

The Assessment of Waste Segregation Exercise Among Malaysian Contractors: A Descriptive Analysis

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Abstract

Construction waste that emerges from construction sites has become a major global concern due to its negative carbon footprint on the environment. Due to underrepresented construction waste specific data in Malaysia, this paper aims to identify sources, causes, types of construction waste and decision-making factors of construction waste management in Malaysia's construction sites. A questionnaire survey was administered to 60 construction practitioners representing different construction sites in Peninsular Malaysia. A descriptive analysis using the Relative Importance Index (RII) was used to rank the items asked in the survey and categorised them into high ($RII > 70\%$), medium ($50\% < RII < 70\%$) or low ($RII < 50\%$) importance levels. The findings show that the top-ranked sources of construction waste categorised as high importance level are demolition, site clearance, and refurbishment. The causes, insufficient construction waste management plan, incorrect materials, design changes, over-ordering, errors in the contract document, and on-site technical errors are ranked as highly important. The top common waste materials include concrete, brick, metal, wood, glass and paper. The importance of all decision-making factors is high-rated; unexpectedly, environmental impact is the least important reason for construction waste management contractors. The results provide a perspective of the current practices of construction waste in Malaysia. The outcome is useful for waste managers and policymakers in developing potential waste management strategies for a more sustainable construction industry.

Keywords: *Malaysia, construction waste, waste segregation, decision-making factors, construction site*

1.0 INTRODUCTION

Million tons of building-related waste to be disposed of in landfills has become a global concern. Rapid urbanisation causes serious construction waste and contributes to the total solid waste stream (Ali et al, 2019). The demand for new construction or refurbishment projects has aroused the construction waste amounts to increase indirectly (Nagapan et al, 2012). In Malaysia, construction waste is estimated at at least 30% of total disposal in landfills (CIDB Malaysia, 2008). This has contributed to the high-cost amounting to USD480 million of waste separation in this country (Rashid, 2015). The scenario worsens with illegal dumping activities from construction sites (Rahim et al., 2017). Previous research found that the main reasons that contribute to an increase in illegal dumping sites are the distance between the project location and the gazetted landfills, as well as to maximise their profit margin by avoiding the payments on the landfill charges and the corresponding transportation fees (Ilham & Esa, 2017). Due to the lack of implementation of sustainable waste management practices in construction sites (Weber, 2017), the circumstance has become nearly uncontrollable. It is becoming an economic burden imposed on the country's financial waste management budget annually. A cure to tackle this problem is needed immediately.

Construction waste problems keep arising leading to frustrated society, mainly due to the gap between policy in place and their implementation in practice. A study by Sa'adi and Ismail (2015) gathered Malaysia's government's initiatives in construction waste minimisation. The study concluded that current existing regulations and policies in Malaysia focus on household, municipal and hazardous industrial waste with a lack of emphasis on construction waste minimisation. Furthermore, the study also highlighted that the National Solid Waste Management Policy introduced in 2006 is quite general and does not specify the classification of construction waste.

Due to underrepresented construction waste specific blueprints, the country needs to take action towards sustainable construction waste management so that contractors can manage waste responsibly to conserve the

planet's natural resources and minimise damage to the environment. To develop a solid framework for construction waste management, it is essential to comprehend the evidence-based trend of common construction waste management practices. It is vital to comprehend the evidence-based trend of the typical construction waste management practices to develop a solid framework for construction waste management.

Thus, the questions that need to be addressed are; what are the practices of construction management on-site and factors that determine practitioners' decision to undertake it? This study aims to identify sources, causes and types of construction waste and decision-making factors of construction waste management in Malaysia's construction sites. Understanding this trend helps the construction industry develop a practical framework for reducing, reusing, and recycling waste before disposing of them. In the long run, it minimises its environmental impact, contributes to the circular economy, and helps achieve the country's goal to become carbon neutral by the year 2050.

2.0 LITERATURE REVIEW

Construction waste is unwanted, unused, or discarded materials produced during the pre- construction, and post-construction stages. From a waste management perspective, carbon dioxide emissions represent the metabolic by-product of construction activities (Lackner & Jospe, 2017). The higher percentage of greenhouse gas emissions in the air will cause gradual warming, bringing climate change progressively to global warming. The construction industry accounts for 38% of carbon emissions (Huang, 2018). Building construction consumes 40% of materials and 40% of primary energy and generates 40% of waste annually (Sizirici, et al., 2021). The recent United Nations Climate Change Conference (COP26) reported that the construction sector was responsible for over 35% of the European Union's total waste generation. A study in Shenzhen, China, has found that wood, steel and concrete wastes are the top three contributors to carbon emissions with proportions of 23, 23 and 13% respectively (Wu, et al, 2015). Brazil found that their country

generates 1244 m³ of construction waste per month, about 40,440 kg CO₂ per year (Maués, Beltrão & Silva, 2021). In Malaysia, however, data regarding construction waste is underreported, which could be due to a lack of energy efficiency legislation in the Malaysian construction and building industry (Zaid, et al, 2014).

In general, construction waste contains inert and non-inert materials. About 50 to 90% of construction waste is inert, also known as public fill (Bustillo, 2021). The inert construction waste is neither chemically nor biologically reactive and will not decompose or only decompose very slowly. Some examples include debris, rubble, concrete and masonry. On the other hand, non-inert materials are subject to recovery of reusable or recyclable items and disposed of at landfills. For example, bamboo, wood, timber, and other organic materials.

Ideally, construction wastes should be treated according to the proper waste management hierarchy, reduced, reused, recycled and disposal (Hasmori, et al, 2020). Waste reduction is related to minimising waste generation at its source. In a construction project, waste minimisation can be achieved as early as the planning stage and continuously monitored throughout the construction life cycle. In an unavoidable waste generation situation, maximisation of reusing and recycling of construction waste materials can deliver environmental, social and cost-saving benefits (Hamid, et al, 2020). Recycling involves waste segregation and re-modelling into usable new items. Effective waste segregation practice helps contractors to recycle larger amounts of waste materials.

The waste segregation process can be divided into two; on-site segregation and off-site segregation. The on-site waste segregation encourages contractors to recycle and create more reuse options in other construction processes, avoiding landfills and higher disposal costs (Franchetti & Apul, 2012). However, the remaining unused waste must be transported out from the construction site for recycling. Before deciding either to send the trash out to a materials recovery facility or landfills, contractors are responsible for detecting the re-usability of the materials and

segregating them according to their type. Separating different waste streams and storing them can effectively minimise the overall waste volume. It could, in turn, reduce collection costs. To achieve this, on-site segregation requires a cultural shift and training among staff in attitudes towards waste management.

On the other hand, off-site segregation works better for finite urban sites as it does not require space on-site for waste containers. It typically involves the transfer of construction waste to a third-party operated materials recovery facility. Although it reduces training costs and effort for the contractors, it may lead to wastage if reusable materials are not properly separated, resulting in increased transportation costs and carbon footprints. In Malaysia, on-site waste management off-site waste segregation is facing obstacles in terms of recycling resources due to lack of facilities, lack of accurate and well-established information on solid waste management and recycling, and lack of specific legislation for solid waste management (Moh, 2017).

3.0 METHODOLOGY

This research began with a literature review to obtain a relevant foundation of knowledge on the topic. The keywords for search engines were sustainable construction waste management and construction waste segregation. The literature reviewed includes books, journal articles, conference papers, dissertations, news sources and web pages. The data sourced were first skimmed through by reading its title, abstract, introduction and conclusion. Irrelevant materials were filtered out. Subsequently, the remaining materials were read, and key points were noted. These key points were then sorted into themes. Finally, the literature review is written by summarising the key points under each theme.

A survey was then conducted to explore the activities related to sustainable waste management on the construction sites. The targeted respondents were construction managers who have experienced works in construction sites and have knowledge of Malaysia's construction site waste management. Respondents were selected by random sampling. A list of construction companies was acquired from the leading construction body in Malaysia,

Construction Industry Development Board (CIDB) Malaysia, to ease the email sending procedure to potential respondents. Due to the Covid-19 pandemic and safety reasons, the survey was administered fully online through the Google Docs platform. A cover letter was issued together with the email, and reminders were sent out twice to ensure a reply from respondents. All feedback was delivered into a common database. The data collection period for this research was eight weeks.

The questionnaire consists of three main sections, with the first section focusing on participants' demographic information. The second section requires the respondents to identify the most common types of construction waste going to landfills and their level of disposal. Finally, the third part evaluated the techniques and practices that provoked industry players to comply with construction waste disposal. In responding to the survey, closed-ended questions were deployed using the Likert-type scale. No identifiable information was required to maintain the anonymity of the respondents. However, before filling in the questionnaire, the respondents had to indicate their consent to participate in the research. Descriptive statistics of this study was presented in the following section. The ranking of the sources, causes and types of construction waste were quantified by the Relative Importance Index (RII) method. Based on the ranks obtained from the analysis, the capabilities were categorised as high level ($RII > 70\%$), medium level ($50\% < RII < 70\%$) or low level ($RII < 50\%$).

4.0 RESULTS

The response rate is 24%, representing 60 respondents out of 250 questionnaires sent

out. Cronbach's Alpha coefficients α for the item scores, were 0.923, indicating that the survey has a significantly high internal consistency (Morgan, et al, 2011).

4.1 Demographic

All the respondents have experience working in construction sites, with the majority (70.0%) of more than ten years of working experience in the construction sites, while 30.0% have 5 to 10 years of working experience. It indicates that respondents are familiar with decision-making environments. The respondents vary from different managerial levels, with 28.3% contractors, 21.7% site engineers, 13.3% quantity surveyors, 15.0% architects, and 21.7% construction waste technical experts. The variety is beneficial as a managerial perspective provides accurate measures evaluations. The respondents represented different contractor categories, varying from Grade 1 to Grade 7 (according to the CIDB Malaysia's classification). Most respondents (18.3%) work for Grade 5 contractor companies. Another 13.3% of the respondents work for Grade 1, 10% from Grade 2, 13.3% are from Grade 3, 16.7% from Grade 4, 16.7% from Grade 6 and 11.7% are from Grade 7 contractors. The construction sites referred to in this study vary in location throughout Peninsular Malaysia, of which 16.7% are located in Johor, 16.7% in Melaka and 16.7% in Selangor. This is followed by Kuala Lumpur (11.7%), Negeri Sembilan (10.0%), Penang (6.7%), Kedah (5.0%), Perak (5.0%), Terengganu (3.3%), Pahang (3.3%), Putrajaya (1.7%), Kelantan (1.7%), and Perlis (1.7%). Table 1 summarises the demographics of a sample of 60 construction practitioners from different construction sites.

Table 1: Demographics of a Sample of Construction Practitioners (N=60)

Characteristics	Number, <i>n</i>	Percentage, %
<i>Working Experience</i>		
Less than 5 years	0	0.0
5 to 10 years	18	30.0
11 to 15 years	30	50.0
16 to 20 years	7	11.7
More than 20 years	5	8.3
<i>Managerial Level</i>		
Contractors	17	28.3
Site Engineers	13	21.7
Quantity Surveyors	8	13.3
Architects	9	15.0
Construction Waste Technical Experts	13	21.7
<i>Contractor Classification</i>		
Grade 7 (no limit)	7	11.7
Grade 6 (<RM10,000,000.00)	10	16.7
Grade 5 (<RM5,000,000.00)	11	18.3
Grade 4 (<RM3,000,000.00)	10	16.7
Grade 3 (<RM1,000,000.00)	8	13.3
Grade 2 (<RM500,000.00)	6	10.0
Grade 1 (< RM200,000.00)	8	13.3
<i>Construction Site Location</i>		
Johor	10	16.7
Melaka	10	16.7
Selangor	10	16.7
Kuala Lumpur	7	11.7

Negeri Sembilan	6	10.0
Penang	4	6.7
Kedah	3	5.0
Perak	3	5.0
Terengganu	2	3.3
Pahang	2	3.3
Putrajaya	1	1.7
Kelantan	1	1.7
Perlis	1	1.7

4.2 Descriptive Results of Key Variables

Means, standard deviations and skewness of twenty-six key variables for sources of construction waste are shown in Table 2. All the sources vary widely in Mean. The standard

deviations for most of the sources are considered quite consistent except for the roadwork represents a wide distribution of respondents' views. All items are either positively or negatively skewed, representing a consensus on the value between respondents.

Table 2: Descriptive Results of Key Variables

Key Variables	Number, N	Mean, μ	Standard Deviation, σ	Skewness
<i>Sources of Construction Waste</i>				
Demolition	60	4.92	0.279	-3.093
Refurbishment	60	3.77	0.500	-0.411
Excavation	60	2.92	0.696	0.425
Renovation	60	4.45	0.565	-.0380
Site Clearance	60	3.85	0.547	-0.735
Roadwork	60	2.50	1.033	1.716
<i>Causes of Construction Waste</i>				
Design Changes	60	4.40	0.643	-0.601
Errors in Contract Document	60	3.82	0.701	0.270
Over Ordering	60	3.90	0.681	-0.206

Transit Damage	60	2.30	0.720	1.166
Storage Faulty	60	2.88	0.640	0.104
Inclement Weather	60	2.37	0.843	1.314
Incorrect Material	60	4.57	0.533	-0.623
On-site Technical Error	60	3.65	0.606	0.340
Packaging Waste	60	2.98	0.911	-0.523
Vandalism	60	2.38	0.585	1.263
Insufficient Waste Management Plan	60	4.92	0.279	-3.093
<i>Type of Construction Waste</i>				
Plastic	60	3.23	0.593	0.398
Metal	60	4.43	0.673	-1.129
Wood	60	4.42	0.619	-0.560
Paper	60	3.48	0.624	-1.233
Glass	60	3.53	0.833	-0.200
Concrete	60	4.97	0.181	-5.334
Gypsum	60	3.47	0.623	-0.738
Asphalt	60	2.87	0.596	-0.430
Bricks	60	4.93	0.252	-0.3564
<i>Factors of Decision Making for Construction Waste Management Approach</i>				
Waste Management Cost	60	4.42	0.619	-0.560
Time Demand	60	4.20	0.708	-0.604
On-site Space Availability	60	4.73	0.482	-1.542
Profit from Recycling	60	3.77	0.745	0.411
Waste Management Experts	60	4.35	0.659	-0.520
Labour Demand	60	4.17	0.740	-0.279
Environmental Impact	60	2.13	0.911	1.539

Management Support	60	4.35	0.659	-0.520
Facility Availability	60	4.35	0.547	-0.110

4.3 Sources of Construction Waste

As presented in Figure 1, the demolition contributes most to the total construction waste with an RII of 98%, followed by the site clearance and refurbishment with RII of 77% and 75%,

respectively. The importance of the remaining sources is categorised as medium level. They are renovation with a 69% RII score, and excavation is 58%. Roadwork scores 50% of RII and is considered a low-importance level source.

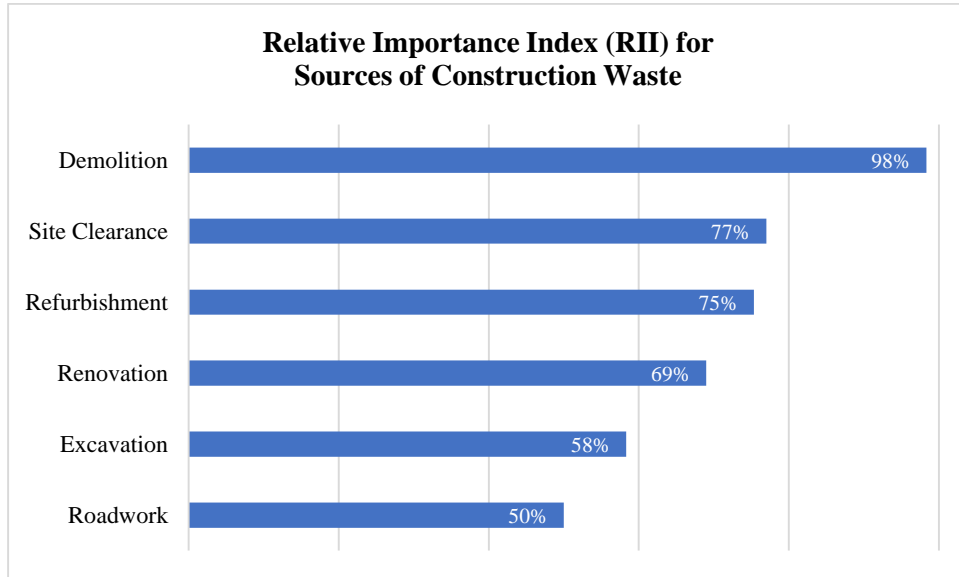


Figure 1: Ranking for Sources of Construction Waste

4.4 Causes of Construction Waste

The insufficient construction waste management plan is ranked as the top cause of construction waste with an RII of 98%. Another leading two causes are incorrect materials and design changes, with RII scores are 91% and 88%, respectively. Over-ordering (78%), error in contract documents (76%) and on-site technical error (73%) are also ranked as high

important causes, indicated by RII of more than 70%. The medium level of important causes includes packaging waste (60%) and storage faulty (58%). Vandalism (48%), inclement weather (47%) and transit damage (46%) are considered low levels of important causes as their RII scores are less than 50%. The ranking for causes of construction waste is presented in Figure 2.

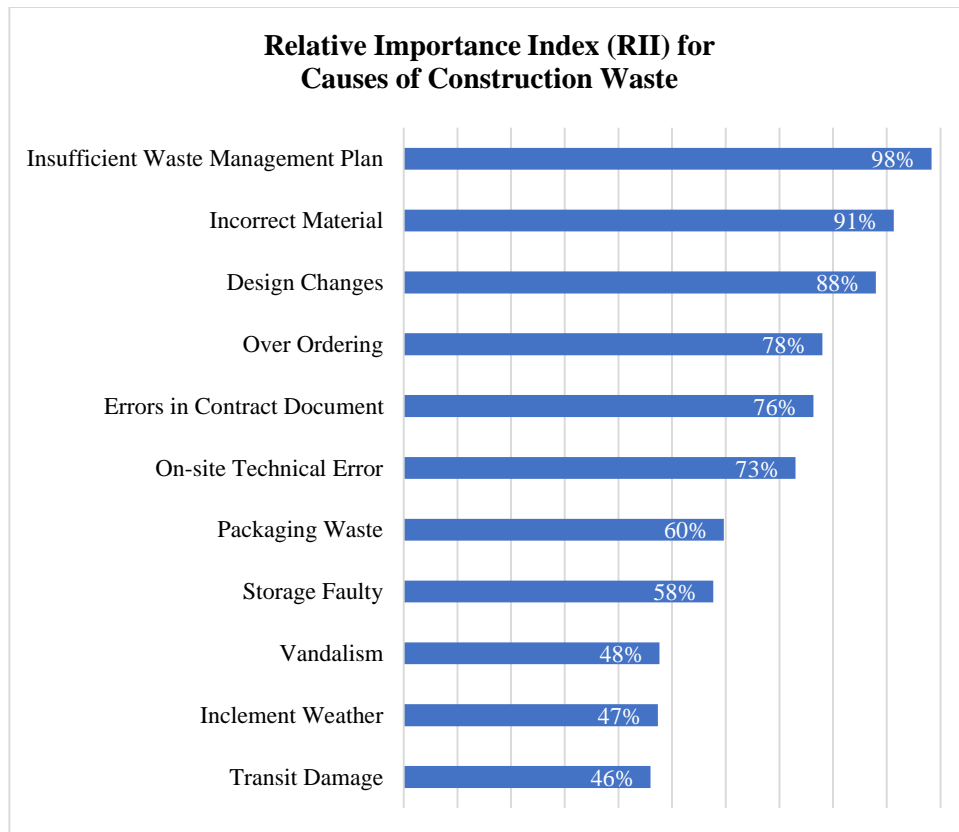


Figure 2: Causes of Construction Waste

4.5 Types of Construction Waste

In overall, all materials are rated as either high or medium level. As shown in Figure 3, concrete and brick are the top-ranked types of materials contributing to construction waste. The RII are 99% for both types, indicating high

consensus between the respondents. Other types of waste that score high-level in RII are metal with an RII of 89%, wood is 88%, glass is 71%, and paper is 70%. Gypsum (69%) and plastic (65%), and asphalt (57%) are considered medium importance level materials.

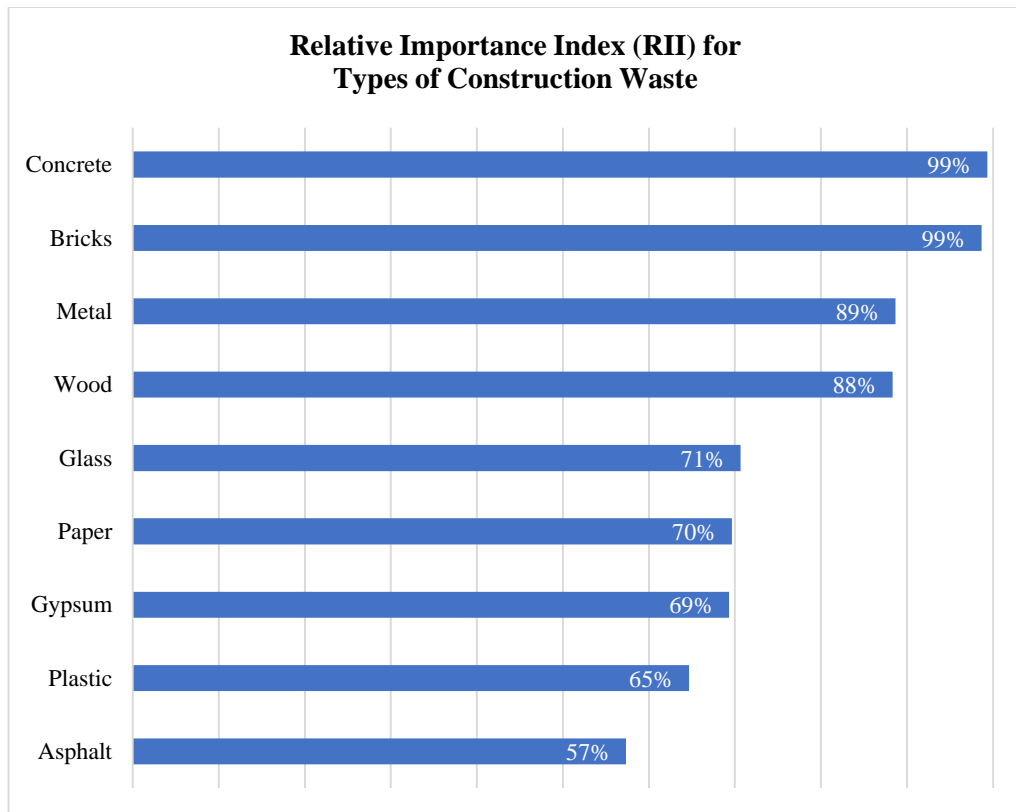


Figure 3: Types of Construction Waste

4.6 Waste Segregation

All the respondents agree that on-site sorting increases clean waste fractions. Interestingly, off-site segregation still has a

waste segregation method for 60% of respondents, while another 40% chose on-site segregation. The result is presented in Figure 4.

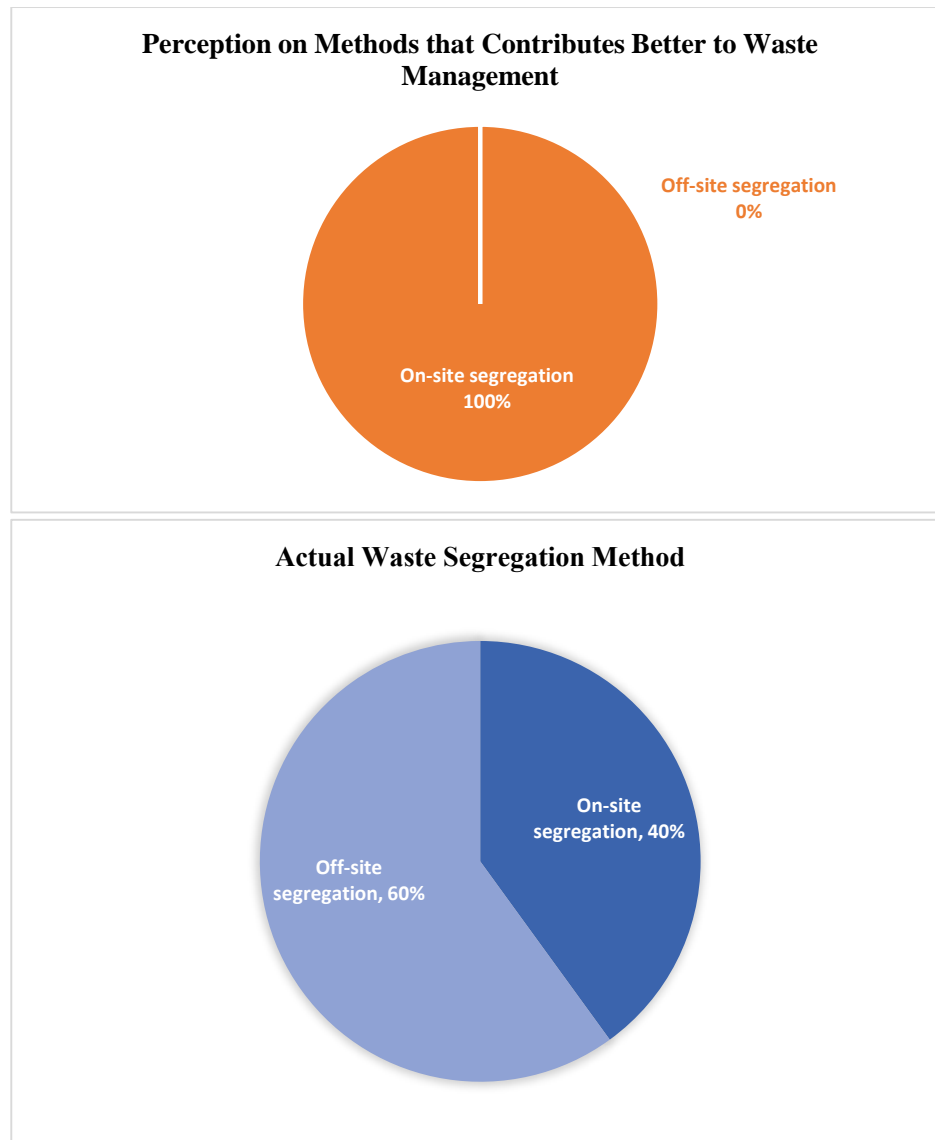


Figure 4: Waste Segregation Perception and Actual Practice

This study assesses factors that determine decision making for the waste segregation method. According to Figure 5, the most influencing factor is on-site space availability, with a 95% RII score. It is followed by waste management cost (88%), facility availability (87%), management support (87%) and waste management experts availability

(87%). The next less influencing factors are time demand (84%), labour demand (83%) and profit coming from the recycling market (75%). Surprisingly, the environmental impact factor scores as the least important factor that affect practitioners' decisions on waste segregation method with an RII of 43%.

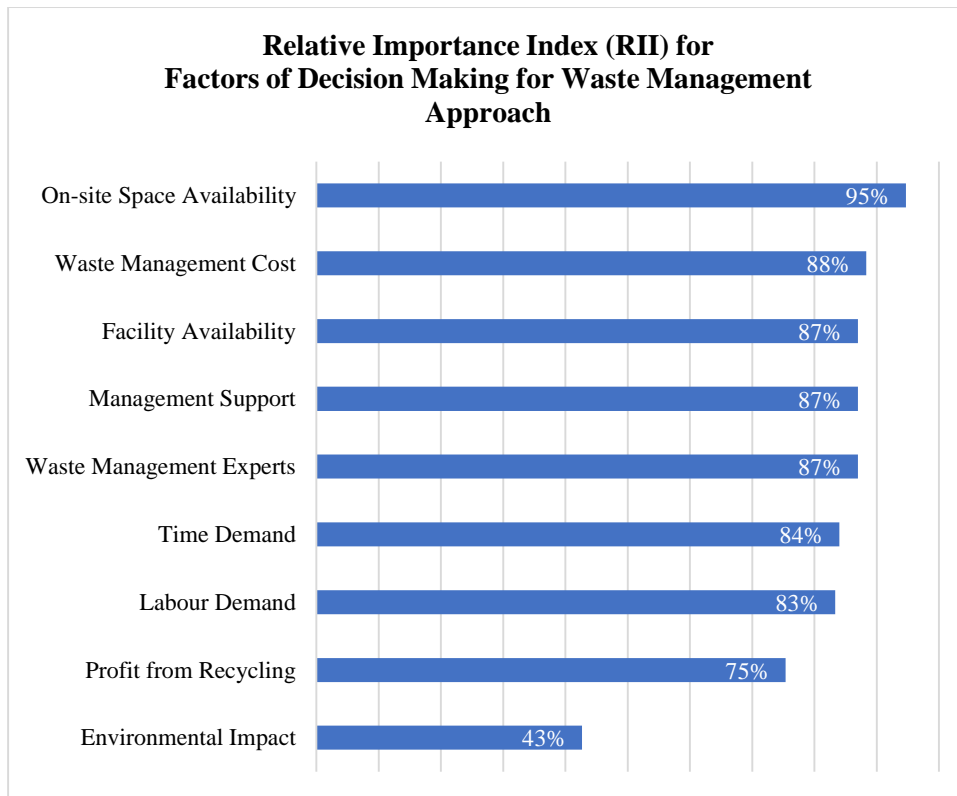


Figure 5: Factors of Decision Making for Waste Management Approach

5.0 DISCUSSION

This study reveals that a building's end-of-life phase contributes most to construction waste caused by demolition activities. Demolition of buildings generated 70% to 90% of the total construction industry waste (Liu, Huang & Wang, 2020; the United States Environmental Protection Agency, 2020). Therefore, it justifies why many developed countries and scholarly works are moving towards encouraging refurbishment over demolition. The reason is about energy and carbon and the environmental impacts of the production of water, concrete, and many other materials used in the new building construction (Bell, et al, 2014). Ironically, refurbishment and site clearance is still considered the high-level contributors to construction waste in Malaysia. Numerous studies have presented positive environmental and economic impacts of recycling in refurbishment, site clearance, and even construction. Therefore, this study suggests the urgency of improved recycling in construction initiatives to provide a long-term, cost-effective solution that drives a circular economy for the industry. On a positive note,

the finding indicates that Malaysian contractors are aware of how these sources play a part in contributing to construction waste. This awareness helps them gain pertinent knowledge about this issue and subsequently supports the government's environmental initiatives.

Findings on the causes of construction waste in Malaysia are consistent with previous issues reported thirteen years ago (Umar, Shafiq & Ahmad, 2021; Nagapan, et al, 2012; Mahayuddin et al, 2008). This flaw corresponds to ineffective project management practices that have also become the primary concern among construction industry scholars for over a decade (Chang, et al, 2021; Jatarona, et al; 2016; Abdul-Rahman, et al, 2006). It is alarming that the construction authorities and practitioners should prioritise drawing up a holistic construction waste policy and project management approach. As Malaysia has agreed to the Paris Agreement goals and the Glasgow Climate Pact, which among others, aim to support climate actions, this is the best time for the industry to take action and play a serious role in combatting climate change. The industry should look into waste segregation and recycling and look into construction waste

minimisation. Findings on the type of construction waste materials are a good start to set a target of sending zero waste to landfills. Classifying the type of construction waste is an excellent start towards zero construction waste to landfills. Additionally, identifying decision-making factors for undertaking construction waste management for a project could become a baseline for policymakers to develop relevant policies that work for everyone and construction practitioners to improve project performance. The use of technology, such as Building Information Modelling (BIM), is an effective platform for environmental-friendly construction (Condinhoto, et al, 2021), which a country like Malaysia should fully utilise.

Based on the findings, respondents have a perception that on-site segregation contributes better to improving construction waste management. However, the majority of them undertake off-site segregation. Even though findings by Moh (2017) show off-site segregation in Malaysia is facing challenges in terms of lack of information and specific legislation, it is still a preferable option for contractors. It could be because they have limitations in on-site space and on-site waste management costs for training and set-up facilities that hinder them from exercising on-site segregation. Interestingly, the findings revealed one surprising point; the environmental impact factor is not the main reason to conduct construction waste management exercises; it was found to be the least important factor. This scenario shows the level of awareness among construction practitioners is considerably low. Not just in the construction industry, a study by Susskind et al. (2020) also finds nascent environmental awareness in Malaysia as a whole, and it has become a limiting factor for decarbonisation efforts in the country. Hence, it is vital for the authorities and learning institutions to improve education on sustainability and climate change. Education is critical to cultivate environmental awareness in the young and encourage people to change their attitudes and behaviour to help the government address the causes of climate change. Education also motivates construction practitioners to adopt sustainable construction.

6.0 CONCLUSION

The construction industry plays a vital role in combatting climate change as it is one of the most significant contributors to global carbon emissions. In the effort to move the construction industry onto a low-carbon pathway, managing construction waste is a vital action due to its massive proportion of greenhouse gas. This study identifies sources of construction waste, its causes, types of waste materials and implementation factors of construction waste management exercises. It highlights the current key sources of construction waste: demolition, site clearance, refurbishment, renovation, excavation, and roadwork, ranked from highest to lowest. Almost all types of construction waste commonly end up in landfills, considered as high to the medium significance level. This study also finds that the high-level causes of waste are related to insufficiency of construction waste and project management, which include insufficiency of construction waste management plan, incorrect materials, design changes, over-ordering, errors in the contract document, and on-site technical error, packaging and storage faulty, ranked from top to bottom.

This study also concludes that the high-level cause of waste is inefficient project and construction waste management. It includes insufficient construction waste management plan, incorrect materials, design changes over-ordering, errors in the contract document, on-site technical error, packaging and storage faulty, ranked from top to bottom.

The lack of environmental impact consideration to exercise construction waste management among Malaysian construction practitioners provides an exciting highlight that calls for immediate and future attention. Therefore, to develop a long-term solution for construction waste issues in this country, education is essential in creating awareness and knowledge, coupled with a holistic-approached policy that encourages construction practitioners to take effective construction waste management into practice. This study received a low response rate due to the restricted data collection approach impacted by the COVID-19 pandemic. Therefore, future

research should consider more respondents to represent more construction sites. A higher response rate will enable the research to generalise the results to represent the whole of Malaysia's construction industry. It will also be very insightful to conduct a comparative analysis study, looking into how the industry has improved, taking this study's findings as a baseline.

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