Adopting the Zero Waste Concept for Eliminating C&D Waste in the Construction Industry

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Abstract: Construction industry is one of the key economic players in any region, where Construction and Demolition (C&D) waste generation occurs due to continuous construction and demolition activities. The C&D waste mainly comprises cement, timber, brick, concrete, aluminium, tile, steel, plastic, polythene, paper, and cardboard. Such wastes have led to several environmental, economic, and social issues over the past years. Therefore, C&D waste management is considered as a persuasive matter that needs to address, and hence, the "Zero Waste" concept has emerged as a solution to eliminate the C&D waste. Zero waste is the elimination of waste at the source and throughout the construction activity. Accordingly, implementation of the Zero waste concept in the construction industry helps to optimise the use of natural resources, reduce environmental issues and to promote sustainability. However, only limited studies are available on zero waste management in the construction industry, and hence the present study aims to investigate the adoption of zero waste concept to eliminate C&D waste in developing countries. The paper outcomes based on a comprehensive literature review and the significant findings of this research paper are the recognition of strategies, enablers, and barriers to adopting zero waste concept in the construction industry.

1. Introduction

Construction & Demolition (C&D) waste is one of the main contributors to the solid waste generation throughout the world [1]. Waste management is a challenging sector in almost every city and country, and attention has been paid to solve waste problems since the early nineteenth century [2]. The growth in the consumption of resources has led to waste generation, and still, there is no straightforward solution to waste problems [3].

Waste is defined as the end of the life of the product that raises social and environmental issues [2]. According to [4], it is a challenging task to manage and handle the waste in an economical and environmentally-friendly manner due to the dynamic nature of waste composition and quantity. Most developing countries of Asia practice open dumping and landfilling methods to dispose of waste while developed countries of Asia use the incineration method. Emission of hazardous substances through landfilling, incineration and open dumping induces the pollution of surface water, groundwater, and air pollution [5], and poor waste management leads to environmental issues and health problems [4].

C&D waste contributes to a large portion of solid waste [6]. C&D waste means the waste of valuable natural resources, and the disposal of C&D wastes to landfills leads to the scarcity of land resource [7]. The composition of the C&D waste could be identified as cement, timber, brick, concrete, aluminium, tile, steel, asbestos, heavy metals, persistent organic compounds, and Volatile Organic Compounds (VOCs) [8, 9]. As per [10], C&D wastes are generated due to design changes, poor communication between design and construction teams, extended project duration, and lack of design information.

The construction sector is considered as a leading contributor to the global waste production and generates 30% of the landfilled wastes [11]. Such construction waste landfilling induces environmental and health hazards [1]. According to [11], landfilling of construction waste has resulted in environmental problems such as degradation of land, habitat destruction, contamination of soil and groundwater, and release of methane. Thus, there is a compelling need to reduce waste in all stages of construction by considering the long-term impacts [12]. As per Mahpour [13], practices such as boosting resource exploitation efficiency and the circular economy is practised with the increased public concern to manage C&D waste. Economic and environmental benefits could be achieved by implementing C&D waste management techniques [6].

Zero waste is a whole system approach that focuses on the elimination of waste at the source and throughout all points of the supply chain [14]. The zero waste concept

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has emerged as an innovative method to handle waste management problems, where waste is considered as a resource [2]. In recent years, attention is paid to waste minimisation in the construction industry by understanding the waste minimisation benefits, cost-saving benefits, and environmental issues due to C&D waste [10]. The implementation of the Zero waste concept helps to achieve the optimum use of natural resources and reduction in environmental issues [2]. This statement confirms that zero waste is the correct solution for C&D waste management in the construction industry. Thus, this paper presents the significant literature findings on enablers, barriers, and strategies to adopt the zero waste concept in the construction industry, as a part of a research study in investigating the adaptability of zero waste concept to the Sri Lankan construction industry.

2. Research Method

A review of prior literature is essential to identify the existing knowledge gaps [15], and conducting an initial systematic literature review enriches and reinforces the research process. Therefore, journal articles, books, published and unpublished bibliographies, conference proceedings, industry reports, and documents that are specifically related to the construction industry, C&D waste, zero waste, strategies, enablers, and barriers to C&D waste management, and zero waste management were referred to collect comprehensive literature findings.

3. C&D Waste and Its Impacts

C&D waste can be generated through both construction and demolition processes [11]. Similarly, C&D waste is generated by the extraction of raw materials, manufacture of materials, construction processes, and demolition and waste disposal [1]. In the global context, 35% of C&D waste is disposed of in landfills without following any waste treatment method [16]. Further, C&D waste generates 25% of municipal solid waste and 50% of hazardous waste [17]. C&D waste can be defined as the waste generated through new constructions, renovations, and demolition of buildings and structures [18], and as the waste of valuable natural resources [7]. Similarly, C&D waste can also be defined as a mixture of different materials generated through construction, renovation, and demolition activities, and it comprises of inert waste, non-inert and non-hazardous waste, and hazardous waste [16].

C&D waste generated in the construction industry is due to the surplus or damaged materials, on-site processing, packaging, refurbishment, replacement, and demolition, which are ultimately sent to a landfill or a resource recovery or recycling facility [11]. C&D waste consists of concrete, combustible materials, gypsum, scrap iron, unpainted wood, and other waste [17]. Further, [16] stated that depending on the source, C&D waste is divided into two sections as human-made source and nature-made source. C&D waste is also comprised of concrete, wood, steel, copper, aluminum, bricks and mortar, plastic, PVC pipes, plastic films for packaging, wall coverings, glass, ceramic tiles, mineral wool insulation, drywall/gypsum board, gravel, sand and soil, paper, cardboard, marble, and granite [1, 6].

C&D waste dumping into landfills leads to natural resource depletion and problems associated with energy and material conservation [1]. C&D waste also creates negative impacts on the environment, economy, and in the public health and social life [19]. The negative environmental impacts of C&D wastes are water and soil pollution, air pollution, and adverse effects on flora and fauna, whereas loss of primary resources and fuel consumption in transportation are the economic impacts [19]. Similarly, public health and societal life get influenced by health hazards, consumption of public space, and a negative impact on work safety [19].

The management measures such as on-site waste reduction, implementation of waste management plans, and the technique-oriented approaches like the adoption of prefabricated components and prefabrication techniques have to be followed to minimise the C&D waste in the construction industry [19]. C&D waste minimisation helps to reduce the environmental stress of the population [20], and the sustainability in the construction industry can be gained through the designing of deconstruction and disassembly of structures during the design stage [17]. Through design and construction strategies, C&D waste generation can be controlled, and C&D waste can help to create useful products [17]. Therefore, zero waste is an idealistic concept to address the critical waste issue in society, which is an ambitious goal to handle waste [21].

4. Zero waste

The current waste management issues such as lack of resource conservation, pollution control, and recovery in the integrated waste management have led to an innovative waste management approach called "Zero Waste" [2]. According to [22], the Zero waste concept includes the prevention of waste, behavioural change, and a high level of recycling and resource recovery. Waste materials are converted into useful resources through the zero waste concept [23, 24], and thus, the C&D waste issue can be solved effectively by redesigning the resource life cycle so that all products are reused through the zero waste concept [3]. According to [14], the traditional views of waste management are challenged through the implementation of the zero waste concept. It is believed that zero waste strategy needs to move in a cyclical system according to a cradle-to-cradle approach rather than moving in a linear system, to ensure the effective use of materials [1].

Adopting zero waste concept triggers community benefits, economic and financial benefits, environmental benefits, and industry and stakeholder-specific benefits

[24]. Community benefits such as public health risk minimisation, the increase in job offers by recycling and usage practices, and by the opening and consolidation of waste collection and separation cooperatives can be gained [24]. A reduction in cost and increase in profit, prevention of the costs of environmental restoration, losses related to process inefficiency, increase in profits from the sales of recycled materials, and an increase of income flow can be accomplished via economic and financial benefits [24]. Moreover, the environmental benefits of zero waste management are a reduction of waste generation and negative impact, extend the useful life of sanitary landfills and increased efficiency in using raw materials and reduction of virgin raw material extraction. Other environmental benefits are the reduction of greenhouse gases emission and energy consumption because of the higher eco-efficiency of the production and recycling processes, creating opportunity to produce energy through wastes and the sale of carbon credits, increased environmental protection, and reduction of the use of toxic materials in the products can be identified as environmental benefits [24]. The industry and stakeholder benefits that can be achieved are the improved efficiency and productivity, improved product design to extend life cycle, an increment of companies' competitive potential through customer satisfaction and increased reliability, an incentive to the elaboration of a sustainable chain of suppliers, and industrial symbiosis practices [24]. In order to eliminate environmental threats caused by human behaviours and consumption, both product design and waste management principles are considered under zero waste management [2]. Besides, [2] has elaborated that the zero waste concept ensures all the discarded waste is either recycled, recovered, or nourished through natural processes, without harming the natural environment. Therefore, zero waste concept helps to safeguard the natural resources and minimise the adverse environmental impacts.

5. Strategies for Zero Waste

Implementation of new waste handling methods and approaches have led to changes in the waste management system [25]. The waste can be managed effectively through prevention and minimisation [26]. If C&D waste creation cannot be controlled, then strategies such as scrap metal dumpsters and recycling the scrap metal, returning waste products into corporate inventory and offering unused materials for future projects, and selling the unused materials to recyclers can be followed to handle C&D waste [17]. Similarly, material handling and control, training and supervision, procurement related strategies, management of subcontractors and workforce, and communication and documentation strategies can also help to manage C&D waste in the construction industry [17]. In addition, [27] have stated that capacity development, bridging policy gaps and harmonizing policies, creating economic opportunities, social marketing and advocacy, sustainable financing, knowledge management on technologies and innovation, good governance, organizational development and enhancing inter-agency cooperation, caring for vulnerable groups, compliance monitoring, enforcement and recognition, and reducing disaster and climate change risks can also be used to manage waste. Waste treatment strategies have shifted from landfilling to incineration in recent years [28]. Similarly, strategies such as, reinforce the source control, economic incentives, use of innovative technologies, management, and supervision enhancement and design effective circular model can be used to manage C&D waste [29].

An effective strategy implementation along with reliable performance measurement is needed for zero waste management [2]. Mainly four levels, i.e., design, manufacturing, application, and recycling and disposal are followed in the application of the zero waste system [3]. Firstly, at the design level, a method of energy and environmental analysis could be used through eco-design, life cycle assessment, new technologies, product stewardship, and closed-loop supply chain management [3]. Secondly, at the manufacturing level, cleaner production strategies are used in the design and manufacture processes to minimise waste emissions and to maximise product output [3]. Thirdly, in the application level, strategies such as eco-labelling and environmental awareness are followed to meet environmental criteria [3]. Finally, in the recycling and disposal level, the effective environmental management plans, schedules, and implementation and monitoring of activities to improve environmental performance take place [3]. Figure 1 summarises the above-mentioned four levels:

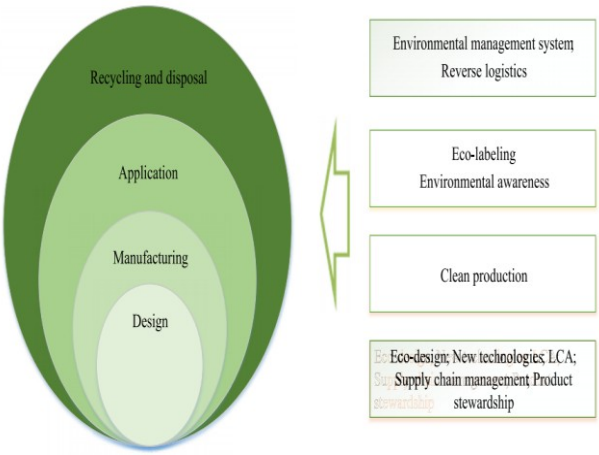

Figure 1: Zero waste system [3]

6. Enablers for Zero Waste

Various enablers can be encountered to implement zero waste concept in the construction industry effectively. Legislation and policy, awareness and understanding, manufacture of construction products, designing and operating buildings, business, recovery of materials and products, and economics were identified as enablers in the construction industry for C&D waste management [30]. Moreover, enablers can be divided into four sectors as institutional, technological, internal action, and

market influence, where institutional enabler creates an environment which both stimulates and enforces change [31]. Similarly, technological enabler provides the ways and opportunities to make the changes while changes are required through market influence enabler [31]. Further, resources and capability to change are considered as institutional enablers [31].

Similarly, some researchers have focused on analysing the influencing factors for waste management and identified factors such as technical, political, legal, socio-cultural, environmental and economic [32]. In addition, enablers such as design tools and guidance, measuring the value of material/product, financial incentives to use secondary materials, assurance schemes for reused/secondary materials, awareness raising campaigns, development of enabling technologies to recover material, development of higher value secondary markets, and viable take-back scheme have identified to permit zero waste in the construction industry [30]. Working together with the government, professional bodies, and academia to revisit existing standards and rules, encourage local suppliers to produce green products, and knowledge-sharing and training on the use of new green technology also promote zero waste in the construction industry [31].

Based on the findings of enablers to implement zero waste concept in the construction industry, enablers such as institutional effectiveness, a robust policy and legal framework, public participation, innovative and cost-effective technology, financial stability, improved resource availability, effective waste segregation and collection, and recycling and reproduction could be followed [32]. Further, as per [24], governance and planning, and operationalizing could help to achieve zero waste in the construction industry. Through governance and planning, enablers such as a substantial change in behaviour and consumption, regulations of rates and financial incentives, modifications in the logistic system, and green innovation can be used, while enablers such as product redesigning and qualifying infrastructure can be used in operationalizing. Consequently, the government should play a leading role by enhancing C&D waste management regulations, for the timely release of the waste amount, cultivating a better policy environment to support waste recycling factories, and implementing an active waste disposal charging fee to implement the zero waste in the construction industry [19].

7. Barriers for Zero Waste

Barriers such as lack of policies, lack of legal framework, and low level of public education, insufficient payment and training for waste workers, in addition to negative public attitude and availability of open dumping grounds hinder the effective C&D waste management [33]. According to [11], barriers related to cost and time, associated with on-site waste management, industry culture, lack of education, competing for project priorities, and lack of financial incentive make adverse impacts on improving the environmental performance of C&D waste management. Moreover, weak political will, ineffective representation of communities in decision-making bodies, lack of knowledge on green procurement, lack of planning, monitoring and performance evaluation activities are also identified as barriers for effective C&D waste management in the construction industry [34]. Other barriers that affect the C&D waste management are, ineffective C&D waste dismantling, sorting, transporting and recovering process, undeveloped individual engagement, overemphasising recycle and non-environment friendly methods during C&D phases of construction projects, and ineffective C&D waste management [13].

Achieving zero waste in the construction industry by eliminating C&D waste is negatively influenced by barriers such as lack of environmental commitment, lack of technical expertise, poor social values and ethics, large population, unscientific waste disposal, unscientific planning, and ineffective process and administration [32]. Another set of barriers identified by [20] explains that C&D waste management is affected because project participants are unaware the amount of waste generated from their work practice, unwillingness and over-reliance on sub- contractor, and prioritisation of progress rather than minimising waste. Apart from that, C&D waste management also affected by lack of time, money, knowledge and expertise, ineffective cooperation among project players, inability to measure construction waste, and insufficient enforcement of laws and regulations on waste management. Similarly, lack of waste processing facilities, poor communication and coordination between parties, poor awareness and behaviour from project stakeholders, lack of awareness of the environmental implications of waste disposal, cultural resistance to implement C&D waste diversion, and poor project processes and activities create difficulties to achieve zero waste in the construction industry [16].

The primary barriers to reduce C&D waste are the lack of building design standards for reducing C&D waste, low cost for C&D waste disposal, and inappropriate urban planning. Similarly, lack of guidance for a useful C&D waste collection and sorting, lack of knowledge and standard for reuse C&D waste, and a weak market for reuse C&D waste have identified as barriers for the reuse of C&D waste. Furthermore, an ineffective management system, immature recycling technology, under-developed market for recycled C&D waste products, and immature recycling market operation are the identified barriers influencing the recycling of C&D waste [29]. Similarly, a varied commitment of senior management and politicians, and the absence of training programmes to explain the concept of Zero Waste prevents the successful implementation of zero waste concept in the construction industry [22].

8. Conclusions

The construction industry is one of the key contributors to the solid waste generation, and hence, waste management in the industry is a challenging issue to be addressed. Thus, this paper aims to identify the strategies, enablers, and barriers to implement zero waste concept in the construction industry. The paper has identified that cement, timber, brick, concrete, aluminium, plastic, steel, tile, paper and cardboard as the types of C&D waste, and the C&D waste generation imposes adverse impacts upon the environment, social and health of the population. The paper further discusses the zero waste concept, considers waste as a useful resource. Zero waste means a holistic approach, which eliminates wastes. Finally, the strategies, enablers, and barriers were identified to adopt zero waste in the construction industry, to realise the aim of this research investigation.

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9. References

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