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Evaluating 3R Waste Management Practice for Construction and Demolition Waste among Contractors in Malaysia

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Abstract

This study investigates the implementation of the 3R (Reduce, Reuse, Recycle) principles in reducing construction waste among contractors in Malaysia. Given that the construction industry is substantial contribute to environmental degradation thereby effective waste management for sustainable development is warranted. Therefore, the present study aims to identify the key materials contributing to construction waste, examine influencing factors, and assess contractor awareness related to 3R practices adoption. For this, a quantitative approach through Likert-scale questionnaire distributed via Google Forms to contractors across various regions and company grades in Malaysia was used. The questionnaire comprised seven sections covering background information, waste materials, contributing factors, 3R awareness, current practices, barriers, and perceived benefits. A total of 33 valid responses were analysed using descriptive statistics in Microsoft Excel. Results showed that concrete and aggregates were the highest contributors to construction waste (mean value = 3.58), followed by wood and ceramics. Furthermore, the respondents demonstrated a strong awareness of 3R principles (mean = 4.15) and environmental impacts of waste, but moderate familiarity with relevant policies and sustainable construction practices. For instance, the major 3R implementation barriers included limited knowledge, lack of training, and inadequate waste management resources. Despite these challenges, respondents acknowledged the environmental (mean = 4.58), economic, and social benefits of 3R practices, such as reducing landfill use, improving profitability, and enhancing public perception. The study concludes that increasing education, training, and policy support is vital to improve 3R adoption among contractors, thereby promoting more sustainable construction practices in Malaysia.

Keywords: 3R Principles, Construction Waste, Contractor Awareness, Waste Management, Sustainable Construction

1. Introduction

The construction industry is one of the key contributors to Malaysia's economic development and infrastructure expansion. In 2023, the sector generated approximately RM34.1 billion in completed works and reflecting a 6.8% year-on-year increase (Department of Statistics Malaysia, 2023). Looking ahead, this sector is projected to expand by 7.4% in 2024 (GlobalData, 2024). This growth is expected to be driven by large-scale infrastructure projects such as the Mutiara Line, formerly known as the Bayan Lepas LRT (Metro Report

International, 2025), Malaysia Vision Valley, and data centre developments in Johor (Bernama, 2023). In addition to construction activities, demolition works are also part of the construction sector's scope. Presently, the major demolition projects, that have been carried out including redevelopment of Shah Alam Stadium and Kampung Sembulan Tengah. Studies have shown that construction and demolition (C&D) sectors generate substantial amounts of waste (Rahim et al., 2017; Yuan & Shen, 2011). If this waste not properly managed, it can contribute to land degradation, environmental pollution, and increased pressure on landfill capacity. However, there are question arise regard what kind of C&D waste and the factor influences the waste generated waiting to be explored.

The 3R approach of reduce, reuse, and recycle is widely recognized as a foundational principle in managing C&D waste. It offers a structured framework for achieving long-term waste reduction and environmental sustainability (Yuan & Shen, 2011). Among the C&D stakeholders, contractors play a pivotal role in advancing sustainable development by minimizing negative environmental impacts while maximizing economic contributions through efficient construction practices. Their capacity to implement waste reduction strategies, optimize resource use, and prevent environmental pollution is critical to aligning with the sustainability goals of the construction industry such as cost savings, improved operational performance, and enhanced reputation. However, the extent to which these practices are understood and adopted remains unclear. Challenges such as limited awareness, inadequate training, lack of regulatory enforcement, and minimal stakeholder collaboration often hinder effective 3R implementation at the contractor level. Therefore, a comprehensive evaluation of contractors' awareness, attitudes, and practices regarding 3R strategies is essential to inform policy development and industry-wide improvements.

This study aims to evaluate the current state of 3R waste management practices among Malaysian contractors. Specifically, it seeks to (i) identify key materials contributing to construction waste, (ii) examine the factors influencing waste generation, (iii) assess contractors' awareness and adoption of 3R practices, and (iv) identify barriers and benefits associated with 3R implementation. The findings of this study are intended to mapping waste management practice in order to support the development of targeted strategies for promoting sustainable construction practices and improving waste management performance across the industry.

2. Research Method

This study adopted a quantitative approach to examine the implementation of 3R (Reduce, Reuse, Recycle) waste management practices among construction contractors in Malaysia. The methodology was structured in two distinct phases as shown in Figure 1 and elaborated in the following section.

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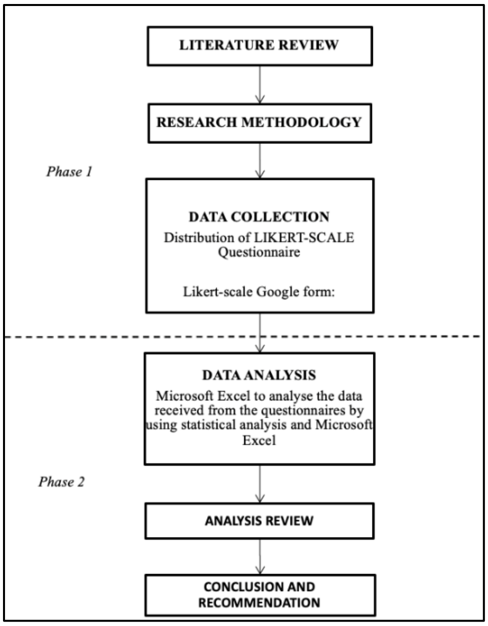

Figure 1. Methodology framework.

2.1 Research Design

This research was employed a quantitative research design using a structured questionnaire as the main data collection tool. The study was divided into two phases:

Phase 1: Research Problem Identification, Research Objectives Formulation, Review of Related Literature, Design and Questionnaire Distribution – This phase developed a comprehensive understanding of the issue and facilitated the primary data collection from contractors to achieve the research objectives.
Phase 2: Data Collection and Statistical Analysis – This phase analysed the questionnaire data using Microsoft Excel with descriptive statistics. The results were summarized and presented using tables, charts, and graphs, and interpreted based on the research objectives. The study limitations were also notified.

2.2 Participants

The participants comprised 33 contractors registered under the Construction Industry Development Board (CIDB), representing a mix of small (G1–G3), medium (G4–G5), and large (G6–G7) firms. These contractors were selected from various regions in Malaysia, including the northern (Perlis, Kedah, Penang, Perak), central (Selangor, Kuala Lumpur, Putrajaya, Negeri Sembilan, Melaka, Johor), east coast (Pahang, Kelantan, Terengganu), and East Malaysia (Sabah, Sarawak, and Labuan). This purposive sampling technique was employed to ensure that the respondents were actively involved in C&D activities. Participants' identities and company details were anonymized to preserve confidentiality.

2.3 Materials/Measures

The primary data collection instrument was a structured questionnaire. The questions were developed based on a review of relevant literature and aligned with the research objectives. That questionnaire consisted of the following sections:

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Section A: Background Information – This section aimed to collect basic organizational and demographic details including company grade, location, and years of experience in the construction industry.
Section B: Waste Materials – This section identified the types of materials most commonly contributing to C&D waste.
Section C: Contributing Factors – This section explored the factors that contribute to the generation of C&D waste.
Section D: Awareness of 3R – This section assessed the 3R level of knowledge and awareness among contractors.
Section E: Implementation Practices – This section examined the extent to which contractors have adopted 3R strategies in their construction activities.
Section F: Barriers –This section investigated the challenges and constraints faced by contractors in implementing 3R waste management practices on construction sites.
Section G: Perceived Benefits –This section examined the environmental, economic, and social advantages perceived by contractors as a result of implementing 3R waste management practices on construction sites.

Responses were recorded using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Open-ended questions were included to gather additional qualitative insights. The data analysis in Phase 2 facilitated a comprehensive understanding of contractors' practices, challenges, and perspectives related to 3R implementation.

2.4 Procedure

The research procedure was conducted through the following steps:

1. Instrument Development: The questionnaire was developed based on an extensive review of relevant literature on construction waste and 3R practices.
2. Participant Selection: Construction contractors registered under CIDB (grades G1 to G7) were selected using purposive sampling. Contractors actively involved in construction and demolition projects were targeted.
3. Survey Distribution: The questionnaire was distributed via Google Forms to contractors across Malaysia.
4. Data Collection: Participants were given sufficient time to complete the questionnaire. The reminders were issued to ensure a high response rate.
5. Data Compilation: Responses were collected, reviewed, and compiled for analysis. All responses were anonymized to protect participant confidentiality.

2.5 Data Analysis

Descriptive statistics were used to analyze the survey data, providing a summary of contractor characteristics, behaviors, and perceptions regarding 3R practices in Malaysia's construction sector. The analysis was conducted using Microsoft Excel by applying frequency distributions, mean values, and visual tools such as charts and tables to present the results clearly.

Table 1 presents the 5-point Likert scale used to evaluate responses where 1 indicates "Strongly Disagree" and 5 indicates "Strongly Agree." In sections assessing material contribution to construction waste, respondents rated items from 1 (Lowest contributor) to 5 (Most contributor). This approach streamlined data collection and interpretation (Abdullah & Baba, 2013) and helped determine the frequency and strength of agreement across all questionnaire items.

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Table 1: The likert-scale interval for mean data frequencies.

Likert Scale Description	Scale	Likert-scale interval
Strongly disagree	1	1.00 – 1.80
Disagree	2	1.81 – 2.60
Neither agree nor disagree	3	2.61 – 3.40
Agree	4	3.41 – 4.20
Strongly Agree	5	4.21 – 5.00

In addition to descriptive statistics, inferential statistical methods were employed to examine the relationships and differences among selected variables in the dataset. A one-way Analysis of Variance (ANOVA) was conducted to determine whether there were statistically significant differences in 3R awareness levels among contractors of different company sizes (categorized as Small: G1–G3, Medium: G4–G5, and Large: G6–G7).

Furthermore, a Pearson correlation analysis was performed to explore the relationship between respondents' awareness of 3R practices and their perceptions of the associated environmental, economic, and social benefits. These analyses were conducted using SPSS, with a significance level set at $p < 0.05$.

These statistical methods provided additional insights into the underlying patterns and associations in the data, beyond what descriptive statistics alone could reveal. However, given the limited sample size, the results of these analyses are interpreted with caution and primarily serve to guide further research.

3 Results and Discussion

This section presents and analyzes the results obtained from 33 contractors across Malaysia who responded to the structured Likert-scale questionnaire. The analysis focuses on identifying key contributors to construction waste, the level of awareness regarding 3R practices, and the perceived benefits of implementing 3R principles from environmental, economic, and social perspectives.

3.1 Material Contribution to Construction Waste Generation

Table 2 presents the analysis of contractor responses regarding the contribution of various materials to C&D waste generation. Based on the Likert-scale responses, the mean scores for each material were calculated to identify the most significant sources of construction waste.

Table 2: Material Contributions to C&D Waste.

Materials component	Lowest Contribution (1)	Less Contribution (2)	Moderate Contribution (3)	High Contribution (4)	Most Contribution (5)	Mean
Concrete and aggregates	1	4	11	14	3	3.58
Wood and timber	0	7	7	12	7	3.42

Metal/ reinforcement bar	5	4	8	13	3	3.15
Bricks and blocks	3	5	13	7	4	3.03
Soil and excavated materials	3	1	15	11	3	3.30
Tiles and ceramics	1	5	9	14	4	3.45

The data shows the level of contribution of different construction materials of C&D waste rated by contractors. Concrete and aggregates had the highest mean score of 3.58 indicating that they are major waste contributors. That materials are the most commonly used in construction material, and its management is crucial due to the significant waste generated during construction and demolition activities (Mahartin, 2023). Most respondents rated them as having a moderate to high contribution, suggesting that excess concrete, spills, and improper disposal are common issues. The management of concrete waste is critical, as the emergence of C&D waste has increased significantly since 2010 due to accelerated construction activities (Kumar & Shajan, 2023). This supports the notion that concrete, and aggregates are among the most significant contributors to construction waste.

Wood and timber have a mean score of 3.42, showing that they are moderate to high contributors to waste. The waste management issues associated with wood and timber, emphasizing that improper handling of can lead to significant waste generation, including offcuts, handling and disposal (Sharma, 2022). Metal reinforcement bars, with a mean of 3.15, is seen as a moderate contributor to waste. This finding echoes the conclusions of Phan (2019), who also identified inefficient cutting methods and improper storage as key factors contributing to metal waste. In their study, contractors frequently noted that incorrect measurements during the cutting process, along with inadequate storage that resulted in rusting or deformation, led to a considerable increase in waste production.

Bricks and blocks contribute moderately to waste, with a mean score of 3.03. Though considered less significant than other materials, contractors still noted waste from breakage or excess materials during large-scale projects. Breakage during handling and transportation is one of the factors contributing to this material waste. The innovations in recycling technologies that can minimize waste by reusing broken concrete as aggregates in road pavements, thereby reducing the need for new natural aggregates (Hadiwardoyo, 2024). This approach not only addresses the waste issue but also promotes sustainable construction practices by utilizing recycled materials. Soil and excavated material, with a mean of 3.30, are considered moderate contributors to waste. The challenges here include improper handling and disposal of excavated soil, leading to waste generation. Lastly, tiles and ceramics have a mean score of 3.45, showing that they are significant contributors, mainly due to breakage, overordering, and inaccurate measurements during installation.

3.2 Individual Practice and Awareness

Figure 2 illustrates the levels of awareness and knowledge among contractors regarding 3R practices in C&D waste management. Respondents demonstrated strong awareness of the 3R concept itself, with a mean score of 4.15, and were also highly aware of the environmental impacts of construction waste, scoring 4.14. However, while they recognized the importance of the 3R concept, the understanding of its significance in sustainable construction practices was more moderate, with a mean score of 3.30.

Familiarity with laws and regulations related to construction waste received a mean score of 3.58, indicating moderate awareness, though with some variability in responses. This is consistent with findings by Ng et al. (2015), who found that while awareness of legal requirements is increasing, many contractors still lack detailed knowledge of specific laws related to waste management.

Awareness of techniques for reducing construction waste also scored moderately at 3.42. This is further supported by a previous study which emphasizes the role of community involvement and education in enhancing the effectiveness of 3R practices (Muljaningsih, 2021). The lowest score was observed for awareness of policies and regulations promoting 3R practices, with a mean of 2.79, suggesting that respondents are less informed about specific legal frameworks or initiatives in this area. Supporting evidence from previous studies indicates that while general awareness of sustainability practices is widespread, knowledge of specific legal frameworks and regulations remains limited. For instance, Marwanti et al. (2023) found that many construction professionals recognize the environmental benefits of the 3R concept but are often unaware of the legal policies and regulations that support its implementation.

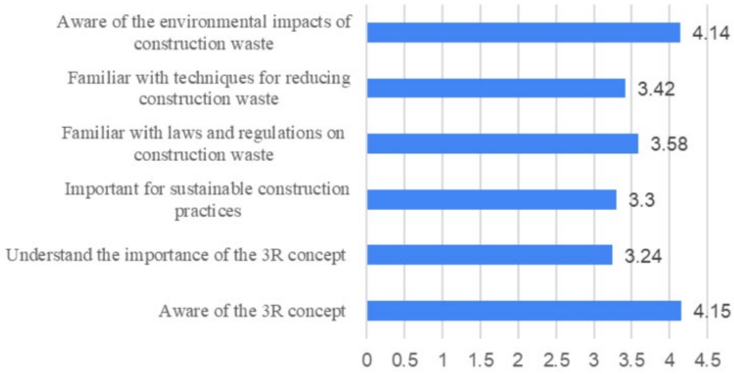

Figure 2. Awareness and Knowledge in 3R Practices.

3.3 Benefit of Implementation 3R

The findings on the adoption of the 3R principles for environmental, economic, and social benefits in the construction industry are presented and discussed in the following subsections.

3.3.1 Environment

Figure 3 shows that the respondents strongly acknowledged on the positive environmental impact of construction waste with a mean score of 4.58 wherein they believe that the 3R approach significantly reduces the environmental impact of construction waste. This reflects the reduce principle, which aims to cut down on waste and its harmful effects on the environment. Durgadevi et al. (2023) argue that identifying sustainable building materials is essential for addressing the critical challenges faced by the construction industry, including environmental and economic impacts. Their findings suggest that adopting sustainable practices, such as recycling and reusing materials, can significantly contribute to environmental protection.

A mean score of 4.36 shows that respondents recognize that 3R practice contribute to lowering pollution levels in the construction industry, particularly by reusing materials and recycling waste. The standard deviation of 0.65 indicates some variation in responses, but the general opinion is that these practices help reduce pollution.

According to Alemayehu et al. (2021), the integrated waste management strategy that promotes 3R practices provides an opportunity to utilize construction resources effectively while minimizing the amount of valuable land used for dumping. This sustainable waste management strategy allows for resource recovery and environmental protection

The statement about reducing landfill waste and promoting sustainability also scored high, with a mean of 4.39. This indicates that respondents believe the 3R approach helps minimize landfill waste and supports sustainable practices in construction. Islam et al. (2019) provide additional evidence that recycling construction waste can help preserve natural resources and reduce landfill waste. Their research indicates that the use of recycled aggregates in concrete not only minimizes waste but also contributes to a more sustainable construction process. This proactive stance is crucial, as the construction industry in Malaysia generates approximately 25,600 tonnes of construction and demolition waste daily, underscoring the need for effective waste management strategies (Zainal & Abas, 2020).

Finally, a mean score of 4.58 for the statement about protecting natural resources and ecosystems shows that respondents believe the 3R principles play an important role in preserving the environment. By using fewer raw materials, the 3R approach helps protect ecosystems from the harm caused by resource extraction.

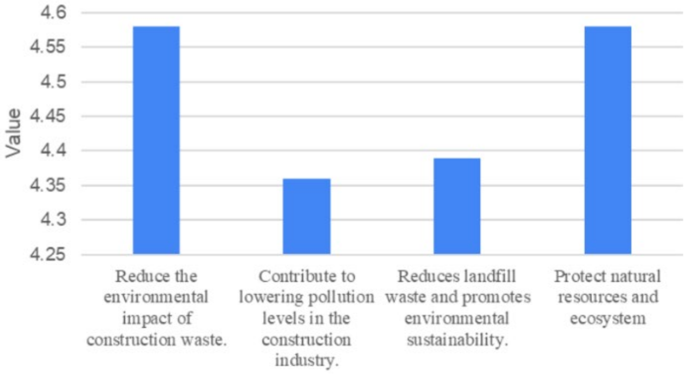

Figure 3. Benefit of 3R towards Environment.

3.3.2 Economic

Figure 4 indicates high mean score of 4.30 for improved profitability indicates that respondents believe that the adoption of 3R principles can lead to increased financial performance for construction firms. Neto et al. (2016) argue that sustainable practices, including recycling, can enhance productivity and efficiency, ultimately leading to higher profit margins. This is echoed by Marek (2024), who asserts that the circular economy, which embodies the principles of 3R, allows construction companies to optimize resource utilization and reduce costs throughout the lifecycle of projects.

The next highest mean score of 4.21 for reusing and recycling materials leading to cost savings. It is indicate that respondents recognize the value in reusing and recycling materials, which can lower the need for purchasing new resources and thus reduce material costs. Recycling of construction materials can lead to the recovery of valuable resources, further enhancing the economic viability of construction projects (Usapein & Chavalparit, 2014).
Furthermore, respondents see the wide use of 3R principles to reduce the overall cost of construction projects., as evidenced by the mean score of 4.18 for this category. Costs associated with disposal are directly reduced

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when waste is reduced through effective resource management. According to Tangwanichagapong et al.(2017), waste reduction is given priority in the hierarchy of sustainable solid waste management, which is followed by reuse and recycling. Construction organizations can lower associated expenses by concentrating on waste reduction, which will reduce the amount of materials that need to be disposed.

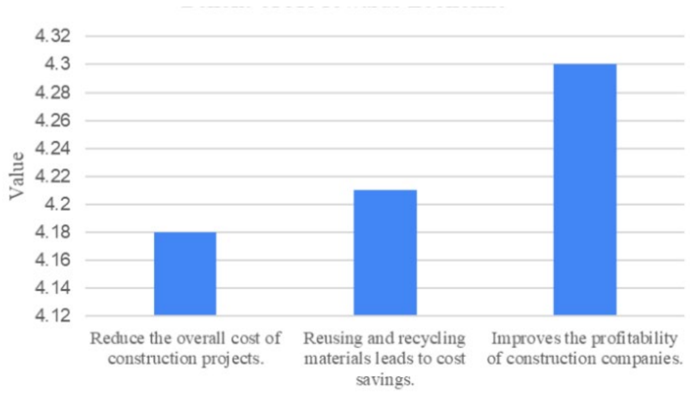

Figure 4. Benefit of 3R Towards Economic.

3.3.3 Social

Figure 5 indicates the social advantages of implementing 3R principles in the construction industry. Respondents indicated that 3R practices are seen as contributing to a positive public perception as they perceived as environmentally responsible by the public, with a mean score of 4.18. This reflects the view that adopting sustainable practices enhances a company's environmental reputation. Similarly, the 3R principles promote a culture of sustainability within the construction industry received the same mean score of 4.18, indicating that respondents believe 3R principles play a key role in fostering a broader industry-wide culture of sustainability. The integration of lean construction principles, which include waste reduction activities, is essential for achieving sustainable development goals, particularly in the construction sector (Hasan, 2024).

Furthermore, it improves the relationships with stakeholders, including government and local communities, scored 4.15, showing that respondents view 3R practices as a way to improve relationships with key stakeholders, such as governments and local communities, which can lead to better cooperation and community support for construction projects. This is consistent with Zhang (2016) research, which emphasizes that corporate social responsibility is increasingly linked to environmental performance, particularly in the context of a low-carbon economy. Companies that actively engage in sustainable practices, such as the 3Rs, are perceived as more responsible and trustworthy by the public, which can lead to improved customer loyalty and brand equity.

The statement about enhancing the company's reputation and corporate social responsibility (CSR) had a slightly lower mean of 3.94 but still indicates that respondents believe 3R principles are important for boosting a company's CSR efforts and overall reputation. There is some significant understanding of sustainability principles among industry professionals that can lead to enhanced CSR practices and a stronger commitment to environmental impact (Weerakoon, 2023). The relatively low standard deviations (0.81) suggest that there is a strong consensus among respondents regarding the positive social impacts of adopting 3R practices, demonstrating broad recognition of these benefits in terms of reputation, sustainability, and stakeholder relations.

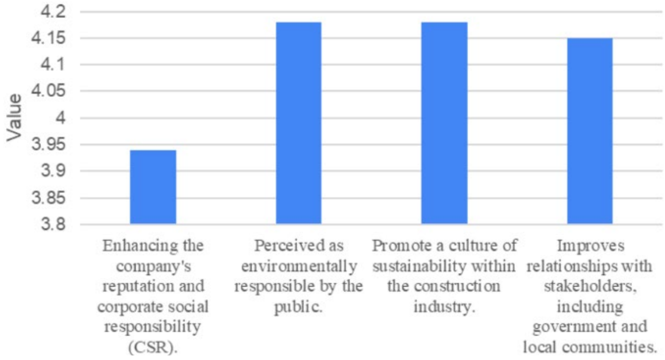

Figure 5. Benefit of 3R Towards Social.

3.4 Inferential Statistical Analysis

In addition to descriptive statistics, inferential analysis was conducted to explore deeper relationships in the dataset. A one-way ANOVA was used to compare the mean 3R awareness scores among contractors of different company sizes (Small: G1–G3, Medium: G4–G5, Large: G6–G7). The results revealed no statistically significant differences in awareness levels across the groups ($p = 0.809$), indicating that company size did not influence 3R awareness in this sample.

Furthermore, a Pearson correlation analysis was conducted to evaluate the relationship between awareness of 3R practices and perceived benefits. The analysis showed a moderate positive correlation ($r = 0.291$), although this relationship was not statistically significant ($p = 0.140$). These findings suggest that while contractors with higher awareness may perceive more benefits, the association is not strong enough to be conclusive. Due to the limited sample size, these results should be interpreted with caution.

4. Conclusion

In conclusion, the implementation of 3R principles among contractors in Malaysia remains essential yet underutilized in addressing C&D waste. This study revealed that concrete and aggregates are the primary contributors to C&D waste, followed by tiles, wood, and timber. Despite a generally high level of awareness regarding the 3R concept and the environmental impact of construction waste, contractors demonstrated only moderate familiarity with regulatory frameworks and sustainable construction practices. Moreover, it was found that the barriers to implement 3R are limited knowledge, lack of training, and insufficient waste management resources. Nevertheless, respondents recognized the significant environmental, economic, and social benefits of adopting 3R principles, including reduced landfill dependency, improved profitability, and enhanced public image. These findings highlight the need for stronger policy enforcement, targeted education, and capacity-building initiatives to support 3R integration within construction practices.

This study is not without limitations. Firstly, the sample size of 33 contractors may limit the generalizability of the findings across the broader construction industry in Malaysia. Secondly, the use of self-reported data through a questionnaire may introduce social desirability bias, where respondents provide answers they perceive as more favourable. Lastly, the statistical power of inferential analyses is constrained due to the small sample, and future studies with larger datasets are recommended to confirm these findings.

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Declaration of Conflicting Interests

All authors declare that they have no conflicts of interest.

Authors Contribution

Conceptualisation: Jalina Kassim; Methodology: Muhammad Aminullah Abd Rahim, Jalina Kassim; Validation: Siti Aisyah Ghazali; Analysis: Muhammad Aminullah Abd Rahim, Siti Aisyah Ghazali; Investigation: Muhammad Aminullah Abd Rahim; Resources: Muhammad Aminullah Abd Rahim, Azyan Zafyrah Mohd Zahid; Writing-Draft Preparation: Muhammad Aminullah Abd Rahim; Writing-Review & Editing: Jalina Kassim, Noor Fazreen Dzulkafli; Visualisation: Azyan Zafyrah Mohd Zahid, Noor Fazreen Dzulkafli; Supervision: Jalina Kassim

All authors have reviewed and approved the final version of the manuscript for publication.

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