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Construction Waste Management Strategies Towards Sustainable Practices in Malaysia

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ABSTRACT

Malaysia has witnessed substantial rapid growth in construction waste management (CWM). However, this expansion has brought with it an obvious dilemma, namely an increasing amount of construction waste. The main aim of this study was to examine the critical issues of CWM in Malaysia, considering its various impacts on the environment, economy and society. Waste from various building materials increases with time, placing a heavy burden on ecosystems, public health and the economy. This study develops a strategic approach to CWM in Malaysia. The study focuses on identifying the common practices of construction waste and its' relevant future strategies for enhancing sustainability. The method approach for this study was qualitative research, which consists of observation and semi-structured interview techniques. Respondents were from developers, management teams, contractors and site supervisors with expertise in CWM. Open-ended questions were designed and distributed to the respondents during the interview session to achieve information related to the current practice, challenges and solutions for improving CWM practices in Malaysia. The study highlights the importance of incorporating safety, health and environmental factors into CWM to facilitate the transformation of Malaysia's construction industry into a more ecologically conscious and productive sector. This will ultimately lead to a future characterized by enhanced security, improved sanitation and greater sustainability.

1. Introduction

The construction sector drives economic growth and can also boost global population growth [6]. Population growth will boost affordable housing and infrastructure for rapid urbanisation. Malaysia's middle-class and urban areas depend on its building sector [12]. With population growth, people need more housing. Hussain, (2019) [15] suggests that the government should increase accessible housing for Malaysians due to the housing shortage. Malaysian economic growth is driven by rising concrete, steel and wood consumption [33]. From mobilisation to deconstruction and demolition, building waste is a major issue. Strategic CWM and sustainable waste management solutions are needed to address environmental, economic and social issues [20].

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Construction waste's first concern is landfill shortages, which affect safety, health and the environment. Wong & Alia Roslan, (2019) [33] reported 289 landfills exists in all states. Only 113 of these sites in Malaysia have been closed owing to community protests. Malaysia has a landfill shortage, forcing construction companies to dump waste carelessly, harming the environment. According to Oliveira *et al.,* (2020) [25], recent studies reveal that improperly dumped building trash harms the environment and increases solid waste management costs. Such solid trash typically contains dangerous compounds that threaten people and the environment. Workers who dispose of such material risk a variety of health and safety hazards, emphasising the need for planned waste management [1]. The construction waste problem is complicated by poor waste management, awareness and legislation [13]. The building structure and construction methods determine construction waste production [26]. The lack of research institutions to compare construction waste generation rates in Malaysia using certain construction methods shows the field's knowledge gap. Strengthening waste management protocols, raising awareness and establishing safety, health and environmental sustainability regulations are needed to address these issues [29].

Due to these repercussions' on environmental, social and economic scope, CWM is an urgent international issue from a deep building viewpoint. Globally, sustainable development and resource efficiency make construction waste treatment and recycling, crucial [26]. As people pursue sustainability, they realise that transporting raw materials to construction sites and waste to landfills uses a lot of fuel, which is bad for the environment and the economy [35]. Callun Keith *et al.,* (2021) [26] stated that construction sites with limited budgets can cut material costs, increase revenue from material reuse and recycling, and lower handling and shipping expenses by reducing construction waste. Guidelines on CWM in Malaysia, published by the Construction Industry Development Board (CIDB) Malaysia in 2008, stresses how important it is for the construction industry to follow the right waste management processes. The document lists the main goals, which include setting standards for waste management, explaining the roles and responsibilities of people in the industry, assisting on waste management plans and stressing legal obligations. People involved can save money by reusing and recycling building waste and reducing the amount of trash that is produced. They can also protect workers and the environment.

Besides, the guidelines stresses the importance of using environmentally friendly building methods and getting everyone involved to work together to protect the earth [22]. The standards are an important tool for making sure that waste is handled properly, and that the Malaysian building industry grows sustainably. Also, Malaysia makes more than 20 million tonnes of construction waste every year, but only 15 % of it is recycled because people don't know how to separate their trash properly and the law doesn't police it [24]. Because of this, Malaysia has a big problem with managing its construction trash because it makes a lot of it and not many people recycle it.

In conclusion, Malaysia's construction industry drives economic growth by building infrastructure and expanding cities [12]. This expansion has increased construction waste, posing environmental, social and economic issues [26]. Sustainable expansion requires efficient building waste management (BWM), which then requires a detailed examination of Malaysian strategy strategies. The potential of the circular economy concept in CWM and innovative techniques in new construction projects include demolition design, waste management, material recycling and waste reuse [31].

Therefore, this study focuses on developing strategic approaches to CWM in Malaysia to address key research gaps by promoting environmentally friendly waste management methods e.g. waste reduction, site plan management and management tool disposal. The success of these methods in the construction sector was examined to determine their effects on human safety, health and the environment. These methods were also examined for their effects on waste, resource use, regulatory compliance and economics. These findings should help Malaysia establish a more sustainable BWM

procedures, making workers and the public safer and healthier and addressing environmental deterioration.

2. Literature Review

2.1 Construction Waste Management (CWM)

CWM is a comprehensive strategy that aims to properly manage construction resources to limit the generation of waste and make good use of the waste generated [28]. This involves the planning, design, construction and demolition phases of the entire building life cycle, and requires comprehensive consideration of material selection, construction processes, waste sorting and reuse. Effective CWM not only helps to mitigate adverse impacts on the environment but also promotes resource recycling and reduces the dependence of waste on limited natural resources [38]. Hence, the objective of CWM is to attain the sustainable utilisation of resources and foster the advancement of the construction sector towards a more ecologically sound and sustainable path [35].

2.2 Challenges in Handling Construction Waste Management

The challenges in handling CWM include a lack of environmental awareness and skilled labour. Xu *et al.,* (2020) [34] emphasise the crucial role of corporate environmental awareness, environmental leadership and corporate social responsibility (CSR) in improving the efficiency of CWM. This paper emphasises the complexity of this task, where the qualification of site personnel and the involvement of designers are both important factors in improving the feasibility of waste segregation and design. In contrast, Zhang *et al.,* (2018) [37] provided insights into the challenges posed by the shortage of skilled designers, suppliers and contractors that hinder the ongoing process of cost reduction in the construction industry. Besides, insufficient financial resources pose a significant barrier in the realm of BWM. Effective waste management relies heavily on adequate financial resources, which are often limited in numerous nations [5]. Limited financial resources might impede the development of efficient waste management and recycling systems, ultimately resulting in environmental contamination and resource wastage [9]. As a result, because waste reduction comes with higher costs, many construction experts are hesitant to use waste management techniques.

2.3 Possible Solutions of Construction Waste Management Issues Towards Sustainability

Based on the subtopic, one of the solutions is to recover discarded construction waste for reuse is essential, to promote sustainable waste management as it provides significant benefits related to the environment and resources. Crawford *et al.,* (2017) [10] emphasise that diverting materials from landfills not only avoids the negative impacts of waste disposal but also maximises the intrinsic value of these materials as a resource. This strategy is in line with the principles of the waste hierarchy set out in the Waste Framework Directive, which emphasises a sequential process from prevention to preparation for reuse, recycling, recovery and final disposal [3].

Moreover, improved CWM tools can reduce construction waste. According to Bilal *et al.,* (2017) [8], an essential element of waste reduction is the comprehensive adoption of various technologies to manage construction waste. In addition, information technology tools used for CWM technology can lead to better CWM. The construction industry can promote the management technology to further know on how to properly manage construction waste [17]. For example, Building Information Modelling (BIM) is a powerful tool that can simulate building designs before construction begins,

making it a revolutionary tool in this regard. BIM can incorporate material volumes into the planning and design phase, enabling designers to make informed choices about material utilisation.

Other than that, the Site Waste Management Plan (SWMP) has become a recognised and beneficial method for the construction industry. It helps stakeholders to predict, record and make informed choices about the amount and type of construction waste [8]. This comprehensive strategy is designed to cover the entire period of a construction project, starting from the beginning stages of planning and design, and extending through to the demolition phase. Furthermore, SWMPs have become a regulatory requirement in many countries, highlighting their importance in encouraging responsible waste management practices [11].

3. Methodology

Research methodology process involves researching the methods used in the field and the underlying theories or core concepts behind these methods [23]. A comprehensive literature analysis was undertaken to collect information on the features and classification of projects, as well as CWM, waste management plans and their advantages. Afterwards, a series of inquiries was created to obtain an understanding and perspectives on the choice of project attributes and specific advantages of BWM. These questions were then distributed to everyone for their input. The survey had the following objectives which were to:

- Identify the current practice of CWM in Malaysia,
- Analyse the major challenges of CWM in Malaysia and
- Recommend solutions for improving CWM practices in Malaysia.

Mixed-technology research was chosen for this study because it better explains the occurrence. This study develops a comprehensive approach to CWM in Malaysia to encourage and implement sustainable practices. To achieve the intended purpose, a mixed-technology research methodology must be used to conduct a field visit to the construction site to gather insights on how to improve the current practice based on respondents' own experiences and to collect many responses to understand the main challenges. To get a better picture of current CWM, the researcher visited current sites and interviewed experienced CWM experts, who helped the researcher to better understand the research question. The mixed-technology approach helps researchers get more data and meet their goals.

Thus, observation in data collection is the best way to get information about the research questions and Malaysia's CWM practices. The methodology identified, allowed building site observations to reveal Malaysia's CWM practices and main issues. Besides, the researcher believed a questionnaire would be the best technique to collect data for this investigation. This was done because questionnaires are effective in collecting standardised data from large numbers of respondents relevant to the research aims, which were CWM difficulties in Malaysia. Next, qualitative research applied semi-structured interviews extensively. Effective interviews probe the respondent's opinions, experiences and perspectives on the study subject, which is how to improve Malaysia's CWM methods.

Data collection requires obtaining, assessing and measuring precise data from many people. This helps explore research difficulties, solve questions and objectives, evaluate outcomes and predict future trends and probability [30]. Purposive sampling was the focus of the investigation, where respondents were chosen based on study-related factors. The research purposely selected BWM experts.

Thematic analyses are a valuable tool for examining building sites, specifically in the context of CWM. Thematic analysis in this context allows researchers to methodically find, examine and interpret reoccurring themes or patterns associated with the management of construction waste. Thematic coding enables the extraction of significant information by closely observing building site operations, such as trash generation, treatment, disposal methods and communication among personnel.

In addition, theme analysis is crucial for evaluating the acquired data. The process entails the identification of keywords, analysis of context and reporting of trends observed in the data [2]. The interviews and questionnaires were transcribed in their entirety to provide precise documentation of all the information gathered. The supplementary information for data analysis comprised interview transcripts, audio recordings and field notes. Figure 1 shows the overall framework applied in the research.

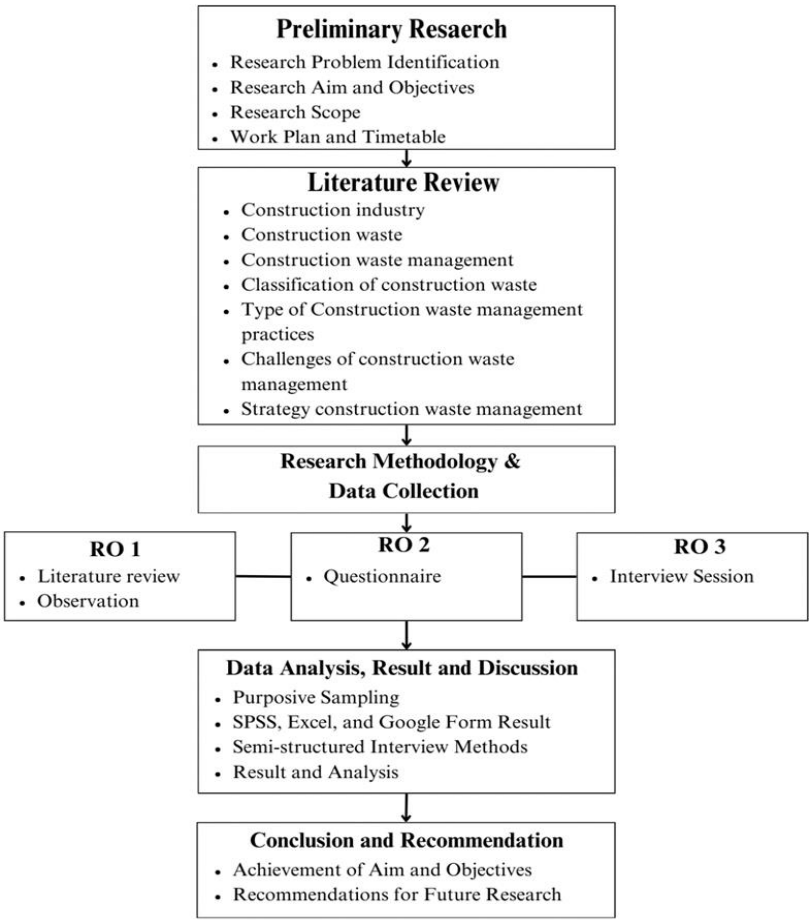

Fig. 1. Framework of research design

4. Results and Discussion

4.1 Current Practice of Construction Waste Management in Malaysia

This observation aimed to obtain well-sounded information within the research objectives described above. Through purposeful sampling, a total of five construction sites participated in the observation of this study. The fieldwork was conducted using a combination of site visits to gather comprehensive data on the CWM practices implemented at these sites. Figure 2 depicts the bar chart informing the frequency of implementation of different waste management strategies at construction sites.

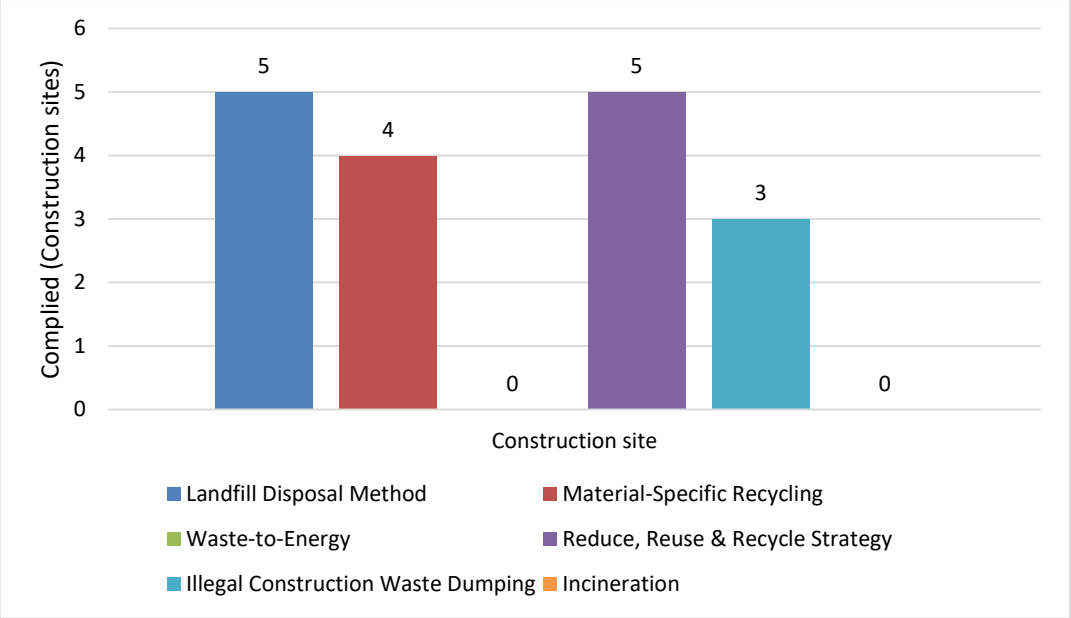

Fig. 2. Current practice of CWM in Malaysia

The chart shows that landfill disposal methods and 'reduce, reuse and recycle' programs are the main practices, with each being used in five construction sites. This implies a comprehensive strategy that combines traditional waste management methods with sustainable measures. Material recovery is widely practiced at four construction sites, demonstrating our commitment to segregate and recycle certain materials to encourage resource conservation. However, the charts show that waste-to-energy and incinerator procedures were not implemented or followed at any of the construction sites, indicating a lack of infrastructure or knowledge of these methods. There were three incidents of illegal disposal of construction waste, highlighting a worrying problem that poses serious environmental and health hazards. This practice suggests possible deficiencies in the enforcement or compliance with regulations. The chart depicts the diverse strategies for managing construction waste in Malaysia, relying mainly on landfill disposal and recycling methods. Enhanced implementation of waste-to-energy technologies and increased steps against illegal dumping could strengthen waste management practices [7]. In addition, the continued promotion of recycling and the implementation of reduce, reuse and recycle methods will help the construction industry to promote sustainable waste management in the future [27].

4.2 Major Challenges of Construction Waste Management in Malaysia

Table 1 shows the ranking of opinions on the degree of difficulty in dealing with construction waste based on the number of people who strongly agreed with each statement. 79.2 % of respondents (highest %), strongly agreed that there are limited recycling options in Malaysia. In response to this challenge, the various policymakers, regulatory agencies, industries and all stakeholders need to increase the number of recycling facilities, develop better recycling stations and encourage proper recycling all over Malaysia [16]. Among the respondents, 59.7 % strongly agreed that the recycling infrastructure in Malaysia is poor. The present scenario about CWM brings out an urgent requirement for the existence of more recycling centres and a proper waste management program for construction waste [19].

Table 1
Composite ranking of views on the difficulties of managing construction

Description	Strongly agree (%)	Rank
Lack of a well-developed waste recycling market	59.7	2
Lack of coordination among divisions	10.4	7
Lack of time to develop plans for waste reduction	46.8	3
Lack of awareness among clients about sustainable management	27.3	6
Lack of enforcement of construction and waste management policies and plans	39	5
Poor skills in construction practices of on-site operatives	44.2	4
Lack of knowledge about CWM tools	9.1	8
Limited recycling options	79.2	1

Besides, concerns about the skills and work habits of site staff were raised by 44.2 % of respondents. According to Zainol *et al.,* (2020) [36], the attitude of workers is important, so that with improvements in skills and attitude to work, there can be wide gains made in the reduction of wastage and efficiency of the construction projects. This clearly shows that construction workers need better training and rules. On the other hand, clients' lack of knowledge about sustainable management ranked eighth with 27.3 % strongly agreeing. Despite, the public and the clients have been sensitized to the opportunities that accompany sustainable management practices, the challenge of ensuring that the clients are fully informed about sustainable construction practices, persists [32]. This shows that although some are aware of the issue, there is still a lot of work to be done in this area. A significant barrier is the lack of enforcement of construction and waste management policies and plans, with 39 % per cent strongly agreeing with this in fifth place. According to Hasan *et al.,* (2023) [14], enforcement plays a significant role in ensuring companies are answerable for their actions, provides a mechanism to punish reckless conduct and creates fairness for all parties involved in construction projects.

In addition, not knowing how to use tools to manage construction waste ranked 8th with 9.1 % strongly agreeing. According to Kabirifar *et al.,* (2020) [18], an essential element of waste reduction is the comprehensive adoption of various technologies to manage construction waste. Besides that, a big issue is that there is not much time to make plans to reduce waste (46.8 % strongly agreed), which puts it in third place. According to Ahmad Rafidi *et al.,* (2023) [4], the current system can hardly cope with the task, which in fact underscores the need to devote more time and money to this issue. This means that enough time needs to be set aside to ensure better use of effective waste reduction methods in construction projects.

4.3 Solutions for Improving Construction Waste Management Practices in Malaysia

Table 2 shows the solutions for improving CWM and describes the research findings in a detailed tabular format in which different solutions relevant to the respondents' opinions regarding CWM in Malaysia. The sufficiency of onsite construction waste facilities, having an average level of agreement at 83 %, supports the need to have separate construction waste. According to Al-Otaibi *et al.,* (2022) [3], this solution is designed to simplify waste management with a better understanding of segregation and disposal of waste enhancing the value of a clean and safe working environment. Moreover, a 50 % agreed-on statement on improving the comprehensive pre-construction planning, implies the need to pay more attention to the pre-construction planning about waste management. Improvement of these planning processes may allow the identification of waste generation places, setting the strategies aimed at minimising generation and incorporating sustainable measures from the very beginning of the project [27]. Furthermore, commitment to the creation of specific BIM standards and procedures was expressed with a 33 % agreement thus, the existence of unclear BIM

roles and responses to waste management might be suspected. Nevertheless, Akinade *et al.,* (2017) [8] highlighted that the application of standardized behaviours among the members of the project can improve data quality as well as make communication between the various role players easier and enable better management of waste throughout the lifecycle of the project. Regarding the Checklist of SWMP where its average percentage rating was 67 %, this suggests acceptance of performing SWMP check-up analysis. Peer-reviewing is another best practice that enables the discovery of factors that can be harnessed to improve waste management activities and highlights areas of weakness that could be detrimental to waste management goals and objectives to help improve the effectiveness of waste management and diversion [11].

Employing 83 % agreement of proper waste management practices in staff and subcontractors through capacity-building education and training implies that more resources should be dedicated to workforce development. Knowledge transfer empowers organizations' personnel to align their actions with best safety practices for handling waste, to enhance organizations' accountability to safety legislations and to set benchmarks for constant enhancement of waste management practices [34]. Given 100 % agreement on the implementation of the 3R concept of construction waste disposal that prompts 'Reduce, Reuse, recycle', the study has a reflection on the consciousness that is embraced by the participants in endorsing environmentally friendly waste disposal. We acknowledge that incorporating the 3R approach would come in handy in reducing the quantity of waste that is produced, as well as in optimising the use of available resources and construction activities to near environmentally sustainable levels [33].

Table 2
Solutions for improving CWM

Description	Strongly agree (%)	Rank
Schedule for collecting rubbish from construction sites	50	6
CWM in the project with proper procedure	67	4
*Provision of on-site construction waste facilities	83	2
Upgrade comprehensive pre-construction planning	50	7
Develop and enforce a uniform set of BIM standards and processes to ensure data consistency and compatibility among team members	33	8
Perform a comprehensive SWMP review and identify areas requiring enhancement	67	4
* Providers educate and train staff and subcontractors on proper waste management practices	83	2
Adopt the 3R concept for construction waste disposal	100	1

Note: * Same rank

5. Conclusions

In conclusion, the construction industry is a significant contributor to global economic growth and development as it is a stimulant for the expansion and prosperity of urban areas. The construction industry in Malaysia is also experiencing tremendous growth and the country is currently undergoing massive economic expansion and urban development. On the other hand, this expansion has resulted in considerable costs due to the exponential growth in the amount of waste generated from construction activities. This study focused on the many aspects of CWM in Malaysia and shows the wide range of environmental, economic and social impacts associated with CWM. When construction waste is present, the environment is polluted, trees are depleted and natural resources are degraded. The entire environment, including people, animals and plants, is negatively affected by this event. It also pollutes the air and water and puts the health of the general population at risk.

There are several economic barriers and benefits to the effective disposal of construction waste. Using inefficient waste management processes burdens resources and drives up prices. However, there is potential for economic growth through effective waste reduction and recycling strategies. In considering these challenges, it is important to recognise that there is an inherent duality in the construction business. Whilst it undoubtedly contributes to the region's economy, it also poses significant risks to the environment and human health. There is a need for researchers, practitioners and government agencies to collaborate to develop and act on effective waste management programmes to adequately address these issues.

Environmentally-responsible waste management has become critical in the context of the expanding construction industry in Malaysia. This include enhanced understanding of regulations and research on various viable recycling methods to reduce the burden on landfills. To safeguard workers and the public, this strategy has the potential to make the construction industry more environmentally friendly, compliant and safer. By an integrated approach, this study provided important insights that can be applied by policymakers, researchers and practitioners. These insights will contribute to the development of environmentally-responsible and sustainable construction practices in Malaysia, thereby safeguarding human health, safety and the environment.

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