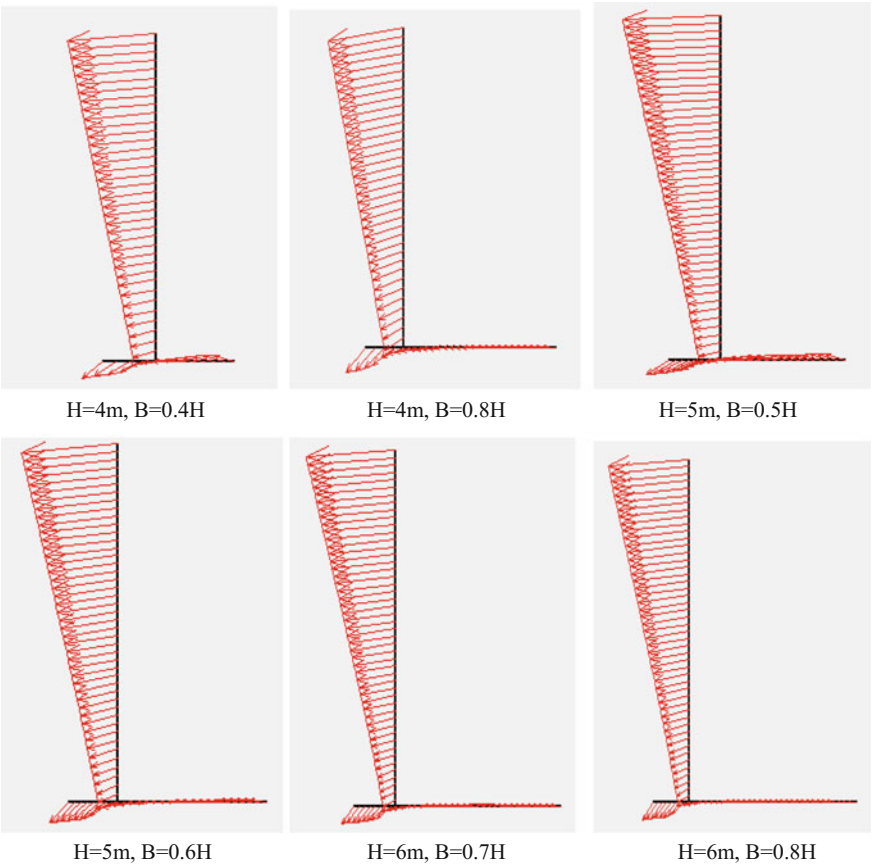

Fig. 7 Wall displacement

showed the profile of active pressure computed using Rankine approach. The Rankine theory assumed the retaining wall is completely frictionless also the ground and failure surface are straight planes. Hence, in common practice, lateral pressure is assumed to be linear, however in the numerically computed result, the lateral pressure distribution apparent as nonlinear. In real condition, retaining walls are rarely constructed completely smooth, so it is important to consider the interaction between the wall and the soil.

Furthermore, it can be argued that the distributions and location of earth pressure depend on the height of the wall and seem not influenced by the width of the base. Additionally, also can be seen the gradual change in increasing value of the lateral earth pressure in the lower third of the height of the wall, that is common to all the walls considered but at different depth noted as studied by Rouili et al. (2005).

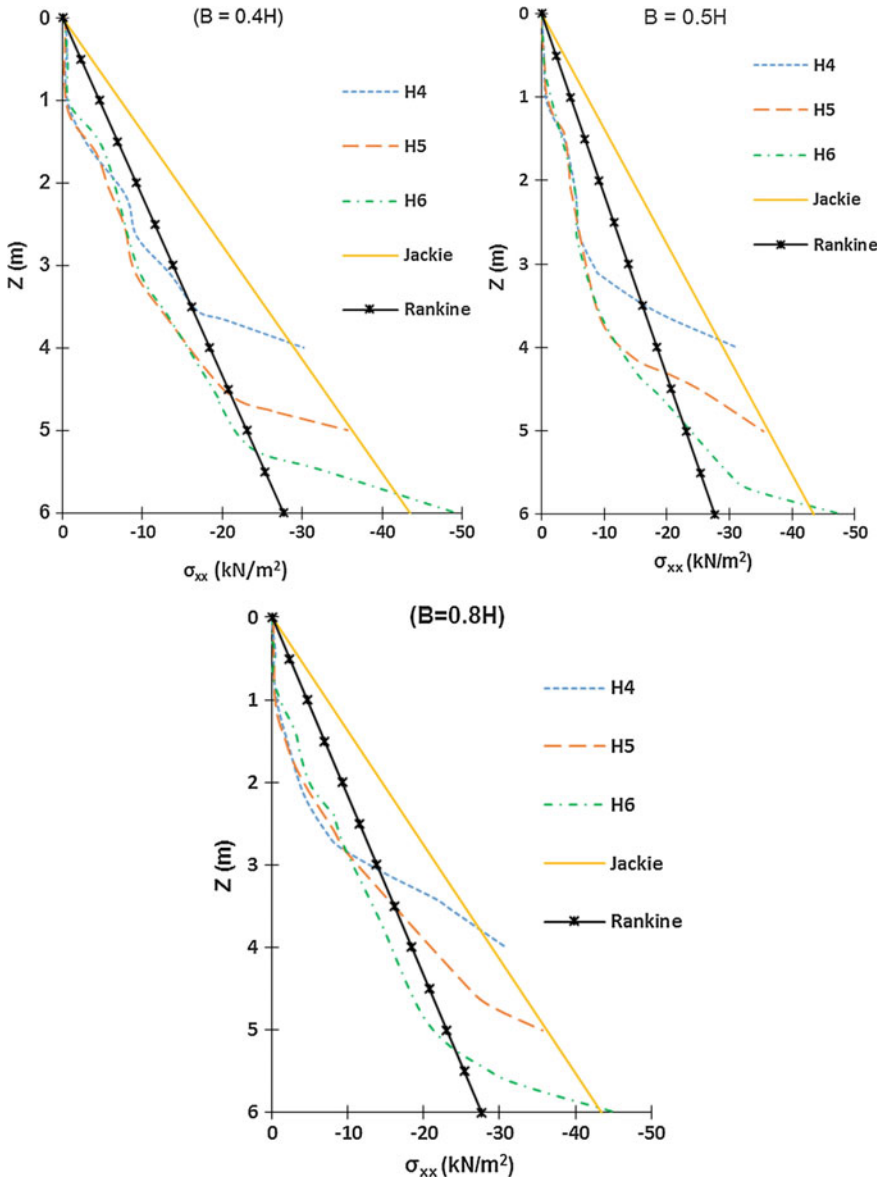

Fig. 8 Lateral pressure profile

4 Conclusion

In this study, the computed numerical analyses are presented for different wall geometries. The results show that the proportioning governs the equilibrium of the wall displacement. Also, the length of the base through the ratio of the stem height governs the effect of the wall movement at the toe. It was shown that for ratio B equal to $0.4H$ for stem height 4, 5 and 6 m, the displacement is the largest, between 0.006 and 0.022 m. Whereas, for the base length $0.5H$–$0.8H$, the displacements are in the range of 0.004–0.017 m and the rotational is dominant movement in this study. From the results, it is evident that the findings have reasonable agreement with the design practice and recommended values of B that fall between $0.5H$ and $0.8H$ (Oliphant 1997; Das 2013; Rouili 2013).

The lateral pressure estimation was increased from the top to the bottom of the wall as suggested by Rankine. The distribution of earth pressure was influenced by the height of wall rather than the base length. However, the distributions are not linear as Rankine because it replicates the real condition of the load by the weight of the soil. Although the monitoring field observations on real structures are the best way to fully validating numerical simulations, that procedure remains expensive and time-consuming. The numerical model was able to produce the displacement pattern and the magnitude of the displacement. Hence, using Plaxis numerical analysis will give the first prediction in designing and choosing the best dimension for the retaining wall.

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Chapter 39
A Study on Behaviour of Soil Bonding State Using Wave Propagation Method

Nur 'Ain Mat Yusof and Noorfaizah Hamzah

Abstract Nondestructive Testing (NDT) technique has a very important role to play due to new demands that required advanced characterization technique to monitor the bonding state condition of soil structures. In the technique not only the material under test is not impaired but also information on test results gathered is much faster and easier without any disturbance to the sample test. The broad usage of NDT will also include detection flaw, thickness measurement, classification of material, and others. Here, the NDT technique based on wave propagation method is conducted experimentally and reviewed in order to evaluate the better method in the determination of bonding state of soil. The dynamic properties of soil are evaluated by a Free–Free Resonant Column (FFRC) test to determine the P-wave and S-wave velocities after which an Impact-Echo (IE) method is then used to obtain the bonding state of soil based on signal obtained from time–frequency domain analysis The result shows a contour shape. Various bonding conditions (i.e., fully bonded, debonded, and void) are discovered suggesting that bonding state condition of soil can be evaluated through these contour shapes. It also can be deduced that bonding condition becomes worse when the tail is longer on time axis than the frequency axis.

Keywords Bonding condition · Bonding state · Contour shape
Impact-Echo (IE) · Wave propagation

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_39

1 Introduction

Civil engineering constructions require advanced characterization techniques to assess in situ conditions and to monitor processes such as bonding state condition of soil structures, where the use of Nondestructive Techniques (NDT) lead to better understanding of the material behavior without massive materials alteration. The NDT technique based on wave propagation method is reviewed for this study. The wave propagation method is one of the nondestructive method that can be used in order to know the characteristics of soil. As a matter of fact, wave propagation method used for establishing stratification of subsurface materials, the profile of the top of bedrock, depth to groundwater, limits of types of soil deposits rip ability of hard soil and rock, the presence of voids, buried pipes, and depth of existing foundations (Luna and Jadi 2000).

The increasing demand in order to get initial information of the site due to a few factors has caused problems in the world of geotechnical engineering. In order to overcome these problems, the NDT using Impact-Echo method (IE method) to determine the wave propagation should be attempted and compared with destructive techniques. Using this IE method, the information gathered is easier, faster, and cheaper. Moreover, it is more environmental friendly and can save energy.

This study is aimed to understand the behavior of soil bonding state using the wave propagation methods. In this study, Free–Free Resonant Column (FFRC) is conducted to identify the value of P-wave and S-wave. On the other hand, the IE method is conducted as in situ testing. The in situ model was prepared with the specific size which is (2.00 m $\times$ 1.00 m $\times$ 1.00 m) and was divided into three sections for the purpose of different types of bonding state. Each section used different materials to get different results of bonding state which are fully bonded conditions, debonded conditions, and void conditions. Styrofoam is used for void condition while plastic is placed between the mortar and surface of soil for debonded condition. The mortar is poured directly onto the surface layer fully bonded condition. Result verification is by analysis of data and comparison of the result between previous study and present study.

2 Literature Review

2.1 Wave Propagation Method

Gough et al. (1983) stated that wave is means of transmitting energy from one point to another without any net transfer or matter. That means transmitting information from one point to another. From the researchers view, all waves need source and medium of propagation, (Gough et al. 1983). In the case of sound waves, the medium can refer to air itself while the source is sound such comes from human.

There are two basic types of elastic waves which are body waves and surface waves. However, the body waves are focused in this study. Body waves are nondispersive, meaning that all frequency component of body waves travel through a homogeneous medium with the same velocity depending only on the properties of the medium, Keary et al. (2002). The body waves refer to longitudinal wave (P-wave) and transverse wave (S-wave).

2.2 *Longitudinal Wave*

Longitudinal waves are called as primary waves or compression wave (P-wave). P-wave is wave that transfer energy in the same direction as the disturbance in the medium of propagation. The particle motion is parallel to propagation methods. Traveling in a medium as a series of alternate compression and rarefaction, the longitudinal waves vibrate particles back and forth in the direction of wave propagation, Su and Ye (2009).

The example of longitudinal waves is sound waves. When in conversation, a person hears another by receiving and processing the sound waves that travel through air. Other than travel through gases (air), sound waves also can travel through solids and liquids. P-wave is used widely due to the speed of longitudinal waves which is faster than the other type of waves. Furthermore, the longitudinal may consist of single or multiple pulses. A pulse is a single disturbance moving through a medium from one location to another location.

2.3 *Transverse Wave*

Shear body waves, termed secondary, transverse or S-waves propagate by a sinusoidal pure shear stain in a direction of the waves. The transverse waves transfer energy under vibration particles perpendicular to the direction of wave propagation such as the vibrating string, Su and Ye (2009). The transverse wave will move perpendicularly along the length of string. The particle motion of the transverse wave is up and down in vertical plane known as S_V. However, the transverse waves may also oscillate in horizontal plane which is S_H wave.

Different from longitudinal waves, the transverse waves only can propagate through solid. It requires a relatively rigid medium in order to transfer their energy. In a case, the medium is not rigid (fluid), the particles will slide past each other. In addition, the transverse waves consisting of many pulses. The wave train is a series of an initial pulse followed immediately by other pulses of opposite displacement. Figure 1 shows schematic elastic wave propagation in the ground where P-wave and S-wave are known as body waves while Rayleigh and Love waves are surface waves.

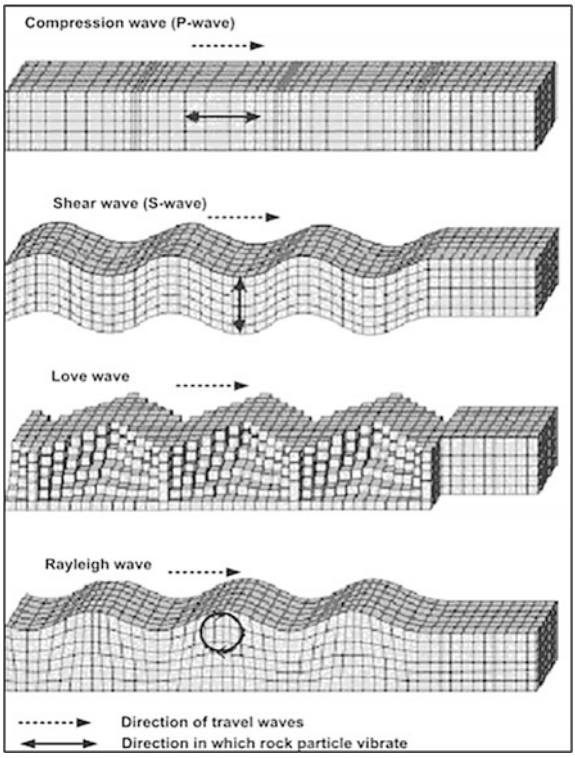


Fig. 1 Schematic elastic wave propagation in the ground (Aziman et al., 2016 J. Phys.: Conf. Ser. 710 012011)

2.4 Impact-Echo (IE) Method

Song and Cho (2009) stated that the detection of flaws in concrete structures has been successfully performed using what is known as the impact-echo (IE) method; stress wave propagation characteristics enable the quality to be evaluated, the thickness to be estimated, and cracks and voids to be found based on phase and frequency analyses of received waves. IE is a method for nondestructive testing of concrete and masonry structures that based on the use of impact-generated stress (sound) wave that propagate through concrete and reflected by internal flaw and external surfaces, Sansolone and Street (1997).

The IE method is widely used for the detailed nondestructive evaluation of concrete structure. In this method, the crucial parameter in the determining the thickness of concrete slab and the location of cracks or other defects is P-wave velocity of concrete. Kim et al. (2004) pointed out that IE method is the stress pulse generated by an impact on the surface propagates back and forth between the internal defects or bottom and top surfaces of the object. The arrival of these reflected waves at the surface is recorded by receiving transducers, and the received signal is periodic. Both time domain and frequency domain analyses are used to

identify the transient resonance conditions occurred by the multiple reflections of waves between impact surface, defects, and or other external surfaces, which can be used to determined the locations or defects or member thickness. If the compressive wave speed, V_p is predetermined, the thickness of structure and the location of internal defects can be evaluated. Figure 2 shows the IE test configuration.

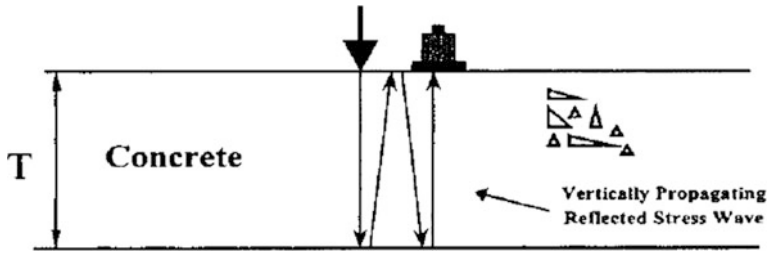


Fig. 2 Impact-echo test configuration (Kim et al. 2004)

According to Sansalone and Carino (1986), IE method is a technique based on the use of transient stress waves generated by elastic impact. The American Society of Testing Materials 'ASTM' adopted a test method that consists two procedures, which are Procedure A used to measure the P-wave speed in the concrete while another one, Procedure B for measuring the thickness frequency ASTM C 1383 (2004). In this study, the Procedure A is used. Until mid-1990s, the P-wave speed is determined from cores or performing a test on a portion of solid element with known dimension. However, in 1995, the value of P-wave could be found by determining the time taken for P-wave to travel between two points.

2.5 Time–Frequency Domain Analysis

For this study, the wavelet transformation is used in analyzing the signal obtained at the receiver in the time–frequency domain analysis. However, Song and Cho (2009) used short-time Fourier transform (STFT) for their study which is "Bonding state evaluation of tunnel shotcrete applied onto hard rocks using the impact-echo method". STFT is referring to study a signal in the time and frequency domains by using various time–frequency representation. According to Song and Cho (2009), a feasibility study of IE method is performed using finite element analysis and an experimental study is carried out to investigate the validity of numerical studies. Figure 3 shows the result of the time–frequency analysis (numerical modeling) in contour plots by Song and Cho (2009).

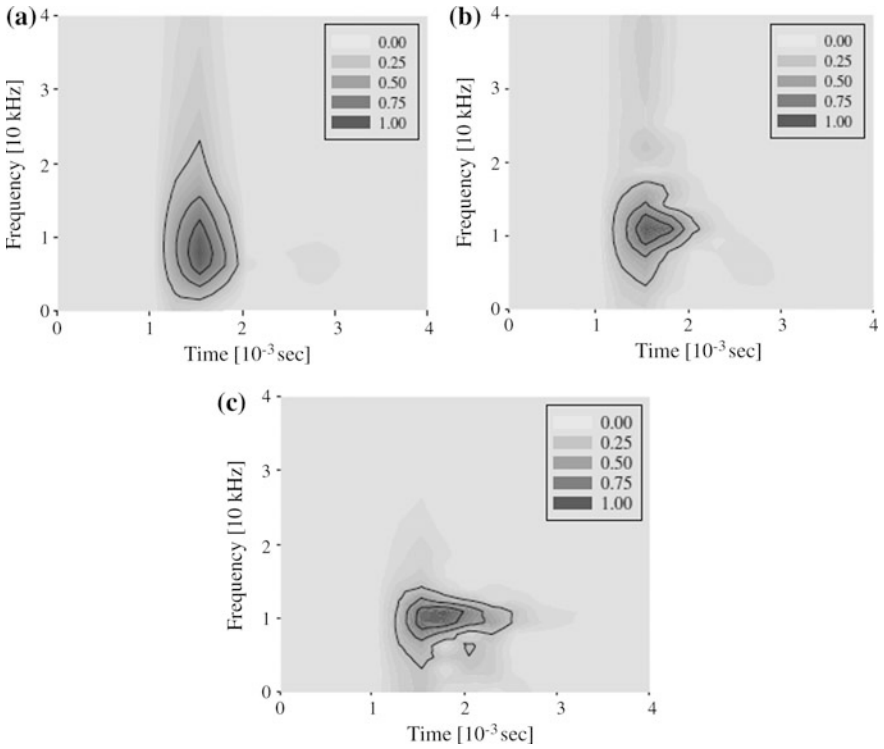


Fig. 3 Time–frequency domain analyses–numerical modeling. **a** Fully bonded condition. **b** Debonded condition. **c** Void condition (Song and Cho 2009)

3 Methodology

The soil samples were collected from the hill which located in Damansara Perdana, Selangor. Samples preparation, in situ tests, and laboratory tests were undertaken by Soil Laboratory, Faculty of Civil Engineering, UiTM Shah Alam. Preparation of samples and test procedures were in accordance to British Standard (BS). For the dynamic properties test, Free–Free Resonant Column (FFRC) used to determine the P-wave and S-wave value and the bonding condition can be determined by conducting IE method.

3.1 Free–Free Resonant Column (FFRC)

Free–Free Resonant Column (FFRC) is used for measuring the dynamic properties of soil in the laboratory. The FFRC test is quite rapid and it is a simple laboratory testing. The FFRC is conducted in order to determine the body waves

of soil namely P-wave and S-wave. For making this test more effective, specimens with a length to diameter ratio of at least two is required. First, the soil samples are compacted in the cylinder mold with size 50 mm diameter and 100 mm height. Then, the cylindrical mold is hung, connected with the accelerometer and impact using hammer with load cell. When a cylindrical specimen is subjected to an impulse load at one end, seismic energy over large range of frequencies propagate within the specimen. The travel time t_1 and t_2 are recorded by oscilloscope. Once the length of specimen, L and average time, Δt are known, the P-wave value can be obtained using the Eq. (1). Figure 4 shows the experimental setup for FFRC.

Fig. 4 Experimental setup for FFRC

$$\text{Compression wave, } Cp = \frac{\mathrm{L}}{\Delta t} \tag{1}$$

3.2 *Impact-Echo (IE) Method*

The IE method consists of measuring both time and frequency. Other than that the measurement of P-wave velocity is also made. This measurement is based on the travel time of the P-wave (Δt) between two transducers and a known distance apart (L). The P-wave velocity (V_p) is measured using Eq. (2).

$$f = \frac{Vp}{2T} \tag{2}$$

The equipments used in IE method for this study include an impactor (small steel bearing ball), a receiver, and a data acquisition tool. Initially, small steel ball falls free from the height of 100–200 mm used as the impact source. The small steel ball with diameter size 15 mm used onto different conditions. As stress waves propagate through the mortar surface, they reflect off internal and external boundaries and cause periodic displacement on the surface. These motions are monitored by transducers located adjacent to the impact. The piezoelectric crystal in the transducers produces a voltage proportional to displacement. The resulting voltage time signal (waveform) is digitized and transferred to the memory of a computer. Then, it is converted mathematically into a spectrum of amplitude versus frequency. The IE equipment setup is shown in Fig. 5.

Fig. 5 IE equipment setup

For the experimental setup, the samples for IE test have been prepared which consist of three different conditions. There are void condition (Section A), debonded condition (Section B), and fully bonded condition (Section C). The materials used are Styrofoam, thin plastic film is placed between the mortar and surface of soil while the mortar is poured directly onto the surface layer, respectively. Figure 6 shows the experimental setup of IE method.

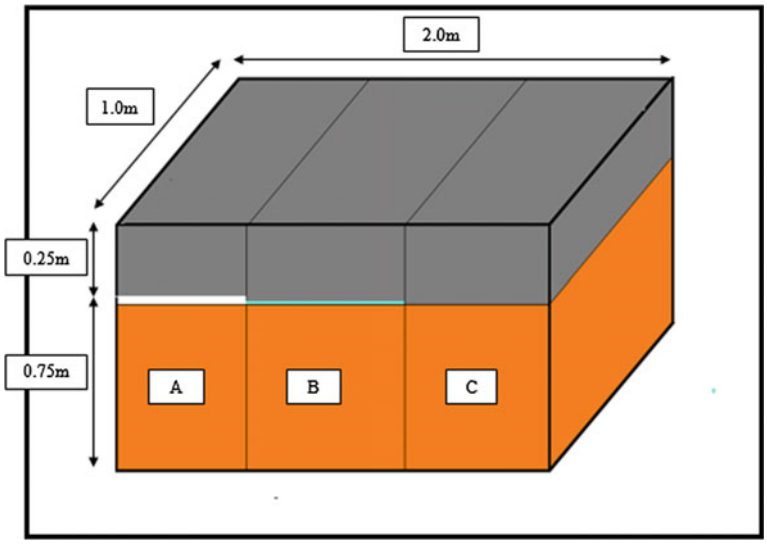


Fig. 6 Experimental setup of IE method. **a** Void condition. **b** Debonded condition. **c** Fully bonded condition

4 Results and Discussion

4.1 Free–Free Resonant Column (FFRC)

The summary of test result for Free–Free Resonant Column (FFRC) test is presented in Table 1.

Based on the findings of materials properties for three samples above, the average S-wave velocity and P-wave velocity were obtained. The value for P-wave velocity was greater compared to the S-wave velocity. This is proven where the particle motion for P-wave is parallel to propagation method. Otherwise, particle motion for S-wave is perpendicular to propagation method. According to the particle motion, the P-wave is fastest when compared with S-wave. Table 2 shows the table of S-wave and P-wave velocity.

In order to make this study acceptable, the results gained were compared with Song and Cho (2009). The difference between this study with Song and Cho (2009) is type of material used. The laterite soil is used for this study while hard rock is used for Song and Cho (2009). Since the material used is different, the result obtained is also different, where P-wave and S-wave obtained by using hard rock material is greater compared to the results using laterite soil due to the voids

Table 1 Material properties of soil

Material properties	Unit	Sample 1	Sample 2	Sample 3
	Kg	Mass = 0.401	Mass = 0.398	Mass = 0.395
	kg/m^3	$\rho = 2.044 \times 10^3$	$\rho = 2.025 \times 10^3$	$\rho = 2.011 \times 10^3$
Young's Modulus, *E*	GPa	1.374×10^9	1.362×10^9	1.353×10^9
Shear Modulus, *G*	GPa	$4.46 \times 10^8 - 2.287i \times 10^8$	4.882×10^8	$6.442Z \times 10^8 - 1.159i \times 10^8$
Bulk Modulus, *K*	GPa	$1.365 \times 10^8 + 3.05i \times 10^8$	2.152×10^9	$4.081 \times 10^8 + 1.545i \times 10^8$
Constraint Modulus, *M*	GPa	7.311×10^8	2.803×10^9	1.267×10^9
Poisson's ratio, *v*	–	0.22 + 0.626i	0.395	$0.017 + 0.183i$
Rod Velocity, *V* rod	m/s	820	820	820
P-wave velocity, *Vp*	m/s	598.086	1.176×10^3	793.651
S- wave velocity, *Vs*	m/s	481.355	491.002	568.178

Table 2 S-wave and P-wave velocity

Sample	Average travel time, δt (s)	S-wave velocity, v_s (m/s)	P-wave velocity, v_p (m/s)
1	0.0001672	481.355	598.086
2	0.000085	491.002	1.176×10^3
3	0.000126	568.178	793.651
Average velocity		513.51	855.91

between particles. When the stress wave applied, there are partly of the stress transmits through it, and others is reflected. On the other hand, hard rock material is usually represented in solid condition. Therefore, the stress wave which reflects from interface is less compared to laterite soil. From the result obtained, the value for P-wave and S-wave of hard rock material are shown in the range of thousand, while the value for laterite soils material are shown in range of hundreds. The comparison between both studies has been shown as in Table 3.

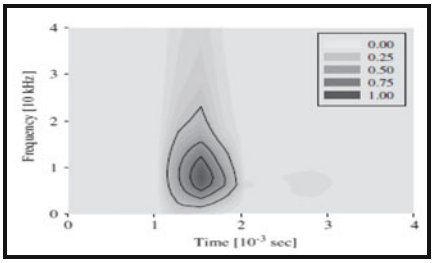
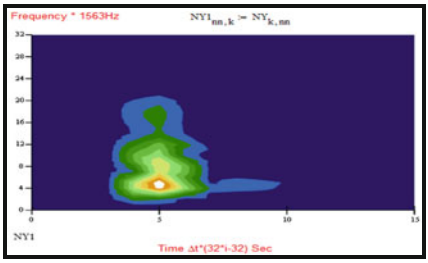
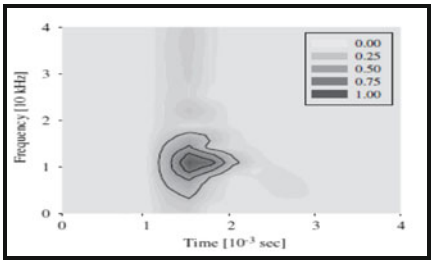
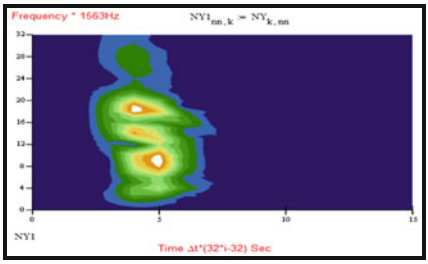
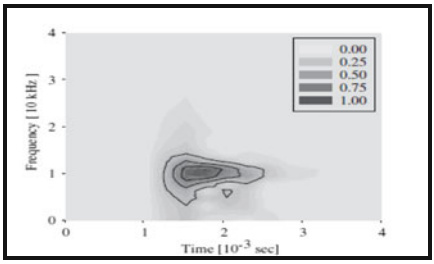
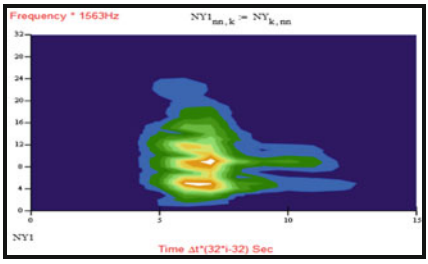
Table 3 Comparison table

Researcher	Material	V_p (m/s)	V_s (m/s)
Song and Cho (2009)	Shotcrete	4000	2450
	Hard rock	4500	2755
This study	Laterite soil	855.91	513.51

4.2 Impact-Echo (IE) Method

The results are shown in contour plots after the signals are analyzed using time–frequency domain analysis. The time–frequency domain analysis is a combination of time domain analysis and frequency domain analysis. The results are compared in term of contour shape. Due to the table below, the contour line for fully bonded condition (a) is nonsymmetrical. The tail is longer on frequency axis compare to the time axis. Meanwhile, the debonded condition (b), represents the symmetrical contour line with small tail on both of time and frequency axes. When the contour line is nonsymmetrical and shows a longer tail on the time axis compared to the frequency axis, it is a void condition (c). It can be concluded when the conditions worsen, the time taken is longer for wave to travel. The frequency is lower due to losses of energy. Table 4 shows the comparison of time–frequency analysis results between Song and Cho (2009) and this study in term of contour shape.

Table 4 Comparison time–frequency analysis results between Song and Cho (2009) and this study in term of contour shape

SONG AND CHO (2009)	THIS STUDY
	
(a) Contour Shape of Fully Bonded Condition	
	
(b) Contour Shape of Debonded Condition	
	
(c) Contour Shape of Void Condition	

5 Conclusion

Based on the findings from this study, the following conclusions can be made:

1. The value of P-waves and S-waves of the soil samples using Free Free Resonant Column is successfully obtained. The results obtained for P-wave velocity is 855.91 m/s while S-wave velocity is 513.51 m/s. Since the particle motion for P-wave is parallel to propagation method, this is proven when results shows that the P-wave has greater value compare to S-wave.

2. From the IE tests, the signals are analyzed using time–frequency domain analysis. The results show a contour plot, whereby the contour shape is differing from one condition to another. Bonding condition become worse when the tail becomes longer on time axis than frequency axis. It can be deduced that the time taken is longer for wave to travel and the frequency is lower due to losses of energy when the conditions worsen; fully bonded condition to void condition.

Acknowledgements The authors wish to extend appreciation to UiTM Shah Alam to provide required facilities for this research. Valuable comments from Noorfaizah Hamzah is also warmly acknowledge. Sincere gratitude offer to the geotechnical laboratory staffs and my friends especially Mu'az Bin Dato'Aznam and Mohd Rafiq bin Jaafar for their kind help in the laboratory work.

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Chapter 40
Feasibility Study of Solar PV Installation in UiTM Sarawak

Nur Farahiah Ibrahim, Zahari Abu Bakar and Wan Suhaifiza W. Ibrahim

Abstract Malaysia is gearing towards renewable energy source and is blessed with an excellent geographical location, providing abundant solar energy. Improvement in solar panel efficiency and reduction in panel cost has made solar energy a very viable option for RE and is being adopted in utility-scale installation around the world with one of the lowest Levelized Cost Of Energy (LCOE) index. This study aims to determine the financial feasibility of a small-scale solar installation under Sustainable Energy Development Authority (SEDA) Feed-in Tariff (FiT) in UiTM Sarawak. A solar irradiance meter is used to intermittently measure solar power output at the targeted location. Analysis of collected data has shown that UiTM Sarawak has a median PSH of 4.44 h and a sustained maximum irradiance of over 1 kW/m^2. Malaysia SEDA promotes RE by introducing FiT in 2011 and has been very popular with investors. Although FiT rate has been on the decline, a small–medium-scale solar PV installation in UiTM Sarawak shows promising results with ROI of less than four years and a 26.8% return per year over deployment cost.

Keywords Feed-in-Tariff (FiT) · Levelized cost · Renewable energy
Solar energy

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_40

1 Introduction

Solar power generation has always been considered as a sensible approach to sustainable green energy with Malaysia's high insolation. Malaysia's 10th Entry Point Project (EPP) under the Economic Transformation Plan (ETP) has put an emphasis on renewable solar energy. Under this initiative, renewable energy is to generate 985 MW or 5.5% of total energy production by 2015 with solar photovoltaic (PV) to contribute at least 65 MW to the total country's energy generation. The 2013 SEDA annual report shows that approved installation of solar PV plant in Malaysia amounted to 209 MW for the year 2013, a significant 39% of total proposed renewable energy (RE) produced in Malaysia with 5% production by individual small-scale solar PV is shown (SEDA 2013). SEDA is formed to administer and manage the implementation of FiT under the Ministry of Energy, Green Technology and Water (KeTTHA). From the Localized Cost of Energy (LCOE) in (Lazard 2009), individual small-scale solar PV has a very high LCOE due to expensive solar PV panels compared to the bulk pricing by manufacturers to utility-scale plant.

Malaysia has incoming flux of investors building solar plant with output capacity of more than 100 MW. These investors are attracted by Malaysia 10th Malaysian Plant and Renewable Energy Act 2011 (Act 725) under the National Renewable Energy Policy and Action Plan (NREPAP) 2009, providing high Feed-in Tariff (FiT) rate and various fiscal tax exemptions given to these solar plants. This helped solar PV to become the highest contributor to Malaysia proposed RE generation at 39% or 209 MW for the year 2013. Actual production for solar PV power generation as of 2014 is 177 MW as outlined (SEDA 2013) as some of the plant approved in 2013 has not reached their commencement date or is not yet at full capacity. The response for RE has been overwhelming and as of today, SEDA FiT allocation has been depleted until the second quarter of 2019. All allocation for solar RE in the next three years has been awarded.

With rising energy cost, the purpose of this research is to determine the feasibility of an on-grid solar PV installation in Universiti Teknologi MARA (UiTM) Sarawak. Initial factors to be considered are the actual sun insolation and solar power generation at said location. This would be the main criteria of the study in which alongside initial deployment cost. This study can be divided into two main tasks: collection of peak sun hour (PSH) and sun insolation at UiTM Sarawak and analysis of said data to acquire the deployment cost and return of investment (ROI). With the research, it is expected that the feasibility of such installation could be concluded.

2 Literature Review

Geographically, Malaysia is located between latitudes 1° and 7° in the northern hemisphere near to the equator and longitudes 100° and 104°. The daily average sunshine throughout the year is recorded at 6 h with Kota Samarahan receiving a below average of 5 h of solar insolation based on Metrology Department of Malaysia, (MetMalaysia). Malaysia's tropical climate has good potential for PV systems. The average daily insolation for most parts of the country is between 4.5 and 5.5 kWh/m^2 and the annual variation between maximum and minimum is about 25% due to seasonal weather exchange. MetMalaysia has recorded a promising average sun insolation of 4.2 kWh/M^2 in Kota Samarahan area in the last five years. It has been proven that PV systems would be most effective in the northern part of Peninsular Malaysia and Sarawak, where the insolation levels are higher (Idris et al. 2010).

Located at the Equator, with tropical rainforest climate, exposed the area to El Niño which disrupts normal weather patterns (intense storms or extensive drought). MetMalaysia closest weather station to UiTM Kota Samarahan is located 13 km away (1.483N, 110.333E) in Kuching, equipped with rain and solar thermopile pyranometer. Kuching is one of the wettest place in Malaysia with an average rainfall of 4128 mm with average 247 days of rain. Kuching has the lowest average solar insolation of 1470 kW/m^2 compared to other city location (up to 1800). Data from the MetMalaysia for the monthly distribution of these parameters is shown in Fig. 1 encompassing the monthly rainfall distribution and average number of rain days in the month.

Off-grid solar is an independent system that supplies electricity to the load without being connected to the main grid. Off-grid system directly converts solar into electricity, offers significant advantage in term of pollution free and inexhaustible supply (Idris et al. 2010). Also known as solar home system, this simpler off-grid system is largely used in rural areas that are disconnected from the main

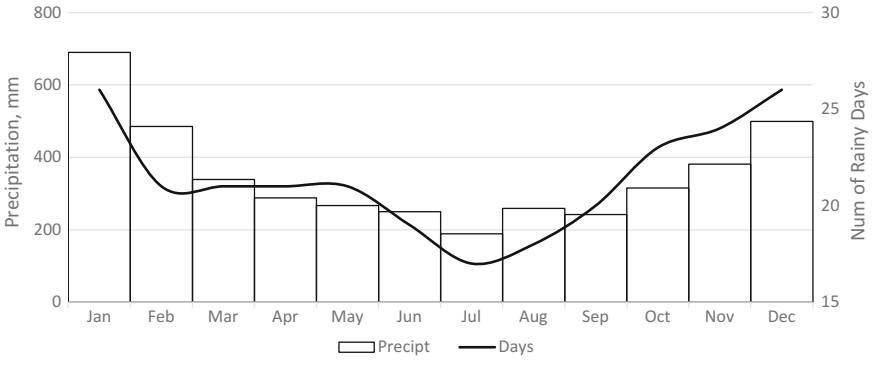

Fig. 1 Monthly rain days and precipitation in Kuching

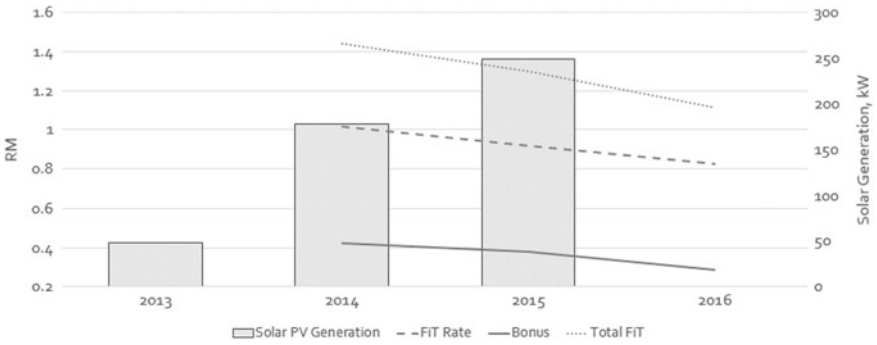

Fig. 2 SEDA FiT rate declination and generation

grid to improve the quality of life for these rural people. Several researches have been conducted to study the implementation and economic analysis of the performance of such system. Study has shown that the use of improved PV can reduce the costs of installation and maintenance as compared to the use of diesel generator for Malaysian rural electrification (Malek et al. 2010). Off-grid solar system is widely used in Thailand, Bangladesh and Indonesia (Ibrahim 2013). These installations typically consist of the solar PV array, solar controller with optional maximum power point tracker (MPPT), battery bank, inverter and the electrical load.

However, SEDA has been reducing their FiT rate throughout the year and FiT quota for new solar PV installation (company and personnel) has been awarded to recipients and is not available until the year 2019. Declining FiT rate is a global occurrence and some countries such as Spain has decided to abolish FiT completely. Increasing RE adoption rate has been very promising, added by the lowered cost of entry due to cheaper PV panel and battery cost. Figure 2 shows the declining FiT rate by SEDA over the years. FiT has always been a mechanism to attract investment in renewable energy and has now reached that goal as seen from SEDA quota depletion. Additionally, the high pay-out and long contract tenure of FiT indirectly transfers the cost to utility grid users and increases energy tariff.

Grid parity is a referral point in which alternative energy source is able to generate power at a LCOE that is less than or equal to the commercial rate of utility grid. A study by (Lau et al. 2014) evaluated the possibility of a grid parity occurring in Malaysia, based on the current trending data. It is foreseen that Malaysia would reach grid parity by the year 2029. This is of concern to FiT users, since SEDA has clearly allocated an alternative cheaper rate in the agreement if grid parity is achieved. As of 2016, displaced cost for grid parity is RM0.30 per kWh without adjustment for tariff revision. This represents a drop of 69–75% in revenue based on installation size for 2016 FiT rate. However, the oil slump of 2015 would extend the estimate presented in the chapter. As of 2014, 19 countries have reached grid parity for solar PV RE. Parties who have interest in SEDA FiT would have to consider the grid parity possibility for long-term investment purposes.

3 Methodology

Solar Irradiance data is collected at designated location at UiTM Sarawak. Measured parameter is then analysed to measure the PSH and maximum solar irradiance. Extensive data was collected throughout the research period from September 2015 to May 2016 at an interval of 30 min at specific configuration between the hours of 0800–1700. The PSH value will be used to evaluate the efficiency of a solar installation at location and to determine the financial feasibility of such installation.

Analysis of the feasibility of a solar PV installation will be concluded based on the data collected and the expected ROI period. Operation and maintenance (O and M) of these panels will also be neglected in the calculation, since the cost is significantly low for small-scale installation. On-grid Net-Metering scenario will also be considered for inclusion in the analysis.

A. Location

Location of interest was set at an unobstructed open field at UiTM Sarawak (1.483N, 110.333E). Data collected is analysed and taken into consideration for localized use of solar energy.

B. Measurement Device

A solar irradiance meter (Solar Survey 200R from Seaward Solar UK) was used to collect vital solar irradiance data at designated location. The 200R came with factory certified calibration and complies with IEC-62446 (PV Systems: Requirements for Testing, Documentation and Maintenance). It uses a PV reference cell which is more accurate and reflects real life solar PV performance compared to a thermopile pyranometer (Dunn et al. 2012). The 200R is also equipped with built-in digital compass and inclinometer, providing more accurate data collection due to high replicability of test environment. Additional data logging capability ensures unmanned and uninterrupted data collection.

C. Panel Tilt and Direction

The earth has an axial tilt of 23.44° and the amount of incident solar energy on the surface differs over the course of the year due to the varying entry angle. An optimum tilt and direction is needed so that the solar panel would effectively collect the most irradiance, which happens during the solar noon of the day. Tilting the panel would also reduce dust and water spot accumulation that would reduce panel performance. Limiting manual adjustment to twice a year would reduce the O and M (Chandrakar and Tiwari 2013) work for the installation and incremental benefit from more adjustment is negligible for latitude between 30°N and 30°S (Irena 2012). Optimum tilt angle for location is shown in Fig. 3 and taking mean tilt angle between two equinoxes, the following setup in Table 1 was made.

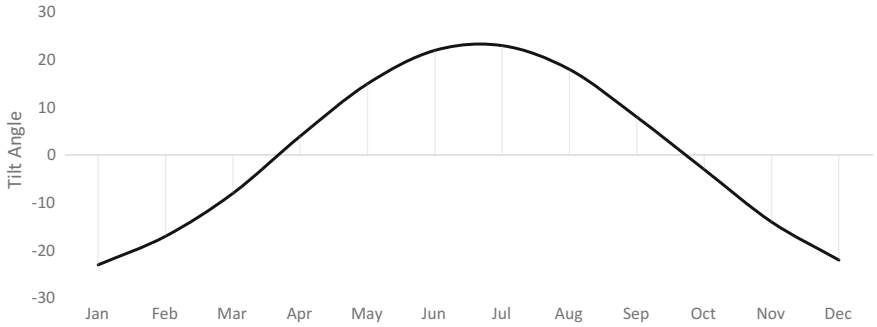

Fig. 3 Optimum PV panel tilt

Table 1 Panel tilt and direction

Direction	Month	Tilt angle
0.42°E	April–September	−17°
	October–March	+15°

4 Results

Semihourly data is compiled and the average daily irradiance and average monthly PSH is extracted. Monthly average irradiance data is outlined in Fig. 4 with the recorded average PSH for the month. PSH from the MetMalaysia, accumulated throughout the year for Kuching area is shown in Fig. 5 alongside measured value for the corresponding months. It is observed to be empirically identical excluding the insolation data for the month of September and October due to 2015 haze situation. The slight reduction in PSH is contributed by the measurement device used. The MetMalaysia uses a thermopile pyranometer which captures a wider

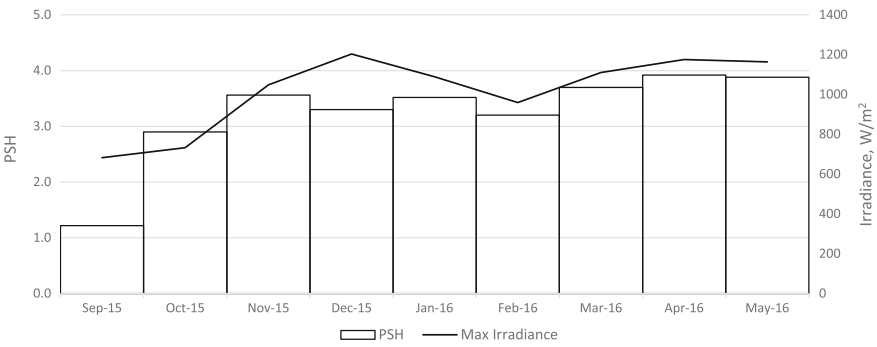

Fig. 4 Total and average daily irradiance

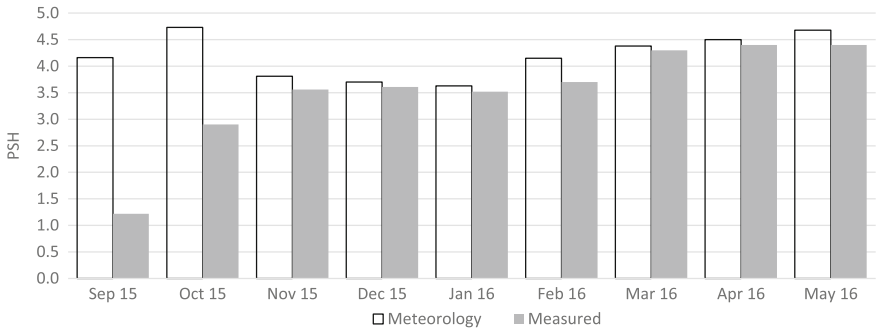

Fig. 5 Measured PSH versus MetMalaysia PSH

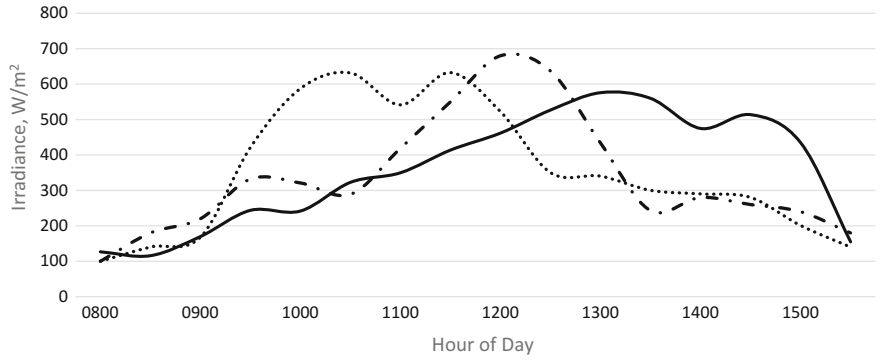

Fig. 6 PSH, optimal day

spectrum of solar irradiance compared to the 200R PV reference cell. These difference should not be taken into account since not all of the spectrum can be converted by a PV panel to energy (Dunn et al. 2012). The amount of precipitation in Fig. 1 is also directly correlated with the number of rain days in the month and this indirectly reflects the PSH for the month since higher rain days would lower the mean PSH for the month.

Figure 6 shows the daily irradiance in sampled days with highly favourable conditions for solar power generation; no precipitation and no cloud coverage. These values could be set as best case scenario for Kota Samarahan with a very favourable PSH of over 6 h and maximum daily irradiance of over 1 kW/m^2. Sun insolation is observed to be at their maximum point from 10 AM to 3 PM throughout the year as determined from collected data.

SEDA has various rate tier for their FiT. They are divided into 4, 24 and 72 kW and the calculation for FiT revenue for each installation is shown in Table 2. These calculations take into account the average measured PSH at designated area and a FiT contract of 21 years (from the year 2016). It can be seen that FiT is a very

Table 2 ROI and profit for solar PV installation

Solar PV Capacity	4 kW	24 kW	72 kW
Monthly FiT payment	RM 574	RM 3392	RM 8772
Annual FiT payment	RM 6888	RM 40,706	RM 105,268
Capital investment	RM 21,8000	RM 130,800	RM 392,400
ROI	38 Months	39 Months	45 Months
Potential profit	RM 122, 847	RM 724,017	RM 1,818,235
Average monthly profit	RM 488	RM 2873	RM 7215

promising green income generator with significantly short ROI for such capital investment. Deployment cost is calculated based on price correlation between solar PV panel and the industry standard for small–medium-scale installation. It is an advantage that Sarawak has some of the largest solar PV panel factory and panel cost could be cheaper if a collaboration between these manufacturers is made. These calculations do not take into account the eventual grid parity and displaced clause in the FiT agreement.

5 Conclusion

From the analysis of collected data, UiTM Sarawak shows promising potential in solar power generation. It has sufficiently high PSH and above average solar irradiance, ensuring maximum power generation throughout most of the days. The potential is limited by the wet climate with high monthly rain days and cloud coverage. Calculation proves that with a FiT contract, such an installation has an ROI of less than four years and an average nett profit of 26.8% over deployment cost per year. With decreasing PV panel price and increasing panel performance, this would lead to better panel-space efficiency and higher energy generation in the near future. Vast clear unobstructed fields and low rise flat roof buildings further accommodate these installations. Such solar PV installation is highly recommended in UiTM Sarawak with wide expansion and deployment options. Even taking into account the possibility of grid parity happening in the next 10–15 years, FiT is still a promising revenue generator, not to mention switching to net-metering if the need arises.

Acknowledgements We would like to express our utmost gratitude to UiTM for the opportunity and trust given and for the funding awarded to us to complete this study.

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Chapter 41
Empirical Correlation of Tropical Weathered Sandstone Uniaxial Compressive Strength Using Unconfined Compression Test and Point Load Test

Nur Masyitah Osman, Ahmad Syauqi Md Hasan, Mohd Khairul Azhar Ismail, Aniza Albar and Mohd Mustaqim Noordin

Abstract This study aims to determine both of the uniaxial compressive and point load strength of tropical weathered sandstone. The sample was collected at Puncak Perdana, Selangor (sandstone). Furthermore, the correlation of both strength has been developed to further investigate the usefulness of point load test in determination of uniaxial compressive strength. There are two different shapes of samples that has been used, cylindrical with H/D ratio of 2:1 for unconfined compression test and irregular shape (3–4 cm wide) for point load test. The irregular shape was used as to simulate the sample condition on site, as with the development of the correlation between UCS and PLS will allow engineers to get an early determination of UCS on site. This will give benefit to engineers to make proper planning, especially for an emergency condition. The verification of laboratory test data shows that the correlation is excellent with the conversion factor of 20.172.

Keywords Point load strength (PLS) · Tropical weathered rock
Uniaxial compressive strength (UCS)

1 Introduction

Weathering process is one of the factors that are affecting the properties of rock. Malaysia encountered humid and hot climate throughout the year and also known as the tropical rainforest country. Heterogeneous physical deterioration and unique weathering profile of rock mass had been produced by tropical climate (Zainab et al. 2007). Weathering is the process of parent rock decomposing or fragmenting. Since

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_41

our country is wet, the minerals will chemically decompose more rapidly. Weathering profiles of rock were different to each other. Characterization and classification of rock mass by weathering grade requires knowledge on the principle of it.

Sandstone had been formed when the grains of sand are compacted together over significant periods of time. In our construction development usually used rock and one of it is sandstone in building foundation, dam, road surface, subgrade and retaining wall, which are exposed directly to the climate change. For example, North–South Highway and East–West Highway that had complex geological features and problem in sedimentary formation are the one of the large-scale infrastructure (Zainab et al. 2007).

The effect of weathering caused the progressive changes to the strength of the rock. The occurrence of physical and chemical changes in the weathering process can lead to significant reduction in strength value (Sadisun et al. 2001). The weak zones will be further developed depending on the process and degree of weathering. Thus, the identification and quantification of the strength degradation are ultimately important, especially for civil engineering purposes. The quantification of deterioration of rock strength is ultimately important in order to confirm the stability of the ground before foundation construction works started. It is especially for shallow types of foundation which very much depend on the stability of the ground which it stands on. Their problems could arise when the foundation has to be constructed on the moderately weathered layer of which the actual strength value is unknown because it is highly dependent on the degree of weathering. The mean strength could be varied for different types of rock at the same grades of weathering, therefore the relationship of weathering grades associated with uniaxial compressive strength would be essential as a reference for rock strength classification.

To determine the strength of rock, there were several parameters that had been used. They were porosity, density, slaking and durability. However, several factors such as weathering, erosion, transportation, deposition, burial and digenesis had affected all the parameters that had been stated above (Matthew et al. 2000). Accordingly, it is necessary to know how the reduction in rock strength will occur and how the relationships between different variations of weathering intensity and rock strength will appear. Hence, weathering grade analysis and point load test had been conducted in this study, then the analysis of point load strength [Is(50)] is correlated with unconfined compressive strength, which had also been done on the further laboratory test.

Unconfined compression test usually required more procedures to be carried out. In practice, samples from the site required being transported to the laboratory to be tested on unconfined compressive machine. Thus, it will require longer testing procedure, and further delay the construction process, especially in emergency situation. On the other hand, point load test is a simple test that can be operated on site, which the equipment can be brought to the site. Therefore, with the availability of equipment on the site, it will allow the test to be conducted as soon as possible, especially during emergency cases.

Table 1 Correlation point load strength and uniaxial compressive strength (Komoo 2007)

References	Correlation, σ (MPa)	Rock types
Deere and Miller (1966)	15.3 Is_{50} + 16.3	Igneous, sedimentary, metamorphic
Broch and Franklin (1972)	24 Is_{50}	Granite
Beniawski (1975)	23 Is_{50}	Quartzite, sandstone
Tugrul and Zarif (1999)	15.25 Is_{50}	Basalt

Point load test is also the laboratory test that can be used to measure the uniaxial compressive strength indirectly. There are some researchers who had done this study previously as Broch and Franklin (1972), Beniawaski (1975) and Tugrul and Zarif (1999). Based on their study, they have come out with a simple equation to correlate between point load indexes with the uniaxial compressive strength (Table 1).

2 Methodology

The purpose of this research is to determine the empirical relationship of uniaxial compressive strength using two different methods, unconfined compression test (UCT) and point load test (PLT). This study is focusing on the tropical weathered sandstone rock in various weathering grades such II and III. The grades classification is based on the typical characteristics and appearance of sandstone Mohamad et al. (2015). A total number of eight bulk samples of tropical weathered sandstone with a dimension of at least 300 cm width were collected at the Puncak Alam, Selangor for laboratory testing and analysis.

2.1 Sample Preparation

Two different shapes of samples were prepared, which are cylinder for UCT and lump for PLT. The size of cylinder sample is 100 mm (length) by 50 mm (diameter), meanwhile, the average width of lump size is 50 mm as shown in Figs. 1 and 2. The lump sample was taken from the part of the cylinder that has been cored using coring machine, as to confirm its consistency of weathering grade and characteristics. Only rocks with no presence of bedding were selected to avoid any anisotropic and heterogeneous effects on testing results. Rebound hardness was used as an initial identification of the weathering degree of the granitic rock mass. For each bulk samples, three cylindrical specimens and three lump specimens were produced. Therefore, the total number of samples is 24 cylindrical and 24 lump, which 12 for each weathering grade.

Fig. 1 Lump samples for PLT

Fig. 2 Cylinder samples for UCT

2.2 Experimental Setup

There are two tests that has been adopted in this study, UCT and PLT. Both of these tests were carried out in accordance with the International Society of Rock Mechanics Standard Procedures (ISRM 1982). The tests were conducted with a proper handling of samples so as to avoid any circumstances that can affect the findings. For PLT, the lump size was placed between two platens, and then the platen twas slowly levelled to avoid applying any pressure or force to the specimen before the test. The samples were labelled with the same code for PLT and UCT (i.e. PLT 1/UCT 1) so as to make sure that the samples have represented the same characteristics that originated from similar sources.

UCT is the test mainly intended for strength classification and characterization of intact rock. A cylindrical core is loaded axially to failure, with no confinement (lateral support). Conceptually, the compressive strength is measured by recording the peak stress (defined as the maximum load sustained by a specimen divided by its cross-sectional area.

3 Results and Analysis

3.1 Uniaxial Compressive Strength and Point Load Index

Table 2 is summarized value of uniaxial compressive strength (UCS) and point load index (Is_{50}), which represent a total 48 number of samples tested in this study. From the table, it can be summarized that the average value of UCS is 141.15 MPa for WD II and 60.455 MPa for WD III. Meanwhile, the Is_{50} for WD II and WD III is 5.5775 and 1.63, respectively. It is shown that the strength of the sandstone decreases as the weathering degree increases. This represents that as the weathering process progresses, it has weakened the bonding between particles, thus creating more pore inside the rock. Therefore, it will reduce the ability of rock to withstand the imposed axial load.

From the Fig. 3, the correlation of UCS and Is_{50} has been successfully developed. The test result was analyzed using the method of least-squares regression. The line showed that the correlation equation is as shown in Eq. (1).

$$\mathrm{UCS} = 20.172\,\mathrm{Is}_{50} + 28.106 \tag{1}$$

The relationship equation that has been developed in this study has shown good agreement with the previous relationship produced by other researchers including Sadisun et al. (2001), Kahraman et al. (2005) and Mark (2000). Mark (2000) in his

Table 2 Uniaxial compressive strength and point load index for tropical weathered sandstone

Weathering degree (WD)	Uniaxial compressive strength, UCS (Mpa)	Average uniaxial compressive strength, UCS (MPa)	Point load index (Is_{50})	Average point load index (Is_{50})
WD II	145.3	141.15	6.08	5.5775
	156.1		6.67	
	142.5		5.57	
	120.7		3.99	
WD III	82.7	60.455	2.03	1.63
	79.19		2.18	
	46.43		1.2	
	33.5		1.11	

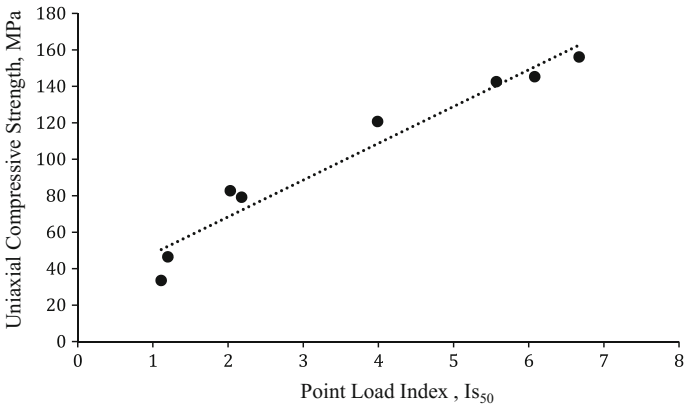

Fig. 3 Correlation of UCS and Is_{50}

study to determine the uniaxial compressive strength of coal using point load test has produced an equation as shown in Eq. (2). Meanwhile, Sadisun et al. (2001) has focused on granitic rock and they establish Eq. (3), and the other study by Kahraman et al. (2005) has produced Eq. (4) which their study is on a different type of rocks.

$$UCS = 21.0\, Is_{50} \tag{2}$$

$$UCS = 20.5\, Is_{50} \tag{3}$$

$$UCS = 24.83\, Is_{50} - 39.64 \tag{4}$$

3.2 Inter-relation Between Strength and Porosity

Porosity is one of the main factors that controls the mechanical characteristics of rock. As the weathering progress, the fracture of mineral grains (grains boundary) continuously develop and create the bulk of crack line all over the rock mass. The crack can be subdivided into two categories, which are microcracks and macrocracks. The weathering process may change the structure of the rock mass in term of mineralogy. Quartz and feldspar in granitic rock that has experienced weathering are creating "open microcracks", which can onlybe observed using a microscope (Takemura et al. 2003). The mineral contains is different for each degree of weathering and it is become the factors that controlling the porosity of the weathered rock mass.

The changes of porosity due to the weathering process has a significant influence on the various engineering properties as shown in Fig. 4 of additional experimental test results. The expansion of pore structure weakens the cementation between

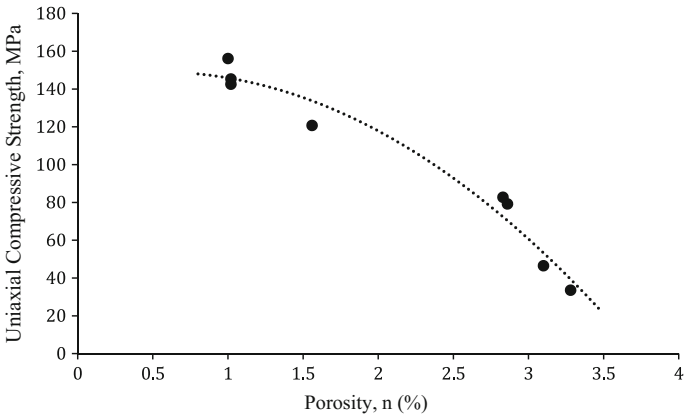

Fig. 4 Correlation of UCS and porosity

particles. Uniaxial compressive strength decreases as the porosity increases (Fig. 4). The strength of sandstone decreases as the weathering degree increases since the expansion of pore structure and cracks makes the rock less continuous, thereby, contact forces acting on the particle skeleton and breakability under compression increase as the porosity increases.

4 Conclusion

From the study, it can be concluded that the empirical correlation of uniaxial compressive strength and point load index are successfully developed. The equation has good agreement with the relationship that has been produced by the previous researcher on different types and condition of rock samples. PLT is a simple test that can be correlated with UCS by substituting the corrected point load index into the equation that has been developed in this study. As PLT is a portable device and easy to transport to the site, it is an alternative way to obtain the UCS value as soon as possible to allow reconstruction or repairing works begin. On the other hand, it can be summarized that the porosity is one of the major factors that contribute to the failure of the rock structure. As the porosity increased, the ability of the rock structure to sustain imposed load will be decreased. Thus, the understanding of the development and propagation of microcrack and microfissures is very important as this will eventually reduce the strength of the rock structure.

Acknowledgements The authors are thankful to the Ministry of Higher Education Malaysia and Research Management Center (RMC), Universiti Teknologi MARA for the research grant RAGS (600-RMI/RAGS 5/3 166/2014). Special thanks also to Universiti Teknologi MARA Pulau Pinang for the facilities provided.

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Chapter 42
Synthetic Jet Study on Resonance Driving Frequency for Electronic Cooling

S. M. Firdaus, M. Z. Abdullah, M. K. Abdullah, A. Z. A. Mazlan, Z. M. Ripin, W. M. Amri and H. Yusuf

Abstract Overheated electronic components are one of the major concerns, as the device system needs to process multitasking application. Current device for electronic cooling, such as fan-based method, and liquid cooling has major disadvantages on space availability and extra piping for cooling within the thin packaging. Synthetic jet cooling has been introduced with its zero-net mass flux and thin dimension advantages. In this paper, piezo-based synthetic jet has been fabricated using rapid prototyping to determine the resonance frequency by numerical analysis and validate with experimental result. Previous researcher reported that the maximum heat removal occurs at resonance driving frequency that leads to the production of maximum amplitude of the piezo-diaphragm motion. ANSYS® mechanical has been used to determine the model resonance driving frequency. Results show that the resonance driving frequency occurs at 500 Hz. Then, the fabricated synthetic jet was tested using impact testing for Modal Analysis to verify the resonance frequency occurred at 500 Hz. A heated surface was setup at 70 °C and sinusoidal wave was applied to the synthetic jet device for heat transfer experiment at various frequencies. Results show that maximum temperature reduction happens at 500 Hz with 10 °C different.

Keywords ANSYS® · Heat transfer · Modal analysis · Resonance driving Synthetic jet

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_42

1 Introduction

The advance in miniaturization of electronic device leads to high-density electronic components in a devices/systems. Due to this, heat generated by the electronic components has increased rapidly (Firdaus et al. 2010). Figure 1 shows the growth in microprocessor operating power until year 2020 by Chu (2003). The International Technology Roadmap for Semiconductors (ITRS) predicts the increasing power of electronic devices as more micro/nanocomponents are being introduced to improve the device or system capability and performance (Liu et al. 2015; Randy et al. 2013; Rylatt and O'Donovan 2013; Firdaus et al. 2008). Chandratilleke and Rakshit (2013) suggested that the internal heat generated need to be dissipated to the surrounding to preclude overheating towards device thermal failure. Overheating heat exposure also reduce the device reliability as it grow unpredictable operation and undergo the thermal breakdown overheating. They also stated that 55% of failures in electronic industry are due to overheating of internal components. The cooling system has been used to prevent the component from overheating, instability, malfunction and damage leading to a shortened component lifespan. Over the last decade, fan system has been a popular method used to cool down the temperature of particular component by moving cooler air across an attached heat sink. Current electronic device requires an effective thermal management as the device space constraint with miniaturization trend, which fan-heatsink cooling is facing challenges (Chaudhari et al. 2010a, b; Mahalingam and Glezer 2005; Pavlova and Amitay 2006).

Synthetic jet has created significant interest for its Zero-Net Mass Flux (ZNFM) advantage, low power consumption and flexible design for low space availability

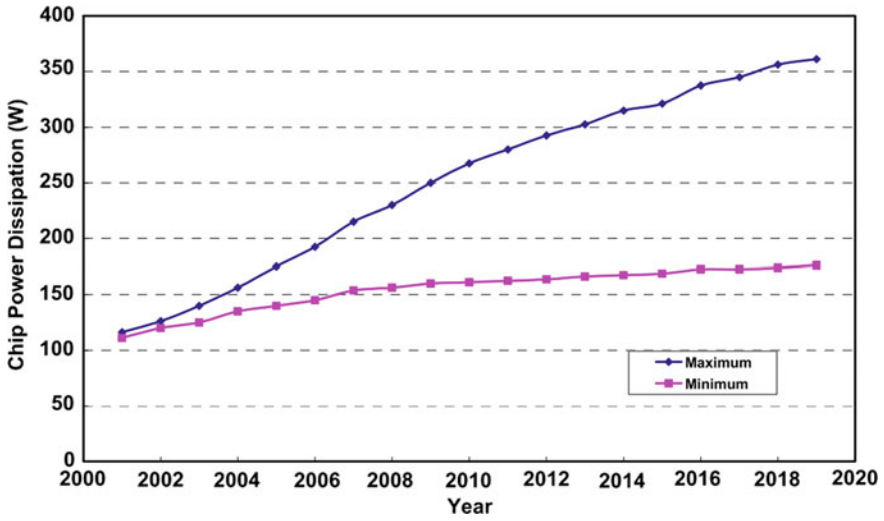


Fig. 1 Chip power dissipation growth (Chu 2003)

(Greco et al. 2014; Holman et al. 2005). ZNFM means that the streamwise momentum is formed by the interaction of vortices (Cater and Soria 2002). The vortices are generated by the periodic oscillation of a fluid boundary and propagated due to the nonlinear term in the equations of motion. The vortices are created within the fluid in which the generator is deployed without the net injection of additional fluid. It consists of a flexible diaphragm, an air cavity and an air orifice nozzle as shown in Fig. 2a. As the flexible diaphragm moves upward, surrounding air is sucked into the cavity as shown in Fig. 2b. When the diaphragm moves downward, air inside the cavity is forced out and creates a vortex ring that moves outward as shown in Fig. 2c.

Driving frequency is an input for the diaphragm, which initiates the oscillate at certain amplitude which is related to the supplied voltage. It can differ for each proposed cooling structure, since Chaudhari et al. (2010a), Pavlova and Amitay (2006) have used different driving frequency in their works. Abdullah et al. (2008) and Chaudhari et al. (2010a) have pointed out that large amplitude serve to agitate the surrounding fluid which is able to enhance the heat transfer compared to natural convection. Larger amplitude can be achieved when the driving frequency is applied at resonance driving frequency for cooling (Chaudhari et al. 2010a; Pavlova and Amitay 2006). When the frequency drive at resonance, the synthetic jet device is operating at most efficient as mentioned in Chandratilleke and Rakshit (2013). Therefore, resonance driving frequency state should be used for synthetic jet and it will produce largest amplitude value to higher heat transfer coefficient, h compared to other frequencies. Chaudhari et al. (2010a) stated that the values of heat transfer coefficient, h can be calculated from the following:

$$\boldsymbol{h} = \frac{q_{\text{conv}}}{T_s - T_\infty} \left(\text{W/m}^2\,^\circ\text{C}\right), \tag{1}$$

where T_s is the temperatures of the heated surface, q_{conv} is the total net heat flux and T_∞ is the ambient temperature, which in this study was 22 °C.

In this chapter, the synthetic jet was modelled and characterized to determine the resonance driving frequency using ANSYS® Modal Analysis method. The model was fabricated and experimented with LMS® impact testing. The fabricated synthetic jet device is tested to determine the heat transfer coefficient (h). Results obtained from the simulation and experiment were compared and discussed.

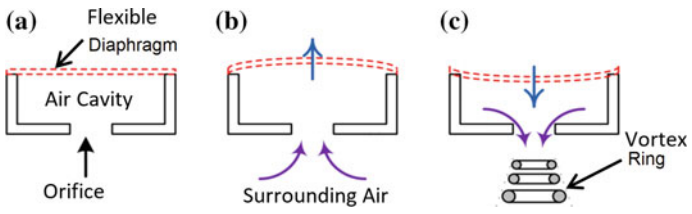


Fig. 2 Synthetic jet Work; **a** general structure; **b** air entrance; **c** generation of vortex ring

1.1 Numerical Simulation

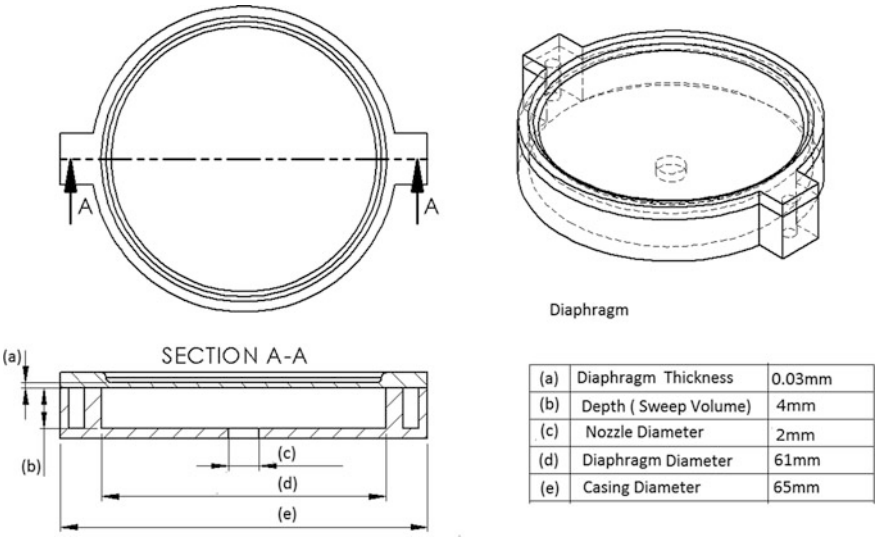
This section provides the numerical setting such as geometry, meshing and others solution parameters. ANSYS® Mechanical has been used to determine the mode shape frequency of the synthetic jet model. Figure 3 shows the details of the synthetic jet model.

In this numerical study, the casing volume was set to ABS plastic material properties and brass metal for diaphragm. Table 1 summarizes the material setting and properties been used throughout this research.

Fixed support boundary condition has been set at the synthetic jet model. Fine meshing with 400,000 number of element has been selected in this study since coarse meshing produced low result accuracy of diaphragm deformation. Figure 4 shows the meshing of synthetic jet device and boundary condition setting.

1.2 Synthetic Jet Experimental Setup

Two different experiments have been conducted to validate the numerical simulation that is conducted. Impact Hammer LMS (Modal Analysis) experiment has been setup to determine the resonance driving frequency of the fabricated synthetic jet device. A 20 W heater at 70 °C has been setup for thermal experiment in order to verify the driving frequency performance for the fabricated device.



(a)	Diaphragm Thickness	0.03mm
(b)	Depth (Sweep Volume)	4mm
(c)	Nozzle Diameter	2mm
(d)	Diaphragm Diameter	61mm
(e)	Casing Diameter	65mm

Fig. 3 Detailed dimension of synthetic jet

Table 1 Material properties

Part	Diaphragm	Casing
Material	Brass	ABS plastic
Young Modulus	125 GPa	3.1 GPa
Density	8.55 g/cm^3	1.04 g/cm^3
Poison ratio	0.33	0.35

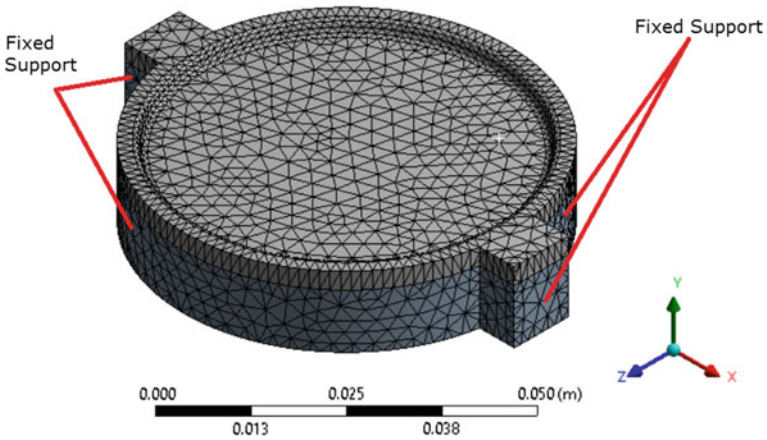


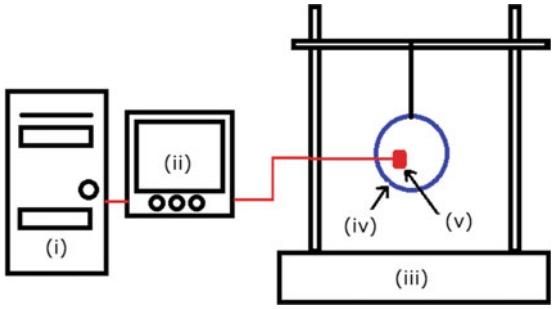
Fig. 4 Meshing and boundary condition

1.2.1 Modal analysis experimental setup

Arik and Utturkar (2008) and Bhapkar et al. (2014) pointed out that highest heat transfer coefficient can be obtained at resonance driving frequency of the fabricated device. Figure 5 shows the resonance experimental setup to determine the resonance frequency of the fabricated synthetic jet. The modal analysis is suitable for lightweight structure analysis. Before start, the accelerometer was calibrated with LMS® vibrator to check the sensor output response. The hanging synthetic jet was knocked with a hammer to initiate an impulse. The synthetic jet is deformed with a range of amplitude in the frequency domain. A host computer with integrated data logger has been used to log the amplitude and frequency data from the accelerometer sensor.

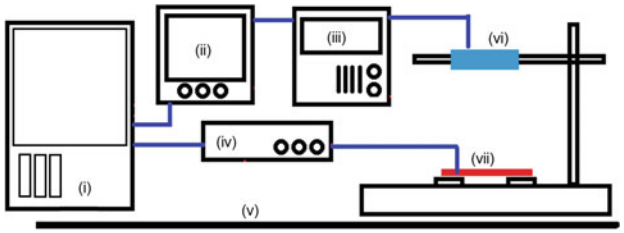
1.2.2 Thermal Experiment

Figure 6 illustrates the thermal experiment setup, where 20 W aluminium heater has been applied to a 16 cm^2 area. The fabricated synthetic jet was fixed at 10 mm distance from the heated surface. Function generator has been used to supply the 10 V peak to peak with 300 Hz until 700 Hz with 100 Hz increment. Sinusoidal



(i) Data Logger System
(ii) LMS with amplifier System
(iii) Retort Stand
(iv) Synthetic Jet Device
(v) Accelerometer Sensor

Fig. 5 Modal analysis experimental setup



(i) Data Monitoring System
(ii) Oscilloscope
(iii) Signal Generator
(iv) Current Supply
(v) Anti-Vibration Table
(vi) Synthetic Jet
(vii) Heat Generator

Fig. 6 Thermal experimental setup

frequencies wave signal was applied and monitored with external oscilloscope. Temperature output data at the heated surface and ambient are recorded with data logger system that converts from analogue data of resistance alterations obtained at the welded tip of thermocouple based on Wheatstone bridge circuit to temperature value difference.

2 Results and Discussions

Modal analysis simulation using ANSYS® and modal experimental has been set to view the first mode shape. Figure 7 shows the simulation results plotted with the experimental results. Results illustrate that simulation and experimental show 500 Hz is the resonance frequency of the fabricated synthetic jet. Bhapkar et al. (2014) mentioned that resonance frequency produces highest amplitude compared to other frequencies, which agrees with this research outcome.

The synthetic jet was placed 10 mm distance from the heated surface during thermal experiment. Figure 8 illustrates the thermal experimental results. Results show that the synthetic jet was able to reduce the heat surface temperature at all driving frequencies within the first two minutes. The synthetic jet was not able to reduce or

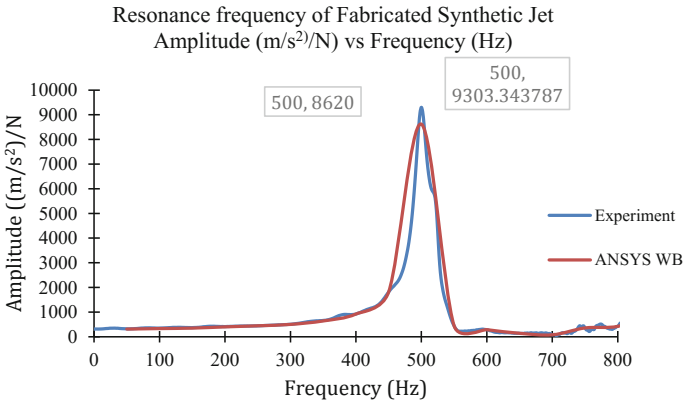


Fig. 7 Modal analysis results for simulation and experimental

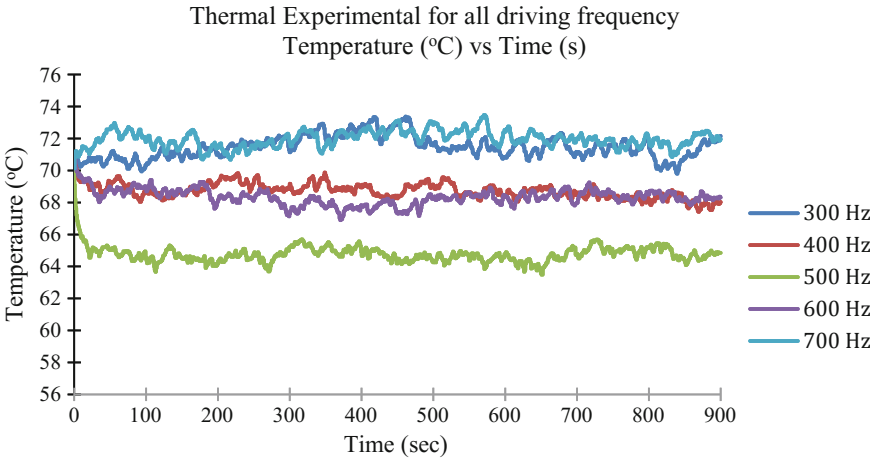


Fig. 8 Thermal experimental results

maintain the heated surface temperature at 300 and 700 Hz. The 400 and 600 Hz frequency were able to keep reducing the heated surface temperature and retain around 68 °C. The resonance driving frequency from the modal analysis experiment produce maximum temperature reduction down to 64 from 70 °C. It is also able to maintain the 64 °C temperature throughout the 14 min of experiment time.

Heat transfer coefficient, h value one of the most important value in heat transfer. Fig. 9 shows the heat transfer coefficient, h calculated from the Eq. (1). The 500 Hz frequency has the highest value of heat transfer coefficient, h at 31.06 W/m^{2}K.

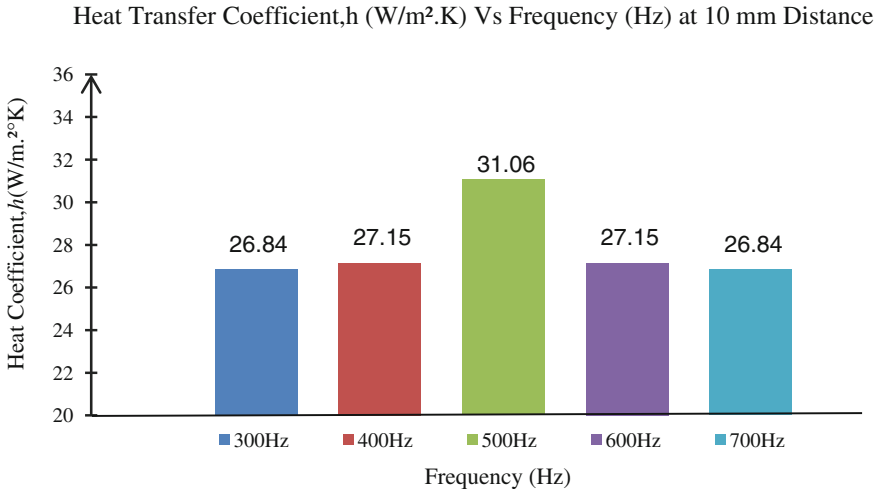


Fig. 9 Heat transfer coefficient, *h*

The non-resonance frequency has lower *h* value. This verify that the synthetic jet drive at resonance frequency was able to achieve higher heat removal compared to non-resonance frequency.

3 Conclusion

Synthetic jet design has been model for numerical study and fabricated for thermal experiment. The resonance driving frequency for the synthetic jet was determined at 500 Hz by numerical and experimental results. Driving at resonance frequency produce maximum temperature reduction compared to other frequencies which lead to maximum heat transfer coefficient, *h* value.

Acknowledgements The authors would like to acknowledge the support of the Ministry of Education (MOE) under the Research Acculturation Grant Scheme (RAGS/1/2014/TK01/UITM/2), Universiti Teknologi MARA (UiTM) and Universiti Sains Malaysia (USM) for their support in undertaking this work.

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Chapter 43
Supply Chain Management (SCM) on Industrialised Building System (IBS) in Construction Industry: Supplier Perspective

Mohd Azrizal Fauzi, Sulaiman Hasim and Masmiera Aini Mustafa

Abstract Industrialised Building System (IBS) is a system where the components of the building are manufactured in factory or order from the supplier and it will be transported to the site to form the structure. Fragmented and disconnected construction supply chains are the leading causes of low construction performance and limited uptake to IBS construction. This chapter identifies issues in adopting SCM in construction practices in implementation more effectively to endure IBS in the construction industry and analyze SCM obstacles in IBS in the construction industry from the perspective of the Supplier. The chapter uses the case study as research methodology and the analysis is based on the primary data through interviews and questionnaires. The main part of this chapter is presentation and discussion of case studies with the supplier in the Klang Valley area. This chapter shows that the IBS supply chain needs close management to avoid the issues and obstacles that occur during timely delivery of construction components on the site. The findings also show that the majority agree with parameters such as collaborative tools, communication skills and attitude that interfaces with the implementation of SCM in delivering IBS to customers at construction sites. Suggestions on how supply chain management practice could be implemented more effectively to pursue IBS implementation will be concluded.

Keywords Supply chain management (SCM) · Industrial building system (IBS) Supplier perspective · Klang valley

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_43

1 Introduction

IBS system is widely adopted and commonly used across the globe. Within this rumour on IBS, some of the researchers were called IBS such as off-site manufacture or office production or 'modern method of construction' are recognised as a key vehicle for driving further enhancement in the construction industry (Gibb 1999). With the reference to the definitions classified, the IBS were involved in the supply chain activity. With reference to the definition, classified on IBS involves supply chain activities. Therefore, the appropriate application of the Supply Chain Management (SCM) is the best opportunity for the industry to be more efficient and effective in managing the existing IBS system.

In Malaysia, the construction industry, Supply Chain Management (SCM) has been considering by many as the alternative solution to improving the reality of the industry (Abdullah et al. 2012). As a collective initiative, Construction Industry Master Plan (CIMP) was collaborative with the entire stakeholders who were concerned about the flow of construction planning. Within this collaboration, all negative and positive feedbacks must be considered appropriately to achieve the success of SCM on IBS in Malaysian construction industry.

Supply chain management (SCM) is the concept that has originated and flourished in the construction industry. However, the fragmented scenario in the construction industry gives the effect on industrial building system (IBS) supply chain with noticeable difficulties in the term of competitive and efficiency.

The case study and existing research show the problems in construction supply chain on IBS are largely characterised by interdependency.

The case study and existing research show the problems in construction supply chain on IBS are largely characterised by interdependency. Even the problem issues happen; SCM is seen as successful in achieving to improve delivery system management in the construction industry. The alternative solution to overcome these issues by identifies the obstacles that occur on SCM on the implementation of IBS. As mention above, any possible solutions to improving the reality of the industry have been considered in the construction industry (Benton and Mc Henry 2009).

2 Literature Review

2.1 Industrialised Building System (IBS)

According to the Construction Industry Development Board (CIDB), IBS is the alternative innovation on the construction site which applies the construction techniques, where components are manufactured, transported, positioned and assembled into a structure with minimal addition site work. Design and detail as a standardised component at the factory and are then brought to the site assembly

have the parts of the building that are repetitive but difficult, too time-consuming and labour intensive to be cast on site (CIDB 2003). As highlighted by CIDB (2009), improving supply chain is the key to achieving IBS success in the Malaysian construction industry. Therefore, this chapter will expose this problem, especially on IBS supply chain process in order to determine an issue and analyse that obstacle appropriately.

An IBS component produces a higher quality of components attainable through careful selection of materials, use of advantages technology and strict quality assurance control. Within this, IBS can give an advantage in the construction industry. Based on the statistics of the previous research, report shows only 15% of construction projects utilised IBS in 2003 and only 10% in 2000 (Nawi et al. 2013). From this, it can show that majority of the construction companies still unconvinced about adopting IBS. Briefly, there are several disadvantages of IBS that should be addressed to incorporate sustainability into construction.

Many problems may be encountered in the use of IBS due inappropriate method selection such as changing order, delay in production and constructability conflicts. Lack of cooperation among the key stakeholders, especially at the design stage is the main factor affecting the lack of assessment tool. According to Blismas 2006, comparing various construction method only take component, labour and transportation cost into account as the most tools for IBS. They often disregard other cost-related items and also some issues which are perceived as insignificant like effect on energy consumption.

2.2 Supply Chain Management (SCM)

A supply chain consists all the parties involved directly or indirectly in fulfilling a customer request. While the supply chain management has been defined as 'the network of an organisation that are involved, through upstream and downstream linkages indifference process and activities that produce a value of product and services in fulfilling a customer request' (Martin 1992).

Supply chain activities begin with a customer order and end when a customer has paid for a value purchase. The term supply chain conjures up images of product or supplies moving from relationships between all the players involved perspectives. It is important to visualise information and performance flow both direction of this chain, especially on supplier's perspective.

The integration of key business processes from the end user through an original supplier that provide products, services and information flow that add the value of the customer is term supply chain was defined. The integration of supply chain should aim to boost efficiency and effectiveness across all supply chain member with identifying the issues in adopting SCM in construction such as while in service to the customer, an expectation occurred in dealing with the quality, quantity and price the product with suitable and the satisfied customer needed. As a result, the order information of transparency was effectively stopped.

Suppliers to Take the Lead–Clients will struggle to lead the way–we need suppliers to show how they can create additional value. This issue is on how to reduce variability and to make supply chain robust facing uncertainty (Shukor et al. 2011a, b). This issue is on how to reduce variability and to make supply chain robust facing uncertainty (Shukor et al. 2011a, b). The construction industry has commonly been plagued by fragmentation issues. Made up of separate parties from a diverse profession that operate own rules and it will create a category of problems faced in construction such as fragmentation, adversarial relationship, project uniqueness and weaknesses. solving, enemy relations, uniqueness and weaknesses of the project.

In addition, the management factors are the niche of the whole supply chain system in IBS. It demonstrates a process of controlling and way how it is done or used. However, it still has an obstacle that disturbs the success of SCM in implementation IBS. For example, the several obstacles are less working collaboration, effectiveness communication channel, lack knowledge management of supply chain and logistics and negative attitudes.

3 Methodology

The chapter uses the case study as a research methodology. The case study is used to present the supplier perspective in flow of the supply chain management (SCM) in delivering Industrialised Building System (IBS) construction projects. Structured questionnaires have been used to collect data in this study and respondents have more freedom to express their preferences. The questionnaire given in the close-ended question was arranged in a logical order and also sent by email to the respondent. Another alternative to distributing the questionnaire is by creating the Google form and submit it to the entire respondent who is unavailable to answer in questionnaire or interviewer session. The structured format for the Google form question covers the same as questionnaires. The context and scope of this research are on area Klang Valley supplier perspective that is involved in IBS project either government or private sector, which is under the Construction Industry Development Board (CIDB)'s registration scheme. Being large, the supplier will most probably take the lead in the flow delivering the IBS product construction industry to the customer. The supplier perspective, thus creating the issues and obstacles in supply chain IBS adoptions, where their perspective towards IBS is worth being measured.

4 Results and Analysis results

The scope of this research is based specifically on the supplier perspective. A number of questionnaires were distributed through email and on-site (by hand, visiting the construction site and office) with more than 50 questionnaires but only 35 of them responded to it. The possibility for respondents to respond that actually

provide the barriers to analysis more specific. However, the positive feedbacks by respondents from the visit site generate better results than with feedback from email.

For example, respondents distribute personal details to give their opinion on this case study. The scope of this research in the Klang Valley, Selangor which has been dedicated to the perspective of supplier either on a construction site or office. Questionnaires were distributed to the respondents as shown in Tables 1, 2, 3 and 4.

Figures 1 and 2 represent the view of the respondent about the Supply Chain Management (SCM) and Industrialised Building System (IBS). Based on the survey, it was found that the majority of respondents knew SCM and only a small percentage of respondents did not really understand what SCM meant while the percentage of views on IBS, majority of respondents were familiar with IBS and approximately three percent (3%) had not heard of IBS.

The obstacles of SCM on the delivery IBS in the construction industry were getting positive feedback from respondents. The majority of respondents agreed that the obstacles above have an impact on quality and service to deliver the product. Other than that, knowledge and understanding of IBS will prevent interaction between IBS supply chain also get the positive feedback from the respondents. Fig. 3 was expressed the satisfaction with the implementation of SCM to deliver IBS in the construction industry. Based on the rating scale value, the majority agreed with the above parameters that interface with the implementation SCM in delivering the IBS to the customer at a construction site. In addation, the majority had agreed to their SCM concept is very important to achieving the company's goals and objectives. It can be proved by the represented by a bar chart

Table 1 Gender

	Frequency	Percent	Valid percent	Cumulative percent
Male	27	77.1	77.1	77.1
Female	8	22.9	22.9	100.0
Total	35	100.0	100.0	

Table 2 Age

	Frequency	Percent	Valid percent	Cumulative percent
Below 30	15	42.9	42.9	42.9
31–40	18	51.4	51.4	94.3
41–50	1	2.9	2.9	97.1
51–60	1	2.9	2.9	100.0
Total	35	100.0	100.0	

Table 3 Qualification

	Frequency	Percent	Valid Percent	Cumulative Percent
Certificate	5	14.3	14.3	14.3
Diploma	9	25.7	25.7	40.0
Degree	18	51.4	51.4	91.4
Master	1	2.9	2.9	94.3
Professional	2	5.7	5.7	100.0
Total	35	100.0	100.0	

Table 4 Position

	Frequency	Percent	Valid percent	Cumulative percent
Engineer	17	48.6	48.6	48.6
Manager	4	11.4	11.4	60.0
Technician	13	37.1	37.1	97.1
Service provider	1	2.9	2.9	100.0

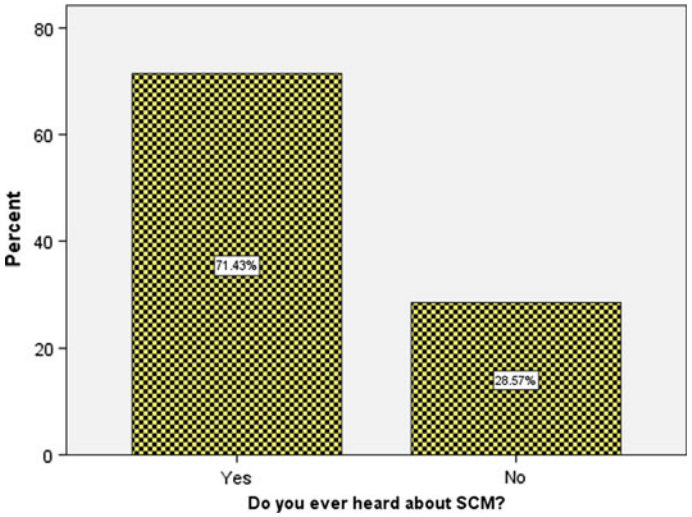

Fig. 1 View of SCM

that the entire respondents answer in the range normal, range important and very important.

Based on the data survey and analysis, the majority had agreed to their SCM concept is very important to achieving the company's goals and objectives. It can be proved by the represention on a bar chart that the entire respondents answer in the range normal, range important and very important.

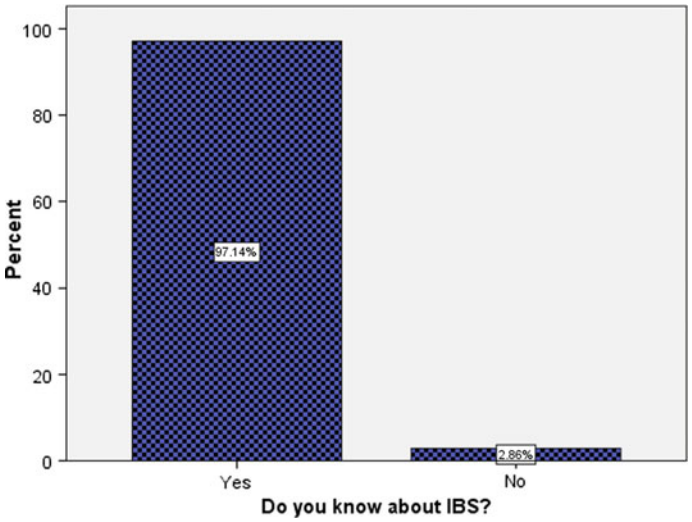

Fig. 2 View of IBS

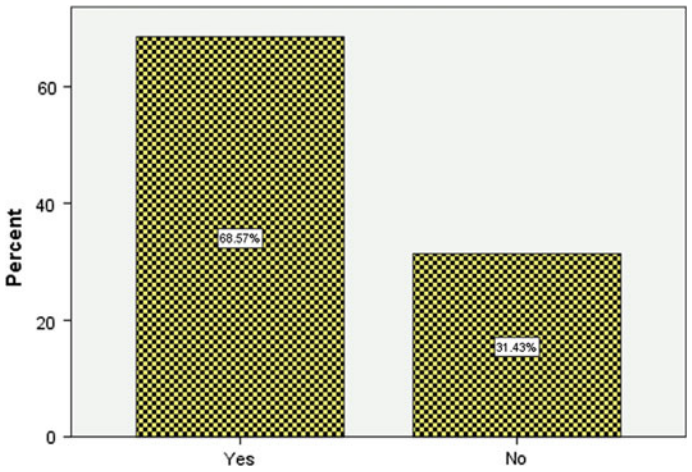

Fig. 3 Satisfaction implementation of SCM in IBS

4.1 Issues on SCM in Delivering IBS

Table 5 shows the percentage of SCM issues in the delivery of IBS based on the feedback respondent. In addition, the mean value is also presented to create rating scale for each question. Based on the rating scale view, SPSS software almost the respondents agreed with the issues in adopting SCM in implementation more effectively to pursue the IBS in the construction industry.

Table 5 Issues on SCM deliver IBS

Question	Scale (%)					Mean	Rating scale	Remark
	1	2	3	4	5			
IBS and SCM as the movement of innovation to enhance the project performance in sustainable concept	0	0	31.4	51.4	17.1	3.86	4	Agree
Adoption issues of IBS specifically can affect the various stakeholders in IBS value chain	0	2.9	40.0	40.0	17.1	3.71	4	Agree
SCM as a collaboration tool to pursue IBS implementation in the construction industry	0	0	17.1	65.7	17.1	4.00	4	Agree
In the construction industry, supply chain integration is technically challenging due to high fragmentation of the industry	0	0	22.9	60.0	17.1	3.94	4	Agree

4.2 Obstacles on SCM in Deliver IBS

Table 6 indicates the percentage of obstacles to SCM in the delivery of IBS based on the feedback respondent. In addition, the mean value is also presented to create rating scale for each question. The obstacles of SCM on the delivery IBS in the construction industry were getting positive feedback from respondents. The majority of respondents agreed that the obstacles above have an impact on quality and service to deliver the product. Other than that, knowledge and understanding of IBS will prevent interaction between IBS supply chain also get the positive feedback from the respondents.

In Table 6 appearances that the majority agrees with the above parameters that are connected with the implementation of SCM in delivering IBS to customers at construction sites.

5 Conclusion

The entire conclusion is based on the data or results of the study are summarised in the following research objective.

- It can be supported by the results from the studies that have been conducted among respondents needed perspective. Therefore, this case study shows the majority of respondents are in favour of prevailing issues that can interfere with the flow of implementation SCM. From the view of one of respondent feedback based on the issues implementation SCM in delivering IBS on construction industry occurs because IBS is still new and the implementing SCM is a new method that was taken times to achieve a smooth delivery of IBS.

Table 6 The obstacles on SCM in delivering IBS

Question	Scale (%)					Average index	Rating scale	Remark
	1	2	3	4	5			
SCM concept have spread and in crossway industry	5.7	0	31.4	48.6	14.3	3.66	4	Agree
Lack of knowledge or understanding of IBS will hinder interaction between IBS supply chain	0	0	34.3	51.4	14.3	3.80	4	Agree
Attitude is a very important thing in 4.14 handle some project which related to the innovative method such as IBS and SCM	0	0	20.0	48.6	31.4	4.11	4	Agree
The less working collaboration which other parties involved in the construction industry that will delay the work process	0	2.9	5.7	65.7	25.7	4.14	4	Agree
Lack of communication will delay the way of information flow within the organisation to other organisation	0	0	14.3	54.3	31.4	4.17	4	Agree
Effective communication being important consulted in deciding which new product to develop	0	0	11.4	57.1	31.4	4.20	4	Agree
The quality product and service on IBS will be affected if lack of knowledge management of supply chain and logistic	2.9	2.9	8.6	51.4	34.3	4.11	4	Agree

- The review of the case study research, the stakeholder constraints that prevent the construction to fully implement SCM in delivering IBS. A major obstacle that having support from the respondents in the implementation SCM in presenting IBS are as follows:
  - Less working collaboration
  - Effective communication channel
  - Lack of knowledge management of supply chain and logistics
  - Negative attitude

To analyse the obstacles of supply chain management (SCM) in industrialised building system (IBS) in the construction industry to perspective suppliers can conclude based on the general key obstacles. From the respondent feedback, all agreed that these obstacles and ahead of the ineffective implementation of SCM in continuing industrialised building system (IBS) in the construction industry.

Based on the responses of respondents, it still has the difficulty in the supply chain in delivering the product such as IBS. It can be proved by the interviewer section that nearly respondents knew about SCM but they also agreed not one hundred percent is followed accurately. That is why the issues and obstacles in the implementation of SCM in delivering IBS still exists. However, the supply chain can flow fluently deliver the IBS into their stakeholder mainly' involve the construction of over supplier if the management is followed properly. Since the concern or awareness of SCM in the delivery IBS remains in the local industry is not high, there are many areas for further research and improvement.

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Chapter 44
Utilisation of Sugarcane Bagasse Ash and Sawdust Ash as Cement Replacement Material in the Production of Structural Concrete

Mohd Azrizal Fauzi, Siti Rahimah Rosseli and Mohd Jamuri Abu Seman

Abstract This study examined the performance of workability, water absorption and compressive strength of the concrete produced with the use of sugarcane bagasse ash (SCBA) and sawdust ash (SDA) as a partial replacement of cement concrete. Replacement of cement have been made at the rate of 0%, 5%, 10% and 15% with SCBA and SDA (50:50) with a total of 72 cubes 100 mm × 100 mm ×100 mm was prepared for this study. For fresh concrete, slump tests were carried out and the test cube compressive and water absorption tests were conducted on hard concrete at 7, 14 and 28 days after curing. The high utilization of SCBAs and SDAs tend to produce lower density concrete as well as reduce the workability of concrete showing that more water is needed to make it feasible. SCBA's and SDA's ability to act as a filler between the pores and the voids in concrete can be seen when the amount of water absorbed is reduced due to the presence of the SCBA and SDA in water absorption tests. Cement replacement is optimum at 5% indicating the presence of its pozzolans reaches maximum value in terms of compressive strength and has a negative impact on concrete after 5% addition of SCBA and SDA replacement.

Keywords Sugarcane bagasse ash · Sawdust ash · Agricultural waste Structural · Concrete compressive strength

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_44

1 Introduction

Many by-products, either from industrial waste and agricultural waste, are proposed for the purpose of partial replacement of cement. This is because both of these waste types contain the pozzolans characteristic in them. Pozzolans consist of materials that contain high silica dioxide which promotes the hydration process. Partial replacement is used because the cementations characteristic from cement is still needed for the purpose of binding materials together. Many waste materials from industrial waste have been researched for this purpose such fly ash (Naidu and Pandey 2014), waste paper pulp (Balwaik and Raut 2011) and blast furnace slag (Huang et al. 2014). All these researchers are using the industrial waste as cement replacement. Industrial waste is the by-products of large industries such as power plants, paper factory or even wastewater treatment plants. It is already known that industrial byproducts such as fly ash, bottom ash, wastewater sludge and paper pulp are among those that have been implemented as cement replacement materials. All of them a few common similarities which are abundant in amount and pozzolanic in nature. Thus since these byproduct are industrial in scale, using them as partial cement replacement not just going to cut the cost and save the environment but at the same time making a way of handling and disposing of such waste materials. Besides that, fly ash has also been used as a supplement to enhance concrete integrity.

Sawdust is by-product from the timber industry. This sawdust is usually abundantly available in sawmills which produce timber related items on a daily basis. Combustions of wood would produce less ash but combustion of wood-related waste such as sawdust would produce more. Sawdust ash (SDA), like all of its others, favourite choices of cement materials counterparts is a good pozzolan. The high amount of silicon dioxide in sawdust ash proves that it is a good pozzolan. Raheem et al. (2012) state that SDA is a good candidate for pozzolan with combined SiO_2, Al_2O_3 and Fe_2O_3. In terms of compressive strength, Ettu et al. (2013) found out that the compressive strength of concrete partially replaced with sawdust ash has lower strength compared to the control concretes at 28 days but increases from there until 90 days of curing exceeding the control specimen. This shows that the reaction of pozzolan in hydration process is slower compared to the normal Ordinary Portland Cement (OPC) but continues to happen rapidly after 28 days. This concludes that it can be used for structures that required 90 days of curing.

Another one of the agricultural waste that is used before for replacement of cement is sugarcane bagasse ash (SCBA). SCBA is used in the factory, for example, the manufacturing of sugar. The vast availability of this agricultural by-product made it great candidates for many types of research. Besides that, Abdulkadir et al. (2014) proved that the amount of SiO_2, Al_2O_3 and Fe_2O_3 care approximately 81.89% which for a material to be pozzolans the amount of silica, alumina and ferric components have to be more than 70%. Thus, this shows that SCBA is a very good pozzolan material. Based on the research being done by

Srinivasan and Sathiya (2010), the compressive test of concrete cubes that being partially replaced with SCBA shows that there is an increase in compressive strength on 28 days of curing at the replacement rate of 5–10% of replacement. The fine size of SDA helps the pozzolanic activity, where the size of materials particles is one of the factors affecting pozzolanic activity. However, there is a factor affecting the quantity and the quality of wood waste ash such as the temperature when the sawdust ash is being burned. Different temperature would result in different amount of chemical composition. Besides that, the source and types of wood of where the sawdust being obtained also affects its chemical composition, thus directly affecting its capacity for pozzolanic activity. Since sawdust, ash is told to be a good pozzolan material. Its chemical composition of silica, alumina and ferric have to be more than 70% of its material.

2 Experimental Details

2.1 Materials

OPC Type-I, local sources of SCBA and SDA with a specific gravity of 3.14, 1.81 and 2.18, respectively. The chemical composition of cement, SCBA and SDA are shown in Table 1.

The SCBA in this study is collected from Chuping Sugar Mill, Perlis where it is already being burned to ashes in a furnace at the temperature of 500–600 °C. The collected sugarcane bagasse ashes are then blended to ashes smaller and finer as shown in Fig. 1. The SCBA will then go sieving process using the 600 µm sieve size. A number of ashes passing through the sieve will be used for the preparation of samples while the ashes that are retained in the sieve were discarded.

The SDA in this study was collected from Penanti Hardware and Carpenters at Permatang Pauh. The collected sawdust is readily packed in sacks by the worker

Table 1 Chemical compositions of OPC, SCBA and SDA used

Chemical composition	OPC Type-I (%)	SCBA (%)	SDA (%)
SiO_2	15.05	65.58	65.60
Al_2O_3	2.56	5.87	5.23
Fe_2O_3	4.00	4.32	2.09
CaO	72.17	1.78	9.62
MgO	1.27	1.23	4.09
Na_2O	0.08	1.02	0.06
K_2O	0.41	6.41	2.43
SO_3	2.90	0.18	1.09
$SiO_2 + Al_2O_3 + Fe_2O_3$	–	75.77	73.01
LOI	1.33	10.48	4.30

Fig. 1 Blended SCBA

and in fine forms. The sawdust was first dried in the oven for 24 hours due to its fine nature easily blown by the wind if to be dry in open space. The sawdust was then being burnt in the burning furnace at the temperature of 550 °C. The SDA will then be sieved using 600 µm. Just like the SCBA, the SDA was sieved using the 600 µm sieve size. Figure 2 shows a number of ashes passing through the sieve will be used for the preparation of samples while the ashes that are retained in the sieve were discarded.

River sand as a fine aggregate with fineness modulus and specific gravity of 2.43 and 2.64, respectively, were used throughout the study. Locally obtained crushed limestone has been used as a coarse aggregate with a maximum of 20 mm and a fineness modulus of 7.72, in compliance with grading standards for the production of concrete.

Fig. 2 Sawdust ash (SDA)

Table 2 Mix proportion

Mix	SCBA (kg/m^3)	SDA (kg/m^3)	Cement (kg/m^3)	Coarse aggregates (kg/m^3)	Fine aggregates (kg/m^3)	Water (kg/m^3)
S1	0	0	375	1375	685	205
S2	9.40	9.40	356.25	1375	685	205
S3	18.75	18.75	337.5	1375	685	205
S4	28.13	28.13	318.75	1375	685	205

2.2 Mix Proportion

In this study, four (4) types of a mix of concrete were used with 0% of replacement as control specimens and then mixed with 5, 10 and 15% of cement replaced with the combination of SCBA and SDA as shown in Table 2. The amount between SCBA and SDA are divided equally or with the ratio of 50:50 from the total percentage of cement replaced. The integrity of cement used in concrete cubes was measured in the parameters of its workability, its performance in compressive strength and its durability.

Thus, concrete cubes were tested with slump test according to BS EN 12350: Part 2 (Testing of Fresh Concrete), the cube compression test according to BS EN 12390: Part 3 (Testing of Hardened Concrete) and water absorption test according to BS1881: Part 122 (Methods for Determination of Water Absorption). The cube compression test and water absorption test were carried at the age of 7, 14 and 28 days of curing.

3 Results and Discussion

3.1 Effect of the Percentage Replacement on the Workability of Concrete

Table 3 shows the results of the slump test on concrete mixes. The slump test is carried out according to BS EN 12350: Part 2 (Testing of Fresh Concrete). Based on the results of slump test obtained in this experiment, it is safe to infer that the replacement of cement with SCBA and SDA in any amount would directly decrease

Table 3 Workability of concrete using slump test

Sample	Slump (mm)	Type of slump	Compacting factor (%)
S1	48	True	0.89
S2	22	True	0.82
S3	12	True	0.75
S4	9	True	0.65

the workability of fresh concrete. This can be explained where the presence of SCBA and SDA, which are pozzolans materials consumed more water when they are mixed together with water. The results also showed the interrelationship between the compacting factor test and the slump test.

3.2 *Effect of the Percentage Replacement on the Density of Concrete*

Table 4 shows the results of concrete densities. The density of concrete was decreased gradually by increasing the percentage of SCBA and SDA used. Overall, the results showed that the used of SCBA and SDA will decrease the density of concrete. This finding showed that the increase of SCBA and SDA will produce lower dry density and was similar to the proposed of many researchers that the use of waste material, for instance, fly ash can produce the lower density of concrete.

3.3 *Effect of the Percentage Replacement on the Compressive Strength of Concrete*

The results of the weight, density and compressive strength tests are presented in Table 4 for 7, 14 and 28 days. The cube compression test are carried out according to BS EN 12390: Part 3 (Testing of Hardened Concrete).

Table 4 Variations of weight, density and compressive strength of concrete mixes

Mix	Age	Weight of cube (kg)	Density of cube (kg/m^3)	Mean strength (N/mm^2)
S1	7	2.4631	2463	27.18
	14	2.4756	2476	33.87
	28	2.4757	2476	40.41
S2	7	2.3712	2371	25.79
	14	2.3836	2384	35.83
	28	2.4058	2406	43.1
S3	7	2.3571	2357	22.56
	14	2.3369	2337	29.09
	28	2.3924	2392	33.71
S4	7	2.3303	2330	19.82
	14	2.3017	2302	23.37
	28	2.3831	2383	27.22

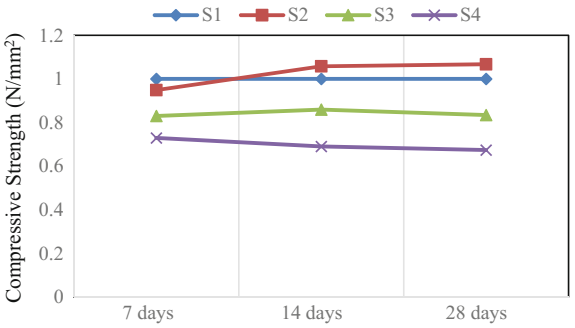

Fig. 3 Relative compressive strength of concrete

It is seen that the variation of strength shows similar trends with respect to pozzolana replacement. At this early stage of curing, it is expected for concrete with their cement replaced with pozzolans materials to have lower strength due to only a few hydrations between silica of ashes and calcium of OPC occurs. At 14 days of the curing stage, both the control specimen and the 5% rate of replacement cubes have achieved the design strength of 30 N/mm^2 with the 5% replacement having 5.79% higher in strength as in Table 4. This is due to the chemical reactions that have started between silica of ashes and lime from OPC at that age.

The pozzolanic reaction starts immediately after the hydration of cement and continuing for a long time, and thus increase the strength. Table 4, shows the strength of concretes cubes at 28 days of curing where the strength of 5% replacement cubes is higher compared to the control concrete as much as 6.67%. This can be explained where at 28 days of curing, a lot of time has been provided for pozzolans to reacts with the calcium in lime of OPC. From Fig. 3, it is seen that the average rate of growth is constant during the first seven days, after that, the average rate of growth dropped to a fixed rate, but relatively low. The profit rate of force against time is highest for concrete with the replacement of 5% of OPC by pozzolana. This is due to the optimum response to a 5% replacement of OPC by pozzolana.

Changes in the relative compressive strength of concrete are presented in Fig. 3. It can be seen that except for the replacement of pozzolan concrete with 5%, as age increases, strength ratio decreased despite the strength of concrete increases with age. This is because of the rate of increase in the compressive strength of concrete control, which is higher than the replacement of the concrete at all levels except for the replacement of 5% pozzolana.

These reactions between siliceous and aluminous properties of ashes and calcium from OPC along with the presence of water helps to form additional Calcium Silicate Hydrate (C–S–H). Calcium Silicate Hydrate (C–S–H) possess cementitious and binding properties which help to bind the particles in concrete closer, thus making it responsible for the compressive strength of concrete too.

Table 5 Water absorption test

Mix	Average water absorbed (%)		
	7 days	14 days	28 days
S1	4.25	4.16	3.70
S2	3.99	3.84	3.38
S3	3.61	3.54	3.20
S4	3.53	3.38	3.14

3.4 Effect of the Percentage Replacement on the Water Absorption of Concrete

The absorption test is carried out according to BS1881: Part 122 (Methods for Determination of Water Absorption) to determine its durability. The results of water absorption test for 7, 14 and 28 days are shown in Table 5.

From Table 5, a pattern can be seen where the amount of changes in mass decreases as the days of curing and the amount of cement replaced increases. The 28 days results for control specimens show a reduction in the amount of water being absorbed as much as 12.94% of compared to its 7-days results. Besides that, Fig. 2 shows the changes in the reduction of the amount of water absorbed for specimens with 5% rate of replacement shows a difference of 15.29% which is more compared to the control specimens. Last, specimens with 10and 15% replacement give out the average of 11.35 and 11.04%, respectively from their respective 7-days results.

The occurrence of additional hydration process in concrete containing pozzolans helps to add extra ingredients bind comparing hydration of OPC ordinary single solitary concrete cube it helps to be more compact. A study from Meddah and Hamou (2009) supports this finding, where they have found that the presence of calcium silicate hydrate (C–S–H) helps increase the strength of the concrete density and microstructure. Subramaniam et al. (2015) also explains, the pores and the permeability of concrete with pozzolans are lower because of the smoothing hole with ash in concrete.

4 Conclusion

- The use of SCBA and SDA tends to produce a lower density concrete.
- Increases in SCBA and SDA replacement decrease the workability of fresh concrete showing more water is needed to make it workable.
- Replacement of cement is optimum at Mix S2 with pozzolans achieved the maximum value of compressive strength of the concrete.
- Replacement of cement with SCBA and SDA at mix S3 and S4 have a negative effect in terms of compressive strength to concrete.

- Replacement of cement with SCBA and SDA can be done up to 10%. This can be seen, where, although, the 10% replacement of cement is lower compared to the control it is still in the range of required strength for the concrete design which in this case is 30 N/mm^2 and still can be used for structural purposes.
- The 14 days and 28 days compressive strengths at mix S2, respectively showed increases of 5.79 and 6.67% compared to the compressive strength of the control mix at those ages.
- The presence of pozzolans in the form of ashes alone can decrease the level of absorption of water in concrete, where the concrete with 15% replacement absorbed 15.83% less water compared to the control specimens at 28 days of curing age.

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Chapter 45
Processing and Compatibility of High-Density Polyethylene Blended with Particle and Liquid Biopolymer on Ultraviolet Exposure

Nurulsaidatulsyida Sulong and Anika Zafiah Mohd Rus

Abstract Recently, there has been pronounced interest in polymer blends. Different types of polymer blends of two or more are mixed to create new type of polymer with different physical properties. Common type of high-density polyethylene (HDPE) is selected and has been mixed with biopolymer. Two different forms of biopolymers, that is, particle biopolymer and liquid biopolymer were mixed with HDPE, namely as HP and HL, respectively. The ratio of both biopolymer form is at 5, 10, 15, 20, 25 and 30% weight by weight percentage ratio (wt/wt) of HDPE. This is to study the processing condition and compatibility of HDPE with biopolymer in different form. HP and HL were mixed by using Brabender Plastograph machine complete with mixer and roller screw. The mixture of HP and HL were then injected into dumbbell shape of tensile specimen using injection moulding. Next, the specimen of tensile was exposed to the ultraviolet exposure for 3000 h in Ultraviolet Weatherometer chamber. The physical and mechanical properties of both forms of blended polymers were tested. The tensile strength of all ratios of HL shows higher mechanical strength as compared to HP. Meanwhile, Melt Flow Index (MFI) of HP shows higher value for all percentage ratios loading as compared to HL. This shows that the liquid form of biopolymer mixed with HDPE gives stronger intermolecular forces, which attracts polymer molecules towards each other. The liquid form of biopolymer was cross-linked and chemically joined together in places, by creating branched, or network structure. High crosslinked bonds in the polymer molecules hold the groups of polymer chains together to form stronger new types of polymeric material of HL.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_45

Keywords Biopolymer · Blends · Ultraviolet · Tensile · Crosslinked Network structure · Covalent bonds

1 Introduction

The word "polymer" means "many parts" (from the Greek word "poly", meaning "many" and "meros", meaning "parts"). According to Kaplan (1998), polymer is a substance composed of molecules characterized by the multiple repetitions of one or more species of atoms or group of atoms linked to each other. Polyethylene, polypropylene, polystyrene, polyethylene terephthalate and polyvinyl chloride are the examples of polymers that are derived from petrochemical feedstock. The utilization of fossil fuels in the manufacture of plastics or polymers accounts for about 7% of worldwide oil and gas. These resources will arguably be depleted within the next one hundred years, and the peak in global oil production, as estimated by some, will occur within the next few decades (Williams and Hillmyer 2008). At present, all the raw materials are derived from petrochemicals, and the toxicity and volatility of starting materials require careful environmental, health and safety monitoring (Shah et al. 2008). An approach to decrease the solid waste is to substitute conventional material with biodegradable raw materials to reduce costs and to enhance the degradation of the final product. Therefore, plant oils are now being considered as the most important renewable raw materials for the production of bio-based polymer materials. In this study, virgin oil (palm oil) was converted to biopolymer (VOP) as an alternative to substitute petrochemical-based materials.

According to Glossary of Basic Terms in Polymer Science (IUPAC 1996), polymer blend is a macroscopically homogeneous mixture of two or more different types of polymer. While, according to Kuitian and Obendorf (2007), polymer blends are defined as combination and intimate mixtures of two kinds of polymer. Polymer blend represents very important field in processing of new materials, which has better properties in comparison with the net polymers. They are significant also from ecological and economical viewpoint. Thus, for example, municipal commingled plastic waste, composed of various immiscible polymers can be recycled by mixing in molten state, and so it can be transformed to the material, which would satisfy the relevant application Ibrahim and Kadum (2010).

In this study, polymer derived from petrochemical feedstock, that is, high-density polyethylene (HDPE) was blended with biopolymer (VOP) that was produced from virgin oil (palm oil) in two different forms, that is, particle and liquid form as one of the alternative to enhance the properties of biopolymer itself and to produce biodegradable polymer by exposing to UV- Weatherometer as the one of the testing part.

2 Methodology

2.1 Materials

Injection grade HDPE (HI1600) was supplied by Titan Petchem (M) Sdn. Bhd, having density of 0.94–0.965 g/cm^3 and the melting point of HDPE is >120°.

The origin biopolymer (VOP), VeSawit Palm oil was used as original palm oil. The monomer conversion begins with the catalyst preparation to generate the epoxies from the unsaturated fatty compound, and second reaction is the acid-catalyst ring opening of the epoxies to form polyols or bio-monomer (Hassan et al. 2013; Ghani and Rus 2013; Mohid et al. 2013; Mohd Rus 2009a, b). After that, the bio-monomer produced from oils was mixed with cross-linking agent that is 4, 4′-Methylene Diphenyl Diisocyanate (MDI) and added with toluene as the lubricant. The portion that was used is 1:0.5 for bio-monomer and MDI, respectively. The mixture stirred at 50 °C at about 15 min until the mixture becomes high viscous compound, then the compound is casted into the mould to produce thin film polymer known as VOP.

2.2 Biopolymer Particle (HP)

The thin film (VOP) was cut manually into the smaller size, and then crushed by using Pulverisette14 (Brand Fritch from Germany). The first sieve ring used was 6 mm at the speed 14,000 rpm at about 1 min while for the second cycle, the sieve ring size used was 0.75 mm, the speed was 10,000 rpm and the time was about 2 min to produced biopolymer particle. HP was produced by mixing HDPE with particle biopolymer at different loading 5, 10, 15, 20, 25 and 30% (wt/wt), respectively by using BrabenderPlastograph® EC machine (from Germany) at 130 °C and 25 rpm speed rate for 20 min. The blended biopolymer produced was crushed by using Plastic Granulator SLM 50FY to produce smaller particle to do injection moulding process to produce HP.

2.3 Biopolymer Liquid (HL)

HDPE blended with liquid biopolymer was produced by mixed HDPE with liquid biopolymer at different loading which is loading 5, 10, 15, 20, 25 and 30% (wt/wt), respectively using BrabenderPlastograph® EC machine (from Germany) at 130 °C and 25 rpm speed rate for 20 min same as procedure as before. The bio-monomer produced from oils was mixed with cross-linking agent that is MDI and added with Toluene as the lubricant. The portion that was used is 1:0.5 for bio-monomer and MDI, respectively. The mixture was mechanically stirred at 50 °C at about 10 min

until the mixture becomes high viscous compound. Then, the compound poured to the BrabenderPlastograph® EC machine (from Germany), while HDPE already mixed in 10 min before. The blended biopolymer produced were crushed by using crusher (Plastic Granulator SLM 50FY) to produce smaller particle and ready for injection moulding process. This blended biopolymer named as HL.

2.4 Injection Moulding

The blended materials were then fed to injection moulding machine (Nissei Horizontal Screw Type Injection Moulding NP7 Real Mini from Japan) to produce dogbone tensile sample. The mould was designed according to ISO 527 (5A) standards to produce specimens for tensile tests. Barrel temperature set points of nozzle zone, front zone, middle zone, rear 1 zone, rear 2 zone and feed zone were 170, 165, 160, 155, 135 and 70 °C, respectively. The samples were named as HL for blended liquid biopolymer and HP for blended particle biopolymer.

2.5 Tensile Test

The tensile tests sample was prepared according to ISO 527 (5A). Five samples for each percentage were selected to get the average results. Universal Tensile Machine AG-I, Shimadzu, 10 kN types with 5 mm/min crosshead speed were used for this testing.

2.6 Scanning Electron Microscopy (SEM)

The morphological study based on the fracture surface of HL and HP were examined using a SEM (JSM-6380LA Analytical Scanning Electron Microscope manufactured by JEOL Company Japan). The samples were cut at the fracture surface at around into 1 cm × 1 cm and was ultrathin coated with gold to produce electrically conductive specimens by JFC-1600 Auto Coater manufactured (JEOL Company Japan). The gold deposited on the sample either by low vacuum sputter coating or by high vacuum evaporation. Samples were examined after coated with ultrathin gold, at 5 kV voltage at 70× magnification supplied by the SEM.

2.7 UV Weathering Test

60 dumbbell shape samples produced from injection moulding were exposed to the UV light in UV Lamp Test Chamber Model HD-703 (Haida International

Equipment Co., LTD) at 3000 h exposure time at 50 °C. 5 samples for each percentage of loading were conducted to calculate the average value of mechanical testing. The UV irradiation of the dumbbell sample was carried out using an array of UV fluorescent lamp emitting light in the region from 280 to 320 nm with a tail extending to 400 nm.

3 Discussions

Referring to Fig. 1, HL shows the highest mechanical property of tensile strength results for all percentages of loading, i.e. loading 5, 10, 15, 20, 25 and 30% (wt/wt) compared to HP after exposed to 3000 h in UV chamber. The highest tensile strength for HL is at 5% liquid biopolymer loading that is 19.37 MPa, while for HP is 16.75 MPa also at 5% particle biopolymer loading. The lowest tensile strength for HL is at 30% liquid biopolymer loading that is 13.35 MPa while for HP is 12.14 MPa also at 30% particle biopolymer loading. Tensile strength is often referred as maximum engineering stress, in tension, that may be sustained without fracture and often termed as ultimate tensile strength. If this strength is applied and maintained, fracture will be produced (Callister 2005). This shows the technique of mixing process and the form of biopolymer that is in liquid form were affected the result of tensile strength. This may be due to the liquid biopolymer was improved the adhesion between the liquid form and HDPE. The interfacial bond between these two materials; HDPE and liquid biopolymer were seemed to be better to improve the tensile strength. Tensile strength is more dependent on the filler–matrix interaction. Strong interaction benefits the tensile stress transfer from matrix to filler, thus reinforces the composite. The interfacial action increases with the decrease of the particle size (Zhang et al. 2011).

As referring to Fig. 2, HP shows the higher MFI result for all percentages of loading 5, 10, 15, 20, 25 and 30% (wt/wt) compared to HL after exposed to 3000 h in UV chamber. MFI is measurement measuring the ease of a thermoplastic

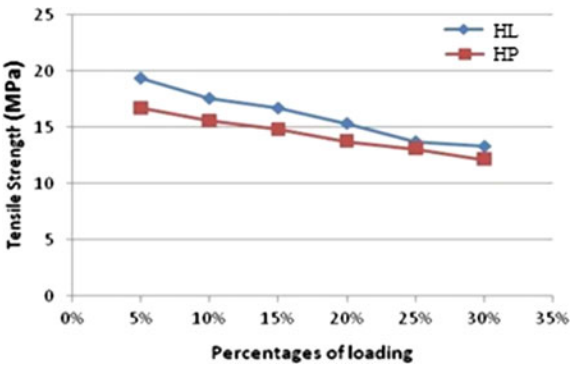


Fig. 1 Tensile strength for HP and HL after 3000 h exposure

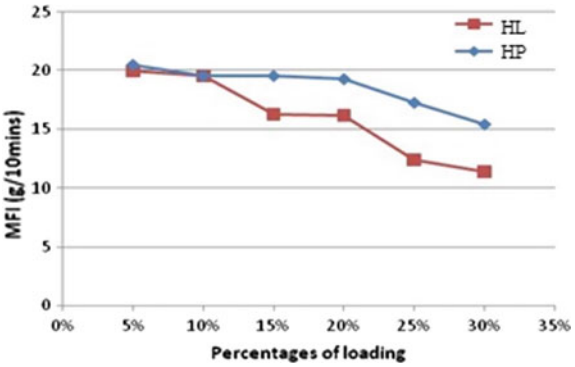


Fig. 2 Melt Flow Index (MFI) for HP and HL

material to flow. The melt flow rate is also a measurement of how well the melt flows under pressure. The test also shows the material viscosity, how well the material can flow. But the flow of the material is also depending on the weight, with which the material is pressed down with. From here, the results show, low MFI of HL give in higher tensile strength and higher MFI for HP results in lower tensile strength. This is because MFI also is an indirect measurement of the molecular weight of a plastic. High MFI corresponds in low molecular weight and vice versa. The strength of the material is located in the bonds holding molecules together in atoms within the polymeric material. The length of the bonds are also important when determining the strength of a polymeric material. Long chains give better strength than shorter chains (Geoffroy 2004).

Figure 3 shows the morphological results of fracture surface of solid HL and HP after tensile test. The morphology of immiscible polymer blends depends on the components, ratios, component melt viscosities, and processing conditions. In this research, the percentages of liquid biopolymer and particle biopolymer were added were 5, 10, 15, 20, 25 and 30% (wt/wt) loading, respectively into the HDPE. Referring to Fig. 3, the fracture surface of HP shows the particle biopolymer spherulites were observed while in HL, no spherulites of liquid biopolymer appeared because liquid biopolymer is in liquid form and HL became the homogeneous phase. This shows that liquid biopolymer uniformly distributed or dispersed in the HDPE compared to the particle biopolymer. For both HL and HP shows ductile fracture surface with numerous spherical 'dimples' resulting from uniaxial tensile failure. Each dimple is one half of a microvoid that formed and separated during the fracture process. But, for HP as the percentage loading of particle biopolymer increase, spherulite of particle biopolymer appeared in the matrix of HDPE resulting weak interfaces and also poor stress transfer, generally lead to poor overall composite performance. Poor adhesion is generally believed to be the major factor leading to the large mechanical property decreases observed upon incorporation of particle biopolymer into HDPE matrix.

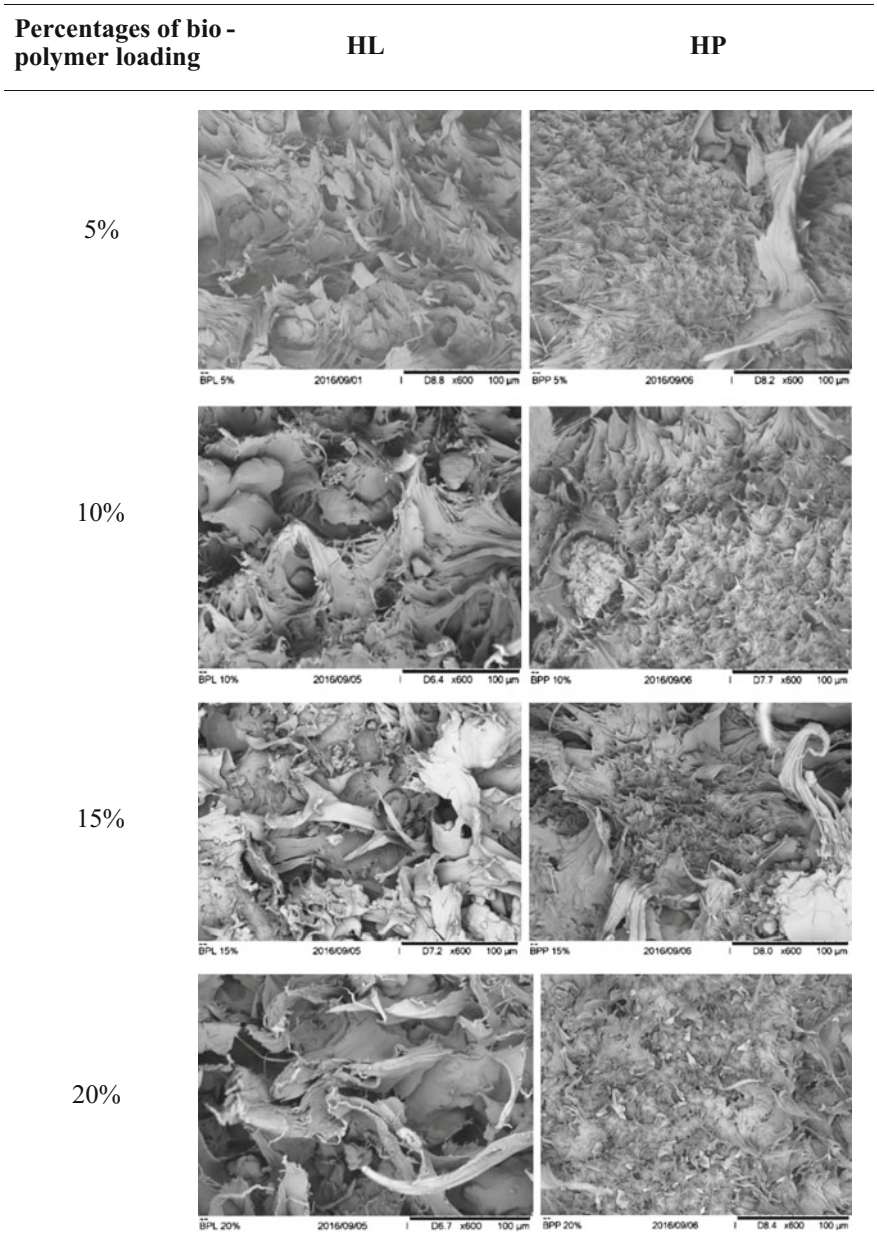


Fig. 3 Morphological results of fracture surface of solid HL and HP after tensile test

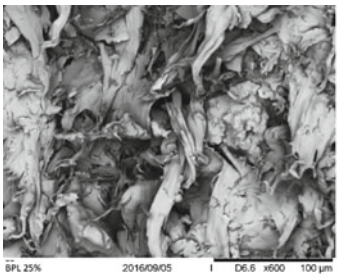
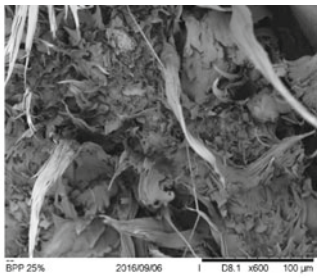
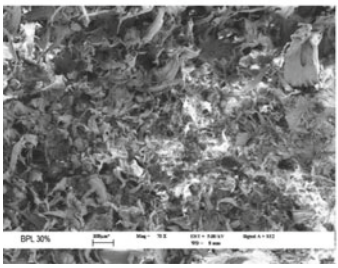
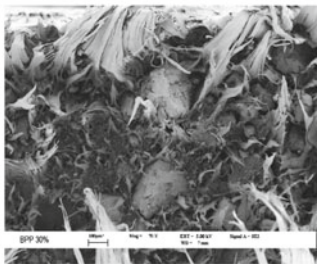
Percentages of bio-polymer loading	HL	HP
25%		
30%		

Fig. 3 (continued)

4 Conclusion

As the conclusion, HP and HL were successfully prepared by injection moulding process. HL shows homogenous blending process as shown in morphological result and produced good mechanical properties, which is 13.35–19.37 MPa higher than HP that were 12.14–16.75 MPa. The mechanical properties also proportional to the melt flow index result (MFI) for all percentages of loading of liquid biopolymer and particle biopolymer. For HP, the mechanical property is still good but shows lower results compared to the HL. However, this study revealed the compatibility of both HL and HP to be mixed and used in industrial applications based on mass production.

Acknowledgements The authors would like to thank the Head Principal Researcher of Sustainable Polymer Engineering, Advanced Materials and Manufacturing Center (SPEN, AMMC), Universiti Tun Hussein Onn Malaysia (UTHM), Johor for providing raw materials and facilities and Malaysian Government for supporting this research under Fundamental Research Grant Scheme, FRGS Vot 1481.

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Chapter 46
Modification and Characterization of Non-expandable Muscovite with Quaternary Ammonium Surfactant by Ion-Exchange Process

Nor Hafizah Che Ismail and Hazizan Md Akil

Abstract Muscovite clay minerals were treated via two stages of ion-exchange process. The main aim of this study was to investigate the effect of two types of surfactants with different quaternary alkyl salts namely cetyltrimethylammonium bromide (C16) and octadecyl trimethylammonium bromide (C18) on the surface properties of muscovite. The first stage was conducted first to improve the swelling characteristic of muscovite, while the second stage to improve the compatibility between hydrophilic clay and hydrophobic polymer. Both of these treatments were found to have significant effect on the chemical composition of organoclay produced. The organoclay produced were characterized by x-ray diffraction (XRD). The effectiveness of the ion-exchange treatment was proven from the enlargement in basal spacing, indicating both of the surfactants significantly intercalated in muscovite layers. The intercalated structure was confirmed by FESEM images. The intercalated structure of organomuscovite produced from this treatment may become a promising material as a reinforcement filler to form polymer/organoclay nanocomposites.

Keywords Ion-exchange · Muscovite · Organic surfactant · Organoclay

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_46

1 Introduction

Polymer-layered silicate nanocomposites (PLSN) have initiated a revolutionary change in the polymer composite system. The interest in PLSN was stimulated when Giannelis and coworkers (Vaia et al. 1993) came up with the idea of mixing the layered silicates with polymers via the melt intercalation process without the use of an organic solvent. From then on, large volumes of works both by the academic and industrial sectors have been devoted to this area through aggressive study and research. The platelets contained in layered silicates can be exfoliated to produce high aspect ratio fillers with a minimal quantity of about 1-5% nanosized particles. The most commonly layered silicate used in PLSN is montmorillonite (MMT) due to its outstanding ion-exchange properties. However, the other alternative clay minerals such as muscovite have attracted remarkable attention because it has the highest layer charge density and homogeneous charge distribution (Osman et al. 2003).

Muscovite is the dioctahedral mica with the chemical formula $KAl_2(Si_3Al)O_{10}(OH)_2$. The possible exfoliation of muscovite is interesting for several reasons, such as good dielectric properties, high thermal stability, and excellent mechanical properties. However, in spite of the excellent properties of muscovite, the usage of muscovite as reinforcement filler in composite is inherent due to face to face stacking in muscovite layers. Muscovite has minimum swelling degree due to non-expandable properties resulting from the potassium ions closely fitting the hole created from the isomorphous substitution (Shih and Shen 2009). On the other hand, the fabrication of muscovite with polymer matrices is very challenging due to intrinsic incompatibility between hydrophilic clay and hydrophobic polymer matrix. Based on this concern muscovite must be treated with alkaline salt, then modified with an organic surfactant. Alkyl ammonium is the most commonly used surfactant in clay modification (He et al. 2005; Xi et al. 2007; Chuayjuljit et al. 2008). The intercalations of organic surfactant in clay not only change the surface properties from hydrophilic to hydrophobic but also render the layers to be more compatible with the polymer chains. Since the properties of nanocomposites depend significantly on the dispersion of the polymer in layered silicates, their modification and preparation methods are rather important.

Therefore, it is necessary to treat the muscovite, thus promoting intercalated structure preferentially used as a filler in polymer matrices. The effect of chain length of organic surfactant on the basal spacing of muscovite was investigated. Many studies and papers published have demonstrated that the length of the alkyl chains and the packing density of the surfactants have a major influence in making interlayer clay minerals to be expanded (Lagaly 1981).

In this chapter, muscovite is modified with two different types of quaternary salts: cetyltrimethylammonium bromide (CTAB) and octadecyl trimethylammonium bromide (ODTMA). XRD was used to study the surface structure of muscovite before and after modification with cationic surfactants. The morphology and

microstructure of the synthesized organoclays were studied using field emission scanning electron microscopy (FESEM). Such a study is of high importance for understanding the structure and potential applications of organomuscovite in various area of PLSN

2 Experimental Section

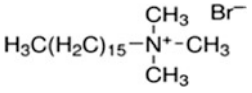
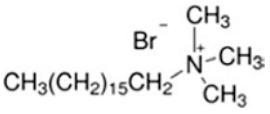
2.1 Materials

The muscovite material used in this study was supplied by Lingshou County Xinfa Mineral Industry Co. Ltd. The lithium nitrate ($LiNO_3$) used for alkaline treatment was supplied by Merck. The surfactants selected for this study are cetyltrimethylammonium bromide (CTAB) and octadecytrimethylammonium bromide (ODTMA) and were supplied by Sigma–Aldrich. The main characteristics of surfactants are given in Table 1.

2.2 Alkaline Treatment Using Molten $LiNO_3$

The Li-muscovite and the organomuscovite (OM) were prepared using the cation exchange process as proposed by (Yu et al. 2006). 5 g of muscovite powder were mixed with 85 g and $LiNO_3$ powder. After the mixing was completed, the resulting mixture was transferred and heated in a furnace at 300 °C for 12 h. The resulting product was washed with deionized water and vacuum-filtered. Then, the filtrate was then dried in a vacuum oven at 110 °C for 12 h. The product obtained was labeled as Li-muscovite.

Table 1 Main characteristic of surfactants

Name	Molecular structure	Melting point (°C)
Cetyltrimethylammonium bromide $CH_3(CH_2)_{15}N(Br)((CH_3)_3)$, MW = 364.46 (g/mol)		230
Octadecyltrimethylammonium bromide, $CH_3(CH_2)_{17}N(Br)((CH_3)_3)$, MW = 392.50 (g/mol)		250

2.3 Preparation of Surfactant-Modified Muscovite

First, 1.2 g of Li-muscovite was dissolved in 150 mL of deionized water. The Li–muscovite was then mixed with 0.3 g of the CTAB under stirring for 10 min at room temperature. Then, the mixtures were put in a hydrothermal reactor (300 mL) and heated at 200 °C, for 12 h. After the reactions took place, all surfactant–muscovite products were filtered, washed at least three (3) times with ethanol to ensure removing of any excess of ammonium ions. Last, the products were dried in a vacuum oven at room temperature. Then, the powder was ground in an agate mortar, and stored in a desiccator. The procedure to prepare ODTMA- modified muscovite was similar as mentioned above. The product obtained labeled as CTAB-Muscovite and ODTMA-Muscovite, respectively.

2.4 Characterization

2.4.1 X-Ray Diffraction

Characterization of muscovite before and after treatment with alkaline salt, $LiNO_3$ was analyzed using XRD, (Bruker D8 Advance) with a Cu target of $k = 1.5405$ A° at a generator voltage of 35 kV and a generator current of 30 mA. The diffraction patterns in the 2Θ range from 5° to 80° were collected with a step-scanning speed of 10°/min. The small-angle diffraction patterns (SAXD) from 1° to 10° were collected using a step size 0.05 and scan speed of 3°/s. The interlayer distance of muscovite, Li-muscovite and modified muscovite were calculated using Bragg's equation of $2d \sin \Theta = n\lambda$.

2.5 Field Emission Scanning Electron Microscope

The morphologies of muscovite, Li-muscovite, and organomuscovite, i.e., CTAB-Muscovite and ODTMA-Muscovite were analyzed using a Leo Supra-35VP Field Emission Scanning Electron Microscope (FESEM). All the samples were coated with gold under vacuum conditions for the FESEM studies.

3 Results and Discussion

3.1 X-Ray Diffraction analysis

X-Ray diffraction (XRD) pattern of muscovite and Li-muscovite are illustrated in Fig. 1. From Fig. 1a the intensities of peaks of muscovite are sharp and narrow

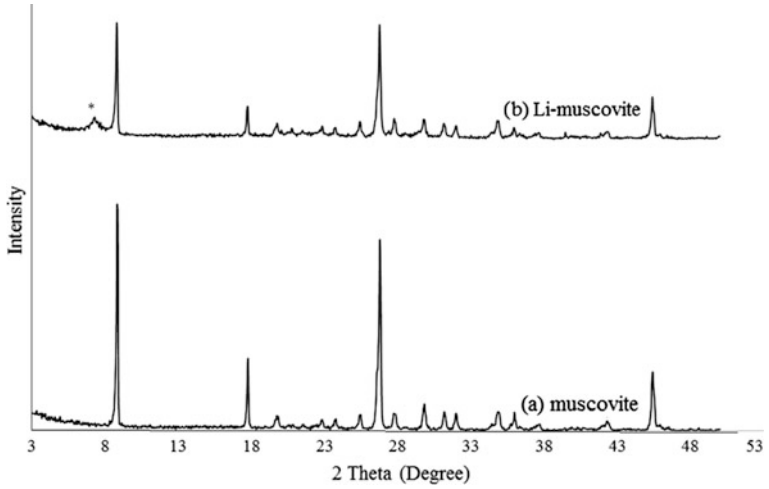


Fig. 1 XRD pattern of **a** muscovite and **b** Li-muscovite

confirming that high quality and good crystallinity of the samples. Muscovite was subjected to alkaline treatment at 200 °C because the interlayer cations of muscovite which is potassium ions are not exchangeable under ordinary condition (Zhang et al. 2010). The reaction of molten $LiNO_3$ with the muscovite shown in Eq. (1).

$$KAl_2[AlSi_3O_{10}](OH)_2 + LiNO_3 \rightarrow LiAl_2[AlSi_3O_{10}](OH)_2 + KNO_3 \quad (1)$$

Lithium ions were frequently used as it has more highly hydrated cations (promotes swelling). The smaller size of lithium ions enables it to migrate into the crystal lattice of muscovite and occupy vacant octahedral sites. Owing to an excessive negative charge, the Li^+ will neutralize the local negative charge, resulting in a layer charge density (Laird 1987). Consequently, the charge will then be lowered due to the weakening interlayer attraction force that will cause an increment in the interlayer spacing, as observed by XRD. The results show changes in XRD patterns (marked by *) at a plane of 002 as shown in Fig. 1b.

The existence of new diffraction peaks at $2\theta = 7.30°$, does not mean that a new compound formed but this appearance relates to delamination occurs in muscovite layers (Osman and Suter 1999). The diffractions peak moves to lower angle indicate an increment in the interlayer spacing of muscovite layers. From Bragg's law equation the value of d-spacing of muscovite before and after treatment was 0.99 nm, and 1.21 nm, respectively. It indicates that the alkaline treatment indeed opened the interlayer of the muscovite. Therefore, this process improved the swelling properties of muscovite. Meanwhile, the aluminosilicate structure of muscovite before and after treatment remains unchanged throughout the process suggests the treatment does not alter the original structure of muscovite.

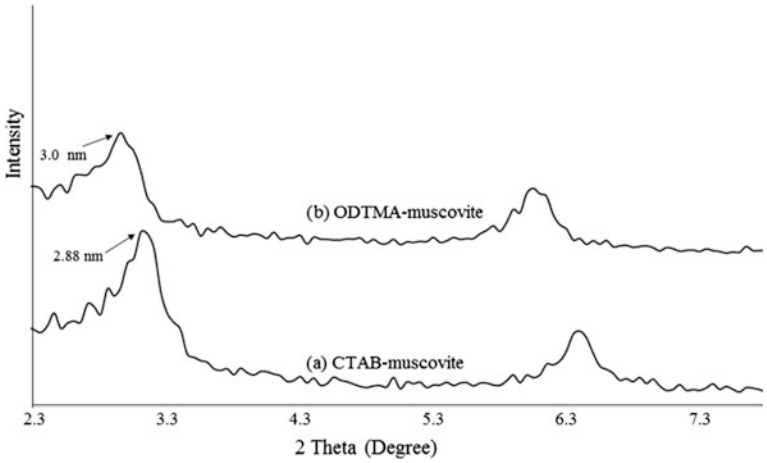


Fig. 2 XRD pattern of **a** ODTMA-muscovite and **b** CTAB-muscovite

The selection of the surfactant with regards to their chemical structure is an important role which influences the basal spacing of the resulting organoclay. Figure 2 shows the XRD patterns of CTAB-muscovite and ODTMA-muscovite, while the changes in basal spacing from untreated muscovite, Li-muscovite, and organomuscovite is summarized in Table 2.

After modification with CTAB and ODTMA, the basal spacing of muscovite increased dramatically. The peak was greatly shifted to lower angle at $2\theta = 3.08$ for CTAB-muscovite, which corresponded to the interlayer distance of $d = 2.88$ nm. On the other hand, the diffraction peak of ODTMA-muscovite appeared at $2\theta = 2.95$ with the interlayer distance of d = 3 nm. From this result, it shows an increase in the basal spacing is successfully achieved by using ODTMA, which the ion exchange with protonated C18 produces much higher interlayer spacing with respect to 0.99 nm for the unmodified muscovite. The importance of increment in basal spacing is beneficial for the intercalation of polymer chain into the interlayer of muscovite. Hence, the formation of intercalated structure or exfoliated polymer clay nanocomposite will improve physical and chemical properties (Singla et al. 2012). The result reveals that the ion-exchange treatment was successfully done in order to introduce and intercalate long carbon chain alkyls into the interlayers of muscovite clay. The interlayer increased with increasing alkyl chain length of the

Table 2 Basal spacing of prepared organomuscovite

Organomuscovite clay	2 Theta (°)	Final basal spacing (nm)
Muscovite	8.87	0.99
Li-muscovite	7.30	1.21
CTAB-muscovite	3.08	2.88
ODTMA-muscovite	2.95	3.00

alkyl substituted primary amine. This finding is also accordance with observations of Singla et al. (2012) who reported more effective interlayer basing account when using larger alkyl chain.

3.2 *Field Emission Scanning Electron Microscopy Analysis*

The changes in particle morphology were obtained by Ziess Supra-35VP, FESEM as shown in Fig. 3a–d. As observed under the SEM with magnification 5000×, the muscovite has a flake-shape with the multilayer arrangement as observed in Fig. 3a. After treatment with $LiNO_3$, the image shows the stacked layers of clay lamellae were opened due to an increment in basal spacing after ion-exchange process as observed in Fig. 3b. The exchange process between K^+ with Li^+ caused a delamination process to occur which improved the swelling properties of muscovite. This is due to hydration properties acquired by lithium-ion and this result supports the XRD pattern as illustrated in Fig. 1.

The comparison of the ODTMA-muscovite and CTAB-muscovite were given in Fig. 3c, d. The separation of muscovite particles can be seen clearly at 10,000× magnification. The image of ODTMA-muscovite shows looser framework with a

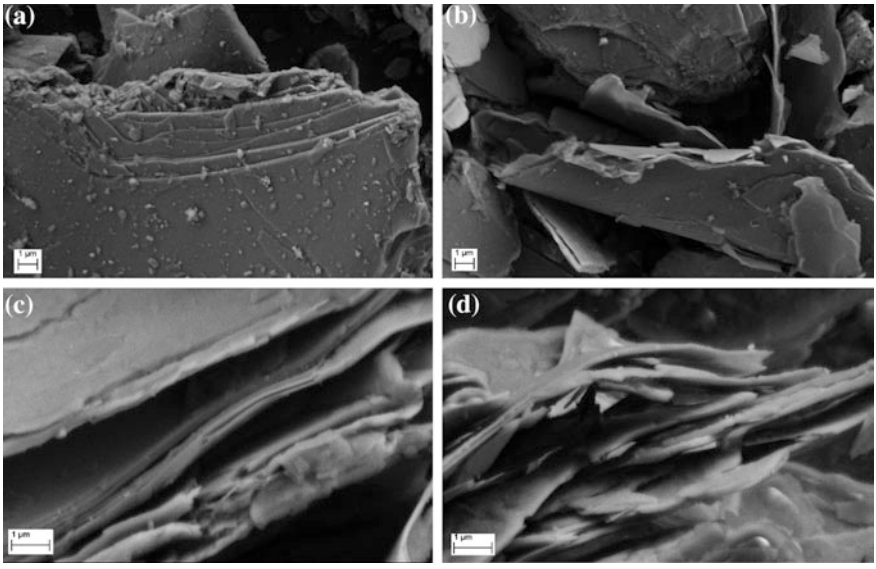


Fig. 3 SEM micrograph of the **a** Muscovite, **b** Li-Muscovite, **c** ODTMA-muscovite and **d** CTAB-muscovite

greater separation between the layers, which was quite different from that of original muscovite as shown in Fig. 3a. This might be attributed to the expansion of the muscovite due to the increase of the basal spacing after the organic cation exchange.

4 Conclusions

The organic modification of muscovite clay particles was successfully carried out using the two-step ion-exchange treatment. Based on the basal spacing from the XRD patterns, the intercalated structure of muscovite is obtained. It is shown that the ODTMA-muscovite gave greater basal spacing compared to CTAB-muscovite due to the longer alkyl chain. Enlargement in basal spacing signifying better interfacial interaction between modified muscovite with polymer matrices. The morphology investigated by FESEM showed clearly the silicate layers of muscovite were enlarged after modification. Thus, understanding the organomuscovite obtained is worth finding for their industrial applications.

Acknowledgements This work was supported by the Research University Grant (1001/PBAHAN/8640013) of Universiti Sains Malaysia (USM) and the Ministry of Higher Education (MOHE), Malaysia for the financial support under SLAB/SLAI Programme.

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Chapter 47
Power Converter for Dual-Power PV-Grid System Utilizing Optimized Switching Angles of 21-Level Cascaded H-Bridge Multilevel Inverter

Intan Rahayu Ibrahim, Emilia Noorsal and Ahmad Maliki Omar

Abstract In the dual-power PV-grid system, the PV-battery system and grid system are operated alternately during the on-demand and off-demand period. Power converter in the system is used to boost, regulate and convert DC sources from PV to AC. Multilevel inverter is desirable in the PV energy system owing to its capability of synthesizing 'stepped' AC output from several DC sources. The structure allows the inverter to reach high voltages with low harmonic and low component ratings. However, the main drawbacks of this type of inverter may include high number of power switches in the circuit, voltage balancing problem and it only operates when the sum of the input DC voltages is higher than the amplitude of the grid voltage at all the time. This chapter explains and discusses the design of power converter in the dual-power PV-grid system utilizing 21-level cascaded H-bridge multilevel inverter. Five PV strings of separate DC sources are cascaded to produce the 21-level H-bridge cascaded multilevel inverter. Low-frequency optimized switching angles of selective harmonic elimination (SHE) switching technique is chosen to minimize harmonic contents and switching losses in the inverter output. The simulation analysis of the proposed inverter recorded total harmonics distortion of 3.94%.

Keywords H-bridge · PV-grid system · PV energy · Selective harmonic

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_47

1 Introduction

The dual-power PV-grid energy system is capable of reducing the installation cost for PV plant and manipulating low off-peak tariff during the night (Ibrahim et al. 2011). The power converter in the PV energy system function to ensure power was tapped at the maximum points, regulate the voltage to operating system voltage and invert the DC energy to AC to be readily connected to the grid system or load. The power converter is critical in avoiding power losses and system failures (Ibrahim et al. 2014). Basically, the power converter component may include a DC–DC converter and an inverter. A DC–DC converter is considered DC equivalent to an AC transformer, which is used to step-up or step down the DC voltage.

Solar modules output current and voltage are dependent on solar irradiation, temperature and total resistance which produce a non-linear output behaviour as described in the *I-V* curve. The maximum power point tracking (MPPT) is adapted to ensure that maximum power is transferred to the load for any given environmental conditions (Koutroulis et al. 2002; Bratcu et al. 2011). Famous MPPT techniques are perturbation and observation (P and O) and incremental conductance (IC).

Inverter converts DC electrical power from PV-battery system to AC power. There are three common topologies of inverters, pulse width modulated (PWM), resonant and multilevel. Topologies and various configurations evolved from various applications of power converters. Multilevel inverters claimed to have high efficiency and low switching losses because the power switches are switched at low frequency (Lai and Peng 1996; Peng et al. 1996; Lai and Shyu 2003; Daher et al. 2008; Seyezhai and Mathur 2008; Babaei and Laali 2015). The fast response and autonomous control of frequency and output voltage (Tolbert and Peng 2002) enable them to be used in medium to high voltage (Seyezhai and Mathur 2008). In absence of any PWM techniques, switching losses can be limited (Nam 1991; Lai and Peng 1996; Lai and Shyu 2003). Furthermore, increase in voltage and current rating of devices are not necessarily required if the output voltage and power of multilevel inverters are to be increased (Lai and Shyu 2003). There are three types of most common multilevel inverters; diode clamped, flying capacitor and cascaded multilevel inverter.

By proper implementation of switching strategy, inverter efficiency could be improved by means of minimizing the harmonic contents of output current and voltage. Harmonics influence current and voltage distortions, which consequently, affect the power quality (Sadikin et al. 2013). There are three most common switching schemes, which are sinusoidal pulse width modulation (SPWM), space vector modulation (SVM) and selective harmonic elimination (SHE). In SPWM, a low-frequency sinusoidal reference waveform is compared to a high triangular carrier waveform to generate the switching signal to trigger power switches in the inverter (Colak et al. 1994, 2011; Adithya and Raghu Raman 2014). On the other hand, the space vector modulation (SVM) observes the predefined control variables

and identifies switching vector as a point in complex space (α, β). This switching technique is noticed to be effectively applicable to three-phase power system (Celanovic and Boroyevic 1999; Colak et al. 2011). Meanwhile, in SHE, the switching angles of power switches are precalculated and predefined to eliminate certain harmonic orders.

This chapter discusses the design of power converter for the dual-power PV-grid system. The main components in the power converter system are the DC–DC boost regulator and the 21-level cascaded H-bridge inverter. The inverter consists of five strings of PV modules connected in cascaded configuration. The switching scheme applied to the 21-level cascaded H-bridge multilevel inverter was designed using low fundamental selective harmonic elimination technique (SHE). The switching angles were optimized to eliminate selected low order harmonics. Simulation analysis was carried out to compare the performance of the inverter using the proposed optimization technique and the Newton–Raphson technique in achieving low percentage of total harmonic distortion.

1.1 Design of Power Converter System for Dual-Power PV-Grid Energy System

The design analysis is aimed to determine the design parameters of the inverter, the boost regulator and the battery converter. In the proposed 21-level cascaded H-bridge multilevel inverter, five strings of PV modules operate as separate DC sources (SDCS), boosted to 72 V of voltage each and supply as an input to the cascaded H-bridge multilevel inverter to generate 21 level of 'stepped' output voltage. The optimum number of string and output 'stepped' level of the cascaded H-bridge multilevel inverter for the dual-power PV-grid system was mathematically evaluated by considering conduction losses and system voltages. The system voltage is confined to the battery voltage. It is observed that the configuration of five strings of PV modules with system voltage of 72 V gives the optimum result as displayed in Fig. 1. From this conclusion, the new topology of 21-level cascaded h-bridge multilevel inverter and the power converter system for dual-power PV-grid energy system were designed as depicted in Fig. 2. Design parameters of the power converter were determined based on the standard test condition (STC) data of PV module (MITSUBISHI PV-AE125MF5 N) of Table 1.

1.2 Design of the Boost Regulator

By using PV module with parameters as in Table 1, the design parameters for the boost regulator are calculated and tabulated in Table 2.

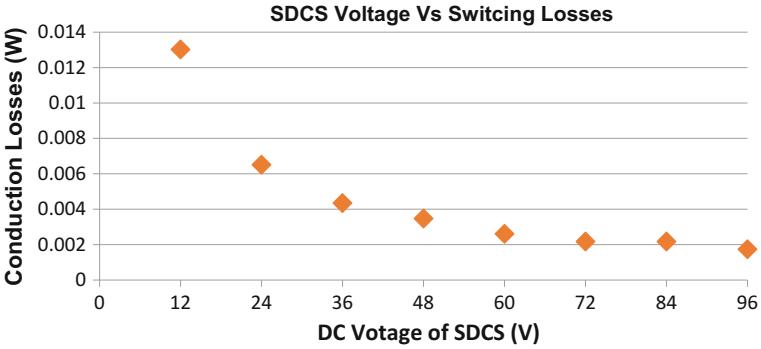

Fig. 1 Graph of conduction losses versus the system voltage

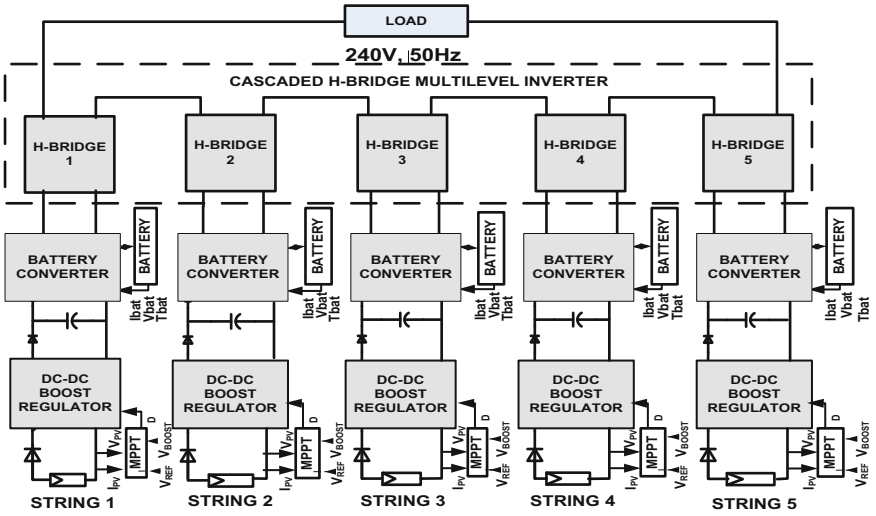

Fig. 2 Power converter for dual-power PV-grid energy system

Table 1 Electrical characteristic at STC

Type	Monocrystalline
V_{oc}	21.8 V
V_{pm}	17.3 V
I_{sc}	7.9 A
I_{pm}	7.23 A
P_m	126 W

Table 2 Parameters for the boost regulator

Parameter	Value
V_{in}	17.2 V
V_{out}	72 V
ΔI (p-p ripple current)	5%
ΔV (p-p ripple voltage)	5%
L	1.28 mH
C	47 μF, 200 V
f (switching frequency)	25 kHz
D (duty cycle)	76%

1.3 Simulation Design and Analysis of Boost Regulator with MPPT

The simulation design involves the designing of the boost regulator to boost and regulate PV outputs to fixed voltage while maintaining power captured at maximum point. The simulation model constructed as in Fig. 3.

1.4 Design of the 21-Level Cascaded H-Bridge Multilevel Inverter

1.4.1 Circuit Topology

By adding a power switch, four diodes and two capacitors in front of the H-bridge as shown in Fig. 4, the output level of H-bridge is increased from three to five. Each of the H-bridge produces five levels output of 1/2 V_{DC}, V_{DC}, 0, −1/2 V_{DC} and $-V_{DC}$. Table 3 tabulates the switching pattern for the power switches to achieve 5 levels of $-V_{DC}$, −1/2 V_{DC}, 0 V, 1/2 V_{DC} and $+V_{DC}$. Overall, this configuration produces (4n + 1) of output AC "stepped" level, where n = number of H-bridge. Hence, combination of five-cascaded H-bridge with the desired individual output waveform will produce the 21-level 'stepped' AC waveform. Table 4 further elaborates the switching sequence of five cascaded SDCs to produce 21 level of voltages ranging from −360 V to +360 V.

1.4.2 Selective Harmonics Elimination (SHE) Switching Strategy

Switching strategy is implemented to efficiently control switching angles of each of power switches in the inverter. In SHE, the switching angles of power switches are precalculated and predefined to eliminate certain harmonic orders. In order to

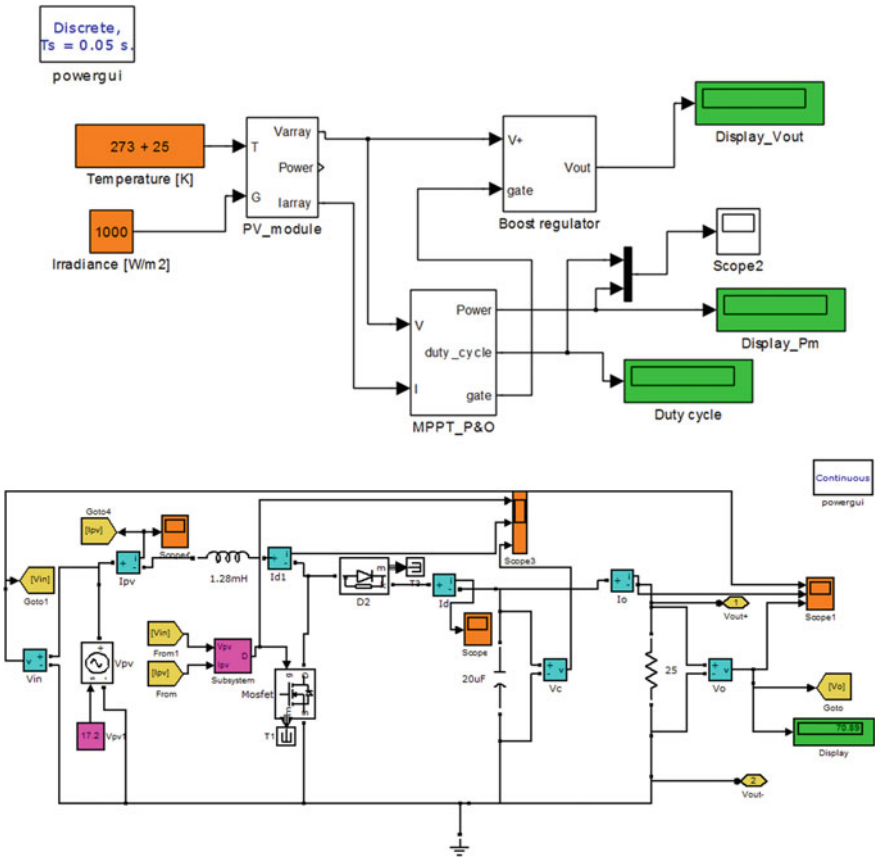

Fig. 3 The MPPT implementation in the boost regulator simulation circuit

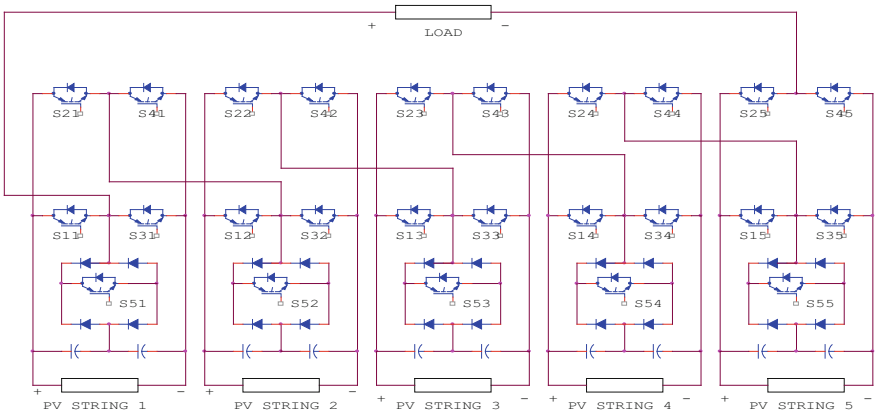

Fig. 4 Proposed 21-level cascaded H-bridge multilevel inverter

Table 3 Switching sequence of power switches in an H-bridge to produce five-level output

	Power Switches				
	S1	S2	S3	S4	S5
$+1/2V_{DC}$	OFF	OFF	OFF	ON	ON
V_{DC}	ON	OFF	OFF	ON	OFF
0	OFF	OFF	OFF	OFF	OFF
$-1/2V_{DC}$	OFF	ON	OFF	OFF	ON
$-V_{DC}$	OFF	OFF	ON	OFF	ON

Table 4 Active power switches, an output voltage level and switching angles

Active switches	Output voltage	Switching angle (θ)
S11, S41, S12, S42, S13, S43, S14, S44, S15, S45	$5V_{DC}$	θ_{10}
S11, S14, S12, S42, S13.S43, S14, S44, S45, S55	$9/2V_{DC}$	θ_9
S11, S41, S12, S42, S13, S42, S14, S44	$4V_{DC}$	θ_8
S11, S41, S12, S42, S13, S43, S44, S45	$7/2V_{DC}$	θ_7
S11, S41, S12, S42, S13, S43	$3V_{DC}$	θ_6
S11, S41, S12, S42, S43, S53	$5/2V_{DC}$	θ_5
S11, S41, S12, S42	$2V_{DC}$	θ_4
S11, S41, S42, S52	$3/2V_{DC}$	θ_3
S11, S41	V_{DC}	θ_2
S41, S51	$1/V_{DC}$	θ_1
All power switches are inactive	0	0
S21, S51	$-1/2V_{DC}$	$\Pi + \theta_1$
S21, S31	$-V_{DC}$	$\Pi + \theta_2$
S21, S31, S22, S25	$-3/2V_{DC}$	$\Pi + \theta_3$
S21, S31, S22, S32	$-2V_{DC}$	$\Pi + \theta_4$
S21, S31, S22, S32, S23, S53	$-5/2V_{DC}$	$\Pi + \theta_5$
S21, S31, S22, S32, S23, S33	$-3V_{DC}$	$\Pi + \theta_6$
S21, S31, S22, S32, S23, S33, S24, S54	$-7/2V_{DC}$	$\Pi + \theta_7$
S21, S31, S22, S32, S23, S33, S24, S34	$-4V_{DC}$	$\Pi + \theta_8$
S21, S31, S22, S32, S23, S33, S24, S34, S25, S55	$-9/2V_{DC}$	$\Pi + \theta_9$
S21, S31, S22, S32, S23, S33, S24, S34, S25, S35	$-5V_{DC}$	$\Pi + \theta_{10}$

eliminate third, fifth, seventh, eleventh and thirteenth harmonics, and to maintain the fundamental voltage to 100%, transcendental equations with 10 unknowns, as shown below, need to be solved. The transcendental equations of (1) to (6) may be solved using mathematical calculations or using optimization techniques.

$$[\cos(\theta_1) + \cos(\theta_2) + \cos(\theta_3) \cdots + \cos(\theta_{10})] = (k-1)M \tag{1}$$

$$[\cos(3\theta_1) + \cos(3\theta_2) + \cos(3\theta_3) \cdots + \cos(3\theta_{10})] = 0 \tag{2}$$

$$[\cos(5\theta_1) + \cos(5\theta_2) + \cos(5\theta_3) \cdots + \cos(5\theta_{10})] = 0 \quad (3)$$

$$[\cos(7\theta_1) + \cos(7\theta_2) + \cos(7\theta_3) \cdots + \cos(7\theta_{10})] = 0 \quad (4)$$

$$[\cos(11\theta_1) + \cos(11\theta_2) + \cos(11\theta_3) \cdots + \cos(11\theta_{10})] = 0 \quad (5)$$

$$[\cos(13\theta_1) + \cos(13\theta_2) + \cos(13\theta_3) \cdots + \cos(13\theta_{10})] = 0 \quad (6)$$

1.5 Proposed Modified Particle Swarm Optimization (MhyPSO) Technique

From the observation and literature reviews, the Newton–Raphson method needs very close initial values to the optimized values which are difficult to predict. Totally random values generated in Newton–Raphson, PSO and EP techniques sometimes result in good fitness value of lowest percentage of THD but cannot satisfy requirement of switching angles for multilevel inverter such as θ_1 should less than θ_2. To avoid that, the modified PSO technique is introduced. In this technique, the random angle generations are modified using EP method. Instead of satisfying fitness equation, the program keeps generating random switching angles until 20 particles of accepted switching angles are achieved. In this technique, instead of using multiobjective PSO (MOPSO), the third, fifth, seventh, ninth and eleventh harmonics are reduced, while maintaining fundamental component to 100% by using only one fitness equation. The combination and modification of PSO and EP techniques are called modified hybrid PSO (MhyPSO).

As a summary, MhyPSO method is adopted by following the steps below:

i. Initialize population size, modulation index, maximum iteration and iteration counter.
ii. Generate random switching angles for each particle which fulfil the criteria, which are given as follows:
    a. Each switching angle lays on the specific range so that $\theta_1 < \theta_2 < \theta \cdots < \pi$.
    b. Each particle generates minimum third, fifth, seventh, ninth, eleventh and thirteenth harmonics.
    c. Generate the initial conditions of each particle ($0 < \theta < \pi$). Initial values are computed based on manual estimation.
iii. Evaluate particles using fitness function of harmonic minimization problem. Accepted particle should comply with six fitness equations to reduce third, fifth, seventh, ninth, eleventh and thirteenth, respectively.
iv. Update the personal best position of the particles. If the personal best of the particles is better than the position of global best, replace global best with the best position of the personal best.

v. Update the velocity and position vector.
vi. Termination criteria—if iteration reaches maximum iteration, stop the iteration, otherwise increase the iteration counter and repeat step 3, 4 and 5.

1.6 Simulation Design and Analysis of 21-Level Cascaded H-Bridge Multilevel Inverter

The optimized switching angles generated by MhyPSO technique are used to generate switching signals for power switches in 21-level cascaded H-bridge multilevel inverter. The new topology of 21-level cascaded H-bridge multilevel inverter is simulated in MATLAB environment to generate 240 V, 50 Hz AC voltage to supply the AC load. All the DC input of each H-bridge is regulated to 72 V to provide summation of 240 V, 50 Hz at the inverter output.

2 Results and Discussion

2.1 Simulation Analysis of the Boost Regulator with MPPT

Operated at maximum power with V_{pm} of 17.3 V the output of the boost regulator is regulated at 72 V as indicated by input and output signals in the Fig. 5.

The simulation circuit with the MPPT algorithm is tested by applying signal of varying solar irradiance. It is shown in Fig. 6, as solar irradiance increasing, the PV current increased so as the PV power, while the output voltage is maintained at 72 V.

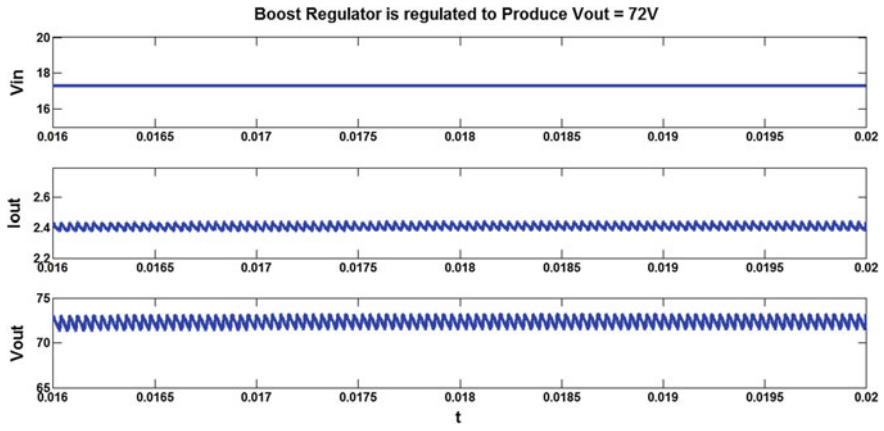

Fig. 5 Input voltage, output current and voltage of the boost regulator

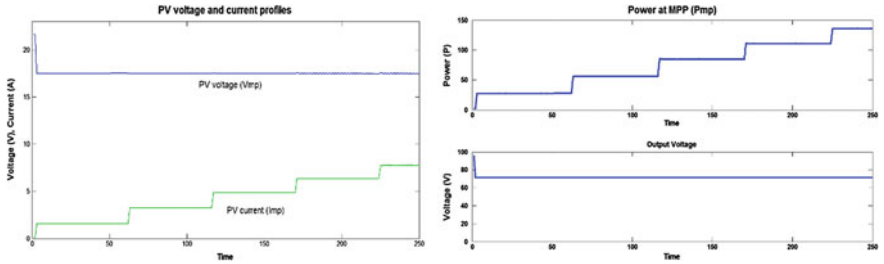

Fig. 6 The PV voltage, PV current, power at MPP and output voltage profiles of the simulated MPPT technique using P&O of the boost regulator

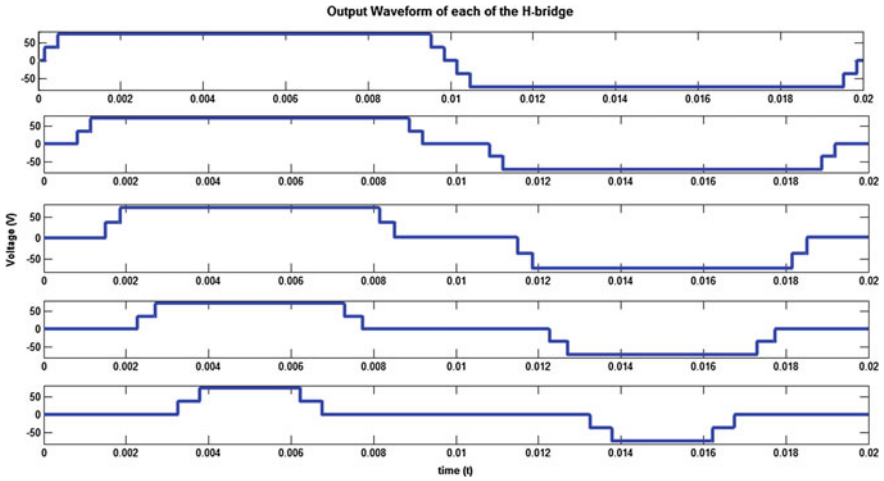

Fig. 7 Output waveforms for each of H-bridge

Figure 7 shows the output waveform of each block of the H-bridge of the inverter. Meanwhile, Tables 5, 6 and 7 tabulate switching angles generated by MhyPSO technique and compare the performance of the technique to Newton–Raphson technique in minimizing percentage THD.

As a conclusion, the optimization switching angles generated using the proposed MhyPSO records lower percentage THD in the 21-level of cascaded H-bridge multilevel inverter circuit compared to the Newton–Raphson. Fig. 8 illustrates the output waveform of 21-level cascaded H-bridge multilevel inverter. It is shown that the waveform is almost sinusoidal with percentage THD of 3.94.

Table 5 Switching angles generated by MhyPSO to reduce selected harmonic contents

	Switching angles									
	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9	θ_{10}
Reduced fifth harmonic	2	8	14.14	20	26	34	40	48.46	59	68
Reduced seventh harmonic	3	9	13.72	20.36	26.7	33.79	40.56	48.34	59	67.4
Reduced fifth and seventh harmonics	3	9	13.77	20.43	26.78	33.88	40.64	48.43	59	67.47
Reduced third, fifth, seventh, eleventh and thirteenth harmonics	2.16	8.26	14.24	20.23	26	33	40	48	58.18	68.02

Table 6 Percentage THD for fifth and seventh harmonic reductions using Newton–Raphson method and using MhyPSO technique

Switching strategy	%THD
Newton–Raphson method	4.71
MhyPSO	3.93

Table 7 Percentage THD of third, fifth, seventh, ninth, eleventh and thirteenth harmonic reductions using Newton–Raphson method and using MhyPSO Technique

Switching strategy	%THD
Newton–Raphson method	4.47
MhyPSO	3.94

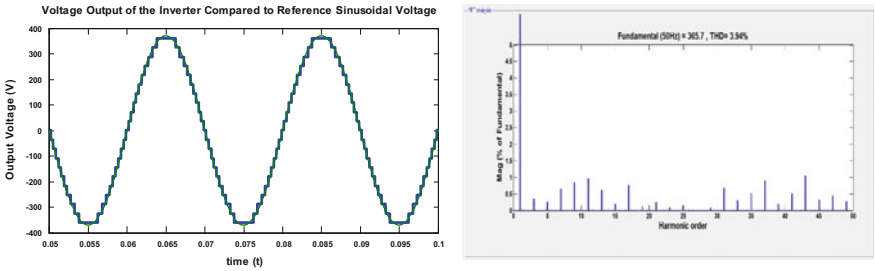

Fig. 8 21-Level 'Stepped' AC output waveform of 21-level cascaded H-bridge multilevel percentage THD of the Inverter

3 Conclusion

The designed power converter successfully track the maximum point of power transfer, boost and regulate DC voltage. By cascading five of five-level H-bridge with five separate DC sources from five PV modules, the configuration of 21 'stepped' level is achieved. The proposed topology increases the number of 'stepped' level with reduced number of power switches. The proposed MhyPSO technique is capable of evaluating fitness function by minimizing third, fifth, seventh, ninth, eleventh and thirteenth harmonics. The technique produces optimized switching angles, which records lowest percentage THD. The optimized switching angles using new improved MhyPSO technique successfully reduced the THD level to 3.94%.

Acknowledgements Authors gratefully acknowledge the financial and technical support from Ministry of Higher Education of Malaysia and Universiti Teknologi MARA, Malaysia.

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Chapter 48
A Review of Domestic Subcontract in Construction Industry

Nor Marina Rosli, Nur Emma Mustaffa and Hamizah Liyana Tajul Ariffin

Abstract Construction contract general conditions which are also known as a standard form have the major influence on the likelihood and degree of project success. The first essential requirement for a standard form is that it should be drafted with clarity so that it is possible to easily ascertain from the wording just where the risk falls. In Malaysian construction industry, there are several choices of standard forms of main contracts and nominated subcontract. There has never been any published standard form of domestic subcontract in Malaysia. So far, however, there seems to be no comprehensive review to summarize existing research on the domestic subcontract. The review presents the state of the art domestic subcontract form, identifies the research gaps and proposes new directions for further studies.

Keywords Construction · Domestic subcontract · Conditions of subcontract

1 Introduction

One of the major components of a contract document is the general conditions of contract, which is also known in Malaysia as the standard form of contract (Nee et al. 2014). Construction contract general condition clauses have major

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_48

influences on the likelihood and degree of project success. The first essential requirement for a standard form is that it should be drafted with clarity so that it is possible to easily ascertain from the wording just where the risk falls. The main reason of using the standard form of contract is to allocate risks fairly between the parties and should imply that contractors need not include an allowance in their prices for risks (Hughes et al. 1997). Banwell Report 1964 recommended that the building industry should develop and use a single standard form of contract for all construction projects.

A domestic subcontract, which could be a simple written contract or just an oral contract, may have undefined and unclear terms and conditions which can lead to disputes and work suspension (Yik and Lai 2008). Domestic Subcontractors often use a non-standard form to form subcontract relationship with the main contractor. In general practice, the contract terms were drafted by the main contractor. Most main contractors impose their own standard terms on subcontractors and these often contain one-sided provisions which place these subcontractors at a disadvantaged position in a dispute.

In Malaysian construction industry, there are several choices of standard forms of main contracts; likewise for nominated subcontract yet there has never been any published standard form of the domestic subcontract. Most of the subcontract between main contractor and domestic subcontractor are unpublished 'in-house' contracts, ad hoc or 'one-off' contract. With regards to this, CIDB has drafted Model Terms of Construction Contract for Subcontract Work (2007) in order to full fill this gap. CIDB Form of Building Contract, Nominated and Domestic Subcontract Forms are viewed as too pro-contractor and it is seldom used in the Malaysian construction industry.

Domestic subcontracts are frequently entered into on an informal basis. Such contracts have provoked fierce criticism from trade associations representing subcontractors, as being one-sided to the point of unfairness. Malaysia has been faced with increasing growth in the number of contractors and more than 90% of registered construction companies are SMEs which form the smallest scaled category (Supardi et al. 2011). These contractors carry out several types of construction works with the cost limit of works up to RM 200,000 (CIDB 2015). Even though a major portion of a construction project is usually executed by subcontractors, the issues regarding domestic subcontracting are seldom acknowledged and addressed. Table 3 shows very little research work that has been conducted and there is little published information available on the subject especially regarding the standard form of domestic subcontract (conditions of contract). Hence, this paper reviews the scholarly research works in the discipline of domestic subcontracting focusing on crucial conditions and attributes of the domestic subcontract. The discussion in the paper begins with an exploration of the advantages of subcontracting, types of a subcontractor, followed by a review of various studies on conditions of the subcontract.

1.1 Advantages of Subcontracting

Malaysian construction industry is highly competitive with a large number of contractors and the small size of the industry. There are long chains of subcontracting culture in the industry. The importance and extent of subcontracting are familiar to all involved in construction. Its prevalence has been documented in numerous studies. This has been added to and a synopsis is provided in Table 1.

Most large companies usually work as main contractors for the projects, appointing a few small companies as subcontractors with different work scope through a competitive tendering. These subcontractors will then appoint other small companies as their subcontractors to do part of the works which have been assigned to them. A subcontractor is a person or a company hired by the main contractor to perform part of the work of a construction job. The subcontractor does the works based on direction given by the main contractor and the works are carried out as part of the main contractor's works.

1.2 Types of Subcontractor

In construction projects, there are two types of subcontractors which comprise of nominated subcontractor and domestic sub-contractor. This has been tabulated in Table 2 for further clarification.

The duties and responsibilities of the parties, who enter into the contract, are bound as stipulated in the contract which has been agreed in the earlier stage. The contract may be entirely in writing, entirely orally or partly in writing and partly oral and a well-written construction contract will specify a full description and the extent of work, timing, quality standards and the price. This involves drawing up contract conditions which will allow the contract to be administered and future contract disputes settled.

Table 1 Advantages of subcontracting

Advantages of subcontracting	
Cost	Bargain down labour cost, avoid workers' compensation cost, economical, equipment/maintenance cost, reduced overhead cost, reduced overall construction cost, temptation to increase profits
Labour	Labour flexibility, increase efficiency, accessing necessary resources, shortage of experienced workers, sporadic and unpredictable workload, off-loading direct employment responsibility
Risk	Technical and financial risks are shared between parties, subcontractors sustain their businesses, downloading financial risk, externalize less rewarding and dangerous activities, and risk reduction
Time	Encourage quicker completion of tasks, market volatility, faster construction time
Quality	Complexity, better workmanship, value to the owner

Table 2 Types of subcontractors

Nominated subcontractor	Domestic subcontractor
Firms that are preselected by the client, but the subcontract that they enter into establishes a binding contract solely with the prime contractor. Nominated subcontractors are most commonly employed for work involving piling, HVAC, elevators, firefighting, and other specialized work	Employed in labour-intensive tasks such as excavating, formwork, rebar work, and painting
Arises where the design team/client requires control in the selection of a specialist	Exhibit a compromise requiring a limited control of the selection including naming a number of firms (1–3) in the tender documents for a particular section of work
Chosen by employer and appointed by the main contractor	Selected and appointed by main contractor
Perform their duty under main contractor supervision	One in whose selection and appointment the employer normally plays no part, other than simply giving consent where there is required under the terms of the main contract
Specialist in one project	The main contractor remains fully liable to the employer for the works particularly in respect of the workmanship and delay caused by the subcontractors

2 Method

Content analysis was carried out on the paper published in top journals in the area of construction management. Both Scopus and Science Citation Index Expanded (SCI) were used because some of the journals were not indexed by each other. By assuming that author(s) may be keen to publish their papers in a first-tier journal based on the quality of the journals.

3 Results and Discussions

To date, research on domestic subcontract in the construction industry has received far less attention than in say, main and nominated subcontract. Table 3 clearly tabulated previous research which are related to subcontracting. Based on the literature review conducted, the number of the researcher done on domestic subcontract is very limited.

Table 3 Previous research on subcontracting

Authors	Data and method	Contribution to this study
Manu et al. (2015)	Semi-structured interviews, non-participant observation and document reviews	Factors contributing to trust in between contractor and subcontractor
Hidzir et al. (2015)	Literature review	Troublesome clause in subcontract
Abdullahi (2014)	Literature review	Subcontracting practices in general
Oviedo-haito et al. (2014)	Open-ended interview	Factors facilitating the survival of subcontractors in a scenario of severe economic crisis
Rahman et al. (2014)	Mixed method	Ongoing Ph.D. research (framework to improve the relationship between the main contractors and subcontractors in the construction industry)
Abbasianjahromi et al. (2013)	Literature review	Develop a comprehensive model for subcontractor selection based on the fuzzy preference selection index
Rafiq et al. (2013)	Questionnaire and interview	Major problems in subcontracting
Ng and Tang (2010)	Questionnaires	Establish a set of Critical success factors for subcontracting
Othman (2008)	Content analysis and semi-structured interviews	Drafting policies for standard form of contract in general
Yik and Lai (2008)	Interview and desktop study	Multilayer subcontracting in building projects (Hong Kong)
Talukhaba and Mapatha (2007)	Questionnaires	Factors necessary for selection of domestic subcontractor

General conditions spell out the general project rules and relevant commercial terms and are usually expressed in a standardized prepared printed contract form which is known as a standard form, developed and published by different professional associations and bodies and are widely used throughout the construction industry. Tables 4 and 5 clearly specified attributes of the domestic subcontract and most crucial clauses for subcontract which have been gathered from previous research.

Table 4 The attributes of domestic subcontract

Authors	Attributes
Paciaroni (2013)	Best suited to deliver the project Integrated, well-considered whole Clear, concise, unambiguous language Mechanically sound Clearly defines the scope of work Anticipates a wide variety of potential problems Risk allocation Balanced Insurance Dispute resolution mechanism Understood and followed at the project level
Chong and Zin (2010)	Clarity—shortened the sentences, active voices, no repetition of words, in a complexity of phrases, avoid 'shall', positive style of language, good explanation on procedure and process, good word formation
Wong et al. (2008)	Clear Information should be explainable to parties who may affect Clarification of contract terms and agreement
Mohamad and Madon (2006)	Clarity Written in simple language Precise, objective and practical Prepared by qualified professional Clearly explained on regulatory requirement Minimize use of complicated legal phrase General condition to be made familiar Induction session before contract to be implemented
Yik et al. (2006)	Clearly define scope of work Ambiguous terms and conditions
M O'reilly (1999)	Clear Certainty

Table 5 Crucial condition of domestic subcontract

Conditions of subcontract (clauses)			
Termination clauses	Performance Bond	Damage	Delays
Scope of work	Defect	Variation order	Indemnification
Site conditions	Claim and Payment	Site conditions	Warranty
Pay when paid clauses	Liquidated damages	Rights and obligations	Dispute resolution
Time limit of project		Insurance	Process, quality, cost, administration
		Extension of time	

4 Conclusion

This research may provide a good basis for future discussion about domestic subcontract. This ongoing research may also reduce the present problems on 'bullying', and may provide the ways to improve domestic subcontract practice and management. It is believed that these research contents may be very useful to the practitioners of both legal and construction contract community as well as the academic students especially to those involved in construction contract management. The findings presented in this paper are the result of a literature review in an attempt to the establishment of a framework for domestic subcontract in Malaysian construction industry.

Acknowledgements The authors would like to express their appreciation to the Universiti Tunku Abdul Rahman (Lee Kong Chian Faculty of Engineering and Science) and Univerisiti Teknologi Malaysia (Faculty of Built Environment) by providing a good research environment and facilities to support this research work.

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Chapter 49
Exploration on Drivers' Perception Towards Roadway Inventory Elements

Azlina Ismail, Intan Suhana Razelan Mohd, I. Putu Mandiartha and Nadia Arib

Abstract Accidents due to driver's fault occur in many ways including human perception and driving behaviour. It varies with age, emotion, belief and attitude. In addition, the fact that accident can happen due to poor roadway inventory management should not be neglected. Therefore, this study is intended to explore how drivers' perception subjectively reviews the roadway inventory elements performance that might be a potential factor affecting road safety. To achieve this, Jalan Kuantan-Gambang was chosen as a study location. This study was conducted using a qualitative study by means of questionnaires distribution. Then the average index method was performed to indicate the driver's perception towards the roadway inventory elements performance. The results explain that drivers' perception of different age affects the performance of roadway elements, where attention for older drivers during road design and construction are essential.

Keywords Average index · Drivers' perception · Road inventory
Road safety · Roadway elements

1 Introduction

Road accident has become one of the national problems since the early days of motorization industry in Malaysia. Due to the increase in economic sector coupled with the increment in Malaysian standard of living, the number of registered vehicles in 2005 has increased by 15 times as compared to the number in 1974 (Mustafa 2004). Since then, the accident percentages were also kept on increasing. Assum and Sorensen (2009) and Papelis et al. (2010) have revealed a number of factors that may lead to road traffic accidents such as the driver's fault (70%), vehicle's failure (10%) and roadway condition and environment (20%).

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_49

Many studies have been done extensively focusing on the driver's fault and countermeasures always aimed at changing and controlling the human beings in the system. Government has set up a few policies to control this issue includes introducing application of three 'Es': education, engineering and enforcement which involve the solicitation of appropriate safety policies, vehicles inspections, new approach in road engineering and not to be missed a medical and trauma management. Government and nongovernmental agencies also have successfully played their role by running vast awareness campaign especially during the festive seasons when the numbers of vehicles travelling on the road is almost double than usual volume. However, according to Ibrahim and Karim (2005) who has done extensive studies on the road safety trends in Malaysia, he has concluded that in order to ensure that safety aspects are well blend among Malaysians, enforcement and certification alone is not adequate. This shows that in order to provide safe facilities and services, certain characteristics and limitations must be understood.

Since it is known that human factors are among main contributors to accidents, the characteristics and behaviour of the driver must be well recognized. Drivers have varying skills and perceptual abilities that are demonstrated by their abilities to hear, see, evaluate and react to information. These abilities are also influenced by varying conditions such as age, gender, emotion, fatigue and time of day (Garber and Lester 2002). Therefore, it is expected that exploration on drivers' demographic profiles regarding road safety is a significant issue.

On the other hand, other critical contributing factors that lead to road safety issues that should not be neglected are the roadway condition and environment. The determination of road condition and environment contributory factors is important for drivers and road users as it is strongly associated with driver's ability to predict hazards and consequently will affect the drivers' ability to anticipate hazards and its reaction towards hazards. If the drivers are successful in manoeuvring the hazard, the risk of accident can be minimized (Wetton et al. 2009).

Over the years, industrialization and urbanization with high growth rate have caused several traffic issues all over the world especially on road safety issues data. The road safety data include not only crash data but also roadway inventory data, traffic data, driver history data and many more (Lefler et al. 2010). Nowadays, lacking of roadway inventory information data is an important problem worldwide. Like most of the developing country, Malaysia is facing an increase of vehicle occupancy and of accompanying problems with the loading of the traffic volume. Unceasingly, road facilities experience failures more rapidly than expected due to the increases in traffic volume and insufficient degree of maintenance. Therefore, it will be desirable to minimize the issues and increase the competencies of traffic management in handling roadway inventory data so that it will benefit not only safety but other disciplines such as operations, asset management and maintenance road facilities.

Roadway inventory information data is an important transportation consideration because it relates to geometry design, road furniture, network location and environment (Paterson and Scullion 1990). It is often suggested that new roads are designed without adequate investigation of driver's risk perception (Kanellaidis et al. 2000). Therefore, association of driver's risk perception towards road

inventory elements should be taken into account when conducting a relevant study. Although the attitude of road users is hard to be emphasized, however according to many researchers, it is imperative that human factor can be considered during the design of the road infrastructure. Prior to this issue, this study was conducted to explore how drivers' perception subjectively assesses the roadway inventory elements performance that may be a potential factor affecting road safety. On the other side, it also may become necessary in order to foreseen traffic needs as to improve traffic management strategy.

2 Literature Review

Kowtanapanich et al. (2005) expressed road as the system with which people have to deal every day and amongst of all the systems, road traffic system is the most complex and dangerous. Road is a very complex system which holds a blend of peoples, machines and environments at one time. Driving can be considered as a dangerous game where this scenario involved simultaneous interactions of human, vehicles, roadway and environment. These interactions have certain characteristics and limitations that must be understood by drivers to provide safety while driving. Driving does not always took place in an ideal condition, in which a well rested, well trained and well behaving individual interacts with a simple and undemanding road environment. One issue that can make driving performance suboptimal is distraction, both from within the vehicle and from the road environment (Horberry et al. 2005). But somehow, drivers sometimes do not know what constitutes dangerous traffic behaviour and as a result, they cannot refrain from behaving dangerously (Vanlaar and Yannis 2005).

One of the factors that will constitute dangerous driving is the road condition and environmental factor. As cited by Peter Larsson from The Swedish Transport Agency in his presentation to Ministry of Work (MOW) Malaysia, he pointed out that more than 29% of the road accidents factors are caused by road condition and environment. Road condition and environment itself covers many aspects of the physical elements of the road system such as road conditions, roadside conditions, traffic volumes, operational speed and not to be missed out the driving ambience itself. Putting aside the other mentioned factors, this study tried to focus on the factors of roadway inventory elements such as road condition and environment factor that influenced the traffic safety condition that may be highly risky leading to crashes.

According to Bennett et al. (2007), physical elements of the road system are the roadway inventory data. Roadway inventory data are typically collected in a one-off exercise and require updating when changes are made to the road, such as new roads or realignment. It is common to verify or update the data every 5 years or so. During the feasibility stage, road condition and environment are safe in terms of design aspect and procedure but the problems started to show when the roads are in operation. Therefore, it is known that road inventory should be viewed as an important national asset and must be regularly maintained to keep them serviceable

like any other assets (Mohamed 2010). From the view of road users, road asset must be well maintained by the authority as to provide safety and comfort. According to Ahmad (2002) as cited in (Mohamed 2010), maintenance is always a must for any structure in order to maintain its serviceability and to prevent deterioration that may shorten the service life.

3 Data Collection

Route Jalan Kuantan-Maran was selected to serve as a case study area. As shown in Fig. 1, the road links Kuantan Town to Gambang Town from KM3 until KM27 and forms the backbone of Kuantan road network. At present, it is an urban arterial of dual two-lane carriageway similar to the East Coast Expressway in the number of lanes but a rank lower in the hierarchy of roads in Malaysia. Operated as a main route, it clearly shows that the traffic flow catered along Jalan Kuantan-Gambang is relatively heavy and becoming much heavier especially due to the traffic generated from the East Coast Expressway in combination with the rapid development along the road. In addition, the variability of the road environment that passes through residential areas, commercial and educational areas, plantation areas and also reserved forest exhibited environments that are typical along any other federal roads in Malaysia. It was chosen as a study area by considering both combination of high volume of traffic together with the variability of dense road environment that may expose to road safety issues as has been reported by Intan Suhana et al. (2014).

Data collection was done by distributing 90 sets of questionnaire randomly to the respondents who frequently used this section of road. The respondents were

Fig. 1 Location of study area

Table 1 The index attributes

5 points Likert scale	Attributes of indexes	Average index
5	Most agree	4.5 < Average index < 5.0
4	Agree	3.5 < Average index < 4.5
3	Average	2.5 < Average index < 3.5
2	Disagree	1.5 < Average index < 2.5
1	Most disagree	1.0 < Average index < 1.5

stratified into younger age, middle age and older age. Younger age comprises of people aged from 18 to 34 while middle aged ranges from 35 to 64 and older people account for 65 years old and above.

The questionnaires consist of two parts which were Part A and Part B. In Part A, the questions were related to driver's background while in Part B, it consists of elements on roadway inventory performance which were geometry design, road furniture, network location and environment. It was made up of Likert scale questions to indicate drivers' perception with the statement in the questionnaire ranging from 1 (most disagree) to 5 (most agree). The questionnaire was formulated in such a way that it is easy to understand, direct and clear where jargons and terminologies are kept at a minimum level and simple English is used. The concept of Keep it Short and Simple (KISS) was used in developing the questionnaire.

The analyses were done using average index analysis to gather the level of driver's perception towards the roadway inventory elements performance at the study area. Average index scale has been proposed by Abd. Majid and McCaffer (1997) based on agreement attributes and frequent index as shown in Table 1.

4 Results and Discussion

The focus of this study was to explore on how drivers' perception subjectively reviews the roadway inventory elements performance. As mention above, the drivers were grouped into younger age, middle age and older age as predictors towards the roadway inventory elements of geometry design, road furniture, network location and environment. The results demonstrated that the comparison of three groups of drivers is not consistent throughout. Figure 2 shows the analysis on how roadway inventory elements associated with geometric design may be perceived by drivers.

From the tabulated data, it has been noted that all drivers rate speed limit in 'Average' category, but the older drivers ranked highest among the three groups. It means that older drivers satisfy that the speed limit at the study area was too high. This is corresponding to research done by Kanellaidis et al. (2000) where he states that older driver demand lower speed limit than the existing speed limits.

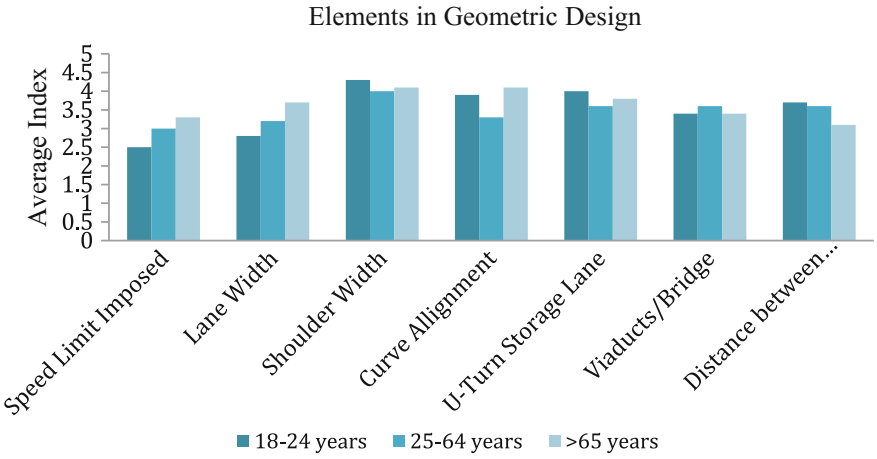

Fig. 2 Average index of elements in geometric design

Other than that, older driver ranked 'Agree' saying the lane width is too small. It proves that older driver need more space to feel safe and drive in a safer manner. It is stressed that older drivers are used to driving at low speeds in order to balance their decreasing driving abilities.

For other attributes, shoulder width being significant to all groups of drivers as they 'Agree' in statement for the width to be too small. According to Nesnas et al. (2004), most vehicle operators drive closer to the edge of the pavement in the presence of adequate shoulders therefore, it is necessary to provide shoulders for the safe operation and to allow the development of full traffic capacity. As for the length of U-turn storage lane, all grouped of drivers 'Agree' that the storage lane being too short. Only middle age drivers 'Agree' that the existing bridge have small spaces and the distance from the first traffic light intersection to the next traffic light intersection is short.

Then, this study was further analysed to explore if different groups of drivers present differences in perception towards elements of road furniture as shown in Fig. 3.

Based on data in Fig. 3, only older drivers ranked 'Agree' for guardrail while other groups ranked 'Average'. This indicated that all drivers satisfy with the claimed made in the questionnaire that there were no guardrails on road curve. Moreover, other attributes are in 'Agree' by all drivers including marginal strip and edge line, service information sign, road median, night reflectors or cat's eye, street lights at U-turn and distance between U-turn. This shows that road markings and edge lines were invisible, no help signs for road or vehicles services, no median that could prevent vehicle crashes from the opposing lane and night reflector or cat's eye studs were missing. In addition, street lights are absent at U-turn interchange and the distance between two U-turns was too far. Thus, it can be said that the elements

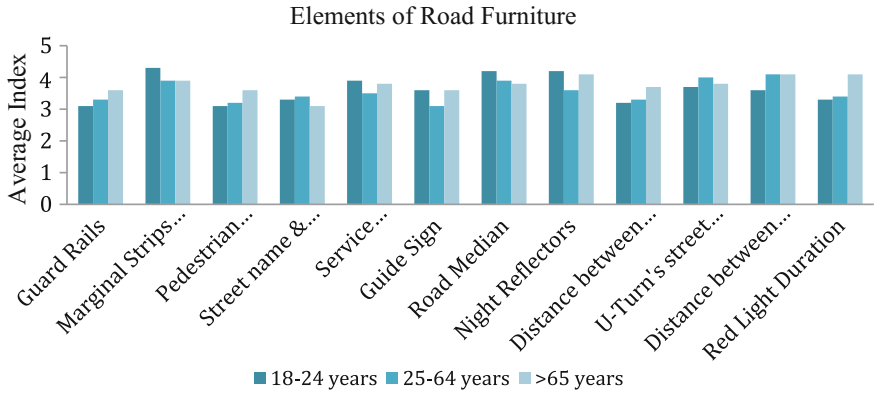

Fig. 3 Average index of elements in road furniture

of road furniture were being perceived consistently from the various driver groups examined in this study.

Next, the study identified whether the different groups of drivers present differences in perception of network location. It is well recognized that land use and transportation systems interact strongly with each other, and the consideration of only one of these systems will not fully reveal system's responses to major infrastructure developments and policy changes (Ho and Wong 2005). Care is needed when evaluating the impacts of specific land use factors. Impacts vary depending on definitions, geographic and timescale of analysis, perspectives and specific conditions, such as area demographics. Most factors only apply to subset of total travel, such as local errands or commute travel. This report only focuses on land use mix, connectivity and mobility factors as shown in Fig. 4.

Figure 4 shows that mobility and interferences in converging area were in 'Agree' category ranked by younger drivers. It shows that younger drivers think that the road is interfered by converging area such as residential, business and industrial area and by using the road, time travel increases. This is because younger

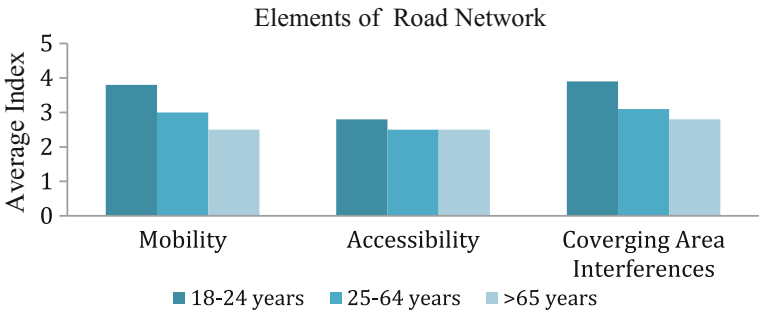

Fig. 4 Average index of elements in road network

driver tends to drive fast upon facing convergence area they feel delayed while traveling.

Other groups viewed these two attributes as 'Average'. However, all groups are in agreement by rating 'Average' for accessibility. Therefore, ability to reach desired destinations such as housing, commerce and industrial was neither difficult nor easy. According to Litman (2003), different land use patterns have different accessibility features, which affect mobility.

Last but not least, as depicted in Fig. 5 was drivers' perception based on age group towards elements of road environment. The main difference between well-designed features during design stage and during operational stage is the road environment. As been discussed earlier, road environment itself covers many aspects such as road conditions, roadside conditions, traffic volumes, operational speed and not to be missed out the driving ambience itself. This study only focuses on the factors of road conditions and roadside conditions as a road environment factor that influenced the traffic safety condition that may result in accidents occurrences.

On the subject of road environment as shown in Fig. 5, only younger drivers viewed fixed objects as 'Average' while other attributes were in 'Agree' category by other groups. Younger drivers oversee fixed objects along the road being neither too far nor too close to the carriageway. Meanwhile for the middle age and older age group drivers, they ranked 'Agree' on the fixed objects elements which were too close to the carriageway. Referring to these findings, it can be said that for this study area, an appropriate action should be made on the existing features along the road as we know that it may become one of the factors that contributes to the road crash at the study area. This judgement is consistent with the outcomes reported by Intan Suhana et al. (2014) that high risks also could be generated from roadside hazards such as trees and guardrails and in combination with the high volume of traffic where the composite road environment risk index found to be 1.88.

From the result obtained for the other attributes, all group of drivers agree that the road is poorly damaged with potholes, ruts and irregularities as well as do not

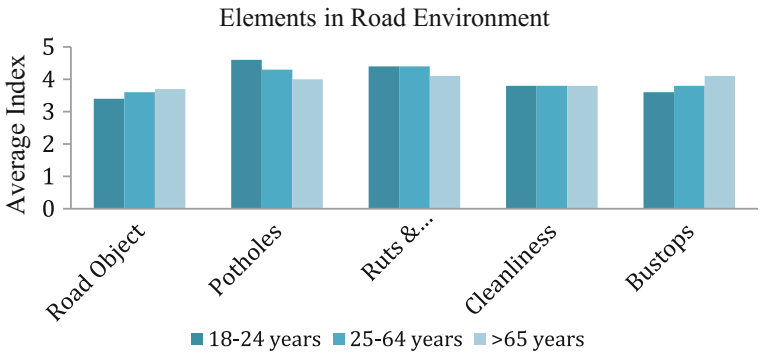

Fig. 5 Average index of elements in road environment

have strategic bus stop locations or clean surroundings. As mentioned by Mannering et al. (2005), the motoring public usually associated pavement failure with poor ride quality. This poor riding condition might lead them to consistently agree on statement claimed in the questionnaire.

5 Conclusions

From the analysis, it can be concluded that different age of drivers as predictors do play a significant impact on the perception of roadway inventory elements performance especially on the elements of geometric design. This is in line with the claimed made by Kanellaidis et al. (2000) that the influence of age is expected and shows that ageing affects risks' perception to a great extent. Another interesting finding of the analysis was the comparison between different groups of drivers regarding the four elements in the roadway inventory may give a more detailed description of the nature of this influence. From the four elements of the roadway inventory, the respondents seemed to be very sensitive to road environments. All groups of drivers consistently agree that potholes, ruts and irregularities seem to be the critical attributes that affect overall perception. Basically, this finding is important as the problem occurred can cause poor quality ride for the public.

As the issue was raised, urgent professional judgment is needed on how to improve road condition that reflects the special needs among various group of drivers. Clearly the data analysed in this study give insight on how drivers' perception subjectively reviewed the following roadway inventory elements; geometry design, road furniture, network location and environments. This study may provide a handy reference to the road authorities and can be used in value engineering consideration if required by an interested party.

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Part IV
Environmental Science and Management

Chapter 50
Occupational Noise Exposure of Construction Workers at Construction Sites in Malaysia

Nur Muizzah Nawi, Zaiton Haron, Saiful Jumali and Asmawati Che Hasan

Abstract Noise exposure is one of the hazards in construction site that could lead to accidents and also negative impacts on human health. However, most of the construction workers lack in awareness about the impacts of the noise emission to their health. The aim of this research is to investigate the occupational noise exposure levels among construction workers during working hours and then it was compared to the permissible exposure limit regulated by Factories and Machinery Regulation (Noise Exposure) 1989 (FMR). Dosimeter was used to measure the noise exposure level for 1 h work duration and 30 construction workers were involved in this research. The results showed that 33% of construction workers were exposed to high noise level more than 90 dB(A) due to noises emitted by the machineries in the construction sites. It shows that the construction site emits high noise level because majority of the working equipment are machineries. However, the construction workers do not apply the proper PPE when performing the works even though they know that noise is a general problem. Furthermore, continuous exposure to noise could lead to health problems if no safety measures are taken by the employer and construction workers themselves.

Keywords Awareness · Construction workers · Noise exposure Occupational

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_50

1 Introduction

Construction site is the common area that produces sound and could become noisy for certain people. For example, people in the neighbourhood will feel disturbed and annoyed if they often hear the noise coming from the construction site nearby. Noise in construction site is the physical and continuous contaminant to human health. It could cause negative effects such as loss of hearing if a person is overexposed to the contaminant it may result in hazard. While people outside the construction site feel uncomfortable, the workers in the site may probably be exposed to higher noise level. This condition will lead to negative impacts to their health such as hearing impairment (Eleftheriou 2002; Koushki et al. 2004), cardiovascular system (Tomei et al. 2009; King 2003; Nadya et al. 2010), interfere with working efficiency and disturb concentration (Wachasunder 2007), permanent deafness (Fernandez et al. 2009; Eleftheriou 2002), noise-induced hearing loss (NIHL) (Neitzel et al. 1999), hypertension and elevated blood pressure (Koushki et al. 2004). Therefore, safety and health steps on noise emission in construction site have to be considered and need to be complied by the employers and employees.

Studies on a noise emission level in construction site have continuously been conducted for the past 10 years. Majority of the study shows that noise emission level is high which is mostly emitted from construction equipment and machineries (Ballesteros et al. 2010). The range of the level measured previously is between 80 and 120 dBA (Haron et al. 2012; Koushki et al. 2004; Neitzel et al. 1999; Legris and Poulin 1998). Heavy equipment produces the highest level of noise emission, therefore, the exposure will risk the construction workers working with and around the equipment (Neitzel et al. 1999).

Continuous exposure of noise to the construction workers could become hazardous to their health. The previous study stated that construction workers who are overexposed to the noise will possibly suffer from hearing impairment, hypertension and elevated blood pressure level (Koushki et al. 2004). In the United States, hundreds of millions of dollars have been spent for noise-induced hearing loss (NIHL) disease claims and 16–50% of them are from construction workers (Neitzel et al. 1999). These studies show that noise exposure could harm the worker's health if none or less prevention is taken by the construction workers to avoid the hazard.

Another study that has been conducted in Malaysia shows that noise is one of the common hazards at construction site that is related to the risk of ill health that can only be notified after a long and continuous period of exposure time. Out of 140 sites involved in this study, 134 of them have problem related to noise. Through the observation at the site, most of the workers had lack of awareness on using the personal protective equipment when performing their work. In addition, employers failed to provide adequate equipment according to the number of workers. This situation has to be taken into consideration to improve the safety and health of the workers (Hamid et al. 2003).

Level of education is also essential in evaluating the awareness of the negative effect of noise exposure (Koushki et al. 2004). Therefore, employers should convey

adequate information and provide enough training to their workers to improve the knowledge at the same time complying with the regulations and act. The problem is the information and training for safety in construction site to the workers in Malaysia are not provided adequately. It will lead to lack of knowledge and awareness about safety specifically in noise exposure and the level of compliance to the regulation is low. Some managements have implemented engineering and administrative control but do not impose construction workers to wear proper PPE. This study determines the occupational noise exposure levels among construction workers during working hours and then compares the permissible exposure limit regulated by Factories and Machinery Regulation (Noise Exposure) 1989 (FMR).

2 Method

2.1 On-site Measurement

A total of four construction projects were located in Johor Bahru, so Johor was selected to undergo the on-site measurement. Dosimeter type 3 M Quest EDGE Noise Dosimeter was used to measure the noise exposure level experienced by the construction workers and it was placed on the shoulder of the workers. Within these four construction projects, 30 selected workers performing the work or operating machineries that were expected to produce a high noise emission level were selected to record the measurement. The measurement of noise exposure was taken for the duration of 1 h. The measurement was recorded for 1 h only assuming that particular hour reflects the normal operating cycle of the daily working routine and all noise sources during the working hours are presented while measuring the data (Lester et al. 1995). While waiting for 1 h measurement, the workers were observed in aspect of possible noise source around them, types of activities they perform and safety measures such as wearing personal protection equipment. After that, the interview session was conducted to survey the awareness of noise hazard in construction site and the respondents were the workers at the construction site who have the potential exposure to the noise emission.

Data gathered from dosimeter then was compared to the permissible exposure limit regulated by Factories and Machinery Regulation (Noise Exposure) 1989 (FMR) as shown in Table 1. According to FMR Regulation, workers who were exposed to noise level more than 85 dB(A) for 8 h exposure time are required to be protected and no workers should be exposed to noise level more than the permissible limit of 90 dB(A). Table 2 shows the exposure limits and its related proposed action to reduce the noise exposure stipulated by FMR Regulation.

Table 1 Exposure limit of Factories and Machinery Regulation (Noise Exposure) 1989

Exposure limits (dB (A)/8 h)	Exchange rate [dB(A)]	Exposure limits (dB (A)/1 h)	Peak sound pressure dB(C)
90	–	105	140

Table 2 Exposure limits and its related proposed action to reduce noise exposure

Regulations	Exposure limits (dB(A)/8 h)	Exposure category (EC)	Propose action
Factory and machinery regulation (FMR) (1989)	<85	–	– (Normal workplace)
	85	First action level	– Providing hearing protection – Training of exposed workers
	90	Permissible exposure limit	– Hearing protection required – Noise reduction program – Warning signs posted in work areas

2.2 Interview Survey

The questions asked to the construction workers are basically related to the perception about the hazard of noise to human health. This interview session was a close interview structure where the same questions were asked to the construction workers and they were encouraged to give their point of view and opinion too. The respondents were asked about their perception of noise at construction site whether it could become a problem or not to them. Then, they were asked about the level of noise during the duration of daily work and how long the noisy situation happens at the construction site. While conducting the interview, safety aspect taken by the construction workers was observed to identify their concern about noise pollution.

Responses obtained from interview session were analysed using pie chart and expressed in terms of frequencies. The perception of the construction workers about the hazard of noise was identified by the relation between the questions asked. The important information needed to verify was whether the construction workers are aware of the effects that come from long-term and over exposure to the noise to their health. Furthermore, observation related to the usage of hearing protection devices was also carried out during the measurement period and this involved the whole construction workers within the site area.

3 Results and Discussion

3.1 Noise Exposure Level

Table 3 shows the maximum, average and peak noise exposure level experienced by 30 selected construction workers. According to the measurement results, 33% of the construction workers were exposed to average noise exposure level more than

90 dB(A), 53% were exposed to average noise exposure level between 80 and 89 dB(A) and the remaining were exposed to average noise exposure level below than 79 dB(A). 47% of them are dealing with heavy machineries during their working hours and the rest are handling small machineries that also produce noise. 30% of the construction workers dealing with heavy machineries were exposed to more than 85 dB(A) average noise exposure level. The construction workers dealing with assembling the steel formwork were recorded to be exposed by 107.1 dB(A) of average noise exposure level which was the highest level of noise exposure level among all the construction workers.

Table 3 On-site measurement results

N	Equipment/Operator	Max (dB)	Avg (dBA)	Lpeak (dBc)
1	Backhoe	105.9	88.8	119.5
2	Concrete mixer	107	91.5	121.9
3	Carpentry	113.9	91.8	141.2
4	Drilling and hacking	115.9	99.2	132
5	Formwork steel	128.1	107.1	141.2
6	Scaffolding work	122.5	96.2	141.2
7	Generator	94.9	83	115.7
8	Piling jack hammer	107.8	92.3	125.8
9	Piling hydraulic jack	110.6	89.9	121
10	Piling jack hammer	101.5	88	119.7
11	Piling hydraulic jack	109.8	88.2	120
12	Carpentry	107.3	91	133.8
13	Backhoe	105.9	88.5	120.4
14	Excavator	94.4	79.2	118.8
15	Generator	95.4	73.2	114.8
16	Concrete mixer	104.9	80.1	117.5
17	Drilling	122.3	93.8	132.6
18	Backhoe	112.9	87.8	125.4
19	Excavator	99.7	77.6	117.7
20	Crane	109.3	81.7	121.8
21	Carpenter	93	75	119
22	Generator	85.7	80.6	108.2
23	Concrete Mixer	97.9	84.3	121.2
24	Bar Bender	112	91.2	137.5
25	Carpentry	105.3	88.1	123.5
26	Backhoe	104	91.2	126.7
27	Concrete Mixer	93.4	84.3	116.8
28	Crane	90.4	81	117.7
29	Excavator	103.7	88.1	124.7
30	Generator	115.9	87.3	127

Then, the 8-h daily personal noise exposure level, $L_{EP,d}$, was calculated using the following formula:

$$L_{EP,d} = L_{Aeq,T_e} + 10\log_{10}\left(\frac{T_e}{T_0}\right) \quad (1)$$

where T_e is the duration of the person's working day, in seconds, and T_0 is 28,800 s (8 h) (HSE 2005).

The 8-h daily personal noise exposure level, $L_{EP,d}$, was also compared to the Factories and Machinery Regulation (Noise Exposure) 1989 (FMR) to identify whether the noise exposure level recorded exceeds the permissible noise exposure limit or not. Only the data from construction workers who were exposed to more than 85 dB(A) of average noise exposure level were calculated and the results were tabulated in Table 4. It showed that construction worker performing scaffolding work exceeded the first action level. The employer must provide them hearing protection and give adequate training about the effects of noise on hearing and the purpose of hearing protection during performing their works (FMR 1989). The construction worker dealing with drilling and hacking works and also assembling steel formwork were recorded to exceed the permissible limit. These construction workers are required to wear hearing protection during their daily working hours. The employer must organize the noise reduction program for the construction workers. In addition, they should post the warning sign of high noise level at the working area and hearing protection should be worn in that area.

3.2 *Interview Survey*

Interview survey was carried out to determine some factors that may lead to the lack of awareness among construction workers about the hazards of noise in the workplace. 81% of the respondents agreed that noise is a general problem among them and the rest stated that the noise was not a problem (Fig. 1). On the other hand, 52% respondents agreed that the duration of noise in a construction site is 8 h long (Fig. 2). It means the construction workers may be exposed to noise continuously during work duration and without applying appropriate hearing protection devices, the possibility to suffer noise-induced hearing loss (NIHL) is high. However, they are not aware that construction site could be harmed by continuous noise exposure as they agreed noise is a general problem nonetheless they do not take safety measures to reduce the exposure. Regarding the observation when the measurement was carried out, none of the construction workers was protected by the usage of hearing protection devices. Furthermore, if this mentality is still the same for the rest of their career, it might lead them to suffer from even worse on NIHL cases.

Only some of the respondents are aware that the personal protection equipment is important for their daily job and suggests the employer to provide adequate

Table 4 Noise exposure level comparison with Factories and Machinery Regulation (Noise Exposure)

Equipment/ Operator	Avg > 85 dBA	$L_{ED,d}$ (dBA)	Factories and Machinery Regulation (Noise Exposure)
Backhoe	88.8	79.8	Normal
Concrete mixer	91.5	82.5	Normal
Carpentry	91.8	82.5	Normal
Drilling and hacking	99.2	90.2	Exceeded the permissible limit
Formwork steel	107.1	98.1	Exceeded the permissible limit
Scaffolding work	96.2	87.2	Exceeded First action level
Generator	83	77.0	Normal
Piling jack hammer	92.3	83.3	Normal
Piling hydraulic jack	89.9	80.9	Normal
Piling jack hammer	88	79.0	Normal
Piling hydraulic jack	88.2	79.2	Normal
Carpentry	91	79.5	Normal
Backhoe	87.8	78.8	Normal
Bar Bender	91.2	82.2	Normal
Carpentry	88.1	79.0	Normal
Backhoe	91.2	82.2	Normal
Excavator	88.1	79.0	Normal
Generator	87.3	78.3	Normal

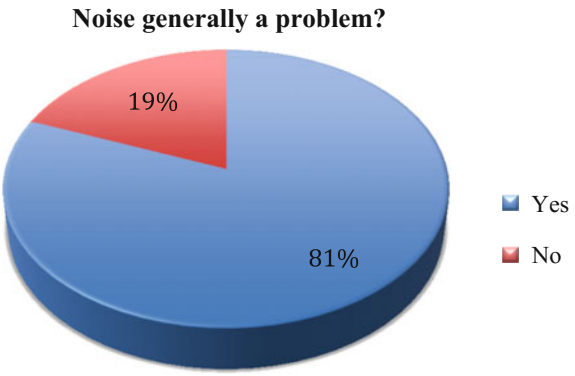

Fig. 1 Noise generally a problem

personal protection equipment for them. Employer should provide better machineries and equipment to ensure the safe working area. On the other hand, one of the respondents' comment was "*Noise has been hazardous in most construction*

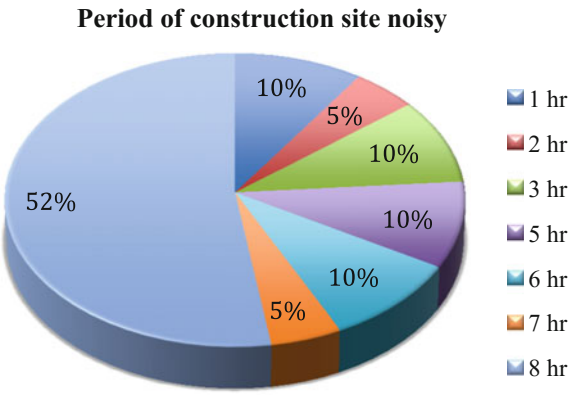

Fig. 2 Period of construction site noisy

site hence it affects the neighbouring residence. As a result, noise should be minimised to limit the hazard and nuisance." This statement contributes to the importance of monitoring the noise exposure level at the construction area and for it to be maintained within the permissible limit so that the potential of harm could be minimized to the construction workers and also to the surroundings.

4 Conclusion

This study found that the construction workers handling with machineries are exposed to high noise level as the noise source is the machine itself. Almost half of the construction workers were dealing and operating heavy machineries and one-third of them were exposed to more than 85 dB(A) average noise exposure level. The construction workers who are involved with activities of drilling and hacking and assembling steel formwork were exposed to noise level which exceeded the permissible limit stipulated by FMR 1989. It shows that the construction site is one of the working areas that produce high level of noise and could be harmful to the construction workers. However, the awareness of the construction workers about noise hazard at the construction site is still at low level because they admit that noise is a general problem but did not apply proper personal protection equipment when performing their works. It is suggested that the management team should monitor noise exposure level among the construction workers instead of only monitoring at the boundary so that they could improve the mitigation ways to reduce noise emission.

Acknowledgements The authors would like to acknowledge the respondents of the study and also the data collection team namely Nur Fadilah Binti Darmansah, Stephanie Stella Anak Dawi and Mohd Mursyid Bin Sarbayni for their greatest commitment to complete the study.

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Chapter 51
An Evaluation of the Water Conservation System: A Case Study in Diamond Building

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Abstract Water conservation has become a critical issue in urban areas where it is becoming a major challenge for policy makers, both now and into the future. This study aimed to evaluate the reliability of water conservation systems at Diamond Building, Putrajaya by reviewing the determinants for water conservation systems. The data were collected through observation of two type of alternative water sources in the Diamond Building for three different time slot. The calculation of the overall data was based on water efficiency calculator produced by BREEAM UK. The result showed that each system which associated with water conservation system has unpredicted data for collection, storage, and outflow. This depended either on the main water sources, rainwater, or even graywater. The effect of water efficient technology was mixed: some were associated with less water use, while others were associated with more water use or highly cost in maintenance. However, this evidences that the performance data (water saving) collected through the observation is reliable and the results showed that the installation of the water conservation systems within a building was able to achieve the water saving.

Keywords Diamond Building · Graywater recycling system · Office building Rainwater harvesting system · Water conservation

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_51

1 Introduction

Water conservation issues are common in Malaysia, but there is lack of study and data toward the comprehensive implementation. It had been debated on its determinants and the capability for helping the water scarcity (Olmstead and Stavins 2009; Van Loon and Van Lanen 2013).

Malaysia started first regulations toward sustainable design on 1996 on energy resources and renewable. After several years, on Tenth Malaysia Plan (2011–2015), the key emphasis became broad and it includes improving the standards and sustainability for better access on electricity and water (Basri et al. 2015). By having this strong effort, it urged the building owner into implementation of the water conservation system.

There are various types of water conservation system available on the market but among all, rainwater harvesting system had been in market for over a decade (Helmreich and Horn 2009). It had been proved by many researchers on the capability of this system toward providing the alternative water sources had been proved by many researchers such as Helmreich and Horn (2009), Jones and Hunt (2010), Aladenola and Adeboye (2010) and Ward et al. (2012). Generally, those systems which provided an alternative water source require other water sources either from rainwater or from use water. However, this alternative water sources maybe harder to be implemented on the areas which have less or limitation on water sources (Santos Pereira et al. 2002; Merz et al. 2003; Mukheibir 2010; El Kharraz et al. 2012).

In 2011, the Government of Malaysia had built the first ever green building which was named Diamond Building for Energy Commissioner in Putrajaya. It had been awarded Platinum rating award under Green Building Index (GBI) Malaysia and had received several awards from other countries. The design and system were fully integrated toward sustainability and efficiency (Ng and Akasah 2011; Xin and Rao 2013). Previous studies on this building concluded that this building had achieved their target on energy efficiency by recorded only 85 kwh/m^2/year of energy index over the standard energy index which is 135 kwh/m^2/year (Xin and Rao 2013). Anyhow, on the element of water efficiency, it seems only a few studies had been done on the overview without assessing their system (Chua and Oh 2011; Aliagha et al. 2013; Rashid et al. 2011). This is mainly due to the uncertainty on the determination and factor of water conservation system.

This 4000 m^2 office building was completed in June 2010, and has 200 employees who work 8-h shifts, and receives around 50 visitors every day. Based on the water audit done by United States Agency for International Development (2011), the daily water usage per person in the office building is approximately 37 L. By calculation, daily water usage in Diamond Building will be around 148,000 L. By planning and design, Diamond Building had put an extensive water saving strategies by installation of rainwater harvesting system and graywater recycling system. On installation of rainwater harvesting system, it was expected to reduce water consumption by 35% for toilet flushing and landscape irrigation (Energy Commissioner Malaysia 2013). Other than that, this Diamond Building had

a graywater recycling system which required all the waste water from wash basins for recycling purposes and it was estimated to be around 2000 to 3000 L every weekdays.

2 Methodology

This study was conducted within 3-month period between January 2016 and March 2016. In order to get the exact data from both of the alternative water sources associated with water conservation system in Diamond Building, an observation been carried out in three different time frame. The data had been collected within 9 am, 12 pm, and 5 pm every Monday to Friday. This data collected represents the collection, storage, and output performance on each system. Figure 1 showed two types of water conservation system available in Diamond Building.

Every data collection in every different time frame was meant solely to check on the competency and efficiency of each system. These data were recorded on every collection and distribution stage in order to evaluate the output performance result of rainwater harvesting system and graywater recycling system toward reducing the water consumption in Diamond Building. All the data were then to be calculated using the water efficiency calculator produced by Building Research Establishment Environmental Assessment Method (BREEAM) in order to determine the total water consumption (BREEAM UK 2009).

The main guideline methods for this research were based on report that was published by (Cheng 2003; Cheng et al. 2006), Nevertheless, this study also refer to other former researchers (Ilha et al. 2009; Zhang et al. 2012; Gabbar et al. 2014) as guidance, to ensure there was no doubt on the results of the study.

(b) Graywater Recycling System (a) Rainwater Harvesting System

Fig. 1 Water conservation system in Diamond Building

3 Results and Discussion

Based on the maintenance report by Diamond Building, the water consumption was distributed into two channels in which 99% is for toilet flushing, urinal, and faucet while another 1% is for irrigation and landscape. The detail breakdown of water consumption is shown in Fig. 2. The highest usage is by toilet flushing which accumulated 60% from overall results which 89,697 L per month.

Rainwater harvesting system is a technology used for collecting and storing rainwater from rooftops. The catchment area at Diamond Building is 700 m^2 with the capability to store 2271 L per tank. For this system, they had four rainwater storage tanks to supply for toilet flushing with capacity 4 L dual flush and irrigation at landscape area surrounding Diamond Building.

Discharge of rainwater runoff from the roofs at Diamond Building was simulated using hourly rainfall time series for Putrajaya which received rainfall annually with average 2307 mm. By referring to the detail calculation sheet on Fig. 3, this system has 100% rainwater collected for the catchment area of 700 m^2. However, an amount of 2648 L is needed as backup daily by the cold water supply in order to supply water for toilet flushing and landscape irrigation. It has two main reasons for the above problem which are: (1) small catchment area which is only at the top of the small circular building roof (Fig. 4), (2) small size of rainwater storage tank.

Another type of alternative water source in Diamond Building is the graywater recycling system. The main source for this system is from the waste water produced from every wash basin in every floor washroom. The precondition of the operation of this system is that the user should not dump any food waste into the wash basin as it causes mechanical damage to the sand filter of this system.

The location of this system is at the roof truss in the guest washroom at ground floor level. The capacity of the storage tank is 1135 L and it will supply water for wetland landscape area only. Although it has been claimed incurred a high maintenance cost, it actually helps to reduce the water consumption in a building. By referring to the calculation sheet on Fig. 5, the collections from the wash basin in every washroom in Diamond Building were 1516 L per day which estimated 7.58 L

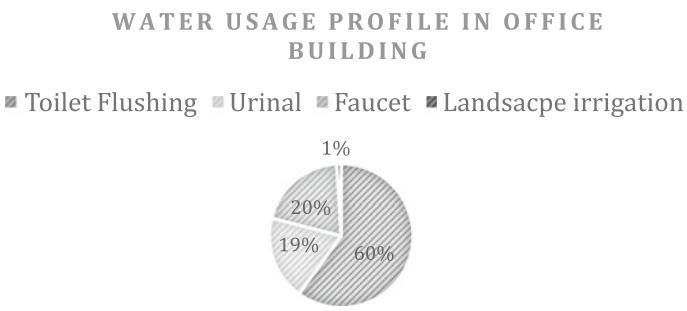

Fig. 2 Percentage of water consumption in Diamond Building

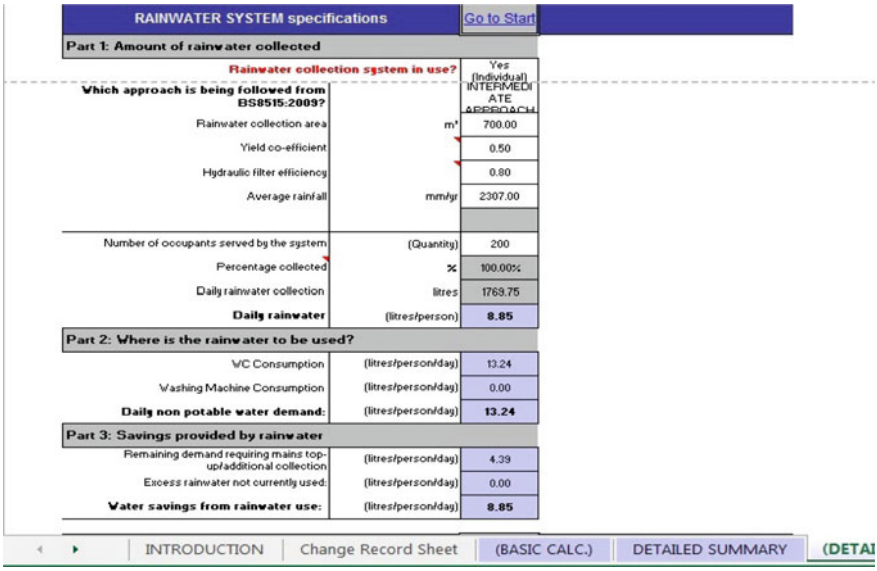

Fig. 3 Rainwater system specification

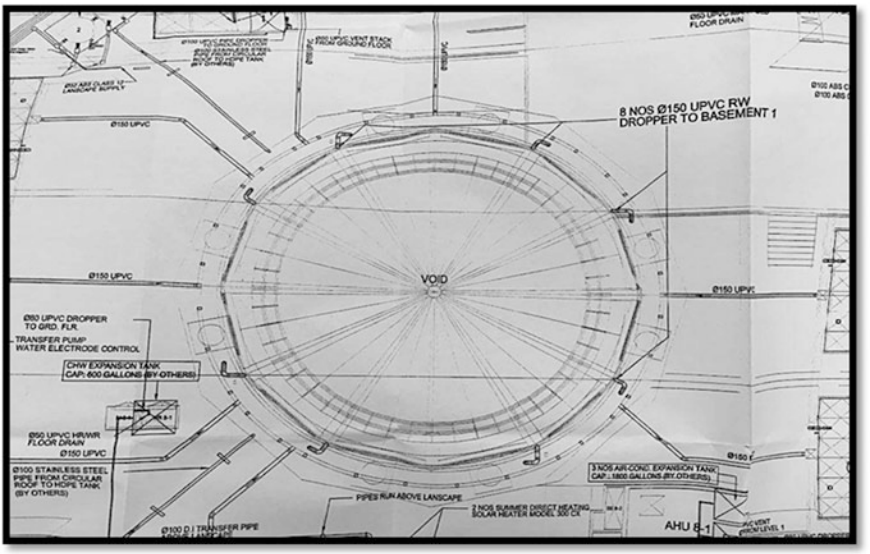

Fig. 4 Plan view of the rainwater system catchment area

per person per day. Around 80% of the waste water will be recycled and supplied for wetland landscape irrigation outside the building. However, another 20% was probably trapped as leftover inside the sand filter tank in the system. The outflow

GREYWATER SYSTEM specifications		Go to Start
Part 1: Amount of greywater collected		
Taps Consumption	(litres/person/day)	7.58
Baths Consumption	(litres/person/day)	0.00
Showers Consumption	(litres/person/day)	0.00
Total greywater collected from above fittings:	(litres/person/day)	7.58
Percentage of used water to be recycled	%	80.00%
Total greywater collected	(litres/person/day)	**6.06**
Part 2: Where is the greywater to be used?		
WC Consumption	(litres/person/day)	0.00
Washing Machine Consumption	(litres/person/day)	10.08
Total water consumed by above fittings	(litres/person/day)	**10.08**
Part 3: Savings from greywater		
Remaining demand requiring mains top-up/additional collection	(litres/person/day)	4.02
Excess greywater not currently used	(litres/person/day)	0.00
Potential Water saved from greywater use	(litres/person/day)	**6.06**

INTRODUCTION | Change Record Sheet | (BASIC CALC.) | DETAILED SUMMARY | (DETAILED_CALCs)_Type1 | (DETAILED_

Fig. 5 Graywater recycling system specification

also recorded around 10.08 L per person per day for the irrigation purposes. In addition, this system also needs to supply approximately 4.02 L cold water per person per day as a backup especially on the first day of weekdays.

Although there always are some amount of cold water supply needed as backup to both the systems, yet it still achieved the target into potential water saving. It is calculated as 1770 L for rainwater system and 1212 L for graywater recycling system. Again, this is a green building in which all the sanitary appliances in washroom were labeled as water efficiency fitting such as dual flush flushing system, faucet tap aerator, and waterless urinal.

Fittings & Appliances	Normal fittings	Efficiency fittings	Normal usage (monthly)	Water saving (monthly)	Reliability (saving)
Flushing	6.2L/flush	4.0L/flush	89,697L	31,394L	35%
Urinal	2.0L/flush	1.9L/flush	28,404L	142L	0.5%
Faucet	8.3L/min	5.9L/min	29,899L	8,671L	29%
		Total	148,000 L	40,207 L	

End Use Area	Calculation	Water Usage (Monthly)	Grey Water Usage (Monthly)	Domestic Water Usage (Monthly)
Irrigation (1 zones)	1,495 x 12% (1/8)	179 L	36 L	143 L

End Use Area	Calculation	Water Usage (Monthly)	Rainwater Usage (Monthly)	Domestic Water Usage (Monthly)
Irrigation (7zones)	1,495 x 88% (7/8)	1,316 L	658 L	657 L
Toilet Flushing	-	58,303 L	29,151 L	29,152 L
	Total	59,619 L	29,809 L	29,809 L

Fig. 6 Water saving calculation for each of water saving system

Fig. 7 Comparison of water saving

Monthly Total Water Usage(Normal office Building) = 149,495L (irrigation, flushing, faucet, urinal; 200 employees)	
Water Conservation Systems	Water Saving (monthly)
RWH System	29,809 L
GWR System	36 L
Efficiency Fittings	40,207 L
Total	70,052 L (save up to 47% of water consumption)

Based on the results obtained, it is found that a person used 21.5 L water per day which accumulated 4300 L water per day for the 200 employees in the Diamond Building. As in Figs. 6 and 7, it showed a comparison of the water saving between traditional office building and the Diamond Building. The reduced water consumption every month for the Diamond Building can be up to 47% with the implementation of rainwater harvesting system, graywater recycling system, and the efficiency water saving appliances.

4 Conclusion

Our findings indicated that having this water efficiency system is a great saving effort. Although the results obtained were not similar as per planning and design stage, it still showed a positive impact on the reducing water consumption per day. These data proved that Diamond Building had achieved their objectives by having water saving strategies.

Acknowledgements The authors would also like to acknowledge the assistance from the Energy Commissioner and INTI International University in giving full support toward this research.

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Chapter 52
Development of a Microsoft Visual Basic for Municipal Solid Waste Management (Case Study: Permatang Pauh, Pulau Pinang)

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Abstract Municipal solid waste has been considered as one of the most immediate and serious problems confronting urban government in most developing countries. In this few decades, the production of solid waste was increased by more than 91%. The authority of Malaysia has discovered 11,824 disorganized dumping sites in Pulau Pinang area. Thus, a decision support system was developed to manage the solid waste disposal via the use of Microsoft Visual Basic program. The existing guidelines are embedded within the proposed web-based program, so that practitioners or ordinary citizen can peruse the best management practice for solid waste management. The application was develop based on the questionnaires and interviews on the solid waste composition at the district of Permatang Pauh, Pulau Pinang. It was found that that food and plastic become the highest waste generated in Permatang Pauh followed by paper, bottle, aluminium and others. To accommodate these waste generation, the collection system using hauled container system (HCS) and stationary container system (SCS) was embedded in the application. In addition, the software gives decision on the time required per trip, picked up time per trip and number of trips waste collector per day.

Keywords Disposal · Microsoft · Municipal waste · Solid waste Visual Basic

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_52

1 Introduction

In Malaysia, the municipal solid waste is a common issue reflecting due to the rapid increase of urban population and its solid waste generation. Based on the study for few years, it is expected that population in urban area will increase up to 50%, hence the solid waste will proportionally increase to 3% annually (Zhang et al. 2013). The contributing factors towards the increasing generation rate in Malaysia are almost similar to other developing countries which are population growth and rapid urbanization.

As shown in Fig. 1, the total daily MSW generation was 29,711 t/day in 2012, 30,518 t/day in 2013 which varies for different cities: from 45 t/day in Klang to 3000 t/day in Kuala Lumpur. From 2000 to 2015, the total population increased from 23.49 to 30.65 million indicating a growth of 30.5% in the 15-year period. Proportionally, an ever-increasing generation rate of MSW is also expected. Figure 1 illustrates an overall of 36,165 t/day of MSW that has been projected to be hit by 2020. The data indicates that the increase in MSW generation is exponentially proportional to the population growth in Malaysia (Fazeli et al. 2016).

The rapid urbanization process is another major contributing factor to the MSW production rate in Malaysia. In 2005, the rates of urbanization in Pulau Pinang, Wilayah Persekutuan Labuan, Selangor, Wilayah Persekutuan Kuala Lumpur, Melaka and Johor were higher than the average rate of national urbanization (2.5%) (Fazeli et al. 2016).

The implication of poor handling solid waste management such as ineffective collection system can lead impropriate practices from civilians such as disposing the waste directly to the nearest river. The continuous poor management of waste

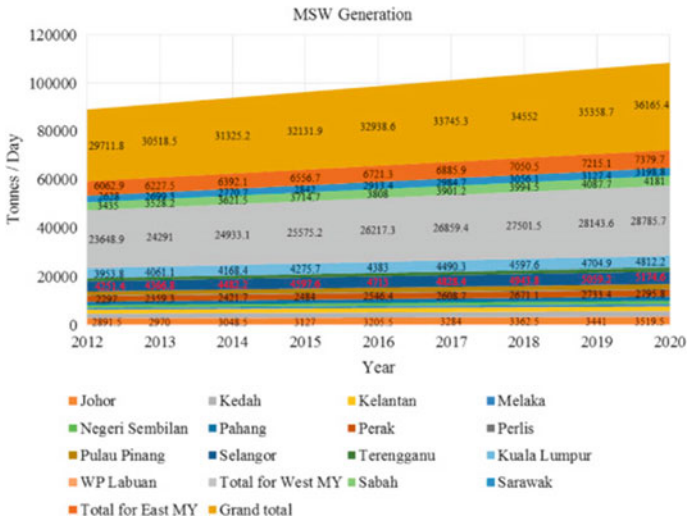

Fig. 1 Annual MSW generation in Malaysia by state

disposal and bad habit of civilian may endanger the watercourse body and pollute the environment in the long run.

Therefore, good management system must be formulated to promote a healthy environment. The main issues must be overcome with delivering knowledge to civilians in order to identify the numbers of household production and the consumption pattern along the waste disposal process. A new policy was put in place beginning from 2016 to introduce in-house recycle and imposing the penalty for related matters.

This paper attempts to review the situation of MSW management in Malaysia. With this main aim, this paper seeks to: (i) identify daily composition of MSW at residential area in Permatang Pauh, Pulau Pinang, and (ii) propose a new model of solid waste management system using Microsoft Visual Basic.

2 Literature Review

2.1 Solid Waste Management

Municipal solid waste (MSW) can be defined as unwanted or useless solid materials generated from combined residential, industrial and commercial activities that should be disposed. A systematic waste collection and transportation process must be provided to the community to ensure that quality of life is not at risk. The resources of MSW production may come from residential area, institutional or commercial waste with contribution from culture and society consumption pattern.

Normally, the resources of MSW consist of around 20 different categories: food waste, paper (mixed), cardboard, plastic (rigid, film and foam), textile, wood waste, metals (ferrous or nonferrous), diapers, news print, high grade and fine paper, fruit waste, green waste, batteries and construction waste and glass, these categories can grouped into organic and inorganic (Kalanatarifard and Yang 2012).

As shown in Fig. 2, the transfer station is an interval of collection and disposal stage and may act as a processing site for the temporary disposal of waste. In Malaysia, the transfer station is required to reduce the volume of leachate, hence controlling the air pollution and soil contaminants. Transfer stations are often used as places where local waste collection vehicles will deposit their waste cargo prior to loading into larger vehicles. These larger vehicles will transport the waste to the end point of disposal facility either in an incinerator, landfill, hazardous waste facility or recycling facility. The stations are fully equipped with material recovery facilities and localized mechanical biological treatment systems to remove recyclable items from the waste stream.

By emulating current practices, it is high time to develop a model assisting authority or practitioners to manage the solid waste disposal. Prior to the model development, it is very crucial to understand the composition of solid waste in

Fig. 2 Solid waste management system

Permatang Pauh, Pulau Pinang and intensity of waste generation which can reflect to the best choices of collection or transferring method.

2.2 Microsoft Visual Basic

Microsoft Vsual Basic is computer software in which a programmer can create a user-defined application using the component provided in Microsoft Visual Basic. This software was developed by Microsoft Company and has undergone various upgrades since then. To approach the residential waste disposal in Pulau Pinang, a software development was commenced using Microsoft Visual Basic to educate civilians and various stakeholders towards realization of best management practice at the MSW disposal.

The latest version of Microsoft Visual Basic is ver.6.0 which accommodates faster compiler, new ActiveX data control object, and allows database integration with wide variety of applications, new data report designer, additional internet capabilities, new package and development wizard. It allows the user to develop window with the graphic user interface—GUI applications. The Visual Basic process from start event until shut down is shown in Fig. 3.

Management of waste is very important in order to establish a good and convenient environment to the public and also to society. Development of user-defined application will provide useful information and analysis to the user. The information and analysis include types of waste, municipal solid waste system and analysis on the selected types of waste collector based on the production type of waste. It is expected that the final outcome of this research will create awareness to the civilians and various stakeholders towards understanding the best management practice of MSW.

2.3 Application of Microsoft Visual Basic

Visual basic is widely used to develop a programming with the availability of visual languages for programmers and the programs written in visual programming

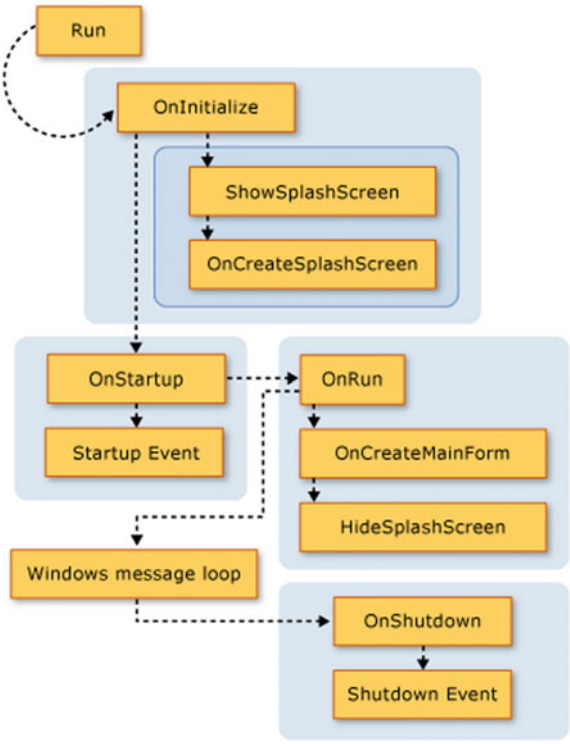

Fig. 3 Microsoft Visual Basic process

environment are easily accessible to users through its user interface. Visual programming offers a set of screens, object buttons, scrollbars and menus. The objects can be positioned on a form, and their behaviours are described through the use of a scripting language associated with each one. It seems to be an excellent tool for developing flexible and user-friendly software for various applications Kumar and Pandey (2015).

Kumar and Pandey (2009) developed a program to predict haulage and field performance of 2WD tractors. These programs predominantly used models recommended by ASABE standards for predicting draft, fuel consumption and tractive performance of tractors. However, these models were not found very accurate for predicting the drawbar performance of Indian tractors when used under cohesive-frictional soils.

In 2014, the SUPERPOSE program was developed by Ozkaya (2014) to offer a simple alternative for sophisticated geomechanical programs for fracture prediction. SUPERPOSE is based on basic concepts and assumptions to enable a quick assessment of fracturing in a field.

Ali and Salih (2013) present a paper for development of a Visual Basic based software package that designs a stand-alone photovoltaic system, the developed software offers a friendly graphic user interface tool to size the system components

according to the load requirements and site specification. The results of the design for the case study are quite in agreement with the analytical method, thus validating the accuracy and precision of the tool.

Sipos and Sweeney (2003) used VBA macros embedded with Microsoft Excel to visualize daily changes in behavioural data easily, reduce the number of data entry errors, increase the speed at which the data can be processed (from hours to seconds) and free the skilled technicians for more important tasks. In addition, data files are easily organized and retrieved, subjects are easily pair matched and assigned to treatment conditions or test chambers, and data are rapidly transformed for direct import into statistical packages for rapid evaluation of experimental outcomes.

The present manuscript targets individuals with an intermediate level of expertise: individuals who know what VBA macros can do, but have never considered applying them to his/her own laboratory. More inexperienced users are directed to review more general references to gain a basic understanding of what VBA is and how macros can be used to automate repetitive functions.

Using VBA macros to perform repetitive data manipulations increased productivity and reduced errors in data entry. The macros were embedded into the worksheets of an Excel workbook that also served to organize, analyse, plot and store the data. A workbook was created as a template that could be copied and renamed for use during studies examining the effects of chemical warfare nerve agents on the acoustic startle response in guinea pigs. Although this paper is based on using VBA macros to process acoustic startle response data, VBA macros have also been used at USAMRICD to process data collected from active avoidance studies, radial arm maze studies, and operant procedures, as well as to process data collected using electronic laboratory monitoring systems that collect body weight data and temperature.

Zhang et al. (2016) presented Excel software, together with the development method VBA, which was used to build the BTLSIM software module. Several objectives were achieved: (1) BTLSIM reduces manual operations and improves efficiency; (2) it offers more parameter selections for LSA allowing the use of different types of local windows including anisotropic windows to explore different forms of singularities, and both mean value and median value can be used to represent the average content for the local window; and (3) it presents a relatively self-adaptive local singularity determination algorithm which can result in an optimized LSI map, providing three kinds of parameter layers for variable range, direction and compressibility of anisotropy in space, respectively.

3 Methodology

In this research, three methods were applied in order to fulfil the objective of this manuscript. The approaches to complete the works are distribution of questionnaire, data collection from primary sources (questionnaire) and interview session with

selected respondents as shown in Fig. 4. During distribution of questionnaire, the question was designed up to three sections based on the information extracted from the previous literature review. The first section is the demographic information of the respondent such as age, types of gender and marriage status. The second section is binary option of yes or no and some multiple choice questions. In this section, the question was created based on the information and knowledge of the municipal solid waste such as type of waste, method of disposal, the recycled centre in Pulau Pinang and many more information about the study. The third section consists of rating-based questions. Respondents will have to rate their opinion on the specific fact of option which is by 5 scales.

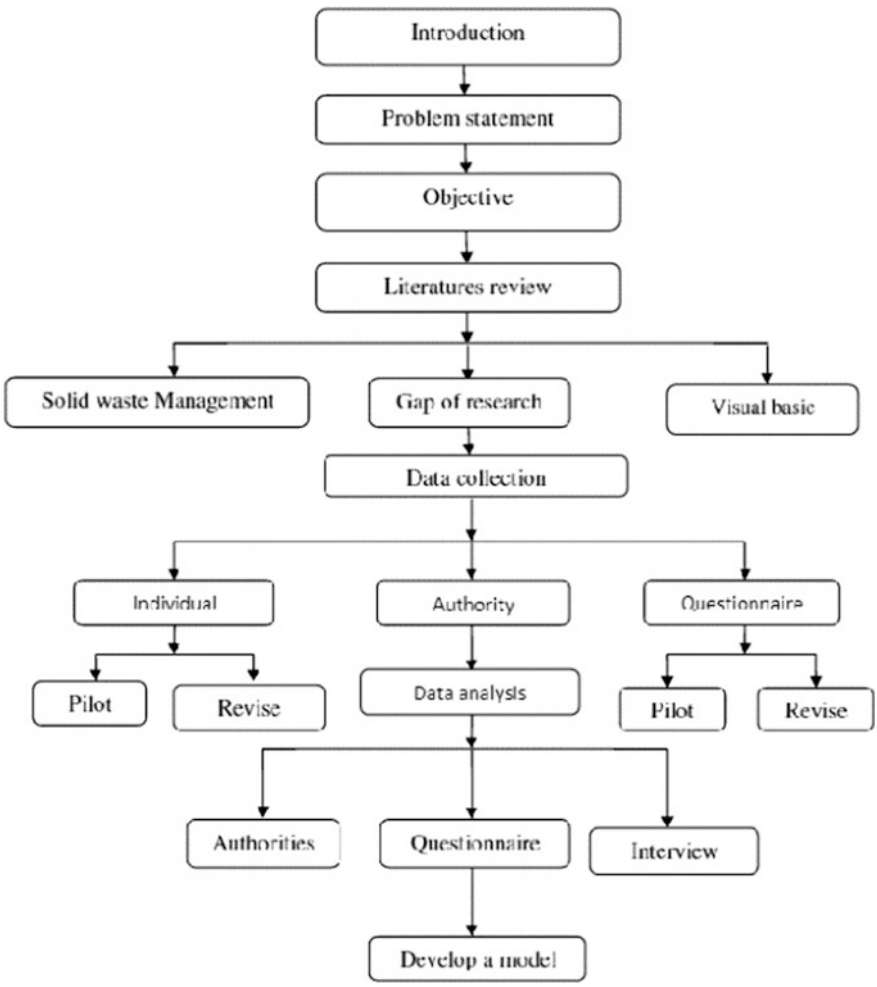

Fig. 4 Flow chart

For the second method, the data was collected from the sample of households in the residential area. The subject matters are coming from the family's houses, student's houses and worker's house. Percentage of waste composition will be tabulated from these three subject matters for further analysis.

The last method that has been used to fulfil the research objective is by conducting interview session with all individual, parties and stakeholders which directly involved with MSW. The interview was conducted by asking the basic questions pertaining to municipal solid waste technologies and general perspective about MSW management in Pulau Pinang.

4 Discussion

4.1 Results

Based on the data gathered from the survey and questionnaire session from 30 respondents, the percentage of solid waste production was tabulated followed by categories type of waste. Each type of waste production was plotted in Fig. 5 to determine the mode and median of analysis as shown in Table 1. The table also shows that the bottle and food were the highest productions followed by plastic. Most of the civilian generate more than 3 times per week as 33, 27% generate 3 times, and 20% produce 1 or 2 times waste per week respectively with average 4 peoples per household.

4.2 Visual Basic Application

In this system (Fig. 6), the main menu was set as a first interface of the software with four (4) main buttons for users selections. At the left button, the user will be guided towards the basic knowledge of municipal solid waste system. The type of

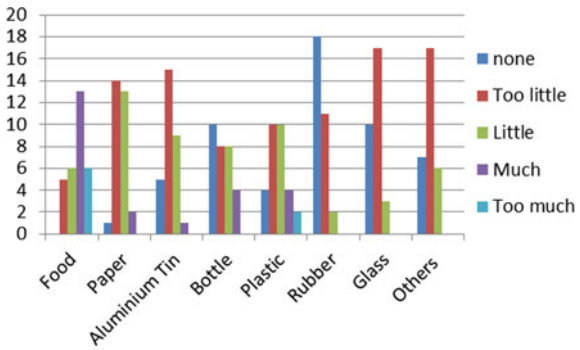

Fig. 5 Mode analysis rating type of waste

Table 1 Type of waste generated at residential area in Permatang Pauh, Pulau Pinang

Type of waste	None	Too Little	Little	Much	Too Much	Mode	Median
Food	0	5	6	13	6	6	6
Paper	1	14	13	2	0	0	2
Aluminium Tin	5	15	9	1	0	0	5
Bottle	10	8	8	4	0	8	8
Plastic	4	10	10	4	2	4	4
Rubber	18	11	2	0	0	0	2
Glass	10	17	3	0	0	0	3
Others	7	17	6	0	0	0	6

Fig. 6 Main menu

waste button as shown in (Fig. 6) are exposed the user to specific various type of waste that applicable in Malaysia which includes industrial, hazardous, agricultural and nuclear wastes and also municipal solid waste. At the top right button, the user will be directed to the analysis part by fitting user input information. Users can store the information on the project and user profile by clicking the bottom right button. One of the analyses provided was the type of garbage collector that can be applied based on the type of waste.

The selections menu interface on related solid waste (Fig. 7) will immediately appear after user clicks on the type of waste button. It consists types of waste storage, disposal method, location of dumping site, effect on society health and environment; and the related law and regulations. In the type of storage interface, there are roll-on/roll-off (RORO) that normally use for high-rise building and bin with capacity 600 and 800 L normally use for landed houses. Each residential area

Fig. 7 Selection menu

must be provided waste storage for daily collection by garbage collector. The municipal solid waste was managed by the appointed company under authority supervision to ensure our environment was secure from any disease caused by waste.

Our government has launched 3R campaign to encourage civilian and household towards sorting waste material for recycling purpose. The campaign proved to be fruitful to the consumers and indirectly will perverse our environment from polluting. Failure to manage MSW will increase greenhouse gases effect as the waste will produce emission of carbon dioxide to the atmosphere and trapping the heat inside the earth surface.

For the last option, the users have an option to select analysis to choose the suitable waste collector according to the types of waste as shown in Fig. 8.

5 Conclusion

The problem regarding the municipal solid waste is a problem that cannot be taken for granted and this problem is considered as the global issue in the certain country. This is due to the effect of the municipal solid waste to the environment and public health which in turn will affect other sectors such as politics and economics. It is

Fig. 8 Analysis

hoped that the development of this program will educate our kids and society at larger preserving our precious environment and having ample knowledge of MSW management.

The first objective of this research is to identify the composition of municipal waste in Pulau Pinang. The composition of municipal waste was obtained from the questionnaire distributed to the public who live in the residential area in Pulau Pinang. This questionnaire was distributed randomly to the citizens who stay in Permatang Pauh in order to collect the data on the daily production of municipal solid waste. The municipal solid waste management system is a waste that has many compositions in that waste (Zhang et al. 2013). The second objective is to develop a model of solid waste management system using Microsoft Visual Basic with friendly user button to serve the best information for users.

The final objective of the study is to give the information to the society about how to manage the municipal waste using the right method. This software will give all the information regarding the municipal solid waste plus it also gives a little bit of info about the others types of waste. With the information given in the software hopefully, the society can change their behaviour about how they manage the municipal waste so that in the future, the municipal solid waste can be reduced and hopefully increase the number of recycling done by the society.

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Chapter 53
Assessing Risk Management Maturity for Construction Projects in Jabatan Kerja Raya

Saiful Jumali, Siti Rashidah Mohd Nasir, Azizan Mohamed Yasin and Nur Muizzah Nawi

Abstract Under the Ninth Malaysia Plan, Jabatan Kerja Raya (JKR) was burdened by too many projects. Therefore, financial and time losses sometimes occurred during the process of building procurement until project implementation when managing risks is not properly. The aim of this study was to assess the maturity of risk management for construction projects in JKR. In this study, four attributes were chosen for the JKR risk management maturity models. The four attributes namely culture/ awareness, experiences, processes, and practices. Therefore, this study used four levels of maturity namely level 1: Initial, level 2: Established, level 3: Managed and level 4: Optimized. This study was conducted using a questionnaire survey among professional in all JKR. The empirical research findings showed that the overall risk management maturity levels for construction projects in the JKR were 2.52 over 4. It is concluded that the maturity of risk management for construction projects in JKR was achieved between "level 2 and level 3", which means it has good managed and optimized for maturity level in the construction projects. The proposed model is suitable for JKR to assess their risk management maturity level and find ways for improvement.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_53

Keywords Construction projects · JKR · Maturity model · Risk assessment Risk management

1 Introduction

The construction industry in Malaysia has become one of the sectors that significantly contributes to Malaysia's economy. Under the Ninth Malaysia Plan (9MP), Jabatan Kerja Raya (JKR) is entrusted to handle major infrastructure project delivery. JKR has recognized the risk management in order to improve their capacity and competency by establishing the Complex Project Management Division (PROKOM) and implemented a Project Managed Change Program (PMCP) to institute best practice project management and risk management within JKR (Nasir 2011). A variety of unexpected events occurred during the project procurement and implementation process and this can create delays and financial losses to the client or others interested parties. Risk management is either ignored or done by simply adding contingencies in a contract. As a result, many projects fail to meet the quality standards, expected deadlines, and cost under budget (Basiron 2009).

The risk maturity concept in JKR is utilized for benchmarking the current capability toward the competitors and best practices thoroughly by determining the strengths and weakness in a particular area to develop improvement strategies. Risk management maturity reflects the sophistication of JKR's construction projects to understand the risk portfolio and how to manage those risks. Assessing the current risk management for construction project in JKR is important to identify the priority or weakest of attributes areas needed for improvement and actions can be taken to increase the project performance.

2 Literature Review

JKR has adopted risk management as a key process in their work (JKR 2008). JKR projects are always associated with risks. The purpose of risk management in JKR is to completed projects successfully with ensuring levels of risk and uncertainty managed effectively. JKR used a risk management as a planning technique to avoid or minimize damages. The project management team and key stakeholders should work together to develop strategies and plans, and to identify risks in advance to managing them (JKR 2008). The strategies are (i) use preventative measures as strategies plan whenever possible, (ii) before a problem occurs, keep problem resolution plans ready ahead of time, and (iii) use a repeatable process, best practice, structured for problem resolution.

2.1 Risk Management Maturity

The risk management maturity of an organization reflects the sophistication of an organization's understanding of its risk portfolio, its knowledge of its internal business continuity system and the extent of how to mitigate those risks needed to cope with and recover from risk events (Loosemore et al. 2006).

On the other hand, risk mature organization typically has an awareness and sensitivity to organizational risks, culture of openness, social and financial responsibilities to stakeholders, general public, and wider environments. Risk mature organizations are important to encourage collective responsibilities for the management and effective communication system of the interdependent risks between supply chains and others parties involved (Loosemore et al. 2006). A comprehensive risk management plan, continuously communicates, coordinate and review risk management efforts can be achieved by creating a permanent risk management team responsible in large organizations.

2.2 Risk Management Maturity Model

The risk management maturity model works as a guideline for the organization. It is able to locate where it stands based on the model (Mayer and Fagundes 2009). Hillson (1997) states the risk management maturity model is needed for an organization in order to know its capability and current maturity in managing risk, it model should also assist in defining progress toward increased maturity.

A risk maturity model is designed as an assessment tool to evaluate risk management maturity and improving its performance and enhancing its own future. Some research has been conducted by the researcher such as Hillson (1997), Crawford (2002), PMI (2002), BRM3 (2003), Ren and Yeo (2004), Loosemore et al. (2006), Mayer and Fagundes (2009), Shah et al. (2009), and Zou et al. (2010) for diagnosing risk management maturity of a project or an organization. Several advantages and disadvantages were identified in terms of usability and effectiveness. The evaluation criteria were specified as attributes and number of maturity levels. Through reviewing the function and characteristics of these existing models, the most maturity level and suitable attributes were determined as described.

2.3 Identifying RM Model Attributes

Risk maturity model by Hillson (1997) provides a simple and reasonable attribute namely culture, process, experience, and application. In this model, culture attribute consists of awareness, top management commitment, and approach toward risk management. Under process attribute, the model examines a concerned with the

existence of formal processes and organizational learning from risks. Experience attribute consists of staff dealing with risk management, use of tools, and training which are examined. The final attribute for this model application consists of a structured application of risk management, resources, and dedicated tools. The Risk Management Maturity Model (PMI 2002), IACCM Business Risk Management Maturity (BRM3) and Risk Management Capability Maturity Model Integration (RM-CMMI) utilize the same attribute headings with Hillson model. All of the researchers were developing the risk maturity model similar to Hillson (1997).

Project Management Maturity Model and Risk Management Process in Information Security (MMGRseg) have focused on the processes. These models take risk management processes as attributes. Risk Management Capability Maturity Model for Complex Product System Projects was developed by different approaches which utilize three key attributes such as process, culture, and knowledge/ techniques.

PMI's Risk Management Maturity Model to the Construction Industry (Loosemore et al. 2006) has extra attribute headings that are integrated into the RMM framework namely awareness, image, confidence, and resources. This risk maturity model emphasizes the "organizational culture's" attribute in the descriptions was seen that the scope of "culture" attribute comprises awareness. Therefore, creating an extra attribute may be is not necessary. The confidence and image attributes do not add any value to the model. The attributes of the confidence can be under the experience attributes. Finally, resources attributed in this model were deemed reasonable in terms of comprehensiveness, since this subject is involved under the application attribute in Hillson (1997) model.

On the other hand, Risk Management Maturity Model (RM3) proposed by Zou et al. (2010) utilized five attributes such as management (people and leadership) capability in relation to risk, organization risk management culture, ability to identify risks, ability to analyze risks, and development and application of standardized risk management process. This model focused on the culture and process attributes. The attributes provided in this model just focus on construction enterprises without supply chain risk management in construction.

2.4 Identifying Maturity Levels

In several maturity models, different maturity levels were used. These models clearly used either four or five levels to measure risk management maturity. Four levels of maturity provide simplicity, clarity, and reduce fuzziness for the determination of the maturity level of the organization Hillson (1997). Similarly, PMI (2002) states the maturity model with four levels of maturity is full enough compared with five levels. If the level of maturity is added more than four, it isn't seen giving any advantageous and makes the respondent become ambiguity/ confused.

3 Method

After a thorough examination of the attributes in the existing maturity model and literature, four attributes were chosen for the JKR risk management maturity models. A little effort has been committed to research on assessing RM maturity for construction projects in JKR. This paper attempts to fill this knowledge gap. The four attributes are culture/ awareness, experiences, processes, and practices as shown in Table 1.

The culture/ awareness attributes focus mainly on the overall operations of the JKR organization. Hillson (1997) and Loosemore et al. (2006) add that culture/ awareness is one dimension to assess the attitude of the organization toward risk management. This attribute means to have a good cultural environment in terms of productivity and morale in JKR. The second attribute is experienced dealing with JKR risk management experiences in terms of people, learning and training. Pointing out to the criticality of risk management experiences, Royer (2001) states that the risk management planning stresses the importance of experience-based risk assessment. The third attribute is processed. Based on the previous study that was discussed in the literature, the risk management processes are essential and are the backbone of risk management. This attribute consists of the main processes of risk

Table 1 Attributes and index of the proposed model

Attributes	Index
Culture/ Awareness	Acceptance of risk management
	Top management commitment
	Communication of risk management
	Attitude toward risk management
Experiences	Staff dealing with risk management
	Risk management process learning from the past
	Risk management training
Processes	Identified potential risks for new projects
	Responsibility in risk identification
	Risk identification
	Risk analysis
	Risk treatment or mitigation
	Risk monitor and review
	Risk documentation
Practices	Formalization of practices
	Budget for risk management
	Benefit of risk management on JKR success criteria
	Integration of risk management with other JKR project management areas

Source Hillson (1997), Crawford (2002), PMI (2002), IACCM (2003), Ren and Yeo (2004), Loosemore et al. (2006), Ongel (2009), and Zou et al. (2010)

management in JKR. Practices attribute is to examine the application of formal risk management practices within the JKR organization. It is the ability to properly and systematically address arising issues while taking into account possible risk factors, constraints, and magnitudes of risks (Zou et al. 2010). This will demonstrate the capabilities of JKR to handle risks. By combining these four attributes, it will show the overall risk management maturity level of JKR.

Using the selected attributes as a starting point, a series of questions were developed to evaluate JKR's risk management maturity. Their answers are used to calculate maturity levels. It should be pointed that more questions/ description could be used for each attribute. However, in this case, 18 questions/indices in total were chosen to measure different aspects under four attributes.

3.1 Proposed JKR Risk Management Maturity Level

The proposed JKR risk management maturity level is used to assess the maturity of risk management for construction projects in JKR. This model aims to improve risk management maturity, to assess risk management maturity for construction projects in JKR and its benefit.

A series of questions for each attribute were developed based on models in literature like Hillson (1997), PMI (2002), Loosemore et al. (2006), Mayer and Fagundes (2009), and questionnaire by Ongel (2009) as starting point to evaluate the risk management for construction projects in JKR. The answer to the question for each attribute is used to calculate maturity levels. Based on literature review, four levels of maturity are more advantageous when compared with five levels. The proposed model is used to analyze the maturity level of JKR through the answer gathered in the model and the result may be present as follows: level 1: (Initial), level 2: (Established), level 3: (Managed), and level 4: (Optimized).

3.2 Questionnaire Survey

The questionnaire was chosen for this study as a tool for data collection. The methodology was used from previous study by Shah et al. (2009), Zou et al. (2010), and Loosemore et al. (2006) also used a questionnaire for risk management maturity level in gathering data.

Based on *Sistem Maklumat Pegawai JKR*, there are 3500 numbers of population or professional under several disciplines such as architect, civil, mechanical, and electrical, and a quantity surveyor in all JKR branches such as management sector, business sector, expert sector, and JKR State. Based on Krejcie and Morgan (1970) Table, the sample size corresponding to the size of a population for this study to assess risk management maturity for construction projects in JKR is 346.

The questionnaire consists of two main sections which are section A and section B. Section A is demographic that includes current position and discipline in JKR areas. Section B has four (4) attributes component for assessing the risk management maturity. Section B includes 18 questions in total and some of them with subcomponents. Four levels of maturity are present in answers choices with most of them comprising of detailed description and four-point Likert scale ranging are "none, low, medium, and high" that are used in subindices questions. In this section, the respondent was asked to rate the level of maturity from the question for each attribute using an answer provided by the researcher (level 1, level 2, level 3, and level 4).

Pilot study was conducted with experts. The Cronbach's Alpha value of section B is 0.919 which indicated that those items had relatively high internal consistency. A total of 580 survey questionnaires were sent out via email randomly to selected professionals at 29 venues of JKR branches or states where 20 survey questionnaires were sent to each JKR branch or state. The respondents were officers (who have a role and responsibility as project director, project manager, and engineer) from J41, J44, J48, J52, and J54 post that involved in project management and risk management. A total of 133 out of 580 completed questionnaires were returned. This resulted representing a response rate of 23%, which was in accordance with the norm of 20–30% with most questionnaire surveys in the construction industry (Akintoye 2000).

3.3 Fuzzy Synthetic Evaluation Method

This method used to assess multiple criteria decision-making is a fuzzy synthetic evaluation. Hsu and Yang (1997) state that the purpose of this method is to provide a synthetic evaluation of an object relative to an objective in a fuzzy decision environment with a number of indices. In this study for assessing risk management maturity for construction projects in JKR, the fuzzy synthetic evaluation has been used. This method has been adopted in many fields for an application of fuzzy set theory. Shiyu et al. (2014) adopted fuzzy synthetic evaluation for assessing risk management capability of contractors in subway projects in mainland China. Zhao et al. (1997) proposed a Fuzzy Integrative Evaluation Method for assessing the risk factors of a project in general. From these previous research studies, it can be seen that fuzzy synthetic evaluation has merits in handling complicated evaluation with multi-attributes and multilevels. Thus, the fuzzy synthetic evaluation method is adopted to identify the current overall risk management maturity of construction projects in JKR.

4 Results and Discussion

4.1 Demographic Analysis

The data finding will be analyzed using The Statistical Package for Social Science (SPSS version 21). Table 2 shows the data finding of the respondents. According to Table 2, the number of respondents for the current position is the most widely J41 was 36.1%, followed by the J48 was 28.6%, J44 was 21.1% and the J52 was 8.3%. The number of respondents J54 was the least number which is 6.0%. In terms of discipline, a total of 57.9% were respondents from civil discipline, followed by 19.5% of respondents who were from the mechanical and electrical discipline, and 13.5% of respondents were from the discipline of a quantity surveyor. The fewest number of respondents was 9.0% who are respondents from architecture discipline.

4.2 Assessment of the Current Overall Risk Management Maturity for Construction Project in JKR

In order to assess the current overall risk management maturity for construction projects in JKR, the mean rating, weighting for the risk management maturity indices, and fuzzy synthetic evaluation were performed. The mean ratings of a particular index are calculated by the summation of individual ratings (provided by the respondents) of a particular index divided by the total number of respondents who provided the ratings. Then a series of weighted indices were developed based on the mean ratings of these data. The weightings for each of the index were computed by using Eq. (1).

Table 2 The data finding of the respondents

Characteristic		N	(%)
Current position	J41	48	36.1
	J44	28	21.1
	J48	38	28.6
	J52	11	8.3
	J54	8	6.0
Discipline	Architect	12	9.0
	Civil	77	57.9
	M&E	26	19.5
	QS	18	13.5

$$
\begin{aligned}
&X = (X_1, X_2, \ldots, X_m) \\
&X_j(M_1, \ldots, M_m) = \frac{Mj}{\sum_{j=1}^{m} Mj} \\
&j = 1, 2, \ldots, m \\
&X_j €[0, 1]\ X_1 + X_2 + \cdots X_m = 1 \\
&j = 1, 2, \ldots, , m
\end{aligned} \tag{1}
$$

where

X_j represents the weighting of a particular index;
M_j represents the mean ratings of a particular index;
ΣM_j represents the summation of mean ratings of all the indices.

A total of 18 risk management maturity indices was identified for assessing the overall risk management maturity for construction projects in JKR. Let the set of basic criteria in fuzzy risk maturity models to be $f = \{f_1, f_2, f_3, f_4, \ldots, f_{18}\}$ and the grades for selection for the states of risk management maturity level are defined as $E = \{1, 2, 3, \text{and } 4\}$ where 1 as level 1, 2 as level 2, 3 as level 3, and 4 as level 4. For each JKR's professional (respondent) current risk management maturity level, the membership function can be formed by the results of a survey questionnaire. For example, the survey results on the acceptance of risk management indicated that none of the respondents selected the maturity of this level as level 1, 6% as level 2, 56% as level 3, and 38% as level 4. Equation (2) indicated the membership function of this maturity level.

$$
\begin{aligned}
B1 &= \frac{0.00}{\text{level 1}} + \frac{0.06}{\text{level 2}} + \frac{0.56}{\text{level 3}} + \frac{0.38}{\text{level 4}} \\
&= \frac{0.00}{1} + \frac{0.06}{2} + \frac{0.56}{3} + \frac{0.38}{4}
\end{aligned} \tag{2}
$$

It also can be written as (0.00, 0.06, 0.56, and 0.38). Similarly, the membership functions of all risk management maturity for indices' in JKR can be written in the same way.

There are three levels of membership function to assess the current overall risk management maturity for construction projects in JKR. Level 3 refers to each of 18 risk management maturity indices (membership function of each risk management maturity index). Level 2 refers to each of 4 risk management attribute (membership function of each risk maturity index). Level 1 refers to the overall risk management maturity (membership function of overall risk management maturity). For example, take risk management culture/ awareness attribute, its membership function is as follows:

$$
\begin{aligned}
(0.29, 0.24, 0.21, 0.26) &= \begin{pmatrix} 0.00, & 0.06, & 0.56, & 0.38, \\ 0.04, & 0.33, & 0.47, & 0.16, \\ 0.05, & 0.52, & 0.30, & 0.13, \\ 0.05, & 0.17, & 0.42, & 0.36, \end{pmatrix} \\
&= \begin{pmatrix} 0.29 * 0.00, & +0.24 * 0.04, & +0.21 * 0.05, & +0.26 * 0.05 \\ 0.29 * 0.06, & +0.24 * 0.33, & +0.21 * 0.52, & +0.26 * 0.17 \\ 0.29 * 0.56, & +0.24 * 0.47, & +0.21 * 0.30, & +0.26 * 0.42 \\ 0.29 * 0.38, & +0.24 * 0.16, & +0.21 * 0.13, & +0.26 * 0.36 \end{pmatrix} \\
&= (0.03, 0.25, 0.45, 0.27)
\end{aligned}
$$

Therefore, the overall current risk management maturity model for construction projects in JKR is as follows:

$$0.14 * 1 + 0.35 * 2 + 0.36 * 3 + 0.15 * 4 = 2.52$$

The level of a particular risk management maturity attribute can be also be calculated by in-depth analysis using the same method. Table 3 shows the results of risk management maturity level for construction projects in JKR. The example of calculation the maturity level of the "culture/awareness" attribute is as follows:

$$0.03 * 1 + 0.25 * 2 + 0.45 * 3 + 0.27 * 4 = 2.96$$

The findings showed that the overall risk management maturity levels for construction projects in JKR was 2.52. Therefore, the overall risk management maturity for construction projects in JKR is far from maturity. It can be regarded as between "level 2" and "level 3" or between "managed" and "optimized" and the results are similar to assess risk management capability of construction in subway projects in mainland China adopted by Shiyu et al. (2014) and maturity assessment in risk management in manufacturing engineering proposed by Shah et al. (2009). JKR needs to be emphasized and improve the risk management in order to achieve JKR vision and mission. Therefore, JKR needs to pay more attention to their experiences, processes, and practices in managing risks to improve the level of maturity in risk management.

Table 3 The result of risk management maturity for construction projects in JKR

Risk management maturity attribute	Level
Culture/Awareness	2.96
Experiences	2.29
Processes	2.31
Practices	2.45
Overall risk management maturity in JKR	2.52

5 Conclusion

The objective of this paper is to find out the risk management maturity levels for construction projects in JKR was successfully achieved. The empirical research findings showed that the overall risk management maturity levels for construction projects in JKR was 2.52. The four attributes to assess risk management maturity for construction projects in JKR namely culture/ awareness, experiences, processes, and practices were achieved between "level 2" and "level 3" or between "managed" and "optimized" based on the JKR risk management model proposed by researchers. Therefore, JKR needs to be emphasized and improve on risk management in order to achieve JKR vision and mission. Besides, JKR needs to pay more attention to their experiences, processes, and practices in managing risks to improve the level of maturity in risk management.

In order to improve the risk management maturity for construction projects in JKR, there are several recommendations that can be done by them. The recommendations are: (i) top management of each JKR branch of state needs to give full support and encourages to risk management and requires a risk management report for each project, (ii) communication of risk events is not only within the project team, but it should be within JKR organization and other parties involved in the project, (iii) regular training should be developed to enhance risk management skills, (iv) in risk identification of each project at the beginning, a documented, repeatable process for identifying project risk and an improvement process should be done as early as possible are in place, (v) using an advanced methods such as simulation, sensitivity testing in risk analysis besides using qualitative methods such as risk rating technique and probability impact matrices, and (vi) in all projects, risk management plans, contingency plans, and risk allocation plans should be prepared and risk control strategies should be formulated as well as risk finance.

There were some limitations in this study. The sample size in this study was small. Only 133 respondents or 23% returned the questionnaires. The caution should be warranted when the analysis result is generalized and interpreted. The studies with larger populations will be able to produce better research results. For future study, they can use the JKR risk maturity model to assess the risk management maturity level with other parties that involved in JKR projects such as a contractor or consultant. Besides, further studies should be conducted focus to assess risk management maturity for small construction projects or large construction project in JKR and how to improve its performance and investigate the relationship between the risk management attributes.

Acknowledgements The authors would like to acknowledge the respondents who have contributed and give valuable input to complete the survey questionnaire. Also, the authors gratefully acknowledge and thank the JKR experts for their constructive comments and suggestions in this study.

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Part V
Forestry

Chapter 54
The Effect of Board Density and Hot-Pressing Time on Mechanical and Physical Properties of Oil Palm Trunk Phenol Formaldehyde Particleboard

Shaikh Abdul Karim Yamani Zakaria, Ermadasila Mohamad and Jamaludin Kasim

Abstract This study was conducted on the oil palm (*Elaeis guineensiss*) trunk particles to determine the influence of hot-pressing time and board densities on the physical and mechanical properties of the particleboard. The oil palm plants are harvested after 25 years for replacement planting. The oil palm trunk (OPT) was felled from FELDA plantation in FELDA Jengka 25, FELDA Jengka 24 and FELDA Ulu Jempol, Pahang, Malaysia. In this study, OPT particleboard was made at 500, 600, and 700 kgm^{-3} density with 12% phenol formaldehyde resin content. Hot-pressing times used were 6, 8, and 10 min. The properties of particleboard studied were modulus of rapture (MOR), modulus of elasticity (MOE), internal bonding (IB), water absorption (WA), and thickness swelling (TS). The results showed that when the board densities were increased from 500 to 700 kgm^{-3}, all mechanical properties increased and physical properties decreased. When pressing time is increased from 8 to 10 min, it increased all the mechanical properties and decreased the physical properties of the board. The properties showed all boards produced at targeted board density of 500, 600, and 700 kgm^{-3} were able to meet the minimum strength requirement of BS EN 310, 319 (1993).

Keywords Modulus of rupture · Modulus of elasticity · Internal bonding Thickness swelling · Water absorption

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_54

1 Introduction

The oil palm (*Elaeisguineensis jacq*) in Malaysia was introduced in the early 1900s and has become an important crop by 1960s (Lim and Gan 2005). The oil palm became the best-known crop nowadays, especially in Southeast Asia and its origin country that was in West Africa (Basiron and Chan 2000). Malaysia and Indonesia were reported as the main producer supplying most of the world consumption of palm oil products (Malaysian Oil Palm Statistics 2015).

In the oil palm plantation, the oil palm trees with the ages of 25 and above will be cut down for replanting (Jamaludin et al. 2010). At that age, the trees have grown too tall and affect the harvesting process and decreasing the yield of the oil palm (Lim and Gan 2005). The oil palm trunk is usually burned on the field but for the fresh felled, trunk has high moisture content and cannot be easily burned. Leaving the trunk in the field without any process will hinder the replanting process with entire felled trunk taking 5 years to decompose completely. By burning the trunk in the field, this will cause serious air pollution and harm the human health (Lim and Gan 2005). Nowadays, oil palm is considered to be one of the non-wood lignocellulosic promising raw materials for different types of wood-based panels (Hashim et al. 2010).

A large number of oil palm biomasses were produced in Malaysia. The oil palm biomass yields are useful for permanent feedstock and renewable resource for higher value products. Biomass has a high potential to be one of the raw materials to supply finished product which is traditionally been made from wood. Nevertheless, the biomass still awaits the commercial exploitation for the development of system for handling and processing (Kamaruddin et al. 1997).

Malaysia is among the largest wood-based product exporter in the international market. In 2020, Malaysia Timber Industry Board (MTIB) has targeted RM 53 billion in the export of timber and timber related products (MTIB 2012). In 2010, the value of exported timber and timber related products was RM 20.52 billion. However, in 2011, the value of exported timber and timber related products dropped to RM 20.06 billion (MTIB 2012). In 2011, the exported particleboard was 524,386 m^3 and the value was RM 3.11 billion (MTIB 2012).

Particleboard is a panel material which manufactured under pressure and heat consists of particles of wood and or other lignocellulosic material with the addition of adhesive in the form of particles called particleboard. It also called particle panel product, which defines as any wood-based product made from thousand pieces of wood smaller than veneer sheets but longer than wood fibers (Pizzi 1994).

The characteristics of particleboard are influenced by particle geometry, density, and resin content because it can affect the strength properties of bending, internal bonding, nail and screw holding properties, surface smoothness, dimensional and machining properties. The main raw material in particleboard industry in Malaysia is rubberwood. However, the supply of rubberwood nowadays cannot meet the demand of the particleboard industry anymore. The industry needs new materials to support the lack of these materials Jamaludin et al. (2010). There is a need to search

other raw materials in particleboard manufacturing due to the increasing price of wood. Therefore, an investigation of raw material other than wood and a study of particleboard manufacture without the synthetic adhesives had been carried out because of the need of formaldehyde-free particleboard and also the decreasing supply of raw material (Hashim et al. 2010).

1.1 Materials and Methods

The raw material used in this study was oil palm trunk. The oil palm trunk use was harvested from the oil palm plantation in FELDA Jengka 25, FELDA Jengka 24, and FELDA Ulu Jempol, Pahang. Then it was transported to UiTM Pahang using a lorry. The adhesive used was phenol formaldehyde (PF) which was made available by Malayan Adhesives and Chemicals Sdn. Bhd. (MAC) in Shah Alam, Selangor. The oil palm tree was harvested after 25 years for replacement planting.

Phenol formaldehyde (PF) was used as the binder in this study. The oil palm trunk (OPT) particle was mixed together with PF using the laboratory mixer. 12% resin content has been added to the mixture. Then, the mixture was formed into mat size of 350 mm × 350 mm using forming box and then prepressed by a cold press. The mat was then hot-pressed at 175 °C. Three different pressing times and densities were used in this study, and the hot-press times were 6, 8, and 10 min and densities were 500, 600 and 700 kgm^{-3}. A 12 mm stopper was used in this study to form 12-mm-thick boards. The board was conditioned in a climate chamber at a temperature of 20 °C and relative humidity of 65%. The board was cut into the sample size based on BS EN standard. The testings conducted in this study were internal bonding (IB), modulus of rupture (MOR), modulus of elasticity (MOE), thickness swelling (TS), and water absorption (WA).

After all the testings were done, the results were analyzed for statistical analysis using the Statistical Packages for Social Sciences (SPSS). The Analysis of Variance (ANOVA), Waller Duncan, Duncan and correlation analysis were used to analyze the significance of physical properties, mechanical properties, density, and press cycle time on the particleboard properties.

2 Results and Discussion

2.1 General

In this study, a total of 18 particleboards were made from OPT. These boards were made with two different variables, which are board density and hot-press temperature. The board densities were 500, 600, and 700 kgm^{-3}. Temperatures used to press the board were set at 165 and 175 °C. Those two variables were represented by boards' samples of three replicates. The moisture content of particle used in making the board was approximately 3%.

2.2 Physical and Mechanical Properties

Table 1 shows the physical and mechanical properties of the OPT Particleboard. With an increment of board density from 500 to 700 kgm^{-3}, the mechanical properties (MOR, MOE, and IB) exhibit an increasing trend but for physical properties (WS and TS), it showed the decreasing trend.

2.3 Statistical Analysis

Table 2 shows the analysis of variance (ANOVA) on the effect of board density, and hot-pressing time on the mechanical and physical properties of phenol formaldehyde OPT particleboard properties. The density of the board shows the significant effect on all board properties. However, for pressing time, only mechanical properties show the significant effect. Table 3 shows the correlation coefficients of board density and pressing time on the board properties.

Table 1 Physical and mechanical properties of OPT particleboard

Press time	Target density (kgm^{-3})	Density (kgm^{-3})	MOR (MPa)	MOE (MPa)	IB (MPa)	WA (%)	TS (%)
6	500	513	16	2246	0.4	90	22
8	500	498	18	2354	0.5	78	18
10	500	508	21	2464	0.55	86	19
6	600	602	23	2782	0.43	70	19
8	600	625	20	2469	0.78	58	14
10	600	614	23	2714	0.71	63	14
6	700	722	28	3246	0.78	48	11
8	700	706	28	3141	1.0	53	12
10	700	692	34	4027	1.0	39	13
BS EN 310, 319 & 317 (1993)			Min. 14	Min. 2000	Min. 0.5	–	Min. 12

Table 2 Analysis of variance (ANOVA)

Source	Df	MOR	MOE	IB	TS	WA
Density (D)	2	93.325*	113.687*	35.307*	19.428*	121.648*
Press time (P)	2	26.83*	18.68*	9.9*	0.2 ns	0.9 ns

Notes *F-value are significant at $p < 0.05$, and ns—not significant, *df* degree of freedom, *MOR* modulus of rupture, *MOE* modulus of elasticity, *IB* internal bonding, *TS* thickness swelling, *WA* water absorption

Table 3 Correlation coefficients of density and press time on the board properties

SOV	MOR	MOE	IB	TS	WA
Density	0.494*	0.537*	0.553*	−0.372*	−0.802*
Press time	0.262*	0.220*	0.320*	−0.19 ns	−0.024 ns

Notes *SOV* source of variance, *ns*—not significant, *significant at $p < 0.05$

3 Effect of Board Density

3.1 Mechanical Properties

Figure 1 shows the effects of board density on mechanical properties. The MOR properties increase with an increase in board density. The higher board density had greater compaction ratio on the board. By increasing board density from 500 to 700 kgm^{-3}, the MOR increases by 51.4%. This significant increase in MOR is further supported by the correlation analysis ($r = 0.494^{*}$) as shown in Table 3. The MOE also increases about 41.78%, and this was further supported by the correlation analysis significant of $r = 0.54^{*}$.

Figure 1 also shows the effects of board density on internal bonding (IB) properties. The IB properties significantly increased with an increase in board density. By increasing the board density from 500 to 700 kgm^{-3}, the IB increases by about 101.12%. This significant result for IB was supported by the correlation

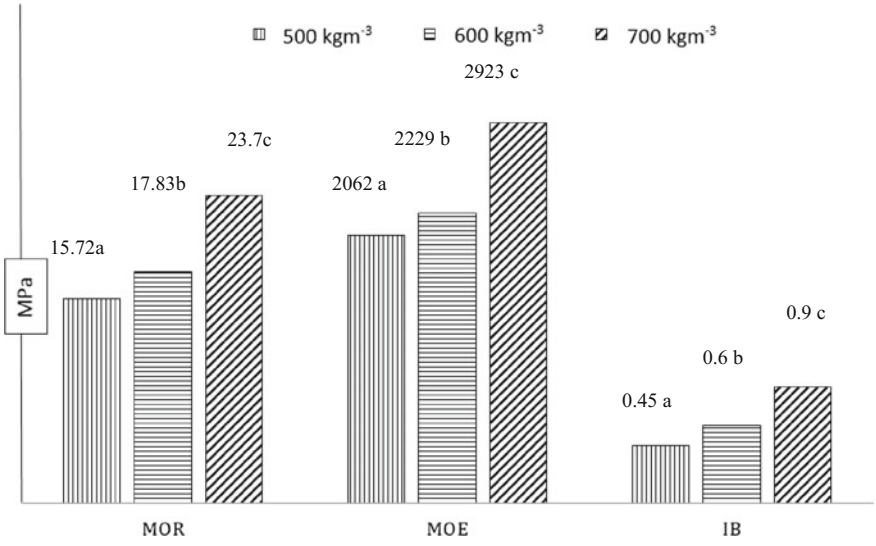

Fig. 1 Effect of board density on mechanical properties

analysis ($r = 0.55^{*}$) (Table 3). The findings from this study do not correlate with other findings in the past. Mohamad et al. (2004) and Jamaludin et al. (2010) reported better mechanical properties at higher density.

3.2 Physical Properties

The effects of board density on water absorption (WA) and TS values are shown in Fig. 2. The WA values improved with an increase in board density. By increasing the board density from 500 to 700 kgm^{-3}, the WA improved about 43.98%. This was further supported by the correlation analysis (Table 3) of $r = -0.82$. The TS values were also improved with an increase in board density. By increasing the board density from 500 to 700 kgm^{-3}, the TS improved by 27.68%. This improvement is shown by the correlation analysis in Table 3 where $r = -0.37^{*}$. Board containing the high amount of particle increases the particle bonding and higher compaction ratio thus better board stability is created. Jamaludin et al. (2010), Xu et al. (2004), and Mohamad et al. (2004) also reported a similar relationship between board density and TS.

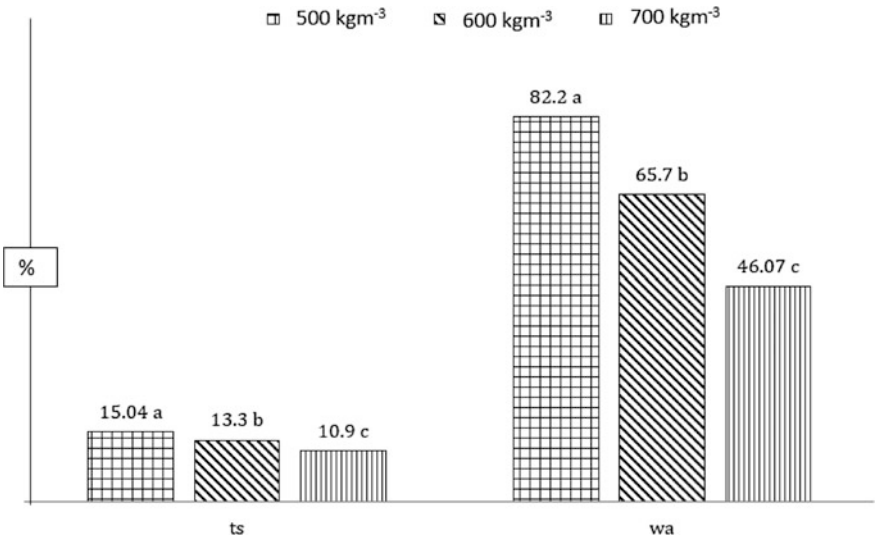

Fig. 2 Effect of density on physical properties

4 Effect of Pressing Time

4.1 Mechanical Properties

The effects of press time on mechanical properties are shown in Fig. 3. The MOR and MOE values increase significantly with pressing time. By increasing the pressing time from 6 to 10 min, the MOR increases about 24.71%. This was support with correlation analysis is significant at $r = 0.262^{*}$. The MOE values increases significantly with an increase in press time. By increasing the press time from 6 to 10 min, the MOE increases about 15.66%. This was support with correlation analysis is significant at $r = 0.220^{*}$. At higher press time, more heat is spread through the thickness of the board providing enough heat to cure the resin thus giving the high MOR and MOE value (Alireza and Amir 2008). The bond between resin and the particle is improved, and the resin will cure perfectly.

The effects of pressing time on internal bonding (IB) values are also shown in Fig. 2. The IB properties significantly increased with an increase in hot-pressing time. By increasing the pressing time from 6 to 10 min, IB increased by 39.62%. This is because the resin may cure perfectly while the hot-pressing time is increased. This significant result for IB is supported by the correlation analysis ($r = 0.320^{*}$).

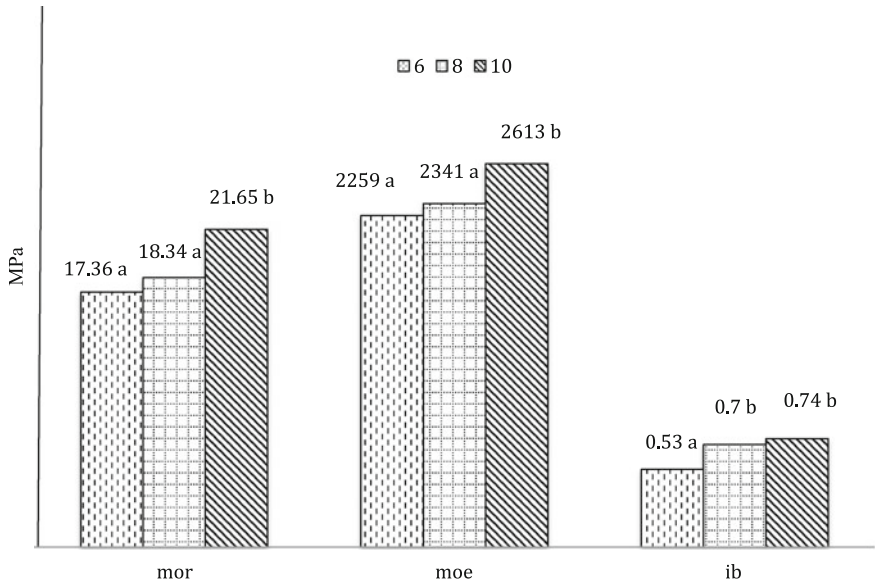

Fig. 3 Effect of press time on mechanical properties

Increasing pressing time will improve the mechanical properties of the particleboard. This is because of the increased bonding between the particles and hardening of the resin become more efficient during hot-pressing. Similar results were recorded in previous studies by Nemli et al. (2007) and Alireza and Amir (2008).

4.2 Physical Properties

The effects of pressing time on water absorption and thickness swelling values are shown in Fig. 4. The TS values show an insignificant trend with an increase in hot-pressing time. By increasing the press time from 6 to 10 min, the TS changed about 1.81%. This improvement is shown by the correlation analysis where $r = -0.19$ ns.

The effect of hot-pressing time on WA values shows that WA values improved insignificantly with an increase in press time. By increasing the press time from 6 to 10 min, the WA values decrease about 1.56%. This was further supported by the correlation analysis of $r = 0.024$ ns.

The insignificant trend of thickness swelling is due to high parenchymatous tissue inside the oil palm trunk. Almost 80% of the total area is composed of

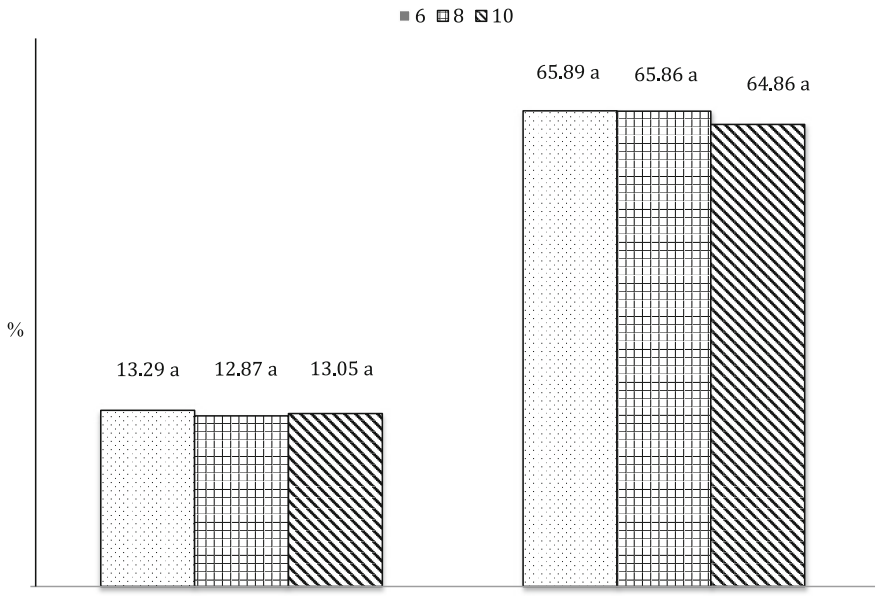

Fig. 4 Effect of press time on physical properties

slightly larger and greatly scattered vascular bundles embedded in the thin-walled parenchymatous ground tissue make up the central zone on the oil palm trunk (Sulaiman et al. 2012). Francesco et al. (2008) reported that the presence of high amount of parenchyma will affect the glue effectiveness and affect the properties of particleboard.

5 Conclusion

Effect of hot-pressed time on some of the basic properties of phenol formaldehyde particleboard panels made from oil palm trunks was investigated. The results showed that the hot-press time and board densities have an influence on the properties of the samples. However, thickness swelling of the samples needs to be improved using either some kind of chemical, steam treatment, or adding of some wax in the furnish. The study shows that the best hot-pressed time is 10 min and density is 700 kgm^{-3}.

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Chapter 55
Anthropometric Data of Primary School Children in Malaysia for School Chair Design

Hanani Yuhaniz, Asnawi Seraila, Siti Rafedah Abdul Karim, Suhaimi Muhammed and Abdul Hamid Saleh

Abstract Anthropometrics data of Malaysian Primary school children are yet to be compiled and used for producing ergonomic school furniture. In this study, anthropometrics data of six body dimensions were collected, these are the hip width, shoulder breadth, sitting subscapular height, sitting shoulder, buttock-popliteal length, and popliteal height. The objectives were to compare current school chair dimensions with the newly proposed chair in order to prove the need of having anthropometric data as a basis in furniture design. Method: A custom-made measurer was used to measuring samples of 2400 school children across four states in Malaysia which include Perak, Pahang, Selangor and Johor and consists of students aged 7–11 years old. The 5th and 95th percentiles were used and data were evaluated by differentiating the current school chair with the newly proposed chair where results showed differences in sizes between the two. In conclusion, there is a need for having new chair dimensions that follow Malaysian children's anthropometry.

Keywords Anthropometric · Children · Ergonomics

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_55

1 Introduction

Anthropometrics which means body measurement is a factor that needs to be fulfilled when designing ergonomic compliance furniture. Ergonomics can be termed as a scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design, in order to optimize human well-being and overall system performance (Dul and Weerdmeester 2008). Ergonomics in Malaysia is not entirely new, but it is still a subject that is still in its development phase where ergonomics applications can be seen adapted in workplaces such as in the factory and offices. Furthermore, studies on ergonomics are increasing, making it a wide acceptance matter throughout the country. However, the application of ergonomics towards children was not concentrated, as database of the children was still not complied and applied. The objectives of this study were to evaluate current school chair and proposing new dimensions to achieve ergonomic compliance school chair.

The majority of children in Malaysia spend their time in schools, making them prone to disorders such as back pain, neck pain, and other musculoskeletal disorders due to the long period of sitting in class. In the classroom, children are reported to sit in a poor position where often, their chest, back, and neck flexed or rotated for a long time (Murphy et al. 2004). According to a 2009 study on musculoskeletal disorder (MSD) among primary school children in Malaysia, it is found that 31.82% of 2nd grade and 62.2% of 5th grade students experience upper MSD (Syazwanl et al. 2009). Also reported in a study by Nurul Asyiqin et al. (2009), 32% of students aged 7 to 9 years mostly suffer from knee leg pain and as for 10–12 years old, 35% of them experienced neck pain. Despite these reports, school furniture is yet to be reevaluated and redesigned.

Mismatches of furniture were also found in numerous studies throughout the world. Chairs were reportedly being too high and too deep for children in Greece (Panagiotopoulou et al. 2004). Another study in the USA by Parcells et al. (1999) indicated 65% of students had seats that were also too high and too deep. Meanwhile, in Malaysia mismatches were also found. As reported by Isa et al. (2013), 80% of students had mismatches of the seat and popliteal height. This will lead to the student's feet dangling from the seats, and worst making them have severe musculoskeletal disorders. Furthermore, a 100% mismatch was reported in Year 1 students for the seat height, depth, and seat to desk clearance (Yusoff et al. 2016). This alarming percentage was also seen in a field study made recently as in Fig. 1. The disproportionate of furniture to the student's body will even lead to numerous musculoskeletal disorders. It is important to tackle the mismatches of furniture to body composition by proposing new dimensions, enabling school children not only has good health but also will make children much more efficient while learning.

Fig. 1 Furniture too big for children's body

Furthermore, there are reports of overweight in Kuala Lumpur where 5.8% of children aged 6–10 years were overweight (Shariff et al. 2000), and in Perak, group ages of 5–9 years old were registered as 0.87% overweight (Zamaliah et al. 1998). However, in 2004, a study by Moy et al. (2004) showed that 48.9% were not underweight. This shows that children's body is changing.

School furniture has changed throughout the years where it differs in sizes. In Fig. 2, four different types of chairs are shown. The first chair from the left is the oldest found in the school. The second chair which is in blue color was used previously before changing to the recent third chair which is in the brown wood color. Lastly, the fourth chair is plastic, which was quite common to be found in classroom nowadays. All of these chairs are still being used in schools, however, in this study, comparison of sizes was based on the current chair design which is the third chair.

Fig. 2 School chairs at school

2 Method

2.1 Sampling

The sampling method that was used was multistage sampling, where three stages of samplings were undertaken. Multistage sampling was used due to its cost and time effectiveness. This sampling method divides the population into smaller clusters into several stages. Figure 3 shows the illustrations of the stages of samplings were made.

In Stage I, the determination of regions was made by clustering Peninsular Malaysia by four clusters. With that, each cluster was represented by each region. Then, a state was chosen to represent the whole region. Afterwards, in Stage II, districts were then selected by the number of schools. The district with the highest number of schools was chosen and lastly, in Stage III, schools from rural and urban areas were also selected by the highest amount. Based on the rule of thumb by Roscoe (1975), a minimum sample size of 30 for each category is necessary (as cited by Sekaran 1992). Therefore, the total amount of samples in this study are 2400 school children who are between the ages of 7 and 11 years comprising boys and girls.

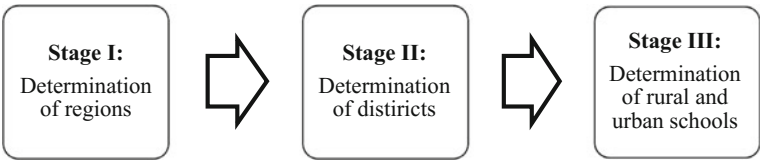

Fig. 3 Sampling stages

2.2 Equipment Preparation, Data Gathering, and Evaluation

Data were collected through direct measurements using a custom-made anthropometer and a stadiometer. A custom-made measurer was made for this study as can be seen in Fig. 4. The custom measurer enables the researcher to measure children in their sitting posture efficiently and effectively. A total of six body dimensions were measured, these were shoulder breadth, hip width, sitting shoulder, sitting subscapular height, buttock-popliteal length, and popliteal height. The dimensions were chosen primarily to design a chair. In Fig. 5, an illustration of the body parts was shown. Afterwards, the anthropometric data were evaluated using SPSS and comparisons of current chair measurements with the newly found dimensions were made.

Fig. 4 Custom-made measurer

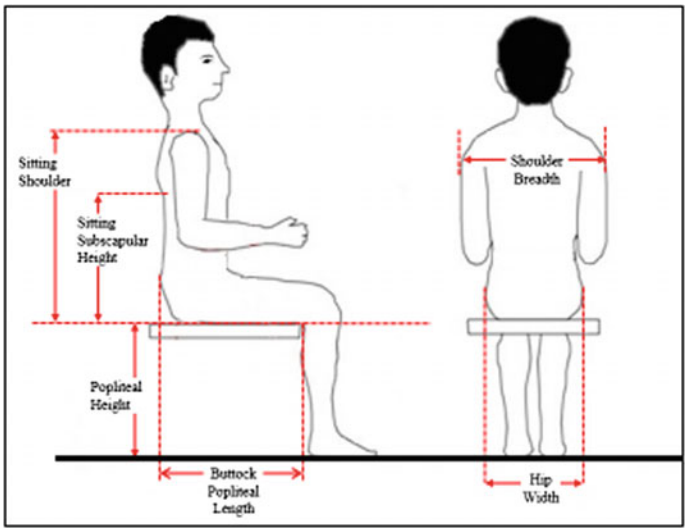

Fig. 5 Body parts measured

3 Results and Discussion

The collected anthropometrics data of year 1 to 5 were evaluated using SPSS and the results are shown in Table 1. Percentiles of 5th and 95th were used as this is important when providing measurements for design. The 5th represents the smaller group of children, as for the 95th represents the larger sized group. The overall average body dimensions were between 200 and 400 mm, therefore a chair should be designed by these measurements as this will help children have a better sitting posture and prevent musculoskeletal disorders at a young age. Furthermore, the data can be used not only for school chairs but also in playgrounds such as the seesaw, swings, and other sitting furniture.

Table 1 Anthropometrics data of year 1–5 in millimeter (mm)

Body parts	Mean (mm)	SD	Percentiles (mm)	
			5th	95th
Shoulder breadth	293.91	38.41	239.00	360.00
Hip width	249.95	46.84	190.00	338.48
Sitting shoulder	417.45	46.53	346.00	495.00
Sitting subscapular height	321.52	33.78	273.00	382.00
Buttock-popliteal length	361.06	38.10	303.00	428.00
Popliteal height	345.91	35.21	290.00	402.95

Table 2 Comparison of current and proposed dimensions of chair

Chair Parts	Body parts	Proposed dimensions (mm)	Current dimensions (mm)
Backrest	Shoulder breadth (95th percentile)	360.00	390.00
	Sitting shoulder (5th percentile)	346.00	270.00
	Sitting subscapular height (5th percentile)	273.00	270.00
Seat	Hip width (95th percentile)	338.48	400.00
	Buttock-popliteal length (5th percentile)	303.00	400.00
Legs	Popliteal height (5th percentile)	290.00	400.00

A comparison of the current design school chair with student's anthropometrics data was looked at. Based on Table 2, there were mismatches of body concerning to the chair. However, for the backrest, the differences in the sitting subscapular height were not too prominent, the same as shoulder breadth where only 30 mm of difference were seen. Therefore, the backrest may not even need to be changed. However, for the seat and legs of the chair, changes in sizes are needed. A smaller version of the chair is crucial to be redesigned as results showed more than 100 mm of difference between current and proposed dimension.

4 Conclusion

Anthropometrics data is undeniably important when designing ergonomic furniture. However, when developing a standardized chair for all ages of children, the probability of having a perfect fit is hardly achievable. Due to this, a further investigation of anthropometrics based on ages may resolve this issue. Various sizes of chairs may have to be produced to help in tackling musculoskeletal disorders in school children. Other than that, the design and material used also need to be considered as this will contribute to a better action of redesigning current school furniture.

Acknowledgements The authors would like to thank the Ministry of Education, State Education Department, and all of the selected schools for the acceptance, involvement, and cooperation given in conducting this study. We would also like to thank Universiti Teknologi MARA Pahang for the instruments used throughout the study.

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Chapter 56
Effects of Different Tenon Width Dimensions on T-Joints

Asnawi Seraila, Hanani Yuhaniz, Jamaludin Kasim and Abdul Hamid Saleh

Abstract There are many types of wood joinery used in carpentry projects, one of which is the mortise and tenon. Mortise and tenon are used in wooden school chairs, which need to be durable due to its frequent usage. The objective of this paper was to determine strength properties on three different tenon width of 25, 30, and 35 mm. Tree species that was used was *Shorea leprosula* or also known as Meranti Tembaga in Malaysia. In constructing the joints, gluing technique of brushing was applied to the mortise and tenon, then clamped and conditioned for 24 h. Two mechanical tests were undergone for this study, which were bending and tensile tests to evaluate the strength properties of each T-joints. ANOVA test using SPSS was evaluated to determine strength properties and its effect on different tenon width. Based on the results, the width dimension of 35 mm was reported to have the highest bending and tensile strength properties. The study concluded that tenons with wider dimensions have higher strength values.

Keywords Mortise · Tenon · Joinery · Wood joint

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_56

1 Introduction

Mortise and tenon which is a joinery technique that is dated back to centuries ago is still used in this modern day. It is commonly used for furniture construction of railings and chair posts (Aman et al. 2008). The joining of two different pieces of wood that consists of a mortise and the tenon is widely used in basic joinery for its simple and strong application. The mortise and tenon also come in various shapes, which include rounded and rectangular edges. However, the strength between these two edges is different, the rectangular mortise and tenon are found to be stronger due to its larger surface (Tankut and Tankut 2005). Figure 1 illustrates the defining parts of mortise and tenon joints of rounded edges.

The usage of mortise and tenon can be seen in chair parts such as at the back of the legs and for its railing (Eckelman 1999). It is important to provide great strength properties of mortise and tenon as the strength of the furniture relies on the joints. The problems of mortise and tenon joints may come up if it does not fit correctly with each other. The shrink fit of the wood is important because if it is too loose, the joints will be weaker (Acuna et al. 2000). Other than that, the glue application is also crucial as the shape of glueline influences strength on tenon joints (Prekrat and Smardzewski 2010). Furthermore, the type of wood used also affects the strength of the joinery, as in a study conducted by Ratnasingam and Ioras (2011), where they found mortise and tenon using different wood species of oil palm lumber that had half the strength of rubberwood. Nevertheless, for many years, mortise and tenon were also added reinforcements such as cross-pins to the joinery for better strength (Eckelman et al. 2004).

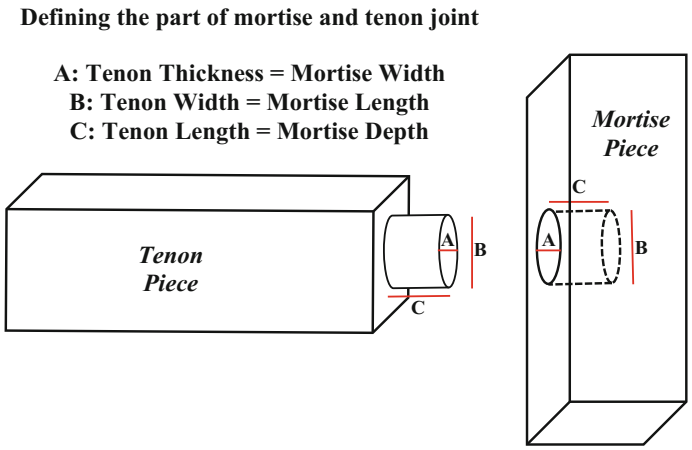

Fig. 1 The defining part of mortise and tenon joint

Fig. 2 Loosen joinery

In Malaysia, mortise and tenon are used in school chair construction currently and years ago. The wooden school chair that is supplied by the government is used in public schools and has the tendency to break as it is used frequently and sometimes abusively by the students. A preliminary study investigating school chairs' mortise and tenon was made to comprehend the condition of the chairs. From the study, many mortise and tenon were found loose as shown in Fig. 2 and cracked and broke at the mortise as in Fig. 3. Due to this, a better joinery application in school chairs needs to be investigated. Therefore, the objective of this paper is to determine strength properties on different tenon width of T-shaped joints.

Fig. 3 Broken at the mortise

2 Materials and Methods

2.1 Sample Preparation

The material used for the joints is made from *Shorea leprosula*, or also known as Meranti Tembaga. The reason behind this is because this type of wood is listed in the types of wood that is permitted in constructing school chairs in Malaysia. The tree was felled and processed by cutting into planks and dried, making sure the moisture content was less than 12%. Afterwards, the dried wood was cut to size and ready for mortise and tenon production. A tenon machine was used to construct tenons of width sizes 25, and 35 mm, length of 30 mm and thickness of 10 mm respectively (Fig. 4). Once the joints are sized accordingly, it is glued by using brushing technique, where both the mortise and the tenon are applied glue to. The finished T-joint with its dimension can be seen in Fig. 5.

2.2 Testing

Once the T-joints are conditioned for 24 h, tests were undergone using a Universal Testing Machine as in Fig. 6. In this study, bending and tensile tests were

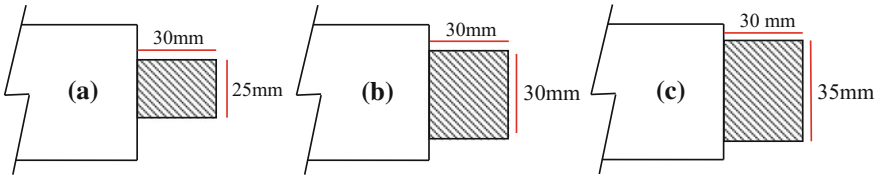

Fig. 4 Dimension of sample tenon width, all length and thickness are same (30 mm × 10 mm)

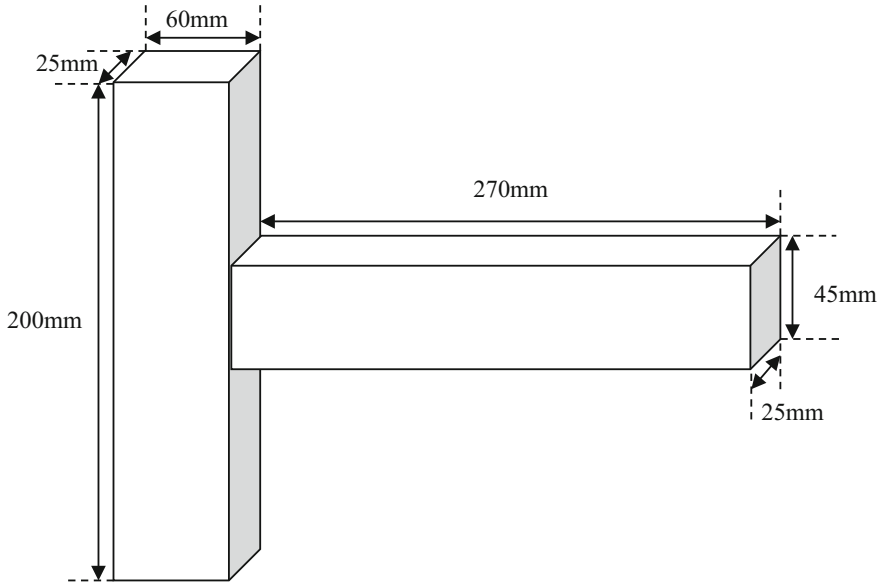

Fig. 5 T-joints dimensions

conducted to determine its strength properties. A special jig was made to hold the T-joints during the test.

Based on Fig. 7, two forces pulled the jointing system until failures was set to a load crosshead at constant of 3.00 mm/min with full scale load range of 10,000N for bending test. As for tensile, the applied load was put at a constant 6.00 mm/min with a full scale load range of 10,000 N as illustrated in Fig. 8.

3 Results and Discussion

3.1 Strength Properties

Table 1 shows the strength properties of both bending and tensile tests of tenon joints for width 25, 30 and 35 mm. According to the bending test results, it can be seen the wider the tenon width, the greater the strength. However, for tensile test, there was a different result where 30 mm showed the lowest strength properties of 7180.00 N compared to 25 and 35 mm.

In Table 2, a standard analysis of variance (ANOVA) was applied and showed significant differences on both bending and tensile tests. This means there are differences in strength properties between the three varieties of tenon width of 25, 30, and 35 mm tested.

Fig. 6 Universal testing machine used for testing

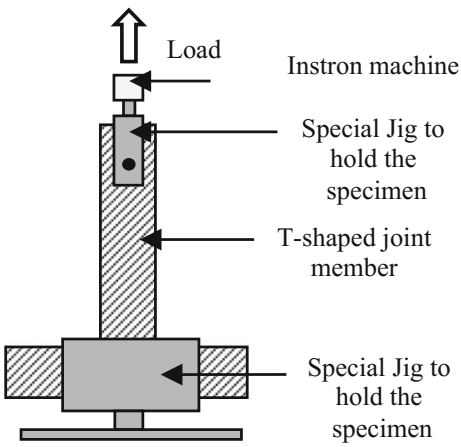

Fig. 7 Tensile test

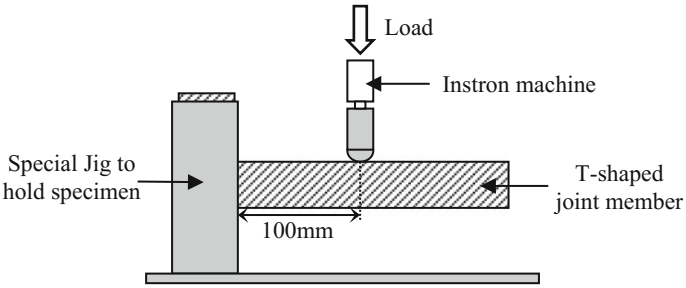

Fig. 8 Bending test

Table 1 Strength properties of tenon joint width

Tenon width (mm)	Bending test		Tensile test	
	Load at break (N)	SD	Maximum load (N)	SD
25	652.24	13.94	7477.98	771.94
30	680.07	55.90	7180.00	292.83
35	754.57	44.29	8581.51	1022.57

N newton, *SD* standard deviation

Table 2 Summary of ANOVA on the strength properties of tenon joint width

Source	Dependent variable	Sum of square	*df*	Mean square	*F*	Sig.
Tenon joint width	Bending test	27993.401	2	13996.700	7.951	.006
	Tensile test	5451312.043	2	2725656.021	4.734	.031

F values are significant at $p < 0.05$, not significant at $p > 0.05$

3.2 Bending Test

The bending test results as in Fig. 9 shows that the highest strength properties was tenon width of 35 mm where the load at break of 754.57 N was reported, followed by 30 mm with 680.07 N and 25 mm with 652.24 N. Using Duncan test for statistical analysis, there were two subset groups represented as letters of a and b in Fig. 9. Tenon width of 25 and 30 mm carries the same strength as it is in the same subgroup, 35 mm, however, differs from the two. Based on this, it can be said there was a substantial significance of strength properties between 35 mm when compared to 25 and 30 mm.

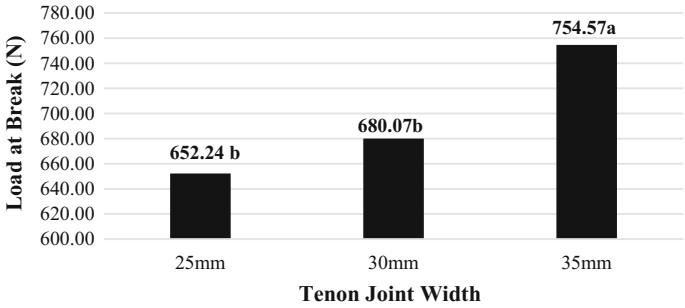

Fig. 9 Effects of tenon joint width on mortise and tenon joint based on bending test

3.3 Tensile Test

Figure 10 illustrates the result for tensile strength where there were two subgroups emerged after performing statistical analysis computed on Duncan test. According to the results, tenon width of 25 and 30 mm are in the same group (b), meanwhile tenon width of 35 mm is in another group (a). Furthermore, the width of 35 mm also had the highest strength properties in tensile strength, which was the same as in bending test.

The results of this study have proven that the wider the tenons are, the stronger the jointing is, which agrees on a study by Tankut and Tankut (2005) where they also found as the tenon width increases, the strength of the joint also improved. It is clear from the results that the dimensions of tenons width of 35 mm should be used when constructing chairs.

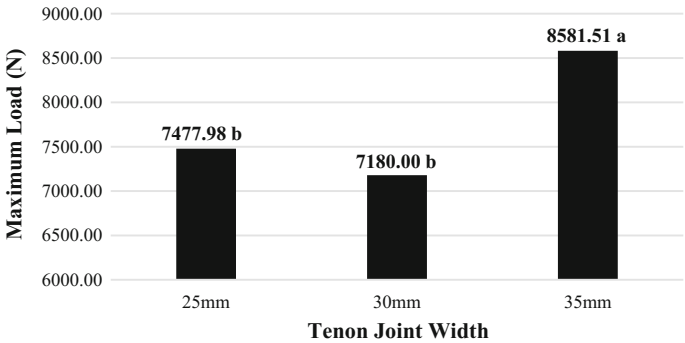

Fig. 10 Effects of tenon joint width on mortise and tenon joint based on tensile test

4 Conclusion

In conclusion, the wider the tenon size, the higher the strength of the joints. Therefore, during chair construction, in order to have a more durable chair, wider tenon is a must. Mortise and tenon are undeniably an important factor in making a chair long-lasting. However, for further investigation, tenon's length also needs to be evaluated.

Acknowledgements The authors would like to acknowledge Universiti Teknologi MARA Cawangan Pahang for providing laboratory throughout the period of this research.

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Part VI
Health and Medicine

Chapter 57
Investigation of Total Faulty Breathing Scale (TFBS) Using Visual Observation and Videogrammetry Methods

Vikram Mohan, Aatit Paungmali, Patraporn Sitilerpisan, Romizan Jathin, Norazlin Mohamad, Sulaiman Md Dom, Siti Hawa Mohd Nasir and Munirah Mustafa

Abstract Background: Breathing pattern is one parameter that is currently proposed to be affected even in healthy subjects. However, most of the assessment techniques available for assessing breathing pattern have not been systematically evaluated. In this context, Total Faulty Breathing Scale (TFBS) is one of the assessment tools which can be used simply to assess breathing pattern. However, clinical applicability has not yet been established. The objective of this study was to investigate breathing pattern using TFBS on visual observation and video recording

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_57

methods. Method: This was a cross-sectional study which was carried out on 24 healthy male subjects. The assessment of scoring system was carried out by an experienced physiotherapist using TFBS for both visual and videogrammetry methods. Results: The results of the study showed that there was no statistically significant difference in the score between visual and videogrammetry methods ($p > 0.05$). This signifies that TFBS of scoring can be used to assess the breathing pattern. Conclusions: Both visual and video recording methods can be used interchangeably for assessing breathing pattern using TFBS. This breathing scale is a potential tool for assessment of faulty breathing patterns in clinical practice.

Keywords Breathing · Faulty breathing · Videogrammetry · Visual observation

1 Introduction

Breathing is an important component for all processes to take place in our human body system. Hence, breathing pattern assessment could be considered as one of the essential indicators to evaluate. In general, normal breathing is characterized as diaphragmatic breathing which involves coordinated movement of chest wall and abdomen (Bradley and Esformes 2014). The coordinated movement takes place with initiation of inspiration when the diaphragm contract and descends downwards. This further increases the pressure in the abdominal cavity and the abdominal wall moves outwards. During quiet expiration, the diaphragm relaxes and the abdominal wall ascends towards the spine. On the other hand, the ribs and thorax move downward and inward during expiration (Perri and Halford 2004). The whole process of expiration occurs passively by elastic recoil of the lungs and chest wall. In addition, expiration may take place actively by contraction of abdominal and internal intercostal muscles.

In contrast to the normal breathing, altered breathing pattern occurs when the superior thoracic expansion is greater than abdominal and lateral costal expansion during inhalation (Ha et al. 2014). The alteration in pattern of breathing can be called as faulty breathing (FB) or breathing pattern disorders (BPD) or dysfunctional breathing (DB) (Barker and Everard 2015; Clifton-Smith and Rowley 2011; Perri and Halford 2004). As a result, it requires accessory muscles to work more while breathing and causes muscle strain which could lead to musculoskeletal problems. On the other hand, expiration is faulty if rib motion is reduced, the breath is held and not fully exhaled or paradoxical breathing takes place (Perri and Halford 2004).

Breathing pattern can be altered by diseases and injuries to lung tissue, rib cage, respiratory muscle and nerves (Gunnesson and Olsén 2011). According to Clifton-Smith and Rowley (2011), the mechanisms of underlying breathing pattern disorders could involve physiological, psychological and biomechanical factors, and these components cannot be completely separated. Hence, it can be inferred that the alteration in breathing pattern could occur even among healthy subjects

when these factors alter even without active disease process. In addition, faulty breathing patterns could present differently among healthy individuals.

In clinical setting, the techniques used to assess breathing pattern are usually through observation and manual palpation. However, these two methods of assessments have not been standardized as there is difference in hand placement of the therapist and the assessment findings also differed among assessors (Courtney et al. 2009). The objective methods of recognizing breathing pattern are carried out by several tools which include the Manual Assessment of Respiratory Motion (MARM) (Courtney et al. 2009); the Hi Lo Breathing Assessment (Courtney et al. 2009); the Respiratory Induction Plethysmography (RIP) (Courtney et al. 2008); the Respiratory Movement Measuring Instrument (RMMI) (Gunnesson and Olsén 2011); the photogrammetric method (Cihak et al. 2006); and the videogrammetry method (Herráez et al. 2013). However, these tools are not widely used as it requires experienced and trained examiners to perform these assessment methods (Courtney et al. 2008). In addition, most of the assessment techniques available for assessing breathing pattern have not been systematically evaluated.

An earlier study conducted by Perri and Halford (2004) investigated both relaxed and deep breathing to measure the incidence of normal and faulty breathing using a simplified rating scale to evaluate the breathing pattern. This scale was adopted in this present study, and its reliability measures of Total Faulty Breathing Scale (TFBS) were also established before conducting the study. In this context, TFBS is one of the assessment tools which can be used simply to assess breathing pattern. However, clinical applicability has not yet been established. In addition, to compare the breathing pattern, the theory of the videogrammetry method was also employed to estimate breathing patterns and to compare the clinical applicability with visual observation method. Therefore, the aim of this research was to compare breathing pattern via visual and video record techniques based on the scale created.

2 Materials and Methods

A cross-sectional study was conducted as one single measurement from a physiotherapy department clinic of a public university after obtaining ethical approval from university ethics committee. A total of 24 healthy male subjects were recruited based on the criteria as set by the study protocol. Subjects who were aged between 18 and 30 years with no complaints of pain in the body on the day of testing and those who are able to understand the instruction from examiners were included. Those who had a history of smoking, chronic diseases, abdominal or chest wall surgery and cardiorespiratory diseases were excluded. Information about the study procedures and purpose of the study was briefed to the study subjects before obtaining written informed consent.

3 Instrumentations

3.1 Breathing Pattern Assessment

The subjects were rested for 5 min in seated position to restore normal breathing, respiratory rate and blood pressure. Then, they were requested to remove the shirt such that area of assessment can be exposed and assessed. The breathing assessment through visual observation and video recording was carried out in standing position without additional support for a period of 1 min against the same background for every subject (Cihak et al. 2006). The assessment techniques of visual and video observation technique were as follows:

Visual Observation Technique
The assessment was evaluated by an experienced physiotherapist using TFBS form. Initially, the examiner observed relaxed breathing without patients' awareness. Next, the examiner instructed the subjects to take several deep and slow breaths in and out. The examiner observed for abdominal and chest breathing as well as the presence of upper chest lifting along with lateral rib expansion (Perri and Halford 2004).

Video Recording Technique
Simultaneously, when the visual observation was carried, the video was recorded by using a digital video camera (Canon EOS 600D, lens EFS 18–15 mm macro 0.25 m/0.8 ft). A tripod stand was used to hold the camera in upright position such that the height of camera was adjustable based on subject's height. The reference point of the camera was from anterior superior iliac spine to clavicle. The distance between the camera/examiner and the subjects was kept as 30 cm. The video was recorded from the anterior side of subjects' chest wall.

3.2 Image Processing

The videos caught were exported to a computer for analysis. The examiner analysed the videos through the computer and recorded the findings on the scoring sheet as provided by the principal researcher. The videos of the entire subject were analysed for both relaxed and deep breathing. The total score of TFBS for all of the subjects was calculated by the examiner after analysing the videos (Table 1).

3.3 Total Faulty Breathing Scale (TFBS)

The criteria of the scale were set as according to an earlier study (Perri and Halford 2004). Both relaxed and deep breathing scores were used to create a scale called

Table 1 Total faulty breathing scale form

Date of assessment		ID
Normal/relaxed breathing		
Score	Criteria	Observation ($\sqrt{}X$)
1	Absence of outward lateral rib motion	
2	Lifting of the clavicle	
3	Paradoxical breathing	
Deep breathing		
Score	Criteria	Observation ($\sqrt{}X$)
1	Absence of outward lateral rib motion	
2	Lifting of the clavicle	
3	Paradoxical breathing	

Symbols $\sqrt{}$ = 1, 2 or 3 depending on the criteria, $X = 0$

'Total Faulty Breathing Scale' with a modified scoring system which ranged between 0 and 12 as described in Table 1.

3.4 Statistical Analysis

SPSS windows version 21 was used to analyse the data. Descriptive statistics for the mean and standard deviation was calculated for age, height, weight and Body Mass Index (BMI). Frequency and percentage was calculated for visual and video recording of TFBS. Wilcoxon-signed rank test was opted to know if there is any significant difference between the visual and video recording method using TFBS and the level of significance was set at $p < 0.05$.

4 Results

The subjects were 24 males, with a mean age (21.04 ± 1.68) years, height (1.67 ± 0.06) metres, weight (64 ± 12.38) kilograms and BMI (22.98 ± 3.34) kilograms/meter^2. Frequency and percentage of TFBS for visual and video recording were presented in Table 2. Wilcoxon-signed rank test revealed that there was no significant difference in the values between visual (mean = 2.58, s.d = 1.34) and video recording (mean = 2.54, s.d = 1.2) with a t-value of 0.73 and p value of 0.74.

Table 2 Descriptive statistics of the study variable

TFBS	Visual method frequency (%)	Video recording method frequency (%)
Normal breathing	3 (12.5)	2 (8.3)
Mild faulty breathing	21 (87.5)	22 (91.7)

TFBS Total Faulty Breathing Scale

5 Discussion

This study was designed to investigate the potential of TFBS in eliciting faulty breathing between visual observation and video recording method. According to the findings, the results showed that TFBS scored by the examiner was not different between visual observation and video recording method among healthy male adults. Therefore, the study demonstrates that both the technique can be used to assess the breathing pattern using TFBS.

The key findings of the present study are that TFBS has the ability to detect altered breathing pattern based on the scoring pattern as normal and mild among healthy male subjects. Hence, it can be believed that healthy subjects also exhibit altered breathing pattern. The results of this study were supported by an earlier study in which the authors have shown that the healthy subjects exhibited altered breathing pattern (Bradley and Esformes 2014). Even though the present study was supported by an earlier study, the methodological components used in these studies were different. The methodology used to assess BPD was through capnography, Hi Lo method and Nijmegen Questionnaire which was beside the present study methodological perspective (Bradley and Esformes 2014).

Hi Lo and MARM technique utilizes hand palpation to elicit altered breathing pattern which could probably influence the subject to alter their breathing pattern (Courtney et al. 2009). Therefore, the method of observation method which was utilized using TFBS could be of advantage to the examiner, since it utilizes only observational scoring method in the form provided.

In addition, the scoring system which was used in the present study using TFBS was able to identify faulty breathing pattern. The visual observation method of scoring showed normal (12.5%) and mild (87.5%) faulty breathing pattern. Similarly, video recording method showed,normal breathing pattern (8.3%) and mild faulty breathing patterns (91.7%). This signifies that the values of scoring are approximately the same between the methods (Table 2). Hence, it can be alleged that this method of scoring system is easy to score which requires only basic knowledge on respiratory mechanics. Conversely, the MARM which utilizes a system of notation, where the examiner is required to draw lines based on their findings through palpation, requires specialized training (Courtney et al. 2008).

With respect to videogrammetry method, the concept and the techniques were adapted from earlier studies to compare the difference between the two methods of

assessment techniques. The examiner in the present study was able to detect the breathing pattern with the help of video clips which had been shown randomly. This signifies that this method of assessment may be helpful in assessing breathing pattern if the amenities are available in clinical set-up. It can, therefore, be assumed that TFBS could be used in future work either using visual or video recording methods.

The major limitation of the study was it did not implicate female subjects due to ethical and cultural constraints. In addition, the study utilized less number of subjects as the study is a preliminary investigation to test the assumption. Future studies to test the validity of the techniques need to be carried out in a clinical setting on diseased individuals.

6 Conclusion

The study suggests the incorporation of TFBS to evaluate normal and faulty breathing patterns either using visual or video recording methods. This breathing scale is a potential tool for assessment of normal and faulty breathing patterns in clinical practice.

Acknowledgements This study was supported by the Research Management Institute (RMI), Universiti Teknologi MARA (UiTM), Malaysia [600-RMI/DANA 5/3/LESTARI (104/2015)].

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Chapter 58
The Reliability and Validity of the Malay® Version of Tampa scale of Kinesiophobia in Older Persons with Low Back Pain

Nor Azizah Ishak, Zarina Zahari and Maria Justine

Abstract The objectives of this study were to describe the translation process of the Malay® version of Tampa scale of kinesiophobia (TSK-MV) and to determine the reliability and validity of TSK-MV among older persons with Low Back Pain (LBP). Sixty-one participants (age = 70.57 ± 8.31 years) were recruited for testing TSK-MV. During the first test, demographic characteristics, cognitive functions, Fear Avoidance Beliefs Questionnaire (FABQ), Short Form-36 version 2 (SF-36 v2) and TSK-MV were evaluated. In the second test, TSK-MV, was assessed after 2 weeks interval. The TSK-MV showed good internal consistency for the total score and its subscales (Cronbach Alpha > 0.7). The TSK-MV has excellent test-retest reliability for total score and avoidance activity factors (ICC > 0.7). The TSK-MV demonstrated good concurrent validity with FABQ physical activity (FABQpa) ($p = 0.001$) and SF-36 Physical Health (SF-36PH) ($p = 0.004$). The activity avoidance and somatic focus subscales of TSK-MV showed excellent inter subscales correlation ($p < 0.01$) and good correlation with FABQpa and SF-36PH ($p < 0.05$). The reliability and validity of the TSK-MV were acceptable for assessing kinesiophobia level in Malay speaking older persons with LBP. Future studies are required to assess changes of kinesiophobia levels over time and after intervention.

Keywords Kinesiophobia · Malay version · Reliability · Validity

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_58

1 Introduction

Low back pain (LBP) can be defined as pain between the costal margins and the inferior gluteal folds that accompanied with limitation to perform movement (Kovacs et al. 2008). Based on fear avoidance model (Vlaeyen et al. 1995), when individuals experience pain, they may misinterpret the experience of pain, which will create fear of pain perception and later develop avoidance and escape behaviour. The avoidance behaviours occur in movements, physical activities, exercises and also work activities. Subsequently, avoidance behaviours would lead to kinesiophobia, which is an excessive, irrational and debilitating fear of physical movement and activity as a result of feeling of susceptibility to painful injury or re-injury (Burwinkle et al. 2005).

A person who had high degree of kinesiophobia may show more avoidance behaviours even in a simple movement (Vlaeyen et al. 1995). The avoidance behaviours often arise from fear of movement that may create avoidance to daily activities, which lead to a decline in muscular strength, fitness and later develop functional disability (Huijnen et al. 2013). Kinesiophobia was recognized as an important factor that may cause disability, disuse and depression with persistent musculoskeletal pain (Lundberg et al. 2011), including LBP. In clinical settings, kinesiophobia is an important factor that needs to be addressed in order to ensure successful outcomes of rehabilitation programs, as it may interfere an individual compliance to exercise program.

The Tampa scale of kinesiophobia (TSK) was developed to assess the kinesiophobia. The original version of TSK consists of 17 items which assessed subjective ratings of fear-related concept (Gregg et al. 2015). The version of TSK varies into another shortened version which involved 13 and 11 items. The psychometric properties revealed that the Tampa scale of Kinesiophobia-11 is a valid and reliable instrument to assess the fear of movement/re-injury pain in patients with chronic pain (Tkachuk and Harris 2012).

The TSK has been widely used in both research and clinical setting purposes for the assessment of kinesiophobia in various musculoskeletal problems. This instrument has been translated and validated in other languages such as Brazilian (Siqueira et al. 2007), Chinese (Wong et al. 2010), Dutch (Goubert et al. 2004), Finnish (Koho et al. 2015), Italian (Monticone et al. 2010), Japanese (Kikuchi et al. 2015), German (Rusu et al. 2014), Norwegian (Haugen et al. 2008), Spanish (Lo 2011) and Swedish (Larsson et al. 2014). The translation of TSK into different languages allows the exchange of information in terms of screening kinesiophobia levels as well as predicting chronicity and disability across different population, worldwide. Despite the high potential of application of the TSK in clinical and research settings, it might not be suitable to be applied in Malaysia, due to language barrier. In Malaysia, clinicians are currently using the English version of TSK for the evaluation of kinesiophobia. The assessors tend to translate the questions directly into Malay language and language manipulation could happen during the

interview processes. Therefore, the score of the questionnaire might be inaccurate in determining the level of kinesiophobia in patients with LBP.

A new version of TSK in the Malay version needs to be developed and tested for its reliability and validity before it can be used among Malay speaking population as a proper measure. A valid and reliable instrument in evaluating movement-related fear is crucial for clinical practice and will provide understanding on pain, fear, and fear of movement in the Malaysian population. Because a Malay version of TSK has not been available until now, this study was conducted with the aims to (1) describe the translation process of the proposed Malay® version of TSK; (2) to determine the reliability and validity of the Malay® version of TSK. We hypothesize that the Malay® version of TSK is a valid and reliable instrument in Malay speaking older persons with LBP.

2 Methods

2.1 Subjects and Study Design

This study involved 61 institutionalized older persons (age 60–89 years) from public funded institutions. The subjects would be included if the following inclusion criteria were satisfied: (1) age 60 years and above; (2) have low back pain/backache/back pain/back disorder, diagnosed by medical doctors; (3) able to understand and respond to Malay/English language and follow instructions on study procedures. The subjects were excluded if they present with: Cognitive impairment (score of Mini Mental State Examination less than 24) (Bastone and Filho 2004). This study was approved by the Research Ethics Committee of Faculty of Health Sciences, Universiti Teknologi MARA (UiTM) (Ethical Research Meeting Bil. 8/2015, Ref. No. 600-FSK (PT. 5/2). Approval to conduct the study at the institution was received from The Social Welfare Department of Malaysia (Ref. No. JKM 100/12/5/2 JLD 71 (4)). All subjects who agreed to take part in this study were informed with the objectives and procedures of the study, prior to signing an informed consent.

2.2 Study Procedures

During the first measurement, demographic questionnaire, TSK-MV, fear avoidance beliefs questionnaire (FABQ) and Short Form 36 (SF-36) were distributed to all subjects. Subjects who were able to answer the questions independently completed the questionnaire and returned to the researcher. The researcher read the questionnaire to subjects and asked their response to the subjects who were unable to complete the sets of questionnaire independently. In the second measurement which was done after 2 weeks interval, subjects were required to complete the TSK-MV only.

3 Instrumentations

3.1 Evaluation of Pain

The pain intensity in the lower back region was assessed by a Numeric Rating Scale (NRS) that ranged from '0' (no pain at all) and '10' (worst pain). Subjects select a whole number (0–10 integers) that best represents the intensity of their pain (Hawker et al. 2011); in which higher NRS indicates higher severity of LBP. The subjects' duration of pain at the lower back area also was assessed in the general demographic data.

3.2 Tampa scale of Kinesiophobia-11

The 11 items of Tampa scale of Kinesiophobia (TSK-11) was used to measure the level of fear of movement or re-injury among older persons. This questionnaire has acceptable level of internal consistency, evidence of discriminants, concurrent criterion and incremental validity with Cronbach's α 0.8 (Tkachuk and Harris 2012). The TSK-11 consists of 11 questions that can be divided into two factors which are somatic focus and activity avoidance (Roelofs et al. 2011). The somatic focus will predict perceived disability (items 1, 2, 7, 9, 10, 11) while activity avoidance focus on actual physical performance, controlling for pain severity (items 3, 4, 5, 6, 8) (Walton and Elliott 2012). This questionnaire is provided with 4-point Likert scale, from 'strongly disagree' to 'strongly agree'. The scoring of TSK-11 ranges from 11 to 44, and the higher score of TSK-11 represents higher levels of kinesiophobia.

3.3 Translation process

Step 1: Translation into Malay
The TSK-11 was translated from English to Malay with the aim to maintain its original questions and keep the same meaning. The translations were done by three native Malay speakers, who had medical background and compared their versions. Finally, all of the researchers agreed on a new single version, after the correction of inconsistencies.

Step 2: Back Translation into English
The back translation of the Malay version into English was conducted by one English lecturer, who did not have medical background. The English back translation was compared with the original version of TSK-11 to check for inconsistencies and to ensure the same meaning and item contents. Then, the inconsistencies were corrected in the final Malay® version.

3.4 Fear Avoidance Beliefs Questionnaires (FABQ)

The FABQ was originally developed by Waddell et al. in 1998, to assess fear avoidance beliefs (Williamson 2006). In this current study, the Malay version of FABQ was used for the validation of TSK-MV. This questionnaire was translated by Zahari (2013) and had a good reliability (Cronbach $\alpha = 0.83$) and validity. This questionnaire consists of 16 items which evaluate fear avoidance beliefs in both physical activity and work. The FABQ work (FABQw) consists of seven questions, while FABQ physical activity (FABQpa) consists of nine questions. In this instruments, subjects were required to rate their agreement based on a 7-point Likert scale from 0, 'totally disagree' to 6 'totally agree', regarding their fear avoidance beliefs in physical activity and work. The total score for FABQw and FABQpa are 42 and 24 respectively, whereby the higher score represented the higher fear avoidance beliefs.

3.5 Short Form-36 (SF-36)

The SF-36 Malay version was used for the purpose of validation of TSK Malay® version, which was developed and validated by Sararaks et al. (2005). SF-36 is the generic outcome measure of sickness or disease (Klooster et al. 2013) and has been widely used as a tool for examining the health-related quality of life. This questionnaire contains 36 questions regarding general health status in terms of mental and physical health of the subjects which are physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health. Overall, the total score of SF-36 can be divided into mental and physical health summary, in which the total score were 70 respectively. The scoring of SF-36 for mental and health summary were as follows: 0–30 (worst), 30–50 (average) and 50–70 (best).

3.5.1 Statistical Analysis

The data was analysed using IBM Statistics software version 20. The mean and standard deviation of all the variables were calculated. The descriptive statistics were used for socio-demographic data and pain intensity among subjects. Power analysis was conducted using G-Power 3 software©, where power is set at 0.95 and at 0.05 using Correlation: Point Biserial Model. Therefore, the sample size of 59 participants was sufficient to provide moderate effect for the correlation analysis. For the purpose of reliability of the TSK-MV, the internal consistency was evaluated by Cronbach's α coefficient. The test-retest reliability was analysed using intra-class correlation coefficients (ICC) of test and retest measurements. In order to determine the concurrent validity, the correlations were analysed using the

Pearson's correlation coefficient between TSK-MV and its subscales with the Malay version of FABQ and SF-36 as well as the inter-item correlations between TSK-MV with its subscales (TSK-AA and TSK-SF). The p values < 0.05 were set as statistical significant.

4 Results and Discussion

4.1 Demographic Characteristics of the Subjects

Table 1 shows the demographic data of the subjects in this study. This study involved 61 subjects, whereby 33 subjects were male and 28 were female, with the mean age 70.57 ± 8.31 years old. About 55.7% of the subjects had experience of LBP more than 12 months.

Table 1 Demographic characteristic of subjects (n = 61)

Variables	Mean ± SD
Age (years) (range 60–89)	70.57 ± 8.31
Pain intensity (range 0–10)	4.23 ± 1.62
TSK-AA test	16.31 ± 4.06
TSK-SF test	14.13 ± 3.74
TSK-MV (total score) test	30.42 ± 7.09
TSK-AA retest	15.62 ± 4.66
TSK-SF retest	12.84 ± 3.88
TSK-MV (total score) retest	28.39 ± 7.93
FABQpa	13.10 ± 7.95
FABQw	15.72 ± 9.44
SF-36PH	45.51 ± 6.93
SF-36MH	43.57 ± 9.59
Gender	*n* (%)
Male	33 (54.1)
Female	28 (45.9)
Duration of pain (months)	
<1	9 (14.8)
1–3	6 (9.8)
3–6	5 (8.2)
6–12	7 (11.5)
>12	34 (55.7)

TSK-AA Tampa scale of Kinesiophobia Avoidance Activity; *TSK-SF* Tampa scale of Kinesiophobia Somatic Focus; *FABQpa* Fear Avoidance Beliefs Questionnaire physical activity; *FABQw* Fear Avoidance Beliefs Questionnaire work; *SF-36PH* Short Form-36 Physical Health; *SF-36MH* Short Form-36 Mental Health

Table 2 Reliability properties TSK-MV

Scale	No of items	Cronbach's Alpha	ICC
Factor SF	5	0.795	0.464
Factor AA	6	0.741	0.778
TSK-MV	11	0.841	0.874

4.2 Reliability Properties of TSK-MV

The mean score (SD) for the first measurement (T1) of the TSK-MV was 30.42 ± 7.09 and 28.39 ± 7.93 for retest (T2) measurement. The Cronbach's alpha for the total score of TSK-MV was 0.84; while for the SF and AA subscales were 0.795 and 0.841 respectively (Table 2). The ICC for total score, SF and AA subscales were 0.874, 0.464 and 0.778, respectively.

4.3 Validity Properties of TSK-MV

Table 3 demonstrates the concurrent validity of the TSK-MV using Pearson correlation coefficients between TSK-MV, SF and AA subscales as well as other related measures. For the intercorrelations of TSK-MV with its subscales, the results showed a strong and significant correlation in between SF, AA subscales and TSK-MV ($p < 0.001$).

For the correlations between TSK-MV and other theoretical related measures, the TSK-MV showed significant correlation with FABQpa ($p = 0.001$) and SF-36PH ($p = 0.004$). However, the TSK-MV were not correlated with FABQw ($p = 0.279$) and SF-36MH ($p = 0.767$). The SF scale showed significant correlation with FABQpa ($p = 0.000$), SF-36PH ($p = 0.005$). For the AA scale of TSK-MV, the results demonstrated significant correlation with FABQpa ($p = 0.000$) and SF-36PH ($p = 0.015$). In contrast, the TSK-SF were not correlated with FABQw ($p = 0.388$) and SF-36MH ($p = 0.870$). However, the TSK-AA were not correlated with FABQw ($p = 0.261$) and SF-36MH ($p = 0.592$).

5 Discussion

This study demonstrated the translation process, reliability and validity of the Malay® version of the Tampa scale of kinesiophobia. To our knowledge, this is the first study that translates the English version of TSK into Malay language. The Malay® version of TSK seems to be clear; easy to be understood and answered by the subjects. The 11-items questionnaire is a short version rather than 17 and 13 items versions, which might be efficient and consistent to be used; therefore may reduce patient's burden to answer that particular questionnaire and in turn may enhance their understanding.

Table 3 Validity properties of TSK-MV

	Validity criteria	TSK-AA*r* *p*	TSK-SF*r* *p*	TSK-MV*r* *p*
Inter correlations of subscale	TSK-AA	–	0.735** 0.000	0.937** 0.000
	TSK-SF	0.735** 0.000	–	0.915** 0.000
Correlations with other outcome measures	FABQpa	0.458** 0.000	0.915** 0.000	0.419** 0.001
	FABQw	0.146 0.261	0.112 0.388	0.141 0.279
	SF-36PH	−0.311* 0.015	−0.355** 0.005	−0.366** 0.004
	SF-36MH	−0.070 0.592	0.021 0.870	−0.039 0.767

TSK-AA Tampa scale of Kinesiophobia Avoidance Activity; *TSK-SF* Tampa scale of Kinesiophobia Somatic Focus; *FABQpa* Fear Avoidance Beliefs Questionnaire physical activity; *FABQw* Fear Avoidance Beliefs Questionnaire work; *SF-36PH* Short Form-36 Physical Health; *SF-36MH* Short Form-36 Mental Health

The test was conducted using Pearson Correlation coefficient

*The test was significant at the level of 0.05 (one-tailed)

**The test was significant at the level of 0.01 (two-tailed)

In the current study, the 11-items of TSK-MV showed acceptable level of internal consistency (Cronbach $\alpha = 0.84$). Bland and Altmannd (1997) suggested the Cronbach's α value above 0.7 is acceptable for internal consistencies. It is interesting to note that the internal consistency of the Malay® version was higher than the English version of TSK-11 by Tkachuk and Harris (2012). In addition, the subscales of TSK-MV which were SF and AA demonstrated slightly below than the total scores Cronbach α values which were 0.8 and 0.74, respectively. However, the α value of each subscale still reaches the acceptable values of Cronbach α. The findings of the study were consistent with other 11-items versions in other languages (Kikuchi et al. 2015; Larsson et al. 2014; Lo 2011; Rusu et al. 2014). The results of reliability of TSK-MV indicated that the TSK-MV could be used in clinical settings, as the total score demonstrated good reliability.

Subsequently, our study demonstrated good test-retest reliability (ICC = 0.87) for the 11-item questionnaires of TSK. For the subscales of TSK-MV, the AA subscale also showed good test-retest reliability (ICC = 0.78). However, the SF subscale presented with low ICC values (0.47). The low values of ICC of SF subscales might be explained in this way. We performed test-retest analysis of TSK-MV within 2 weeks intervals. Goubert et al. (2004) highlighted the SF subscale explained the belief in underlying and serious medical problems. Therefore, in this case, in the 2 weeks duration, there is a possibility that subjects' beliefs about their medical problems might change as their condition improved. In this study, subjects' score of SF subscale drop from 14.13 to 12.84, which might show their beliefs about their LBP problems, is in the positive way.

For concurrent validity, the present study found strong correlation between TSK-MV, SF, AA subscales with SF-36PH and FABQpa. The AA subscale explained pain anxiety, fear avoidance beliefs related to activity, avoidance of physical activity and social as well as negatively to minimization (Rusu et al. 2014). Therefore, the correlation between AA subscale and the physical health subscale of SF-36 and fear avoidance beliefs related to physical activities showed that the AA subscale was a valid measure of avoidance. In contrasts, although SF subscale was related to feeling harm to underlying conditions, an individual physical health and fear avoidance of physical activities might be contributed by somatic factor, making strong correlation between SF and FABQpa and SF-36PH.

Our study also revealed the SF and AA subscales had strong correlation with one another as well as with total score of TSK-MV. The findings of our study were in the same line with German version (Rusu et al. 2014) that revealed strong correlation between each subscales and total score of TSK. The findings showed both subscales as valid parts of the whole concept of kinesiophobia, which comprised of the concept of fear of movements or physical activities feeling of re-injury. Hence, the two factors in TSK-MV which were somatic focus and avoidance activities fit the previous model suggested by Roelofs et al. (2007).

Additionally, our study revealed no correlation between TSK-MV, SF and AA subscales with SF-36MH and FABQw. However, our study findings were inconsistent with the Brazilian version (Siqueira et al. 2007) that found moderate to strong correlation between TSK and FABQw. The possible explanation of weak correlation between TSK-MV and FABQw might be due to the study population. Subjects involved in the Brazilian version were 18–65 years old, which can be assumed that most of them are working, thus, LBP may lead to fear avoidance beliefs in work. In contrast, the subjects in our study were institutionalized older persons, in which all of them were retired. Therefore, LBP might not affect their fear avoidance beliefs related to work, making weak correlation with TSK, in which the TSK focussed on physical activities or movements.

Our study demonstrated that the TSK-MV was valid and reliable in Malay speaking subjects with LBP. We kept the same meaning from the original (English) version, therefore, the content of each item was similar. This study added theoretical knowledge about kinesiophobia in older persons with LBP. In general, the validity and reliability of Malay version of FABQ was comparable to other languages worldwide, including Brazilian (Siqueira et al. 2007), Chinese (Wong et al. 2010), Dutch (Goubert et al. 2004), Finnish (Koho et al. 2015), Italian (Monticone et al. 2010), Japanese (Kikuchi et al. 2015), German (Rusu et al. 2014), Norwegian (Haugen et al. 2008), Spanish (Lo 2011) and Swedish (Larsson et al. 2014).

6 Limitation

There are several limitations while conducting this study. First, this study was conducted in public funded institutions for older persons, thus, the findings are limited to older persons with LBP residing in institutions. The reliability properties that had been investigated were limited to internal consistency and ICC, whereas the repeatability, inter-rater and intra-rater reliability were not examined. In addition, for validity properties, the face validity, structural validity, predictive validity were not assessed. In future, the TSK-MV need to be explored for other validity and reliability properties, to provide the extension of study regarding the validity and reliability of TSK-MV to be used in other medical problems and populations.

7 Conclusion

In conclusion, the reliability and validity of the Malay® version of the TSK were acceptable for assessing kinesiophobia level in the Malay speaking older persons with LBP. Therefore, we recommend this instrument to be implemented in both clinical settings and research for assessing kinesiophobia in the LBP population as this questionnaire was practically relevant. Future studies are required to assess changes of kinesiophobia levels over time and after intervention.

Acknowledgements We would like to express our gratitude to the public funded institution centre for their participation and help in this study. We also wish to thank the Ministry of Education, Malaysia for funding the research project through the Fundamental Research Grant Scheme (Ref. No. 600-RMI/FRGS/5/3(54/2015)) and the Research Management Centre (RMC), Universiti Teknologi MARA (UiTM) Selangor for administrative support.

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Chapter 59
Low-Dose Methamphetamine Addiction Induced Opioid Receptor Sensitization in Polydrug-Dependent Mice

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Abstract Polydrug dependence shows an increasing trend in prevalence among addicts. It is a result of an addict abusing another drug to mask the undesirable effects of another drug. However, this could lead to adverse neuroadaptations. Therefore, we aim to investigate the effects of low-dose methamphetamine use in morphine-dependent subjects during reinstatement following treatment (0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone combination) in mice. Using tail withdrawal assay, the involvement of opioid receptors was investigated at 1.0–5.0 mg/kg methamphetamine, i.p. at 52 °C. The results showed that analgesic activity was only detected at the highest dose given, which was successfully blocked with

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_59

1.0 mg/kg naltrexone, i.p. ($p < 0.001$, $n = 6$). Next, naïve mice were randomly divided into three groups ($n \geq 12$) where the mice were made dependent ($p < 0.01$) to morphine (7.5 mg/kg, i.p.), methamphetamine (1.0 mg/kg, i.p.) or morphine/methamphetamine combination (7.5 and 1.0 mg/kg respectively). Although relapse was successfully attenuated with non-significant difference compared to baseline, it was found that 6 out of 13 mice showed sign of opioid receptor sensitization through stereotype and Straub's tail response (>45°) which was not detected in the morphine- and methamphetamine-dependent groups during pre-screening of treatment drug. This suggests that although methamphetamine has little apparent withdrawal symptoms, it has the ability to sensitize the opioid receptors even at 'inactive' doses when it is used concurrently with morphine.

Keywords Methamphetamine · Opioid receptor · Polydrug

1 Introduction

Drug addiction is a chronic brain disorder and illness characterized by persistent compulsive drug-seeking and drug-taking behaviours regardless of the harmful consequences (Feltenstein and See 2008). While relapse to drug taking is a major contributing factor to the low success rate of opioid addiction treatment programme, the co-occurrence of polydrug addiction further complicates the treatment (Bailey and Husbands 2014). In Asia, the addiction pattern shows an increase of methamphetamine (a psychostimulant) addiction among patients who take methadone as opioid substitution therapy (Shariatirad et al. 2013). The main reason for them to take methamphetamine is to overcome the sedative and lethargic effects associated with methadone treatment (Duvauchelle et al. 1998; Leri et al. 2003). The use of different classes of abusive drugs is termed as polydrug dependence (Carruth and Wallen 2014). Methadone (a long-acting and full μ-opioid agonist) is proven to be effective as a substitution drug for opioid dependence, but not for psychostimulants (Lingford-Hughes et al. 2012). The concurrent use of psychostimulant leads to an issue of the ineffectiveness of methadone therapy since the brain neurocircuits in modulating dependence for these two classes of drugs are quite different. Although both classes of drugs increase the level of dopamine at the synaptic clefts in the mesocorticostriatolimbic's brain regions (especially nucleus accumbens [NAcc]), the involvement of the opioid receptor system is still unclear, especially for methamphetamine (Chiu et al. 2006; Lan et al. 2009). Buprenorphine is another drug that is approved by USFDA as one of the treatments for opioid dependence. Compared to methadone, buprenorphine has a very unique pharmacological profile at opioid receptors since it has mixed agonist/antagonist property. Despite the partial efficacy at the μ-opioid receptor (the receptor that is highly associated with drug dependency), its antagonistic activity at the κ-opioid receptor and partial agonist activity at the nociceptin opioid peptide (NOP) receptor are strongly believed to contribute to anti-relapse potential of this drug (McCann 2008). These κ- and NOP opioid receptors activity have also shown to reduce the

drug-seeking behaviour of many drugs of abuse, including cocaine (a psychostimulant) and alcohol (Redila and Chavkin 2008; Rutten et al. 2010). Thus, this study aims to investigate the effects of low-dose methamphetamine addiction towards the opioid receptor system in morphine-dependent mice (polydrug dependence) treated with a buprenorphine/naltrexone combination (a mixed μ-/κ-opioid antagonists/partial NOP agonist).

2 Materials

2.1 Subjects

All experiments were done using adult male Swiss albino mice (8–10 weeks old) weighing around 25–35 g. Mice were housed in groups of 10 for each cage in a room with 12 h light/dark cycle and the temperature maintained was at 21 ± 1 °C. All mice received a week of acclimatization period in the animal house before any experiment starts (National Research Council of the National Academies 2011). Food and water were available ad libitum until the time of experiment. Each subject was tested only once and the experimental protocols were approved by the IIUM's Institutional Animal Care and Use Committee (IIUM/IACUC Approval/2014/[3] [13]).

2.2 Drugs

Morphine sulfate solution was obtained from Hameln Pharmaceuticals (UK), buprenorphine hydrochloride and methamphetamine hydrochloride were purchased from Lipomed (Switzerland), while naltrexone hydrochloride was obtained from Tocris Bioscience (UK). Nor-Binaltorphimine dihydrochloride was purchased from Sigma-Aldrich (USA). Buprenorphine hydrochloride, methamphetamine hydrochloride, naltrexone hydrochloride and nor-Binaltorphimine dihydrochloride were dissolved in normal saline (0.9% sodium chloride) (Ain Medicare Sdn. Bhd., Malaysia). All drugs were administered in a volume not exceeding 0.1 mL/10 g of body weight. All doses are expressed as the free base of the drug. All drugs were prepared as a stock solution and stored at −20 °C.

3 Methods

3.1 Tail Withdrawal Test

A total of 30 mice used in this experiment were divided into five different groups of 6. Each group was assigned for morphine (10.0 mg/kg), methamphetamine (1.0, 2.0

and 5.0 mg/kg) and methamphetamine (5.0 mg/kg) pretreated with naltrexone (1.0 mg/kg). All procedures were adapted from Le Bars et al. (2001) with slight modifications. Approximately one-third of the distal portion of the tail was immersed in water bath (52 ± 1 °C) and latency to withdraw its tail was measured and compared to the average individual baseline. Latency to withdraw the tail was taken following drug administration. The readings were taken every 5 min (for morphine) and every 7.5 min (for methamphetamine) up to 30 and 75, min respectively. All drugs were given through intraperitoneal route. The readings recorded at the end of the experiment were used in subsequent analysis.

3.2 Conditioned Place Preference (CPP) Test

The naïve mice were divided into six groups (with at least 12 mice for each group) depending on the drugs received during the conditioning phase (7.5 mg/kg morphine, 1.0 mg/kg methamphetamine or 7.5 mg/kg morphine/1.0 mg/kg methamphetamine [polydrug]) and the interventions received during reinstatement phase (0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone combination [treatment] or saline [control]). All procedures for CPP were adapted from Cordery et al. (2014) with slight modifications. The CPP procedures consist of four major phases, which includes exploratory (3 days), conditioning (6 days), extinction training (7 days minimum) and reinstatement (1 day) to establish a valid reinstatement (relapse) model using a three-compartment CPP box. Percentage preference at the drug-paired compartment was calculated for each phase and was compared to its baseline. All drugs (including saline) were given through intraperitoneal route.

3.3 Straub's Tail Response

The naïve mice were randomly divided into four groups (with at least 3 mice for each group) depending on the treatments received. The drug was given once with either 3.75 mg/kg morphine (pretreated with 0.3 mg/kg buprenorphine), 1.0 mg/kg methamphetamine (pretreated with 0.3 mg/kg buprenorphine), 3.75 mg/kg morphine/1.0 mg/kg methamphetamine (polydrug) (pretreated with 0.3 mg/kg buprenorphine) or 3.75 mg/kg morphine/1.0 mg/kg methamphetamine (polydrug) (pretreated with 0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone combination). Immediately after injection, the mice were placed inside one of the large compartments of the CPP box and the degree of tail elevated was observed and measured.

3.4 Statistical Analysis

All data were expressed as mean ± *SEM* with 95% confidence intervals. The data were then statistically analysed using one way ANOVA with Benferroni post hoc test (for tail withdrawal test) and paired samples *t*-test (for CPP test). A *p*-value less than 0.05 is considered to be statistically significant.

4 Results and Discussion

4.1 Tail Withdrawal Test

The results showed that 5.0 mg/kg methamphetamine caused marked analgesia in mice during the tail withdrawal test with no significant difference to 10.0 mg/kg morphine (Meth 5 = 11.08 ± 0.33 s vs. Morphine 10 = 11.00 ± 0.43 s, $n = 6$). However, when lower doses of methamphetamine were tested (1.0 and 2.0 mg/kg), both of the doses failed to produce analgesic activity (Meth 1 = 0.08 ± 0.64 s, Meth 2 = 0.42 ± 0.44 s, $n = 6$). The analgesic activity of 5.0 mg/kg methamphetamine was diminished when the mice were pretreated with a non-selective opioid receptor antagonist (1.0 mg/kg naltrexone) with extremely significant difference compared to the standard drug used, 10.0 mg/kg morphine ($p < 0.001$) (Fig. 1).

Tail withdrawal test is used to indirectly identify the involvement of the μ-opioid receptor in mediating drug dependence since this receptor is responsible in both

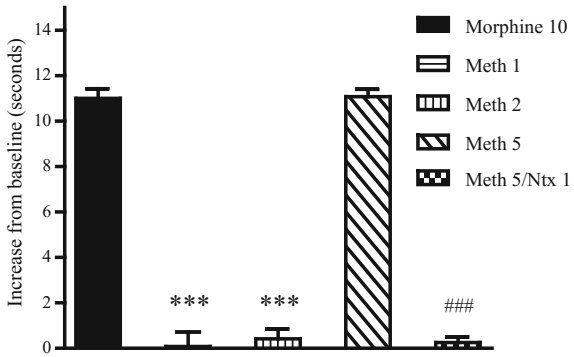

Fig. 1 Tail withdrawal test, comparing the latency of tail withdrawal between 10.0 mg/kg morphine (Morphine 10) and different doses of methamphetamine; 1.0 mg/kg methamphetamine (Meth 1), 2.0 mg/kg methamphetamine (Meth 2) and 5.0 mg/kg methamphetamine (Meth 5) and the effects of 1.0 mg/kg naltrexone pretreatment on the analgesia induced by 5.0 mg/kg methamphetamine in mice (Meth 5/Ntx 1). *** indicates an extremely significant difference ($p < 0.001$) from 10.0 mg/kg morphine (Morphine 10), while ### indicates an extremely significant difference ($p < 0.001$) from 5.0 mg/kg methamphetamine (Meth 5)

analgesia and dependence effects (Cordery et al. 2014). The water bath temperature was maintained at a slightly higher temperature (52 ± 1 °C) in order to also detect any κ-opioid receptor agonist activity of methamphetamine (Christoph et al. 2005). From these data, it shows that 10 mg/kg morphine was equipotent to 5.0 mg/kg methamphetamine to produce analgesic activity, while the lower doses of methamphetamine did not increase the latency to tail withdrawal in mice. A previous study shows that 2.5 mg/kg methamphetamine affects the endogenous opioid ligands in the brain which leads to downregulation of the μ-opioid receptors. This test was conducted in Swiss mice for seven consecutive days using a behavioural sensitization paradigm (Chiu and Ho 2006). The downregulation of the μ-opioid receptors might lower the activation threshold of this opioid receptor system at this dose.

From the current experiment, it is not necessary for the μ-opioid receptors to be directly triggered when methamphetamine is abused, especially when it involves a low-dose methamphetamine. Therefore, based on the current findings, the 1 mg/kg methamphetamine dose selected to be used in the CPP test should not activate the μ-opioid receptors. This methamphetamine dose is lower than the dose tested by Chiu and Ho (2006).

4.2 Conditioned Place Preference Test

4.2.1 Morphine-Conditioned Group

7.5 mg/kg morphine significantly developed dependence in both control and treatment (0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone) groups with the preference at the drug-paired compartment of 29.81 ± 5.51% ($p < 0.001$, $n = 9$) and 16.80 ± 6.23% ($p < 0.01$, $n = 7$), respectively. During reinstatement, the treatment group successfully attenuated reinstatement to morphine after priming dose (2.5 mg/kg morphine) was administered. The attenuated reinstatement happened after complete abstinence was achieved, and this was not significantly different compared to the baseline, which showed a preference at the drug-paired compartment of −22.46 ± 18.17% ($n = 5$) and −0.01 ± 5.03% ($n = 12$). This was not observed in the control group, where priming dose of morphine given was proven to induce reinstatement to morphine, which was very significantly different from the baseline with percentage preference at the drug-paired compartment of 60.4 ± 9.06% ($p < 0.01$, $n = 7$) and −5.57 ± 5.47% ($n = 13$) respectively (Fig. 2). This is in line with the previous study conducted by Cordery et al. (2014) where the buprenorphine/naltrexone combination successfully attenuated reinstatement in morphine-dependent Sprague Dawley rats (5.0 mg/kg) when the priming dose of 1.25 mg/kg morphine was administered.

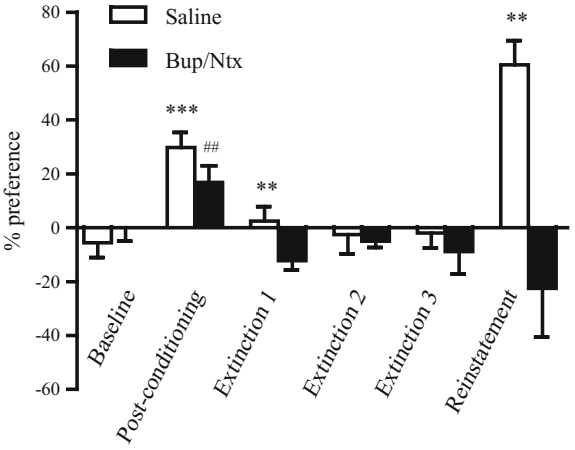

Fig. 2 CPP test for morphine-conditioned (saline [control] and buprenorphine/naltrexone [Bup/Ntx] [treatment]) groups. ** and ## indicate a very significant difference ($p < 0.01$) from baseline and *** indicates an extremely significant difference ($p < 0.001$) from baseline

Buprenorphine is a unique opioid drug because it targets multiple opioid receptors. Compared to methadone that solely acts on the μ-opioid receptor as a full agonist, buprenorphine has a mixed agonist/antagonist activity at the opioid receptor (partial μ-/NOP agonist, κ-antagonist) McCann (2008). The combination of buprenorphine and naltrexone will additionally suppress the μ-opioid receptor activity of buprenorphine and unmask its κ-opioid receptor antagonist activity. Rothman et al. (2000) suggested that the κ-opioid receptor system is linked to dysphoria which happens following sudden abruption of opioid. The sudden rise of dynorphin which is meant to compensate the excessive activation of the m-opioid receptor following opioid consumption will lead to dysphoria, a negative mood that is unbearable if the drug addict stops taking opioid. This unbearable symptom is one of the major factor that causes relapse to drug taking (Duvauchelle et al. 1998).

4.2.2 Methamphetamine-Conditioned Group

1.0 mg/kg methamphetamine significantly developed dependence in both control and treatment (0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone) groups with the preference at the drug-paired compartment of 38.24 ± 4.34% ($p < 0.001$, $n = 12$) and 42.32 ± 4.40% ($p < 0.001$, $n = 10$), respectively. During reinstatement, methamphetamine was reinstated after priming dose was administered (1.0 mg/kg methamphetamine), following complete abstinence which was significantly different compared to the baseline preference at the drug-paired compartment of 46.21 ± 7.33% ($p < 0.01$, $n = 9$) and 2.98 ± 3.64% ($n = 12$), respectively. This was similar to the control group where the priming dose of methamphetamine given was proven to induce reinstatement to methamphetamine, which was significantly different from the baseline preference at the drug-paired compartment of 49.75 ± 12.70% ($p < 0.05$, $n = 8$) and −5.57 ± 5.47% ($n = 13$), respectively (Fig. 3).

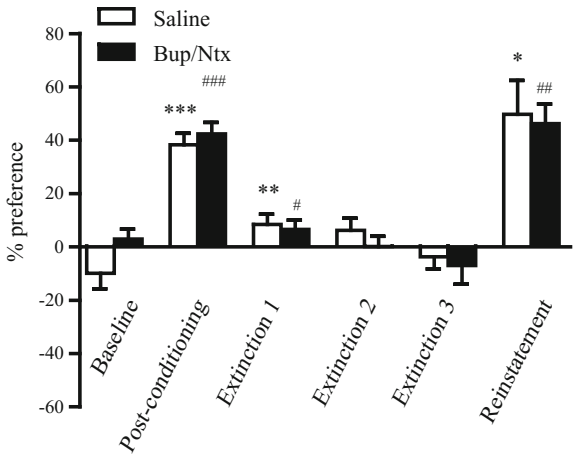

Fig. 3 CPP test for methamphetamine-conditioned (saline [control] and buprenorphine/naltrexone [Bup/Ntx] [treatment]) groups. * and # indicate a significant difference ($p < 0.05$) from baseline, ** indicates a very significant difference ($p < 0.01$) from baseline, *** and ### indicate an extremely significant difference ($p < 0.001$) from baseline

From the results obtained, it shows that low-dose methamphetamine as used in this experiment can lead to drug dependence. However, this might not be mediated by the opioid receptor system since the treatment used (0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone combination) failed to attenuate reinstatement to 1.0 mg/kg methamphetamine. This is further supported by the earlier findings where 1.0 mg/kg methamphetamine did not produce analgesia in the tail withdrawal test, where if the μ-opioid receptor is involved, methamphetamine would have exerted analgesia in this test.

Therefore, an increase in dopamine activity that is associated with drug rewarding effects of many drugs including methamphetamine (Feltenstein and See 2008) is unlikely related to the opioid receptor system when a low-dose methamphetamine is abused. The most possible explanation for the dependence that is associated with the use of low-dose methamphetamine is the direct stimulation of dopamine release at the presynapstic terminals. Besides, methamphetamine itself could displace dopamine neurotransmitter from its vesicles at the presynaptic level due to its similarity in structure to dopamine (Taylor et al. 2013).

4.2.3 Morphine/Methamphetamine-Conditioned (Polydrug) Group

In doses of 7.5 mg/kg morphine/1.0 mg/kg methamphetamine (polydrug), dependence was significantly developed in both control group and treatment (0.3 mg/kg buprenorphine/1.0 mg/kg naltrexone) groups, with the preference at the drug-paired compartment of $25.63 \pm 4.88\%$ ($p < 0.001$, $n = 12$) and $24.01 \pm 3.03\%$

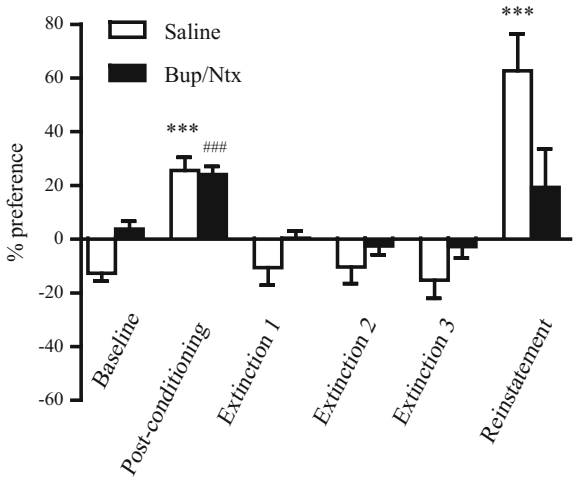

Fig. 4 CPP test for morphine/methamphetamine-conditioned (polydrug) (saline [control] and buprenorphine/naltrexone [Bup/Ntx] [treatment]) groups. *** and ### indicate an extremely significant difference ($p < 0.001$) from baseline

($p < 0.001$, $n = 14$), respectively. During reinstatement, a non-significant morphine/methamphetamine reinstatement was observed after priming dose of polydrug was administered (2.5 mg/kg morphine/1.0 mg/kg methamphetamine) following complete abstinence with the preference at the drug-paired compartment of $19.29 \pm 14.32\%$ ($n = 13$) compared to its own baseline which was $3.81 \pm 2.86\%$ ($n = 22$) (Fig. 4).

Although previous findings in methamphetamine-dependent mice showed that a buprenorphine/naltrexone combination fails to attenuate reinstatement to a low-dose methamphetamine, this is not true for polydrug dependence case. This drug treatment successfully attenuated reinstatement to polydrug dependence, even when a very low dose of methamphetamine is used. A dose of 2.5 mg/kg methamphetamine was given for seven consecutive days (in vivo) has been previously reported to cause morphine tolerance (in a radioligand binding assay), which suggests that the μ-opioid receptors underwent downregulation (Chiu and Ho 2006). Therefore, this problem can be significant when polydrug addiction that involves concurrent use of opioid and methamphetamine takes place.

4.2.4 Straub's Tail Response

The results show that both drugs used to induce dependence (morphine and methamphetamine) caused positive Straub's tail response after 0.3 mg/kg buprenorphine was administered. The degree of tail elevation seen in morphine-treated mice is twice as large than in methamphetamine-treated mice. It is more severe when both morphine and methamphetamine were concurrently used.

Table 1 Results for Straub's tail response

Treatment		Conditioning	
	Morphine/ Methamphetamine	Morphine	Methamphetamine
Buprenorphine	180°	90°	45°
Buprenorphine/ Naltrexone	0°	nd	nd

A positive Straub's tail response was shown by the persistent elevation of the tail higher than 45° horizontally
nd not determined

Interestingly, when the treatment candidate (0.3 mg/kg buprenorphine/1.0 mg/kg methamphetamine combination) was given, the Straub's tail reaction that was previously seen in polydrug dependence mice halted (Table 1).

The Straub's tail response reflects the involvement of opioidergic system (Kitanaka et al. 2012). The recent findings suggest that polydrug dependence activates the opioidergic system greater than when one single drug of either morphine or methamphetamine was used. A previous study suggested that the involvement of monoamine pathway can also lead to positive Straub's tail response (Zarrindast et al. 2006). Our recent findings revealed that the involvement of the μ-opioid receptor is clear since it was proven that the treatment combination given suppressed the partial μ-agonist activity of 0.3 mg/kg buprenorphine. A higher elevation of the tail is seen in the polydrug group, compared with the elevations in each individual drugs, which suggests that the opioid receptor system undergoes neuroadaptation and neuroplasticity which might lead to opioid receptor sensitization (Feltenstein and See 2008).

5 Conclusion

From our findings, it is proven that the concurrent use of an opioid and a considerably low dose of methamphetamine can activate the opioid receptor system (particularly the μ-opioid receptor) and hence cause sensitization of this receptor. The subjects might not physically feel the danger because the psychostimulant used masked the sedating effects of opioid. This should be an alarm to the healthcare providers if opioid substitution treatment (methadone or buprenorphine as a single drug) is to be given. Therefore, it is suggested that a potential candidate for this case to be a drug that has mixed activity at the opioid receptor system as shown in the buprenorphine/naltrexone combination (μ-/κ-antagonist/partial NOP agonist).

Acknowledgements This research work is funded by Ministry of Higher Education (MOHE, RAGS12-025-0025).

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Chapter 60
Kidney Modeling Using a Polynomial Function

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Abstract In the analysis methods for dynamic positron emission tomography (dPET) data, compartment model has been recognized as the gold standard. But, the studies on the development and validation of a model are relatively complex and time-consuming. Hence, fast algorithms become frequently used for analysing dPET data and parametric images. The purpose of this study is to simulate the ^{18}*F-Fluorodeoxyglucose* (^{18}F-FDG) concentration in the kidneys from different individuals by applying polynomial regression function and quantitatively describe the fitted data with R-squared correlation coefficient. Four subjects had been injected intravenously with ^{18}F-FDG dose of 302.29 ± 18.75 MBq prior to dPET/CT kidney scanning. The time–activity curve (TAC) of abdominal aorta and kidneys were plotted based on the drawn region of interest (ROI) in each frame of image acquisitions. The ^{18}F-FDG concentration was measured by averaging the values of entire voxel within the ROI. Four sets of PET data were entered into the polynomial function of MATLAB R2015a software to implement and analyse the model for

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_60

fitting the observed data. The best fit was stated by a 15th-degree polynomial function for both sides of the kidneys. The mean *R*-squared for the right kidney is 0.85 while 0.86 is for the left kidney. Therefore, the model developed can simulate the distribution of ^{18}F-FDG concentration in the kidneys using dPET data.

Keywords ^{18}F-FDG · Kidney · PET/CT scan · Polynomial function

1 Introduction

Dynamic positron emission tomography (dPET) or dynamic positron emission tomography/computed tomography(dPET/CT) imaging with ^{18}*F-Fluorodeoxy-glucose* (^{18}F-FDG) is mainly utilized for research purposes as compared to static imaging as it takes longer scanning time and needs more complicated assessment software (Dimitrakopoulou-Strauss et al. 2012). It permits quantitative information about the radiotracer kinetics over time from obtained tissue time–activity curve (TTAC) to determine the parameters. As to estimate the parameters, the model-fitting technique can be categorized into two different techniques which are linear estimation technique and nonlinear estimation technique (Dai et al. 2011).

In the dPET data analysis methods, there are two methods for quantitative evaluation of dPET data, they are region of interest (ROI) based on compartment model and parametric imaging. The compartment model has been recognized as the gold standard (Jennings et al. 2015). It is a common technique used to model radiotracer concentration over time. In addition, nonlinear least squares regression is a frequently utilized method to calculate the parameters for compartment model method by modeling a curve to fit the data (Acharjee et al. 2014). However, the studies on development and validation of a model are relatively difficult (Carson 2003) with high levels of noise since it requires solving complex differential equations and the large group of nonlinear parameters (Zaidi and Karakatsanis 2018).

Non-compartment models are computationally rapid and commonly used to obtain more comprehensive information regarding the tracer distribution at different time point and space (Dimitrakopoulou-Strauss et al. 2010). A non-compartmental technique which is parametric imaging with a linear regression algorithm is typically used to model a tracer activity curve fit for the assessment of dPET studies (Strauss et al. 2012). This development in the analysis of dPET data contributes a more extensive function of dPET or dPET/CT within the clinical areas. Thus, fast algorithms are favourable for regular utilization of dPET/CT and parametric imaging analysis.

The high quantity of ^{18}F-FDG in adjacent tissue for the normal kidney and urinary bladder can cause difficulty in disease detection in static images. This is due to the fact that ^{18}F-FDG could not be reabsorbed by the proximal tubule of the kidney causing the excretion of ^{18}F-FDG through urine and it may lead to the high uptake in

the renal collecting system and the urinary bladder. This excreted ^{18}F-FDG in the urinary tract imitates disease and can obstruct with image interpretation. Therefore, the evaluation of radiotracer kinetics could be useful because it is capable to distinguish the difference between the normal tissues and cancerous tissues.

Because of the efficient and robust curve fitting method of polynomial regression model to fit nonlinear data, it is suggested to model the nonlinear data between the ^{18}F-FDG concentration in the abdominal aorta (input) and the ^{18}F-FDG concentration in the kidneys (output). The objective of this study is to simulate the ^{18}F-FDG concentration in the kidneys from different individuals by applying polynomial regression function and quantitatively describe the fitted data with R-squared correlation coefficient.

2 Materials and Methods

2.1 Human Samples Recruitment

Four healthy volunteers with no history of any kidney diseases were recruited for the dynamic ^{18}F-FDG-PET/CT kidney scans. The age of volunteers was between 19 and 20 years (mean ± SD; 19.25 ± 0.5 years), height from 150 to 153 cm (152.50 ± 2.08 cm), and weight from 47 to 48 kg (47.25 ± 0.5 kg). The characteristics of the volunteers that underwent PET/CT scanning are described in Table 1. They were explained about the objectives and procedures of the research clearly before obtaining their written consent. Prior to scanning, all volunteers were ensured to fast for at least 6 hours and empty their urinary bladder before entering the PET/CT scanning room. Then they were asked to lie down on the table in a supine position without making any movement during the scanning. The scanning process took about 1 h and 30 min to be completed for each volunteer. The volunteer's information such as age, sex, body weight, body mass index, administered radiotracer dose, uptake time, blood glucose levels at the time of injection and diagnoses were recorded.

Table 1 Characteristics of the volunteers

Subject	Gender	Age (year)	Weight (kg)	Height (cm)	Injected activity (MBq)
1	F	20	48	153	298.96
2	F	19	47	152	307.10
3	F	19	47	155	324.12
4	F	19	47	150	278.98
Mean	–	19.25	47.25	152.50	302.29
SD	–	0.5	0.5	2.08	18.75

m mean, *SD* standard deviation

2.2 PET/CT Scanning Protocol and Process

This research used the Siemens Somatom Biograph 64 TruePoint PET/CT scanner (Siemens Biograph-64, Germany) using a 3D-PET camera (lutetium oxyorthosilicate) with a 64-MDCT scanner which integrates the structural and functional image information that are created into a single system. First, each volunteer underwent CT topogram followed by completing the CT scanning protocol with the parameters of 120 kV, 150 mAs, transmission with a pitch of 0.8 (5.0 mm slice thickness), with scanning area from the vertex to the mid-thigh area for anatomical localization and attenuation correction. CT data was resized from 512×512 matrix to a 128×128 matrix to match the PET data for image fusion, and CT transmission map was produced.

A dynamic PET kidney scanning protocol then was carried out immediately after intravenous injection of 302.29 ± 18.75 MBq of ^{18}F-FDG. The experiments were operated in a single bed position covering the kidneys using PET sampling protocol based on Qiao et al. (2007), the dynamic imaging sequences consist of six frames of 10 s; eight frames of 20 s; six frames of 30 s; five frames of 60 s; four frames of 300 s; and three frames of 600 s, totalling 32 frames with a total scan time of 62 min.

3 Data Collection

From the sequentially 3-D PET image, the organs such as the abdominal aorta and kidneys were identified by manually drawing the ROI of organs for each frame of image acquisitions. The average value of the concentration of ^{18}F-FDG within the organs was recorded for each frame.

3.1 Data Analysis

Based on the collected data from drawn ROI, the TAC of abdominal aorta and kidneys were plotted. TAC describes the concentration of ^{18}F-FDG in these organs at different time steps. The TAC of the blood and TAC of the kidneys were obtained from the ROI in the abdominal aorta and the entire kidneys for each frame respectively. MATLAB 2015a software was used to plot the TAC of abdominal aorta and kidneys to describe the concentration of ^{18}F-FDG at different time points and determine the input and output of ^{18}F-FDG in the system respectively.

Collected data from the PET images were kept in a computer where a ‘best fit’ analysis was performed using the MATLAB 2015a functions which are polyfit and polyval functions. Once the polyfit and polyval functions had been entered, the best approximating polynomial order was determined, by taking into account the mean

square error (mse) and R-square (R^2) term. The value of mse that is closer to 0 signifies a fit that is better for prediction. Whereas, R^2 value closer to 1 denotes a more fit to the original data.

3.2 Ethical Consideration

This research had been approved by the Research Ethical Committee Universiti Teknologi MARA (UiTM): 600-IRMI (5/1/6) as this experiment involved human as a subject. Besides, all the volunteers had been briefly explained about the objectives of this research and informed consent also had been taken. Their participation is based on volunteerism duty. The selections of volunteers are based on their age, height and weight.

3.3 Statistical Analysis

Calculated R^2 determined from each subject of dPET data were expressed as means ± SD using descriptive statistics in IBM SPSS Statistic 23. The values of four volunteers were compared using one-way ANOVA. P values of less than 0.05 were considered statistically significant.

4 Results

4.1 Imaging

The distribution of ^{18}F-FDG concentration in the kidneys can be visualized in the dPET image. Figure 1 is the sequence of PET axial images that demonstrated the accumulation of ^{18}F-FDG at different frames of image acquisition. The concentration of ^{18}F-FDG in the kidneys was fluctuating during 62 min of scanning time, initially increases and then decreases as the time increases. These dynamic images have demonstrated that kidneys were clearly seen as one of the common sources of high ^{18}F-FDG uptake in PET examination compared to surrounding tissues.

By adjusting brightness (window centre) and contrast (window wide), the highest and lowest accumulation of ^{18}F-FDG in kidneys area can be demonstrated. It can be visualized from Fig. 2a that in the frame for 40–50 s after injection, the highest average concentration of ^{18}F-FDG is in the renal cortex and certain area of the renal medulla at an initial time after the injection. As shown in Figs. 2b, c, both coronal images display that mostly the ^{18}F-FDG accumulation appears in the renal

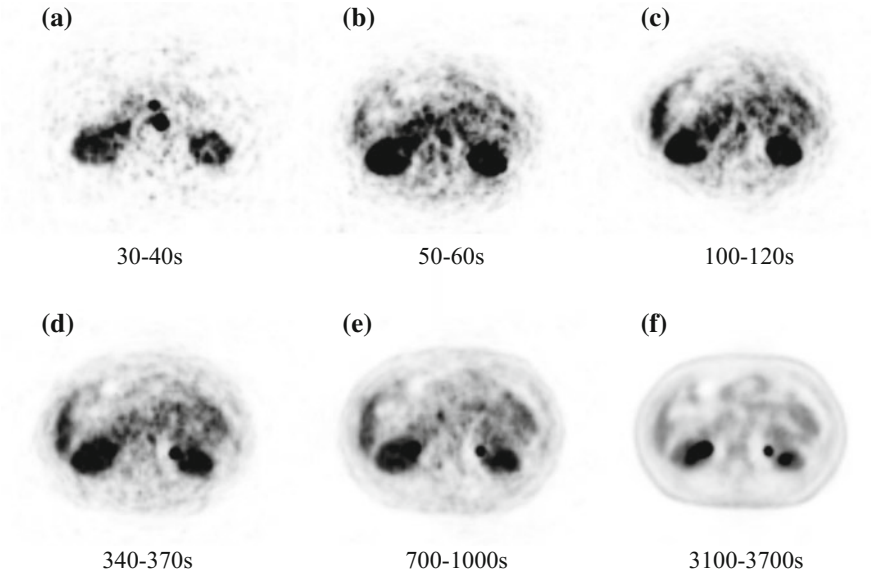

Fig. 1 Sequence of PET axial image of the kidneys at different time points of subject 1

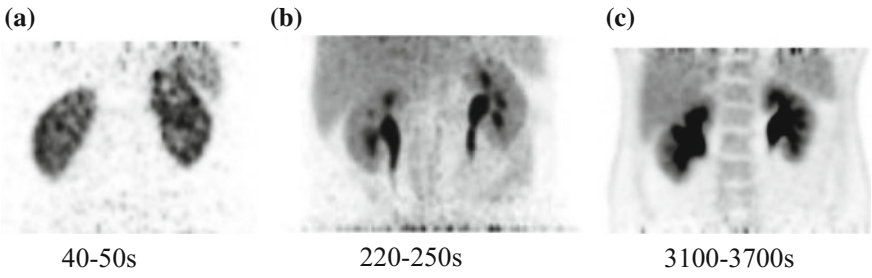

Fig. 2 Adjusted brightness and contrast kidney images: **a** is one coronal section at 40–50 s, **b** is the coronal image at 220–250 s, and **c** is the coronal image at 3100–3700 s

pelvis and renal parenchyma. This is because ^{18}F-FDG cannot be reabsorbed in the proximal tubule of kidney, causing detection of ^{18}F-FDG in renal pelvis in several frames (Qiao et al. 2008).

4.2 Fitting

Four sets of dynamic data were utilized to analyse the model. The TAC of the blood that is derived from the abdominal aorta is the input of the model, whereas the TAC

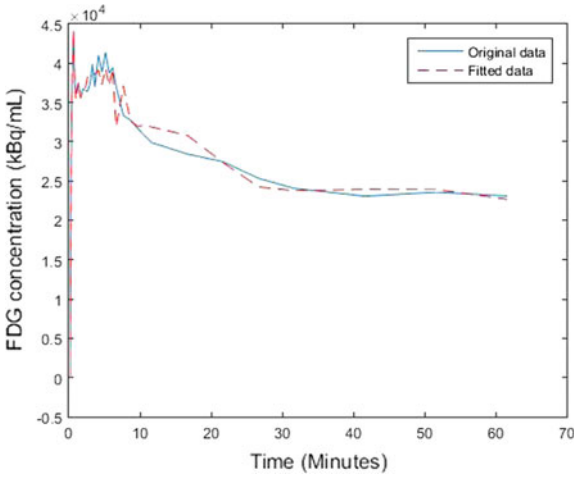

Fig. 3 Solid line: TAC of left kidney. Dashed lines: fitted curve. *Y*-axis: concentration of ^{18}F-FDG in the left kidney (Bq/mL). X-axis: scanning duration (min). R^2= 0.96

of the kidney is the output of the model. The polynomial regression function was used to fit the data. For all the subjects, the best fit (the dashed line in the Fig. 3) was expressed by a 15th-degree polynomial function as shown in Eq. (1)

$$y(x) = p_0 + \sum_{n=1}^{15} p_n x^n \tag{1}$$

in which y and x indicate the concentration of ^{18}F-FDG in the blood and the concentration of ^{18}F-FDG in the kidney, respectively. The R^2 values of each volunteer are compared with each other as shown in Table 2. The mean value of R^2 for the left kidney is 0.86 and 0.85 for the right kidney in which a value equal to 1 would indicate the ideal correlation between experimental and predicted values. Subject's features such as age, height or weight may give distinctions in the rate constants result (Qiao et al. 2007). The result of ANOVA analysis shows no significant value between R^2 for four volunteers.

Figure 3 demonstrates the TAC of one of the healthy volunteer. The normal line indicates the concentration of ^{18}F-FDG in the left kidney at different time steps.

Table 2 *R*-squared values

Patient	*R*-squared	
	Left kidney	Right kidney
1	0.96	0.97
2	0.62	0.60
3	0.98	0.99
4	0.88	0.82
$m \pm SD$	0.86 ± 0.17	0.85 ± 0.18

m mean, *SD* standard deviation

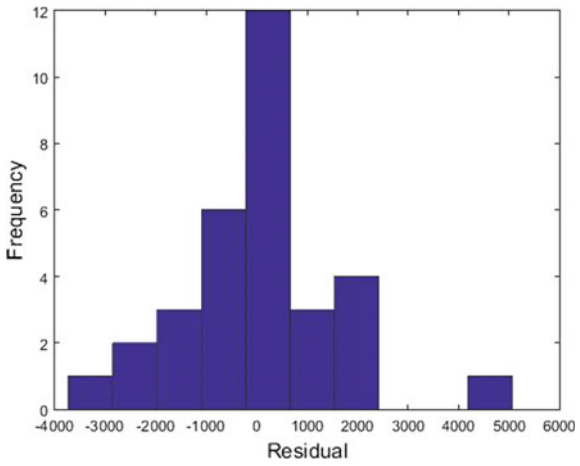

Fig. 4 Histogram of residual. Normal distribution indicates the model is well fitted

The dashed line is the result from fitted data using the polynomial function. These fitted data revealed R^2= 0.96, the value closer to 1 indicates the model fits perfectly. Apart from that, Fig. 4 is the histogram of residuals. This histogram showed that the residuals are normally distributed as it produces a bell-shaped curve that indicates the model is well fitted.

5 Discussion

Radiotracer kinetics can be commonly evaluated from dPET data using two methods which are ROI kinetic modeling and parametric imaging (Wang and Qi 2013). Both methods involve estimation of kinetic parameters that represent tracer metabolism in vivo such as vascular transport and cellular activity. They have established to be effective in the detection of tumour and therapy monitoring (Häggström et al. 2016). Identification of appropriate input and output function of the model is essential in PET data analysis of kinetic modeling as to estimate the accurate parameters. Linear estimation technique and nonlinear estimation technique are basically two model-fitting techniques in dPET data analysis for parameter estimation (Dai et al. 2011).

A research from Dimitrakopoulou-Strauss et al. (2012) used a linear regression function to fit the time–activity data. The purpose of data fitting is to evaluate parametric images of the intercept, which represents blood volume, and parametric image of slope represents phosphorylation of ^{18}F-FDG in a patient with liver metastasis. The parametric image of liver metastasis has shown reduction in blood volume and increase phosphorylation in the ventral portion which can be differentiated with normal adjacent tissue. In another research by Strauss et al. (2012), they fitted slope of the curve by using a linear regression function to determine the

relationship between the two-tissue compartment parameters and slope values. The finding has shown that the compartment parameter, k3 (rate of phosphorylation in ^{18}F-FDG), contributed the most impact on the slope values which produced greater squared correlation coefficient, 0.9716 of R^2. Therefore, the application of non-compartmental model with a linear regression technique is well known in the parametric imaging area for model-fitting technique.

In the present study, polynomial regression analysis is a nonlinear regression method that is used to fit nonlinear relationship between ^{18}F-FDG concentration in the abdominal aorta and ^{18}F-FDG concentration in the kidneys for different subjects. An input function of the model which is ^{18}F-FDG concentration in the abdominal aorta was applied in the polynomial algorithm to fit the curve with the output of model by using MATLAB software. Four sets of subject data were utilized to estimate the best value of the polynomial order and to plot estimated points with the best fitting model. All four fitted data are well fitted with the output of the model by using a 15th-degree of polynomial order that could be visualized from the value of R^2 as shown in Table 2. These values have demonstrated some variation for different individuals. According to Qiao et al. (2008), the characteristics of an individual subject such as age, weight and height may affect the differences in R^2 values. The verification of best fit was obtained by averaging the values of R^2 in four subjects which produced values of less than 1 and exceeding 0. We believed that polynomial regression can be applied in dPET data for simulation of the distribution of ^{18}F-FDG in the kidneys from different subjects.

A number of studies have been carried out using the polynomial regression function in the fields of nuclear medicine and neurology. For example, in research by Strauss et al. (2003), they used a second degree of polynomial order in polynomial regression function to fit the standardized uptake values (SUVs) of the particular time frames in order to precisely estimate the kinetic parameters and the influx in a modified short dynamic protocol. The results have shown that the correlation coefficients exceeded 0.9 for estimated kinetic parameters, VB and k1 and the predicted influx from SUVs. In the neurology study from Giaquinto et al. (2007), they used a ninth-degree polynomial function to fit the data in order to determine the mean curve of the gait performances by comparing separate recordings of gait parameters acquired from the same individual during a treatment course. The value of adjusted R^2 exceeded 0.9 between experimental and predicted values.

In contrast, studies based on the compartmental model by Qiao et al. (2008), they used nonlinear least square to fit a curve to TAC of the kidney by estimating the rate constants. They found that the mean value of R^2 is 0.9276 which indicates a better fit. Unlike compartmental model technique, this polynomial regression analysis does not involve estimation of kinetic parameters which is tracer metabolism because it is only related to simulation of ^{18}F-FDG distribution in the four human kidneys by fitting the model. Despite the fact that this polynomial regression model does not involve parameter estimation, this model type is capable to model the physiological pharmacokinetic in a way that it offers relevant common mathematical approaches with promising result being obtained.

A dPET and dPET/CT studies provide additional information about the time-dependent distribution of a tracer compared to static imaging (Strauss et al. 2012). According to Bouchet et al. (2003), the kidneys symbolize a regular source of radionuclide substance uptake in nuclear medicine field. Kidney uptake depends on the radioactivity of blood, which differs with injection speed of radiotracer, physiology of kidney, physiology of the other tissues and radiotracer recirculation (Lawson 2010). The concentration of radiotracer radioactivity is higher within several parts of the kidney including the renal cortex, outer medulla, inner medulla, papillae and renal pelvis (Bouchet et al. 2003). Therefore, the inhomogeneous ^{18}F-FDG distribution within the kidneys could be visualized in this current study by evaluating TAC extracted from dPET data.

With reference to Fig. 3, TAC was plotted using concentration values based on ROI of whole kidney which these kidney curves consist of superimposition of the renal parenchyma activity and renal pelvis activity (Taylor 2014). There are peaks representing the highest ^{18}F-FDG concentration in the kidneys at different time steps. The first ^{18}F-FDG peak occurred during first 40 s (Fig. 2a) which has demonstrated high intensity in the renal parenchyma (renal cortex and renal medulla). This is in agreement with a previous research by Qiao et al. in 2007, they found TAC of the parenchyma demonstrates the highest peak at the initial time of injection compared to peak from renal pelvis curve. This showed that the concentration of ^{18}F-FDG in the renal pelvis is lower than in the renal parenchyma at the initial time (Fig. 2a) and higher as the time increases. Hence, we can conclude that retention of ^{18}F-FDG may have occurred temporarily in the several parts of the kidneys such as renal parenchyma (renal cortex and renal medulla), renal calyces and renal pelvis. The process cannot just be explained by a fitted data and PET images. Therefore, extensive exploration should be made as this present research is only a preliminary study.

6 Conclusion

The development of kidney model in this research can be used to simulate the distribution of ^{18}F-FDG concentration and would benefit the research of dynamic PET specifically with ^{18}F-FDG. This polynomial function analysis can increase the evaluation of dPET/CT which might be useful in a clinical area specifically handling different kinds of patients with kidney-related diseases.

Acknowledgements The authors gratefully acknowledge the Faculty of Health Sciences, Universiti Teknologi MARA (UiTM) Puncak Alam Campus for continuous support, Research Acculturation Grant Scheme (RAGS): 600-RMI/RAGS 5/3 (150/2014) for financial support and Pusat Pengimejan Diagnostik Nuklear, Universiti Putra Malaysia (UPM) for allowing the scanning process and data collection.

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Chapter 61
Diploma in Pharmacy Student's Knowledge Level on Cupping Therapy as a Traditional Complementary Alternative Medicine

Nursyuhadah Othman, Roz Azinur Che Lamin and Nurhidayah Abdul Rahim

Abstract The prevalence of cupping is increasing worldwide because more people are interested in trying natural or holistic therapies to avert and treat sickness. To date, studies on the knowledge of the junior health science students towards cupping are limited. This study was conducted to assess the knowledge about cupping among the first-year students on a Diploma in Pharmacy, Universiti Teknologi MARA. A total of 81 respondents interested to participate in this study. The surveys accumulated information on the respondents' backgrounds and their general knowledge about cupping. From this study, the students generally possessed a moderate level of cupping knowledge. Our suggestions is that this study can be the first step in preparing the next pharmacist generation equipped with both conventional and holistic knowledge while handling certain health issues.

Keywords Cupping · Knowledge · Students

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_61

1 Introduction

People throughout the world have started to recognize the practice of traditional complementary alternative medicine (TCAM). This perception transition is believed to happen when numerous people are experiencing a variety of unpleasant outcomes of the conventional medicine (Zhang 2002). Thus, the World Health Organisation (WHO) also insisted the enforcement bodies to study the potential of TCAM for health and wellness. These responsible bodies should provide a clear standard regulation, continuous research and development on products, practitioners and practice into healthcare systems (Burton et al. 2015).

TCAM services that are commonly used in Asian countries are cupping therapy, homeopathy, massage therapy, acupuncture and local herbs. There are many reasons for TCAM practice among the patients such as lower cost compared to modern treatment and medicine. Some people use TCAM along with conventional treatment because they believed it will help and fasten the healing process. As a starting point, in 2008, three government hospitals in Malaysia (Hospital Kepala Batas, Hospital Putrajaya and Hospital Sultan Ismail) have made an effort in a pilot project to integrate TCAM into national healthcare system. As a result, this service has been expanded to Low Risk Maternity Center, Putrajaya in 2012 ("TCM," n.d.).

One of the popular TCAM that has been widely used in many countries is cupping therapy. Cupping therapy is an ancient form of TCAM practice for many health conditions such as respiratory, gastrointestinal and gynaecological disorders (Tham et al. 2006), treating eczema and removing toxins and waste from the body (AL-Shamma and Abdil Razzaq 2009), acute gouty arthritis (Zhang et al. 2010), back pain (Kim et al. 2011), chronic osteoarthritis (Teut et al. 2012), acute trigeminal neuralgia (Zhang 1997) and in treatment of tension and migraine headache (Ahmadi et al. 2008). Generally, there are two different methods of cupping therapy: wet and dry cupping. In this study, we would like to focus on the knowledge of the students about wet cupping, which involves creating an incision in the skin, and applying a cup-like device with some pressure to allow the blood to be removed via the skin (Qasim 2012).

Pharmacy is an area that provides services in drug counselling, medicine preparation, and in certain countries, pharmacists are allowed to prescribe the drugs to the patients. Besides that, the pharmacist also has an important role in TCAM. The knowledge of the pharmacists about TCAM can be classified as insufficient as they are unable to respond confidently to the patients' questions or discussions about TCAM (Brown et al. 2005; Naidu et al. 2005). Therefore, it is beneficial for pharmacy students to gain knowledge on TCAM as the number of TCAM users is increasing from time to time. The knowledge and awareness of pharmacist on TCAM are important so that they can give an accurate information regarding TCAM in order to help patients to make a decision. The prevalence and knowledge among pharmacy students towards cupping therapy are therefore of interest due to the limited studies available at this time.

2 Methodology

The first-year of Diploma in Pharmacy at Universiti Teknologi MARA students were invited to take part in this research. A total of 81 students were interested to participate in this study. All respondents were selected through systemic sampling. A self-constructed questionnaire developed from the literature review and previous studies was tested for its validity and reliability among academic staff before being distributed to the respondents. The survey instruments consisted of two main sections: demographic data and several questions that assessed their knowledge of cupping practice. All data were then analysed using SPSS version 16.0 and Microsoft Excel.

3 Results

3.1 Demographic Data

The questionnaires have been distributed to 81 students of Diploma in Pharmacy. Table 1 shows the background data of the respondents and their source of information about on cupping. There were 34.6% (n = 28) male and 65.4% (n = 53) female respondents. The age of the respondents is between 17 and 19 years. About 75 respondents stated that they were in a good health condition while six respondents claimed they have certain medical concerns. Most of the students were aware

Table 1 Background of respondents

Characteristic	Respondents (n)	Percentage (%)
Gender		
Male	28	34.6
Female	53	65.4
Age (years)		
17	2	2.5
18	69	85.2
19	10	12.3
Have a medical problem?		
Yes	6	7.4
No	75	92.6
Practising cupping		
Yes	3	3.7
No	78	96
Source of information about cupping practice		
Relatives	45	55.1
Scientific articles	24	29.9
Others	12	15

of cupping practice (98.8%; $n = 80$) and only one student did not know about cupping. Students were also asked how they gained knowledge about cupping practice. Based on the data shown in Table 1, 45 students (56%) gained knowledge about cupping from their relatives. When further asked, their relatives were practising cupping therapy either for their wellness or to treat certain medical issues.

3.2 *Knowledge of Cupping Practice*

In this part, the respondents were assessed on their knowledge about cupping. The first question being asked is the effect of practising cupping in order to support a person with a certain general illness such as an antidote if a person has been poisoned, backache, depression, anaemia, menstrual pain, psoriasis, gout, osteoarthritis or hair-related disorders. From this population, 58% ($n = 47$) scored moderately while 15% of the study population achieved high score in this section as displayed in Fig. 1. Amjad (2010) stated that cupping may help people who being poisoned, has back-ache problem, and those who suffer from depression, psoriasis, gout and osteoarthritis. While, according to Lee et al. (2008), cupping therapy may induce iron deficiency anaemia in a healthy man and their iron levels were then raised to the normal level after taking the iron supplement. Therefore, cupping should not be considered as treatment methods for those suffering from the blood-related disease, such as anaemia. However, further investigation should be conducted to confirm these findings.

The knowledge of the students on the improvement of certain health condition after performing cupping was investigated in this study. The respondents were being asked whether cupping may improve the blood circulation and immunity system, removing body's toxins and impurities, or as a method of beauty therapy. From the result in Fig. 2, most of the students ($n = 67$) were able to get the high score and only three students scored poorly in this section. According to Al-Shamma and Abdil Razzaq (2009), the act of cupping will improve the blood circulation.

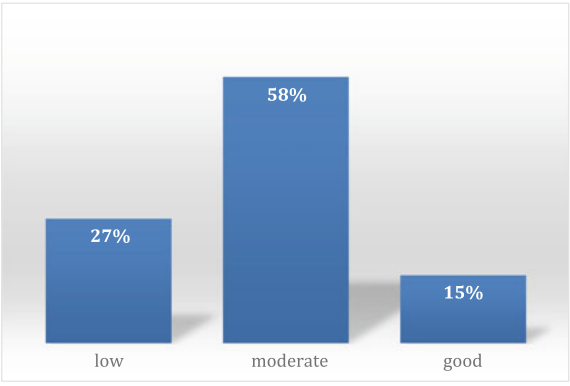

Fig. 1 Level of knowledge among respondents on the practice of cupping as an alternative way to overcome certain illness

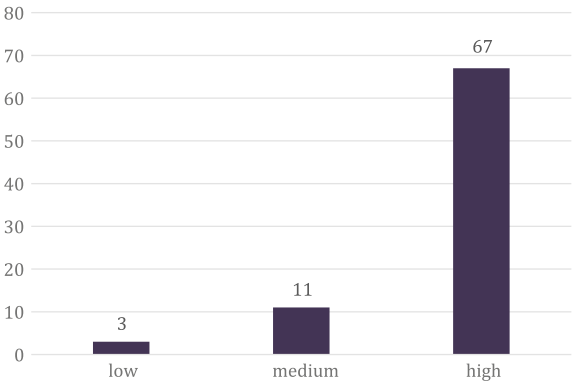

Fig. 2 Level of knowledge among respondents on the effect of cupping to a person's body condition

In this study, we also investigated the knowledge of students on some preferences while performing cupping. Students were asked whether incision should be made at specific points on the skin and if they answered yes, they are required to answer the following question, 'are these points represent certain organs in our body?'. It is found that a total of 57 (70%) students answered correctly and 38 (66%) from 57 students answered correctly for the following question. The most common areas for cupping are the back, abdomen area, chest, buttock and areas of abundant muscle (Yoo and Tausk 2004). Students were also requested to answer whether cupping therapy should be performed at a certain time to enhance its therapeutic value. As a result, only 23 (28%) students answered correctly. It is recommended to perform cupping during the full moon. According to prophetic medicine, the blood-letting therapy should be done during 17th, 19th and 21st of the lunar months according to Islamic calendar (Mahmoud et al. 2013). Ibn Sina or Avicenna, an Islamic scholar, believed that during the full moon the body liquid is incredibly expanded and as a result, the treatment will be more successful ("Canon of Medicine 21. The Operation of Cupping," n.d.).

4 Conclusion

From the results obtained, we concluded that the level of knowledge of the students about cupping is generally moderate. In this study, few limitations should be considered as they are not being exposed formally on cupping therapy since it is not included in the Diploma in Pharmacy syllabus. Even though it is not included in the syllabus, the knowledge about TCAM especially cupping can be a part of a step in preparing a knowledgeable pharmacist with a good knowledge in both modern and traditional approaches while handling certain health issues.

Acknowledgements The authors would like to thank the staff and students of the Faculty of Pharmacy and Faculty of Health Sciences, Universiti Teknologi MARA, Bertam Campus Penang. We also would like to thank Universiti Teknologi MARA Cawangan Pulau Pinang for providing us with financial support for this research.

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Chapter 62
Malaysian Version of Physiotherapy Osteoarthritis Based Care Protocol (PTOA-BCP): Effects on Lower Limb Functional Strength Among Overweight and Obese Women with Knee Osteoarthritis

Zuraidah Mohamad, Rohani Haron and Maria Justine

Abstract This study aims to evaluate the effect of an 8-week participation in the Malaysian version of the Physiotherapy Osteoarthritis Based Care Protocol (PTOA-BCP) on lower limb functional strength (LLFS) among overweight and obese women with knee osteoarthritis (OA). A total of 63 women aged 45–65 years with knee OA were recruited in a quasi-experimental single-blinded study with repeated measures design. The participants were divided into three intervention groups based on their body mass index (BMI) categories: $\leq$ 23.5 kg/m^2 (n = 11), < 27.5 kg/m^2 (n = 15), and $\geq$ 27.5 kg/m^2 (n = 37). All participants completed an 8-week training program that comprised lower extremity strengthening, stretching, and range of motion, balance, proprioception, and aerobic exercises. The LLFS was tested using the five-times-sit-to-stand test at baseline, at the fourth and eighth weeks. Post hoc test with intention-to-treat analysis and completers-only analysis revealed significant differences (p = 0.001) in the LLFS of participants under the overweight and obese BMI categories, but not between the

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_62

groups ($p > 0.05$). Notable improvement was observed from baseline to eighth week and from fourth week to eighth week, but not from baseline to fourth week. In terms of LLFS, the overweight and obese groups benefitted the most from the implementation of 8 weeks of Malaysian version of the PTOA-BCP compared with the normal weight group.

Keywords Functional strength · Obese · Osteoarthritis · Physiotherapy Women

1 Introduction

Obesity is one of the prominent risk factors for knee osteoarthritis (OA). Obesity may lead to a number of diseases, such as diabetes, epilepsy, hypertension (HPT), coronary or myocardial infarction, angina, congestive heart failure, chronic lung disease, asthma, stroke, and arthritis (Blagojevic et al. 2010). However, in Malaysia, females have a higher morbidity rate than males, with HPT (31%) as the leading cause of death, followed by diabetes mellitus (20%) and heart problem and joint arthritis (8%) (Selvaratnam et al. 2010). A previous study reported that those with a body mass index (BMI) of $\geq$ 30 kg/m^2 had a sevenfold risk of developing knee OA compared with those who have a BMI of < 25 kg/m^2 (Impivaara et al. 2010). Excess body weight places extra pressure on the body, particularly on the weight-bearing joints, which in turn may lead to joint pain. Such problem may limit physical activity, leading to a decline in functional ability and mobility.

A recent epidemiological study had reported that obesity is related to increased disability regardless of how it is measured (Rafael 2013). The most common functional limitations related to knee OA include difficulty in kneeling, squatting, standing up from sitting down, and ascending and descending stairs (Raj 2015). These activities are more challenging for overweight and obese people. Muscle weakness, pain, and postural instability had also been reported to be the predictors for the decrease in daily functional activities, particularly among overweight and obese women with knee OA (Hiengkaew et al. 2015).

A few outcome measures had been developed to measure lower limb strength and develop physical therapy that may improve functional ability rather than just muscle strength and postural stability. The five-times-sit-to-stand test (FTSST) is one of the valid and reliable tests to measure lower limb functional strength (LLFS) as a measure of functional status among the elderly and people with knee OA (Batista et al. 2014). Therefore, this study aims to evaluate the LLFS among women with knee OA in the normal weight, overweight, and obese BMI categories following an 8-week participation in the adapted Malaysian version of the Physiotherapy Osteoarthritis Based Care Protocol (PTOA-BCP).

2 Subjects and Methods

This study is quasi-experimental with repeated measures design using a convenience sample. An 8-week exercise training program was developed with reference from the original Malaysian version of Osteoarthritis Knee Care Protocol (OKCP) to an adapted Malaysian version of PTOA-BCP. A total of 63 female participants, aged 45–65 years, were recruited and divided into three groups according to their BMI, namely, (1) normal weight (BMI $\leq$ 23.5 kg/m^2), (2) overweight (BMI < 27.5 kg/m^2), and (3) obese (BMI $\geq$ 27.5 kg/m^2). The inclusion criteria are as follows: diagnosed by an orthopedic specialist to have knee OA with or without x-ray investigations; no associated ankle and hip pain; understand the Malay language, which means that they are able to read and answer questionnaires in Malay independently, with or without aids; moderate knee pain score (4–7); and a score of $\geq$ 20 for the mini mental state examination. The exclusion criteria include the following: history of total knee arthroplasty, uncontrolled HPT, acute cardiopulmonary disorder, lower limb surgery, vision and hearing problems, and neurological disorders affecting the lower limbs. The LLFS in this study was measured through the FTSST.

The participants were recruited from the Physiotherapy Outpatient Department of Sungai Buloh Hospital, Malaysia from May 2015 to December 2015. Informed consent was obtained in writing from all participants. The study was approved by the Medical Research Ethics Committee of the National Medical Research Registry (NMRR 14-1294-22914) and the Ethical Committee of Universiti Teknologi MARA, Malaysia.

2.1 Interventions (Malaysian Version of the PTOA-BCP)

All participants were exposed to the exercise training program, which was the PTOA-BCP. Approximately 90% of the exercise training was conducted based on the original Malaysian version of OKCP, whereas other exercise routines were adapted from previous studies (Bennell and Hinman 2011; Al-Khlaifat et al. 2016). The training started off with an explanation of the disease aspect, the importance of the support and contribution of family members, and coping strategies when daily activities are limited. These include the half-hour rule, exercise progression, avoidance of high-impact exercises, and tasks adjustment (dividing tasks into smaller activities). The importance of exercise in relation to knee OA and the need for dedication to the exercise regime to achieve long-term effects was also explained. The effects of being overweight and obese on knee OA were also explained to the participants.

The exercise training program started with stretching routines for the quadriceps, hamstring, and gastrocnemius muscles with 10–30 s durations which were performed at least 6 reps/day. The exercise training also included movements for

developing general joint mobility and endurance, with cycling for 20 min followed by specific isometric and isotonic muscle-strengthening exercises particularly for quadriceps and hamstring at 40–80% of one-repetition maximum (1RM). The exercise training program is shown in Table 1. Proprioceptive and balance exercise or perturbation were also included in the training program to improve balance and knee stability. Knee stability was confirmed by a single leg stance (SLS) test, as stipulated in the PTOA-BCP. For aerobic exercise, the maximum heart rate (MHR), the target heart rate, vital signs such as respiratory rate, peripheral oxygen saturation (SpO_2), and blood pressure, and the rating of perceived exertion of each participant were monitored and evaluated. The intensity of aerobic exercise was based on a standard formula (MHR = 220 − age). Approximately 50–75% of MHR was calculated three to five times per week for 20–30 min during the initial session and was increased to 2.5% weekly. Calculating the MHR is important to establish maximum cardiovascular and respiratory function. The findings of each measurement or assessment were explained to the participants on the same day. The exercise routine and parameters progressed concurrently on a weekly basis according to the participant's achievement. Weight loading is an essential element for muscle building; therefore, each patient was asked to perform weight loading exercises at home for maximum training effect. The suggested initial loads were 1, 1.5, 2, 3 kg, and up to a maximum of 4 kg depending on their performances and 1RM initial load preferences. Exercise handouts were given at the end of the session and whenever additional exercises were included.

2.2 One-Repetition Maximum

1RM is defined as the maximum load that a person could lift within a single movement (Brach et al. 2009). The concept of 1RM has been established and applied to most musculoskeletal rehabilitation programs and care protocols involving isometric, aerobic, isotonic, isokinetic, and muscle-strengthening exercises (MPA Technical Committee 2003; Peter et al. 2013). Based on the PTOA-BCP, 1RM for isometric training was set as 30–75% maximum, 40–80% maximum for isotonic training, and 50–75% maximum for aerobic training. In this study, 1RM determination was based on the assumption of the participant's ability to lift a weight within a single movement. The principles apply to any muscle of a person undergoing strengthening program, particularly the quadriceps and hamstrings. The loads could be limited to sandbags/cuff weights, pulleys, theraband, or hydraulic system. A 5-min rest period was given, and the routines were repeated with an increase of 500 g–1 kg, depending on the degree of difficulty reported by the participant. The maximum load is considered the weight at which the participant is unable to perform the routine to its fullest extent, shows signs of fatigue, and/or increases the speed of the motion, with no more than five attempts made throughout

Table 1 Exercise recommended in Physiotherapy Osteoarthritis Based Care Protocol (PTOA-BCP)

PHYSIOTHERAPY OSTEOARTHRITIS BASED CARE PROTOCOL (PT-OABCP)			
WEEK 1–2	**WEEK 3–4**	**WEEK 5–6**	**WEEK 7–8**
i) PATIENT EDUCATION: Knowledge of disease Patients and family expectation ii) Coping strategies The half-hour rule Break-up tasks into smaller bits Avoid high-impact activities/joint protective measures Gradually increase the amount iii) Exercise handouts & recall the exercise on each follow-up			
FLEXIBILITY:	CONTINUE PROTOCOL WEEK 1–2	CONTINUE PROTOCOL WEEK 3–4	CONTINUE PROTOCOL WEEK 5–6
Stretching (quadriceps, hamstrings, gluteal, gastrocnemius, and soleus); 20 s. hold; 2–4 rep daily	PROGRESSION: FLEXIBILITY: Follow week 1	PROGRESSION: FLEXIBILITY: Follow week 1	PROGRESSION: FLEXIBILITY: Follow week 1
ISOMETRIC STRENGTH TRAINING	ISOMETRIC STRENGTH TRAINING	ISOTONIC EXERCISES	ISOTONIC EXERCISES
Static quadriceps exercise (SQE); Static hamstrings exercise (SHE); static vastus medialis oblique (VMO) 8–10 rep, 5 s. hold, 20 s rest, 3 sets/day (30–75% max. effort)	Static quadriceps exercise (SQE); Static hamstrings exercise (SHE); static vastus medialis oblique (VMO) 8–10 rep, 5 s. hold, 20 s rest, 3 sets/day (30–75% max effort)	Add: – VMO (sitting with weight and standing) – Leg press – 40–80% 1RM – increased 5–10%/week – 8–10 reps (both or alternate leg)	Add: – Hydraulic quadriceps/ modified hamstring bench – 40–80% 1RM – increased 5–10%/week – 8–10 reps (alternate leg)
ISOTONIC EXERCISES	ISOTONIC EXERCISES	PROPRIOCEPTIVE TRAINING	PROPRIOCEPTIVE TRAINING
4 plane SLR in lying (hip flexors, hip extensors, hip abductors, and hip adductors) with or without weight; 8–10 rep, 5 s hold, 2x/week (40–80% 1RM)	4 plane SLR (hip flexors, hip extensors, hip abductors and hip adductors) in standing with therabands – 40–80% 1RM – increased 5–10%/week – 8–10 reps; 3 sets/day	Add: Forward/side and backward lunges; 8–10 reps; 3 sets/day Heel raise	Add: Wobble board Step-up/down SLS on balance mat
		AEROBIC EXERCISE	AEROBIC EXERCISE
		Treadmill – 50–75% MHR – 20–30 min; 3x/week increased resistance – 2.5%/week	Treadmill – 50–75% MHR – 20–30 min; 3x/week – increased resistance 2.5%/week

(continued)

PHYSIOTHERAPY OSTEOARTHRITIS BASED CARE PROTOCOL (PT-OABCP)			
WEEK 1–2	**WEEK 3–4**	**WEEK 5–6**	**WEEK 7–8**
AEROBIC EXERCISES	PROPRIOCEPTIVE TRAINING	PAIN RELIEF MODALITIES/ TECHNIQUE (VAS > 5 points)	PAIN RELIEF MODALITIES/ TECHNIQUE (VAS > 5 points)
Cycling on Cybex static bicycle— 20 min, (50–75% of MHR); 3x/week	Single leg stance (SLS) ¼ squats	15–20 min/treatment Hot packs Ice packs/cryotherapy Transcutaneous electrical nerve stimulation (TENS) Manual therapy	15–20 min/treatment Hot packs Ice packs/cryotherapy Transcutaneous electrical nerve stimulation (TENS) Manual therapy
PAIN RELIEF MODALITIES/ TECHNIQUE (VAS > 5 points)	AEROBIC EXERCISE	FUNCTIONAL TRAINING	FUNCTIONAL TRAINING
Hot packs Ice packs/ cryotherapy Transcutaneous electrical nerve stimulation (TENS) Manual therapy	Static cycling – 50–75% MHR – 20–30 min; 3x/ week – increased resistance 2.5%/week	Facilitate normal task: Climbing up/down the staircase Squatting down and up on wall bar with 3–5 s hold in 3 stages (0°–30°, 30°–60° and 30°–90°) Normal gait/pacing with or without aids (emphasize on equal weight loading) Kneeling with support on knees Sit-to-stand task	Facilitate normal task: Climbing up/down the staircase Squatting down and up on wall bar with 3–5 s hold in 3 stages (0°–30°, 30°–60° and 30°–90°) Normal gait/pacing with or without aids (emphasize on equal weight loading) Kneeling with support on knees Sit-to-stand task
ADVICE: Empowered on: All exercise to be continue at home; 8–10 rep, 5 s hold, 3 sets/day. Apply hot packs or ice packs Apply half-hour rule on loading activities Joint protective measure (knee guard/lateral insole/walking devices)	PAIN RELIEF MODALITIES/ TECHNIQUE (VAS > 5 points) 15–20 min/treatment Hot packs Ice packs/ cryotherapy Transcutaneus electrical nerve stimulation (TENS) Manual therapy ADVICE: Empowered on: All exercise to be continued at home;	ADVICE: Empowered on: All exercise to be continued at home; 8–10 rep, 5 s hold, 3 sets/day. Apply hot packs or ice packs Apply half-hour rule on loading activities Joint protective measure (knee guard/lateral insole/walking devices) Avoid high-impact activities	ADVICE: Empowered on: All exercise to be continued at home; 8–10 rep, 5 s hold, 3 sets/day. Apply hot packs or ice packs Apply half-hour rule on loading activities Joint protective measure (knee guard/lateral insole/walking devices) Avoid high-impact activities

(continued)

<table>
<tr><td colspan="4">PHYSIOTHERAPY OSTEOARTHRITIS BASED CARE PROTOCOL (PT-OABCP)</td></tr>
<tr><td>WEEK 1–2</td><td>WEEK 3–4</td><td>WEEK 5–6</td><td>WEEK 7–8</td></tr>
<tr><td>Avoid high-impact activities</td><td>8–10 rep, 5 s hold, 3 sets/day.
Apply hot packs or ice packs
Apply half-hour rule on loading activities
Joint protective measure (knee guard/ lateral insole/walking devices)
Avoid high-impact activities</td><td></td><td></td></tr>
<tr><td>UPPER LIMB WORKOUTS</td><td>UPPER LIMB WORKOUTS</td><td>UPPER LIMB WORKOUTS</td><td>UPPER LIMB WORKOUTS</td></tr>
<tr><td rowspan="2">8–10 reps, 3 sets, < 6 s hold, moderate intensity
Hand group exercises using a sponge
Weight lifting (elbow flexor/extensor; Shoulder flexion, extension, external rotation and abduction)
Wall pumping</td><td>Same as week–1</td><td>Same as week–1</td><td>Same as week–1</td></tr>
<tr><td>OUTCOME MEASURES (WEEK 4) (TUG, FTSST,6MWT, WOMAC AND AFI)</td><td></td><td>OUTCOME MEASURES (WEEK 4) (TUG,FTSST,6MWT, WOMAC AND AFI, hamstring length, HHD & VAS)</td></tr>
</table>

the day. With the establishment of RM, the work percentage was calculated. Loads were increased in accordance with the participant's tolerance. As stated in the OKCP, the load was increased in increments of 5–10% load weekly until 8 weeks of follow-up.

2.3 Statistical Analysis

Data analyses were performed using the SPSS version 20.0. Outliers were screened using univariate box plot, histograms, and z score, whereas normality was screened using Kolmogorov–Smirnov, skewness, and kurtosis tests (Salkind 2010). Data were also computed for the means, standard deviations, and 95% confidence interval (CI). Given that normality was determined to be violated, log10 and square root transformation were conducted twice, but still failed to meet normality. Therefore, a nonparametric statistical tool was accepted because it is also known to

be a free distribution. General linear model with repeated measures ANOVA was used to assess changes within- and between-group effects. Post hoc test with Bonferroni correction revealed significant differences among all three groups. All results were compared using intention-to-treat (ITT) analysis and completers-only analysis (COA). The significance level was set at $p < 0.05$ (95% CI).

3 Results

Table 2 outlines the participants' baseline characteristics. Of the participants, 44 (66.7%) completed 8 weeks of physiotherapy (PT) sessions, 10 (12.2%) completed less than four sessions, and 12 (19.7%) completed less than eight sessions. Of the 66 participants, 22 failed to complete the entire procedure: 1 (4.5%) in G1, 3 (13.6%) in G2, and 18 (81.8%) in G3. The reasons for noncompliance include transportation problems (four participants), financial problems (two participants), job commitment (four participants), babysitting responsibilities (three participants), no companion (three participants), and cannot be contacted (six participants). These reasons were also the common reasons for missing data in a previous experimental study (Kroon et al. 2014). Therefore, ITT analysis was used for follow-up analysis where all incomplete data were replaced according to the last observed carry forward (LOCF) and baseline observed carry forward (BOCF) principles. Overall, 44 participants were completers, 13 were LOCF, and 9 were BOCF during the follow-up. However, for analysis purposes, 3 (4.5%) outliers were removed, leaving only 63 participant data analyzed using ITT analysis, 43 (68%) of which completed

Table 2 Baseline characteristics of participants following 8 weeks of Physiotherapy Osteoarthritis Based Care Protocol (PTOA-BCP) among BMI groups

Baseline characteristic	BMI $\leq$ 23.5 kg/m^2 (n = 11)	BMI < 27.5 kg/m^2 (n = 15)	BMI $\geq$ 27.5 kg/m^2 (n = 37)	p-value
Mean (± SD)	G1	G2	G3	
Age (years)	56.1 (± 7.4)	56.1 (± 7.0)	54.8 (± 6.9)	0.76
Weight (kg)	60.0 (± 3.3)	62.5(± 5.6)	75.1 (± 8.6)	0.46
Height (m)	160.8 (± 3.5)	155.3 (± 7.0)	155.8 (± 8.2)	0.12
BMI (kg/m^2)	23.2 (± 0.3)	25.9 (± 1.2)	31.1 (± 3.3)	0.001
Outcome measure Mean ± SD				
FTSST (ITT analysis) FTSST (COA)	15.8 (± 4.1) 16.2 (± 4.2)	6.8 (± 8.6) 15.7 (± 8.0)	17.1 (± 7.2) 17.7 (± 7.7)	0.79 0.61

G1 group 1; *G2* group 2; *G3* group 3; *ITT* intention-to-treat analysis; *COA* completers-only analysis; *SD* standard deviation; *BMI* body mass index
Data expressed as mean and ± SD

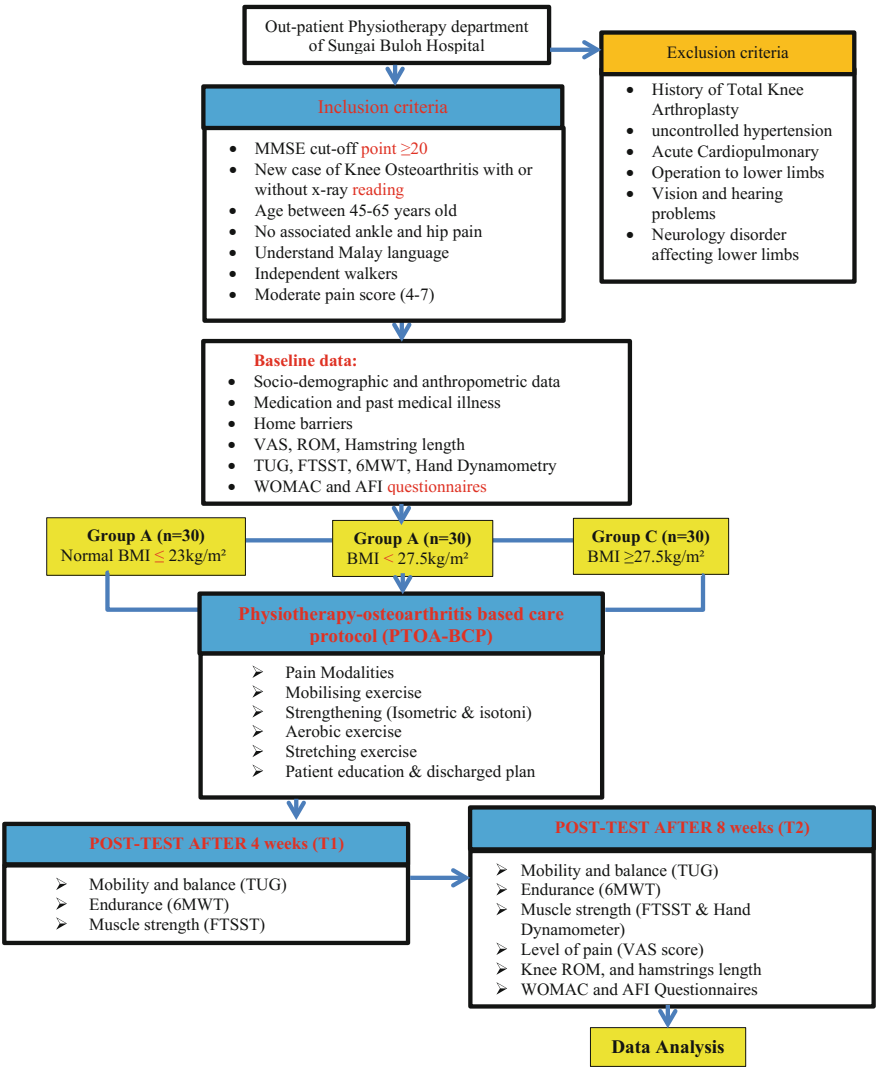


Fig. 1 Participant's flowchart

the program, 9 (14.3%) with BOCF analysis, and 11 (17.4%) with LOCF analysis. The participants' flowchart is displayed in Fig. 1.

Table 3 shows the LLFS mean scores within and between BMI groups. A score > 13.6 s indicates increased morbidity and disability. The repeated measures ANOVA results indicate that the LLFS within and between BMI groups did change significantly over time ($F = 15.19$, $df = 2, 60$, $p = 0.001$) on ITT analysis with large effect size ($\eta^2 = 0.84$) between groups and small effect size ($\eta^2 = 0.20$) within groups. The results also showed the statistical significance of LLFS

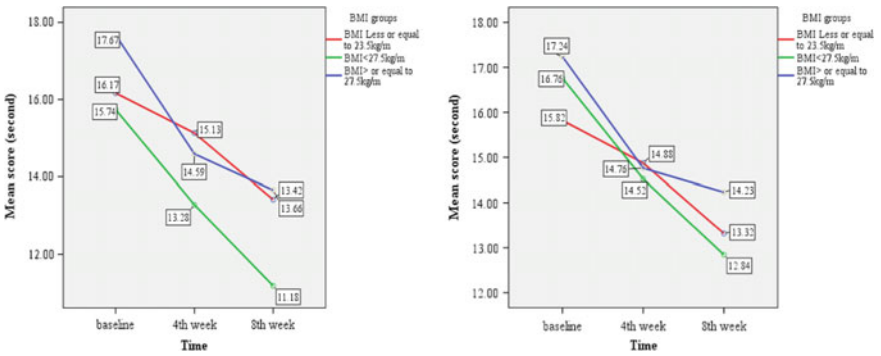
Table 3 Mean changes of lower limbs functional strength within and between BMI groups following 8 weeks of PTOA-BCP with ITT and COA

Lower limbs functional strength	Intervention groups				Δ *p*-value/Partial eta square (η^2_p)	
	BMI ≤ 23.5 kg/m_2 mean, 95% CI (G1)	BMI < 23.5 kg/m_2 mean, 95% CI (G2)	BMI > 27.5 kg/m_2 mean, 95% CI (G3)	*F* (*df*)	Within	Between
ITT (*n* = 63) (LOCF/BOCF)						
	(11)	(15)	(37)			
Baseline	15.8 (13, 18.6)	16.8 (12, 21.5)	17.2 (14.8, 19.6)	15.19 (2, 60)	0.001/0.20	0.001/0.84
Fourth week	14.9 (12.8, 16.9)	14.8 (11.1, 17.9)	14.8 (12.8, 16.8)			
Eighth week	13.3 (11.7, 14.9)	12.8 (9.6, 16.1)	14.2 (12.2, 16.3)			
COA (*n* = 43)						
	(10)	(12)	(21)			
Baseline	16.2 (13.2,19.1)	15.7 (13.2, 20.8)	17.4 (13.7, 21)	13.4 (2, 40)	0.001/0.25	0.001/0.88
Fourth week	15.1 (12.9, 17.4)	13.3 (10.6, 15.9)	14.5 (11.5, 17.6)			
Eighth week	13.4 (11.6, 15.2)	11.1 (9.7,12.7)	13.6 (10.5, 16.8)			

BMI body mass index; *ITT* intention-to-treat analysis; *COA* completers-only analysis; *LOCF* last observed carry forward; *BOCF* baseline observed carry forward; *PTOA-BCP* Physiotherapy Osteoarthritis Based Care Protocol; *df* degree of freedom
All values expressed as means; 95% CIs

($F = 13.4$, $df = 2, 40$, $p = 0.001$) on COA with large effect size ($\eta^2 = 0.88$) between groups and small effect size ($\eta^2 = 0.25$) within groups. Baseline means with ITT analysis and COA on all BMI categories and scores were within 15.7 s to 17.4 s, which is beyond the cutoff value of 13.6 s, indicating that all participants had increased disability and morbidity prior to enrollment in the research. The trend of mean reduction was more significant within BMI groups on the fourth and eighth weeks following PTOA-BCP, particularly with COA (Fig. 2).

The post hoc tests using adjusted Bonferroni correction with pairwise comparison on LLFS were generated in view of significant differences ($p < 0.05$) among BMI categories (Table 4). The results showed nonsignificant differences on lower limb strength between normal weight and overweight (G1–G2), normal weight and obese (G1–G3), and overweight and obese (G2–G3) groups. The 95% CI between BMI groups ranged from negative to positive, which includes 0 value in the range, indicating a clinically insignificant value.



Completers-only analysis (COA) Intention-to-treat analysis (ITT)

Fig. 2 Mean changes of lower limb functional strength within and between BMI groups following 8 weeks PTOA-BCP measured at baseline, fourth week and eighth week with COA and ITT analysis

Table 4 Post Hoc test with pairwise comparison of lower limb functional strength within and between BMI groups following 8 weeks of PTOA-BCP with ITT and COA

Pairwise comparison	ITT (n = 63)			COA (n = 43)		
	Mean diff. (95% CI)	p-value	Observed power	Mean diff. (95% CI)	p-value	Observed power
FTSST Between groups effects						
G1 and G2	−0.38 (−5.7, 5.6)	1.00		1.5 (−4.1, 7.1)	1.00	
G1 and G3	−0.74 (−5.6, 4.1)	1.00	15%	−0.4 (−5.4, 4.6)	1.00	14%
G2 and G3	−0.70 (−5.0, 3.6)	1.00		−1.9 (−6.6, 2.8)	0.96	
FTSST Within group effects						
Baseline to fourth week	1.9 (0.33, 3.4)	0.012*		2.2 (0.18, 4.2)	0.029*	
Baseline to eighth week	3.1 (1.4, 4.9)	0.001**	99%	3.8 (1.5, 6.0)	0.001**	98%
Fourth week to eighth week	1.3 (0.5, 2.0)	0.001**		1.6 (0.5, 2.6)	0.001**	

G1 group 1; *G2* group 2; *G3* group 3; *FTSST* Five-times-sit-to-stand test; *ITT* Intention-to-treat analysis; *COA* Completers-only analysis; *PTOA-BCP* Physiotherapy Osteoarthritis Based Care Protocol

All values expressed as mean differences; 95% confidence intervals (CI)

Significant level was set at ($^{*}p < 0.05$) and highly significant ($^{**}p < 0.001$)

However, highly significant increases ($p < 0.001$) of the mean difference on LLFS within BMI groups from baseline to 8 weeks were detected with COA and ITT analysis, but higher mean differences from baseline to 8 weeks were detected with COA. Clinical significance could be observed when the mean differences and 95% CIs were on the positive range and 0 value was not included. The finding was supported by a high statistical power of exercise training effects observed within groups.

4 Discussion

After completion of the 8-week Malaysian version of the PTOA-BCP, the exercise training program did not have a significant effect on LFFS between BMI groups. The reason is that the increase in BMI was associated with the decrease in muscular strength per mass ratio; thus, a stronger muscular force is required to produce a single functional task (Jadelis et al. 2001). Therefore, a longer time is needed for the participants to complete the FTSST (Batista et al. 2014).

Exercise interventions that are observed to improve lower limb strength are isometric, isotonic, and proprioceptive routines (Siriphorn and Chamonchant 2015). However, fat loss on the thighs and hips among overweight and obese elderly and middle-aged women was challenging because lipolysis (fat breakdown) is low (Wilmore et al. 2007). Moreover, exercise frequencies and durations in this study were similar between all BMI groups (Hulens et al. 2001). The exercise frequencies, durations, intensities, and types, which were similar in all groups, seem to be less beneficial to the overweight and obese groups because of the different metabolism of fat mass and free fat mass in overweight and obese participants, and the effect was difficult to quantify between groups. Endurance exercises in overweight and obese women with knee OA should be prescribed at least 5 days per week, whereas strengthening exercises should be prescribed at least 3 to 5 days per week to ensure greater benefit (Ho et al. 2012).

Strengthening exercise is needed because an increase in muscle mass increases the amount of cartilage in the knee joint, particularly at the tibiofemoral compartment (Cicuttini 2008). However, in this study, the training program was scheduled only once weekly with the inclusion of a continuous home exercise program for 3 to 5 days per week where the amount of exercise for each participant may vary and may be difficult to measure. Moreover, having a larger sample size is warranted to produce better treatment effect between groups' differences in view of higher effect size, although observed power was low. This could be due to overlapping of mean differences (95% CI) which were at 79th percentile of both groups during the analysis (Kersten et al. 2010).

Meanwhile, significant improvements of LLFS were observed within the overweight and obese groups, particularly with COA from baseline to 8 weeks.

Endurance exercise and resistance training with the intention to lose weight were observed to help in the preservation of bone mineral density in overweight and obese adults (Skrypnik et al. 2015). Furthermore, higher bone mineral density was determined to be a predictive factor for good muscle strength of the upper and lower limbs (Shin et al. 2014). Body composition changes of the lower extremities (lean mass and body fat) were related to physical activities, such as walking, and the ability to perform SLS and FTSST. Therefore, the results were, unsurprisingly, more confound in G2 and G3 because FTSST is also a valid and reliable measure for functional strength of the lower limb. In fact, prescribed exercise training (isotonic, proprioceptive, and perturbation) may have contributed to the improvement of functional lower limb strength in the targeted population (Siriphorn and Chamonchant 2015).

This program also emphasized on the training of functional tasks, which may have contributed to the significant improvement in LLFS within BMI groups. The training included sit to stand, half-squat supported, step-up, and deep squatting at different stages and was maintained for 3–5 s (0°–30°, 30°–60°, and 60°–90°) while both hands were supported. Facilitating co-contraction of the quadriceps muscle (mainly biceps femoris, vastus lateralis, and vastus medialis) and hamstring muscle (semitendinosus) throughout the duration of the exercise is important to improve stability and muscular endurance, particularly during midstance of knee flexion (Al-Khlaifat et al. 2016). In their studies on isometric and concentric knee flexion and extension training at 30°, 45°, 60°, and 90°, Isear et al. (1997) and Al-Khlaifat et al. (2016) reported significant improvement on stability following a once-weekly PT program for 6 weeks. In fact, the researchers claimed that knee stability is needed during midstance to achieve full knee extension, which enhances functional mobility. Each phase was maintained for 3–5 s because the focus group was within 45–65 years old, which was slightly younger than the study participants of Sayers et al. (2012) (67.6 $\pm$ 6.8 years) and had a hold time of 2 s. A hold time of 3–5 s was selected, considering the age range, moderate pain intensity, and BMI differences of the participants in the present study. Therefore, not much force was given, particularly on the overweight and obese group, as it may increase the pain and eventually decrease their ability to perform functional activities.

5 Conclusion

Once-weekly supervised exercise training for 8 weeks with planned home exercise program may be effective to improve LLFS among overweight and obese Malaysian women. An improved LLFS would improve their daily functional activities, and thus, decrease the morbidity and mortality rate of obesity-related diseases. Exercise empowerment may be an additional strategy to encourage people with knee OA to achieve long-term physical independence.

6 Future Recommendations

A well-designed and implemented randomized controlled trial is warranted in the future study because a quasi-experimental study tends to have a limitation on internal validity. For a study that assesses exercise effect between groups, a larger sample size is recommended to ensure a high statistical power, guaranteeing better generalizability. Despite the significant improvement in lower limb strength observed with the exercise protocol, future study could extend the focus to a weight reduction program, which may reduce loading impact among overweight and obese people with knee OA.

Acknowledgements We wish to thank the Ministry of Education, Malaysia for funding the research project through the Fundamental Research Grant Scheme (Ref. No. 600-RMI/FRGS//3 (54/2015) and Research Management Centre, Universiti Teknologi MARA, Selangor for the administrative support.

We would also like to thank the Malaysian Physiotherapy Association for the permission given to use the Malaysian version of the knee osteoarthritis care protocol in this study. We wish to express our gratitude to the clinicians, head of the Physiotherapy Department of Sungai Buloh Hospital, and all participants for their assistance and contribution.

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Chapter 63
The Effect of Massage and Spinal Manipulation on Substance P: A Narrative Review

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Abstract Pain is an unpleasant sensation and involved a complex sensory response due to tissue damage. Currently, one of the chemical mediators increasingly being recognized is substance P and it has as a major role as a biomarker in the onset of pain and inflammation. Nowadays, the physical therapy including massage and spinal manipulation has beneficial effect on pain reduction. This study was aimed to review the available evidence about the effectiveness of massage and spinal manipulation on substance P. Online search using databases (Ovid™, Science Direct, Scopus, EMBASE, and PubMed) was performed using keywords "substance P", "massage" and "spinal manipulation". Two experimental studies and one

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_63

review explored about the effect of massage on substance P were found. Furthermore, we analyzed two studies studying the effect of spinal manipulation on substance P level. Four studies have shown that massage can reduce the substance P level after massage and spinal manipulation whereas one study has revealed that the substance P remained unchanged after spinal manipulation treatment.

Keywords Massage · Spinal manipulation · Substance P · Inflammatory mediator Nociceptive pain

1 Introduction

Pain is an unpleasant sensation and involved a complex sensory response due to tissue damage (Patel 2010). The pain intensity varies from mild pain to severe pain that requires treatments (Da Silva 2014). When cellular damage occurs, chemical mediators will be released and detected by sensory neurons whereby pain receptor will be activated. Numerous chemical mediators are involved in pain and inflammation period. Currently, one of the chemical mediators increasingly being recognized playing yet to be identified role modulating pain and inflammation is substance P.

In 1931, the substance P was first discovered by Ulf von Euler and John Henry Gaddum and they found this mediator during extracting the tissue that involved in intestinal contraction. Structurally, the substance P is one kind of neuropeptide that contains an 11-amino acid polypeptide with C-terminal amino acid arranged in sequence. In addition, the substance P is also categorized as one of the tachykinin peptides that acts as a neurotransmitter for pain indicator (Li and Zhao 1994). The substance P and other chemical mediators may be released in peripheral sensory neuron at the skin, muscle, and joints when nociceptors are activated (Otsuka and Takahashi 1977). The nociceptors only react when the tissue damage occurs. The substance P has its specific receptors and mostly binds with neurokinin 1 receptor (NK-receptor, NK1R) which is grouped under the tachykinin receptors (Tang et al. 2007). The substance P and NK-1 receptor originate from peripheral and central nervous system which are mostly found in the dorsal root of the spinal cord (Inoue et al. 1999). Generally, substance P, TNF-α, and IL-1β are categorized as pro-inflammatory mediators.

The binding of substance P with NK-1 receptor causes changes in calcium ion (Ca2+) and potassium ion (K+) activities. Initially, the changes occur when the enzyme phospholipase C is activated and phosphatidylinositol biphosphate bound to two second messengers include inositol-1-1, 4,5-triphosphate and diglyceride via cleavage membrane. Thus, the calcium ion released from intercellular will influx into the cells. Additionally, an increase in the intracellular level of cyclic adenosine monophosphate (cAMP) and cyclic guanosine monophosphate resulted in prolonged depolarization and elevated sensitization to C-fibers (Radhakrishnan and Henry 1995).

The pain stimuli pass through to the spinal cord when the substance P binds to NK-1 receptor. Then, the neuron conducts the information to the brain via spinothalamic tract which regulates pain transmission (White et al. 2007). The brain then processes the information and interprets it as pain sensation. Moreover, the SP and NK-1 receptor also localized in brain area which controls human's emotion. There might be a relation between pain perception and the level of SP after massage and spinal manipulation. The aim of this study was to review the available evidence about the effectiveness of massage and spinal manipulation regulated via substance P.

2 Method

In this review, all types of articles were identified using four online databases: Ovid™, Scopus, EMBASE, and PubMed. A Boolean search strategy was used to reduce the systematic error and to limit the articles search in order to discover all relevant articles. We included the publication from inception of database until December 2016 that involved human as subjects in the research performed. Other than that, the articles must be published in English version as well as available in full text article. The main keywords used to search the related articles were substance P, manipulation and massage, and spinal manipulation.

3 Results

After screening through the abstract and then full text, we have finally included two articles that fulfilled the criteria of this review. The main themes identified were shown below.

3.1 Level of Substance P After Massage

An experimental study done by Mackawan et al. (2007) identified the effects of traditional Thai massage versus joint mobilization on substance P and pain perception in patients with nonspecific low back pain. In this randomized controlled trial study, 67 patients with nonspecific LBP were randomly allocated into two groups based on interventions applied. The TTM group was allocated with 35 patients and 32 patients for joint mobilization group. The duration for each treatment was 10 min for both groups. The outcome measures used were substance P (analyzed from saliva samples) and Visual Analog Scale (VAS) from pain scale. The results showed that there was a significant decrease on substance P after treatment of TTM and joint mobilization. However, comparison between groups indicated insignificant difference on substance P level. Additionally, the other

outcome revealed that the TTM group has slightly decreased in VAS compared with joint mobilization group. They concluded that TMM has a more positive effect on pain reduction rather than joint mobilization.

A study done by Field et al. (2010) investigated the efficacy between massage therapy and relaxation therapy on sleep, substance P, and pain among fibromyalgia patients. The patients were randomly allocated to massage and relaxation therapy group. The duration of treatment was 30 min and intervention was given two sessions per week for 5 weeks. The saliva was taken before and after treatments to analyze substance P level. The other assessments were mood questionnaires measuring anxiety and depression and dolorimeter indicating the pressure of pain. The results revealed that substance P level and pain pressure score have declined. Their study claimed massage could possibly reduce the anxiety as well as depression. Furthermore, it is also improved sleeping hours and a decrease in their sleeping movements too.

3.2 Level of Substance P After Spinal Manipulation

A randomized controlled trial study done by Molina-Ortega et al. (2014) has investigated the immediate effects of spinal manipulation on nitric oxide, substance P, and pain perception. The total sample in this study was 30 asymptomatic subjects. These subjects were randomly assigned equally to three groups: control, cervical and dorsal manipulation groups. Cervical and dorsal groups were categorized as a spinal manipulation. The blood serum was used to analyze the substance P and nitric oxide. The other pain measurement was pressure pain threshold using pressure algometer. Outcome measures were taken before, as soon as and 2 h after treatment. Analyzed data showed a significant increase in substance P level immediately and 2 h after treatment in cervical manipulation groups compared with control and dorsal manipulation groups. In comparison between groups, the result did not show a significant difference on substance P level right before and 2 h post intervention. The other biomarker, nitric oxide showed no significant change between groups in two different times post intervention. However, the pain pressure threshold level elevated immediately after the intervention. Based on the result of this study, the pain threshold level had increased in tandem with elevated substance P level. On the other hand, nitric oxides need further investigation to identify its relation with substance P.\.

Meanwhile, experimental study done by Teodorczyk-Injeyan et al. (2006) explored the efficacy of a single spinal manipulation therapy (SMT) on the in vitro production of inflammatory cytokines, tumor necrosis factor α (TNF-α), and interleukin 1β (IL-1β), in relation to the systemic (in vivo) levels of neurotransmitter substance P. The sample size involved was 64 asymptomatic subjects and allocated into three groups: SMT, sham manipulation (control), and venipuncture group (control). The blood and serum were taken before, 20 min and 2 h after intervention. Whole-blood cultures were activated with lipopolysaccharide for 24 h

to measure the level of TNF-α. The IL-1β and substance P level were assessed by its specific immunoassays. The findings have shown a reduction of TNF-α and IL-1β production in SMT group whereas an increase of cytokines level in both sham and venipuncture groups. In terms of time course, TNF-α and IL-1β increased significantly in both control groups within 2 h of treatment compared with SMT group which showed a reduction on these cytokines. In contrast, substance P level did not show any significant difference in all groups after 2 h interventions.

4 Discussion

Based on our review, the treatments could reduce pain symptom as well as pain metabolite such as substance P. The immediate effect of massage had shown its ability to help and recover patient's discomfort. A consistent massage might improve the quality of life. Field (2010) has discussed the role of touch in massage therapy that affected various conditions including pain metabolites specifically in substance P. This review proposed theoretical framework involved based on the previous study done about the reaction of massage therapy on pain reduction. The most established theory is the Pain Gate Theory (Bicalho et al. 2010). The pressure stimulation of touch could reach the brain faster than pain stimulation. This is because pain transmits to the brain via C-nerve fibers that has a slower conduction compared with A-delta fibers used in pressure stimulation (Da Silva 2014). As an instant effect, the gate would be closed and pain stimuli are not able reach the brain (DeLany 2004). Finally, patients reported reduced pain intensity and were more relaxed during the massage (Sejari et al. 2014).

The serotonin and substance P are linked to each other during massage. The serotonin was supposed to be increased during performing massage and would cause decrease of cortisol level as well as pain mediators include substance P (Field et al. 2002). Another theory related to substance P level is deep sleep theory. The deep sleep probably reduces the pain symptoms due to the lessening of substance P. The study had shown that massage can enhance the deep sleep pattern as well as trigger the reduction of substance P among patients with fibromyalgia (Field et al. 2010).

In contrast, current literature has not demonstrated the effectiveness of spinal manipulation on nociception and inflammatory mediator. Two studies have reported conflicting findings of substance P level. One study has shown no fluctuations in serum concentrations of substance P although TNF-α and IL-1β level are reduced after spinal manipulation. Substance P supposedly would decrease along with other pro-inflammatory metabolites. Therefore, they concluded that time-dependent attenuation of inducing lipopolysaccharide was unrelated to the changes of substance P for SMT treatment. Again, it might be related to downregulation of inflammatory responses through central nervous system that has yet identified mechanism (Teodorczyk-Injeyan et al. 2006). On the contrary, the increasing substance P level after cervical manipulation treatment could be caused by the

elevated pressure pain threshold in the area of epicondyle after spinal manipulation applied right before the cervical manipulation treatment. The elevation of pressure pain threshold would increase the substance P level (Molina-Ortega et al. 2014).

5 Conclusion

Massage and spinal treatment could be included in rehabilitation therapy for pain management. Evidence has suggested the effectiveness of massage in reducing pain symptoms as well as pain mediators such as substance P. Pain sensation would decrease in tandem with the reduction of substance P after massage treatment. The findings for spinal manipulation did not show significant relationship between the pain perception and substance P level. Hence, more studies are warranted to determine the efficacy of massage and spinal manipulation on substance P as well as pain reduction.

Acknowledgements This study was supported by Research Acculturation Grant Scheme: (RAGS/2013/UITM/SKK02/2); Research Entity Initiative grant: 600-IRMI/DANA 5/3/REI (0004/2016). The authors would like to express their gratitude to Ministry of Education, Malaysia and Universiti Teknologi MARA, Malaysia for providing financial support for this research.

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Chapter 64
Advancements in Parasite Diagnosis and Challenges in the Management of Parasitic Infections: A Mini Review

Reena Leeba Richard and Hartini Yusof

Abstract Intestinal parasitic infections (IPIs) remain a widespread public health concern causing severe implications in both developed and developing countries. Globally, numerous studies have been carried out ranging from various communities to schoolchildren as well as indigenous communities. The infections are commonly caused by helminths (e.g. *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm) and protozoa (e.g. *Blastocystis hominis*, *Cryptosporidium* sp., *Entamoeba histolytica* and *Giardia duodenalis*). Poor sanitation and poverty are some of the factors associated with IPIs. With the ever-increasing impact of IPIs, newer detection approaches have been developed and studied. The efficacy of diagnostic method is crucial to give an accurate identification of these parasites. Recent developments of diagnostic tools such as serology- and molecular-based assays are assisting the conventional method of microscopy in detecting and further confirming current or past infections and the specific species of parasites. Ongoing investigations in parasitic infections using these advanced tools will provide useful information that will enable the evaluation of the effectiveness of the current control program and thus, assist future planning for improved strategies in eradicating these parasitic infections.

Keywords Diagnostic tools · Helminths · Intestinal parasitic infections Management · Protozoa

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_64

1 Introduction

The world's population has long been threatened by infectious diseases throughout the centuries. Currently, intestinal parasites are one of the major contributors to the global disease burden with a wide range of parasites that are reported to be prevalent around the world (Mehraj et al. 2008; Pullan et al. 2014; Mama and Alemu 2016), especially in sub-Saharan Africa, USA and Asia. Although these parasites are highly reported in underdeveloped countries, the emergence of intestinal parasitic infections (IPIs) has continued to compromise the quality of human life in developed nations. Infections are commonly caused by helminths (e.g. *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm) and protozoa (e.g. *Blastocystis hominis*, *Cryptosporidium* sp., *Entamoeba histolytica* and *Giardia duodenalis*) resulting in significant morbidity and mortality, especially in endemic countries (Haque 2007). An estimation of 2 billion people are infected with intestinal parasites (Chan 1997) and the numbers have rapidly increased each year with 4 billion reported to be at risk in acquiring infections (Hotez et al. 2014). Extreme poverty, poor sanitation and social stigma as well as lack of education on the prevention and treatment are some of the factors contributing to these diseases (Liese et al. 2010). Furthermore, Basuni et al. (2012) had stated that the effects caused by IPIs depended on the species of parasites, the affected organ and the host immunological status. Although IPIs rarely cause death, the infection can impair the physical and mental growth, particularly among children (Varkey et al. 2007).

The challenges that arise due to the elevation of parasitic diseases have propelled newer, advance approaches and opportunities towards parasites diagnosis (Elsheikha 2014). In addition, latest techniques should be less time-consuming without compromising the quality of results. Therefore, rapid diagnosis is crucial and remained a top priority in determining the accurate identification of the parasites and eventually providing appropriate treatment as well as preventing fatalities among patients (Tavares et al. 2011). This mini review paper will briefly discuss the techniques commonly used in laboratory diagnosis with each method having its own advantages and disadvantages. The methods that are used for the diagnosis of several parasites that caused IPIs are further summarized in Table 1 as tabulated by Ndao (2009) and Ricciardi and Ndao (2015) with additional data by Wang et al. (2016).

1.1 Advancements in Parasite Diagnosis

For the past decades, various tests had been developed to increase the specificity and sensitivity in identifying parasites. The advancement of knowledge and technology had catapulted the diagnosing of parasitic infections to a new level. These techniques have been employed in numerous studies throughout the world, hence, enabling disease-combating efforts (Ricciardi and Ndao 2015).

Table 1 Diagnostic approaches for the detection of intestinal parasites

Helminth	Diagnostic approaches				References
	Microscopy-based	Serology-based	Molecular-based	Proteomics	
Schistosoma species	Using Kato-Katz technique	IHA, ELISA, dipstick	PCR, real-time PCR, multiplex PCR	LC-MS/MS	Katz et al. (1972); van Gool et al. (2002); ten Hove et al. (2008); Cnops et al. (2013); Sousa-Figueiredo et al. (2013); Lodh et al. (2014); Wang et al. (2016)
Soil-transmitted helminths	Using sedimentation or concentration techniques	ELISA	Multiplex real-time PCR	–	Bungiro et al. (2005); Basuni et al. (2011)
Taenia solium	Using sedimentation or concentration techniques	ELISA, Immunoblot	Nested PCR	Mass Spectrometry	Del Brutto et al. (2001); Bueno et al. (2005); Deckers et al. (2008); Mayta et al. (2008)
Protozoa					
C. parvum, C. hominis	Using modified acid-fast staining	DFA, ICT assay kit	PCR, real-time PCR, multiplex real-time PCR, LAMP, Luminex	LC-MS/MS	Weber et al. (1991); Johnson et al. (1995); Johnston et al. (2003); Bandyopadhyah et al. (2007); Karanis et al. (2007); ten Hove et al. (2007); Jothikumar et al. (2008)
Giardia lamblia	Using trichrome or ion hematoxylin staining; Using concentration or sedimentation techniques	DFA, ICT assay kit	Multiplex real-time PCR	–	Danciger et al. (1975); Young et al. (1979); Garcia et al. (1997); ten Hove et al. (2007); Siddiki (2012)
Entamoeba histolytica	Using staining methods	IHA, IIF, ELISA, ICT assay	Multiplex real-time PCR, LAMP	LC-MS/MS	Hira et al. (2001); Gonin and Trudel (2003); Fotedar et al. (2007); Liang et al. (2009); Ali et al. (2012); Luca-Nacar et al. (2016)

C Cryptosporidium, *IHA* indirect hemagglutination, *ELISA* enzyme-linked immunosorbent assay, *PCR* polymerase chain reaction, *LAMP* loop-mediated isothermal amplification, *DFA* direct fluorescent antibody, *ICT* immunochromatograhic, *LC-MS/MS* liquid chromatography-tandem mass spectrometry

1.2 Microscopy-Based Approach

Routine laboratory diagnosis that includes conventional microscopy technique has been widely used for morphological identification of parasites and was then the only tool for the detection of parasites obtained from cerebrospinal fluid, faeces, blood smears and tissue specimens (Tavares et al. 2011). This method is commonly employed as it requires inexpensive reagents or dyes and using only the microscope alone. However, throughout the years, although microscopy examination is considered as a gold standard, it is rather difficult to determine or distinguish the species through naked eye as it is largely dependent on an experienced microscopist to ensure quality results and it consumes time to process starting from sample collection to concentration of the parasite's identification (Jamil et al. 2016). This situation can be further proven on the inability to distinguish *E. histolytica* and *E. dispar* through only morphological observation. Despite the disadvantage, dual techniques such as formalin-ether sedimentation, trichrome and Ziehl-Neelsen staining are usually applied together as conducted by Ngui et al. (2011) and Shahrul Anuar et al. (2013).

In addition, Kato-katz and McMaster counting methods are also common nowadays and regarded as a standard technique for the detection and quantification of IPIs for nearly forty years as reported by Komiya and Kobayashi (1966), Uga et al. (2002) and Belizario et al. (2015) and had since been recommended by WHO (1991). Meanwhile, McMaster counting method is extensively used to assess soil-transmitted helminths or STHs. It is also rather usual to include McMaster and Kato-katz technique in the same study as stated by previous studies (Pullan et al. 2010; Geiger et al. 2011; Periago et al. 2015). A study done by Levecke et al. (2011) revealed Kato-katz was more sensitive in detecting *A. lumbricoides* but not for *T. trichiura* and hookworm. Both methods were reported to have a considerable variation in sensitivity between different trials as Kato-Katz method covers larger quantity of stool but its drawback is when the infection intensity is rather low (Kongs et al. 2001) while McMaster technique is based on eggs flotation. Furthermore, both techniques are valid for diagnosis of IPIs with the latter being more suitable for further standardization due to its robust factor (Levecke et al. 2011).

1.3 Serology-Based Approach

Indirect identification of parasites using serology-based technique is employed if the parasite density is low or is unable to be directly demonstrated due to its life cycle in the host such as *Toxoplasma gondii* (Ambrosio and Waal 1990). The development of serology-based approach allows for faster and more practical diagnosis of IPIs that further provides an additional insight together with microscopic observation of the parasites. Serology-based diagnosis is further divided into

two categories namely antigen detection assays and antibody detection assays that include enzyme-linked immunosorbent assay (ELISA), hemagglutination (HA) test, indirect or direct immunofluorescent antibody (IFA or DFA), complement fixation (CF) test and immunoblotting and rapid diagnostic tests (RDTs) (Ndao 2009). ELISA test is the most popular antibody detection assay in laboratory diagnosis while dipstick assays have also considered to be a more practical choice due to its simplicity and achieved higher sensitivity as compared to microscopy in detecting intestinal schistosomiasis (Sousa-Figueiredo et al. 2013).

Other serology-based assays namely indirect hemagglutination (IHA) and indirect immunofluorescence (IIF) are commonly performed in laboratories due to its sensitivity but limited studies had been conducted to analyse their reproducibility (Lescure et al. 2010). Furthermore, immunoassays have also become a main tool in diagnosing parasites (Castelino 1986; Okangba et al. 2010). For the detection of *Giardia* and *Cryptosporidium*, several commercial kits available in the market use immunoassay-based technique to test the parasites using FITC-monoclonal antibodies that target cell wall antigens (Ricciardi and Ndao 2015). The results from the assay is easier to interpret and consume less time to perform the test. However, the disadvantage of serology-based approach is that the diagnosis is retrospective due to the presence of antibodies that varies in different periods after infection occurred (Ndao 2009; Ricciardi and Ndao 2015).

1.4 Molecular-Based Approach

Polymerase chain reaction (PCR) method has become an important tool in the quantification of parasites as well as determining the efficacy of treatment process. This approach offers greater sensitivity and specificity in comparison to the current diagnostic examinations. With the advancement of technology, traditional PCR has evolved to nested, multiplexed and real-time PCR. For protozoan infections, PCR assay has successfully detected *Cryptosporidium* from the environmental samples by targeting the 18S rRNA (Johnson et al. 1995). In addition, multiplex real-time PCR assay used to detect *E. histolytica, G. lamblia* and *C. parvum/C. hominis* was reported to be comparable to microscopy as mentioned by ten Hove et al. (2007) and allows to detect multiple sequences simultaneously within the same reaction tube. Previous study carried out by Basuni et al. (2011) has successfully detected four species of soil-transmitted helminths namely *Ancylostoma, N. americanus, A. lumbricoides* and *Strongyloides stercoralis* through a pentaplex real-time PCR method. Meanwhile, nested PCR has revealed 100% of sensitivity and specificity for the detection of *Taenia solium* DNA by targeting the *TSO*31 gene (Mayta et al. 2008). Other previous findings showed that real-time PCR has proven to be sensitive in detecting *Giardia* and *Cryptosporidium* (oo)cysts (Guy et al. 2004; Gasser 2006). Conventional PCR-based method is rather time-consuming and does not provide quantitative data (Lin et al. 2000). However, although cost is a problem for multiplex PCR and real-time PCR, both have given rapid response as compared to

the conventional method (Tavares et al. 2011). Furthermore, restriction fragment length polymorphism (RFLP) is also one of the most commonly used approaches in diagnosing parasites such as *Toxoplasma gondii* (Quan et al. 2008; Tavares et al. 2011). This technique is based on the digestion of PCR products by restriction enzymes and proven to be suitable for environmental samples as it is able to detect multiple genotypes from the same sample (Monis and Andrews 1998).

Besides PCR-based method, several other amplification techniques have also been developed. Notomi et al. (2000) have introduced a novel gene amplification technique, loop-mediated isothermal amplification (LAMP) that has been used in numerous studies. The advantages of LAMP technique are in its ability to amplify DNA with high efficiency under isothermal conditions and highly specific for the target sequence (Notomi et al. 2000). The method is also deemed simple and easy to perform as it only requires four primers, DNA polymerase and a regular laboratory water bath or heat block for reaction (Tavares et al. 2011). In addition, with the combination of reverse transcription, LAMP is able to amplify RNA sequences with high efficiency. Moreover, reagents can be kept at room temperature without any post-PCR steps as mentioned in Ricciardi and Ndao (2015). LAMP has been applied for the detection of both DNA and RNA viruses such as West Nile and SARS viruses as stated from previous study by Parida et al. (2004) and Poon et al. (2005). Previous study was also carried out to compare LAMP with multiplex PCR from stool samples of patients with taeniasis (Nkouawa et al. 2010). Meanwhile, a recent study by Imai et al. (2017) reported a novel diagnostic approach in identifying human *Plasmodium* species by combining LAMP and MinION sequencer method.

In addition, proteomics work has also rapidly expanded in recent years in analysing proteins expressed by the parasites (Boersema et al. 2015). The current interest in proteomics had led researchers to overcome limitations of early diagnosis and treatment (Petricoin et al. 2002) and has since evolved in the need for sensitivity. The identification of proteins involved two approaches namely bottom-up and top-down. The top-down strategy involves a two-dimensional polyacrylamide gel electrophoresis (Ndao 2009). Several other diseases such as malaria (Nyunt et al. 2005), taeniasis (Deckers et al. 2008) and Chagas disease (Santamaria et al. 2014) have incorporated the study of proteomics. Another new approach named microsatellites consisted of simple sequence tandem repeats and have also been described in reports on parasites obtained from both humans and animals (Temperley et al. 2009) with the ability to mutate rapidly (Johnson et al. 2006). Microsatellites are considered useful genetic markers as it is highly polymorphic (Abdul-Muneer 2014). Meanwhile, Luminex-based assays have also emerged as a possible approach in diagnosing parasitic infections that combine flow cytometry, fluorescent beads, lasers and digital signal processing (Tavares et al. 2011; Chen et al. 2016). Luminex was performed in a study conducted by Bandyopadhyay et al. (2007) that is able to differentiate *C. hominis* and *C. parvum* species by a single nucleotide. The differentiation of both species cannot be distinguished by using antigen detection or other serology tests. The study of the assay improves speed, accuracy and reliability of other PCR methods (Tavares et al. 2011).

1.5 Challenges in Management of Parasitic Infections

Our human body is constantly exposed to parasites daily from our surroundings causing diseases to occur. Intestinal parasites which were once considered as harmless commensals are now shown to be potential pathogens (Lukes et al. 2015). Nowadays, it is quite a trend among researches to focus on improving the current diagnostic techniques rather than inventing a new method, hence, with further improvement of the procedures, more parasites can be detected simultaneously. The useful feature of mass screening and rapid diagnostic will improve the understanding of the parasites as well as to reduce transmission of disease (Yansouni et al. 2014). Besides, the development of field-based diagnosis is also necessary to avoid critical delays. However, sensitivity and specificity as well as cost are still an issue. Renewed and sustainable intervention must be carried out especially in endemic regions. There are various ways that can be implemented to enhance the status of public health, notably in the field of medical parasitology, throughout the world such as by incorporating proper guidelines or policies, monitoring, evaluating and strengthening parasitic disease surveillance (Colley 2000; CDC CDC 2012). There is a crucial need for the monitoring of anti-parasite drugs resistance and other alternatives in developing better treatment for patients. Improved awareness such as regular deworming (Traversa 2012) and other preventive measures need to be carried out consistently especially in targeted areas. Finally, increasing the funding towards parasitological research and interventions is also needed to improve and eradicate potential pathogens (Zilungile et al. 2012).

2 Conclusion

Microscopy-based technique still remains as a useful tool in diagnosing patients with parasitic infections, despite the overwhelming development of new approaches. However, serology- and molecular-based methods are considered as excellent alternatives especially in low range of parasitic infections. The ongoing investigations and current available techniques in detecting the diseases provide a better platform in developing more efficient, reliable and inexpensive methods, hence, improving the quality of life as well as future reductions in global disease burden. The implementation of these recommendations requires full commitment from higher authorities that includes public health and healthcare agencies, medical professionals and funding providers. The support from all stakeholders will boost the efforts in combating IPIs. Future studies need to be carried out to further narrow the major gaps in science.

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Chapter 65
Screening of Adenomatous Polyposis Coli (APC) Gene Polymorphism Using Allele-Specific Polymerase Chain Reaction (ASPCR) Method

Siti Nooraishah Hussin and John Kwong Siew Shia

Abstract Colorectal cancer (CRC) ranks the top cancer among men and the third most common for women in Malaysia. Approximately 5–10% is caused by heritable genetic mutation. Therefore, early assessment and screening of CRC risk is important. Adenomatous polyposis coli (APC) gene mutations have been shown to associate well with the incidence of CRC in Ashkenazi patients and thus potentially a good genetic marker to assess the risk of CRC. In the present study, allele-specific polymerase chain reaction (ASPCR) method was used to detect the probable single nucleotide polymorphism (SNP) of adenomatous polyposis coli (APC) gene. Primer sequences were (i) 5'-GAT GAA ATA GGA TGT AAT CAG ACG-3' (forward), (ii) 5'-CAG CTG ACC TAG TTC CAA TCT TTT CTT TCA-3' (reverse wt) and (iii) 5'-CAG CTG ACC TAG TTC CAA CTT TTC TTT CT-3' (reverse mt). The housekeeping gene, HGH, was used as internal control. Results showed that both subjects (n = 3) with family history of CRC and the subjects with low risk of CRC (n = 3), carried homozygous wildtype variants. This preliminary result suggested that APC mutation may not be a suitable genetic marker to assess the CRC risk level in Malaysian population.

Keywords APC gene · Colorectal cancer

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_65

1 Introduction

Colorectal cancer (CRC) is a cancer of the large intestine. It starts with a polyp, a small abnormal growth, projecting from the inner surface of colon. Some of these polyps eventually turn into cancer (Jasperson et al. 2010). The long-term decline in CRC incidence rates since the mid-1980s has been attributed to both changes in risk factors and the CRC screening program (Edwards et al. 2010). However, the rapid decline in recent years ($\geq$4.0% per year from 2008 to 2011) possibly reflects the aggressive efforts of screening (colonoscopy) and early surgical intervention and removal of precancerous lesions (Siegel et al. 2015; Ghee 2014).

Approximately 5–10% CRC is caused by heritable genetic mutation. Familial adenomatous polyposis (FAP) is an autosomal-dominant CRC in which the presence of mutation or polymorphism of APC gene on chromosome 5q21 will lead to direct phenotypic changes (Faisal 2011). The lesion is characterised by having hundreds or more polyps in colon. Allele-specific polymerase chain reaction (ASPCR) method was used in the present study to assess the suitability of widely used APC primer set (Chan and Gersen 2001) as CRC risk marker on Malaysian population. ASPCR method is highly specific, cost-effective, non-invasive and hassle-free in result interpretation.

2 Materials and Methods

2.1 Ethics Approval

Ethics approval was acquired from the Universiti Teknologi MARA (600-RMI 5/1/6).

2.2 Selection of Subjects

Six subjects were recruited; three were presented as having the potential to colon cancer (P group) and another three as healthy controls. Subjects from P group were identified from families where both their parents were diagnosed with cancers. Subjects were age- and gender-matched for both groups. Prior to blood sampling, each subject was given a subject information sheet and consent form. All participants were briefly explained on the undertaken research and signed the consent form willingly. Inclusion criteria were: (1) willing to participate in this study and giving informed consent. (2) Male and female adults aged 18 years and above.

2.3 Blood Sampling and DNA Extraction

Three millilitre of venous blood was drawn from each subject. DNA extraction was done using DNA extraction kit (Nucleospin^{TM} Blood Kit, Machery-Nagel) according to manufacturer's protocol.

2.4 Primers

The primers used in this experiment were adopted from Chan and Gersen (2001). Primers used to amplify the APC gene were 5'-GAT GAA ATA GGA TGT AAT CAG ACG-3' (forward), 5'-CAG CTG ACC TAG TTC CAA TCT TTT CTT TCA-3' (reverse wt) and 5' CAG CTG ACC TAG TTC CAA TCT TTT CTT TCT-3' (reverse mt). Housekeeping primers used to amplify the growth hormone (HGH) gene were 5'-TGC CTT CCC AAC CAT TCC CTT A-3' (forward) and 5'-CCA CTC ACG GAT TTC TGT TGT GTT TC-3' (reverse).

2.5 PCR Cycling Parameters and Gel Electrophoresis

PCR amplification was performed in 25 µL reactions of 5 pmol/µL of respective primers, 100 µM dNTPs, 1.5 mM $MgCl_2$, 1 X PCR buffer, 0.5 U *Taq* Polymerase and 50 ng/µL of DNA samples. DNA was denatured at 94 °C for 3 min, followed by 35 cycles of denaturation at 94 °C for 30 s, annealing at 61.0 °C for 30 s, and extension at 72 °C for 30 s, with a final extension step for 5 min at 72 °C. The PCR products were size-fractionated by electrophoresis in a 2% agarose gel and stained with ethidium bromide (EtBr). Bands were visualised with a gel documentation system.

3 Results

The APC primer set (reverse wt) successfully amplified target sequence from all six subjects, with the size of approximately 97 bp. All samples from P group (P1, P2, P3) and control group (C1, C2, C3) showed homozygous wildtype variants for APC gene polymorphism (Fig. 1). Housekeeping gene, *HGH*, was successfully amplified in all samples, with the size of approximately 434 bp.

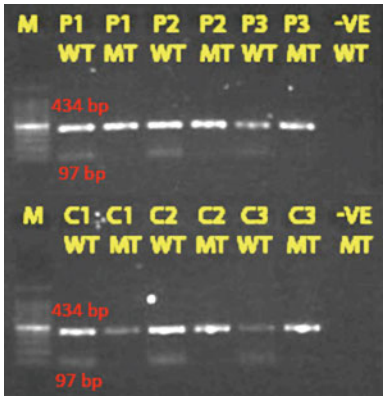

Fig. 1 ASPCR for P group (P1, P2 and P3) and control group (C1, C2, and C3). *M* = 100 bp DNA Marker, APC homozygous wildtype variants = 97 bp, HGH gene = 434 bp

4 Discussions

APC gene encodes for tumour suppressor protein that acts as an antagonist of the Wnt signalling pathway. It is also involved in other processes including cell migration and adhesion, transcriptional activation, and apoptosis. Defects in this gene cause FAP, an autosomal-dominant premalignant disease that usually progresses to malignancy (Faisal 2011). Disease-associated mutations tend to be clustered in a small region that designated the mutation cluster region (MCR) and resulted in a truncated protein product. The initial event of CRC is the activation of Wnt signalling pathway. Wnt signalling pathway involves binding of oncoprotein ß-catenin to nuclear partner (Goss and Groden 2000; Vogelstein and Kinzler 2002). Binding of ß-catenin leads to the formation of transcription factor which controls gene that involved in cellular activation. Function of APC gene is degrading ß-catenin and inhibits nuclear localisation. Hence, mutation of APC gene increases level of ß-catenin and this leads to uncontrollable activation of Wnt signalling pathway (Lynch et al. 2008). Most sporadic CRC adenomas and cancer are associated with somatic mutation or deletion of APC gene, the gatekeeper for colorectal tumorigenesis.

The frequency of the APC I1307K mutation in the general Jewish Ashkenazi population, both in Israel and in the United States, is similar (~6%) (Rozen et al. 1999). Although it was reported that there is a remarkably high proportion of the APC I1307 K mutation among Ashkenazi CRC patients (10.4%) (Giardiello et al. 1997), the recent findings showed the carrier rate to be even higher (53.6%) (Dundar et al. 2007). Possible explanations for high carrier rates include ethnic differences or dietary habits and various other lifestyle risk factors.

Since APC gene was shown inappropriate as a genetic marker in the present study, i.e. both p group and healthy controls exhibited homozygous wildtype variants, other genetic markers should be considered to assess the risk of CRC for Malaysian population. For instance, (i) TP53 gene, in which missense mutation leads to inactivation of P53 pathway (Grady and Markowitz 2002). (ii) Genes that

reduce inactivation of TGF-ß signalling (Markowitz and Bertagnolli 2009), such as *SMAD4* or *SMAD2* and *SMAD3*. In addition, certain oncogenes are deemed responsible to increase incidence of CRC. Mutation of RAS and BRAF oncogenes will activate the MAPK signalling pathway. There were 37 and 13% of CRC patients associated with RAS and BRAF mutation, respectively. RAS mutation activates GTPase activity and directly signal to RAF (Sartore-Bianchi et al. 2009). Then, mutation of BRAF will signal BRAF serine threonine kinase activity that primarily leads to APK cascade and causes CRC. Another genetic mutation related to CRC is PI3KCA (Parsons et al. 2005) which encodes the catalytic subunit of PI3K. One-third of CRC patients were associated with PI3KCA mutation.

5 Conclusion

This preliminary result suggested that APC mutation may not be an important genetic marker to assess the CRC risk level in Malaysian population. The limitation of the present study is the size of the sample population. A larger sample population should be examined to confirm the findings.

Acknowledgements This research is fully supported by the Faculty of Pharmacy, Universiti Teknologi MARA Selangor.

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Chapter 66
Prognostic Factors for Rheumatics Heart Disease After Mitral Valve Repair Surgery Using Cox Proportional Hazard Model

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Abstract Mitral valve repair surgery is associated with the improvement of prognostic outcomes. However, it is unclear whether mitral valve repair surgery alone is sufficient or requires a combination of repair with other repair procedures to improve the survival rate among rheumatic heart disease (RHD) patients. The aim of the study is to determine the risk of death among RHD patients after mitral valve repair surgery. A cohort-retrospective study was conducted among 771 RHD patients. The overall 10-year survival rate after mitral valve repair surgery was 93.7%. This study employed cox proportional hazard (PH) model to determine the significant prognostic factors among RHD survival patients after mitral valve repair surgery. Prognosis factors are considered statistically significant when Wald statistic produces *P*-value less than 0.05. A multivariate model analysis indicates

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_66

that only five prognostic factors are statistically significant, namely hypertension (HPT), emergency status diagnosed at intra-operation, combination mitral valve repair surgery, higher coronary pulmonary bypass (CPB), longer number of days of hospital stay (HOSP), and redo surgery diagnosed at post-operation. The study concludes that the combination mitral valve repair surgery with other surgical procedures improved survival rates of RHD patients with given good surgical outcomes.

Keywords Cox proportional hazard model · Mitral valve surgery
Prognostic factors · Rheumatic heart disease · Risk analysis · Time to death

1 Introduction

Rheumatic heart disease (RHD) is a chronic and progressive condition of illness and remains an important cause of heart diseases. It has also become the most common health disease among children in most developing countries with estimates of at least 15 million people affected by this disease worldwide (Zakkar et al. 2009; Feringa et al. 2006). The disease commonly leads to regurgitation (Remenyi et al. 2012; Enriquez-Sarano et al. 2009) and less commonly to valve stenosis or mixed regurgitation and stenosis (Bhandari et al. 2007). Even though most of the RHD is mildly affected with minor marginal progress to more severe conditions (Carapetis et al. 2005) but the patients still require valve surgery to treat with the disease (Baskerville et al. 2012).

The surgical community is aware that mitral valve repair surgery is the most effective valve surgery to restore normal life expectancy and for better quality of life (Detaint et al. 2006; Ling et al. 1997) compared to replacement valve surgery (Remenyi et al. 2014). Most studies have demonstrated that mitral valve repair results in long-term benefits including associated lower rate of reoperation, endocarditis, thromboembolism, anticoagulant related to complications and valve infection compared to replacement valve surgery (Perier et al. 1984; Gillinov et al. 1998; Suri et al. 2006; David et al. 2005; Mohty et al. 2001). Furthermore, mitral valve repair surgery nowadays known as gold standard restores mitral valve dysfunction (Meyer et al. 2007) and improves prognostic outcomes such as reduced long-term incidence of disease recurrence (Perier et al. 1984; Akins et al. 1994; Galloway et al. 1989). However, it is unclear whether mitral valve repair alone is sufficient or it requires a combination repair with other procedures with improved survival rate among RHD patients. Major hindrances to the less-frequent repairs in this population have been the unpredictability of long-term results and, more important, the complexity of the disease process, which makes it difficult to choose the appropriate procedure for any given patient (Erez et al. 2003). Patients with acute rheumatic fever may develop varying degrees of pericarditis with associated

valve disease, health failures and pericarditis (Carapetis et al. 2005) and also can be a fatal disease without proper treatment given. The aim of the study is to determine mitral valve repair procedures as one of the independent prognostic factors in estimating the risk of death among RHD patients after mitral valve repair surgery.

2 Methods

A cohort-retrospective study was conducted using secondary data among 721 RHD patients at University Kebangsaan Malaysia (UKM) Heart and Lung Centre and National Heart Institute (Institut Jantung Negara, IJN), Malaysia who underwent mitral valve repair between January 1, 1992, until December 31, 2011. Information was obtained from hospital records which comprise of four categories of major prognostic factors; **Demographic** factors: gender, age, ethnicity; **Pre-operative factors**: *New York Heart Associations* before (Pre-NYHA), hypertension (HPT), diabetes mellitus (DM), coronary artery disease (CAD); **Intra-operative factors**: Coronary pulmonary bypass (CPB), cross-clamp time (Xclamp, Intra-operation status (Intra-Operative status), tricuspid annuloplasty (TAP), mitral valve repair procedures) and **Post-operative factors**: Number of days of hospital stay (HOSP), *New York Heart Associations* after (Post-NYHA), post-operation status (Post-operative status). Survival time was measured in days starting from the date of first surgery until death due to RHD. For each patient, status is recorded as either death or censor. Censor cases occur when there is no reported cases of death which is either due to a loss in follow up, withdrawal, or death from unrelated events. Otherwise, it is considered as death cases. The censor cases are assumed to be non-informative.

2.1 Statistical Analysis

In this study, continuous variables were summarized as mean ± standard deviation (Range) while categorical variables were reported as frequency and percentage. The relationship between risk factors and time to death were assessed by Cox proportional hazards (PH) regression analysis. The event of interest in this study is time to death due to RHD. The response variable comprises of both time to death (days) and censoring status. Univariate and multivariate analyses were employed to determine the risk death among RHD patients. The stepwise method was used to identify the least set of variables jointly correlated with survival: at each step, the variable with the highest computed P-value was removed until all significant factors were included in the model. Statistical significance was defined as P-value < 0.05. Survival curves were calculated by the Kaplan–Meier method. All data were analyzed using SPSS version 18.0.

3 Results

3.1 Patients Characteristics

The demographics and operative characteristics of 721 patients who underwent mitral valve repair are shown in Table 1. The total number of 721 patients with RHD was included in the study, of whom, 334 patients (46.3%) were male and 387 patients (53.7%) female. It indicates that females were more exposed to RHD compared to males. The mean age was 30.52 ± 19.054 years (Range: 1–75 years). Out of 721 RHD patients who underwent mitral valve repair surgery, 697 patients (96.7%) were alive while 24 patients (3.3%) died by December 31, 2011. The majority of patients were Malays with 481 cases (66.7%) followed by Chinese 148 cases (20.5%), Indian 39 (5.4%), and other races 53 cases (7.4%) studied.

3.2 Pre-operative Factors

The New York Heart Associations (NYHA) clarification provides simple classification of the extent of heart failure based on their limitations during physical activity. All patients were monitored for Pre- and Post-NYHA mitral valve repair surgery to access the progress of the illness after the surgery. There were 363 cases (50.3%) of RHD patients who experience Pre-NYHA Class II followed by Class III (185 cases = 25.7%), Class I (151 cases = 20.9%) and Class IV (22 cases = 3.1%). It shows some improvement in Post-NYHA classes where the majority of RHD were converted into class I with 617 cases (85.6%) followed by class II, class III, and class IV with 19 cases (2.6%), 5 cases (0.7%) and 1 cases (0.1%) respectively. RHD patients with HPT give the highest percentage (16.1%), followed by DM (6.9%) and CAD (6.5%).

3.3 Intra-operative Factors

The total number of patients who completed the study decreased to 19 cases (2.6%) of death and 60 cases (8.3%) of incomplete follow-up. The mean of CPB and Xclamp time taken during the surgery are 113.43 ± 50.541 min and 81.74 ± 36.465 min, respectively.

Table 1 Mitral valve repair patient characteristics (n = 721)

Variable	Subgroup	n (%)	Mean ± standard deviation (Range)
Age			30.52 ± 19.054 (Range: 1–75)
Gender	Male Female	334 (46.3) 387 (53.7)	
Ethnicity	Malay Chinese Indian Others	481 (66.7) 148 (20.5) 39 (5.4) 53 (7.4)	
pre-NYHA	Class I Class II Class III Class IV	151 (20.9) 363 (50.3) 185 (25.7) 22 (3.1)	
Status	Alive Death	697 (96.7) 24 (3.3)	
HPT	Yes No	116 (16.1) 605 (83.9)	
DM	Yes No	50 (6.9) 671 (93.1)	
COD	Yes No	47 (6.5) 674 (93.5)	
CPB			113.43 ± 50.541 (Range: 0–632)
Xclamp			81.74 ± 36.465 (Range: 0–296)
Intra-Operative status	Elective Emergency	707 (98.1) 11 (1.5)	
TAP	Urgent Yes	3 (0.4) 202 (28.0)	
Mitral valve procedure	No Repair only	519 (72.0) 508 (70.5)	
HOSP	Repair + other	213 (29.5)	
Post-Operative status			9.4 ± 6.022
Post-NYHA	1st operation Redo Class I Class II Class III Class IV Death Lost	715 (99.2) 6 (0.8) 617 (85.6) 19 (2.6) 5 (0.7) 1 (0.1) 19 (2.6) 60 (8.3)	(Range: 0–63)
Total		721 (100)	

3.4 Post-operative Factors

According to the results from Table 1, the mean HOSP for all RHD patients was 9.4 ± 6.022 with ranges 0–63 days. Each RHD patient was checked to determine his/her priority for the operation status and, the results of the operation status were grouped as follows: Most of RHD patients were diagnosed as elective status in intra-operation with 707 cases (98.1%) followed by emergency status, 11 cases (1.5%) and urgent status 3 cases (0.8%). There were 6 cases (0.8%) of RHD patients who require to redo the surgery. Two types of mitral valve repair procedures were performed with most of the being RHD patients who underwent mitral valve repair alone with 505 cases (70.5%) while the rest of 213 cases (29.5%) were required to perform the combination of mitral valve repair with the other procedures. Most of RHD patients did not require to perform TAP with 519 cases (72%).

3.5 Long-Term Survival

The results in Table 1 also indicate that not more than half RHD patients have experienced death after mitral valve surgery. The estimated survival rates of RHD at 30 days was 97.7% and over time the expected survival rate dropped to 96.9% within 1 years, 94.7% within 6 years, and 93.7% within 7 years. Overall survival rate of RHD patients after mitral valve repair surgery was about 93.7%. The estimate of overall Kaplan–Meier survival rate reveals that most of the deaths occurred within 30 days after mitral valve surgery with 14 cases (1.82%) while 10 cases (1.32%) for late death which is 30 days after mitral valve repair surgery. The survival curve indicates that RHD after mitral valve repair surgery has higher survival rates as shown in Fig. 1.

As depicted in Fig. 2, the survival curves for combination mitral valve repair procedures show higher survival rates with overall survival of 96.9% as compared to mitral valve repair alone with overall survival rate of 91.1%. For combination mitral valve repair procedures, there were 3 patient deaths after the surgery while 21 deaths after performing mitral valve repair only. The survival curves show there are significant differences between the survival rates among two mitral valve procedures (P-value = 0.022).

3.6 Predictors of Mitral Valve Repair

The univariate analysis was carried out before proceeding to multivariate analysis. The effect of one variable on time to death was determined. There were 12 possible prognostic factors in RHD that are highly significant in predicting the risk of death namely older age (P-value = 0.002), higher class Pre-NYHA (P-value = 0.044),

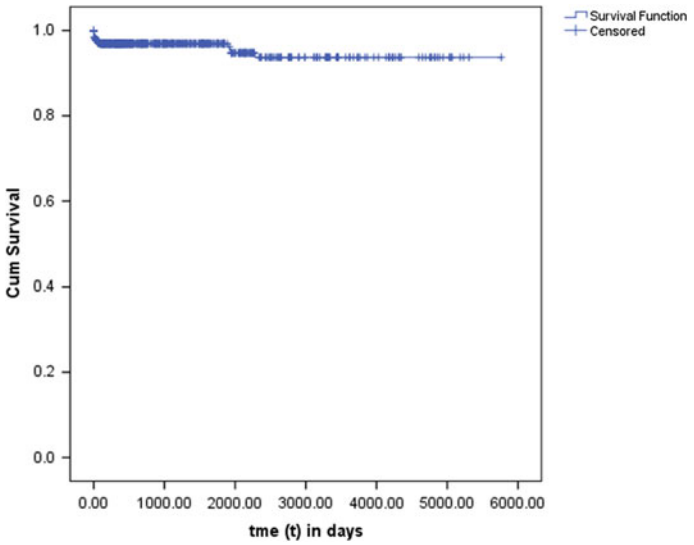

Fig. 1 Overall survival curves of 721 cases with Rhuematic Heart Disease

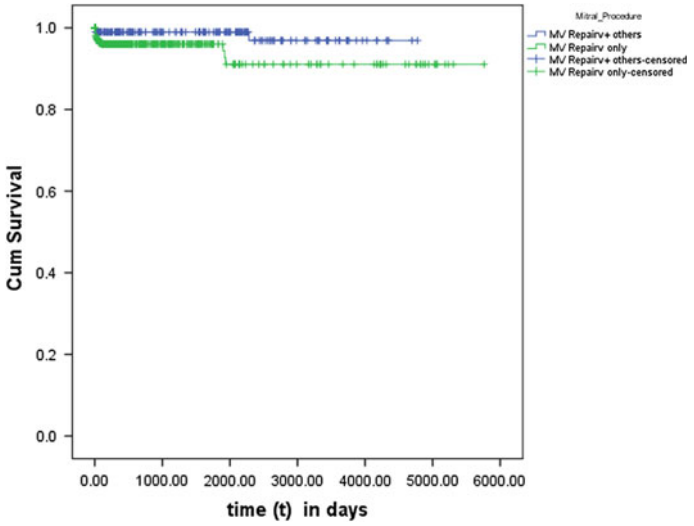

Fig. 2 Overall survival curves of mitral valve procedures

DM *(P*-value = 0.001), CAD (*P*-value = 0.005), diagnosed as emergency status in intra-operation, higher CPB, combination mitral valve repair procedures, redo surgery diagnosed at post-operation status, longer HOSP, having HPT, and longer Xclamp (all at *P*-value = 0.000) (Table 2).

Table 2 Univariate survival analysis of mitral valve repair

Variable	Regression coefficient	HR	*P*-value
Age	0.034	1.035	0.002
Gender	0.714	2.042	0.920
Ethnicity	0.025	1.025	0.920
Pre-NYHA	0.550	1.734	0.044
HPT	1.698	5.465	0.000
DM	1.642	5.168	0.000
COD	1.409	4.093	0.005
CPB	0.012	1.012	0.000
XClamp	0.016	1.017	0.000
Intra-operative	1.483	4.406	0.000
Status TAP	−0.049	0.952	0.917
Mitral valve	1.343	3.830	0.032
Procedures HOSP	0.061	1.063	0.000
Post-operative status	2.887	17.933	0.000
Post-NYHA	0.000	1.000	1.000

These significant prognostic factors associated with the risk of RHD at *P*-value < 0.250 were further tested in multivariate analysis using stepwise regression (Kleinbaum and Kupper 1978). There are only 11 prognostic factors associated with risk of death among RHD in the univariate analysis were included in the multivariate analysis. To identify significant prognostic factors that influence the risk of death among RHD patients, the insignificant variables are dropped one by one each time until the final model consisting of all the significant variables at *P*-value < 0.05 are observed.

Table 3 shows the results of the significant prognostic factors of RHD patients. There are only six statistically significant prognostic factors namely HPT (*P*-value < 0.024), intra-operation status (*P*-value = 0.001), mitral valve repair procedures (*P*-value = 0.040), CPB (*P*-value = 0.000), HOSP (*P*-value = 0.025) and post-operation status (*P*-value = 0.004) were included in the final model.

Table 3 Final model

Variable	Regression coefficient	HR	*P*-value
HPT	−1.028	0.358	0.024
CPB	0.012	1.012	0.000
Intra-operation status	−1.910	0.148	0.001
Mitral valve procedures	−1.327	0.265	0.040
HOSP	0.046	1.047	0.025
Post-operation status	−2.213	0.109	0.004

It was found that RHD patients who did not have HPT face less risk of death compared to patients who had HPT after mitral valve repair. For those who were diagnosed as elective status in the intra-operation have less risk of death as compared to those classified as emergency and urgent status. The combination of mitral valve surgery with other procedures presents less risk of death than for those who perform mitral valve repair alone. Having the first experience of surgery is less likely of the risk of death compared to those who redo the surgery. The risk of death for RHD patients increased by 4.7% for each day's stay in hospital. The risk of death for each minute in CPB among RHD patients will increase by 1.2%.

4 Discussion

Rheumatic fever remains a major health problem especially in developing counties. It is well known that mitral valve repair is superior to mitral valve replacement for valve disease. (Dibardino et al. 2010). However, mitral valve repair technically is more difficult and has mixed results in term of durability and long-term outcome. Thus, lack of study has been done to show the overall benefit of treatment between combination mitral valve repair procedure and mitral valve repair alone (Kumar et al. 2006). Five major types of repair can be classified into five procedures namely chordal procedure, leaflet procedures, valve commissure, ring annuloplasty and papillary muscle split. All five procedures can either be done alone or to combined with other repair procedures (Mamat 2012).

This study is aimed at examining the efficiency of the valve repair procedures among RHD at the same time to determine the significant prognostic factors among RHD survival patients. Our study shows that although mitral valve repair alone gives good surgical outcomes, the combination mitral valve repair with other surgical procedures has significantly improved the surgical outcome after among RHD patients. It has been found that the prognostic factors that influence the risks of death for RHD after undergoing mitral valve repair surgery are namely for those who have Hypertension, diagnosed as emergency status, those who redo surgery, performed mitral valve repair alone, higher coronary pulmonary bypass and longer number of days of hospital stay. This finding is similar to other studies (Mamat 2012; Akins et al. 1994; Braunberger et al. 2001; Kumar et al. 2006; Meyer et al. 2007; Mohty et al. 2001).

5 Conclusion

The combination of mitral valve repair surgery with other surgical procedures has improved survival rates with good surgical outcomes. The prognostic factors show that with hypertension, emergency status, combination mitral valve repair with other repair surgery, higher coronary pulmonary bypass, longer number of days of

hospital stay and redo surgery were significantly associated with the risk of death after mitral valve repair surgery among RHD patients.

Acknowledgements We would like to dedicate our appreciation and gratitude to University Kebangsaan Malaysia (UKM) and Heart and Lung Centre and National Heart Institute (Institut Jantung Negara, IJN), Malaysia. Special thanks also goes to Universiti Teknologi MARA (UiTM) for supporting this study under the Research University Grant No. 600-RMI/DANA 5/3/PSI (197/2013).

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Chapter 67
Effect of Indoor Rowing Exercise on Body Composition, Blood Glucose, and Lipid Profile Among Obesity: A Pilot Study

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Abstract Rowing exercise involves aerobic and resistance exercise which is considered as one of the safest forms of exercise among obese subjects. To date, the effect of rowing exercise on body composition, blood glucose, and lipid profile among obesity is not known clearly. Thus, the aim of this study was to determine the effect of indoor rowing exercise on body composition, fasting blood glucose, and lipid profile among obese subjects. A pilot study was carried out using 11 obese subjects. Participants were divided randomly into either exercise group ($n = 6$) in which they received indoor rowing exercise or a control group ($n = 5$) where they are requested to continue routine daily physical activities. Subjects in the exercise group were subjected to perform three times/week indoor rowing exercise with moderate- to high-intensity exercise. The outcome measures such as body composition, blood glucose, and lipid profiles were measured before and after 12 weeks in both groups. The results showed that body mass index (BMI) in experimental group altered with $p < .05$, whereas for the other variable there are no significant changes. This pilot study indicated there are changes in BMI following indoor rowing exercises among obese subjects.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_67

Keywords Body mass index · Glucose · Lipid · OB

1 Introduction

Obesity (OB) is defined by World Health Organization (WHO 2006) as abnormal or excessive fat accumulation that may impair health. It is one of the global health issues in the growing economic scenario which leads to higher chances of OB-related disorders. Most of the outcome measures used to assess OB are related to adiposity such body mass index (BMI), waist circumference (WC), and waist–hip ratio (WHR). Body mass index is the simplest and most widely accepted measure of OB as recommended by WHO using cut-off points of 30 kg/m^2 (WHO 2004). Waist and hip circumferences are measurements to identify abdominal OB and a stronger predictor of subsequent development of cardiovascular disease (CVD) (Zaki et al. 2010). Excess body fat leads to severe consequences on health, such as high blood pressure and changes in lipid profile including total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides (TGs) (Augusto and Silva 2014).

Studies suggested that exercise training which increases muscle activity may allow the adipose tissue to be used as a fuel source (Prior et al. 2007; Tuttle et al. 2012). Aerobic exercise-based interventions showed reductions in BMI and body fat percentage, increased HDL cholesterol, and decreased TGs levels (Augusto and Silva 2014). In addition, it was also reported that aerobic exercise has an effect on reduction of body fat mass, visceral, and subcutaneous adipose tissue (Willis et al. 2012). Similarly, changes in body composition such as fat mass (FM) and BMI together with a decrease in TGs and total cholesterol have been reported in the overweight young women group involved in long aerobic training (Kostrzewa-nowak et al. 2015).

Furthermore, studies reported a significant effect of combined aerobic and resistance exercise training on the reduction of FM and adipose tissue in OB (Hunter et al. 2010; Willis et al. 2012; Dâmaso et al. 2014). Sanal et al. (2013) found significant changes in body composition such FM and fat-free mass (FFM) after combined aerobic and resistance exercise. It was suggested that a combination of aerobic and resistance exercise gives greater benefits for weight loss, fat loss, and cardiorespiratory fitness in overweight and obese (Ho et al. 2012).

Indoor rowing exercise provides both aerobic and resistance exercises. The advantage of rowing exercise is lower injury rate compared to other exercises because rowing exercise is practiced on a seat which contributes less impact on the knee joints. These factors make rowing exercise to be safe and recommended for obese people. To date, the effect of indoor rowing exercise has been explored among visually impaired subjects (Shin et al. 2015) and elderly (Asaka et al. 2012). Both studies showed a positive effect on changes in body composition and skeletal muscle mass.

To our knowledge, the effect of rowing exercise on body composition, blood glucose, and lipid profile among OB is not known clearly to date. Thus, indoor rowing exercise was chosen as an exercise tool in this study to determine its effect on body composition, blood glucose, and lipid profile among obese subjects.

2 Materials and Methods

A pilot study was conducted as pre–post-measurement after obtaining ethical approval from university ethics committee (600-RMI(5/1/6). A total of 11 obese subjects were recruited on voluntary basis based on convenience sampling. Subjects who were aged between 18 and 35 years old with BMI $\geq$ 0 kg/m^2, active in daily functional activities, able to comprehend study procedures, and able to comply with the exercise intervention were included. Those who had existing heart and respiratory disease, musculoskeletal problem of lower limbs, and abnormal body geometry such as amputation of lower limbs and neurological deficits on lower limbs were excluded. The 11 subjects recruited were divided into two groups: exercise (n = 6) and control (n = 5). Anthropometry and body composition together with fasting blood glucose and lipid profile were determined before and after completion of the 12-week indoor rowing exercise. The study protocol is shown in Fig. 1.

3 Instrumentations

3.1 Anthropometric Measurements

i. Height
Height was measured to the nearest 0.5 cm using a SECA wall-mounted stadiometer (SECA Mod 220, SECA GMBH & Co. Germany) with the subject not wearing shoes. When measuring the height, the subject was standing without shoes, heels together, back as straight as possible, heels, with buttocks, shoulders, and head touching the wall and looking straight ahead.

ii. Weight
Body weight was measured to the nearest 0.1 kg using a SECA weight scale (SECA Mod 220, SECA GMBH & Co. Germany). During weight measurement, subjects wore light clothing without shoes.

iii. Body mass index (BMI)
Body mass index was calculated as weight in kilograms divided by the square of height in meters. Following the recommendations of World Health Organization (2006), BMI of less than 18.4 kg/m^2 was categorized as underweight and BMI in the range of 18.5–24.9 kg/m^2 was normal. In addition, BMI of 25.0–29.9 kg/m^2 was considered as overweight, whereas BMI above or equal 30.0 kg/m^2 were categorized as obese.

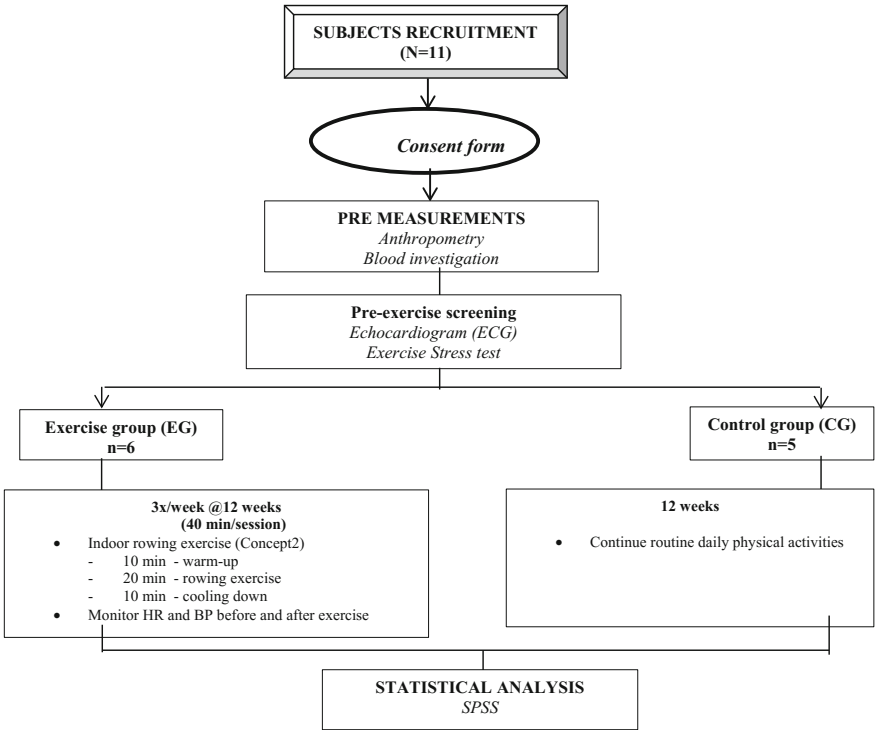

Fig. 1 Flowchart of the study protocol

iv. Body fat percentage
Body fat percentage was measured using the foot-to-foot Bioelectrical Impedance Analyzer (BIA) (Tanita TBF-300A, USA). The BIA is a noninvasive measurement, based on the principle of resistance to the flow of electrical current due to differences in water content of fat and lean tissue (Wagner and Heyward 1999). For this measurement, the subject stood barefoot on the footpads, while a low-level electrical current is introduced into the body at a fixed frequency. This measurement includes fat mass, free fat mass, total body water, and bone mass.

v. Blood collection and analysis (glucose and lipid profile)
Fasting venous blood samples were collected pre- and post-intervention on all subjects. The blood sample was taken from the antecubital veins by a trained nurse. The blood samples were centrifuged at 3500 revolutions per minute (RPM) for 10 min within 2 h after collection. Routine biochemical analyses performed were fasting plasma glucose and fasting serum lipid concentrations. All analyses were performed using an automated analyzer (Cobas C501, Roche Diagnostics USA).

3.2 Exercise Program—Indoor Rowing Exercise

Subjects from exercise group (EG) were performed indoor rowing exercise using Concept2 rowing model E (Concept2 Inc., Morrisville, VT, USA) 3×/week for 12 weeks. The exercise was conducted at the physiotherapy gymnasium. Before the exercise, subjects were given instructions on proper stretching exercise and warm-up. All sessions started with 10 min warm-up, 20 min rowing exercise, and 10 min cooling down period which accounted to total of 40 min per session. The subjects were given instructions on how to use the rowing machine prior to the exercise training. Subjects were instructed to wear the wireless heart rate sensor and watch (Polar Heart Rate FT7, USA) before starting the rowing exercise to record heart rate, caloric expenditure, and exercise duration per session. Exercise intensity during the first 2 weeks was 60–70% of heart rate maximum (HR_{max}) as an adaptation period and 70–85% during week 3–12 as a progression period. Initial intensity and progression were compatible with the recommendations of ACSM (ACSM 2010). The HR_{max} for each subject was achieved from exercise stress test. The subjects rowed at a self-selected stroke rate and resistance level. The subject's heart rate, rate of perceived exertion using Borg scale, caloric expenditure, and duration were recorded for each exercise session in the subject's exercise log. Blood pressure and heart rate were checked before and after exercise to monitor abnormal cardiopulmonary response. On the other hand, subjects from control group (CG) were asked to continue their routine daily physical activities.

3.3 Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 21 was used to analyze the data. Descriptive statistics was used to analyze age. Since the data is not normally distributed because of less sample, Wilcoxon-signed rank test was chosen to know is there any significant difference between pre- and post-exercise on exercise and control group and Mann–Whitney U test to compare between both groups. Level of significance was set at $p < .05$.

4 Results

The subjects were 11, mean age of 25.73 ± 4.98 years old with 4 male and 7 women. Mean of parameter among exercise and control group is presented in Table 1. Comparison of the parameters between exercise and control group is presented in Table 2. The indoor rowing exercise caused a significant difference in the body mass index with $p = .04$ among exercise group. However, no significant differences were observed in all variables in control group and between control and exercise group.

Table 1 Mean of parameter among exercise and control group

	Control			Exercise		
	Pre-exercise (Mean ± SD)	Post-exercise (Mean ± SD)	*p*	Pre-exercise (Mean ± SD)	Post-exercise (Mean ± SD)	*p*
BMI	30.91 ± 1.63	30.6 ± 2.2	.89	33.5 ± 3.82	32.28 ± 3.42	.04*
Weight	84.34 ± 7.57	83.48 ± 7.78	.72	88.47 ± 15.93	88.08 ± 15.13	.60
Fat mass	33.2 ± 6.98	33.18 ± 8.45	.89	33.6 ± 7.86	32.98 ± 7.38	.60
Fat-free mass	51 ± 5.83	50.58 ± 5.89	.50	54.42 ± 13.32	54.55 ± 13.25	.47
Glucose	5.0 ± .38	4.96 ± .18	.68	5.13 ± .37	5.12 ± .31	.71
Cholesterol	4.66 ± .43	5.06 ± .54	.14	5.07 ± .79	5.07 ± .74	1.00
Triglyceride	1.02 ± .51	.92 ± .19	.71	1.25 ± .33	1.18 ± .55	.60
HDL	1.34 ± .36	1.54 ± .40	.06	1.18 ± .27	1.27 ± .39	.13
LDL	2.86 ± .53	3.1 ± .81	.49	3.3 ± .89	3.23 ± .68	.66

*$p < .05$ compared to their respective BMI at baseline

Table 2 Comparison of study variables between exercise and control group

	Group	Mean rank	*p*		Group	Mean rank	*p*
BMI	Exercise	6.83	.43	Cholesterol	Exercise	5.83	.93
	Control	5.00			Control	6.20	
Weight	Exercise	7.00	.33	Triglyceride	Exercise	6.75	.43
	Control	4.80			Control	5.10	
Fat mass	Exercise	6.00	1.00	HDL	Exercise	5.17	.43
	Control	6.00			Control	7.00	
Fat-free mass	Exercise	6.33	.79	LDL	Exercise	6.50	.66
	Control	5.60			Control	5.40	
Glucose	Exercise	6.92	.33				
	Control	4.90					

5 Discussion

This study was designed to investigate the effect of indoor rowing exercise on BMI, glucose, and lipid profile. According to the findings, the results showed that BMI was significantly reduced after 12 weeks of indoor rowing exercise among exercise group as compared to the control group. The study did not observe any significant reduction in blood glucose and lipid profile between the groups. However, inconsistent result was observed from the present study as against an earlier study in which they reported FM decreased and increased in FFM after 6 weeks of indoor rowing exercise among visually impaired subject (Shin et al. 2015).

Previous study on elderly persons showed increase in lower body skeletal mass for both men and women after rowing training (Asaka et al. 2012). The result of

present study is in line with (Ho et al. 2012) who also found a decrease in weight, BMI, and total body fat after 12-week combination of aerobic and resistance exercise training; however, this present study did not observe significant effect on total body fat. The combined aerobic and resistance exercise in Ho et al. (2012) study was aerobic exercise on treadmill and resistance exercise with two sets of 8–12 repetitions at 10-RM for leg press, leg curl, leg extension, bench press, and rear deltoid row, whereas the present study was performed indoor rowing exercise which has both aerobic and resistance exercises. It can be recommended that an indoor rowing exercise is simple and useful exercises which also bring an effect on decreasing BMI after 12-week training.

A study which was carried out on aerobic exercise alone showed a decrease in body fat percentage and FM, while increase in FFM and HDL among experimental group (Augusto and Silva 2014). In addition, combined aerobic and resistance exercise showed significantly increased FFM of arms and trunk in men and decreased FM of legs in women compared to aerobic exercise alone (Sanal et al. 2013).

The possible limitations of this study include small sample size. However, despite small sample, clinically significant changes in body composition and physical fitness were found. Future studies need to be carried out in large number of sample.

6 Conclusion

The study suggests that the indoor rowing exercise is a potential exercise tool for OB together with treadmill and cycle ergometer which has been used in clinical practice. The advantage of indoor rowing exercise which includes aerobic and resistance may also save time to perform two exercises at one time.

Acknowledgements Research Funding: This work was supported by Research Acculturation Grant Scheme (RAGS/2013/UiTM/SKK09/4;600-RMI/RAGS 5/3(113/2013).

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Chapter 68
Falls Risk Factors Among Hospitalized Older Adults

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Abstract Hospitalized older adults have a higher risk of falls which will require longer hospitalization and increase in healthcare cost. The aim of our study was to determine falls risk factors among hospitalized older adults. Hospitalized older adults were recruited based on inclusion and exclusion criteria from January to March 2016. Participants' demographic data was obtained and modified Baecke physical activity, general self-efficacy scale, and Lawton Instrumental Activities of Daily Living (IADL) questionnaires were administered. Participants performed Physiological Profile Approach (PPA) and Timed-Up and Go (TUG) tests. Ninety-six older adults admitted at medical wards (mean age of 70.15 ± 7.6 years) participated in this study. Approximately, 44% participants had experienced a fall. Results of PPA showed that approximately 90% of the participants have mild to high risk of falls. Hospitalized older adults aged 65 and above (OR = 3.12 95% CI 0.03-0.44, $p < 0.05$) and with four and higher number of medications (OR = 3.02 95% CI 0.04-0.76, $p < 0.05$) were identified to have a significant falls risk. Clinically, falls prevention care plan should be applied to all hospitalized older adults. However, hospitalized older adults aged 65 and above and taking four and more medications will require additional falls prevention care.

Keywords Falls · Hospitalized · Older adults · Risk factors

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_68

1 Introduction

The world's population is aging. In Malaysia, the number of people aged 60 and above is also increasing and is estimated to be around 7.2% of the population in the year 2020 (Wan-Ibrahim and Zainab 2014). Aging is associated with changes in multiple systems leading to negative consequences including decline in physical performance and falls (Rubenstein 2006). Falls in older adults lead to injury, fractures, hospitalization, and even death (Rubenstein 2006). A fall is defined as "an event which caused a person to come to a rest unintentionally on a ground or on floor or other lower level" (World Health Organization 2015).

The risk of falls among inpatients is around 5.3%, and it increases with age (World Health Organization 2015). Falls-related injuries lead to longer hospital stay and higher chances of been admitted to long-term care facilities (Nadkarni et al. 2005). Hospitalized older adults who fall are reported to require additional stay from 1 to 5 weeks (Nadkarni et al. 2005). Increase in the length of hospitalization leads to an increase in healthcare cost. About 1.5% of total healthcare expenditures have been used to manage falls-related injuries among older adults globally (Heinrich et al. 2010).

Generally, falls in older adults have been linked to various factors which include internal and external (environmental) factors. Specifically, falls in hospitalized older adults have been associated with previous falls, use of benzodiazepines, weakness of lower limbs, disorientation, postural hypotension, use of mobility aids, self-perceived mobility problems, and a new stroke (Chu et al. 1999). In addition, falls among hospitalized older adults have been linked to their clinical conditions such as anemia and taking certain classes of medications such as antidepressants, sedatives, and hypnotics (Chu et al. 1999).

It is important to understand the relationship between falls and its various risk factors. Identifying falls risk factors among hospitalized older adults can assist in falls prevention plans that are tailored to the specific identified needs. Prevention of falls among hospitalized older adults is also important to reduce medicolegal issues caused by falls in hospitals and reduce the burden of medical care providers. This study was carried out with the aim to determine falls risk factors among hospitalized older adults.

2 Methods

This cross-sectional study among hospitalized older adults was performed in medical wards at Hospital Canselor Tuanku Muhriz from January to March 2016. A total of 96 participants were chosen based on sample size calculation of a previous local study (Sazlina et al. 2008). Ethical approval was obtained from Research Ethics Committee, Universiti Kebangsaan Malaysia (UKM1.5.3.5/244/NN-094-2015).

Inclusion criteria for this study were hospitalized older adults who were 60 years old and above, admitted for more than 3 days, able to communicate in Bahasa Malaysia, English, or Chinese dialects, and able to walk with or without walking aids. Exclusion criteria for this study were hospitalized older adults who were bed-ridden, diagnosed by a medical practitioner to have dementia or were depressed (screened using geriatric depression scale). All participants were given information sheets and verbal explanations before they signed the consent form. Their demographic data was then taken.

Modified Baecke physical activity, general self-efficacy scale, and IADL questionnaires were administered to participants who fulfilled the criteria. The participants then performed TUG test and were tested for their falls risk using PPA.

2.1 Measures

Modified Baecke physical activity questionnaire (Pols et al. 1995) measures habitual physical activity during the past year. Its test–retest reliability was shown to be between 0.65 and 0.89 (Pols et al. 1995). General self-efficacy scale assesses participants' general sense of perceived self-efficacy. It has ten questions with responses on a 4-point scale. This questionnaire has been reported as a valid and reliable (0.76–0.90) scale (Schwarzer and Matthias 2010).

Lawton IADL scale was used to assess the level of independence of the participants. It assessed the ability of participants to use telephone, do shopping, prepare food, do housekeeping and laundry and manage transportation, medication, and finances. IADL is found to be significantly (at the 0.01 and 0.05 level) correlated with physical classification, mental status questionnaire behavior, and adjustment rating scale (Buurman et al. 2011).

TUG test was used to assess functional mobility among the participants. TUG has a high interrater reliability, with intra-class correlation of 0.80 (Beauchet et al. 2011). Participant was seated comfortably on a standard chair with armrest. At the instruction "go", participant was required to stand up and walk at a comfortable speed for a distance of three meters and then turn back to sit on the chair again. The time taken to complete the test was recorded in seconds.

PPA was used to assess falls risk of participants. It has been found that the measurements from PPA are able to predict falls with 75% accuracy (Lord et al. 2003). It consists of several tests, which include edge contrast sensitivity, proprioception, knee extension (quadriceps) strength, reaction time (hand), and sway on a foam rubber mat with eyes open.

3 Analysis

Results were analyzed using Statistical Products and Service Solution (SPSS) version 22.0. Demographic data was analyzed using descriptive analysis. Bivariate regression analysis was performed to identify the clinical and physical performance risk factors for falls.

4 Results

Ninety-six hospitalized older adults from medical wards with a mean age of 70.15 ± 7.6 years old participated in this study. The sociodemographic characteristics of the participants are shown in Table 1. Approximately, 44% of the participants have had an experience of a fall before. The results of PPA showed that approximately 90% of the participants had a mild to high risk of falls with about 58% categorized in the high risk of falls group. Around half of them (56.3%) had three or more chronic conditions such as diabetes mellitus, hypertension, osteoarthritis, etc. About two-fifths of the participants took three or more than three medications.

Table 2 depicts regression analysis of falls risk factors using bivariate regression as most data for variables were not normally distributed. Cut-off values for age were taken as 65 years based on most international studies. TUG cut-off score of $\geq$ 13.5 s was used to categorize older adults with risk of falls as proposed by Shumway Cook et al. (2000). Older adults aged 65 and above (OR = 3.12 95% CI 0.03-0.44, $p < 0.05$) and those taking four or more number of medications (OR = 3.02 95% CI 0.04-0.76, $p < 0.05$) were shown to have a significant falls risk. For functional performance factors, the results showed that none were significant falls risk factors.

5 Discussion

The main objective of this study was to identify risk factors among hospitalized older adults. Older adults aged 65 and above and taking four and higher number of medications were identified to have a significant falls risk. We found that approximately 58% older adults hospitalized in medical wards had high risk of falls assessed using physiological profile assessment (PPA). This falls risk lies between older adults at community settings (12%) and with malnourishment at residential institutions (98%) reported previously at our local settings using the same assessment method (Singh et al. 2014, 2015). In a national-based study across many hospitals in the United States, older adults in medical units were shown to have highest falls incidence with a 4 falls per 1000 patient days (Bouldin et al. 2013).

Table 1 Sociodemographic characteristics of the participants

Parameters	Males (n = 52)	Females (n = 44)	Total (n = 96)
Age [years old; mean (SD)]	69.4 (7.6)	71.1 (7.7)	70.15 (7.6)
BMI [kg/m^2; mean (SD)]	23.9 (4.8)	24.4 (4.2)	24.1 (4.5)
Race [*n* (%)]			
Malay	23 (44.2)	19 (43.2)	42 (43.8)
Chinese	25 (48.1)	21 (47.7)	46 (47.9)
Indian	4 (7.7)	2 (4.5)	6 (6.3)
Others	–	2 (4.5)	2 (2.1)
Marital status [*n* (%)]			
Single	6 (11.5)	1 (2.3)	7 (7.3)
Married	43 (82.7)	30 (68.2)	73 (76.0)
Divorced	1 (1.9)	–	1 (1.0)
Widowed	2 (3.8)	13 (29.5)	15 (15.6)
Educational level [*n* (%)]			
No formal education	10 (19.2)	5 (11.4)	15 (15.6)
Primary education	20 (38.5)	22 (50.0)	42 (43.8)
Secondary education	18 (34.6)	13 (29.5)	31 (32.3)
Tertiary education	4 (7.7)	4 (9.1)	8 (8.3)
Number of falls [*n* (%)]			
Never	29 (55.8)	25 (56.8)	54 (56.3)
1 time	12 (23.1)	9 (20.5)	21 (21.9)
2 times	6 (11.5)	8 (18.2)	14 (14.6)
$\geq$3 times	5 (9.6)	2 (4.5)	7 (7.3)
Self-perceived health status [*n* (%)]			
Very good	1 (1.9)	2 (4.5)	3 (3.1)
Good	10 (19.2)	13 (29.5)	23 (24.0)
Average	33 (63.5)	24 (54.5)	57 (59.4)
Poor	8 (15.4)	5 (11.4)	13 (13.5)
Number of chronic conditions [*n* (%)]			
0	1 (1.9)	2 (4.5)	3 (3.1)
1	5 (9.6)	6 (13.6)	11 (11.5)
2	14 (26.9)	14 (31.8)	28 (29.2)
3	24 (46.2)	12 (27.3)	36 (37.5)
4	4 (7.7)	7 (15.9)	11 (11.5)
>5	4 (7.7)	3 (6.8)	7 (7.3)
Number of medications [*n* (%)]			
1	10 (19.2)	12 (27.3)	22 (22.9)
2	23 (44.2)	12 (27.3)	35 (36.5)
3	14 (26.9)	12 (27.3)	26 (27.1)
>4	5 (9.6)	8 (18.2)	13 (13.5)

(continued)

Table 1 (continued)

Parameters	Males (n = 52)	Females (n = 44)	Total (n = 96)
General self-efficacy scale, score [mean (SD)]	33.37 (0.6)	32.89 (1.0)	32.69 (5.6)
Lawton instrumental activities of daily living scale, score [median]	7.00	7.00	7.00
Modified Baecke physical activity score [mean (SD)]	42.40 (1.3)	45.00 (1.4)	43.59 (9.1)
Physiological profile approach [n (%)]			
Low risk of falls	8 (15.4)	1 (2.3)	9 (9.4)
Mild risk of falls	12 (23.1)	6 (13.6)	18 (18.8)
Moderate risk of falls	11 (21.2)	2 (4.5)	13 (13.5)
High risk of falls	21 (40.4)	35 (79.5)	56 (58.3)
Timed-up and go test, seconds [mean (SD)]	12.72 (0.6)	15.99 (0.7)	14.22 (5.0)

Table 2 Regression analysis results of falls risk factors

Risk factor variable	Non-faller (N = 53)	Fallers (N = 43)	P value	Odd ratio	95% CI
Age (above 65)	54.7%	79.1%	0.02*	3.12	0.03, 0.44
Walking aid (yes)	15.1%	30.2%	0.06	2.43	−0.01, 0.46
Number of chronic conditions (3 and above)	45.3%	65.1%	0.18	2.25	−0.06,0.33
Number of medications (4 and above)	20.8%	44.2%	0.02*	3.02	0.04, 0.76
General self-efficacy scale (lower efficacy)	77.4%	72.1%	0.90	0.75	−0.06, 0.33
Lawton instrumental activities of daily living (with disability)	54.7%	72.1%	0.49	2.13	−0.20, 0.18
Physiological profile approach (high falls risk)	47.2%	34.9%	0.27	0.60	−0.11, 0.40
Timed-up and go (13.5 s and above)	49.1%	53.5%	0.16	1.19	−0.44, 0.07

*$p < 0.05$

High percentage of older adults with risk of falls in the hospital settings may be due to multiple factors including taking in their health status and chronic conditions. Deterioration of health and possible changes in body structures with aging such as postural deformities and reduced spinal mobility may also increase the risk of falls among older adults (Grundstrom et al. 2012).

Taking four medications and above increased the risk of falls among hospitalized older adults in our study findings. There is an abundance of evidence supporting this study results based on falls risk factors reviews (Ambrose et al. 2013, Severo et al. 2014). The use of four or more types of medications is reported to increase risk of falls by 30% (Hartikainen et al. 2007). Similarly, the results of another local study conducted at a primary care clinic at Kuala Lumpur showed that

polypharmacy increased risk of falls among older adults (Sazlina et al. 2008). Reasons for increased risk of falls among hospitalized older adults with higher number of medications may be due to the adverse drug effects. Psychoactive drugs, such as sedatives, hypnotics, and antidepressants, are also known to increase the risk of falls among older adults (Chu et al. 1999, Rubenstein 2006).

Using a walking aid did not appear to be a falls risk factor among hospitalized older adults in our study. Biomechanically, walking aids provide more stability by increasing the base of support (Bateni and Maki 2005). Despite this fact, it can interfere with the ability to maintain balance, resulting in falls in certain circumstances such as unanticipated loss of balance from placement of the walking aid on uneven surfaces or perturbations due to motions required in process of managing a walking aid (Bateni and Maki 2005).

In our study results, physical performance tests that included IADL, PPA, and TUG were also not risk factors for falls in hospitalized older adults. In contrast, physical performance measurements were identified as risk factors for falls in older adults in previous studies (Hsu and Jhan 2008). It is noteworthy that older adults in our study were confined to hospital in medical wards in a cross-sectional study, compared to the study by Hsu and Jhan (2008) that included all older adult population in a longitudinal study. The difference in study method, sample size, settings, and physical measurement tools could have influenced the study results.

Visual acuity, reaction time, muscle strength, balance ability, and proprioception test are components tested in PPA test. Loss of visual acuity, slower reaction time, decreased lower limb muscle strength, decreased balance ability, and decreased proprioception are known risk factors for higher risk of falls in older adults (Lord 2006). The difference in the results of our study may also be due to the fact that the physical performance cut-off values used in our study were established among community-dwelling older adults. Thus, these cut-off values may not be sensitive to identify falls among older adults with illnesses.

The main limitation of our present study is that the participants were recruited for a short period of time from only medical wards in a hospital. Hence, the results of our study should be applied with caution. We suggest future studies to include several hospitals from different states with longer recruitment time for generalization.

6 Conclusion

The identification of risk factors for falls among hospitalized older adults can assist in effective falls prevention approach in hospital settings. Clinically, falls prevention care plan should be applied to all hospitalized older adults. However, hospitalized older adults aged 65 and above and taking more than four medications will require additional falls prevention care.

Acknowledgements The author would like to thank all participants for their participation and the staff in medical wards for their assistance.

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Chapter 69
Effects of Dynamic Neuromuscular Stabilization on Lumbar Flexion Kinematics and Posture Among Adults with Chronic Non-specific Low Back Pain: A Study Protocol

Yi Lin Lim, Magdalena Lepsikova and Devinder Kaur Ajit Singh

Abstract Optimal lumbar posture during stressful postures in activities of daily living (ADL) among adults with chronic non-specific low back pain (CNSLBP) will be explored in this study. An experimental randomized controlled study will be conducted to examine the effects of dynamic neuromuscular stabilization (DNS) on lumbar kinematics and curvature during a flexion and a step climb tasks among adults with CNSLBP. The differences in lumbar flexion kinematics and curvature between those receiving standard physiotherapy and DNS will be compared. A total of 42 participants will be recruited from a private physiotherapy clinic in Petaling Jaya and randomly divided, equally to a control and intervention group using a block randomization. The control group will receive eight sessions of standard physiotherapy, while the intervention group will receive eight sessions of DNS added to the standard physiotherapy treatment. Two measurements will be taken using a portable inertial measurement system before and after the eight sessions. Repeated measures of ANOVA will be used to compare within- and between-subject effects. The significance of including a body awareness component with the DNS centration concept in CNSLBP physiotherapy treatment should be explored as this finding may lead to more effective and customized physiotherapy management.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_69

Keywords Body awareness · Chronic non-specific low back pain
Dynamic neuromuscular stabilization · Lumbar flexion kinematics
Lumbar posture · Physiotherapy

1 Introduction

Low back pain (LBP) is known to be one of the most common reasons of disability among adults below 45 years of age (Rockville 1994). It is often defined as pain, stiffness or muscle tension experienced at the region between the lowest costal margin and above the inferior gluteal folds, with or without leg pain (Middelkoop et al. 2010). LBP can be divided into specific and non-specific, whereby non-specific low back pain was classified as low back pain with the absence of neurological symptoms (Majid and Truumees 2008) and has an unclear origin (Middelkoop et al. 2010). Chronic LBP is defined as symptoms that lasted for more than 3 months (Wong et al. 2010). A Malaysian survey revealed that low back pain was the second highest musculoskeletal pain reported at 11.6% (Veerapen et al. 2007) reflecting its significance of the impact of LBP socioeconomically.

Logically, individuals with chronic non-specific low back pain (CNSLBP) may find certain activities of daily living (ADL) task stressful for lower back postures. These stressful postures are peculiar to their disorder, task and environment. Studies among adults have commonly reported that stressful postures tend to involve standing, bending forward or backward and returning, sitting and twisting movements (Seidel et al. 2011). It has been suggested that these are considered as stressful postures because of the combination of rotation, compression and shear forces on the spine (Engkvist et al. 1998). Several studies have indicated that lumbar flexion movement is often associated with low back pain (Wilhelmina et al. 2000). Furthermore, information about association between gender and amount of lumbar curvature may assist in the evaluation of a patients' movement-related LBP (Norton et al. 2004).

Studies suggest that individuals with CNSLBP may have motor control impairment (O'Sullivan 2004). The lack of control exposes the individuals to repetitive strain and stress (Dankaerts et al. 2006). In recent years, there is a shift of emphasis from strength and endurance for trunk muscles in LBP to issues of motor control (Hodges and Moseley 2003). This shift reveals two main schools of approach in musculoskeletal medicine. They are the structural approach and the functional approach (Page and Frank 2003). The structural approach emphasizes the pathology of specific structures being strongly based on localized evaluation and special tests such as X-rays, MRI and other such static imaging diagnostic tools. The functional approach, however, emphasizes the consideration of the function of all processes and systems within a body in the assessment process while recognizing the influence of the structures involved in addressing musculoskeletal pain (Page and Frank 2003). Hence, these respective approaches will encompass a manner of assessment and treatment strategy that will differ in emphasis and focus.

The dynamic neuromuscular stabilization (DNS) by Kolar approach is in line with the functional approach view. It advocates that the efficacy of motor control lies in the interdependence of both the central nervous system (CNS) and the musculoskeletal system in a movement (Frank et al. 2013; Hodges and Moseley 2003; Page and Frank 2003). The DNS strongly suggests that a good sensorimotor system is needed to produce an optimal movement which places the joints in centration (Frank et al. 2013; Kobesova and Kolar 2013). This joint centration occurs when the joint surface congruency and supporting muscles of that joint are at optimal mechanical advantage consistently through the range of movement. The effect of joint centration is minimal mechanical stress on relevant passive tissues (Frank et al. 2013). The centration concept of DNS is based on the scientific principles of developmental kinesiology of a child with a normal central nervous system maturation in the first year of life (Kobesova and Kolar 2013).

DNS also envelopes its management strategies around the reflex model of posture and locomotion, whereby it stresses the importance of the stabilization of the spine, chest and pelvis simultaneously while moving the extremities. It aims to keep the spine, chest and pelvis in centration during selective movement of the arms or legs using the stabilization patterns typical for physiologic development as the reference point of ideal stabilization patterns (Frank et al.2013; Kobesova and Kolar 2013).

DNS strongly correlates a given functional movement with one's body awareness (Kolar et al. 2013). It begins this process by manually and verbally guiding the individual to identify the difference between their poor habitual pattern versus the optimal stabilization pattern (Kobesova and Kolar 2013). This process of self-identifying the individual's stabilization and movement patterns is linked to the body awareness perception of an individual. It is suggested in the DNS approach that quality of movement control is better with better body perception (Kobesova and Kolar 2013).

Effective rehabilitation of chronic non-specific musculoskeletal pain disorders requires a bio-psychosocial model. It was suggested that body perception of an individual with CLBP has been shown to be altered, consequently exhibiting in proprioception deficits and altered trunk muscle recruitment patterns (Wand et al. 2011). It is also well established that modification of lumbar posture to reduce the passive tissue strain can be enhanced through postural advice, relearning motor patterns and exercise as part of the rehabilitation programme. However, the significance of body awareness perception in the sensorimotor system for the achievement of good motor control and optimal movement is lacking.

The aim of this study is to examine the effects of DNS on lumbar kinematics and curvature during a flexion and a step climb task among adults with CNSLBP. It will also compare the difference in lumbar flexion kinematics and curvature among adults with CNSLBP between those receiving standard physiotherapy and DNS.

2 Method

2.1 Participants

Participants in this study consist of adults with CNSLBP from Hospital Canselor Tuanku Muhriz, PPUKM and a private physiotherapy clinic in Petaling Jaya. The inclusion criteria of this study consist of male and female participants aged 20–45 years diagnosed to have CNSLBP with an Oswestry disability index questionnaire score of 21–60%, visual analogue scale (VAS) of pain above zero and ability to pick up a 500 ml bottle of water (placed 1 foot in front of individual) from the floor with dominant hand without increasing visual analogue scale (VAS) pain score. The participants will be excluded if they experienced serious trauma leading to spinal vertebrae fractures and dislocations of spine prior to back surgery; have any known inflammatory joint diseases, rheumatological condition, tumour, spinal infections and tuberculosis; diagnosed to have spinal deformities such as scoliosis, ankylosing spondylitis, spondylolisthesis and spondylolysis; are pregnant or less than 6 months post-partum; have any neurological deficits; and are unable to achieve straight leg raise (SLR) test of 70° on either leg (contralateral knee flexed).

2.2 Study Design

This single-blinded experimental randomized controlled study will adopt a block randomization sampling with block size of $2 \times 2 = 4$ among adults with CNSLBP at PPUKM and private physiotherapy clinic in Petaling Jaya from January 2016 to June 2017. Forty-two participants will be recruited. Participants that pass the baseline screening will undergo a pre-intervention measurement for their lumbar spine in movements of lumbar flexion, extension, left and right flexion, left and right rotation while performing tasks of picking a 2 kg basket and taking a step up with alternate leg measured by a research assistant not involved in the clinical treatment of the participants. The dimensions of the two tasks are fixed for all participants and not adjustable (Fig. 1). The process of the pre-intervention measurement with the Xsens MTx is shown in Fig. 2. After this, the participant will be randomly divided equally into a control and intervention group using block randomization (block size $2 \times 2 = 4$, 11 blocks) with concealed allocation by a receptionist not involved in the clinical trial. The receptionist will arrange and communicate the follow-up visits with the respective physiotherapist over a period of 8 weeks.

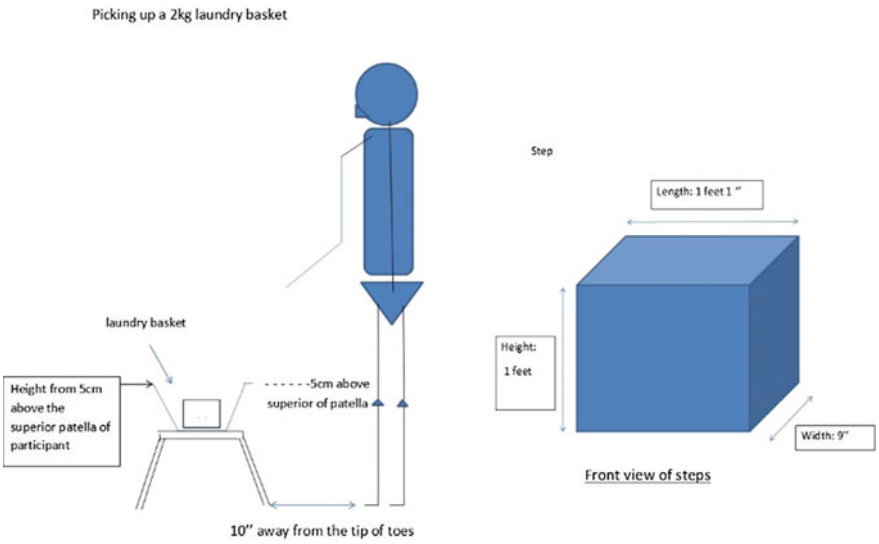

Fig. 1 Dimensions of the two tasks

1st measurement

1. L1-S2 spine measurement for trunk flexion, extension, left and right lateral flexion, left and right lateral rotation movement with Xsens MTx. Three repetitions of the measurements will be done for all movement. The mean of three measurements will be taken as the measurement.

2. L1-S2 spine measurement for task of bending forward to pick a 2kg laundry basket with Xsens MTx. Three repetition of the task will be measured. The mean of three measurements will be taken as the measurement.

3. L1- S2 spine measurement for task of going up a step with one leg. Three repetition of the task for each leg will be measured. The mean of three measurements will be taken as the measurement.

Fig. 2 Process of the pre-intervention measurement

2.3 Intervention

In the experimental group, each participant will be given standard physiotherapy care as described in the guideline for the control group (Table 1) with an added component of the DNS approach with the guideline below. The choice of the standard physiotherapy care will be according to the discretion of the treating physiotherapist.

Table 1 National collaborating centre for primary care May 2009 guideline and common electrotherapy physiotherapy practices in Malaysia

Category of treatment	Description
Exercise therapy	A structured one-to-one supervised exercise programme customized to the individual's presentation
	Eight sessions
	May include aerobic activity, movement instruction, muscle strengthening, postural control and stretching components
Manual therapy	May include spinal mobilization (joint movement within the normal) and massage (manual manipulation/mobilization of soft tissues)
	Eight sessions
	The type of manual therapy selected will be based on the individual's presentation and physiotherapist's assessment
Electrotherapy	May include heat pads and therapeutic ultrasound for thermal effect; TENS for immediate pain management post treatment session according to physiotherapist's assessment
Education	Information and advice to promote self-management of their low back pain

2.4 DNS Approach Guideline

The aim of the treatment is to achieve good intra-abdominal pressure and ribcage centration. This is observed as a cylindrical shape of abdominal region and non-anteriorly flared ribcage. This intervention will be performed via verbal cues, manual guidance and visual feedback to correct the spine, ribcage, pelvic, scapula alignment and abdominal wall shape. This intervention will be done in developmental kinesiology positions in relation to the position of spine (Horizontal/vertical/angled). Operational definition of angled position is any position between horizontal and vertical. The actual developmental kinesiology position adopted during intervention for that day will vary according to the individual's limitation of pain, weakness or tightness.

The physiotherapist who is by a fully certified DNS practitioner will manually guide (verbally/visual feedback/tactile facilitation) the participant to achieve ideal pattern of muscle activation in stabilizing the body in the developmental kinesiology position adopted with the aim mentioned above in the exercise. The component of body awareness to have adequate appropriate muscle relaxation is integrated according to DNS approach via participant's conscious awareness to the identified muscle area informed by the therapist during the DNS exercise. Each individual session will allow brief rest periods if required. The participant will be given the home programme advice of the same DNS exercise done in the session of that day. The home programme requires approximately 10–20 min per session of home programme when self-done at home. The frequency of sessions is shown in Table 2.

Table 2 Frequency of sessions

Week	No. of session
1st week	2
2nd week	2
3rd week	1
4th week	1
6th week	1
8th week	1
Total	8 sessions

Standard documentation of each session by the physiotherapist and subjective checking of adherence of participants to the home programme advice will be done at each session. Once the eight sessions are completed, a post-intervention measurement with the Xsens MTx is repeated.

The control group will receive only standard physiotherapy care as shown in Table 1 with the frequency of sessions as shown in Table 2. Each session is approximately 40–45 min by the same physiotherapist throughout the eight sessions.

2.5 Outcome Measures

Primary outcomes include the mean changes pre- and post-intervention on the endpoint of the eighth week for the VAS of pain and lumbar curvature and kinematics via the Xsens Mtx. The pain VAS is a 10-cm line anchored by two verbal descriptors, commonly stated as 'no pain' (left end) and 'worst imaginable pain' (right end) at each opposite end (Hawker et al. 2011). The pain VAS is self-administered, whereby the respondent will mark a line perpendicular to the VAS line at the point that denotes their pain intensity (Hawker et al. 2011). The outcome is determined by measuring the distance (mm) on the 10-cm VAS line. A higher value is interpreted as greater pain intensity (Hawker et al. 2011).

The Xsens MTx is an inertial sensor which utilizes 3D gyroscopes, accelerometers and magnetometers in order to provide drift-free motion data during the spine kinematic measurements. According to the manufacturer, the Xsens system has a static accuracy of 0.5 degrees for roll and pitch, 1° for yaw and 2° for RMS dynamic accuracy (Ha et al. 2012). It employs the Xbus master system to have the capability of communicating with a personal computer using Bluetooth technology. Secondary outcome includes the mean changes of the FABQ score which is self-filled pre- and post-intervention on the endpoint of the eighth week.

2.6 Statistical Considerations

The sample size in this study was calculated with the G-power 3.0 analysis (ANOVA). Power analysis revealed that 42 participants should be sufficient for any reflection of significant differences between two different groups within effect size (0.25) for any variables, α is the significance level ($p < 0.05$) and 1-β err probability is the power = 0.8 and allowing for a 10% drop out rate.

The raw orientation data from the Xsens Mtx will be processed through MATLAB which will undergo statistical analysis performed using SPSS 20.0. Demographic data will be analysed using descriptive analysis. Repeated measures of ANOVA will be used to compare within- and between-subject effects. Post-hoc analysis will be carried out where required.

2.7 Ethical Considerations

Ethical approval has been obtained from the Research Ethics Committee of Universiti Kebangsaan Malaysia. The study is also in process for clinical trial registration with the declaration of Australia New Zealand Clinical Trials Registry.

3 Discussion

The protocol intends to set a process that will explore whether an added component of customized DNS approach for body awareness in addition to standard physiotherapy care is more effective than only providing standard physiotherapy care to adults with CNSLBP. We hypothesize that there will be a significant difference in lumbar flexion kinematics and lumbar posture between using standard physiotherapy and using the dynamic neuromuscular stabilization (DNS) approach among adults with CNSLBP after eight sessions of physiotherapy sessions. Exercise therapy is a common standard protocol for physiotherapy treatment for adults with CLBP (Middelkoop et al. 2010).

According to the NICE 2009 Guidelines for persistent NSLBP, a structured eight-session exercise programme customized to an individual's need is recommended. This programme may include aerobic activity, movement instruction, muscle strengthening, postural control and stretching components (National Institute for Health and Care Excellence 2009). However, a gap of knowledge exists concerning the significance of body awareness perception for adaptations of the lumbar spine that occur in strategies employed to relearn motor patterns in a CNSLBP rehabilitation programme.

4 Conclusion

Although studies have suggested that a form of education is required for an effective rehabilitation programme for adults with NSLBP (O'Sullivan et al. 2010), literature related to including a body awareness perception component in a more formal and educative manner in exercise therapy is lacking. Furthermore, the practice of including a body awareness component with the DNS centration concept in the exercise therapy of a physiotherapy treatment for NSCLBP in Malaysia is also unknown. The findings of this study may lead to further studies regarding the effectiveness and implementation of a more customized exercise therapy programme incorporating the DNS approach to joint centration among adults with CNSLBP.

Acknowledgements This study is funded using a grant from Universiti Kebangsaan Malaysia (GUP-2015-046).

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Part VII
Material Science

Chapter 70
The Influence of Curing Conditions on the Compressive Strength of Lightweight Geopolymer Composite Containing Wood Aggregates

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Abstract In this study, lightweight geopolymer composite was produced using fly ash, metakaolin, and wood aggregate. The changes caused by the geopolymerization on the properties of the final product were investigated by applying curing on geopolymer composites using different types of wood aggregates at different curing temperatures and curing times. The purposes of this process were to determine the relationship between types of wood aggregates, curing temperature, and curing times toward the compressive strength of the lightweight geopolymer composites. Wood particles (WP), wood flour (C100), and wood fiber (WF) were added to fly ash and metakaolin-based geopolymers at 10% solid content as reinforced materials. 14 M NaOH in combination with Na_2SiO_3 was used as the alkaline activator with a liquid-to-solid ratio of 1.33:2.00. The samples were cured at 20 °C for 7, 14, and 28 days, and at 60 °C for 6 and 24 h (two different curing temperatures and

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_70

five different curing times) and thereafter kept at room temperature (26–29 °C) until the day of the physical and mechanical test. As a result, this study determined that curing temperature and curing time had an effect on the compressive strength of the composite. It was observed that compressive strength values of the lightweight geopolymer composite cured at 20 and 60 °C increased depending on the curing time. Highest compressive strength values of 38.4 and 36.25 MPa were obtained from the mortar with C100 addition cured at 20 °C for 28 days and 60 °C for 24 h, respectively.

Keywords Curing periods · Compressive strength · Geopolymer Lightweight composite · Wood aggregates

1 Introduction

Cement is indispensable material in the development of concrete. The used of ordinary Portland cement (OPC) was not environmentally friendly and caused the adverse effect, resulting from the calcination of limestone and high energy consumption from OPC manufacture (Turner and Collins, 2013). In 1978, Davidovits proposed that binders could be produced by the reaction between the alkaline solution and source materials that are rich in silica (SiO_2) and alumina (Al_2O_3), commonly known as geopolymer. Geopolymers are amorphous three-dimensional aluminosilicate binder materials (Shaikh 2013) which have been proposed as an ecologically friendly alternative to OPC. Geopolymer materials contain aluminum (Al) and silicon (Si) species that are soluble in highly alkaline solutions (Davidovits 2008). Any material that is rich in Si and Al in amorphous form can be a possible source material for geopolymer binder (Shaikh 2013).

Lightweight concrete (LWC) is an ideal material construction in order to reduce building costs, eases construction, and has the advantage of being relatively "green" building material. LWC is a concrete with unit weight less than 2000 kg/m^3 (Dulsang et al. 2016) and is classified into three types depending on the method of production: LWC with lightweight aggregate; LWC with incorporation of voids by aeration, cellular, foamed, or gas concrete; and LWC with no-fine aggregate (Dulsang et al. 2016; Ahmaruzzaman 2010). LWC has several valuable characteristics such as good thermal and acoustic insulations, easy to fabricate, excellent freezing and thawing durability, internal curing, and reduced dead load.

Currently, plant-based aggregates are the most widely used in LWC production as a result of the increasing demand for environmentally friendly materials and the high cost of synthetic lightweight aggregates. These plant-based aggregates exhibit a grading comparable to that of conventional aggregates and in fact, an entirely renewable resource. They are low-density materials yielding relatively lightweight

composite. Utilization of plant-based aggregates is the subject of the several studies, for example, Torkaman et al. (2014) used wood fiber waste as a replacement material for lightweight concrete blocks; Faustino et al. (2015) found that corn cob is relevant to produce lightweight concrete masonry; Bouguerra et al. (1998) reported the microstructure properties of lightweight concrete that were prepared using wood aggregates; the study by Sales et al. (2010) concluded that the lightweight composite concrete produced using sawdust presented a 23% lower thermal conductivity than the conventional concrete and Kidalova et al. (2012) describes the effect of different binding agents in combinations with hemp fibers and wood cellulose in the preparation of lightweight composites.

There has been a rise in the research on the development of sustainable LWC-reinforced plant-based aggregates such as cotton fiber, oil palm shell, hemp fabric, wood fiber, and basalt fiber-based geopolymer concrete. However, the curing conditions varied from one case to another but the evaluation of temperature effects showed general trends. Thus, since there is no clear statement as to which curing conditions is the best, the main objective of the current research was to investigate the effect of different curing conditions of 20 °C for 7, 14, and 28 days, and at 60 °C for 6 and 24 h (two different curing temperatures and five different curing times) on the compressive strength of lightweight geopolymer composites synthesized from alkali activated fly ash and metakaolin. Different types of wood aggregates, varied in form and size, were introduced into the lightweight geopolymer concrete.

2 Materials and Method

2.1 Materials

Low-calcium Class F fly ash and metakaolin were used as the basic materials for the preparation of geopolymers. The fly ash was supplied by the power plant GK Kiel GmbH, Kiel, Germany, while Metakaolin–Argical M1000 was obtained from IMERYS Refractory Minerals, Clérac, France. The chemical composition of fly ash and metakaolin is shown in Table 1.

Table 1 Chemical composition (% Mass) of fly ash and metakaolin

Oxide materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	TiO_2	L.O.I.	Total
Fly ash	56.8	23.8	6.79	2.9	1.28	0.43	1.99	0.94	3.5	98.43
Metakaolin	55.0	40.0	1.4	0.15	0.15	0.4	0.4	1.5	1.0	100.0

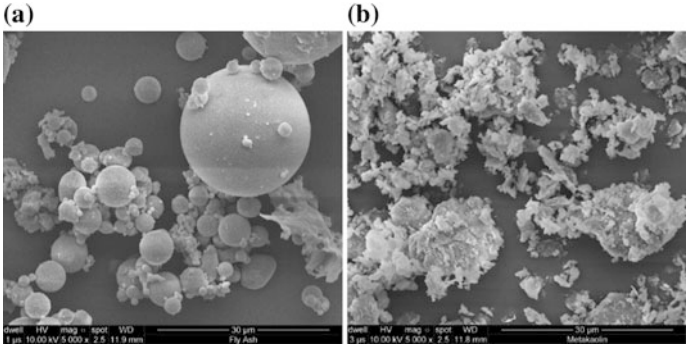

Fig. 1 FESEM image of **a** fly ash and **b** metakaolin with 5000× magnification

The microstructure of as-received fly ash and metakaolin was studied by the FESEM (Fig. 1). The fly ash particles were spherical in shape, having relatively smooth outer surfaces, with a size distribution between 930 and 25,000 nm. FESEM micrographs of metakaolin shown in Fig. 1b revealed vitreous unshaped fragments. It was clearly identified as non-crystallized, lamellar particles. The particle size distribution of the metakaolin ranged from 63 to 200 µm.

Sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) solutions were used as alkali activators in the preparation of geopolymer paste. Analytical-grade NaOH in pellet form with 98% purity and 2.13 g/cm^3 specific gravity was obtained from Fisher Scientific UK Ltd, Bishop Meadow Road, Loughborough. The Na_2SiO_3 solution (SiO_2 = 30.2%, Na_2O = 14.7%, water = 55.1%, SiO_2/Na_2O molar weight ratio = 2.0, with a density of 1.54 g/cm^3 at 20 °C) from Woellner GmbH & Co. KG, Ludwigshafen am Rhein, Germany, was used along with NaOH as the alkali activator.

Wood aggregates of different shapes and sizes were used to reinforce the geopolymer matrix. Three types of wood aggregates—wood particle (WP), wood flour (C100), and wood fiber (WF)—were obtained from local mills in Germany. The characteristics of each aggregate are shown in Table 2.

Table 2 Properties and structure of wood aggregates

Properties	Wood flour (C100)	Wood fiber (WF)	Wood particle (WP)
Color	Beige	Brown	Light brown
Structure	Cubic	Longish fiber	Particle
Size	70–150 µm	–	–
Length	–	3–7 mm	3–5 mm
Width	–	43.6–44 µm	0.2–0.5 mm
Bulk density (g/cm^3)	0.20	0.17	0.15
Moisture content (%)	8.6	7.5	6.8
Species	Mix softwood	Mix softwood	Mix softwood

2.2 Preparation of Geopolymer Composites

In total, eight mixtures were prepared by varying the types of wood aggregates, curing time, and curing temperature. The fly ash, metakaolin, and activator contents were kept constant. The ratio of solid to alkaline solutions was 2.0:1.33. Figure 2 summarizes the synthesis protocol for the geopolymer composites. The alkali activator solution was prepared by dissolving NaOH pellets in water and then adding the $NaSiO_3$ solution in a weight ratio of 2.5:1. The activator solution was prepared at least one day prior to its use. 70% fly ash and 30% metakaolin were first dry-mixed with 10% wood aggregate, WP, C100, and WF in order to ensure a uniform solid supply. The alkaline liquid was then added to the dry materials and mixed for 5 min to ensure homogeneity of the mixture. The fresh pastes were cast into 5 cm cubic molds. Immediately after casting, the test specimens were wrapped with plastic film to minimize water evaporation during curing. The samples were cured at 20 °C for 7, 14, and 28 days and at 60 °C for 6 and 24 h, and during that period, after 24 h they were removed from the molds. The specimens were left to air-dried in the climate chamber at 20 °C and humidity of 60% until the day of the test.

2.3 Material Characterizations

The cubes were tested in compression in conformity with the test procedures given in ASTM: C109/C109M-12 (2012), using a Zwick universal testing machine. The

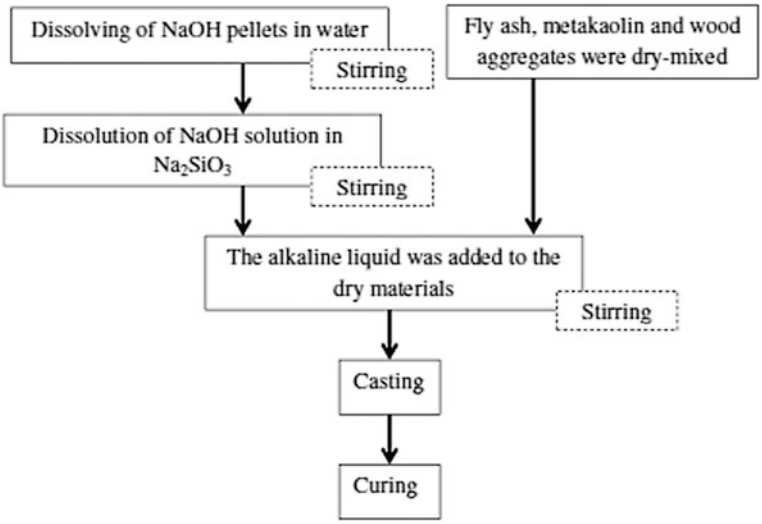

Fig. 2 Synthesis protocol of geopolymer composites

compressive strength values reported were averaged over the measurement of nine samples. The oven-dried density and water absorption were determined to ascertain the quality of the geopolymer composite specimens according to ASTM C140-01 (2012). The specimens were immersed in water at room temperature (22 °C) for 24 h. Weigh the specimens while suspended by a thin wire and completely submerged in water and record W_i (immersed weight). Remove the specimens from water and allow water to drain for 1 min by placing them on a wire mesh, removing visible surface water with a damp cloth, weigh and record as W_s (saturated weight). Then, dry all specimens in a ventilated oven at 105 °C for not less than 24 h, and two successive weightings at intervals of 2 h show an increment of loss not greater than 0.2% of the last previously determined weight of the specimen. Record the weight of the specimens as W_d (oven-dried weight). The calculation of oven-dried density (D_b) and water absorption were carried out using the following equation:

$$D_b = \frac{W_d}{W_s - W_i} \tag{1}$$

$$W_a = \left(\frac{W_s - W_d}{W_d}\right) \times 100 \tag{2}$$

The microstructures and fracture surfaces of the geopolymer composites were examined using a FESEM, Quanta FEG Type 250, FEI Electron Optics (SN: D9122), Netherlands. The specimens were crushed into small pieces before being coated with a thin layer of gold (to avoid charging).

2.4 Results and Discussion

In regards to the lightweight requirement, density indicates the important parameter in this study. The result of density is shown in Fig. 3. Generally, the density values ranged from 1215 to 1478 kg/m^3 for all specimens. The highest density of the lightweight concrete composite in this study (1478 kg/m^3) was in the range of 1440–1850 kg/m^3 for structural lightweight concrete in accordance with ACI 213 (2003). The use of wood aggregates for making lightweight concrete composite produced lower density concrete. Two factors were considered regarding this phenomenon. The first assumption was the formation of voids in the interface areas between the wood aggregates and the geopolymer matrix. Poor dispersion and agglomerations of the wood aggregates may have an effect on the density value of specimens in this study. The agglomerations create more voids or large pores after geopolymerization and leave a large number of inter-granular pores in the microstructure after curing. In addition, wood aggregates are likely to tend to clump together during mixing, resulting in more voids and irregular microstructure of the composites. The second assumption was the density and specific gravity of wood aggregates. As the specific gravity of wood aggregates used is recorded to be within

0.15 (WP) to 0.20 (C100), the replenishment of the wood aggregate to the geopolymer mixture supposed to lower the density value of hardened specimens. It was clearly seen from Fig. 3 that the lowest density value experienced by specimens with WP followed by WF and C100. From this result, it can be concluded that the specific gravity and the density of wood aggregates contributed to the reduction of the density of the geopolymer concrete.

Figure 4 shows the percentage of the water uptake of geopolymer composite specimens with wood aggregates after immersion in tap water for 7 days at room temperature. The water absorption of all specimens was high in the early stages of exposure. After a long time, it slowed down and reached the saturation level. The hydrophilic nature of wood aggregates enhances the increase of water uptake in the geopolymer composite with wood aggregates (Dhakal et al. 2007). Additionally, Alomayri et al. (2014) reported in their study on cotton fiber-reinforced geopolymer composites that the increase in water absorption is due to the greater interfacial area

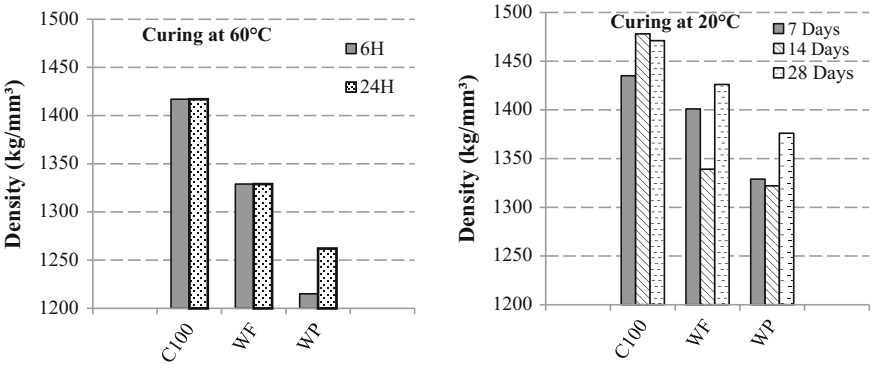

Fig. 3 Density values of the lightweight geopolymer composite as a function of different aggregates

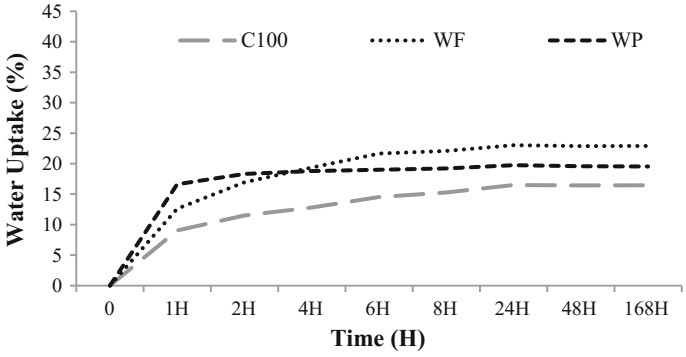

Fig. 4 Water absorption behavior of lightweight geopolymer composite

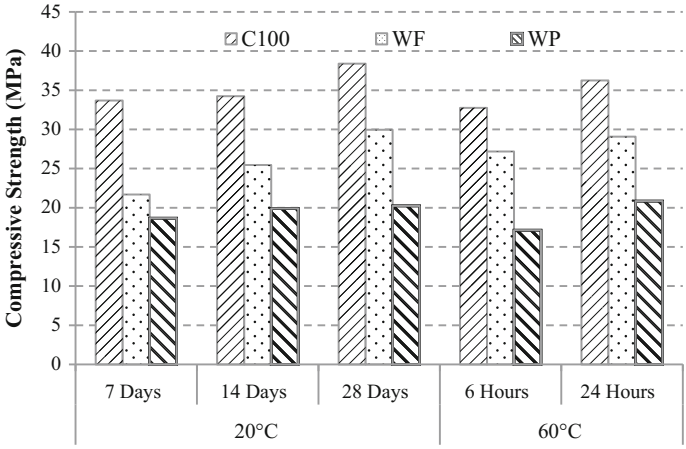

Fig. 5 Compressive strength of the lightweight geopolymer composites at different curing conditions with respect to the addition of wood aggregates

between the fiber and the matrix. In this study, the high cellulose content in wood aggregates absorbs water that penetrates the interface of the specimens. This phenomenon can be explained by considering the water uptake characteristics of WF compared to C100 and WP where WF experienced the highest percentage of water uptake.

Figure 5 shows the effect of curing temperature and curing time on the compressive strength of lightweight geopolymer composites after curing the test cubes for (i) 6 and 24 h at 60 °C and (ii) 7, 14, and 28 days at 20 °C. All other test variables were held constant. As expected, elevated temperature accelerated the early stage of geopolymerization reaction, resulting in better performance properties of the lightweight geopolymer composites. For all compositions, the compressive strength of the specimens cured at 20 °C for 7 days could be slightly reached by accelerated curing at 60 °C after only 6 h, whereas the specimens cured at 60 °C for 24 h showed the same strength if cured at 20 °C for 14–28 days. Therefore, it was concluded that, when the cost is taken into account, it is important to increase the curing temperature of the samples to gain strength quickly when higher strengths are intended to be achieved during a shorter period of time. This work is also in agreement with the research done by Hardjito et al. (2005). They found that fly ash-based geopolymer concrete cured at 60 °C up to 48 h shows an increase in its compressive strength. Al Bakria et al. (2011) reported that the maximum compressive strength of fly ash-based geopolymers was obtained at 60 °C. Rovnaník (2010) and Görhan et al. (2016) also reported the significant roles of temperature and the curing time based on their findings.

According to the data, the compressive strength development of lightweight geopolymer composites has been increased by increasing the curing time from 6 to 24 h and from 7 to 28 days. The increase in strength was affected by the increase of

the duration of the curing periods. The curing period of 24 h and 28 days produced the maximum compressive strength development. Longer curing time improved the polymerization process resulting in higher compressive strength. At longer curing duration, the geopolymer developed slowly and its quality is better in terms of lower porosity and higher strength. This suggestion is supported by comparison of the density of the specimens (Fig. 3). The density value increases with rising time of curing.

Figure 6 shows the representative FESEM images of the fracture surface of the lightweight concrete composite with and without the addition of wood aggregates after compression strength test. It is evidently noticeable that the dense and compact structure with heterogeneous, some un-reacted phases, pores, crack bridging, fiber pull-out and rupture, and matrix fracture are observed. In the geopolymer matrix

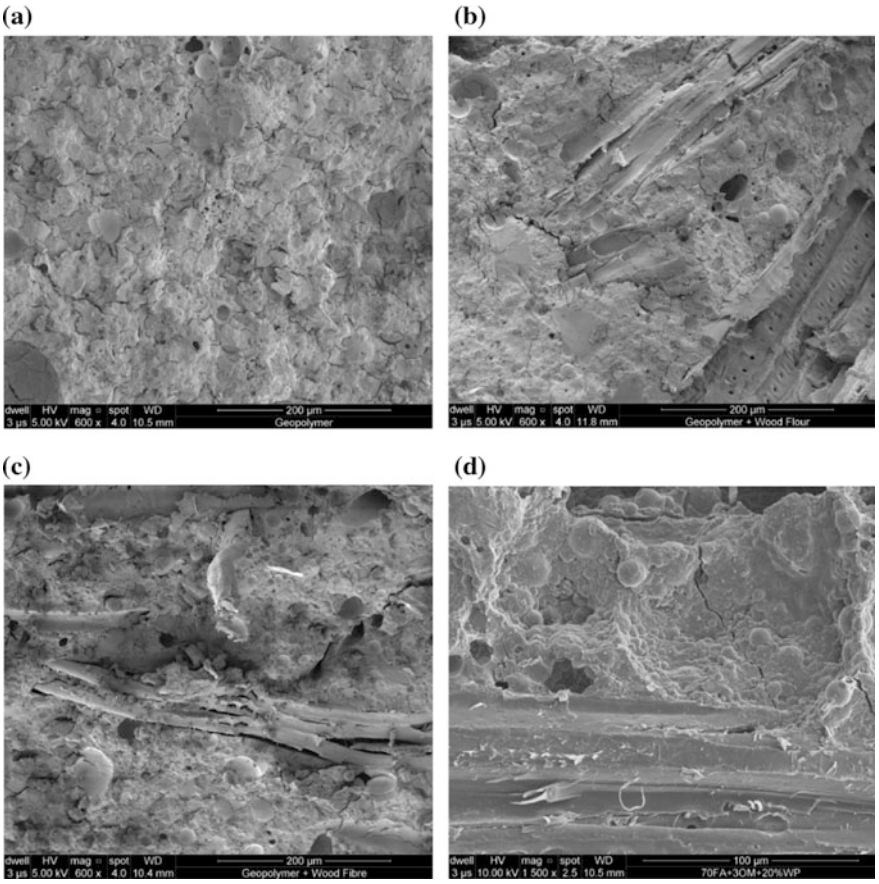

Fig. 6 FESEM image showing **a** plain geopolymer at 600× magnification, **b** geopolymer with C100 at 600× magnification, **c** geopolymer with WF at 600× magnification, and **d** geopolymer with WP at 1500× magnification

without wood aggregate addition, there was only dense aluminosilicate matrix (Fig. 6a), whereas the samples with wood aggregates addition contained aluminosilicate matrix and wood aggregates embedded in the matrix (Fig. 6b–d). The cracks observed in microstructure were believed to be caused by the compressive strength test. Closer inspection shows that some wood aggregates have good bonding with the matrix (Fig. 6b, d). It can also be observed extensive fiber pull-out (Fig. 6c) with traces of matrix adhere the WF which is an indication of good WF-matrix adhesion. Wood aggregates with good bonding with the surrounding matrix tend to fracture rather than pull-out at the failed surface. Wood aggregates poorly bonded to the geopolymer matrix contribute little to the improvement of the compressive strength, ductility, and toughness, and sometimes they may act as a flaw or crack initiation deteriorating the strong performances of the concrete composite.

3 Conclusion

The experimental results reported in this research indicate the significant effects of curing conditions on the compressive strength of lightweight geopolymer composite prepared using different types of wood aggregates. The results show that the compressive strength of the geopolymers increases with increase in the duration of heating periods. The samples with C100 were observed to have the optimum compressive strength values. It was determined that an increase in the curing temperature and curing time increased the compressive strength while it did not have a significant effect on the physical properties.

Acknowledgements The author would like to extend their gratitude to the **University of Hamburg, Germany and Thünen-Institute of Wood Research** for the research opportunity. The authors also acknowledge the Ministry of Higher Education, Malaysia and Universiti Teknologi MARA, Malaysia for scholarship and granting study leave for Siti Noorbaini Sarmin.

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Chapter 71
Elastic Property of Palatal Tissues Expanded with Anisotropic Self-inflating Tissue Expander

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Abstract This study describes the effect of anisotropic-controlled rate self-inflating tissue expander on the elastic property of the palatal tissue. Two groups of male Dorper sheep were used. One group served as control, while tissue expanders were inserted subcutaneously in the mid-palatal region of the expanded group. The elastic property of the collagen fibrils was determined at the (i) macro- and (ii) microlevel by means of Universal Testing Machine and Atomic Force Microscope, respectively. Two weeks after the expansion, the collagen fibrils of the expanded groups were observed to be in stretched position and aligned parallel towards the direction of expansion. Meanwhile, the Young's modulus of collagen fibrils of the expanded groups was observed to be significantly higher in comparison to the control groups, when measured at both macro- and microlevels.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_71

Keywords Elastic property · Palatal tissue · Self-inflating tissue expander Surface topography

1 Introduction

Cleft palate has been treated successfully using surgical methods; conventionally, mucoperiosteal flaps transposition technique is employed. However, the approach of cleft palate treatment remains a concern among clinicians. Regardless of the successful treatment, tendency of bone relapse, nerve dysfunction, hypoplasia and deformity of the maxilla still occur (Van Damme and Freihofer 1996).

These problems paved the way for the utilization of tissue expansion techniques in the management of cleft palate (Wysocki et al. 2011). De Mey et al. (1990) had reported the treatment of a large anterior palatal fistula in human by means of two custom-made silicone balloon implants with external filling ports. Later, it is reported by Van Damme and Freihofer (1996) on the unsuccessful case using traditional balloon-type devices on subperiosteal palatal expansion in cats. This type of tissue expander was not well accepted as the device was bulky and impractical for intra-oral application.

The use of hydrogels in biomedical application was first suggested by Wichterle and Lim where the hydrogels have been successfully used as contact lenses. In 2007, Kobus published a preliminary report using self-inflating hydrogel tissue expanders in a two-stage cleft palate repair in rabbits (Kobus 2007). The additional soft tissue facilitated the suturing stage by minimizing the risk of transposition of mucoperiosteal flaps (Kobus 2007).

This first-generation hydrogel osmotic expander was originally designed without coating. It absorbs body fluids in the first few weeks, leading to gradual swelling of the device to approximately 10% of its final volume, isotropically. With respect to tissue expansion in a confined anatomical location such as the palate, the direction of expansion is a major concern. Thus, the use of tissue expander for palatal tissue expansion is still very limited due to the uncontrollable rate of expansion as reported in clinical studies (Obdeijn et al. 2009; Chummun et al. 2010). Further, catastrophic soft tissue necrosis in pigs was observed following the rupture of devices as reported by Swan et al. (2011). Clearly, in the confines of cleft palate, isotropic devices inherently risk potentially catastrophic complications. An anisotropic device which allows swelling in one direction, coupled with controlled rate of expansion, would be advantageous in facilitating obliteration of the cleft.

Apart from the uncontrollable rate of expansion, another main concern of using tissue expander is whether the collagen in the expanded tissue maintains its physiological and mechanical properties. Collagen, the most abundant protein in the human body, is pivotal in aiding the healthy growth of tissues. Typically, most studies on structure and mechanical properties of collagen were done on collagen type I, which has the most well-organized structure of all collagen types (Austad

1987; Chapman and Hulmes 1984; Nimni and Harkness 1988; Petruska and Hodge 1964; Schmitt et al. 1942).

To date, only one study has reported on the mechanical properties of bulk palatal tissue expanded with tissue expanders (Wysocki et al. 2011). However, no attempt has been made to study the collagen at the fibril level scale. Unlike hard tissues, the mechanical properties of soft tissues are difficult to characterize due to its instability (Isaksson et al. 2010; Zhu et al. 2013). The advent of atomic force microscope (AFM) has proven to be a powerful tool for the characterization of biological samples through high-resolution topography imaging. Therefore, in this study, we aim to evaluate the elastic modulus of palatal tissue expanded with anisotropic rate-controlled self-inflating tissue expanders at the (i) macro- and (ii) microlevel by using the universal tensile machine and the atomic force microscope (AFM), respectively.

2 Methods and Materials

2.1 Study Design and Animal Model

Two groups of adult male Dorper sheep, weighing between 30 and 50 kg, were used and divided equally into control and expanded groups (n = 5/group). Custom-made anisotropic rate-controlled self-inflating tissue expanders (Oxtex Ltd., Oxford UK) were used in this study. Unlike conventional expanders, this device absorbs body fluid from the surrounding tissues and allows tissue expansion in one direction only. The final volume and swelling time were pre-determined through manufacturing process. This study was approved by Animal Care Use Committee (ACUC) of the Faculty of Veterinary Medicine, Universiti Putra Malaysia (R031/2013).

2.2 Anaesthesia and Implantation of Tissue Expander

All sheep were fasted 24 h prior to the surgery. Xylazine 0.1 mg/kg and 2% halothane were administered intramuscularly as an induction and to maintain deep anaesthesia, respectively, and vital signs were monitored throughout the procedures. Baseline pre-operative impression of the palate was carefully made using hydrocolloid impression materials, and baseline photographs were taken using intra-oral digital camera (Canon 60D, Japan). The oral cavity was thoroughly cleaned using 0.12% chlorhexidine gluconate and the incision line adjacent to the left maxillary premolars was marked with surgical ink. After the incision was made, periosteal flap was raised and a pocket was tunnelled through the incision (Fig. 1). A tissue expander was inserted and implanted along the region of mid-palatal

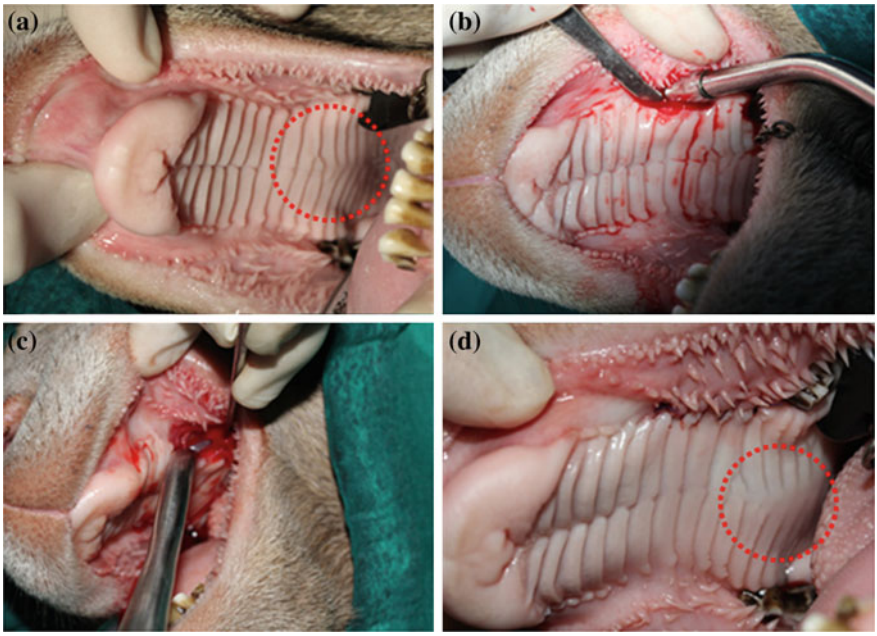

Fig. 1 Implantation of tissue expander: **a** incision and targeted area for implantation, **b** tunnelling of a pocket via a small anterior incision, **c** implantation of tissue expander along the region of mid-palatal suture, and **d** expanded area

suture, and thereafter the surgical incision was sutured (Ethicon Inc, Johnson & Johnson, UK). Impressions of the palate and intra-oral photographs were taken for further analysis. The tissue expanders were left in situ for 3 weeks and sheep were fed regularly. The oral cavity was checked once a week for signs of infection and to ensure that the tissue expanders have not been displaced.

2.3 Sample Collection and Preparation

The sheep were euthanized, and the entire palatal tissues were harvested from both groups (Fig. 2). Upon explanation, 5 × 5 mm of expanded tissues were incised and cryopreserved at −80 °C. Henceforth, the tissues were embedded in optimal cutting temperature compound and sectioned to 60 µm thick using a cryostat (Leica CM1850UV, Italy) for AFM analysis purposes.

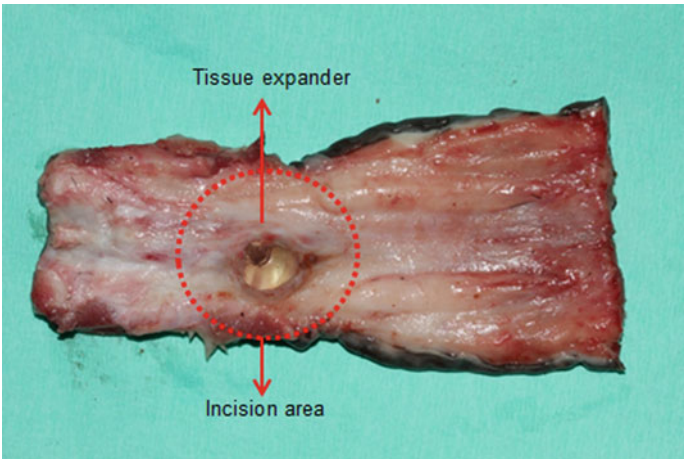

Fig. 2 Self-inflating tissue expander and expanded palatal tissue harvested after 3 weeks of expansion

2.4 Uniaxial Tensile Test

The palatal tissues were cut into a strip of 20(L) × 5(W) mm from the same expanded area and stored at −20 °C to preserve its physiological and mechanical properties. The identical palatal strips were damped in tissue grips and tested on the Universal Testing Machine (5848, Instron Microtester, UK). The exact initial strip length between clamps was measured (l). The mechanical characteristics of the palatal tissue were determined under the uniaxial tensile test performed at a constant loading rate of 1 mm/min (Wysocki et al. 2011) until rupture. To eliminate the effect of tissue hysteresis during the test, each specimen was preconditioned by three loading–unloading cycles to obtain reproducible curves. The stress and strain values were plotted in the same graph as the data obtained directly from the tensile tests. The Young's modulus (E) was taken as the slope of curve (linear region of the stress–strain curve).

2.5 AFM Imaging and Force Spectroscopy Measurement

Imaging and force spectroscopy was performed using an AFM (NanoWizard® 3 JPK Instruments, Berlin, Germany) interfaced with an inverted microscope (IX-81, Olympus, Germany). A parabolic probe was mounted on the AFM scanner head and an empty microscope glass slide (Agar Scientific, Essex, UK) was used as a calibration base to calibrate the cantilever. Images were obtained using contact mode, with a cantilever tip of nominal spring constant 0.2 N/m and sensitivity of 65.76 nm/V in order to match the stiffness of the collagen. The extension and

retract speed was set to 5 µm/s, and closed loop was used. All measurements were taken in air and at room temperature where each of the samples was imaged in six different locations. Force spectroscopy was performed at ten different fibrils for each sample. In order to ensure the cogency of the result, only indentation curves located simultaneously at the overlap region of the collagen D-banding were considered. The Young's modulus of the control and expanded group in this region were analysed using force spectroscopy, and the reliability test was performed to obtain the consistent values. Data and images produced were then analysed using JPK data processing software.

2.6 Statistical Analysis

The data collected were analysed using non-parametric independent *t*-test, Mann Whitney (SPSS version 22.0) at 95% confidence interval. Normal distribution of data sets was confirmed using Shapiro–Wilk test.

3 Results

3.1 Surface Topography of the Collagen Fibrils

AFM images of control and expanded palatal tissue are shown in Fig. 3. The individual fibrils and their repeat units are clearly visible. The collagen fibrils obtained from the control group suggested that the collagens were assembled into thin fibrils organized in network-like structures, aligned randomly with staggered

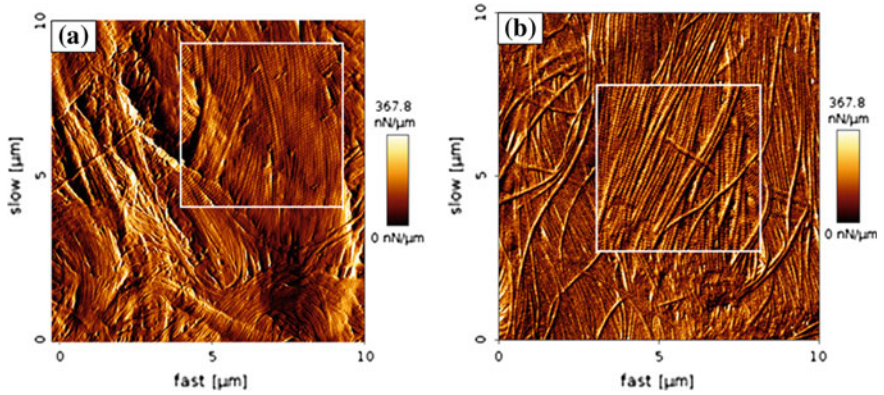

Fig. 3 AFM micrograph of collagen fibrils of the **a** control groups and **b** expanded groups

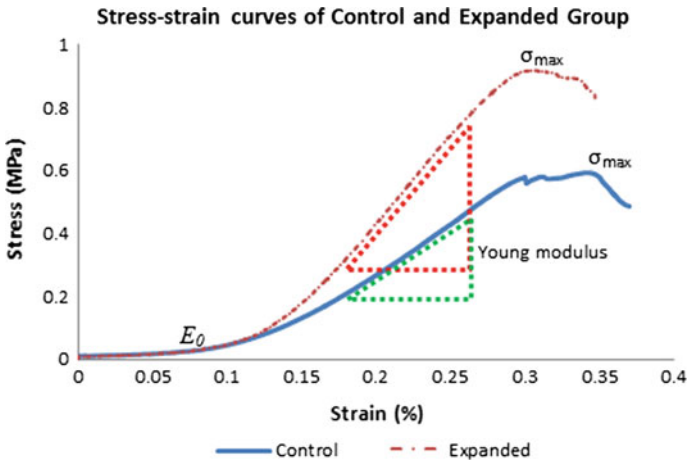

Fig. 4 Stress–strain curve of the control and expanded groups

packing. On the contrary, the collagen fibrils of the expanded palatal tissue were found to be aligned in an orderly fashion, where the collagen fibrils were observed to be significantly longer and narrower.

3.2 Elastic (Young's) Modulus of the Collagen Fibrils

The Young's modulus measured from both the uniaxial tensile test (Fig. 4) and force deflection curve (Fig. 5) are shown in Table 1; the Young's modulus of the expanded groups was significantly higher than the control groups. This value was somehow further evaluated in Figs. 4 and 5, where the gradient in both stress–strain and force–deflection curves of the expanded groups was observed to be steeper than the control groups.

4 Discussion

This study demonstrated the characteristics of palatal tissues expanded with anisotropic rate-controlled self-inflating tissue expanders in Dorper sheep. It has been found that sheep's palate approximates the size of the human palate, thus creating a comparable condition for tissue expansion. Moreover, the selection of Dorper sheep was based on its relatively low genetic variation (Dorper Breeders of South Africa 2000). In addition, they are fertile, parasite tolerant and have low disease susceptibility.

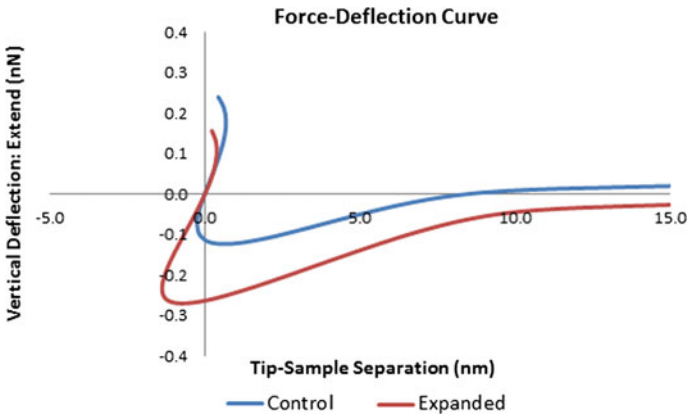

Fig. 5 Force–deflection curves of collagen fibrils of the control and expanded palatal tissue representing the modulus obtained at the overlap region

Table 1 Statistical analysis of the elastic (Young's) modulus of collagen fibrils

Group	Control		Expanded		
Test	m	1 SD	m	1 SD	*p*-value
Tensile	3.70	1.03	5.54	1.15	0.04
AFM	4.62	1.01	12.96	2.81	0.02

m mean, *1 SD* standard deviation

The knowledge of the mechanical properties of tissues is crucial not only for the development of new materials based on biological polymers but also aid in understanding the collagen-related disease. Therefore, in order to examine the properties of collagen and associated polymers, it is important to conceive its structure and functional mechanisms on the microscopic level. In this paper, the surface topography of the collagen was studied at both bulk and fibrils levels, and the elastic property (Young's modulus) of the expanded palatal tissues was investigated in order to gain better insight of its biomechanical property.

It is showed that the expansion of the palatal tissue has led to the changes in the surface topography at the microstructure level which is clearly shown in Fig. 3b. The collagen fibrils were observed to be in stretched alignment, orderly fashion and positioned parallel towards the direction of the expansion. This finding seemed to be in contrast with the control groups, where the collagen fibrils observed under the AFM were assembled into thin fibrils organized in network-like structures, aligned randomly with staggered packing (Fig. 3a). Although the collagen bundles were observed to be in crimped and packed alignment, each of the collagen fibrils was clearly visible. This staggered packing was somehow similarly observed by Smith (Smith 1968) and supported by the model proposed by Hodge and Petruska (1963).

Stiffness is defined as the resistance of a material against deformation when subjected to stress. One of the prevalent methods used to evaluate the mechanical properties of soft tissues in vitro is the uniaxial tensile. At the macro-level, the palatal tissues (bulk tissues) were tested immediately following harvesting, in order to attain reliable measurements and preserve the mechanical behaviour of the tissue. It was observed that the expanded group shows a significant difference in the Young's modulus compared to control group, where the gradient in the stress–strain curve seemed to be steeper (Fig. 4). This finding was also observed in the study of the expanded palatal tissues of rabbit done by Wysocki et al. (2011).

Meanwhile, at the microlevel, the elastic modulus of collagen fibrils was tested using force spectroscopy from the AFM. It is observed in Table 1 that the collagen fibrils of the expanded group exhibit significantly higher elastic modulus (12.96 ± 2.81 GPa) than the control group (4.62 ± 1.01 GPa) when an independent *t*-test was done. This indicates that the tissue has been stretched for a certain period and has become stiffer. Wenger et al. (2007) who did an indentation study using AFM on rat tail tendon type I collagen fibrils also observed a similar value of Young's modulus, which was found to be in the range of 5–11.5 GPa ($N = 34$). The Poisson's ratio υ of a solid material is commonly in the range of 0–0.5; thus, lower and upper limits for the Young's modulus can be given by 3.75 GPa ($\upsilon = 0.5$) and 11.5 GPa ($\upsilon = 0$), respectively. Using this as an argument, it is safe to say that the data obtained from the control group is somehow valid. Though the Young's modulus measured in the expanded group is higher (as the collagen fibrils have become stiffer due to the expansion), this data was also observed in the study found by Harley et al. (1977). In their study, a Brillouin technique was used to concede the modulus of the collagen fibrils in three different states and the result obtained was 9, 14.7 and 21 GPa, consecutively. Therefore, though the palatal tissue has gone an expansion process for quite some time, one can say that the value obtained in the present work is in reasonable agreement with earlier results obtained through various methods (Harley et al. 1977; Wenger et al. 2007), where the Young's modulus of both groups was still found to be in the normal physiological range of collagen fibrils. This result can also be supported by the facts that the micrograph of the collagen fibrils in the expanded groups shows no signs of fibrosis or tissue damage.

5 Conclusion

This study has clearly ascertained that there was an effect of expansion on the elastic (Young's) modulus at both macro- and microlevels. Despite the significant differences found in the elastic modulus, it is safe to say that the values obtained from this study are somehow valid and were still in the normal physiological range, which have been supported by results found in previous studies. Higher modulus (E) indicates higher stiffness in the tissue, which leads to a higher tensile strength acquired to stretch the tissue. Nevertheless, in treating cleft palate, the elastic

modulus is one of the means to instigate whether the expander will produce normal biomechanical properties or not. The main concern in treating cleft palate is obtaining the adequate volume of tissue required for surgery, while maintaining its physiological and mechanical properties. Further work is, however, required to study this relationship. Considering the cogency of the results obtained, it is enthralling to note that the information gathered in this study is paving the way of using tissue expansion in treating cleft palate.

Acknowledgements This research is supported by High Impact Research MoE Grant UM.C/625/1/HIR/MOHE/DENT/01. I would like to thank the rest of my Tissue Expander team members, for their encouragement, insightful comments and unlimited help throughout this whole process. In the various laboratories and operating rooms, I have been aided by many respectful surgeons and technicians, from Faculty of Dentistry, University of Malaya and Faculty of Veterinary Medicine, Universiti Putra Malaysia. Additionally, I also thank University of Oxford, for such contribution in implementing such novel tissue expanders, Department of Paediatrics and Orthodontics University of Malaya for providing contented environment to work on and lending equipment for this study purposes. Last but not least, I would like to thank Universiti Teknologi MARA for giving me the opportunity to publish and acknowledge this study.

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Chapter 72
Recycled Paper Enhancement with Semantan Bamboo Virgin Pulp for Corrugated Paper Manufacturing

Nurul Husna Mohd Hassan, Suhaimi Mohammed and Rushdan Ibrahim

Abstract The effect of Semantan bamboo virgin pulp on the recycled paper properties enhancement, for corrugated paper manufacturing, has been studied. The pulping of Semantan bamboo revealed that pulping condition with 15% alkali charge and 150 °C cooking temperature with 8000 beating revolutions leads to good paper properties. The paper tensile index was 87.71 Nm/g, bursting index was 6.94 kPa m^2/g, tearing index was 12.72 mN m^2/g and folding endurance was 613 double folds. These are the important strength determination for paper mechanical properties prediction. After that, the bamboo pulp was blended with recycled paper pulp and made into 120 g/m^2 paper for corrugated paper manufacturing. The results revealed improved values with increasing bamboo percentage added to the recycled paper. Zero-span index and flat crush test (FCT) index of 2.5, 5, 7.5 and 10% bamboo added with recycled paper properties were 90.06, 91.38, 95.23 and 96.90 Nm/g and 1.49, 1.49, 1.53 and 1.61 Nm/g, respectively. Zero-span and FCT index are the testing for corrugated paper determination strength. It showed that the addition of Semantan bamboo virgin pulp gave positive impact to the strength properties of recycled paper. In conclusion, Malaysian bamboo possesses great potential in enhancing the recycled paper properties. Therefore, bamboo serves as a good substitute for currently imported virgin softwood pulps.

Keywords Corrugated paper · Recycled paper · Semantan bamboo

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_72

1 Introduction

Corrugated paper consists of medium core and liners that are usually used for making corrugated box. It needs a very strong structure to protect the goods inside it, especially electrical and electronics products. Corrugated paper mainly used for package box with structural integrity. 90–95% of corrugated paper raw material used recycled paper from various sources such as old corrugated cardboard, writing paper, old newspaper and many more.

Despite the goodness of using recycled paper, there are some disadvantages of using it. One of them is that recycled paper can only be recycled up to five to seven times before the fibre become weak after each time being recycled. The recycled fibre will be stiff due to lack of fibre flexibility after going through the papermaking process, especially the drying and calendering processes. It needs to be added with virgin pulp to maintain the paper strength (Rushdan 2003) as the recycled paper fibre was stiff and hardly collapse during the paper formation process. This caused less inter-fibre bonding and decreased the paper strength.

Another problem is, the virgin pulp as the raw material to maintain the recycled paper at a certain level of strength, need to be imported. Imported virgin pulp is expensive and can contribute to the additional cost in papermaking industry. Nowadays, most of the virgin pulp is made from imported softwood fibre and it costs from USD550 to USD1100 per metric tonne (Brian 2017).

Semantan bamboo is scientifically known as *Gigantochloa scortechinii*. Semantan bamboo was chosen in this study because it is the most common species available in Malaysia forest. In the latest study by Nazlin and Mohd Nazip (2011) in Kuala Keniam, Pahang National Park, they found that Semantan bamboo has the highest relative density, up to 58.8%, in comparison with other species such as Buluh lemang (*Schizostachyum brachycladum*), Buluh nipis (*S. latifolium*), Buluh semeliang (*S. grande*) and Buluh aur (*Bambusa vulgaris*) at 27.5, 3.9, 7.8 and 2%, respectively. Relative density describes the species richness in a specific area.

The objective of this study is to introduce Semantan bamboo fibre as a potential virgin raw material to substitute the expensively imported softwood virgin pulp in the production of paper that needs to be strong, yet lightweight in their application, such as corrugated paperboard (as corrugating medium or liners), sandwich honeycomb and composite panel structure that needs paper material in order to make it strong but at the same time maintain the lightweight of the structure. Based on bamboo fibre characteristic studied, it would be suitable or comparable to be used in the above-mentioned application due to its longer fibre length (Abd. Latif et al. 1994) and produced a relatively stronger paper after went through a certain beating process to improve the inter-fibre bonding in bamboo paper. Ironically, in Malaysia, most bamboo exist naturally in the forest, while plantation bamboo needs shorter time to be harvested compared to hardwood or softwood fibre sources (Chen et al. 2000).

2 Method

The best bamboo paper was produced from Semantan bamboo (treatment number 4 with 15% alkali, 150 °C pulping temperature and 8000 beating revolutions), based on the highest bonding index, which was chosen to be blended with commercial recycled paper collected from Pascorp Paper Sdn Bhd, Bentong, Pahang (Nurul Husna et al. 2013). The papermaking was based on TAPPI standard T205 cm-88 (TAPPI 2011) with slight modification during the mixing process of Semantan bamboo with the recycled pulp to change the grammage to be 120 g/m^2 instead of 60 g/m^2.

The recycled pulp was reslushed by using the hydrapulper for 20 min and then it was spun to remove the excess water and the recycled pulp moisture content was determined by using the moisture content analyser. The mixing was based on 36.4 g of oven-dried pulp, in producing 10 sheets of papers for each batch of paper treatment with 0, 2.5, 5, 7.5 and 10% of Semantan bamboo pulp mixed with 100, 97.5, 95, 92.5 and 90% of recycled pulp, respectively.

The zero-span index testing was based on TAPPI standard T231 cm-96 (TAPPI 2011) by using zero-span jaws with 10 replications for each paper sample. The 120 g/m^2 paper produced was passed through the Concora Medium Flutter machine to turn it into a corrugated form and tested for the flat crush test (FCT) strength based on TAPPI standard T809 cm-99 (TAPPI 2011) with 10 replications for each paper sample.

The statistical analysis is important to determine the paper strength effect after adding 2.5, 5, 7.5 and 10% of Semantan bamboo virgin pulp into the recycled pulp. The statistical analysis was carried out using the statistical package for the social science (SPSS). Analysis of variance (ANOVA) was used to determine the effect of *Semantan* bamboo and recycled paper mixing in zero-span index and FCT index. After that, Duncan's multiple range test (DMRT) was used to determine the significance level of the parameters evaluated. This method ranks the means (at $p \leq 0.05$) and calculates the least difference that must occur between the means in order to be significantly different with each other. The differences were reflected in the letters (a, b, c, etc.) given in each mean. Means followed by the same letter are not significantly different at $p \leq 0.05$.

3 Results and Discussion

Table 1 shows the treatment conditions for bamboo and recycled paper blending and the results for zero-span index and FCT index. There are five treatments based on the percentage of the Semantan bamboo pulp and recycled paper pulp. The papermaking used is 120 g/m^2 as the thicker paper is needed to transform the paper sheet into corrugated paper form.

Figure 1 shows the zero-span index for the 120 g/m^2 bamboo-recycled paper blending. The lowest zero-span index (78.83 Nm/g) was found in the first treatment (A) which consists of 100% recycled paper pulp. The zero-span index slightly

Table 1 Treatment conditions for bamboo and recycled paper blending

Treatment	Bamboo (%)	Recycled Paper (%)	Zero-span Index (Nm/g)	FCT Index (Nm/g)
A	0	100	78.83	1.49
B	2.5	97.5	90.06	1.49
C	5	95	91.38	1.49
D	7.5	92.5	95.23	1.53
E	10	90	96.90	1.61

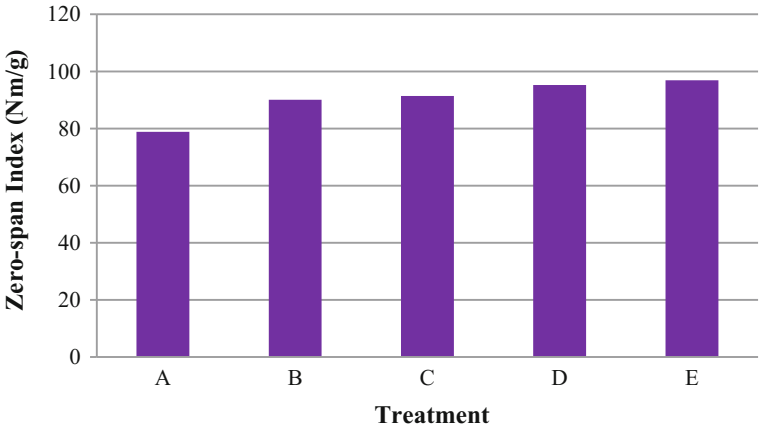

Fig. 1 Zero-span index for different percentages of bamboo and recycled paper pulp blending

increased with the increase of the addition of the bamboo pulp from 2.5, 5, 7.5 and 10%. It finally increased up to 96.90 Nm/g when 10% of Semantan bamboo pulp was added to the recycled paper pulp. It showed the positive behaviour of the bamboo-recycled paper pulp blending as the addition of the bamboo pulp gave the higher strength of the zero-span index. Ghasemian et al. (2012) studied the effect of cationic starch (Cat St) on the properties of papers made from recycled old corrugated container (OCC) and virgin neutral sulfite semi-chemical (NSSC) pulp. They evaluated the usage of OCC fibres as a supplement raw material for papermaking. The paper samples contained a series of mixtures of OCC and virgin NSSC pulp (0:100, 20:80, 30:70 and 40:60 by weight) and Cat St (0, 0.5, 1.2, 2 and 3 wt%). The results showed that addition of Cat St significantly enhances all the strength properties of paper.

Figure 2 shows the FCT index for the five treatments as stated in Table 1. The FCT index increased slightly with the increase of the percentage of bamboo pulp added in the bamboo-recycled paper pulp blending. Initially, there was no improvement on the paper properties in treatment A (control sample), with the addition of 2.5 and 5% of Semantan bamboo pulp for FCT index, as indicated in

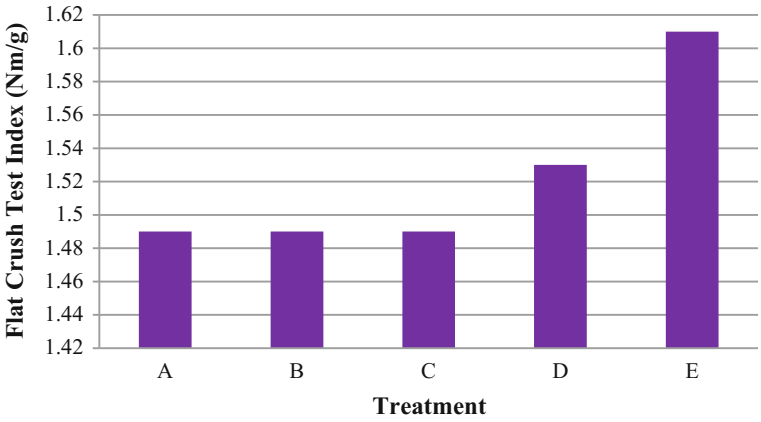

Fig. 2 FCT index for different percentages of bamboo and recycled paper pulp blending

treatment B and C. But, as the percentage of the Semantan bamboo increased to 7.5 and 10%, the improvement started to be seen as the FCT index increased from 1.49 Nm/g to 1.53 Nm/g in treatment D and finally 1.61 Nm/g in treatment E, which consists of 10% bamboo and 90% recycled paper pulp. Ramdhonee and Jeetah (2017) evaluated the use of banana fibre with sugarcane bagasse and wastepaper to produce paper in 20:80, 40:60, 60:40 and 80:20 ratios. Highest bursting index was from banana paper with 20% wastepaper mix (2.00 kPa m^2/g).

Table 2 shows that the increases of zero-span index and FCT index reading (Figs. 1 and 2) on the addition of Semantan bamboo pulp from 2.5 to 10% were highly significant for zero-span index as the *p*-value is less than 0.001 but were not significant for FCT index due to which the *p*-value is 0.133. It means that the addition of bamboo fibres only influenced the zero-span index which was improving the strength of individual fibres in the paper sheets but has no significant influence on the paper strength in terms of FCT index. This may due to the orientation of the testing procedure for FCT which was in vertical compression, compared to another type of paper testing that normally by horizontal elongation that can be evaluated for paper strength.

Table 3 shows the effect of Semantan bamboo percentage of the corrugated paper properties. Means followed by the same letter were not significantly different.

Table 4 shows the correlation and regression between Semantan bamboo corrugated paper with zero-span and FCT index. The Semantan bamboo percentage was strongly correlated with zero-span index at 0.776 and moderately correlated

Table 2 Summary of ANOVA for zero-span and FCT index

Variable	df	F-value (Zero-span Index)	F-value (FCT Index)
Bamboo percentage	4	17.228**	1.907 ns

**highly significant; *ns* not significant

Table 3 Effect of Semantan bamboo percentage of corrugated paper properties

Bamboo (%)	Zero-span index (Nm/g)	FCT index (Nm/g)
0	78.62[a]	1.49[a]
2.5	90.21[b]	1.49[a]
5	91.43[bc]	1.49[a]
7.5	95.40[bc]	1.52[ab]
10	96.90[c]	1.61[b]

Note: [a,b,c]Means within a column followed by different letters are significantly different at $p \leq 0.05$

Table 4 Correlations and regression between zero-span and FCT index on Semantan bamboo corrugated paper

Variable	Zero-span index	FCT index
Bamboo (%)	0.605**	0.857**
Adjusted R-square	0.728	0.352

Note: **- highly significant

with FCT index at 0.374. Based on the adjusted R^2, it can be concluded that the addition of Semantan bamboo pulp according to certain percentage contributed 59.2% on zero-span index strength and only contributed 12% to the FCT index strength. From the regression, the equation for corrugated paper properties in terms of zero-span and FCT strength can be predicted as shown in Eqs. (1) and (2):

$$\text{Zero-span: } y = 77.244 + 4.378x \tag{1}$$

$$\text{FCT: } y = 1.436 + 0.27x \tag{2}$$

4 Conclusion

At 100% of recycled paper pulp, zero-span index was found to be 78.83 Nm/g, and with the addition of Semantan bamboo pulp as low as 2.5% up to 10%, the zero-span index for 'recycled paper-Semantan bamboo paper' increased and zero-span ranged from 90.06 to 96.90 Nm/g. There was also some increment in FCT index from 1.49 to 1.62 Nm/g for 0% and 10% of Semantan bamboo addition, respectively. According to the zero-span index and FCT index, it showed a positive relationship of paper properties with the addition of bamboo pulp into the recycled paper pulp. It showed that the paper strength can be improved by using virgin bamboo pulp.

Acknowledgements The first author would like to thank JPbSM UiTM for sponsoring the scholarship for this study. An appreciation of Pulp and Paper Programme, Forest Research Institute Malaysia (FRIM) for the equipments provided throughout the study. Also, thanks to Pascorp Paper Sdn Bhd, Bentong, for providing the recycled paper pulp for this study.

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Chapter 73
Physical and Chemical Properties of Different Portions of Oil Palm Trunk

Nurrohana Ahmad, Jamaludin Kasim, Nor Yuziah Mohd Yunus, Junaiza Ahmad Zaki and Ainul Munirah

Abstract A total of three-felled oil palm trunks (OPT) was obtained from the Ulu Jempul, Pahang. The physical properties of oil palm trunk were determined at different tree portions for basic density and distance from pith for moisture content. The finding revealed that the specific gravity and moisture content are significantly different on tree portion and highly significant difference for distance from pith. The chemical composition of the oil palm trunks was analysed for hot water, ash content, 1% NaOH, alcohol–toluene extracts, lignin, holocellulose and alpha-cellulose from bottom to top portion. Based on the results, there were significantly different between the tree portion and the highest value that was found at the top portion except for lignin content, holocellulose and alpha-cellulose. The highest percentage of the chemical properties were from hot water, ash content, 1% NaOH and alcohol–toluene extract at the top portion. Thus, the potential of using such oil palm trunk could serve as a raw material for the particleboard production.

Keywords Chemical properties · Distance · Oil palm · Physical properties Portion

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_73

1 Introduction

Looking at the current scenario in Malaysia wood-based industry, the wood industry has contributed significantly towards the socio-economic development while maintaining the vast usage of wood. However, Malaysia is facing the declining supply of wood as raw material, especially rubberwood and now trying to shift to use other local natural resources as an alternative. Therefore, non-woody plants such as oil palm trunk (OPT) need to be introduced in order to sustain the wood-based industry.

Oil palm (*Elaeis guineensis*) is produced in 42 countries worldwide which is estimated around 27 million acres. Its production has nearly doubled in the last decade, and oil palm has been the world's foremost fruit crop, in terms of production, for almost 20 years. In 2006, 2008 and 2010, the total area of oil palm trees planted in Malaysia has increased from 4.17 million, 4.49 million hectares to 4.85 million hectares, respectively, in Malaysia (MPOB, 2010).

According to this great increment of statistic of oil palm plantation and biomass, it has a big potential to be the most viable alternative to be used other than wood for employment and converting into various composite panels such as particleboard and fibre products, as well as chemical derivatives in future wood-based industries (Abdul Khalil et al. 2010).

The density of the oil palm trunk would be in the range of 0.22–0.55 g/cm^3 (Anis et al. 2008). According to Balkis Fatomer et al. (2013), moisture content (MC) of the palm stem increased from the outer towards the inner section while the density decreased. Along the tree height, the MC was found to increase from the bottom to the middle part, but slightly decreased towards the top, while the density decreased from bottom to top. Thus, the outer and lower zones are the driest. Due to the high MC and density variations along the longitudinal and transverse direction of the tree, drying and treatment processes of the stem may result in certain difficulties of the wood (Lim and Gan 2005).

According to Balkis Fatomer et al. (2013), a middle portion and centre sections of the oil palm stem contained the highest amount of extractives which ranged from 4.6 to 32.8%. On the other hand, the lowest amount of extractives was located at the bottom portion and outer sections of the oil palm stem, ranging from 2.0 to 9.2%. Therefore, the objective of this study is to determine the effects on the physical and chemical properties of oil palm trunk. A good understanding will help to develop productive uses for OPT such as particleboard as an alternative material to wood.

2 Methods

Oil palm trunk (OPT) was felled by an excavator at FELDA Ulu Jempul, Pahang. The discs from three height portions were labelled as the bottom, middle and top at 1, 3.7 and 6.5 m from the ground level, respectively. The discs were sealed with a

plastic sealer to make sure the moisture remained and were kept in the deep freezer until the preparation period of the samples.

The physical properties of moisture content and density were determined from the samples. Billets along the radial section 20 mm × 20 mm × 2 mm dimension from each portion were cut. Before being dried in the oven at 103 ± 2 °C for 24 h, the samples were weighed and measured. After 24 h, the samples were then measured again in order to calculate the results.

The sampling and preparation of sawdust were based on the Technical Association of the Pulp and Paper Industry (TAPPI). For the chemical compounds determination, T257 cm-85 (1996) specifies that an air-dried sawdust was ground to form sawdust before being sieved which passed through 40 mesh sieve and retained on the 60 mesh sieve. Few analyses were conducted including hot water soluble, alkali (1% NaOH) soluble, alcohol–toluene soluble, ash content, lignin, holocellulose content and α-cellulose content. The experiments on hot water soluble, alkali (1% NaOH) soluble, alcohol–toluene soluble, ash content, lignin content and alpha-cellulose content were conducted according to the TAPPI Standard T 207 cm-99 (TAPPI 1999), T212 cm-02 99 (TAPPI 2002b), T 204 cm-97 99 (TAPPI 1997), T 211 cm-02 99 (TAPPI 2002a), T 222 cm-02 99 (TAPPI 2002c), and T 203 cm-99 99 (TAPPI 2002e). Besides, the method developed by Wise, Murphy and D'Addieco (1946) had been used in the determination of holocellulose content.

3 Results and Discussion

3.1 Physical Properties

The results on physical properties of OPT are summarized in Table 1 according to height portion and distance from near bark to near pith. According to the physical properties that had been carried out, the results showed that the oil palm trunks are highly significant difference for a distance on density and moisture content. But it is only significant for height portion at both physical properties. Meanwhile, the interaction between height portion and distance shows no significant difference according to the physical properties.

Table 1 Analysis of variance of physical properties on OPT

SOV	df	Basic density	Moisture content
Portion	2	6.221*	4.176*
Distance	2	138.157**	188.318*
Portion * Distance	4	1.398 ns	0.064 ns

SOV Source of variance, *df* Degree of freedom, **Highly significant difference at $p < 0.01$, *Significant difference at $p < 0.05$, *ns* Not significant at $p > 0.05$

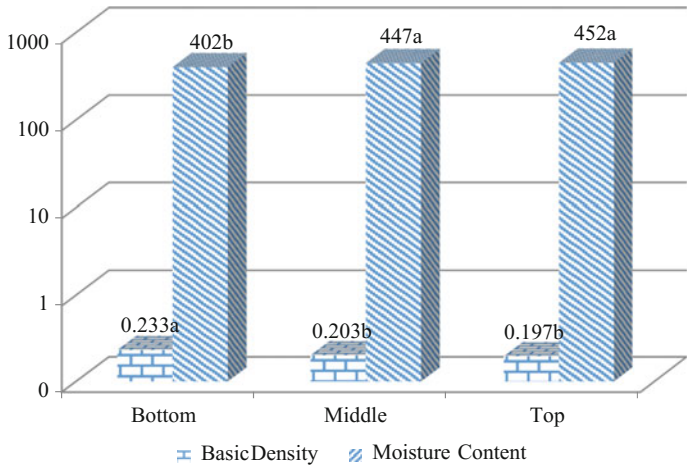

Fig. 1 Effects of basic density and moisture content on tree portion of OPT

Figure 1 shows the basic density and moisture content based on different portions. The middle portion gives higher value compared to the top but there is no significant effect between both. There is a significant effect for bottom portion on the basic density. However, it did not significantly affect the middle and top portions. According to Balkis Fatomer et al. (2013), there is a significant variation of density values at different portions and direction of the oil palm trunk.

Figure 2 shows the distribution of moisture content that decreases from near pith to bark, and basic density increases from bottom to top portion of the oil palm trunk. The moisture content decreases from near pith (661%) to bark (253%), and

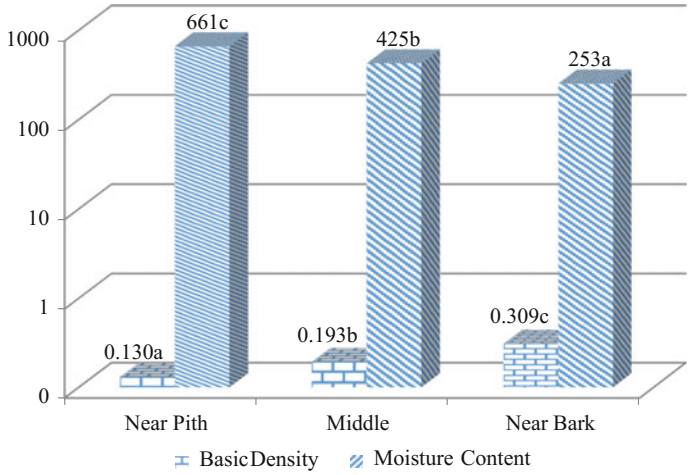

Fig. 2 Effects of basic density and moisture content on distance of OPT

basic density was increased from bottom to top portion of oil palm trunk. It is clear that when the numbers of vascular bundles increased, the density and mechanical properties of oil palm trunk were also increased (Darwis et al. 2013).

3.2 Chemical Properties

The chemical properties of OPT are summarized in Table 2 based on the height portions. According to the analysis of variance, the results show that all the board properties were affected by the height portion but not for holocellulose content.

The distribution of chemical properties of oil palm trunk in height portion is presented in Table 3. The hot water, ash, alkali content and alcohol content increase linearly with oil palm trunk height and decrease for lignin and alpha-cellulose content. Meanwhile, holocellulose content shows that the middle portion was higher than middle and top.

The determination of hot water solubility of wood is referred to the material such as sugar, starch, tannin, gums and colouring matter that existed in wood. The hot water solubility values for top portion were higher than a middle and bottom portion. As pointed out by Bowyer et al. (2007), the bottom portion of trees contains sugar needed for the development of new wood cells.

The ash content normally related to the amount of mineral salts as well as silica in wood (Abdul Latif et al. 1992). These mineral salts and silica are found in the cell wall and lumen cell (Jane et al. 1970). This study revealed that the percentages of ash content increased from bottom to top portion with (2.86%), (2.68%) and (2.18%), respectively. High percentage of ash content is reported to be harmful to the cutting tool as mentioned by (Junaiza et al. 2012).

The value of alkali-soluble for OPT shows that top portion has a higher value compared to other portions. Normally, higher in alkali solubility is closely related to the rate of degradation of wood (Hill 2006). According to different height levels, the value of alkali-soluble increased with the increase of height levels.

The alcohol–toluene solubility is performed in order to determine a number of extraneous materials such as waxes, fats, resins and certain other insoluble component so-called gums. Further, the chemical properties were found to be significantly affected by height portion (Table 3). Top portion gives higher percentages (20.24%) than the middle (17.03%) and bottom portions (12.50%).

Lignin is a lignocellulosic material that functions as a binding agent which holds the individual fibres together (Miller 1999). The results are shown in Table 3; the lignin content was significantly affected by the height portion. The lignin content tended to be higher in the bottom portion (20.47%) compared to the middle and top portions (19.19 and 17.21%).

Holocelluloses are a combination of cellulose and hemicellulose. The composition of cellulose and lignin is closely related where the greatest lignin content lowers cellulose in wood. In chemical analysis of wood, the holocelluloses are soluble in 17.5% caustic soda known as β-cellulose and γ-cellulose (Jane et al.

Table 2 Analysis of variance of physical properties on OPT

SOV	df	Hot water	Ash	1% NaOH	Alcohol–toluene	Lignin	Holocellulose	Alpha-cellulose
Portion	1	140.377**	254.089**	542.895**	39.649**	12.327*	0.609 ns	37.659*

SOV Source of variance, *df* Degree of freedom, **Highly significant difference at $P < 0.01$, *Significant difference at $P < 0.05$, *ns* Not significant at $P > 0.05$

Table 3 Chemical properties of OPT according to tree portion

	Hot water	Ash	1% NaOH	Alcohol–toluene	Lignin	Holocellulose	Alpha-cellulose
Bottom	17.12a	2.18a	29.63a	12.50a	20.47c	79.35a	55.51c
Middle	21.04b	2.68b	35.21b	17.03b	19.19b	78.96a	51.26b
Top	26.93c	2.86c	40.95c	20.24c	17.21a	79.05a	49.38a

1970). As illustrated in Table 3, the percentage of holocellulose decreased along the trunk height with the bottom portion had a higher value (79.35%) of holocellulose compared to middle portion (78.96%) and top portion (79.05%).

Cellulose content is higher in secondary walls and it has larger molecules. According to Jane et al. (1970), α-cellulose is insoluble in 17.5% caustic soda. According to Table 3, the α-cellulose content decreases when the height levels of tree increasing with bottom portion of OPT had higher value (55.51%). This happens due to the development of thicker secondary wall by cellulose and hemicellulose at the top portion of the tree, whereas Kollmann and Côté (1975) reported the bottom portion of the tree consists of matured cells.

4 Conclusion

The physical and chemical properties of the oil palm trunk were successfully determined. The basic density of oil palm trunk was found significantly affected by the tree portion, and it decreases from bottom to top portion and increases gradually from the near pith to the near bark. Moisture content was found to increase from the bottom to the top portion and the near bark gives the lowest percentage of the moisture content. From the chemical properties aspect, there are highly significant difference for all properties except for holocellulose content. This study hopefully can be used as guidance for further research to produce oil palm trunk as a raw material in wood-based industries.

Acknowledgements We would like to thank Faculty of Applied Science, Universiti Teknologi MARA Shah Alam for the fee, and the Universiti Teknologi MARA Pahang for the permission to use the facilities in the laboratories.

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Chapter 74
Effects of Resin Content Dosage, Density and Wax Addition on the Physical and Mechanical Properties of Particleboard from Oil Palm Trunk

Jamaludin Kasim, Nurrohana Ahmad, Nor Yuziah Mohd Yunus and Anis Mokhtar

Abstract This study investigates the effects of resin dosage, board density and wax addition on physical and mechanical properties of oil palm trunk particleboard. The oil palm trunk was harvested from FELDA Ulu Jempul, Pahang and flaked to produce the particles. The particles were blended with urea formaldehyde (UF) as a binder and added with wax in order to enhance board dimensional stability. The oil palm trunk particleboards are consolidated at temperature of 165 °C with pressure cycle of 1800, 1200 and 500 psi for six minutes. Mechanical properties, namely, modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB), physical properties of water absorption (WA) and thickness swelling (TS), are tested according to Japanese Industrial Standards (Particleboard, Japanese Standards Association, Japan, 2003). The results for different resin contents show that the particleboards with 12% resin content have given better performance in physical and mechanical properties as compared to 10% and 8%. Besides, the results for different densities show that the mechanical properties of particleboards improve as the density increases which was the particleboard with density 600 kg/m^3 with MOR and MOE of 6.81 and 957.17 MPa, respectively, which gives the best performance. Addition of 1% wax was improve the physical properties of the board from 15.6 to 36.9%. However, wax addition gives negative impact on the mechanical properties of particleboard.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_74

Keywords Density · Oil palm · Particleboard · Resin content
Wax addition

1 Introduction

Particleboard is a composite wood product manufactured using certain temperature and pressure from any size of particles and using resin as a binder. It is used widely in the manufacture of furniture, floor underlayment, cabinets, stair treads, home constructions, tabletops, vanities, speakers, sliding doors, lock blocks, interior signs, displays, table tennis, pool tables, electronic game consoles, kitchen worktops and work surfaces in offices, educational establishments, laboratories and other industrial product. From the previous study, a wide variety of annual plants, agricultural residues, bark, branch wood, wheat straws, rice husks, groundnut shells, bamboo, bagasse, cotton, hemp, and jute stalks, sunflower stalks, maize husk and cab, kiwi and wine pruning, coconut coir, flax shiv, corn pith, castor stalks, *miscanthus*, steam-treated rice industry residues, mimosa bark, *Pinus radiata,* ponderosa and tanoak bark and decayed and branch woods were used in manufactured particleboard (Nemli and Aydın 2007).

The demand for agricultural waste has been growing due to its function as timber resources for wood composites. Today, agricultural waste is mostly ploughed into soil or burnt in the field after harvested without any particular uses (Laemlaksakul 2010). Oil palm (*Elaeis guineensis*) is one of the major agricultural plantations in Malaysia (Jumhuri et al. 2014). Oil palm trees are replanted every 25 years, while the trees can still produce fruits every month. Oil palm biomass consists of fronds, trunks and empty fruit bunches. It was estimated that 13.9 million tonnes of dry weight produced from oil palm biomass (Anis et al. 2011). Originally, oil palm trunk has contributed 90% from the total of biomass produced by oil palm tree (Balkis et al. 2013).

Oil palm trunk has a great potential to be converted into value-added product as raw material to manufacture wood composite panels such as particleboard, veneers, plywood and medium density fibreboard. In the previous study, oil palm trunk can be used in binderless manufacturing process of particleboard manufacturing (Hashim et al. 2011).

In this study, the use of oil palm trunk as an alternative raw material for manufacturing particleboard is studied. Moreover, the effects of resin dosage, board density and wax addition on the physical and mechanical properties of the resulted board are also be investigated.

2 Method

2.1 Preparation of OPT Particles

The oil palm trunks were collected from FELDA Ulu Jempul, Pahang. Three trees of 25-year-old oil palm trunks were then cut after one metre from the ground. Oil palm trunks were then cut into billet at nine foot each and then brought to UiTM Pahang for further process.

The trunks were cut using a movable bandsaw to remove the bark and cut into a block with 7 in. width and 10 in. length. The trunks were flaked using knife ring flaker to obtain the OPT particles. The trunks later were processed on the same day to prevent from fungus and insects. The particles were then dried until they reach below 15% moisture content (MC). After that, the particles were removed from the oven using a dust extractor to separate the vascular bundle and parenchyma. Then, the particles were screened by using vibrator screener machine to remove the fines. Before the board was fabricated, the particles were dried until the MC was below than 5%.

2.2 Fabrication of Particleboard

Particleboards with size 340 mm × 340 mm × 12 mm with targeted density of 500 and 600 kg/m^3 and final MC of 12% were fabricated. The OPT particles were bonded together with urea formaldehyde (UF) resin at 8, 10 and 12% (w/w oven-dried weight of the particles). The characteristics of UF resin supplied by Malaysian Adhesives and Chemical Sdn. Bhd. are shown in Table 1. The amount of resin, particle, ammonium chloride solution used 20% concentration and wax was calculated and weighed before blending.

The particles were placed into the particleboard mixer and sprayed with resin, hardener and wax. After spraying, the particles were matted at the caul plate in the wooden forming mould. The silicone release agent was sprayed on the caul plates to prevent from sticking. The mat was then pre-pressed manually to reduce mat thickness before hot pressing. The mat was pressed with a temperature of 165 °C for 6 min and steel bars of 12 mm thickness were used as a stopper. All boards were conditioned at the conditioning room before trimmed and cut into test specimens.

Table 1 Characteristic of urea formaldehyde resin

Viscosity of poise @ 30 °C	2.00
Solid content @ 105 °C/3 h	64.8%
pH @ 30 °C	8.29

2.3 Properties Assessment

The physical and mechanical properties of the particleboards were carried out according to Japanese Industrial Standards (JIS A 5908:2003). The boards were conditioned in a conditioning room at 65 ± 5% relative humidity (RH) and 20 ± 2 °C for a week. Bending strength (BS), internal bonding (IB), thickness swelling (TS) and water absorption (WA) properties were determined.

2.4 Physical Properties

Testing specimens with the dimension of 50 mm × 50 mm × 12 mm were taken for each board to measure the TS and WA. TS and WA data were obtained after the thickness and weight of the test specimen measured before and after submerged in water for 24 h at ambient temperature.

2.5 Mechanical Properties

Particleboard samples were tested for bending strength [modulus of rupture (MOR) and modulus of elasticity (MOE)] and tensile strength values. The sample size used was 50 mm × 50 mm × 12 mm and the span for each test was 230 mm. For IB test, the epoxy glue was used to bind the sample with two steel blocks. The sample was left to cure the glue for a day to permit appropriate bonding.

3 Statistical Analysis

The statistical analysis was employed to determine the significance of data by using statistical software of IBM SPSS Version 23. The results for resin content were evaluated by using analysis of variance (ANOVA) to assess the effects of resin content on the physical and mechanical properties of the particleboard. Significant differences between the average values of types of the composite boards were determined using Duncan's multiple range test. Sample for density and wax addition were evaluated by t-test, a mean separation technique to identify a variable that has a significant effect on the physical and mechanical properties.

4 Results and Discussion

Table 2 shows the mean values for physical and mechanical properties of the particleboards with two different densities (500 and 600 kg/m^3), and three different percentages of resin dosage 8, 10, 12 and 1% addition of wax and wax as 0% in the boards. Boards made from 600 kg/m^3 density, 12% resin dosage and wax as 0% have the greatest MOR (7.56 MPa), MOE (1283 MPa) and IB (0.11 MPa) values. Meanwhile, it is reported that the lowest MOR, MOE and IB values are from particleboards produced from 500 kg/m^3 density, 8% resin dosage and 1% addition of wax. According to Nurrohana et al. (2011), with the increase of the board density and resin dosage, the physical and mechanical properties will also be increased. In contrast, due to the addition of wax, the thickness swelling and water absorption have given the lowest values for boards from 600 kg/m^3 density and 12% resin dosage.

Mostly, the mechanical properties of particleboard increase as the density and resin content of the board increase. In general, the particle size plays as an important parameter to meet the minimum requirement for the mechanical properties of the particleboard. However, all boards failed to meet the minimum requirements of the JIS Standard A5908 (2003).

A summary of ANOVA results for both physical and mechanical properties: MOR, MOE, IB, TS and WA are presented in Table 3. Density of the particleboard shows high significance for all properties of the board except for thickness swelling (r = 0.08 ns). Meanwhile, the improvement of the resin dosage has significantly increased the physical properties and mechanical properties except for MOR (r = 3.09*) because it is extensively different at $p \leq 0.05$. Wax is found highly

Table 2 Properties of particleboard according to density, resin dosage and wax addition

Density (kg/m^3)	Resin dosage (%)	Wax (%)	MOR (Mpa)	MOE (Mpa)	IB (Mpa)	TS (%)	WA (%)
500	8	0	5.58	802	0.04	36.9	168.1
500	8	1	2.91	614	0.04	29.3	163.3
500	10	0	5.79	806	0.05	29.2	150.2
500	10	1	3.39	603	0.05	22.1	144.6
500	12	0	5.90	941	0.11	21.4	148.9
500	12	1	4.90	754	0.06	20.8	135.8
600	8	0	5.97	934	0.07	31.2	184.5
600	8	1	5.40	901	0.05	24.3	137.7
600	10	0	6.38	1138	0.07	30.9	169.0
600	10	1	6.08	1116	0.06	24.6	128.0
600	12	0	7.56	1283	0.11	30.1	158.2
600	12	1	6.88	1201	0.07	15.6	100.8
JIS A5908:2003 Type 8			8.0	2000	0.15	12	–

MOR Modulus of rupture, *MOE* Modulus of elasticity, *IB* Internal bond, *WA* Water absorption, *TS* Thickness swelling, *JIS* Japanese Industrial Standard

Table 3 Summary of ANOVA for the effects of density, resin dosage and wax on mechanical and physical properties of oil palm trunk particleboard

SOV	df	MOR (Mpa)	MOE (Mpa)	IB (Mpa)	TS (%)	WA (%)
Density	1	25.88**	22.51**	13.93**	0.08 ns	11.00**
RD	2	3.09*	32.80**	34.04**	82.88**	13.13**
Wax	1	4.68**	7.05**	30.52**	93.70**	108.46**
Density * RD	2	0.22 ns	21.69**	2.13 ns	24.19**	7.80**
Density * Wax	1	5.35*	3.33*	0.28 ns	0.07 ns	180.70**
RD * Wax	2	0.19 ns	0.44 ns	10.34**	20.57**	12.30**
Density * RD * Wax	2	3.58**	1.59 ns	0.06 ns	57.59**	36.15**

SOV Source of variance, *df* Degree of freedom, *RD* Resin dosage, **Highly significant difference at $p \leq 0.01$, *Significant difference at $p \leq 0.05$, *ns* Not significant at $p > 0.05$

significant to be affected by all boards properties at $p \leq 0.01$. These effects were further analysed by ANOVA and t-test and the results are shown in Figs. 1, 2, 3, 4, 5 and 6.

Figure 1 shows the particleboard made from 12% resin has higher values compared to 10 and 8%. The resin dosages were significantly affected MOE and IB but not for MOR ($r = 0.22$ ns). The excessive amount of resin used has affected the MOR, MOE and IB properties of particleboard. It will reduce the wettability properties when the amount of resin increases (Siti Noorbaini et al. 2013).

Figure 2 shows that MOR has a highly significant effect on the density and significantly affects the MOE and IB. Besides that, TS and WA do not significantly affect the density of the particleboard. Mechanical properties of 600 kg/m^3 have produced the highest MOR (6.81 MPa), MOE (957.2 MPa) and IB (0.07 MPa) values than at 500 kg/m^3. The high-density particleboard has lower porosity so that adhesives and particles are easy to interact with each other to form crosslink (Zheng et al. 2007).

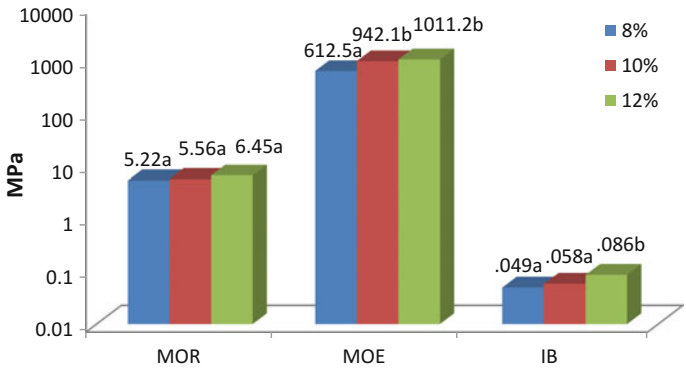

Fig. 1 Effects of resin dosage on the mechanical properties

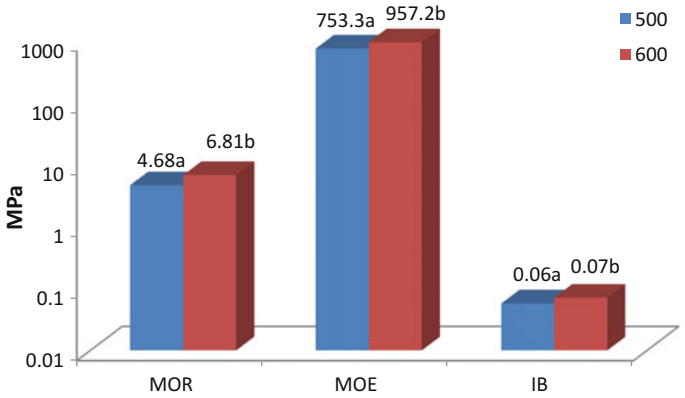

Fig. 2 Effects of density on the mechanical properties

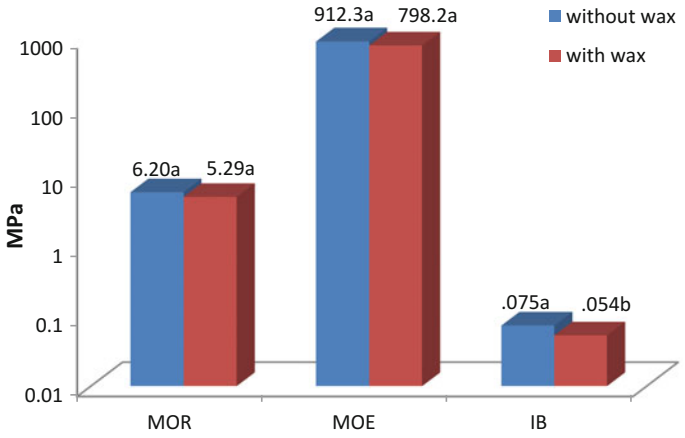

Fig. 3 Effects of wax addition on the mechanical properties

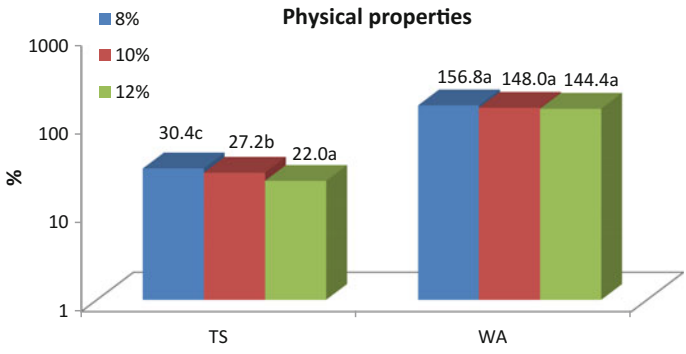

Fig. 4 Effects of resin dosage on the thickness swelling and water absorption

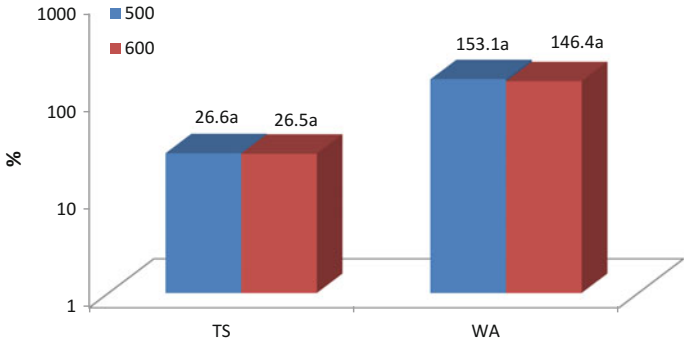

Fig. 5 Effects of density on the thickness swelling and water absorption

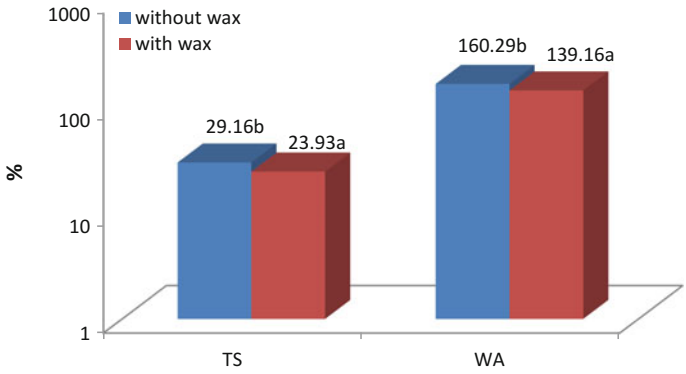

Fig. 6 Effects of wax on the thickness swelling and water absorption

However, the mechanical properties of the particleboard decrease for the addition of one percent of wax compared to without wax (Fig. 3). Meanwhile, the addition of wax could increase the physical properties of the panels. Only IB gives the highly significant effect of the wax content, but not for MOR and MOE. According to Hashim et al. (2010), the addition of wax affects the strength properties of the panels, either it is used 1% or 1.5% of wax on the boards. The thickness swelling is reduced by adding wax or other hydrophobic substances during particleboard manufacturing (Pan et al. 2007).

As can be seen in Fig. 4, the TS rates were different for the 12% versus the 10 and 8% resin dosage. The highest TS value is recorded at 8% resin dosage and decrease at 10 and 12%.

Figure 5 shows that, based on mean values of the 500 kg/m^3 for thickness swelling (26.6%) of the particleboard, it is found that the particleboard absorbs more water than 600 kg/m^3, while, for the water absorption values, 146.2% of

water was absorbed from the particleboard with density 600 kg/m^3. Generally, if the density of the boards is high, the mass of the particles is also higher (Siti Noorbaini et al. 2013).

With respect to the addition of wax, the thickness swelling and water absorptions have reduced the mean values due to the resistance offered by wax during mixing. The lowest values are shown by the 12% resin dosage, the density of 600 kg/m^3 and addition of 1% wax. The dimensional stability is improved with the higher amount of resin content due to more particle surfaces are covered with resin. Moreover, wood is a hygroscopic material that easily absorbs water from the atmosphere. The higher density of the boards will consume higher mass of the sawdust in making the particleboard (Siti Noorbaini et al. 2013). The one percent of wax will be added to coat the particles and will decrease the mechanical properties and improve the dimensional stability. This was happened when the chemical content of the wax was affected the adherent behaviour of the particles (Halvarsson et al. 2008).

5 Conclusion

Based on the findings of this research, there are several conclusions drawn:

i. Physical and mechanical properties of OPT particleboard are affected by different resin dosages, densities and wax additions.
ii. Generally, all the mechanical properties increased with the increase in resin dosage, density and without wax.
iii. All the particleboards did not achieve the minimum requirements of the Japanese Industrial Standards A 5908:2003 when tested for the physical and mechanical properties of the particleboard.
iv. Particleboard made from OPT is dimensionally less stable. However, the product still can be used for interior applications, like partition, insulated board, wall panels, etc., but is not recommended for places under frequent humidity changes.

In further studies, particle size of the samples could be investigated to have a better understanding of the OPT particle behaviour.

Acknowledgements The authors would like to acknowledge Universiti Teknologi MARA (Pahang) for providing facilities. Besides, the appreciation also goes to Malayan Adhesives and Chemicals (MAC) Sdn. Bhd. for supplying the resin.

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Chapter 75
Effects of Particle Sizes and Board Densities on OPF Phenol Formaldehyde Particleboard Properties

Nor Yuziah Mohd Yunus, Jamaludin Kasim, Norfarahin Yusof and Wan Mohd Nazri Wan Abd. Rahman

Abstract In Malaysia, the search for methods of utilization of oil palm biomass (OPB) is an intensified Government agenda as the biomass availability is registered at approximately 14 million tonnes dry weight annually. In support of development of potential usage, oil palm frond (OPF) particleboard using phenol–formaldehyde resin was investigated using a 3 × 3 factorial experimental design. The parameters used were densities (500, 600 and 700 kg/m^3) and particle sizes (0.5, 1.0 and 2.0 mm). The results of physical and mechanical properties, which have been tested according to Malaysian Standard, MS1787:2005, yielded the following conclusions. The bending strength showed improvement with an increase in density for all particle sizes. Both modulus of rupture (MOR) and modulus of elasticity (MOE) values decrease moving from small towards bigger particle sizes. Board made using particle size 0.5 mm with density 700 kg/m^3 gave the best MOR (25.19 MPa) and MOE (3488 MPa) values. The internal bonding was also dominated by the same board at 0.70 MPa. Physical testing for thickness swelling (TS) emphasizes the difficulties currently known by OPT users. On average, the TS improved as the densities increase and as particle size decreases.

Keywords Density–particle size · Phenol formaldehyde · OPF particleboard

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_75

1 Introduction

Oil palm biomass (OPB) generated from oil palm plantation was reported to be at 13.9 million tonnes dry weight annually comprising of fronds, trunks and empty fruit bunch (EFB) (Anis et al. 2007). Other than the conventional burning and field dumping for removal of OPB, novel usages such as cellulose gel production have been researched. This niche product adds value to OPB but does not help to elevate OPB disposal issues. For a more viable and higher OPB consumption volume, making conventional wood-based panel such as particleboard, medium density fiberboard (MDF), cement-bonded particleboard, fibre-reinforced plastics and ply boards remains a solution.

Previous work by Liew and Razalie (1994) on oil palm trunk (OPT) fails to attain internal bond (IB) for JIS A 5906 Type 200, with acceptation on MDF at density 700 kg m^{-3} using melamine urea formaldehyde resin combined with isocyanate. Mohd Nor et al. (1994) combined rubberwood with oil palm frond (OPF) at 50:50 ratio, with urea formaldehyde (UF) resin which resulted in IB value only at 60% of the control rubberwood board. Also, the board's thickness swelling (TS) hovers around 19%. Later, Abdul Khalil et al. (2010) finds 50:50 mixed of rubberwood and EFB particleboard can attain IB of 0.7 MPa and MOE of 2600 MPa. Particleboard made of empty fruit bunch (EFB) particles using 10% UF by Shaikh Abdul Karim Yamani et al. (1994) manages to attain IB of 0.6 which passed British Standard BS5669. The TS remains a challenge for both research teams with value of above 20%. Other work carried out by Maylor et al. (1994) and Paridah et al. (2000) show the needs of the specific resin with a wider molecular weight profile which gave better glueing and swelling properties for OPF.

Low number of commercialization with relation to OPB has been recorded. One of the deterrent factors is the lack of understanding of the true characteristics of oil palm fibres and their relation to working variables and product requirements. Functionally, trunks are full of fibre bundles for vertical support, fronds fibre radially support leaves during photosynthesis and EFB protects oil palm fruits from impact damages due to dropping fruit bunches during harvesting thus needs to have good shock absorption properties.

Looking at properties of oil palm fibres (Table 1), OPF has the longest fibre length similar to rubberwood and has the best slenderness ratio and should be able

Table 1 Fibre characteristic for OPB and rubberwood

	Trunk		Frond	EFB		Rubberwood
Length (mm)	1.22[a]	1.22[b]	1.52[a]	0.89[a]	–	1.67[b]
Width (μ)	35.3[a]	22.9[b]	19.4[b]	25.0[a]	18.5[b]	31.2[b]
Cell wall thickness (μ)	4.5[a]	5.2[b]	4.6[b]	2.8[a]	4.0[b]	5.3[b]
Buffer capacity, ml 0.1 N HCl	5.5[c]		12.5[c]	28.5[c]		6.3[c]

Source [a]Mohamad Husin et al. (1985); [b]Liew (1996); [c]Nor Yuziah et al. (1997)

to form acceptable boards. OPF buffer capacity against acid is, however, doubled from rubberwood, and will not be able to get optimized performance when turned into boards using off-the-shelf resin. This initiates the idea that OPF could be more compatible with phenol formaldehyde (PF), an alkaline-based resin. Thus, the work was done using this material with a PF resin system.

2 Materials and Methods

2.1 Raw Materials Preparation

A total of 400 samples of OPF was collected during harvesting season from Universiti Teknologi MARA (UiTM) Pahang's plantation from trees with an age range of 10–15 years. The leaflets of OPF were removed and the petiole was measured, cut into three equal parts from tip to base, and marked as top, middle and bottom portions. The portions were then transported to the laboratory and air-dried within a week to avoid fungal attack. The OPF were then flaked to particle size and screened. The PF resin was supplied by Malayan Adhesive and Chemicals Sdn. Bhd., Shah Alam, Selangor. The resin specification was pH at 12.3, solid content of 40% and viscosity of 45 cP.

2.2 Particleboard Production

Screened particles were oven-dried at 103 °C for 24 h to a moisture content of 3–5%. The single-layer board making variables are particles sizes of 0.5, 1.0 and 2.0 mm and board densities of 500, 600 and 700 kg/m^3. The resin amount used was fixed at 11%. Weighted particles were fed into particleboard mixer, and resin was sprayed at 0.35 MPa pressure in order to obtain even resin distribution on the particle surface. Resinated particles were then manually laid into 350 mm × 350 mm wooden mould and pre-pressed at room temperature for a minute at 3.5 MPa to reduce the thickness and remove air bubble between particles. The wooden mould was removed before another caul plate placed on the top of the consolidated mat and two 12 mm stoppers were placed between caul plates on each side of the mat. The mat was then hot-pressed at 175 °C for 6 min. The hot-pressed pressure cycles are 3 min at 1800 psi, 2 min at 1200 psi and another 1 min at 600 psi. Three replicates were prepared for each parameter.

3 Results and Discussion

3.1 Summary of Testing

Listed in Table 2 are the average values of mechanical properties and thickness swelling (TS) of single-layer board affected by tested parameters. The highest modulus of rupture (MOR, 25.19 MPa), modulus of elasticity (MOE, 3488 MPa) and internal bond (IB, 0.70 MPa) values exhibit by sample C board produced at 700 kg/m^3 target density with 0.5 mm particle size. The lowest TS or the most excellent dimensional stability was also displayed by board C (8.77%).

Throughout the study, sample G, manufactured at 500 kg/m^3 target density with 2.0 mm particle size, displayed poorest mechanical strength and TS. The MOR, MOE and IB of sample C were 3.7, 2.7 and 11.7 times higher than the result obtained by sample G in that order. In accordance with the Malaysian Standard (MS1036) for particleboard, only samples C and F meet and surpass all minimum requirements.

3.2 Statistical Significance

The analysis of variance (ANOVA) of particle size and board density and their interactions are shown in Table 3. All board properties are found to be significantly affected by particle sizes and board densities. With interactions between particle sizes and board densities, the test results are found to be only significant for IB strength and TS.

Table 2 Summary of mechanical and physical properties of single-layer oil palm frond particleboard

Sample	Particle size (mm)	Target density board (kg/m^3)	Actual density (kg/m^3)	MOR (MPa)	MOE (MPa)	IB (MPa)	TS (%)
A	0.5	500	502	9.58	1833	0.24	14.87
B	0.5	600	606	17.88	2603	0.37	14.53
C	0.5	700	695	25.19	3488	0.70	8.77
D	1.0	500	503	10.18	1768	0.18	15.46
E	1.0	600	614	14.27	2541	0.27	15.47
F	1.0	700	702	24.86	3382	0.62	9.26
G	2.0	500	503	10.01	1560	0.12	20.57
H	2.0	600	610	13.29	2482	0.32	20.01
I	2.0	700	719	22.92	3317	0.57	18.38
MS requirement				14.00	2000	0.45	15.00

Table 3 ANOVA on effect of particle size and board density

	MOR	MOE	IB	TS
Particle Size (PS)	7.21*	3.43*	175.60*	468.25*
Density (D)	521.54*	254.74*	2216.74*	111.08*
PS × D	2.13 ns	0.24 ns	3.21*	6.45*

Notes $p \leq 0.05$: *Significant
$p > 0.05$: Not significant (ns)

Density showed a strong correlation effect on all tested mechanical and physical properties (negative). For particle size, IB is negatively correlated while TS is positively correlated. There is, however, no significant correlation coefficient between particles sizes for MOR an MOE.

3.3 *Effect of Particle Size*

Figure 1 displays the bending properties of oil palm frond particleboard affected by different particle sizes. Both MOR and MOE values decrease from small towards bigger particle size. The DMRT analysis shows that combination of 0.5 and 1.0 mm particle size is insignificantly different for both MOR and MOE. However, these two sizes are significantly different in MOR compared to the 2.0 mm. For MOE, 0.5 and 2.0 mm particle sizes are significantly different at $p < 0.05$. The correlation analysis (Table 4) reveals decreasing bending strength with bigger particle size but at an insignificant value of MOR ($r = -0.10$ ns) and MOE ($r = -0.09$ ns). Theoretically, the larger particle diameter has smaller surface area–volume ratio that leads to lower contact points reflected in the lower MOR and MOE (Leng et al. 2017). MOR strongly reflects the surface compaction of a board. With smaller particles, the surface is more compact, less porous and the strength is expected to be stronger as surface density gets higher.

IB (Fig. 2) of particleboard manufactured by the different sizes of particle shows 0.5 mm exhibited highest result (0.35 MPa), 21 and 40% higher for both 1.0 and

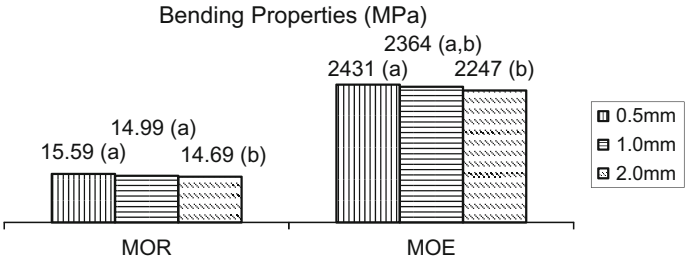

Fig. 1 Effect of particle size on bending properties

Table 4 Correlation coefficient of particle size and density on mechanical and physical properties particleboard

	MOR	MOE	IB	TS
Particle size	−0.10 ns	−0.09 ns	−0.23**	0.46**
Density	0.86**	0.81**	0.84**	−0.23**

Note **Correlation is significant at the 0.01 level (2-tailed)
ns Not significant

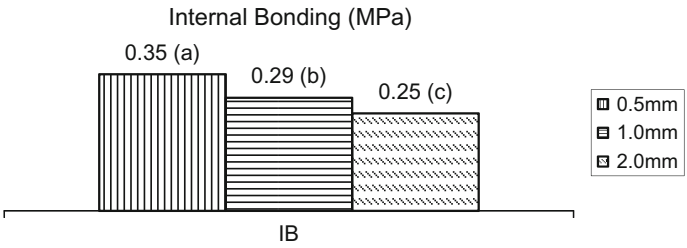

Fig. 2 Effect of particle size on I

2.0 mm particle, respectively. DMRT analysis shows that internal bonding significantly differs with different particle sizes. The significance further supported by correlation analysis (Table 4) had a slight negative trend with $r = -0.23$ at $p < 0.01$. IB measures interaction at resin to fibre interface level. One major rule of glueing effectiveness is the accessibility and availability of surface to interact. With smaller size, the particle can come into contact better than the larger ones. One peculiarity of phenolic resin is the presence of low molecular weight oligomers in the resin (Li et al. 2001). These oligomers could be readily absorbed into the substrate especially if it is porous. This will create a compatible surface for bonding interaction at the interface. Thus, with more interaction, it leads to stronger IB.

Figure 3 shows the DMRT of TS affected by different particle sizes. TS of the board significantly differs and increased from 0.5 to 1 to 2.0 mm. Dimensional stability of boards worsens with bigger particle size. Correlation analysis (Table 4) further reveals the significance of a positive trend with moderate correlation ($r = 0.46$**). Increasing in TS after 24 h water immersion is caused by the presence of voids between particles that allowed water molecule to penetrate from surface of the board towards core layer. The water migration into the board by capillary action will cause bulking to occur on the board. This creates expansion as water is capable of having hydrogen bonding (–OH, hydroxyl presence) which occupies a larger volume compared to normal dipolar interaction (Parthasarathi et al. 2005). The hydrogen bond expansion effect is akin to the expansion of water at freezing point. The greatest changes in thickness of bigger particle size show that it had bigger and/or more voids presence: and this lessens the bond strength between particles

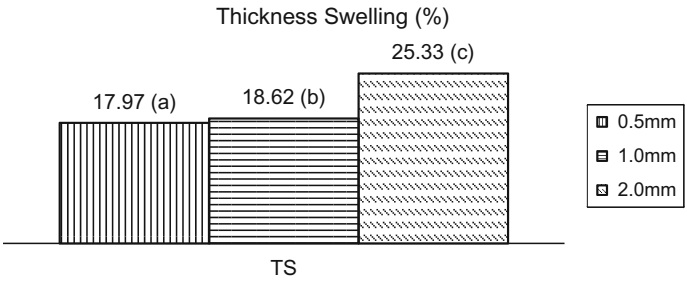

Fig. 3 Effect of particle size on TS

resulting in weaker bond and poorer dimensional stability of the board. The smaller particles will have lower water uptake as the pores will be tighter despite all boards having the same density target.

3.4 Effect of Density on Mechanical Properties and Thickness Swelling

Figure 4 compares the MOR and MOE of single-layer oil palm frond particleboard affected by board density. Both MOR and MOE of board increased with increasing board density. The 700 kg/m^3 particleboard had highest MOR and MOE values, 2.53 and 2.03 times higher compared to 500 kg/m^3 board values, respectively. The significant difference of bending strength affected by board density further supported by correlation analysis (Table 4) for MOR ($r = 0.86$**) and MOE ($r = 0.81$**). Bending properties determined the overall strength dominated by the material content on the board. Higher density had a denser arrangement of particles as higher amount of particles is available for compaction in constant volume. The compact arrangement of particles brought the particle surface proximity close to one another creating more intimate contact. The presence of solid particle provides support and relaxation path against stress application during the bending test. The

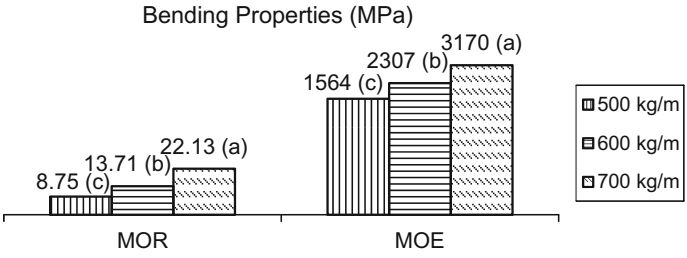

Fig. 4 Effect of density on bending properties

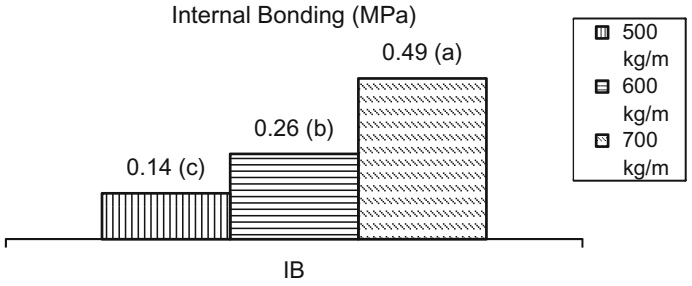

Fig. 5 Effect of density on IB

availability of more contact point will also impose higher inertia due to friction. Thus, this situation is commonly noted by the 'cracking' sound of the test sample once it breaks during bending test. The low-density board has more voids creating two types of interfaces: resin to wood and air to wood. The presence of multi-interfaces results in different surface tensions and different stress levels. The voids also gave a soft appearance to the board as seen in the lower MOR and MOE of 500 kg/m^3 board.

The impact of contact density between particles was also seen in the IB where the same trend as per bending properties was repeated. Figure 5 displayed the effect of board density of single-layer OPF particleboard on IB. IB of board doubled with each increment of 100 kg/m^3 in board density. The high correlation of board density at $r = 0.84$ with IB is significant at $p < 0.01$. The 700 kg/m^3 board displays highest internal bonding strength with 0.79 MPa, which are 3.5 and 1.9 times higher than 500 and 600 kg/m^3 samples, respectively. IB is very strongly related to strength of resin wood interphase contributed through covalent, hydrogen bond and dipolar interaction. All types of bonding need close proximity for active site to be triggered. For the denser packed particle, the bonding mechanisms have a better chance to occur. DMRT differentiated each density to individual subsets.

TS of boards is affected by moisture where the moisture will weaken the bond linkage that forms between particles. The presence of voids between particles contributes to dimensional stability strength. Voids between particles provide passage of water molecules through the samples' thickness. Higher density implies the bigger amount of particles compressed at constant volume compared to lower density, thus better contact area between particle surfaces for bonding linkage. Figure 6 shows the effect of board densities on TS. Poorest TS was displayed by 500 kg/m^3 board with 22.75% followed by 600 and 700 kg/m^3 board with 20.36 and 18.81%, respectively. Lower TS shows that samples are dimensionally stable. DMRT analysis indicated that TS of different board densities significantly differs to each other. Table 4 on correlation analysis reveals the relation of board density to TS. Board density significantly correlated with negative trend to TS ($r = -0.23^{**}$) at $p < 0.01$. The result of this study contradicts research conducted by Rokiah et al. (2010) and Wong et al. (2000). They found higher thickness swelling exhibited by

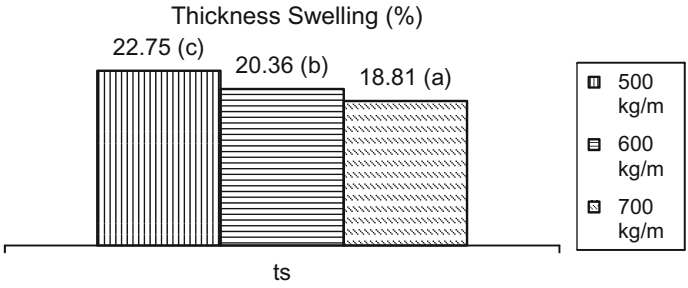

Fig. 6 Effect of density on TS

higher density particleboard due to spring-back effects. This different observation is likely due to the use of PF resin which contains oligomers which are able to penetrate into the fibre and form a rigid structure upon curing. The filling of voids provides a partial barrier to water penetration. Subsequently, it negates the normal bulking behaviour forced by the water–hydrogen bonding interactions if urea-based resins are used. Urea formaldehyde has the tendency to hydrolyze in the presence of high moisture. Work recently reported by Paridah et al. (2014) showed the vast improvement (250%) of plywood tensile property when the veneers have been impregnated with low molecular weight PF. Another factor to be considered is the density profile of boards, which also gave impact to swelling properties (Wong et al. 2000). Too high compaction on the board surface means the particles might release bound stress via spring-back action.

4 Conclusion

When using OPF to form single-layer particleboard with 11% resin content (PF), the particle size gave inversely proportional behaviour to mechanical properties. As compaction increases, mechanical properties improve and the thickness swelling showed direct relationship. Densities have a less-complicated relationship where an increase in density helped to improve MOR, MOE, IB and thickness swelling properties significantly. The use of phenolic resin as binder indicated a potential stabilization of the board where spring-back of high-density panel was less observed.

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Chapter 76
Impact of Alkaline Treatment on Mechanical Properties and Thickness Swelling of Exterior Particleboard Made from Kelempayan (*Neolamarckia cadamba*) Wood

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Abstract Alkaline treatment was carried out to remove barrier for the interaction between wood particle and resin in order to develop exterior particleboard with better mechanical properties and dimensional stability. Kelempayan particles were treated using 0.5, 1, and 2% sodium hydroxide (NaOH) at 90 °C for 60 min. Phenol formaldehyde (PF) was used as binder for the boards. Single-layer particleboard with a density of 700 kg m^{-3} was fabricated from 0.5 and 1.0 mm particle sizes, bonded with 11% PF resin at 165 °C of hot press temperature. Experimental samples were tested for modulus of elasticity, modulus of rupture, internal bonding strength, and thickness swelling according to Malaysian Standards (MS 1787:2005). Based on the findings of this work, particleboards made from 0.5 mm particle size and treated with 2% NaOH had the highest mechanical performance

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_76

and the lowest thickness swelling. The particleboards met the requirements of the MS standard for structural applications used in high humid conditions.

Keywords Kelempayan · Particleboard · Sodium hydroxide

1 Introduction

Wood-based industry struggles in obtaining raw material due to the shortage supply of timbers mainly rubberwood. The price of rubberwood has become very competitive and relatively higher since more rubber plantations are being converted into oil palm plantations and into housing areas. Due to that, *e*xtensive research should be made to look for new species and to reduce pressure on rubberwood. Ensuring sustainable supply of Malaysian timber for wood-based industries is essential to achieve the target of National Timber Industry Policy (2009–2020) which is RM53 billions of export earnings in 2020.

Kelempayan (*Neolamarckia cadamba*) belongs to the family of Rubiaceae. Kelempayan timber is light creamy yellowish color with a tall and straight bole. This species is classified under Light Hardwood with a density 290–465 kg m^{-3} air dry (Lim et al. 2005). Kelempayan is categorized as one of the eight selected species in plantation program also include *Hevea brasiliensis* (Rubberwood), *Acacia hybrid* (Acacia spp), *Tectona grandis* (Teak), *Azadirachta excelsa* (Sentang), *Khaya ivorensis* (African Mahogany), *Paraserianthes falcataria* (Batai), and *Octomeles sumatrana* (Binuang) (Zaini Ithnin 2010). Kelempayan was recommended as a plantation tree due to its fast growth and could be used to overcome the problem of raw material shortage.

Particleboard is made by gluing particles of wood with adhesive under heat and pressure. The strength properties of particleboard are more consistent although it is lower than natural wood. Particleboards are widely used in furniture, wall and ceiling panels, office dividers, flooring, cabinets, bulletin boards, countertops, and desktops. The development of particleboard in Malaysia has been beneficial to the wood-based industry because it provides a strong export market particularly to China, India, Indonesia, and Republic of Korea (MTIB 2015).

Wood is made up primarily of cellulose, lignin, and hemicellulose which presents numerous of hydroxyl groups in the substances. Ndazi et al. (2007) mentioned that bonding between wood particle and resin in particleboard could be achieved through interaction between hydroxyl groups of cellulose and functional groups of resin. However, the accessibility of resin to cellulose is restricted in wood, where cellulose is surrounded by lignin and hemicellulose. Lignin forms protective covering around the cellulose structure, contributes to the cell wall hardness, and limits the availability of sites for the cellulose and resin interactions. Amorphous hemicellulose with hydrophilic characteristic is strongly bound to cellulose fibrils. The water uptake of wood can be ascribed to hydrogen bonding of free hydroxyl groups presented in hemicellulose to water molecules (Pirayesh et al. 2013). Due to that,

the moisture absorption of particleboard is high, which leads to poor bonding between resin and particle when exposed to environment. Alkaline treatment is considered an effective method to remove lignin and hemicellulose to improve resin–particle bonding (Li et al. 2014). The treatment reduces cellulose crystallinity to make cellulose more accessible for contact with resin (Irfan et al. 2011). The following reaction takes place as result of alkaline treatment (Eq. 1).

$$\text{Wood} - \text{OH} + \text{NaOH} \rightarrow \text{Wood} - \text{O}^{-}\text{Na}^{+} + \text{H}_2\text{O} \quad (1)$$

For environmentally exposed particleboard, alkaline treatment aims to improve the mechanical properties and dimensional stability of particleboard. This study attempts to assess the potential of Kelempayan for particleboard manufacture and the impact of alkaline treatment on the physical and mechanical properties of particleboard.

2 Materials and Methods

2.1 Sample Preparations and Treatments of Kelempayan

Kelempayan trees used in this study were harvested from UiTM Pahang Forest Reserve. The tree diameter of breast height (DBH) is of 35–45 cm. The felled trees were sawn into 1 in × 1 in × log length of small billets, fed into wood chipper to produce chips and then flaked into small particles using knife ring flaker. The particles were air-dried for a week in a shaded area. Kelempayan particles were then screened into 0.5–1.0 mm (0.5 mm) and 1.0–2.0 mm (1.0 mm) particle sizes using a vibrating screener. The screened particles were further oven-dried at 80 °C for 2 to 3 days to reduce the moisture content to less than 5%.

Kelempayan particles treatment with 0.5, 1, and 2% NaOH was at 90 °C for 60 min in a rotary digester. The alkali-treated particles washed with running tap water to a final pH 7 followed by oven drying (80 °C) to moisture content around 5% for particleboard manufacture.

2.2 Particleboard Manufacturing

Single-layered particleboards at the density of 700 kg m^{-3} were fabricated. Commercial phenol formaldehyde (PF) resin was used. A weighted amount of untreated and alkaline-treated particles was blended separately with 11% of PF resin. The resulting mat was manually formed to a size 350 × 350 × 12 mm. The mat was pre-pressed with a cold press at 1000 psi for 1 min before being hot pressed to the required thickness for 6 min at 165 °C hot press temperature. Three

replicate boards were fabricated for each treatment with a total of 24 boards produced. All boards were kept at 20 °C and 65% relative humidity in a conditioning room for 1 week before they were cut into various sizes for property evaluation.

2.3 *Evaluation of Mechanical and Dimensional Stability Properties*

Finished particleboards were cut into required sizes for testing modulus of elasticity (MOE), modulus of rupture (MOR), internal bond strength (IB), and thickness swelling (TS) according to Malaysian Standard MS 1036 (2006). The samples were evaluated based on relevant MS 1787 series.

3 Results and Discussion

Table 1 presents the mean particleboard properties made from untreated and treated particles. The range of data in the MOE was from 3087 MPa to 3833 MPa. All the boards met the minimum requirement for MOE set by MS 1036 (2006) for furniture

Table 1 Properties of untreated and treated particleboards

Treatment (T)	Particle size (mm)	Concentration (%)	MOE (MPa)	MOR (MPa)	IB (MPa)	TS (%)
T1	0.5	0	3833	38	0.97	13
T2	0.5	0.5	3087	25	0.81	10
T3	0.5	1	3247	28	1.14	8
T4	0.5	2	3489	32	1.22	8
T5	1.0	0	3584	34	0.91	17
T6	1.0	0.5	3544	32	1.01	10
T7	1.0	1	3656	34	0.89	10
T8	1.0	2	3782	37	0.96	9
	Particleboard Classification (MS1036)					
	PF1		1800	13	0.40	n.a
	PF2		2000	14	0.45	15
	PF3		2000	16	0.45	12
	PS1		2100	15	0.40	16
	PS2		2500	18	0.45	11
	PS3		2500	18	0.45	9

MOE Modulus of elasticity, *MOR* Modulus of rupture, *IB* Internal bond strength, *TS* Thickness swelling
PF1 Furniture in dry, *PF2* Furniture in humid, *PF3* Furniture in high humid, *PS1* Structural in dry, *PS2* Structural in humid, *PS3* Structural in high humid

(1800 MPa) and structural purpose (2100 MPa). Modulus of rupture data ranged from 25 to 38 MPa. All the particleboards produced from untreated and treated Kelempayan were higher than the minimum requirement for furniture grade (PF) (13 MPa) and structural grade (PS) (15 MPa) of MS 1036 (2006). The highest MOE 3833 MPa and MOR 38 MPa values were from the untreated boards manufactured with particles of 0.5 mm (T1). Alkaline-treated boards had lowered bending properties compared to those of untreated boards. The reductions of MOE and MOR values of alkaline-treated boards were 19 and 34% lower than untreated boards from 0.5 mm particle size. However, the MOE and MOR values increased with increase of alkaline concentration for both particle sizes. The IB strength for untreated and treated particles increased from 0.81 to 1.22 MPa for both particle sizes. In addition, all boards comply with IB strength values for furniture (0.40 MPa) and structural grade (0.40 MPa) to be used in all conditions as stated in MS 1036 (2006). The IB values increased with increasing treatment concentration for both particle sizes. Boards made from 0.5 mm of particle size and treated with 2% alkaline (T4) showed the highest value of IB strength, which is 1.22 MPa. The increment was about 25.77% of untreated boards made from 0.5 mm of particle size. These were expected results with considering the previous study that alkaline treatment was found to increase the interfacial bonding between particle and resin (Ciannamea et al. 2010). Average TS of the boards was in the range of 8 to 17% for 24 h immersion. The results indicated that increasing alkaline concentration improved the dimensional stability of the boards. The lowest value of TS (8%) for boards made from 0.5 mm of particle size and treated with 1 and 2% alkaline concentration (T3 and T4). The highest TS was found from untreated boards made from 1.0 mm particle size (T5). The results indicate that alkaline treatment is an effective method for improving the bonding between Kelempayan particles and PF resin, thus to improve dimensional stability of the boards. Overall, the untreated boards made from 0.5 mm particle size (T1) gave the highest MOE and MOR, while the boards from T4 manufactured with 0.5 mm particle size and treated with 2% alkaline concentration had the highest IB strength and the lowest TS. The boards from T4 achieved the requirement for structural applications used in high humid conditions (PS3). From the results, its optimum treatment for furniture grade exterior particleboards or used in humid conditions (PF2) was untreated board made from the density of 700 kg m^{-3} with particle size of 0.5 mm and pressed under 165 °C of hot press temperature (T1). Meanwhile, the optimum treatment for structural purpose exterior particleboards or for used in humid conditions (PS2) was the board treated with 0.5% alkaline concentration at the density of 700 kg m^{-3} using 1.0 mm of particle size and pressed at 165 °C hot press temperature (T6).

3.1 Statistical Significance

The analysis of variance (ANOVA) for the effects of particle size and alkaline concentration, and their interactions on the properties of particleboards is shown in

Table 2 Summary of the ANOVA on untreated and treated particleboards

SOV	df	MOE (MPa)	MOR (MPa)	IB (MPa)	TS (%)
PS	1	105.51*	111.02*	22.27*	73.10*
CONC	3	64.58*	131.23*	18.03*	232.49*
PS × CONC	3	53.85*	60.63*	31.17*	17.17*

SOV Source of variance, *df* Degree of freedom, *Significant at $p < 0.05$, *PS* Particle size, *CONC* Alkaline concentration, *MOE* Modulus of elasticity, *MOR* Modulus of rupture, *IB* Internal bond strength, *TS* Thickness swelling

Table 2. The test results related that particle size and alkaline concentration have significant effect on MOE, MOR, IB, and TS. It was also found that the interaction between particle size and alkaline concentration affects all variables significantly.

3.2 *Effects of Particle Size*

Bending properties as affected by particle size are shown in Fig. 1. The values of MOE and MOR of particleboards increased with increasing particle size from 0.5 to 1.0 mm. The t-test comparison shows that the bending properties are significantly different at $p < 0.05$. Boards with bigger particles demonstrated significantly better bending properties than the boards made from smaller particles. The correlation analysis (Table 3) further revealed that MOE and MOR had significant positive correlation with increasing particle size ($r = 0.45$* and $r = 0.39$*). Alkaline treatment also affects the morphology of particle, particularly the particle diameter and aspect ratio. The treatment reduces particle diameter and increases the aspect ratio due to loss of material. High aspect ratio of the particles contributed to the enhancement in the mechanical strength of the wood composites (Magzoub et al. 2015).

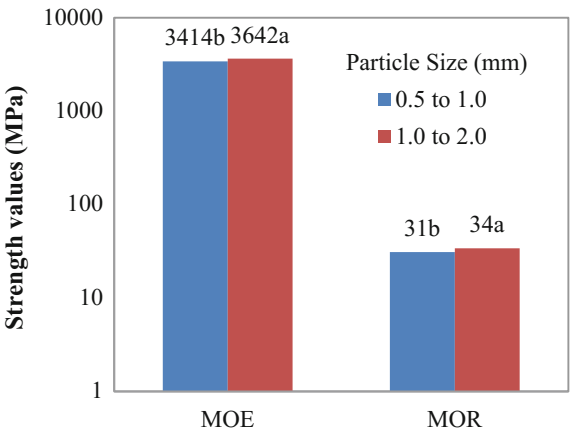

Fig. 1 Effects of particle size on bending properties

Table 3 Correlation coefficients of the effects of particle size and NaOH concentration on boards properties

Variable	MOE (MPa)	MOR (MPa)	IB (MPa)	TS (%)
PS	0.45*	0.39*	−0.31*	0.29*
CONC	0.04 ns	0.03 ns	0.44*	−0.68*

PS Particle size, *CONC* Alkaline concentration, *Correlation is significant at the 0.05 level, *ns* Not significant

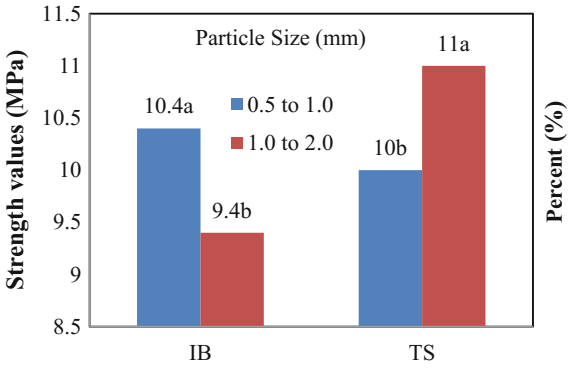

Fig. 2 Effects of particle size on internal bond (IB) and thickness swelling (TS)

Figure 2 shows the effects of particle size on IB strength. The IB strengths of the boards were significantly affected by the particle size. Bigger particles were found to decrease the IB strength of particleboards. The correlation analysis (Table 3) showed that the IB strength showed a significant negative correlation with increase in particle size ($r = -0.31$*). Bigger particles with smaller surface area per unit resulted in weak contact between the particles and the pores between particles could be easily observed because not all the particles were bonded well by the resin (Pan et al. 2007).

After 24 h of soaking, the particle size showed significant effect on TS (Fig. 2). The statistical analysis indicated that smaller size of 0.5 mm had better role to resist

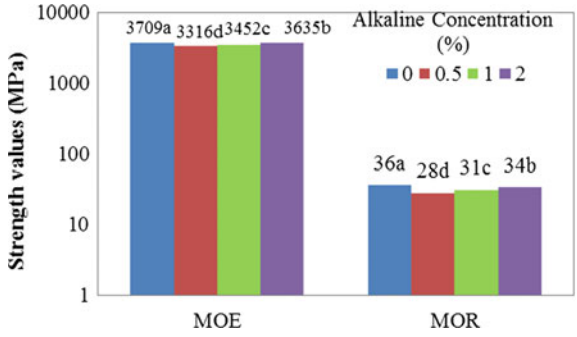

Fig. 3 Effects of alkaline concentration on bending properties

the board to swell more as compared to the boards made from 1.0 mm of particle size. Table 3 further revealed that the TS values showed a significant positive correlation with increasing particle size ($r = 0.29$*). Higher bulk density of smaller particles results in lower porosity of the boards. Smaller particles make denser structures between the particles and have the ability to fill the pores between the particles. Filling porous particles reduces interparticle porosity and thus decreased water entry into the particleboards (Sari et al. 2012). Smaller particles offer so compact structure (Kalaycioglu and Nemli 2006) and are more compressively pressed (Sari et al. 2012) than bigger particles. Thus, smaller particles reduced the water uptake into the particleboards and subsequently decreased thickness swelling of particleboards.

3.3 *Effects of Treatment Concentration*

Figure 3 displays the Duncan Multiple Range Test (DMRT) on the effects of alkaline concentration on MOE and MOR. It is seen that as the alkaline concentration increases from 0.5 to 2%, the values of MOE and MOR increase. However, untreated boards had significantly higher MOE and MOR than those of alkaline-treated boards. Alkaline treatment degrades certain amount of hemicellulose, lignin, wax, and oils of fiber cell wall. Reduction of lignin could weaken the particle strength as the lignin acts as binder of cellulose fibers. Gums, which function as a matrix to facilitate transfer of stress between fibrils, are also reduced after alkali treatment. These reactions result in a reduction of particle strength and hence reduce the mechanical strength of particleboards (Vasquez et al. 2016). One possible reason for the boost in the bending strength of alkaline-treated boards with increase in alkaline concentration from 0.5 to 2% may be due to the fact that cellulose microfibrils normally encapsulated by lignin and hemicellulose in wood particles are properly exposed. Table 4 shows that as the alkaline concentration increases, more lignin and hemicellulose are degraded. Reduction of hemicellulose and cementing components presence on particle surface can remove barrier for the interaction of cellulose to the resin and thereby improve the bending properties of the boards (Hamayoun et al. 2016).

For IB strength of alkaline-treated and untreated boards, no significant difference can be seen for between untreated boards and boards treated with 0.5% alkaline concentration (Fig. 4). However, with particles boards treated with 1% and 2% alkaline concentrations, there is profound increase in IB strength compared to untreated boards. A significant positive correlation coefficient between IB ($r = 0.45$*) with alkaline concentration is seen (Table 3). The increase in alkaline concentration leads to increase the degradation of lignin (Shaha et al. 2011). Despite providing stiffness to the particle, it is important to reduce lignin as proven from Table 4 in this study, because lignin is inflexible and prevents the reorientation of the particle required for the proper transfer of load (Carvalho et al. 2010). Reduction of lignin caused ease in cell wall self-compression and permits a good

Table 4 Chemical composition between untreated and alkaline-treated Kelempayan

CONC (%)	CW (%)	HW (%)	AT (%)	Ash (%)	Lignin (%)	Holo (%)	Hemi (%)	Cellulose (%)
0	5.65	6.56	2.45	0.62	28.57	69.84	38.17	31.67
0.5	2.80	2.78	0.55	0.58	26.99	67.51	25.85	41.67
1	2.20	2.22	0.56	0.56	25.67	66.84	22.17	44.67
2	2.22	1.65	0.55	0.55	24.99	64.09	18.42	45.67

Note: *CONC* Alkaline concentration, *CW* Cold water extracts, *HW* Hot water extracts, *AT* Alcohol toluene
Extracts, *Holo* Holocellulose, *Hemi* Hemicellulose

interface between resin and particle. In addition, when lignin is reduced, the effective surface area of wood available for contact with resin also increased (Rai et al. 2011). The existence of extra pores inside the particles due to the degradation of lignin after alkaline treatment can increase resin penetration into the particles and resulted to improve IB strength (Hossain et al. 2014). From the observation, the treatment of particleboard using 2% alkaline concentration is required for a good bonding quality of particleboards.

Water sometimes serves as critical source of damage on the particleboard properties. A significant improvement in TS was achieved by the alkaline-treated boards. Figure 4 revealed that the TS showed profound improvement with increasing alkaline concentration. This trend is in agreement with results reported by the Zheng et al. (2007). The correlation analysis (Table 3) further revealed that the TS had significant negative correlation with the alkaline concentration ($r = -0.68$*). High TS of particleboards made from untreated Kelempayan particles was probably due to the inherent properties of the wood being a hygroscopic material. The presence of hydroxyl groups in wood resulted in dimensional deformation under moist condition (Rai et al. 2011). The hydroxyl groups in wood will easily form hydrogen bonding with water due to its hydrophilic properties that will contribute to higher thickness swelling of untreated particleboards. Alkaline

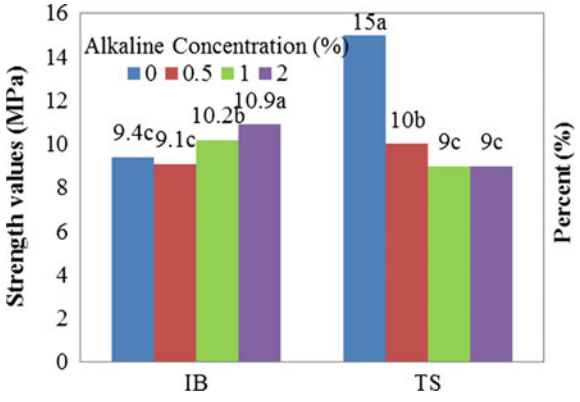

Fig. 4 Effects of alkaline concentration on internal bond strength (IB) and thickness swelling (TS)

treatment involved degradation of hemicellulose. The hydrophilic characteristics of hemicellulose have attracted the water to reside in it (Gwon 2010). The reduction of hemicellulose after alkaline treatment has a great effect in minimizing the water penetration into the particleboards. After alkaline treatment, the number of OH groups present in wood reduces due to the reduction of hemicellulose and lignin, which in turn decreases the amount of water absorption and hence reduces TS values. Thickness swelling is related to the internal IB of the boards. Untreated boards with low IB strength showed that the particles were not bonded effectively together, and hence could not prevent the water from penetrating into the boards and subsequently cause a rise in thickness swelling. The lower values of TS indicated the higher consistency between particles which gives better dimensional stability and higher values of IB strength (Norul Izani et al. 2013). Overall, alkaline-treated boards resulted in lower TS compared to untreated boards.

4 Conclusion

Based on the findings of this study, it was concluded that Kelempayan can be considered as a potential resource for particleboard manufacture. It appears that both physical and mechanical properties of treated boards improved with increasing treatment concentrations. Alkaline treatment is found to be an effective treatment technique of wood surface to improve interaction between particle and resin.

Acknowledgements The authors would like to thank Institute of Graduate Studies of Universiti Teknologi MARA Malaysia for providing funding support. In addition, the authors thank Malayan Adhesives and Chemicals Sdn. Bhd. Shah Alam Selangor for providing adhesive for this research. The authors gratefully acknowledged Center of Wood Industries of Universiti Teknologi MARA Pahang for providing raw materials, necessary facilities, and much guidance for the experimental work.

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Chapter 77
NaOH Treatment on Oil Palm (*Elaeis Guineensis*) Frond and Its Effects on Polypropylene Composite Properties

Nor Farhana Jasmi, Jamaludin Kasim, Iffah Izzah Maidin and Nurfaizah Abd Latif

Abstract Oil palm (*Elaeis guineensis*) frond (OPF) is proven to be feasibly used as a natural filler in polypropylene (PP) matrix. Hence, this study looks forward to examining the benefits of surface modification on OPF by sodium hydroxide (NaOH) and its effect on 50 wt% filler-loaded OPF–PP composite. The immersion technique treatment with NaOH (concentrations 0, 2, and 4%) was used to modify the OPF surface. The impact of this treatment on composite was also tested with and without 3% maleic anhydride polypropylene (MAPP). Results obtained showed that the mechanical properties of the composites filled with the alkali-treated filler and cross-linked with MAPP were improved. Regression analysis proved the positive trend of composite performance for filler treated with NaOH. R^2 of all derived equations for each strength property is $\geq$60%. This showed a strong relationship between NaOH treatment, MAPP addition, and the OPF–PP composite properties. Scanning electron micrographs showed the reduction of unwanted materials clogging the surface of the treated particles and leaving the cell cavity hollow and clean. The findings are hoped to be the benchmark of applying one of the significant methods in fabricating OPF–PP composite and as information source for future researches.

Keywords Maleic anhydride polypropylene · Oil palm frond · Polypropylene composite · Sodium hydroxide

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_77

1 Introduction

Past studies explored the potential of oil palm frond (OPF) to be consumed as filler in thermoplastic composite rather than to be wasted. In addition, the filling in the plastic composite is also purposely to reduce more than half of the product price if 100% of plastic is used. Unfortunately, different characteristics of hydrophilic OPF and hydrophobic plastic make them incompatible with each other. Thus, a coupling agent of maleic anhydride polypropylene (MAPP) is added to improve the interaction between the OPF particles and plastic. In order to increase the availability of sites for that interaction, the frond particle surface was treated with the alkali of NaOH. It is assumed that there are more OH groups available on the alkali-treated particle surfaces for chemical bonding, and thus more MAPP is required to saturate these OH groups.

NaOH reacts with the hydroxyl groups of the hemicellulose, it brings on the destruction of the cellular structure, and the fiber splits into filaments (Cao et al. 2006; Sreekumar et al. 2009). Separating the fiber bundles into elementary fibers is attributed to the degradation of the cementing materials that bind the fibers together. Dissolving the cementing materials may increase the particle dispersion (Ichazo et al. 2001). When particles dispersed well, the average diameter of all-treated particles may decrease as well compared to untreated one due to the removal of surface impurities of wax, pectin, and fats (Sawpan et al. 2011). Improved in interfacial adhesion between fiber and polypropylene might be due to the higher crystallization area of the wood fiber, greater area for possible reaction with MAPP (Kuo et al. 2009). This will result in an increase of effective surface area and more hydroxyl groups are available for chemical bonding (Khalid et al. 2008). Good interaction between the treated particle and plastic may lead to better mechanical properties performance of the composite.

This paper describes the effects of NaOH on the OPF surface particles that are used as filler in thermoplastic composite named as OPF–PP composite. Test results from the test laboratory such as flexural and impact strength are presented and discussed. This paper also proposes new predictive equations derived through the research. Additional data such as scanning electron micrographs (SEM) and Fourier transform infrared (FTIR) are included as supporting details.

2 Method

The OPF was obtained from in-house oil palm plantation at Universiti Teknologi MARA Pahang. The matrix polymer is homopolymer polypropylene (PP) in the form of pellets with a melt flow index of 33 g/10 min at 230 °C and melting temperature of 163 °C which was supplied by the local manufacturer. The finest size of the ground OPF particles which is < 0.5 mm was collected from vibrator screener machine, ground to its finest size, and then sieved again into three

sizes of 75, 250, and 425 µm. Immersion procedure was done in a mechanical machinery called rotary digester for a good alkali distribution toward particles. The chamber was rotated consistently within the duration of one hour following a preset time. Whole particles are ensured to be evenly immersed in the NaOH solution. The treated particles were then washed thoroughly with water until the colored residues disappeared. They were rinsed off with distilled water until pH number turned to seven. The fines were oven-dried at 80 °C to 5% moisture content prior to compounding process for composite preparation.

The composites were then tested for flexural and impact properties in accordance with ASTM D790 and ASTM D256, respectively. SEM samples were gold coated by using SCD 005 sputter coater (BAL-TEC) coating unit prior the scanning process by using a SUPRA 40VP (ZEISS) scanning electron microscope at 5.0 kV strength. Spectra for Fourier transform infrared (FTIR) were run on Perkin Elmer precisely spectrum one, FTIR spectrometer. Sample transmissions were measured for the range of wavenumber 400–4000 cm^{-1}.

3 Results and Discussion

3.1 Flexural Strength

The bar chart in Fig. 1 gave the mean values of flexural strength at 50 wt% filler loading (FL). When the OPF particles were treated with increase of NaOH concentration from 0 to 4%, the composite flexural strength improved significantly from 26.91 to 34.36 MPa, respectively. Alkali treatment has produced a shrinkage and toughness effect on the natural filler that inbuilt a chemical strength between the natural filler and polymer matrix (Mylsamy and Rajendran 2011).

In general, NaOH treatment and 3% MAPP addition are indeed sufficient to improve the flexural strength of the composite at 50 wt% FL as compared to the control sample. However, in accordance with the effect of increasing the NaOH concentration, flexural strength is seen to be more apparently increased when there is no MAPP added to the composite. The effect of alkali concentration has only slight effect on the coupled samples. The effect of NaOH treatment on coupled sample seems to be only at par to the untreated coupled sample. Summary of

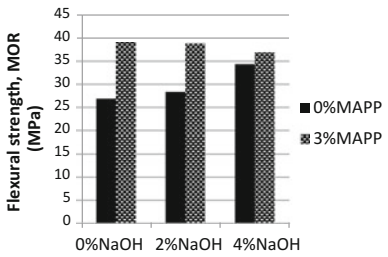

Fig. 1 Effects of alkalization and MAPP addition on flexural strength at 50 wt% filler loading

Table 1 Summary of DMRT analysis of flexural strength for OPF–PP composite at different NaOH concentrations

Treatment	NaOH concentration (wt%)		
	0	2	4
50 wt% FL	26.91c	28.35b	34.36a
50 wt% FL + MAPP	39.10a	38.89a	36.92a

Note a, b, c Different letters in a row represent a significant difference at $p < 0.05$

DMRT analysis of flexural strength of different NaOH concentrations is enumerated in Table 1. The treatment of 50 wt% FL + MAPP shows no significant difference among the NaOH concentration as compared to the 50 wt% FL treatment.

There are greater numbers of OH groups available on the treated particle surfaces for chemical bonding. This is attributed to the larger surface area of that treated particle surface areas. This caused the requirement of more MAPP to saturate the available OH groups (Beckermann and Pickering 2008). Thus, in this study, it is assumed that in order to increase the effect of MAPP additions to the treated sample, the percentage of the coupling agent should be increased. This may allow the composite to gain higher flexural strength.

3.2 *Flexural Modulus*

Figure 2 illustrated the mean values of flexural modulus at 50 wt% FL. It is interesting to note that samples with 50 wt% FL gave similar trend between flexural strength and flexural modulus. The trend being, treated samples without MAPP, achieved higher flexural modulus and vice versa. This may be attributed to the plasticization effect that started to happen with to relation effect of MAPP addition.

Summary of DMRT analysis of flexural modulus of different NaOH concentrations is enumerated as in Table 2. Treatment 50 wt% FL shows a significantly increasing trend of flexural modulus when the NaOH concentration increases. However, when MAPP is added, the trend is declining significantly with the increment of NaOH concentration.

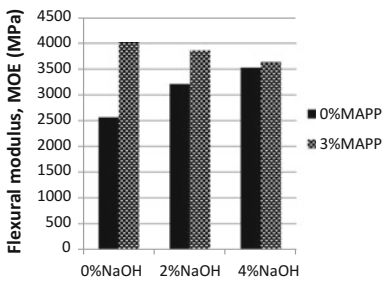

Fig. 2 Effects of alkalization and MAPP addition on flexural modulus at 50 wt% filler loading

Table 2 Summary of DMRT analysis of flexural modulus for OPF–PP composite of different NaOH concentrations

Treatment	NaOH concentration (wt%)		
	0	2	4
50 wt% FL	2566b	3212a	3529a
50 wt% FL + MAPP	4020a	3864a	3637b

Note a, b Different letters in a row represent a significant difference at $p < 0.05$

3.3 Impact Strength

Figure 3 shows the effect of alkalization and MAPP addition on impact strength at 50 wt% filler loading. The impact strength achieved by the composites is directly proportional to the NaOH concentration and MAPP addition. This shows that at higher FL which is at 50 wt%, the impact strength improvement is distinct. This may be attributed to the improvement of the filler and matrix adhesion and the increment of the aspect ratio due to the clean surface by means of treatment effect that later increased the impact strength (Punyamurthy and Sampathkumar 2014).

Summary of DMRT analysis of impact strength at different NaOH concentrations is shown in Table 3. Treatment 50 wt% FL + MAPP shows a significantly gradual increment of impact strength when NaOH concentration increases as compared with the treatment without the MAPP.

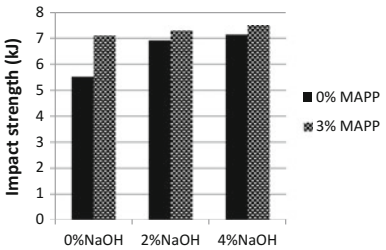

Fig. 3 Effects of alkalization and MAPP addition on impact strength at 50 wt% filler loading

Table 3 Summary of DMRT analysis of impact strength for OPF–PP composite at different NaOH concentrations

Treatment	NaOH concentration (wt%)		
	0	2	4
50 wt% FL	5.52b	6.92a	7.14a
50 wt% FL + MAPP	7.10c	7.29b	7.50a

Note a, b, c Different letters in a row represent a significant difference at $p < 0.05$

3.4 Predictive Equation

The regressions were derived from the model $Y = a + bX1 + cX2$, where Y is the board property, a is the coefficient, $X1$ is the MAPP addition, and $X2$ is the NaOH concentration. The regression equations developed are listed in Table 4 which represents the relationship of 50 wt% FL and the effects of MAPP and NaOH concentration.

Table 4 enumerates the list of the new predictive equations for the composite of 50 wt% FL. It is observed that MAPP addition and NaOH concentrations gave significant impact on the mechanical properties of the composite with 50 wt% FL. The R^2 of all the derived equations for each board property were above 60% without any exception which showed a very strong relationship.

It may be noted that there may be a lot of other factors that affect the composite properties values and yet this study has concentrated on fixed MAPP and NaOH treatments. This is a part of uncontrolled events that affect the composite properties. To take this into consideration, the regression equation proposed has included the coefficient "a" such as 1956.962 for FMOE. This coefficient can be by any chance become a random variable that causes the actual observation. Apart from that, the existence of these deviations may represent the average relationship between the variables.

3.5 Scanning Electron Micrograph

Figure 4 shows the fractured surface of untreated OPF/PP sample at 50 wt% FL. There are clearly seen a numerous number of pull-out fibers on the composite surface. Other than that, there are also large voids seen in between the pull-out fibers. This shows inefficient wetting and weak coverage of PP toward the OPF.

Similar observation was exhibited on the coir fiber–polyester impact test fractured surface scanned at low magnification (Shawkataly and Jaafar 2003). It is believed that the prime failure mechanism is caused by the coir fiber fracture itself which then resulted in a crack propagation that can be seen on the failure surface of the polyester matrix. It is also reported that when stress is applied on the poor

Table 4 Relationship of MAPP addition and NaOH concentrations with board mechanical properties at 50 wt% filler loading

Eqn.	Property	Regression equation	F-ratio	R^2 (%)
1	FMOR	$Y = 18.155 + 8.718M + 1.506N$	56.284*	81
2	FMOE	$Y = 1965.962 + 777.481M + 171.105N$	20.331*	60
3	IMPACT	$Y = 4.695 + 0.79M + 0.51N$	36.245*	73

Note * significant at $p < 0.05$, M—MAPP addition, N—NaOH concentration, FMOR—flexural modulus of rupture, FMOE—flexural modulus of elasticity

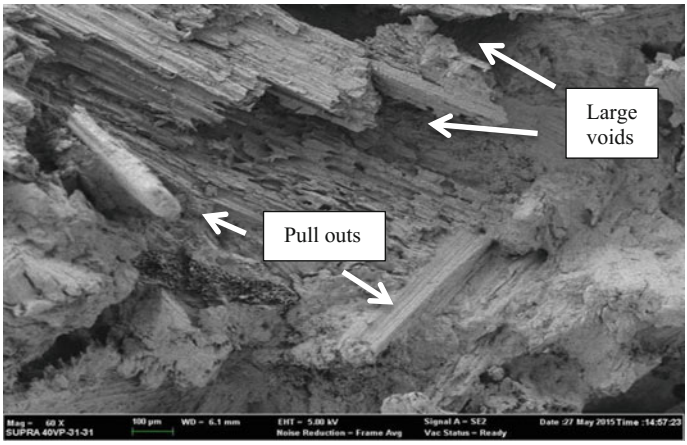

Fig. 4 Fractured surface of untreated OPF/PP sample at 50 wt% filler loading

adhesion of fibers–matrix composite, it may cause the fibers to pull out from the matrix and hence leaving gaping holes on the fractured surface (John et al. 2008). This has resulted in low mechanical strength of untreated OPF filled in the polypropylene matrix.

Figure 5 observes the fractured surface of OPF/PP/3%MAPP/2%NaOH sample at 50 wt% FL. Better encapsulation of PP matrix toward OPF particles can be clearly seen here. The composite seems to be homogenously bound with the help of the MAPP as the coupling agent. Pull outs are moderately seen on the fractured coupled surface due to a better particles dispersion within the composite as a positive effect from the NaOH treatment. They are more suitably called as particles breakage out of the OPF particles covered by PP rather than pullouts. Breakage defines better anchor from PP toward the OPF particle, resulting in better performance of mechanical properties of the composite.

3.6 Fourier Transform Infrared

Figure 6 shows the Fourier Transform Infrared (FTIR) spectra of treated OPF–PP composite with the addition of MAPP as a coupling agent. From the figure, there is a reduction in absorbance of the hydroxyl bond zone in the range of 3700–3200 cm^{-1}. This reduction indicates that there are fewer hydroxyl groups remaining in the sample of treated OPF–PP sample with the addition of MAPP. Previously, NaOH treatment has led to more hydroxyl groups available for chemical bonding. However, the peak at 3700–3200 cm^{-1} is broader as compared to the untreated OPF spectrum (not shown here), indicating the presence of stretch hydroxyl groups contributed by NaOH (Dahlan and Abdul 1993).

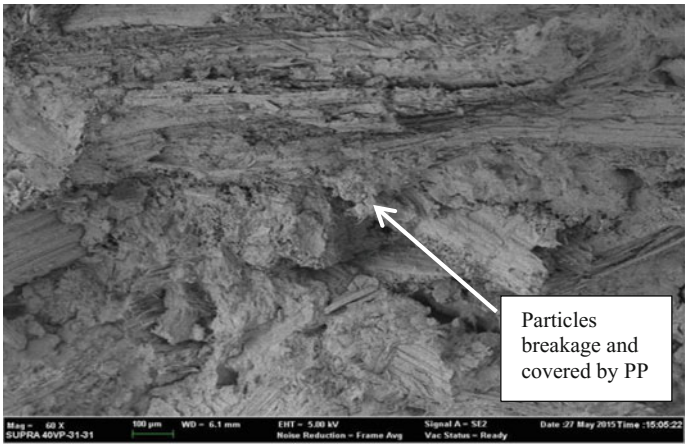

Fig. 5 Fractured surface of OPF/PP/3%MAPP/2%NaOH sample at 50 wt% filler loading

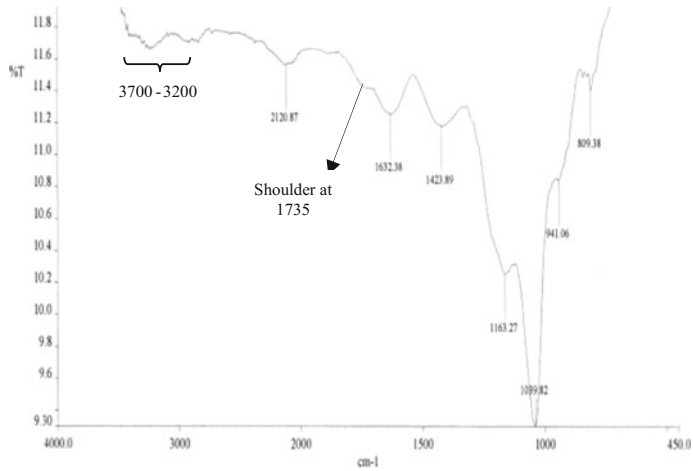

Fig. 6 FTIR spectra of treated OPF/M/PP

When MAPP was added to the treated sample, it seems to be effective as they saturated these available hydroxyl groups. As a result, better entanglement might have occurred. Two peaks of 1775 and at 1715 cm^{-1} as observed previously on FTIR spectra of MAPP are attributed to the carboxyl bonds (–C=O) of the maleated group. It is corresponding to the existence of maleic anhydride. However, in Fig. 6, the peaks are absent when the MAPP was added to the composite as additive. In addition, there is a shoulder peak of 1735 cm^{-1} as also can be seen in the spectra of the OPF–PP sample. This shoulder may be ascribed to the esterification of the hydroxyl groups that led to the increment of carbonyl (C=O) group stretching

vibration in the ester bond. This may be a proof that maleic anhydride has been absorbed and there is a reduction of non-reacted maleic anhydride in the treated samples appeared (Bodilau et al. 2009).

Double bond of alkene at the peak of 1632 and 809 cm^{-1} and also alkyne group at 2120 cm^{-1} can be attributed to the bond in maleic anhydride. The other functional groups are alkane CH_3 at 1423 and 941 cm^{-1} and carboxylic acid at 1039 and 1163 cm^{-1}.

4 Conclusion

This study evaluated the performance of lignocellulosic plastic composite properties with relation to the effects of NaOH treatment on OPF and MAPP addition into the treated composite. Low concentration of NaOH of 2% did give significant effect on the composite properties except for the flexural and impact strength. A set of regression equation was developed in order to estimate the thermoplastic board properties made of OPF with high FL of 50 wt%. All the derived equations were found to be significant with R^2 value between 60 and 81%. It can be deduced that the board properties of the thermoplastic composites can be estimated if the relationship has the coefficient of determination (R^2) of greater than 50%.

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Chapter 78
Effects of Ratio on Particleboard from Cultivated *Leucaena leucocephala* (*Petai Belalang*) and *Hevea brasiliensis* (Rubberwood)

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Abstract Suitability of new raw material for particleboard can be measured by testing the mechanical and physical properties' performance. The objective of this study was to determine the strength of the particleboard manufactured by using different ratios of *Leucaena leucocephala* (petai belalang) and *Hevea brasiliensis* (rubberwood). Increasing ratio of *L. leucocephala* particles gave a positively significant increase in modulus of elasticity (MOE) and internal bonding (IB). Highest MOE was 3086 MPa with an 80:20, *L. leucocephala*: *H. brasiliensis* ratio. For physical properties, higher ratio of *L. leucocephala* leads to lower performance in physical strength. Resin content gave higher results for MOE and MOR and no significant change in IB with increase in percentage used. A strong negative correlation ($r = -0.84^{**}$) was seen for resin content percentage. Overall, only board made with ratio 20:80 and board with 8% resin content did not meet the minimum required standard in BS EN. The study on the effects of ratio on the properties of particleboard indicated that the strength of the mechanical properties can be improved by increasing *L. leucocephala* ratio.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_78

Keywords *Hevea brasiliensis* · *Leucaena leucocephala* · Particleboard properties Species ratio · Resin content

1 Introduction

Availability of solid wood in Malaysia is on decreasing trend as time progress. Alternatively, the solid wood was replaced by engineered wood panel products. The wood panel products helped to overcome the shortage of raw materials through full utilization of a tree inclusive of stumps, off-cuts and branches. The introduction of aged *Hevea brasiliensis*, a plantation species, in the early 1990s as raw material helps to reduce dependency on tropical solid wood from the forest. However, *H. brasiliensis* plantation conversion to oil palm trees instead of replanting lead to the dwindling in its' supply, which subsequently affects the production of the wood panel product (Teoh et al. 2011).

Leucaena leucocephala is studied as a potential tree to accommodate the demand for wood by the wood-based industry. *L. leucocephala* is also known as petai belalang in Malaysia, Ipil-ipil in the Philippines and Kubabul in India (Brewbaker et al. 1985). It belongs to the leguminous tree group, which has the ability to grow faster, even in drought-prone or semi-arid areas (Sethi and Kulkarni 1995). Aptly called a miracle tree, it is multipurpose in which all parts of the tree could be fully utilized. Originally, it was used as windbreakers and firebreakers. The leaves were used as sources of food for ruminant livestocks such as cows. The previous study of *L. leucocephala* has shown that the seeds and fruits that underwent the process of decoction were drunk to treat disease such as diabetes (Ong and Norzalina 1999). Incidentally, *L. leucocephala* has the ability to coppice which helps to reduce the time taken for harvesting cycle (Tewari et al. 2004).

The *H. brasiliensis* is the main current raw material in Malaysian wood-based industry. As such it was chosen as the complementary material used in this study. According to Hong (1995), the *H. brasiliensis* timber has found its way into making different types of wood products, such as particleboard, medium density fiberboard (MDF) and wood furniture. The colour of the *H. brasiliensis* (light to pale cream) will produce lighter colour board when mixed with *L. leucocephala* wood which has inflorescence cream colour (Lim et al. 2003; Aganga and Tshwenyane 2003). As such it could be easily used and mixed with rubberwood without causing alarmingly colouration difference in panel appearance.

2 Materials and Methods

The wood materials used in this study were *L. leucocephala* and *H. brasiliensis*. Cultivated *L. leucocephala* with age of 60 months old was harvested in UiTM Pahang cultivation area. The *H. brasiliensis* wood chips were supplied by a

commercial company. Harvested *L. leucocephala* was debarked and the tree-boles cut into approximately 0.5–1 m before being chipped. The wood chips were then flaked into smaller sized wood particles using a flaker. The fresh particles were air-dried for a week, followed by further oven drying to a moisture content of 3–5%.

The processes of the making particleboard were carried out in the laboratory of a particleboard mill. The three-layer particleboard formation started with mixing of wood particle, resin and wax in a blender. The blending process continued for 4 min after the last drop of resin has been sprayed. The resin used in the study was urea formaldehyde (UF), a commonly used resin in the manufacturing of panel product, especially in Peninsular Malaysia. Resin amount used on the surface and back of board were 8, 10 and 12%. The percentage of resin used for the core layer was fixed at 6.2%. Resinated particles were evenly spread to form a mat before pre-pressed. Pre-pressed mat was placed on the heated platens at 210–220 °C for 200 s under a set cyclic pressure. After the hot press, the particleboard was left to cool at room temperature before cutting into selected dimensions for testing. The particleboard samples were tested according to the British Standard (BS EN).

2.1 Bending Test

The process of bending test used in this study was based on British Standard (BS EN 310 1993). The particleboard samples were cut into 370 mm dimension with thickness 16 mm. The board samples were tested by using three-point bending. The span used during the bending test was 320 mm. The iron load was lowered until it touches the surface of the samples. Forces were then applied to the board samples until the sample breaks.

2.2 Internal Bonding Test

The process of internal bonding (IB) test was according to the British standard (BS EN 319 1993). Samples with dimensions 50 mm × 50 mm were cut. Two steel holders were bonded to the face and back of the test sample with hot melt adhesive. The steel holders were placed in the machine before a force being exerted to pull the test sample holder apart.

2.3 Thickness Swelling Test

The thickness swelling (TS) process was done according to the British standard (BS EN 317 1993). The dimensions of the board samples were 50 mm × 50 mm. The

Table 1 Experimental design

Ratio of particleboard (*Leucaena*: *Hevea*)	Resin contents (%)		
20:80	8	10	12
50:50	8	10	12
80:20	8	10	12

board samples were weighted using the electronic balance. After that, the board samples were immersed fully in the water for 24 h. The board samples were weighted after 24 h, and the TS was calculated. All the data collected through the test were analysed by using the statistical package for the social sciences (SPSS) programme. The experimental design in this study is shown in Table 1.

3 Results and Discussion

The summary of ANOVA analysis on the effects of ratios and resins is shown in Table 2. From the table, the mechanical properties of modulus of elasticity (MOE) (F = 13.27**) and IB (F = 9.68**) show a positively highly significant value on the effects of ratios, while the mechanical properties of the effects of resin contents show a positively highly significant on MOE (F = 53.69**) and modulus of rupture (MOR) (F = 62.75**) value. Based on Table 2, there is an interaction between ratios*resins on mechanical properties. The interaction of ratios*resins MOE (F = 4.09*) shows positive significant, while MOR (F = 4.17**) shows positively highly significant.

The physical properties of ratios (F = 52.63**) and resins (F = 231.39**) show a positively highly significant value (Table 2). The decreasing ratios of *L. leucocephala* in the board are significantly affecting the value of ANOVA.

3.1 Mechanical Properties

The mechanical properties of MOE, MOR and IB can be seen in Fig. 1. All mechanical properties of the particleboard meet the minimum requirements

Table 2 The summary of ANOVA analysis on the effects of ratios and resins

SOV	df	MOE (MPa)	MOR (MPa)	IB (MPa)	TS (%)
Ratios	2	13.27**	1.16 ns	9.68**	52.63**
Resins	2	53.69**	62.75**	1.71 ns	231.39**
Ratios*Resins	4	4.09*	4.17**	0.07 ns	5.07*

Notes F *Values are significant $p < 0.05$, **Highly significant $p < 0.01$, *ns* Not significant, *df* Degree of freedom, *MOE* Modulus of elasticity, *MOR* Modulus of rupture, *IB* Internal bonding and *TS* Thickness swelling

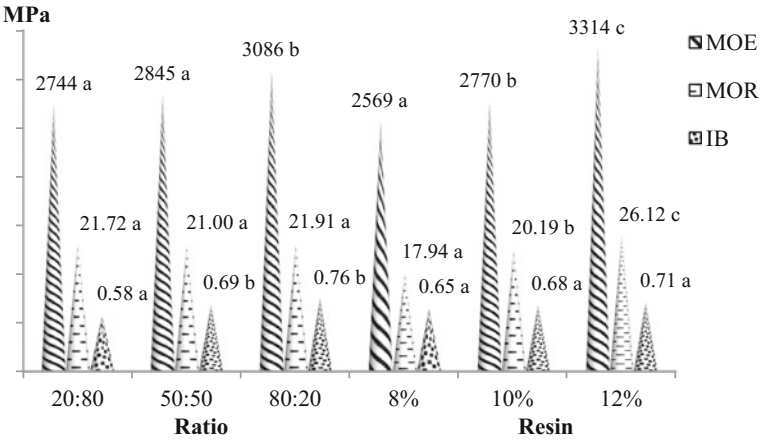

Fig. 1 Mechanical properties of particleboard

standards for Type 2 particleboard according to the particleboard specification (BS EN 312 2003).

Figure 1 shows a significant effect on the particleboard with ratio 80:20 in the MOE and 20:80 on IB strength. For mixing ratio, the highest value of mechanical properties MOE (3086 MPa) was particleboard with ratio 80:20. The correlation coefficient results shown in Table 3 indicated that the higher the amount of *L. leucocephala* ratio portion compared to the *H. brasiliensis* ratio in the particleboard, the higher the mechanical strength. There was a weak positive significant correlation between the mechanical properties MOE ($r = 0.36$*). With respect to the IB strength shown in Fig. 1, particleboard samples with ratio 20:80 show a significantly different result against particleboards with ratio 50:50 and 80:20. The particleboard with ratio 50:50 and 80:20 has no significant difference in IB strength. The particleboard IB shows significant positive correlation ($r = 0.55$**) with increasing amount of *L. leucocephala* (Table 3).

The strength of the mechanical properties MOE and MOR is dramatically increased as the percentage amount of resin contents used in the board increased. From Fig. 1, the increasing percentage of resin contents also shows a significant difference in MOE and MOE. The correlation coefficient displays positively highly significant for both mechanical properties MOE ($r = 0.75$**) and MOR

Table 3 Correlation coefficients on the effects of species ratio and resin content

	MOE (MPa)	MOR (MPa)	IB (MPa)	TS (%)
Ratios	0.36*	0.07 ns	0.55**	−0.53**
Resins	0.75**	0.83**	0.27 ns	−0.84**

Notes *Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed) and *ns* Not significant

(r = 0.83**). Effect of resin content gave highest MOE (3314 MPa) and MOR (26.12 MPa) for boards with 12% resin content. The IB strength seems to have a marginal increased as the percentage of surface resin increased. The strength differential of IB in relation to surface resin content shows insignificant effect (Fig. 1 and Table 3). Studies on increasing the percentage of resin contents (overall) in the particleboard have been shown to influence the mechanical strength where the value increased, at times dramatically (Ashori and Nourbakhsh 2008; Ayrilmis et al. 2012; Ali et al. 2014). For this study, the effect is less as the IB test zone was actually kept at 6.2% resin content. The slight variation in IB with resin content change may be due to partial influence from the surface layers and layout of fibres.

3.2 *Physical Properties*

Figure 2 shows the physical properties of the particleboard with the different wood ratios. According to Fig. 2, the highest value of physical properties was indicated in particleboard with ratio 20:80, while the lowest value recorded for physical properties in Fig. 2 is shown in particleboard with ratio 80:20. The physical properties of particleboard on the effects of the ratio are significantly affected in the ratio 20:80 (17.19%). Further results in Table 3 on the correlation coefficient of ratios show a negatively high significant value (r = −0.53**). As the ratio of *H. brasiliensis* decreased in the manufacturing of particleboard, the TS value decreased.

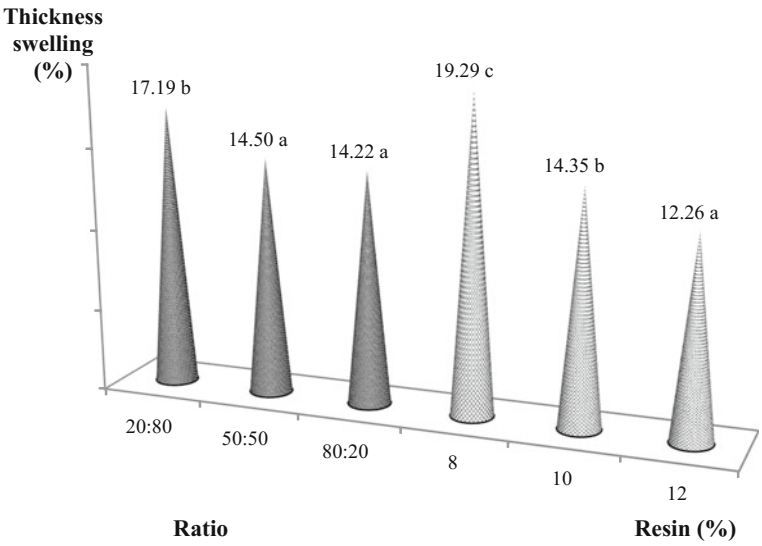

Fig. 2 Physical properties of particleboard

Based on Fig. 2, particleboard with 8% resin contents shows the highest TS value (19.29%), followed by 10% (14.35%) and 12% (12.26%) resin content. The result of correlation coefficient for TS shows a negatively high significant effect at $r = -0.84^{**}$, indicating the strong impact of resin content on physical properties of the particleboard (Table 3). Finding of increased percentage of resin contents in the manufacture of particleboards causing decrease in the value of TS was reported by Jamaludin et al. (2001) and Mohamad Jani and Izran (2012).

4 Conclusion

This study reports on the effects of species ratio on the mechanical and physical properties of particleboard from cultivated *L. leucocephala* and *H. brasiliensis*. The mechanical properties of the particleboard could be improved by increasing the content of the *L. leucoephala*. The mechanical properties of particleboard with less amount of *L. leucocephala* ratio also meet the required standards in BS EN. The physical properties of particleboard with ratio 50:50, 80:20 and particleboard with resin contents 10 and 12% met the minimum required standards for BS EN as the amount of *L. leucocephala* ratio increased. However, the particleboard with ratio 20:80 and particleboard with 8% resin content fails to pass the minimum required standard in BS EN. The increasing percentage of resin contents in the particleboard manufacturing effectively affected the value of TS.

The above results suggest that it is completely feasible for *L. leucocephala* usage in the manufacture of high-quality particleboard. Based on physical and mechanical properties' evaluation in particleboard, *L. leucocephala* has potential to be developed as a raw material in particleboard manufacturing.

Acknowledgements The authors acknowledge the financial support of the Ministry of Education Malaysia in Knowledge Transfer Program, KTP (703000130002) and MIECO Chipboard Bhd which also contributed to this study.

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Chapter 79
Fibre Morphology of *Leucaena leucocephala* Wood: Effects on Fiberboard

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Abstract In this paper, *Leucaena leucocephala* sawdust was treated with glacial acid and sodium chloride to produce mushy and slivery fibre. The fibre morphology consists of fibre length, fibre diameter, lumen diameter, cell wall diameter, Runkel ratio and slenderness ratio. Approximate fibres morphology is often used to determine the size of fibres in wood species. Fibres dimension and morphology have an important effect on the physical and mechanical properties of wood composite such as medium density fibreboard (MDF) and insulation board. Fibre morphology properties of 5- and 3-year-old *Leucaena leucocephala* were collected. The images of fibre length, fibre diameter and lumen diameter were collected using an image analyser microscope. The data obtained were used to calculate the cell wall diameter, Runkel ratio and slenderness ratio. The result indicated that slenderness ratio was positively affected by the age of *Leucaena leucocephala*.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_79

The statistical analysis also shows that fibre length, cell wall diameter and Runkel ratio showed positive increase with increase of *Leucaena leucocephala* age. The results of intercorrelation indicated that the effect of the fibre morphology of *Leucaena leucocephala* on board properties was insignificant. Generally, the board properties are not depended on the variation of fibre morphology.

Keywords Fibre morphology · Fiberboard · Juvenile wood · *Leucaena leucocephal*

1 Introduction

Leucane leucocephala is one of the fast-growing species that originated from Central America and has been introduced to many countries such as Southeast Asia (Zobel and Sprague 1998), South America and Africa (Panshin and De Zeeuw 1980). *Leucaena leucocephala* could have shoots emerging from coppiced stumps and grow with excellent height and diameter (Misra et al. 1995). *Leucaena leucocephala* is classified as medium to heavy hardwood with density of 800 k/gm^3. Height of *leucaena leucocephala* is only 5–10 m with diameter of trunk of 5–50 cm. Result of mechanical properties testing (bending, compression and toughness) proved that *Leucaena leucocephala* has outstanding qualities (Viena et al. 2009), while its specific gravity ranges from 0.45 to 0.55 at the age of 2 years (McDicken and Brewbaker 1982). *Leucaena luecocephala* is also suitable for pulping and writing paper because of excellent pulping qualities (Diaz et al. 2007).

Fibre morphology is regularly used to determine the size of fibres in wood species. Fibre dimension and morphology have significant effects on the physical and mechanical properties of wood composite such as medium density fibreboard (MDF), insulation board, hardboard, paperboard and paper (Huber et al. 2003; Lee et al. 2001). Fibre morphology consists of length of fibres, diameter of fibres, lumen and cell wall, Runkel ratio and slenderness ratio. Different results can be acquired although wood fibres are from the same species, different tree species and different manufacturing processes (Mark and Gillis 1983). In hardwood, the cells that make up the anatomical organization are the vessels, fibres, parenchyma cells and the wood rays. Fibres are the key component that is responsible for the strength of the wood (Tang 1981). The strength properties of the MDF are mainly attributable to the physical and mechanical properties of individual wood fibre, fibre orientation and the manner in which these components were combined in the structure. It also has been recognized for years that fibre morphology has significant influences on paper properties (Cross and Bevan 1907). The main objective of this study is to determine the fibre morphology of juvenile *Leucaena leucocephala* wood (5-year-old and 3-year-old).

2 Experimental

2.1 Materials and Methods

To determine the fibre morphology, a wood block (10 × 10 × 15 mm) was cut from disc portions of each *Leucaena leucocephala* tree. Each sample block was split into pieces of matchstick size. The matchstick-sized sample was placed in the conical flask containing distilled water and labelled. The samples were cooked in the water bath with the temperature at 80–90 °C until the samples sunk. Later, the water was replaced with a solution of equal parts of glacial acid and hydrogen peroxide (30–35%). The volume of the solution used in each test tube was 10 times the volume of the wood samples. During the maceration process, the conical flask was kept inside a water bath and maintained at 80–90 °C for at least 8 h. About 5 mL of 10% glacial acetic acid and 1.5 g of sodium chloride were added to the test tubes every 2 h to ensure that the wood samples' colour becomes silvery white and mushy.

After the wood samples became mushy and silvery white, the chemicals were then washed away from the samples with distilled water by several consecutive washing steps. Solitary fibres were obtained within the suspension through gentle shaking of the conical flask with glass beads. The fibres can be preserved in safranin and glycerine. A pipette was used to transfer a drop of suspended fibres onto the slide before a coverslip was placed on top of the drop. Microscope images of the cross sections of each sample were collected using an image analyser microscope (Motic Images 2000 Software).

Fibre length of 100 randomly selected fibres was measured by the image processing software using magnification of 40×. The length was measured from the end to end of fibre. Fibre diameter and lumen diameter used magnification of 100×. Fibre diameter was measured in cross section of fibre. Fibres were selected randomly for measurement with the selection towards the longer or shorter fibre. The lumen diameter measured the inner part of the fibre. Cell wall diameter was assessed by collecting data from fibre measurement. Values of fibre diameter were obtained by calculation with minus of lumen diameter from fibre diameter before being divided with two. Runkel ratio was acquired by dividing the value of cell wall diameter with value of lumen diameter multiplied by two. Meanwhile, result of slenderness ratio was obtained by dividing fibre length with fibre diameter.

3 Results and Discussion

3.1 Length of Fibre

Table 1 shows the fibre length distribution of 3- and 5-year-old *Leucaena leucocephala*. Comparing two types of fibre, 5-year-old *Leucaena leucocephala* has the longer fibre (0.74 mm) than the 3-year-old (0.58 mm). According to Dean et al.

Table 1 Summary of general linear model on effects of age

Age	Fibre length (mm)	Diameter fibre (μm)	Lumen diameter (μm)	Cell wall diameter (μm)	Runkel ratio	Slenderness ratio
3	0.58a	22.57a	12.32a	5.13a	0.92a	26.55b
5	0.74a	21.36a	10.61a	5.38a	1.09a	38.54a

Table 2 Correlation coefficients of fibre morphology

SOV	Fibre length (μm)	Fibre diameter (μm)	Lumen diameter (μm)	Cell wall diameter (μm)	Runkel ratio	Slenderness ratio
Age	0.30 ns	−0.11 ns	−0.22 ns	0.09 ns	0.23 ns	0.34*

SOV Source of variance

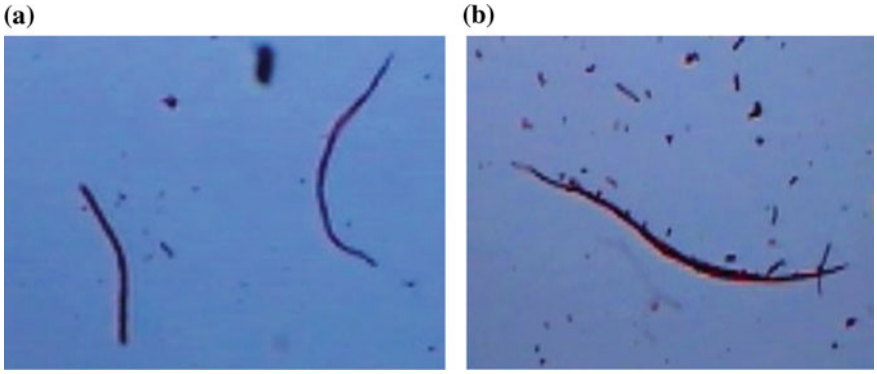

Fig. 1 Images of fibre length of 3 years old (**a**) and 5 years old (**b**) using 40× of magnification

(2002), fibre length was increased from 0.57 mm at 1 year to 1 mm at 9 years old. Age gives no significant effects on the length of fibre. Result in Table 1 is further supported by correlation analysis in Table 2. This is probably because there is not much difference between 3-year-old *Leucaena leucocephla* and 5-year-old *Leucaena leucocephla.* However, based on study by Alvin (1982), matured wood produces longer fibre than juvenile wood. Fibre length is usually influenced by the properties of fibreboard (Akgul and Camlibel 2008) and tearing resistance of paper (Doughty 1932) (Fig. 1).

3.2 Diameter of Fibre

Fibre dimension is determined by the dimension of the cambial fusiform cells from which they are derived and by the process that occurs during cell differentiation

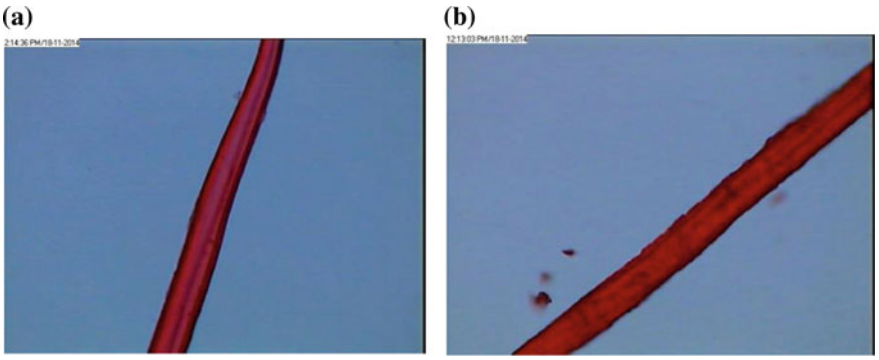

Fig. 2 Images of fibre diameter of 3 years old (**a**) and 5 years old (**b**) using 100× magnification

(Tang 1981). Table 1 presents that fibre of 3-year-old *Leucaena leucocephala* (22.57 µm) is thicker than 5-year-old *Leucaena leucocephala* (21.36 µm). *Leucaena leucocephala* of 5 years old has longer and thinner fibre that will produce excellent quality for board and papermaking, while 3-year-old *Leucaena leucocephala* has poor properties than other fibre. This is because short and thick fibre does not produce good surface contact and fibre bonding (Okigbo 1984). But the result in Table 1 still shows that diameter of fibre is not significant with increase of *Leucaena leucocephala* age. This result is supported by correlation analysis in Table 2 ($r = -0.11$ ns). Research by Majid (2012) using one species also found that fibre width decreases when age increases (Fig. 2).

3.3 Diameter of Lumen Cell

Based on Table 1, *Leucaena leucocephala* fibre shows a decrease in lumen diameter when age increases. *Leucaena leucocephala* of 5 years old has a low value of lumen diameter (10.61 µm). According to Majid (2012), fibre width, lumen diameter and flexibility ratio decreased when age increased. However, Table 2 indicates that there is no significant effect of age on diameter of lumen cell. Table 2 of correlation analysis also shows that age does not give effect to diameter of lumen cell ($r = -0.22$ ns).

3.4 Cell Wall Diameter

Table 1 shows that fibre of *Leucaena leucocephala* of 5 years old has wider cell walls than the 3 years old. This is because matured woods have wider cell wall fibre than juvenile woods (Gbadamosi 2001). However, cell wall value of 5-year-old

Leucaena leucocephala (5.38 µm) has no significant difference with 3-year-old *Leucaena leucocephala* (5.13 µm). Correlation coefficient (Table 2) also supports this statement when it shows positive significant (0.09 ns) when age increases. According to Zobel and Sprague (1998), juvenile wood has less cell wall thickness than matured wood. Wall thickness has also been proven to affect the bulk, burst, tear, fold and tensile strength of paper (Akgul and Tozluoglu 2008).

3.5 Runkel Ratio

Runkel ratio is one of the most important parameters in qualifying the fibre for paper industry; if it is more than one, the fibre is hard and difficult to feel during the paper production, and the quality of the paper will be grossed with poor bonding (Zobel and Sprague 1998). Table 1 shows that Runkel ratio exhibits definite trend with age. It was seen that the Runkel ratio increased from 3-year-old *Leucaena leucocephala* compared to 5-year-old *Leucaena leucocephala.* The higher Runkel ratio was observed from 5-year-old *Leucaena leucocephala* (1.09). *Leucaena leucocephala* of 3 years old has the lower Runkle ratio (0.92). Therefore, 3-year-old *Leucaena leucocephala* is suitable for making paper because Runkel's ratio value is less than one, it indicates that the fibre has a thin fibre wall and easy to felt and can produce paper with good quality (Viena et al. 2009). But Table 1 shows that there is no significant between types of fibre. This result is supported by correlation analysis (Table 2) that Runkel ratio had insignificant positive correlation with age (r = 0.23 ns).

3.6 Slenderness Ratio

Slenderness ratio usually affects paper properties; if slenderness ratio is less than 70, then fibre is invaluable for pulp and papermaking (Ates et al. 2008; Igartúa et al. 2005). Table 1 shows that the higher slenderness ratio is observed from 5-year-old *Leucaena leucocephala* (38.54), while the lower values are for *Leucaena leucocephala* of 3 years old (26.55). The result observed in Table 1 also indicated a clear increasing trend on the effects of age in slenderness ratio. This was further strengthened by the correlation analysis (Table 2) which revealed that slenderness ratio increased significantly with age (r = 0.34*). Slenderness ratio (Length/diameter) of a wood fibre decreases consistently with a decrease in screen size (Ayrilmis et al. 2009).

The results indicated that the intercorrelation between fibre morphology of *Leucaena leucocephala* and board properties was insignificant (Table 3). However, fibre length gave positive impact to mechanical properties (MOR, MOE and IB) of board (r = 0.04 ns, r = 0.16 ns and r = 0.19 ns, respectively). Intercorrelation analysis also shows that board with longer fibre is more resistance to water

Table 3 Intercorrelation coefficients of fibre morphology and fibreboard properties

Properties	MOR (MPa)	MOE (MPa)	IB (MPa)	TS (%)
Fibre length	0.04	0.16	0.19	−0.10
Fibre diameter	−0.13	−0.11	0.12	0.05
Lumen diameter	−0.12	−0.13	0.06	0.08
Cell wall diameter	−0.08	−0.04	0.15	−0.02
Runkel ratio	0.10	0.09	0.06	−0.09
Slenderness ratio	0.15	0.22	0.12	−0.15

MOR Modulus of rupture, *MOE* Modulus of elasticity, *IB* Internal bonding, *TS* Thickness swelling

($r = -0.10$ ns), while fibre diameter, lumen diameter and cell wall diameter have shown that increase in width of fibre can decrease the properties of fibreboard. Runkel ratio and slenderness ratio show similar result with fibre length, where increase of value of Runkel ratio caused the increase of fibreboard properties.

4 Conclusion

(i) Age of *Leucaena leucocephala* was found not to affect the fibre length, fibre diameter, lumen diameter, cell wall diameter and Runkel ratio except for slenderness ratio.
(ii) However, fibre, diameter of cell wall, Runkel ratio and slenderness ratio are increased when age increased from 3 years old to 5 years old.
(iii) Meanwhile, diameter of fibre and diameter of lumen cell are decreased with the increase of age.
(iv) The correlation between fibre morphology and fibreboard properties was found to be insignificant. It could be deduced that the board properties have less association with fibre morphology.

Acknowledgements The authors are grateful for the support of the KTP Research, Grant. No. 703000 13 0002, Universiti Teknologi MARA (UiTM) Pahang, Daiken Sarawak and Forest research instituted of Malaysia (FRIM).

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Chapter 80
Mechanical and Dimensional Stability Properties of Particleboard from *Neolamarckia cadamba* Wood

Hazwani Lias and Jamaludin Kasim

Abstract *Neolamarckia cadamba* tree is a viable alternative substitution material in the particleboard industry as it is a fast-growing species that has many benefits. Urea formaldehyde was used as a binder in this study. Experimental three-layer particleboard panels of *N. cadamba* tree were fabricated from two different sizes of 1.0 and 2.0 mm and used three different resin contents which were (7:9:7, 9:9:9 and 11:9:11). This study focuses on the influence of urea formaldehyde on the mechanical and dimensional stability properties. Modulus of rupture (MOR), modulus of elasticity (MOE), internal bonding (IB), water absorption (WA) and thickness swelling (TS) were evaluated in accordance with the Japanese Industrial Standard: Particleboards for General Purpose (2003). The results showed that there was relationship between resin contents and particle sizes of three-layer particleboard composites. Result obtained showed that bending and internal bond strength particleboard using ratio of 11:9:11 resin content with 700 kg/m^3 density was better compared to ratio of 7:9:7 and 9:9:9 resin contents. When the resin content was increased, the mechanical properties also increased and physical properties decreased. Large particle sizes were found effect in bending and bonding properties.

Keywords Urea formaldehyde · Resin content · Three-layer particleboard Particle sizes

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_80

1 Introduction

The use of particleboard is seeing a persistent increase in Malaysia due to the depletion of solid wood sources (Ratnasingam and Wagner 2009). The wood resources in Peninsular Malaysia have declined since the demand for solid timber in furniture construction decreases when the market introduced timber veneers on particleboard or chipboard. The disadvantages of solid timber are due to splitting with changes in humidity and a propensity to twist, whereas particleboard is not affected. Particleboard can be characterized as a composite wood and is an engineered product using sawmill shavings, wood chips, and even sawdust, and uses a high number of synthetic resins before finally being pressed under pressure and high temperature. However, with the increasing price of wood, there is a need to discover alternative sources of raw materials for particleboard manufacture.

As alternative raw material, forest plantation is well established for particleboard industry. Eight of selected species for forest plantation programme were commercialized which are Rubberwood, Acacia, Sentang, Batai, Teak, Khaya, Binuang and Kelempayan. Commercial forest plantations will continue as sustainable resource of timber and at the same time the natural forests can be reserved for non-timber benefits such as ecotourism and recreation, biodiversity and germplasm conservation. *Neolamarckia cadamba* is widely known as Kelempayan and classification under the family of Rubiaceae. It is a fast-growing species with a tall and straight bole. The timber is soft and light with creamy yellow colour wood and categorized under Light Hardwood in Malaysia (MTIB 2007). The timber is broadly used as mouldings, general utility furniture, veneer and plywood. As it is a fast-growing species, it could be developed as a substitute raw material to sustain the wood industries. The tree is a prospect to be used for sawn timber, veneer, chips, pulp and composites (Ismail et al. 1995).

Urea formaldehyde (UF) is categorized as a polymeric condensation product of the chemical reaction of formaldehyde with urea and is the most suitable compared to MUF, MF and PF resins for furniture manufacturer (Guru et al. 2006; Dunky 1998; Park and Jeong 2011). The advantages of UF resins properties include as better adhesion, better curing rate and lower cost. Particleboard industries in Malaysia mostly depend on urea formaldehyde (UF) resins due to its economically cheaper cost and preferred particleboard properties (Nemli and Ozturk 2006) although melamine urea formaldehyde (MUF) has been successfully proven as a potential alternative binding agent for UF (H'ng et al. 2011). This study was carried out to evaluate the different resin contents and two particle sizes of three-layer particleboard *N. cadamba* wood.

2 Materials and Methods

Three trees of *N. cadamba* were harvested from Diploma Plantation Industry Management plantation in Universiti Teknologi MARA, Cawangan Pahang. The trees were cut down, debarked, cut into small timber planks chipped, flaked and

Table 1 Dimension of samples

Test of item	Dimension of test piece (mm)	The number of test piece to be sample from one board
Bending strength test	Width 50 mm × length Span (12) + 50	3
Internal bond test	50 × 50	7
Density test	100 × 100	1
Test of swelling in after immersion in water	50 × 50	7

screened. The particles were collected from the screening process at five different screens of >5.0, 2.0, 1.0, 0.5 mm and fines. After screening, all the particles were dried in an oven for 48 h. The core layer was used in particle sizes 1.0 mm and 2.0 mm. Face layer is an admixture of percent particle sizes 1.0 mm and 0.5 mm. Three different ratio resin contents were used for this experiment: 7:9:7, 9:9:9 and 11:9:11, and the target density 700 kg/cm^3 was used for all fabrication boards. UF used was supplied by Malaysian Adhesives Chemical.

The solid content of this resin is approximately 65%. Ammonium chloride (NH4Cl) with 20% solid content was used as a hardener in this study and was used with UF. The amount of hardener was calculated 3% based on the resin used and added. Three-layer particleboard needs two times mixing of face/back and core layer. The mats were formed in the wooden mould with a measurement of 35 mm × 35 mm × 12 mm. The mats were pre-pressed to consolidate them. The mats were then hot pressed, and two metal stoppers with 12 mm thickness were placed on both sides of the mats. The mats were pressed for 6 min at 165 °C temperature.

2.1 Evaluation of Sample and Testing

All boards were cut according to the JIS standards. The test pieces were placed in a conditioning room to reach the constant weight at the temperature of 20 + 2 °C and relative humidity of 65 + 5 °C. All the samples' dimensions were measured as specified in the Japanese Industrial Standard: JIS A 5908:2003 as shown in Table 1. The mechanical properties like modulus of rupture (MOR), modulus of elasticity (MOE), and tensile strength perpendicular to surface were determined using an INSTRON machine.

3 Results and Discussion

Table 2 shows the mechanical and dimensional stability properties of particleboard from *N. cadamba* wood at three ratios of resin content 7:9:7, 9:9:9 and 11:9:11 and two different core particle sizes of 1.0 mm and 2.0 mm. The highest value of MOR (33 MPa) was from resin content 11:9:11, particle sizes 2.0 mm and MOE

Table 2 Mechanical and physical properties of *Neolamarckia cadamba* Particleboard

Resin content (%)	Particle sizes (mm)	MOR (MPa)	MOE (MPa)	IB (MPa)	WA (%)	TS (%)
7:9:7	1	22.25	2996	0.68	120.23	52.87
	2	24.05	3617	0.52	126.21	66.43
9:9:9	1	26.82	3528	0.69	100.37	42.16
	2	26.54	3768	0.55	107.86	53.37
11:9:11	1	29.42	3911	0.82	101.59	38.47
	2	33.00	4051	0.65	107.13	35.26
JIS:2003	Type 18	18 min	3000 min	0.3 min	n.a	12 max

Table 3 Summaries of ANOVA of the resin content and particle sizes

SOV	df	MOR	MOE	IB	WA	TS
RC	2	40.32*	76.52*	4.69*	34.89*	50.52*
PS	1	5.39*	56.35*	15.14*	8.76*	15.07*
RC × PS	2	2.30 ns	10.84*	0.09 ns	0.07 ns	8.01*

*Significant at the 0.05 level (2 tailed), *RC* Resin content *df* Degree of freedom, *MOR* Modulus of rupture, *MOE* Modulus of elasticity, *WA* Water absorption, *TS* Thickness swelling

(4051 MPa). Higher resin content 11:9:11 gave better mechanical and decrease in dimensional stability. The lower resin content ratio 7:9:7 had the lowest value of MOR (22.25 MPa) and MOE (2996 MPa). All results of MOR and MOE meet the standard requirement. Internal bond shows that the highest value is from resin content 11:9:11 (0.82 MPa) from particle size 1.0 mm and the lowest value are from resin content 7:9:7 (0.52 MPa) from particle size 2.0 mm. Thickness swelling of the board did not achieve the minimum requirement of the Japanese Industrial Standard. Based on these results, increased resin content leads to higher bending strength and bond value. All results of MOR, MOE and IB achieved the requirements of the JIS standard.

Table 3 shows the summary of the analysis of variance on the effect of resin content and particle sizes on the particleboards properties. Resin content shows a significant effect on MOR, MOE, IB, WA and TS properties. A particle size also significantly affects all the mechanical properties and physical properties. The interaction between resin content and particle sizes showed insignificant effects on MOR, IB and WA.

4 Effect of Resin Content

4.1 Mechanical Properties

Figure 1 shows the effects of resin content on mechanical properties. Increased resin content results in an incremental increase in bending strength and internal

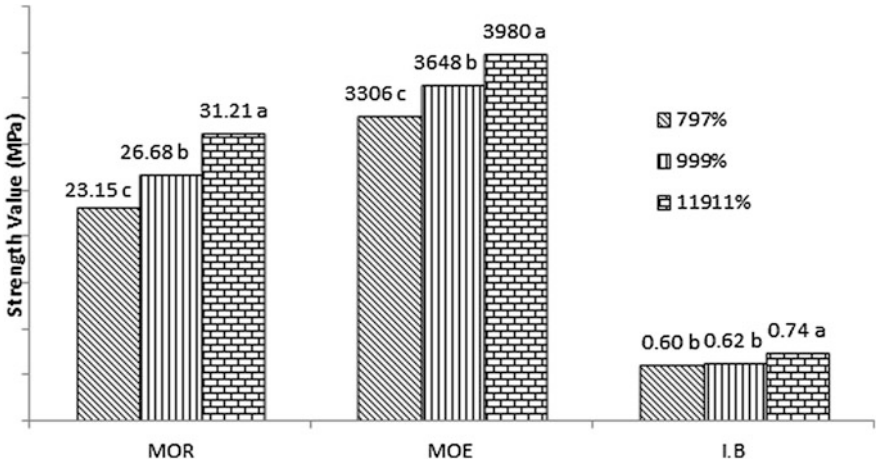

Fig. 1 Effect of resin content on mechanical properties

bonding. Resin content significantly affects all mechanical properties. When resin content was increased from 7:9:7 to 11:9:11, MOR, MOE and IB improved by 14, 16.6 and 42%, respectively. This is due to a higher amount of resin content forming more bonding sites, thus creating the stronger board properties.

Ayrilmis et al. (2012) also reported a similar result with an increase in resin content. Increasing resin content contributed to better bond particles. The greater bonding between wood and resin provided more surface area on panel properties. Internal bonds also revealed significant resin content ratios of 11:9:11 and 7:9:7. The distribution of resin content also played an important role. The higher amount of resin content directly affected the compatibility of the board. This behaviour could be related to the ability of particle coating between each other.

4.2 Physical Properties (WA/TS)

Figure 2 shows the effects of resin content on dimensional stability properties. An increase in resin content shows significant improvement in water absorption and thickness swelling percentages. Based on the results, lower resin content caused a decrease in dimensional stability. It is concluded that the thickness swelling and water absorption improvements were due to resin content coats to better particle bonding. Medved et al. (2011) also reported that increase resin content, decrease percentages of thickness swelling and water absorption. Sarmin et al. (2013a, b) also presented similar findings. This might have been due to the resin itself which occupied the void among the particles and thereby reduced the moisture uptake from the environment. The reduction of the percentage thickness showed improvement. However, the resulting physical properties did not meet the requirement of Japanese Industrial Standard A2908:2003.

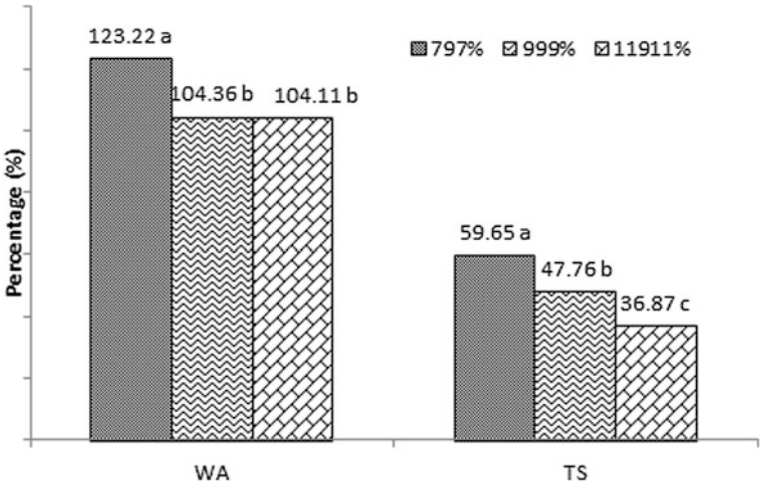

Fig. 2 Effect of resin content on dimensional stability properties

Table 4 Correlation analysis of resin content and particle sizes on board properties

Variable	MOR	MOE	IB	WA	TS
Resin content	0.82**	0.77**	0.38*	−0.69**	−0.79**
Particle sizes	0.21 ns	0.46**	−0.53**	0.28 ns	0.31 ns

*Correlation is significant at the 0.05 level (2 tailed)

Table 4 shows the correlation analysis of resin content and particle sizes on board properties. The increase of resin content further revealed significant relationships on MOR (r = 0.82**), MOE (r = 0.77**) and IB (r = 0.38*) results. The result shows better performance on mechanical properties when the amount of resin content was increased. Dimensional stability is the main point to determine the effectiveness of resin content on dimensional stability properties. The higher resin content shows thickness swelling (r = −0.69**) and water absorption (r = −0.79**) negative correlation. Particle sizes show insignificant relationship on MOR, WA, TS and negative correlation between internal bond tests.

5 Effect of Particle Sizes

5.1 Mechanical Properties

Figure 3 shows the effects of two core particle sizes on mechanical properties. Bending strength shows higher result with particle size 2.0 mm than with particle size 1.0 mm. The findings reported that large particle sizes performed better than

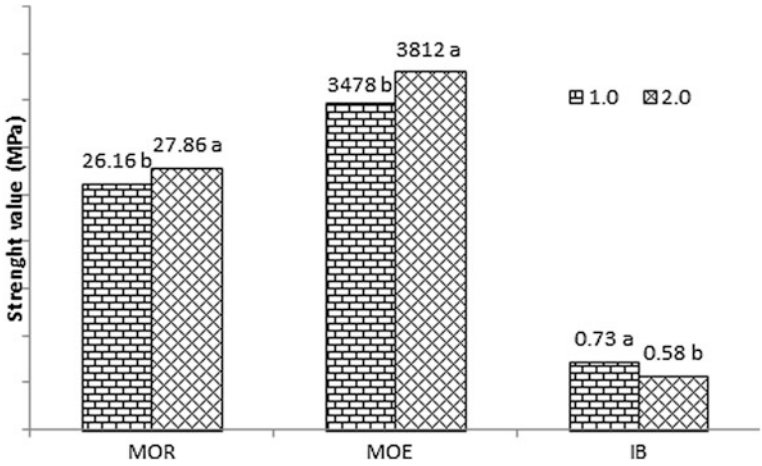

Fig. 3 Effect of particle sizes on mechanical properties

smaller particle sizes. All the results revealed significant differences between particle sizes 1.0 and 2.0 mm. The mechanical properties increase when particle sizes increase from 1.0 to 2.0 mm. Particle made from particle size 2.0 mm in the core layer was found significantly strength in bending and bonding compared to smaller particle sizes.

As can be seen, the higher value of internal bond was found in resin content ratio 11:9:11 with particle size 1.0 mm (0.77 MPa). Kasim (1999) showed similar findings that large particle sizes are related with the higher amount of resin per unit area due to the lower surface area per unit. This is due to a large surface area of particle sizes giving better stress distribution than smaller particle sizes. Hashim et al. (2010) also reported that an increase in surface area will produce stronger properties. This might be due to better glue line which would be responsible for more strength features. Frybort et al. (2008) and Moslemi (1974) indicated that particle geometry has two important aspects such as sizes and shapes which have a great effect on board manufacturing.

5.2 Physical Properties (WA/TS)

Figure 4 shows the effects of particle sizes on dimensional stability properties. Particle size 2.0 mm shows higher values on thickness swelling and water absorption than smaller particle sizes. This is due to particle size 1.0 mm enclosing better by resin and having stronger bonds. Wang and Sung (2002) found similar findings where greater particle sizes have a disadvantage in dimensional stability since the behaviour of WA was very different from that observed for TS. Maloney (1993) reported that particle surface area increased per unit resin content is different

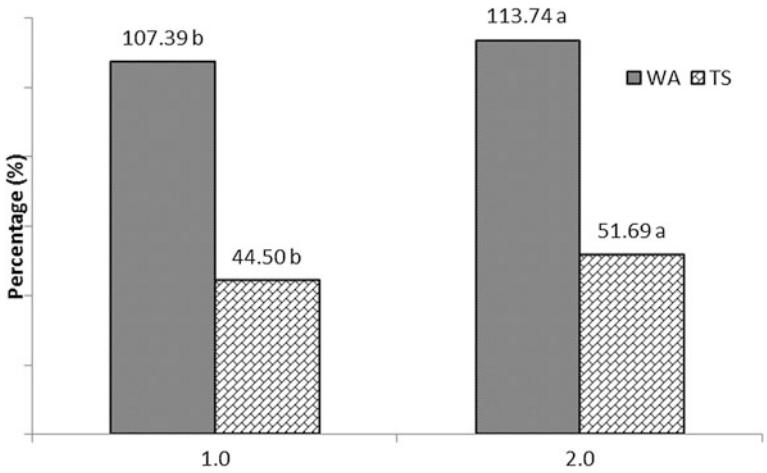

Fig. 4 Effect of core particle sizes on dimensional stability properties

from short ones. The panels did not show a significant improvement in water absorption as they did for thickness swelling. This is due to the bigger particles which caused weak contact between each other, thus producing more pores. This allows water to penetrate easily since not all parts of the particles were covered by the resin. Water absorption shows contrast result in the thickness swelling properties. Particle size 1.0 mm shows better TS due to the compatibility of the particles themselves. The higher stress and pressure produced spring back. Nemli et al. (2007) also reported similar results. Smaller particles or fine particles absorbed less moisture compared to thick particles. Besides that, the inefficient glueing of the particle sizes created more void between particles.

6 Conclusion

From this study, it can be concluded that the three-layer particleboard composite revealed better mechanical properties. The panels with the resin content of 11:9:11 showed better MOR, MOE and IB compared to 7:9:7 and 9:9:9. The particle size 2.0 mm of panels manufactured using the resin content 11:9:11 was higher compared to using resin contents 7:9:7 and 9:9:9. Panels made with *N. cadamba* wood with greater particle sizes had superior properties compared to smaller particle sizes. All types of strength characteristics of the samples manufactured from *N. cadamba* wood met the strength requirements of the Japanese Industrial Standards for general uses. However, further research is required to improve the dimensional stability of the particleboard and *N. cadamba* tree can be commercialized to produce particleboard with low operation cost.

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Chapter 81
Effect of Filler Loadings on Mechanical and Physical Properties of Particleboard Sanderdust–Polypropylene Composite

Iffah Izzah Maidin, Jamaludin Kasim and Nor Farhana Jasmi

Abstract Particleboard sanderdust is a waste available in large quantities during the production of particleboard. In this study, the sanderdust was collected and processed as filler in polypropylene matrix and become particleboard sanderdust–polypropylene composite. Different amounts of sanderdust (10, 30, and 50%) were used in this experiment. Flexural modulus of rupture (FMOR), flexural modulus of elasticity (FMOE), tensile modulus of rupture (TMOR), tensile elongation, and izod impact for mechanical properties and for physical properties water absorption were tested. All tests of flexural, tensile, impact, and water absorption were evaluated in accordance with ASTM (2006). It was found that the strength of the composite board increases as the amount of filler loading decreases. As filler loading increases, the percentage of water that is absorbed in the WPC also increases. All findings obtained from the variable of different filler loadings were significantly different. The outcomes of this research can be used as guide and support the future research.

Keywords Polypropylene · Particleboard sanderdust waste · Thermoplastic composite

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_81

1 Introduction

The term composite is used to define any material that has two or more part which bonded together with adhesive. There are many wood-based composites that existed nowadays such as wood plastic composite (WPC), particleboard, oriented strandboard (OSB), fiberboard, medium density fiberboard (MDF), and laminated veneer lumber (LVL) (Cai 2006). Wood plastics composite (WPC) is derived from a combination of wood sawdust and plastic matrix. The sawdust can be obtained from the range of wood flour to flax and for the plastic, it can be obtained from the range of polypropylene to PVC. WPC has good mechanical properties, and thus it can be used to produce complex shape and has high dimensional stability. More importantly, it is a new generation of high-performance product. WPC can be used to replace the wood product or plastic product such as furniture, decorative profile, window frame, cladding, doorframe, and roofline product (Tangram 2002).

Nowadays, trees are harvested to fulfill the demand for furniture, construction material, paper, and other uses. Many wastes that are produced from these activities, especially from sander dust will end up as an environmental problem if it is not well managed. Wood dust that comes especially from sander dust consists of tiny particle of wood produced during processing and handling of wood, particleboard, and other composite board. The most common waste that we can get is fines or sawdust that came from the wood industry (Azman and Shakri 2009). Particleboard sanderdust is a waste that has been produced during particleboard sanding process. One of the alternative methods to reuse this waste is to make value-added product such as wood plastic composite. The objective of this study is to investigate the effect of filler loadings on FMOR, FMOE, TMOR, tensile elongation, impact strength, and water absorption.

2 Material and Method

Dried particleboard sander dust was obtained from a local particleboard manufacturer at Jengka, Pahang. The polymer matrix is polypropylene (PP) in the form of pellet with melting temperature of 163 °C supplied by a local manufacturer. The range of 150–250 μm particle size was screened and collected to be processed. Different percentages of 10, 30, and 50% filler loading were used in this study.

Particleboard sander dust was compounded with PP matrix in dispersion mixer with temperature of 180 °C. The final mixture was then crushed into pellets form. The pellet was placed in a mold with a dimension of 240 mm × 150 mm × 6 mm for flexural test and a mold with a dimension of 300 mm × 240 mm × 2 mm for tensile, impact, and water absorption tests. The compounded pellet composite compound was hot pressed at 1000 psi within 360 s with temperature of 180 °C followed by the cold press at 1000 psi within 60 s with temperature 25 °C to get the composite board. The board was conditioned in a conditioning room with a relative

humidity of 50 ± 5% for at least 24 h. Nine specimens were selected to perform flexural test, tensile test, and impact test, while for water absorption, only six specimens were used to perform the test. Preparation of specimens testing was done according to ASTM D790 for flexural, ASTM D3039 for tensile, ASTM D256 for impact, and ASTM D570 for water absorption.

3 Results and Discussion

Analysis of variance was conducted to determine the significance of filler loading on particleboard sander dust composite. Filler loading variable shows a significant effect on all composite board properties.

3.1 Effect of Filler Loading on Mechanical Properties

Figure 1 shows the effects of filler loading on the mechanical properties. It was found that FMOR decreases as the filler loading increases. WPC with 10% filler loading shows higher FMOR value (43.24 MPa) as compared to the composite with 30 and 50% filler loading which are 34.69 and 27.25 MPa. High filler loading has caused the problem of particle aggregation in the composite which led to the filler to be failed in the stress transference from the matrix and therefore lowers the composite strength (Yamani 2011). As filler loading increases, the FMOE also increases, significantly. Composite with 50% filler loading shows the highest result which is 2387 MPa. However, when the filler loading goes down to 30 and 10%, the FMOE decreases to 1845 and 1783 MPa, respectively. The ANOVA analysis (Table 1) shows that there is a significant difference among the three-filler loading. The characteristic of particles as filler became rigid when its loading increased, and hence may affect the FMOE of the composite (Kaci et al. 2007). Figure 1 also shows a negative trend of TMOR when the filler loading increases. Composite with 10% filler loading shows the highest TMOR value which is 24.15 MPa as compared to 30 and 50% filler loadings. The significant difference is shown in Table 1. The population of fillers is one of the factors that may affect the uniformity of stress distribution within a composite (Jacob et al. 2004). In this study, at a high filler loading of 50%, the population of sander dusts as filler increased and led to agglomeration. Thus, the stress transfer may be blocked and exert to the reduction of TMOR.

Figure 2 shows that tensile elongation decreases as a filler loading increases. The WPC with 10% filler loading demonstrated the highest value of elongation which is 7.54% as compared to 30 and 50% filler loading which are 4.93 and 2.13%, respectively. The significant difference is also shown in ANOVA analysis (Table 1). The decrease of tensile elongation is a regular observation in all-filled polymer composite and are probably due to the decrease in deformability of a stiff interphase between the matrix polymer and filler (Kasim 2006).

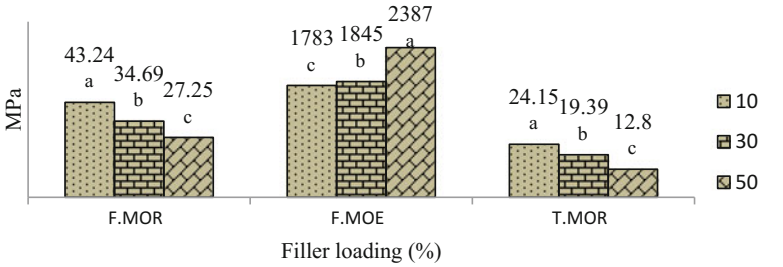

Fig. 1 Effect of filler loading on flexural and tensile properties

Table 1 Summary of the ANOVA on relation effects of different filler loadings

Source of variation	df	F.MOR	F.MOE	T.MOE	T.Elong	Impact	WA
Filler loading (FL)	2	1524.78*	769.78*	3622.87*	1010.71*	1376.31*	3210.17*

Note ns = not significant at $p > 0.05$, * significant at $p < 0.05$
Note F.MOR Flexural modulus of rupture; *F.MOE* Flexural modulus of elasticity; *T.MOR* Tensile modulus of rupture; *T.Elong* Tensile elongation; *WA* Water absorption

Fig. 2 Effect of filler loading on tensile elongation

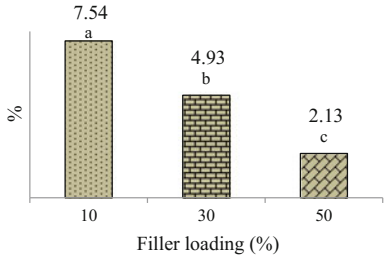

Fig. 3 Effect of filler loading on izod impact

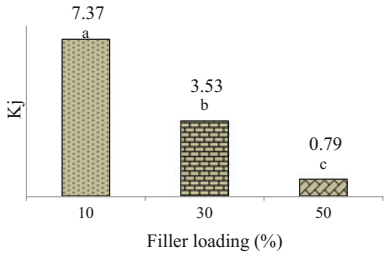

Figure 3 shows that the izod impact strength decreases as the filler loading increases. WPC with 10% filler loading shows higher impact value which is 7.37 kJ as compared to 30 and 50% filler loading. The ANOVA analysis (Table 1) shows that there is a significant difference among the three-filler loading. The less amount of plastic matrix in the composite will cause more stress points between the filler

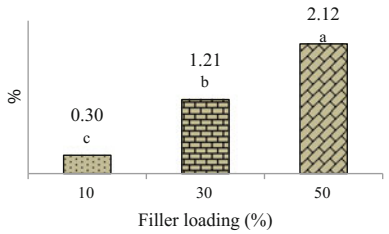

Fig. 4 Effect of filler loading on water absorption

and the plastic matrix, so this will cause crack dissemination that could cause failure even under small amount energy loading. The impact strength will reduce as the filler loading increases (Rozman et al. 1998).

3.2 Physical Properties

Figure 4 shows that as filler loading increases, the percentage of water that is absorbed in the WPC will also be increased. The water absorption value is lowest at 10% filler loading with 0.30% as compared to 30 and 50% filler loading with values of 1.21 and 2.12%, respectively. The significant effects among the three different filler loadings are shown in Table 1. Increasing filler loading will also increase the water absorption (Kasim 1999). Khalil et al. (2006) stated that high filler loading will increase the number of hydroxyl group which may attract more water to be absorbed.

4 Conclusion

It was found that the particleboard sanderdust waste can be reused to make value-added product which is wood plastic composite. For FMOR, TMOR, tensile elongation, and izod impact showed that the lower filler loadings gave higher values, while for water absorption, the lower filler loading content gives the better WA values. It was observed that the filler loading at 10% shows the best performance compared to 30 and 50% filler loading.

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Part VIII
Mathematics

Chapter 82
The Optimality of Profit Sharing in Loyalty Reward Programs

Wan Nuraini Fahana Wan Nasir and Muhammad Safiih Lola

Abstract This paper concerned with finding the optimal allocation of profit arrangement under profit-sharing plans in loyalty rewards programs (LRP). Previous studies did not consider the customer's purchase experience as a factor in their decision to buy and customers are not taken into account in profit-sharing plans. We show how optimal profit sharing can be computed when the objective function of profit maximizing is specified for the loyalty reward program by using stochastic dynamic programming. We consider a firm selling goods or services through two periods and we treat customers' valuation as a random variable by considering their post-purchase satisfaction level on loyalty program. We solve the optimization problem analytically and the obtained solution provides some useful information on the effects of customers' satisfaction with the loyalty program.

Keywords Dynamic programming · Loyalty programs · Profit sharing

1 Introduction

Loyalty reward program is a program based on which customers gain a reward for repeating their purchase. This program initially developed as marketing strategies to enhance customers' loyalty and thereby increase a firm's long-term profitability. Some of the research has been directed toward investigating how this program contributed to the firm's financial and market performance (Kim et al. 2004; Lewis 2004). Few studies evaluated the aspects of program fairness from the customers' vantage points. However, the previous studies only focus on firm's profitability where their objective is to maximize the profit. Danaher et al. (2016) studied the

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_82

comparison between a point price and corresponding market price to see if loyalty reward program members are being fairly rewarded for their points earning effort and they found that if the point price exceeds the market price by as little as 10%, then more than half of loyalty member want to quit the loyalty reward program. Brashear-Alejandro et al. (2016) proposed that loyalty reward program leads to customer and company identification formation. Marketers who interested in building customer identification with loyalty program should design proper investment to strengthen and confirm customer's feeling of status belongingness. Profit share can be one of strategies for this investment. But under profit-sharing plan concept existence today, the plans only consider the profit sharing to the employees, e.g., Kraft and Ugarković (2006), Long and Fang (2012), and Yan (2008). The customers who are the main characters to the profitability of firm's profit are not included in sharing the profit. Customers should be taken into account the profit-sharing plans to give them a sense of ownership in the company and thus give them the satisfaction for the loyalty reward programs. von Lanzenauer (1969) developed a general framework for planning the profit-sharing programs and showed that the dynamic programming is a useful tool in determining the optimal amount to be shared with the labor. Kruse (1992) explored the relationship of profit-sharing plans to productivity. He used a variety of tests to examine whether profit-sharing plans are associated with higher productivity, and the results indicated that the adoption of profit-sharing plans will increase the productivity. Kraft and Ugarković (2006) studied the relationship between profit sharing and profitability by applying a matched difference-in-difference approach and they found that an introduction to profit sharing will increase the profitability. Blair and Lafontaine (2015) developed a simple formula for pricing contract and profit sharing in inter-firm that can be used to generate the vertically integrated level of profits. They discussed the advantages of proposed contract from a transition post-perspective.

In this paper, we develop a new analytic model of profit-sharing plans by considering the profit shared to the labor and the customers. We investigate the customers' valuation on their satisfaction toward the loyalty programs. Customers' satisfaction is one of the important factors to the effectiveness of a loyalty program so that the profit will be maximized. Previous studies did not consider the customer's purchase experience as a factor in their decision to buy. Our model is formulated depending on the customer's valuation distribution. Hence, our model is distinguished from those of von Lanzenauer (1969) which takes the position of capital. Optimization problems are solved analytically by using the dynamic programming, the optimal profit sharing to be shared with labor, and the customers are determined. The objective of the model is to determine the optimal profit sharing for the labor and customers where the firm's profit is maximized in terms of its decision variables by considering the customers' satisfaction for loyalty reward program.

The paper proceeds by discussing the formulation of the model for the objective function of profit maximizing. It then continues with the dynamic programming for profit-sharing problem and the solution methods for the problems are discussed. We conclude with a discussion of key findings and managerial implications.

2 Method

The main methodology of this paper is to consider the loyalty reward programs as a dynamic system. We describe the loyalty reward programs in terms of profit and satisfaction. Firstly, we developed a model to maximize the profit from the loyalty reward program in which customers' valuation along with their satisfaction levels incorporated them as stochastic variables. Then, we expanded the model to solve the profit-sharing problem for the labor and customers by using dynamic programming.

2.1 Profit Maximized Model Formulation

We consider a customer's choice of decision to buy a product depending on the following factors:

i. Current and future price of the product.
ii. Valuation of the product.
iii. Loyalty reward value.
iv. Possibility to rebuy in the next period.

As assumed in extant literature, we consider the operation of loyalty program in two periods. A customer will earn the reward if he/she makes a purchase in both two periods. Similarly to Gandomi and Zolfaghari (2013) and Kim et al. (2001), we assume that only a certain proportion of first-period buyers proceed to the second period. This proportion is modeled as a parameter, γ. So γ is the probability that a first buyer become a potential buyer in the second period. As a result, $(1-\gamma)$ is the probability of buyers in period 1 that fails to proceed to period 2.

Let surplus, S1, be the factors that influence the customers' decision to buy a product in the first period. A customer's surplus from purchasing a product is the value he/she will gain by obtaining the product subtracted from the amount he/she has to pay for it. If a customer gets a nonnegative surplus, he/she will make a purchase. So, the equation for customer's surplus from buying a unit of product in period 1 is given by

$$S_1 = [v_1 - h_1] + \gamma\,[v_1 - (h_2 - l)] \tag{1}$$

where

v	valuation of the product by customer
h_i $(i = 1, 2)$	offer price in period i
l	loyalty reward value

S_1 is the sum of the first-period surplus and the expected surplus from buying the product in period 2. The expected surplus in period 2 is the surplus value multiplied by the probability of proceeding to the second period.

A customer buys the product if the firm's offer gives him/her a nonnegative surplus. Thus, the probability that a customer makes a purchase in period 1 is

$$\Pi_1 = \Pr(S_2 \geq 0) = 1 - \mathrm{F}\left(\frac{h_1 + \gamma(h_2 - l)}{1+\gamma}\right) \tag{2}$$

where F (.) denotes the CDF of the customers' valuation in the first period. Customers who buy in period 1 will proceed to buy in the second period with the probability of γ. For a given customer in period 2, the utility derived from making a purchase is

$$S_2 = v_2 - (h_2 - l) \tag{3}$$

where v_2 is the valuation of the customer in the second period. Here, v_1 and v_2 are neither equal nor independent. To model this dependency, we assume $v_2 = v_1 + \delta$ for each customer. This implies that the past purchase experience leads to a shift size δ in the valuation of the customer. For a satisfied customer, δ is nonnegative and for a dissatisfied customer δ is negative. Therefore, we infer that S_1 and S_2 are dependent. Thus, the probability that a first-period buyer makes a purchase in period 2 is conditioned on the fact that his/her surplus in period 1 has been nonnegative. The equation is given by

$$\Pi_2 = \Pr(S_2 \geq 0 \,|S_1 \geq 0) = \Pr\left(v_2 \geq h_2 - l | v_1 \geq \frac{p_1 + \gamma(h_2 - l)}{1-\gamma}\right) \tag{4}$$

but $v_2 = v_1 + \delta$.

Thus, we get

$$\Pi_2 = \Pr\left(v_1 \geq h_2 - l - \delta \,|v_1 \geq \frac{h_1 + \gamma(h_2 - l)}{1-\gamma}\right) \tag{5}$$

By applying the conditional probability theorem, Eq. (5) can be expressed as a piecewise function:

$$\Pi_2 = \begin{cases} \frac{1-\mathrm{F}(h_2 - l - \delta)}{1-\mathrm{F}\left(\frac{h_1 + \gamma(h_2 - l)}{1+\gamma}\right)} & ; \quad \text{if } h_2 - r - \delta \geq \frac{h_1 + \gamma(h_2 - l)}{1+\gamma} \\ 1 & ; \quad \text{if } h_2 - r - \delta \leq \frac{h_1 + \gamma(h_2 - l)}{1+\gamma} \end{cases} \tag{6}$$

Now, based on the firm's profit from selling a product and customers' probabilities of buying in each period, we can find the firm's expected total profit function as follows:

$$\mathrm{P_t} = h_1\,\Pi_1 + \gamma\,(h_2 - l)\Pi_1\,\Pi_2 + (1-\gamma)h_2\,\Pi_2 \tag{7}$$

2.2 Profit-Sharing Dynamic Programming Formulation

The profit dynamic programming problem has two state variables and two decision variables in each period. The state variables are value of profit belonging to labor and customer at start of the period in loyalty programs and the decision variables are offer price in each period and the loyalty reward. The strategy used in formulating the profit-sharing dynamic programming problem is to formulate the problems for a fixed value of the profit sharing and variables, respectively. The dynamic programming problem in this case is a standard form which can be solved for the decision variables which maximize the objective function. The solution to the profit-sharing problem is then obtained by finding the values of the profit sharing which produce the largest values of the objective function.

The following variables are used in specifying the profit-sharing problem:

$t = 0, 1, 2, \ldots, n$ is the number of periods in the planning horizon;
p_t = Total profit from the loyalty reward program in period t;
$r, (0 \leq r \leq 1)$ is the share of the profit in each period allocated to labor;
$\overline{r} = 1 - r$ is the share of the profit in each period allocated to the customer;
$p_{1t} = rp_t$ is the profit to labor in period t;
$p_{2t} = \overline{r}p_t$ is the profit to customer in period t;
$g_1(p_{1t}) = g_1(rp_t)$ is the profit function for labor which is assumed to be bounded;
$g_2(p_{2t}) = g_2(\overline{r}p_t)$ is the profit function for customer which is assumed to be bounded;
c is the maximum profit of the company;
c_t is the profit at the start of period t;
v_t is the gross profit at the start of the period t, assumed to be independent across time;
$F(v_t)$ is the distribution function of v_t;
α is the proportion of loss in each period;
β $(\beta < 1)$ is the one-period discount rate;

$f_n(c_0, r)$ is the maximized expected profit to company starting with an initial profit level c_0 with n decision periods remaining and profit-sharing variable set at r.

The stage-to-stage transformation of the state variable is found from profit balance equation for the company in period t:

$$p_t = c_t + v_t - c_{t+1} - (c_t + c_{t+1}) \cdot \frac{\alpha}{2} \tag{8}$$

This can be rearranged to yield

$$\begin{aligned} c_{t+1} &= c_t\left(1 - \frac{\alpha}{2}\right)\Big/\left(1 + \frac{\alpha}{2}\right) + v_t\Big/\left(1 + \frac{\alpha}{2}\right) - p_t\Big/\left(1 + \frac{\alpha}{2}\right) \\ &= T(c_t, v_t, p_t) \end{aligned} \tag{9}$$

This expresses the value of the state variable in period $t + 1$ as a function of the state variable in period t, (c_t) the gross profit in period t, (v_t) and the decision variable in period t, (p_t). For a fixed value of the profit-sharing variable p, the dynamic programming problem of maximizing the discounted expected profit from loyalty reward program is characterized by the following recurrence relationship for $n \geq 1$:

$$\begin{aligned} f_n(c_0, r) &= \max_{x_0} \left\{ g_1(r\, p_0) + g_2(\overline{r}\, p_0) + \beta \int f_{n-1}(c_1, r)\, \mathrm{d}F(v_0) \right\} \\ &= \max_{x_0} \left\{ g_1(r\, p_0) + g_2(\overline{r}\, p_0) + \beta \int f_{n-1}(T(c_0, v_0, p_0),\ r)\, \mathrm{d}F(v_0) \right\} \end{aligned} \tag{10}$$

and for $n = 0$:

$$f_0(c_0, r) = \max_{x_0} \{ g_1(r\, p_0) + g_2(\overline{r}\, p_0) \} \tag{11}$$

where the choice of p_0 is restricted to lie in the range of values that would make the opening profit in the following period c_1 feasible. The recurrence relationship Eq. (10) can be solved by using backward recurrence in example starting with the final period and working backward in time to obtain the policy which yields $f_n(c_0, r)$ (Bellman and Kalaba 1965). The optimal profit is the set of functions $\{p_0(c_0, v_0),\ p_1(c_1, v_1), \ldots, p_n(c_n, v_n)\}$ which yields $f_n(c_0, r)$.

Bellman and Kalaba (1965) noted that the solution of Eq. (10) will exist providing the decision variables $(c_0, c_1, \ldots, c_n)$ range over finite sets. The solution to the profit-sharing dynamic programming problems involves finding the value of profit-sharing variable r^* which satisfies

$$f_n(c_0, r*) \geq f_n(c_0, r) \text{ for all } r \in [0, 1]. \tag{12}$$

Since $f_n(c_0, r)$ is defined on compact domain, a solution will always exist if $f_n(c_0, r)$ is continuous in r on [0, 1].

Computationally, a value of r which satisfies Eq. (12) can be found by solving Eq. (10) for value of r on a grid spanning [0, 1] interval. This method will determine the optimal value of the profit-sharing variable.

3 Conclusion

We have proposed a model to maximize the profit and discussed how to share the profit between labor and customer in profit-sharing plans. At first, we developed a model to investigate the profitability of loyalty programs when customers' satisfaction level is taken into account. The model maximized the profit in terms of price and loyalty reward. Then, we use dynamic programming to allocate the profit

sharing for labor and the customer. Profit sharing in each period is used as an instrument to achieve the objective of maximizing profit. The results showed that we can compute the optimal profit sharing between labor and customer by using dynamic programming. The obtained solutions provide useful information into the effects of customer satisfaction with the loyalty reward program. Hence, we believe that the model we proposed represents a useful tool to support company's decision-making on profit-sharing planning in practice. Our future activities include applying the methodology to actual or real data and to expand our model to other loyalty reward firm and loyalty reward partner.

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Chapter 83
Integrated Fuzzy Time Series Model for Forecasting Tourist Arrivals

Nazirah Ramli, Siti Noorul Ain Nor Azemi, Noor Syamimi Omar and Siti Musleha Ab Mutalib

Abstract Tourism is one of the major contributing sectors for most countries including Malaysia. In order to have a well-organized tourism strategy, tourism forecasting is important to satisfy the country demand. Various models based on fuzzy time series have been proposed. However, most of the models define the historical data in terms of discrete fuzzy sets, which is only based on a single-point value. In this paper, tourist fuzzy forecasting model based on fuzzy time series with data in trapezoidal form is proposed. The forecasting procedure involved three phases which are test data for seasonality and trend pattern, model development using trapezoidal fuzzy numbers and deterministic length interval, and verifying the forecasting accuracy. This integrated fuzzy forecasting model is implemented for predicting tourist arrivals to the state of Sabah, Malaysia. The result shows that the data have seasonal and trend pattern with eleven linguistic values in terms of trapezoidal fuzzy numbers. Thus, the forecasted values under different degrees of confidence can be obtained.

Keywords Deterministic length · Forecasting tourist · Fuzzy time series Trapezoidal fuzzy numbers

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_83

1 Introduction

Tourism is one of the major contributing sectors for most countries including Malaysia. This industry has contributed major sources of economic for the countries by generating tax, revenue, growth of private sectors, development structures, and employment opportunities such as transportation and hospitality administration. Thus, estimating the future tourism demand is important for the government and industry as it can facilitate strategy in managing and planning tourism development and effective policy.

Various forecasting tourism demand models have been proposed such as by using the exponential smoothing (Lim and McAleer 2001), Box Jenkins Sarima application (Nanthakumar and Ibrahim 2010), and alpha model (Huang 2012). However, the classical time series models cannot deal with the forecasting problems in which the values of time series are linguistic terms represented by fuzzy sets (Chen and Hsu 2004). Song and Chissom (1993) was the first introduced concept of fuzzy time series (FTS) using the enrollment data at University of Alabama as a sample set. Many improvements have been made on the FTS model proposed by Song and Chissom (1993) such as studies by Singh (2008), Teoh et al. (2009) and Ye et al. (2016). In forecasting tourism, a number of studies have proposed the forecasting models based on FTS such as Lee et al. (2012) and Sakhuja et al. (2015). However, the proposed models by Lee et al. (2012) and Sakhuja et al. (2015) used discrete fuzzy sets as a basis for calculating the forecasted values. Nevertheless, these types of models cannot provide the forecasted ranges under different degrees of confidence.

This paper proposes a forecasting model for predicting tourist arrivals based on trapezoidal fuzzy numbers (TFNs) and deterministic length interval. The TFNs were used to represent the linguistic values of data and its usage produced the forecasted ranges under different degrees of confidence. The deterministic length interval method can reflect the sensitivity of the data (Li and Cheng 2007). This paper is organized as follows. The next section introduces basic definition on FTS and TFNs. Section 3 presents the proposed forecasting model based on trapezoidal fuzzy numbers (TFNs) and deterministic length interval. The procedure and results for forecasting tourist arrivals are presented in Sect. 4. Discussion is presented in Sect. 5 and finally, conclusion is given in Sect. 6.

2 Preliminaries

In this section, some basic concepts of FTS and TFNs are presented. The concept of FTS was first presented and defined by Song and Chissom (1993, 1994). The definitions are given as follows:

Definition 1 Let $Y(t)\,(t = \ldots 0, 1, 2, \ldots)$ be a subset of $\Re$ and $Y(t)$ be the universe of discourse defined by fuzzy set $u_i(t)\,(i = 1, 2, \ldots)$. If $F(t)$ consists of $u_i(t)\,(i = 1, 2, \ldots)$, then $F(t)$ is called FTS on $Y(t) = (t = \ldots 0, 1, 2, \ldots)$.

Definition 2 Let $F(t)$ be an FTS. $F(t)$ be caused by $F(t-1)$ if there exists a fuzzy relationship $R(t-1, t)$ such that $F(t) = F(t-1) \otimes R(t-1, t)$ where $\otimes$ represent as fuzzy operator. The relationship can be denoted as $F(t-1) \rightarrow F(t)$ or $\tilde{A}_i \rightarrow \tilde{A}_j$ if $F(t-1) = \tilde{A}_i$ and $F(t) = \tilde{A}_j$.

Definition 3 A TrFNs $\tilde{A}$ denoted as $\tilde{A} = (a, b, c, d)$ is defined as

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \\ 0. & x > d \end{cases}.$$

3 Proposed Fuzzy Forecasting Model Based on Trapezoidal Fuzzy Numbers and Deterministic Length Interval

In this section, the proposed fuzzy forecasting model based on TFNs and deterministic length interval is presented. The proposed approach consists of three main phases which are investigation on seasonality and trend pattern, model development using TFNs and deterministic length interval, and verification of forecasting performance. The procedure of the proposed approach is given as follows:

Phase 1: **Investigation of seasonality and trend pattern**

i. Use line chart method for determining the seasonality. For data with seasonal variation, deseasonalize the data using moving average method via Minitab software.
ii. Use least square method for determining the existence of trend pattern.

Phase 2: **Development of model**

i. Determine the universe of discourse by using the deterministic method as follows:

   (a) Determine the length of interval l based on the place value of the data.
   (b) Find the maximum value $D_{\max}$ and the minimum value $D_{\min}$ from the deseasonalized data at time t (H_t).
   (c) Find D_{low}, D_{up} and number of TrFNs n such that
   $D_{\text{low}} = \left\lfloor \frac{D_{\min}}{l} \right\rfloor \times l$, $D_{\text{up}} = \left\{ \left\lfloor \frac{D_{\max}}{l} \right\rfloor + 1 \right\} \times l$, $n = \frac{D_{\text{up}} - D_{\text{low}}}{l}$
   and $\lfloor \rfloor$ is the floor function.

(d) Find the universe of discourse as $U = [D_{\text{low}}, D_{\text{up}}]$.

ii. Develop new TrFNs based on n intervals. From Liu (2009), assume that the n intervals are
$u_1, u_2, u_3, \ldots u_n$ with $u_1 = [d_1, d_2]$, $u_2 = [d_2, d_3]$, $u_3 = [d_3, d_4]$, $\ldots$,$u_{n-2} = [d_{n-2}, d_{n-1}]$, $u_{n-1} = [d_{n-1}, d_n]$, and $u_n = [d_n, d_{n+1}]$.
The linguistic terms for $\tilde{A}_1, \tilde{A}_2, \ldots, \tilde{A}_n$ can be defined as follows:

$$\begin{aligned}
\tilde{A}_1 &= (d_1, d_1, d_2, d_3),\\
\tilde{A}_2 &= (d_1, d_2, d_3, d_4),\\
&\vdots \qquad\quad \vdots\\
\tilde{A}_{n-1} &= (d_{n-2}, d_{n-1}, d_n, d_{n+1}),\\
\tilde{A}_n &= (d_{n-1}, d_n, d_{n+1}, d_{n+1}).
\end{aligned}$$

where $\tilde{A}_1, \tilde{A}_2, \ldots, \tilde{A}_{n-1}$ and $\tilde{A}_n$ represent the linguistic values for not too many, not many, …, too many, and too many many.

iii. Generate the fuzzy logical relationship group.

(a) If the value of H_t is within the range of u_j, then H_t belongs to the fuzzy number $\tilde{A}_j$. All H_t must be classified into the corresponding fuzzy numbers.

(b) Derive the fuzzy logical relationship as $\tilde{A}_j \rightarrow \tilde{A}_k$, which means "If the H_{t-1} value of time $t-1$ is $\tilde{A}_j$, then that of time t is $\tilde{A}_k$."

(c) Establish the fuzzy logical relationship groups as $\tilde{A}_j \rightarrow \tilde{A}_{k1}$, $\tilde{A}_j \rightarrow \tilde{A}_{k2} \ldots \tilde{A}_j \rightarrow \tilde{A}_{kp}$.

iv. Determine the forecasted values at time t $\tilde{O}_t$ by using three heuristic rules from Chen and Hsu (2004) and Cheng et al. (2008) as follows:

- If the fuzzy logical relationship group of $\tilde{A}_j$ is empty, $\tilde{A}_j \rightarrow \phi$, then the value of O_t is $\tilde{A}_j$.
- If the fuzzy logical relationship group of $\tilde{A}_j$ is one-to-one, $\tilde{A}_j \rightarrow \tilde{A}_k$, the value of $\tilde{O}_t$ is $\tilde{A}_k$.
- If the fuzzy logical relationship group of $\tilde{A}_j$ is one-to-many, $\tilde{A}_j \rightarrow \tilde{A}_{k1}$, $\tilde{A}_j \rightarrow \tilde{A}_{k2}$, …, $\tilde{A}_j \rightarrow \tilde{A}_{kp}$, then the value $\tilde{O}_t$ is calculated as $\tilde{O}_t = \frac{\tilde{A}_{k1} \oplus \tilde{A}_{k2} \oplus \cdots \oplus \tilde{A}_{kp}}{p}$.

Phase 3: Verification of forecasting performance

Calculate the root-mean-square error (RMSE) to verify the forecasting accuracy. The formula is given as $\sqrt{\frac{\sum_{t=1}^{n} (O_t - R_t)^2}{n}}$ where R_t is the actual value, O_t is the forecasted value, and n is the number of data.

4 Forecasting Tourist Arrival

The proposed fuzzy forecasting model is illustrated using monthly data on tourist arrival to the state of Sabah in Malaysia from 2008 to 2011 as shown in Fig. 1.

Phase 1: The line chart in Fig. 1 shows that the data has seasonal pattern with December as the peak season compared to other months of the year. The deseasonalized data presented in Table 1 was obtained by using the moving average method and via Minitab software. The result of least square method shows that the deseasonalized data has ascending order trend pattern.

Phase 2: The length of interval $l = 10000$. The maximum ($D_{\min}$) deseasonalized data is 169533 in February 2009 and maximum ($D_{\max}$) deseasonalized data is 262666 in September 2011. Then, we obtained D_{low} and D_{up} as 160000 and 270000, respectively. Thus, the universe of discourse U is defined as $U = [160000, 270000]$. Eleven intervals were obtained which are $u_1 = [160,000, 170,000]$, $u_2 = [170,000, 180,000]$, …, $u_{11} = [260,000, 270,000]$. The TrFNs can be defined as follows:

$$\tilde{A}_1 = (160000, 160000, 170000, 180000), \quad \tilde{A}_2 = (160000, 170000, 180000, 190000), \ldots,$$
$$\tilde{A}_{10} = (240000, 250000, 260000, 270000), \quad \tilde{A}_{11} = (250000, 260000, 270000, 270000).$$

After fuzzifying the data in Table 1, the fuzzy logical relationship is developed and fuzzy logical relationship group is generated as shown in Table 2.

Table 3 shows the forecasted tourist arrivals $\tilde{O}_t$ from January 2010 to January 2012.

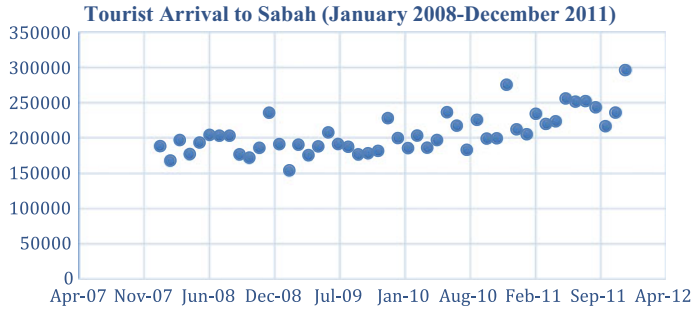

Fig. 1 Time series data for tourist arrival to Sabah (January 2008–December 2011) (Sabah Tourism Board Official Website 2013)

Table 1 Deseasonalize data from January 2010 to December 2011

Year	Month	Deseasonalized data	Year	Month	Deseasonalized data
2010	January	197843	2011	January	210157
	February	204457		February	226170
	March	199288		March	229800
	April	198824		April	235163
	May	203793		May	231428
	June	213116		June	230765
	July	209013		July	242063
	August	184689		August	254791
	September	243404		September	262666
	October	215166		October	234159
	November	211693		November	250676
	December	221744		December	238544

Table 2 The fuzzy logical relationship group

Group	Fuzzy logical relationship
1	$\tilde{A}_1 \rightarrow \tilde{A}_3$
2	$\tilde{A}_3 \rightarrow \tilde{A}_1, \tilde{A}_3 \rightarrow \tilde{A}_3, \tilde{A}_3 \rightarrow \tilde{A}_4, \tilde{A}_3 \rightarrow \tilde{A}_5, \tilde{A}_3 \rightarrow \tilde{A}_9$
3	$\tilde{A}_4 \rightarrow \tilde{A}_3, \tilde{A}_4 \rightarrow \tilde{A}_4, \tilde{A}_4 \rightarrow \tilde{A}_5$
4	$\tilde{A}_5 \rightarrow \tilde{A}_3, \tilde{A}_5 \rightarrow \tilde{A}_4, \tilde{A}_5 \rightarrow \tilde{A}_6$
5	$\tilde{A}_6 \rightarrow \tilde{A}_5, \tilde{A}_6 \rightarrow \tilde{A}_6, \tilde{A}_6 \rightarrow \tilde{A}_7$
6	$\tilde{A}_7 \rightarrow \tilde{A}_6, \tilde{A}_7 \rightarrow \tilde{A}_7, \tilde{A}_7 \rightarrow \tilde{A}_8$
7	$\tilde{A}_8 \rightarrow \tilde{A}_8, \tilde{A}_8 \rightarrow \tilde{A}_9, \tilde{A}_8 \rightarrow \tilde{A}_{10}$
8	$\tilde{A}_9 \rightarrow \tilde{A}_6, \tilde{A}_9 \rightarrow \tilde{A}_{10}$
9	$\tilde{A}_{10} \rightarrow \tilde{A}_8, \tilde{A}_{10} \rightarrow \tilde{A}_{11}$
10	$\tilde{A}_{11} \rightarrow \tilde{A}_8$

5 Discussion

Based on Table 3, the forecasted tourist arrivals for January 2012 are 230000, 240000, 250000, and 260000. The possible forecasted intervals under different degrees of confidence $\alpha \in [0, 1]$ are shown in Table 4.

At minimum confidence level $\alpha = 0$ (maximum uncertainty), the forecasted interval is [230000, 260000]. Under maximum confidence level $\alpha = 1$ (minimum uncertainty), the forecasted interval is [240000, 250000]. Thus, the forecasted range under different degrees of confidence can be easily determined which shows that the proposed forecasting model gives more information on the forecasted values compared to data in the form of discrete fuzzy sets. The forecasted values were defuzzified to crisp numbers using the centroid method. The forecasting accuracy of the proposed model was measured by using RMSE with value 21421 compared to 83460 using Ramli et al.'s (2015) method with natural partitioning length.

Table 3 Final forecasted value $\tilde{O}_t$

Year	Month	$\tilde{O}_t$	Year	Month	$\tilde{O}_t$
2010	January	(186000, 194000, 204000, 214000)	2011	January	(210000, 220000, 230000, 240000)
	February	(180000, 190000, 200000, 210000)		February	(200000, 210000, 220000, 230000)
	March	(183333, 193333, 203333, 213333)		March	(210000, 220000, 230000, 240000)
	April	(180000, 190000, 200000, 210000)		April	(210000, 220000, 230000, 240000)
	May	(180000, 190000, 200000, 210000)		May	(230000, 240000, 250000, 260000)
	June	(183333, 193333, 203333, 213333)		June	(230000, 240000, 250000, 260000)
	July	(200000, 210000, 220000, 230000)		July	(230000, 240000, 250000, 260000)
	August	(183333, 193333, 203333, 213333)		August	(220000, 230000, 240000, 250000)
	September	(186000, 194000, 204000, 214000)		September	(235000, 245000, 255000, 265000)
	October	(220000, 230000, 240000, 250000)		October	(220000, 230000, 240000, 250000)
	November	(200000, 210000, 220000, 230000)		November	(230000, 240000, 250000, 260000)
	December	(200000, 210000, 220000, 230000)		December	(235000, 245000, 255000, 265000)
			2012	January	(230000, 240000, 250000, 260000)

Table 4 Forecasted intervals with different degrees of confidence for January 2012

Degree of confidence, $\alpha \in [0, 1]$	Forecasted interval
0	[230000, 260000]
0.1	[231000, 259000]
0.2	[232000, 258000]
0.3	[233000, 257000]
0.4	[234000, 256000]
0.5	[235000, 255000]
0.6	[236000, 254000]
0.7	[237000, 253000]
0.8	[238000, 252000]
0.9	[239000, 251000]
1	[240000, 250000]

6 Conclusion

This paper proposes an integrated fuzzy forecasting model based on TrFNs approach with deterministic length to forecast tourist arrival to the state of Sabah. The proposed forecasting model is more flexible as it can provide various forecasted intervals under different degrees of confidence instead of the single-point value offered by most of the previous forecasting method. The higher the values of α, the smaller the forecasted output values of length interval which indicates that the forecasted range is more precise at higher confidence level. The RMSE of the proposed model is smaller than the method by Ramli et al. (2015) and thus has a better performance.

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Chapter 84
Benchmarking Service Quality in Retail Store Using DEA

Ummi Humaira Akmal Alias, Siti Rosiah Mohamed and Nor Habibah Tarmuji

Abstract One of the main reasons to produce a single set of service quality evaluation across dimension is by involving benchmarking comparison. The quality of the service will only be determined if the assessment on the various dimensions of service quality and the satisfaction of consumer is measured. It is important to measure the efficiency of each dimension to provide the best returns. However, this approach often encounters problems because of the resource demand. The aims of this study are to design a comprehensive input and output frameworks based on SERVQUAL items of retail stores on service quality and to evaluate data using Data Envelopment Analysis (DEA) model. Questionnaires are distributed to 132 respondents. The collected data are analyzed by using SPSS and Lingo software. In this study, four input variables (reliability, tangible, assurance, and responsiveness) and one output (empathy) of the dimension of SERVQUAL are analyzed. The findings show only two Decision-Making Units (DMUs) out of eight DMUs that are efficient. Meanwhile, six DMUs are inefficient with the score between 0.914 and 0.996. All DMUs which are efficient show that the company is good in providing the service to the customer.

Keywords Data envelopment analysis · Decision-making units
Service quality

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_84

1 Introduction

Recently, service quality has been identified as an important key to increase business performance and become a strategic tool to gain competitive advantage. Practitioners and academicians have given great concern for this service quality for over decades. There are a lot of research, models, and experiments that have been carried out in evaluating the service quality (Lee and Kim 2014). Parasuraman et al. (1985) defined service quality as a key figure in the difference between expectations and performance. Later, Berry et al. (1994) stated that service quality is a concept that is vague and imprecise. In order to meet up sale targets of a product or service, the service quality and customer satisfaction play important roles (Blose et al. 2005). Somehow, to meet the crucial goal of a firm, the incremental cost of service quality per unit may give the additional benefits to the firm (Blose et al. 2005; Berry et al. 1994). Therefore, it is essential for a company that provides services to give attention to the service quality in order to avoid dissatisfaction among customers (Sumaedi and Yarmen 2015).

It is difficult to determine the quality of service when the elusive quality of service cannot be identified and resolved like an assessment of equipment, facilities, and employee (Najafi et al. 2014). Based on studies that have been conducted, the results achieved consensus that the quality of service and customer's satisfaction are inextricably linked and cannot be doubted. The strength and survival of a company to stay exist in the business is perceived by customer loyalty (Alabar et al. 2014).

Despite all previous studies, the most popular scale used to measure service quality that is proposed by Parasuraman et al. (1985) is SERVQUAL (SERV—service and QUAL—quality. SERVQUAL scale has been generally studied by researchers in an attempt to determine the quality of service despite managing many criticisms involving the scale (Caruana et al. 2000). Caruana et al. (2000) discussed the analysis in evaluating data using SERVQUAL which had been done through each item and dimension, based on the gap analysis method. Statistical analysis, Multi-criteria Decision-Making (MCDM), Fuzzy set theory, and Data Envelopment Analysis (DEA) are some examples of analysis that have used SERVQUAL to evaluate the results.

SERVQUAL is mostly being used in evaluating the customer perception and expectation based on a set of gaps identified by the company (Parasuraman et al. 1985). It contains about 22 items to assess the customer's perception and expectation of actual performance over five-domain dimension called RATER: reliability, assurance, tangible, empathy, and responsiveness. The customer could evaluate the service, according to those dimensions as shown in Table 1 (Parasuraman et al. 1988). Each dimension is divided into four or five items which later to be measured. Table 1 shows the list of items that have been generalized into five dimensions of SERVQUAL.

The retail store is a business that can be categorized as a service business. Referring to the above statement, retail stores need to analyze and improve its

Table 1 Items of SERVQUAL model (*Source* Parasuraman et al. 1988)

Dimension	List of items
Reliability	Finish the task in the given time Reassure and sympathetic on the customer Dependable Provide services at the time needed Keep accurate results
Assurance	The customer needs to believe in the workers Workers need to act politely The customer should feel secure with the store workers Workers should get fair supports to settle their jobs
Tangible	Need to have the latest appliances Workers should have a tidy and hygienic uniform Physical facilities need to look nice The presentation of physical facilities needs to suit with the type of service supplier
Empathy	A company could not give an assumption on individual's intention A company could not give an assumption on customer personal Impractical to assume workers to have an idea of what the customer needs Impractical for them to have the customer's best interest at heart Should not be expected to have operating hours convenient for all customers
Responsiveness	Need to be good at keeping information The customer needs to be patient while waiting to be served Workers only need to give help when being called Customers need to understand the condition when workers are busy with other jobs

service quality to obtain the maximum goal of business. Therefore, the managerial level needs to know how to measure the service quality. A study by Tanwar et al. (2012) has measured the service quality in entire India and discovered that convenience is the best practice in textile retailing as India has undergone unexpected growth rate for about almost fifty percent in grocery retailing in a few years later. Huddleston et al. (2009) discussed the satisfactions on conventional grocery store against specialty grocery retail store. Conventional grocery stores put more focus on the big scope of business rather than specialty grocery stores. Mahfooz (2014) discovered the satisfaction on hypermarket, and the result had justified the aspect of physical facilities, clean, and hygienic public area and sufficient amenities as the best elements in grabbing the customer's satisfaction to visit the hypermarket.

According to Malaysian Retailer Association (2015), the retail store had recorded a growing rate of 4.6% in retail sales during the first quarter year of 2015. But it had to be declined in the second quarter for 3% due to the implementation of Good and Service Tax (GST). In the third quarter, the growth was expected to be at 4.8% and becomes stronger in the fourth quarter with 6.9% (A).

Hence, one of the objectives of this study is to design a comprehensive input and output framework based on SERVQUAL items of retail stores on service quality. It

also aims to evaluate the input and output using Data Envelopment Analysis (DEA) model based on which CCR-I is an input-oriented model and CCR-O is an output-oriented model in Bandar Tun Abdul Razak, Jengka.

1.1 Data Envelopment Analysis (DEA)

DEA is originally produced by Farrel (1957) and extended by Charnes et al. (1978) as a developmental method to measure the efficiency of organization's relative performance which includes the multiple inputs and outputs (Thomas et al. 1998). DEA is used to compare all the inputs and outputs at the same times for all units of organization, which recognizes the best solutions that can be implemented to increase the efficiency of a business (Soteriou and Stavrinides 2000). By using DEA, the sources of inefficiency can be analyzed and identified by each unit. Therefore, producing a single set of evaluation on service quality with DEA method will give a solution in managing service in retail stores through each dimension of SERVQUAL model.

Numerous recent studies have implemented DEA as a benchmarking tool to evaluate the service quality. However, benchmarking on a single output is still less in previous studies to identify the limitation and the level of service quality. One of the main reasons to produce a single set of evaluation of service quality across dimension is by involving through benchmarking comparison. Service quality is not a firm, but it is a thing to be achieved by the firm. Service quality measurement can help to identify weaknesses in the management of the service. The quality of the service will only be known if the assessment on the various dimensions of service quality as well as the satisfaction of the consumer is evaluated. It is important to measure the efficiency of each dimension or source level which must be maximized to provide the best returns. Therefore, the performance measurement is an important part of every dimension but this approach often encounters problems because of the resources invested. To reduce these failures, this research implements an extensive framework based on the dimension of SERVQUAL model and using the DEA to measure service quality of retail stores.

1.2 CCR-Oriented Model Input (CCR-I) and CCR-Oriented Model Output (CCR-O)

Charnes et al. (1978) invented the CCR model and it was the first model of DEA. This model is capable of combining weights for different inputs and outputs. There are two types of CCR model which are CCR-1 and CCR-O. CCR-I is an input-oriented model and CCR-O is an output-oriented model.

CCR-oriented model input (CCR-I)	CCR-oriented model output (CCR-O)
Max $e_o = \sum_{j=1}^{s} w_j y_{jo}$	Min $e_o = \sum_{i=1}^{r} v_i x_{io}$
Subject to	Subject to
$\sum_{i=1}^{r} v_i x_{im} - \sum_{j=1}^{s} w_i y_{jm} \geq 0;\ m = 1, \ldots, n$ $\sum_{i=1}^{r} v_i x_{io} = 1$	$\sum_{i=1}^{r} v_i x_{im} - \sum_{j=1}^{s} w_j y_{jm} \geq 0;\ m = 1, \ldots, n$ $\sum w_j y_o = 1$ $w_j \geq 0, j = 1, 2, \ldots s$ $v_i \geq 0, i = 1, 2, \ldots r$
with	with
y_{jo} = jth output of the oth DMU	y_{jo} = jth output of the oth DMU
y_{jm} = jth output of the mth DMU	y_{jm} = jth output of the mth DMU
x_{io} = ith input of the oth DMU	x_{io} = ith input of the oth DMU
x_{im} = ith input of the mth DMU	x_{im} = ith input of the mth DMU
w_j = weight of the nonnegative jth output	w_j = weight of the nonnegative jth output
v_j = weight of the nonnegative jth input	v_j = weight of the nonnegative jth input
n = numbers of DMUs	n = numbers of DMUs
s = numbers of outputs	s = numbers of outputs
r = numbers of inputs	r = numbers of inputs
e_o = the efficiency score of the DMUo	e_o = the efficiency score of the DMUo

2 DEA–SERVQUAL Approach

The selection of an input and output is quite difficult because there are many potential variables to be evaluated. Input is referred as all parts that have been utilized by the DMUs to generate an output that gives effect on the performance of DMUs (Decision-Making Units). Input and output of this research are evaluated based on the SERVQUAL model. Figure 1 shows how the SERVQUAL model is used for the evaluation.

Based on Fig. 1, the dimensions of SERVQUAL were used as the independent variables on the evaluation of customer's satisfaction. Five dimensions of the SERVQUAL model by Parasuraman et al. (1985) were listed based on previous research by Blose et al. (2005). 20 items were generated in this survey. The dimensions were summarized and used as inputs and outputs for retail stores in Bandar Tun Abdul Razak, Jengka. Each criterion was analyzed using "**Likert-Scale**" in scales of ***Strongly Disagree (1)*** until ***Strongly Agree (5)*** for quality evaluation of retail stores. Then, DEA was conducted with simulated data set of SERVQUAL. The value of efficiency lies between the values of 0 and 1. DMUs with the efficiency score of 1 are considered efficient and can be a reference set for the inefficient DMUs. The efficiency was generated with CCR model by

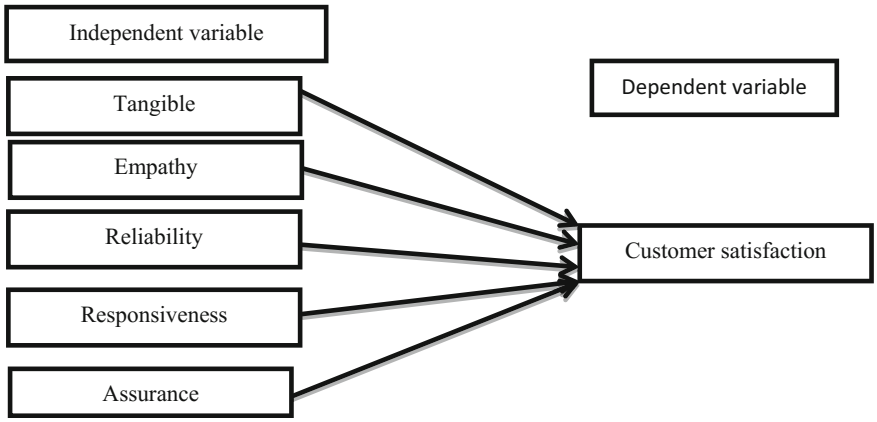

Fig. 1 Theoretical framework of SERVQUAL (*Source* Bharwana et al. 2013)

Table 2 Input and output data from retail store perception survey

	Input				Output
	1	2	3	4	*1
1	3.28	3.44	3.2	3.51	3.36
2	3.56	3.85	3.69	4.0	3.6
3	3.42	3.46	3.68	3.64	3.54
4	3.53	3.59	3.52	3.71	3.74
5	3.25	3.28	3.29	3.42	3.45
6	3.48	3.32	3.07	3.44	3.69
7	3.53	3.43	3.15	3.7	3.43
8	3.13	2.85	2.86	3.07	3.15

The average value of SERVQUAL model
1 = Responsiveness average dimension-level scores
2 = Reliability average dimension-level scores
3 = Tangible average dimension-level score
4 = Assurance average dimension-level scores
*1 = Empathy average dimension-level score (output variable of DEA)

Charnes et al. (1978). CCR-I and CCR-O models are used in this study. Table 2 shows the input and output data from retail store perception survey.

The efficiency score for CCR-I and CCR-O model is shown in Table 3.

By referring to Table 3, the eight DMUs, A, B, C, D, E, F, G, and H, are ranked based on the efficiency score. Based on CCR-I and CCR-O model, DMU E and DMU F are efficient with score of efficiency as one. Meanwhile, DMU A, B, C, D, G, and H are not efficient with the scores of 0.998, 0.994, 0.975, 0.965, and 0.916 according to the test via CCR-I model. By using CCR-O models, DMU A, B, C, D, G, and H are not efficient with the score of 1.0016, 1.0056, 1.0352, 1.0359, 1.0497, and 1.0016. So, the duality formulation by using vector input and output was used.

Table 3 Efficiency score obtained from CCR-I and CCR-O models

Model				
Rank	DMU	CCR-1	CCR-O	Efficiency
1	E	1	1	Efficient
1	F	1	1	Efficient
3	D	0.9980	1.0016	Not efficient
4	H	0.9940	1.0056	Not efficient
5	C	0.9750	1.0252	Not efficient
6	A	0.9650	1.0359	Not efficient
7	B	0.9560	1.0497	Not efficient
8	G	0.9160	1.0016	Not efficient

Table 4 Reference set and duality formulation using CCR-I model

DMU	Reference set	Duality	
		DMU E	DMU F
A	DMU E and F	0.6994	0.2565
B	DMU E and F	1.0430	0
C	DMU E and F	0.6885	0.3155
D	DMU E and F	0.7942	0.2709
G	DMU E and F	0.0776	0.8568
H	DMU E and F	0	0.8536

Table 5 Reference set and duality formulation using CCR-O model

Model	Reference set	Duality	
		Model E	Model F
A	DMU E and F	0.7246	0.2658
B	DMU E and F	1.0954	0
C	DMU E and F	0.7059	0.3235
D	DMU E and F	0.7956	0.2714
G	DMU E and F	0.0848	0.9351
H	DMU E and F	0	0.8584

The vector average input and output of non-efficient for DMU A, B, C, D, G, and H were calculated, and the results are tabulated in Tables 4 and 5.

Based on Tables 4 and 5, it can be seen that DMU E and F are the reference sets for DMU A, B, C, D, G, and H as well as duality score for each DMU for CCR-I and CCR-O models.

Table 6 shows that the comparison between original input and input target for DMU A, B, C, D, G, and H is reduced from the original input. From the results obtained, all inputs should be reduced. It means the dimension of the reliability,

Table 6 Comparison between original input and input target for CCR-I model

DMU	Input	Original input	Input target	Result
A	I1	3.28	3.17	Input I1 reduce
	I2	3.44	3.15	Input I2 reduce
	I3	3.2	3.09	Input I3 reduce
	I4	3.51	3.27	Input I4 reduce
B	I1	3.56	3.39	Input I1 reduce
	I2	3.85	3.42	Input I2 reduce
	I3	3.69	3.43	Input I3 reduce
	I4	4.0	3.57	Input I4 reduce
C	I1	3.42	3.48	Input I1 reduce
	I2	3.46	3.31	Input I2 reduce
	I3	3.68	3.23	Input I3 reduce
	I4	3.64	3.44	Input I4 reduce
D	I1	3.53	3.52	Input I1 reduce
	I2	3.59	3.5	Input I2 reduce
	I3	3.52	3.44	Input I3 reduce
	I4	3.71	3.65	Input I4 reduce
G	I1	3.53	3.23	Input I1 reduce
	I2	3.43	3.10	Input I2 reduce
	I3	3.15	2.89	Input I3 reduce
	I4	3.70	3.21	Input I4 reduce
H	I1	3.13	2.97	Input I1 reduce
	I2	2.85	2.83	Input I2 reduce
	I3	2.86	2.62	Input I3 reduce
	I4	3.07	2.94	Input I4 reduce

tangible, assurance, and responsiveness should be analyzed in order to identify at what characteristic should the retailers need to concentrate to attract customer. After the minimization of the inputs, the output will be optimized. In other words, customer will attract to visit the store again.

From Table 7, mostly input target reduces from the original input. The overall results show that the dimension of reliability and assurances are the important aspects that should be concerned. Most of the DMUs have problem dealing with the customer through employee's behavior. Therefore, the retailers in Bandar Tun Abdul Razak, Jengka should organize teamwork building workshop among the retailers in order to enhance their employee's skills and learn proper attitude. For the output, by viewing Table 8, the output target shows increasing values from original output only for DMU C and H, while other DMUs give a decreasing value. The DMUs with decreasing value need to improve their output. As for these DMUs, the retailers might perform some improvement on the safety of their store environment and add more selection of items at the store.

Table 7 Comparison between original input and input targets for CCR-O model

DMU	Input	Original input	input target	Result
A	I1	3.28	3.28	Input I1 fixed
	I2	3.44	3.26	Input I2 reduce
	I3	3.2	3.2	Input I3 fixed
	I4	3.51	3.39	Input I4 reduce
B	I1	3.56	3.56	Input I1 fixed
	I2	3.85	3.59	Input I2 reduce
	I3	3.69	3.60	Input I3 reduce
	I4	4.0	3.75	Input I4 reduce
C	I1	3.42	3.42	Input I1 fixed
	I2	3.46	3.39	Input I2 reduce
	I3	3.68	3.32	Input I3 reduce
	I4	3.64	3.53	Input I4 reduce
D	I1	3.53	3.43	Input I1 reduce
	I2	3.59	3.41	Input I2 reduce
	I3	3.52	3.35	Input I3 reduce
	I4	3.71	3.55	Input I4 reduce
G	I1	3.53	3.53	Input I1 fixed
	I2	3.43	3.38	Input I2 reduce
	I3	3.15	3.15	Input I3 fixed
	I4	3.70	3.51	Input I4 reduce
H	I1	3.13	2.99	Input I1 reduce
	I2	2.85	2.85	Input I2 fixed
	I3	2.86	2.64	Input I3 reduce
	I4	3.07	2.95	Input I4 reduce

Table 8 Comparison between original output and output targets for CCR-O model

DMU	Output	Original output	Output target	Result
A	O1	3.36	3.48	Output O1 reduce
B	O1	3.6	3.18	Output O1 reduce
C	O1	3.54	3.63	Output O1 increase
D	O1	3.74	3.64	Output O1 reduce
G	O1	3.43	3.74	Output O1 increase
H	O1	3.15	3.17	Output O1 increase

3 Conclusions and Recommendations

The problem of efficiency improvement has been investigated using CCR-I and CCR-O models. The study has used eight models which are DMU A, B, C, D, E, F, G, and H. It is found that DMU E and DMU F are efficient, while DMU A, B, C, D, G, and H are not efficient. In this study, four inputs and one output are used to illustrate the proposed models. The four inputs are reliability, responsiveness, tangible, and assurance, while the output is empathy. With reliability test, the researcher can seek for which sub-element the retailer can upgrade in order to improve their performance. Besides, they can view the relationship between customer and employee, what scope of job need to take action, and what facilities should be added.

From the calculation based on inefficient models using duality formulation, reference sets and vector average input and output are obtained. The comparison between original input and output is settled with a result that has proven the objectives of the study. In the future, the study can be extended by increasing the number of respondents. Moreover, by enlarging the scope of input and output that have been used in this study, it might contribute to more valuable result for retail stores in Bandar Tun Abdul Razak Jengka, Pahang.

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Chapter 85
Academic Poster Evaluation by Mamdani-Type Fuzzy Inference System

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Abstract The evaluation of poster presentation involves decision-making based on multiple criteria that are mostly subjective in nature. A detailed rubric assessment tool is usually used to facilitate the decision-making process. However, this process can be challenging due to the factors of imprecision and vagueness in human judgement. Therefore, there is a need to develop a new evaluation method that can overcome this problem. Fuzzy Inference System (FIS) has been successfully applied in many fields such as automatic control, data classification, expert systems and management science. This study proposed an FIS model for the evaluation process of students' academic poster. The development of the model involved four inputs and one output with 256 rules has been created. The Mamdani inference with trapezoidal fuzzy numbers and centroid defuzzification are implemented in this development process via MATLAB software. Comparison between the FIS method and the conventional method yields different ranking results. Also, the poster rating obtained from the FIS method is thought to be aligned with human reasoning. Conclusively, this model demonstrates that it is more flexible, reliable, and provides ease of use to decision-makers.

Keywords Academic evaluation · Fuzzy inference system · Human judgement

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_85

1 Introduction

Poster presentation has been widely accepted as a good assessment method in teaching and learning. Mcnamara et al. (2010) proved that poster presentation is an effective method to assess various learning outcomes and soft skills among students. In evaluating poster presentations, multiple criteria are considered, such as design, informative, organization and readability, among others. These criteria are often subjective in nature and require linguistic terms to best describe the performance of such works rather than precise crisp values.

In a classical evaluation, poster presentation is usually assessed using detailed rubric assessment tool. However, the final score obtained from the rubric assessment is only based on the average of the score ratings that does not reflect the actual subjectivity of human opinion. Mcloone (2012) stated that there may exist complex situations where two evaluators can have totally different views for the same work, or they agree with the standard of the work but different marks were given for the same grade. Hence, there is a need to develop a new evaluation method that can overcome this problem.

The concept of fuzzy logic can help to quantify the subjectivity of human opinion or judgement. Fuzzy logic theory has been used as a tool in fields of sciences and humanities. It has also been incorporated into the measurement and evaluation technique in education (Gokmen et al. 2010). Sulaiman and Mohamad (2006) developed a fuzzy logic decision model in a case study of ranking the best student in a scholarship selection problem. Saxena and Saxena (2010) found that the fuzzy logic is very useful to analyse the performance of students based on marks and attendance. McLoone (2012) found that the fuzzy logic model produces a fair assessment for poster evaluation compared to the traditional methods using numerical value. Several studies have proposed a fuzzy logic model to assess students' performance academically and holistically (Ingoley and Bakal 2012; Kharola et al. 2015; Bouslama et al. 2006). Apart from that, the fuzzy logic technique has also been used in evaluation problem of teachers' performance and their appraisal (Pavani et al. 2012).

Though the current practice of using rubric assessment tool can give the evaluation score, it is unable to indicate the subjectivity of human judgement and human reasoning. Thus, poster evaluation based on Fuzzy Inference System (FIS) is a new poster evaluation method developed based on the rule of fuzzy inference system to ensure that the students receive fair grades and meet the demands of the university. Since it is based on FIS expressed in the form of IF-THEN rules, the evaluation process is seen to be aligned with human logical thinking. Therefore, it is believed that FIS can give an evaluation that is fair and consistent with human intuition. In this paper, FIS method is used in a case study of an undergraduate final year project poster presentations of Faculty of Computer and Mathematical Sciences (FSKM), Universiti Teknologi MARA, Pahang.

2 Fuzzy Inference System

Fuzzy inference is the process of formulating the mapping from a given input to an output based on fuzzy logic. Fuzzy inference system (FIS) comprises three basic stages which are fuzzification, fuzzy inference rule and defuzzification. Figure 1 shows the structure of FIS based on Ingoley and Bakal (2012). In the fuzzification stage, the crisp inputs are transformed to fuzzy values such as triangular fuzzy numbers, trapezoidal fuzzy numbers or Gaussian fuzzy numbers. Then, the fuzzified inputs are applied to the antecedents of the fuzzy inference rules. A fuzzy inference rule is of the form '*if antecedent then consequent*', with antecedent is a fuzzy logic expression composed of one or more simple fuzzy expressions connected by fuzzy operators, and the consequent is an expression that assigns fuzzy values to the output variables. The fuzzy inference rules produce fuzzy outputs which are transformed into crisp values via defuzzification process namely as centroid method.

2.1 Fuzzy Inference System for Poster Evaluation Model

In this paper, the FIS for poster evaluation has been tested on 21 posters presented in the Bachelor of Computational Mathematics final year project poster exhibition. The panel judges were chosen from the academic staff members of FSKM. The posters were evaluated based on four criteria namely 'Organization' (O), 'Content' (C), 'Appearance' (A) and 'Written Word' (W). These criteria were used as the input variables and the rating of the poster (P) is set as the output variable. Tables 1 and 2 present the trapezoidal fuzzy numbers of input and output variables. A view of FIS for poster evaluation is shown in Fig. 2.

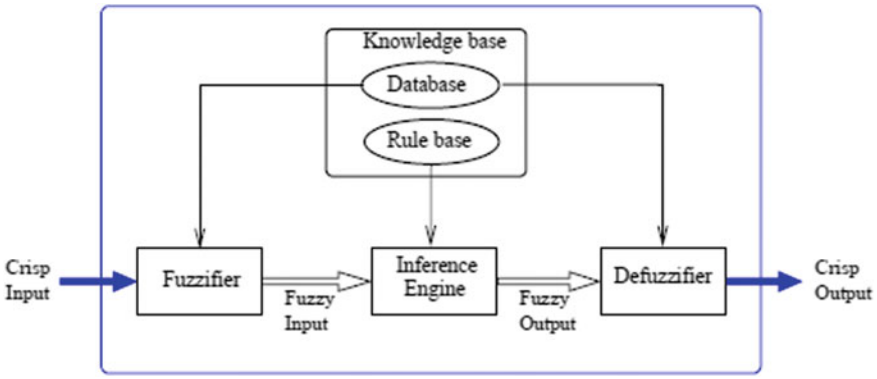

Fig. 1 Basic structure of FIS (Ingoley and Bakal 2012)

Table 1 Trapezoidal fuzzy numbers of input variables

Input variables	
Linguistic values	*Trapezoidal Fuzzy numbers*
Poor (P)	(1, 1, 4, 5)
Satisfactory (S)	(4, 5, 6, 7)
Good (G)	(6, 7, 8, 9)
Excellent (E)	(8, 9, 10, 10)

Table 2 Trapezoidal fuzzy numbers of output variable

Output variables	
Linguistic values	*Trapezoidal Fuzzy numbers*
Not preferred	(0, 0, 25, 30)
Less preferred	(40, 45, 55, 60)
Moderately preferred	(55, 60, 70, 75)
Preferred	(70, 75, 85, 90)
Highly preferred	(85, 90, 100, 100)

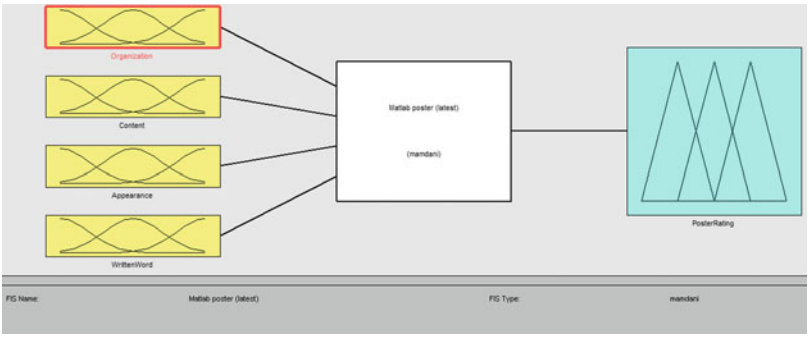

Fig. 2 Poster evaluation model using FIS

Based on experts' opinion, 256 decision rules using Mamdani model were developed for the poster evaluation. Table 3 displays the construction of some of the decision rules with the AND operation applied to the inputs.

The membership functions of all rules are aggregated to a single fuzzy set. Then, by using the centroid defuzzification method, the fuzzy output is transformed to a crisp value.

Table 3 Construction of fuzzy inference rules

No	Input				Output
	Organization	Content	Appearance	Written word	Poster rating
1	Excellent	Excellent	Excellent	Excellent	Highly preferred
2	Excellent	Excellent	Excellent	Good	Highly preferred
3	Excellent	Excellent	Excellent	Satisfactory	Moderately preferred
4	Excellent	Excellent	Excellent	Poor	Less preferred
5	Excellent	Excellent	Good	Excellent	Highly preferred
6	Excellent	Excellent	Good	Good	Preferred
7	Excellent	Excellent	Good	Satisfactory	Moderately preferred
⋮					
243	Poor	Poor	Excellent	Satisfactory	Least preferred
244	Poor	Poor	Excellent	Poor	Not preferred
245	Poor	Poor	Good	Excellent	Least preferred
246	Poor	Poor	Good	Good	Least preferred
247	Poor	Poor	Good	Satisfactory	Least preferred
248	Poor	Poor	Good	Poor	Not preferred
249	Poor	Poor	Satisfactory	Excellent	Least preferred
250	Poor	Poor	Satisfactory	Good	Least preferred
251	Poor	Poor	Satisfactory	Satisfactory	Least preferred
252	Poor	Poor	Satisfactory	Poor	Not preferred
253	Poor	Poor	Poor	Excellent	Not preferred
254	Poor	Poor	Poor	Good	Not preferred
255	Poor	Poor	Poor	Satisfactory	Not preferred
256	Poor	Poor	Poor	Poor	Not preferred

2.2 *Numerical Example*

In this paper, MATLAB (version R2008b) was used in the implementation of the proposed fuzzy system for FIS. Figure 3 shows the inference process of obtaining the final output (rating) for poster 13. The scores given by the Evaluator 2 are 9 for 'Organization', 7 for 'Content', 7 for 'Appearance' and 9 for 'Written Word'. The output poster rating is 85.6 which is obtained after the defuzzification process. The other scores are shown in Table 4.

Table 4 shows that the inputs for 21 poster scores are fed into the model presented (example shown in Fig. 3). When the results are evaluated, a difference in outcomes is seen between the conventional method and proposed a fuzzy logic

Fig. 3 The inference process of obtaining the final output (rating) for poster number 13

method. The conventional method adheres to a constant average mathematical rule where the average score is divided by 2. Meanwhile, evaluation with fuzzy logic has great flexibility based on human reasoning. Comparison of the conventional and proposed model methods is shown in Table 5, the percentage average for poster rating from FIS along with the final results from the conventional method of grading for 21 posters.

For example, the average score for poster 1 is 69 by using the conventional method, but in FIS method, the average score is 69.55. In FIS method, the output was defuzzified by calculating the centroid of resulting geometrical shape as shown in Fig. 3 to produce the poster rating of moderately preferred (previously described in Table 2). This sequence was repeated using the scores from Evaluator 1 and 2 for each poster. As shown in Table 5, the poster rating numbers 8 and 21 are classified as 'Less Preferred'; poster rating numbers 5, 6 and 19 are classified as 'Preferred'; poster rating numbers 1, 3, 9, 10, 11 and 18 are classified as 'Moderately Preferred' and nine favourable posters which are rated as 'Highly Preferred' are for poster numbers 2, 6, 7, 12, 13, 14, 15, 17 and 20. Based on poster ranking in the conventional method, poster number 17 won the highest score with 81.5 marks and poster number 8 scores the lowest mark which is 59.5. The FIS method conforms to human reasoning and it can be interpreted that posters 17 and 20 are the best among all posters presentation which have the same score of 89.8% and the lowest are

Table 4 Inputs and outputs for poster scores

Poster No	Input (evaluator 1)				Output (FIS method)	Input (evaluator 2)				Output (FIS method)
Weightage	3	2	2	3		3	2	2	3	
	O	C	A	W		O	C	A	W	
1	7	7	8	7	85.6	6	8	7	6	53.5
2	8	7	8	8	85.6	8	8	7	7	85.6
3	7	6	6	4	53.5	8	7	8	8	85.6
4	8	8	8	7	85.6	7	7	8	7	85.6
5	7	8	7	8	85.6	8	6	7	7	69.6
6	7	8	7	7	85.6	8	8	8	8	85.6
7	7	7	8	8	85.6	7	7	7	7	85.6
8	6	7	6	7	53.5	5	6	6	5	53.5
9	6	6	6	6	53.5	7	7	6	7	69.6
10	5	7	6	7	53.5	7	8	8	7	85.6
11	6	6.5	7	7	53.5	7	7	7	6	69.6
12	8	7.5	7	8	85.6	8	8	8	8	85.6
13	7	7	7	7	85.6	9	7	7	9	85.6
14	7	7	7	8	85.6	7	8	7	7	85.6
15	8	8	9	8	85.6	8	8	8	8	85.6
16	8	8	8	8	85.6	7	6	7	6	69.6
17	8	8	7	7	85.6	9	8	9	9	93.9
18	5	5	5	5	53.5	8	9	8	8	85.6
19	8	9	9	6	69.6	8	8	8	8	85.6
20	8	8	7	7	85.6	9	9	9	8	93.9
21	6	8	7	6	53.5	6	6	6	5	53.5

**O Organization; C Content; A Appearance; W Written word

posters 8 and 21 sharing the score of 53.5%. Besides that, the best posters also considering the weightage of each criterion (input) as shown in Table 4. Therefore, the FIS method is more reliable because it resembles the human reasoning capabilities and also considering the 256 decision rules.

3 Conclusion

This paper proposed an alternative model to evaluate academic poster rating based on expert human reasoning. The input criteria considered in this research are organization, content, appearance and written word. Based on the result and analysis obtained, poster rating numbers 17 and 20 are ranked the best ranking among the tested 21 posters and are classified as 'Highly Preferred'. Meanwhile, poster numbers 8 and 21 have the lowest score for overall main criteria. The results

Table 5 Percentage average for poster rating and rank for both conventional and fuzzy methods

Poster No	Conventional method				Fuzzy method				
	Evaluator		Average score	Poster ranking	Evaluator		Average score	Poster ranking	Poster rating
	1	2			1	2			
1	72	66	69	10	85.6	53.5	69.55	4	Moderately preferred
2	78	75	76.5	5	85.6	85.6	85.6	2	Highly preferred
3	57	78	67.5	12	53.5	85.6	69.55	4	Moderately preferred
4	77	72	74.5	7	85.6	85.6	85.6	2	Highly preferred
5	75	71	73	8	85.6	69.6	77.6	3	Preferred
6	72	80	76	6	85.6	85.6	85.6	2	Highly preferred
7	75	70	72.5	9	85.6	85.6	85.6	2	Highly preferred
8	65	54	59.5	17	53.5	53.5	53.5	6	Less preferred
9	60	68	64	15	53.5	69.6	61.55	5	Moderately preferred
10	62	74	68	11	53.5	85.6	69.55	4	Moderately preferred
11	66	67	66.5	13	53.5	69.6	61.55	5	Moderately preferred
12	77	80	78.5	4	85.6	85.6	85.6	2	Highly preferred
13	70	82	76	6	85.6	85.6	85.6	2	Highly preferred
14	73	72	72.5	9	85.6	85.6	85.6	2	Highly preferred
15	82	80	81	2	85.6	85.6	85.6	2	Highly preferred
16	80	65	72.5	9	85.6	69.6	77.6	3	Preferred
17	75	88	81.5	1	85.6	93.9	89.8	1	Highly preferred
18	50	82	66	14	53.5	85.6	69.55	4	Moderately preferred
19	78	80	79	3	69.6	85.6	77.6	3	Preferred
20	75	87	81	2	85.6	93.9	89.8	1	Highly preferred
21	66	57	61.5	16	53.5	53.5	53.5	6	Less preferred

demonstrate that the FIS model provides different results compared to the conventional method. The variation of value shows that the FIS method is more flexible and reliable for academic staff to evaluate the poster presentation.

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Chapter 86
Formulation of Evidences in Pointwise Form for Some Jaccard Ranking Fuzzy Numbers

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Abstract The ranking of fuzzy numbers becomes an important part of the component in the decision-making process and procedure. Various ranking methods have been developed but some of the methods have a lengthy calculation, computationally complex and difficult to implement. In this paper, the formulation of evidences in pointwise form for Jaccard ranking index is proposed. Generalized trapezoidal fuzzy numbers Types 1, 2 and 3 have been selected. The procedure to obtain the evidences in pointwise form involved four phases, which are determining the fuzzy maximum and minimum, fuzzy intersection and union, fuzzy evidences and simplification using Maple software. The results show that the values of evidences can be directly determined from the point of the fuzzy numbers.

Keywords Evidences · Jaccard ranking fuzzy numbers · Poinwise form Trapezoidal fuzzy numbers

1 Introduction

The ranking of fuzzy numbers becomes an important part of the component in the decision-making process and procedure. In order to rank fuzzy numbers, one fuzzy number needs to be evaluated and compared with others, but this may not be easy since the fuzzy number can be overlapped with each other (Liu and Han 2005). Various ranking methods have been proposed since it was presented by Jain (1976) such as by Yager (1980), Setnes and Cross (1997), Sun and Wu (2006), Shureshjani and Darehmiraki (2013) and Qiupeng and Zuxing (2017). However, there has been no method that can provide a satisfactory solution to every situation and case.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_86

Some ranking methods produce non-intuitive and non-discriminating results such as in Kim and Park (1990), Choobineh and Li (1993) and Asady and Zendehnam (2007). Some have a lengthy calculation, computationally complex and difficult to implement (Yao and Wu 2000).

In a study by Setnes and Cross (1997), they have proposed a ranking method based on Jaccard similarity measure index and extension principle concept. However, the method is only applicable to normal fuzzy numbers and fails to rank the non-normal fuzzy numbers. Ramli and Mohamad (2009) further improved the method by introducing the function principle concept instead of the extension principle concept. However, the mean aggregation used in the Jaccard ranking index can only represent a neutral decision makers' perspective. Ramli and Mohamad (2010) then integrated the degree of optimism concept in the aggregation process of Jaccard ranking index which considers all types of decision makers' perspective. Ramli et al. (2013) further extended the aggregation process by using Yager class t-norm.

The above-mentioned ranking methods using Jaccard index involved lengthy calculation, which consists of calculation on the fuzzy maximum and fuzzy minimum, the intersection and union of fuzzy numbers, the area of under membership function of fuzzy numbers and lastly the evidences based on Jaccard index. In this paper, we propose the formulation of evidences for Jaccard ranking fuzzy numbers based on pointwise operation. This formulation can simplify the computation process and thus can speed up the decision-making process.

2 Preliminaries

In this section, basic definition on trapezoidal fuzzy numbers (TrFNs), fuzzy maximum, fuzzy minimum, fuzzy intersection and fuzzy union are presented.

Definition 1 A trapezoidal fuzzy number (TrFN) denoted as $A = (a, b, c, d)$ has a membership function defined as

$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a}, & x \in [a, b] \\ 1, & x \in [b, c] \\ \frac{d-x}{d-c}, & x \in [c, d] \\ 0, & \text{otherwise} \end{cases}.$$

For $b = c$, A becomes a triangular fuzzy number denoted as $A = (a, b, d)$ with the membership function defined as

$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a}, & x \in [a, b] \\ \frac{d-x}{d-b}, & x \in [b, d] \\ 0, & \text{otherwise} \end{cases}.$$

Definition 2 (Chen and Hsieh 1998) Let $A_i = (a_i, b_i, c_i, d_i; h_i)$ and $A_j = (a_j, b_j, c_j, d_j; h_j)$ be two generalized trapezoidal fuzzy numbers. The fuzzy maximum of A_i and A_j is defined as

$$\mathrm{MAX}(A_i, A_j) = (a,\ b,\ c,\ d;\ h),$$

such that

$$h = \min\{h_i,\ h_j\}, T = \{\max(a_i, a_j), \max(a_i, d_j), \max(d_i, a_j), \max(d_i, d_j)\},$$
$$T_1 = \{\max(b_i, b_j), \max(b_i, c_j), \max(c_i, b_j), \max(c_i, c_j)\},\ a = \min T, b = \min T_1,$$
$$c = \max T_1,\ d = \max T,\ \min T \leq \min T_1 \text{ and } \max T_1 \leq \max T.$$

The fuzzy minimum of A_i and A_j is defined as

$$MIN(A_i, A_j) = (a,\ b,\ c,\ d;\ h),$$

such that

$$h = \min\{h_i,\ h_j\},\ T = \{\min(a_i, a_j), \min(a_i, d_j), \min(d_i, a_j), \min(d_i, d_j)\}$$
$$T_1 = \{\min(b_i, b_j), \min(b_i, c_j), \min(c_i, b_j), \min(c_i, c_j)\},\ a = \min T,\ b = \min T_1,$$
$$c = \max T_1,\ d = \max T,\ \min T \leq \min T_1 \text{ and } \max T_1 \leq \max T.$$

Definition 3 (Wang 1997) The intersection of fuzzy numbers A_i and A_j with membership functions μ_{A_i} and μ_{A_j}, respectively, is defined as

$$\mu_{A_i \cap A_j}(x) = \min\left[\mu_{A_i}(x), \mu_{A_j}(x)\right],\ \forall x \in X.$$

The union of fuzzy numbers A_i and A_j with membership functions μ_{A_i} and μ_{A_j}, respectively, is defined as

$$\mu_{A_i \cup A_j}(x) = \max\left[\mu_{A_i}(x), \mu_{A_j}(x)\right],\ \forall x \in X.$$

Procedure

The procedure for formulating evidences of fuzzy Jaccard ranking index consists of four steps as follows:

Step 1 For two trapezoidal fuzzy numbers $A_i = (a_i, b_i, c_i, d_i)$ and $A_j = (a_j, b_j, c_j, d_j)$, find the fuzzy maximum $\mathrm{MAX}(A_i, A_j)$ and fuzzy minimum $\mathrm{MIN}(A_i, A_j)$.

Step 2 By using the definition of intersection and union, find $A_i \cap \mathrm{MAX}(A_i, A_j)$,$A_i \cup \mathrm{MAX}(A_i, A_j)$, $A_i \cap \mathrm{MIN}(A_i, A_j)$,$A_i \cup \mathrm{MIN}(A_i, A_j)$,$A_j \cap \mathrm{MAX}(A_i, A_j)$,$A_j \cup \mathrm{MAX}(A_i, A_j)$, $A_j \cap \mathrm{MIN}(A_i, A_j)$ and $A_j \cup \mathrm{MIN}(A_i, A_j)$.

Step 3 Calculate the four general evidences based on Jaccard index similarity measure which are defined as

$$E(A_i \succ A_j) = S_J(MAX(A_i, A_j), A_i), \quad E(A_j \prec A_i) = S_J(MIN(A_i, A_j), A_j),$$
$$E(A_j \succ A_i) = S_J(MAX(A_i, A_j), A_j) \text{ and } E(A_i \succ A_j) = S_J(MAX(A_i, A_j), A_i)$$

with $S_J(A, B) = \frac{|A \cap B|}{|A \cup B|}$ and $|A|$ denotes the scalar cardinality of TrFN A.

Step 4 Simplify the evidences by using Maple software.

3 Implementation

The procedure for the formulation of evidences of Jaccard RFNs is implemented on overlapped TrFNs Types 1, 2 and 3 taken from Ramli (2013). TrFN Type 1 is divided into two conditions which are Types 1.1 and 1.2. TrFN Type 2 is divided into five conditions which are Types 2.1, 2.2, 2.3, 2.4 and 2.5 and TrFN Type 3 is divided into two conditions which are Types 3.1 and 3.2. Table 1 shows the condition of TrFNs.

Table 1 Condition of different types of TrFNs (Ramli 2013)

Types of TrFNs	Condition of TrFNs $A_i = (a_i, b_i, c_i, d_i)$ and $A_j = (a_j, b_j, c_j, d_j)$
1.1	$a_i \leq a_j$, $b_i \leq b_j$, $c_i \geq c_j$ and $d_i \geq d_j$
1.2	$a_i \leq a_j$, $b_i \leq b_j \leq c_i \leq c_j$ and $d_i \leq d_j$
2.1	$a_i = a_j$, $b_i = b_j$, $c_i < c_j$ and $d_i > d_j$
2.2	$a_i \leq a_j$, $b_i \leq b_j < c_i$, $c_j = b_j$ and $d_i < d_j$
2.4	$a_j \leq a_i$, $b_j < b_i$, $c_j < c_i$, $c_j = b_j$ and $d_i < d_j$
2.5	$a_j < a_i$, $b_i < b_j$, $c_j < c_i$ and $d_i = d_j$
3.1	$a_j < a_i$, $c_i < b_j$ and $d_i \leq d_j$
3.2	$a_j < a_i$, $b_i < b_j$, $c_j < c_i$ and $d_i < d_j$

4 Results and Discussion

Table 2 shows the evidences in pointwise form for TrFNs Types 1.1, 1.2, 2.1, 2.2, 2.5 and 3.2. Tables 3, 4 and 5 show the evidences in pointwise form for TrFNs Types 2.3, 2.4 and 3.1 respectively.

Consider TrFNs Type 1.1 with $A_i = (0.1, 0.2, 0.4, 0.5)$ and $A_j = (0.1, 0.3, 0.3, 0.5)$ taken from Chen and Chen (2009). Based on Table 2, we obtain

Table 2 Evidences in pointwise form for TrFNs Types 1.1, 1.2, 2.1, 2.2, 2.5 and 3.2

Types	Evidences	Pointwise form
1.1	C_{ij}	$\frac{-c_i+a_j+b_j-d_i}{-c_i+a_i+b_i-d_i}$
	c_{ji}	$\frac{-c_j+a_j+b_j-d_j}{-c_j+a_i+b_i-d_j}$
	C_{ji}	$\frac{-c_j+a_j+b_j-d_j}{-c_i+a_j+b_j-d_i}$
	c_{ij}	$\frac{-c_j+a_i+b_i-d_j}{-c_i+a_i+b_i-d_i}$
1.2	C_{ij}	$\frac{-c_i+a_j+b_j-d_i}{-c_j+a_i+b_i-d_j}$
	c_{ji}	$\frac{-c_i+a_j+b_j-d_i}{-c_j+a_i+b_i-d_j}$
	C_{ji}	1
	c_{ij}	1
2.1	C_{ij}	$\frac{-c_i+a_i+b_i-d_i}{-c_j+a_j+b_j-d_i}$
	c_{ji}	$\frac{-c_i+a_i+b_i-d_j}{-c_j+a_j+b_j-d_j}$
	C_{ji}	$\frac{-c_j+a_j+b_j-d_j}{-c_j+a_j+b_j-d_i}$
	c_{ij}	$\frac{-c_i+a_i+b_i-d_j}{-c_i+a_i+b_i-d_i}$
2.2	C_{ij}	$\frac{-c_i+a_j+b_j-d_i}{-c_i+a_i+b_i-d_j}$
	c_{ji}	$\frac{-c_j+a_j+b_j-d_i}{-c_j+a_i+b_i-d_j}$
	C_{ji}	$\frac{-c_j+a_j+b_j-d_j}{-c_i+a_j+b_j-d_j}$
	c_{ij}	$\frac{-c_j+a_i+b_i-d_i}{-c_i+a_i+b_i-d_i}$
2.5	C_{ij}	$\frac{-c_i+a_i+b_j-d_j}{-c_i+a_i+b_i-d_i}$
	c_{ji}	$\frac{-c_j+a_j+b_j-d_j}{-c_j+a_j+b_i-d_i}$
	C_{ji}	$\frac{-c_j+a_i+b_j-d_j}{-c_i+a_j+b_j-d_j}$
	c_{ij}	$\frac{-c_j+a_i+b_i-d_i}{-c_i+a_j+b_i-d_i}$
3.2	C_{ij}	$\frac{-c_i+a_i+b_j-d_i}{-c_i+a_i+b_i-d_j}$
	c_{ji}	$\frac{-c_j+a_j+b_j-d_i}{-c_j+a_j+b_i-d_j}$
	C_{ji}	$\frac{-c_j+a_i+b_j-d_j}{-c_i+a_j+b_j-d_j}$
	c_{ij}	$\frac{-c_j+a_i+b_i-d_i}{-c_i+a_j+b_i-d_i}$

Table 3 Evidences in pointwise form for TrFNs Type 2.3

Types	Evidences	Pointwise form
2.3	C_{ij}	$\frac{E}{-b_i-a_i+2c_i+F+c_j-2b_j+d_j}$
	c_{ji}	C_{ij}
	C_{ji}	1
	c_{ij}	1

with $e=\frac{a_jc_i-d_ib_j}{a_j-b_j+c_i-d_i}$, $E=\frac{(e-a_j)^2}{b_j-a_j}+\frac{(d_i-e)^2}{d_i-c_i}$ and $F=-\frac{(e-c_i)(e+c_i-2d_i)}{d_i-c_i}+\frac{(b_j-e)(b_j+e-2a_j)}{b_j-a_j}$

Table 4 Evidences in pointwise form for TrFNs Type 2.4

Types	Evidences	Pointwise form
2.4	C_{ij}	$\frac{-c_i+a_i+b_i-d_i}{-c_i+a_i+b_i-d_j}$
	c_{ji}	$\frac{-c_j+a_j+b_j-d_i}{-c_j+a_j+b_j-d_j}$
	C_{ji}	$\frac{K}{-b_j-a_j+2c_j+L+c_i-2b_i+d_j}$
	c_{ij}	$\frac{E}{-b_j-a_j+2c_j+F+c_i-2b_i+d_i}$

with $e_1=\frac{d_ib_i-a_ic_j}{d_i-c_j+b_i-a_i}$, $e_2=\frac{a_ic_j-d_jb_i}{a_i-b_i+c_j-d_j}$, $E=\frac{(e_1-a_i)^2}{b_i-a_i}+\frac{(d_i-e_1)^2}{d_i-c_j}$, $F=-\frac{(e_1-c_j)(e_1+c_j-2d_i)}{d_i-c_j}+\frac{(b_i-e_1)(b_i+e_1-2a_i)}{b_i-a_i}$, $K=\frac{(e_2-a_i)^2}{b_i-a_i}+\frac{(d_j-e_2)^2}{d_j-c_j}$ and $L=-\frac{(e_2-c_j)(e_2+c_j-2d_j)}{d_j-c_j}+\frac{(b_i-e_2)(b_i+e_2-2a_i)}{b_i-a_i}$

Table 5 Evidences in pointwise form for TrFNs Type 3.1

Types	Evidences	Pointwise form
3.1	C_{ij}	$\frac{E}{-b_i-a_i+2c_i+F+c_j-2b_j+d_j}$
	c_{ji}	$\frac{K}{-b_j-a_j+2c_i+L+c_j-2b_j+d_j}$
	C_{ji}	$\frac{-c_j+a_i+b_j-d_j}{-c_j+a_j+b_j-d_j}$
	c_{ij}	$\frac{-c_i+a_i+b_i-d_i}{-c_i+a_j+b_i-d_i}$

with $e_1=\frac{a_ic_i-d_ib_j}{a_i-b_j+c_i-d_i}$, $e_2=\frac{a_jc_i-d_ib_j}{a_j-b_j+c_i-d_i}$, $E=\frac{(e_1-a_i)^2}{b_j-a_i}+\frac{(d_i-e_1)^2}{d_i-c_i}$, $F=-\frac{(e_1-c_i)(e_1+c_i-2d_i)}{d_i-c_i}+\frac{(b_j-e_1)(b_j+e_1-2a_i)}{b_j-a_i}$, $K=\frac{(e_2-a_j)^2}{b_j-a_j}+\frac{(d_i-e_2)^2}{d_i-c_i}$ and $L=-\frac{(e_2-c_i)(e_2+c_i-2d_i)}{d_i-c_i}+\frac{(b_j-e_2)(b_i+e_2-2a_j)}{b_j-a_j}$

$C_{ij}=0.833$, $c_{ji}=0.8$, $C_{ji}=0.8$ and $c_{ij}=0.833$, and by using algebraic product t-norm operation, the total evidences are obtained as $E_T(A_i\succ A_j)=C_{ij}.c_{ji}=(0.833)(0.8)=0.666$ and $E_T(A_j\succ A_i)=C_{ji}.c_{ij}=(0.8)(0.833)=0.666$. Thus, produces the ranking as $A_i\approx A_j$. Next, we consider TrFNs Type 2.4 with $A_i=(0.4,0.5,0.5,0.6)$ and $A_j=(0.1,0.3,0.3,0.8)$ taken from Chen and Lu (2001). Based on Table 4, we obtain $C_{ij}=0.5$, $c_{ji}=0.714$, $C_{ji}=0.32$ and $c_{ij}=0.167$, and by using algebraic product t-norm operation, the total evidences are obtained as $E_T(A_i\succ A_j)=C_{ij}.c_{ji}=(0.5)(0.714)=0.357$ and $E_T(A_j\succ A_i)=C_{ji}.c_{ij}=$

$(0.32)(0.167) = 0.053$. Thus, produces the ranking as $A_i \succ A_j$. The ranking result can be determined merely based on the values of a_i, b_i, c_i, d_i, a_j, b_j, c_j and d_j which is akin to a pointwise operation.

5 Conclusion

This paper proposes the evidences for Jaccard ranking fuzzy numbers based on pointwise form. The evidences can be determined merely based on the values of a_i, b_i, c_i, d_i, a_j, b_j, c_j and d_j and thus the ranking results can be obtained directly from the point of the TrFNs. The ranking results can be obtained through a simplified computation compared to the lengthy calculation in the previous Jaccard ranking fuzzy numbers method. Thus, the proposed evidences can speed up the decision-making process.

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Chapter 87
Predicting Financial Distress of Companies in Malaysia: A Comparison of Adaptive Neuro-Fuzzy Inference System and Discriminant Analysis

Mazura Mokhtar and Saharani Abdul Rashid

Abstract Financial distress prediction has been a topic of great interest over decades, not only to managers but also to the external stakeholders of a company. The aim of this study is to compare the ability of the adaptive neuro-fuzzy inference system (ANFIS) and multiple discriminant analysis (MDA) in predicting the financial distress of public listed companies in Malaysia. The sample consists of 42 financially distress and 42 non-financially distress companies for the period 2005–2015. The financial data of the companies were collected for 3 years prior to classification as PN17 companies by Bursa Malaysia. Five financial ratios existing in the Altman model were used as the input variables. The results of this study indicate that the ANFIS model could accurately predict 95.98 and 84.62% of the respective training and holdout sample. On the other hand, the MDA model achieves 83.91 and 76.92% overall accuracy prediction rate for the training and the holdout sample respectively. This study will be useful to financial institutions, investors, creditors and auditors to identify companies that are likely to fall into financial distress.

Keywords ANFIS · Discriminant analysis · Financial distress Prediction model

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_87

1 Introduction

Financial distress prediction has been one of the most important research areas in finance. It has been extensively studied in the finance literature over the past few decades. Financial distress is a situation where a company's operating cash flows are not sufficient to satisfy the current financial obligations such as trade credit and interest expenses. "Bankruptcy", "default" and "failure" are the other terms usually used to describe this situation.

The significance of financial distress is extremely felt during financial crises. For example, the Asian financial crisis which erupted in 1997 caused a sharp decline in the value of the Malaysian Ringgit and drastic drops in stock prices. As a result, many Malaysian companies were not able to face the unexpected changes and fell into bankruptcy. Looking at this situation, it is important to identify companies that have the potential of falling into financial distress, so that the relevant preventive or corrective action can be taken.

In Malaysia, companies that fall under the financial distress condition are classified as the PN17 companies (Practice Note 17). These companies are given temporary recovery period and required to restructure their financial affair. As on 1 June 2015, 21 companies fall under the PN17 classifications which represent 2.32% of the total number of 907 listed companies on the Bursa Malaysia.

Various techniques have been employed to accurately predict the financial distress of companies. Early approaches were based on the statistical methods pioneered by Beaver (1966), who used univariate discriminant analysis to distinguish between failure and non-failure companies. A few years later, Altman (1968) extended the Beaver's approach and developed a statistical model using multiple discriminant analysis (MDA) technique. The model which serves as a benchmark for the financial distress studies, was based on a score derived from a linear combination of five financial ratios which are the working capital, retained earnings, sales and earnings before interest and taxes to the total assets, and market value of equity to the book value of the total debt.

Although the Altman's multiple discriminant analysis model showed good accuracy, it has been criticized for several restrictive assumptions, such as linear separability, multivariate normality and independence among input variables, which did not hold in the case of real applications. In order to overcome such limitations, some studies have proposed logit or logistic regression analysis to construct the predictive models. The first attempt was made by Ohlson (1980), who developed a model with nine independent variables and found that the model could correctly predict over 92% of the failed companies 2 years earlier.

In the recent years, there has been a dramatic increase in the number of studies which supported the use of artificial neural networks (ANN) over the traditional statistical methods (Gameel and El-Geziry 2016; Chen and Du 2009; Tan and Dihardjo 2001; Coats and Frant 1993). ANN is a nonlinear model that is easy to use and does not require any restrictive assumptions, such as linearity, normality as well

as independence among input variables. The major drawback of ANN is its 'black box' data processing structure and the rules derived which are not easily understandable. To address these issues, several researchers such as Chen (2013) and Vlachos and Tolias (2003) employed Adaptive Neuro-Fuzzy Inference System (ANFIS) is used to develop the predictive model.

Several studies on financial distress and bankruptcy prediction were also conducted using data from Malaysian companies. Mohamed et al. (2001), for example, compared the performance of MDA and logit models. The results indicate that the logit model correctly predicted 80.7 and 74.4% of the companies in the estimation and holdout samples, respectively, while MDA predicted 81.1% of the companies in the estimation sample and 75.4% in the holdout sample. Similarly, Nur Adiana et al. (2008) compared the performance of the MDA, logit and hazard models using 72 companies. Regarding the performance of estimation sample, they found that the hazard model gives the highest overall accuracy rate of 94.9%, whereas MDA and logit analysis give 80.8 and 82.7% respectively. For holdout sample, the MDA gives a higher accuracy rate of 85%. Another study by Ong et al. (2011) developed a financial distress prediction model amongst public listed companies in Malaysia using logit analysis. The overall predictive accuracy rate is 91.5% and therefore, they concluded that the logistic regression analysis used in the study is a reliable technique for financial distress prediction.

Up to the authors' knowledge, none of the previous studies has used ANFIS to predict the financial distress of Malaysian public listed companies. This study, therefore, aims to fill the gap of comparing the predictive accuracy of ANFIS and MDA model using data from public listed companies in Malaysia. The rest of the paper is organized as follows. The following section discusses the methods used in this study followed by results and discussion. The last section provides a brief summary including some suggestions for future research.

2 Methodology

2.1 Sample Selection

The sample of this study consists of 84 public companies listed on the Bursa Malaysia, out of which 42 were classified as PN17 companies during the time period of 2005–2015 and 42 financially strong companies. The name of companies listed under PN17 was obtained from the Media Releases and Companies Announcements from the Bursa Malaysia website. In order to reduce bias in selecting the sample for the financial prediction models, each financially distress company was matched with a financially healthy company from the same industry and approximately matched to asset size. The use of this type of sampling procedure is consistent with the previous studies by Beaver (1966) and Altman (1968). The financial statements of the financially healthy companies were obtained for the

same fiscal years as those of the financially distress companies, that is, if the financial distress company has a financial year ending 31 Dec 2006, the financially strong company would be chosen with financial statements ending in the same year.

The samples are further randomly split to create training and holdout samples. The training sample comprises of 29 distress companies and 29 financially strong companies to be used for the development of the predictive model. The remaining 13 distress companies and 13 non-distress companies were assigned to the holdout sample.

2.2 Financial Indicators

This study used the same five financial ratios as in the Altman's study as the input variables for the development of financial distress prediction models. These financial ratios could be classified into three broad categories that reflected the company's profitability, liquidity and efficiency. The list of the selected financial ratios is presented in Table 1.

3 Data Collection

The financial data of the financially distress companies were collected for 3 years prior to being listed under the PN17 category by the Bursa Malaysia. For example, for a company which was announced as distress in 2015, the variables were computed for the year 2014 (year 1), 2013 (year 2) and 2012 (year 3). In the case of a non-financially distress company, data were obtained for the same fiscal years as those of its matched distress company. All the financial data used in this study were collected from the *Thomson Reuters Datastream*.

3.1 Adaptive Neuro-Fuzzy Inference System (ANFIS)

Adaptive neuro-fuzzy inference system proposed by Jang (1993) is a fuzzy system that employs the ANN theory to determine its properties. It utilizes the

Table 1 List of selected financial ratios

Ratio	Initials	Category
Earnings before interest and taxes/total assets	EBITTA	Profitability
Retained earnings/total assets	RETA	Profitability
Working capital/total assets	WCTA	Liquidity
Market value equities/book value of total debt	METD	Liquidity
Sales/total assets	STA	Efficiency

mathematical properties of the ANN to tune the rule-based fuzzy system such as the fuzzy membership function parameters extracted from the features of the data set that describes the system behaviour.

In order to simplify the explanation, the fuzzy inference system under consideration is assumed to have two inputs x and y, and one output variable z. The first order of the Sugeno fuzzy model with two fuzzy if–then rules can be represented as follows:

Rule 1: If x is A_1 and y is B_1, then $f_1 = p_1x + q_1y + r_1$
Rule 2: If x is A_2 and y is B_2, then $f_2 = p_2x + q_2y + r_2$

where p, r and q are the linear output parameters. Figure 1 demonstrates the architecture of the equivalent ANFIS system. This architecture is formed by using five layers and the functions of each layer is explained below.

Layer 1: This layer consists of the square nodes that have falsifying inputs with the chosen membership function. Every node in this layer is an adaptive note with a node function

$$O_{1,i} = \mu_{A_i}(x), \quad \text{for} \quad i = 1, 2 \quad \text{or} \quad O_{1,i} = \mu_{B_{i-2}}(y), \quad \text{for} \quad i = 3, 4 \qquad (1)$$

where $O_{1,i}$ is the membership function of A_i and B_i. The parameters in this layer are called the premise parameters.

Layer 2: This is a layer of rules. Every node in this layer multiplies the incoming signal from layer 1 and the output is the firing strength of the rule.

$$O_{2,i} = w_i = \mu_{A_i}(x) \cdot \mu_{B_i}(y) \quad \text{for} \quad i = 1, 2. \qquad (2)$$

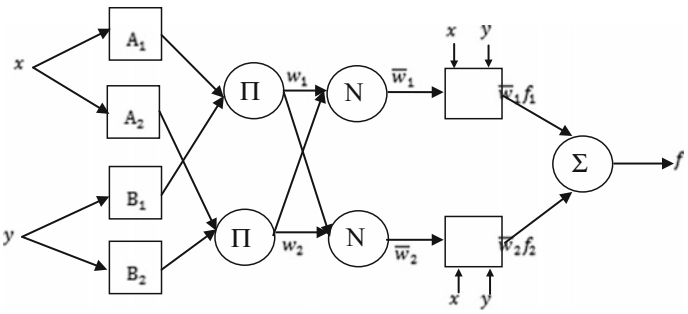

Fig. 1 ANFIS architecture

Layer 3: This is a layer of normalization. Every node in this layer calculates the ratio of the *i*th rule firing strength to the sum of all the firing strength of the rules.

$$O_{3,i} = \bar{w}_i = \frac{w_i}{w_1 + w_2} \quad \text{for} \quad i = 1, 2. \tag{3}$$

Layer 4: This is the clarification layer. Every node in this layer multiplies the normalized firing strength with the parameter set function. The parameters in this layer are called the consequent parameters.

$$O_{4,i} = \bar{w}_i f_i = \bar{w}_i (p_1 + q_1 + r_1) \tag{4}$$

where p_1, q_1 and r_1 are the consequent parameters.

Layer 5: The single node in this layer calculates the overall output as the summation of all incoming signals.

For Fuzzy Inference System (FIS) generation, ANFIS uses two partitioning methods, which are grid partition and subtractive clustering. Grid partition divides the data space into rectangular sub-space using axis-paralleled partitions based on the number of membership functions and their types in each dimension (Wei et al. 2007). Subtractive clustering method clusters data points in an unsupervised way by measuring the potential of data points in the feature space. It assumes that each data point is a potential cluster centre and calculates the potential for each data point based on the density of surrounding data points. In this study, subtractive clustering technique is used to define the fuzzy partition of input data.

3.2 Multiple Discriminant Analysis

Multiple Discriminant Analysis (MDA) is used to predict the classification of a categorical dependent variable. This method is adopted to select the discriminating variables that could predict distress and non-distress companies. Furthermore, this would then be compared to the ANFIS in order to examine which methods could provide a higher accuracy in predicting financially distressed companies. The linear equation of MDA is as follows:

$$Y = a + b_1 V_1 + b_2 V_2 + \cdots + b_n V_n + \varepsilon \tag{5}$$

where a is a constant of prediction, b is the coefficient for particular independent variables, V is independent variables and n is the number of independent variables used.

4 Results and Discussion

4.1 Descriptive Statistics

A descriptive statistic of the variables used to estimate the MDA is presented in Table 2. Based on the result obtained, it can be clearly seen that the mean for all financial ratios of distress companies (PN17) are less than the mean of non-financial distress companies. It also appears that the mean of WCTA and RETA for distress companies is negative, which indicates that these companies have a weaker ability to survive during a credit crunch. In addition, the non-distress companies also have a lower standard deviation for all the variables except for MVETL.

4.2 Statistical Results of Multivariate Discriminant Analysis

The goodness of fit statistic for the data used is shown in Table 3. The Chi-Square value is 98.437 with 5 degree of freedom (df) and the significance value (Sig.) is less than 0.05. It indicates that the model is a good fit for the data. In addition, the Wilks' lambda value stating the variance of the dependent variable that is not explained by the discriminant function. In this case, only 44.1% of the independent variables explain the variation of the dependent variable and another 55.9% are unexplained.

Table 4 shows the canonical discriminant function coefficients for each predictor variable in generating the discriminant function. By referring to the table, the discriminant function is as follows:

Table 2 Descriptive statistics of independent variables

Variables	Mean		Standard deviation	
	Non-distress companies	Distress companies	Non-distress companies	Distress companies
WCTA	0.358832	−0.145354	0.1512806	1.0412357
RETA	0.269000	−0.425056	0.1220293	1.7113321
EBITTA	0.095391	0.094353	0.0669475	1.2003465
MVETL	3.862102	0.674628	3.4870756	0.8889240
STA	0.932000	0.549876	0.5102363	0.4072633

Table 3 Wilks' Lambda

Test function (s)	Wilks' Lambda	Chi-square	df	Sig.
1	0.559	98.437	5	0.000

Table 4 Canonical discriminant function coefficients

Variables	Function
	1
WCTA	0.232
RETA	0.222
EBITTA	0.176
MVETL	0.315
STA	1.283
Constant	−1.689

$$Y = -1.689 + 0.232\text{WCTA} + 0.222\text{RETA} + 0.176\text{EBITTA} + 0.315\text{MVETL} + 1.283\text{STA} \quad (6)$$

Based on the function above, there is a positive relationship between financial distress companies with all the independent variables. A greater value of the coefficient indicates that the higher contribution of the variables to a company to be classified as a financial distress company.

4.3 Classification Results

The ANFIS model was trained using MATLAB R2014a environment. Subtractive clustering with a radius of 0.5 is used to generate a fuzzy inference system. The number of epochs is fixed to be 100. The trained ANFIS model has two rule nodes, each node is represented as a locally defined linear function.

The classification results from the models' prediction for the training sample are presented in Table 5. The results indicate that the ANFIS model has an overall prediction accuracy rate of 95.98%, which is higher than the overall prediction rate of 83.91% for the discriminant analysis. It also appears that the ANFIS predictions for each year are better than the MDA for both distress and non-distress groups. For the first year prior to failure, the ANFIS model correctly predicted 100% of distress companies and 93.1% of non-distress companies in the sample, whereas the predictive accuracy rates of the MDA are 89.6 and 79.3% for the respective distress and non-distress groups.

Table 6 shows the classification results for the holdout sample. The results are similar to the training sample where the ANFIS model gives a better prediction compared to the MDA. Overall, the ANFIS model prediction accuracy is slightly better than the MDA model with 7.7% difference. However, for the first year prior to PN17 classification, both models have achieved the same predictive accuracy rates of 92.3% for distress companies and 76.9% for non-distress companies.

Table 5 Classification results for training sample

Sample	Predicted	Actual						Overall
		Year 1		Year 2		Year 3		
		Distress	Non-distress	Distress	Non-distress	Distress	Non-distress	
ANFIS	Distress	29	2	28	1	28	2	
	Non-distress	0	27	1	28	1	27	
	Percent correct (%)	100	93.1	96.6	96.6	96.6	93.1	95.98
MDA	Distress	26	6	26	7	25	5	
	Non-distress	3	23	3	22	4	24	
	Percent correct (%)	89.6	79.3	89.6	75.9	86.2	82.6	83.91

Table 6 Classification results for holdout sample

Sample	Predicted	Actual						Overall
		Year 1		Year 2		Year 3		
		Distress	Non-distress	Distress	Non-distress	Distress	Non-distress	
ANFIS	Distress	12	3	12	3	13	4	
	Non-distress	1	10	1	10	0	9	
	Percent correct (%)	92.3	76.9	92.3	76.6	100	69.2	84.62
MDA	Distress	12	3	10	5	12	5	
	Non-distress	1	10	3	8	1	8	
	Percent correct (%)	92.3	76.9	76.9	61.5	92.3	61.5	76.92

5 Conclusion

This study developed a financial distress prediction model for the public listed companies in Malaysia using ANFIS and MDA methods. By using financial ratios in Altman's model, the results show that ANFIS model gives a better prediction of financial distress companies compared to MDA approach. The overall predictive accuracy rates of ANFIS model are 95.98 and 84.62% for training and the holdout sample respectively. For the MDA model, it has achieved an overall accuracy rate of 83.91 and 76.92% for the respective training and holdout sample. These findings show that ANFIS is a promising approach for the prediction of financial distress for public listed companies in Malaysia.

Since the financial ratios used in this study were based on Altman's study, which was conducted in 1968, in the future, it is recommended to use different financial ratios to see if the prediction accuracy rate can be increased.

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Chapter 88
Genetic Algorithm Method in Examination Timetabling Problem: A Survey

Farah Adibah Adnan, Syafawati Ab Saad, Zainor Ridzuan Yahya and Wan Zuki Azman Wan Muhamad

Abstract Solving a real-world university examination timetabling is an intractable problem. Examination timetabling problems (ETP) can be defined as a problem of assigning a set of final examinations schedules to a given number of timeslots and rooms subject to a set of constraints. These constraints are usually divided into hard and soft constraints. Hard constraints must be satisfied under any circumstances. Whilst, soft constraints are not only essential but also should be satisfied as much as possible. Due to the complexity of the problem, it is usually impossible to have solutions that satisfy all soft constraints. The quality of the timetable is measured based on soft constraints violation. A weighted penalty/value is attached to each violation of the soft constraint and the objective is to minimize the total penalty value of these violations. Although there have been a numerous approaches in solving the ETP, but this paper only focus on Genetic Algorithm (GA) method based on the fact that it is robust and can fits into complex problem space. This paper gives a summary of the GA method on ETP and it aims in helping other researcher to shorten their time in understanding the application of GA in the selected problem.

Keywords Examination timetabling · Genetic Algorithm · Heuristic

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_88

1 Introduction

Examination timetabling is different with the other type of timetabling such as course timetable or lecturer timetable. It is not only considering the room/hall and the capacity of a student in the room, it must consider the length of examination period such as all subjects must be scheduled within 2 weeks of the examination period. The best timetable is measured differently by the institution. Some institutions define the best examination timetable as either the timetable produced could have more gaps between exams so that it gives more time for students to study. Whereas the other institution defines it as the timetable could satisfy hard constraints.

In examination timetabling problem, there are two terms that the scheduler must consider; hard and soft constraint. Hard constraints have a higher priority than soft, and their satisfaction is usually mandatory. Indeed, timetables will normally only be considered "feasible" if all of the imposed hard constraints have been satisfied. For instance, the timetable produced must avoid two or three consecutive exams on the same day so that students have enough time to prepare for their examination. The more gaps between the examination periods are preferable. Different institution defines soft constraint differently with other institution. Some institution prefers to have an exam in the evening and avoid night slot, but some institutions prefer to have exams in five working days rather than having exams on weekends. Normally, the quality of the timetable produced is measured based on soft constraints violation.

There have been lots of techniques that are well studied in solving examination timetabling problem. Heuristic and artificial intelligent approach is mostly used recently. In this paper, we focus on Genetic Algorithm (GA) which is a heuristic method since it has the capability of solving optimization problems.

The rest of this paper is organized as follows. First, in Sect. 1.1, we explain about GA method in general and the strategy to implement GA in ETP. After that in Sect. 2, we review some previous works of GA in ETP. Next in Sect. 3, the conclusion of the GA method is presented here. Finally acknowledgment and list of references are provided.

1.1 Genetic Algorithm Method

Genetic Algorithm (GA) is a type of Artificial Intelligence (AI) technique. It is based on Darwin's theory of evolution by natural selection. According to Holland (1992), "GA is a directed random search technique which can find the global optimal solution in complex multi-dimensional search spaces". The operators involved such as selection, mutation and crossover could manipulate the individuals in a population over several generations to improve their fitness. The flowchart of GA method as by Pham and Karaboga (2000) is shown in Fig. 1.

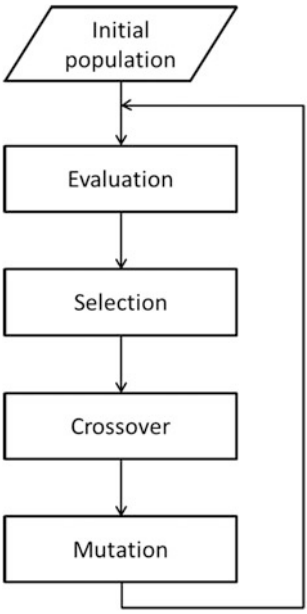

Fig. 1 Flowchart of a simple Genetic Algorithm

Figure 1 shows in brief about GA flowchart. Other authors might use slightly a different flowchart and a different terminology to represent the genetic operators. The first genetic operator, selection aims to reproduce more copies of individuals whose fitness values are higher than those whose fitness values are low and it is usually called as "roulette wheel" selection. This is because it resembles the mechanism of the roulette wheel. To produce the next generation, the roulette wheel is spun with the large segment of the wheel represent the high fitness while the small segment resembles the low fitness. So, the segment with the larger area will have higher chance to be selected as the next generation. The second operator is a crossover. It creates two new individual that is produced by the selection process (parents). There are several kinds of crossover operations such as one-point crossover, two-point crossover, cycle crossover and uniform crossover. Mutation is considered as the last operator in GA and often performs after crossover. It changes a single bit of value at random of the bit string. By randomly selecting a value in the bit string, that particular value is then changed to another value (Mitchell 1997). For instance in the binary case, if the selected value is 0, it is then changed to 1 or otherwise.

1.2 Strategy to Implement Genetic Algorithm Method in Examination Timetabling Problem

The usual step before implementing GA is problem definition. For examination timetabling problem, there exist sets of a student taking subjects, sets of examination venue and sets of constraints that need to be optimized. For example, the data sets are divided into six categories:

i. A set of $S = \{s_1, \ldots, s_j\}$ number of students up to j-number.
ii. A set of $V = \{v_1, \ldots, v_n\}$ of venues (examination halls) up to n-number. Exam venue is sorted according to the size; capacity to hold students.
iii. A set of $C = \{c_1, \ldots, c_m\}$ of courses up to m-number. The courses are offered by the university in that particular semester. The courses might include non-exam and exam courses. But for this case, only exam courses are included while non-exam courses are automatically omitted from this set.
iv. A set of $K = \{k_1, \ldots, k_k\}$ of group of students taking the same exams up to k-number. Group of the student S is then gathered into K according to the same exams taking place.
v. A set of $A = \{a_1, \ldots, a_l\}$ of examinations up to l-number. The number of examinations is according to the courses offered in that particular semester of the university. For each course, there might exist several venues at one time due to the limitation of examination venue.
vi. A set of $T = \{t_1, \ldots, t_p\}$ of time slots where the particular exam takes place up to p-number. Usually, the time slot for each day is divided into two.

The solution of this problem is in term of chromosomes. The quality or fitness of each chromosome is computed using fitness function (Cupic et al. 2009). According to Cupic et al. (2009), the strategies to implement GA in examination timetabling are as follows:

i. Initialize the population; a number of chromosomes (solutions).
ii. Crossover operator will be selected and is combined with two chromosomes to produce new chromosomes or can be called as child.
iii. The child will replace some chromosomes of the population.
iv. Strategy 1–3 will be repeated until the child produced has the best solutions than its parents.

The selected chromosomes (parents) for producing new chromosomes (child) are based on greater chance to be picked. This is done in a probabilistically way. By having this, the child will bear a higher quality of solution and as this procedure repeats, the solution will get better and better. The produced child will be checked to avoid duplicates. The child is discarded automatically if it is resemble exactly one of the solutions in the population. As for the worse solution, it will be discarded and replaced with better solutions.

2 Literature Review

In this section, a summary of selected paper reviewed on the application of genetic algorithm in examination timetabling is presented here. Wong et al. (2002) developed final exam timetable generator which applies the genetic algorithm. The generator has been used in Ecole de Technologie Superieure since 2001. They schedule 173 exams with 32 exam periods and 150 students. Each timetable is represented by a vector with each index representing an examination and each element of the vector representing the timeslot that the examination has been allocated to. They use binary tournament in the selection of the fittest candidate solutions while in crossover process they apply uniform crossover. The crossover rate used is 0.85. When the crossover rate is high, it means that the new child created inherits more elements from parents. The mutation rate use is 0.01 since it indicates the decreasing of clashing occur when rate change from 0.1 to 0.01. The result shows the timetable produced has no conflicts between exams, no students having three consecutive exams and on average only 0.8% of students having 2 consecutive exams.

Cupic et al. (2009) used GA for scheduling a midterm examination at Faculty of Electrical Engineering and Computing (FER), University of Zagreb, Croatia which has 102 courses to be scheduled during a two-week period. There are three slots available each day (09–11 h, 12–14 h and 15–17 h) and in each week, 5 days are available. Thus, it gives a total 30 timeslots to schedule 102 courses. The GA method gives a satisfactory result.

Pillay and Banzhaf (2010) applied two-phase approach of the Genetic Algorithm method for uncapacitated examination timetabling problem. The first phase GA is used to produce a feasible timetable while in the second phase, GA is used to optimize the soft constraint costs. They use Proximity Cost to measure soft constraint violation as introduced by Carter et al. (1996). They introduce new low-level heuristics namely 'highest cost' in the first phase to guide the evolutionary process. The low-level heuristic is used to access the difficulty on an examination, where the most difficult exam is scheduled first to avoid a clash. They represent timetable in a linear structure with each cell representing a timeslot. Each cell stores a string of integer values where it indicates which subject is scheduled to that timeslot. They used three of the Carter dataset to see the performance of using the heuristic technique in developing examination timetable. The results show that using heuristic is better than using the random process in term of shortens the time in producing a feasible timetable.

The application of GA is well studied by Jha (2014) on real case scenario at engineering department at Ibra College of Technology, Oman. He schedules 36 diploma courses in the final exam which consist of 36 courses with 12 rooms to 54 lecturers (invigilators) in a two weeks exam (two time slots available per day times 5 working days per week time 2 weeks, equal to 20 periods). The algorithm runs by using C programming. The objective of his study is to develop a feasible timetable (each subject is assigned to one period, no student sit two exams in one period, no clash room, capacity of the room is large enough to hold students) while satisfying

soft constraint; students and invigilators remain happiest overall. But the author did not mention how to measure happiness as proposed. The author should use the Proximity Cost as introduced by Carter et al. (1996) in order to measure soft constraint violation.

Research by Sani and Yobo (2016) also apply GA on ETP. They use a sample exam's data of college of education located in Sokoto and grouped them into three scenarios; 40, 100 and 200 exams, respectively. They schedule these exams into 36 timeslots (2 weeks of exams from Monday to Saturday with 3 time slots in 1 day). In Sokoto, students are allowed to take elective courses. The elective courses will increase the possibility of clashes since students are free to choose many other courses. They run GA by using the ECJ toolkit. The ECJ toolkit is a software system that is specially designed for GAs and provides most of the standard components needed. This study aims to avoid clash (hard constraint) and also avoid students having two consecutive exams on the same day (soft constraint), but the result shows that the timetable produced have two exams on the same day. This means that the ECJ toolkit is only suitable to schedule courses or subjects which is not an elective courses.

3 Conclusion

Based on the previous research, an efficient method to schedule the examination timetable is to include heuristic method at the early stage to filter the overlapping subjects, and then apply Genetic Algorithm in order to schedule subjects to rooms and to invigilators. These two methods can be used together to minimize time and produce the best timetable (instead of producing a feasible timetable), which satisfies all the soft constraints.

Acknowledgments We would like to put our gratitude to the Ministry of Education Malaysia for funding money in 'Research Acculturation Grant Scheme (RAGS) (9018-00085). The funded money will be wisely used to find a solution and solve examination timetabling problem at Universiti Malaysia Perlis.

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Chapter 89
Numerical Solution of Painlevé Equation II via Daftardar–Gejji and Jafari Method

Mat Salim Selamat, Busyra Latif, Nur Azlina Abdul Aziz and Fatimah Yahya

Abstract Painlevé II equation is one of the six second-order ordinary differential equations namely Painlevé equations. This paper presented the numerical solution for Painlevé equation II via a new iterative method called Daftardar–Gejji and Jafari method (DJM). Comparison of the results obtained by DJM with those obtained by other methods such as optimal homotopy asymptotic method (OHAM), homotopy perturbation method (HPM), Sinc-collocation method, Chebyshev series method (CSM) and variational iterative method (VIM), revealed the effectiveness of the method.

Keywords Numerical method · Painlevé equations · Iterative method

1 Introduction

In this work, we consider the Painlevé equation II, which is formulated in the form

$$y'' = 2y^3 + xy + \mu \tag{1}$$

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_89

with initial conditions

$$y(0) = 1 \qquad y'(0) = 0 \tag{2}$$

where μ is an arbitrary parameters. Equations (1) and (2) have been discussed in Dastidar and Majumdar (1972) using an analytic continuation extension method (ACE) and the Chebyshev series method (CSM).

In recent years, many researchers used the analytical, approximate and numerical technique to solve the Painlevé equation II. For instance, Hesameddini and Peyrovi (2010) conducted a comparative study of Painlevé equation II by using the homotopy perturbation method (HPM), ACE and CSM. Meanwhile, Saadatmandi (2012) applied the Sinc-collocation method and variational iteration method (VIM) for solving the equation. Mabood et al. (2015) presented the series solution of Painlevé equation II via the optimal homotopy asymptotic method (OHAM).

Daftardar–Gejji and Jafari Method (DJM) is a new iterative method discovered by Daftardar-Gejji and Jafari (2006) for solving linear and nonlinear functional equations. It is a valuable tool for scientists and mathematicians where it has been extensively and successfully used for the treatment of linear and nonlinear of integer and fractional order (Bhalekar and Daftardar-Gejji 2008, 2011, 2012; Daftardar-Gejji and Bhalekar 2010; Hameeda 2013). Yaseen et al. (2013) used DJM to find the exact solutions of Laplace equations, while Majeed (2014) used DJM for solving the epidemic model and prey and predator problems.

The purpose of this paper is to employ Daftardar–Gejji and Jafari Method (DJM) to find the numerical solution of Painlevé equation II and compare the results obtained by DJM with those obtained by other methods such as OHAM, ACE, CSM, HPM and VIM-Pade.

2 The Basic Idea of DJM Method

The basic idea of Daftardar–Gejji and Jafari method (Daftarda–Gejji and Jafari 2006) is presented in this section. It is a useful and practical method for solving the following general functional equation:

$$u = N(u) + f, \tag{3}$$

where f is a known function and N is a nonlinear operator. A solution u of Eq. (2) is in the form of the following series:

$$u = \sum_{i=0}^{\infty} u_i. \tag{4}$$

The nonlinear operator N is decomposed as follows:

$$N\left(\sum_{i=0}^{\infty} u_i\right) = N(u_0) + \sum_{i=1}^{\infty}\left\{N\left(\sum_{j=0}^{i} u_j\right) - N\left(\sum_{j=0}^{i-1} u_j\right)\right\}. \tag{5}$$

From Eqs. (3) and (4), Eq. (2) is equivalent to

$$\sum_{i=0}^{\infty} u_i = f + N(u_0) + \sum_{i=1}^{\infty}\left\{N\left(\sum_{j=0}^{i} u_j\right) - N\left(\sum_{j=0}^{i-1} u_j\right)\right\}. \tag{6}$$

The recurrence relation is defined as follows:

$$\begin{aligned} u_0 &= f, \\ u_1 &= N(u_0), \\ u_{m+1} &= N(u_0 + \cdots + u_m) - N(u_0 + \cdots + u_{m-1}), \quad m = 1, 2, \ldots. \end{aligned} \tag{7}$$

Then

$$(u_1 + \cdots + u_{m+1}) = N(u_1 + \cdots + u_m), \quad m = 1, 2, \ldots \tag{8}$$

and

$$u(x) = f + N\left(\sum_{i=1}^{\infty} u_i\right). \tag{9}$$

The m-term approximation solution of Eq. (2) is given by $\mathrm{u} = \mathrm{u}_0 + u_1 + \cdots + u_{m-1}$.

2.1 Solution of Painlevé Equation II by DJM

According to DJM, Eqs. (1) and (2) are equivalent to

$$y = 1 + \frac{1}{2}\mu x^2 + \iint (2y^3 + xy)\mathrm{d}x \tag{10}$$

and the iterative solutions are

$$\begin{aligned} y_0 &= 1 + \tfrac{1}{2}\mu x^2 \\ y_1 &= x^2 + \tfrac{1}{6}x^3 + \tfrac{1}{4}\mu x^4 + \tfrac{1}{40}\mu x^5 + \cdots \\ y_2 &= \tfrac{1}{2}x^4 + \tfrac{1}{10}x^5 + \left(\tfrac{37}{180} + \tfrac{1}{4}\mu\right)x^6 + \cdots \vdots \end{aligned} \tag{11}$$

Therefore, the series solution is given by

$$y(x) = 1 + \left(\frac{1}{2}\mu + 1\right)x^2 + \frac{1}{6}x^3 + \left(\frac{1}{4}\mu + \frac{1}{2}\right)x^4 + \left(\frac{1}{40}\mu + \frac{1}{10}\right)x^5 + \cdots \quad (12)$$

3 Results and Discussion

In order to show the feasibility of the DJM, the obtained series solution up to x^{25} are compared with existing solutions with $\mu = 0, 1$ and 5.

Table 1 shows the comparison of our results with those obtained by Mabood et al. (2015) and Saadatmandi (2012). It shows that the results obtained by DJM are in good agreement with published results using OHAM, Sinc-collocation and VIM-Pade method.

A graphical comparison for $\mu = 5$ is shown in Fig. 1 where it is found that the DJM solutions are exactly same as those obtained by Mabood et al. (2015), Hesameddini and Peyrovi (2010) and Dastidar and Majumdar (1972).

Table 2 shows a comparison of the accuracy of methods DJM, OHM, Sinc-collocation and VIM-Pade. The accuracy of the methods is determined by comparing the results obtained through these methods with results by Runge–Kutta method (RK4) which is a built-in coding in MAPLE software, for $\mu = 1$. It is found that the accuracy of the DJM deteriorates faster than other methods.

The accuracy of DJM for Painlevé equation II with $\mu = 0, 2$ and 5 is determined by comparing the results with the results obtained by Runge–Runge method (RK4). The difference with RK4 results is tabulated in Table 3 where it is shown that the

Table 1 Comparison of value of $y(x)$ by different method at $\mu = 1$

x	DJM	OHAM (Mabood et al. 2015)	Sinc-collocation (Saadatmandi 2012)	VIM-Pade (Saadatmandi 2012)
0.05	1.003775569	1.003775589	1.003775662	1.003775569
0.1	1.015243538	1.015243588	1.015243802	1.015243537
0.15	1.034708877	1.034708856	1.304708564	1.034708876
0.2	1.062614651	1.062614821	1.06261573	1.062614651
0.25	1.099567603	1.099567581	1.099567064	1.099567603
0.3	1.146376027	1.146376031	1.146376034	1.146376034
0.35	1.204104441	1.204104477	1.204104479	1.204104479
0.4	1.274152113	1.274152281	1.274152278	1.274152278
0.45	1.358366667	1.358367341	1.358367333	1.358367333
0.5	1.45921092	1.459213374	1.459213319	1.459213319
0.6	1.725348544	1.725374318	1.725374098	1.725374098
0.7	2.118197394	2.118435214	2.118431139	2.118431139

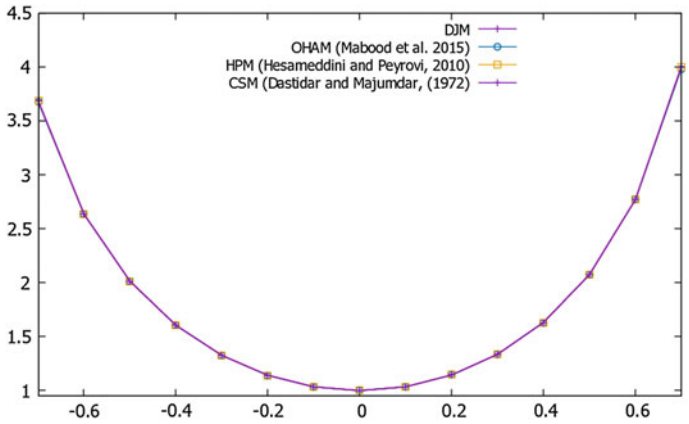

Fig. 1 Comparison between DJM, OHAM, HPM and CSM results for $\mu = 5$

Table 2 Comparison of accuracy by DJM, OHAM, Sinc-collocation and VIM-Pade' for $\mu = 1$, $\Delta y(x) = |y_{\text{RK4}} - y_{\text{method}}|$

x	DJM	OHAM (Mabood et al. 2015)	Sinc-collocation (Saadatmandi 2012)	VIM-Pade (Saadatmandi 2012)
0.1	6.99441E-14	5.06141E-08	2.64614E-07	3.8587E-10
0.2	9.40301E-11	1.69882E-07	1.07888E-06	1.1812E-10
0.3	6.99241E-09	3.60242E-09	1.4854E-06	6.0242E-10
0.4	1.75084E-07	4.3908E-09	2.12239E-06	7.3908E-09
0.5	2.52927E-06	7.41691E-08	3.08583E-06	1.2917E-07
0.6	2.70017E-05	1.22857E-06	7.68143E-06	1.4486E-06
0.7	0.000246068	8.24813E-06	1.65113E-06	1.2323E-05

Table 3 The accuracy of DJM for Painlevé equation II, $\Delta y(x) = |y_{\text{RK4}} - y_{\text{DJM}}|$

x	$\mu = 0$	$\mu = 2$	$\mu = 5$
0	0	0	0
0.1	8.01581E-14	7.99361E-14	8.99281E-14
0.2	8.884E-11	9.95E-11	1.1773E-10
0.3	6.16013E-09	7.92772E-09	1.14725E-08
0.4	1.39964E-07	2.18254E-07	4.14284E-07
0.5	1.78424E-06	3.55776E-06	9.47978E-06
0.6	1.63069E-05	4.40888E-05	0.000178271
0.7	0.000122711	0.00048332	0.003336732
0.8	0.000834945	0.005311296	0.079732959
0.9	0.005550885	0.06832378	4.901401773

accuracy of the results deteriorated when the values of x move away from an initial value of 0. This is due to the range of utility of the power series is limited to the neighbourhood of the origin by its convergence radius that is determined by the singularity closest to that point. Moreover, the Painlevé equation II, which is a type of nonlinear equation, generates singularities spontaneously that move when the initial condition change. Increasing the value of μ did not have a significant impact on accuracy. For example, when $\mu = 5$ accuracy of the results by DJM is in the magnitude of 10^{-14} at the point $x = 0.1$. However, similar to the case of $\mu = 0$, the accuracy declined when the value of x increases.

4 Conclusion

In this work, we employed the Daftardar–Gejji and Jafari method for solving the Painlevé equation II. The numerical results by DJM are in good agreement with those obtained by OHAM, HPM, ACE, CSM and VIM-Pade method. However, in this paper, we show that the approximate solution loses their accuracy for values of x away from the initial value of 0.

Acknowledgments Special thanks and appreciation to Research Management Centre, Universiti Teknologi MARA (UiTM) Malaysia for the research grants and for funding through this research project (File No: 600-RMI/IRAGS 5/3 (18/2015)).

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Chapter 90
Numerical Solutions of Forced Convection Boundary Layer Flow Towards a Horizontal Permeable Stretching Sheet in ZnO–Water, ZnO–Kerosene, MgO–Water and MgO–Kerosene Nanofluids

Nor Azizah Yacob, Anisah Dasman, Salimah Ahmad and Nor Fadhilah Dzulkifli

Abstract Nanofluid is a fluid where the nanoparticles with size less than 100 nm are dispersed in the base fluid to produce a fluid with high thermal conductivity rather than conventional fluid. Previous studies show that different nanoparticles and base fluid give different effects on the flow and heat transfer characteristics of nanofluids. The aim of the study is to numerically investigate these two characteristics on a forced convection boundary layer flow towards a horizontal permeable stretching sheet in four types of nanofluids which are ZnO–water, ZnO–Kerosene, MgO–water and MgO–Kerosene. The partial differential equations of the present problem are reduced to the boundary layer equations using boundary layer approximation. The resulting equations are then reduced to the ordinary differential equations by applying similarity transformation which is then solved numerically using a Keller box method. It is found that the skin friction coefficient and heat transfer rate at the surface for MgO–water and MgO–Kerosene nanofluids are greater than ZnO–water and ZnO–Kerosene.

Keywords Forced convection · Boundary layer · Nanofluids · MgO ZnO

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_90

1 Introduction

Nanofluid is a new generation fluid that is produced by dispersing solid particles (1–100 nm) into a base fluid such as water, ethylene glycol (EG) and oils in order to increase the thermal conductivity since the conventional fluids have low thermal conductivity (Das et al. 2008). Most of the published papers have used water as the base fluid such as Pandey and Kumar (2017). However, there are limited studies that are using kerosene as the base fluid. Khan et al. (2015) studied the viscous dissipation and slip velocity effects on two-dimensional and axisymmetric squeezing flows of Cu–water and Cu–kerosene nanofluid, which are two different nanofluids and solve the governing equations analytically. Similar behaviour is observed for each type of flow; however, the velocity of axisymmetric flow is slightly smaller than two-dimensional flow. Archaya et al. (2016) analysed the effects of squeezing parameter, Hartman number, and Eckert number on the profiles as well as the coefficient of skin friction and Nusselt number between two parallel plates of two types of nanofluids which are Cu–water and Cu–kerosene in the presence of magnetic field where the reduced ordinary differential equations were solved analytically and numerically. Further, Raju et al. (2016) investigated the effects of particular parameters on the flow and heat transfer characteristics over a cone of Cu–kerosene and Ag–kerosene nanofluids using a Carreau model. It was found that Cu–kerosene nanofluid is better in increasing the rate of heat transfer than Ag–kerosene nanofluid at the surface. The effects of other parameters can be found in Raju et al. (2016). Mahmoodi and Kandelousi (2016) investigated the flow and heat transfer characteristic of kerosene–alumina nanofluid in the presence of magnetic field using differential transformation method. It was found that increasing the magnetic field and nanoparticle volume fraction decreases the skin friction coefficient but increases the Nusselt number.

Recently, Hussanan et al. (2017) studied an unsteady free convection flow of different types of oxide nanoparticles that were suspended in a micropolar nanofluid. Three different types of base fluids were considered namely water, kerosene and engine oil and the effects of velocity and temperature profiles were analysed for different types of nanofluid. Moreover, they proposed the exact solutions of micropolar nanofluid that were not reported before. Further, it was observed that the temperature of nanofluids is greater when using water as the base fluid than kerosene and engine oil.

Yacob et al. (2013) studied mixed convection flow towards a stretching sheet of nanofluids by considering water as base fluid with nanoparticles copper, titanium and alumina using Tiwari and Das model (2007). Motivated by the above studies, we extended the work of Yacob et al. (2013) by investigating force convection flow towards a permeable horizontal stretching sheet of four types of nanofluids namely as water–ZnO, kerosene–ZnO, water–MgO and kerosene–MgO.

2 Mathematical Formulation

Consider a steady two-dimensional flow of a nanofluid past a horizontal permeable stretching sheet with a linear velocity $u_w(x) = a\,x$ and the temperature at the stretching sheet is $T_w(x) = T_\infty + b\,x$, where a and b are constant, x is the coordinate measured along the stretching sheet in the horizontal direction and T_∞ is the constant temperature of the ambient fluid. The flow is assumed to take place at $y \geq 0$, where y is the coordinate measured normal to the stretching sheet.

Under the above presumptions, the governing equations are as follows (see Oztop and Abu-Nada 2008; Yacob et al. 2013):

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \tag{1}$$

$$u\,\frac{\partial u}{\partial x} + v\,\frac{\partial u}{\partial y} = \frac{\mu_{nf}}{\rho_{nf}}\left(\frac{\partial^2 u}{\partial y^2}\right) \tag{2}$$

$$u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \alpha_{nf}\frac{\partial^2 T}{\partial y^2} \tag{3}$$

subject to the boundary conditions

$$\begin{aligned} &v = V_w(x),\ u = u_w(x) = a\,x,\ T = T_w(x) = T_\infty + b\,x \quad \text{at } y = 0 \\ &u = v = 0, \quad T = T_\infty \quad \text{as} \quad y \to \infty \end{aligned} \tag{4}$$

where u and v are the components of velocity along the axes x and y, respectively, V_w is a mass transfer at the sheet where $V_w < 0$(suction) and $V_w > 0$(injection). Further, ρ_{nf} is the effective density of the nanofluid, α_{nf} is the effective thermal diffusivity of the nanofluid and μ_{nf} is the dynamic viscosity of the nanofluid, which are given by (see Oztop and Abu-Nada 2008; Acharya et al. 2016)

$$\rho_{nf} = (1-\phi)\,\rho_f + \phi\,\rho_s, \quad \alpha_{nf} = \frac{k_{nf}}{(\rho\,\mathrm{C_p})_{nf}}, \quad \mu_{nf} = \frac{\mu_f}{(1-\phi)^{2.5}} \tag{5}$$

where ϕ is the nanoparticle volume fraction, ρ_f is the density of the fluid, ρ_s is the density of the solid, μ_f is the dynamic viscosity of the fluid, k_{nf} is the effective thermal conductivity of the nanofluid, k_f is the effective thermal conductivity of the fluid and $(\rho\,C_p)_{nf}$ is the heat capacity of the nanofluid which are given by (see Oztop and Abu-Nada 2008; Acharya et al. 2016)

$$\frac{k_{nf}}{k_f} = \frac{k_s + 2\,k_f - 2\,\phi\,(k_f - k_s)}{k_s + 2\,k_f + \phi\,(k_f - k_s)}, \quad (\rho\,C_p)_{nf} = (1-\phi)\,(\rho\,C_p)_f + \phi\,(\rho\,C_p)_s. \tag{6}$$

The governing Eqs. (1)–(4) can be reduced to nonlinear ordinary differential equations by introducing the following transformation:

$$\psi = \left(a\,v_f\right)^{1/2} x f(\eta),\ \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty},\quad \eta = \left(a/v_f\right)^{1/2} y \tag{7}$$

where the stream function ψ is defined in the usual way as $u = \partial\psi/\partial y$ and $v = -\partial\psi/\partial x$, then Eq. (1) is automatically satisfied and v is the kinematic viscosity. Equations (2) and (3), respectively, are reduced to the following equations:

$$\frac{1}{(1-\phi)^{2.5}\left[(1-\phi) + \phi\,\frac{\rho_s}{\rho_f}\right]} f''' + f f'' - f'^2 = 0 \tag{8}$$

$$\frac{1}{\Pr}\frac{k_{nf}/k_f}{(1-\phi) + \phi\,(\rho C_p)/(\rho C_p)_f}\,\theta'' + f\,\theta' - f'\,\theta = 0 \tag{9}$$

subject to the boundary conditions

$$\begin{aligned} &f(0) = s, \quad f'(0) = 1, \quad \theta(0) = 1 \\ &f'(\infty) = 0, \quad \theta(\infty) = 0 \end{aligned} \tag{10}$$

where primes denote differentiation with respect to η, $\Pr = v_f/\alpha_f$ is the Prandtl number and the mass transfer at the sheet becomes

$$V_w(x) = -\left(a v_f\right)^{1/2} s \tag{11}$$

where s is the constant mass transfer parameter at the sheet with $s > 0$ is for suction and $s < 0$ is for injection.

Preferred physical quantities are the skin friction coefficient C_f and the Nusselt number, which are defined as

$$C_f = \frac{\tau_w}{\rho_f u_w^2},\quad \mathrm{Nu} = \frac{x\,q_w}{k_f(T_w - T_\infty)} \tag{12}$$

where τ_w is the wall shear stress and q_w is the wall heat flux, which are defined as

$$\tau_w = \mu_{nf}\left(\frac{\partial u}{\partial y}\right)_{y=0},\quad q_w = -\,k_{nf}\left(\frac{\partial T}{\partial y}\right)_{y=0} \tag{13}$$

Using (7), we obtain

$$\mathrm{Re}_x^{1/2} C_f = \left(\frac{\mu_{nf}}{\mu_f}\right) f''(0), \quad \mathrm{Re}_x^{-1/2} \mathrm{Nu}_x = -\left(\frac{k_{nf}}{k_f}\right) \theta'(0) \tag{14}$$

where Reynolds number is $\mathrm{Re}_x = u_w(x)\, x/\nu_f$.

3 Results and Discussion

Four types of nanofluids which are water–MgO, kerosene–MgO, water–ZnO and kerosene–ZnO have been considered in the present study. Water and kerosene are the base fluids while MgO and ZnO are the nanoparticles. The nonlinear ordinary Eqs. (8)–(9) subject to boundary conditions (10) are numerically solved by a Keller box method with MATLAB 2015a. The numerical results obtained have been compared with the previous study (refer Table 1). It shows a good concurrence with the previous studies. Therefore, we are truly confident with the numerical results and the numerical method that is used in the present study. Further, the values of $\theta'(0)$ when $\phi = 0.1$ are also presented in Table 1. The thermophysical properties of water, kerosene, MgO and ZnO are shown in Table 2. The Prandtl number of water and kerosene are fixed at 6.161 and 28.1, respectively.

Table 1 Various values of the temperature gradient $\theta'(0)$ for $\phi = 0$ and $\phi = 0.1$

$\phi = 0$				$\phi = 0.1$	
Pr	Grubka and Bobba (1985)	Ishak et al. (2006)	Present results	Present results	
				Water–ZnO	Kerosene–ZnO
0.72	−0.8086	–	−0.8086		
1	−1.0000	−1.0000	−1.0000		
6.161	–	–	−2.8668	−2.4199	
7	–	−3.0722	−3.0723		
10	−3.7207	−3.7208	−3.7208		
28.1	–	–	−6.4040		−5.7420

Table 2 Thermophysical properties

Physical properties	Base fluid		Nanoparticle	
	Water	Kerosene	ZnO	MgO
C_p(J/kg K)	4181.4	2010	523	879
ρ(kg/m^3)	997.05	790	5700	3580
k(W/mK)	0.606	0.101	25	30

Figure 1 shows that the skin friction coefficient $C_f \mathrm{Re}_x^{1/2}$ with nanoparticle volume fractions ϕ of different types of nanofluids and the corresponding graph of the local Nusselt number $\mathrm{Nu}_x \mathrm{Re}_x^{-1/2}$ is shown in Fig. 2. The values of $C_f \mathrm{Re}_x^{1/2}$ as displayed in Fig. 1 are negative since the sheet exerts the drag force of the fluid (Muthtamilselvan and Ramya 2016) and all the values of $Nu_x \mathrm{Re}_x^{-1/2}$ are positive since the heat is transferred from hot sheet to cold fluid (Aurangzaib et al. 2016). Further, kerosene–ZnO nanofluid has the highest values $\left|C_f \mathrm{Re}_x^{1/2}\right|$ followed by water–ZnO, kerosene–MgO and water–MgO nanofluids. Meanwhile, the local Nusselt number of kerosene–MgO is greater than kerosene–ZnO, water–MgO and water–ZnO. It is noticed that using kerosene as the base fluid can increase the local skin friction coefficient and the

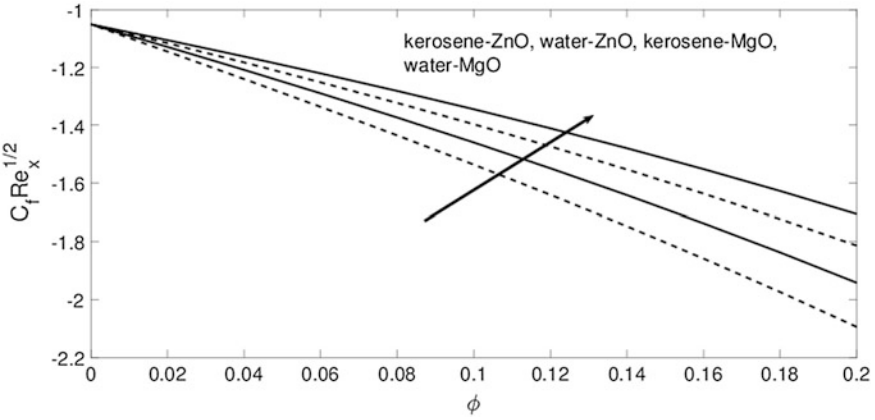

Fig. 1 Skin friction coefficient $C_f \mathrm{Re}_x^{1/2}$ of various nanofluids when $s = 0.1$

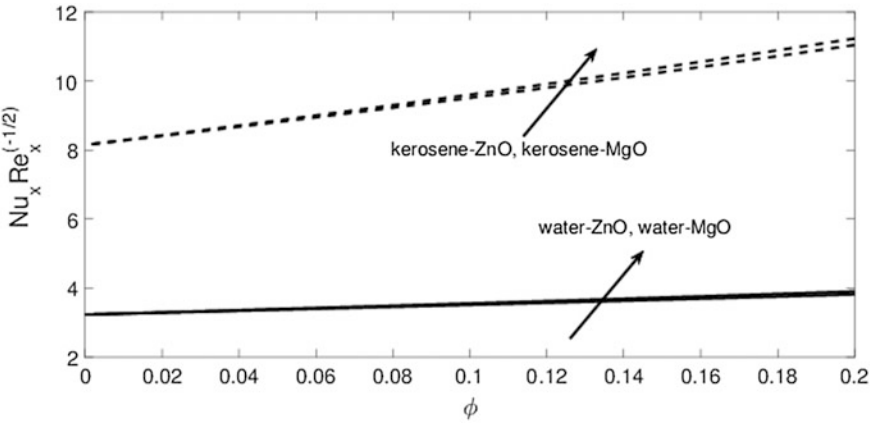

Fig. 2 Nusselt numbers $\mathrm{Nu}_x \mathrm{Re}_x^{-1/2}$ of various nanofluids when $s = 0.1$

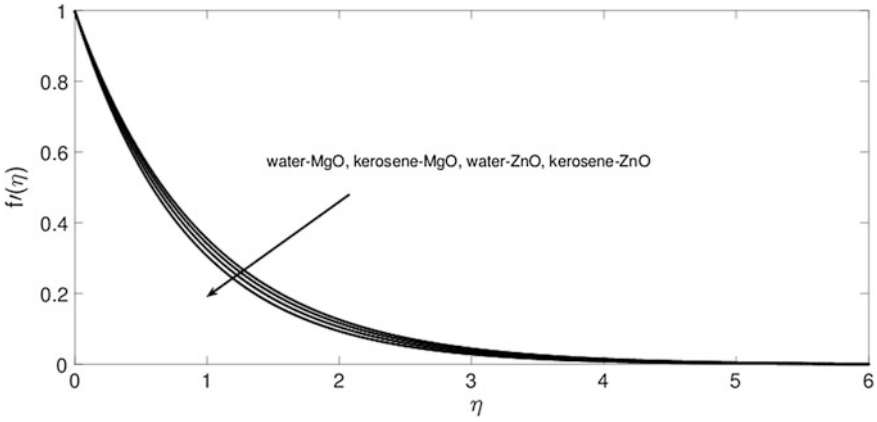

Fig. 3 Velocity profiles of various nanofluids when $\phi = 0.1$ and $s = 0.1$

local Nusselt number at the sheet since Prandtl number of kerosene is greater than water. However, the values of $\left|C_f \mathrm{Re}_x^{1/2}\right|$ and $\mathrm{Nu}_x \mathrm{Re}_x^{-1/2}$ increase with increasing nanoparticles volume fraction for all types of nanofluids as presented in Figs. 1 and 2, respectively. The corresponding velocity and temperature profiles for various nanofluids are displayed in Figs. 3 and 4, respectively. These profiles are generated using a new MATLAb program (Yacob et al. 2017). By using this MATLAB program, we can reduce time to plot the profiles.

Figure 5 displays the skin friction coefficient $C_f \mathrm{Re}_x^{1/2}$ of ZnO–kerosene nanofluid with nanoparticle volume fractions ϕ of various values of the suction parameter s and the corresponding graph of the local Nusselt number $\mathrm{Nu}_x \mathrm{Re}_x^{-1/2}$ is shown in Fig. 6. It is observed that increasing s increases the values of $\left|C_f \mathrm{Re}_x^{1/2}\right|$ and $Nu_x \mathrm{Re}_x^{-1/2}$. The corresponding velocity and temperature profiles of ZnO–kerosene nanofluid when $\phi = 0.1$ for various values of the suction parameter s are shown in Figs. 7 and 8. It can be seen that velocity and thermal boundary layer thicknesses decrease as s increases thus give rise to the velocity and temperature gradients and in consequence increase the values of $\left|C_f \mathrm{Re}_x^{1/2}\right|$ and $\mathrm{Nu}_x \mathrm{Re}_x^{-1/2}$ as depicted in Figs. 5 and 6, respectively. It is worth saying that all the velocity and temperature profiles satisfy boundary conditions (10) asymptotically.

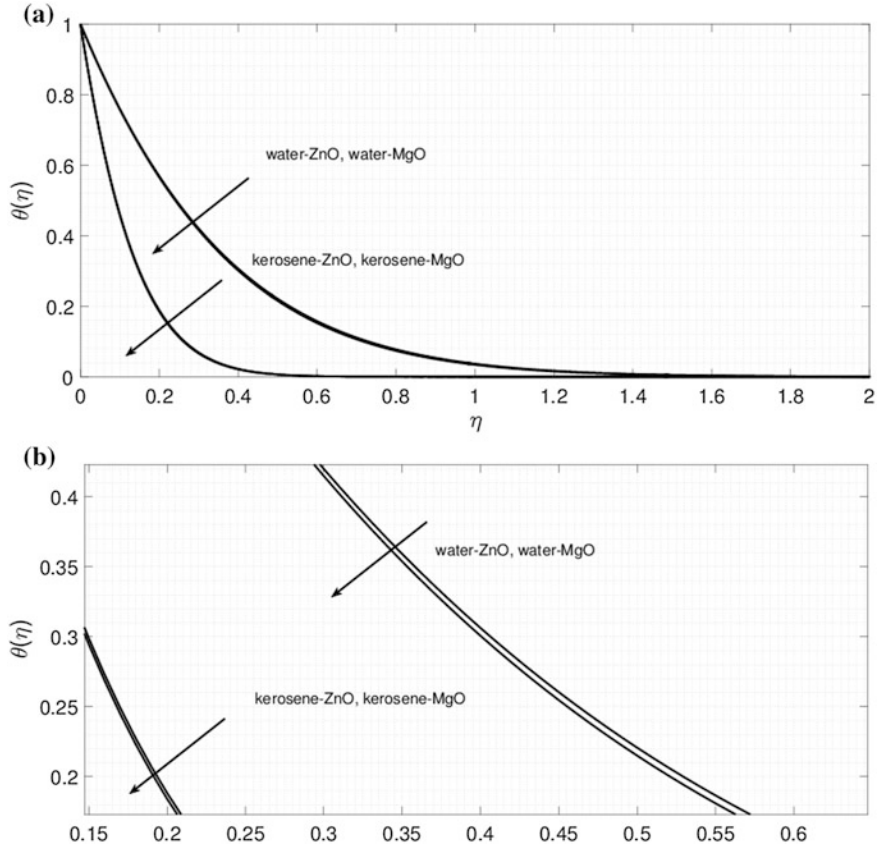

Fig. 4 Temperature profiles of various nanofluids when $\phi = 0.1$ and $s = 0.1$

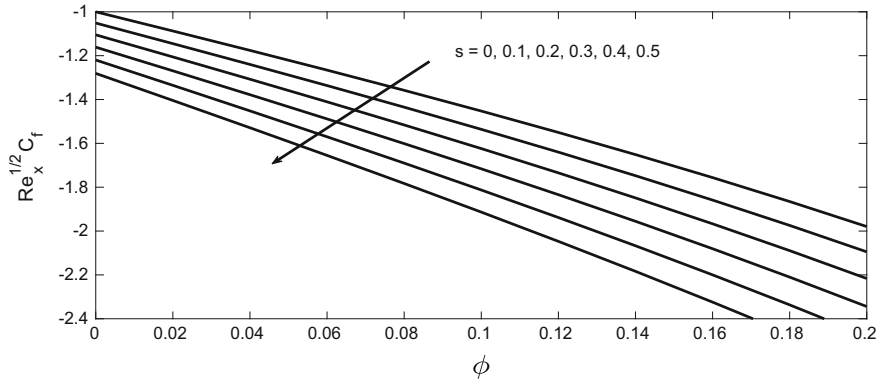

Fig. 5 Variation of skin friction coefficient of ZnO–kerosene nanofluid with various suction parameter s when $\phi = 0.1$

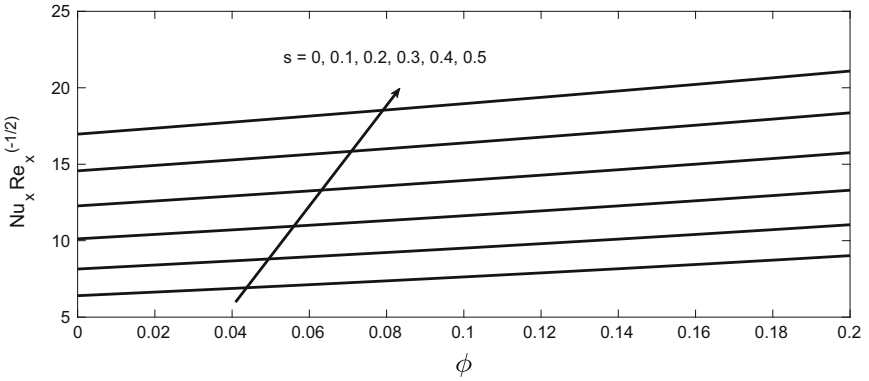

Fig. 6 Variation of Nusselt number of ZnO–kerosene nanofluid with various suction parameter s when $\phi = 0.1$

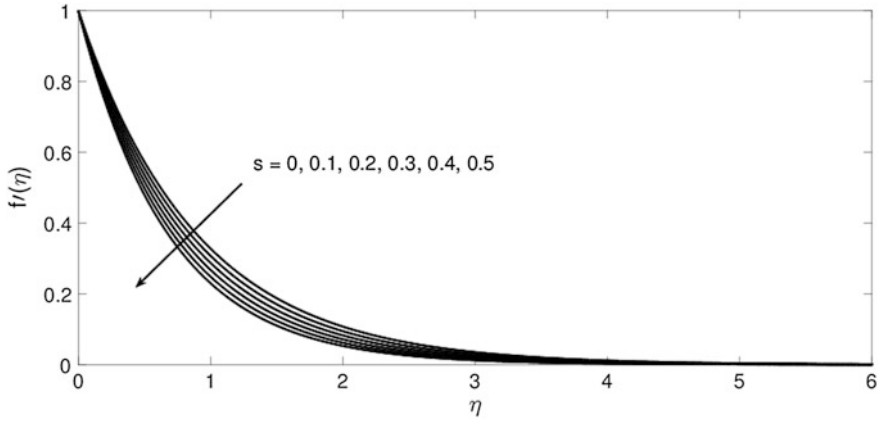

Fig. 7 Velocity profiles of ZnO–kerosene of various suction parameter s when $\phi = 0.1$

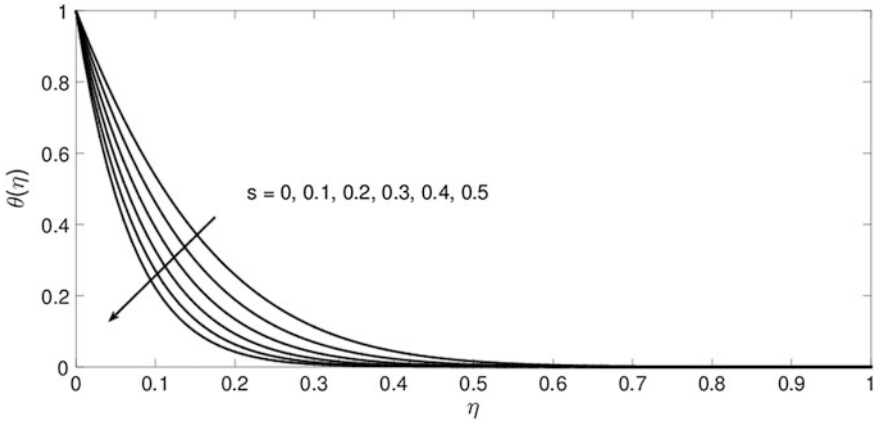

Fig. 8 Temperature profiles of ZnO–kerosene of various suction parameter s when $\phi = 0.1$

4 Conclusion

Four types of nanofluids have been considered in the present study. The ordinary differential equations which are reduced from the governing equation were solved numerically by using a Keller box method. It was found that ZnO-kerosene has the highest absolute value of skin friction coefficient $\left|C_f \mathrm{Re}_x^{1/2}\right|$. Further, the local Nusselt number $\mathrm{Nu}_x \mathrm{Re}_x^{-1/2}$ of MgO–kerosene is the highest compared to the other nanofluids. Moreover, increasing suction parameter s increases the absolute value of skin friction coefficient and local Nusselt number.

Acknowledgments The authors wish to express their thanks to the very competent reviewers for their valuable comments and suggestions. This work was supported by Universiti Teknologi MARA Pahang and Institute of Research Management and Innovation, Universiti Teknologi MARA (Project code: 600-IRMI/PTB 5/3 (008/2017)).

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Part IX
Plantation and Agrotechnology

Chapter 91
The Dominant Effect of *Cabomba furcata* Compost as Non-native Invasive Species Towards the Growth Performance of *Elaeis guineensis* Seedling

Mohamad Amir Shah Yusop, Anisah Mohammed and Muhamad Nazam Abdul Rahman

Abstract Organic agricultural activities are highly recognized as an enhancement for biodiversity, biological cycles and soil biological activities. Used of invasive weeds as organic amendments demonstrated a positive noticeable result in agricultural industries. *Cabomba furcata* was recognized as one of the worst invasive species that harm the aquatic ecosystem. Exploitation of *C. furcata* as an organic compost is an alternative solution to encounter this issue. Composting of *C. furcata* was conducted and the effect of compost was evaluated on the growth performance of *Elaeis guineensis* seedling. Five different amounts of compost were used are 200, 400, 600, 800 and 1000 g with negative control as no compost and positive control as commercial fertilizer. Completely Randomized Block Design (CRBD) was established as an experimental design with 7 treatments and 8 replications. Data on growth performance were collected and analysed using ANOVA and Microsoft Excel. The result shows that 1000 g of *C. furcata* compost indicated the highest result for plant height, leaf width and leaf length. Application of commercial fertilizer dominated the result for stem girth and leaf number. As a conclusion, 1000 g of compost was highlighted as the alternative best rate of compost to obtain the optimum growth performance of *E. guineensis* seedling.

Keywords *Cabomba furcata* · Compost · Invasive · Organic

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_91

1 Introduction

Non-native invasive plants species are defined as an alien species that blooms in new habitat that leads to environmental problems, affects the surrounding environment and lead to human health issues (ISAC 2006). The adverse effects are, it also can lead to extinctions on native species particularly in freshwater ecosystem such as lake (Martin et al. 2011). The path of biological invasion of this non-native invasive plant is influenced by several factors, such as the attributes and mode of transportation of the invaded species, characteristic of the invaded ecosystem and their interactions that are often facilitated by the anthropogenic activities (Baki 2004). Some of this alien species can be considered ecologically villains because it possesses several competitive advantages including the absence of natural enemies that help them to become successful in new environment and flourish at the expense of certain native species. In Malaysia, the concern for these invasive plants are derived mainly due to economic lost especially when it starts to eradicate the common native species that have economic values. In addition, it can also jeopardies the ecosystem of Malaysian water bodies (Rasidah et al. 2010). Majority of this invasive plant enter Malaysia noticed that leads to outbreak that harm our agriculture or aquaculture industries (Mustafa and Shamsul 2006).

Cabomba furcata locally is known as "ekor kucing" and can be identified by its reddish and pink purple leaves, is a famous non-native invasion aquatic plant that are hazardous once released to natural waterways. Its rapid growth allows this plant to dominate native vegetation and disturbed creeks, wetland, lakes and dams. Its density in water bodies blocks direct penetration of sunlight to other vegetation that grows in the same surrounding. *Cabomba* adverse effect also leads to poor water quality by imparting colour and taints that incur cost for water treatment for human consumptions (Department of Agriculture and Fisheries 2016). Warrington (1983) stated that levels of nutrients in this plant are 1.79% of nitrogen, 0.15% of phosphorus, 1.34% of potassium and 0.22% of magnesium.

Composting becomes the best solution converting useless waste from agricultural activities to a product called organic fertilizer. Through composting in an aerobic condition, wild weed seed and pathogen in the waste material could be destroyed with added advantage of enhancing the decomposition and nutrient mineralization (Aldrich and Bonhotal 2006; Kalemelawa et al. 2012). The quick decomposition rates tend to generate heat. The prologue of decomposition was pioneered by a mesophilic organism which functioned best at 75–105 °F and with microbial activities amplifying it, the temperature escalated to 130–150 °F favouring thermophilic microorganism (Chen et al. 2011). Karadag et al. (2013) stated that the thermophilic stage also favours bacterial diversity better than the mesophilic and hyperthermophilic condition.

Oil palm tree subsistence is fully renowned worldwide for its competency in producing the palm oil with the utmost quality and eminence in terms of production and oil content (Gerendas and Heng 2010). The most rapid development of crops worldwide is the oil palm and major plantation sites are in Malaysia and Indonesia

as they are the contemporary top-notch producers of oil palm worldwide (Rupani et al. 2010). The D × P or also known as the Tenera was from the cross breed of both Dura and Pisifera which had resulted in better performance of oil palm tree in term of oil extraction rate (OER), improved fresh fruit bunch weight (FFB) and so forth. In fact, the switch from using the Dura into Tenera had generated an 30% of increment in terms of oil yield. In addition to that, our current national average production of FFB is 20.18 t/ha, OER of 20.12% and lastly the oil yield is at 4.08% t/ha (Kushairi 2009). Since oil palm plays an importance role in Malaysia's economy plus with the problem faced in controlling wide spread growth of *C. furcata*, this study aims to evaluate the growth performance of *Elaeis guineensis* seedling from the application of *C. furcata* compost.

2 Materials and Methods

2.1 *Composting of* Cabomba furcata

The raw materials of *C. furcata* were obtained from Tasik Chini, Pahang. Banana stem, cow manure, goat manure, paddy husk, Indigenous Microorganism (IMO), molasses and charcoal were additional materials that were used for composting process where all the materials were shredded into small piece. Then, it was placed in plastic drum for decomposition process for 33 days. Figure 1 showed the composting procedure.

2.2 *Treatments and Experimental Design*

Seven treatments of *C. furcata* composts were applied in this study that were 200, 400, 600, 800 and 1000 g with one negative control (without compost) and one

Fig. 1 Composting procedure

positive control (commercial fertilizer). Completely Randomized Block Design was employed as an experimental design with eight replications. Rasau series soil were used and filled in 15 in. × 18 in. polybags. *E. guineensis* seedling from D × P Yamgambi variety was selected as tested plant.

3 Data Collections and Statistical Analysis

Data on the growth performance of *E. guineensis* seedling; plant height, size of girth, number of leaf, length of leave, width of leaves were collected to observe the effects of compost on the oil palm growth performance. Data were analysed using ANOVA and interpreted by using Microsoft Excel.

4 Results and Discussion

4.1 Compost Performance

The assessment of the compost performance had demonstrated to be vital in this study as to compute the change and development of the compost which would indicate its maturity, value and its reliability in supplying the nutrient content required by the oil palm seedlings. Hence, *C. furcata* compost was analysed based on its temperature, level of the compost as well as NPK content.

Temperature of the compost was taken from second day after making of compost incubation until the compost became stable and matured. Figure 2 showed the temperature of *C. furcata* compost from day 2 until day 33. The decomposition during composting process caused rising of temperature due to microbial activities. At the first stage, decomposition was pioneered by mesophilic organism which favoured the temperature at the range of 55 °C and later increased to 57 °C which

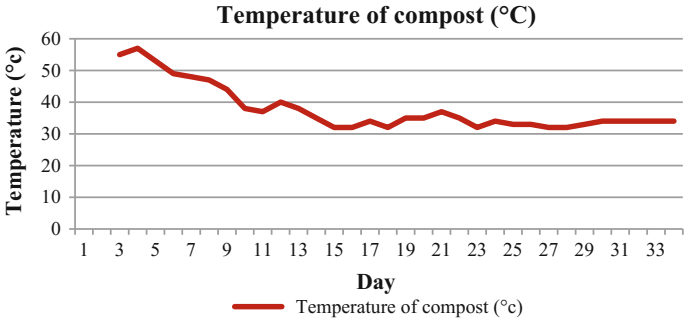

Fig. 2 Temperature of compos

was the thermophilic phase that is due to the amplifying magnitude of microbial activities (Chen et al. 2011). Karadag et al. (2013) mentioned that thermophilic stage favoured bacterial diversity better than the mesophilic and hyperthermophilic conditions. Other than that, thermophilic state could also obliterate harmful pathogens and seed banks as well as enhancing the decomposition rate and nutrient mineralization (Aldrich and Bonhotal 2006; Kalemelawa et al. 2012).

During the composting process, level of the compost was acquired because the foundation of composting was in point with the natural breakdown process of organic remains and waste into stable organic amendments (Cooperband 2002). Rupani et al. (2010) defined that the composting process was all about the stabilization of organic matter by the aerobic microorganism in which it decomposed the substrate by rupturing or revolving it into humic acid and stabilized chemical. Additionally, Huang et al. (2006) had revealed that compost maturity could be verified through physical parameter such as the particle size. Thus, Fig. 3 was highly aligned to the above studies as the level of compost had constantly declined starting on the third day onwards and it had discontinued to be reduced by the nineteenth day. The declining volume of compost materials is due to the decaying process that took place in the composting process and remained constant by day 19 onwards. The reduction in the height of compost was also elaborated by California Compost Quality Council (CCQC 2001), where the organic matter content and its composition had declined as the composting process occurred, which directly complemented the result of this study.

Nutrient analysis had been done to identify the nutrient composition in the *C. furcata* compost. The elements analysed were; percentage of nitrogen (%N), percentage of phosphorus (%P), percentage of potassium (%K) and C/N ratio. Table 1 showed 2.79% was the total of nitrogen content in *C. furcata* compost. Lake

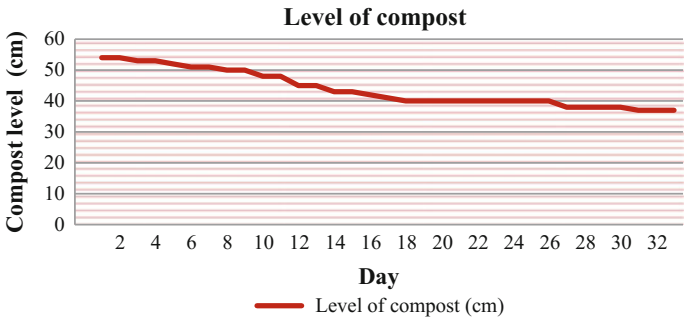

Fig. 3 Level of compos

Table 1 Nutrient content of *Cabomba furcata* compost

Sample	C/N Ratio	Total-N (%)	P (%)	K (%)
Cabomba furcata compost	8	2.79	0.698	2.978

Macdonald catchment care group stated that *C. furcata* contains 2.13% nitrogen and Weeds of National, a significant *Cabomba* project recorded 1.45% nitrogen content in *C. furcata*. The average nitrogen for both resources is 1.79%. The increase in percentage of nutrient content was caused by additional ingredient during composting processing.

4.2 Growth Performance of Oil Palm Seedling

Figure 4 showed that application of 1000 g of compost gave the highest result with height of 47.7 cm. It was followed by the treatment of chemical fertilizer (positive control); 43.2 cm. No application of any kind of treatment (negative control) indicated the lowest plant height; 39.2 cm.

Owolabi et al. (2013) stated that a study on different level of poultry manure had given significant effect toward plant height of oil palm seedling. In this study, additional of manure boosted the nutrient content in *C. furcata* compost. Danso et al. (2013) highlighted that compost had a prominent potential in replacing the commercial fertilizer even in the nursery stage. Siregar et al. (2002) reported there were comparable responds of using both inorganic fertilizer and compost to the plants.

Girth size of *E. guineensis* seedling in Fig. 5 showed the biggest girth by positive control (commercial fertilizer) with the value 9.9 cm. 1000 g of compost showed the second biggest with 9.2 cm. Report from analysis of variance, using adjusted SS for test on one-way ANOVA, F (6.55) = 3.85, MSE = 3.0408, p = 0.004, demonstrated statistical differences between the two group. The null hypothesis at significant level 0.05 fails to reject.

Figure 6 showed application of commercial fertilizer (positive control) again dominated the highest number of leaf with 10 leaves. Seedling by using compost recorded 9 leaves. According to Danso et al. (2013), pattern of growth in both amended and sole green was similar in number of leaves per seedling at all stage of

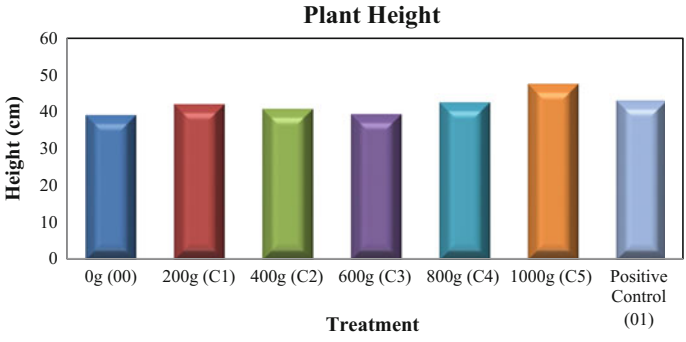

Fig. 4 Height of *Elaeis guineensis* seedling

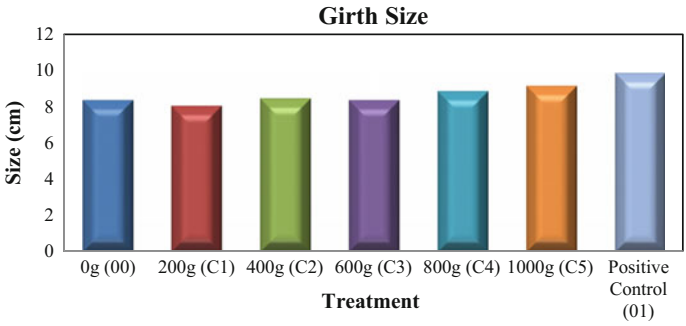

Fig. 5 Girth size of *Elaeis guineensis* seedling

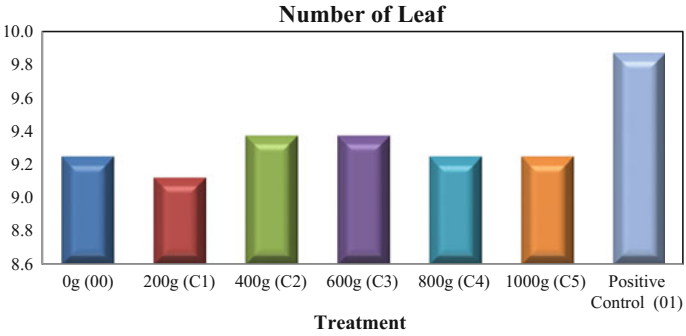

Fig. 6 Leaf number of *Elaeis guineensis* seedling

growth irrespective of inorganic fertilizer was added. The similarities in number of leaves produced per seedling resulted from slow nutrient release and need to be boosted with sufficient amount of crop requirement (Troeh and Thompson 2006). The one-way ANOVA, F (6.55) = 0.95 MSE = 0.4762, p = 0.473, demonstrated no significant differences statistically between the two group. The null hypothesis at significant level 0.05 fails to reject. Based on the finding regarding the leaf number of *E. guineensis* seedling, theory from Danso et al. (2013) and Troeh and Thompson (2006) was accepted.

Figure 7 showed that 1000 g of compost gave the longest length for *E. guineensis* seedling; 19.6 cm. Second is seen for treatment 400 g of compost with 18.2 cm length. In term of leaf length, positive control (commercial fertilizer) indicated the shortest size with 13.6 cm. The result from one-way ANOVA, F (6.55) = 2.24, MSE = 27.94, p = 0.058, gave no significant differences between the two group, as theory would dictate. The null hypotheses at significant level 0.05 fail to reject. The application of compost provided supplementary benefits such as amplified water holding capacity, drainage and aeration, lessening in water and air erosion, encouragement the expansion of microorganisms and earthworms as well

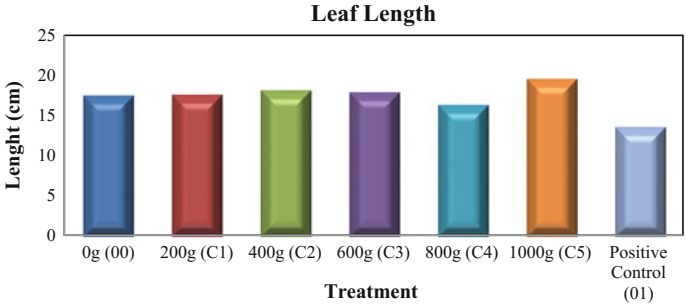

Fig. 7 Leaf length of *Elaeis guineensis* seedling

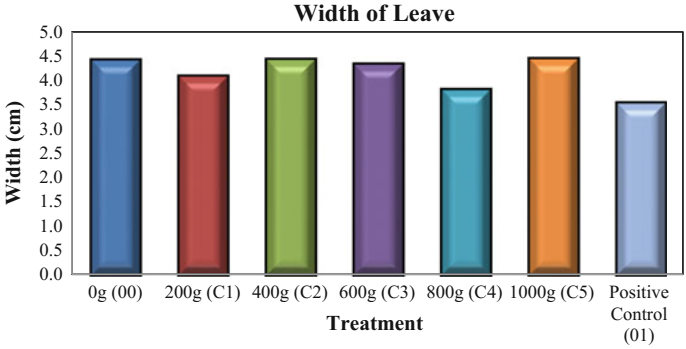

Fig. 8 Leaf width of *Elaeis guineensis* seedling

as executing itself as a basis of slow release nutrients (Rosen and Bierman 2005). The finding of study accompanied with the study done by Garg et al. (2005), where the animal wastes used had an immense potential amount to sustain the soil condition, granting supplementary organic matter as well as sustaining the soil condition.

The widest size of leaf was dominated by 1000 g of compost with 4.5 cm (Fig. 8). Positive control (commercial fertilizer) indicated the smallest size with 3.6 cm. According to Uwumarongie et al. (2012), leaf width obtained from chemical fertilizer was the widest size compared to organic fertilizer. Result from one-way ANOVA, F (6.55) = 1.26, MSE = 1.0349, p = 0.294, demonstrated statistically no significant differences between the two group. The null hypotheses at significant level 0.05 fail to reject.

5 Conclusion

As a conclusion, maturity of compost depended on the temperature and level of compost during composting process. *C. furcata* compost reached thermophilic phase and constant temperature indicated the maturity of compost. Application of compost to the *E. guineensis* seedling with different rate showed the 1000 g is the best rate to gain the optimum plant height, leaf length and leaf width.

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Chapter 92
Utilization Effects of *Asystasia intrusa* Compost Toward the Growth Performance of *Elaeis guineensis* Seedling

Anisah Mohammed, Mohamad Amir Shah Yusop and Nur Ain Zubaidah Amran

Abstract *Asystasia intrusa* was recognized as the most problematic weed in oil palm estate. Manual and chemical processes were required to eradicate the weed. Composting of *A. intrusa* not only controlled weed but also could be used as organic compost due to the great potential of nutrient. The study was conducted to examine the effectiveness of *A. intrusa* compost toward the growth performance of *Elaeis guineensis* seedling. There were six different rates of compost applied: 200, 400, 600, 800, 1000, and 1200 g. Commercial fertilizer was used as positive control while without compost application was used as negative control. A randomized complete block design was employed as experimental design with eight replications. Compost application of 1000 g indicated the highest value of plant height, stem girth, leaf length, leaf width, and leaf number but only plant height and stem girth showed a significant difference. Thus, utilization of 1000 g of *A. intrusa* compost significantly affects the growth performance of *E. guineensis* seedling, where it was unrivaled by the commercial fertilizer in this study. Application of *A. intrusa* compost also reduced the acidity of the soil.

Keywords Asystasia intrusa · Compost · Elaeis guineensis

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_92

1 Introduction

Asystasia intrusa known as Chinese violet weeds belongs to the family of Acanthaceae. It was categorized under the herbaceous dicot with broadleaves weed and whitish purple flower. Some of the countries consider *A. intrusa* as a garden plant but in Malaysia, it was considered as an invasive or noxious weed. Noxious weed was classified as a plant that causes a decline of quality and quantity of crops production due to the competition for nutrient, water, light, and space (Priya et al. 2014). Extreme widespread of *A. intrusa* become a major problem in Malaysian plantation due to the replacement of beneficial legume cover crops in the field. The desire for high nitrogen and phosphorous of weed contribute to the highly competitive uptake of soil nutrients and physical interferences with the plantation crops (Rajiv et al. 2013). *A. intrusa* was removed by using the manual or chemical control in order to maintain the growth performance of crop. Mostly plantations prefer to eradicate noxious weeds by using herbicides which were effective and swift. Application of herbicides increases production cost and creates major pollution to the environment.

According to Rajiv et al. (2013), weeds were emerging at an alarming rate and the distribution rate was very fast in cultivated land, pasture, grassland and forest causing loss of the outstanding amount of nutrient content. Prudent and accurate utilization and management of noxious weed were promising and beneficial in the imminent future due to high organic matter content, fast growing and adaptability to numerous environmental conditions. According to Rajkhowa et al. (2005), weed biomass has rich sources of organic matter and plant nutrients. Decomposition and degradation of weed biomass contained the high presence of nutrient and acid humus. Biomass weed has the potential to acquire a third of applied fertilizer in the first week and capable of removing 1250 tons of water in a season per hectare of land (Chamle 2014). The incorporation of compost, vermicompost, organic manure and all sort of organic products not only improved the agriculture production but maintain a sustainable environment (Ghadge et al. 2013).

Compost was defined as a product which resulted from the decomposition of residues or organic waste through the composting process and can be used as organic fertilizer (Himanen and Hanninen 2011). Organic wastes without composting contribute to the phytotoxicity and immobilization of nutrients (Raj and Antil 2011). Composting process can be in aerobic or anaerobic condition but microorganisms involve required the ideal condition to ensure the success of compost formation (Danso et al. 2013). Adequate moisture, oxygen, and proper balance of carbon to nitrogen are the basic requirements of the composting process. Particle size, structural strength, frequency turning for aeration, acidity, and size of the compost pile are the other factors that contribute to successful composting (Raj and Antil 2011). Application of compost protected the plant from fungal diseases, increase water holding capacity and improve soil structure (Keith and Jackie 2009). Junedi et al. (2013) reported that *A. intrusa* has improved soil chemical properties by increasing soil pH, cation exchange capacity, nitrogen, phosphorus, and

potassium. It contains 21–26% crude protein concentration, 37.8% carbon, 1.26% nitrogen, and 1.57% potassium. It was a great potential of nutrient content, capable to get the high value of compost.

The incorporation of fertilizers in plantation industry is very prominent and crucial practice in which it had constituted around 85% of production cost (Goh 2003). The incorporation of the organic amendment is the main concern nowadays in order to reduce the production cost of chemical fertilizer. Normally, oil palm waste was used as an organic amendment in oil palm plantation (Azmi et al. 2010). Planting of legume cover crops to fix the nitrogen at the young palm was the other alternative to reduce the application of inorganic fertilizer (Zulkifli et al. 2010). According to Khairil et al. (2013), compost tested as planting media for oil palm seedlings showed the highest nitrogen uptake in leaves. Organic practices in oil palm plantation not only reduce the production cost of fertilizer but also cater toward an environmental-friendly situation. Application of sufficient organic material could trim down the chemical fertilizer to as much as 50% in the immature palm and 5% in the mature palm (Comte et al. 2012). Thus, the study aims to examine the utilization effects of *A. intrusa* compost to the growth performance of oil palm seedling. The valuable information on the appropriate amount of *A. intrusa* compost to affect the growth of oil palm seedling is the target of this study.

2 Materials and Methods

2.1 Compost Preparation

Compost preparation started with the placement of raw materials into the open cage. Barkley method composting technique (hot composting) was used in this study. *A. intrusa* used as main material was incorporated into charcoal, manure, paddy husk, and indigenous microorganism (IMO) as additional material in compost making. All the materials were mixed together before being transferred into the cage. The temperature was observed to reach the thermophilic stage in order to obliterate harmful pathogen, seed banks as well as enhancing decomposition rate and nutrient mineralization. Constant temperatures indicated that compost reached maturity and is ready to be used as organic compost.

2.2 Treatments and Experimental Design

The experiment was conducted at 100-acre Jengka Farm, Universiti Teknologi MARA (Pahang). *Elaeis guineensis* (oil palm) seedling from D × P Yamgambi variety was used as a material plant. It was germinated for 1 month before transplanting into the polybag. Rasau series soil was poured into the 15 in.

Table 1 Treatment of study

Label of treatment	Description
Z0	Without compost application (Control)
Z1	200 g of *A. intrusa* compost
Z2	400 g of *A. intrusa* compost
Z3	600 g of *A. intrusa* compost
Z4	800 g of *A. intrusa* compost
Z5	1000 g of *A. intrusa* compost
Z6	1200 g of *A. intrusa* compost
Z7	Commercial fertilizer application (Positive control)

×18 in. of polybags. Sprinkler system was installed for irrigation cycle of twice a day at 15 min per irrigation. Randomized completely block design (RCBD) was employed as an experimental design which had 8 blocks with the total of 64 experimental units. Table 1 shows the treatment of study including 2 types of control.

2.3 Data Collection and Statistical Analysis

Data on growth performance of *E. guineensis* seedling were collected on a weekly basis. These were plant height, leaf length, leaf width, stem girth, and leaf number. Soil pH was taken twice, first before compost application and second at end of the experiment by using pH meter. The content of nitrogen, phosphorus, and potassium was analyzed from a sample of compost. Data were analyzed statistically using Minitab software and Tukey's Simultaneous Test was used for means comparison at alpha 0.05.

3 Results and Discussion

Table 2 shows the availability of nutrient content in the *A. intrusa* compost. The macronutrient (NPK) and C: N ratio was highlighted to confirm the nutrient contents in the compost.

Table 2 Nutrient content of *Asystasia intrusa* compost

Type of nutrient	Content of nutrient
Nitrogen (N)	3.57%
Phosphorous (P)	1.204%
Potassium (K)	4.352%
C/N ratio	16

Analysis of nutrient for *A. intrusa* compost showed the potassium at 4.352% as the highest nutrient content followed by nitrogen (3.57%) and phosphorus (1.204%). An earlier study by Junedi et al. (2013) found the composition of nitrogen and potassium in *A. intrusa* at about 1.26% and 1.57% respectively. Additional charcoal, manure, paddy husk, and indigenous microorganism (IMO) in compost production was to boost up the nutrient in the compost. The ratio of carbon per nitrogen (C/N Ratio) was 16. C/N value recorded above 30 indicated slow decomposition process due to the high degradable substrate for microorganism (Bernal et al. 2009). Based on the result recorded, *A. intrusa* compost did not require a long period to decompose and it could provide a good amount of macronutrient to the plant.

Figure 1 shows the plant height of *E. guineensis* seedling at the final week after treatments application. The value of 54.84 cm recorded as the highest plant height which belongs to 1000 g of *A. intrusa* compost. It was significantly different with $p = 0.00$. A study by Abner and Foster (2006) indicated that compost contains the valuable nutrients that can be utilized by the plants. Plant without application of compost (Z0) showed the lowest height of 42.30 cm. Application of chemical fertilizer to the *E. guineensis* seedling showed the second lowest with the value 43.13 cm. Danso et al. (2013) highlighted that compost had a prominent potential in replacing the commercial fertilizer in the nursery stage. According to Siregar et al. (2002), application of inorganic fertilizer and compost showed the comparable response to the plants.

Figure 2 shows the stem girth of *E. guineensis* seedling. Application of 1000 g of *A. intrusa* compost showed the biggest stem girth with 10.56 cm. It was significantly different with $p = 0.004$. Both negative and positive control indicated the smallest of plant girth with the value 7.89 and 7.94 cm respectively. Presence of organic manure in the compost gave the pertinent impact to the organism in releasing phytohormone which fuels up the plant growth (Arisha et al. 2003). A study conducted by Fairhust and Mutert (1999), showed an increment of nitrogen

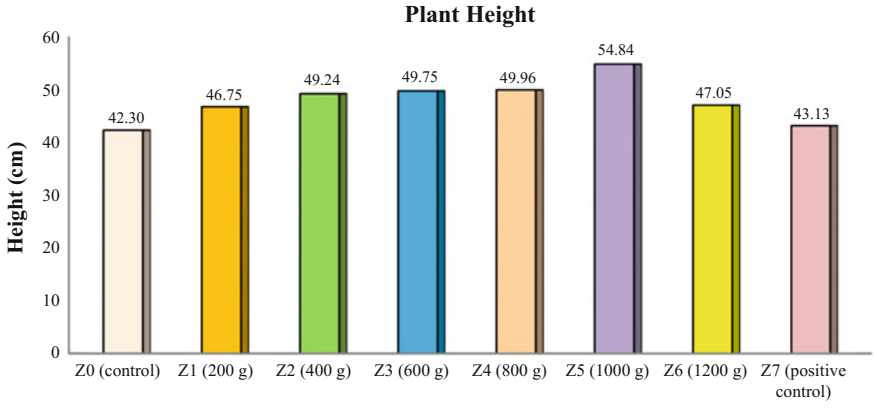

Fig. 1 Plant height of *Elaeis guineensis* seedling

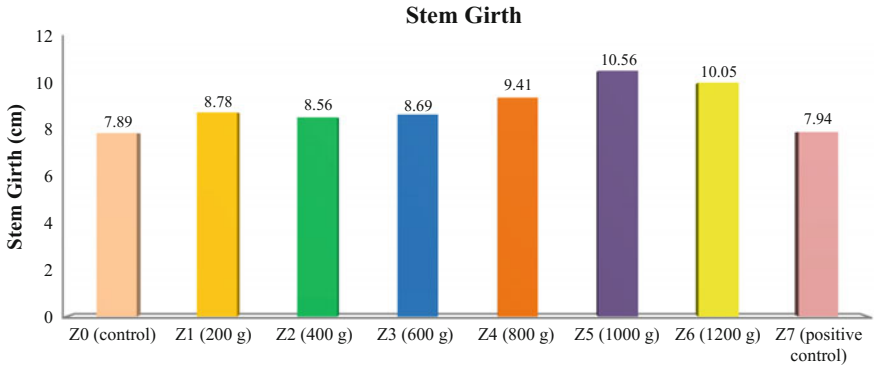

Fig. 2 Stem girth of *Elaeis guineensis* seedling

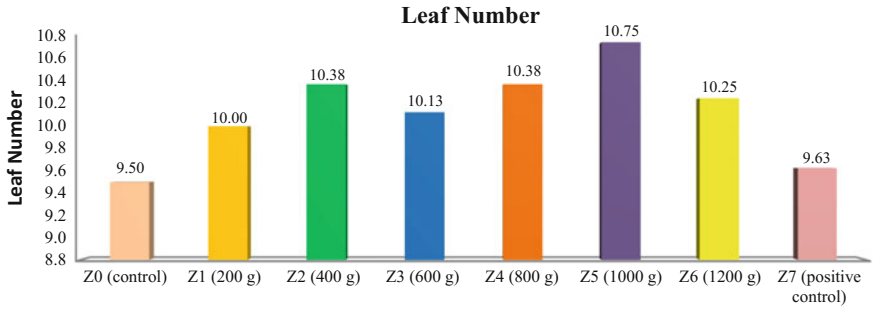

Fig. 3 Leaf number of *Elaeis guineensis* seedling

would directly result in diminishing the potassium content since the growth of seedling required more potassium to be utilized for its growth.

Based on the Fig. 3, 1000 g of *A. intrusa* compost showed the highest number of leaves with the average 10.75. The other seedlings applied with the compost showed 10 numbers of leaves but both the control used only indicated 9 numbers of leaves. From the analysis of one-way ANOVA, leaf number did not show any significant difference with $p = 0.064$. A study from Uwumarongie (2010), indicated the application of composted empty fruit bunch lead to the highest number of leaves compared to the application of NPK Mg. It was supported by a study of Danso et al. (2013) which recorded that number of fronds was the highest with the application of green manure compost compared to synthetic fertilizer.

Figure 4 shows the leaf length of *E. guineensis* seedling at the end of the study. The longest leaves length was seen at 1000 g of *A. intrusa* compost with 23.28 cm. Treatment from both controls recorded the similar value of leaf length about 21.5 cm. One-way ANOVA analysis indicated that there is no significant differences between the treatments. The 3.57% of nitrogen content in *A. intrusa* compost

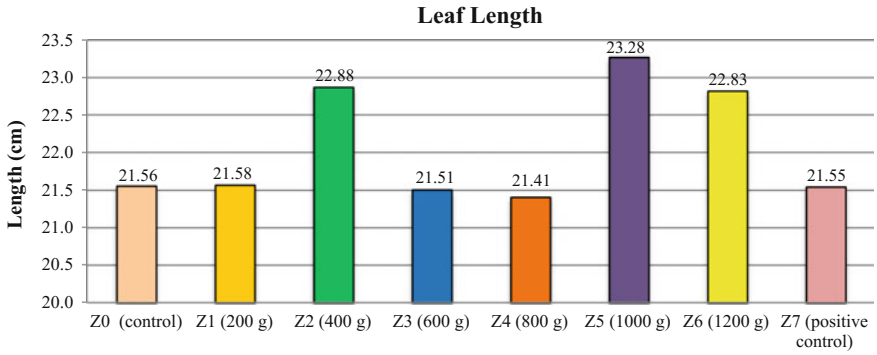

Fig. 4 Leaf length of *Elaeis guineensis* seedling

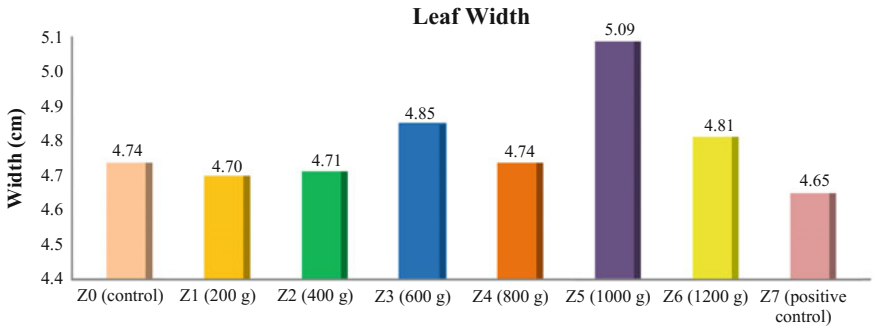

Fig. 5 Leaf width of *Elaeis guineensis* seedling

gave the same effect to the growth of leaf length of *E. guineensis* seedling. According to Al-Khatani and Ahmed (2012), the fertilizing power obtained from organic fertilizer, especially compost was to stabilize the content of organic matter thus increased the length of leaf for the plants.

From Fig. 5, 1000 g of *A. intrusa* compost showed the widest leaf with 5.09 cm. The lowest width of leaf goes to the positive control (chemical fertilizer) with the value 4.65 cm. A study conducted by Ilori et al. (2012) recorded that application of compost reduced the content of chlorophyll that affects the growth performance especially in terms width of the leaf. Farahzety and Aishah (2013) reported commercial fertilizer was easily absorbed by the plant and it would better assist in the higher production of chlorophyll content than compost. Finding from this study showed the same effect for either using compost or chemical fertilizer. With the P value = 0.58, there is no significant difference among the treatment for leaf width of *E. guineensis* seedling.

In the first week of the experiment, soil pH was recorded as 3.50, which was considered as very acidic. However, the change of soil pH was observed when the

Table 3 Soil pH analysis

Treatment	Z0 (Control)	Z1 200 g	Z2 400 g	Z3 600 g	Z4 800 g	Z5 1000 g	Z6 1200 g	Z7 Positive control
pH before	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
pH after	4.62	5.86	5.06	5.10	5.07	5.38	5.08	4.69

pH was taken at the end of the experiment. Both negative and positive control showed the alteration of soil pH to 4.6 but the application of compost to soil indicated the good changes from 3.50 to 5.0 and above (Table 3). According to Trautmann and Krasny (1997), soil pH was changed due to breakdown and volatilization of organic acid in the compost during the latter stage. Report from Cornell Waste Management Institute (1996) stated that the pH was increased from 5.5 to 8 with the incorporation of compost.

4 Conclusion

Based on the finding from this study, it can be concluded that total nitrogen (3.57%), phosphorus (1.204%), and potassium (4.352%) in the *A. intrusa* compost can be utilized with the appropriate rate to obtain the optimum growth. Application of 1000 g of *A. intrusa* compost to the *E. guineensis* seedlings showed significant effects to the plant height and size of girth. In terms of performance for leaf number, leaf size and leaf width of *E. guineensis* seedlings, compost and chemical fertilizer contribute to the similar effects. Changes of soil pH after compost application provided the good soil condition for plant growth. From this study, it was revealed that biomass weed can be converted into the compost which consists of good nutrients capable of increasing the performance of plants.

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Chapter 93
In Vitro Germination and Acclimatization of Sugar Palm (*Arenga pinnata* Wurmb Merr.)

Nazatul Asikin Muda and Asmah Awal

Abstract Sugar palm (*Arenga pinnata* Wurmb Merr.) is a multipurpose tree which provides different products with high economic values and plays an important role in small, integrated farming systems of rural communities in Asia. However, its cultivation is hindered by the limitations of recalcitrant seeds and prolonged dormancy. Thus, an in vitro germination protocol of sugar palm was carried out as an alternative propagation method using mature seeds, young seeds and immature zygotic embryos as explants. Optimized germination including shoot/roots emergence were evaluated on MS medium supplemented with different concentrations of PGRs. The highest frequency of the in vitro germination of sugar palm was observed from the immature zygotic embryo explant cultured on MS medium supplemented with PGRs (100%), while the least germination rate (30%) was recorded on basal MS medium after 8 weeks of culture. Young seed and mature seed explants sown directly on moistened soil for viability test proved dormancy. In vitro germination of explants was depended on genotype and treatments. Complete plantlets formation was observed after 7–9 months of culture. In vitro plantlets with roots were successfully acclimatized in soil: peat moss: perlite (40:40:20) substrates mixture with 80% survival rate after 4 months.

Keywords Acclimatization · In vitro germination · Plant growth regulators (PGRs) · Sugar palm (*Arenga pinnata* Wurmb Merr.)

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_93

1 Introduction

Sugar palm is a monocotyledonous perennial tree belongs to the family of *Arecaceae* (Lim 2012). Geographically, sugar palm is native to North East Asia, Indonesia, Malaysia, Myanmar, Philippines and Thailand (Wu et al. 2010). Sugar palm has been mainly planted and tapped for its high yield sugary sap and starch. The sugary juice tapped from the male flowers can be processed into many food-based and chemical-based products such as sugar, vinegar and bioethanol. Leaves, stem, fruits, underground seedlings, fibres and roots are also valuable products of sugar palm exploited for other economic benefits (Salans and Darling 2011). Sugar palm trees also serve as a great ecological tolerance subject based on the facts that they are able to grow on and stabilize sterile erosion-prone sites such as steep dryland slopes, potentially grown on almost any soil type which include the poorest, infertile arid regions, relatively fast growth rate, potentially increases soil fertility and water conservation, pest and disease resistant, accidental-burning tolerance and that the trees need almost no maintenance (Mogea et al. 1991) to grow.

Naturally, sugar palm trees are regenerated by seeds. Even though plant production through seed regeneration have been reported to be the most effective natural method for many species, seed germination of sugar palm, however, is hindered by the limitations of recalcitrant seed, long seed dormancy period (Bareja 2010) and the use of physiologically mature seed as planting material. These significant constraints then lead to uneven growth and slow seedling growth development upon germination, thus come to be the main reasons as for why the sugar palm trees have not been commercially planted despite the various benefits they offer. Long juvenility, short lifespan and deficiency in reliable information and profitability of this potential crop also lead to its degraded popularity among growers. Meanwhile, nursery germination of sugar palm trees is very poor and non-predictable due to specific temperature and storage requirements to maintain seed viability. In order to maintain the population of sugar palm through cultivation, growers usually obtain wild seedlings from natural regeneration which is then nurtured as nursery seedlings.

As the wild seedlings production depended greatly on natural regeneration; though wild domestication of sugar palm can be least costly as no labour is required for seeds planting, the intensive harvest of sugar palm fruits diminishes the source of seed for natural regeneration prominently (Martini et al. 2010). Without a systematic enrichment planting and conservation efforts of the seedlings by a human, it is feared that the number of sugar palm trees will continuously decline and might lead to extinction. As much as the stated limitations in seed propagation of sugar palm trees is concerned, mainly recalcitrant seed and dormancy, seed propagation may play an important role in sugar palm breeding especially for the variability and germplasm conservation purposes. Depending on plant species, seed dormancy may last for only a few days or as long as several years.

Even though seed dormancy can be regulated by the environment or by the seed itself (Evans and Blazich 2007), numerous techniques are being proposed to

artificially stimulate germination in dormant seeds, taken into consideration the type of plant species and the dormancy period. These practices include scarification, soaking in water, stratification, dry storage, chemical treatments, exposure to light, endogenous hormones treatment and embryo culture technique (Chawla 2002). Endogenous hormones or plant growth regulators (PGRs) treatment and excised embryo culture system are two of the most frequently used methods to break seed dormancy in many plants. PGRs are organic compounds which act inside plant cells to stimulate or inhibit specific enzyme systems and help to regulate plant metabolism (Harms and Oplinger 1993), hence influence plants development, reproduction and overall growth. PGRs in specific types and levels are directly involved in the control of seed development, dormancy and germination (Jha and Ghosh 2005). Meanwhile, excised embryo culture is capable of circumventing various causes of seed dormancy and at the same time allowing rapid testing of seed viability (Bhojwani and Dantu 2013).

This paper thus reports the protocol for in vitro germination of immature zygotic embryo explant of sugar palm under the influence of PGRs to induce uniform and faster plantlet germination aiming for mass propagation. Surface sterilization of plant materials and in vitro seedlings development were also reported. Established seedlings were acclimatized and transferred under greenhouse condition.

2 Materials and Methods

2.1 Plant Material, Surface Sterilization and Seed Viability

Fresh fruits of sugar palm at 15–18 months after anthesis were collected from selected growers in Benta, Pahang, Malaysia. Fruits were detached from the bunch and washed with tap water. Surface sterilization was commenced in 70% ethyl ethanol solution for half an hour and rinsed with sterile distilled water three times. Later, the fruits were soaked in 50% sodium hypochlorite added with a few drops of Tween 20 for another 30 min and thoroughly rinsed with sterile distilled water. The surface sterilized fruits were then dried in laminar air flow cabinets and halves, revealing immature, but fully developed zygotic embryos to be used as explant. Selected embryos were then being squeezed out from the endosperm and placed in sterile distilled water to avoid dehydration prior to incubation on the MS (Murashige and Skoog 1962) culture media treatments. In vitro germination of sugar palm using black mature seeds and young seed explants were also determined using similar MS media treatments. Seed viability of sugar palm's seeds was also observed by sowing the black mature seeds and young seed explants directly on the moistened soil in plastic pots.

2.2 Preparation of Culture Medium and Establishment of Culture

MS culture medium was prepared with 4.41 g/L MS salt, 30.0 g/L sucrose and gelled with 2.5 g/L Gelrite. PGRs at different concentrations and combinations were fortified into the solution mixture. The pH of all culture media was adjusted to 5.8 and gelled with 2.5 g/L Gelrite prior to autoclaving at 121 °C for 20 min. Explants inoculated on MS culture medium devoid of PGRs served as control. Dissected zygotic embryos were incubated on the culture media and maintained in a growth chamber adjusted at the temperature of 25 ± 2 °C. For growth and development of culture, a 16 hours light photoperiod was provided using continuous cool white fluorescent lamps at 2000–3000 lx intensity.

2.3 Data Collections and In Vitro Seedling Development of Sugar Palm

The in vitro germination of explants was determined by culturing the sterile young seeds, mature seeds and immature zygotic embryos individually in culture flasks. Each flask contained a single explant and each treatment was replicated 10 times. The cultures were observed daily and data was recorded at 4 week intervals after incubation. Observations were made until the germination process completed. Cultures with emerged radicles or shoots or both at least 5.0 mm size were counted as germinated. Growth parameter was defined by the average cotyledonary petiole length (cm) of explants. In vitro germination percentage, GRF (%), the shoot development frequency, SDF (%), radicle/adventitious roots frequency, RDF (%) and morphology of the developed seedlings was also recorded. The experiment was conducted twice.

2.4 Acclimatization of Plantlets

Acclimatization of sugar palm plantlets was demonstrated in two phases. First, well-rooted in vitro plantlets were taken out of culture vessels and washed with tap water to remove the remnants of agar from the root system. Washed plantlets were then transferred to new culture vessels containing MS salt solution and incubated at 25 ± 2 °C for 2 weeks. Second, the plantlets were washed with distilled water, treated with fungicide and subsequently transplanted in plastic pots half-filled with different potting mixtures for hardening. Transferred plantlets were then placed under a plastic tunnel followed by frequent water sprays to maintain high humidity. The seedlings were acclimatized by gradually opening the plastic covers. After 8 weeks, they were completely uncovered and hardened to greenhouse condition at

25 ± 2 °C and 70−90% relative humidity. The rate of plantlet survival (%), mean plant height (cm), mean leaf number and mean leaf diameter (cm) were recorded after 5 months of acclimatization.

2.5 Statistical Analysis

Experiments were laid out using completely randomized design (CRD). The significant differences among the treatments were determined by analysis of variance (ANOVA) followed by Tukey post hoc test using Statistical Package for the Social Sciences (SPSS) software. Each mean value was expressed as a mean ± standard error (SE). Statistical significance was set up at $P < 0.05$.

3 Results and Discussion

3.1 Establishment of In Vitro Culture of Sugar Palm from Mature Seeds, Young Seeds and Isolated Immature Zygotic Embryos Explants

In vitro culture of sugar palm using mature seeds (Fig. 3a), young seeds (Fig. 3b) and isolated immature zygotic embryo (Fig. 3d) explants was established to obtain uniform, viable seedlings which were hard to establish under natural regeneration due to low germination rate and prolonged dormancy. Results obtained from this experiment revealed that culturing black mature seeds explant on all MS media treatments under in vitro condition showed no germination response. Similar result was also observed from the mature and young seeds explant directly sown on soil even after 5 months, suggesting dormancy. This observation is comparable to Haris (1994) who reported germination failure from mature seeds of sugar palm planted in soil at ambient temperature for 4 months, even though Tetrazolium test showed them to be viable. The finding was also supported by Masano (1989) who described that the germination of sugar palm may took a long time to germinate. The process can be varied within 30–50 days after sowing and can reach up to more than 6 months concluding to its slow and sporadic germination owing to seed dormancy.

Meanwhile, culturing entire young seed explant (with intact endosperm) of sugar palm on MS0 also failed to give germination response in terms of cotyledonary petiole growth or shoot/root regeneration after 12 weeks of culture. Initially, the young seed explants were yellowish in colour but later turned brown and gradually blackish within 2 weeks of incubation due to the accumulation of phenolic compounds. It takes approximately 12 weeks for the endosperm to vertically crack revealing the beige-coloured embryos (Fig. 3c). The started-to-mature embryos

were swelled five times from the initial size, but no signs of germination were observed. The high rate of culture contamination (60–80%) was also recorded.

Successful in vitro germination of isolated immature zygotic embryo explant was established on MS0. The germination process of immature zygotic embryo explant was defined in two stages; (1) protrusion of cotyledonary petiole/sheath and (2) development of radicle and shoot from the cotyledonary petiole. It was observed that immediately after incubation, some of the cultured immature zygotic embryo explants became swollen and germination started to occur within 4 weeks. In the early development of cotyledonary petiole, the colour was observed to be whitish green, thinner and at an average size of 3.0–5.0 mm (Fig. 3e). After 5–6 months of culture, the cotyledonary petiole size extended to 6.0–10.0 cm long (Fig. 3f). It then eventually turned brown, enlarged and radicle developed before splitting up revealing the beige-coloured plumule (Fig. 3g) through the cleft. The cultured embryos were fully developed into complete plantlets with half of the explants developed eophylls, some with secondary plumule and adventitious roots (Fig. 3h) after 7–12 months. The growth and development of sugar palm using isolated immature zygotic embryos explant cultured on MS basal medium might take an extended time to fully germinate into complete plantlet but the in vitro method was effective with 100% germination occurring after 12–15 weeks of culture as compared to the mature seeds and young seed explants.

'Zygotic' or seed embryos are often used advantageously as explants in many tissue culture procedures frequently at the immature stage as it promotes a higher rate of germination as compared to mature embryos with the explanation of being highly totipotent (Mirza 2013). Isolating the embryos from the endosperms is a great method to assist in the rapid production of seedlings from dormant seeds and enables seedlings to be produced when the genotype conveys a low embryo or seed viability (George et al. 2008). It was thus concluded that the thick endocarp and endosperm of sugar palm seeds may be responsible for its dormancy, delay germination and hindered further development of zygotic embryos. It was explained by Baskin and Baskin (2014) that the presence of hard endocarp (such as in black mature seed of sugar palm) and thick endosperm inhibits seed germination, thus removing the inhibiting factors offers better germination percentage.

3.2 Effect of PGRs on In Vitro Germination of Sugar Palm and Seedling Development

MS culture media fortified with PGRs had a significant effect on growth and development of in vitro seedlings. Depending on the type and concentrations of PGRs used, the morphogenesis patterns also varied. Sugar palm plantlets obtained from the immature zygotic embryo explant cultured with PGRs produces large green haustorium and shorter cotyledonary petioles. The formed seedlings tend to have a shorter period of cotyledonary petiole breakage, revealing protruded

plumules through the base of the cotyledonary petiole as early as 2 weeks after incubation as compared to those cultured on the control treatment. The number of explants producing roots and shoots was greater in number, with better quality of seedlings in terms of plant height, colour and shoot development.

Meanwhile, root production of explant in existence of PGRs was vigorous, and thicker which is an important feature for successful acclimatization in the soil. The majority of the roots were produced within 10 days of culture. It was also observed that in the presence of PGRs, some explants tend to develop multiple radicles followed by adventitious roots at the basal end of the embryos instead of normally growing at the tips of the cotyledonary petiole. It was also observed that in vitro seedlings of sugar palm cultured on MS0 developed thin and fragile radicle which breaks easily during transfer to fresh media or while being prepared for hardening on soil causing the seedlings to wilt and eventually die.

For all of the parameters recorded, MS medium supplemented with Kin (Kinetin) in combination with IAA (3-indoleacetic acid) proved to be the most effective. The highest germination rate (100%) was recorded after 8 weeks of culture on MS medium supplemented with 1.0 mg/L Kin and 1.0 mg/L IAA roots and shoots emergence rate at 70% and 40% of total explants respectively (Fig. 1). The maximum height of seedlings was developed on the same medium composition at 4.25 ± 0.48^{d} cm. 70% frequency of roots development was also recorded on MS medium supplemented with 1.0 mg/L BAP (6-Benzylaminopurine acid) and 1.0 mg/L NAA (1-naphthaleneacetic acid). Statistical analysis using ANOVA and Tukey test proved that there is a significant difference between different treatments tested ($P < 0.05$) [Table 1]. The effectiveness of BAP and NAA in MS culture medium was similarly reported in *Dendrobium chrysotoxum*, promoting higher germination percentage and effective in generating more in vitro rooting (Nongdam and Tikendra 2014).

The interaction of auxin and cytokinin combination has been known for a long time to act either synergistically and antagonistically to control plant developmental

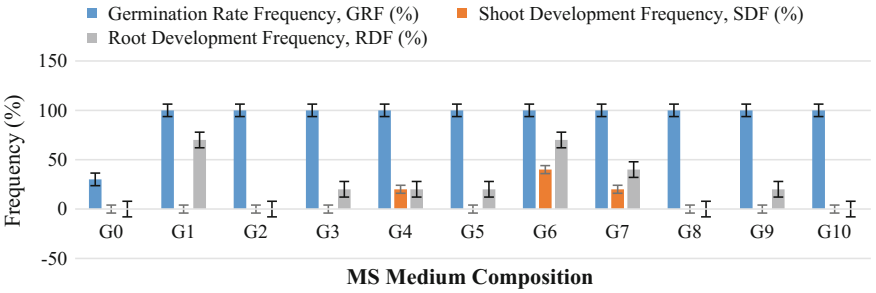

Fig. 1 The effect of different PGRs on in vitro plantlet development of immature zygotic embryo explant of sugar palm after 8 weeks of culture. [1]The frequency of plantlet germination, shoot and root development frequency values = (Number of explants germinated or inducing shoot and roots/Total number of cultured explants) × 100. Error bars indicate the standard error of the mean of ten replicates

Table 1 The effect of different PGRs on the in vitro germination of sugar palm *Arenga pinnata* (Wurmb.) Merr. from immature zygotic embryo explant after 8 weeks of culture

Treatments	MS medium composition	Cotyledonary petiole length (cm)
1.	MS0	2.45 ± 0.13^{bc}
2.	MS + 1.0 mg/L BAP + 1.0 mg/L NAA	2.55 ± 0.05^{bc}
3.	MS + 2.0 mg/L BAP + 1.0 mg/L NAA	2.50 ± 0.08^{bc}
4.	MS + 3.0 mg/L BAP + 1.0 mg/L NAA	2.50 ± 0.08^{bc}
5.	MS + 1.0 mg/L BAP + 1.0 mg/L IAA	3.00 ± 0.21^{bc}
6.	MS + 1.0 mg/L BAP + 2.0 mg/L IAA	3.40 ± 0.22^{cd}
7.	MS + 1.0 mg/L Kn + 1.0 mg/L IAA	4.25 ± 0.48^{d}
8.	MS + 1.0 mg/L BAP + 3.0 mg/L IAA	2.30 ± 0.12^{b}
9.	MS + 2.0 mg/L BAP + 1.0 mg/L IAA	2.50 ± 0.08^{bc}
10.	MS + 2.0 mg/L BAP + 2.0 mg/L IAA	3.00 ± 0.21^{bc}
11.	MS + 2.0 mg/L BAP + 3.0 mg/L IAA	0.85 ± 0.11^{a}

[a]Values represent the mean of five replications ± standard error (SE). [b]Standard error of mean (SEM) was calculated by dividing SD by the square root of sample size (n) [SE = σ/sqrt (n)]. [c]Values followed by the same letter(s) within a column are significantly different by Tukey test at $P < 0.05$. [d]The result is not significantly different at 0.05 level ($P > 0.05$) for the treatments

processes, such as the formation and maintenance of meristems that are essential to establish the whole plant body (Su et al. 2011). The PGRs also provided balance shoot and root development, thus considered to be one of the reasons for higher frequency of plantlet establishment. Together with MS0, culture medium supplemented with higher concentrations of BAP and NAA was less effective, supporting up to only 20% rooting, no shoot produced and the average cotyledonary petiole length of 2.5 cm for all concentrations tested. No regular patterns on root and shoot growth rate to the varying concentrations of PGRs were recorded, except the seedlings height and hypocotyl length decreasing by increasing concentrations. Frequent subcultures to fresh media accelerate the seedlings growth favourably.

3.3 Acclimatization to Greenhouse

Well-rooted sugar palm plantlets obtained on optimum culture medium were taken out from culture tubes and the roots were slightly washed to remove adhering agar. Every washed plantlet was then transferred into new culture tubes containing MS salt solution culture for 2 weeks and subsequently transferred to different soil mixtures for hardening. Plantlets acclimatization was successful with the optimum survival rate of 100% after 4 weeks and 80% after 4 months (Fig. 3a) on soil, peat moss, perlite mixture (40:40:20) (Fig. 2). The optimum plant height was recorded at the mean of 17.80 ± 3.35^{b} cm and mean number of leaf at 2.80 ± 0.45^{a}. The optimum leaf diameter was determined on plantlets being acclimatized on soil at 2.14 ± 0.62^{a} (Table 2).

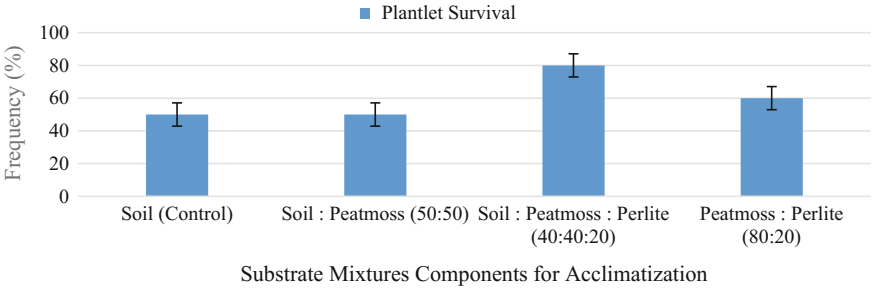

Fig. 2 Frequency of plantlet survival (%) of sugar palm after 4 months of acclimatization. [1]Frequency of plantlet survival (%) = (Number of plantlets survived during acclimatization/Total number of acclimatized plantlets) × 100. Error bars indicate the standard error of the mean of ten replicates

Table 2 Components of media used as substrates for acclimatization of sugar palm and the rate of plantlet survival after 5 months of acclimatization

Components (% by volume)	Plant height (cm)	Leaf number (cm)	Leaf diameter (cm)
Soil (control)	13.70 ± 1.72[ab]	2.40 ± 0.55[a]	2.14 ± 0.62[a]
Soil (50) + peatmoss (50)	11.80 ± 2.41[a]	2.60 ± 0.55[a]	1.90 ± 0.42[a]
Soil (40) + peatmoss (40) + perlite (20)	17.80 ± 3.35[b]	2.80 ± 0.45[a]	1.84 ± 0.23[a]
Peatmoss (80) + perlite (20)	13.00 ± 1.66[a]	2.60 ± 0.55[a]	1.88 ± 0.51[a]

[a]Values represent the mean of five replications ± standard error (SE). [b]Standard error of mean (SEM) was calculated by dividing SD by the square root of sample size (n) [SE = σ/sqrt (n)].

The success of the acclimatization process thus showed that the crucial stage for ex vitro survival of this dormant species has been overcome effectively. The success of acclimatization process depends on many factors including the development of adventitious roots formation of plantlet. Supplementations of PGRs to culture media help in the growth of better roots. Good root growth of plantlets would support shoot growth during acclimatization process (Borkowska 2001). Sumaryono and Riyadi (2011) have demonstrated that in vitro pre-conditioning of oil palm with PGRs is advantageous for ex vitro survival and acclimatization. Thus, the successful acclimatization of the PGRs-treated sugar palm plantlets to greenhouse conditions is in accordance with the literature data. The acclimatized plants were then successfully transferred to the field with 40% of the plants survived after a year.

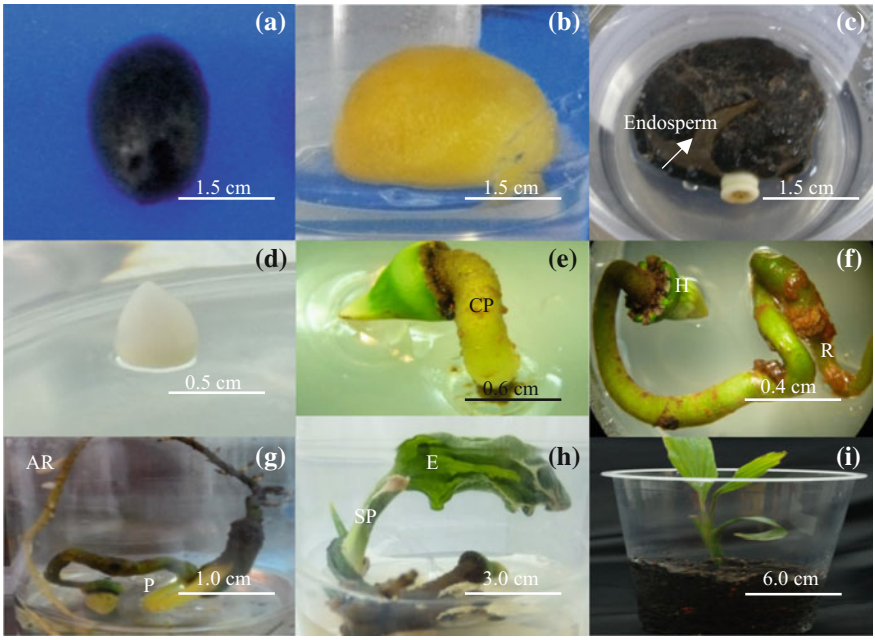

Fig. 3 Morphogenesis of sugar palm germinated in vitro from **a** mature seed and, **b**, **c** young seed explants after 1 and 12 weeks of culture on MS0. The **d** immature zygotic embryo explant cultured on MS0 after **b** 2 months, **e** 5–6 months and **f** 7–8 months. **g** The formation of complete plantlet from immature zygotic embryo explant after 12 months of culture and**f** the acclimatized in vitro seedling after 4 months of transfer. *CP* cotyledonary petiole; *R* radicle; *H* haustorium; *AR* adventitious roots; *E* Eophyll; *SP* secondary plumule

4 Conclusion

The overall objective of this investigation was to define the optimal conditions for in vitro growth of sugar palm by germination using different explants, plantlet development by PGRs and its acclimatization protocol. The main results showed that the immature zygotic embryo explant culture is effective in producing uniform viable seedlings of sugar palm when in vitro germination of mature seeds and soil germination of both mature and young seed explants concluded dormancy. The inclusion of PGRs to the culture medium influenced the germination of the immature zygotic embryo explant significantly. This plant regeneration system could be useful for conservation programs to preserve this economically valued species. Moreover, obtaining enough genetically uniform plant material under controlled growth conditions may be valuable for future genetic modification studies and plant improvement of sugar palm.

Acknowledgments The authors acknowledge the university for financial support by research grant 600-RMI/DANA5/3/REI (1/2013) and Mybrain15 scholarship, Ministry of Higher Education, Malaysia.

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Chapter 94
Potential of *Carica papaya* and *Artocarpus integer* Extracts as Botanical Pesticides for Controlling, Golden Apple Snail, *Pomacea canaliculata*

Siti Noor Hajjar Md Latip, Farah Wahida Mohd Nawi, Erwan Shah Shari and Siti Hawa Puteh Mansur

Abstract Golden apple snail (GAS), *Pomacea canaliculata*, is a major pest of paddy in Southeast Asia. Due to serious effects of GAS in rice cultivation, farmers have resorted to use synthetic molluscicides for controlling damages caused by GAS leading to negative impact toward the environment and human health. Accordingly, it is essential to study and develop new botanical pesticides for controlling GAS. The objective of this study is to expose the potential of selected plant extracts using bioassay test and antifeedant activity are that responsible for controlling GAS. Selective of potent extracts from *Carica papaya* leaves and peels of *Artocarpus integer* were tested on GAS in laboratory conditions. Five different concentrations of crude extracts were extracted using 95% of methanol and ethanol. Mortality of GAS was observed within 96 h with 24 h nterval. The obtained results from bioassay test show that methanol extracts of *C. papaya* (LC_{50} = 18. 5 g/L) gave a higher mortality of GAS compared to *A. integer* extract (LC_{50} = 39.8 g/L). High antifeedant activity of GAS imposed by ethanol extracts of *A. integer* (LC_{50} = 25.7 g/L) is compared with *C. papaya* extract (LC_{50} = 20.6 g/L). Thus, this study showed that extracts of *C. papaya* are more effective for sustainable control of GAS and extracts of *A. integer* have a potential use as an antifeedant activity toward GAS.

Keywords Pomacea canaliculata · Botanical pesticides · Carica papaya Artocarpus integer

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_94

1 Introduction

Pomacea canaliculata, golden apple snail (GAS) is known as major pervasive rice pest in Asia. This invasive freshwater snail was native to South America and Northern Argentina (Du et al. 2007; Joshi 2005). In the early 1980s, GAS was accidentally widespread in Asia when snail-farming projects for a dietary high-protein supplement in Asia were being rejected and low in market value as there were less consumptions of GAS among Asians (Massaguni and Latip 2012; Liu et al. 2006; Teo 2004). Due to that abandoned project, GASs were being released into irrigation ditches, natural waterways, and subsequently invaded into rice fields (Massaguni and Latip 2012). GAS was reported as a major and serious pest in paddy fields as GAS has a voracious appetite in both young rice seedlings of transplanted and direct-seeded rice (IRRI, 2011). This nocturnal GAS tends to eat the succulent base part of young paddy seedling up to 15 days of transplanting. GAS can feed by scraping on plant surfaces with rough tongue, with unique features GAS was able to consume a leaf blade of rice in just 3–5 min (Massaguni and Latip 2015; Massaguni and Latip 2012). An ability of GAS to grow and make an adaptation in high water levesl, able to hibernate up to 3 months during dry season, high in fecundity, and fast growth also influenced rapid multiplication in population and widespread of its distribution and caused mass loss in rice production (Massaguni and Latip 2012; Zhao et al. 2012). Uncontrolled infestation of GAS caused a huge economic loss in rice production, $1.47 billion per annum (Nghiem et al. 2013). Naylor (1996) reported that over 90% of young rice seedlings up to 15 days after transplanting can be damaged by only 8 individuals of GAS per m^2 with size from 10 to 40 mm within overnight (as stated by Massaguni and Latip 2012). The obvious mass destruction caused by GAS can be identified when there are floating leaf parts and missing of hills in the paddy field (Joshi et al. 2005).

Nowadays, most of the farmers relied on heavy use of synthetic molluscicides for immediate and is the fastest way to control and reduce the population of GAS within short time intervals. However, overuse of synthetic molluscicides raised negative effects on human health and increased toxicity in the environment (Joshi et al. 2008). Otherwise, improper and uncontrolled use of synthetic molluscicides among farmers also increased residue impacts in the environment and interrupt the nature of natural enemies and nontarget insects in the environment. Numerous studies investigating molluscicidal properties from potential plants on GAS have been carried out due to concern with this problem. Thus, an alternative use of botanical pesticides to reduce damage caused by GAS is safer and less toxic compared to synthetic molluscicides. Botanical pesticides are eco-friendly pest controls as they are formulated by natural active compound from potential plants. There are many types of plant chemicals known as secondary plant metabolites that act as repellents, antifeedant, and insect growth regulatory activities toward insect's infestation such as lactones, phenols, terpenes, furans, flavonoids, and saponins (Latip et al. 2015; Prakash et al. 2008; Barasa et al. 2002).

In Malaysia, there are numerous indigenous plants that have the potential to be used as botanical pesticides. Neem, *Azadirachta indica,* is able to control the infestation of GAS as its active compound, Azadirachtin, is able to cause anti-feedant activities and mortality toward GAS (Latip et al. 2012). Massaguni and Latip (2015) also reported that butanol extracts of neem leaves and seeds able to cause 100% mortality of GAS. Moreover, *Nerium indicium* Mill, is one of the most poisonous plants which cause toxicity toward freshwater snails such as *Lymnaea acuminate, Oncomelania hupensis,* and *Indoplanorbis excustus.* Glycosidase of fresh leaves of *N. indicium* also had a positive effect in controlling *O. hupensis* (Dai et al. 2011).

Leaves extracts of *C. papaya* are reported to contain alkaloids, saponins, and flavonoids which highly possess antitumor and have pesticidal effects against pest and disease infestation to act as a defensive mechanism (Baskaran et al. 2012; Ayoola and Adeyeye 2010). Otherwise, saponin extracts of soap nut also have potential to be used botanical pesticides as extractions of soap nut able to influence activities of GAS (Huang et al. 2005). Saponin contents in some plants were reported to be highly toxic and can be used as agriculture spray as saponin exhibit hemolytic properties which are able to acts as poison or pesticidal activity (Taguiling 2010). The extraction of *Artocarpus* also has the ability as an anti-inflammatory activity, the potential for antifungal activity and antibacterial activity against the pest. Therefore, this study is conducted to quantify the phyto-chemical content from *C. papaya* and *A. integer* that are responsible for controlling GAS and to identify the mode of action of GAS; either mortality or antifeedant activity toward the extracts of *C. papaya* and *A. integer*.

2 Materials and Methods

2.1 Test Organism

Adults of GAS were collected at paddy field, Sungai Besar, Selangor, Malaysia. The average size of GAS being used in the experiment was 25 mm of shell height and weight 3.0 g each. Uniform size of GAS was selected using the height of shell (Massaguni and Latip 2012).

2.2 Plant Materials

Fresh leaves of *C. papaya* and peels of *A. integer* were collected from Sungai Besar, Selangor, Malaysia. The leaves of *C. papaya* and peels of *A. integer* were dried and stored at 40 °C for 48 h for further used in plant extractions.

2.3 Extraction of Plant Extracts

Plant extracts were prepared by percolation method described by Handa et al. (2008) and Sujatha et al. (2012) with slight modification. Dried leaves of *C. papaya* and peels of *A. integer* were grounded to a powder using a grinder. The powder (20 g) was extracted using 95% of methanol and ethanol using Soxhlet extractor with slight modification. Crude extracts were evaporated under vacuum at 40 °C for 60 min. The plant extracts were stored in a dark container to avoid light intensity at −8 °C.

2.4 Phytochemical Screening Test

The chemical compound in selected indigenous plants was screened using standard methods with modification (Sujatha et al. 2012). Flavonoid compounds in selected indigenous plants were screened by using alkaline reagent test. A few drops of sodium hydroxide solution were added into plant extracts. Formation of decolorizes of intense yellow color into colorless after addition of dilute acid indicates the presence of flavonoids compound (Tiwari et al. 2011). Saponins compound in selected indigenous plants was determine through frothing test. Formation of 1 cm of foam indicated the presence of saponins (Somkuwar and Kamble 2013).

2.5 Toxicity Test

Toxicity effects of leaves extracts of *C. papaya* and peels extracts of *A. integer* on GAS were carried out in the laboratory according to the methods of Talukder and Howse (1994) with some modifications. 20 g of paddy seedlings were sprayed with 10 ml of (range 10–50 g/L) extracts of *C. papaya* and *A. integer* was tested on 10 adults of GAS, sequentially and placed in the aquarium. As control treatments, paddy seedling was treated with methanol, ethanol, Tween 80, and distilled water. All of the treatments were air dried for 30 min to evaporate the solvent (Khani et al. 2011). The experiments were done with five replicates. The mortality of GAS was recorded after 24, 48, 72, and 96 h. The LC_{50} values of both plant extracts were calculated by probit analysis (Finney 1997) using Polo-Plus Software (LeOra 2003). The obtained data were corrected by Abbott's (1925) formula, transformed into percentage and square root values and then variance analysis (ANOVA) was done using SAS V.9.4 programme. Mean values were adjusted by Duncan's Multiple Range Test.

2.6 Evaluation of Antifeedant Activities

Antifeedant activities of GAS were determined using non-choices test as described by Keita et al. (2001) and Mahdi and Rahman (2008) with some modifications. 10 ml of diluted extracts of *C. papaya* and *A. integer* with five different concentrations were sprayed on paddy seedlings respectively. Ten adults of GAS were weighed and placed in the aquarium and allowed to feed for 7 days. After the feeding period, paddy seedlings were weighed and weight loss was measured by Eq. (1):

$$\text{weight loss}(\%\text{WL}) = (\text{IW} - \text{FW}) \times 100/\text{IW} \quad (1)$$

where the IW is the initial weight and FW is the final weight.

Results of mortality were adjusted for mortality in the control using Abbott's formula and expressed as percentages (Abbot 1925). The significance of the mean difference between treatments and control was analyzed using variance procedure at 5% probability level with individual pairwise comparisons with Duncan's test using SAS V.9.4 software package in Microsoft Windows 7 (SAS 2016).

3 Results and Discussion

3.1 Phytochemical Screening Content in Plant Extracts

The phytochemical analysis in Table 1 showed the extracts of *C. papaya* and *A. integer* contained flavonoids, papain, saponins, unsaturated sterols, alkaloids, and triterpenes and phenolic compounds. From the obtained results, active compounds of flavonoids and saponins extracted from leaves of *C. papaya* and peels of *A. integer* showed highly positive (+++) potential toxic effect towards GAS. While alkaloids and terpenoid compounds were moderately (++) found from both plants extracts. Meanwhile, papain was negative (-) in peels extracts of *A. integer*. Leaves extract of *C. papaya* showed larvicidal and pupicidal effects on target insects within 24 h of exposure (Koyendan et al. 2012). The peel and seed of *Artocarpus* were found to be effective as antioxidant agents and displayed higher phytochemical contents as compared with the flesh (Abu Bakar et al. 2015).

3.2 Toxicity Test of Plant Extracts Against GAS

Probit analysis at Table 2 showed higher toxicity for LC_{50} of the methanol extracts of *C. papaya* (18.5 g/L) compared with all treatments. Otherwise, ethanol extracts of *A. integer* (25.7 g/L) imposed high toxicity compared with methanol

Table 1 Phytochemical screening analysis of *Carica papaya* and *Artocarpus integer*

Test for physiologically active constituents	Carica papaya	Artocarpus integer
1. Flavonoids – Alkaline Reagent Test	++	+++
2. Saponins – Frothing Test	+++	++
3. Papain	++	–
4. Alkaloids	++	++
5. Terpenoids – Salkowski Test	++	+

Note (+) Positive, (−) Negative, + low, ++ moderate, +++ high

extracts. Results from Table 3 showed mortality of GAS were significantly increase ($p < 0.05$) as the time of exposure increased for both extracts of *C. papaya* and *A. integer*. Mortality of GAS (Table 3) was gradually increased from 24 to 72 h of exposure with treatments but after 96 h the mortality rate of GAS was declined. Toxicities of tested plant extracts indicate that concentration of crude extracts and the exposure time was dependent as there was a significant correlation between the mortality rate of GAS with exposure time and concentrations. High concentration of plant extracts (50 g/L) caused high in mortality of GAS compared with a lower concentration (10 g/L) of plant extracts that indicates less in mortality of GAS. Moreover, obtained results from Table 4, showed the use of solvents in plant extracts also have a correlation with mortality of GAS. At 96 h of exposure, methanol extracts of *C. papaya* indicate higher mortality of GAS (mean = 5.640) compared with ethanol extracts of *C. papaya* (mean = 4.560). Meanwhile, ethanol extracts of *A. integer* imposed high in mortality of GAS (mean = 4.000) compared with methanol extract of *A. integer* (mean = 2.960).

From the obtained results of phytochemical screening test, a compound that screens from leaves extracts of *C. papaya* and *A. integer* were highly positive (+++) found flavonoids and saponins. Bioactive compounds of flavonoids are able to affect on insect's endocrine systems, diet behaviors, insect development, and reproduction by directly or indirectly interacting with hormone system (Latip et al. 2015; Narciso et al. 2011). According to a study conducted by Musman et al. (2013), seed extracts of *Barringtonia racemosa* has molluscicidal effects toward GAS due to the presence

Table 2 Probit analysis for toxicities of *Carica papaya* and *A. integer* extracts toward GAS

Plant	Solvent	LC50 (Min–Max)	Slope ± SEM	X2	df
Carica papaya	Methanol	18.5 (11.2–24.4)	3.274 ± 0.43	4.669	3
	Ethanol	20.6 (16.7–24.2)	2.356 ± 0.36	1.313	3
Artocarpus integer	Methanol	39.8 (31.7–55.4)	1.917 ± 0.41	1.880	3
	Ethanol	25.7 (16.4–38.6)	2.229 ± 0.36	4.463	3

Units LC_{50} = g/L, applied for 24, 48, 72 and 96 h at 25 °C ± 2 °C. Values were based on 5 concentrations, 5 replications of 10 adults of GAS

Table 3 Mean (± SEM) percentage in mortality of GAS versus time and plant extracts

Treatment	Mortality of GAS			
	24 h	48 h	72 h	96 h
Carica papaya	1.080 ± 01.51[a]	2.440 ± 0.200[a]	3.760 ± 0.237[a]	5.100 ± 0.279[a]
Artocarpus integer	0.800 ± 01.03[a]	1.780 ± 0.122[b]	2.640 ± 0.139[b]	3.480 ± 0.181[b]

Each data represents the mean of five replicates. [a]Means within the same column followed by different letters are significantly different ($P < 0.05$) by two-way ANOVA, Duncan's multiple range test. [b]Mean within a column followed by the same letter is not significantly different: (Duncan's multiple range test, $p < 0.05$)

Table 4 Mean values in mortality of GAS versus time and solvent used in plant extracts

Treatment	Solvent	Mortality of GAS			
		24 h	48 h	72 h	96 h
C.papaya	Methanol	0.800	2.360	3.880	5.640
C.papaya	Ethanol	1.360	2.520	3.640	4.560
A.integer	Methanol	0.840	1.680	2.400	2.960
A.integer	Ethanol	0.760	1.880	2.880	4.000

Means ± SEM mortality of GAS treated with the treatment of *Carica papaya* and *Artocarpus integer*, two-way ANOVA, LSD test, ($P < 0.05$)

of saponins and flavonoids which significantly caused mortality on GAS. Both bioactive compounds of flavonoids and saponins could reduce air supply to the embryos in eggs of GAS, thus altering the normal development embryo of GAS and exhibits ovicidal effects on older egg mass of GAS (Demetillo et al. 2015; Wu et al. 2005). As cited in Joshi et al. (2008), saponins are also able to alter the behavior of GAS at different growth stages which are related to relative use for respiration of their lung and gills as smaller GAS frequently ventilates its lungs by extending the siphon compared to larger or adults of GAS. Saponins are able to cause cell disruption and affect gills of GAS through hydrophobic interactions. Complex forms of saponins with steroids, proteins, and membrane phospholipids are responsible for the action on the cell membrane and causing the destruction of cells for pests (Souza et al. 2013).

3.3 Antifeedant Activities Toward GAS

The results shown in Table 5 revealed the ethanol extracts of *A. integer* and *C. papaya* showed high antifeedant activities compared with methanol extracts for both plants. All concentrations of ethanol extracts for *A. integer* and *C. papaya* showed 80 and 70% of repellency, after 6 h against adults of GAS respectively. However, after 24 h, only ethanol extracts of *A. integer* strongly repelled the adults of GAS (80%). Furthermore, this study demonstrated that the plant extracts tested are effective as a repellent for adults of GAS.

Table 5 Antifeedant activity of extracts of *Carica papaya* and *Artocarpus integer* toward adults of GAS

Treatments	Solvent	Concentration of plant extracts (g/L)	Weight loss, g	
			GAS	Paddy seedling
C. papaya	Methanol	10	0.194	13.172
		20	0.232	12.964
		30	0.360	12.605
		40	0.410	10.835
		50	0.516	8.422
	Ethanol	10	0.160	15.116
		20	0.154	13.694
		30	0.200	13.453
		40	0.300	12.105
		50	0.332	10.340
A. integer	Methanol	10	0.178	16.364
		20	0.242	15.390
		30	0.263	15.402
		40	0.280	14.257
		50	0.326	13.276
	Ethanol	10	0.286	15.282
		20	0.290	14.760
		30	0.267	13.960
		40	0.320	13.382
		50	0.396	12.058

Each data represents the mean of five replicates with five different concentrations (ranging from 10 to 50 g/L) per plant extracts, two-way ANOVA, (Duncan's multiple range test, $P < 0.05$)

There was also a significant weight loss on paddy seedling treated with plant extracts and weight of the GAS. The weight loss in paddy seedling is higher in low dosage (10 g/L) for methanol extracts of *C. papaya* (mean = 13.172) and *A. integer* (mean = 16.364). Meanwhile, high dosage (50 g/L) for ethanol extracts of *A. integer* (mean = 12.058) and *C. papaya* (mean = 10.340) showed a low number in weight loss of paddy seedling. Whereas, highest weight losses in adults of GAS were imposed with a high dosage of ethanol extracts of *A. integer* (mean = 0.396) compared with ethanol extracts of *C. papaya* (mean = 0.332). The similar finding by Khani et al. (2011) on *Jatropha curcas* seed oil showed a repellency of 47.5% of *Callosobruchus maculatus* and *Dinarmus basalis* at the lowest dose (0.5 ml), whereas the highest dose (2 ml) repelled 95% for both *C.maculatus* and *D.basalis*.

Thus, weight loss in adults of GAS was dependant on the concentration of plant extracts. The results showed ethanol extracts of *A. integer* is effective as anti-feedants against adults of GAS. This indicated that plant materials can be considered as alternative controls for GAS. Results of the growth and development study

of the antifeedant test showed that weight gained of larvae treated with *Citrus hystrix* essential oil were lower as compared to control treatment (Loh et al. 2011).

4 Conclusions

The study was conducted to evaluate the toxicity and repellency of crude extracts of *C. papaya* and *A. integer* on mortality of GAS and weight losses of GAS and paddy seedlings. The mortality increased with increasing concentration and exposure time. Methanol extracts of *C. papaya* showed highest toxicities compared to methanol extracts of *A. integer* followed with ethanol extracts of *C. papaya* and *A. integer*. In addition, *A. integer* extracted with ethanol showed a higher repellent effect on GAS compared with ethanol extracts of *C. papaya* and methanol extracts of *C. papaya* and *A. integer* sequentially. Repellency of ethanol extracts of *A. integer* it is possible due to flavonoids compounds and toxicity of methanol extracts of *C. papaya* might be due to saponins compounds. Therefore, it is suggested that further study should consider the comparison of the repellent activity and toxicity of *C. papaya* and *A. integer* with an analytical grade of flavonoids and saponins in investigating the bioactive compounds. As a conclusion, extracts of *C. papaya* and *A. integer* is potent to be used as a supplement for other control methods in sustainable agriculture practices in controlling of GAS.

Acknowledgments This work was supported by funds from the Ministry of Higher Education (MOHE), Malaysia through Fundamental Research Grant Scheme (FRGS) 600-RM1/FRGS 5/3 (150/2013)—Efficacy of extracts from selected indigenous plants as a botanical pesticide for controlling golden apple snail (GAS), *P. canaliculata* headed by Dr. Siti Noor Hajjar Md. Latip. We also gratefully acknowledge the contribution of Mr. Erwan Shah Shari from Malaysian Agriculture Research and Development Institute (MARDI) which is really helpful in this study.

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Chapter 95
Effectiveness of *Curcuma longa* and *Cymbopogon citratus* Leaf Extracts as Botanical Pesticides for Controlling Golden Apple Snail, *Pomacea canaliculata*

Siti Hawa Puteh Mansur, Siti Noor Hajjar Md Latip and Farah Wahida Mohd Nawi

Abstract The golden apple snail (GAS), *Pomacea canaliculata* is a major pest that leads to decline in rice productivity in Malaysia. The farmers used of synthetic molluscicides on GAS in paddy fields resulted in negative impacts to the environment and human health. The botanical pesticide is a potential alternative way to combat GAS. This study is to reveal the effectiveness of *Curcuma longa* and *Cymbopogon citratus* extracts using the toxicity test and antifeedant activities. The leaves of *C. longa* and *C. citratus* were extracted using solvents, ethanol, and methanol. The extracts were tested on GAS for concentrations of 10–50 g/L. The time recorded for mortality of GAS was from 24 to 96 h. The results from toxicity test showed that methanol extract of *C. citratus* (LC_{50} = 30.503 g/L) gave higher mortality GAS compared to its' ethanol extract (LC_{50} = 37.12 g/L). Meanwhile, higher antifeedant activities were imposed using ethanol extract of *C. longa* (LC_{50} = 32.475 g/L) compared to methanol extract of *C. longa* (LC_{50} = 42.042 g/L). The Salkowski test shows terpene compounds in *C. longa* and *C. citratus* extract. The study identifies *C. citratus* as more effective in controlling GAS and *C. longa* extracts have effects on antifeedant activity. Thus, *C. longa* and *C. citratus* extracts have potential to be used as botanical pesticides for controlling GAS.

Keywords Pomacea canaliculata · Botanical pesticides · Curcuma longa Cymbopogon citratus

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_95

1 Introduction

In Asia, Halwart (1994) stated that the golden apple snail (GAS), *Pomacea canaliculata* is the major invasive pest in a the paddy field. GAS caused severe damage throughout all paddy fields in Peninsular Malaysia especially Perlis and Kedah. Farmer's loss is estimated at 37% due to pests (Savary et al. 2000) and GAS is classified one of the hundreds of the world's worst invasive alien species (Yahaya et al. 2010). Approximately, RM 425 per ha was spent by farmers in Malaysia to control the GAS (Yahaya et al. 2006). GAS damage can be identified by the floating leaf part and the missing of hills in the paddy field (Joshi et al. 2002). GAS has the high ability to grow and make an adaptation to high water level and has voracious feeding behaviors that lead to the loss of rice production (Zhao et al. 2012).

The common pest management for GAS is chemical control and to overcome the problem of this pest, synthetic molluscicides such as metaldehyde and niclosamide were used. Unfortunately, the chemical substances can pollute water bodies and gave negative impact to the environment. Botanical pesticides are an alternative way to replace the usage of synthetic pesticides and can reduce the risks to the human health, nontarget organisms and the environment.

Botanical pesticides originated naturally from potential plants and need to be chemically extracted. There are various types of chemical compounds such as lactones, phenols, terpenes, furans, flavonoids, and saponins that acts as repellent towards insect's infection (Barasa et al. 2002). Some plants in Malaysia have potential to be used as botanical pesticides for controlling the infestation of GAS. The seed from *Azadiracahta indica* contains the active compound, Azadirachtin, which possessed molluscicidal effect for controlling the GAS (Masaguni and Latip 2015). Additionally, *Pelthoporum pterocarpum* had a positive effect in controlling the infestation of GAS and is environmentally friendly (Latip et al. 2015).

Plant essential oils can act in a wide range of activity against plant pathogenic fungi and pest insects. The chemical compound of essential oil is predominantly of terpene and is associated with aldehydes, alcohols, and ketones which accumulated in several structures of the plants (Linares et al. 2005). The essential oil of the *C. citratus* was complex mixtures of volatile organic compounds which were usually produced as secondary metabolites in plants and has high repellency against arthropod species (Kalita et al. 2013). *C. citratus* leaf extract can change the growth of the embryo, hatching period and rising mortality rates of GAS (Demetillo et al. 2015). The essential oil *C. longa* leaves had shown antifungal activity that inhibits the mycelial growth of ringworm (Pandey et al. 2010). Therefore, this study is to screen the phytochemical content from *C. longa* (turmeric) and *C. citratus* (lemongrass), responsible for controlling GAS and to identify the mode of action of GAS either such as mortality or antifeedant activity toward the extracts of *C. longa* and *C. citratus.*

2 Materials and Methods

2.1 Test Organism

The GAS was collected from paddy field of Tanjung Karang, Selangor during May 2016. Adults of GAS used in the experiment were 25 mm of shell height and weight 3.0 g each.

2.2 Plant Materials

Matured fresh leaves of *C. citratus* and *C. longa* were harvested after 6 months being planted at rain shelter of University Teknologi MARA, Puncak Alam.

2.3 Plants Extraction

Dried leaves powder of *C. citratus* and *C. longa* were extracted with methanol and ethanol by using soxhlet extractor. The extracts of *C. citratus* and *C. longa* were concentrated using rotary evaporator at 40 °C. The crude extracts of *C. citratus* and *C. longa* were stored in a dark container until further used in bioassay test and antifeedant activity.

2.4 Phytochemical Screening

The chemical compound in *C. longa* and *C. citratus* was screened using standard methods with modification (Sujatha et al. 2012). Terpene compounds were screened by using Salkowski test. A reddish-brown coloration of the interface is formed to show the positive result of the presence of terpenes.

2.5 Toxicity Test

There were five treatment concentrations for each plant extract which ranges from 10 to 50 g/L and was tested on 10 numbers of GAS. As positive control treatments, paddy seedling was treated with methanol and ethanol. Two treatments of different crude extracts with 10 numbers of GAS underwent five replications at room temperature and were placed into the aquarium. The experiment was conducted by giving treated paddy to GAS. Mortality of GAS was observed at 24, 48, 72, and

96 h after treatment. Probit analysis of PoloPlus software package was used to determine LC_{50} (LeOra 2003). Statistical analysis of data for mortality of GAS was determined by Statistical Analysis System (SAS) and mean values was adjusted by Duncan's multiple comparison test.

2.6 Evaluation of Antifeedant Activities

Antifeedant activities were studied based on the methods of Mahdi and Rahman (2008) with some modifications. GAS (n = 10) were individually labeled and weighed before and after the experiment. Antifeedant activities of GAS exposed to the treatment are observed where GAS was allowed to feed for 7 days. After the feeding period, paddy seedlings were weighed and weight loss was measured by Eq. (1).

$$\%\,\mathrm{WL} = (\mathrm{IW} - \mathrm{FW}) \times 100/\mathrm{IW} \tag{1}$$

where the *IW* is the initial weight and *FW* is the final weight.

3 Results and Discussion

3.1 Phytochemical Screening

Table 1 shows the phytochemical analysis of terpenes extracted from *C. citratus* and *C. longa.* Based on Salkowski test, a reddish-brown coloration of the interface is formed to show the positive result and both solvents which reveal the presence of terpenes in plants extract. The major terpenes from *C. longa* and *C. citratus* extract were phellandrenes and citral. The phellandrenes contents in leaves can inhibit growth and larval mortality against *Spilosoma obliqua* (Agarwal et al. 1999). The citral content results in toxicity effects on larger grain borer (*Prostephanus truncatus*) (Masamba et al. 2003).

Table 1 Phytochemical screening of *C. longa* and *C. citratus*

Plant Extracts	Ethanol	Methanol
C. longa	+	+
C. citratus	+	+

Note (+) Present, (−) Absent

Table 2 Mean (±SEM) in mortality of GAS versus time and plant extract

Plants	Mortality			
	24 h	48 h	72 h	96 h
C. longa	0.42 ± 0.08[a]	1.5 ± 0.15[a]	3.26 ± 0.22[a]	4.18 ± 0.27[a]
C. citratus	0.64 ± 0.07[b]	1.78 ± 0.16[a]	3.58 ± 0.26[a]	4.28 ± 0.29[a]

Each data represents the mean of five replicates. [a]Means within the same column followed by different letters are significantly different ($p < 0.05$) by two way ANOVA, Duncan's multiple range test. [b]Mean within a column followed by the same letter is not significantly different: (Duncan's multiple range test, $p < 0.05$)

3.2 *Toxicity Test of Plant Against GAS*

Table 2 shows the mean (±SEM) mortality rate of GAS after being exposed to crude extracts for 24, 48, 72, and 96 h. Mortality of GAS significantly increases ($p < 0.05$) as time increases for both plants. *C. citratus* showed higher mortality (4.28 ± 0.29) compared to *C. longa* at 96 h (4.18 ± 0.278). The mean gradually increases from 24 to 96 h. This reveals that the concentration of extracts and time-affected mortality rate of GAS as there was a significant correlation between mortality of GAS with exposure time and concentrations. Chaubey (2012) reported that bioactive compounds of terpenes are able to affect insect metabolism process by inhibiting oviposition, larvae, and death of the adults due to the suffocation and inhibition of biosynthetic processes. The aromatic plants and their essential oils also can cause antifeedant or repellent effects. The leaf extract of *C. citratus* can change the normal growth of GAS by inhibition of development of the embryo, altering hatching period of eggs and increasing mortality in both juveniles and adult stages (Demetillo et al. 2015).

In Table 3, the probit analysis shows the lowest LC_{50} were observed in methanolic extract of *C. citratus* (30.50 g/L), which indicate the highest potency for controlling GAS, followed by ethanolic extract of *C. longa* (32.48 g/L), ethanolic extract of *C. citratus* (37.12 g/L), and methanolic extract of *C. longa* (42.04 g/L).

3.2.1 Antifeedant Activities Toward GAS

In Table 4, the result shows that the weight loss in paddy seedlings is lower in *C. longa* compared to *C. citratus*. The ethanol extract of *C. longa* shows high

Table 3 Probit analysis for toxicities of *C. longa* and *C. citratus* extracts toward GAS

Plant	Solvents	LC_{50} (Min–Max)	Slope ± SEM	X^2	Df
C. longa	Ethanol	32.48(25.15–44.67)	1.63 ± 0.37	2.37	3
	Methanol	42.04(32.91–62.79)	1.78 ± 0.4	2.65	3
C. citratus	Ethanol	37.12(30.25–50.17)	1.86 ± 0.36	2.62	3
	Methanol	30.50(20.91–51.90)	1.88 ± 0.35	3.35	3

Units LC_{50} = g/L applied for 24,48,72, and 96 h at 25 °C ± 2 °C. Values were based on 5 concentrations, 5 replications of 10 adult GAS

Table 4 Mean values for antifeedant activities for different concentrations against weight GAS and paddy seedlings

Plants	Solvent	Concentration(g/L)	Weight loss(g)	
			GAS	Paddy seedling
C. longa	Ethanol	10	0.152	24.406
		20	0.218	23.370
		30	0.24	23.370
		40	0.254	21.848
		50	0.296	20.764
	Methanol	10	0.182	27.682
		20	0.220	27.158
		30	0.256	25.118
		40	0.282	22.302
		50	0.312	21.518
C. citratus	Ethanol	10	0.152	10.096
		20	0.204	8.476
		30	0.232	9.118
		40	0.270	7.314
		50	0.346	6.136
	Methanol	10	0.166	9.442
		20	0.228	9.026
		30	0.212	7.240
		40	0.282	6.446
		50	0.362	6.084

antifeedant activities compared with methanol extract. The GAS and paddy seedlings weight loss of ethanol extract of *C. longa* in 50 g/L are (0.296 g) and (20.764 g) compared to methanol extract (0.312 g) and (21.518 g). This study revealed that the plant extract of *C. longa* tested is effective as a repellent for GAS. There was also a significant weight loss ($p < 0.05$) on paddy seedling treated with plants extracts and weight of the GAS. The high dosage of extractions showed a low number in weight loss of paddy seedlings. Meantime, the weight loss of GAS is increasing because of high dosage extractions in *C. longa* and *C. citratus*.

Thus, weight loss in GAS was dependent on the concentrations of plant extracts. In the present study, the plants inhibit by making the food unpalatable or inhibit larval feeding behaviors because of active compounds present in the plants (Jeyasankar et al. 2014).

4 Conclusions

The study was conducted to evaluate the toxicity and repellency of *C. longa* and *C. citratus* crude extracts by measuring weight losses of GAS and paddy seedlings. The mortality and antifeedant increased with increasing concentration and exposure time. Meanwhile, methanolic extractions of *C. citratus* showed the higher toxicity compared to ethanolic extractions *C. citratus*. In addition, ethanolic extractions of *C. longa* showed antifeedant activities. This shows that terpene compounds can act as toxic material and repellency of GAS. As a conclusion, extract of *C. longa* and *C. citratus* has the potential to be used as a supplement of other control methods in sustainable agricultures practices. Subsequently, a safer solution should be addressed through education on the awareness of chemical toxicity for farmers.

Acknowledgments This work was supported by funds from the Ministry of Higher Education (MOHE), Malaysia through Fundamental Research Grant Scheme (FRGS) 600-RM1/FRGS 5/3 (150/2013)—Efficacy of extracts from selected indigenous plants as botanical pesticides for controlling golden apple snail (GAS), *P. canaliculata* headed by Dr. Siti Noor Hajjar Md. Latip.

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Part X
Sport Sciences and Recreation

Chapter 96
Hydration Status of T-Team FC Players in Match Against FELDA United FC

Fatin Aqilah Abdul Razak, Muhammad Syafiq Jaafar, Wan Mohd Norsyam Wan Norman and Nurul Nadiah Shahudin

Abstract The aim of this study was to investigate the hydration status among T-Team FC players during Malaysian Cup against FELDA United FC. It is hypothesized that players may experience dehydration before and after the match in the hot and humid environment. Urine samples were assessed before and after the match via urine specific gravity (USG) and urine pH level measurements of 17 elite football players. As result, there were significant differences in both measurements before and after. Players experienced euhydration before the match (USG $<1.016 \pm 0.008$; 82%). Paired sample has shown a significant difference ($p = 0.01$) after match, where players were dehydrated based on the total of (USG > 1.035; 92%). Urine pH before match (6.694 ± 0.519) and post-match (6.278 ± 0.492) also indicated an increase in urine acidity after the prolonged game match. T-Team FC players initially started with euhydrated status and struggled to maintain their body fluid balance due to inadequate water intake during the match. As advised by fluid intake guidelines, it is recommended for players to consume water around 150–300 ml for every 20–30 min during games. This action helps in keeping the body well euhydrated. Consumption of sufficient fluids during a match may also prevent excessive ($\geq 3\%$ BM) dehydration. This evidence has suggested that insufficient water intake may impair the physical performance, and thus it is also will be associated with the degradation of psychological abilities as well.

Keywords Elite football players · Hydration status · Urine PH
Urine specific gravity

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_96

1 Introduction

In football, the players require a regular change in the middle of high and low practice intensities, where the high work rates and augmented nature of the diversions lead to high body temperature and the start of a sweating response (Bangsbo et al. 2007). Hence, this may influence the level of their hydration.

Over the several years, a study has shown that dehydration causes a negative impact on all physiological systems and hence on the performance (Ersoy et al. 2016). In consequence, athletes or players may lose 2–6% body weight amid delayed activity and exercise.

Thirst mechanism can happen when the osmolality increased and the volume of water dropped. To keep the athlete well hydrated, the osmoreceptors in hypothalamus will trigger pituitary gland to secrete antidiuretic hormone (ADH) (Wildman and Miller 2004). Thus, ADH will signal the kidney to absorb back the water. In return, the volume of fluid will be increased while osmolality concentration is dropping. This mechanism will keep on going whenever the body has the signal for thirst sensation. Then, the athlete will be re-hydrated again. Hypohydration is hindering both the active performance and well-being and ought to be avoided by procurement of fluid to match water loss.

Soccer players have regularly been shown to exhibit to wide between individual variability in their sweat and sodium Na+ losses when working out in either hot (Maughan et al. 2004) or cool conditions (Maughan et al. 2005). Supplanting sweat electrolyte losses, especially amid and consequent to practice and play in the warmth or heat, assumes an essential part in the counteractive action of liquid and electrolyte imbalance. Extreme sweating will prompt liquid and electrolyte losses, and the loss of sodium specifically, is an important factor in accelerating the onset of muscle cramps and the related execution of exercise performance (Baker et al. 2009).

Athletes contending in group activities oblige them to switch irregularly between maximal-exertion and low-force activity, conceivably bringing on extensive misfortunes to body water, consequently, hydration is a vital, however, frequently disregarded part of legitimate preparing. Thus, the effect of hydration status on performance and recovery is less well understood. In consequences, this study aims to investigate the hydration status of T-Team FC players during the match against FELDA United FC.

2 Methods

2.1 Subjects

In determining the hydration status of USG and urine pH level, 17 (N = 17) elite football players from T-Team FC were recruited in this study. Players were in good health condition and selected to participate in the match against FELDA United FC.

For participating in this study, participants must be free from any injuries and medication that affected the ability to exercise and free from medications that may influence the body fluid balance. The study complied with the declaration of work and was approved by Faculty of Sports Science Ethics committees. All subjects gave their informed consent to participate prior to the experiments.

2.2 Experimental Design

The study was designed as purposively sampling. The subjects were pre-tested before match based on hydration status: urine specific gravity and urine pH. Afterward, the second reading was taken right after they have ended the game match with FELDA United FC on urine specific gravity and urine pH as well. A urine sample was taken to BP Healthcare Medical Lab for further investigation of data.

2.3 Urine Specific Gravity

Urine specific gravity (USG) is generally accepted as markers of hydration status in the field (Sherwin et al. 2015). USG, the proportion of the mass of an answer contrasted with the mass of an equivalent volume of water, is an assessment of the grouping of substances dissolved in the solution (Silva et al. 2011).

2.4 Urine PH

The human services of lab supplier utilized a dipstick made with a shading touchy cushion. Changes in the shading of the dipstick would indicate the level of acid in the urine. The normal urine pH for an athlete is 6.5–8.0 (Burns 2015). Appropriate pH balance is a key section of good well-being, and it is totally vital to physical performance. There are 14-point scales to measure the pH value, with 7 as neutral. The decrement in the pH value, the greater is the acidity; the greater the pH value, the more alkaline (Burns 2015). Furthermore, to maintain a good pH equalization, acid wastes need to be expelled from the body.

2.5 Statistical Analysis

Descriptive and inferential statistics were used in this study. Mean and standard deviation were highlighted in analyzing the data for descriptive. For the inferential statistical design, paired sample t-test was used to investigate changes over 2 different times which were before and after match hydration status respectively. In determining the effect of hydration status on urine specific gravity and urine pH,

data were analyzed via Statistical Package for the Social Sciences (SPSS. Version 19.0). The significance level was set at $\alpha = 0.05$.

3 Results

3.1 *Difference of Pre-test and Post-test of Urine Specific Gravity Data*

Table 1 indicated the result of pre- and post-match of USG. Sig. (2-tailed) value was set at $p < 0.05$. The data showed, t (17) = −3.20, $p < 0.01$ (2 tailed), mean decrease −0.01 with 95% CI from 0.013 to −0.01. There was a significant difference in pre- and post-match against FELDA United FC on USG.

3.2 *Difference of Pre-test and Post-test of Urine pH Data*

Table 2 shows the result of pre- and post-match of UpH. Subject value has got Sig. (2 tailed). The data has shown that, t (17) = 2.95, $p > 0.01$ (2 tailed), mean increase 0.42 with 95% CI from 0.12 to 0.72. There is a significant difference in pre- and post-test on UpH level.

Table 1 Paired sample of USG pre- and post-test

Paired differences							
95% confidence interval of the difference							
	Mean	Std. Deviation	T	df	Sig. (2-tailed)	Lower	Upper
Pre- and post-match USG	−0.01	0.01	−3.20	17	0.01	−0.13	−0.01

Significant value $p < 0.05$

Table 2 Paired sample of UpH pre- and post-test

Paired differences							
95% Confidence interval of the difference							
	Mean	Std. Deviation	T	df	Sig. (2-tailed)	Lower	Upper
Pre- and post-match UpH	0.42	0.60	2.95	17	0.01	0.12	0.72

Significant value $p < 0.05$

4 Discussion

4.1 Analysis of Urine Specific Gravity (USG)

Moreover, the result of urine specific gravity that is less than 1.035 after the game is considered normal dehydration and the player's result of more than 1.035 after the game is considered very dehydrated (Nall and Spriggs Nall and Spriggs 2012). The result also showed that the value of the players post-match was ±1.035, which showed an increase in urine specific gravity.

Drinking behavior is known to confound urine hydration interpretation (Cheuvront et al. 2010). Specifically, USG can be influenced by the timing of fluid intake, as extracellular fluid (ECF) osmolality is regulated in preference to ECF volume (Popowski et al. 2001). In any case, given that football players regularly have less admission opportunities, it is conceivable that those players who are deficiently dehydrated before preparing turn out to be more dehydrated and have a more noteworthy view of thirst when they have a chance to drink. It is hypothetical that they normally consume much less water during the training (Ersoy et al. 2016).

4.2 Analysis of Urine pH

Urine pH result shows a significant difference in urine pH level before and after the game. Once more, the null hypothesis was rejected due to increase pH level which indicated high acidity after the game. The normal of urine pH for an athlete is 6.5–8.0 (Burns 2015). Thus, at the point when urine pH is normal, then the blood pH is ordinary, however, when the urine pH is excessively acidic, the body discharges excess of electrolytes to keep the pH level typical and keep life. Nonetheless, the pH of urine can go from a very unhealthy low of 4.5 to a high of 8.5, which it endures a little less demanding, contingent upon the acid status of the extracellular fluids.

A high pH worth might demonstrate the body is over buffering to make up for a physiological system that is excessively acidic. Therefore, it may hamper the athlete's performance to reach its optimum level. The urine pH for the athletes in this study before and after match shows a significant higher due to the increase of acidity in the urine PH reading. Consequently, it is concluded that athlete is facing dehydration.

Furthermore, supported by Cohen (2009), the result of urine pH is different between before and after the game because urine pH will be acidic after the game when there is much water output from the body. When the urine is highly acidic, it will make the player automatically feel thirsty and quickly fatigue. The players also will feel difficult to concentrate during the game which eventually affected the performance. Thus, the body must be alkaline to perform well during the game and the players need to drink enough water during the game. According to Simpson and

Howard (2011), to have good results during the training or games, the players must drink water around 88–237 ml every 15–20 min when exercising.

5 Conclusion

This study has concluded that players of T-Team FC experienced dehydration after the match against FELDA United FC on Malaysia Cup. Although they have sufficient water balance before the game, the deficit of water during the match influences their hydration level. Furthermore, urine specific gravity and urine pH level demonstrated significant changes in hydration status though subjects did consume water during the match. Dehydration is not only had negative effects on sports performance but also leads to health problems which may potentially put lives at risk (Evans et al. 2009).

Ersoy et al. (2016) stated effective educational interventions are still necessary to prevent dehydration during matches. Therefore, this finding may serve as guideline coach in aiding the players to prevent from getting dehydrated during the game and also help in understanding their players better. It is also recommended for players to consume water before and during the game to avoid dehydrated. According to Lewis (2015), players are recommended to drink around 500–750 ml of water 2 or 3 h before the game and 150–300 ml during the game every 10–20 min to stay hydrated before, during and after the game. This, however, requires the players not only to avoid from dehydrated but also the players can improve their fitness while sustaining their energy for a long period time without causing injuries or symptoms of dehydration.

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Chapter 97
The Effects of Kinesio Tape on Chronic Low Back Pain Among Young Male Adults in Ampang

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Abstract Kinesio tape has been used to promote healing in sports injury and other musculoskeletal-related illness such as chronic low back pain (CLBP). Therefore, the purpose of this study was to identify the effects of Kinesio tape on CLBP among young adults in Ampang district. Twenty young male adults with CLBP were stratified purposively and randomly divided into experimental and control group. The experimental group intervention was Kinesio tape over the lumbar spine for 1 week while the control group without tape. The low back functional disability and low back mobility were measured using the Oswestry Low Back Pain Disability Questionnaire and Modified–Modified Schober's Test (MMST). The outcomes were measured at baseline, immediately after the first week, and 4 weeks later. Repeated measures of ANOVA were used to assess differences between the groups at three intervals. The results of this study indicate that there were significant differences ($P < 0.05$) between groups in both low back functional disability and low back mobility. In conclusion, Kinesio tape may be beneficial in improving lower back functional disability and low back mobility among young adults.

Keywords Chronic low back pain · Kinesio tape · Male adult

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_97

1 Introduction

Low back pain has been known as the most common injury among the human population across the world for many years. This health problem widely affected the economic distress and social and also can debilitate a community at the same time (Costa et al. 2009). Lower back pain can be constant or periodically experienced by the patient. It was estimated in the general population about 70–80% of adults experience low back pain at least once in their lives (Castro-Sánchez et al. 2012) and about 75% of the low back pain patient still feel the pain after 1 year from the beginning (Bronfort et al. 2011). Chronic pain can be understood as pain where it is more than 12 weeks, which will be experienced after the recovering from previous injury (Hussein et al. 2016). In fact, about 35–90% of all professionals experienced this common occupational injury once in their lives (Chen et al. 2014). Nevertheless, athletes and pregnant women also show a high prevalence of low back pain (Norsyam et al. 2016; Puentedura and Louw 2012).

Chronic low back pain (CLBP) caused limitation in back mobility; reduce the quality of work, long-term incapacity, and the main factor of not going to work (Castro-Sánchez et al. 2012). One of the most recognized contributors to the impairment which increased among chronic pain patients is feeling the fear of pain, injury experienced, and physical activity (Geisser et al. 2000).

Kinesio tape method had been widely used as a therapeutic intervention among professional (Parreira et al. 2013). There were numbers of clinical trial studies regarding the effects of the tape. Despite it is widely used for therapeutic intervention, information on the state of the physiology of this tape is still lacking (Gusella et al. 2014). However, Kinesio tape had been hypothesized to be an effective treatment to restore muscle function and decrease pain (Yoshida and Kahanov 2007). Therefore, it was hypothesized that Kinesio tape was incrteased blood and lymphatic liquid flow in the taped zone because of a lifting mechanism, which produces a more extensive space between the skin and the muscle and interstitial space (Gómez-Soriano et al. 2014).

The evidence in order to sustain the effects from the mechanism of Kinesio taping on musculoskeletal pain is not yet cleared. Furthermore, healthcare profession limits the usage of kinesio tape due to scarce data proof the application and medicine-based effects on the body. Hence, this study was conducted to investigate the effects of Kinesio tape application on CLBP among young adult patients. The objectives of the study were to answer the question raised as to determine the effects of Kinesio taping on pain and functional disability and to determine the effects of Kinesio taping on low back mobility in 5 weeks of the program.

2 Method

2.1 Participants

A cross-sectional design with purposive sampling had screened participants who were diagnosed by a general practitioner as CLBP conditions and attended the physiotherapy centre were selected for the study. Prior to that, all participants were given the information sheets with regard to the study and signing a consent form as they agreed. Participants also were given chance to ask the research assistants for clarification if they had any problems regarding their participation. The inclusion criteria were male, lived in Ampang district and nearby, Kuala Lumpur, and age ranged between 20 and 39 years, while those with previous treatment of Kinesio tape, spondylolisthesis, previous spinal injury, fibromyalgia, and clinical sign of radiculopathy were excluded from the study. Therefore, a total of 20 patients agreed to participate in the study. Later, they were divided equally and randomly into experimental and control groups.

Initial data collection (T_1) was taken using the Oswestry Low Back Disability Questionnaire and Modified–Modified Schober' Test (MMST). The experimental group received Kinesio tape for 1 week on the low back region while no tape application for the control group. The participants were scheduled for a convenient time for the following week for the post data collection.

A week later, the Kinesio tape was removed from the participant's low back region. Both groups undergo the same measurements as a week before (T_2). After measurements were obtained, both groups were scheduled for available time for the next 4 weeks for the follow-up data collection. The same measurements were taken again during follow-up session (T_3).

2.2 Oswestry Low Back Disability Questionnaire

Oswestry Low Back Disability Questionnaire consists of 10 sections and each section has the highest possible score which is 5, while the lowest possible score is 0. The questionnaire was calculated using the following formula by Fairbank and Pynsent (2000). The validity and reliability of the questionnaire were measured in Fairbank and Pynsent (2000). The scores range 0–20%, resulting in minimal disability which means the participant can cope with most living activities and no treatment is indicated apart from advice on lifting, sitting and exercise. The scores range 21–40%, described as moderate disability where the participant experiences more pain and difficulty with sitting, lifting and standing. Travel and social life are more difficult and they may be unable to work. Personal care, sexual activity and sleeping are not grossly affected and the participant can usually be managed by conservative means. If the score range 41–60%, they may experience severe disability described as pain remains the main problem in this group, but activities of

daily living are affected. These participants require a detailed investigation. The score 61–80% crippled and it described as back pain impinges on all aspects of the participant's life and positive intervention is required. Lastly, the score ranges between 81 and 100% described as these participants are either bed-bound or exaggerating their symptoms.

2.3 Modified–Modified Schober's Test

The MMST was used in order to measure the range of motion (ROM) of lumbar flexion among CLBP participants. The validity and reliability of the test were described in Tousignant et al. (2005). Participants were asked to stand to allow the therapist to identify the posterior superior iliac spine (PSIS). The area was marked by the therapist using his or her thumbs. Line marking was drawn along the PSISs. The other mark was located 15 cm superior to the initial mark drawn. The tape was used in order to measure the distance between these two points. Once they located firmly while holding the tape at the area marked, the therapist asked the participant to bend forward as much as he can. When the participant bends forward into full lumbar flexion, the new distance between two points marked was created and it was measured. The difference between the initial length and the second length determined the amount of lumbar flexion by the participant. The therapist recorded the measurement to nearest 1 mm, between first length (15 cm) and the trunk flexion length. After the measurement was recorded, the marking was cleaned up using an alcohol swab.

2.4 Kinesio Tape Application

The Kinesio Tex Gold™, was used in the study. The experimental group received the treatment where three strips tape had been placed on their lumbar region. The tape was stretched to about 15% and the placement from the origin to insertion is recommended for chronic pain (Kase 1994). The tape was applied in flexion position where the participants were asked to bend forward during the application where the tape adhered on the muscles along the lumbar area, for which the base was on sacrum region (Fig. 1).

2.5 Statistical Analysis

Data were analysed by using the Statistical Package for Social Sciences (version 23.0 for Windows, SPSS Inc., Chicago, IL, US). A descriptive statistics was applied to identify the demographic information of the participants. The inferential statistic

Fig. 1 "I" strip technique was used during Kinesio tape application on the lumbar region

was employed to prove this study's hypothesis. The normality of the data was evaluated by counting on the skewness and kurtosis statistic. The data were taken within the bounds of a normal distribution, so long as the dividend of the skewness and kurtosis statistic and their respective standard errors did not exceed ±2.0. Repeated measures ANOVA was applied to assess any difference effects ($P < 0.05$) of Kinesio tape application between both groups during initial, post-test and follow-up week. The data were expressed as a mean with ± standard deviation.

3 Results and Discussion

3.1 Demographic Data

A total of 20 participants participated in the study. All of them were diagnosed with CLBP by a general practitioner. They were divided into experimental and control group randomly via simple randomization technique (Kim and Shin 2014). The characteristics of the participants were shown in Table 1. All of them seemed to have an ideal body mass index (BMI).

Table 1 Participants' characteristics between the groups

Parameters	Group	
	Experimental (n = 10)	Control (n = 10)
Age (Years)	26.3 ± 3.37	25.9 ± 2.92
Height (m)	1.7 ± 0.05	1.7 ± 0.04
Weight (kg)	78.4 ± 10.84	74.1 ± 9.17
Body mass index (kg/m^2)	26.7 ± 3.72	25.8 ± 3.49

3.2 Oswestry Disability Index

All participants completed Oswestry Low Back Disability Questionnaire. The questionnaire was analysed to obtain Oswestry Disability Index (ODI) score. The ODI score was shown in Table 2. Based on the analysis, there was a significant reduction in ODI score after a week of Kinesio tape application and during the follow-up session.

This study showed a reduction in functional disability and improvement in trunk flexion range of motion (ROM) after a week of post-intervention. This improvement only persisted on functional disability after a week of follow-up session. Therefore, this study was in agreement with Al-Shareef et al. (2016).

Ostelo and de Vet (2005) reported that an improvement in the Oswestry Disability Index score of ⩾10 points was clinically significant in all types of low back pain. Therefore, this study has nearly met the criteria for ODI in the experimental group. Lim and Tay (2015) had stated that Kinesio tape was not more effective than minimal or other forms of intervention in the reduction of disability related to chronic musculoskeletal pain. However, this study revealed a significant difference of ODI score between experimental and control group which suggested a beneficial effect of Kinesio tape application on lower back pain. Besides, the duration of Kinesio tape application may influence the ODI outcome since most of the study showed a significant reduction in ODI score after more than a week of Kinesio tape application (Castro-Sánchez et al. 2012; Kelle et al. 2016).

3.3 Lower Back Mobility

The lower back mobility score was shown in Table 2. There was an increase in lower back mobility after 1 week of Kinesio tape application (T_2) in experimental group which did not exhibit in control group. However, this improvement was not long lasting until follow-up session (T_3).

Table 2 ODI score and trunk flexion ROM between the groups

	Group		*P*-value
	Experimental (n = 10)	Control (n = 10)	
ODI score			
T_1	18.2 ± 6.78	18.4 ± 7.50	P < .05
T_2	9.9 ± 5.57	16.6 ± 5.17	
T_3	13.7 ± 3.28	17.8 ± 3.79	
Lower back mobility score (cm)			
T_1	20.7 ± 0.46	20.8 ± 0.57	P < .05
T_2	21.0 ± 0.37	20.6 ± 0.60	
T_3	20.6 ± 0.59	20.6 ± 0.63	

The improvement in trunk flexion in this study was parallel with Al-Shareef et al. (2016) at T_2. Thus, we hypothesized a longer study duration resulting in a better result during follow-up session. The improvement in trunk flexion suggested that Kinesio tapes had to have a unique elasticity which provides passive support to weak or injured muscles. This can assist in everyday activities, high-level sport or even low-tone children.

4 Conclusion

In this study, Kinesio tape appears to reduce functional disability and increase trunk flexion ROM after a week of the application on lower back pain young male adults. However, further investigation is needed in order to obtain a better understanding of the benefits of Kinesio tape application on lower back pain participants

Acknowledgments This study was financially supported by Universiti Teknologi MARA, under the Research Acculturation Grant Scheme (RAGS) 2013 (600-RMI/RAGS 5/3 (199/2013).

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Chapter 98
Comparison of Flexibility, Muscular Endurance, and Speed Among Veteran Male Tennis Player Between Clubs

Mohd Hanifa Sariman, Nik Nabihah Nik Yusof, Mohd Zulkhairi Azam, Wan Mohd Norsyam Wan Norman and Fatin Aqilah Abdul Razak

Abstract The racquet sport is recommended to the veteran players to gain health benefits and sports performance. Elderly also compete in a tennis tournament, where fitness components are crucial for them to excel. The purpose of this study was to compare the flexibility, muscular endurance, and speed among veteran male tennis players between clubs. The total number of subjects were 30 ($N = 30$), half of the subjects were from Majlis Perbandaran Kota Bharu and the other half were from Kelantan Golf Country Club. Several tests were conducted according to the following sequences which are (i) weight and height test, (ii) chair sit and reach test for flexibility, (iii) maximum push up test for muscular endurance test, and (iv) ten meters sprint test for speed. The result shows that there is a significant difference in flexibility ($p < 0.05$). However, muscular endurance and speed did not show significant difference when ($p > 0.05$). In conclusion, it can be concluded that flexibility shows significant difference while muscular endurance and speed shows no significant difference. Many possibilities might affect the findings such as the type of training, the frequency of training, and daily activities. The specific training program would be meaningful to improve the performance of elderly according to appropriate training principles.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_98

Keywords Flexibility · Muscular endurance · Strength · Veteran

1 Introduction

Tennis has improved a number of participants and spectators over the years with emerging of professional players all over the world. Other factors of immense popularity gained by tennis due to the benefits as peoples start consciously to practice healthy lifestyle, where tennis could be participated regardless of age. The racquet sport is not only for young people but is also recommended to the veteran population where it helps to burn a huge amount of calories. Furthermore, the definition of a veteran is over 50 years old for both female and male in the USA (Marks 2006). More than that, typically elderly or veteran relate to the population not under 50 years old (Avers et al. 2011).

Flexibility is one of the important fitness components for tennis as injury rate among tennis players could be minimized and optimum range of motion able to produce greater impact in tennis repetitive movement. According to Kovacs (2006), intermediate or long-term external range of motion which does not amend the imbalance would lead to muscle and joint injury. Besides that, repetitive movement and long rallies are common in tennis which requires a very good upper and lower body muscular endurance to sustain the demand in tennis. It is hard to predict the length point, hit choice, tournament length, and the resister which affect the composite physiological aspect of tennis (Kovacs 2006). The patterns of play for each match are different based on players, who have their own match strategy. In addition, react and run fast are critical in tennis performance because the ball velocity during a match is high. Players have to run from edge to edge of the tennis court to ensure ball is returnable and get ready for the next return ball from the opponent. Mckinley (2010) defined quickness as a multidirectional skill that involves acceleration, reactiveness, and explosiveness. Acceleration to reach the ball before it flops needs an extensive speed training regime.

The training program for tennis requires a solid physiological demand and physical component fitness Reid et al. (2008). The foundation training among tennis player must be comprehensive emphasizing on fitness, tactical, and technical of tennis. It is different for recreational tennis players, where winning is not the objective of the games. Konig et al. (2001) identify tennis as a composite sport regarding strength, power, speed, agility, explosiveness, and endurance. A good tennis player has good multi-fitness components incorporated with sound tactical and technical play.

Moreover, playing tennis can also reduce the fat body percentage and make the body looks leaner compared to being less active. According to Madell (2004) in the European Journal of Applied Physiology and Occupational Physiology, tennis players, including veteran players had a stronger extension and flexors muscle in their knees than those who were less active. The promotion of good health includes enhanced aerobic component fitness, deduction of fat body percentage, well-disposed

lipid profile, deduction of a developing heart disease, and healthy bone condition Pluim et al. (2007). However, physical screening toward elderly is very important, since the nature of tennis is high risk and requires multiple fitness components such as speed and power. Besides that, tennis as an example of a physical activity includes that has a positive effect on cognitive function and reduces dementia (Jedrziewsk et al. 2007). Dementia normally occurs among elderly with a decline in mental ability, where the character is almost similar like Alzheimer.

Fitness level among veteran male tennis players between Majlis Perbandaran Kota Bharu(MPKB) and Kelab Golf Country Club(KGCC) remain unknown, it is because they only undergo training program without any specific fitness test and measurement. Based on previous winning statistic observation between both the clubs, Majlis Perbandaran Kota Bharu (MPKB) is far better than Kelantan Golf Country Club (KGCC). Tennis has been long acclaimed as a hobby and improved the condition of health among active veteran tennis player (Marks 2006) The purpose of this study is to compare the flexibility, muscular endurance, and speed among veteran male tennis players between MPKB and KGCC.

2 Method

Method applied to statistical analysis was independent T-test in order to compare physical fitness involved in this study which is flexibility, muscular endurance, and speed among veteran tennis player between clubs. Total of number of subjects were 30 ($N = 30$) and each club is 15 ($N = 15$).All the tests were conducted in the outdoor scene (field test).The subject was informed regarding the information required before participating in this study. The entire test was demonstrated by qualified demonstrator and subjects were allowed trying for familiarization. Test was conducted in sequence as followed: (i) chair sit and reach to measure flexibility (ii) maximum push ups test to measure muscular endurance (iii) 10 meters speed to measure speed. Maximum push test was conducted once, chair sit and reach and 10 meters speed was conducted three times and best score was recorded. Warming up session was conducted prior actual fitness testing to avoid injury and to ensure the subjects were ready for tests. The entire test was completed in a day for each venue as MPKB and KGCC are not the same venues. All information gathered was analyzed using the Statistical Package for Social Science (SPSS) version 22.0.

3 Results

The purpose of this study was to compare flexibility, muscular endurance, and speed among male veteran tennis player between MPKB and KGCC. Demographic information data is age, weight, height, and body mass index (BMI) were introduced by the descriptive statistic.

Table 1 Demographic Data

Group	N	Age (years)	Weight (kg)	Height (cm)	Body mass index (BMI)
MPKB	15	57.53	70.40	167.73	24.97
KGCC	15	60.87	70.90	166.67	25.42

Investigation was used to guarantee and classifying the physiological profile of the subjects in three hypotheses set by the researcher analyzed with independent T-test to figure out contrasts between MPKB and KGCC.

Table 1 shows the demographic data of subjects. This table represents the demographic data of age, weight, height, and body mass index (BMI). There were 30 subjects that participated in the study. Subjects have been tested in two different groups which are MPKB club and KGCC club. Based on result study the mean for the height of MPKB is 167.73 and KGCC is 166.67. The mean score for the weight on MPKB is 70.40 and for KGCC is 70.90. Moreover, the mean score for body mass index (BMI) for MPKB is 24.97 and for the KGCC is 25.42

Table 2 shows the results of chair sit and reach test component flexibility for both tennis clubs. The results between both clubs indicated that there was a significant difference in chair sit and reach test between MPKB ($M = 6.30$) and KGCC ($M = -0.67$) based on their fitness level. Therefore, Ha is accepted after $p < 0.05$ was set are significant.

Further, Table 3 shows the results of maximum push up component muscular endurance for both the tennis clubs. The result between both clubs indicated that there was no significant differences in maximum push up test between MPKB ($M = 10.73$) and KGCC ($M = 8.73$) based on their fitness level. Therefore, Ha is rejected after $p < 0.05$ was set as no significant (Table 4).

Table 2 Chair sit and reach test for flexibility (cm)

Group	N	Mean	SD	t value	p	df
MPKB	15	6.30	6.70	2.31	0.028	28
KGCC	15	−0.67	9.55			

Table 3 Maximum push for the muscular endurance test

Group	*N*	Mean	SD	*t* value	*p*	df
MPKB	15	10.73	4.25	1.425	0.165	28
KGCC	15	8.73	3.39			

Table 4 Ten meters speed for speed test (second)

Group	*N*	Mean	SD	*t* value	*p*	df
MPKB	15	2.93	0.55	−1.33	0.193	28
KGCC	15	3.33	1.00			

The result is shown in the above table for 10 meters speed for both the tennis clubs. The result between both the clubs indicated that there were no significant differences in 10 m speed between MPKB ($M = 2.93$) and KGCC ($M = 3.33$) based on their fitness level. Hence, Ha is rejected after $p < 0.05$ was set no significant value.

4 Discussion

Flexibility is very necessary for any game of sport. According to Kovacs (2006), tennis athletes have been shown to have a greater range of internal shoulder motion in their dominant arm than other athletes, but also have a smaller range of external shoulder motion. The proper method of angle and the increasing range motion will be the best performance while performing a skill technique. Besides that, proper training intervention to develop a range of motion for specific joints for tennis is important. According to Fernandes (2013) shoulder internal or external rotation ROM significantly improved in both the groups, training ($p = 0.001$) and control ($p = 0.0001$), after the 6 weeks of intervention. Besides that, stretching during warming up and cooling down might contribute to the performance of flexibility among tennis players. A later study conducted by Ronsk et al. (1995) physical activity regardless of the degree of complexity become an important objective in reducing in the degenerative age-related effects, for example like decreased muscle mass, time elasticity, and joint flexibility.

Muscular endurance can strengthen the cardiovascular muscle and enhance efficient blood transportation to the heart. It is hard to predict the point of length, shot selection, strategy, match period, weather, and the challenger all influence the difficult physiological aspects of tennis play (Kovacs 2006). However, the findings in this study contradicts with the study conducted by Babalola (2011). Training method from both the clubs probably has similarity where they train muscular endurance to improve the rallies of the game. Training frequency also might affect the results where most of the veteran athletes involved in this study were not full-time athletes. A longer duration of match will lead to fatigue due to repetitive movements, of which muscular endurance play an important roles in order to sustain the performance. Besides that, more energy will be needed to overcome the shaking of the racquet's head frame which can lead to a tennis elbow injury (Paraskevi 2015). Furthermore, this component fitness is also important in the daily life activities, for example, for lifting a box that has a load or lifting vase.

In tennis, there are different velocities, different types of spin in the whole court to move. For example, when the opponent does the drop shot, the player must move fast and speed in front of the net to return the ball. The study was in contradiction with a study conducted by Ferrauti et al. (Ferrauti et al. 2001) where running time for stroke preparation and stroke speed were significantly decreased. Hence, it is important to train tennis players in the specific movement patterns that are demanded during match play. Furthermore, specificity principles are used to design

training programs and it would seem reasonable to train tennis athlete using sprint activities that are no longer than the furthest distance that the athlete would run per shot during a point.

5 Conclusion

It can be concluded that there was a significant difference in flexibility between both clubs. However, muscular endurance and speed were not significant between both clubs. The elderly must be active in order to gain benefits by practicing a healthy lifestyle. The advantages when participating in physical activities will increase self-confidence, improve cognitive health, and cardiovascular disease. In addition, as we grow older reducing of muscle mass also known as sarcopenia occurs. According to Mikkelsen et al. (2013), the body tends to be weak as a result of muscle mass loss. Strong muscle mass helps in the functionality of elderly and could minimize the risk of injury in sports, recreational, or daily life activities.

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Chapter 99
Peer Leadership in Archery: The Effect of Personal Characteristic and Leader Behaviour on Team Performance

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Abstract The purpose of this study is to examine the relationship of team captain characteristic toward team performance, to examine the relationship of team captain behaviour towards team performance and to examine the impact of personal characteristic and leader behaviour towards team performance. Thirty archers ($N = 30$) participated in this study. The result of this study showed that personal characteristic has significant difference ($P < 0.01$) and has no significant difference ($P = 0.36$) in leader behaviour. The result also shows that personal characteristic and leader behaviour give an impact to team performance. The results revealed that the peer leadership has an impact on the team performance.

Keywords Archery · Personal characteristics · Leader behaviour Team performance

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_99

1 Introduction

Leadership is one of the important elements in the organization and team in order to achieve their objectives. As mentioned by Northouse (2001), leadership is a process in which an individual influences a group of people to in line with the organization or team objectives and also make them achieve the goal. In sport, when mentioning about leadership most of the time people focus on leadership of the coach and team manager where most of the studies also discover about the leadership of coach and team manager. As we know, coach and team manager are the right person to lead the team. However, some of the studies also suggested that athletes in the team also can fulfil the leadership position and also another significant source of leadership within the team members (Fransen et al. 2014).

Since June 2014, there is no new coach appointed for UiTM Pahang Archery Club. The team captain took the responsibility to lead and manage the team in every training session and competition. This condition was leading this study to explore the effect of athlete leadership in term of their personal characteristics and behaviour toward the team performance of UiTM Pahang Archery team. This is because athlete leadership is seen closer with their teammates and can explore more about their teammates. Sometimes this situation can increase teammate's spirit and motivation to win in the competition and training hard.

Loughead et al. (2014) revealed that athlete leadership can give more social support, positive feedback, and democratic behaviour towards their teammates. Previous literature mention that example characteristics that must have in athlete leaders are organized, cooperative, diplomatic, self-confident, and knowledgeable (Dupuis 2004). Research on peer leadership also explained that there are differences in trait and behaviour among peer leaders and non-leader peers (Dupuis et al. 2006). Hence this study is to explore personal characteristics and behaviour of athlete leaders whether it gives impact toward team performance of UiTM Pahang Archery Club. Therefore, the following hypothesis is developed:

H1: There is a positive relationship between athlete leadership's personal characteristics and team performance.
H2: There is a positive relationship between athlete leadership's leader behaviour and team performance.
H3: The impact of personal characteristics to team performance.
H4: The impact of leader behaviour to team performance.

2 Method

2.1 Participants

There are 30 archers from UiTM Pahang Archery Club participated in this study which are 15 archers are female and another 15 archers are male. From totally 30

archers, 11 of them represented for Club, another 11 archers represented for University, 3 represented State and last 2 archers represented Malaysia.

2.2 *Instrument and Procedures*

A brief explanation regarding on answering the questionnaires was given beforehand. The respondents were given the assurance of the confidentiality and anonymity of the information. The archers took their own time to fill out the questionnaires. All 30 questionnaires were returned with 100% response rate within the time given.

The instrument originally has 56 items, which measure the dependent, and independent variables. The dependent variable in this study is team performance. Team performance is measured by 5 items relating to Productivity, Quality, and Achievements. These items are adopted from the relationship between the team and characteristic with team performance in Malaysia teams (Heng 2006). Respondents were asked to indicate their belief about the performance of the teams. A five-point Likert scale is used. (1 = never, 2 = seldom, 3 = occasionally, 4 = often, 5 = always).

Independent variables consist of personal characteristic that is measured by 12 items. For leader behaviour, the measure was adopted from Chelladurai and Saleh (1980). This measurement has 5 dimensions, which consist of Training and Instruction, Autocratic Behaviour, Democratic Behaviour, Social Support, Positive Feedback.

3 Results

Prior to conducting any formal statistical analyses, preliminary steps to ensure the quality of data were conducted to ensure it worthy further analysis (Sekaran 2003). First, inspection of missing data was conducted. Hair (2006) suggested four-step processes to identify missing data. Step one is to determine the type of missing data. It was found that the missing data was not caused by the research design but it was due to ignorable missing data. Step two is to determine the extent of missing data. The statistics showed that each variable has missing values of 0.5%. Therefore, the extent of missing data is not substantial enough to warrant any action. According to (2006), less than 10% of individual case of missing data can be ignored. Step three is to diagnose the randomness of the missing data. It was examined using missing value analysis (MVA). The purpose of using MVA is to detect any possible systematic missing data. This study found no missing data from the returned questionnaires.

Second, construct reliability test using Cronbach's Alpha was conducted using SPSS version 20. The purpose of this test is to assess the internal consistency

reliability of the instrument used. The results show that the Cronbach's Coefficient Alpha values for the 4 constructs are above 0.7 which is considered as acceptable, hence the instrument is appropriate for use in this study (Field 2009; Hair 2006; Nunnally 1978; Sekaran 2003; Smith 2011).

Third, the test of normality was performed. Although Kolmogorov–Smirnov statistics indicated that all variables are significant hence non-normal, test of normality is sensitive and "often signal departures from normality that do not really matter (p. 46)" (Tabachnick and Fidell 2007). To make sure that the data is approximately normal, we identified outliers using boxplot. Skewness and kurtosis statistics or the z-scores of the variables were within ± 1.96 suggesting approximate normal distribution. This was later confirmed through the visual indicator of the histogram and normal Q-Q plot.

In PLS analysis, measurement models for the latent constructs are conducted. It includes assessing validity and reliability of the measures. The majority of the construct was operationalised with multi-item measures and a Likert's five-point scale. Further analysis was conducted for an individual construct using the WarpPLS version 4.0. The individual item loadings for personal characteristic (LB) are ranging from 0.69 to 0.82 which is more than sufficient (Hair et al. 2010; Kock 2013). The composite reliability (CR) is 0.898 which is desirable (Peter 1979), the Cronbach's alpha is 0.874 and average variance extracted (AVE) is 0.471. The AVE is slightly below the desired value of 0.5, however, according to Fornell and Larcker (1981), an AVE with less than 0.5 but the CR is above 0.6 the convergent validity of the construct is still considered adequate. All indicators are well above the desired value, which indicates that the measures for personal characteristic are valid and reliable.

The individual item loadings for leader behaviour (LB) are ranging from 0.65 to 0.94. The CR for this measure is 0.931 and the Cronbach's alpha is 0.920. Both indicators are considered very high. However, the AVE is 0.420 which is quite low. Both Barclay et al. (1995) and Urbach and Ahlemann (2010) mentioned that the value of AVE should be above 0.50. However, according to Fornell and Larcker (1981), if the value of AVE is less than 0.50 but having CR that is higher than 0.6, the convergent reliability for the construct is acceptable where in this case the CR is well above the required value (0.931).

The team performance (TP) was measured using 5 items. The loadings are ranging from 0.81 to 0.96. The CR for this measure is 0.818, Cronbach's alpha is 0.721 and AVE is 0.474. All indicators are considered very high. However, the AVE value of 0.474 is raising concern. Nevertheless, Fornell and Larcker (1981), suggest that an AVE which has a value of less than 0.50 but having CR that is higher than 0.6 is still adequate and the measures are considered valid and reliable.

In summary, Table 1 indicated that the constructs' items are correlated strongly with other items in the same constructs. This is evidenced by almost all the items loaded at the desired value of above 0.50. Convergent validity was evidenced further, by high CR and acceptable AVE threshold.

The discriminant validity is assessed by looking at correlations among latent variables and square root of AVE (Kock 2013) and the variance inflation factor

Table 1 Reliability and validity of variable

Construct	Number of items	Alpha	Factor loading	CR	AVE
Personal characteristic	10	0.87	(0.69–0.82)	0.898	0.471
Leader behaviour	19	0.92	(0.65–0.94)	0.931	0.420
Team performance	5	0.72	(0.81–0.96)	0.818	0.474

Table 2 Correlations and AVE

Variable	Personal characteristic	Leader behaviour	Team performance
PC	0.844		
LB	0.775*	0.485	
TP	0.316*	0.326*	0.688

Square roots of AVE's shown on diagonal; * indicates $p < 0.001$; ** indicates $p < 0.05$; *** indicates $p < 0.5$

Table 3 Variance inflation factors

Variable	Personal characteristic	Leader behaviour	Team performance
PC			
LB			
TP	4.487	4.487	

Four hypotheses were developed in this study and the PLS-SEM is used to test direct paths in this study. Figure 1, provides the beta coefficients and R^2 values of the path model

(VIF) associate it with other construct and by looking at the degree of multi-collinearity among the latent variables to ensure that no latent variables that measure the same thing. Table 2 shows that the instrument used has a good discriminant validity because each latent variable, the square root of the AVE is larger than any correlations of latent variables, in the same column as suggested by Fornell and Larcker (1981).

Table 3 shows block VIF factors, which indicates the VIF is lower than 5 that suggests the existence of no vertical multicollinearity in a latent variable block (Kock 2013) and shows that each VIF is associated with one or more predictors (Hair et al. 2010).

The structural model was assessed based the R-square values and the beta coefficients. Figure 1 shows that exogenous variables in the model explained substantial amounts of the variance of team performance ($R^2 = 0.27$). The values between 0 and 1 are accepted but a higher value is preferable (Hair et al. 2010).

3.1 Relationship of Team Captain's Personal Characteristics Toward Team Performance

Figure 1 shows that both variables have a positive relationship and received strong support from the data with a beta coefficient of 0.49 and 0.36. Thepositive direct relationships exist. These results provide empirical evidence that information PC and LB positively associated with TP, thus providing support for hypotheses 1 and 2. According to Kock (2013), if the model shows the positive value so the model has a positive relationship. Therefore, the null hypothesis for H1 and H2 are rejected.

3.2 Impact of Personal Characteristics and Leader Behaviour Towards Team Performance

Based on this result, personal characteristic gives an impact to team performance. The result shows that personal characteristic has a significant value which is ($P < 0.01$) and there is no significant value for leadership behaviour because the value of P is more than 0.05 which is P for leader behaviour is ($P = 0.36$).

As a result, this study able to reject the null hypothesis for H3, but fail to reject the null hypothesis for H3. The summary of all hypotheses is depicted in Table 4.

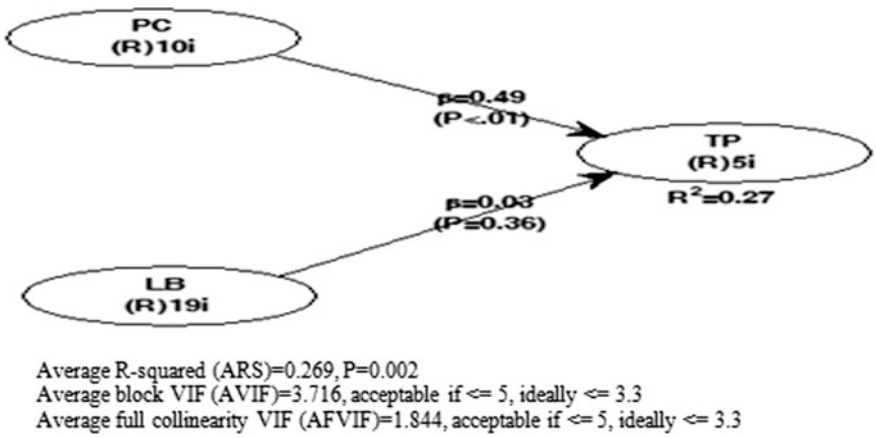

Fig. 1 PLS path analysis of this study

Table 4 Summary of results of the direct effect: PC, LB and TP

Hypotheses	Direction	Beta coefficient	*P* value	Results
H1: There is a positive relationship between athlete leadership's personal characteristics and team performance. H2: There is a positive relationship between athlete leadership's leader behaviour and team performance. H3: The Impact of personal characteristics to team performance. H4: The Impact of leader behaviour on team performance				
PC → TP	+	0.49	<0.001	Supported
LB → TP	+	0.03	0.36	Not supported

4 Discussion

The result highlights that having a good personal characteristic and good leader behaviour can lead a good performance among team members. So, if the team leader has a good behaviour and good personal characteristic automatically the team members will follow all the instructions and skill. In this study, the result shows that personal characteristic of team captain gives an impact on team performance. Meaning that leader who has a good personal characteristic can give an impact to team member and team performance. People who have a good personal characteristic can make others trust with their skill that was he teaches and also give a big impact on team performance to achieve the goal. Moran and Weiss (2006) study also discussed athletes that have leadership character and their behaviours can influence to individual and team performance. Past finding also shows that for effective team work leading to improve team performance are related with individual characteristic (Dupuis et al. 2006; Fransen et al. 2014; Galbraith 1993; Moran and Weiss 2006; Todd and Kent 2004). From this finding and previous research, peer leadership in university team is effective to influence a good performance among the team member and also can be the best way to use in coaching.

5 Conclusion

The conclusion from this study, personal characteristic and leader behaviour give a good impact on team performance in UiTM archery team. A good personal characteristic and leader behaviour of team leader can lead others member to follow his advice and also can be a role model to others. Additionally, when team members are trusted with their team leader so all the task was given can be easy to complete and also can achieve the goal of the team. This study show that personal characteristic and leader behaviour give a positive impact to team performance and hope that this study can be the starting point especially in Malaysia for understanding the impact of peer leadership in Archer.

Recommendation for this study is student can be a temporary leader but must be monitored by the responsible authorized body. Next, there is a need to choose a right person for the task in making sure that the leader can be a good influence to the team members hence in return results in good team performance. Lastly is, the research outcome shows the "Leader Behaviour" construct is insignificant. Future research should look into different dimensions to explore the construct as suggested by Vincer and Loughead (2010).

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Chapter 100
Comparison of Sports-Specific Test Protocol and Procedures to Identify Talent in Goalball Between Students with Blind and Visual Impairment: A Preliminary Study

NagoorMeera Abdullah, Nurlela A. Hassan, Asiah Mohd Pilus and Mohd Sofian Omar Fauzee

Abstract This study was designed to investigate the comparison of sports-specific test protocol and procedure to identify talent in goalball between students with blind and visually impaired which are from Sekolah Menengah Pendidikan Khas (Cacat Penglihatan), Kuala Lumpur. Thirty students with blind and visually impairment (B1; $n = 15$ (male = 5, female = 8), B2; $n = 15$ (male = 10, female = 7)) from a special school for the blind, Kuala Lumpur participated in this study. The study used purposive sampling technique. Subjects undergo eight specific sporting ability protocols in goalball. The study was analyzed used SPSS version 20.0. There is a significant difference between both the blind and visually impaired group on the standing broad jump test (0.046; $p < 0.05$) and 1 min sit-up test (0.001; $p < 0.05$) while there are no significant differences between both blind and visually impaired group on arm span (0.123; $p > 0.05$), standing basketball throw (underhand) (0.145; $p > 0.05$), handgrip strength right (0.102; $p > 0.05$) and left (0.108: p 0.05), sit and reach test (0.763: $p > 0.05$), modified static balance stork test (left 0.081: $p > 0.05$) (right 0.076: $p > 0.05$), and multiple position reaction time for right (0.186: $p > 0.05$) and left (0.903: $p > 0.05$) respectively. The study had shown that there no significant differences between blind and visually impaired group based on the test protocols and all the test protocols are relevant to select goalball players.

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_100

Keywords Goaball · Physical activity · Visually impaired talent
Test protocols

1 Introduction

Currently, there are a few talent identification programs, especially for the disabled athletes. Faber et al. (2011) said that talent identification programs are used to identify talented athletes in time and to succeed at a world-class level. Moreover, talent identification for children with disabilities is quite a complicated area to study. Individuals with disabilities tend to adopt more sedentary lifestyles when compared to their peers without disabilities. Talent identification in sport is a complex, making it not only difficult to define but more difficult to predict (Abdullah et al. 2013). Talent identification is oriented of identified talent within a wide variety of sport and events and needs a complex multistage and multidimensional process (Krasilshchikov 2011). Other than that, talent identification has been defined as the process by which children are measured on a number of physical and performance variables that are perceived for winning within sports that are given (Augustyn 2005). Talent has also can be stated as a contingent on genetics, environment, encouragement, and their influence on physical and psychological traits and the concept of talent as having several properties, and make the nature showed that there was no agreement based on the theory and practice of talent identification in sport (Abdullah et al. 2013). This inactivity can lead to the development of secondary health conditions, like obesity, which is very common among individuals with disabilities. Visual impairment can be defined as any kind of vision loss. There are also many terms used to describe the meaning of blind and visual impairment. According to the previous study that related to visually impaired athletes suggest that athlete's with visual impairment are tended to be inactive throughout their lifespan time (Abdullah et al. 2008). Blindness may cause low physical activity, capacity posture problems, orientation difficulties, depressions, and problems with balance (Cattaneo et al. 2008). Visual information is very important for control of equilibrium and estimation of the moving motion speed of the objects and body segments, also for the time and accuracy of the psychomotor reaction. As we know, eye is one of the most complex and remarkable structures in the human body. It is the most sensitive sensory organ which enables us to perceive things.

Currently, we know that regular involvement in physical activity, sports, and recreation was dominant to able person. Unfortunately, we also know that children with disability especially who have visual impairments often have limited access to such activities (Ponchillia et al. 2005). The nature or type of disability is essential and very important to determine the risk of inactivity and potential development of other health and personal problems. Further, physical activity patterns indicate that even though adolescents with visual impairments demonstrate a similar trend in decreased physical activity followed by age and nondisabled peers. Currently, the status of physical activity patterns of children with blind and visual impairments

determinants are not sufficiently documented (Ayvazoglu et al. 2006). Goalball is a unique sport because it is just focusing on blind and visually impaired only. This game also was invented by Hanz Lorenzen and Sepp Reindle, to help in the rehabilitation of blinded war veterans in 1946. The game was introduced to the world in 1976 at the Paralympics in Toronto and has been played at every Paralympics since. This game is now played in 112 countries in all IBSA (International Blind Sports Federation) regions (Colaka et al. 2004). Goalball was played by three players in one team on a standard gymnasium volleyball court with tactile marking. The ball that player has to throw actually a three-pound ball that has bells inside. To ensure that the game is fair for all categories, all the players must wear a blindfold during the game. So, the study is designed to assess the comparison between students with blind and students with visually impaired on sports-specific test protocols and procedures that to be used to identify sports talent.

2 Methodology

2.1 Research Design

This study is conducted by doing testing protocols because the purpose of the study is to determine the differences that exist between two and more variables.

2.2 Sample and Sampling

The subjects consist of 30 students ($N = 30$) which are 15 males and 15 females. Male students consist of five totally blind (B1) and ten partially blind (B2) subjects, whereas female consists of eight totally blind (B1) and seven partially blind (B2) subjects. The group classification of blind and visually impaired for B1 refers to totally blind and B2 refers to partially blind been identified by school management examined and testified by the Malaysia-certificated optometrist. The average age of the subjects is 13–15 years. The subjects are currently studying at Special School for the Blind, Setapak, Kuala Lumpur.

2.3 Instrumentation

The entire subject been evaluated by using the eight (8) test protocols namely arm span, strength (handgrip strength and standing basketball throw), flexibility (sit and reach), balance (modified standing stork test), power (standing broad jump), reaction time (multiple position reaction time), and muscular endurance (1-min sit-up). Part of that, subject height, weight, and body mass index (BMI) were also recorded.

2.4 Data Collection Procedure

All tests were administrated in group settings with up to 30 subjects with two classifications that were B1 and B2. To accommodate group testing, seven physical fitness tests item plus one arm span evaluation was labeled in each station which was arranged in affixed order. The permission was granted from school principals to do the test, and also the location (school's multipurpose hall). The test raters were given briefing and demonstration on the test protocols and the procedures. The distribution of the consent letter and score sheet begin to all the subjects and assist them to fill the form especially for the totally blind students. The session began with all subjects gathered and briefly explained on purpose of the study, procedures involved and what the study need from them. Test raters demonstrated the entire test and gave the physical instruction to students who are totally blind (B1). After the warm-up sessions which are static run, jumping jack, and static stretching, each of the participants will follow the test raters to the various station to begin their test.

Subjects have been divided into two different groups according to their gender. Each subject has been identified and takes turn according to their sequence number. It is to make sure that the test runs smoothly. Each group was assisted by the test rater that follows the participants. The test raters were responsible to explain and demonstrate the tests to the subjects. The sequence of skills have been demonstrated and its verbal description was standardized according to the one that been listed in the test manual of physical fitness. After the demonstration, a practice trial was given for each subject. The briefing also has been held on how the experiment will be conducted to let them know the information about what they are going to do and this is to ensure the validity and reliability of the session. The entire subject will begin the test by measuring their height and weight. Then progressively they will proceed to strength (handgrip strength and standing basketball throw), flexibility (sit and reach), balance (modified standing stork test), power (standing broad jump), reaction time (multiple position reaction time), and muscular endurance (1-min sit-up).

Both the groups were preceding the fitness test from one station to another as a rotation session. The male group continues with basketball throw (underhand), modified static balance stork test and reaction time whereas female group continued with handgrip strength (180°), sit and reach test, standing broad jump and 1 min sit-up test. During the test, subjects were also provided with some food and mineral water. The data were recorded as two trials, and there was rest in between the trials. At the end of the session, feedback was collected on the performance of the subjects. The entire tests were conducted in one day.

2.5 Data Analysis

The study was analyzed using the Statistical Package for Social Science (SPSS) version 20.0. The significance difference were analyzed with specific test protocol that include component of strength, flexibility, balance, power, reaction time and muscular endurance with talent in goalball among students with blind and visually impaired (totally and partially blind) on specific sporting ability protocols of goalball at Sekolah Menengah Pendidikan Khas (Cacat Penglihatan), Setapak, Kuala Lumpur. The statistical significant value was set as the alpha level of $p < 0.05$.

3 Results

Table 1 below shows the mean and standard deviation of anthropometric data for the male in the study that includes the weight, height, and body mass index (BMI). The mean and standard deviation were used to investigate the anthropometric evaluation of the students with blind and visually impaired. Students with blind, the mean ± SD for weight were 60.92 ± 25.99. For the height was 159.44 ± 9.41 and BMI was 25.24 ± 8.10. Students with visual impaired, mean ± SD for weight were 54.42 ± 8.82 and for height were 163.59 ± 10.87 whereas BMI was 20.33 ± 2.82.

Table 2 below shows the mean and standard deviation of anthropometric data for the female in the study that includes the weight, height, and body mass index (BMI). The mean and standard deviation were used to investigate the

Table 1 The anthropometric data of the male subjects based on the classification of the blind and the visually impaired

Classification	N	Component	MEAN	SD
Blind	5	Weight	60.92	25.99
		Height	159.44	9.41
		BMI	25.24	8.10
Visual impaired	10	Weight	54.42	8.82
		Height	163.59	10.87
		BMI	20.33	2.82

Table 2 The anthropometric data of the female subjects based on the classification of the blind and the visually impaired

Classification	N	Component	MEAN	SD
Blind	8	Weight	43.55	5.55
		Height	148.46	6.12
		BMI	19.76	2.14
Visual impaired	7	Weight	51.90	17.81
		Height	151.81	6.54
		BMI	22.21	6.20

Table 3 Compare means for the subjects with blind and visually impaired based on the specific test protocols of goal ball

Specific protocols	Blind and visually impaired subjects				
	Blind		Visually impaired		
	MEAN	SD	MEAN	SD	*p*-value
Arm span (cm)	152.00	10.98	175.84	9.09	0.123
Standing basketball throw (underhand) (m)	7.63	3.02	9.80	4.47	0.145
Handgrip strength (R) (kg)	19.05	7.37	24.53	9.76	0.102
Handgrip strength (L) (kg)	20.00	5.80	24.68	8.81	0.108
Sit and reach test (cm)	28.15	7.54	28.94	6.60	0.763
Modified static balance stork test (R) (s)	9.48	5.12	15.71	11.55	0.081
Modified static balance stork test (L) (s)	9.44	4.72	14.58	9.14	0.076
Standing broad jump (m)	1.48	0.71	2.09	0.84	0.046
Multiple position reaction time (R) (s)	2.01	1.03	1.62	0.50	0.186
Multiple position reaction time (L) (s)	1.52	0.58	1.55	0.40	0.903
1-min sit-up test	22.15	3.48	29.53	6.77	<0.001*

$P < 0.05$

anthropometric evaluation of the students with blind and visually impaired. Students with blind, the mean ± SD for weight were 43.55 ± 5.55. For the heights 148.46 ± 6.12 and BMIs were 19.76 ± 2.41. Students with visual impaired, mean ± SD for weight were 51.90 ± 17.81 and for height were 151.81 ± 6.54 whereas BMI was 22.21 ± 6.20.

Table 3 revealed the significant difference based on the p-value. There is a significant difference between both the blind and visually impaired group on the standing broad jump test and 1-minute sit-up test that consist of 0.046 and 0.001 that less than the level of alpha value. However, there are no significant differences between both blind and visually impaired group on arm span, standing basketball throw (underhand), handgrip strength right and left, sit and reach test, modified static balance stork test, and multiple position reaction time for right and left. The p-value was 0.123, 0.145, 0.102, 0.108, 0.763, 0.081, 0.076, 0.186, and 0.903, respectively. The mean and SD followed by the sequence of the test protocols or procedure starting from arm span is 152.00 ± 10.98 for blind, and 175.84 ± 9.09 for visually impaired followed by standing basketball throw (underhand) is 7.63 ± 3.02 for blind and 9.80 ± 4.47. Then, for handgrip (right) hand, 19.05 ± 7.37 for blind and 24.53 ± 9.76 for visually impaired. Handgrip strength (left) hand was 20.00 ± 5.80 for blind and for visually impaired are 24.68 ± 8.81. Sit and reach test for both groups blind and visually impaired are 28.15 ± 7.54 and 28.94 ± 6.60. In addition, for the modified balance stork test (right) leg are 9.48 ± 5.12 for blind and 15.71 ± 11.55 for visually impaired. For modified static balance stork test (left) leg, there are 9.44 ± 4.72 for blind and 14.58 ± 9.14 for

the visually impaired category. Other than that, for sit and reach mean and SD for blind and visually impaired are 1.48 ± 0.71 and 2.09 ± 0.84. For multiple position reaction time right and left position, there are 2.01 ± 1.03, 1.62 ± 0.50, 1.52 ± 0.58 and 1.55 ± 0.40. For 1-min sit-up test, the blind group is 22.15 ± 3.48 and 6.77 ± 0.001 for the visually impaired group.

4 Discussion

The results reveal that there are not many differences between the subjects with blind and the visually impaired with regards to their weight, height, and body mass index (BMI) (Abdullah et al. 2013). Although both groups were blindfolded especially for the balance test, the subjects with visually impaired did better than the subjects with the blind. Most probably the subjects with visually impaired subjects (both male and the female) may have throughout their everyday lives been exposed to the situations that may allow them opportunities to master certain level in motor ability performance.

In basketball throw, the blind and visually impaired subjects perform overall the same. According to (Stuart et al. 2006), there no significant difference has been found between the fitness score between children with low vision and those who are blind. However, the subjects with visually impaired have advantages because they may use their full of residual vision when test administrators demonstrated the step of the test. For the subjects with visually impaired, they have better ability to control the correct technique and orientate themselves when throwing a basketball in underhand technique. For subjects with blind (male and female), it may be quite difficult to throw with the correct technique because they difficult to understand with verbal technique and test administrators have to assist them with the simple sequence before they start to throw. So, generally, both male and female subjects with visual impaired on basketball throw (underhand) test (Abdullah et al. 2013). For the handgrip strength test also there are no differences between subjects with blind and visually impaired since the test does not emphasize on vision equity. Both groups perform the same technique because hand grip strength test is easier to perform than another test.

There is no general test for flexibility of the entire body. The flexibility of muscular groups and joints must be analyzed separately. The test used in the present study (sit-and-reach test) was chosen for being the most frequently used flexibility test for all ages. It measures the flexibility of both the lumbar region and muscles on the posterior thigh (Barbosa et al. 2002). In addition, for flexibility sit and reach test, both groups perform overall the same. The result highlighted that subjects with blind and visually impaired have a certain level of flexibility. They are easy to perform because several of subjects already know the correct technique. So, there are no significant differences on sit and reach test between subjects with blind and visually impaired.

According to (Lahtinen et al. 2007), balance in adulthood is a complex phenomenon and based on the development of postural control and locomotion from the birth. Balance is an indispensable factor for the blind and it helps to encourage the people with visually impaired integration in space. In this study, subjects with blind showed a significant difference advantage over the subjects with visually impaired on the Modified Static Balance Stork Test. It may be because subjects with blind are already adapted to the environment. So, it easier to perform the test and can balance on the longer time. Relative performance on fitness items of students with visually impaired varies with the nature of the particular test (Augustyn 2005). Standing broad jump test indicates there have significant differences between subjects with blind and visually impaired. Subjects with visually impaired perform better than the blind subjects because they can see partially the target point before they jump. It differences to subjects with blind because they cannot estimate the target point and the point of landing. However, they perform with the correct technique with clear instruction and motivation from their friends.

Multiple position reaction time regarding the performance of both groups, they have a less difference. However, subjects with visually impaired (male and female) perform better than the blind subjects. According to (Juodzbaliene and Muckus 2006), the time of psychomotor reaction to the sound signal of the sighted person with open eyes appeared significantly shorter than the blind person. The alertness of the subjects was high because they alert to perform test after listening to the instructions from the test administrator. In this study, it indicates that the groups have a good listening and high alertness. There also a significant difference on 1-minute endurance tests, between subjects with blind and visually impaired. Subjects with visually impaired show greater variability in their endurance performance, compared to their sighted peers. This including the variation in vision, how they perform the attitudes and variation in the vision (Abdullah et al. 2013). However, males significantly outperformed females in adulthood for both gender male and female (Lahtinen et al. 2007).

5 Conclusion

The purpose of the study was to determine the differences in each specific test protocols or procedure to identify talent in goal ball between two groups. This study attempt to answer the hypotheses of this study that is whether there were significant differences in specific test protocols and talent in goalball. The increased awareness on physical fitness test can promote a good skill related performance. Though the testing, participation is not essential for a healthy lifestyle, many individuals enjoy taking part in physical activity in daily life and the enjoyment is usually greater for individual possessing physical fitness testing. The entire test indicates the comparison of the test protocols to identify talent in goal ball between two groups.

Furthermore, the individual with disabilities may be similar to individuals without disabilities who are chronological younger. Many individuals with

disabilities have a short attention span and problems with complicated directions. This is often a problem because they have difficulties in predicting spatial movement and localization nor are not good judges of properly executed performances.

6 Recommendations

From this study, there were several further recommendations that could be suggested:

i. These individuals need a special program that can make them exhibit a better coordination of movement in motor skills either in fine motor skills. Therefore, further investigated suggested to investigate their fine motor skills. The imbalance of both motor skills can contribute to deficits in fundamental movement skill performance.
ii. Promoting involvement in sports for the lifetime that will benefit them. Persons with visually impaired have a fundamental right to have the same experiences and expose to a variety of activities to choose from in the future to live healthy, active lives or involve in high sports performance for disable person especially in goalball.
iii. The involvement of the persons in sports activity also important. The sports activity can influents the improvement and the development of motor skills. The lack of ability to perform motor skills competently was a constraint to the development of more advanced skills, and subsequently the comfortable participation in a wide range of sports, recreation, and leisure pursuits.
iv. Promote physical activities and fitness testing among blind and visually impaired so that can increase cardiovascular fitness, upper body strength and flexibility are important. In addition, cardiovascular fitness is closely related to a healthy body composition meaning measured by the BMI in this study.
v. Researchers, sport and recreation programmers, as well as physical educators, should recognize the motor skills level of athletes for proper instruction. Failure to identify athletes of lower levels of physical fitness development might result in athletes being rejected by peers, and consequently their early withdrawal from physical activities.

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Part XI
Statistics

Chapter 101
Stability and Forecastability Characteristics of Exponential Smoothing with Regressors Methods

Ahmad Farid Osman and Maxwell L. King

Abstract Quite recently, two separate methods of exponential smoothing augmented with regressors have been introduced. The inclusion of regressors in the exponential smoothing method is intended to provide explanatory effects to a dependent variable rather than only relying on historical movement of a single series in generating forecasts. The objective of this study is to investigate the stability and forecastability characteristics of the two methods. Satisfying either stability or forecastability conditions ensures the method to produce stable forecast values for long forecast horizons. The findings of the study suggest that one of the methods is able to satisfy the forecastability conditions while another method fails to satisfy both stability and forecastability conditions.

Keywords Discount matrix · Eigenvalues · Stable forecasts

1 Introduction

1.1 Exponential Smoothing method

Since the 1950s, exponential smoothing method became a very popular forecasting technique due to easy implementation and several other advantages. The most popular classical exponential smoothing methods are single exponential smoothing (Brown 1959, 1963), Holt's linear method (Holt 1957) and Holt–Winters exponential smoothing method (Winters 1960). Further development of the exponential

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_101

smoothing method has started to take place after the introduction of a nonlinear state-space framework, characterized by a single source of errors (Ord et al. 1997). As a result, Hyndman et al. (2008) listed 30 different models of the state-space version of the exponential smoothing methods.

All exponential smoothing methods mentioned above are considered as univariate time series models. These models only rely on dynamic movement of a single series to produce future forecasts of the same series. A number of attempts have been made to integrate the effect of regressors into exponential smoothing methods. Hyndman et al. (2008), for example, introduced an augmented version of the exponential smoothing model with independent variables in which regressor parameters are time invariant. An example of a local-level model with one regressor (denoted ETSX-TIP) is given by the following equations:

$$y_t = \ell_{t-1} + p_{1,t-1} z_{1,t} + \varepsilon_t \tag{1a}$$

$$\ell_t = \ell_{t-1} + \alpha \varepsilon_t \tag{1b}$$

$$p_{1,t} = p_{1,t-1} \tag{1c}$$

In the above equations, y_t is the observed value of the dependent variable, ℓ_t denotes the level of the series, $z_{1,t}$ represents the regressor or independent variable while $p_{1,t}$ is its parameter, and ε_t represents errors with the stochastic assumption that $\varepsilon_t \sim NID(0, \sigma^2)$. α represents the smoothing parameter.

If we want to have a local-level model with a regressor in which parameter is time varying (ETSX-TVP) based on the formulation given by Eqs. (1a)–(1c), we can simply add another smoothing parameter, β_1 and error term in Eq. (1c) so that the Eqs. (1a)–(1c) are expressed by the following equations.

$$y_t = \ell_{t-1} + p_{1,t-1} z_{1,t} + \varepsilon_t \tag{2a}$$

$$\ell_t = \ell_{t-1} + \alpha \varepsilon_t \tag{2b}$$

$$p_{1,t} = p_{1,t-1} + \beta_1 \varepsilon_t \tag{2c}$$

Osman and King (2015a) then introduced another formulation of the exponential smoothing method with regressors. Their proposed formulation covers both time-invariant and time-varying regressor parameters for k regressors as given by the following general equations.

$$y_t = \ell_{t-1} + s_{t-m} + \sum_{i=1}^{k} b_{i,t-1} \Delta_{z_{i,t}} + \varepsilon_t \tag{3a}$$

$$\ell_t = \ell_{t-1} + \sum_{i=1}^{k} b_{i,t-1} \Delta_{z_{i,t}} + \alpha \varepsilon_t \tag{3b}$$

$$s_t = s_{t-m} + \gamma \varepsilon_t \tag{3c}$$

$$b_{1,t} = \begin{cases} b_{1,t-1} + \frac{\beta_1\left(\varepsilon^+_{1,t-1} + \varepsilon_t\right)}{\Delta^*_{z_{1,t}}}, & \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \\ b_{1,t-1}, & \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1} \\ \vdots & \end{cases} \tag{3d}$$

$$b_{k,t} = \begin{cases} b_{k,t-1} + \frac{\beta_k\left(\varepsilon^+_{k,t-1} + \varepsilon_t\right)}{\Delta^*_{z_{k,t}}}, & \text{if } \left|\Delta^*_{z_{k,t}}\right| \geq L_{b_k} \\ b_{k,t-1}, & \text{if } \left|\Delta^*_{z_{k,t}}\right| < L_{b_k} \end{cases} \tag{3e}$$

$$\varepsilon^+_{1,t} = \begin{cases} 0, & \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \\ \varepsilon^+_{1,t-1} + \varepsilon_t, & \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1} \\ \vdots & \end{cases} \tag{3f}$$

$$\varepsilon^+_{k,t} = \begin{cases} 0, & \text{if } \left|\Delta^*_{z_{k,t}}\right| \geq L_{b_k} \\ \varepsilon^+_{k,t-1} + \varepsilon_t, & \text{if } \left|\Delta^*_{z_{k,t}}\right| < L_{b_k} \end{cases} \tag{3g}$$

where

$$\Delta^*_{z_{i,t}} = z_{i,t} - z^*_{i,t-1} \quad \text{and} \quad z^*_{i,t} = \begin{cases} z_{i,t}, & \text{if } \left|\Delta^*_{z_{i,t}}\right| \geq L_{b_i} \\ z^*_{i,t-1}, & \text{if } \left|\Delta^*_{z_{i,t}}\right| < L_{b_i} \end{cases} \tag{4}$$

In the above equations, s_t represents the seasonal component while m represents the periodicity of the seasonality. γ is another smoothing parameter. In addition to that, $\Delta_{z_{i,t}}$ represents the change in ith regressor so that $\Delta_{z_{i,t}} = Z_{i,t} - Z_{i,t-1}$, $b_{i,t}$ is the regressor parameter, and $\varepsilon^+_{i,t}$ is a dummy error.

L_{b_i} in Eqs. (3a)–(3g) represents the lower boundary for $\left|\Delta^*_{z_{i,t}}\right|$ in a switching procedure. The use of the lower boundary in the switching procedure is to avoid extreme changes in the regressor parameters, $b_{i,t}$. The idea of using a box-plot to flag outliers as introduced by Tukey (1977) can be used to determine the lower boundary for the switching procedure. By referring to Eqs. (3d) and (3e), extreme change in the regressor coefficients, $b_{i,t}$ can be avoided if all of $\beta_i/\left|\Delta_{z_{i,t}}\right|$ satisfy the following condition:

$$\beta_i/\left|\Delta_{z_{i,t}}\right| \leq \text{upper inner fence of } \left(\beta_i/\left|\Delta_{z_{i,t}}\right|\right) = Q_3 + 1.5(Q_3 - Q_1),$$

with Q_1 = 1st quartile and Q_3 = 3rd quartile of $\left(\beta_i/\left|\Delta_{z_{i,t}}\right|\right)$.

The lower boundary can be determined in three steps. The first step is to compute $\left|\Delta_{z_{i,t}}\right|$ for each regressor, $z_{i,t}$, and then to remove $\left|\Delta_{z_{i,t}}\right| = 0$. The second step is to compute the dispersion summary of $1/\left|\Delta_{z_{i,t}}\right|$ and find the upper inner fence $\left(UIF_{1/\left|\Delta_{z_{i,t}}\right|}\right)$. The final step is to get the lower boundary based on a formula $L_{b_i} = 1/UIF_{1/\left|\Delta_{z_{i,t}}\right|}$ or set it at 0.5, whichever is smaller. The rationale of this setting is given in Osman and King (2015a).

The model specification as given by Eqs. (3a)–(3g) is considered as a model with time-varying regressor parameters. The corresponding model with time-invariant regressor parameters can be constructed by setting all regressor coefficients to be constant, i.e., $b_{i,t} = b_{i,t-1}$. In this case, the model no longer needs to apply the switching procedure.

For the case of the local-level model with one regressor in which the parameter is time varying (ESWR-TVP), the model specification is given by

$$y_t = \ell_{t-1} + b_{1,t-1}\Delta_{z_{1,t}} + \varepsilon_t \tag{5a}$$

$$\ell_t = \ell_{t-1} + b_{1,t-1}\Delta_{z_{1,t}} + \alpha\varepsilon_t \tag{5b}$$

$$b_{1,t} = \begin{cases} b_{1,t-1} + \frac{\beta_1\left(\varepsilon^+_{1,t-1} + \varepsilon_t\right)}{\Delta^*_{z_{1,t}}}, & \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \\ b_{1,t-1}, & \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1} \end{cases} \tag{5c}$$

$$\varepsilon^+_{1,t} = \begin{cases} 0, & \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \\ \varepsilon^+_{1,t-1} + \varepsilon_t, & \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1} \end{cases} \tag{5d}$$

where

$$\Delta^*_{z_{1,t}} = z_{1,t} - z^*_{1,t-1} \quad \text{and} \quad z^*_{1,t} = \begin{cases} z_{1,t}, & \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \\ z^*_{1,t-1}, & \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1} \end{cases}. \tag{6}$$

In contrast, the model specification for a local-level model with one regressor in which parameter is time invariant (ESWR-TIP) is given by

$$y_t = \ell_{t-1} + b_{1,t-1}\Delta_{z_{1,t}} + \varepsilon_t \tag{7a}$$

$$\ell_t = \ell_{t-1} + b_{1,t-1}\Delta_{z_{1,t}} + \alpha\varepsilon_t \tag{7b}$$

$$b_{1,t} = b_{1,t-1}. \tag{7c}$$

All models specified above can be represented in matrix notation of

$$y_t = \bar{\boldsymbol{w}}_t' \bar{\boldsymbol{x}}_{t-1} + \varepsilon_t \tag{8a}$$

$$\bar{\boldsymbol{x}}_t = \overline{\boldsymbol{F}}_t \bar{\boldsymbol{x}}_{t-1} + \bar{\boldsymbol{g}}_t \varepsilon_t, \tag{8b}$$

with matrix notation for four models with one regressor described above are given below.

ETSX-TIP:

$$\bar{\boldsymbol{x}}_t = \begin{bmatrix} \ell_t \\ p_{1,t} \end{bmatrix}, \quad \bar{\boldsymbol{w}}_t = \begin{bmatrix} 1 \\ z_{1,t} \end{bmatrix}, \quad \overline{\boldsymbol{F}}_t = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad \text{and} \quad \bar{\boldsymbol{g}}_t = \begin{bmatrix} \alpha \\ 0 \end{bmatrix}.$$

ETSX-TVP:

$$\bar{\boldsymbol{x}}_t = \begin{bmatrix} \ell_t \\ p_{1,t} \end{bmatrix}, \quad \bar{\boldsymbol{w}}_t = \begin{bmatrix} 1 \\ z_{1,t} \end{bmatrix}, \quad \overline{\boldsymbol{F}}_t = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad \text{and} \quad \bar{\boldsymbol{g}}_t = \begin{bmatrix} \alpha \\ \beta_1 \end{bmatrix}.$$

ESWR-TIP:

$$\bar{\boldsymbol{x}}_t = \begin{bmatrix} \ell_t \\ b_{1,t} \end{bmatrix}, \quad \bar{\boldsymbol{w}}_t = \begin{bmatrix} 1 \\ \Delta_{z_{1,t}} \end{bmatrix}, \quad \overline{\boldsymbol{F}}_t = \begin{bmatrix} 1 & \Delta_{z_{1,t}} \\ 0 & 1 \end{bmatrix} \quad \text{and} \quad \bar{\boldsymbol{g}}_t = \begin{bmatrix} \alpha \\ 0 \end{bmatrix}.$$

ESWR-TVP:

$$\bar{\boldsymbol{x}}_t = \begin{bmatrix} \ell_t \\ b_{1,t} \\ \varepsilon^+_{1,t} \end{bmatrix}, \quad \bar{\boldsymbol{w}}_t = \begin{bmatrix} 1 \\ \Delta_{z_{1,t}} \\ 0 \end{bmatrix},$$

$$\overline{\boldsymbol{F}}_t = \begin{bmatrix} 1 & \Delta_{z_{1,t}} & 0 \\ 0 & 1 & \beta_1 / \Delta^*_{z_{1,t}} \\ 0 & 0 & 0 \end{bmatrix} \quad \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \quad \text{or} \quad \overline{\boldsymbol{F}}^*_t = \begin{bmatrix} 1 & \Delta_{z_{1,t}} & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \quad \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1}$$

and

$$\bar{\boldsymbol{g}}_t = \begin{bmatrix} \alpha \\ \beta_1 / \Delta^*_{z_{1,t}} \\ 0 \end{bmatrix} \quad \text{if } \left|\Delta^*_{z_{1,t}}\right| \geq L_{b_1} \quad \text{or } \bar{\boldsymbol{g}}^*_t = \begin{bmatrix} \alpha \\ 0 \\ 1 \end{bmatrix} \quad \text{if } \left|\Delta^*_{z_{1,t}}\right| < L_{b_1}.$$

1.2 Stability and Forecastability

The objective of this paper is to investigate and compare forecast properties of the two formulations for integrating regressors into the exponential smoothing method.

Any forecasting model is considered a good model if it is able to produce stable forecasts for long period ahead. There are two similar concepts known as stability and forecastability that ensures any model will produce stable forecasts. Osman and King (2015b) give an explanation of these concepts in detail. The same explanation can also be found in Hyndman et al. (2008). As a summary of the two concepts, consider the following expected value of Eq. (8a) which also represents the forecast equation.

$$\hat{y}_{t+1|t} = \bar{\boldsymbol{w}}'_{t+1}\left(\prod_{i=0}^{t-1}\boldsymbol{D}_{t-i}\right)\bar{\boldsymbol{x}}_0 + \sum_{j=1}^{t-1}\left[\bar{\boldsymbol{w}}'_{t+1}\left(\prod_{i=0}^{t-j-1}\boldsymbol{D}_{t-i}\right)\bar{\boldsymbol{g}}_j y_j\right] + \bar{\boldsymbol{w}}'_{t+1}\bar{\boldsymbol{g}}_t y_t, \quad (9)$$

where $\boldsymbol{D}_t = \overline{\boldsymbol{F}}_t - \bar{\boldsymbol{g}}_t\bar{\boldsymbol{w}}'_t$. Matrix $\boldsymbol{D}_t$ is known as discount matrix. In order to produce stable forecasts, any model needs to satisfy either the stability condition or the forecastability condition. Stability requires all eigenvalues of a matrix $\boldsymbol{D}_t$ to be less than 1 in absolute value. In contrast, the forecastability concept requires eigenvalues of a matrix $\boldsymbol{D}_t$ to be no greater than 1 in absolute value. Forecast values, $\hat{y}_{t+1|t}$ will explode (be unstable) if one or more eigenvalue(s) of the matrix $\boldsymbol{D}_t$ is greater than 1 in absolute value.

2 Research Methodology

In order to achieve the research objective, theoretical inspection, and numerical experiments have been conducted. The theoretical inspection was used to investigate the characteristic equations of all four local-level models with one regressor parameter as described in the previous section. The inspection was aimed to determine whether eigenvalues of matrix $\boldsymbol{D}_t$ satisfy any or both of the stability and forecastability conditions. It is done by inspecting the maximum eigenvalues of matrix $\boldsymbol{D}_t$. If the maximum eigenvalues are less than 1, the model satisfies the stability condition. If the maximum eigenvalues are equal to 1, the model satisfies the forecastability condition. However, if maximum eigenvalues are greater than 1, the model does not satisfy both stability and forecastability conditions.

To confirm the findings based on the theoretical inspection, an empirical experiment was conducted to numerically inspect the maximum eigenvalues of the matrix $\boldsymbol{D}_t$. For this purpose, simulated series were used to estimate parameters of each model. The estimated parameters were then used to produce forecasts for short and long period ahead up to 12,000 steps ahead. The maximum eigenvalues of the matrix $\boldsymbol{D}_t$ of the four models were then determined.

3 Results

Table 1 lists characteristic equations and eigenvalues of the four models under consideration. For the two models with a time-invariant regressor parameter, i.e., ETSX-TIP and ESWR-TIP, the discount matrix $\boldsymbol{D_t}$ contains a unit eigenvalue and the other eigenvalue is $(1-\alpha)$. This means that both models do not satisfy the stability concept due to the presence of a unit eigenvalue. However, by restricting $(1-\alpha)$ to be less than 1, these models are able to satisfy the forecastability concept.

With regards to the model with time-varying regressor parameter, ETSX-TVP is also unable to satisfy the stability condition as its discount matrix has a unit eigenvalue. The other eigenvalue which is $\left(1-h_1 z_{1,t}-\alpha\right)$, is clearly dependent on the value of the regressor, $z_{1,t}$. For in-sample period, the second eigenvalue can be controlled by restricting its value to be less than 1 in absolute value during the estimation process. However, the same restriction cannot be imposed for the out of sample forecast period. It means that the second eigenvalue could drift away to be greater than 1 and eventually cause the forecast value to explode.

Another version of the model with a time-varying regressor parameter, ESWR-TVP, has two sets of eigenvalues. The first set of eigenvalues is when the model normally runs the updating process of the regressor parameter and, therefore, the discount matrix is given by a matrix $\boldsymbol{D_t}$. The second set of eigenvalues occurs when the switching procedure is implemented to put on hold the updating process and, therefore, the discount matrix is given by a matrix $\boldsymbol{D_t^*}$. The characteristic equation of matrix $\boldsymbol{D_t}$ contains three roots with the smallest equal to zero while other two are roots of $p(\lambda)$. By applying the switching procedure using the

Table 1 Characteristic equation of matrix $\boldsymbol{D_t}$ or $\boldsymbol{D_t^*}$ and eigenvalues

Model	Characteristic equation	Eigenvalues[a]		
		$\boldsymbol{\lambda_1}$	$\boldsymbol{\lambda_2}$	$\boldsymbol{\lambda_3}$
ETSX-TIP $(\boldsymbol{D_t})$	$f(\lambda)=(1-\lambda)(1-\alpha-\lambda)=0$	1	$(1-\alpha)$	–
ETSX-TVP $(\boldsymbol{D_t})$	$f(\lambda)=(\lambda-1)\left(\lambda+h_1 z_{1,t}+\alpha-1\right)=0$	1	$1-h_1 z_{1,t}-\alpha$	–
ESWR-TIP $(\boldsymbol{D_t})$	$f(\lambda)=(1-\lambda)(1-\alpha-\lambda)=0$	1	$(1-\alpha)$	–
ESWR-TVP $(\boldsymbol{D_t})$	$f(\lambda)=p(\lambda)(-\lambda)=0$, where $p(\lambda)=\lambda^2+\left(\alpha+\beta_1\Delta_{z_{1,t}}/\Delta^*_{z_{1,t}}-2\right)\lambda+(1-\alpha)$. When $\Delta_{z_{1,t}}=\Delta^*_{z_{1,t}}$; $p(\lambda)=\lambda^2+(\alpha+\beta_1-2)\lambda+(1-\alpha)$.	roots of $p(\lambda)$		0
ESWR-TVP $(\boldsymbol{D_t^*})$	$f(\lambda)=(1-\lambda)(1-\lambda)(1-\alpha-\lambda)=0$	1	1	$1-\alpha$

[a]By restricting all but unit eigenvalues to be less than 1

methodology explained before, the $p(\lambda)$ will have the same values of $\Delta_{z_{1,t}}$ and $\Delta^*_{z_{1,t}}$ at most of the times and, therefore, the two eigenvalues are independent of regressor and can be restricted to be less than 1 for both within and out sample forecast periods, except for few times when the updating process is re-activated after being put on hold. In contrast, the matrix $\boldsymbol{D}_t^*$ contains two unit eigenvalues and if $(1-\alpha)$ is restricted to be less than 1, then the model is able to satisfy the forecastability condition.

The above findings of theoretical expectation are supported by the results of the numerical experiment as given in Table 2. It can be seen that the maximum eigenvalue of the characteristic equation of the discount matrix is always equal to 1 for both ETSX-TIP and ESWR-TIP models. Maximum eigenvalues of the

Table 2 Maximum eigenvalue of matrix $\boldsymbol{D}_t$ or $\boldsymbol{D}_t^*$

Period ahead, $t^{\wedge}$	Model			
	ETSX-TIP	ETSX-TVP	ESWR-TIP	ESWR-TVP
1	1.00000	1.00000	1.00000	0.99999
2	1.00000	1.00000	1.00000	0.99999
3	1.00000	1.00000	1.00000	0.99999
4	1.00000	1.00000	1.00000	0.99999
5	1.00000	1.00000	1.00000	0.99999
6	1.00000	1.00000	1.00000	0.99999
7	1.00000	1.00000	1.00000	0.99999
8	1.00000	1.00000	1.00000	0.99999
9	1.00000	1.00000	1.00000	0.99999
10	1.00000	1.00000	1.00000	0.99999
11	1.00000	1.00000	1.00000	0.99999
12	1.00000	1.00000	1.00000	1.00000
1000	1.00000	3.00096	1.00000	0.99999
2000	1.00000	5.81279	1.00000	0.99999
3000	1.00000	8.62344	1.00000	0.99999
4000	1.00000	11.43606	1.00000	0.99999
5000	1.00000	14.24909	1.00000	1.00000
6000	1.00000	17.06063	1.00000	1.00000
7000	1.00000	19.87333	1.00000	0.99999
8000	1.00000	22.68528	1.00000	0.99999
9000	1.00000	25.50043	1.00000	0.99999
10,000	1.00000	28.30823	1.00000	0.99999
11,000	1.00000	31.12159	1.00000	0.99999
12,000	1.00000	33.93246	1.00000	0.99999
Min	1.00000	1.00000	1.00000	0.99999
Max	1.00000	33.93246	1.00000	1.00000

Notes Min = Minimum, Max = Maximum, ^for out-of-sample period

characteristic equation of the discount matrix for ETSX-TVP model, however, is only equal to 1 for short-term forecast horizons. For long forecast horizons, maximum eigenvalues of the characteristic equation of the discount matrix are greater than 1 with maximum eigenvalue exceeds 3 for 1000 steps ahead forecast and almost exceeds 34 for 12,000 steps ahead forecast. Interestingly, inspection on maximum eigenvalues of the characteristic equation of the discount matrix for ESWR-TVP model has shown that the highest value is equal to 1 and most of the maximum eigenvalue are equal to 0.99999.

These results suggest that both time-invariant regressor parameter models and time-varying regressor parameter model formulated by Osman and King (2015a) are able to be forecastable models. The model structure of time-varying regressor parameters based on the formulation proposed by Hyndman et al. (2008) on the other hand, is unable to be a forecastable model.

4 Conclusion

To sum up, this study was aimed to investigate the ability of two formulations of integrating regressors into the exponential smoothing method in producing stable forecasts. For each method, two local-level models with one regressor were considered; one with time-invariant regressor parameter while another with time-varying regressor parameter. The inspection of the characteristic equations suggests that the formulation suggested by Hyndman et al. (2008) is able to produce stable forecasts for the case of time-invariant regressor parameter model. However, the time-varying version of the same formulation failed to produce stable forecasts. In contrast, the formulation suggested by Osman and King (2015a) is able to produce stable forecasts for both time-invariant and time-varying regressor parameter models.

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Chapter 102
Estimating Optimal Parameter of Box-Cox Transformation in Multiple Regression with Non-normal Data

Nur Aufa Mazni Ishak and Sanizah Ahmad

Abstract Normally distributed data are needed in many statistical analyses including multiple regression (MR). When data is not normally distributed, remedial actions in making the data normal are necessary. In this study, the violation of this assumption is overcome by using the Box-Cox transformation (BCT). An investigation using simulation designs with data generated from three skewed sample data of non-normal distributions namely Exponential, Gamma and Beta Distributions based on the various sample sizes (100, 500 and 1000) are carried out. Hence, the simulation studies are implemented to estimate optimal lambda in the BCT based on two scenarios: (i) response variable (Y) follows several non-normal distributions and (ii) errors from several non-normal distributions. The results show that lambda = 0.30, 0.40 and 0.50 are the optimal lambdas produced for Exponential, Gamma and Beta Distributions. Therefore, BCT with optimal lambda value improves analyses in MRs when data are not normal. The performance of BCT method is also illustrated using the real-life data.

Keywords Box-Cox transformation · Multiple regression · Normality
Log-likelihood · Optimal lambda

1 Introduction

Multiple regression (MR) is a widely used statistical method to estimate the effects of several independent variables on a dependent variable (Neale et al. 1994). Like most statistical tests, MR also relies upon statistical assumptions about the variables used in the analysis (Sevier 1957). Ignoring the regression assumptions may con-

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_102

tribute to wrong validity estimates (Antonakis and Deitz 2011). Osborne and Waters (2002) stated that one of the MR assumptions is for the variables to follow normal distributions with errors that are normally distributed. There are certain consequences if this particular assumption is not satisfied such as bias in the coefficient estimates and standard errors which may lead to the confidence intervals and significance tests to wrong conclusions (Andersen 2012). Some researchers stated that small departures from normality do not create any serious problem but major departures from normality should be a concern. In the literature, many types of transformation techniques have been proposed to face data that deviates from normality by using a family of transformation such as natural log, square root and inverse also known as the Box-Cox transformation (BCT) (Olivier and Norberg 2010). However, choosing the type of transformation is trivial to normalize the error terms. The wrong type of transformation may lead to the violation of another assumption in MR. The BCT is usually used to transform the distribution of a non-normal data into a normal data. According to Draper and Cox (1969), the well-adapted BCT brings heavily skewed data sets to near normality. Furthermore, Box and Cox (1964) proposed an objective way of determining the types of data transformation which are considered in determining the suitable transformations for approximate normality. Hence, rather than using common classical transformations, this study aims to use the BCT to overcome the violation of normality since it allows identifying the best transformation. This paper estimates the optimum value, λ^*, the parameter of the BCT in the context of MR. Simulation analyses using BCT are performed followed by illustration with real data. All analyses are performed using R program version 3.2.5.

2 Methodology

There are many techniques to estimate the BCT parameter, λ. Thus, this study will focus on investigating the optimal value of λ in the BCT, denoted by λ^*, using the algorithm of maximum likelihood estimator (MLE) by maximizing the profile log-likelihood of the Box-Cox function. The BCT is given by

$$y(\lambda)_i = \begin{cases} \frac{(y_i^{\lambda}-1)}{\lambda} & \text{if} \quad \lambda \neq 0 \\ \log(y_i) & \text{if} \quad \lambda = 0 \end{cases} \tag{1}$$

where

y_i is the observations
λ is transformation parameter
$y(\lambda)_i$ is approximately with a normal distribution with mean (μ) and variance (σ^2)
i is 1, 2, …, n

Then, let

$$\beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_{p-1} X_{i,p-1} + \varepsilon_i \tag{2}$$

be the multiple linear regression model with n observations, where

$\beta_0, \beta_1, \ldots, \beta_{p-1}$	are parameters
$X_{i1}, \ldots X_{i,p-1}$	are known constants
ε_i	are independent $N(0, \sigma^2)$
i	is 1,…, n

The log-likelihood of the multiple linear regression model in (2) can be written as

$$\begin{aligned} \log L &= -\frac{n}{2}\log(2\pi) - n\,\log\sigma \\ &= -\frac{1}{2\sigma^2}\sum_{i=1}^{n}\left[Y_{(i)}^{(\lambda)} - (\beta_0 + \beta_i X_i)\right]^2 + (\lambda - 1)\sum_{i=1}^{n}\log(Y_i) \end{aligned} \tag{3}$$

It is possible to rewrite the log-likelihood (L) in (3) as

$$L = * - \frac{n}{2}\log\left[\sum_{i=1}^{n}\left(\frac{Y_i^{(\lambda)} - (\beta_0 + \beta_i X_i)}{\dot{Y}^{\lambda}}\right)^2\right] \tag{4}$$

where

$$\dot{Y}^{\lambda} = \exp\left[\frac{1}{n}\sum_{i=1}^{n}\log Y_i\right]$$

The optimal value λ^* is obtained by maximizing the profile log-likelihood in (4).

For the simulation design, skewed sample data are generated from Exponential, Gamma and Beta Distributions with various sample sizes (n = 100, 500 and 1000). Next, each of the created data would have four independent variables to illustrate the MR models.

The algorithm for estimation of λ^* is given as follows:

Step i	Select a sequence of candidate λ values by a fairly precise increment of 1/10 within [−2, 2] interval.
Step ii	Apply the BCT in the data set.
Step iii	Estimate optimal lambda, λ^* by using Maximum Likelihood Estimation (MLE) approach by maximizing the profile log-likelihood in (4).

This study focuses on estimating optimal lambda (λ^*) in the BCT based on two scenarios: (i) response variable (Y) follows several non-normal distributions and (ii) errors with several non-normal distributions. We conduct two simulation

studies. First, an algorithm for simulation I estimates for optimal lambda in the BCT with a response variable (Y) which follows several non-normal distributions. The algorithm for Simulation I is as follows:

Step i Create non-normal samples which generate multiple random samples which response variable (Y) follow non-normal distributions.
Exponential Distribution; $Y \sim \text{Exp}(\beta = 2)$ $\text{Y} \sim \text{Exp}(\beta = 2)$ Gamma Distribution; $Y \sim Gamma(\alpha = 1, \beta = 1)$ $\text{Y} \sim \text{Gamma}(\alpha = 1, \beta = 1)$
Beta Distribution; $Y \sim Beta(\alpha = 2, \beta = 5)$ $\text{Y} \sim \text{Beta}(\alpha = 2, \beta = 5)$

Step ii Apply three distributions in different sample sizes, n = 100, 500 and 1000.

Step iii Estimate λ by using the MLE approach by maximizing the profile log-likelihood BCT. (*Note: Refer the algorithm for estimation of* λ^*)

Step iv Repeat the simulation for 10,000 runs.

Next, simulation II estimates optimal lambda in the BCT on data set with errors generated from three distributions as in simulation I. The algorithm is as follows:

Step i Create non-normal samples which generate multiple random samples with errors from non-normal distributions.

Step ii Apply each distribution to sample sizes n = 100, 500 and 1000.

Step iii Estimate λ by using the MLE approach by maximizing the profile log-likelihood BCT. (*Note: Refer the algorithm for estimation of* λ^*)

Step iv Diagnose the MR assumption which is normality for original data set and optimal lambda, λ^* obtained in Step iii. (Before and After Transformations).

Step v Repeat the simulation for 10,000 runs.

3 Results and Findings

Figure 1 shows the comparison of profile log-likelihood against for the Exponential, Beta and Gamma distributions with the range of [−2, 2]. Here, using the MLE method, the optimal lambda, λ^* is found by searching for the highest log-likelihood (L) value. The simulation results indicate that the highest value of L for $Y \sim \text{Exp}(\beta = 2)$ occurs when $n = 500$ with $\lambda^* = 0.20$ while for $n = 100$ and 1000, the optimal value is $\lambda^* = 0.30$. The highest value of L for $Y \sim Gamma$ $(\alpha = 1, \beta = 1)$ occurs $n = 100$, 500 and 1000 with $\lambda^* = 0.40$, $\lambda^* = 0.20$ and $\lambda^* = 0.30$, respectively. Meanwhile, the highest value of L for $Y \sim Beta\,(\alpha = 2, \beta = 5)$ occurs when $n = 100$ with $\lambda^* = 1.60$ while for $n = 500$ and 1000, the optimal values are $\lambda^* = 0.50$ and $\lambda^* = 0.60$, respectively. As a summary, Fig. 1 comprised the profile log-likelihood against λ for Exponential, Gamma and Beta Distribution which frequently produced $\lambda^* = 0.20$ and $\lambda^* = 0.30$ as an optimal lambda for algorithm of Simulation I.

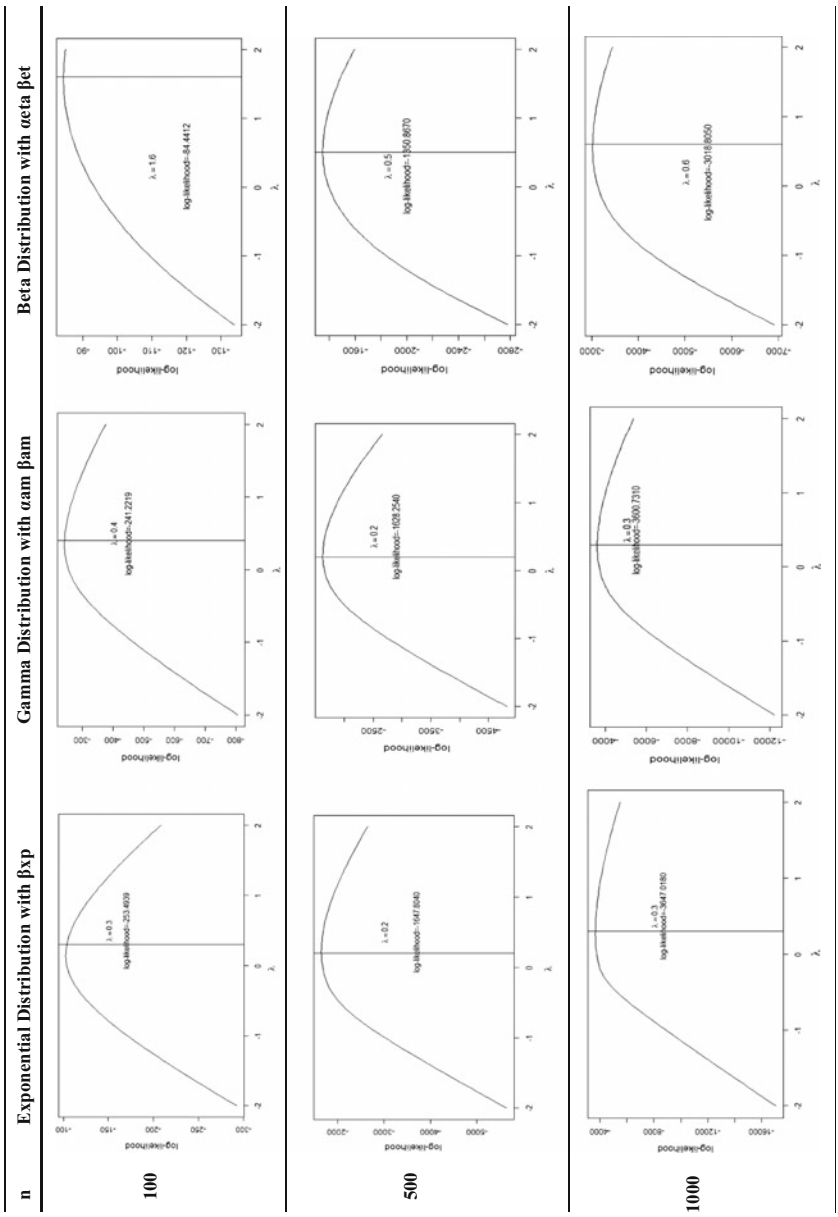

Fig. 1 Comparison of Profile Log-likelihood against λ for exponential, Gamma and Beta distributions and sample sizes $n = 100, 500, 1000$

There are several ways to detect the violation of normality assumption. According to Pallant (2005) and Field (2009), skewness represents the measure of symmetry in a data set or distribution. Meanwhile, whether the data are peak or flat relative to a normal distribution is measured by the value of kurtosis. Overall, data are approximately normal distribution if skewness and kurtosis value lies in the range of ±2 (Field 2009). A common acceptable range for skewness and kurtosis is between −1 and +1 (Hair et al. 2010). Therefore, skewness and kurtosis values will be used in this study to indicate either the normality assumption is violated or not. In terms of normality, the purpose of applying data transformation is to bring data closer to normal distribution including reducing skewness and kurtosis. However, only performances' results of untransformed data with optimal lambda via skewness and kurtosis values for all three distributions are reported here due to page limitations.

The results in Table 1 show that, when performing the BCT in data set with errors from Exponential Distribution with $\beta = 2$, the optimal lambdas are $\lambda^* = 0.30$ and $\lambda^* = 0.40$. Therefore, for simulated data set with errors generated from Exponential Distribution at different sample sizes, it seems to have different optimal lambdas. Meanwhile, Table 2 gives the values of skewness and kurtosis for the simulated errors from Gamma Distribution with parameters $\alpha = 1, \beta = 1$. Hence, regardless of sample sizes, the optimal lambda for Gamma Distribution of $\alpha = 1, \beta = 1$ is $\lambda^* = 0.70$. Table 3 summarizes the values of skewness and kurtosis for Beta Distribution which produced $\lambda^* = 0.40$ and $\lambda^* = 0.50$ as the optimal lambdas. As a summary, the simulation results indicate the skewness and kurtosis values of optimal lambda seem to be smaller than the original sampled data (λ = 1.00) for Exponential, Gamma and Beta Distributions.

The BCT is also illustrated on real-life data application. The dataset from Sheather (2009) named *car04* which is available in R is used involving 234 automobiles. Based on the *car04* data set, the dependent variable is *HighwayMPG* and the independent variables are *EngineSize, Cylinders, HorsePower, Weight* and *WheelBase*. Figure 2 shows the results profile Box-Cox log-likelihood against lambda, λ via MLE method for *car04* dataset. The highest log-likelihood value is −33.3987, which corresponds to $\lambda^* = -1.70$. Thus, the performance of this optimal lambda, $\lambda^* = -1.70$ will be compared to untransformed data to justify the effectiveness of the optimal lambda, $\lambda^* = -1.70$.

Table 1 Comparison of untransformed data (λ = 1.00) with optimal Lambda, λ* for exponential distribution with $\beta = 2$

Sample size	Lambda (λ)	Skewness	Kurtosis
100	$\lambda = 1.00$	2.2793	9.1009
	$\lambda^* = 0.30$	0.0710	−0.3739
500	$\lambda = 1.00$	2.2259	6.6245
	$\lambda^* = 0.40$	−0.1030	−0.2758
1000	$\lambda = 1.00$	1.9772	5.9433
	$\lambda^* = 0.40$	0.0318	−0.3626

Table 2 Comparison of untransformed data (λ = 1.00) with optimal Lambda, λ* for Gamma distribution with $\alpha = 1, \beta = 1$

Sample size	Lambda (λ)	Skewness	Kurtosis
100	$\lambda = 1.00$	2.0985	4.1675
	$\lambda^* = 0.70$	−0.0346	−0.5419
500	$\lambda = 1.00$	2.4332	9.1097
	$\lambda^* = 0.70$	−0.3418	−0.9187
1000	$\lambda = 1.00$	2.7862	10.128
	$\lambda^* = 0.70$	−0.1580	−0.4527

Table 3 Comparison of untransformed data (λ = 1.00) with optimal Lambda, λ* for Beta distribution with $\alpha = 2, \beta = 5$

Sample size	Lambda (λ)	Skewness	Kurtosis
100	$\lambda = 1.00$	1.3083	2.6968
	$\lambda^* = 0.40$	0.1173	0.3847
500	$\lambda = 1.00$	0.9106	0.4824
	$\lambda^* = 0.50$	−0.3418	−0.9187
1000	$\lambda = 1.00$	1.0757	1.3488
	$\lambda^* = 0.50$	0.2263	0.0724

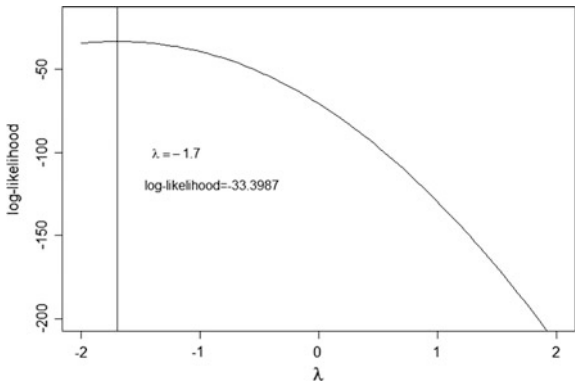

Fig. 2 Profile Log-Likelihood against Lambda, λ on *car04* data set

Based on Table 4, the value of skewness and kurtosis of untransformed data ($\lambda = 1.00$) is 3.1200 and 18.6762, respectively, which concludes the error terms departure slightly from normality. When performing the BCT, the value of skewness and kurtosis for $\lambda^* = -1.70$ dramatically drops. This means, $\lambda^* = -1.70$ produces skewness and kurtosis value close to zero with 0.2785 and 0.9261, respectively. It can be concluded that the error terms approximately follow normality distribution.

Table 4 Comparison of untransformed data (λ = 1.00) with optimal Lambda, $\lambda*$ on *Car04* data

Lambda (λ)	Skewness	Kurtosis
$\lambda = 1.00$	3.1200	18.6762
$\lambda* = -1.70$	**0.2785**	**0.9261**

4 Conclusion

The results of this study based on simulation studies and real-life data application successfully illustrate that the BCT technique under selected transformation is able to transform non-normal data to become normal. This study covered the BCT in the context of MR based on (i) response variable (Y) follows several non-normal distributions and (ii) errors with several non-normal distributions. Therefore, these results and findings have successfully satisfied the research objective which is to find the suitable value of parameter BCT. The optimal lambda can be found by searching the highest value of Box-Cox log-likelihood. The results show $\lambda^* = 0.30$, $\lambda^* = 0.40$ and $\lambda^* = 0.50$ are the most often optimal lambda is produced for all the types of distributions (Exponential, Gamma and Beta). Besides that, for the real-life data application, it can be concluded that, after performing the BCT, the optimal lambda, $\lambda^* = -1.70$ clearly shows that the transformed data set satisfy the normality assumption. Hence, the data can proceed for further analysis using MR.

Acknowledgments The authors wish to thank the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) Shah Alam for the conference support fund.

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Chapter 103
Box-Cox Optimal Parameter Estimation for Multiple Regressions with Homoscedasticity

Nur Aufa Mazni Ishak and Sanizah Ahmad

Abstract Many real data do not conform to the assumption of homoscedasticity. In multiple regressions, the violation of the homoscedasticity assumption can be a complicating factor in estimating parameters, hypothesis testing and model selection. In this study, the violation of this assumption can be overcome by using the Box-Cox transformation. An investigation using simulation designs with data generated from three skewed sample data of non-normal distributions namely Exponential, Gamma and Beta distributions based on the various sample sizes (n = 100, 500 and 1000) are carried out. Hence, the simulation studies are implemented to estimate optimal lambda in the Box-Cox transformation based on data sets with different variances with errors that follow a normal distribution with a mean (μ = 0) and different variances (σ^2 = 50, 100). Results show that lambda = 0.30* and lambda = 0.40* are the most often optimal lambda produced for these three distributions. As such, Box-Cox transformation with optimal lambda value improves analyses in multiple regressions particularly in the presence of homoscedasticity.

Keywords Box-Cox transformation · Homoscedasticity · Log-likelihood Multiple regression · Optimal lambda

1 Introduction

One of the main assumptions of multiple regressions (MR) is the errors ε_i of the independent variables have equal variances, $\sigma^2(\varepsilon_i) = \sigma^2$ also known as homoscedasticity (Osborne and Waters 2002). This occurs when the errors spread

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_103

out between the variables are consistent (Keith 2006). Homoscedasticity helps in (i) conducting tests of hypothesis and construct confidence intervals through the use of the formula of the coefficient variance, (ii) making unbiased in small and large samples, (iii) predicting the variable of interest (dependent) for particular given values of the exploratory (independent) variables, and (iv) simplifying the standard estimation techniques (Hossain 2011). There are certain consequences when homoscedasticity assumption is not met in the MR model. Heteroscedasticity can affect the results by weakening the overall analysis and statistical power of the analysis. Furthermore, the possibility of Type I error is increased, results of *F*-test are untrustworthy, and it may lead to the wrong conclusions (Osborne and Waters 2002). Assuming the other assumptions of MR are met except for heteroscedasticity, the parameter estimates are still considered as unbiased. However, the ordinary least squares (OLS) estimators are no longer the Best Linear Unbiased Estimators (BLUE) because they are no longer efficient, and will also cause the regression predictions to be inefficient (Muhammad 2012). Furthermore, if heteroscedasticity is present, the standard errors will be biased. Thus, it leads to bias in test statistics (*t*-test, *F*-test) and confidence intervals (Williams 2015).Therefore, some remedial measure is required for this assumption to meet. In the literature, there are many types of transformation techniques have been proposed to overcome this assumption such as natural log, square root and inverse transformations. Choosing the type of transformation is trivial to stabilize the variance of the error terms. Besides that, the method of "trial and error" for choosing the transformation is not recommended. The wrong type of transformation may lead to the violation of another assumption in MR. Hence, this study aims to use Box-Cox transformation (BCT) in the context of MR to overcome the violation of homoscedasticity assumption since it allows identifying the best transformation based on the lambda value that maximizes the estimator of maximum likelihood. This technique produces the best transformation of the dependent variable (Y) which can satisfy the homoscedasticity assumption. First, this paper discusses on Box-Cox transformation followed by the methodology for simulations studies. All analyses are performed by using R program version 3.2.5. Results and findings of the simulation studies are discussed and followed by the conclusion.

2 Methodology

The applications of the BCT algorithm can reduce the heterogeneity of error and enable the assumption of equal variance to be met (Peltier et al. 1998). Box and Cox (1964) proposed an objective way of determining the types of data transformation by considering the suitable transformations for homoscedasticity. There are many techniques to estimate the BCT parameter, lambda (λ). However, this study will only focus on investigating the optimal value of λ in the BCT using the algorithm of maximum likelihood estimator (MLE) such that maximizing the profile log-likelihood of the Box-Cox function. The BCT is given by

$$y(\lambda)_i = \begin{cases} \frac{(y_i^{\lambda}-1)}{\lambda} & \text{if} \quad \lambda \neq 0 \\ \log(y_i) & \text{if} \quad \lambda = 0 \end{cases} \tag{1}$$

where y_i is the observations, λ is the transformation parameter, $y(\lambda)_i$ approximately follows normal distribution with mean (μ) and variance (σ^2) and $i = 1, 2, \ldots, n$. Then, assume the following in the multiple linear regression model with n observation

$$Y_i^{(\lambda)} = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_{p-1} X_{i,p-1} + \varepsilon_i \tag{2}$$

be the multiple linear regression model with n observations, where

$Y_i^{(\lambda)}$	are distributed as independent normal random variables with mean μ and variance σ^2
$\beta_0, \beta_1, \ldots, \beta_{p-1}$	are parameters
$X_{i1}, \ldots X_{i,p-1}$	are known constants
ε_i	are independent $N(0, \sigma^2)$
i	is 1,…, n

The log-likelihood of the multiple linear regression model in (2) can be written as

$$\begin{aligned} \log L &= -\frac{n}{2}\log(2\pi) - n\,\log\sigma \\ &= -\frac{1}{2\sigma^2}\sum_{i=1}^{n}\left[Y_{(i)}^{(\lambda)} - (\beta_0 + \beta_i X_i)\right]^2 + (\lambda - 1)\sum_{i=1}^{n}\log(Y_i) \end{aligned} \tag{3}$$

It is possible to rewrite the log-likelihood (L) in (3) as

$$L = * - \frac{n}{2}\log\left[\sum_{i=1}^{n}\left(\frac{Y_i^{(\lambda)} - (\beta_0 + \beta_i X_i)}{\dot{Y}^{\lambda}}\right)^2\right] \tag{4}$$

where

$$\dot{Y}^{\lambda} = \exp\left[\frac{1}{n}\sum_{i=1}^{n}\log Y_i\right]$$

The optimal value λ^* is obtained by maximizing Eq. (4) also called the profile log-likelihood.

For the simulation design, skewed sample data from (i) Exponential Distribution with parameter $\beta = 2$ and $\beta = 5$, (ii) Gamma Distribution with parameters

$\alpha = 1, \beta = 1$ and $\alpha = 1, \beta = 1/2$, and (iii) Beta Distribution with parameters of $\alpha = 2, \beta = 5$ and $\alpha = 5, \beta = 2$ are generated. In addition, the simulation runs are generated for various sample sizes (n = 100, 500 and 1000) for the three types of distributions mentioned. Each of the created data would have four independent variables to illustrate the multiple regression models. The algorithms for estimation of λ^* are given as follows:

Step 1: Select a sequence of candidate λ values by a fairly precise increment of 1/10 within [−2, 2] interval.
Step 2: Apply the Box-Cox transformation in the data set.
Step 3: Estimate optimal λ^* by using Maximum Likelihood Estimation (MLE) approach by maximizing the profile log-likelihood in (4).

This study focuses on estimating optimal lambda (λ^*) in the BCT based on artificial data sets with different errors that follow Normal Distribution with mean ($\mu = 0$) and variances ($\sigma^2 = 50\ ,\ 100$). The related methodology is shown in the steps below.

Step 1: Create non-normal samples which generate multiple random samples from three distributions.
For Exponential Distribution
$Y \sim \text{Exp}(\beta = 2)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$
$Y \sim \text{Exp}(\beta = 2)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$
$Y \sim \text{Exp}(\beta = 5)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$
$Y \sim \text{Exp}(\beta = 5)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$
For Gamma Distribution
$Y \sim \text{Gamma}(\alpha = 1, \beta = 1/2)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$
$Y \sim \text{Gamma}(\alpha = 1, \beta = 1/2)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$
$Y \sim \text{Gamma}(\alpha = 1, \beta = 1)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$
$Y \sim \text{Gamma}(\alpha = 1, \beta = 1)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$
For Beta Distribution
$Y \sim \text{Beta}(\alpha = 2, \beta = 5)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$
$Y \sim \text{Beta}(\alpha = 2, \beta = 5)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$
$Y \sim \text{Beta}(\alpha = 5, \beta = 2)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$
$Y \sim \text{Beta}(\alpha = 5, \beta = 2)$ with $\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$
Step 2: Apply each of the distributions to different sample sizes, n = 100, 500 and 1000.
Step 3: Estimate λ^* by using the MLE approach by maximizing the profile log-likelihood BCT.
(Note: Refer the algorithm for estimation of λ^*)
Step 4: Diagnose the multiple regression assumption which is homoscedasticity for original data set and optimal lambda, λ^* obtained in Step 3 (Before and After Transformations).
Step 5: Repeat the simulation for 10,000 runs.

3 Results and Findings

Homoscedasticity assumption can be detected either it is violated or not through the plot of the standardized residuals against the regression predicted values (Osborne and Waters 2002). The decision will be made if there is no systematic pattern between the two variables, suggesting perhaps no heteroscedasticity is present in the data. On the other hand, if there exhibits a definite pattern, heteroscedasticity is present. The Breusch–Pagan Test is widely used in the regression models for testing heteroscedasticity. The null hypothesis of the test is that variances are constant. Thus, if the p-value is more than the chosen significance level $(\alpha = 0.05)$, then we fail to reject the null hypothesis and hence there is evidence that the errors, ε_i, at each value of the predictor have equal variances. This means the homoscedasticity assumption $(\sigma^2(\varepsilon_i) = \sigma^2)$ is satisfied. However, only results of untransformed data $(\lambda = 1.00)$ with optimal lambda, λ^* via Breusch–Pagan (BP) Test and Non-Constant Variance (NCV) Test for three types of distributions with different variances are reported here due to page limitation. Tables 1, 2 and 3 display the simulation results

Table 1 Results of untransformed data $(\lambda = 1.00)$ with optimal lambda, λ^* for exponential distribution

n	β	$\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$			$\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$		
		Lambda (λ)	BP (p-value)	NCV (p-value)	Lambda (λ)	BP (p-value)	NCV (p-value)
100	2	$\lambda = 1.00$	5.3994 (*0.2487*)	4.5265 (*0.0333*)	$\lambda = 1.00$	5.4478 (*0.2444*)	4.0555 (*0.0440*)
		$\lambda^* = 0.30$	4.5689 (*0.3345*)	0.3278 (*0.5669*)	$\lambda^* = 0.20$	4.8277 (*0.3054*)	0.2112 (*0.6459*)
	5	$\lambda = 1.00$	4.2136 (*0.3779*)	0.7292 (*0.3931*)	$\lambda = 1.00$	4.5856 (*0.3325*)	0.9945 (*0.3187*)
		$\lambda^* = 0.30$	8.9474 (*0.0624*)	2.0363 (*0.1526*)	$\lambda^* = 0.30$	8.4762 (*0.0756*)	1.9319 (*0.1645*)
500	2	$\lambda = 1.00$	2.4021 (*0.6623*)	2.3166 (*0.1280*)	$\lambda = 1.00$	2.0831 (*0.7205*)	1.9916 (*0.1581*)
		$\lambda^* = 0.50$	3.2789 (*0.5123*)	2.3166 (*0.7299*)	$\lambda^* = 0.40$	3.1107 (*0.5395*)	0.1118 (*0.7381*)
	5	$\lambda = 1.00$	1.4398 (*0.8373*)	1.2688 (*0.2600*)	$\lambda = 1.00$	1.4271 (*0.8395*)	1.3013 (*0.2540*)
		$\lambda^* = 0.40$	3.4670 (*0.4829*)	0.4679 (*0.4939*)	$\lambda^* = 0.40$	3.5519 (*0.4700*)	0.4915 (*0.4832*)
1000	2	$\lambda = 1.00$	1.2923 (*0.8627*)	0.4573 (*0.4989*)	$\lambda = 1.00$	1.7401 (*0.7834*)	0.4320 (*0.5110*)
		$\lambda^* = 0.40$	0.2143 (*0.9947*)	0.0192 (*0.8897*)	$\lambda^* = 0.40$	1.1823 (*0.8810*)	0.2527 (*0.6152*)
	5	$\lambda = 1.00$	4.2796 (*0.3695*)	0.2579 (*0.6116*)	$\lambda = 1.00$	4.1267 (*0.3891*)	0.1482 (*0.7002*)
		$\lambda^* = 0.40$	4.5609 (*0.3417*)	0.7913 (*0.3738*)	$\lambda^* = 0.40$	4.5736 (*0.3339*)	0.6512 (*0.4197*)

Table 2 Results of untransformed data $(\lambda = 1.00)$ with optimal lambda, λ^* for gamma distribution

n	α	β	$\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$			$\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$		
			Lambda (λ)	BP (p-value)	NCV (p-value)	Lambda (λ)	BP (p-value)	NCV (p-value)
100	1	1/2	$\lambda = 1.00$	7.0241 (*0.1346*)	7.2808 (*0.4215*)	$\lambda = 1.00$	5.6356 (*0.2281*)	5.0070 (*0.0252*)
			$\lambda^* = 0.30$	21.072 (*0.7161*)	0.4215 (*0.5162*)	$\lambda^* = 0.30$	1.7335 (*0.7846*)	0.0012 (*0.9725*)
	1	1	$\lambda = 1.00$	4.6877 (*0.3209*)	3.9711 (*0.0463*)	$\lambda = 1.00$	3.4475 (*0.4859*)	2.6084 (*0.1063*)
			$\lambda^* = 0.30$	3.2047 (*0.5242*)	0.3491 (*0.4456*)	$\lambda^* = 0.40$	2.3643 (*0.6691*)	2.6084 (*0.5293*)
500	1	1/2	$\lambda = 1.00$	45.5290 (*0.0000*)	57.4057 (*0.0000*)	$\lambda = 1.00$	34.1080 (*0.0000*)	47.4351 (*0.0000*)
			$\lambda^* = 0.40$	6.9911 (*0.1364*)	1.6647 (*0.1970*)	$\lambda^* = 0.40$	15.2300 (*0.0042*)	6.5492 (*0.0205*)
	1	1	$\lambda = 1.00$	119.4400 (*0.0006*)	29.4111 (*0.0000*)	$\lambda = 1.00$	13.867 (*0.0077*)	20.9699 (*0.0000*)
			$\lambda^* = 0.40$	6.8528 (*0.1439*)	1.7767 (*0.1826*)	$\lambda^* = 0.40$	3.6988 (*0.4483*)	1.4712 (*0.2252*)
1000	1	1/2	$\lambda = 1.00$	57.0501 (*0.0000*)	71.0391 (*0.0000*)	$\lambda = 1.00$	15.4070 (*0.0039*)	17.2099 (*0.0000*)
			$\lambda^* = 0.50$	3.5767 (*0.1235*)	2.3730 (*0.1235*)	$\lambda^* = 0.40$	1.8320 (*0.7666*)	0.3375 (*0.5613*)
	1	1	$\lambda = 1.00$	419.4400 (*0.0006*)	29.4111 (*0.0000*)	$\lambda = 1.00$	57.0510 (*0.0000*)	71.0391 (*0.0000*)
			$\lambda^* = 0.40$	6.8528 (*0.1439*)	1.7767 (*0.1826*)	$\lambda^* = 0.40$	3.5767 (*0.1235*)	2.3730 (*0.1235*)

for the values of BP and NCV tests for Exponential, Gamma and Beta Distributions with variances $(\sigma^2 = 50, 100)$ and sample sizes (n = 100, 500 and 1000). The results indicate that some simulated data have the problem of heteroscedasticity when p-values of BP and NCV tests are less than $\alpha = 0.05$. There are some values of BP and NCV tests which show that simulated data does not have serious heteroscedasticity problem. It is observed that $\lambda^* = 0.30$ and $\lambda^* = 0.40$ are the most suitable optimal lambdas for these three types of distributions.

Furthermore, when the variance value is increased from 50 to 100, majority of the distributions produce different optimal lambda which are Exponential Distribution with (i) $\beta = 2, n = 100$, (ii) $\beta = 5, n = 500$; Gamma Distribution with (i) $\alpha = \beta = 1, n = 100$ (ii) $\alpha = 1, \beta = 1/2, n = 100$; and Beta Distribution with (i) $\alpha = 2, \beta = 2, n = 100$ and 1000 (ii) $\alpha = 5, \beta = 2, n = 100$, while only three cases where the optimal lambda remains the same. After performing BCT for simulated data, these optimal lambdas produce p-values more than alpha value

Table 3 Results of untransformed data ($\lambda = 1.00$) with optimal lambda, λ^* for beta distribution

n	α	β	$\varepsilon \sim N(\mu = 0, \sigma^2 = 50)$			$\varepsilon \sim N(\mu = 0, \sigma^2 = 100)$		
			Lambda (λ)	BP (p-value)	NCV (p-value)	Lambda (λ)	BP (p-value)	NCV (p-value)
100	2	5	$\lambda = 1.00$	74.7741 (*0.3113*)	2.9818 (*0.0842*)	$\lambda = 1.00$	3.8095 (*0.4323*)	2.0008 (*0.1572*)
			$\lambda^* = 0.30$	6.4156 (*0.1702*)	0.4075 (*0.5232*)	$\lambda^* = 0.40$	1.9495 (*0.7451*)	0.4796 (*0.4886*)
	5	2	$\lambda = 1.00$	34.108 (*0.0000*)	47.3451 (*0.0000*)	$\lambda = 1.00$	15.3540 (*0.0040*)	8.0577 (*0.0045*)
			$\lambda^* = 0.40$	11.3490 (*0.0229*)	04.5082 (*0.0337*)	$\lambda^* = 0.30$	3.6509 (*0.4553*)	0.2690 (*0.6040*)
500	2	5	$\lambda = 1.00$	3.2811 (*0.8769*)	0.6960 (*0.4041*)	$\lambda = 1.00$	3.0692 (*0.5463*)	1.1110 (*0.2919*)
			$\lambda^* = 0.40$	3.2811 (*0.5119*)	0.0021 (*0.9885*)	$\lambda^* = 0.40$	8.1383 (*0.0866*)	5.9831 (*0.0144*)
	5	2	$\lambda = 1.00$	2.4032 (*0.6621*)	0.2785 (*0.5977*)	$\lambda = 1.00$	2.3160 (*0.6778*)	0.1529 (*0.6958*)
			$\lambda^* = 0.40$	11.3490 (*0.0229*)	2.5324 (*0.1115*)	$\lambda^* = 0.40$	4.9984 (*0.2875*)	1.5618 (*0.2114*)
1000	2	5	$\lambda = 1.00$	3.7924 (*0.4348*)	0.2981 (*0.5851*)	$\lambda = 1.00$	5.2766 (*0.2601*)	4.6097 (*0.0318*)
			$\lambda^* = 0.50$	6.5492 (*0.0105*)	5.7111 (*0.2218*)	$\lambda^* = 0.40$	4.2593 (*0.3720*)	0.5237 (*0.4655*)
	5	2	$\lambda = 1.00$	2.2489 (*0.0690*)	3.3356 (*0.0678*)	$\lambda = 1.00$	2.4964 (*0.6453*)	3.7072 (*0.0054*)
			$\lambda^* = 0.40$	0.5779 (*0.9655*)	0.16333 (*0.6862*)	$\lambda^* = 0.40$	1.1437 (*0.8873*)	0.3403 (*0.5597*)

which leads to homoscedasticity. As a summary, it can be concluded that the applications of Box-Cox transformation can reduce the heterogeneity of errors. All the results are provided in Tables 1, 2 and 3.

4 Conclusion

The simulation results in this study successfully illustrate the Box-Cox transformation technique for selected transformations is able to overcome the problem of homoscedasticity. This study only covered the Box-Cox transformation of the response variable (Y) in the context of multiple regression. Transformation of response (Y) changed the shapes and spreads of the distribution. In the simulation study, data sets were generated with different distributions of increasing variances ($\sigma^2 = 50, 100$) and errors that follow Normal Distribution with mean ($\mu = 0$). The value of Breusch–Pagan test and Non-Constant Variance test were used to check for

the presence of homoscedasticity or heteroscedasticity assumptions. Some of the optimal lambda, λ^* successfully showed that both tests for heteroscedasticity show evidence of non-constant variances in the simulated data, where the p-value is greater than alpha value $(\alpha = 0.05)$. On the other hand, some results do not show the presence of non-constant variances in data sets. As a conclusion, it can be concluded that $\lambda^* = 0.30$ and $\lambda^* = 0.40$ are the most often optimal lambdas produced for the three types of distributions chosen in this study. These two optimal lambdas are proven able to reduce the heterogeneity of variances in data sets.

Acknowledgments The authors wish to thank the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA (UiTM) Shah Alam for the conference support fund.

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Chapter 104
Using Simulation to Model Queuing Problem at a Fast-Food Restaurant

Norani Amit and Nurdia Azlin Ghazali

Abstract Queuing system is a process to measure the efficiency of the model in terms of utilization and waiting time. The queuing process is common in many locations, including supermarkets, petrol stations, fast-food restaurants and also in food courts. The data can be monitored using an empirical data which may include variables, such as arrival time in the queue (server) and service time. This study describes a queuing simulation for multi-server model. This research focused on a fast-food restaurant in Seremban. The data were collected on Friday during busy working hours, from (10.30 am to 2.30 pm). The model was developed using ARENA simulation software. The main aim of this paper is to describe the behaviour of a queuing system and develop a queuing model for the fast-food restaurant using ARENA. In this paper, queue length, queue time and system time are measured. It was found that during peak hour, there is a problem with keeping the customer in queue for a long period of time. The results show that the average queuing time at the restaurant exceeded the restaurant's policy.

Keywords Simulation model · Fast-food restaurant · Queue · Multi-server

1 Introduction

Queuing line is one of the most common events in our everyday lives. Queuing lines can be observed in our daily life activities, such as to pay bills, to purchase a movie ticket, to pay for food and groceries and also to cash a cheque. A queueing line forms because the customers have to spend an amount of time to wait before getting the services. A long queuing line indicates that the service facility has a low

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N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_104

service quality, and consequently, increasing waiting time. The reduction of waiting time is important for service-related company because time is a valuable resource. In this regard, every company needs improvement in reducing customers' waiting time and the total time spends in the system to increase customer satisfaction through the improvement of service quality.

Queuing theory is developed for predicting the characteristics of waiting line and can be measured using the quantitative analysis technique. The goal of queuing theory is to analyse how much time a customer has to wait to be served, to provide an idea about what can be improved to increase the performance of the waiting line system and to serve customers faster than they arrive. Waiting time is the time a customer waits in a queue before receiving the service while the service time refers to the fraction of the time used by the server to complete the service for the customer (Seow 2000). Service time in an organization is personal, customers are either served immediately or they will join the queue if the system is busy (Odirichukwu et al. 2014).

Fast-food restaurants use standard operating procedure while serving their customers. This standard procedure begins with customers placing their orders and then collecting their food at the counters. The long queuing line usually occurs during peak hours, especially during lunch and dinner time and also during promotions. According to Ahsan et al. (2014), long queuing lines can be seen more frequently during the night shift compared to the day shift. The restaurant management must make sure the customers are not waiting too long for the system, otherwise, the customers will go to another restaurant and management would suffer losses due to loss of goodwill. Thus, service time in the restaurant may need to be improved. This shows that there is a need to model the queuing system at the restaurant to understand the situation better.

Dharmawirya and Adi (2011) conducted a queuing analysis for customers at the Sushi Thai restaurant in Jakarta and discussed the application of queuing theory, while Olajedo et al. (2015) studied the queuing behaviour at a fast-food restaurant and found that queue size was reduced as the number of servers increased. Therefore, in this study, the goal is to look at the behaviour of a queuing system in a fast-food restaurant at Seremban using ARENA, as well as to determine queue length and system length, queue time and system time.

2 Methodology

Each service system can be characterized by the number of waiting lines, the number of servers, the arrangement of the servers, the arrival and service patterns and the service priority rules (Reid and Sanders 2012).

In a service system, the number of waiting line systems can be in the form of either single or multiple lines. Multiple lines exist when the situation of a single line is inconvenient or when specialized servers are used. In the waiting line systems, there are two terms that are used interchangeably, which are server and channel

with the assumption that a server or channel can serve one customer at a time. Waiting line systems also can be described as either single-server (single channel) or multi-server (multichannel). The difference between single and multiple line systems are shown in Fig. 1.

The third characteristic of a waiting line is the arrangement of the servers. According to Fig. 1, the term of phase was used to identify service activity. It can be defined as a single-phase or multiphase system. In a single-phase system, the service is completed simultaneously. In a multiphase system, the service is completed in a series of steps. Two input parameters required in waiting line models are an arrival rate and a service rate. The arrival rate can be described as the average number of customers per time period. The customers arrive according to a Poisson probability distribution. The service rate refers to the average number of customers that can be serviced during a time period and service times are described by an exponential distribution. A frequently used priority rule in waiting line is first-come, first-served (FIFO), which is considered as the fairest method for determining priority (Sameer 2014). Other priority rules include best customers first, reservation first, highest profit customer first, quickest-service requirement first and largest service requirement first.

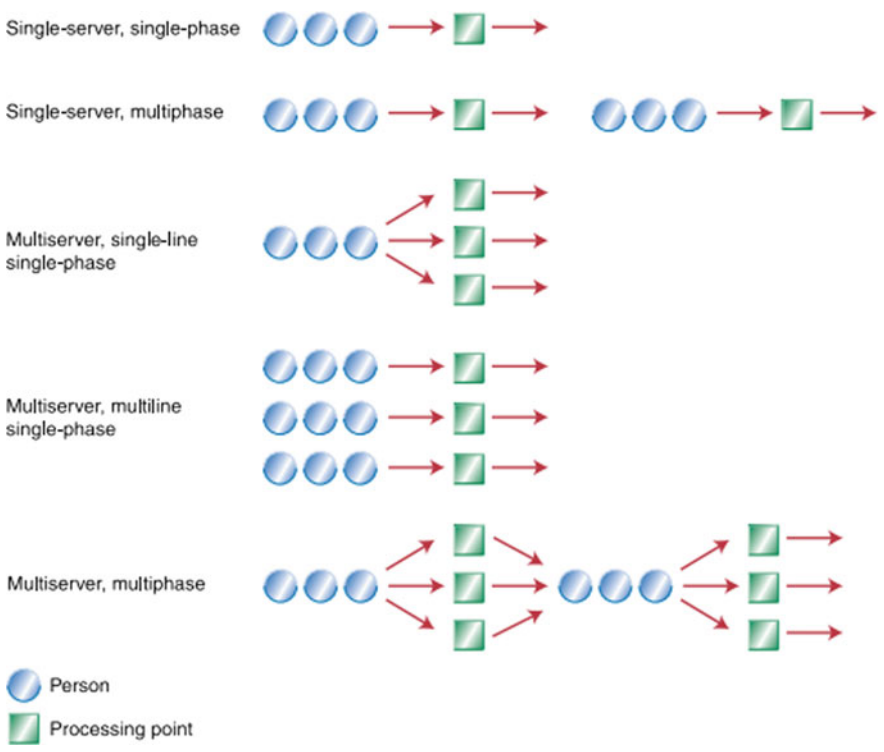

Fig. 1 Waiting line systems

Kendall's notation for the queue is very useful to represent different types of queues. Kendall's notations describe the multi-server queuing mathematical model in Kendall's notation is the *M/M/m* model, where the first *M* indicates arrival process (Poisson distribution), the second *M* indicates the service time distribution (Exponential distribution) and *m* stands for the number of parallel servers in the system (Reid and Sanders 2012). The *M/M/m* model is one of the most commonly used to analyse the queuing problem (Amin et al. 2014). This model computes the average wait times and queue lengths, given arrival rates, number of servers and service rates.

The outputs of the model are as follows:

(i). Average waiting time per customer in the system.
(ii). Average waiting time of customer in the queue.
(iii). Average queue length of the queue.

In this research, the operating characteristic of the fast-food restaurant is considered as *multi-server multi-line single-phase model.* Figure 2 shows the flow of the restaurant's queuing system. Based on the system, customers arrive at the restaurant and form queues at service channels. Customers order food and make payment at service channels and leave the system once service is completed. Queuing model of the fast-food restaurant can be characterized based on the following components:

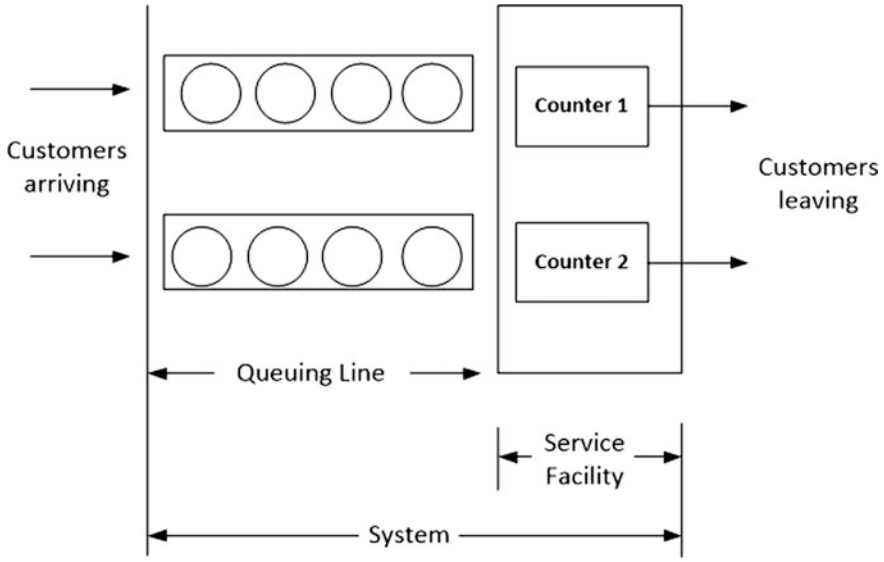

Fig. 2 Flow of the queuing system at the fast-food restaurant

(i). Arrival time distribution: interarrival time can follow one of the following distributions; Poisson distribution, a deterministic distribution or a general distribution.
(ii). Service time distribution: service time can be constant, exponential or any general distribution.
(iii). Service channels: system follows multi-line service channel model. Customers can queue at any of the queue lines which served by 2 servers.
(iv). Calling population: maximum number of customers is infinite because once customers are served, they leave the restaurant immediately.
(v). Queue discipline: customers follow a queue discipline of first-come, first-served basis.
(vi). Customer behaviour: customers in the queue do not leave the queue unemployed.

In the meantime, simulation can be defined as a process of building a model of a system or a decision problem and experimenting with the model to obtain insight into the system's behaviour or to assist in solving the decision problem (Kelton et al. 2007). In this regard, the ARENA Simulation Software is used to build the model. The model for this research follows the characteristic of multi-server model and the simulation model was developed using the create, process, decide and dispose of modules of ARENA. The ARENA simulation model for the fast-food restaurant is shown in Fig. 2.

Based on Fig. 3, there are two counters in the system. Thus, when the first customer arrives at the system then he or she can go to any counter to place an order and wait for the food they are ordered. Once the customer gets the food ordered, he or she will leave the system. As for the second customer, he or she can go to the next available counter. If both counters are busy, then the newer customers will have to wait in line either at Counter 1 or Counter 2.

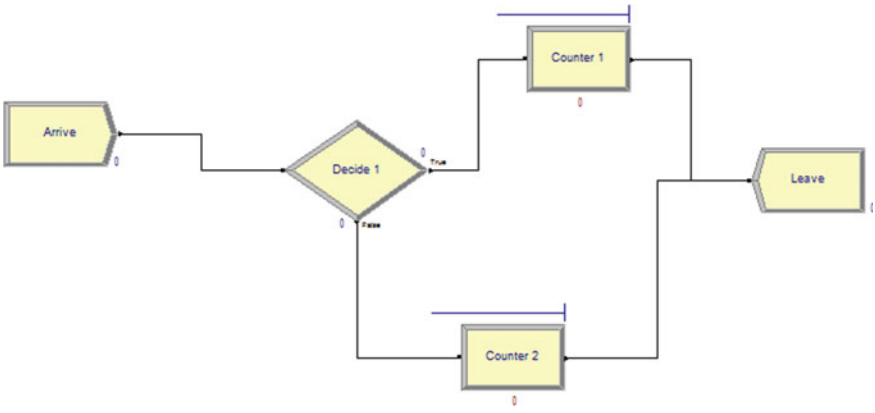

Fig. 3 Simulation model at fast-food restaurant in Seremban

A fast-food restaurant in Seremban was selected as the study location as it is convenient and easily accessible for the researchers. The data were obtained through an interview with the restaurant manager and along with data collection through observations. The data collection was held on Friday during busy working hours, from 10.30 am to 2.30 pm. Waiting lines occur at a fast-food restaurant during peak meal times where customers who cannot be served immediately have to queue (wait) for service (Patel et al. 2012). The restaurant has 3 counters, but only 2 counters were operated during the data collection process. The capacity of staff at each counter is one. The fast-food restaurant has two servers who serve only one customer each time.

The data were obtained by observing and recording customers' arrival and departure time at the fast-food restaurant. Furthermore, the researchers also recorded the queuing and service times. Based on the data collected, the number of customer arrivals and departures, queuing time, service time and waiting time for each customer were calculated. Then, the probability distributions of the customer arrival time and the service times at counters 1 and 2 were computed using an input analyzer. Input analyser is a standard component in the ARENA software used to generate a probability distribution of variables.

3 Results and Discussion

The distribution of the waiting and service times for the processes in the fast-food restaurant using the Input Analyzer tool is summarized in Table 1.

Table 2 summarizes the performance measures based on the simulation results using ARENA at each counter in the restaurant. The average waiting time of customers at Counter 1 and Counter 2 were 5.03 and 2.27 min, respectively, and customers at Counter 1 waited for a longer time than the customers at Counter 2.

Table 1 Process distribution of the system

Process	Distribution	Expression
Customer's arrival	Weibull	−0.5 + WEIB (2.97, 1.17)
Counter 1 service	Lognormal	−0.5 + LOGN (3.11, 1.78)
Counter 2 service	Gamma	−0.5 + GAMM (0.907, 3.42)

Table 2 Performance measure at Counter 1 and 2

	Counter	
Performance measure	1	2
Average waiting time	5.0282	2.2716
Average queue length	1.1104	0.44486
Number of customers	53	47
Utilization rate	68.63%	57.68%

Table 3 Performance measure of the system

Performance measure	Average
System queue time	3.7326
System total time	6.7638
Number of customers	100

For the simulation period, it was observed that 53 customers ordered their meals at Counter 1 and 47 customers ordered their meals at Counter 2. The utilization rate value is between 0 and 100%, where 100% indicates that the server is fully occupied all the time, while 0% indicates that the server is idle. From Table 2, the utilization rate of server at Counter 1 was 68.63% higher than the utilization rate of server at Counter 2, which was 57.68%.

Table 3 shows the performance measure for the system at the restaurant. The average queue time in the system was higher than the 3-min service policy of the fast-food restaurant, which is 3.73 min. This suggests that the restaurant management needs to take actions to reduce customers' waiting time to adhere to the restaurant's policy. The time a customer spent in the system is 6.76 min.

4 Conclusion

The queuing theory is a mathematical model which is used to analyse how much time customer has to wait in order to make the system become more efficient, make it easier to serve and at the same time increase the number of users that can be served (Amin et al. 2014). The queue theory comes in many roles, particularly when many customers arrive at the same time where they can be served in a queue. Thus, the ultimate objective of the analysis of the queueing systems is to understand the behaviour of their underlying processes and meet the assumptions required by standard analytical modelling approaches so that intelligent decisions can be made in their management.

In the meantime, simulation is the art to imitate a real-world situation which can represent a system or create the illusion of reality that incorporates time and changes that occur over time (Suhadak et al. 2015). ARENA is an effective software is based on a simple flowchart that presents the system as a logical network of related activities (Amit et al. 2012). This paper introduced the basic concepts of queuing models. The key operating characteristics of a system shown are the first, the utilization rate, second, the average time spent waiting in the system and in the queue, and third, the average number of customers in the system and in the queue. Based on the result, it was found that the average waiting time of the customer at Counter 1 is 5 min exceeded the 3-min service policy of the fast-food restaurant. Future studies may try to extend this work by considering the new pickup counter is suggested would reduce both service time and waiting time, thus providing more efficiency as compared to the regular counter.

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Erratum to: Geovisualization of Nonresident Students' Tabulation Using Line Clustering

Zainura Idrus, Zanariah Idrus, Siti Zaleha Zainal Abidin, Nasiroh Omar and Nur Syamimi Aziah Mohamat Sofee

Erratum to:
Chapter "Geovisualization of Nonresident Students' Tabulation Using Line Clustering" in:
N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_9

The original version of the book was inadvertently published without the second author name "Zanariah Idrus" in Chapter 9, which has been now included. The erratum chapter and the book have been updated with the change.

The updated online version of this chapter can be found at https://doi.org/10.1007/978-981-13-0074-5_9

N. A. Yacob et al. (eds.), *Regional Conference on Science, Technology and Social Sciences (RCSTSS 2016)*,
https://doi.org/10.1007/978-981-13-0074-5_105