ON-SITE WASTE SEGREGATION PRACTICE IN MALAYSIA: MRT POLICE QUARTER PROJECT

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Abstract
In Malaysia, construction waste generation increases annually, with the majority of construction waste ending up in illegal dumping sites. Indeed, construction waste can be effectively recycled if it is segregated. Waste segregation is currently enforced and mandatory in Malaysia's states that have enacted the Solid Waste and Public Cleansing Management Act 2007 (Act 672). However, construction companies are not required to practise sustainable waste management practices such as waste segregation. In Malaysia, there has been no widely published research describing the practice of on-site waste segregation. The research aims to identify the approaches to on-site waste segregation that have been implemented and the factors that influence their implementation. The data collection method used was a case study of the MRT police quarter project in Gombak, where a literature review, site survey, and interviews were conducted. It was discovered that waste segregation had become a more integral part of routine construction activities in Malaysia. Disruption to normal site activities, management effort, and project stakeholders' attitudes are the most critical factors. In contrast, cost, site space, environmental confinement, and facility demand are no longer identified as factors to consider when implementing on-site segregation. Rather than that, education is now viewed as a new potential factor in these practices. The study's findings can be used to assess the state-of-the-art and effectiveness of current on-site segregation in Malaysia and develop benchmarking strategies and best practices for on-site segregation.

Keywords: *On-site waste segregation practice; Approaches; Factors; MRT police quarter project*

INTRODUCTION

Due to the country's growing waste generation, solid waste is one of Malaysia's environmental problems. The waste originated from a variety of sources, including residential, industrial, commercial, and institutional construction, as well as new construction, renovation, and demolition. Waste generation in West Malaysia has increased by approximately 25,000 tons per day. Despite this, only 5% of waste is recycled (Mohammadinia et al., 2019). This demonstrates that waste generation on a domestic and industrial scale continues to grow year after year.

The construction industry generates 29% of solid waste in the United States of America (Mukherjee et al., 2020). According to waste statistics in the United Kingdom, the construction industry accounted for half of all waste in 2012, accounting for 50% of total waste (Department for Environment, 2015). Malaysia generates an estimated 627kg of construction waste per capita each year, according to the Construction Industry Development Board (CIDB). According to studies conducted by the Solid Waste and Public Cleansing Corporation, construction waste was expected to increase to 1.34 million metric tonnes annually by 2020. This demonstrates that the generation of construction waste has developed into a serious problem in Malaysia (Islam et al., 2019). An irresponsible contractor turned a protected tropical mangrove swamp along the Bandar Hilir coastline into a construction dump in Malacca. The estimated 30 tonnes of construction debris discovered along the Bandar Hilir coastline (Murali, 2011). The debris could wreak havoc on the mangrove swamp's eco-system. Additionally, a study conducted in the Johor district revealed that 42 percent of 46 illegal dumping sites are comprised of construction waste (Rahmat & Ibrahim, 2007). Since the construction industry generates a significant amount of waste and consumes a substantial amount of landfill space, it is critical to implement an effective waste management system.

On the other hand, Kuala Lumpur has approximately 300 hotspots for illegal dumping. According to PPSPPA, 80 percent of 300 hot spots illegally discarded construction waste contained concrete, rock, wood, steel, and other construction materials that could be reused as basic materials for roads and buildings. This demonstrates the critical nature of waste management practices such as waste minimisation, reuse, and recycling.

If construction waste is not properly managed, it will have a negative impact on the environment, society, and economy. Prior to disposal, construction waste should be reduced, reused, sorted, and recycled (Ann, Poon, Wong, Yip, & Jaillon, 2013). However, construction firms have no mandatory requirement to practice sustainable resource and waste management, and authorities continue to deal with illegal dumping (Papargyropoulou, Preece, Padfield, & Abdullah, 2011). Now, a small number of industrial sectors utilise source segregation as a method of waste minimisation in order to achieve the goal of on-site recycling (Babu, Bhanu, & Meera, 2009).

However, effective recycling is contingent upon effective segregation. In short, this research aims to enhance on-site waste segregation practises for construction waste, as the implementation of a planned recycling programme is critical for Malaysia to meet its target of 22% recycling by 2020. Thus, it is critical to ensure that on-site segregation is as effective as possible.

LITERATURE REVIEW

Construction waste segregation refers to the process of separating, sorting, or classifying waste generated at the point of generation based on its composition. In layman's terms, construction waste segregation is the practice of categorising construction waste to facilitate subsequent management. Construction waste is frequently a blend of inert and organic materials in the form of building debris, concrete, steel, wood, and a variety of site clearance materials.

Segregating construction waste is a good practise that entails separating and sorting waste generated during construction or demolition activities based on its composition and characteristics. Additionally, waste separation on-site significantly reduces construction and demolition waste (Wang et al., 2020). Several valuable components can be identified and collected for reuse or recycling through construction waste segregation. It is possible to increase reuse and recycling rates while reducing transportation and disposal costs by segregating construction waste on-site (Bao et al., 2020; Véliz et al., 2022).

However, only 5% of waste is recycled in Malaysia (Umar et al., 2021), and recycling accounts for only 11% of total solid waste produced (Kutty, 2015). Since the construction industry generates significant waste, waste management on construction sites should be emphasised and addressed. Thus, this research will examine on-site waste segregation practices, as they have the potential to increase recycling rates.

On-Site Segregation

According to the Solid Waste Management and Public Cleansing Corporation, segregation is one method for preventing and reducing construction solid waste (PPSPPA). Segregation is the process of separating recyclable and non-recyclable solid waste according to the type and composition of the waste being disposed of. Its objective is to increase the monetary value of segregated materials and to promote 3R activities on the jobsite. It contributes indirectly to the reduction of solid waste disposed of in landfills (Samsudina et al., 2021). Waste segregation is the process of categorising waste at the source. Construction and demolition waste are separated on-site. The contractor should provide and label skips for a variety of materials, including wood, bricks, metals, and hazardous waste. When mixed wastes are separated off-site, the term "sorting" is used instead of "segregation" (Lu et al., 2021).

On-Site Segregation Malaysia

Construction waste segregation is encouraged. Each construction site must have at least one location or location for separating and collecting construction waste, according to the Solid Waste Management and Public Cleansing Corporation (PPSPPA). All recyclable and reusable construction waste, including concrete, brick, wood, and metal, must be separated or divided by type and clearly labelled. Each type of construction waste can be separated or isolated based on its material composition, including land clearing debris, wood or timber, glass, plastic, metal, natural aggregates, concrete, clay, plaster, asphalt, electric and electronic material, and paper. However, if the area or location designated for waste segregation is limited and the waste generated is impractical to separate due to its volume and composition, the waste can be mixed and then separated from non-recyclable materials (Samsudina et al., 2021).

Roll-On-Roll-Off (RORO) bins are used to segregate waste and are also encouraged. However, waste can be segregated without using barrels if it is not mixed with food waste or non-recyclable waste. The size and area allotted for segregation should be adequate to contain all types of waste without spilling over. A minimum of one set of blue, brown, and orange coloured recycling bins shall be provided for the development of which has operational offices near the construction site to facilitate the separation of recyclable materials such as bottles, glass, plastic, paper, and aluminium cans (Samsudina et al., 2021). According to the general compliance statement in the Construction Waste Management Plan (CWMP), construction waste must be classified into at least two categories: those that can be reused and recycled and those that must be disposed of. Segregation of waste for concrete, wood, and steel is required for those that can be reused and recycled. Meanwhile, residual waste generated on-site, such as food waste from the office, workers' quarters, and canteen, is not permitted to be mixed with construction solid waste bins (Samsudina et al., 2021).

To summarise, different countries implemented various on-site waste segregation methods for construction waste. Despite studies providing context for understanding waste segregation practises in Malaysia, no widely published research has been conducted.

On-Site Segregation in Hong Kong

Construction waste is classified in Hong Kong as inert or non-inert materials. Sand, bricks, and concrete are considered inert materials, whereas bamboo, plastics, glass, wood, paper, vegetation, and other organic materials are considered non-inert. By separating inert waste from non-inert waste, the inert portion of construction waste can be accepted by public fill reception facilities and deposited in general filling areas for land reclamation, while the non-inert portion can be disposed of in landfills as solid waste (Wu et al., 2019; Lu et al., 2021; Chen et al., 2021).

On-site waste segregation can be accomplished in three ways. Alternatively, each building block could have two refuse chutes, one for inert waste and another for non-inert waste. Separate refuse chutes will collect inert and non-inert waste, which will be emptied and disposed of separately at public filling stations and landfills. The second option is for each building block to have a single refuse chute that is dedicated to a single type of waste, inert or non-inert. On a regular basis, such as every one or two days, separate inert and non-inert waste will be collected and removed. The third option is to have one refuse chute per block, with waste being manually sorted in a ground-level temporary storage pit. The sorted waste will be removed separately (Lu et al., 2021).

According to Lu et al. (2021)'s survey, the most effective method of on-site segregation in Hong Kong appears to be alternative one, which outperforms the other two alternatives. Alternative one is preferred for large construction projects with sufficient site space to accommodate two refuse chutes. Alternative two should be used for small projects that do not require the use of multiple debris chutes, whereas alternative three should be used as a last resort unless minimal interference with site activities becomes prevalent and impairs normal site operations.

In Hong Kong, a Waste Disposal Charging Scheme (WDCS) was implemented to promote on-site construction waste segregation. Producers of construction waste are required to pay the applicable fees for the disposal of various types of construction waste under the scheme. Construction waste containing less than 50% by weight of inert substances will be charged HK$125 when disposed of in landfills, HK$100 when disposed of in off-site segregation facilities, and only HK$27 when disposed of in public fill reception facilities (Wu et al., 2019).

On-site segregation, on the other hand, is not yet a widely used measure in the construction industry for a variety of reasons, including the need for skilled workers, available site space, cost, management effort, and investment in necessary equipment. Additionally, segregation work may cause delays in the normal course of construction (Chen et al., 2021). As a result, it's unsurprising that approximately 70% of contractors refuse to conduct on-site waste segregation unless specifically requested in the contract (Lu et al., 2021).

On-Site Segregation in China

Construction waste is classified in China in two ways: by material type and by construction stage. Construction waste is classified into two categories based on the inert and non-inert nature of the materials: inert and non-inert. According to the stage of construction, construction waste is classified into three categories: structure waste, finishing waste, and demolishing waste. Structure waste includes concrete fragments, steel reinforcement, abandoned timber plates and pieces, and plastic packaging, whereas finishing waste includes excess cement mortars, finishing material packaging, and broken raw materials such as mosaic and tiles. Waste demolition is always method dependent and encompasses a diverse range of waste types and their status, whether mixed or not (Tamiz et al., 2021).

On-site waste segregation can be accomplished in three ways. Alternatively, only those construction wastes with current economic value, such as steel reinforcement, could be classified. The remainder of the construction waste, or mixed construction waste, is collected in a fixed location, typically on the ground floor, and cleaned up on a weekly or ten-day basis. The second option is to separate waste into distinct substances or materials and to create multiple pits on the ground level for each type of waste to be removed separately over time, such as every week or ten days. The third option is to segregate the poisonous waste in accordance with the law's requirements, separating the waste that generates economic value from the toxic waste. It then collects and separates the remainder of the construction wastes or mixed construction wastes over a period of time, such as every week or ten days (Tamiz et al., 2021).

According to Bao et al. (2020), the most effective method of on-site segregation in China appears to be the alternative method, which outperforms the other two alternatives. Alternative one is preferred for large construction projects with adequate site space for collection facilities, whereas alternative three should be used as a last resort unless the government specifies the toxic waste. According to the survey findings, approximately 90% of contractors are hesitant to conduct on-site construction waste segregation unless the contract specifically requires it. Even with a relatively high waste tax of between 2 and 5 yuan per tonne, the construction industry has little incentive to implement on-site segregation.

Factors Affecting On-Site Segregation

Cost is one factor that affects on-site segregation. Waste must be segregated on-site, stored, and transported to a processing centre to begin the recycling process. Therefore, the contractor's bid must include the increased handling and processing fees (Blaisi, 2019). Thus, the increased cost acts as a deterrent in this instance.

Separating each material prior to recycling necessitates increased waste handling, which results in additional work for the contractor (Dolan et al., 1999). This operation is not only time consuming, but it also delays the work indirectly, as contractors must complete numerous steps. Additionally, the attitude of contractors toward segregation is a factor to consider.

The other factor is site space availability. There may be insufficient space for waste storage, separate waste containers, and haulier access to the debris on some construction sites. Much waste, such as wood and gypsum, takes up much space because these materials are frequently transported in large pieces (Dolan et al., 1999). Once the waste has been separated, it must be stored on-site for a specified period to reach the required level for transport to the processing centre.

Following that, a dearth of rehabilitation facilities contributes to the problem. Even if contractors desired to separate debris for recycling, they are unable to do so due to a lack of waste recovery facilities, especially for small-scale construction and demolition projects such as office remodels or small building construction (Dolan et al., 1999).

Poon et al. (2001) identified seven possible factors affecting on-site waste segregation in Hong Kong. These factors include the availability of site space, management effort, labour, and cost, the impact on normal site activities, waste sortability, the market for recyclables and environmental benefits, and project stakeholder attitudes toward implementing on-site waste segregation. In Hong Kong, the primary factors affecting on-site waste segregation are available site space, labour and cost, management effort, and disruption of normal site activities. In comparison, minor factors include waste sortability, the market for recyclables, the associated environmental benefit, and project stakeholder attitudes toward on-site waste segregation.

According to Ghaffar et al. (2020), the most critical factors affecting on-site waste segregation are available site space, management effort, and project stakeholders' attitudes toward implementing on-site waste segregation, whereas labour and cost are no longer major concerns when implementing on-site segregation. This is because waste is separated immediately after construction waste is generated, and the project does not require specialised labour. On the other hand, waste sortability, the recycling market, and environmental benefits are becoming increasingly important in implementing on-site waste segregation, as recycling traders are insufficient, the Hong Kong construction market is contracting, and environmental considerations are becoming more important in construction projects.

According to a survey conducted by Bao et al. (2020), the primary factors influencing on-site segregation of construction waste in China are cost, impact on construction duration, site space availability, disruption of normal site activities, market for recyclables, environmental constraint, management effort, waste sortability, labour demand, and facility demand. The term "site space availability" refers to the amount of original site space, the layout, and the space available for waste management, particularly poisonous waste, whereas "waste sortability" refers to the ease with which wastes can be separated. Contractors' costs will increase, and project completion times will be extended due to on-site waste segregation. Additionally, the size of the recycling market affects the incentives for waste segregation. Implementing on-site waste segregation affects normal site activities by interfering with and constraining them by the surrounding environment, which includes noise control, dust control, roads, and time for waste transportation. On-site segregation is impacted by labour requirements, necessitating additional labour to complete the task. Enhancing current waste management practices is critical for implementing on-site segregation effectively (Bao et al., 2020).

Another survey, however, identified six critical success factors for adequate on-site waste segregation: manpower, a market for recycled materials, waste sortability, improved management, site space, and construction waste segregation equipment (Huang et al., 2021).

According to prior research, manpower is critical in determining the effectiveness of waste management in construction (Wu et al., 2019; Kabirifar et al., 2020).

Contractors cannot profit from recycling materials because there is no market for them, leaving contractors with few incentives to promote on-site segregation. Because Chinese environmental regulations prohibit the reuse, recycling, or landfilling of contaminated waste materials, respondents reported difficulty separating waste materials from the mixture to ensure the remainder was suitable for reuse and recycling. Compared to some western countries, China's construction industry has a lower management level (Bao et al., 2020). In Shenzhen, no space has been set aside for on-site segregation of construction waste, and on-site segregation is primarily manual.

To summarise, several factors influence on-site segregation, including available site space, labour and cost, management effort, interference with normal activities, waste sortability, market for recyclables and environmental benefit, and project stakeholder attitudes. By examining the factors affecting on-site segregation in Table 3, we discovered that a common barrier exists while the factors affecting on-site segregation implementation vary by country. On-site segregation is influenced by site space availability and cost in Malaysia, Hong Kong, and China. It is critical for both researchers and industry practitioners to understand the factors that influence on-site segregation in order to conduct effective on-site segregation. Additionally, more improvements are needed by identifying the factors that influence on-site segregation.

RESEARCH METHODOLOGY

Qualitative research is data collection, analysis, and report writing. The qualitative method was chosen because the research question sought to elucidate the reality of the information retrieved and transferred, rather than to examine people's beliefs, understandings, opinions, views, and perceptions (Bresler, 2021). The second reason was that the question should be answered from a broad perspective that can yield findings about the phenomenon, rather than from specific and detailed findings from multiple studies.

Participating in a real-world construction site environment is critical for determining the on-site segregation techniques used on the MRT police quarter project. This study aimed to increase awareness of the current reality of on-site segregation practises in the MRT police quarter. The instruments used to collect data for this study were observations, interviews, and recording. Following a review of the research objectives and purpose, it was determined that the best method for this study would be participant observation. On the other hand, semi-structured interviews were conducted with the environmental officer, site supervisor, and project manager to ascertain their familiarity with on-site segregation practises.

The research population, in this case, is the construction company that has implemented on-site waste segregation in new construction projects, whereas the research samples are contractors that have implemented on-site waste segregation in new construction projects. On the other hand, the interview sample included an environmental officer, a site supervisor, and a project manager who practised on-site segregation. The sample chosen satisfied the research objectives and title by having subsets of the variables "Construction Company" and "on-site segregation."

Additionally, content analysis was used to analyse the data for this study. Content analysis is a systematic technique for condensing large amounts of text into a smaller number of content categories using explicit coding rules (Joung & Byun, 2021). Content analysis enables the systematic identification of large quantities of textual data properties. The analysis focused on determining the state-of-the-art on-site segregation and the relative importance of factors affecting on-site segregation implementation.

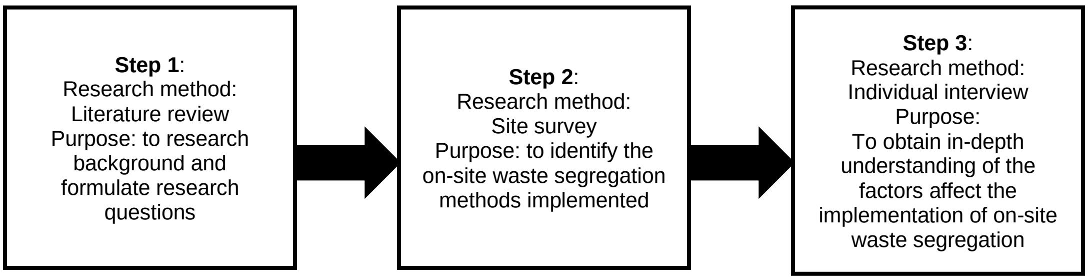

Figure 1. The Research Methodology Process Adopted in This Research

FINDINGS AND DISCUSSIONS

On 31 March 2016, Mass Rapid Transit Corporation Sdn. Bhd. (MRT Corp.) awarded WCT a contract worth RM133.93 million to redevelop the existing police quarters (Block 10 & 11) in Taman Keramat, Bandar Ulu Kelang, Selangor. This is a residential (government) project that is included in one of the MRT Line 2 packages. WCT will design and construct a 20-story police quarters that will consist of 300 Police Quarters Class F units, a five-story podium car park, and amenities such as a multipurpose hall, shops, and surau. The project began in April 2016 and is scheduled to conclude in August 2018. WCT will also perform external and infrastructure work during the 28-month project, including landscape, pedestrian linkages, road and road signage, security fencing, and earthwork.

Respondents Backgrounds

Table 1 showed the respondents' background involved in the survey through interviews conducted by the researchers. The respondents' perspective is from several parties, including environmental officer, site supervisor, and project manager.

Table 1. Background of Respondents

No. of Respondents	Position	Working Experience
Respondent 1	Environmental Officer	Almost 3 years
Respondent 2	Site Supervisor	1.5 Years
Respondent 3	Project Manager	2 Years

Approaches of Implementation of On-Site Segregation

According to respondent 1, there are numerous stages involved in the approval of a WMP. To begin, a Waste Management Plan (WMP) or Environmental Management Plan (EMP) must be developed prior to initiating on-site segregation. The WMP/EMP must then be revised as necessary and approved prior to being sent to the client, such as a project partner.

Client will review and then submit for approval to MRT. Following that, the MRT is returned to the authority for approval.

> *"We got the waste management plan. I am doing the WMP, and it is compulsory to have the WMP that need to be checked first and then approved. After that, our EMP will go to the client; the client will review. After approval, it will be sent to another client and then sent back to the MRT; after approved, send it back to the authority to approve, many stages, it is challenging." (Respondent 1)*

On-site segregation will be implemented largely following the plan. Segregation of materials will occur according to construction waste, household waste, scrap metal, chemical waste, and scheduled waste. Workers will carry out waste segregation once construction waste is generated to avoid mixing waste materials. The waste will be stored in a store or bins on the site, and general workers will perform housekeeping once a week or every two or three days. Waste will be disposed of monthly.

> *"…the materials we will segregate based on the construction waste, the domestic waste, scrap metal, chemical waste and scheduled waste. We give the construction and domestic waste to the approved contractor by our authority and local authority. And some of the waste we will recycle back like scrap metal." (Respondent 1)*

> *"…Approved dumpsite for this project, not for the demolishing is Sungai Kertas at Gombak and also the domestic waste is Alam Flora [Sdn Bhd]. We have the general workers, and they will do the housekeeping every week or every two or three days. They will segregate, and I will monitor and analyse. So, we will dispose every month, but we will locate at the store here, every week we do housekeeping and make some segregation on plastic, [waste that] can recycle. We got the 3R bins for recycling." (Respondent 1)*

According to respondent 1, the MRT police quarters project will utilise RORO bins for on-site segregation. RORO bins are available in two colours: blue and green. The larger Blue RORO bins are used for construction waste, while the smaller Blue RORO bins are used for household waste. Green RORO bins are used to collect scrap metal.

> *"Yes, currently is two types. Blue and Green. The large size is for construction [waste] for the Blue bin, and the small size is for domestic waste. The Green bin is for scrap metal. But for the scrap metal, we will send it back to our WCT store then recycle back." (Respondent 1)*

Besides that, the MRT police quarter project also adopts the 3R system in the site. There are three types of recycling bins for which Green, Orange and Blue colours are used for different categories of domestic waste. Green recycling bins are for glass; Orange recycling bins are for aluminium, whereas Blue recycling bins are for paper.

> *"…currently this site practices the recycle, the 3R [system]." (Respondent 1)*

Respondent 1 claimed that MRT police quarter project did not adopt the national colour coding scheme to segregate different categories of construction waste because they are not familiar with these practices, and DOE did not focus on this coding scheme. Based on respondent 1, the national colour coding scheme is an excellent method to adopt in the future, but Malaysia is not ready to embrace this scheme as Malaysia is having difficulty in waste segregation practice.

> *"No. not so familiar. Because we do not have the requirement as strict as this, it depends on the waste bin sizes, not the colour. Maybe this one is practice for the segregation centre or also the manufacturing. Because construction is not focusing too much on that, also the DOE not stress on that." (Respondent 1)*

> *"…Our level now, they are not focusing on what types of your bins, to educate the people to segregate the waste already difficult. I think Malaysia is not ready for that. But we can propose to implement it." (Respondent 1)*

Factors Affect The Implementation of On-Site Segregation

According to the literature review, various factors influence the implementation of on-site segregation. Based on a literature review, the researcher identified 11 distinct factors that will affect the performance of on-site segregation. Cost, impact on construction duration, site space availability, disruption to normal site activities, the market for recyclables, environmental constraint, management effort, waste sortability, labour demand, facility demand, and project stakeholder attitudes are the factors. This section tabulates and analyses respondents' feedback on the factors identified during the literature review and their actual impact on on-site segregation in the MRT police quarter project.

Table 2. Factors Affect The Implementation of On-Site Segregation in MRT Police Quarter Project

Factors	R1	R2	R3
Cost			
Impacting to construction duration		√	
Availability of site space			
Disruption to normal site	√	√	√
market for recyclables		√	√
Confining by the environment			
Management effort	√	√	√
Waste sortability			√
Labour demanding		√	
Facility demanding			
Project stakeholder's attitudes	√	√	√
Others	Level of Education	-	-

Several factors were identified as potential constraints on on-site segregation practises in other countries' construction projects, including cost, impact on construction duration, availability of site space, disruption of normal site activities, the market for recyclables, environmental constraints, management effort, waste sortability, labour demand, facility demand, and project stakeholder attitudes.

According to the survey findings, seven factors contributed to on-site segregation in the MRT police quarter project. These factors included the impact on construction duration, disruption of normal site activities, the market for recyclables, management effort, waste sortability, labour demand, and project stakeholder attitudes. The factors identified in this study were identical to those identified in the literature review. However, four factors affecting the implementation of on-site segregation in the MRT police quarter project are not identified: cost, site space availability, environmental constraint, and facility demand. Meanwhile, education level has emerged as a new factor affecting the implementation of on-site segregation in the MRT police quarter project, which was not previously considered in the literature review.

Table 3. The Relative Importance of Factors Affecting On-Site Segregation Practices in MRT Police Quarter Project

Factors	R1	R2	R3
Major Factors			
Disruption to normal site	√	√	√
Management effort	√	√	√
Project stakeholder's attitudes	√	√	√
Middle factors			
Market for recyclables		√	√
Minor Factors			
Impacting to construction duration		√	
Waste sortability			√
Labour demanding		√	
New factor			
Level of education	√		

According to Table 3, all interviewees in this study believed that disruption to normal site activities was the primary factor affecting on-site segregation practises in the MRT police quarter project. Bao et al. (2020) stated that disruption to normal site activities was only one of the factors influencing on-site segregation practices. However, as the researcher discovered in his case study, all interviewees argued that these factors are critical in that implementing on-site construction waste segregation may reduce worker productivity and cause disorder in other activities. Due to the limited site space in the case studied, allocating dustbins for waste segregation is particularly challenging and may cause disruption to normal site activities by blocking access for workers or site personnel. This is likely to reduce worker productivity and cause interruptions in the construction process, obstructing the normal flow of operations. Thus, disruption of normal site operations is now viewed as a critical aspect of these practices.

The role of management in reducing construction waste generation has been extensively researched and highlighted in previous studies (Wu et al., 2019). The findings of this study indicate that management effort is a significant factor influencing the implementation of on-site waste segregation in the MRT police quarter project. All interviewees agreed that management, particularly top management, was critical in facilitating the implementation of on-site waste segregation. The top management support is required, as an effective management effort results in adequate on-site segregation practices. Additionally, several interviewees stated that management effort is critical for site team enforcement. The management team must compel the site team to adapt to the on-site segregation practice to ensure that all personnel are aware of the implementation's benefits and consequences. This is reinforced by Wu et al. (2019), who stated that strengthening management capacity for construction waste management, including on-site segregation of construction waste, is a lengthy process that requires the collaboration of managerial and operational staff. Thus, coordination among the various practitioners involved is critical to maximising the effectiveness of on-site waste segregation. This, in turn, necessitates improved construction management.

By comparing the findings from the case studies to those from Bao et al. (2020) and Ghaffar et al. (2020), project stakeholders' attitudes toward implementing on-site segregation are consistently viewed as the most critical determinants of on-site segregation. Managing construction waste places additional demands on the environmental officer and the site management team. Senior management must empower workers and site managers to achieve successful waste management. Both practitioners and researchers are now aware that the expansion of all stakeholders' roles is crucial to ensure the effectiveness of on-site segregation implementation. Stakeholders have varying stakes in a system and can positively or negatively impact it (Bao et al., 2020). The case study interviewees endorsed this concept. The following quote from an interviewee provides a reasonable justification for this: "the success of on-site segregation is contingent upon the project stakeholders" attitude. As previously stated, project stakeholders are critical in implementing waste segregation.

The market's growth for recycled materials is ranked as the second most important factor affecting the effectiveness of on-site waste separation in the MRT police quarter project. During interviews, most respondents asserted that the market for recycled material is quite limited. Only a few recyclable materials are readily available in the market, for example, plastic, paper, steel, and metal. A dearth of markets for recycled materials was a significant factor in the slow adoption of on-site segregation practices. Without such a market for recycled materials, construction industrialists would have little incentive to promote on-site segregation practices.

> *"Market for recycling such as construction waste is less. So, we just appoint sub-contractor to handle this waste." (Respondent 3)*

This is because the market for recycling construction waste is smaller. This statement is backed up by Bao et al. (2020), who stated that total recycling equipment market for construction waste is only 11%. This example appears to shed light on the construction waste recycling market's scarcity. By cultivating a market for recycled construction materials, it is hoped that construction industrialists will take the lead in implementing on-site segregation if alternate markets for each recyclable material are readily available, thereby encouraging on-site segregation implementation.

According to Table 3, affecting construction duration has a negligible effect on on-site segregation practises in the MRT police quarter project. According to Yu et al. (2020), additional time will be required for construction waste segregation activities, resulting in project delays.

> *"Sometimes, if poor planning and no control over the on-site segregation, it might create impact to the construction duration." (Respondent 2)*

Inadequate planning may affect the construction duration, causing the project to be delayed. This is most likely the result of poor planning and scheduling tasks in an illogical order or sequence. For instance, placing dustbins at corners that are inconveniently located to the site container—additionally, attempting to adhere to that schedule without considering other factors that may cause delays may lose control over the project, affecting the construction duration. Although only one interviewee mentioned this factor, the supporting statement from the literature review and the interviewee's response indicates that impacting construction duration is also a significant factor affecting the operation of on-site segregation practice. Additionally, it is a factor to consider when implementing on-site segregation. However, the acceptance of time spent on waste management should not be viewed as a time-consuming inconvenience but as a critical necessity.

By comparing the results from the case studies to those reported by Bao et al. (2020), it is clear that waste sortability's influence on on-site segregation practices is consistently regarded as minor. This is consistent with the findings of Bao et al. (2020), who concluded that it was difficult to separate waste materials once they had been mixed. The respondent asserted that separating specific waste from the mixture is difficult.

> *"Sometimes, it is quite difficult to separate out contaminated waste from the mixture, and some labours will make mistakes on this task. So monitoring is always needed." (Respondent 3)*

Since waste segregation is performed by general workers from foreign countries such as Bangladesh, it is undoubtedly challenging to separate waste from the mixture. This partially explains the difficulty associated with waste sortability in the construction industry. Thus, providing appropriate education to general workers regarding the proper separation of specific construction waste may be a good solution for the effective implementation of on-site segregation.

Interestingly, the case studies revealed that labour demand is no longer a primary consideration when conducting on-site segregation practices. This is in stark contrast to the findings of Poon et al. (2001), who discovered that labour demand is the essential factor in determining the construction waste segregation scheme among various alternatives.

> *"Not really. We have the general workers, they will do the housekeeping every week or every two or three days. They will segregate, and I will monitor and analysis." (Respondent 1)*

As reported above, it is clearly justified that enough general workers are to carry out housekeeping and segregation. In this sense, labour demand is the most negligible decisive factor in affecting on-site segregation mainly because general workers do waste segregation in the project and no specialised labour is required and assigned for this task. This practice involved all team members, whether educated or non-educated. It is not surprising to see that education level is perceived as a new factor affecting the effective implementation of on-site segregation of construction waste in MRT police quarter project. This reflects a fundamental impediment to on-site segregation of construction waste, which echoes with an interviewee claiming that education level is a critical factor affecting the implementation of on-site segregation.

In construction, there are different levels of education. The higher level of education people may refer to engineer, contractor, environment officer, site supervisor and others whereas the lower level of education people may refer to labours. Since the education level is different, the knowledge attained is also additional. The survey results revealed that even the engineer currently does not know how to segregate, although they know the environmental aspect. So, it is quite difficult for non-educated people such as general workers and labours who have zero knowledge of environmental knowledge to carry out the on-site segregation practice. Thus, it should be noted that education on environmental aspects such as the implementation of on-site segregation practices for general workers and labours is needed for effective implementation of on-site segregation practices.

CONCLUSION AND RECOMMENDATIONS

The findings of this study paint a clear picture of how on-site segregation should be implemented. The approaches used to implement on-site segregation in the MRT police quarter project provide a more detailed understanding of current on-site waste segregation practices in real-world projects. The factors affecting on-site segregation implementation in the MRT police quarter project aid in identifying the obstacles on-site waste segregation practice. Due to the lack of widely published research describing on-site waste segregation practises in the Malaysian construction industry, this study is expected to contribute to future researchers conducting additional research on this field topic. Thus, the contribution of this study signifies that the improvement of on-site segregation practices is crucial and should continue to enhance and applied in future construction projects in Malaysia. Finally, we hope that the research findings will benefit the Malaysian construction industry by facilitating the implementation of on-site segregation practices.

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REFERENCES

Bao, Z., Lee, W. M., & Lu, W. (2020). Implementing on-site construction waste recycling in Hong Kong: Barriers and facilitators. Science of The Total Environment, 747, 141091.

Blaisi, N. I. (2019). Construction and demolition waste management in Saudi Arabia: Current practice and roadmap for sustainable management. Journal of cleaner production, 221, 167-175.

Bresler, L. (2021). Qualitative paradigms in music education research. Visions of Research in Music Education, 16(1), 93.

Chen, J., Lu, W., & Xue, F. (2021). "Looking beneath the surface": A visual-physical feature hybrid approach for unattended gauging of construction waste composition. Journal of Environmental Management, 286, 112233.

Ghaffar, S. H., Burman, M., & Braimah, N. (2020). Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery. Journal of cleaner production, 244, 118710.

Huang, Z., Ma, M., Tam, V. W., & Lang, H. (2021, March). Critical success factors for developing construction and demolition waste management in China. In Proceedings of the Institution of Civil Engineers-Engineering Sustainability (Vol. 40, No. XXXX, pp. 1-11). Thomas Telford Ltd.

Islam, R., Nazifa, T. H., Yuniarto, A., Uddin, A. S., Salmiati, S., & Shahid, S. (2019). An empirical study of construction and demolition waste generation and implication of recycling. Waste Management, 95, 10-21.

Joung, E., & Byun, J. (2021). Content analysis of digital mathematics games based on the NCTM Content and Process Standards: An exploratory study. School Science and Mathematics, 121(3), 127-142.

Kabirifar, K., Mojtahedi, M., Wang, C., & Tam, V. W. (2020). Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste management: A review. Journal of Cleaner Production, 263, 121265.

Kutty, R. R. (2015). Work together to recycle, The Star. Retrieved from http://www.thestar.com.my/metro/views/2015/04/14/work-together-to-recyclealarming statistics-a-wakeup-call-for-better-waste-management/.

Lu, W., Yuan, L., & Xue, F. (2021). Investigating the bulk density of construction waste: A big data-driven approach. Resources, Conservation and Recycling, 169, 105480.

Mohammadinia, A., Wong, Y. C., Arulrajah, A., & Horpibulsuk, S. (2019). Strength evaluation of utilizing recycled plastic waste and recycled crushed glass in concrete footpaths. Construction and Building Materials, 197, 489-496.

Mukherjee, C., Denney, J., Mbonimpa, E. G., Slagley, J., & Bhowmik, R. (2020). A review on municipal solid waste-to-energy trends in the USA. Renewable and Sustainable Energy Reviews, 119, 109512.

Samsudina, K. S., Mat, S., Razalia, H., Basrib, N. E. A., & Aini, Z. (2021). Review on Awareness and Practices in Malaysia Land-Use Planning on Municipal Solid Waste Management. Jurnal Kejuruteraan, 33(3), 503-515.

Umar, U. A., Shafiq, N., & Ahmad, F. A. (2021). A case study on the effective implementation of the reuse and recycling of construction & demolition waste management practices in Malaysia. Ain Shams Engineering Journal, 12(1), 283-291.

Véliz, K. D., Ramírez-Rodríguez, G., & Ossio, F. (2022). Willingness to pay for construction and demolition waste from buildings in Chile. Waste Management, 137, 222-230.

Wu, Z., Ann, T. W., & Poon, C. S. (2019). An off-site snapshot methodology for estimating building construction waste composition-a case study of Hong Kong. Environmental Impact Assessment Review, 77, 128-135.

Wang, Z., Li, H., & Yang, X. (2020). Vision-based robotic system for on-site construction and demolition waste sorting and recycling. Journal of Building Engineering, 32, 101769.

Yu, B., Wang, J., Li, J., Lu, W., Li, C. Z., & Xu, X. (2020). Quantifying the potential of recycling demolition waste generated from urban renewal: A case study in Shenzhen, China. Journal of Cleaner Production, 247, 119127.