Advances in Intelligent Systems and Computing 493

Jerzy Charytonowicz *Editor*

Advances in Human Factors and Sustainable Infrastructure

Proceedings of the AHFE 2016 International Conference on Human Factors and Sustainable Infrastructure, July 27–31, 2016, Walt Disney World®, Florida, USA

Springer

Advances in Intelligent Systems and Computing

Volume 493

Series editor

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

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Editor
Jerzy Charytonowicz
Department of Architecture
Wrocław University of Technology
Wrocław
Poland

ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-3-319-41940-4 ISBN 978-3-319-41941-1 (eBook)
DOI 10.1007/978-3-319-41941-1

Library of Congress Control Number: 2016944409

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Advances in Human Factors and Ergonomics 2016

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7th International Conference on Applied Human Factors and Ergonomics

Proceedings of the AHFE 2016 International Conference on Human Factors and Sustainable Infrastructure, July 27–31, 2016, Walt Disney World®, Florida, USA

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Preface

The discipline of Human Factors and Sustainable Infrastructure provides a platform for addressing challenges in human factors and engineering research with the focus on sustainability in the built environment, applications of sustainability assessment, demonstrations and applications that contribute to competitiveness and well-being, quantification and assessment of sustainable infrastructure projects, and the environmental, human, social, and economic dimensions of sustainable infrastructure. A thorough understanding of the characteristics of a wide range of people is essential in the development of sustainable infrastructure and systems, serves as valuable information to designers, and helps ensure design will fit the targeted population of end users.

This book focuses on the advances in the Human Factors and Sustainable Infrastructure, which are a critical aspect in the design of any human-centered technological system. The ideas and practical solutions described in the book are the outcomes of dedicated research by academics and practitioners aiming to advance theory and practice in this dynamic and all-encompassing discipline.

A total of two sections are presented in this book. Each section contains research paper that has been reviewed by the members of the International Editorial Board. Our sincere thanks and appreciation to the board members as listed below:

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We hope that this book, which is the international state of the art in Sustainable Infrastructure domain of human factors and ergonomics, will be a valuable source of theoretical and applied knowledge enabling human-centered design for global markets.

Wrocław, Poland Jerzy Charytonowicz
July 2016

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Part I
Ergonomics and Material Environment Design

Comparison Between Domestic Water Heating Systems Based on Either Solar Heaters or Electrical Boilers by the Life Cycle Assessment Approach

Raquel Diniz Oliveira, Eduardo H.M. Nunes, Jessica de Oliveira Notório Ribeiro and Rodrigo de Mello Morado Penna

Abstract The construction sector is one of major consumers of energy in the world. In this paper, the domestic water heating systems was compared based on solar heaters and electrical boilers by the Life Cycle Assessment (LCA) approach. We considered both energy spent and emissions related to the production and use of these systems. The results indicate that the use of solar water heaters is a more attractive choice. Higher energy and economic savings are obtained when they are used, especially in Brazil, where occurred an expressive increase of the electrical energy costs over the past years. This option also has a shorter payback period than electrical boilers. However, it observed that the environmental impact associated with solar water systems is higher because of the flat plate collector's production. The findings exhibited in this work can provide a useful way to help the consumer to make his decision.

Keywords Life cycle assessment · Solar water heater · Electrical boilers

R.D. Oliveira (✉) · R. de Mello Morado Penna
Department of Civil Engineering,
Federal Technological Education Center of Minas Gerais (CEFET MG),
Av.Amazonas 7675, 30510-000 Belo Horizonte, MG, Brazil
e-mail: raqueldo@gmail.com

R. de Mello Morado Penna
e-mail: rodrigomoradopenna@gmail.com

E.H.M. Nunes · J. de Oliveira Notório Ribeiro
Department of Metallurgical and Materials Engineering,
Federal University of Minas Gerais (UFMG),
Av. Antônio Carlos 6627, Escola de Engenharia,
Bloco 2, Sala 2233, 31270-901 Belo Horizonte, MG, Brazil
e-mail: eduardohmn@gmail.com

J. de Oliveira Notório Ribeiro
e-mail: jessicanotorio@gmail.com

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_1

1 Introduction

The world demand for energy has increased over the past decades, due in a great part to the growth of the Earth population. According to the International Energy Agency (IEA) and the U.S. Energy Information Administration (EIA), this demand is projects to more than double by 2050 [1]. It establishes as well that the production of energy is associated with the emission of greenhouse gases. As far as we know, the greenhouse gases are necessary to life because they keep the Earth surface warmer than it otherwise would be. However, the planet temperature has greatly increased over the past years because the concentrations of these gases continue to increase, significantly, in the atmosphere [2].

In Brazil, the National Institute of Metrology, Quality and Technology (INMETRO) classifies, through a label, the energy consumption of equipment (since 1984) and buildings (since 2009 for commercial and public building and since 2010 for residential building). According the Brazilian Labeling Program (PBE) the score varies from A to E, best and worse class, respectively. In 2001, a serious energy crisis motivated the creation of the Energy Efficiency Law no 10.295 about National Conservation and Rational Use of Energy Policy [3]. The Brazilian Energy Balance (BEN) indicated in 2014 that the residential sector is among the largest consumers of electricity in the country with 24.9 % of representativeness, behind only the industrial sector with 38.8 % [4]. In this context, the energy savings for residential consumption are relevant, especially in Brazil, where occurred an expressive increase of the electrical energy costs over the past years. Currently, the energy rate have three tariffs: green, yellow and red, ranging from the cheaper to the most expensive, respectively, according to generation condition of production [5].

For carrying out this goal, it was applied the LCA to verify which system is more suitable for dwelling needs considering the energy consumption and the emission associated. Many studies points out on the benefits and impacts of domestic hot water systems around the word [6–9]. This paper aims to discuss trough a Brazilian case study, with water heating systems should be use on residential building considering the LCA approach. It was selected a solar heaters and electrical boilers to be compared.

2 Characterization of Case Study

This research evaluate a domestic water heating systems based on solar heaters (Fig. 1) and electrical boilers (Fig. 2) by the Life Cycle Assessment approach. A case study was carried out considering a family of four persons living in Belo Horizonte (Minas Gerais, Brazil). The study of these systems have special relevance in this city. Belo Horizonte won, on 2014 and 2015, the Earth Hour City Challenge, organized by The World Wide Fund for Nature (WWF). This initiative

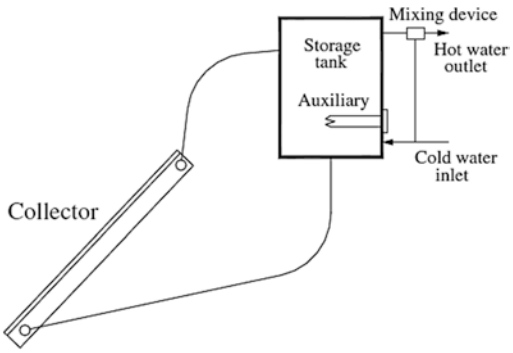

Fig. 1 Scheme of solar system considered to heating the water [11]

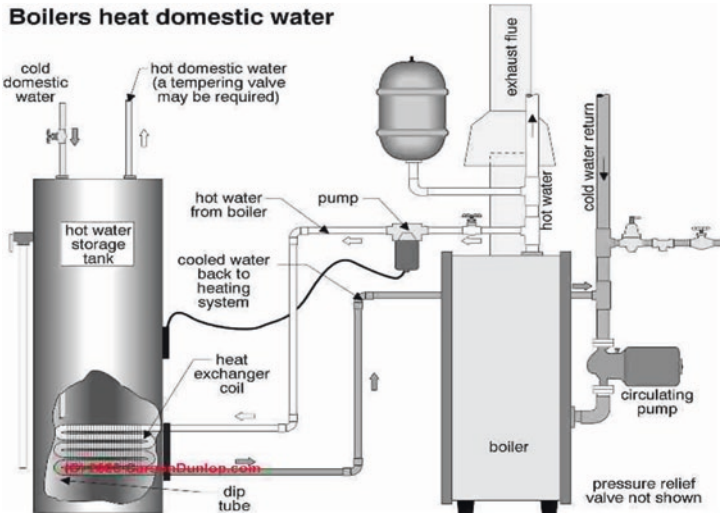

Fig. 2 Scheme of electrical boilers system considered to heat water [12]

celebrate cities that are taking amazing steps forward in creating a more sustainable place to live in, while inspiring other cities to do the same. It is noteworthy that Belo Horizonte has 326 m^2 of solar panels installed per thousand inhabitants. In Brazil, this average is 27 m^2 [10].

It assumes that they consume about 200 L of hot water per day. It also considers the heat required to heat the water from 20 to 60 °C. The water tanks used for the two systems (solar heaters and electrical boilers) are identical, made of galvanized steel, stainless steel, polyurethane and copper. The support material is galvanized steel and stainless steel. The only difference between them was the water heating system. Two flat plate collectors of two m^2 each composed the solar system taken into consideration. The system material is galvanized steel, tempered

glass, copper, stainless steel, polyurethane and aluminum. The annual average daily solar radiation considered was 5.5 kW/h/m^2/day.

The system power supplies comes from the Itaipu power plant (Brazil-Paraguay). The distance for road transport considered was 600 km (From São Paulo to Belo Horizonte). The selected equipment had the best rating of the category according to the INMETRO evaluation of system efficiency and average monthly energy consumption or production. Thus, the flat plate collectors have Class "A" and the electrical boiler "B". For the flat plate collector's average monthly energy production was 80.4 kW/h/month/m^2 with 64.8 % efficiency. For the electrical boiler average monthly energy consumption was 325 kWh/month with 81.9 % efficiency. Monthly demand of electricity is considered and for 1, 5, 10 and 20 years. The cost of the investment[1] was around 371.62 USD for the flat plate collector's and 990.98 USD for electrical boiler, excluding freight for both options. For the energy rate, it considers the worse condition. In this case, the price of electricity was 0.13743 USD. To evaluate the impact of the production, use and disposal of selected equipment it considers the Eco-indicator 95, Manual for Designers.

3 Life Cycle Assessment Analysis

This topic presents the energy demand, emissions and the payback of selected water heating systems for comparative analysis.

3.1 Evaluation, Measurement and Verification of Energy Consumption

For the development of this research, some considerations and calculations were carry out in order to realize the comparison between water solar heaters and electrical boilers. To estimate the daily energy consumption for heat water it was applied the Eq. 1. In this case, this formula consider the heat capacity (Q), the specific heat capacity (c), the mass of the water (m) as well as the difference between the final and the initial temperature (ΔT).

$$Q = c \times m \times T \tag{1}$$

The Brazilian Association of Technical Standards (ABNT) published the NBR 7198/1993 [13] that address design and execution of hot water building facilities.

[1]Considering 1.0 USD, for sale fee, equal to 4.0364 BRL (Brazilian currency) according to the quotation of Brazil's Central Bank of the day 01/18/2016. Further information on: http://www4.bcb.gov.br/pec/taxas/batch/taxas.asp?id=txdolar.

This standard recommend at least 45 L of water supply per person, daily, for residential use. The minimum temperature required in this standard in which the water must be supplies for personal use and bath is 35–50 °C. It considers a wider range of temperature variation. In this case, the ambient temperature of water was 20 °C and the maximum 60 °C. In Brazil, according to the National Sample Household Survey (PNAD) of 2012, the average number of people by sex (men and women) and the condition of activity (economically active or not) per household is 3.1 people [14]. For this reason, it considers the reference of 200 L for hot water supply per four person, daily for the case study. For these references, the heat capacity value is nearly 3.3 × 107 J/day.

The calculation of the energy conversion of each system considers the thermal efficiency. These dimensionless performance measures are different according to the technology used for water heating systems. These performances was tested and also are available for different systems, brands and models traded in the Brazilian market [15]. For the electrical boiler and solar systems analyzed it selects the most efficient of each system (see Tables 1 and 2). The lowest energy consumption was a second variable considered for the electric water heating system's choice. It can be calculated the generated heat by the electric boiler, in order to present the length of time required to provide the amount energy to warm the water (found in Eq. 1). This index multiplied by the consumption results on the real consumption (see Table 1).

In order to calculate the energy balance for solar water heating system (SWH), it must be established the energy supplied by the sun for the system. Considering the measures of the model, 2 panels give a satisfactory collector area (A1) for heating the water in the conditions settled. It must be mentioned that the solar irradiation fluctuates over the year, and the annual average daily solar irradiation (I) at Belo Horizonte is provided by the CEMIG [16]. Other physical variables are given in Table 3.

Table 1 Technical information of Electric Water Heating System and its real consumption

Manufacture	Model	Efficiency	Consumption (KWh/year)	Potency (W)	Real consumption (KWh/year)
Transsen	AP 200 LT	0.819	3.9×10^3	2.0×10^3	917

Table 2 Technical information of Solar Water Heating System

Manufacture	Model	Efficiency	External area of the collector (m^2)
Aquatherm	Aquaprime 2.0	0.665	2.01

Table 3 Informations considered for the solar heating system

Parameter	Solar water heating system
Collector area (m^2)	4.0 (2 panels)
Albedo	0.95
Solar irradiation (Kwh/m^2)	5.5
Surface emissivity	0.07

The equation to calculate the amount energy from the sun per day is given by Eq. 2. Transforming to joules per year it results in 2.5×10^{10} J/year.

$$Q_{sun} = A1 \text{ x } N \text{ x } \bullet \text{ x } (1\text{-}þ) \text{ x } I \quad (2)$$

The efficiency of the collector (E_{swh}) applied to the result of the Eq. 2, results 1.7×10^{10} J/year which is the useful energy supplied form solar collectors (Q_{eff}). See Eq. 3. Considering that these results is higher than the energy required to heating the water needed, the chosen model suits the case study.

$$Q_{eff} = Q_{sun} \times E_{swh} \quad (3)$$

3.2 Evaluation, Measurement and Verification of Emissions

First of all, to quantify and qualify the emissions it requires to build an inventory of inputs and outputs of all product's life, such as gaseous, liquid and solid sources. To simplify the investigation, the product's life cycle had divided in production process, transport of the technology and its discard. It must be mentioned that for the LCA of the electric water heaters (EWH), another phase is included which is related to electricity consumed by the system. This additional analyses will be done after the examination of the common phases of the technologies.

Considering the technologies and its respective chosen models, it was raised material and the masses from each part of the system (see Tables 4 and 5). Consequently, the material and the masses that will be discarded are the same for both technologies (see Tables 6 and 7).

Another phase that is important to quantify and qualify the emissions is the transport of the equipment. For this analysis, the distance and the load weight in the transportation are necessary. After presenting the particular data of each phase and for both technologies, the next execution is to relate them to an indicator. The index from Eco-indicator 95 demonstrated a good performance to evaluate the environmental effects of the material and processes. The respective Eco-indicator for the production and discard for the materials per kilo are exposed in Table 8.

Table 4 Data of employed materials, masses and result based on the Eco-indicator of production of SWH

Absorbing collector			Water tank			Support		
Material	Mass (kg)	Result	Material	Mass (kg)	Result	Material	Mass (kg)	Result
Galvanised steel	33.9	745.8	Galvanised steel	49.6	1091.2	Galvanised steel	27	594.0
Stainless steel	6.1	103.7	Stainless steel	21	357.0	Stainless steel	0.5	8.5
Copper	8.2	697.0	Copper	3.8	323.0			
PUR	4.2	35.3	PUR	4.8	40.3			
Glass	10.5	22.1						
Aluminium	4	72.0						

Table 5 Data of employed materials, masses and result based on the Eco-indicator of production of EWH

Water tank			Support		
Material	Mass (kg)	Result	Material	Mass (kg)	Result
Galvanised steel	49.6	1091.2	Galvanised steel	27	594.0
Stainless steel	21	357.0	Stainless steel	0.5	8.5
Copper	3.8	323.0			
PUR	4.8	40.3			

Table 6 Data of employed materials, masses and result based on the Eco-indicator of discard of SWH

Absorbing collector			Water tank			Support		
Material	Mass (kg)	Result	Material	Mass (kg)	Result	Material	Mass (kg)	Result
Galvanised steel	33.9	40.7	Galvanised steel	49.6	59.5	Galvanised steel	27	32.4
Stainless steel	6.1	7.3	Stainless steel	21	25.2	Stainless steel	0.5	0.6
Copper	8.2	−21.3	Copper	3.8	−9.9			
PUR	4.2	2.9	PUR	4.8	3.3			
Glass	10.5	3.7						
Aluminium	4	−12.0						

Table 7 Data of employed materials, masses and result based on the Eco-indicator of discard of EWH

Water tank			Support		
Material	Mass (kg)	Result	Material	Mass (kg)	Result
Galvanised steel	49.6	59.5	Galvanised steel	27	32.4
Stainless steel	21	25.2	Stainless steel	0.5	0.6
Copper	3.8	−9.9			
PUR	4.8	3.3			

Table 8 Indicator (ECO) of the materials for they production and discard

Material	Galvanised steel	Stainless steel	Copper	PUR	Glass	Aluminium
Indicator—production (ECO)	22	17	85	8.4	2.1	18
Indicator—discard (ECO)	1.2	1.2	−2.6	0.69	0.35	−3

Table 9 Details for the calculate of the transportation and its result based on the Eco-indicator, for both example of technologies

Technology	Total mass [ton]	Distance(SP-BH) (km)	Indicator (ECO)	Result
SWH	0.2	600	0.34	35.4
EWH	0.1	600	0.34	21.8

Table 10 Consumption of SWH, Eco-indicator for Electricity low voltage and its result impact

Consumption [KWh]	346.75 (per month)	4161 (per year)	20805 (per 5 years)	41,610 (per 10 years)	83,220 (per 20 years)
Eco-indicator	0.67	0.67	0.67	0.67	0.67
Result	232.3225	2787.87	13939.35	27878.7	55757.4

Similarly, the Eco-indicator related to the transport for each tonne loaded per kilometer is displayed in Table 9.

Finally, to obtain accurate results of the environmental effects it needs to multiply the indicators with the related mass of each material. The result of this calculation is divided from each part from both technologies exposed on the columns of result in Tables 4, 5, 6 and 7. Since the impact in transport depends on the distance and the load weight, the multiplication with these two variables with the respective Eco-indicator result in a total showed in Table 9.

Differently from the solar water heaters (SWH), the EWH consumes electric low voltage daily to its function, which causes an environmental impact. Eco-indicator 95 provides an indicator per KWh consumed. The total energy from different periods and the results impacts are displayed in Table 10.

After obtain all results based on the Eco-indicators of each phase from both technologies it is possible to compare between the two systems. Considering just the common phases—production, transport and discard—the EWH cause less environmental impact. The explanation for that is because the SWH equipment has the absorbing collector as an additional part, while both technologies have the same parts of water tank and support. The absorbing collector has a great mass of materials that requires more sources to the production and generates more waste. Furthermore, this extra equipment part, increase the weight on the transport, culminating in more environmental impacts related to the transport.

However, the electric consumption of the EWH shifts the best alternative of which technology affects more the environment. Whilst the impacts from SWH cease in the phases of production, discard and transport, the EWH has a continuous consumption of sources. Thus, in 20 years the global result from Eco-indicator of the EWH can be thirteen times more than the SWH. It only takes about 1 year and 2 months to equalize the global results based on the Eco-indicator (see Fig. 3).

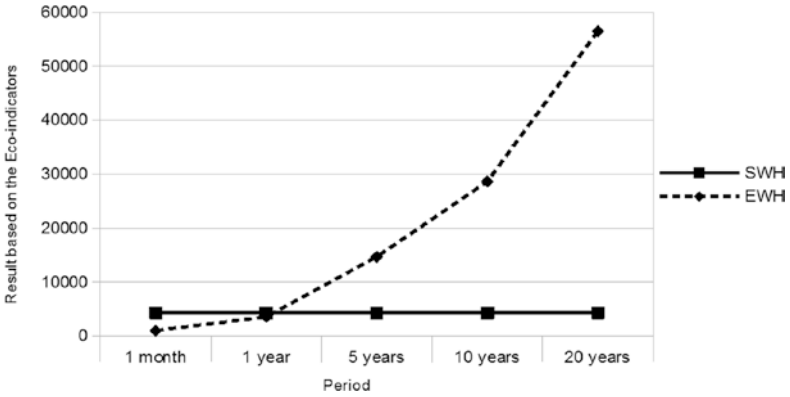

Fig. 3 Scheme of the systems total energy from different periods and the results impacts

Table 11 Consumption of SWH, Eco-indicator for Electricity low voltage and its result impact

System	Consumption (KWh/year)	Energy savings (KWh/year)	Energy rate ($)	Saved value ($)	Investment ($)	Payback (years)
SWH	0	2214	0.13743	304.27	371.62	1.22
EWH	3900	0	0.13743	0	990.98	–

3.3 Payback

Considering the cost of the investment, the flat plate collector is cheaper than the electrical boiler, excluding freight and maintenance costs for both options. The city of the case study has an intense insolation and can contribute for 100 % of the building energy requirements for water heating. In this case, for the SWH system the input energy is free (solar) enabling substantial energy savings whereas the EWH can be quite expensive over time, considering the energy rate. The Table 11 shows a short payback for the SWH compared to the EWH. The electric water heaters can be interesting to use together with the SWH mainly in cities that the solar radiation show inadequate to supply water-heating demand. Moreover analyzing separately the cost parameter of the EWH system it can be noted that this option shown unfeasible compared with SWH.

4 Conclusions

Based on the methodology of Life Cycle Assessment, it was found that the use of solar heaters is much more promising than the use of electric heaters, both environmentally and economically for the case study. The main environmental impacts associated with solar heaters refer to the production stage of system components.

Galvanized and stainless steel employed in the construction of these systems have proved the great "villains" of the process. CO_2 is the main gas related to the production of solar heating systems. The use of recycling can minimize environmental impacts in the process. In addition, government incentives can be significant to strengthen the adoption of this technology.

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Aggregate Replacement and Its Usefulness in Cement Concrete for Sustainable Development—A Study on Rubber, Jarosite and Sandstone Aggregates

Sanjeev Kumar, Ramesh Chandra Gupta, Blessen Skariah Thomas and Priyansha Mehra

Abstract Disposal of wastes such as tire rubber, jarosite and sandstones have become a major environmental issue in all parts of the world especially in India. Every year millions of tires are discarded representing a serious threat to ecology. It was estimated that almost 1000 million tires end their service life every year and out of that, more than 50 % are discarded to landfills or garbage without any treatment. By the year 2030, there would be 5000 million tires to be discarded on a regular basis. Similarly, huge quantity of jarosite is being released as solid residues during the process of metallic zinc extraction from sulphide ore or zinc sulphide. Rajasthan in India alone produces 900 million tons of sandstone waste thus leading to a large dumping of these materials without any essential utilisation. The increasing annual production and those already accumulated is one of the major sources of environmental pollution. This study focusses on the effective utilisation of these wastes as aggregate in cement concrete which leads to an overall sustainable development in the field of concrete research.

Keyword Tire rubber · Jarosite · Quartz sandstone · Compression · Flexure

S. Kumar (✉) · R.C. Gupta · B.S. Thomas · P. Mehra
Department of Civil Engineering, Malaviya National Insitute of Technology, Jaipur, Rajasthan 302017, India
e-mail: sanmfsd@gmail.com

R.C. Gupta
e-mail: chaprathu44@gmail.com

B.S. Thomas
e-mail: irarcg@hotmail.com

P. Mehra
e-mail: priyansha.mehra@gmail.com

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_2

1 Introduction

Concrete is a mixture of cement, aggregates and water. Aggregates constitute about 70 % by weight of the concrete. There is a great demand for natural aggregates as the construction activities are increasing every day. As the natural resources are decreasing every day, some alternative materials that will serve the purpose of the natural aggregates should be introduced [1]. Solid waste disposal is a worldwide problem. If not properly disposed, these materials become sources of environmental pollution and the problems related to it. Various studies are done worldwide to dispose these solid waste materials by using them for partial or complete replacement of aggregates in cement concrete. Discarded tyre rubber is an important solid waste material that destroys the ecological environment. Environmental and Ecological disturbances have been caused due to huge accumulation of waste/by-products generated during the different manufacturing and production processes. Extraction of metal from its ore is one such process, generating non-hazardous as well as hazardous by products. Sandstones are sedimentary type of rock which are composed of rock grains and silt sized particles. They are of different types based on the geological property, elemental framework and most of the sandstones has quartz and feldspar due to abundance of them in earth's crust. Being a widespread aggregate resource, sandstones are widely used in concrete construction around the world [2]. The geological properties of sedimentary rocks are fairly diverse such as quartzite, arkose, subarkose and greywacke aggregate that may produce a range of hardened concrete properties. This paper discusses compression and flexural strength results in utilising tire rubber, jarosite and quartz sandstones in concrete as a partial replacement for aggregates.

2 Materials and Methods

2.1 Rubber Tire

Ordinary Portland cement of grade 43, conforming to IS 8112: 1989 [3] was used (specific gravity 3.15, normal consistency 34 %, initial setting time 99 min, final setting time 176 min). Natural river sand confirming to zone II as per IS 383: 1970 [4] (void content 34 % as per ASTM C 29/C 29M: 2009 [5], specific gravity 2.63, free surface moisture 1 %, fineness modulus 2.83). Coarse aggregates, 10 mm size was used 40 % (fineness modulus 5.573) and 20 mm size was used 60 % (fineness modulus 7.312) crushed stone were used as coarse aggregates with an average specific gravity 2.63. Discarded tyre rubber was grinded into three sizes (powder form of 30 mesh, 0.8–2, 2–4 mm). The specific gravity of rubber powder was 1.05 and that of the other two sizes were 1.13. The three sizes of crumb rubber were mixed in definite percentages (2–4 mm size in 25 %, 0.8–2 mm size in 35 % and rubber powder in 40 %) to bring it to zone II as per IS 383: 1970.

2.2 Jarosite

Jarosite and fly ash have been procured from Hindustan Zinc Limited, Debari, Udaipur, Rajasthan and Kota Super Thermal Power Station, Kota, Rajasthan respectively. Other raw materials for concrete such as aggregates, water, cement and chemical admixtures have been used as per the requirement for concrete mix design. The compressive and flexural strength of concrete was tested as per procedure laid in IS: 516 (BIS 1959) [6]. Concrete cube specimens of size 100 mm were used for compression test at 3, 7, 28 and 90 days and concrete beams of size 100 × 100 × 500 mm were used for flexural test at 7 and 28 days [7, 8].

2.3 Quartz Sandstone

Ordinary Portland cement of grade 43, conforming to IS 8112: 1989 was used (specific gravity 3.15, normal consistency 32 %, initial setting time 66 min and final setting time 164 min). Natural river sand confirming to zone II as per IS 383: 1970 (void content 34 % as per ASTM C 29/C 29 M: 2009, specific gravity 2.63, free surface moisture 1 % and fineness modulus 2.83). Coarse aggregates, 10 mm size (fineness modulus 6.08) and 20 mm size (fineness modulus 7.22) crushed stone were used as coarse aggregates with an average specific gravity 2.64. Quartz sandstone coarse aggregate, 10 mm size (fineness modulus 6.04) and 25 mm size (fineness modulus 7.24) were used as partial replacement for coarse aggregates with an average specific gravity of 2.45. The particle size distribution, composition of aggregates, cement properties and gradation details given are same as in Kumar et al. [9].

3 Results and Discussions

3.1 Rubber Tire

Compressive Strength. Concrete cubes of size 100 mm × 100 mm × 100 mm size were cast with varying percentages of crumb rubber and varying water-cement ratios. The specimens were de-moulded after 24 h and tested for compressive strength after 7 and 28 days of curing as per IS 516: 1959. Specimens stored in water were tested immediately on removal from the water, while they are still in the wet condition. Surface water and grit were wiped off the specimens and the projecting fins were removed. The results showing the variation in compressive strength (average of three test values) are given in Figs. 1, 2 and 3.

From the results of the compressive strength test, for water-cement ratios of 0.4, 0.45 and 0.5, the compressive strength showed a decreasing trend when the

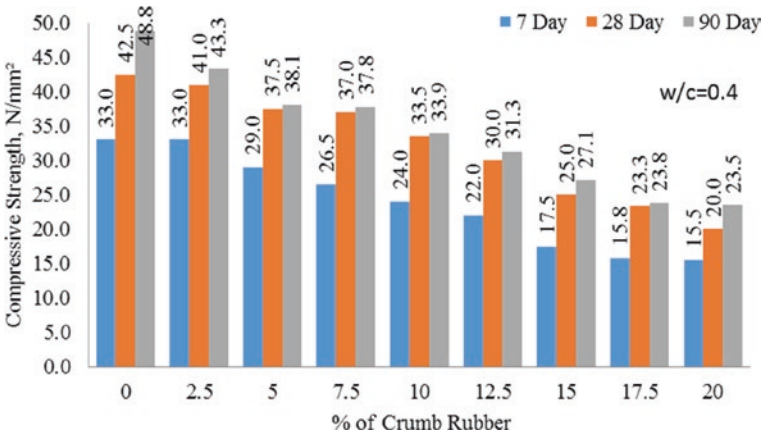

Fig. 1 Compressive strength of *cubes* for water-cement ratio 0.4

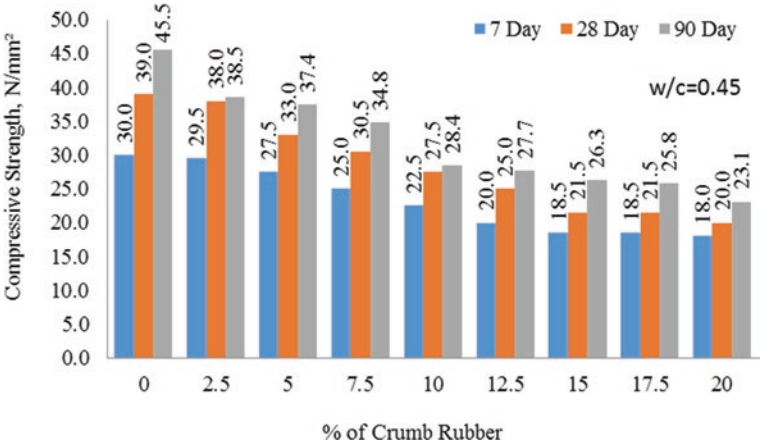

Fig. 2 Compressive strength of *cubes* for water-cement ratio 0.45

percentage of crumb rubber is increased. This loss in strength is mainly due to the lack of adhesion between the rubber particles and the cement paste. When the water–cement ratio is 0.4, the strength above 30 N/mm^2 has been obtained up to 12.5 % of crumb rubber replacement and up to 7.5 % replacement when the water–cement ratio was 0.45 and 5 % replacement when the water-cement ratio is 0.5. The compressive strength showed a decrease up to 50 % in all the three water–cement ratios when the percentage of tyre rubber reached 20 % of fine aggregates.

Flexural Strength. Concrete beams of size 100 mm × 100 mm × 500 mm size were casted with varying percentages of crumb rubber and varying water-cement ratios. The specimens are cured and tested on a flexural testing apparatus for 7 and 28 days as per IS 516: 1959. The results showing the variations in flexural

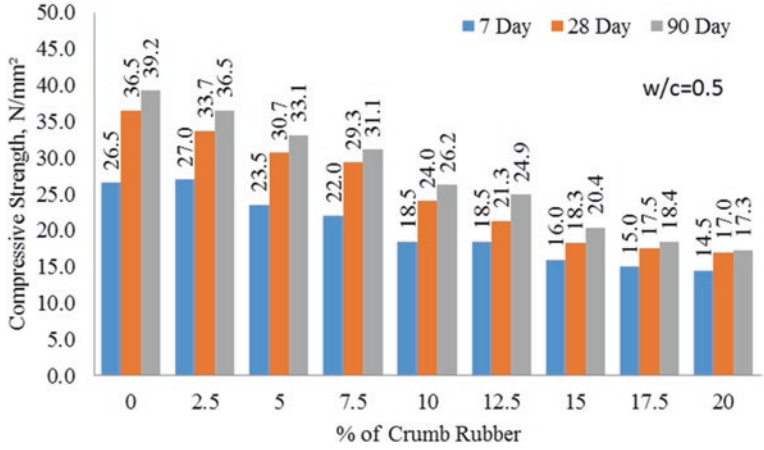

Fig. 3 Compressive strength of *cubes* for water-cement ratio 0.50

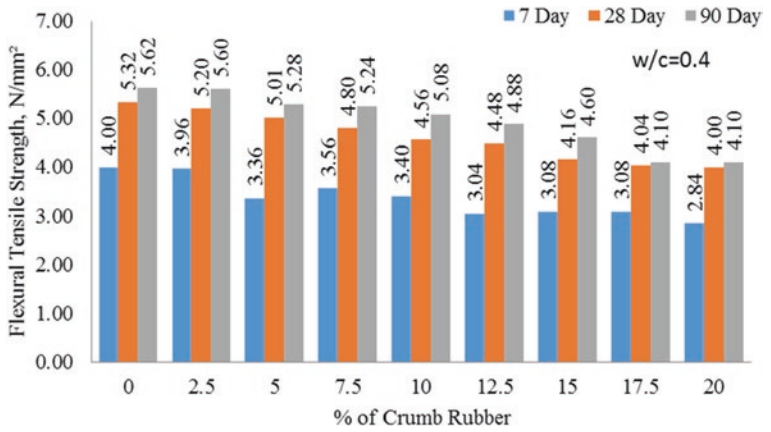

Fig. 4 Flexural strength of *cubes* for water-cement ratio 0.4

strength (average of three test values) of beams are given in Figs. 4, 5 and 6. From the results of the flexural strength test, there was decrease in the strength upon increasing percentage of crumb rubber. But the reduction in flexural strength was approximately half of that of compressive strength. When the water–cement ratio was 0.4, the flexural strength at 28 days was 5.28 N/mm^2 for the control mix and 4 N/mm^2 for the concrete with 20 % tyre rubber. When the water–cement ratio was 0.45, the flexural strength at 28 days was 5.28 N/mm^2 for the control mix and 4 N/mm^2 for the concrete with 20 % crumb rubber.

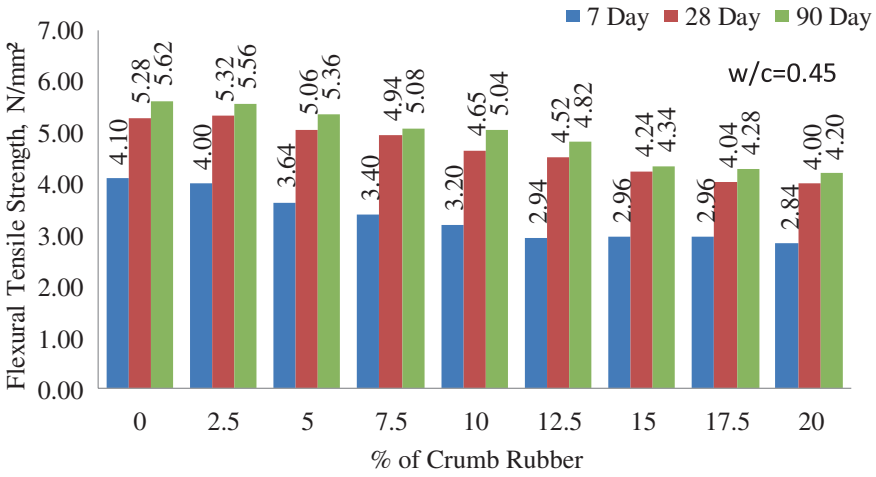

Fig. 5 Flexural strength of *cubes* for water-cement ratio 0.45

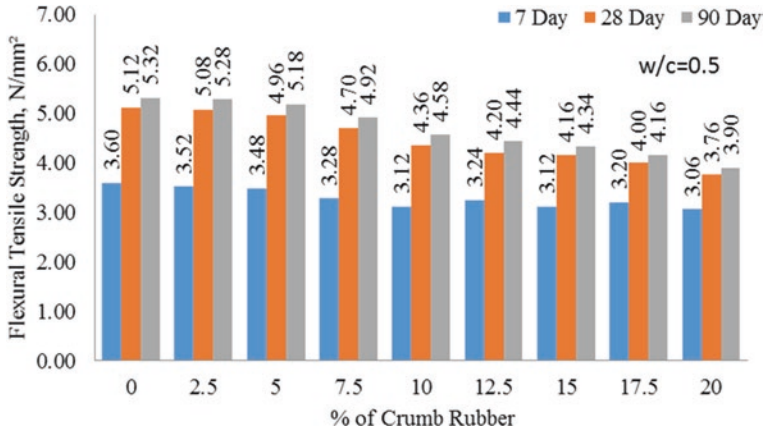

Fig. 6 Flexural strength of *cubes* for water-cement ratio 0.50

3.2 Jarosite

Compressive Strength. At the early age of 3 days, there seems an increasing trend in strength with reference to replacement levels of jarosite in concrete with all water-cement ratios (0.40, 0.45 and 0.50). Moreover, concrete mixtures with w/c ratios 0.40 and 0.45 experienced almost the same strength up to 20 % replacement of fine aggregates. The lower strength of the concrete samples with w/c 0.50 has been observed at all replacement levels in comparison to samples with w/c 0.40 and 0.45. After 7 days curing, the strength following the same trend as that of 3 days strength. However, the concrete mixtures with w/c 0.50 has achieved the strength almost similar to mixtures with w/c 0.45. At later ages of 28 and 90 days, the strength improvement has been clearly visible in concrete mixtures with all w/c ratios (0.40, 0.45 and 0.50). At 28 days, the concrete mixtures with w/c 0.50, strength is almost constant up to 15 % replacement levels and increased further till 25 %. The concrete mixtures with w/c 0.40 have obtained good strength after 28 and 90 days (Fig. 7). Complete hydration of cement and binder (fly ash) has resulted in good mechanical strength (compressive and flexural strength). Also, the increasing percentage of jarosite has properly filled the pores and developed a dense particle packing.

Flexural Strength. Flexural tensile strength of concrete at 7 and 28 days is shown in Fig. 8. Flexural tensile strength seems to be following almost the same trend of compressive strength. However, in 7 days, concrete mixtures with w/c 0.40 and 0.45 achieved almost the same strength at all percent of jarosite while

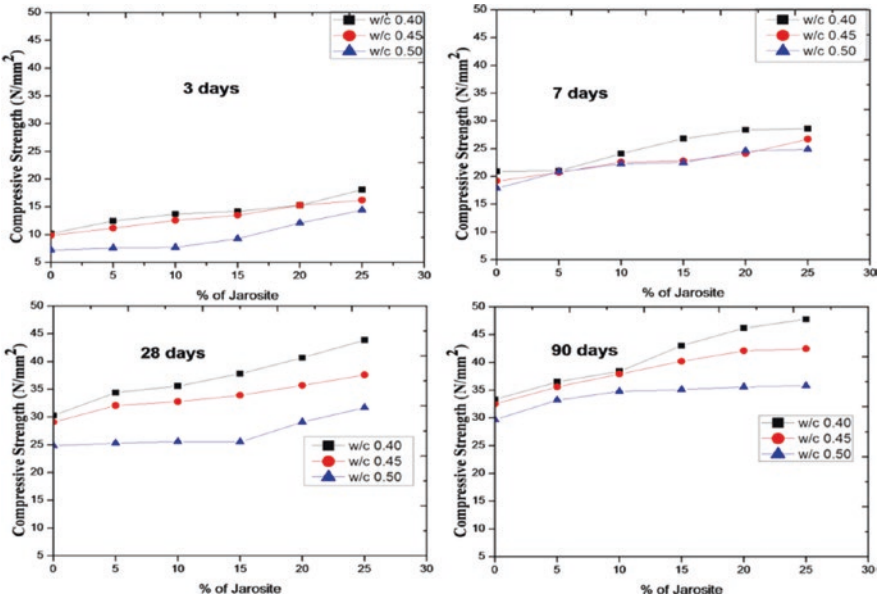

Fig. 7 Compression strength of *cubes* for water-cement ratio 0.4, 0.45 and 0.5

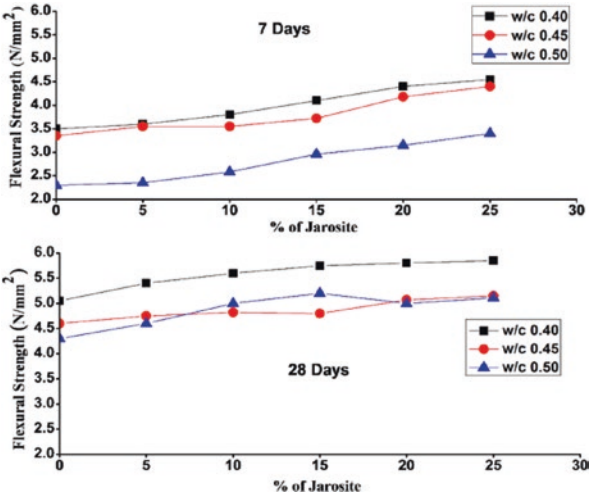

Fig. 8 Flexural strength of *beams* for water-cement ratio 0.4, 0.45 and 0.5

after 28 days curing, concrete mixtures with w/c 0.45 and 0.50 hold the same strength at higher replacement levels.

At higher replacement levels, the flexural strength of coal bottom ash concrete seems to be comparable with control concrete. Concrete with higher ash content (30 % and up to 50 %) possessed increased strength. However, at lower levels (up to 20 %), reduction in strength was observed.

3.3 Quartz Sandstone

Compressive Strength. From the test results of three average values for water-cement ratios of 0.35, 0.4 and 0.45, the compressive strength showed a decreasing trend whilst adding quartz sandstone as coarse aggregate. Upon 100 % replacement, a maximum of 21 % decrease in compressive strength was observed at 0.45 water/cement ratio. However, a maximum decrease of only 8 % in compressive strength was observed up to 40 % substitution when compared with the control concrete (Figs. 9, 10 and 11).

Flexural Strength. Concrete beams of 100 mm × 100 mm × 500 mm size were cast with various percentages of quartz sandstone aggregates and various water/cement ratios. Flexural strength tests were carried out in accordance to IS 516: 1959 after 7 and 28 days. The test samples were stored in water at a temperature of approximately 27–29 °C for 24 h before testing. The samples were tested whilst they were still in wet condition. Loose and foreign materials were wiped off the bearing surfaces and the axis of the specimen was aligned with that of the loading device. Then load was applied at a rate of 400 kg/min until the specimen

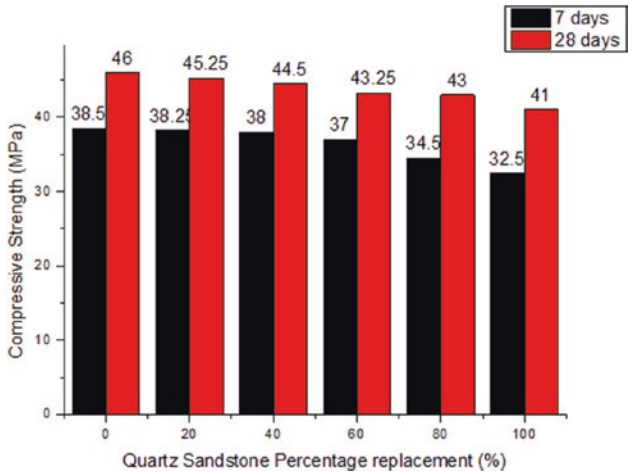

Fig. 9 Compressive Strength of *cubes* for water-cement ratio of 0.35

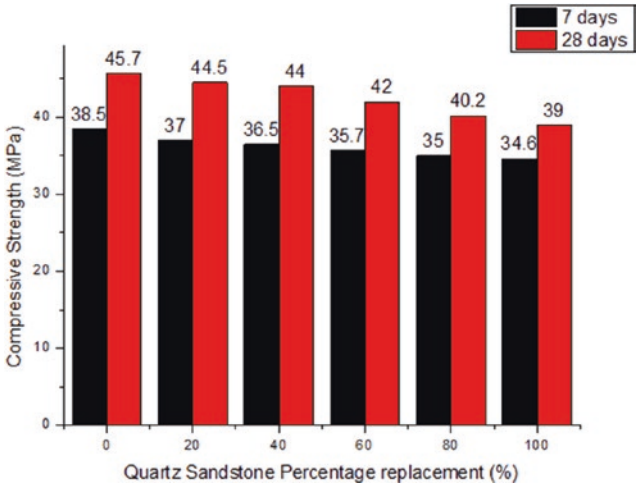

Fig. 10 Compressive Strength of *cubes* for water-cement ratio of 0.40

failed to attain the peak load. The test results showed a decrease in flexural strength as the quartz sandstone was added in concrete. The maximum decrease was found to be 12 % when compared to the control concrete for the water/cement ratio of 0.35 (Figs. 12, 13 and 14).

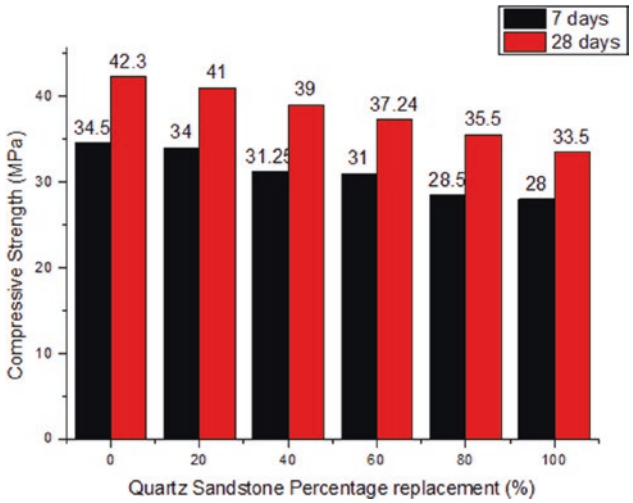

Fig. 11 Compressive Strength of *cubes* for water-cement ratio of 0.45

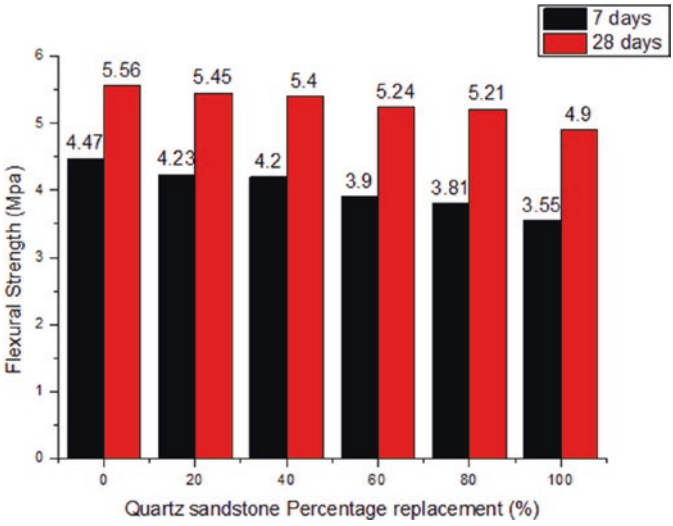

Fig. 12 Flexural Strength of *cubes* for water-cement ratio of 0.35

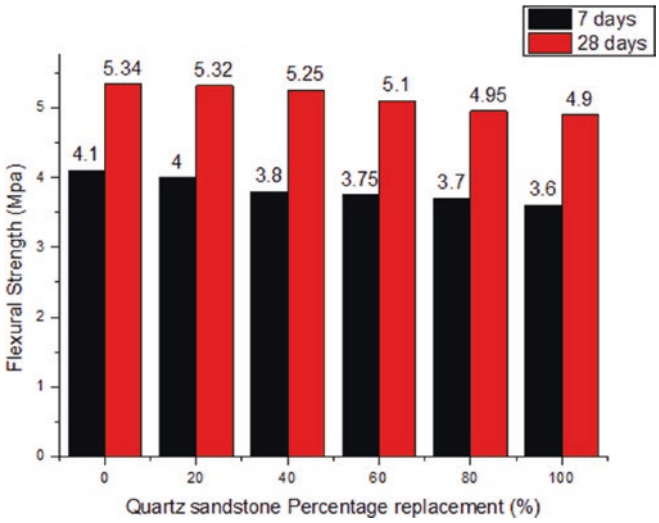

Fig. 13 Flexural Strength of *cubes* for water-cement ratio of 0.40

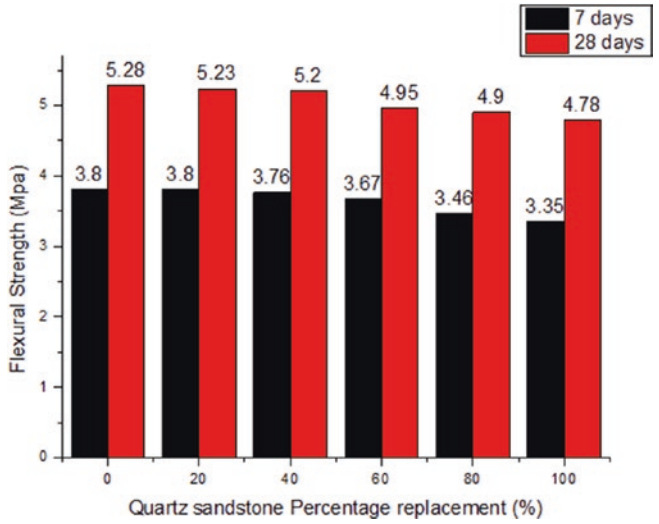

Fig. 14 Flexural Strength of *cubes* for water-cement ratio of 0.45

4 Conclusions

4.1 Rubber Tire

- From the results of the compressive strength test, for water-cement ratios of 0.4, 0.45 and 0.5, the compressive strength showed a decreasing trend when the percentage of crumb rubber is increased. When the water–cement ratio is 0.4, the strength above 30 N/mm2 has been obtained up to 12.5 % of crumb rubber replacement and up to 7.5 % replacement when the water–cement ratio was 0.45 and 5 % replacement when the water–cement ratio is and 5 % replacement when the water-cement ratio is 0.5. The compressive strength showed a decrease up to 50 % in all the three water–cement ratios when the percentage of crumb rubber reached 20 % of fine aggregates.
- From the results of the flexural strength test, there was decrease in the strength upon increasing percentage of crumb rubber. But the reduction in flexural strength was approximately half of that of compressive strength.

4.2 Jarosite

- The compressive and flexural strength of concrete mixtures has been almost higher at higher replacement levels at all w/c ratios.

4.3 Quartz Sandstone

- While utilising quartz sandstone in concrete, proper selection of water/cement ratio becomes mandatory as the strength plots decrease due to increase in water/cement ratio.
- For mix designs having water/cement ratios more than 0.40, quartz sandstone aggregate replacement can be limited to 40 % to attain target strength for M30 grade of concrete.

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Incubating and Nurturing Sustainable Practices Through Staged Social Engagements

Satyakam Sharma and Kin Wai Michael Siu

Abstract Social interventions emerging from the field of social psychology and sociology have been quite effective in encouraging a positive change in environmental behaviour under the influence of a social setting. They also provide a suitable social environment for learning, adopting, incubating, and nurturing the new behaviour. The study analyzes several such cases through an exhaustive document analysis. It aims at building a deeper understanding of the complex mechanics of such contrived social engagements including their process of encouraging sustainable behaviour. It dissects the whole process into smaller activities, and maps them against the behaviour change techniques (BCT) and the relevant theories to identify their role in the process of change. Further classification of these activities on the basis of their role resulted in a model, which comprises of five key phases through which a participant undergoes during the process of change. The model provides an overview of the process, which can be useful in understanding and devising such social engagements for encouraging a positive change in behaviour for environmental benefit.

Keywords Sustainable behaviour · Social interventions · Staged social networks · Collaborative networks · Behaviour change techniques (BCT)

1 Introduction

A positive change in consumption behavior is required to strive towards the concept of a sustainable society [1]. Design-led approaches drawn heavily on cognitive and environmental psychology have mainly focused on the design of specific

S. Sharma (✉) · K.W.M. Siu
School of Design, The Hong Kong Polytechnic University,
Hung Hom, Kowloon, Hong Kong
e-mail: satyakam.sharma@connect.polyu.hk

© Springer International Publishing Switzerland 2016

J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_3

products and their interactions to target behaviour towards more efficient usage. Although, these approaches have been quite effective in steering the behaviour towards more efficient usage of the products and resources, they seldom consider the social context in which the practices emerge, evolve, incubate, transform, persist, spread, and defect [1–4].

Social interventions emerging from the field of social psychology and sociology have shown that group-level interventions can be an effective way to encourage a positive change in behaviour. Such social interventions are based on the assumption that human practices are socially grounded, thus influencing the social nature of practices of a unified social group through a devised social network, can be an effective way of encouraging adoption of sustainable behaviour [3–11]. These strategically designed social networks engage the participants towards a common objective, and stimulate them to adopt new practices under the influence of a social setting. The process of engagement typically involves activities like teamwork, competition, collaboration, and rewards. These social engagements also provide a suitable social environment for incubating and nurturing the newly adopted practices, which eventually replace the habitual behaviour. They aim to address the social and systemic nature of practices by engaging the practitioner into an arranged social environment where practices can be shared, restructured and incubated under the influence of the social structure [2].

The term 'staged' conveys that these are strategically and thoughtfully structured engagements, designed to achieve certain objectives inscribed by the designer. Based upon the objectives, these social engagements can broadly be classified into two categories: (1) *educational*—the ones which focus only on educating the participants and (2) *action-oriented*—the ones which focus on the actions taken by the participants in the real-world.

The theoretical constructs provide a foundation for outlining the strategies used in these staged social engagements aiming behavioural change. These theories provide an understanding of the process of behaviour change (from cognitive stand point), the key determinants of behaviour change, and the associated cause and effect [3]. They also provide a basis for predicting the new behaviour patterns, maintenance of already adopted behaviour, and understanding how habitual behaviour gets replaced by conscious decisions. The theories highlight the key motivators of behaviour change as—personal benefits, conformity with social norms and personal values, concern for societal and environmental values, and fear of adverse consequences [3]. The theories from Social sciences consider that behaviour is a consequence of societal norms and expectations held by the system in which the individual is living, therefore a unified social group should be considered for targeting behaviour change [12]. Besides this, the theories such as *social cognitive theory* and *social learning theory* indicate the importance of social engagements in behaviour change. They indicate that a social intervention should allow the individuals to engage, participate, socialize, share, play a role, get incentivized, get hands-on experience, and above all, it should allow the individuals to experience the immediate consequences of their actions [3, 12]. These social engagements are based on a mix of several such theories.

The overall objective of the research is to conduct a systematic investigation into several such implemented cases in order to understand how these solutions inspired adoption of sustainable practices. The aim is to build a deeper understanding of the complex mechanics of such contrived social engagements, and the motivation behind adoption of new practices from the perspective of the users. The idea is to understand—the key activities involved in the entire process of behaviour change, the role of these activities, corresponding theories from behavioural science, sociology, and social and cognitive psychology, and the interwoven strategies (behaviour change techniques) that trigger the adoption of new practices. The analysis of the successful cases would provide an understanding of the mechanics of staged social engagements, and an overview of the entire process of change from the perspective of the user (or the participant). This understanding could be useful in devising such arranged social engagements for fostering pro-environmental behaviour.

2 Methodology

Six diverse cases were identified for the analysis. These cases varied from each other in terms of their context of implementation, targeted social group (communities, employees, students etc.), targeted behaviour, method of engagement, and the techniques used for behaviour change. The common factor across all these cases was that they all followed an action-oriented approach, which means that they encouraged performing sustainable actions in the real-world. These cases were implemented for at least 2 months, and had resulted in at least 2 % savings on energy bills, or consumption of resources, or resulted in at least 2 % savings (calculated on the basis of the actions performed or the points earned by the individuals).

In order to develop a base for studying the cases, in the first phase of the project an in-depth exploration was conducted to identify various theories and models pertaining to behaviour change from the field of behavioural science, sociology, and social psychology. Thenceforth, a systematic review of various behaviour change techniques (BCT) was conducted. These common BCT have been identified by various researchers in the past [13, 14].

In the second phase, a document analysis was conducted to review the selected cases of staged social networks, which have been effective in fostering a positive change in environmental behaviour. The reviewed published documents included reports on ongoing organizational activities, journal articles, newspapers, training materials, promotional materials, project reports, and project websites.

These documents provided an unbiased insight into each of these cases. These insights were related to the context of implementation, process, functioning, structure, targeted group, activities involved, motivations, effectiveness, and the results of each case. Each document was coded to precisely identify all the activities that take place in the entire process of change, particularly from the perspective of the

user. Thereafter, each activity was linked with the relevant BCT and the theories to identify the role of that activity in the process of change. This process of dissection and association helped in understanding the role of each activity in the entire process.

In the third phase, all the activities (across all the cases) were classified into certain recognizable categories based upon their role in the process of change. This categorization symbolized the overview of the key phases involved in the process of change.

3 Cases

3.1 JouleBug

JouleBug projects itself as a playful engagement, which encourages the participants to adopt certain sustainable practices, win rewards, and share their achievements through online social networks. To engage and motivate the participants, it uses elements such as competition, rewards, comparative feedback and goal-setting. It provides the participants with a list of easy-to-implement sustainable actions that can be performed in the real-world. It focuses on encouraging a wide range of sustainable actions, such as minimizing energy and water consumption, and waste reduction. It allows the participants to compete with their Facebook and Twitter friends to earn rewards in the form of badges and pins. It also shows the users their regular progress and the impact of their actions in terms of savings each month. It also learns a user's habit over time and recommends the actions to others in the social group to make the highest impact [3]. On the basis of the pins and badges earned by its users, JouleBug estimates average saving of $200 a year. The report from I-Cubed and Wesleyan University suggests that JouleBug triggered an intense competition, which resulted in a significant behaviour change among the employees and the students respectively [3, 15].

3.2 Bidgely

Bidgely provides a comparison of a household's energy usage with that of other neighbourhood dwellers. It also provides a product-specific and usage-wise breakdown, and compares this data with the average consumption. This information is provided to the users through regular feedbacks and persuasive action-oriented messages, which prompts them to take appropriate actions to cut down on energy bills [3, 16]. Its appliance-specific breakdown, comparative feedback, personalized communication, persuasive actionable messages, and timely reminders keep the consumers engaged and motivated. It also provides the real-time monitoring

of the energy consumption, and accordingly alerts the user through personalized recommendations when the actions need to be taken. A Study of 300 participants for over 6 months revealed an average reduction of 6 % in household energy consumption over those who were not exposed [3, 16].

3.3 Big Energy Race

Big Energy Race was a program developed and run by Global Action Plan in collaboration with four energy companies. The objective was to minimize the energy consumption of 4000 households by encouraging them to adopt certain practices such as, turning off the lights and appliances when not in use. A team of community leaders talked to each household and set them challenges to reduce their energy consumption. Each household was provided with information on easy step-wise achievable actions and other relevant supporting material, which prepared them for the challenge. Communities started working towards the shared goal, and earned incentives in the form of points for every challenge they completed. An additional incentive of £20 k was announced, which the winning team could invest in their community. To motivate and engage the participants, it used goal-setting, competition, comparative feedbacks and rewards [3, 17]. Big Energy Race saved the participants up to £117 each on their bills, which is equivalent to 484,259 kilowatt hours (kWh) or 239,349 kg in CO_2 emissions. 90 % of the participants said that they will continue with their energy-saving actions in future [3, 17].

3.4 Operation TLC Program

Operation TLC program implemented at Barts health NHS Trust resulted in significant savings on their energy bills. This was achieved by making the staff perform three simple actions, *T*-turn off equipment when not in use; *L*-switch off lights; *C*-close doors and windows. Hundreds of staff members who participated in the program were grouped into teams. These teams were engaged and motivated by naming the team of the month, and by providing a luxury hamper of tea for their extra efforts in managing the wards efficiently. Stickers and posters such as 'if they could let the sun shine in' were used as prompts to remind the participants of their actions. It used techniques such as competition, collaboration, goal-setting, and rewards to encourage and engage the participants. Besides this, a *quiet time* was also introduced in the routine, during which the staff dimmed the lights, and asked the patients to rest in their rooms [3, 18]. The program has shown effective results for the past 2 years since its implementation. With savings of £428,000 (approximately 1900 tonnes CO_2) annually, Operation TLC delivered long-term cost benefit to the organization [18].

3.5 MyEnergy

MyEnergy helps its consumers make small daily differences by taking control of their personal energy use. It collects the data on household energy usage by reading the utility metres through the web, and provides a breakdown of consumption of energy water and gas. It allows the consumers to compare their consumption pattern to that of their friends in the neighborhood, and earn rewards for saving the resources. It uses comparative feedback, break-up information, tailored tips, persuasive messages, prompts, and rewards to engage and motivate the consumers. It rewards with one redeemable point for every kilowatt hour of energy saved. A study commissioned by the company showed that the consumers saved as much as 14 % on their energy bills [3, 19].

3.6 Sainsbury's UK's Greenest Grocer

Sainsbury's UK's Greenest Grocer campaign was designed to raise awareness amongst its store employees, reduce the supermarket's carbon footprint and energy bills by encouraging the employees to adopt certain practices. The stores were engaged in a competition by setting a goal of 3 % savings, which resulted in a friendly rivalry between the stores. Stores were informed about their comparative performances using league tables. Monthly events were also conducted to guide the staff of specific actions they can take to reduce energy use, and the most efficient store team was rewarded. The campaign used a number of strategies such as competition, collaboration, prompts, goal-setting and rewards to engage and motivate the employees. Since its implementation, the program has seen a 3.20 % reduction in energy against a 3 % target, which means a saving of 22 m kWh of energy, or 9000 tonnes of CO_2, or a saving of over £2 m, or enough energy to power over 4700 homes for a year [3, 20].

4 Result

The analysis resulted in a comprehensive understanding of the mechanics of the staged social networks, and how they encourage a change in behaviour through social engagement. The dissection of the entire phenomenon into smaller activities, and the linking of these activities with the relevant BCT and theories helped in understanding the role of each activity in the process of change. The categorization of these activities on the basis of their role resulted in the formulation of a model comprising of five key phases (Fig. 1). These phases are: (1) association, (2) preparation, (3) engagement, (4) experimentation, and (5) incubation. These five phases provide a general overview of the process of change that takes place

Fig. 1 Model representing five key phases in the process of behaviour change through staged social engagements

through these staged social engagements. They also represent the stages through which a participant undergoes during the process of change. Each phase comprises of a large number of activities. The Tables 1, 2, 3, 4 and 5 show the BCT used in each phase and the supporting theories and models.

Although each case followed a unique approach to make the participants interact, share, observe, learn, collaborate, compete and restructure their practices, they still had certain common touch points in terms of their objective, the BCT used, and the outlining theoretical constructs. It was also observed across the cases that most of the activities were designed to target multiple levels of motivations to encourage a change in behavior. These motivations include—desire for personal gain (money, time, reward, resources), desire for approval by peers (conformity with social norms, expectations), desire for self-approval (conformity with personal values, commitment and self-image), and the concern for societal values (altruism, environmental concern) [21].

Table 1 Association phase: Behaviour change techniques (BCT) and supporting theories

Association	
Behaviour change techniques (BCT)	Provide information about the system, its image and credibility; information on likely consequences of association and benefits of performing the behaviour (personal, social and environmental); information on the process of engagement (interactive, fun, entertaining); information about the social and symbolic significance of participation, and how the participant may feel ones associated; information on social proof (that others have already associated, improved, contributed, and had also been benefitted)
Theories and model	Information-Motivation-Behavioural Theory; Theory of Planned Behaviour; Theory of Reasoned Action; Rational Choice Theory; Stages of Change; Social Marketing; Social Proof; Self-determination Theory; Diffusion Of Innovation Theory; Framing Theory; Self-verification Theory

Table 2 Preparation phase: Behaviour change techniques (BCT) and supporting theories

Preparation	
Behaviour change techniques (BCT)	Skill and competence development (training and education); barrier removal; instructions about the rules; teach to use prompts (reminders, cues, feedback, when to perform etc.); setting graded tasks; prompt specific goal-setting; information on making the desired behaviour easy to perform (self-efficacy); demonstrate the behaviour; information on when and where to perform the behaviour; information on—likely consequences of performing the behaviour (personal, social and environmental); provide information about rewards; provide information about others' approval; prompt intention formation; communicate expected social norms; provide general encouragement; action planning (step-by-step instructions on achieving the goals)
Theories and model	Information-Motivation-Behavioural Theory; Self-Efficacy; Theory of Planned Behaviour; Theory of Reasoned Action; Rational Choice Theory; Control Theory; Stages of Change; Social Marketing; Social Proof; Elaboration Likelihood Model; Self-determination Theory; Framing Theory; Social Norms; Nudge Theory

Table 3 Engagement phase: Behaviour change techniques (BCT) and supporting theories

Engagement	
Behaviour change techniques (BCT)	Provide normative information about others' behaviour; provide opportunities for social comparison and monitoring of others' actions; facilitate social interaction (sharing practices, learning from others); grouping and team formation; encouraging competition; prompt intention formation; provide specific goal setting; action planning; stimulate anticipation of future rewards; provide information on when and where to perform the behaviour; provide specific action-oriented messages (ex: appliance-specific breakdown and action)
Theories and model	Drive Theory; Goal Setting Theory; Goal Commitment; Social Comparison Theory; Social Cognitive Theory; Social Learning Theory; Social Identity Theory; Social Proof; Social Norms; Situated Learning Theory; Nudge Theory; Self-verification Theory; Observational Learning (social learning); Control Theory

4.1 Association

The Association phase (Table 1) refers to the first phase wherein the activities primarily focus on attracting the attention of the individuals to encourage them to associate and engage with the network. This phase involve promotional activities such as advertisements through social media and even direct communication with the individuals. During this communication, people are informed about the benefits of associating with the network (including the personal, social and environmental benefits). Social proof is one of the most commonly used strategies

Table 4 Experimentation phase: Behaviour change techniques (BCT) and supporting theories

Experimentation	
Behaviour change techniques (BCT)	Remind when and where to perform the behaviour; use of follow up prompts; provide immediate rewards (or praise) for attempting the behaviour; provide immediate feedback; provide immediate consequences of new behaviour (personal, social and environmental); provide immediate positive constructive feedback; provide social comparison, provide specific feedback for improvement; provide action-oriented persuasive messages; share new behaviour and consequences with social group (social media, friends); stimulate anticipation of more rewards in future with consistent performance; prompt review of behavioural goals; goal setting (new goals); prompt self-monitoring of behavioural outcome
Theories and model	Goal Setting Theory; Elaboration Likelihood Model; Stages of Change; Social Cognitive Theory; Social Learning Theory; Social Comparison Theory; Social Identity Theory; Social Proof; Social Norms; Situated Learning Theory; Nudge Theory; Cognitive Behavioural Therapy; Drive Theory; Cognitive Dissonance; Self-Verification Theory; Observational Learning; Self Enhancement Theory; Operant Conditioning; Control Theory

Table 5 Incubation phase: Behaviour change techniques (BCT) and supporting theories

Incubation	
Behaviour change techniques (BCT)	Prevent relapse (coping planning); prompt practice (consistency in performance); prompt self-monitoring of behaviour; provide regular information on when and where to perform the behaviour; provide information on others' actions; reward consistent performances; reward successful behaviour; prompting focus on past success; facilitate social comparison; stimulate anticipation of more rewards in future with consistent performance; encourage setting new targets; share performance in social group; prompt review of behavioural goals, prompting identification as a role model; prompt focus on past success
Theories and model	Goal Setting Theory; Stages of Change; Social Cognitive Theory; Social Comparison Theory; Social Identity Theory; Social Proof; Social Norms; Situated Learning Theory; Nudge Theory; Cognitive Behavioural Therapy; Drive Theory; Cognitive Dissonance; Self-verification Theory; Self-Enhancement Theory; Operant Conditioning; Control Theory

focusing on portraying that a large number of people have already participated and are being benefited. During this stage, the system also tries to portray its image to the users by communicating the credibility of the system they are associating with, and the social and symbolic significance of participation. From the perspective of the user, this stage is important because he gets to know about the benefits of associating with the network. Accordingly, he decides whether he should associate with the network or not.

4.2 Preparation

Once an individual (or a social group) associates with the network, he undergoes through the Preparation Phase (Table 2). This is an important stage because it trains and prepares the participants to effectively engage, learn the desired actions, understand the tools and technology, develop essential competence, understand the rules of the game, and infer the meaning of the cues during the process. Besides this, it also hints at the anticipated personal gains (points, savings, rewards), social benefits (social image, status), and other positive consequences of the new actions that will be performed. Participants are also informed of the environmental consequences of their actions and their social and environmental responsibility. Although the mode and techniques used for preparation differed from case to case, but the objectives were same i.e., to educate, motivate and prepare the users for active participation.

4.3 Engagement

The activities such as group or team formation, monitoring of others' behaviour, sharing of practices, cross-referencing, social comparison, competition, collaboration, goal-setting, learning from others, and reflection on one's own behaviour play a key role in pursuing the user to perform the desired actions. All these activities are grouped under the Engagement Phase (Table 3). The objective of these activities is to motivate the participants to adopt certain practices as a part of the engagement process. While the participants are engaged, they can monitor the actions performed by others, which helps them in comparing, cross-referencing and reflecting on their own actions. This motivates them to make a positive change in their practices in order to compete with others. It was observed that technology plays a key role in this process. It provides an indispensable platform for sharing, interacting, monitoring and cross-referencing of practices even if the participants are geographically far apart.

4.4 Experimentation

Once the participant is actively engaged in the social network, he is motivated to perform the new behaviour in the real-world. Since it is the first time he is trying out the new behaviour, this phase is termed as Experimentation phase (Table 4). During this phase he experiments with the new behaviour in the real context, receives feedback on the new actions, monitors the consequences of actions (personal, social and environmental), compares his performance with the social group, learns where he needs to improve, and sets new performance target to gain more benefits. This phase is important from the participant's perspective because, it is

the first time he adopts the new behaviour and experiences its consequences. Based upon this experience and the feedback on his performance, he decides whether to perform the behaviour again or not. Therefore, constructive, action-oriented, and practical feedbacks are usually provided to motivate the participants to perform consistently. For instance, JouleBug immediately provides the consequence of the actions in terms of points, and also makes the actions visible to others.

4.5 Incubation

Once the participant has performed the new behaviour and has experienced its consequences, the next step is to incubate this new behaviour by encouraging him to perform consistently so that it becomes a part of the routine and replaces the old habitual behaviour. All activities falling under this zone have been grouped under the Incubation phase (Table 5). The purpose of the Incubation phase is to prevent the relapse by encouraging the user to stay engaged with the system and perform the new action consistently. During this period the participants receive persuasive action-oriented messages, reminders informing when to perform, new goals and challenges, information on more rewards, and regular update on the performance of others.

5 Conclusion

The study provides an exhaustive understanding of the mechanics behind the staged social networks, and how they encourage adoption of sustainable behaviour through social engagements. The model provides an overview of the entire phenomenon in the form of five key phases through which a participant undergoes in the process of behaviour change. The BCT and the underlying theoretical foundation establish the objectives of the activities involved in each phase. The model can be useful in understanding and devising such social engagements for encouraging a positive change in behaviour for environmental benefit.

Acknowledgments The authors would like to thank The Hong Kong Polytechnic University for the research support of the study. The university also provided the postgraduate study fund for data collection and analysis. The authors also thank the Wuhan University of Technology for the partial support of the preparation of this paper.

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Public Facilities Driven by Service Demand for Space

Robert Rusek and Joan Colomer-Llinas

Abstract Pubic facilities provide spatial conditions for public services delivery. In the ideal case the amount of space available in a facility should be adjusted to the amount of space demanded by the service. However demand for space is very susceptible to fluctuations of the socio-economic environment and changes with time. This causes maladjustment between the amount of space demanded by the service and the area available. It results in either wastage of spatial resources or worsening of the working conditions. Thus we argue that the space of public facilities is a valuable resource and should be managed in function of space demand rendered by public services. To this end we propose and exemplify a method that allows us to determine the service demand for space and compare it with available spatial resources. The method uses only basic and inexpensive data, which makes it accessible for any municipality.

Keywords Public facilities · Public services · Space planning · Demand for space · Facility management

1 Introduction

Public facilities play an indispensable role in urban environment functioning. They provide public goods to inhabitants by assuring spatial conditions for public services. Every facility should provide an appropriate amount of space according to the

R. Rusek (✉) · J. Colomer-Llinas
Institute of Informatics and Applications, Politecnica IV,
Campus Montilivi, 17071 Girona, Spain
e-mail: Robert.Rusek@udg.edu

J. Colomer-Llinas
e-mail: Joan.Colomer@udg.edu

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_4

activities carried out within. The problem that arises in this context is that public services are very sensitive to environmental, economic and, most of all, social changes. Due to these circumstances they experience constant modifications. However public facilities, as a built environment, are not very prone to this variation. In consequence the demand for space changes over time whereas the amount of space available in the facility remains constant. Thus it is not rare that facility spatial conditions are not aligned with spatial requirements demanded by the service.

We estimate that the majority of public facilities were designed and constructed twenty, thirty or even more years ago. Meanwhile, the socio-economic environment has changed dramatically. According to the results of a survey and personal interviews conducted in June 2014 with 30 directors of public services in Girona, Catalonia (Spain), the two most reported factors that impact the public service provision were the recent economic crisis and the transformation of the society's age structure. The latter factor is mostly influenced by a significant decrease in the fertility rate in developed countries [1].

To exemplify how this phenomenon affects the demand for space, let us consider a school facility designed and constructed 30 years ago for 500 students. Owing to the difference in fertility rate, the number of students has decreased to about 350. That leads us to state the following observation: if the same amount of space is used for teaching fewer students it means that probably the service is occupying more room than is needed. Nonetheless the space is a valuable resource that is wasted if not used accordingly. Therefore it is important from the economic as well as the social point of view to assure required spatial conditions conform to the service needs, but no more.

This problem is not new and has been analyzed especially in the private sector. Both Facility Management (FM) and Building Information Modelling (BIM) provide solutions for detailed monitoring and analysis of the built environment [2]. However, in our opinion, these solutions are not very suitable for city environments for two reasons. First of all they are focused on a detailed analysis of complex but singular buildings, while in the urban context we rather have to cope with a set of buildings spread all over the city area. Another reason is that those solutions are expensive and require very exhaustive operational data—a cost that few municipalities can afford.

For the above-mentioned reasons, in this paper we address the issue of public facilities that should be driven in function of service spatial demand. To this end we propose a method that can be used for evaluation as well as spatial planning to determine the service demand for space and compare it to the area available in the facility building. We take advantage of the area per person factor to compute the service demand using only basic, easy to obtain data regarding the service activities. The quantitative outcome is expressed in square feet or square meters and reflects the amount of space required to carry out the service successfully. This value is subsequently compared with the amount of space available. In the result we obtain information on whether the facility provides appropriate spatial conditions demanded by a service or not. Any maladjustment is an indication for a more in-depth analysis.

2 Method

The method of determining service spatial demand requires both the service and the facility to be decomposed to their basic activities and functional areas respectively.

2.1 Service Decomposition

Service decomposition is the first step necessary to assess the service demand for space. The service that is considered for evaluation has to be decomposed to its elementary activities because every activity may require a different amount of space. For example, a static activity like book reading or studying will have lower requirements than a physical activity such as aerobics, which obviously requires more room. However, service decomposition may be a problematic task due to the lack of a common definition of service and activity. For this reason we adopt the concept of service granularity.

Service Granularity. Service granularity helps in defining an appropriate level of decomposition. It is especially important in case of complex services where the difference between service, subservice and activity may be not clear. For this purpose we take advantage of Service Oriented Architecture (SOA) and make an analogy to Business Value Granularity, where each service should fulfill some business goal [3]. In line with this, every public service should fulfill a particular goal of public administration, otherwise it can be only considered as a sub-service or, in other words, secondary service.

For example, a catering service usually forms part of an education service offered in a school facility. However it does not fulfill the main education goal but has a supportive function. Thus in this case catering would be a good example of a sub-service.

Furthermore every service can be decomposed to its basic activities. An activity is defined as a unit of work having: explicit duration, relationship with other activities, cost and resource consumption [4]. In this context the resource we are particularly focused on is space. Thus we consider the above-mentioned factors while decomposing a service and pay explicit attention to space usage. In other words we differentiate activities based mainly on the amount of space they require to be accomplished.

Yet service can be also decomposed on the basis of Business Process Modelling. The process maps are a very valuable tool for service decomposition since they denotes the set of activities that have to be carried out to achieve a particular objective and provide a graphical representation of how the organization does its work [5].

2.2 Service Demand for Space

Service spatial demand is a sum of the demand of its all activities. Every activity has a certain number of participants and each participant requires a certain amount of area to successfully accomplish the activity. For this reason we take advantage of the Occupant Load Factor (OLF), which designates the measure of area per person based upon the use of a given area [6]. For the same purpose the Assignable Square Feet (ASF) value per station can also be used [7].

There are a variety of standards for assigning the amount of area per person to type of activity. Beginning from the most general and global one, they are: the International Building Code [6]; more local ones, like the State of Washington Space Allocation Standards Manual [8]; and those focused on a particular domain, such as The Minimum Design Standards For Health Care Facilities [9]. The area per person values varies slightly from one standard to another, hence the choice of which is arbitrary. However to the best of our knowledge there is no one, coherent, standard that provides measures for all types of activities. Therefore when the standard does not specify the required measure it can be derived from others similar to the desired one.

The final value of service spatial demand (S) that has a determined number of activities (n) can be expressed by the following formula:

$$S = \sum_{i=1}^{n} (number\ of\ users \times area\ per\ person\ factor). \tag{1}$$

2.3 Facility Decomposition

Facility, similarly to service, has to be decomposed to its basic, functional areas. To this end an inventory of all facility areas needs to be prepared. Then, according to the UNE-EN 15221-6 standard [10], all areas have to be grouped in four clusters: Primary areas, which are used for principal activities and support the service main goal, such as class-room or consulting room; Circulation areas that are formed by corridors, access areas, etc.; Amenity areas which are not used for principal service activities but are necessary to support them, such as restrooms, storerooms, etc.; and Technical areas that are necessary for facility operations and maintenance, such as heating or server rooms.

To evaluate how the facility fulfills the service spatial needs, only the primary area cluster is considered. It is further subdivided to basic functional areas such as office space, classroom, etc. The circulation, amenity and technical areas should be subtracted from the total facility area and could be used for comparison. For example a circulation area usually represents 25–35 % of the total facility area (depending on building type). Thus any greater deviation from this rate should be an indication for a more detailed analysis.

Fig. 1 Illustration of matching service activities with corresponding facility areas

2.4 Service—Facility Matching

Once the service is decomposed to its principal activities and the facility to its primary functional areas, a relation between the activity and the corresponding area can be established, as depicted in Fig. 1.

When all activities are correlated with the corresponding areas, the final assessment comes down to the comparison of service spatial demand with the amount of area of appropriate type available in the facility. The entire process has been demonstrated on the example of an academic research service, which is described in detail in Sect. 3.

3 Case Study

As described in Sect. 2, this method has been exemplified on a real case study. For this purpose we analyzed the *academic research service* that takes place in the *research facility building* of the Polytechnic School at the University of Girona.

3.1 Decomposition of the Academic Research Service

The general research service has been analyzed and decomposed to principal activities that require the majority of the facility area. They are: research, professors' organizational activities, maintenance of IT infrastructure and research administration. In addition secondary activities, such as: staff meetings, assembly, tutoring, etc., were also identified but not considered for evaluation due to their

Table 1 Number of participants of every activity assigned to the corresponding facility floor

Activity	Number of participants			
	Floor 0	Floor 1	Floor 2	Total
Research	33	17	14	64
Professor's activity	14	16	54	84
IT inf. maintenance	4	0	0	4
Administration	0	12	0	12
Total	51	45	68	164

supportive function and occasional character. Subsequently the participants of every activity were counted and assigned to the corresponding facility floor, as it is presented in Table 1.

In this case participants of the academic research service were associated with the corresponding floor number where they physically carry out their tasks. However a more intuitive method would be their assignment to the appropriate department or entity. In the analyzed case, however, the personnel affiliation is very unstable and changes frequently. For that reason, on this particular occasion we see the association of participants with floor number to be more appropriate.

3.2 Academic Research Service Demand for Space

To calculate the service demand for space, the number of participants of every activity has to be multiplied by the appropriate area per person factor. For that purpose we took advantage of Space Planning Guidelines provided by Idaho State University that contains specific values for academic activities [7], as presented in Table 2.

Consequently the service demand for space was calculated by substituting the area per person values to the formula (1). The results of this calculus are presented in Table 3.

Summarizing the outcome of Table 3, it is evident that professors' activities have the highest demand for space, while the IT infrastructure maintenance the lowest one. The particular area values will be later compared with the amount of space available in the research facility building in Sect. 3.5.

Table 2 The values of area per person factor for principal activities

Activity	Area per person factor
Research	60 sf (5.57 m^2)
Professor's activity	120 sf (11.15 m^2)
IT infrastructure maintenance	120 sf (11.15 m^2) (engineering use)
Administration	100 sf (9.29 m^2)

Table 3 Academic research service spatial demand

Activity	Spatial demand			
	Floor 0	Floor 1	Floor 2	Total
Research	1980 sf	1020 sf	840 sf	3840 sf
	183.95 m^2	94.77 m^2	78.04 m^2	356.75 m^2
Professor's activity	1680 sf	1920 sf	6480 sf	10.080 sf
	156.01 m^2	178.4 m^2	602.01 m^2	936.46 m^2
IT infrastructure maintenance	480 sf	0 sf	0 sf	480 sf
	44.6 m^2	0 m^2	0 m^2	44.59 m^2
Administration	0 sf	1200 sf	0 sf	1200 sf
	0 m^2	111.48 m^2	0 m^2	111.48 m^2

Table 4 Measures of the facility areas grouped into four clusters

Cluster	Area measures				
	Floor 0	Floor 1	Floor 2	Total m^2	Total (%)
Primary area	80374.12 sf	5523.5 sf	7753.78 sf	21314.69 sf	55.63
	746.7 m^2	513.15 m^2	720.35 m^2	1980.2 m^2	
Circulation area	3352.42 sf	3532.18 sf	2835.214 sf	9719.81 sf	25.37
	311.45 m^2	328.15 m^2	263.4 m^2	903 m^2	
Amenity area	1351.41 sf	2528.98 sf	1865.38 sf	5745.77 sf	15.00
	125.55 m^2	234.95 m^2	173.3 m^2	533.8 m^2	
Technical area	346.06 sf	898.25 sf	289.55 sf	1533.86 sf	4.00
	32.15 m^2	83.45 m^2	26.9 m^2	142.5 m^2	
Total	13087.3 sf	12482.90 sf	12743.93 sf	38314.14 sf	100.00
	1215.85 m^2	1159.7 m^2	1183.95 m^2	3559.5 m^2	

3.3 Research Facility Decomposition

The research facility consists of three floors. Its principal objective is to provide appropriate spatial conditions for the research service, such as: research laboratories for researchers and office space for professors. The facility was analyzed, broken down into functional areas and grouped into four clusters according to the UNE-EN 15221-6 standard [10] as shown in Table 4.

Next, the primary area was further decomposed to primary functional areas as shown in Table 5.

3.4 Service—Facility Matching

In previous sections the research service has been decomposed to its principal activities and the demand for space for every activity was determined. Similarly

Table 5 Primary functional areas of the research facility with corresponding area measures

Functional area	Area measures			
	Floor 0	Floor 1	Floor 2	Total
Research lab	5919.61 sf	1973.02 sf	2126.41 sf	10019.05 sf
	549.95 m^2	183.3 m^2	197.55 m^2	930.8 m^2
Professor's office	1637.19 sf	1941.81 sf	5627.37 sf	9206.37 sf
	152.1 m^2	180.4 m^2	522.8 m^2	855.3 m^2
IT workshop	480.60 sf	0 sf	0 sf	480.61 sf
	44.65 m^2	0 m^2	0 m^2	44.65 m^2
Administration office	0 sf	1608.66 sf	0 sf	1608.67 sf
	0 m^2	149.45 m^2	0 m^2	149.45 m^2
Total	8037.41 sf	5523.50 sf	7753.78 sf	21314.69 sf
	746.7 m^2	513.15 m^2	720.35 m^2	1980.2 m^2

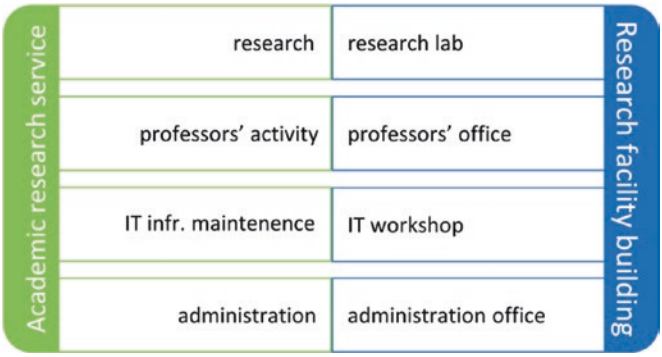

Fig. 2 Service activities matched with corresponding functional areas

the research facility has been decomposed to its primary functional areas. Subsequently both components were matched as depicted in Fig. 2.

3.5 Service Demand Versus Available Area

Finally, the spatial demand of the research service (Table 3) was compared with the amount of area available in the research facility (Table 5). The corresponding values were subtracted and the resulting difference is presented in Table 6.

As is shown in Table 6, the research activity has been assigned much more space than is needed, especially on the ground floor level. Space demanded by professors' activities can be considered as adjusted to the area available on the ground and first floor where the discrepancy is minimal. However there is a visible space scarcity for professors' activities on the second floor.

Table 6 The result of comparison of the academic research service demand for space with area available in the research facility building

Activity/area	Functional area—activity spatial demand			
	Floor 0	Floor 1	Floor 2	Total
Research/research lab	3939.59 sf	952.93 sf	1286.39 sf	6178.91 sf
	366 m^2	88.53 m^2	119.51 m^2	574.04 m^2
Professor's activity/professor's office	−42.07 sf	21,53 sf	−852.61 sf	−873.17 sf
	−3.91 m^2	2 m^2	−79.21 m^2	−81.12 m^2
IT infrastructure maintenance/IT workshop	0.54 sf	0 sf	0 sf	0.54 sf
	0.05 m^2	0 m^2	0 m^2	0.05 m^2
Administration/administration office	0 sf	408.70 sf	0 sf	408.70 sf
	0 m^2	37.97 m^2	0 m^2	37.97 m^2
Total	3898.04 sf	1383.16 sf	433.78 sf	5714.88 sf
	362.14 m^2	128.5 m^2	40.3 m^2	530.93 m^2

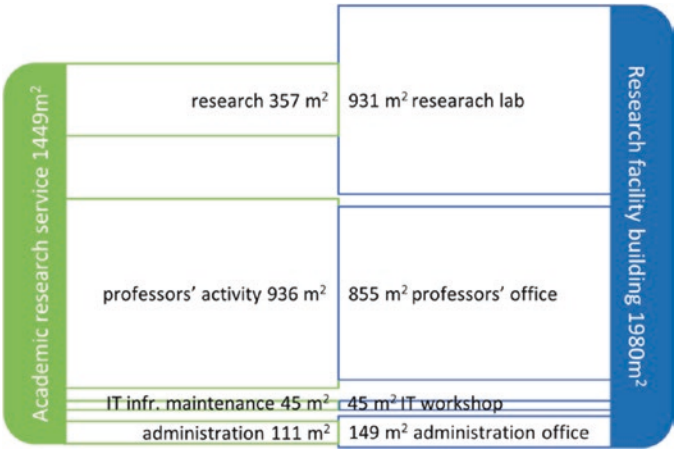

Fig. 3 Proportional matching of spatial demands and available area between activities of the academic research service and corresponding areas of the research facility building

The IT maintenance activity has a relatively low demand for space but as it turns out it is completely satisfied by the available area.

However the amount of administration office area exceeds the demands of the administration activity.

In short, out of all four principal activities, only one has an accurate amount of space assigned (IT infrastructure maintenance). Another one (Professors' activity) suffers from a space scarcity. The last two activities (Research and Administration) dispose of significant space excess resulting in strongly positive outright balance as it is depicted in Fig. 3.

The most obvious conclusion coming up from the presented case study is that a part of the area devoted to research on the second floor should be repurposed to satisfy the spatial demand of the professors' activities.

4 Discussion

Regarding the result obtained in Table 6, it is possible to provide a monetary value for the additional, unnecessary area. Considering the average price per rented square meter, which currently in Girona is about 8 Euro per month [11], the approximate value of space excess in the evaluated facility is equal to 4247 Euro per month, a considerable amount. This demonstrates the importance of proper adjustment between the amount of space demanded by the service and the amount of area available in facility.

However, depending on the specific case, the discrepancy may take two forms. The first is when the space excess is identified (as in the case of the explained example). Such a situation does not affect the conditions of service, but could be considered as a waste of public money. Therefore it is an especially undesirable situation from the point of view of economic efficiency. The possible solution for this kind of discrepancy may be space lease or space shared use with another service.

Another form of disagreement between space demand and offer occurs when there is not enough area and the service demand for space cannot be satisfied. This may have a negative repercussion on working conditions and overall service quality. In such cases, relocation of loosely related activities to another, approachable facility may be a suitable solution.

One more important concern to deliberate is the changing environment. The service demand for space is strongly dependent on the number of participants, which is unstable. In consequence, demand for space may vary significantly over time. In line with this, the evaluation should be repeated every certain period of time. Moreover the results should always be analyzed through the prism of the socio-economic context. In this light some discrepancy does not necessarily have to be an indication for action if a changes in space demand is expected to come. For this reason some "space margin" should be established to take into account such fluctuations of service demand.

The substantial advantage of the presented method is that it does not require application of expensive technology or a large amount of data. This makes it accessible for any public administration. However the lack of rigorous data may also affect the precision of the final result.

The method application is convenient for numerous public facilities. It helps to identify and focus future actions on facilities where the discrepancy reaches its highest value. This decreases significantly the time and cost of facility evaluation due to the reduced number of cases that require in-depth analysis. Only the reduced number of facilities should be verified in detail before any action is taken.

Another important concern to stress is that the method concentrates only on the spatial dimension of service provision. This, although very important, is not the only aspect that has to be considered for decision-making. Some services, especially health care, have very specific requirements that go beyond the spatial component but are not within the frame of considerations in this paper.

5 Conclusions

The method described and exemplified in this paper is a tool that aims to determine a service demand for space. This demand is posteriorly compared with area available in the facility building to detect any maladjustment.

The proposed solution has been verified on a real case study of the academic research service hosted in a research facility. The outcomes indicate a substantial area surplus over the service demand. This result turns out to be aligned with subjective estimations of the service staff. Because of this, the usefulness of the method has been confirmed.

The method can be used as evaluation as well as a planning tool to determine a service demand for space. Furthermore, although designed for assessment of public services and facilities, the method can be used for evaluation of other types of buildings as well.

However there are also some limitations. The method application is restricted only to the spatial aspect and does not deal with other important elements of service-facility adjustment, such as accessibility, layout, etc. Moreover due to the lack of rigorous data, the final result should not constitute a conclusive proof but should be an indication for a more in depth analysis of facilities where the discrepancy is maximal. In addition the decision making process should also consider context fluctuations that may cause periodic changes in service demand for space.

The future research will be focused on minimizing the current limitations. Moreover, the assessment of secondary, supportive activities will be included in the evaluation process to improve the quality of the results.

Acknowledgments This work has been developed within the project Plataforma para la monitorización y evaluación de la eficiencia de los sis-temas de distribución en Smart Cities, ref. DPI2013-47450-C2-1-R with the financial support of the Secretaria d'Universitats i Recerca del Departament d'Economia i Coneixement de la Gener-alitat de Catalunya [grant number: 2014 FI_B00971].

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Adaptive Reuse of Buildings as an Important Factor of Sustainable Development

Krystyna Strumiłło

Abstract Adaptive reuse is a successful global strategy applied in many types of facilities around the world, including prestigious heritage buildings. The aim of this article is to illustrate the potential of the adaptive reuse of buildings and their impact on sustainable development. Implementation of solutions for sustainable construction in this case entails the opportunity to combine tradition with modernity. The analysis of adaptations shows the main strategies, design criteria, and the scope of implementation, because the adaptations usually include not only the objects, but also their immediate surroundings.

Keywords Adaptive reuse · Sustainability · Built environment · Architecture

1 Introduction

Considering the field of construction and architecture, sustainable development can be an important factor not only in improving living conditions and raising the general standards, but also in reducing energy consumption and greenhouse gas emissions. According to the definition set out in the Brundtland Report, sustainable development is understood as socio-economic development, which features the process of integration of political, economic and social activities balanced with environmental protection and sustainability of basic natural processes in order to ensure the possibility of satisfying the basic needs of individual communities or citizens of, both, the present generation and the future generations. The relation of

K. Strumiłło (✉)
Institute of Architecture and Urban Planning, Lodz University of Technology,
Al. Politechniki 6, 90-924 Łódź, Poland
e-mail: kstrumillo@interia.pl

© Springer International Publishing Switzerland 2016

J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_5

sustainable development and architecture was first presented in 1998 in Gävle and published as part of the Agenda 21 in a document titled Sustainable buildings.

The document draws attention to three main domains that affect the balance in the world economy—these are environmental, economic and social aspects. Thus, an appropriate and economically viable use of natural resources and energy for the purposes of producing construction materials comes as a very important task. Agenda 21 also refers to 'rehabilitation' of older buildings, historic precincts, degraded land [1].

The idea of sustainable construction entails that buildings should be designed, constructed and used considering their future role and impact. Our task is to prevent their degradation and limit the amount of waste produced. Economy assumes that the quality of life is the highest possible at a given stage of the developments of civilization, but it is also meant to manifest itself in the economic growth and the enhancement of living standards. In this context, consciously shaped relationships between the economic growth, environmental care (not only natural, but also artificial, i.e., created by man), and the quality of life become truly significant.

The main aim of sustainable architecture is to reduce the negative impact made by buildings on the natural environment and human health. There are also some indirect objectives, such as protection of the users' health (social benefits), effective use of energy, water and other commonly accessible resources (financial benefits) and reduction of waste and pollution, as well as limited environmental degradation (both social and financial benefits) [2]. The postulates of sustainable architectural design should also include minimization of environmental impact, introducing balance between the built environment and the natural environment, and the recovery of degraded areas [3].

How do all these issues relate to the adaptation and reuse of facilities? The existing buildings represent the greatest opportunity for the reduction of energy consumption and carbon emissions. As has already been noted, sustainable development covers ecological, economic and social aspects. The ecological aspect is fulfilled by reducing the consumption of energy, water and materials, greenhouse gas emissions, and waste generation. The reuse of existing structures on site means less energy needed to create and renew these places. We can easily see the reduction of waste that would have been incurred in the event of the destruction and rebuilding using new materials. The economic aspect plays an important role and translates into widely perceived savings.

In addition, through the adaptive reuse of old, disused buildings, we can form new functions. The benefits are noticeable, as the process of adaptation can not only affect savings, but also improve the social and economic conditions. Thanks to the revitalizations performed, historical and important buildings have a chance to retain their unique atmosphere and character, and to become a testimony for future generations. Adaptations contribute to a more historically and culturally sustainable architecture and make an impact on society. This entails the improvement of living conditions and raising the overall standards of the city.

The degree of the implementation of individual postulates depends on the awareness of the designers and their ability to use tools developed for the

construction of energy-efficient and environmentally friendly facilities. Adaptive reuse of buildings is in the interest of all of us, not just environmentalists, because these solutions form the modern city in line with the principles of sustainable development. Simon Guy [4, 5] clarifies this issue and distinguishes six types of sustainable development. These include: the eco-technic, centric, aesthetic, medical, social, and eco-cultural.

2 Challenges Related to the Implementation of Heritage Buildings to the Adaptive Reuse

The process of adaptation and reuse of the existing facilities has developed around the world. It entails the transformation of the existing old buildings into new, modern and eco-friendly facilities. In this respect, the growing ecological awareness of entrepreneurs and designers is also not without significance.

It is essential that the adaptation of the buildings is conducted properly, that is, in a way that preserves the building's value, emphasizes its qualities, minimizes operating costs, and satisfies the investor. Any assessment of this ability should identify decisions that must be made to balance occupant needs with considerations of sustainable adaptive reuse [6].

Nonetheless, we should keep in mind that opinions whether a particular construction should be retained or demolished are not unanimous. According to Ball [7], it is generally preferable to repair a building than replace it because the value of the location and quality of a new building is not necessarily better than the old one. In contrast, there is an opinion that an adapted building will not completely match a new building in terms of performance, but the shortfall should be balanced against gains in social value. Moreover, we cannot forget about cultural values. Historical buildings are often symbolic places with special architectural qualities. They play a vital role in building the identity of the place and the city.

Demolition is often selected when the life expectancy of an existing building is estimated to be less than a new alternative; despite any improvements that adaptive reuse may inject [8]. This would only justify limited investment on a short-term basis prior to disposal and redevelopment. Certainly the life cycle expectancy of the materials in an older building may well fall short of those in a new building. The age of materials will also directly affect the on-going maintenance costs of an adapted building, which, as a result, may well be higher than those for a new building. However, adaptive reuse can offer a more efficient and effective process of dealing with buildings than demolition.

Nevertheless, successful implementation of such initiatives comes as a big challenge. The cycle of the project should start from the stage at which we draft a concept and discuss the project design focusing on the conservation requirements and the needs of the new features with the design team (all specialties), consider all technical and material possibilities, and present the findings concerning the detailed scope of works in order to gain the acceptance of the instructing party—also in

terms of the overall investment costs. It is the spatial arrangement of historical facilities that should determine the possibility of introducing new features, and not vice versa. The necessary tasks are: the improvement of the technical condition, implementation of modern and properly routed installations, the possibility of adapting the basement, modification of the heating methods considering the needs of energy savings (energy efficiency and insulation of the interiors), introduction of effective methods of protection against moisture, and ensuring proper fire safety [9].

Adaptive reuse of facilities is the process of converting the existing old buildings into new, modern, eco-friendly facilities. This is why growing ecological awareness of entrepreneurs and designers is a crucial factor in such initiatives.

The most desirable actions for adapted buildings include: increasing energy efficiency, increasing the share of renewable energy, reducing greenhouse gas emissions. This involves replacement of central heating and modernization of heat substations, improving the insulation of walls, installing proper ventilation systems, and the reduction of heat loss through windows. In this respect, the degree of general facility conservation, the degree of survival of original sections of the building and their value are particularly important.

According to the Polish Act on the Protection and Care of Monuments (2003), the concern for the preservation of monuments is primarily the responsibility of the owner or the user of a given property. Wise adaptation can thus serve as a salvation to such facilities.

3 Examples of Re-used Buildings—Good Practices

One of the most successful revitalizations is Karol Kretschmer's wool and cotton products factory located at 62 Kopernika Street in Lodz, Poland. This large plot includes a complex of post-industrial buildings. The main building from Kopernika street side has been transformed into "Tobaco Hotel" with interior decoration based on the fifties, whereas the remaining post-industrial buildings have been converted into lofts. The architectural design has taken into account the need to preserve the characteristic features of the factory, such as a red bricks in the facade, but it also introduced new walls plastered in white, with transparent railings. The hotel uses energy-efficient and cost-effective solutions, just like the Andels Hotel located in a former spinning mill that belonged to Izrael Poznanski. The facility has undergone thorough revitalization conducted according to maintenance instructions, which has preserved its historical character.

It is worth mentioning that in the United States there are incentives for investors who decide to adapt and reuse the existing facilities, as they are this way entitled to participate in programs leading to financial benefits incurred through significant tax exemptions. These new incentive programs for investors, which promote efforts to revitalize urban and rural areas through the re-use of historical buildings, help reduce construction costs, which may lead to substantial savings in the project's budget. In a word, the choice of adaptive reuse instead of the

construction of a new building enables hotel owners and developers to use their budgets more effectively. As far as this domain is concerned, the hospitality industry readily takes up such initiatives and commits to creating environmentally friendly hotels. This has enabled to create such facilities not only in metropolitan areas, but also in smaller cities and suburban locations. Such measures can provide significant savings and stimulate preservation of historical structures, which in turn translates into sustainable development.

A good example of such adaptations comes with the Nylo Hotels that form a network of environmentally friendly buildings which preserved many of their historical and original features. Adaptations meet the criteria of energy efficiency, as they use modern systems and recycled materials. They also meet the objectives of conservation, aesthetics and the combination of tradition with modern design [10]. Moreover, hotels in Dallas and Providence operate using 100 % renewable energy that comes from solar, wind, biomass and hydroelectric power sources.

Let us take a closer look at one of such facilities: the Nylo Hotel in Dallas is located in a former warehouse for dry products built almost one hundred years ago (in 1924) and adapted for the new purposes. The facility was closed for more than a decade. After the adaptation, the five-storey building became a part of the revitalized structure. As such, it is a combination of historical and modern elements. The project meets the criteria of energy efficiency, as it is registered under the NC Rating System LEED 2009 and holds the LEED Gold Certificate [11]. Ecological solutions implemented here include the use of natural materials (e.g., cork, wooden fornites) and low-emission materials and windows. All paints, coatings, adhesives and sealants used inside the shell of the house are environmentally friendly. The adaptation of the building takes into account the reduction of water consumption (e.g., the reuse of water from the staff toilets) through the use of reclamation of water from sinks and showers, which drains into the sewer and is then used to flush toilets. This solution and the use of low-flow water fixtures will enable to reduce water consumption by 35 %. Rainwater from the roof is collected in special tanks and then used for watering plants (both on the roof and in the areas adjacent to the building). The existing floors have been retained by sealing the concrete floor below them and restoring the existing terrazzo. In addition, as much as 75 % of the debris from small demolition works was reused in the rooms.

The implementation of energy and light control system also entails the use of presence detectors in the rooms. When the hotel rooms are empty, the detectors turn off the lights and lower the temperature. Due to the historical status of the facility, there were some limited opportunities to improve the efficiency of the buildings, but sustainable solutions have been introduced whenever and wherever possible.

Another interesting example of the reuse of the existing buildings is the adaptation of the oldest shopping mall in the USA called Westminster Arcade, located in Providence. The mall was built in 1828 in the Greek Revival style, and served in office until the twentieth century. The modernization project was proposed later, when the building was already closed. The adaptation design retained the original appearance of the facility and it included an adaptive re-conversion to create the

combination of commercial functions on the ground floor and residential functions on the top two floors, i.e., micro-apartments.

When it comes to adaptive reuse, we cannot forget about the huge potential of post-industrial areas. Although a number of revitalization initiatives have already been taken in such locations, this topic is still valid. Through adaptive reuse, the former industrial areas are a good base to solve and mitigate environmental and social problems in accordance with the principles of sustainable development. Reintegration of former industrial areas into the socio-economic structures plays a significant role. Post-industrial monuments are a chance for many cities. In Poland, the flagship revitalization of this kind is Manufaktura in Lodz. Former factory complex (one of the largest in Poland) was transformed into a center of cultural entertainment and shopping. After many years of its successful operation, we can speak not only about environmental benefits, but also about its positive social impact, because it is a place integrating the residents of the city. Moreover, the complex enriched the value of public space. The author's hometown includes more such examples and the former EC1 power plant is yet another adaptation of this type. EC1 is a part of the New Centre of Lodz, which is just being construed. The purpose behind the transformation of this facility was to change the function of the existing building into the center of science and culture, while preserving as much of the existing structure as possible. Nevertheless, some new elements have also been added, which has created an interesting form. This is proved by the fact that the building has been awarded the title of Bryła Roku (The Shape of the Year) in 2013. This way, the New Centre of Lodz is an example of sustainable revitalization of the city's downtown.

One of the most successful and unique projects entailing the reuse of industrial buildings in Europe is the old gas tank is the Gasometer City, Vienna, Austria. Four huge disused gasometers were rebulit in the late 90s. Gas tanks in Vienna were used from 1899 to1984, but when the city turned to natural gas, they were closed. Tanks have now found a new use, as all four of them have been divided into specific areas for living, working and entertainment. In Gasometer there are currently 800 apartments, a dormitory, a music hall, a cinema, and city archives. The facility has retained its character thanks to the respect for the existing brick walls. Actions that stimulate such new features and help restore old buildings (and groups of buildings) to life are helpful in achieving sustainable development. They regenerate the area and enhance residence capabilities (lofts).

4 The Importance of Activities Oriented at Saving the Existing Facilities

Adaptive reuse of facilities is the process of converting existing buildings into new, modern, eco-friendly facilities. The main objective of the reuse of the existing buildings is to improve the quality of residence and life while reducing the power consumption necessary for the construction and operation of these

buildings. Moreover, it enables to reduce material consumption. It is assumed that as a result of modernization the facilities retain their functionalities and gain new features while the conditions of their use are improved (e.g., heating costs and utility consumption are reduced). In this respect, the financial capacity of the investor is significant as well. Typically, an adaptation changes the purpose and principles of operation of a given facility. Nevertheless, it also has aesthetic value of historical importance. Many historical buildings in Poland survived thanks to the functions that they have been given in the post-war period, after radical change of ownership. It is worth noting that in Poland many residential properties with gardens have been preserved. From the point of view of properly carried out restoration and maintenance of facilities in their original shape, proper use of historical buildings is obligatory [12].

Thanks to the fact that many such buildings have been turned into museums, a number of facilities of this type avoided devastation and the impact of inevitable aging resulting from the lack of hosts. They have been subjected to constant conservation works and covered by special care because of the collections gathered by their owners, and as such they have become a valuable testimony to the cultural tradition. Many of them feature well-preserved authentic interior decorations, while other retained their original design. In Lodz, examples of such buildings include the Museum of the City of Lodz located in the former Poznanski Palace and the Central Museum of Textiles located in the Ludwig Geyer's White Factory.

Another group consists of facilities that have been abandoned for many years and are subject to a more thorough adaptation because of the damage caused by negligence. They are mostly designed to function as hotels or residential buildings and there are many facilities of this type in Poland. The adaptation of buildings is either total or partial, including the expansion of "the existing" construction volume. The scope of intervention (ranging from repair works to full reconstruction) determines the scale of the transformation of the facility. The latter is generally lower in the case of buildings that, for example, "originally" served as hotels, but there are also larger adaptations that lead to new features of the building. Sometimes the adaptation for hotel purposes leads to a change of the original purpose of a given facility.

Adaptations without changing the original functions were carried out in the following hotels in Poland: "Pod Orłem", "Ratuszowy" and "Centralny" in Bydgoszcz, and "Polonia", "Trzy Korony" and "Pod Orłem" in Torun.

Hotels located in historical buildings combine two important features. They are a component of tourism development and as such they increase the attractiveness of a given place. This is because the preserved or restored original pieces of equipment are in fact functional, while they still retain their historical or artistic value [13].

Historical heritage conservation is a fundamentally important element of the world's social capital. All actions taken in favor of the reuse of the existing facilities, that is, the adaptation to the needs of the society, create benefits for the environment and for the future. Opportunities for the adaptability depend on the condition of the facilities and the scope of proposed changes.

The activities for the development of sustainable architecture should highlight the important role of the architect as the creator and coordinator of the design process, because this enables to ensure proper relationships with the existing environment [14]. This is one of the factors that affect the success of projects of adaptive reuse. Human activity should enhance natural environment.

It is worth mentioning that sustainable development proposes the improvement of the quality of life in cities by recovering old and abandoned buildings, limiting construction expansion and increasing the amount of greenery. Therefore, there is a tendency to limit the territorial expansion of cities in favor of compact city areas, the current space of favors greenery and places of social activities rather than road infrastructure. There are also activities aimed at the elimination of cars as the primary mode of transport. These initiatives promote public transport and develop systems of bicycle routes. Such activities also have economic justification, as people are more eager to invest in places that are friendly to them.

5 Conclusions

It should be noted that urbanized space is the living environment of a modern man, whose quality of life is ensured by sustainable architecture. Therefore, sustainable architecture contributes to the fulfillment of basic human needs.

Transformations and reuse of facilities are thus one of the ways of saving our environment and as such they fit in with the ideas of sustainable development. Moreover, preservation and protection of many built cultural archetypes that already exist, combined with concern for the cultural continuity, present huge environmental benefits.

Strategies and design criteria result from individual analyses of individual objects. Technological possibilities change over time. Nevertheless, any adaptation using the existing opportunities and modern solutions comes as a salvation to the natural environment. Reuse of facilities is meant to minimize the impact on the environment, but we must remember that adaptations also raise the value of the facility itself.

Substantially, adaptive reuse projects help to revitalize urban city centers and reinvigorate neglected neighborhoods, while utilizing energy-saving innovations and creatively incorporating sustainable materials into the structures. The adaptive reuse of buildings is a climate-friendly strategy to stimulate built environment sustainability.

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Part II
Ergonomics in Building and Architecture

New Concepts in Arrangement of Living Spaces for Students

Anna Jaglarz

Abstract Designing living spaces for young people studying in secondary schools and universities is now a big challenge, because the needs, requirements, behaviors and habits of this social group to a large extent are influenced by social processes and social and cultural transformations resulting from technological progress and innovations. The ability to provide an adequate level of comfort needed for daily activities associated with learning, recreation and entertainment necessitates a number of insightful observations and understanding of the needs of users. The analysis will be concerned with student accommodations and living quarters in boarding houses, dormitories, hostels as well as individual private apartments and flats designed with a view to the preferences of this social group. Article will focus on possibilities in the area of innovative methods for functional and spatial shaping these objects, and will present the abilities of modern technologies and materials which allow for adaptation of these objects and facilities to the different requirements and needs of users.

Keywords Living space design · Student housing · Dormitory · Arrangement of dorm room · Flexibility of space · Multi-functionality · Modularity

1 Introduction

Currently, there are many ideas and concepts related to the development and formation of living spaces designed for full families, pairs, or independent singles. However, a much greater challenge for architects and interior designers is to create

A. Jaglarz (✉)
Faculty of Architecture, Wroclaw University of Technology,
Prusa Street 53/55, 50-317 Wroclaw, Poland
e-mail: anna.jaglarz@pwr.edu.pl

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_6

living spaces for students—young people who due to the location of educational institutions and campuses need to leave their family homes and live in new places and surroundings, which is often different from their home conditions. It is usually the first time when these young people need to live away from their households, in the unfamiliar environment, so ensuring them friendly and favorable living conditions is such an important issue. In addition, they represent a particular social group whose needs, requirements, expectations, and behaviors and habits are to a large extent influenced by the processes of social and socio-cultural transformations resulting from technological progress and innovations.

Ensuring an appropriate level of comfort of living that is necessary for daily activities associated with learning, recreation and entertainment requires, above all, understanding the needs of young users. Practical, functional, emotional and social needs of the students are completely different than needs of the other groups. These needs should be carefully analyzed and taken into account in the process of student living space formation. Such actions apply to both the design of collective student accommodations and living quarters in boarding houses, dormitories, hostels as well as the design of student housing in private apartments and flats.

2 The Needs, Requirements and Expectations of Students

Over the last decade we have observed pronounced change in how students engage with the surrounding world. Social interactions occur completely differently and in more diverse environments than several years ago. There are new social networking opportunities, learning opportunities and new ways of sharing knowledge and experiences. This situation has much in common with the development of modern technologies that accelerate and support the observed transformations. Therefore, the use of the latest technical and technological advances in the creation and development of student living space is essential and obvious. The question arises how to properly use innovative methods in the formation of functional and spatial interiors for students and how to think about these spaces that may foster social interactions, support individualism, provide an opportunity for self-expression, while ensuring a sense of privacy and intimacy. The challenge is finding a way to optimal plan, organize and use the available space so that it can meet the needs, requirements and expectations of users [1].

In order to create the living conditions for the proper functioning of the future users in the context of the above aspects and taking into account current trends, it is necessary to analyze what contemporary students need, want and expect in their living places and to examine their previous experiences in this regard.

First of all, we should consider the fact that these young people need to realize most of their essential needs, functions and tasks in a one, often a small, space. Their daily life activities, such as sleeping, learning, rest, play, integration with other people, are held in the one place. They also need to hold the necessary

everyday items there and sometimes need to prepare and eat meals in the same place. It is important to define living and sleeping spaces and the introduction of partition, even contractual, between the roommates, providing an adequate degree of privacy. It turns out that traditional furniture that is popular equipment of rooms in dormitories impedes optimal use of the space. For this reason, it is necessary to find other reliable and flexible solutions.

Today's students as representatives of the culture created by the digital information age prefer other ways of acquiring knowledge than their peers before years ago. They use the latest technical and technological achievements and innovations frequently and intensively. They often learn and work together. For them, cooperation is a very important part of education. Contemporary students are good at the multi-tasking and very intuitive in problem-solving. It is necessary to create for them well-organized places of group work, but also a quiet and secluded spaces provided for individual study. Students in their living quarters need space dedicated not only to sleep, study and storage. They also want a place to rest, play, recreation. Common space, that they can use for meeting with others, integration and collective actions, is essential for them. These young people need a sense of privacy, intimacy and security. They desire space that supports individualism, provides personalization and gives possibility of self-expression, but also wish an environment conducive to social interaction, co-operation, socializing. Their expectations are focused on the comfort, easy, efficiency and flexibility of use of space. Desirable features of contemporary students' living space include versatility, flexibility, multi-functionality, mobility, transformability, adaptability, adjustability, modularity, compactness, space-saving. Easy to adapt to the changing needs of the inhabitants is very important. Observations, analysis and unconventional thinking about living space can help find the best solutions allowing for optimal use of available space, for meeting the needs, requirements and expectations of users and for creation a friendly environment foster their everyday life [1, 2].

3 Arrangement of Student Housing

3.1 Methods and Principles of Shaping Living Quarters for Students with Regard to Their Suggestions

The ways of designing living spaces for students should be the answer to their demands in this area. Based on the analysis of needs, requirements, expectations and preferences, we can focus on the most important issues and elements which should be especially taken into consideration during the process of functional and spatial shaping of the interior.

- Ability to reconfigure the room layout and ability to transform the interior is very important.

- Not all students learn in their rooms, some of them doing it in other places. Therefore, we should consider whether desk are necessary in all the bedrooms and that their quantity should be adjusted to the number of inhabitants. Limiting the number of desks can increase space in the room and can allow for greater flexibility.
- Students prefer configured, compact, modular, built-in furniture, with possibility of forming the walls and partitions, that defines the space and isolates areas. Idea of reconfiguration and mobility of furniture is priority.
- The idea of mobile bed is also desirable. It can be retractable or folding. It can comprise the drawer or container for the storage of bedclothes. The space above the bed should be used for the bookshelves placing.
- A convenient solution is the seat—cushion, that doesn't take up too much space, is soft and easy to hide.
- A large part of the students uses the laptops, but they must be able to freely set desktop computers and additional computer accessories in the right place that provides the connection to the network.
- Rooms should provide access to the Internet, fast connectivity and the growing use of the latest technological achievements.
- Traditional desk can be replaced by tabletop or other solution which fits the idea of the work surface.
- Storage space for both books and clothes is always the problem to be solved. It is generally lacking or uncomfortable, inadequate, poorly organized, not flexible. Students usually prefer modular bookcases and built-in closets over traditional wardrobes.
- Customizing student living space should include the possibility of creating private zones particularly in rooms with multiple inhabitants.
- Students do not like traditional "dorm looking" furniture. They prefer configured, compact, modular, mobile, flexible furniture, with possibility of settings adapted to the changing needs.
- Color in the student rooms is extremely important. Students like vivid, warm, bright tones. The interior in gray, beige or white may be perceived as boring and sad. Maybe even one wall should be in a different hue? Maybe some color accents should appear? The interior should be energizing, not depressing.
- Colors in combination with light, materials, textures, shapes, size and placement of interior elements, and even style of interior can affect users perception of living space. Therefore, properly selected and matched interior elements can be a simply way to improvement of visual size and proportion of the rooms and simply way to creation of pleasant atmosphere in the interior. It all determines how the students feel in the room.
- It is important to use friendly materials, patterns, graphics which affect "domestication" and coziness of the interior. Students prefer warm, pleasant materials, such as wood. More negative feelings are caused by the "hard" materials, such as concrete, steel, glass which are perceived as "cold".

- An important element of the interior is the use of adequate lighting (both utility and aesthetic) and its location. The quality of light is as important as its quantity. It should be noted, that the light should not be dazzling.
- Appropriate use of colors, patterns, materials, pictures can also give the inhabitants a sense of individualism, the ability to personalize and identify with their semi-private zones.
- Ensuring sense of privacy, intimacy and keeping the "safe" distance between the contractual areas of inhabitants, especially between the beds, are necessary. Not everyone likes view of his roommates face or feet when he wakes up.
- An interesting idea and a good method of providing some degree of privacy is setting along the edge of the bed, light, openwork, translucent partition—divider wall. It sometimes comprises other functional elements—shelves, hangers, panels for attaching notes and pictures. It can also be just a concept of room decoration.
- Today's young people are getting taller. They need a large, comfortable beds.
- Students expect the easy adaptation of space to their needs that are variable both during the day and during the whole semester. Room system and elements of equipment, which can be configured in many ways are the most desirable.
- Optimal planning of the room and maximum and effective use of the space in all three dimensions is extremely important. Students do not like bunk beds, but are eager to use the space above the beds. Appropriate organization and design of this place can enable them storage a lot of things.
- The idea of entresol can be a convenient option. This place can be used as common, recreational part of room, but it can also be an isolated place to sleep. The space under stairs can be designed as a place for storage.
- In order to ensure adequate learning conditions for students, taking into account their preferences for common places for collaborative study and work, but at the same time the possibility of individual learning in isolated areas, we should design spatially arranged nooks and recesses, which should be isolated acoustically, but not entirely visually. Young people combine education with socialization and the visual communication can provide sense of integration rather than isolation.
- Students while studying like to use comfortable, soft, and at the same time playful, whimsical seats, which also guarantee them relaxation, fun and good mood. Sitting on a rigid, hard chair at the desk completely does not work.
- For the purpose of learning more often they choose bright, well lit, preferably by natural light, spaces. The planned arrangement of the room should provide such places as much as possible. Access to natural light is extremely important.
- Students appreciate the access to the window, the opportunity to enjoy the view outside the window. They appreciate the "justice" in organization of room interior respecting the location of windows.
- Additional places located outside the building, such as balconies, loggias, terraces are advisable. They can be used for learning, rest and recreation.

- Thermal comfort is extremely important. We should pay attention to the possibility to adjust the room temperature to the users' needs, the ability to open windows and to ensure good ventilation [1–5].

3.2 Multi-Functionality, Mobility, Flexibility—Desirable Qualities of Student Rooms

Great opportunities in arrangement of student rooms can be provided by multifunctional, compact modules and walls containing a bed, desk and storage, configured for mobile, portable partitions that allow for adequate separation of areas depending on requirements of inhabitants. They provide flexibility and efficiency of space in the rooms and more comfortable functioning and using without increasing the usable space. They facilitate transformability of spaces, affect their versatility, while increasing the ability to easily adapt to the changing needs of users [1].

The use of multi-functional modules helps not only save place generally used for several mono-functional facilities, but also reduce the space required for their use. The multi-functional module is a combination of functions and tasks that are traditionally provided for several individual objects. This compact combination reduces the space occupied by different separate mono-functional facilities and allows for extra space. Taking into account the limitations of areas in students rooms, retrieval of space is very important from the point of view of the demand for physical space for users.

Multifunctional, mobile solutions, adapted to different tasks, affect the flexibility and versatility of space, providing possibility of modification the layout of the room at any time and any configuration of pieces of equipment according to expectations of inhabitants. The required degree of privacy and intimacy for the individual can be achieved by the use of mobile, portable partitions, which are helpful in getting semi private spaces. Movable partitions and mobile, portable, foldable, retractable and extendable elements of room equipment allow users to create quickly and seamlessly a larger common space needed for group work. They allow students to change the workplace for a place to rest or recreation and vice versa at any time.

The modularity is an important factor in optimal shaping a small space. It facilitates collating and matching various components depending on the individual preferences. It affects the maintenance of spatial order and aesthetics of interior, while allowing for easier and more convenient keeping cleanness.

A prerequisite in the arrangement of small rooms is optimal flexible shaping space in its all three dimensions and effective use of it. Functional and spatial solutions in the form of built-in furniture or recesses in walls and spaces under the stairs adapted for storage are favorable and valuable in terms of space saving. Furthermore the use of the spaces above or under the beds can be helpful in customizing small rooms to needs of students.

3.3 Exemplary Methods of Shaping Living Space for Students—Projects

As part of the competition *Live Comfortably* organized by *The Goga* dormitory in Wroclaw, students of the Faculty of Architecture from Wroclaw University of Technology have created modernization projects of residential rooms for students living in this institution. The projects were made in the academic course *Design of Interior Architecture*.

The Goga dormitory is a private, residential, care and educational institution, designed for secondary school students aged 16–19 studying outside their place of permanent residence. Inhabitants of dormitory are students of Wroclaw high schools and technical colleges. Most of the boys living in a dormitory are athletes attending sports classes (they are height approx. 2 m). Living spaces are located on three floors of the building. On the first floor there are rooms for boys (mostly sportsmen), on the second floor—rooms for girls and boys, on the third floor—rooms only for girls. Each floor contains seven three-bed rooms, one five-bed room, one four-bed room and one two-bed room.

The aim of the competition was to select the best proposals for arranging interior of rooms, designed according to the principles arising from the needs, requirements, expectations and preferences of students.

Design bases and requirements were as follows:

- taking into account the number of people living in individual rooms,
- taking into account the location of the beds with a length of 210 cm for athletes,
- taking into account opened beds, containing inside spaces for the storage (no drawers),
- elimination of bunk beds,
- arrangement of individual places for storage in clothing closets (more shelves, hangers less),
- designing common hangers for outerwear,
- organizing of spaces to store shoes,
- designing spaces to store suitcases and travel bags,
- designing places to learn and study,
- designing shelves and other places to store books,
- taking into account the location of mirrors and towel rails,
- designing individual cupboards—places for storage of food, utensils and sanitary accessories (according to sanitary regulations),
- taking into account the ability to easily maintain order and cleanliness in the room.

With these principles in mind and taking into account the design bases, needs, requirements, expectations and the current trends in the development of living spaces for students, authors have proposed innovative solutions to the various possibilities of the interior rooms formation. They have submitted many ideas and concepts of functional and spatial arrangements. Selected projects have proven

Fig. 1 *The Frame Wall*—example of shaping student living space. *Source* student project depicted by W. Cebula, tutor—A. Jaglarz

Fig. 2 *The Living Platforms*—example of shaping student living space. *Source* student project depicted by W. Cebula, tutor—A. Jaglarz

the best adapt to the needs and demands of young people, and have presented the most optimal, flexible and creative approach to arrangement of the living spaces for students.

The first of the awarded projects *The Frame Wall* is the idea of organizing a small space in the most valuable way. The room was divided into smaller, private zones by light partition walls, which, thanks to the perforations provide a visual communication with the whole room. This action enables the integration of roommates. The openings in the walls are not only decorative elements, but contain a shelf, space for temporary hanging clothes and special hangers and supports for books, pictures etc. Common area was located closest to the wall with a window (Figs. 1 and 2).

The Living Platforms is the idea of creating a completely new living space, unusual and very different from what is known so far in this area. The concept is based on the division of space into similar, repetitive, modular units, which are multi-functional objects. Characteristic platforms, whose primary task is the function of sleep, are the leitmotif. Both the graphic and spatial form of the walls texture and pieces of equipment refers precisely to them. The interior is

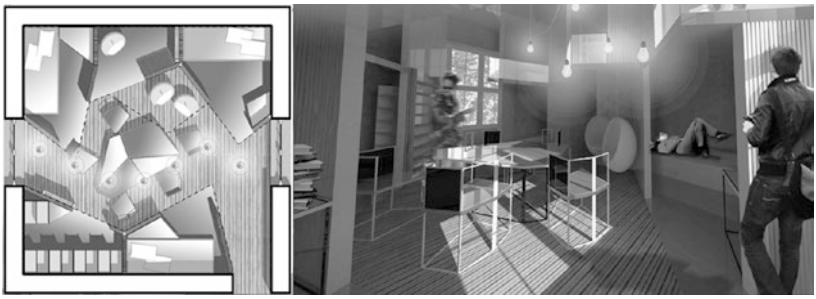

Fig. 3 *The Geometry*—example of shaping student living space. *Source* student project depicted by W. Cebula, tutor—A. Jaglarz

complemented by segmented walls that contain a space for storage, shelves, additional lighting, seats and other places to rest.

The Geometry is the concept of modern interior that is formed by two-level space. The idea of project is creation of dynamic, neon, geometric solid that brings together all the required functions and tasks. Way of organizing space allows to isolate and separate zones of common areas, study and work areas and private areas. The entresol has been organized as a sleeping area and a recreation space (Fig. 3).

The leitmotiv of the next standout design is *The Rectangular Frame*. This form of different sizes occurs in various spatial configurations and creates individual elements of the interior. Perforated and openwork partitions separating the beds consist of such a frames, which are not only decorative elements, but they also have the functions of the shelves, hangers, supports. Such forms also appear on the walls as a place for storage. Also lamps have the same shape. Multi-functional, compact, modular wall unit consisting of open or closed shelves, cupboards and extendable drawers, is a place to store practically everything. The all box is a configuration of rectangular modules of different sizes. This distinctive element is not only a place to store and dressing room, but it is also a barrier separating the study and work area from the rest of the room. This area is located above, on a raised platform. The space under the platform and under the stairs is used as a place for storage. The wall unit, which divides and defines the space is topped with the rectangular horizontal tabletop to work. The rectangular strip—panel, which can be used for attaching different pictures and notes runs around the room, on the walls at a height of about 2 meters. There are also deep lockers hanged on the wall that are used to store larger items such as suitcases and travel bags. The main idea of this project was the notion that place for storage is always lacking, and it is always desirable. Concept has been presented in three different color variants—orange, green and red. They have showed the ways of shaping rooms of various sizes (Figs. 4 and 5).

Example of effective use of a small space is another award-winning project. The concept is based on the use of multi-functional, compact enclosures of beds,

Fig. 4 *The Rectangular Frame*—the leitmotiv in arrangement of student living space. *Source* student project depicted by A. Kieliszek, tutor—A. Jaglarz

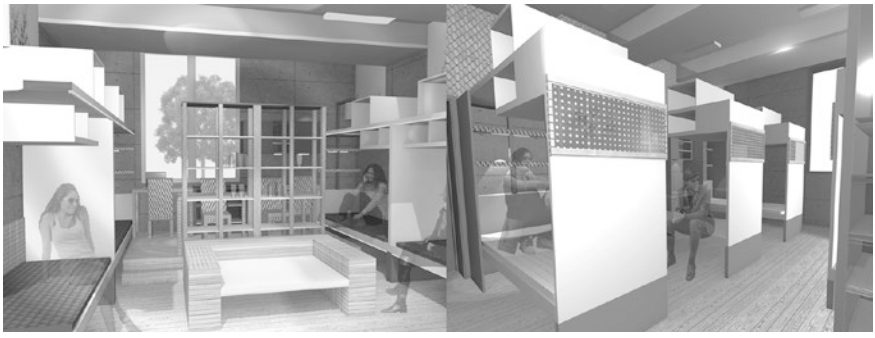

Fig. 5 *Beds with the enclosures and the central common area*—example of shaping student living space. *Source* student project depicted by M. Bronowicka, tutor—A. Jaglarz

which in addition to function of storage the necessary items, provide the possibility of intimacy by creating a separate, private zones. At the same time, such a solution does not interfere with the visual communication of inhabitants with the environment. The project emphasizes a clear division of space into a sleeping area,

a common storage area and a study and work area. Interior of four-bed room is an example of how to organize a versatile common place. Among the solutions used in the project we can find interesting material, color, pattern, graphics and lighting concepts.

4 Conclusion

The observations and analysis the latest trends in shaping the living spaces for students confirm that the rooms of today's students should not only meet the diverse needs of inhabitants, but should also have certain characteristics that affect the way their implementation and degree of users satisfaction. The most required and expected features of contemporary student's living space include versatility, flexibility, multi-functionality, mobility, transformability, adaptability, adjustability, modularity, compactness, space-saving.

It turns out that students are not interested in ordinary "dorm" style in their residential areas. They want to escape from boredom and they expect excitement, diversity in their daily lives. Today's students need inspirations and incentives to work, create, express themselves and their emotions. Therefore, they are open to innovative ideas and unconventional solutions and they expect ingenuity and creativity from the designers. Interiors should be friendly, encouraging, stimulating, giving the possibility of visual communication, integration, while providing the ability to sense of privacy and intimacy. Using of them should be comfortable, easy, secure, ergonomic and ensuring well-being of users.

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Re-consumption of Materials in Architecture

Jerzy Charytonowicz and Maciej Skowroński

Abstract In the paper we present the statistics showing how the building industry influences natural environment. The conclusion drawn will make it possible to define the connections between the re-consumption architecture and the issues within ecology, as well as eco-ergonomics. The further issue discussed in the paper refers to the review of modern strategies within pro-ecological engineering design, which are now obligatory in the European Union countries, including Poland. At this background, the hierarchy of actions towards those buildings which are close to the end of their primary lifetime, developed by the Author, will be presented. In the main part of the paper the results of the analysis concerning the branch literature will be presented, which is to examine the technical potential of the re-using materials in architecture. The results mentioned will give practical recommendations as to the guidelines, showing how reclaimed materials and elements of buildings can be used.

Keywords Re-consumption of materials · Reuse · Recycling · Green design

1 The Impact of the Building Sector on Natural Environment

The world economy of today is characterized by an extended impact on the natural environment, which may pose a global threat to it. All the phenomena and processes observed in economic structures are affected by a continuous anthropogenic

J. Charytonowicz (✉) · M. Skowroński
Department of Architecture, Wroclaw University of Technology,
Bolesława Prusa 53/55, 50-317 Wrocław, Poland
e-mail: Jerzy.Charytonowicz@pwr.edu.pl

M. Skowroński
e-mail: Maciej.Skowronski@pwr.edu.pl

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_7

pressure exerted on them. This is closely connected with the exploitation of resources and all natural environment, which is compelled by the needs and the existence of man. According to the statistics, it is the building sector that significantly exerts this pressure. All building activity results in a higher exploitation of resources and a lot of waste produced, accompanied by a high consumption of energy throughout all the life cycle of building materials: beginning with a wasteful extraction of resources that are necessary for production, through processing and transforming, then transport and using as building components, up to demolition and—if possible—utilization. Due to a high durability and often too demanding technical parameters, as well as massive weight and volume, building materials and the waste left after them contain a significant potential of the so-called 'grey energy' that is necessary to make them, transport and use in their original life cycle.

The impact on the natural environment made by construction industry is observed as early as the stage when the resources necessary for production are extracted. Another threat appears while the ready-to-use products are made in a more or less advanced technological processes which consume a lot of energy, water and other natural resources. Simultaneously, technical sewage as well as solid waste and poisonous gases are produced, which contaminates the natural environment. When the building process has begun, a negative impact on the environment involves the preparation and cleaning of the area for the building lot (removal of greenery, humus, earthworks, etc.), making access roads and temporary objects and quite often storing some dangerous materials in that place. Moreover, in the building area the noise and vibrations are much higher (as heavy machines are employed), the landscape and the level of ground water distorted, and many others negative effects may appear as well. The building process itself generates a high consumption of energy and the pollution of the atmosphere. Nevertheless, the biggest impact is made while a building object is being used. In most climatic zones, due to a long time of use, the total consumption of energy in order to keep the comfort of warmth, as well as good microclimate of the interiors throughout the whole utility cycle is significantly higher than during the stage of manufacturing building materials or when the object is being constructed. In the European Union, as much as 40 % of energy is consumed while the object is being used, which contributes to large emissions of carbon dioxide—a gas which creates 50 % of the greenhouse effect [1]. What also influences the natural environment is the phase of demolition and later utilization of the waste produced.

To illustrate the current impact of the building industry on the natural environment in the European Union, including Poland, some basic statistics and facts should now be presented as follows [2, 3]:

1. In the last century the consumption of fossil fuels in the world has grown 12 times whereas the exploitation of non-renewable resources is 34 times bigger now
2. In European countries almost 50 % of the currently extracted fossil fuels are processed and used by the building sector

3. In the countries belonging to the European Economic Area [EEA] the building sector produces the highest percentage (32 %) of all the waste generated
4. In the first decade of 21st century for one European citizen statistically there were 2 tons of building waste yearly—not including the waste while the resources necessary to produce building materials are being extracted (then the figure should be doubled)
5. As for the building materials, at the end of the noughties, the average level of recycling in the European Union countries reached approximately 46 %
6. In Poland the recycling in the building sector has reached only about 30 %. Due to the obligation imposed on the member countries by the European Union, in 2020 the potential amount of building materials recycled or reclaimed in other ways should reach at least 70 % by weight.

The statistics thoroughly analyzed show the intensive exploitation of resources and the amount of waste produced has been growing continually for many decades now. The factors confirming a high consumption of energy and materials in the building sector may incidentally hesitate but this is rather due to general economic disturbances than a lower demand for primary building materials in consequence of technological advances and cleaner manufacturing processes.

2 Modern Strategies in Engineering Design

In 20th century, the world experienced a visible civilization leap, continually accompanied by a growing consumption in many industrial sectors. The leaders of this economic expansion were the United States, Europe, and some Asian countries. The progress was driven by a wasteful extraction of resources, as well as a relatively easy access to cheap, non-renewable sources of energy. Throughout decades the side effects of this process were ignored and a gradual degradation of natural environment as well as depletion of resources were neglected. The turning point of this involuntary drift to destruction appeared when the UN Secretary-General Mr. U' Thant presented his Report at the 23rd session of the General Assembly in 1969. The Report revealed some symptoms of a global crisis resulting from a wrong attitude of man towards the natural environment and predicted serious threats if the environmental limits are still exceeded. Mr. U' Thant's warning against a possible global ecological disaster was then confirmed in a report issued by the Club of Rome in 1972, published as 'The Limits to Growth'.

Modern architecture of 21st century that is created with respect to the natural environment ought to meet the basic principles of balanced development, including various aspects, such as: the social one (being healthy and friendly both to the users and their surrounding), ecological one (not doing harm to natural environment) and economical one (as there is no point in implementing modern solutions and ideas if only few people can afford to pay for them). As far as the social aspect is concerned, one should consider a wide range of ergonomic factors involved

in a proper creation of the inner areas of buildings. The balanced development mentioned above ought to be achieved in accordance with the decouple, which assumes the separation of economic growth from the degradation of natural environment. The quality of living should be accompanied by a decreasing amount of waste and a relieved burden on the environment, which would be just contrary to what is happening now.

Another principle to be respected in the modern architectural design and the building sector is the rule 3 × R: reduce, reuse and recycling. The order is meaningful here as the biggest advantage would be taken from a reduced amount of waste, then there would come a secondary use of materials and at last recycling whose third position results from a necessary use of energy involved in it. To make Rule 3 × R work properly, another R should be added to emphasize the re-orientation of views and a new attitude to waste which is perceived now as a valuable source of materials in which a popular trend to have everything new is gradually forgotten. The European hierarchy as to how the waste should be processed is also based on this 3 × R Rule.

Another strategy refers to the analysis of the materials' life cycle. The impact of the building industry on the natural environment is measured for all the time while the object is being used, including its sub-components as well. Thus, the assessment is not reduced to the phase when the product—here the building object—is being used.

The current trends in the world architecture more and more often include ecological aspects. We may say that in the second half of 20th century a new direction in architecture, the so-called re-consumption architecture, understood as the architecture constructed from recycled or reclaimed materials, has been formulated. As we now see, due to the use of secondary materials, with reduced costs, energy consumption and limited extraction of resources, the problem of ubiquitous waste can be relieved and the aims of architectural design can be achieved as well.

3 Re-consumption of Materials

The re-consumption of materials is a relatively new idea that appeared in Polish publications at the beginning of 21st century. Yet, the branch literature does not give a precise definition to it, so it seems reasonable to explain it first. The re-consumption of materials means that materials are re-used and this includes such issues as:

1. The use of reclaimed materials and components, and
2. Re-use of materials and components.

Materials are reclaimed when the waste materials are used for good purpose replacing the new materials. Also, the process of reclaiming takes place when the waste material is being prepared to perform this new function. According to the updated law: 'On the waste materials' [O odpadach], the process of reclaiming

refers only to those products which have been defined as ‘waste’. A particular form of reclaiming is recycling. Recycling is a reclaiming process in which waste is processed and consequently becomes a product again—a recycled element is not treated as waste anymore. As ‘recycled materials’ one should understand, first of all, new products manufactured in the industrial process of transforming waste. Re-consumption of materials also involves the re-using of those materials. Re-using means a secondary use of those elements which have not been earlier defined as waste. For instance, this takes place when the existing construction system of the building is being adapted during the process of rebuilding.

Having reviewed and classified the realizations completed so far, we may say that re-consumption of materials is being developed in three forms:

1. Secondary use of building materials in the place where they were originally applied, e.g.: architectural adaptation of the building, renovation, alterations, rebuilding of some parts, etc.; secondary use of elements or components obtained after the demolition of the building in order to construct a new building in the same place
2. Use of materials and components obtained after the demolition but applied in a new place
3. Using new recycling products that include waste material totally or partially.

It may also happen that building objects are made with the use of waste obtained from other industrial sectors. These realizations are characterized by a variety of forms and colors.

As far as the ecological point of view is concerned, the slightest intervention takes place when a building or its part is preserved and adapted to its new or a former function in the original location. This action will have a much less negative impact on the environment, as compared with the situation when the object has been demolished and reconstructed from fairly new materials. The decision to preserve the existing building considerably relieves the investment process as it eliminates the phase of a costly transport and demolition with a lot of waste left behind and helps to limit the exploitation of resources. If the investment allows an architectural adaptation, alteration or just a slight rebuilding, one should consider a necessity to replace those elements that can easily be dissembled. The key factor here is the attempt to preserve the existing foundation, as well as the bearing structure and if possible the facade of the object due to a huge weight and volume of the materials. This usually involves a necessity to prepare a technical expertise for the given building and, when recommended, to improve the durability of the individual bearing elements.

When the re-use of the whole existing object in its natural location is impossible, one should remember that at least some components may be used for other buildings. In this case, it may be necessary to renovate and repair the reclaimed elements in order to restore the qualities lost while the object was being used originally. The range of modifications can be very wide, varying for different components and their technical condition. From the ecological point of view, the best situation takes place when the demolished elements are re-used directly in the

Table 1 Hierarchy of actions to the buildings finishing their primary existence

1	Preservation of buildings, repair, adaptation
2	Disassembly and re-use of reclaimed goods in original location (same construction site)
3	Disassembly and re-use of reclaimed goods in new location (new construction site)
4	Disassembly and recycling of goods
5	Disassembly and landfill

place where they were obtained (on the same building site although for a new object constructed). When there are any obstacles, such as a specific character of the investment, a negative attitude of the investor or other unfavorable conditions and this kind of action seems impossible, the reclaimed material can at least be used for construction in another location.

Another group contains the materials which have been processed before. They are obtained through recycling and the new function is usually different that the original one. As a typical example applied in the building industry, one should mention the manufacturing of chip boards from sawdust that is a waste product after the construction of bearing elements in sawmills, as well as the making of cardboard framing for concrete from reclaimed paper, etc.

In Table 1 the hierarchy of actions to the buildings that are just finishing their primary existence recommended by the Author is presented. This is based on the European hierarchy referring to the disposal of waste and the $3 \times R$ rule mentioned before.

4 Recommendations on How to Apply Reclaimed Building Materials

Different groups of building materials are characterized by a different potential to be re-consumed. Having analyzed those groups of materials as well as various technical solutions available, we may say that in the majority of cases it was possible to re-consume the worn out products—either through a secondary use in the previous or a newly set location, or through processing and using as a substrate for manufacturing materials by recycling. The method and the potential way of re-using of building elements are influenced by many factors, such as the composition and construction of such components, the scale and way of the previous processing, the method applied to fix them and build in the object, the way and intensity of exploitation planned, the previous and the new function to be performed by the sub-component, ergonomic aspects essential for the microclimate of interiors to be created, expected technical and aesthetic parameters, the location of the investment, etc. Whether the element should be re-consumed in this or another way (renovated and re-used in its original place, or reclaimed, renovated and applied again in a new place, or processed and recycled) every time is an

Table 2 Potential for re-consumption—foundations and system for the ground stabilization

Foundations and systems for the ground stabilization	
High potential—recommended actions	Recycling of ferroconcrete foundation bases and wall footing; secondary use in original location of ferroconcrete foundation stakes; secondary use in original location or recycling of steel foundation stakes; secondary use of Larsen walls in original and new locations or recycling of its components; recycling of gabions; secondary use in original location or recycling of prefabricated retaining walls; secondary use in original location or recycling of monolithic wet-cast retaining walls
Medium Potential—possible actions	Secondary use of foundation bases and wall footing in original location; secondary use of wooden foundation stakes in original location; secondary use in new location of steel foundation stakes; secondary use in original location or recycling of geotextiles; secondary use of gabions in original or new location; secondary use in new location of prefabricated retaining walls

Table 3 Potential for re-consumption—building envelope and other non-bearing products

Building envelope and other non-bearing products	
High Potential—recommended actions	Recycling of glass blocks; recycling of wood-base boards, secondary use of drywalls and rakes in original location; recycling of wooden wainscot, recycling of facade metal sheets, secondary use of facade stone cladding in both original and new locations, recycling of concrete cladding, recycling of glass structural facades, secondary use of roof tiles in both old and new locations, recycling of window joinery and metal work
Medium potential—possible actions	Secondary use of glass blocks in old and new locations, secondary use of wood-based boards in old and new location. Secondary use of wooden wainscot in old and new locations, secondary use of facade metal sheets in old and new locations, recycling of stone facade cladding, secondary use of concrete cladding in old and new locations, secondary use of structural facades in old and new location, recycling of roof tiles, secondary use of window joinery and metal work in old and new location

individual decision after the analysis of different changeable aspects of which the most important ones have just been mentioned.

Having compared the technical solutions available, one can see some regularities and recommended solutions, which are presented below. The specification is based on both Polish and foreign publications, as well as the critical review of technological solutions available in which the building process involves the re-consumption of materials (Tables 2, 3 and 4).

The specification above clearly shows that the re-consumption of materials is technically applicable to nearly every group of building materials (the study excludes the technical equipment for a building). Additionally, having examined every building element, we may say that in every case the idea of re-consumption can be applied in one of its different forms available. Even if in some situations it would be difficult to use reclaimed materials directly for the construction of a building object, it should at least be possible to act in another way, for example to recycle the elements that are worn out.

Table 4 Potential for re-consumption—elements of bearing construction

Brick elements	
High potential—recommended actions	Secondary use in original and new locations and recycling of lime—mortar brick; secondary use in original location of cement—mortar brick; secondary use in original locations and recycling of concrete blocks on cement mortar; secondary use in original location of stone on cement mortar; secondary use in original location and recycling of prefabricated lintels and window sills
Medium Potential—possible actions	Recycling of brick on cement mortar; secondary use in a new location of stone on cement mortar; secondary use in new location of prefabricated lintels and window sills
Construction wood	
High potential—recommended actions	Secondary use in old and new locations and recycling of wall frames; secondary use in old and new locations and recycling of ceiling beams, secondary use in old and new locations and recycling of the roof truss and beams, secondary use in old and new locations of the glue-joint wood
Medium potential—possible actions	Secondary use in a new location of the roof truss and beams
Metal products	
High potential—recommended actions	Secondary use in original location and recycling of columns and beams made of forged metal, secondary use in original location and recycling of ferroconcrete beams and columns, as well as ferroconcrete roof truss, secondary use in original location and recycling of steel construction posts, secondary use in original location and recycling of steel roof truss and beams, secondary use in original location and recycling of trapezium bearing metal sheets
Medium potential—possible actions	Secondary use in a new location of steel construction posts
Ferroconcrete	
High potential—recommended actions	Secondary use in original location and recycling of the elements of a monolithic frame construction; secondary use in original location and recycling of the elements of a prefabricated frame construction, secondary use in original location and recycling of ferroconcrete monolithic ceilings, secondary use in original location and recycling of ferroconcrete prefabricated ceilings, secondary use in original location and recycling of prefabricated wall panels, secondary use in original location and recycling of monolithic ferroconcrete walls
Medium potential—possible actions	Secondary use in a new location of the elements of a prefabricated frame construction, secondary use in a new location of prefabricated ferroconcrete ceilings, secondary use in a new location of prefabricated wall panels

5 Recapitulation

The issues presented above, concerning the re-consumption of materials applied in architectural design, look like a novelty and may raise a lot of controversy in the circle of building engineers and architects in Poland. Nonetheless, the legitimacy of the technical solutions recommended is generally beyond question, which is proved by the reference publications and the study done in that matter, especially in the present, threatening situation when non-renewable resources are shrinking and being under the pressure of ecology and statistics that emphasize the long-lasting impact of industry, including the building sector, on the natural environment. In Poland, due to the integration with the European Union, those innovatory solutions as to the building materials, following the idea of balanced development, will hopefully become more and more important in architectural design. In the first quarter of 21st century the Polish society is gradually changing and starts to recognize the advantages of a healthy lifestyle, preservation of nature and pro-ecological ideas employed in industry, which reflects a worldwide tendency with good examples given by highly developed western countries of the European Union and the United States.

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Le Corbusier in Algeria: The Quest for the Human Scale in Architecture

Leila Chebaiki-Adli

Abstract During the french colonisation of Algeria (1830–1962), and after more than one century of discrimination, some studies were done in the aim to understand, search and draft a new form of housing for Muslim population. At this moment, the visit of Le Corbusier was done (1931). The question of housing brings other interest on human proportion, habits, ways of life, religion and culture. Consequently, new concepts appeared such as «habitat», «échelle», «cité de recasement». The principal questions were the integration of human scale as a complex paradigm. Our aim through this paper is to draft at first, a brief theoretical overview on the quest of human scale in the vernacular architecture of Algiers, which were classed universel heritage by UNESCO (1992), then, to demonstrate the evolution of this question and their relationships with the «Modulor».

Keywords Human scale · Vernacular architecture · Algeria · Le Corbusier

1 Introduction: The Search for a New Building Form

After a century of French colonization in Algeria, based primarily on industrialization and ethnic separation, the question of how to house the native Muslim population arose [1, 2]. The question concerned whether to construct houses that met their specific needs, or whether the population should adapt their lifestyle to that of Europeans [3, 4, 5]. These questions became more pressing as housing shortages led the population to begin to build shanty towns [5, 6]. This provided the trigger for the active development of housing suited to the needs of the colonized population. Initial work took into account not only the architectural heritage, but

L. Chebaiki-Adli (✉)
Laboratoire Architecture et Environnement,
École Polytechnique d'Architecture et d'Urbanisme, Algiers, Algeria
e-mail: chebaikiepau@hotmail.fr

© Springer International Publishing Switzerland 2016

J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_8

also customs, traditions, lifestyle and sanitary conditions [1]. Although this led to a phenomenological understanding of the problem, it was not reflected in the development of a native, vernacular architecture (the Casbah), but new, autonomous settlements.

This highlights a striking parallel. While the architects of the International Modern Architecture Congress (CIAM) were trying to understand the principles underlying new, anarchical housing forms, the visit of Le Corbusier to Algiers in 1931 focused on the vernacular constructions of the medieval historic city [7, 8, 9, 10]. While the CIAM's work led to the construction of 'resettlement' cities, Le Corbusier's work was enriched. He completely revolutionized architectural paradigms, based on a human-centred theoretical approach that viewed man as the ideal scale [11, 12, 13].

The question of the human scale is a multidimensional problem. Here, we clarify the issues through a brief comparison of the following philosophies:

Vernacular architecture: where the social scale takes precedence over the spatial scale.

'Resettlements': where the spatial scale takes precedence over the social scale.

The Modulor: where the ideal scale takes precedence over the socio-spatial scale.

2 Vernacular Architecture: Where the Social Scale Takes Precedence Over the Spatial Scale

In the Muslim world and more specifically in the north-African context, architectural forms developed as the result of knowledge transfer from Middle Eastern and Muslim civilizations during the Middle Ages [14]. This architecture, which was grafted onto existing traditional Berber foundations then came into contact with Muslim Spain and led to a subtle fusion between its clear semantic conventions and vernacular construction principles [15, 16].

Several famous architects took an interest in these forms, which led Le Corbusier to say, "He [the builder] is more of an architect than ever before. He is like those who built the houses of past times, when everything was present: the best techniques, the most effective, pleasant, fertile and economic dimensions and attitudes, where wisdom reigned and was expressed by poetry […] until the day when schools were established, and with them, academicism" [7].

The environment that resulted from the vernacular architecture of Algiers is a reference to a complex stratification of know-how. The harmony between the site, climate, religion and culture, respect for the neighbourhood, a philosophy of participation and sharing, the desire for spatial quality and adaptation to the human scale is a perfect example of what Ravéreau calls the "law of coherence". Ravéreau says, "the law that is established by a prescription is socially received as a balance. However, even if we did not receive the prescription, the blind arcades of the Casbah of Algiers, even without these ceramic ornaments, still seem very accomplished and coherent" [8].

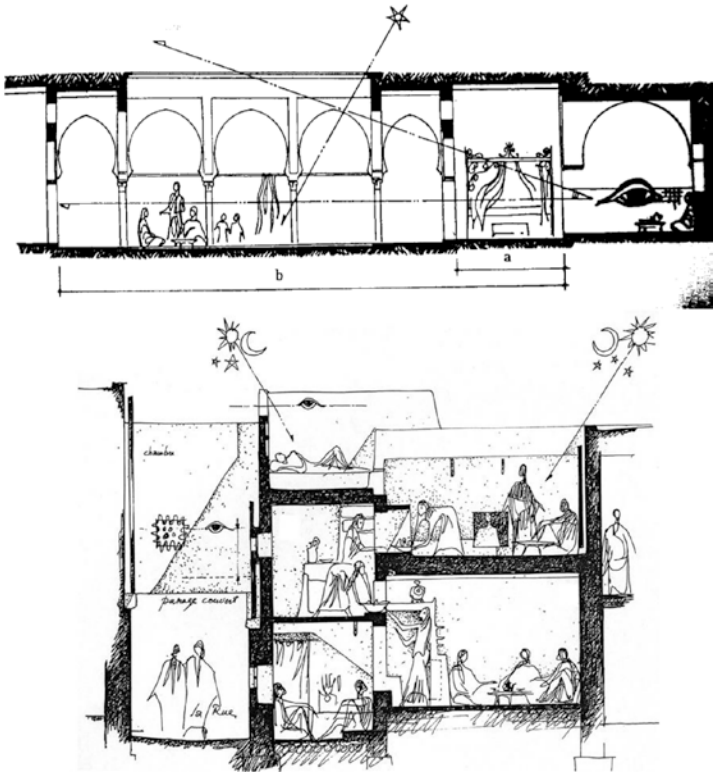

Fig. 1 Drawing of Ravéreau on harmonic law of vernacular architecture of Algeria. © André Ravéreau/ADAGP

Based on their in-depth study of stylistic and morphological elements, Cotereau [17] and Ravéreau [8] established the stylistic and functional characteristics of this architecture. Specifically, they identified two housing models: *intra-muros* and *extra-muros* as a function of their type and corresponding social needs.

The *inta-muros* model (the houses of the medina) are characterised by the complexity of the links between them, strong volumetric and constructive interlocks that are due to respect for the same principles of organization and execution, best seen in the patio in most residential buildings [18, 19]. The *extra-muros* model (country homes) are characterized by vast courtyards and patios, rich cubic volumes, and multiple views of nature (the sky, gardens and the sea) [20, 21].

The human, social and individual scale is the main element of all of these types of housing. It leads to forms of construction that are in perfect harmony with their function. Ravéreau [8] highlights the following points (Fig. 1):

- The link between the architecture and its environment through views of the sky, notably from the patio.
- A duality of public and private spaces. Their spatial distribution follows a dual rationale: perpendicularity and diagonal.

- The (dis)junction between spaces achieved through main doors that integrate smaller ones.
- Interlinked spaces materialized through small details.
- Visual continuities that are made concrete and strengthened by the proportions and heights of all openings used by humans in the course of their activities.
- A duality between the visible and the invisible, found in a chicane-type entrance space and the arrangement of secondary, accessory spaces on a diagonal axis.
- The harmony between the size and proportion of spaces through the length of wooden beams that support floors.
- Agreeable views of nature and decorated surfaces.
- The proportions of openings and ornamental attributes.
- Etc.

Other characteristics are linked to daily individual or group activities, and seasonal changes that each has its own law of coherence.

3 'Resettlements': When the Spatial Scale Takes Precedence Over the Social Scale

After a decade of colonization and urbanization based on ethnic control [5], 'resettlements' were constructed on the sites of the former shanty towns [1, 2]. The location of these cities clearly showed French disinterest in developing suitable housing. Initially, the Muslim population was crammed into the highest part of the Kasbah. From 1925 it was displaced to the most inaccessible sites, which also ruled out the possibility of achieving a coherent urban composition. In 1935, Bienvenu [3] highlighted the urgency of the problem of housing the Muslim population in Algiers, "In the very complex task of town planners, the problem of the resettlement of the native population seems to be the priority, the key problem upon which all of the others depend: sanitation, movement, development, embellishment" [3].

After a decade of colonization the city had become a heterogeneous set of socially-segregated districts [2, 5]. Segregation was expressed through locating areas housing the Muslim population in areas that were far from the city centre and on very uneven ground. These shanty towns gradually became established and eventually led to the construction of a typology known as the 'rhorfa' (cell).

These resettlements were the outcome of research carried out by the CIAM. This group based its work on a study of shanty towns between Mahieddine and Algiers [22]. In its meeting held in 1953 in Aix-en-Provence (France) the group identified a system of spatial distribution corresponding to two types of apartments (Fig. 2). The first consisted of a single room with a small loggia and a water source. The second was a duplex, where the upper level was similar to the single-room apartment [22].

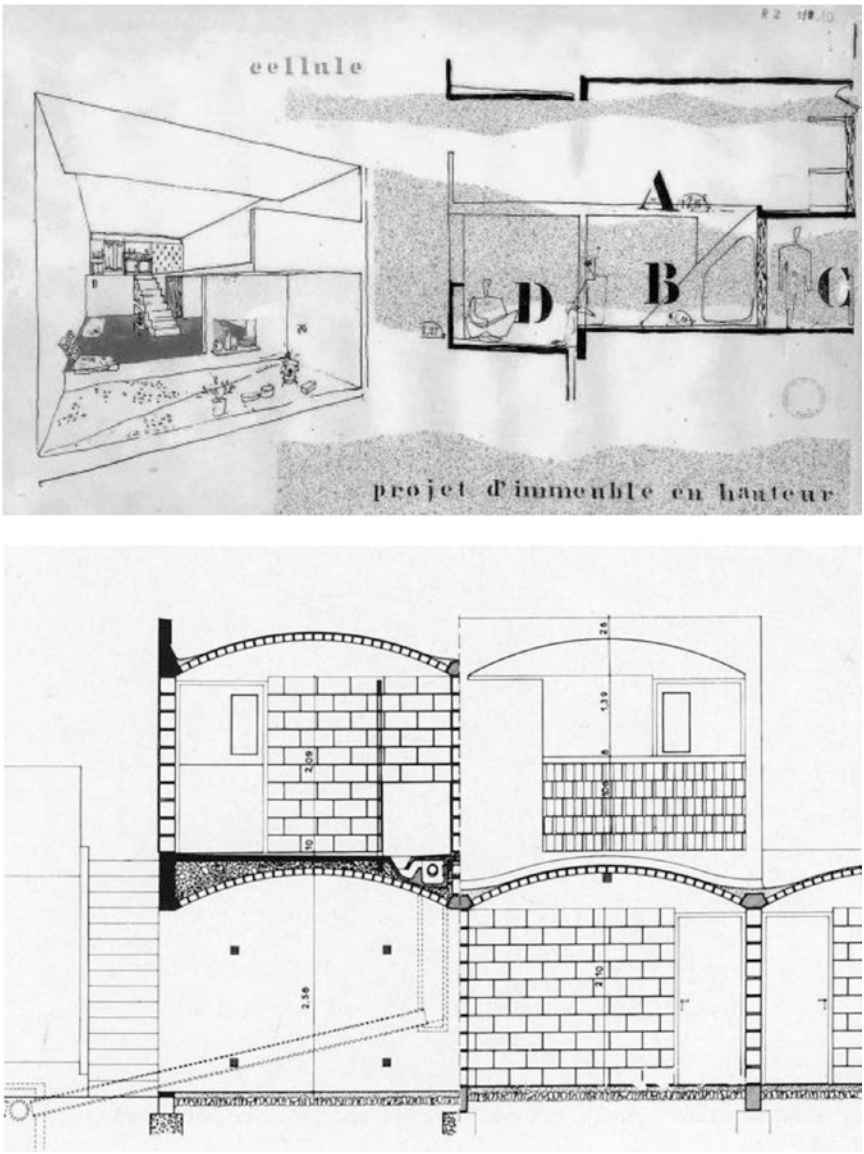

Fig. 2 View of the studies of CIAM Algiers and Djenan el Hassan sketch © archiwebture.citechaillot.fr

As a result of their work, several resettlements were developed, such as Maison-Carrée (in 1953), Carrières Jaubert (in 1957) and Djenan el Hassan (in 1959) [1]. In their search for a typology that met the needs of the Muslim population, designers limited themselves to rational principles. The main organising

element was the notion of the cell, together with the need for sanitary facilities and natural ventilation. From the spatial point of view, these cities were characterised by (Fig. 2):

- Tiered, horizontal housing on sloping sites.
- Prefabrication and load-bearing walls.
- Vaulted covers that limited vertical extension.
- Ventilation systems that opened into communal spaces.
- The integration of small loggia.
- Identical orientation for all houses.
- The lack of any indication of the human scale.
- The latter refers to the ideal, manifested in the Casbah (e.g. the link with nature, external and internal views, links between spaces, patios, passive ventilation, thermal comfort, religious and cultural identity, etc.)

The choice of a single volume, from which different spaces flow through the arrangement of ceilings, floors, etc. is found in resettlement cities. However, it is translated into (quantitative and qualitative) spatial limitations to the detriment of the socio-cultural needs.

Most of these cities—that had been increasingly modified by their inhabitants—were completely destroyed during celebrations marking 50 years of independence. Djenan el Hassan was destroyed in 2012 (Fig. 3).

Fig. 3 View of Djenan el Hassan 1959. © archiwebture.citechaillot.fr

4 The Modulor: When the Ideal Scale Takes Precedence Over the Socio-Spatial Scale

After his visits to the Casbah of Algiers, and southern Algeria, Le Corbusier repeatedly expressed his passion for Algerian vernacular architecture [7, 8, 10]. In 1931, the 'Association of the Friends of Algiers' welcomed him to a meeting to discuss individual and collective housing in the Mediterranean context. Of Le Corbusier's first visit to Algiers, Claro says, "[…] But what struck him most was Qaçba, the compact Turkish city […] his first words when he arrived at the quay were short and to the point: 'I want to see Qaçba'". Following his subsequent visits to Algiers, Claro repeated at a conference organized in Algiers in 1942, Le Corbusier's "worship for Qaçba" [9].

Celebrations marked a hundred years of Algerian colonisation, and a special edition of the "*Chantier Nord African*" was dedicated to the Moresque house [17]. In it, Cotereau asserts that, "there is curious analogy between the Arabic villa and the modern villa. The desire to disguise wealth produced the same outcome as the taste for simplicity. Both cases concern juxtaposed white cubes, uncouplings, big floor-spaces and clean angles that give rise to the same aesthetic effects. In both cases, the terrace crowns the construction" [17].

In asserting the influence of the Corbusier school, De Maisonseul [23] highlights the significant influence that Algeria had on the work of Le Corbusier and how it changed after he had studied the Casbah of Algiers and the architecture of the M'zab, "it seems clear that his journeys to Algiers were a key factor in the evolution of Le Corbusier's work, in what could be called its 'humanization'. It is the man he became in Algiers, architecturally and plastically" [10]. Although many authors can testify to the influence of Algerian vernacular architecture on Le Corbusier's work, here we focus on the master himself who says, "Arabic architecture gives us a precious lesson. It is best appreciated when walking, on foot" [10].

The architectural revolution that Le Corbusier brought to life lies in the close relation between man (as the ideal, or even universal scale), and his environment supported by the concept of the humanization of space. The ideas he expressed, notably in 1914 (the Dom-Ino house) and 1922 (the Citrohan house) that shed particular light on "the rationality of production" [11] the architect shifted his perspective to "the rationality of form" leading to an innovative aesthetic.

Although Farel [11] claims that the elementary geometry of the Platonic tradition is the origin of these theories, he asserts that Le Corbusier's appeal to mathematics was aimed at satisfying the spirit. He adds that idea of visual harmony was the origin of regular trace and the Modulor. Consequently, the goal of the spatial geometry was to achieve a real interaction between man and his space that included aesthetics and spatial beauty, and which he translated into the slogan "what is useful is beautiful" [11].

Jencks offers a completely different opinion. He argues that Le Corbusier's "dualism" is the combination of scientific objectivity and subjectivity. He adds that in certain cases somewhat irrational personal choices can be seen [11]. Farel and

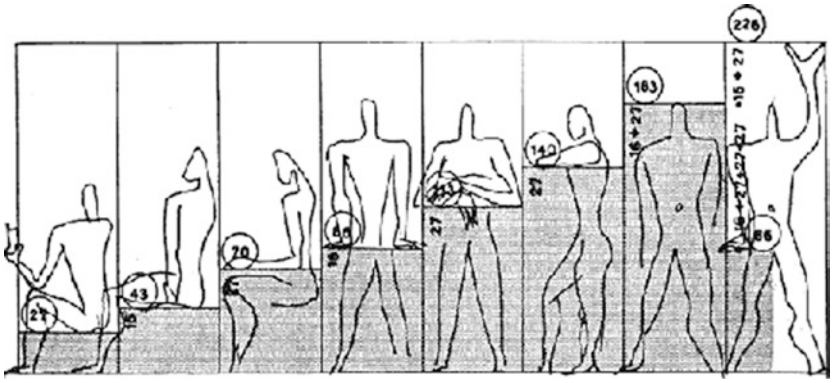

Fig. 4 Human activities according to the Modulor. © marcus-frings.de

Jencks [24] give the example of the chapel of Notre-Dame-du-Haut at Ronchamp (1955) as a perfect illustration of this dualism. Its curved forms contradict orthogonal rationalism. Despite designs based on Modulor mathematics, his architecture addresses the contradiction at the visual level (aesthetic-symbolic) referring to both expressive and figurative formulae [25] and manifesting the inspiration provided by Algerian vernacular architecture.

According to these theorists, only partially Le Corbusier's successors understood that his main concern was to respond to societal problems, in the most complex sense. The dogma of the primacy of reason could not create a universal architecture. In fact the opposite was the case, as its philosophical principles were directly translated into tasks or acts.

The foregoing postulates about Le Corbusier's philosophy lead us to deduce that it reflects a profound rethinking of architectural design processes, and that the question of the human scale cannot be limited to morphological proportions. On the contrary, it should draw upon values that recognise the importance of the human being relative to his real and ideal context (Fig. 4).

5 Conclusion: The Human Scale, a Complex Paradigm

The issue of the human scale in architectural design has always attracted the interest of mankind. It is seen in Platonic, Hegelian and other philosophies as well as modern concerns about the environment and sustainable development. The question of scale includes issues related to values, identity, temporality and particular situations (for example Algeria under colonization). This brief study demonstrates the following subtle phenomenological relationships.

The first highlights the dominance of socio-cultural values over architectural concerns, leading to what is called 'vernacular' architecture. The methodology

creates socio-spatial harmony through meaningful attributes that pervade and order architecture. This naturally requires a greater degree of temporality.

In the second, constructive values take precedence over social and cultural values. The latter can be classified as architectural practice in colonies, given the lack of studies dedicated to the question. Here, the methodology stipulates that physical attributes take precedence over architecture considerations.

Finally, the third manifests in the search for the ideal, the role of man, the search for spatio-temporal harmony and finally, the desire for further evolution with respect to the question.

In conclusion, we support the paradigm put forward by Jencks [24] on the tight links between architectural thinking and intelligent movement, mini movement, methodologies, and the probable multivalence universal evolution.

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Design Aspects Applied to Engineering: Technology Sustainable Development and Innovation in the Science Parks

Ekaterina Emmanuil Inglesis Barcellos, Galdenoro Botura, Jr. and Luiz Carlos Paschoarelli

Abstract Science Parks are sustainable environments where design, aligned with engineering, can achieve its maximum concept by linking scientific research and practical application. This action can facilitate implementation of new sustainable systems and methodologies in project areas as "design process" and "design driven Innovation". The development of products focusing on R&D mixing engineering and design can produce conscious sustainable technological innovation. In Neo-Schumpeterian view, the development and evolutionary economics require constant innovation. Innovation creates new research-based frameworks applied in R&D. It allows the scientific production associated with scientific results, tested by design concepts and techniques and associated to engineering technical basis. The return of knowledge in a continuous systemic transfer system of science and practice in design promotes the improvement of the innovative technology in a more conscious way, which excels for verifying the theories and innovative ideas. in a more conscious contemporary lifetime.

Keywords Design · Innovation · Technological parks · Sustainable technology

1 Introduction

Developed in the early twentieth century, studies and contributions of Joseph Schumpeter in development, innovation and methodology have an evolutionary character of economic theory. This position has been generating new paradigms

E.E.I. Barcellos (✉) · L.C. Paschoarelli
São Paulo State University, Av. Engenheiro Luiz Edmundo Carrijo Coube, nº 14-01, Bauru, SP 17033-360, Brazil
e-mail: kettyinglesis@bol.com

G. Botura, Jr.
São Paulo State University, Sorocaba, SP, Brazil

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_9

for consumer society, reshaping the means of production and consequently the understanding academic view. Schumpeter's view means that capitalist development is a process of change whose engine is innovation, and that "the disruption of established routines transforms existing structures, and in the process, innovation creates new structures." Laplane [1] cited Schumpeter [2]. Therefore, innovations are a significant factor of capitalist dynamics. "The evolutionary approach of Schumpeter understands innovation as a dynamic and cumulative process, resulting from relations (interactions) involving actors and institutions, with logic, interests and distinct functions" [3]. In a similar design to Jordão, in an economic perspective, [1] shows that the last two decades mark profound technological, economic and social changes in our country production systems. For this reason, the renowned evolutionary economist becomes an important conceptual framework on the issue of structural changes to their theories on innovation. Among them, the vision that determines the future of problems located primarily in the "social" rather than "economic order", explaining that competition between companies and oligopolicists groups ensures the flow of innovations, however individual entrepreneurs lose in this context [1]. In the situation described, only differentiation in design coupled with technology can assure the individual entrepreneur a unique character to survive in a globalized world. "The resulting transformations since the late 70s, in the relations between science, technology and industrial activity made the technology a factor of competitiveness, often decisive, whose characteristics affect virtually the entire industrial system (understood in a broad sense, and thus covering part of the service)" [4]. The new methods of management in design may provide greater competitiveness by adding important aspects of the design idea, branding, usability, ergonomics, safety and modifying the concept of brand and value-added services and products. The system of work implemented in the Parks is based on theoretical and practical projects and their operation. It contemplates all stages and phases inherent to the research, the planning, the project and the development of technologies, products and services applying transdisciplinary concepts.

2 The Approach Between Design Aspects and Engineering

The management of Design develops itself in the technological environment of the twenty-first century, as defined [5], to "train professionals for a market that requires multidisciplinary knowledge and, especially, strategic."

Design as the word of Latin origin "signum" (sign), resembles the German word "zeichen" ('sign', 'design') and the English "drawing or design." However, the "popular" conception of the word is confused with its real meaning. As confusing as the statement made by [6]: "Design is to design the design to produce a design", the meaning of design is surrounded by complexity, especially in Brazil, where there is no exactly translation for the absence of an equivalent term. The 'multi-definitions' also do not generate a consensus in academia. By a planning bias, this is the ideal that lays the foundation for realization of each object or

system, and its multidisciplinary and interdisciplinary feature works several areas of knowledge. In the perspective of academia, this view is confirmed and gives it the meaning of "correlative area of expertise to the development of product design, the principles of which rely on meeting the requirements and expectations of man (producer, consumer, user and viewer), in its production design," [7]. The Michaelis Dictionary supports design definition as:

1. Design of a design or model; planning; 2. The product of this planning.

The design as a creation refers to ideas and innovation especially related to industrial production and sets the [8]. It is described as the word originated in English designating: (1) Discipline that aims to create objects, environments, graphic works, etc., at the same time functional, aesthetic, and comply with the requirements of an industrial production; (2) Set of objects created according to these criteria (ex.: sell design); (3) Appearance of a product created according to these criteria (ex.: the design is innovative); (4) Created, designed according to the design criteria (ex.: furniture design). Löbach ratifies this: that there is also a major economic and social feature, setting the design as "any activity that tends to turn into industrial product capable of manufacturing, the ideas for the satisfaction of certain needs of an individual or group" [9].

In highly developed industrial society, the goal of almost every activity is the raising of economic growth and living standards. Then the satisfaction of needs and aspirations have a substantial role, encouraging the creation and improvement of objects. The process begins with research needs and aspirations, from which will develop the ideas to your satisfaction in the form of industrial products (product design). It is the transformation of these ideas into use products (product development) that industrial designer participates actively [9].

In addition to the terms described above, we found in Schneider and Flusser systematic characteristics and scientific value, assigned as a new form of culture. For Schneider: "Design is the creative visualization and systematic interaction processes and different social actors messages; It is the creative visualization and systematic of the different functions of use of objects and their suitability to the needs of users or effects on receptors" [10]. For Flusser: "(…) design means that place where approximately art and technique (and consequently thoughts, scientific evaluative) go together with equivalent weights, making possible a new culture medium" [11]. As for the character interaction, interdisciplinary and technological updating [12] confirms:

"(…) Over time design has been understood from three different types of knowledge and practice." At first the design is seen as an artistic activity, it is valued in their professional commitment to artificer, with the enjoyment of use. In the second, it is understood that the design as an invention, a plan in which the designer has priority commitment to the productivity of the manufacturing process and technology updates. Finally, the third appears the design and coordination, where the designer has the function of integrating the contributions of different experts from the specification of raw materials through production to use and the final destination of the product. In this case, interdisciplinary is the keynote.

Engineering is also described as a science that involves the project with the technique. The development of products focusing on R&D and mixing engineering and design can produce better and more conscious sustainable technological innovation. The approach of aspects of human and aesthetic design associated with creative thinking using design driven innovation and design process methodologies can enhance innovation by creative engineering. Both areas can enhance mutual way the sustainable development working together.

And as a result, in fact, methodologies of design process, co-designing and redesigning can insert and differentiate products in the fierce global competition, providing indexes benchmarking on a national and world stage that has increasing innovation and quality applied to goods and services attending to social needs and aspirations.

3 Development and Innovation

"Knowledge and information have come to play a new and strategic role for technological development, as they are essential to the creation and diffusion of innovations" [13, 14]. In the opinion of Paschoarelli and Silva, technological developments changed the shape and design methodology for planning and industrial development, accentuated by the increasing complexity of systems and products. It became necessary to introduce an approach to scientific evidence, as well as experimental, improving functionality issues, usability, ergonomics and safety of products.

It is determined that the "technological evolution and the relationship processes between man and technology have been changing over time and hence new methodological needs have arisen" [7]. According to the understanding of Jordão [3], citing Lundvall [13, 14], the changes generated by globalization, responsible for the dissemination of technologies in information and communication led to changes in the economies and contemporary societies and configured a new technological and business paradigm. Those have also created a new paradigm of sustainability.

In Felipe's vision, technological development and innovation depend on human and scientific potential and resources and solid long-term investment. He mentions "Brazil has adopted the strategy that academic research would generate knowledge that naturally turn into technological innovation, which is not reflecting the reality of the sector in the country" [15]. For this reality to intensify and become effective, it is necessary to create larger appropriate conditions and places for interaction and exchange between academic knowledge and technology and creative based industries, with appropriate methods to grounded technological development in knowledge and academic excellence to be applied in practice.

Paschoarelli e Silva complete that "One of the most complete and current proposals for product design development methodology is called Total Design" [7]. "Scholars refer to the method of Total Design, Stuart Pugh, known for its

integrated approach to product engineering as a technological alternative methodology, with the function of being a systematic and disciplined process, in order to create products with the development accompanied in all variables of the project, from beginning to end, in all its stages" [7] cited [16].

Technology involves advanced technique, that comes from engineering technical knowledge, and involves both exchange and transfer. By definition, technology is the study and scientific knowledge of technical operations or technical (set of practical rules to do certain things, involving the ability of the performer and transmitted skills, all the processes of science, art or craft, to obtain a certain result with the best possible performance). It includes the systematic study of instruments, tools and machines used in the various branches of the art of gestures and working times and costs, materials and energy used. The technology involves "applying the methods" of the physical and natural sciences with the ownership of knowledge. Several research institutions and companies want to train and improve the skills of its employees.

A multidisciplinary and interdisciplinary structure would enable the application of theoretical content in a practical, comprehensive and participatory. That, as its mission is to provide technological development grants and innovation abroad, in order to support the participation of experts, technologists, technical and scientific personnel for the development of research projects, studies, training and training in foreign institutions of excellence, through placements and courses.

Where and how to use that trained work force but in innovative environments that test their knowledge and skills excellence? In the study of Felipe was found that the great scientific advances of Brazil in the last three decades, however, the scientific competence and training of qualified personnel within and outside the country, weakened by object of economic and political fluctuations.

According to Felipe "Brazil accounts for 1.3 % of scientific articles published in international refereed journals" [15]. "The increase in graduate structures formed 10,000 doctors a year and triples the scientific contribution on the world. It is known, however, that the scientific production does not generate because of immediate production technology. "The constant research and technological development conducted in the context of partnerships between R&D institutions and the productive sector should be developed in specialized training centers, primed and trained in scientific excellence for interaction between theory and practice. In the area of Research and Science, for Schneider [10].

Design is part of the social, cultural and economic. Their economic and technological roots as well as the social and political factors are indisputable. It is a statement today that in market segments where there are more than quality or price differences, the design has become the only differentiating factor between competitors [10]. In the "knowledge society" we live in, governments and international organizations recognize the design as a knowledge and technology resource that must be transferred to the economy as a creative and artistic potential agent and has the perception that increases the flexibility of competing with the wishes from the market. The pressure of global economy as stated Schneider "led to the political call for more transfer of knowledge and technology with it is to be generated

in higher education as much as possible of innovative knowledge that will flow directly to the economy, especially for small and medium enterprises". The project methodology or design process, which is the backbone of Design, is the ideal form of understanding and troubleshooting. The central method of acquisition and transfer of knowledge.

In addition, Schneider adds, "in the area of design and art, there are currently many projects that have added value of cultural innovation, for which, however, there is no first economic partner that it will benefit." The author also emphasizes that in the case of design the transfer of scientific knowledge track different paths from other areas or study centers. In this sense, the Technology Parks have a key role and to highlight the performance of the system of exchange of knowledge and innovation, characterized by partnership academia-industry-government, one of the possibilities offered by Schneider:

"The science of design almost consciously rewarding research projects with partners; she stands with determination as critical scientific discipline and as a social practice, and, therefore, collects subsidies and public resources available" [10].

The role of Science Parks in partnership with universities is essential to transfer the academic and scientific research. It is what is perceived in the international scenario and in the further development of greater impact technology. The application of aspects of design to engineering projects, products and developments. This can bring the most innovative companies to the proximity of the Parks, and these have greater ability to connect with the paradigms of sustainability, and yet enhance innovation.

4 Technological Parks

A Technological Parks can be defined as an urban organization in a given geographical area, focused on activities of knowledge, research (R&D), development and production of innovation, goods and services based on science. Understanding the links between academic and university research and business initiatives encouraging technological development created the planned institutional systems, known as Science Parks, since the 1960s The Ultimate, pioneer and worldwide success, the "Silicon Valley" or "Silicon Valley in California" became known as the first Technology Park, focused on microelectronics and its ramifications.

The organization of a Technology Park consists of a partnership between four types of institutions: universities, research laboratories, high-tech companies and related service providers [16]. In this environment, interactions are established between these organizations exploring potential R&D cooperation. Projects using concepts and design methods, strategic design and overall design align the interests and working structures of Science Parks. The purpose of the Parks is to contribute to the development of the local system of science and technology, and innovation as the main objective of the R&D effort. Among the goals is the

creation and development of new specialized products and services markets; the rise of new skilled jobs; the contribution to the development and the increase in average local income. In these areas, the new knowledge must be transformed into new products and processes, stimulated by innovation agents in the exchange of expertise and become innovative based on new knowledge, generated especially through local information networks and sites of global information networks connections. Technology-based companies should be formed on site from local institutions such as universities, major or individual companies. Parks received different denominations as the scope and time, some of them: science city, technological city, Science Park, Research Park, Technological Park, incubators. The formation of a shared learning environment and continuous interaction facilitates coding knowledge associated with different cognitive frames, making possible a process of creation and dissemination of knowledge.

According to conclusions of Jordão, and contrary to what is disclosed, academia-industry relationship is not limited to meet the interests of industries. The approach of the triple helix working the association in partnership university-industry-government attaches to science and technology institutions a new function: the production of knowledge to solve business problems in addition to their traditional functions of teaching and research, putting them such as the firms at the center of creation and innovation diffusion sites [17]. In fact, it is conclusive that the Thematic Network of Research and Science Parks has generated development regional science, technology, present scientific production, and positive scientific results. They are related to the research of undergraduate and graduate students, and publication of articles in national and international journals by inserting young researchers (undergraduates and postgraduates) in research "border". Despite of this the Research Thematic Networks has improved undergraduate education and graduate and as a result, students must be inserted more easily in the Brazilian labor market [3].

5 Conclusions

As a pioneer and worldwide success case, the "Silicon Valley in California" became known as the first Science Park. A Park facing the segments of microelectronics and its ramifications. However, among these developments, in several stages, the importance of design is noted in the companies and spin-offs, responsible for "viralization" and exceptional commercial and economic performance, and the consolidation of this model of partnership between academia, industry and government.

Several iconic products have been created in this partnership system, the transfer of knowledge, and are the result of joint work between designers and engineers. And also by technicians from various fields and specialties in various enterprises of success. led by more than a decade by Noyce (Intel), Steve Jobs (Apple), or Bill Gates (Microsoft), and then leveraged by the graphic design and

the creative projects stripped of Google, Facebook and others. How to ignore the visual aspects, the style, the desire and the 'fashion approach' caused by these products and revolutionary and innovative releases? The fact is that the role of design is present, subjective or latent in most of the objects and services that moved and move the trade and consumption in postmodern times of contemporary society. But this design is always associated to an engineering technique.

The conclusive study believes that it is possible to enable and implement of design, design thinking, design process, overall design and strategic design within the scientific and practical studies and development of engineering. This required partnership would support a better application of materials and a lower waste disposal with satisfactory results. As Dijon de Moraes [18]: "The new design processes are complex design interactions, design new networks in which individuals, businesses, non-profit organizations, local and global institutions use their creativity and entrepreneurship for some shared values." So develop and improve technological innovation and performance of products and services, allowing scientific research and transfer of knowledge is fundamental task of R&D, and design with all its aspects, fields of activity and its innovative feature. It emerges as one of the principles of operation of a Technological Park. Due to its complexity, inter- and transdisciplinary, through design thinking, designing processes, code signing, redesigning, meta-project and other systems of networks, knowledge in Design "is a set of views, proposals, tools and reflections to feed and direct discussions to be applied in a variety of specific projects to help understand what we are doing and what we can do" [19]. The organizational structure of Science Parks must apply this interaction between design areas and engineering areas in their projects as a tool for future innovation.

Acknowledgments The authors want to thank the support for this research afforded by the Foundation for Support of Research of the State of São Paulo—FAPESP—by process 2014/19854-2, and Coordination of Improvement of Higher Level Personnel—CAPES, who provided conditions to assist the research, although they may not agree with all of the interpretations or conclusions of this paper.

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Cross-Cultural Design and Its Application in Architecture

Wojciech Bonenberg

Abstract The article presents the author's view on multicultural context in architectural design as a key to spatial and social harmony. The review that was carried out suggests that multicultural context is an important element in the identity and in the history of a place and points out that multicultural context is an essential feature of sustainable development. The analysis led to selecting a range of elements of multicultural approach in architecture: cultural patterns, cross-cultural communication, glocalization, space branding, and multicultural canons. By placing the problem within current debates in multicultural context, we offer a new approach to amplifying architectural identity through developing intercultural capital that enables attaining creative architectural solutions. We conclude that the cross-cultural context is an important element of contemporary architecture.

Keywords Cultural requirements engineering · Design · Architecture · Cross-Cultural

1 Problem

The perception of cultural heritage has evolved in the ergonomic approach to architectural design. Ergonomic analyses have seen a rise in the concept of cultural capital as a crucial development factor. Cultural capital includes cultural property that is traded in a global society, namely knowledge, skills, and creativity [1]. The main feature of cultural capital is that it can be turned into economic capital. This concerns both cultural capital in its tangible form (utilitarian objects, buildings, streets and squares), and its intangible form (work organization,

W. Bonenberg (✉)
Faculty of Architecture, Poznan University of Technology, Poznan, Poland
e-mail: wojciech.bonenberg@put.poznan.pl

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_10

innovativeness, education, etc.). It is noticeable that cultural capital is quite a stable type of capital. In addition, it is an exceptionally safe investment of resources which is hard to obtain, yet difficult to lose. Cultural capital carries significant practical meaning. It is an unappreciated economic potential that has not as yet been balanced at the stage of architectural design development.

Cultural capital found in architectural design is an added value that does not have to entail additional investment costs, but it does require expertise, skills and talent on the part of the designer.

The paper aims at proposing a cross-cultural approach to architectural design that addresses new challenges at the interface of investment, consumption, and life style.

Toffler called these new challenges "a cultural explosion", which is manifested in the individualisation of needs, multiculturalism and the increase of a society's cultural capital that ensues from it. The traditional perception of culture as a cost factor and an element that requires extra outlays has been replaced by an approach that sees culture as a generator of profits for investors. For example the idea can be used to revitalise squalid urban areas that have lost their attractiveness, declined economically and have seen a rise in inhabitant migration. The successful revitalization based on cross-cultural design should raise the status of urban space and ensure social stability. It is worth noticing that the cross-cultural approach is relatively rarely used in architectural design and its methodology has not been sufficiently developed yet.

2 Analysis

Culture is a complex entirety that comprises knowledge, art, technology, morality, beliefs, customs, and skills acquired by people as members of social groups. Therefore they are features that make up material and spiritual cultures.

In order to enter the realm of culture an idea or a thought needs to be recorded in a tangible form.

Against this background, material culture is a physical manifestation of spiritual features on art objects, utilitarian objects, technical artefacts, and first of all in architecture. Material culture results from manners of creation being adapted to suit an individual's mental and physical capabilities. From this perspective culture influences the relationship between an individual and their surrounding in an ergonomic aspect.

Culture needs tangible media, out of which architecture plays a primary role. As a manifestation of material culture, architecture, in turn, needs spiritual culture to be created. The spatial form of cities, houses, and gardens is not haphazard and results from creative concepts dependent on an era and its culture. In this understanding culture shapes the spatial environment, which then shapes people.

The notion of cultural space is not new and is associated with the concepts of sociologists that explore the interactions between a spatial system and the social

structure. Representative studied on urban sociology include those by Wirth [2], Simmel [3], Weber [4], Durkheim [5], Harvey [6], and Castells [7]. They have their origins in the achievements of the Chicago School, which formulated the sociological and cultural theory of urban development [8]. According to the theory, people's spatial behaviours, their ability to design the surrounding, system of assessments and values are dependent on natural factors to little extent and they are mostly determined by social ones. In this understanding every area shaped by a human being is an expression of their culture. Wallis [9] pays attention to this aspect of cultural value of urbanized areas. Odum [10] makes a distinction between folk culture (traditionally stable) and urban culture, which undergoes rapid transformations and is associated with life in great metropolitan areas. In a similar manner, Toennies associates community (Gemeinschaft) with rural culture and life, whereas association (Gesellschaft) is linked to a more complex and organized culture of urban life [11]. Ogburn stresses the problem of "cultural lag" and states that instilled cultural preferences and customs (or folk culture) do not catch up with technological advancement [12]. Wallis [13] points out the costs of cultural lag incurred by new inhabitants of big cities. Adapting this social group to a new environment is a long-standing process that requires economic, social, and mental sacrifices.

2.1 Culture Globalization and Glocalization

Since the descriptions defining urban culture as the opposite to folk culture were formulated, there have been significant changes that challenge sociologists' definitions [14]. In the era of globalization and mass media most social groups regardless of whether they live in the suburbs, urban or rural areas can be classified in a similar manner from the viewpoint of culture. The trend relates to the geographical areas in which cultural differences are becoming blurred. Cultural patterns are being homogenized and standardized.

Nowadays, in the era of globalization inter-cultural interactions are inherently present in business and personal contacts. Globalization that reduces cultural differences leads to unification mainly for economic reasons. People from various cultures are becoming consumers of homogenized goods as a result of aggressive marketing supported through global media. Mass media that international companies use to promote "universal patterns" aimed at all customers show no consideration for cultural varieties and diversity. The most prominent example of this phenomenon of the architecture of the second half of the 20th century was the expansion of the international style—the cubistic variation of modernism detached from vernacular patterns.

Tensions that stem from the uncompromising cultural expansion have produced negative outcomes in the form of people's defiant attitudes aiming at protecting their own cultures. In many countries the attitudes have turned fundamentalist, radicalising a negative society against values promoted globally. It was the

main reason why the globalization policy was replaced with the strategy "Think globally, act locally". The slogan is an old idea—now back in grace—by Patrick Geddes, a Scottish town planner, that concerned the principles of urban planning at the beginning of the 20th century. Geddes was against mindless copying of the fashionable architectural and urban designs of European metropolitan areas and transferring them into colonial cities. He believed that it was necessary to retain the identity of cities by protecting the local traditional buildings and urban structures [15].

Contemporary media manipulated by skilled marketing specialists were eager to pick up the local in spirit but global in character notion, which was later called glocalization. Robertson defines glocalization as an adaptation of global strategies to local conditions [16]. Considering local conditions, glocalization builds a new kind of consumer loyalty strengthened by the sense of protecting the local culture. To some extent, glocalization highlights the uniqueness of local cultures locating production in countries that are economically dependent on global companies and customising products to local preferences. As opposed to globalization that aims at unifying consumption patterns, glocalization treats cultural differences as an attractive commodity, providing global companies with greater chances of economic success in local markets.

2.2 Evolution in the Perception of Culture

Evolution in the way culture is perceived stems from the civilisation transformations that can be characterized synthetically by means of a set of juxtapositions that differentiates the traditional 20th century corporate development model from the contemporary postindustrial situation [17]: Old—New, Industrialization—Deindustrialization, Hierarchical structure—Network structure, Production integration and concentration—Outsourcing and deconcentration, Large scale—Small and medium scale, Economy of goods and storage—Economy based on creating and transferring symbols, Collective and anonymous—Individual and personified, Mass culture logic—Logic of social groups, Imitating others (the surrounding)—Standing out among others (in the surrounding).

It is worth pointing out that post-industrial reality necessitates the need to take a fresh look at the role and place of culture in spatial and economic development. In a functional sense, culture becomes a product. Culture is no longer a set of ideal values that determines our approach to space, and is becoming an economic value. It is therefore associated with material values in the form of visual attractions, images, signs, sounds, symbols, and events designed for consumer markets.

A typical example is an urban landscape. It constitutes cities' skyline that has been developed over the centuries and that offers views that are attractive to recipients to a varying degree. The art of urban composition is able to highlight such values as picturesqueness, uniqueness, and mood, for which a consumer (e.g. tourist) is able to pay a specific price.

In an economic approach, the unique look of architecture, the rare form of squares and streets, the intimate scale, the extraordinary urban composition and architectural detail that draw on local tradition, the contact with water and greenery are gaining more and more significance and affect property prices. They are positive factors of a new urban ergonomics that describes the relationships between an individual and their surrounding.

2.3 Culture-Generating Attributes and Cultural Patterns

This way of perceiving the relationships between an individual and their surrounding enables identifying the following culture-generating attributes that can be used in architectural design:

- aesthetic attributes,
- cognitive attributes,
- utilitarian attributes,
- identification attributes,
- integrative and adaptive attributes,
- religious and magical attributes,
- emotional attributes,
- educational attributes,
- ludic attributes,
- symbolic attributes,
- expressive attributes,
- ideological attributes.

Culture picks and chooses only a few characteristics out of this range that become leading attributes of architectural form that make up some kind of a "pattern of culture". It is impossible to analyse single attributes detached from their entirety because architecture is a functional and integrated whole that is a unique arrangement of culture-generating attributes.

A "pattern of culture" is a set of attributes that a particular community see as its "own", and worthy of respect and imitation. It change in time and is associated with fashion. It plays a significant role in shaping the collective memory of a given social group. In architecture, "patterns of culture" are materialized in such elements as form, colour, ornament, and architectural detail. Aesthetic values and spatial elements such as size, distance, boundaries, territories, dominants, and composition axes etc. can also be included here. The notion of a "pattern of culture" is derived from Benedict's anthropological research and concerns basic culture-generating aspects [18]. In architecture, the pattern enables identifying architectural form as belonging to a specific culture circle.

Cultural patterns may be competitive, and even exclusive, depending on the context. Most patterns are easily identifiable, yet there are hidden ones the meaning of which we often do not realize. The knowledge of cultural patterns may

be profound or superficial, and a context approach is needed to promote them in architectural practice.

3 Cultural Requirements Engineering

An advantage of the context approach is that it is concentrated on analysing cultural expectations on part of users of architecture. This approach is already part of the Cultural Requirements Engineering trend. It concerns defining, documenting, and managing requirements as to the detailed aspects of a cultural system. Cultural Requirements Engineering is a key stage of decision making during which requirements are formulated that a designed construction is meant to meet.

In a broad sense, it is a process of identifying users'/clients' cultural needs and documenting them in the form of design standards [19].

In this approach the main criterion (overriding objective) of design optimization is requirements. They stem from the attributes that build specific patterns of culture. Because of that determining the importance of particular attributes in building a pattern of culture is moved into the foreground. It should be remembered that in the cross-cultural approach users have more often than not diversified requirements, which is connected with their systems of values. That is why it is essential to associate design requirements with the cultural profile of the customer for whom a building is being constructed.

Not only does the method request analysis of and forecasts as to how users will use the building (or the effects of design works), but also mainly aims at confronting compositional and functional features against cultural requirements. This approach is an efficient way of enhancing design solutions. This approach is characterised by the fact that based on research into attributes of culture we attempt to adapt the building to suit its users' needs rather than force them to change their cultural preferences and use a building (a product) that has not been customised. Hence first we look for answers concerning cultural requirements, and then we assess the proposed solutions to see whether they meet the requirements.

A question arises as to the criteria of assessment of the project in the context of meeting cultural requirements.

4 Architectural Form

Architectural form is a clear sign the meaning of which carries specific functions of culture. Architectural form may be distinctive in its exclusive visual features that make up its unique identity. Architectural form (the way in which architectural creations look) is designed for promotion (attracts prospective tourists, inhabitants and clients), values (presents unique values related to tradition and culture), and identification (is distinctive from other cultures).

Features that create cultural identity gain particular importance as some kind of a promotional message that is designed to draw tourists', inhabitants', and investors' attention. Architecture drawing on tradition and culture is a proof of the value of the place in which it was created. Architecture that is alien to our culture promotes the culture of other (competitive) regions with which it identifies. Therefore it is important to create a unique image of architecture as a brand identified with its location. This aspect is important for marketing and makes it possible to assess the architectural form as an element of space competitiveness.

In this context, the most important criteria of assessing the efficiency of design solutions include:

(a) Uniqueness. Uniqueness comprises a set of features that differentiate local architecture from their competition.
(b) Familiarity. Familiarity is a set of architectural features that cause people to take preference over particular architectural forms rather than others and long for these forms when they have no contact with them (e.g. if they have emigrated).
(c) Personalization. Personalization comprises architectural features that reflect inhabitants' own aesthetic tastes and preferences that arise from their cultural habits and systems of values. It is an expression of inhabitants' identity and original preferences.
(d) Local symbolism. Local symbolism is created through architectural features that are symbols of pride and prestige.
(e) Cultural identification. Cultural identification is a set of architectural features that are directly equated with local tradition, history and collective memory of the location. Cultural identification is an important element of stylistic identity in culture.
(f) Expression of tradition. Expression of tradition concerns architectural features that are worthy of protection and preservation because they value the society from the viewpoint of emotions and hence they have been considered important for current and future needs.

The aforementioned features form the basis for determining a pattern of culture of architectural form suits the location best.

Figure 1 shows a practical use of the method in the design of the new development in Harbin (China) that makes references to Polish cultural heritage with the first urban development plans prepared by Adam Szydłowski in 1898.

5 Assessment of Cross-Cultural Solutions

It can be noticed that people assess architecture based on their own cultural preferences and motives that stem from a behavioural profile. Bagnall pays attention to the regularity, saying that an individual's memory, emotions, ideas, cognitive preferences, and the way they perceive their surroundings are a vital element of "visual consumption of goods of culture" [20].

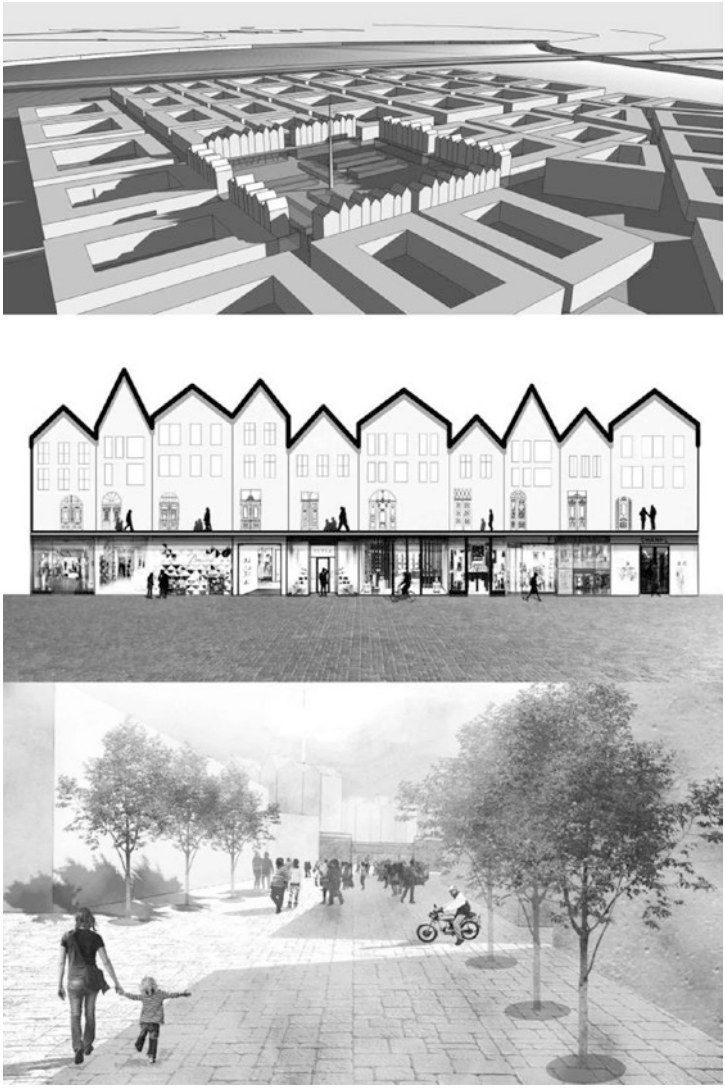

Fig. 1 "Polish (is)land in the City of Habin" design that makes use of cultural designs related to Polish cultural heritage. The design was made by students M. Koczewska, Z. Pietkiewicz, and M. Stępniak supervised by Prof. W. Bonenberg, University of Arts, Poznan, Poland

"Visual consumption" is associated with material attributes that make up architectural form. Following from that it is possible to define specific design requirements relating to:

- Cultural context: society, history, tradition, language, customs, climate, lifestyle, technology etc.,

- General design approach: design theories, approach to nature (the earth, water, air, sky, fire) and their cultural significance,
- Elements of a building: walls, roofs, eaves, cornices, balconies and loggias, windows, pilasters, bay windows, ornaments, structure, colour, fabric,
- Entrances, doors, gates, fences: size, shape, colour, structure, sculptures and their cultural significance,
- Design principles: articulation, contrast, adaptation, balance, rhythm, proportions, scale, composition simplicity/complexity, clarity,
- Spatial organization: linear, central, radial, chequered, organic,
- Spatial dependencies: space permeability (interior/exterior), transparency, separation,
- Adaptive capabilities: flexibility, changeability, multi-functionality, directions of extension,
- Crystallizing elements: paths, edges, nodes, corridors,
- Narrative elements: ornamental, allegoric and symbolic decorations, their hierarchy and cultural significance,
- Horizontal surfaces: landform features, land cover (flowers, grass, stone slabs, ceramics, wood, concrete), water levels,
- Vertical elements: architectural dominants, columns, arches, vaults, trees (and their cultural significance),
- Properties of architectural interiors: shape, size, proportions, lighting, microclimate, acoustics, equipment, furniture, facilities,
- Environmental protection: waste disposal, sustainability, and energy efficiency,
- Building maintenance design: strength of materials, cleanliness, safety, susceptibility to changes resulting from inhabitants' emerging needs.

6 Conclusions

The discussed problems form the basis for assessing a design against its conformity with a "pattern of culture". The lack of conformity means that architecture has not been adapted to the cultural context. It is most often manifested through such faults as wrongly selected building development scale, no stylistic originality, and colours and materials that are not associated with the local tradition. Architectural uniqueness is also affected by little attention having been paid to local ornaments and architectural details. Another error that can be listed is a building not tailored to its inhabitants' cultural preferences.

An interesting approach to solving the problem is proposed in the theory and practise of urban empathy [21]. Urban empathy stresses the importance of cross-cultural design from the perspective of the local community's preferences. Before taking decisions relating to design, an architect should research how proposed design solutions will be accepted by the local community. The cross-cultural ability to reconcile various and often clashing interests is the basic benefit of the

method. Such an approach in architectural design offers a chance of preserving local culture and arrive at creative solutions that bring new value added to urban space.

Hence, it is possible to obtain positive values that raise the attractiveness of a space:

- Sense of space,
- Uniqueness of a place,
- Familiarity of a place,
- Safety of a place,
- Spirit of a place.

These features have a favourable effect on strengthening social ties, raising a sense of security (neighbour watch), and caring about the unique heritage of a place. The cross-cultural approach to design makes it possible to tailor architecture to better suit a local community's preferences, and understand how tradition and history may be used in contemporary architectural design.

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Aesthetics and Composition of Forms in the Design of Means of Transport and Rehabilitation for People with Disabilities

Agata Bonenberg

Abstract The paper presents practical design achievements, which are the result of research in the field of human factors and ergonomics (HF/E) for persons with disabilities. The implementation of design solutions for transportation and rehabilitation purposes has been shown on the example of two constructions: electrically powered transporter and quadriplegic training device. The aim of the research was to determine both the design phases of device body-forms and aesthetics proposed to the specific target group. All presented solutions have been developed within the project "The new product line to support mobility and accessibility ambient seniors and people with disabilities" at Poznan University of Technology.

Keywords Designing for the disabled and the elderly · Customization

1 Introduction

In the face of the demographic and social phenomena of the 21st century, related to the changes in the age structure of western societies, the improvement of medical care and, even more importantly, the drive of the elderly persons and persons with disabilities towards self-reliant and satisfactory lives, the design of devices helping to overcome the physical limitations has become an imperative. The paper presents practical design achievements, which are the result of research in the field of human factors and ergonomics (HF/E) for persons with disabilities. The implementation of new forms of casing (body) solutions for transportation and rehabilitation purposes has been shown on the example of two constructions: electrically powered transporter and quadriplegic training device. The aim of the research was to determine both the design phases of device body-forms and aesthetics proposed to the specific

A. Bonenberg (✉)
Faculty of Architecture, Poznan University of Technology, Nieszawska 13 C, 60-021 Poznan, Poland
e-mail: agata.bonenberg@put.poznan.pl

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_11

target group. Both projects meet the European principles of universal and inclusive design [1], implementing theory from the research fields of: Human Factors and Ergonomics in Healthcare, Ergonomics in Design, Design for Accessibility.

2 Structure of the Study and Research Methods

The paper consists of the two main parts:

- presentation of the projects of the electrically powered transporter and quadriplegic training device
- description of the design process and decisions which led to the obtained results.

The methodology accepted for research purposes included a combination of design ideas, as well as conclusions and theoretical research carried out according to the *research by design* method, i.e. *practice-based research*. *Research by design* is a recognized method which makes it possible to draw conclusions and expand knowledge in disciplines related to creative activities: architecture, industry design and art [2]. The designs presented herein constitute a creative input in spatial problem solution and play a role of an occasional experiment.

Research analysis stages:

- Developing a research thesis/design ideation
- Establishing criteria of concept evaluation
- Establishing of optimal variant
- Thesis verification in the form of design simulation (design)
- Conclusions (Fig. 1).

3 Electrically Powered Transporter

Electrically powered transporter for persons with disabilities sitting on a manual wheelchair belongs to a family of constructions of electrical transport-rehabilitation devices with a common base-platform. With the power to lower the platform and pull out the tilt-ramp from the frame it is possible for a stand-alone user to enter the transporter. Modern mechatronic drive of the rear wheels together with self-adjusting front wheels allows driving and twisting transporter. Susceptible suspension of the rear wheels and high transportation clearance provides a comfortable ride. The properties of the transporter allow for the independence of use, ease of use and safety. The scope of work undertaken by the author was the design of the device body, illumination system and casings in order to receive an stylistically adequate and attractive product. The transporter has been designed in two variations: for external use (with fully-covered body) and for indoors. The construction of the transporter has been developed within the framework of the project “New lines of products supporting mobility and accessibility of the senior and

Fig. 1 Rendering of final form of the body of the electrically powered transporter for persons with disabilities, author: A. Bonenberg

disabled persons' environment" led by Prof B. Branowski at Poznan University of Technology (Figs. 2 and 3).

4 Quadriplegic Training Device

Quadriplegic training device allows for the simultaneous exercise of upper and lower limbs. Thanks to the making of the mechanism, when spinning lower pedals, top pedals spin automatically—and vice versa. Special clips allow the foot to stabilize the limb to force their movement. The product has a smooth resistance adjustment knob. Quadriplegic training device allows training to people sitting in a wheelchair, and the use of a wide weighted base provides excellent stabilization of the device during exercise. The quadriplegic training device can be used to exercise the arms and legs both at home and hospital. The scope of work undertaken by the

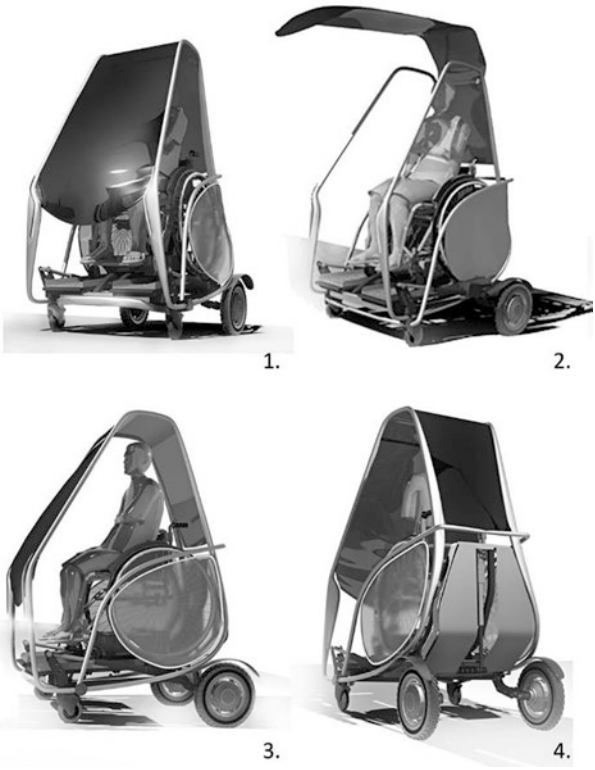

Fig. 2 Rendering of final form of the electrically powered transporter for persons with disabilities (A. Bonenberg)

Fig. 3 Rendering of the final version of the casing of electrically powered transporter for persons with disabilities for outdoor use (A. Bonenberg)

Fig. 4 Renderings presenting the final form of concept of the quadriplegic training device (A. Bonenberg)

author was the design of the device body, and casings in order to obtain adequate form of the product. The construction of the Quadriplegic training device has been developed within the framework of the project "New lines of products supporting mobility and accessibility of the senior and disabled persons' environment" led by Prof B. Branowski at Poznan University of Technology (Fig. 4).

5 Form Development Phases

Phases of form development from concept to ergonomic analysis consisted of series of listed below methodical of steps. These were completed in presence of research team; interviews with future equipment users (target group) followed. Main form development phases of both electrically powered transporter and quadriplegic training device were:

1. design ideation
2. conceptual, initial phase of form-building through sketch, drawing and 3D modelling
3. establishing criteria of concept evaluation
4. establishing of optimal variant

5. pre-construction phase of drawings and 3D models
6. 3D model and physical model
7. ergonomic analysis of 3D model and physical model
8. evaluation of the aesthetics of final form (Table 1).

Table 1 Design phases of the body of electrically powered transporter for persons with disabilities (by A. Bonenberg)

No.	Design phase	No. of people	Duration weeks	Actions undertaken
1.	Design ideation	3	1	Brainstorming, free association method, method of observing similarities, creative imagination
2	Initial phase of drawing/modelling	1	1	Preparation of series of sketches and 3D computer-generated models with color scheme proposals
3	Establishing criteria of choice	2	0, 3	Following criteria have been established: – Compatibility with existing rehabilitation equipment. Users should be able to access the transporter using any commonly available wheelchair – Light structure – Full protection against rain and sun – Build-in illumination system – Narrow body allowing for small-radius turns (suitable size) – Possibilities of product customization – Design must appeal to both men and female market – Must contain possibility of transportation of medium size items (shopping bags)
4	Establishing optimal variant	3	0, 3	The proposal of transporter with full roof and tall body has been chosen
5	Pre-construction phase	4	2	Preparation of 2-dimensional CAD-drawings
6	Model preparation	1	2	Constructing an up-to scale model to be assessed both in terms of ergonomics and aesthetics
7	Ergonomic analysis	1	0, 3	Analysis of 3D model and physical mode
8	Evaluation of aesthetics	3	0, 3	– Modern, smooth, light forms – Design appealing to both men and female market – following the modern stylistic patterns and the universally accepted trends in car design – smooth, visually light forms

Final forms have been established after analyzing over 10 conceptually different solutions (Figs. 5, 6, 7 and 8). The general role of separation of the support-and-drive systems from the protective body–panels enables to further customize both electrically powered transporter and quadriplegic training device. Colors, graphics on their bodies can be changed accordingly to the individual wishes of the users. This has already become a standard feature in the industrial production [3]. The process of co-designing the patterns on the product's bodies can be a positive element of the client experience.

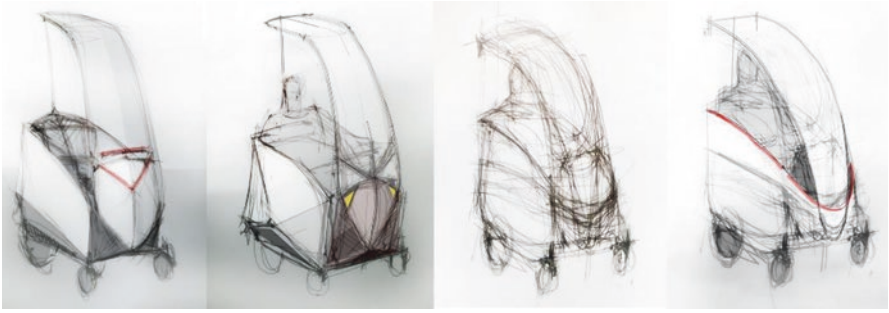

Fig. 5 Drawings presenting conceptual, initial phase of form-building of the electrically powered transporter for persons with disabilities. Sketch by A. Bonenberg

Fig. 6 Rendering of the concept version of the electrically powered transporter for persons with disabilities for the outdoor use. Solution has been declined due to the absence of front shielding (windscreen) (A. Bonenberg)

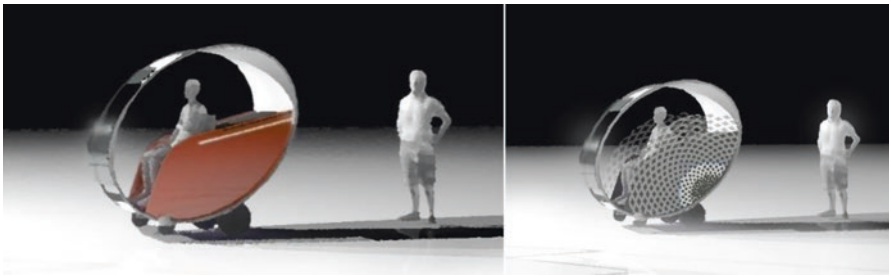

Fig. 7 Rendering of the concept version of the electrically powered transporter for persons with disabilities for the outdoor use. Solution declined due to large size of the vehicle (A. Bonenberg)

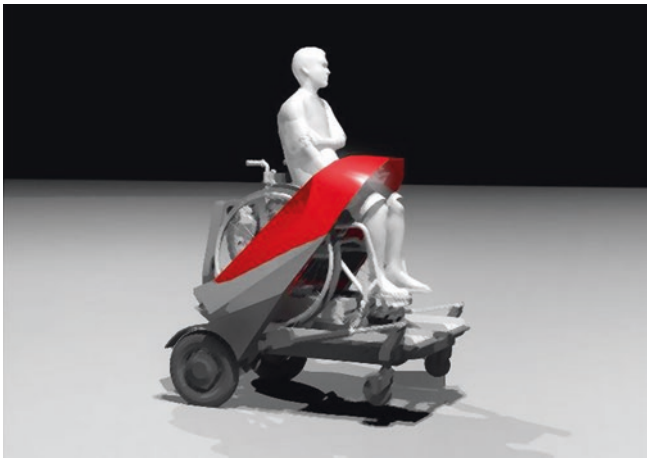

Fig. 8 Rendering of the version of the electrically powered transporter for persons with disabilities for the outdoor use (A. Bonenberg)

6 Summary

The design and aesthetics of the transportation and rehabilitation equipment for elderly people and people with disabilities can help improving the perception of such persons within their social environment. Products dedicated to this target group may be modeled in a futuristic, dynamic forms since this way it does not evoke associations with the restrictions caused by the disability and the old age. This constitutes a crucial element of improving life quality for the disabled persons. In the face of the demographic and social phenomena of the 21st century, related to the changes in the age structure of societies and the development of medical care, seeking solutions that help overcome physical limitations and negative psychological associations becomes the necessity.

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Application of the Green Roof System in Small and Medium Urban Cities

Mo Zhou and Wojciech Bonenberg

Abstract The urban green roof has been built in many large cities, such as Hong-Kong, Singapore, New York, Tokyo and in the like around the word. Anyhow, this idea already brings a lot of benefits to the society, environment and the economy. However, in my opinion, a lot of small towns also need to develop the green-roof system in order for it to be promoted as an easy and effective strategy for beautifying the living environment and increasing investment opportunities. In this research including functional analysis based on the designed projects, there are some high buildings in small cities used to be designed with the Green roof system; Furthermore, green roofs can also help reduce the dispersion of dust and particulate matter throughout the city, and limit smog. This can play an important role in reducing greenhouse gas emissions and adapting urban areas to the hot summer season climate of the future.

Keywords Green roof · Design · Urban city · Sustainable · Application

1 Current Problems

With the rapid development of cities around the whole world many are growing much faster than in the past which means that most citizens live in high rise buildings without enough green space. And as statistics from Eurostat show that most people are living in big cities towns and suburb there isn't enough space for people to get close to nature and relax.

M. Zhou (✉) · W. Bonenberg
Faculty of Architecture, Poznan University of Technology,
Nieszawska 13C, 61-021 Poznań, Poland
e-mail: mo.zhou@put.poznan.pl

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_12

The green roof is considered to be an effective way to make the city more vivid than the massive buildings. Already there are successful examples in big cities worldwide e.g. in New York the urban roof in Hong Kong lots of urban cities are trying to improve the urban sustainability by making more greenery and promoting urban farming on the roofs.

2 Introduction

Green roofs have been established for over 100 years and they have become one of the key elements of urban area in the past few decades [1].

Many urban cities in the world are trying to enhance sustainability by improving urban greenery and promoting urban farming.

During the 19th and 20th century, rooftops in major cities of the United States were greened to replace the rising land costs of building parks in the inner [2].

By installing green roofs with urban farming, it is possible to achieve environmental, social and economic sustainability for the buildings in urban cities, because it can contribute to the mitigation of environmental problems, enhancement of community functions and development of urban food systems. This paper describes a research to investigate green roof urban farming for urban cities like Hong Kong. The benefits and potential of rooftop urban farming are examined; some experiences and examples around the world are described. The characteristics and constraints of urban cities are studied and the practical situation in Hong Kong is evaluated. It is hoped that the research information will be useful to promoting sustainable buildings and environment in urban cities.

This ‘green’ concept is also known as green roof landscape architecture, and it offers a powerful alternative to the conventional building process which, on the contrary, uses fewer natural resources which are proven to increase the happiness of the human as well as the positive effects to their health.

As we know, urban green roofs bring a lot of benefits for the cities e.g. commercial or residential projects, easy installation. They enhance energy efficiency, roofing membrane durability, green roofs contribute to noise reduction, fire retardation, public benefits of green roofs, aesthetic improvements—residential green roofs have a special aesthetic appeal to the general public since they are easy and effective to make and build a beautiful environment and enhance the investment opportunity. The plants present on a green roof acts like air purifiers that filter in noxious gases and release fresh oxygen into the environment. They also capture airborne pollutants and other atmospheric depositions to make the air fresh and clean for breathing.

Intensive green roofs—these roofs are also known as rooftop gardens. They can serve a number of purposes such as vegetable gardens, playgrounds, or walkways. They can also accommodate diverse plants and trees and they will require regular care and maintenance (Figs. 1 and 2).

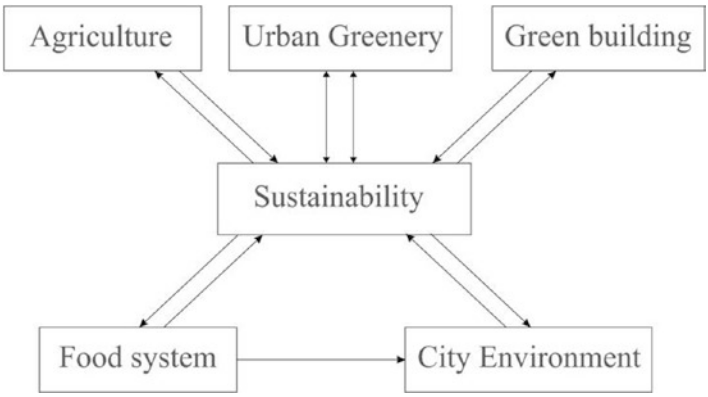

Fig. 1 The green roof- how to help improve urban green and sustainability [3]

Fig. 2 Via Lloyd Alter (@lloydalter) design/green architecture [4]

A roof is one of the most fundamental aspects of your property. It not only protects you from adverse climatic conditions, but also provides you with a safe and secure place to live in. When you are sleeping sound at night, it is the roof of your house fighting the battle against the wind and storm…

Nowadays, there is a whole new revolution of eco-friendliness invented by the so called green roof architecture. This type of roof architecture is an innovative concept of eco-friendly design in urban areas which minimizes the negative impact of any building construction materials as well as construction activities harming our environment.

Though the research, it is very necessary to improve the harmony of nature and architecture from building information modelling [5].

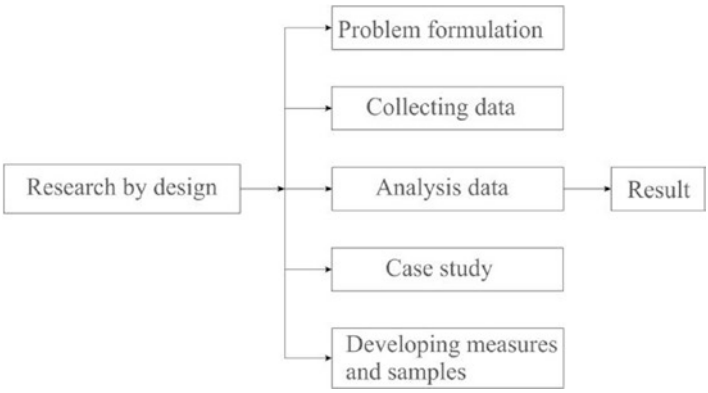

Fig. 3 Scheme of the methodology of research by design

3 Methodology

This paper mainly described the results by different proposals through the main method is research by design.

There are about 150 different designs for enhancing sustainability of the green space for small-medium cities like in Poznan city with 0.5 million people living. From those sets of projects, the outstanding ones were chosen for the research. Students selected some of the excellent work from sets of projects, then chose the ones which are compatible to the themes.

Then each point of the outstanding project was analysed in terms of creations, and efficiency of improving the greenery in the city.

Before examining types of research designs it is important to be clear about the role and purpose of research design. We need to understand what research design is and what it is not. We need to know where design fits into the whole research process from framing a question to finally analysing and reporting data. This is the purpose of this chapter.

Compare the different function of those works and then describe them individually in different functions (Fig. 3).

4 Functional Analysis

The main feature and function analysis were done from the design projects with the green roof on the buildings located in small and medium cities like in Poznan.

Through some outstanding examples in the small and medium cities with installation green roof system design, different functions to the urban cities from green roof system were analysed separately.

4.1 Historic Preservation

The effect of design work is consistent with the style of the historical architecture style around. In the example from model Market *Bernardynski* as in Figs. 4 and 5.

The project "Green roof market" was chosen for analysis due to the fact that the design style is keeping the same style with the historical heritage buildings around. As a renovation project of an old market located in the citer center. Somehow, the old Catholic churches and other residential buildings are not going to change their own style. So, on the one hand the new project could improve the city appearance by an aesthetic improvement and remodelling the vegetable markets for citizens and add more greenery space to the old square, on the other hand the remodelling style conserves the traditional local style. It reflects the close connection with modern architecture and historical style.

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Fig. 4 Green roof market project in Poznan Bernardynski market (designed by Zuzanna Marcinkowska; supervised by dr.inż. Mo Zhou)

Fig. 5 Green roof market project in Poznan Bernardynski market (designed by Zuzanna Marcinkowska; supervised by Mo Zhou)

Fig. 6 The layout of the Green market (designed by Zuzanna Marcinkowska; supervised by Mo Zhou)

4.2 Aesthetic Improvements

Urban greening has long been promoted as an easy and effective strategy for beautifying the built environment and increasing investment opportunity. As is shown in Fig. 6 the green roof market, by growing vegetables and flowers, has offered the citizens in Poznan very good environment and effectively gave people an aesthetic improvement when comparing the old market with crowded spaces and messy market status. By the green wall along the market, it is no doubt attractive for many people coming to the market.

4.3 Improved Air Quality and Leisure Space for Citizens Specially in Winter Time with the Green Roof Garden

In Europe, many medium size cities in winter are not so attractive due to the harsh weather in cold season and lack of the green space.

Through modelling as in Figs. 7 and 8, the green roof garden in the city can offer leisure space to residents who will be able to enjoy the spare time in a garden nearby their apartments.

Furthermore, the installation of a green roof garden can effectively improve the air condition. The plants on green roofs can capture airborne pollutants and atmospheric deposition.

They can also filter noxious gases. Because in winter season, many small and medium cities in Europe still heat houses and offices by burning wood, coal and other polluting materials, generating a lot of pollution in the city. Green roof garden with plenty of plants and flowers can help to purify the air quality.

Fig. 7 Big green roof park in the city center (designed by A. Gawron and E. Szlapa; Suoervised by Mo Zhou)

Fig. 8 Transparent green roof offer great place for citizen enjoying the spare time (designed by Zuzanna Marcin kowska; supervised by Mo Zhou)

Therefore, the temperature moderating effects of green roofs can reduce the demand on power plants, and potentially decrease the amount of CO_2 and other polluting by-products being released into the air.

The similar report f.g. other scopes of green roof studies are including the temperature reduction caused [1].

4.4 Green Roof Market with Green Stairs and Green Walls

See Figs. 9 and 10.

Fig. 9 Green roof design with renovation of the main second hand market (designed by Patrycjia Kur; supervised by Mo Zhou)

Fig. 10 Renovation of the main second hand market (designed by Patrycjia Kur; supervised by Mo Zhou)

4.5 Sustainable Energy Contribution by Green Roof System

The aim is to promote medium city ecological and sustainability, the green roof project with the installation of photovoltaic system in the education centre not only improves the sustainability but also represents benefits for education and the whole society. Therefore, the design with renewable energy system could be very helpful for the city development from the energy saving aspect as we could get from the design project Figs. 11 and 12.

Using the harnessed solar energy, the green roof system can work more efficiently for the renewable urban city.

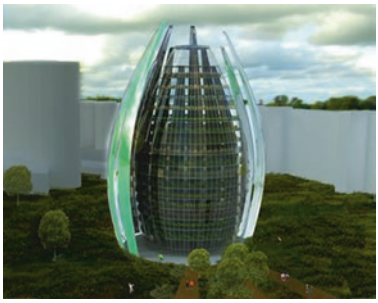

Fig. 11 Vertical farm with green roof as well as solar panel and mirrors (designed by Alicja Michowska; supervised by Mo Zhou)

Fig. 12 Education centre for students with installation of photovoltaic system and green roof (designed by Lukasz Gaska and Marta Sowinska; supervised by Mo Zhou)

4.6 Green Roof with Balcony or Terrace Effectively Promote the Inhabitants' Health

Green roofs in urban and suburban areas act as green corridor for entering the nearby habitats [6].

The design of the residential buildings with a balcony garden (from Figs. 13 and 14) can give inhabitants more space and an opportunity to get in touch with nature easily. So it proved that people living in high-density developments are supposed to be less susceptible to illness., if they have a balcony or terrace roof garden. From experience, plants grown on a balcony and terrace can give more oxygen emission and make the air more humid. All of those factors above can result in more flexible space and healthy living conditions for people living there. The variety of sounds, smells, colours and movement provided by plants, although not quantifiable, can significantly add to human health and wellbeing.

4.7 Green Roof System in a Medium City to Promote the Urban Biodiversity

As in the Fig. 15 showed us a lot of plants could be grown in the green roof, So it improves the biodiversity for long term in the urban cities.

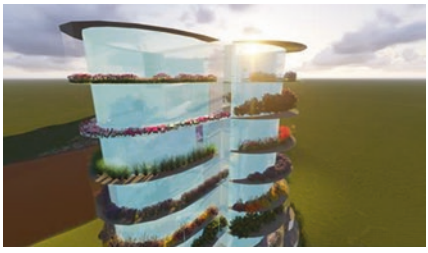

Fig. 13 The residential building with green roof and balcony (designed by Aleksandra Musialowska and Aleksandra Neunert; supervised by Mo Zhou)

Fig. 14 Balcony corner with Terrace roof garden (designed by Aleksandra Musialowska and Aleksandra Neunert; supervised by Mo Zhou)

Fig. 15 Green farm with plenty of vegetables for citizens (designed by Zuzanna Marcinkowska; supervised by Mo Zhou)

4.8 Green Roof Farm Provides Fresh and Organic Food for Local People

As in Figs. 16 and 17 the design showed us that green roof farms also provide the local people fresh and organic food, which, together with progressive urbanization, people living in a city care more and more about. Because of the space shortages in the city, normally most fresh food is transported from the traditional farm outside of city. So with this function, a green roof farm is definitely welcome in the developing medium-size city.

Fig. 16 Vertical farm with green roof design in city Poznan (designed by Filip Zielinski; supervised by Mo Zhou)

Fig. 17 The green roof garden with various kinds of plants (designed by Filip Zielinski; supervised by Mo Zhou)

5 Conclusion

As we can see, an urban green roof system can bring a lot of possibilities to the urban medium and small size city, through the functional analysis from the case designs.

Generally, it makes more green space in the city and makes it more attractive due to aesthetic improvement. Especially in winter, it offers citizens more space for sports, leisure and entertainment.

What is more, the urban green system provides people with a healthy environment, so it is beneficial and environmentally friendly. Importantly, the green roof farm not only gives us more fresh air, but also brings fresh food to local citizens in the city.

In conclusion, through green roof system in the urban small and medium city it is a vegetated form that blends landscape and structure, nature and high-tech and symbolizes the creativity and sustainability of our city!

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Shift of the Function of "Temple of the Travelling" from Railway Stations to Airports

Romuald Tarczewski, Elzbieta Trocka-Leszczynska and Joanna Jablonska

Abstract Human culture, lifestyle and economy are strictly connected to traveling and shipping goods at long distances. Means of transport have influenced societies and architecture through history, however the strongest impact was related to industrial revolution of XIX century and invention of rail. Possibility and commonness of covering long distances in a short time gave impact of developing whole cities and regions, as well as creation of specific architecture of transportation. Serving as not only a shelter and distribution hub for travelers, but allowing fulfilling certain journey habits and specific customs, train stations became kind of "Temples of Traveling". Nowadays traveling function has shifted towards new means of transport—airplanes and their sanctuaries—airports. New religion become shopping and usage of all commercial services, offered in ever-expanding terminals. Also neglected and forgotten to some point railway stations are nowadays being subject of transformation and upgrading. This article was devoted to presentation of conclusion from research on European "Temples of Travelling" with a special focus on: architecture and structure significance, users, their needs, ergonomic aspect and surprising shifts of functions. It seems that architecture of transportation is now balancing between commercial and cultural function, therefore is especially interesting scientific study object.

Keywords Architecture of large-scale spaces · Architecture for traveling · Temples of traveling · Structure and architecture of large-scale spaces

R. Tarczewski (✉) · E. Trocka-Leszczynska · J. Jablonska
Faculty of Architecture, Wroclaw University of Technology,
Prusa Street 53/55, 50-317 Wrocław, Poland
e-mail: romuald.tarczewski@pwr.edu.pl

E. Trocka-Leszczynska
e-mail: elzbieta.trocka-leszczynska@pwr.edu.pl

J. Jablonska
e-mail: joanna.jablonska@pwr.edu.pl

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J. Charytonowicz (ed.), *Advances in Human Factors and Sustainable Infrastructure*, Advances in Intelligent Systems and Computing 493,
DOI 10.1007/978-3-319-41941-1_13

1 Introduction—The Birth of "Temple of Travelling"

Travelling on distances longer than resulting from every day's needs, has always been a somehow a special event. It was celebrated and therefore required unusual service. Especially long travels, which had to be carefully prepared, consumed a lot of time and were connected with several inconveniences, became related with specific rituals and habits. To give an example, it always concerned an obligation for local communities to help newcomers, who—not being on their own territory—could feel lost and disoriented. On the other hand, travelers felt obliged to be as self-sufficient as it was possible. Due to the latter, long-distance travels required support by specially adjusted buildings, providing shelter and a number of necessary facilities and services.

As aforementioned uncommon travel required proper celebration, therefore most of the buildings serving travelers, were distinguished by their significant architectural features. Interestingly enough, for each mean of transport characteristic type of architecture was established, with specific expression and recognizable features. Different for altered conveyance method, i.e. for land (road, rail) there can be mentioned: stations, stops, gas stations, sheds; for air: airports, landings, hangars, control towers; for water (marine): ports, harbors, docs, lighthouses, marinas; and at last for underground: metro stations, service station, etc. Thus, varied in form and aesthetical expression, they all undergo similar processes, that affect: function, space, comfort, ergonomics and structure. Changes that are closely related to social and commercial aspect of their usage, effecting with excessive overgrowing of these buildings. This, in connection to aforementioned architectural significance, expanded to the point where travel service building could be called "Temples of Traveling".

1.1 Scope and Method

This article was devoted to presentation of this spatial and functional shift, analyzed at the background of ergonomic aspect of such changes. Due to broad field of problematics authors focus was limited to European rail stations and airports, as elements of most popular and common means of transportation. The research were developed on two levels: literature and case studies. The scope of analyzed site examples took into account historic and contemporary airports and train stations as well as nowadays refurbishments of both. Moreover major and minor buildings were researched, in order to gain possibly broad source material. During all analysis an urban characteristic was taken into account. Researchers used following methods: visual, critical and graphical analysis, synthesis and comparative synthesis.

2 From the Use of Simple Services to Savor of the New Subculture

The technological revolution in the ways of travelling on long distances appeared in two "waves". The first one came with the development of railways, and the second—when the air transport stopped being used mainly for military purposes. In both of mentioned processes, two phases can be distinguished. First, the emergence of new technology and assurance of its' elementary technical support. Then the "timid" completion between basic functions and additional ones. Afterwards, after the acceptance of innovative solutions and appearance of massive demand—"explosion" of new proposals. The sequence of this process is substantially identical in the two "waves" of the technological revolution.

2.1 Railway Stations

Since 19th century, during the shift of society from agrarian to technological culture [1], technical civilization has radically changed way of travelling providing totally new means of transportation, enabling fast and easy covering long distances, as well as popularizing journeys among widespread society. This phenomenon of massive movement was both supported and caused by industrial revolution and primal development of railway. All new possibilities—i.e. easiness of travelling—interacted with rituals developed throughout centuries, resulting in an emergence of new specific subculture related to rail mean of transport. These transformations manifested in appearance of peculiar "Temples of the Travelling"—monumental buildings designated not only to provide basic services for the travelers, but also all new attractions and amenities that became available and assisted widespread audience—these were railway stations.

Of course, objects designated for serving the traveler were built also in the past e.g. wayside inns or caravanserais, but they have never (until 19th century), achieved a status of independent center-creating hubs. Once they appeared, railway stations shortly became nodes within the cities, which stimulated the development of neighboring quarters and characteristic points, so called "determinants of the central area". Examples of edifices with tremendous, distinguished architecture built at that time, such as: Grand Central Station in New York (end of XIX cent., arch. John B. Snook), Gare d'Austerlitz and Gare d'Orsay in Paris (beginning of XX cent. arch. Victor Laloux, Lucien Magne and Émile Bénard), Helsinki Central railway station (beginning of XX cent., arch. Eliel Saarinen), allows imagining their luxurious standards and importance of the supplementary, assigned functions (Fig. 1).

Fig. 1 Helsinki central station (*Photo* J. Jablonska)

Fig. 2 Expanded duty-free shopping zones at the Istanbul-Atatürk airport (*Photo* R. Tarczewski)

2.2 Airports

After WW II, and especially at the turn of the 20th and 21st centuries, the importance of the air transport has rapidly increased. Similarly as the railway in the 19th century it has radically changed the way of travelling on long and medium distances. This mean of transport is now widespread and airports are operating not only in the significant cities but also in smaller regional centers. That change had a strong influence on decreasing importance of railway transportation. It has also diminished the importance of railway stations themselves, thus function of the "Temples of the Travelling" had shifted to the airports. Range of services accessible for air-travelers is superior to nowadays offer of railway stations. Commercial zones in the aerodromes are expansive and highly profitable. Frequently, duty-free shopping becomes itself a destination for many customers. It is characteristic, that those services are usually oriented on the highest segment of the market, i.e. luxury goods. Thus, the airports' shops have influence on the global fashion trends (Fig. 2).

3 Unity in Diversity—Common Features of New "Temples"

As it was aforementioned main common feature of contemporary public use buildings for passengers' service are usually distinguished by their representational architecture. Due to functional character in such object, the need occurs to design a large hall, which can shelter simultaneous influx of people going in different directions. A scale, a form and architectural solutions of this interior, are elements of recognition and prestige of whole complex. This way importance and uncommonness of journey can be highlighted. In addition, because of a room's elongated span and often due to a unique configuration, structures provide a very strong support for the visual appeal of the interior. Trusses, columns and entablatures become characteristic elements of the hall and serve for identification or even symbols. Just to mention such icons, like: Waterloo Station London in England (rebuilt, arch. Nicholas Grimshaw, 1993)—with amazing, organic and glazed hall, Kansai International Airport Terminal in Japan (arch. Renzo Piano, 1994)—covered by highly aesthetic structure of contemporary girders, Southern Cross Station Melbourne in Australia (rebuilt, arch.: Nicolas Grimshaw, 2006)—distinguished by outstanding, "wavy" roof [2]. It must be stressed that airports and train station will be seen by many, hence in the past there was tendency to use especially decorative solutions, while nowadays there is a trend to use exclusive contemporary design, based on perfect symbiosis between architecture and structure. A great number of travelers are also a big challenge to ensure adequate durability. Therefore, in the described objects high quality is used, by long-lasting materials, which further raises the standard of these facilities.

To give an example: recognizable, sculpturally shaped roof over new terminal in Wroclaw Starachowice airport in Poland (arch. JSK Architekci, 2009), is supported by tall V-shaped pillars, which give an extraordinary outlook of passengers main hall. Wavy shape of ceiling—based on sinusoidal geometry—not only draws attention of interior guests and landing commuters, but also allowed creation of additional lighting by lateral skylights. The coverage was divided into stripes of 15 m length each and shifted against each other, in order to receive optimum surfaces of glass, placed between extremums of opposite sinusoids. The passengers hall's walls have been glazed as well, in order to gain additional natural lighting and contemporary, but elegant architectural expression. Achieved transparency provides background for the covering and all lively activities taking place inside hall and outdoor. In the front area, roof slabs have been extended as cantilevers outside wall, in order to mark and shelter main entrances and achieve interesting architectural effect [3]. Dynamic roof architectural-structural solution is also dominant for passengers' terminal in Gdańsk (arch. JSK Architekci, 2012). Taking into account cities' industrial character, architects decided on exposure of brutal esthetics of steel structure, implemented in the building. "Branched" pillars support ceiling of asymmetrical crooked stripes, also shifted against each other, allowing light

to penetrate interior from side skylights. Vibrant inside is opposite to geometrical, symmetrical form of exterior, where fully glazed walls are dominant [4].

Importance of unusual structure can be confirmed by the example of refurbishment of Train Station in Katowice (connected with bus station), which was famous for its modern structure (original from 1972, arch. W. Klyszewski, J. Mokrzynski, E. Wierzbicki, struct. eng. Waclaw Zalewski). It was a beautiful example of brutalist architecture, descending from the late modernist (called locally "a brute from Katowice"). The initial substance of the building was demolished, which effected with wave of critics from professional environment, however most important parts of it were re-created, with use of old patterns and technology (refurbishment arch. SUD Architects). This was a pioneering reinforced concrete structure composed of large adjacent mushroom columns, constructed as thin-walled shells casted in the formwork made of narrow wooden slats [5, p. 86]. The new columns where erected according to initial span, but of a new height (higher) and over large underground parking. On their surface a drawing of wood as a leftover after formwork was removed. Also natural esthetic of materials was revealed like: concrete, steel and glass [5]. Finally, the building in part corresponds visually to the original one but as a whole has a rather eclectic character.

The other similarities are an outcome of synonymous actives, functioning methods and human needs realization. Public use buildings of transportation system are designated to service people, their luggage and in many cases means of transport. Therefore, there is a necessity to handle:

- movement of large groups of people,
- massive drive of vehicles,
- temporary character for use of space,
- universal features for design,
- increase of hazards (accidents, robberies, terrorists, diseases, sanitary threats, fires).

Aforementioned halls are usually naturally lit by large glazed surfaces, used in walls and roofs. Additionally, access of sun rays to the interior decreases sanitary threats, while incising overall safety and clear orientation. At the same time huge windows provide further sense of significance to architecture.

As far as functions are considered, both for historic and contemporary solutions all temples of traveling contain: gastronomy zones, shopping malls, relaxation lounges (i.e. massage chairs at airports), public sanitary facilities, luggage storages and hotel areas are quite common. Among other important features there must be mentioned specific accessibility. Public zones are usually open and designated for everyone (despite psycho-physical condition), but technical and service areas have strictly controlled access (even under the threat of penalty).

3.1 Management of Large Group of Users

As it was mentioned, one of the most important features of buildings of transportation is presence of large groups of users, whom often may be new to the environment. They are sure to act uncertain and showing intensified interest to the surroundings, therefore may block the flow of streams of people, as well as create disorientation and disorganization. The other characteristic aspect of behavior, while staying in new spaces, is looking for cues, which traditionally mark places of higher importance. Thus, it is necessary to provide clear sign and directions—preferably on traffic crossroads or near them, as well as broaden the communication routes towards parameters that came from basic calculations [6, 7].

Occasionally, large users group may form a crowd, which is specific due to its' mass character and may occur dangerous. As Le Bon [8] states in the crowd a sense of individuality disappears and main feature of such collection is unawareness, thinking with pictures and in some cases hostility and primitivism. So, in order to avoid nervous situation, it is crucial to use distinguished communication roads and easy-to-read, probably iconic, orientation elements and signs. Sources [8] point also to need for use of recurrence, which helps to control the crowd behavior. It must be stressed that carefully thought through and ergonomic solutions of these issues, are especially valid during panic occurrence—so during realization of threats or evacuation scenarios.

Very positive element that was observed during the case studies is a significant limitation of commercials in the entrance and exit zones, communication routes, platforms and gates areas. Such approach allows for easy orientation of passengers and increases visibility and readability of signs and directions. However it must be stressed that orientation on contemporary train stations seems to be simplified, while on airports there are still a lot of zones (especially commercial ones), where navigation is highly complicated (Figs. 3 and 4).

Fig. 3 Proper orientation. Information signs and boards at train station in: on *left*—Porta Susa in Torino, on *right*—in Berlin (*Photo* J. Jablonska)

Fig. 4 Orientation chaos. Information signs and boards in commercial zones of Istanbul-Atatürk airport (*Photo* R. Tarczewski)

3.2 Challenging Demands for Structure

Complex functional requirements related to handling heavy passenger traffic, pose challenging requirements for designing the structural system. The basic, common to all objects condition, is to provide maximum flexibility for management of the interior, which means above all the use of structures with large spans. At the same time, substantial height of hall is required. This implies solutions that are far from standard and are themselves evidence of rank and prestige of the object. An example is the structure of the new Oslo-Gardermoen airport finished in 1998. The building is sheltered by roof of lightweight wavy form, obtained by the application of glued-laminated timber trusses. The use of glulam in the capital airport was intended to emphasize the national character of the timber industry in Norway. Total span of the main girders is 133 m, and the free span is 52 m. Trusses are mounted on tall post-tensioned concrete cantilever columns with a height of up to 28 m. Designers (Aviaplan AS and Moelven Limtre AS) were able to not only find a solution that meets all the requirements, but also distinguished by high aesthetic and functional values (Fig. 5).

A similar example is the airport in Stuttgart, where the form of structural system also refers to the local tradition. The roof of the airport building is supported on steel tree-shaped columns, repeatedly branched (Fig. 6, center). This is a reference to the concept of structures developed by Frei Otto. However, large spans are also often achieved by the use of much less sophisticated, simple structural elements. An example would be the Brussels Airport (Fig. 6, left).

The opportunity to use iconic forms may also be generated by requirements for seemingly less spectacular problems, e.g. communication service of the facility. In the case of airport in Porto (designed by ICQ and WS Atkins) huge, sculptured concrete girders are used, which support flyover for traffic of departing travelers to the upper concourse (Fig. 6, right).

Fig. 5 Glulam trusses of extremely large span used in roof structure of the Oslo-Gardermoen airport. Trusses are mounted on tall post-tensioned concrete columns (*Photo* R. Tarczewski)

Fig. 6 Unique structural components applied in the construction of airports in (from *left*) Brussels, Stuttgart and Porto (*Photo* R. Tarczewski)

Another technical problems challenging for the design are: the need to ensure adequate protection of acoustic environment (both in the interior and outside), preventing the transmission of vibrations, eliminating reflection of radar waves from the walls of the building (the apparent image of the aircraft on the radar) and all the issues related to ensuring the safety and durability of the object. All these issues will be discussed in future elaborations.

4 Nowadays Shift of Functions

Railway stations in most cases have lost their former center-creating function and their importance within the urban tissue decreased. Firstly, rail in opposite to bus and air transport is no longer main carrier for passenger, mail and cargo. Secondly, as head-station solutions were typical for centers of European cities of XIX/XX century (i.e. Rome—Termini or Helsinki Central) [9], possibility of expanding such buildings no longer exists. For today's train stations, a drive-through system and expansion of surface with flexibility of function, are most typical features. In addition XIX/XX century decorative architecture is very cost-consuming in maintaining and heating. Energy ineffectiveness is also common for all station

Fig. 7 Commercial zones and plazas covered by majestic roof at Munich Airport Franz Josef Strauß, on the *left* gastronomy, shops and office area, on the *right* hotel (*Photo* J. Jablonska)

built during modern period, which is very valid problem now in many countries, e.g. Poland. Also, a lack of sufficiently expanded commercial zones, is one of the problems of contemporary rail. Attempts to complement existing stations with large commercial areas often end with the destruction of the former, as was in the case of the above described railway station in Katowice.

In opposite and as it was already mentioned, airports' commercial centers and zones, connected to luxury goods merchandising, are overgrowing and set up new trends for services. Especially interesting example of such process is Munich Airport "Franz Josef Strauß" (arch.: Helmut Jahn and PLPArchitecture), where terminals are proceeded by large plaza. The complex includes: shops, gastronomy areas, large-scale hotel and vast office complex. All courtyard is covered with overwhelming glass-membrane roof, which became world widely recognizable element of this aerodrome (Fig. 7).

However Pszczulny [4] states that, nowadays airports' shopping area surfaces must be balanced with the duty for quick and efficient distribution of passages. Mover, author noticed that today's commuters appreciate more their comfort and service quality than shopping opportunities.

The other new and obligatory element are large parking lots for suburban localization (airports) or underground garages for centrally placed complexes (main railway stations). There is also a strong tendency to create these facilities for renewed complexes, enabling society to comfortably access traffic nodes and effectively use "park and ride" solutions.

One of the other tendencies is de-centralizations of entrances and exits. Historically for railway stations it was obvious to create one dominant entrance, distinguished by architectural details. However, even the smallest airport required one door set for departures and other for arrivals. Additional entrances started to appear due to parking, busses, trains or taxi zones. Also with the increasing number of passengers, it stared to be convenient to multiply number of entry points, in order to avoid crowding or queuing, segregate streams of incoming and outgoing travelers, as well as facilitate camera monitoring of safety. These solutions can be found not only at airports but at cotemporary train stations as well, where

additional entrances placement is dictated by main city attractions or directions and functional zones of town transport. Very often, the separation of traffic flows is achieved by directing them to different levels, which has consequences in adequate separation of functions within the object.

The other ergonomic elements are movable walkways, speeding up individual movement process and being comfortable solutions for people with kinetic problems. They also sate a proper response for growth of halls and terminals length. Likewise, all buildings are being adjusted to the needs of people with disabilities. Properly designed lifts for connecting levels, non-slippery floors, extra railings, adjusted sanitary areas and trained staff are commonly observed solutions. Hoverer, to give an example of extra thoughtfulness towards people with special needs, at Porta Susa in Torino train station (arch. Silvio d'Ascia Architecture, AREP, Agostino Magnagh, opened 2013) the information boards are written in Brail language (Fig. 3).

4.1 Revitalization Aspect

Refurbishment is a case mainly connected to railway stations. Not all of them serve original function and occasionally their designation is changed. It can be stated that implementing new solutions is usually connected to culture. The direction of this changes is optimal, especially if we take into account significant city location of old head-stations and their past center-creating role. To give an example, in the case of the mentioned above Gare d'Orsay, new function of a museum, enabled preserving high importance of the object. Built in 1900, designed by Victor Laloux impressive building was closed after thirty nine years of being in service. Then it housed the theater, auction house, and other functions. After it has been signed up on the list of monuments in 1978, began reconstruction according to the design of Gae Aulenti, completed in 1986. Then was established Musée d'Orsay, which holds collection of Impressionist paintings transferred from the Galerie nationale du Jeu de Paume, as well as other collections of French art of the 19th century. Today, the building is one of the most important museum institutions of Paris.

However, more often modernized railway stations are still serving travelers, but at the same time became multifunctional complexes, dominant in the cities' grid. An example of such transformation is the Main Station in Wroclaw (arch. modernisation: grupa 5 architekci, revitalisation consultants K. Kirschke, P. Kirschke). Fortunately, the process of refurbishment was strictly consulted with experts and controlled by city's conservation office, thus character of main hall and platforms was preserved. (Fig. 8) Commercial zones have been placed in the side alleys and contain mainly gastronomy points, travel offices, supplemented by pharmacy. Moreover, the cultural functions have been exhibited in the main hall, like: sculptures, artistic installations, book exchange point or info kiosk for renting an e-book. Also rooms on upper level have been refurbished and designated to

Fig. 8 Wroclaw central train station after the renovation (*Photo* J. Jablonska)

cultural functions, meetings and conferences. Naturally, whole complex have been complemented by large underground garage.

Another important aspect for refurbishment was implemented during revitalization of East Warsaw railway station (arch. modernization: Biuro Projektów Architektonicznych i Budowlanych AiB, 2010–2012), where building erected in modern style (energy consuming) was turned into economical and eco-friendly. It was possible due to use contemporary heating methods, proper energy management and BMS System. Moreover, taking into account the fact that modern architecture is being slowly treated as monumental in Poland, new structure was designed as a copy of original with use of primary materials. Architects took care of new, user friendly interior arrangement, which is accessible for everyone. Among obvious functions like: gastronomy and services, there are spaces for exhibitions. Bicycle and car parking complement the complex and whole can be expanded in the future [10].

5 Conclusions

"Temples of Traveling" emerged at a time when technological progress has allowed travelers to move most of their attention from practical issues related to travel on the accompanying context—social cultural, commercial. Then they evolved according to means of transport, social trends and human needs. Airports, devoted to highly evolved commerce, are being turned into large shopping centers, where duty-free shops offer illusion of luxury and pleasure. The spatial chaos of advertisements, adds and eye-catching shop exhibitions are creating difficult environment for new-comers or for people with disabilities, both disorienting them and impending movement. Fortunately, while analysis of contemporary refurbishments of central cites' train stations, it was observed that cultural function is now overtaking main role. It must be stressed that new architecture of transportation should transgress towards multifunctional complexes, where culture brings back traditional significance to these edifices and highlights uncommonness of travel experience.

Moreover, due to railway and airports complex multifunction and vibrant activities taking place inside and outside interiors, it can be stated that basic architectural dominants of contemporary "Temples of Traveling are roofs". There architecture and structure can come together in a dynamic, unexpected and contemporary forms. These elements become not only important points in maps of the cities but also obtain iconic meaning worldwide.

To conclude, contemporary passenger service buildings are retaking their central role in the city, attracting commuters and other users with cultural functions and commerce subjected to their needs and comfort. Moreover they become objects of true universal design, accessed for everyone and respecting the need for ergonomics, economy and ecology in contemporary building function. It can be expected that observed trend will continue and expand to other buildings of public use.

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