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REVIEW

A review on adoption of novel techniques in construction waste management and policy

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Abstract The purpose of this study is to review extensively the literatures associated with the adoption of different novel techniques in Construction Waste Management and Policy (CWMP) to find out the state and development of the construction waste stream and to reveal gaps for further investigations through the exploration of several publications which have emphasis on construction waste management. A cross-referencing examination was performed to ensure the comprehensiveness of the study. All references cited by the selected papers were searched manually, and then the titles of potentially related articles were aggregated into an Excel table to avoid replication. Following a systematic evaluation of the retrieved papers, two characteristic classification criteria of the current literatures were revealed as waste management and waste regulatory or policy. The findings show that there is a substantial growth in the number of studies associated with construction waste which attempts to reveal comprehensive results in the adoption of numerous methods from various perspectives. Nevertheless, there are several areas which need further research in both theoretical and intensive approaches in the empirical aspect to experiment the real application of the proposed methods. This study shows that reuse and recycle rates of construction waste is still minimal which continue to impact the environmental well-being. This review presents future direction and research gaps as well as recommendations on CWMP adoption which will be helpful to academics and professionals that are working or intend to operate in the related area.

Keywords Construction and demolition waste · Waste management · Waste minimization · Waste policy

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Background

Over the past decade, construction waste problems have drawn significant interest from researchers, hence, resulting in a range of studies successfully published in different scholarly articles. This success evidently indicates a growing challenge regarding construction waste issue reveals from the academic environment. However, it appears that the authorities and the high percentage of professional stakeholders show virtually less interest towards these challenges. Meanwhile, present literature covers a broad variety of subjects pertaining to Construction Waste Management and Policy (CWMP) by development of various quantitative models [1–4].

The focus on the CWMP comes up due to the accelerated waste generation after the housing growth of the past years.

Ever since, Construction and Demolition (C&D) waste has become an environmental issue, not for its detrimental nature but also for the poor management of C&D waste, which can be transported to landfills in an uncontrolled manner [2]. This circumstance ties down the landfill area, raises the amount of unlawful disposal and results in public resistance towards the ecological deterioration created by the C&D practice [5]. For example, a regulatory framework is established within European Union with the Directive 99/31/EC on landfills to abide with the 3Rs (Reduce, Reuse and Recycle) principles striving towards sustainable building. Among the objectives of the agenda, are minimizing waste which ends up at last as disposals for incineration or landfill sites, preserving natural resources, putting on the greater management of C&D waste, illegal landfills, building new recycling facilities and, altogether, preventing adverse environmental effects [6].

Recognizing and determining the factors affecting the CWMP assist in regulating the waste source [7]. For instance, many developing nations do not possess the technical and financial resources to control C&D wastes properly. This means storage at the point of the waste generation is usually insufficient and waste collection providers are ineffective and inadequate. Final disposal in these nations is a matter of moving the accumulated waste to the closest accessible open yard and discharging them. Effective CWMP demands the assistance from the public and many resources to the area as well as the help and support from decision makers. It is, therefore, essential to guarantee that general public and decision makers' awareness programs are integrated into the external support package [7]. The purpose of this study is to review, systematically, the literature related to the adoption of various novel techniques in CWMP. These will aid us to discover the state and progress of the construction waste stream of research, and to expose any gaps for further research through the analysis of numerous articles from journals and conferences that focus on the C&D waste.

Study approach

The method used in this study was through review of literatures on construction waste and its management. According to Okoli and Kitchenham, data extraction forms must be made to gather all the information required to address the review objectives [8, 9]. Previous studies indicate that an abundant yet diversified body of theoretical and empirical work has been carried out to examine the construction waste management principle. Exploring the research techniques employed in each study has assisted the researchers to recognize how effectively the CWMP studies have been conducted. As a result, sections like research methods, theories, models constructs, empirical work and context have been employed for data extraction to fulfil the objective of examining the CWMP flow of research and finding the recommended future study. A few articles did not possess a methodology section related to CWMP, in particular aspects, or they adopted theories without scientific testing. These articles have been labelled as conceptual. A cross-referencing examination was additionally performed to ensure the comprehensiveness of the study. All references cited by the selected papers were searched manually and then, the titles of potentially related articles were aggregated into an excel table to avoid replication. Following a systematic evaluation of the retrieved papers, two specific classification criteria of the current literature were revealed as waste management and waste regulatory or policy that resulted in the selection of 81 related articles which cover the published articles from 2000 to 2015. In total 65 waste management and 16 waste policy researches were reviewed. Corresponding explanations are provided in the subsequent sections were the most cited articles are critically reviewed. It was discovered in literatures that there was discrepancy research outcomes between the developed and developing countries. Obviously, the majority of the papers studied in this review were about developed countries practices in construction waste management while few papers were found that address construction waste management in developing countries. Lack of number of studies in this sector could be due to incapable statistical system as well as comparatively less input for R&D in C&D waste in most developing countries.

Construction waste management

The successive development and urbanization of an old city, substantial needs of national infrastructure, modern homes, commercial buildings and social amenities undoubtedly produce significant amount of construction waste from C&D activities [10, 11]. This waste provides a severe impact on individual life. Construction waste presents an enormous amount of building materials, which is a waste of valuable natural resources. Furthermore, it consumes a massive landfill space, which additionally decreases scarce land resources. Moreover, it contains harmful substances that jeopardize human wellbeing and the surrounding natural environment. For instance, in China, the annual construction waste accounts for about 40 % of the overall municipal waste, that is, over 200 million tons, of which 100 million tons are produced by new buildings [12]. Therefore, the most practical approach to minimizing the effect of waste on the environment is to prevent generating waste [11, 13, 14].

Historically, experts in the construction sector regarded that the wastes were directly related to just the debris taken out from the site activities. Moreover, every project has diverse amount of waste from the same source of materials; consequently, a tremendous amount of waste exists in the construction operations, and lots of it is not known or is undetectable. As a result of this, C&D waste has generated adverse effects on natural environment, economic climate, community health and social life [15].

Following the end of The Second World War, the majority of the rules and policies in urbanized countries have recommended that C&D waste to be managed properly. Several of these rules were promulgated to minimize environmental influences. Benefits have been launched to prevent using a virgin product and discourage landfilling and incineration of C&D waste using penalties such as heavy taxation and charges [16]. The key C&D waste management techniques consist of waste prevention or minimization through recycling or reusing waste to energy alternatives and safe disposal and discharging solely as the last option [17, 18]. Several environmental policies have been promulgated to protect environmental surroundings and ensure appropriate control of C&D waste. Most of them have attempted to lessen and manage C&D waste [19]. However, compliance along with and enforcement of present regulations is difficult when there are no instruments to manage the volumes of generated C&D waste. Therefore, the initial step in proper management of C&D waste is to generate determination [20, 21].

Study of previous works shows that most of the generated waste globally (57–85 %) which includes C&D waste, is generally disposed of in landfills or open dumps [22–24]. Different methods of waste disposal and the percentage rate of disposal are shown in Table 1. In an effort to safeguard the environment and to enhance the sustainability of the construction sector, numerous nations around the world have formulated different rules and initiatives to reduce C&D waste. In the United Kingdom (UK), the code for sustainable houses via on-site waste reduction, sorting and recycling is necessary [25]. Many laws have existed to manage C&D waste in Hong Kong [26]. For instance, a waste management plan has been mandatory for all building projects in Hong Kong since 2003. The Brazilian Environmental Protection Agency published Resolution 307 in 2002, which demands that all local government bodies organize and carry out programs for the sustainable management of C&D waste [27]. In mainland China, the Administration of Urban Construction Garbage was promulgated in 2005 to promote some local rules on C&D waste control [28, 29]. Based on a study carried out in 2009 by McGraw-Hill Construction, 80 % of building contractors in the UK believe that sustainable waste management would become an essential practice by 2014, an increase of 19 % in comparison to 5 years back [30]. With this recognition, C&D waste problems have received growing interest from every professional and researchers all over the world [31]. Nevertheless, the quantity of C&D waste is still rising consistently without efficiently being managed in many of the nations around the world [32].

Sustainable construction waste management and policy for sustainable environment

C&D waste is defined by the Environmental Protection Agency (EPA) as the waste materials generated in the process of construction, remodeling, or demolition of structures (both buildings and roads). Moreover, it includes the materials produced due to natural disasters [33]. Therefore, sustainable construction is a crucial approach that should be regarded in accomplishing sustainable advancement by deliberating environmental, social, economical and cultural challenges. A more substantial meaning for sustainable construction is the need to uncover the equilibrium between the economic, environmental and social elements of the design, construction and use of buildings. Indeed, sustainable construction is regarded as a significant subcomponent to drive sustainable development [34]. For example, Poon et al, and Saez et al. [35, 36], highlighted the advantages of highly performed C&D waste management which give smooth execution of construction activities while reducing the effects to natural environment. This approach is in-line with the two pillars of sustainability in construction, which reduce resource utilization and eliminate environmental pollution [37]. As a result, new strategic tools are essential as waste reduction seeks not just at minimizing the volumes of waste, but even

Table 1 Percentage of waste disposal technique by region [22–24]

Region	Percentage of waste disposed by					
	Recycling	Sanitary landfill	Open dumping	Incineration	Open burning	Others
Africa	3.9	29.3	47	1.4	9.2	8.4
Asia	10–40	30.9	50.9	5	1.7	4.5
Europe	>25	27.6	33	>25	11.8	44
North America	8.1	91.1	0	0	0	0
Latin America	3.2	60.5	34	2	5.5	2

at reducing the risks of the waste to the environment. Similarly, all goods and products consist of raw materials as well as energy. When they are discarded, wasting of precious natural resources will be increased. Waste disposal can always have negative influences on local air pollution and greenhouse gas (GHGs) emissions. Sustainable Waste Management (SWM) is thus, crucial for preserving the vital natural resources, reducing the unwanted emission of GHGs and safeguarding public wellness and the natural environment. As shown in Fig. 1, the sustainable construction essentially relies on the management of waste and prevention of pollution [38]. The achievements of sustainable construction will have considerable impacts on the measurement of Construction Waste Management (CWM) results. It is widely acknowledged that the CWM results are influenced by the environmental sustainability [39–41], social sustainability [39, 42, 43], and economic sustainability factors [44, 45].

Furthermore, CWMP has been a concern for long periods, as a result of poor management and controlling procedures which affect the environment as well as the general public. Solid wastes are produced by residential, commercial, industrial, institutional, C&D, municipal services and other human processes [46]. When explaining waste regulation rules and policies, the established guidelines must be specified. Perceiving the nature of the rules is prime to realizing its objectives and approaches to comply with them. It is clear and understandable that the present process does not represent the waste management policy in position. Components like lack of implementation, poor enforcement, uncertainness over roles and responsibilities between regulating bodies and limited stakeholder coordination have led towards this disconnect between policy and practice. Moreover, despite initiatives by the regulators, public awareness of the environment and, more particularly, waste management is low. Nevertheless, authorities acknowledge that proper waste management is vital for achieving sustainable development [47]. General awareness of sustainability in the

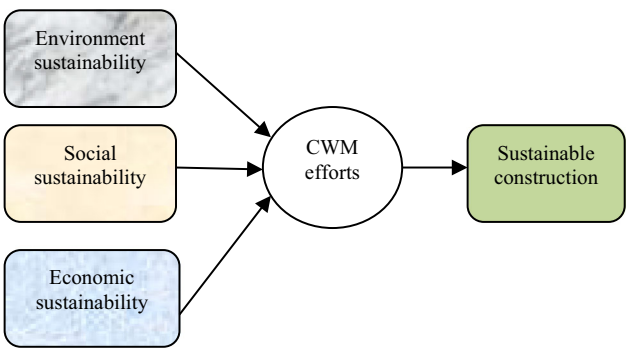

Fig. 1 Conceptual model for sustainable construction waste management

construction and building industry have been facilitated by various sustainability assessment standards and initiatives around the world. Like the Green Building Index (GBI) for Malaysia, Leadership in Energy and Environmental Design (LEED) in the US, Building Research Establishment Environmental Assessment Methodology (BREEAM) in the UK, Green star for Australia, etc., has drastically improved the interest towards international sustainability assessment standards. However, provided that all these initiatives remain voluntary and outside of the remit of government guidelines, extensive scale usage of sustainability standards throughout the industries will continue to be low. Despite the low levels of environmental awareness and unsustainable waste management activities, there are several cases of good waste management practices on site. According to Papargyropoulou et al. [48], waste segregation at the source is practiced with the ultimate goal to recycle materials with some values. Waste materials like scrap metal could be separated and stored on-site to be sold to waste recycling agencies. There are many sustainable methods carried out on site by the building contractors, for instance, recycling and re-using of certain materials or using the Industrialized Building System (IBS) which minimizes the volume of waste generation on-site.

Waste hierarchy principle

C&D waste generation and its reduction and recycling have been the three main interests of researchers in last 15 years. As result of that, concept of Waste Hierarchy Principle (WHP) emerged to tackle some of these challenges. WHP refers to the 3Rs of reduce, reuse and recycle, classifying waste management options in terms of the waste minimization goal [49, 50]. More factors could be included to comprise the hierarchy with different stages. For instance, an increasingly demanding hierarchy is found with a 7Rs as rethink, redesign, reduce, reuse, refurbish and recycles and expands WHP, which can even reach waste treatment and disposal. The purpose of the WHP is to draw out the optimum gains from products and, concurrently, to produce the lowest amount of waste [49, 51]. Despite the fact that the WHP has been used globally, its utilization as the most useful environmental alternative continues to be competitive. Figure 2 demonstrates the whole process of waste management structure as the guiding process in zero waste, which is a primary factor in driving waste management measures through continually figuring out the necessity for flexibility according to regional, local economical, social and environmental circumstances. The waste management hierarchy is a nationally and globally recognized guideline for prioritizing waste management approaches with the aim of realizing maximum environmentally friendly success.

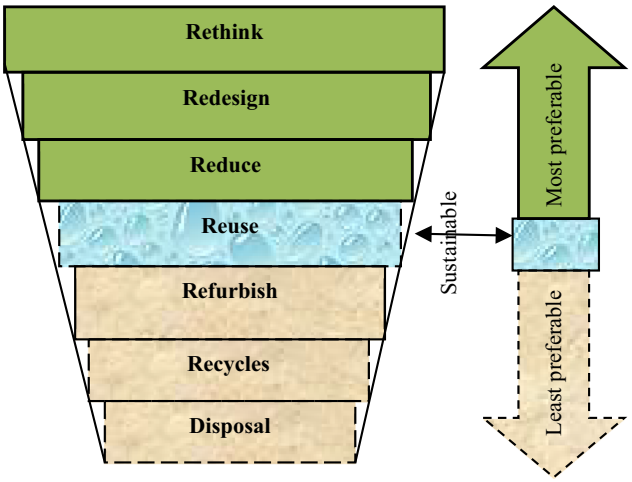

Fig. 2 Waste management hierarchy [52]

Furthermore, WHP establishes the recommended sequence of waste management practices from most to least preferred [52].

Zero waste principle

According to Glavic and Lukman [53], the meaning of the zero waste principle was not identified by the United States Environmental Protection Agency (USEPA), or the European environmental agency glossaries. However, zero waste can be described as a preferred way by which there is no creation amount of waste, considering that most materials regardless of their natural conditions will be utilized before reaching the waste level [54]. The concept consists of recycling but also takes an alternative approach to attaining the circulation of resources and waste from the anthropogenic environment. Zero waste increases recycling, reduces waste to practically zero, minimizes utilization, and guarantees that goods are planned to be reused, regenerated, repaired, and recycled internally or back into nature or the marketplace. Furthermore, in zero waste approach waste is not considered as materials that should be disposed of or incinerated but it could be reused or recycled to the maximum benefit of the waste potential.

International sustainable construction waste management policy and structures

Since the early 1990s, international and national developments have encouraged and motivated for innovative measures from authorities, dedicated individuals, and citizen groups to enhance the current waste management. The development of new perception of waste management connected with a revised look at the improvement that has been found to raise recognition in the world community has been of effective importance of these connections. Currently, CWMP is among the main environmental challenges confronted by municipalities throughout the world [55] and the greatest environmental issue. The landfill dump remains a widespread technique in managing C&D waste as it is economical and uncomplicated, in contrast to the other traditional disposal method using the incinerator that is expensive and needs technological experts to manage it.

Since 1992 in Rio de Jenairo, at the world conference on environment and development, most nations have promised to observe the concept of sustainable development in their economic activities. The core thought regarding this idea was of positive aspects; development must be fairly distributed, and environmental resources treated with restraint to ensure that the future generation is not at a disadvantage. In the framework of waste management, the following revealed that techniques of collection, transportation and disposal must be proactive about health and productive capability of all waste handling employees. Irrespective of whether they are from the municipal workforce or the informal system, and that waste emission degrees must be within the ability of the local environment to absorb the pollutants [48]. In another survey, it appears that C&D waste in a low-income nation is in a category by itself. It has become an intractable issue not so much as a result of insufficient technological innovation or funds for discarding it safely and securely but rather by the method with which it has been conceptualized and the selection of methods for managing it. Furthermore, at the Rio de Jeneiro conference, the developed community offered the developing nations an idea of a sustainable waste management system. One which was in line with the physio-chemical character of the waste, socio-economic realities, technological capacities and at the same time sensitive to their aspiration for a greater degree of economic development and mass consumption. It is vital to find out the major problems in every issue to be addressed. Furthermore, obstacles that prevent the realization of sustainable waste management have to be uncovered so as to implement appropriately the concept of sustainability in waste management (Table 2).

Construction waste management techniques

Management of waste is now a challenge of considerable significance, especially since the last few decades mainly as a result of the nature of waste streams and the continuously growing generated amounts. Most frequently, the decision-making process towards efficient waste management requires the attention of a substantial amount of commonly uncertain criteria to come up with the optimal solution among preference circumstances. Waste management demands not just the reliable technical evaluation of

Table 2 Major construction and demolition waste issues

Authors	Issues	Description
[50, 52]	Inadequate technology and facilities	The rising rate of waste generation has caused the present technologies like landfilling to be incapable to deal with it
[30, 35, 51]	Absence of effective recycling market	Recycling demands strong advertising campaigns to find a market and sell with greater value. The absence of this will limit the successful implementation of waste recycling
[54–57]	Insufficient funds	Since waste minimization needs a higher cost, as a result, several industry professionals are cautious to apply the waste management method. A reward or appropriate fund could be their motivation to use waste reduction as one of the waste management processes
[13, 35, 58–62]	Insufficient regulation, guidelines and enforcement	Guidelines are required for the industry professionals to adhere to and employ their method of waste management. Nevertheless, it is a challenge to produce a holistic C&D waste management system incorporated, cost efficient, sustainable, and satisfactory to the society, with focus on environmental resource efficiency and technological innovation selection
[14, 34, 63, 64]	Lack of awareness	Despite the fact that there are many guidelines initiated, most of the industry professionals do not recognize the significance in employing C&D waste management according to the waste management hierarchy that provides the priority to waste reduction, minimization and recycling
[25, 65–67]	Lack of implementation	Despite the well-developed strategies of C&D waste management, the implementation of these management methods in practice is far from effective
[68, 69]	Inadequate low-waste technology	For instance, application of prefabrication continues to be highly recommended, as it could assist to improve site safety by offering a cleaner and tidier site condition, maximize quality by creating components under factory conditions and eradicate site mismanagement
[1, 70]	Lack of on-site sorting of construction waste	On-site sorting raises the rates of reuse and recycling, lowering the price for waste materials disposal and transportation, and extending the lifetime of landfills
[1, 71]	Insufficient manpower	Lack of manpower development can leads to low productivity, and ascertain the link between poor waste management on site
[72–74]	Inadequate reuse and recycling materials	Reuse and recycling can provide a promising solution to the C&D waste management problems. The acceptability of recycled materials is hampered due to poor image associated with recycling activity, and lack of confidence in a finished product

risk but additionally community involvement, deliberation and stakeholder discourse on recommended alternatives and related hazards. Majority of articles suggest strategies on how to assist in controlling the waste. Yong Chi et al. [56] described their approach to general waste management as effected when they applied the Life Cycle Analysis (LCA). In accordance with this article, the diversion of waste from a landfill to incineration is an excellent way to minimize environmental effects which can be accomplished through the stakeholder's effective participation. Kularatne [57] demonstrated that generation of MSW can be managed just by presenting efficient and effective site sorting plans with regular supervision. In another critique studied on how to manage waste carried out in Malaysia by Aja and Al-Kayiem [58], they proved that about 22,367.9 and 5734.5 tons/day of MSW including C&D waste were generated in Peninsular Malaysia and East-Malaysia, correspondingly, in 2010. Using a 3 % annual increase rate of waste generation, the projected waste generation for Peninsular Malaysia by 2013 was 24,291 tons/day while about 30,518.5 tons/day of MSW generation is estimated for the entire nation. About 80–95 % of this waste was being shipped to landfills. Many of the landfill sites reviewed in this study were poorly maintained and posed threat to the natural environment. In another study by Wen et al. [59], it has been shown that an efficient waste classification method is the basis and precondition for successful waste management. For example, waste classification systems are developed to assist in data collection, supervision, and monitoring to make appropriate management guidelines on waste management, and enable them to reduce costs by preventing waste treatment methods afterward. This method has indicated an optimistic outcome when carried out in China, EU, Japan and the USA. Moreover, Shiotani and Katsumi revealed that the efficient use of small-scale compact solid waste management systems with material recycling can be more appropriate alternate options within the small-scale regional settlements. According to their finding, sanitary landfills and related power plants tend to be suitable disposal methods. Despite the fact that landfilling is the cheapest method for the disposal of wastes, it is getting harder to

find appropriate landfill sites every year by the escalating charges. Inazumi et al. [60] have applied Life Cycle Analysis—Environmental Accounting (LCA-EA) model on the current waste disposal stream of the Bangkok Metropolitan Region (BMR) to ensure treatment fees, environmental loads, and environmental expenses can be examined quantitatively. Though introducing a suggested scenario indicated a rise in costs because of the inclusion of an intermediate treatment process and a final disposal process for the waste disposal stream, it can reduce environmental costs. Because the environmental cost consumes a vast amount of the total value, the proposed scenario is an efficient approach to lower the entire costs. They further reveal that, as waste treatment is performed over an extended period, it is necessary to consider variations in environmental load as well as the areas that experience environmental effects in the future. Thus, it is essential to perform an LCA-EA model assessment over extended periods to study the environmental impacts over time.

Waste minimization is an important element of waste management. It is the process of elimination that requires lowering the volume of waste generated in contemporary society, and aids in minimizing the creation of hazardous and persistent waste products, assisting the initiatives to enhance a more sustainable modern society [2, 11, 14, 37, 47, 57, 59]. According to those authors in their various researches that have been conducted through a structured questionnaire, they discovered issues associated with the wastes and their causes in the construction stage that possess a considerable impact on the project along with the surrounding environment. The results established that the identification of waste and its management capability are very huge. However, the connection between them is very minimal. To reduce this effect, construction professionals must assess the major contributory elements prior to engaging with construction works. This essential element does not merely offer designers and project administrators with an important number of standards for successful design techniques to decrease construction waste but will also act as useful sources for the authorities to produce appropriate construction waste reduction guidelines [14, 61–63]. Building Information Modeling (BIM) which is an important application for construction waste reduction during the design stage, had generally been applied in recent times. According to Cheng and Ma [32], the tools were utilized in Hong Kong to assess the quantity of waste during construction can allow building contractors to determine essential waste generation processes and to prepare waste management techniques and strategies. The LCA has long been applied as a sustainability solution to enhance the 3Rs (reduce, reuse and recycle) and decreases the disposal of construction waste material by implementing sustainable and extensive techniques throughout the entire lifecycle of construction projects. This method could make judgments regarding the selection of material, sorting, recycling, reusing, and the treatment or disposal alternatives for C&D waste. In this study, the extensive and integrated lifecycle-based C&D waste management structure that incorporates the 3Rs into the planning, design, construction, renovation and demolition phases of the construction project are important too. These significantly decreases the material in the design and planning phases, minimizing scrap and waste at the building site, reusing materials on-site and recycling materials [36]. Moreover, the Systematic Dynamic Modeling (SDM) has often used for examining the impact of management approaches to the minimization of C&D waste. However, based on Yuan [64] examination of dynamics and interrelationships of the major variables in C&D waste reduction and finding out the volume of reduced waste can be promoted significantly through a higher waste landfill charges. The study proved that investment in waste minimization and the main stakeholders' compliance with waste management regulations; both possess some influences on C&D waste minimization. For instance, according to findings of Lu and Yuan [65], the achievements of off-site construction waste sorting (CWS) method is primarily related to sustaining policy support from the Hong Kong authorities. The achievement was due to good policy execution, motivating off-site CWS through excessive disposal rates and the setup of the trip ticket program. These are not just beneficial for decision makers to additionally enhance the entire performance of this process, but also offers useful references for other nations or areas in reducing construction waste by an off-site waste sorting system. Arif et al, [62] suggested that enforcement of existing laws and regulations can aid the implementation of waste minimization successfully. They further emphasized that crowded construction sites, sites in densely built-up places without any capability to provide an alternative storage area or staging place for supplies, absence of ownership of waste as a result of existence of several contractors on the construction site and awareness and education among the construction employees were considered as main issues related to the execution of waste minimization methods in India. Osmani [66] mentioned that in the UK there is a need for a culture change for waste minimization to be efficient and self-sustaining. They emphasis that it is essential for all stakeholders together in the construction supply chain to undertake a more positive strategy for managing waste before disposal. For instance, architects should shift beyond the idea of eco-efficiency through bolt-on environmental techniques and aim to embrace eco-effective practices by employing alternative methods in their design. The necessity for reuse and recycling of generated waste materials as the most efficient method of waste minimization were the motivation by

many authors. Merino et al. [67] and Rodríguez et al. [68] highlighted that the application and implementation of the waste disposal laws and regulations must be imposed on waste recycling and reused. Furthermore, other studies demonstrated that implementation of waste minimization plan on-site has proved to be successful in combination with waste minimization tool like SMARTH Waste and methods such as pre-casting and prefabrication of building components and the Industrial Building System (IBS). Those methods provide significant possibilities for the minimization of waste [68–74]. Kofoworola [75] propose that an effective waste minimization needs to implement a national integrated waste management plan that can increase the effective recycling of C&D waste when enforced and encourage the recovery and recycling of construction waste.

Waste regulatory or policy concept

The waste management policy is set by the authorities, which means that the generators of the waste are forced to make sure that waste is effectively managed. In their latest study on construction waste management policies and their effectiveness in Hong Kong, Lu and Tam [76] describe that C&D waste consists of central portion of the total municipal solid waste resulting in the actual environment deterioration in many metropolitan areas including Hong Kong. These discloses that Hong Kong is positively seeking new CWM policies according to the current waste management concepts available (e.g. 3R principle and polluter pays principle). The guidelines have formed an interlocking and comparatively strong policy structure for controlling CWM in Hong Kong. Among them, the inert and non-inert dichotomy as a CWM philosophy has helped divert the inert construction materials to open filling facilities. Thus significantly relieved the pressure on valuable landfills for accepting non-inert waste. While, the Construction Waste Disposal Charging Scheme (CWDCS) and its related measures (e.g., the construction waste off-site sorting facilities) executed in the year 2006 have the greatest magnitude regarding genuinely reducing construction waste both on-site and of disposal at landfills [77–79]. Furthermore, a significant international working area for 3Rs and waste management policy makers was held in Kyoto, Japan, and a bibliographic survey was also conducted to collect information. 3Rs policies are apparently given concern within the structure of waste management in EU, the USA, Korea, Japan, China, and Vietnam [80]. These revealed that the pathways of 3Rs policies are formulated not only as basic waste management methods but also as an efficient method to acquire synergistic influences with national approaches which aim at landfill prevention, procurement associated with resources and lowering of GHG emissions [80]. In Spain, based on the recent Spanish regulation, the volume of non-hazardous C&D waste by weight should be minimized by at least 70 % by 2020. However, the present behavior of the stakeholders towards waste management practice makes this aim difficult to attain. To increase changes in their approaches, they have adopted the Environmental Management System (EMS) in accordance with regulation measures and economic incentives which integrate universities as a leading expert to develop a 3Rs model in the C&D waste management with cost savings. To accomplish this objective, they developed a simulation model using the Systems Dynamic (SD) to evaluate the possible effect of two policies (incentives and tax penalties) so as to assess how the authorities can affect the behavior of the firms in the recycling system of C&D waste aggregates [6]. In another situation also in Spain, the absence of mandatory regulations has resulted in lower amounts of recycled material from these waste materials in comparison with other European nations. The proposed EMS has the possibilities to assist stakeholders to understand better complexity of information and relations involved in managing C&D waste and to establish a successful 3Rs process. Increasing the benefits of recycling waste can provide incentive for building and civil construction sector to create greater usage of C&D waste [6]. While waste volumes are still increasing in the EU, there is a clear shift in the waste management options applied to deal with waste. Less waste is landfilled and more is recycled or incinerated with energy recovery. The drivers for this change in waste management have been EU and national policies and legislation that have set up clear goals for recycling and the recovery of waste. The records show that more efficient waste management can contribute to reduction of GHG emissions in the EU and so contribute toward fulfilling the GHG reduction targets set out in the Kyoto Protocol [81–84]. While more scientific researchers have been established, there is immediate need to promulgate strong regulation and laws to reduce the ubiquitous utilization of asbestos, due to facts that asbestos waste in environment consistently leads to increased levels of health issues, mortality rate, materials waste and impact significantly on landfill management [23, 85, 86]. Tey et al. [87] reveal that government policies are still not effectively applied and taken as measures by industry professionals. The policies are insufficient to include the whole concept of sustainability, apart from that are the technology mainly used is landfill. However, landfill causes various adverse effects on the environmental, social, and economic factors [87]. The appropriateness of each and every management system relies on the local scenario and the features of each region, which may create several natural and technical limitations. The integrated management plan should be in line with the provisions and guidelines of the relative environmental policy and legislation [88]. Manowong and Ektewan [89] highlighted that sustainable construction in developing nations can be accomplished in an affordable way through effective exploitation of

resources in construction, material recovery, an enhanced system of waste management and energy savings. To realize this, good regulatory initiatives such as specific laws and policies for construction waste management, need to develop, enforced and implemented.

Construction and demolition waste management strategies

The majority of the literatures reviewed in this study highlighted that good handling of waste is a vital part of the sustainable construction. In this perspective, minimizing waste where feasible; signifies avoiding waste where possible; and reusing materials which can usually end up as a waste. C&D waste management strategies have regarded the reduction, recycling, and reuse of wastes as essential for sustainable management of resources since much C&D waste produced is legitimately destined for disposal in landfills. In certain regions, most or portion of the waste flow is illegitimately put on land, or in natural drainages such as waters, regardless of policies to safeguard the environment and human health. As some of the issues describe by several authors in this review prove, the amounts of building associated waste produced are substantially affected by macroeconomic circumstances impacting, societal consumption developments, anthropogenic hazards, and construction. These motivate construction sector awareness of disposal and recycling challenges identified to minimize amounts of C&D waste disposed of in a landfill, as numerous possibilities occur for the positive minimization and recovery of materials that will rather be meant for disposal as waste. The review results further show the significant of waste policy that required authorization to execute any waste-related activities, with reveal that particular authorizations are necessary for the collection of waste and its recovery or disposal. It is imperative that all policies to be complied in order to assure that the recovery technique such as handling, transport and treatment of the C&D waste and use of the recycled materials is managed in a secure, eco-friendly and commercially feasible way. This result mostly discusses the traditional practice of C&D waste. Therefore, further studies need to be continued to establish various novel techniques that will come up with the modern approaches to this challenges to be able to achieve the present sustainable development agenda goals.

Key findings

1. According to this review, many legal instruments control the management of waste and describe the duties of waste generators, waste control establishments (private companies and local regulators), waste planning regulators and waste authorities. This specifically implies that a policy for all authorities on waste generally discusses these particular challenges. Conformity with waste management's legal guidelines, minimization of generated waste guarantees the secure handling and safekeeping of waste and preventative measures of suitable education for communities on waste management challenges.
2. More effective waste management could reduce 17–18 % of the GHG emission needed to be offset by the EU participant countries from 1990 to 2012. More efficient waste management consequently benefits not just in less carbon dioxide in the soil, water, and air and cost reductions of pure materials but also more in the minimization of GHG emissions.
3. The total number of articles in construction waste has been growing extremely from 2000 to the present. This means that the construction industry is in need of continual enhancement concerning CWMMP to guarantee the attainable sustainable construction.
4. Many of the articles reviewed in this study have shown that landfill sites were poorly maintained and posed a threat to the natural environment. On the other hand, construction waste reused and recycled rate are still very minimal. These scenarios continues to impact the environmental wellbeing and contribute to global warming due to CO_2 emission from generated waste.
5. Another significant finding showed that an efficient waste classification method is the basis and precondition for successful waste management. For example, waste classification systems are developed to assist in data collection, supervision and monitoring to make appropriate management guidelines. This method has indicated an optimistic outcome when carried out in China, EU, Japan and the USA with the major C&D contributor.
6. Government policies are still not effectively applied and taken as measures by industry professionals. The policies are insufficient to include the whole concept of sustainability, apart from that, the technology mainly used is the landfill.

Recommendation

1. Waste minimization demands additional techniques, e.g., eco-design, goods specifications, quantitative waste avoidance goals or guidance of usage in industries with considerably lower waste generation.
2. Landfill prohibition, recycle management model of building project, adjusting steps of project value

factors, assessment and authorization process involving resource consumption of construction waste businesses, review and authorization process of resource usage of construction waste in the construction area, preferential guidelines of resource consumption of construction waste, financed funds of resource consumption of construction waste and accommodating plans such as inducement measures for recycled products.

3. Excessive dependence on regulation to drive waste management as well as the basic usage of guidelines from developed nations without considering the circumstances of the local, cultural, socio-economic and political waste management challenges needs to be dealt with.
4. Construction practitioners need to accept manpower growth, as collaborative and operations technique. This can gradually enhance a practical experience, attitude and skills required by workers to operate well on an assigned activity, and cumulatively improves waste reduction target. Furthermore, presenting inducement incentive plan by rewarding employees based on the volumes and values of resources they saved from their activities can improve waste minimization strategies.
5. Recycled products rates must be affordable in comparison with new material to motivate the construction sector in implementing the use of recycled materials.
6. Construction sector experts and building holders can enlighten and be educated regarding issues like advantageous of reuse, separation of wastes, efficient techniques for identification and economically possible way of encouraging environmentally and culturally acceptable method of minimizing total waste disposed. This can be easily implemented by periodic organizing workshops and training courses in a related area by professional speakers.
7. Providing more pre-fabrication concepts into the design, can help the contractor to minimize C&D waste generated substantially. It also aids to accomplish an enormous reduction in truck activities that can accelerate the construction practices.
8. Increasing the rates of reuse and recycling, can lower the price for waste transport and disposal as well as extending the lifetime of a landfill, as recycling and reuse can offer alternatives for conserving time, materials, money and energy.
9. Organizations and authorities can assume stewardship obligations to the organized, acceptable, and efficient disposal of building-related waste through publicity to public and business awareness of disposal challenges, and provide strong business-friendly surroundings for processing, repurposing, and collection of wastes. Organizations can make benefit through the return of wastes to production processes, promoting and looking out possibilities for development of recycled materials into products and prioritizing lowering of building-related wastes.
10. Outline the way planners, designers, clients, suppliers, contractors and sub-contractors can work cooperatively to minimize C&D waste arising and to enhance the method in which any waste generated is managed. This can be done by establishing construction waste reduction techniques through concentrating on the efficient control of resources, such as effective purchasing and ordering of materials, careful storage and the utilization of materials to reduce loss, just-in-time delivery and decrease in packaging waste.
11. Provide both general and certain policies pertaining to planning of acceptable waste management plans for particular groups of projects which exceed a particular limit size.

Conclusion

The challenges of waste management are presently high on the list of priorities of various government organizations and agencies globally. Therefore, ranges of the waste related directives have been executed to solve these problems. A common goal of these is to manage resource exploits through the guidelines for waste disposal by highlighting or introducing specific responsibilities on products. Concurrently, governments are trying to minimize the burden on the primary resource, sometimes by a more direct way, for instance, taxation. The focus on the CWMP comes up due to the accelerated waste generation after the housing growth of the past few years. Ever since, the C&D waste has become an environmental issue, not for its detrimental nature only, but also for the poor management of these waste products, which can be transported to landfills in an uncontrolled approach. This review adheres to the fundamental principles of writing a systematic review. According to the gathered information, many legal instruments control the management of waste. It describes the duties of waste generators, waste control establishments, waste planning regulators and waste authorities. The authors recommend that excessive dependence on regulation to drive waste management as well as the basic usage of guidelines from developed nations without considering the circumstance of the local, cultural, socio-economic and political waste management challenges

needs to be dealt with. Collectively, these will outline the crucial element of future sustainable society. Finally, sustainability is an issue of growing significance for all construction. According to this review, further researches are needed on sustainability issues and carbon reduction on construction waste, particularly with the application of innovative tools, such as BIM, at the design and planning stage. Carbon reduction is a complex problem for all sectors. The construction industry assessment sequence means regarding all aspects of the design, construction, demolition of buildings and infrastructure by reducing CO_2 emissions. These will ultimately reduce the costs of construction and reduce their impacts by delivering buildings with low carbon footprint, make savings on construction sites and makes progress on measuring the embodiment of the carbon design for waste management and regulation.

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