Pertanika J. Sci. & Technol. 30 (2): 1363 - 1380 (2022)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Review Article

A Systematic Literature Review (SLR) on the Strategies of Managing Waste in Relative to Green Building (GB) Practice

Puteri Sidrotul Nabihah Saarani*, Asniza Hamimi Abdul Tharim, Asmalia Che Ahmad and Rozana Mohamed Salleh

Department of Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Perak Branch, 32610 UiTM, Seri Iskandar, Perak, Malaysia

ABSTRACT

The construction industry is very important for a developing country, but the rapid development has caused an excessive generalization of solid construction and demolition (C&D) waste. Many solutions have been discovered to prevent C&D waste from destroying the environment—one of them being the implementation of 'green building' (GB) that focuses on construction activity that is best able to minimize pollution. Therefore, the strategies employed in waste management are becoming vital, especially in GB, as they must be able to cope with future sustainability developments. Hence, this paper attempts to review the strategies for waste management relative to green building practices. The systematic literature review (SLR) method was employed to achieve the aims and objectives of this research paper. Findings from the SLR indicate that construction waste can be minimized during the planning or design stage, the managing or construction period as well as demolition phase. C&D waste can be controlled by selecting the prefabricated materials, good site management skills that help with on-site coordination, communication, just-in-time (JIT) ordering and receiving of materials, training of workers that can be achieved by reducing C&D waste. Furthermore, the reusing and recycling of C&D waste during the construction period can be the strategies in managing waste. Besides that, in the aspect of GB practice, waste management can be controlled by applying sustainable operation, resources management, and environmental health in every decision-making throughout the development lifecycle.

Keywords: Green building, strategies for managing waste, sustainable building, systematic literature review (SLR), waste management

ARTICLE INFO

Article history:
Received: 24 May 2021
Accepted: 09 August 2021
Published: 28 March 2022

DOI: https://doi.org/10.47836/pjst.30.2.28

E-mail addresses:
puterisidrotul@uitm.edu.my (Puteri Sidrotul Nabihah Saarani)
asniz286@uitm.edu.my (Asniza Hamimi Abdul Tharim)
asmalia809@uitm.edu.my (Asmalia Che Ahmad)
rozanasalleh@uitm.edu.my (Rozana Mohamed Salleh)
* Corresponding author

ISSN: 0128-7680
e-ISSN: 2231-8526

INTRODUCTION

The construction industry is considered the most important industry in many countries since it stimulates the national economy and generates job opportunities. According to Mohammed et al. (2020), the industry currently contributes to 4% of Malaysia's total gross development product (GDP) and is expected to contribute 5.5% of the total GDP by the end of 2020. However, on the downside, the construction industry is also one of the largest contributors to construction and demolition (C&D) waste. According to Nawi et al. (2018), although the construction industry is a major contributor to the economy, if construction activities are not well managed, they have a negative impact on the environment, economy, and society. Furthermore, the construction industry is also the main contributor to pollution in the environment, which has led to it becoming a global issue. Therefore, it is critical to control each phase of construction, from building design to demolition, and green building (GB) plays an essential part in accomplishing the goal of sustainable development in terms of environmental protection and people's well-being.

Schafiei et al. (2017) and Akdağ and Beldek (2017) add that the construction sector has the biggest environmental impact of all industries and that it also creates pollution that has a direct impact on our lives. As it is harmful to our health and poses a significant threat to future generations, one of the strategies involved in managing its impact is to adopt green building designs and set standards to reduce energy consumption in construction activities. According to both papers, the concept of green building was introduced to achieve sustainable development goals in the construction industry. C&D waste is a prevalent issue that needs to be addressed since the construction industry is considered a leading contributor to solid waste generation. Liyanage et al. (2019) and Shafiei et al. (2017) mention that GB is highly efficient in managing waste compared to non-GB practices. The objective of the paper is to investigate the strategies of managing waste relative to GB practices. An SLR was conducted to produce this paper.

LITERATURE REVIEW

Construction and Demolition (C&D) Waste

C&D waste can be defined as solid waste generated from the construction and renovation of buildings, civil and infrastructure construction work; site clearance; and other demolition activities. The basic construction waste produced includes brick, concrete, asphalt, glass, wood, plastic, and metal (Ng et al., 2017). According to Liyanage et al. (2019), the generation of C&D waste has a negative impact on the environment, basic health, economy, and society and creates undesirable landfills. This situation has grown more critical over the years, as C&D waste has kept increasing year by year. For example, as per the report of Hasmori et al. (2020), Malaysia has up to 289 landfills, which also include dumpsites,

but due to protests from the nearby residents and having reached full capacity, 113 of those landfills are no longer in operation.

Hasmori et al. (2020) also mention that expanding awareness of the environmental impact of C&D waste has driven proper waste management to be implemented as an imperative approach in construction project management. Therefore, waste management is crucial in construction projects to coordinate sustainable development goals.

As the levels of construction waste increase, many efforts have been undertaken by the Malaysian government to attempt to minimize the generation of waste, one of which is the application of sustainable construction. Unfortunately, many contractors mismanage construction waste; therefore, several methods have been introduced to utilize construction resources to reduce the quantity of waste produced while simultaneously recycling and reusing such waste.

Green Building

Schafiei et al. (2017), Dwaikat and Ali (2018), and Akdağ and Beldek (2017) define 'green building' as a building's design, construction, operation, maintenance, and demolition. It works by enhancing the efficiency of resources consumed in terms of energy, water, and materials, while also lowering the building's impact on human health and the environment throughout its lifecycle. The above authors mention that GB represents the response of the construction industry to sustainability requirements, and, as such, energy and water efficiency; reduction in the consumption of natural resources; and improved health and environmental impact are all key characteristics of a green building. Its implementation should be planned and operated to minimize the building's total impact on its surroundings.

Figure 1 shows that the GB development phase starts from the initial stage of construction to the demolition of the building. The professional parties involved are required to assess the building's performance using green building rating tools before moving on to the operational and maintenance phases to ensure that the building meets the GB standard (Latief et al., 2017).

In other words, GB can be interpreted as an initiative to manage C&D waste throughout a building's lifecycle. Based on the actual data recorded, Dwaikat and Ali (2018) state that the investigated green buildings saved around 71.1% of energy compared to the industrial baseline. From a lifecycle perspective, the green building saves around 5756 kW h/m2, which corresponds to $2, 796, 045 at a 1% average annual increase in energy price; and it saves more than fourfold at a 5% average annual increase in energy price, reaching around $12, 107, 060. Aghili et al. (2016) elaborate on five practices of GB management, as depicted in Table 1.

Therefore, to fulfill the aims of GB, proper waste management strategies should be planned concurrently with the GB practice.

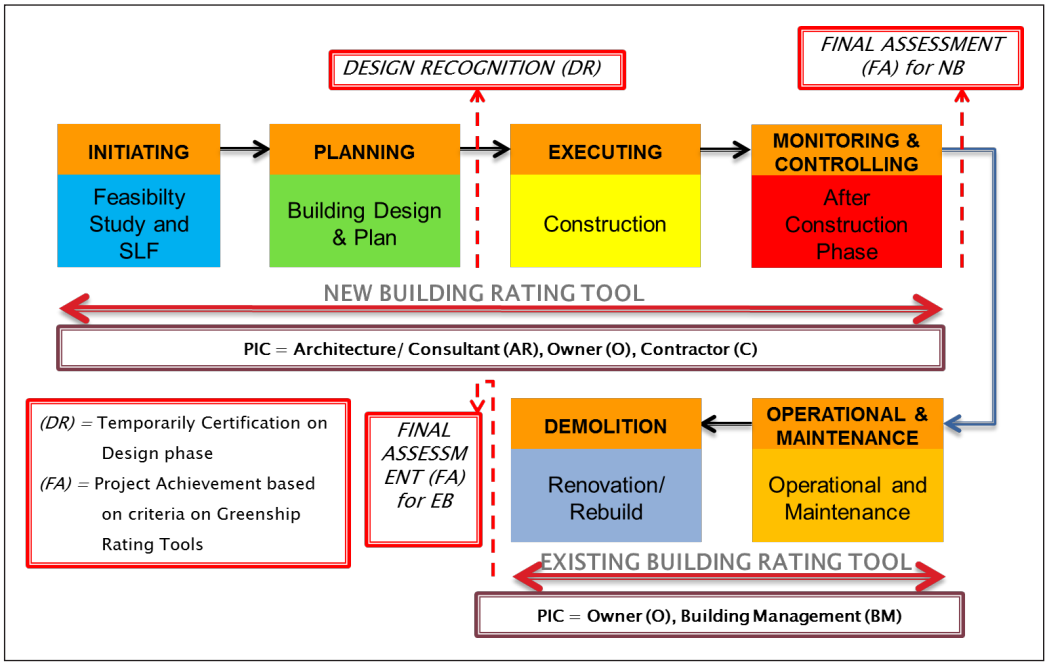

Figure 1. Flowchart on the process of green building assessment
Source. Latief et al. (2017)

Table 1
Five (5) practices of green building management

No	Practice of Green Building Management	Details
1	Sustainable Procurement	Ensures a safe procedure for purchasing goods, services, and functions to reduce the effects on society, the economy, and the environment during the lifecycle.
2	Sustainable Operation	Sustainable operation involves various activities in the lifecycle, from inception to the demolition of the building. These activities comprise the evaluation of the acquisition and building cost; selection of building components, which lead to saving energy; reduction of maintenance costs and having a good impact on the environment; and alteration and demolition costs. It includes the planning, coordination, and control of construction projects that save money and protect natural resources and the environment.
3	Resource Management	Encourages the usage of natural and artificial resources, which are least polluting, while reducing operating costs and improving the productivity and profitability of a building. These activities include the storage, reuse, recycling, treatment, and disposal of waste.
4	Repair and Maintenance Management	The practice of minimizing the repair and maintenance work is required during the operation of the building using the appropriate materials and tools.

Table 1 *(continue)*

No	Practice of Green Building Management	Details
		Maintenance management is the ability to keep a building in good condition by maintaining correct and consistent maintenance from the beginning of the building's lifecycle to its end. It can improve the environment of the building and the occupant's quality of life.
5	Environmental Health	It is the process of taking care of the human health perspectives, considering the biological, social, and psychosocial aspects of a building's maintenance.

Strategies in Managing Waste

The reduce, reuse, and recycle (3R) practice has grown popular because of its adoption in policies and as an alternative to the waste hierarchy notion. This strategy is based on the principle of fully utilizing resources before disposal. Efforts have been made to focus on the 3R practice to reduce solid waste (Ng et al., 2017)

Reduce. According to Ng et al. (2017), the reduction is the most effective and efficient approach to managing construction waste. Not only does reduction reduce the production of C&D waste, but it also lowers transportation, waste disposal, and waste recycling costs. Akdağ and Beldek (2017) stress that supply chain management should enhance the interface between site operations and the supply chain, improving the supply chain by shifting activities from the site to the supply chain and integrating the two. In addition to this, Othman and Abdelrahim (2020) add that proper discussion between project stakeholders during the design stage helps in providing efficient design and innovation, which not only involves the client in decision-making but also helps identify the constraints and issues impressed upon a project, thus leading to a selection of technology and materials best suited to minimizing waste.

Reuse. Ng et al. (2017) and Akdağ and Beldek (2017) classify reuse as one of the most popular choices of waste management because some building debris can be reused in other construction projects. Reuse is a cost-effective option as contractors can save money by avoiding disposal costs. Some materials can be used in many ways, such as formwork and used doors and windows. Any material that cannot be reused, but can be recycled, will be sent to a recycling center.

Recycle. Recycling can be used to create certain new materials. Construction waste recycling can be divided into on-site and off-site recycling. On-site recycling is the separation of construction trash that can be used as raw materials in other construction projects. On the other hand, off-site recycling separates C&D waste as a raw material for

other projects. For example, brick waste can be converted into broken bricks (Akdağ & Beldek, 2017).

METHODOLOGY: THE SYSTEMATIC LITERATURE REVIEW

A systematic literature review (SLR) involves significant databases with many publications, as well as effective search methods, that allow sophisticated and logical expressions to be used (Mesa et al., 2021; Wijewickrama et al., 2021). For this paper, such a review was carried out on literature obtained from research databases related to strategies for managing waste relative to GB practices. The researchers used the data obtained from the SLR to hypothesize the best strategies for managing waste relative to GB practices. According to Shaffril et al. (2018), there are four phases in the SLR method: (i) identification, (ii) screening, (iii) eligibility, and (iv) data abstraction. Figure 2 shows the four phases of the SLR method for the paper.

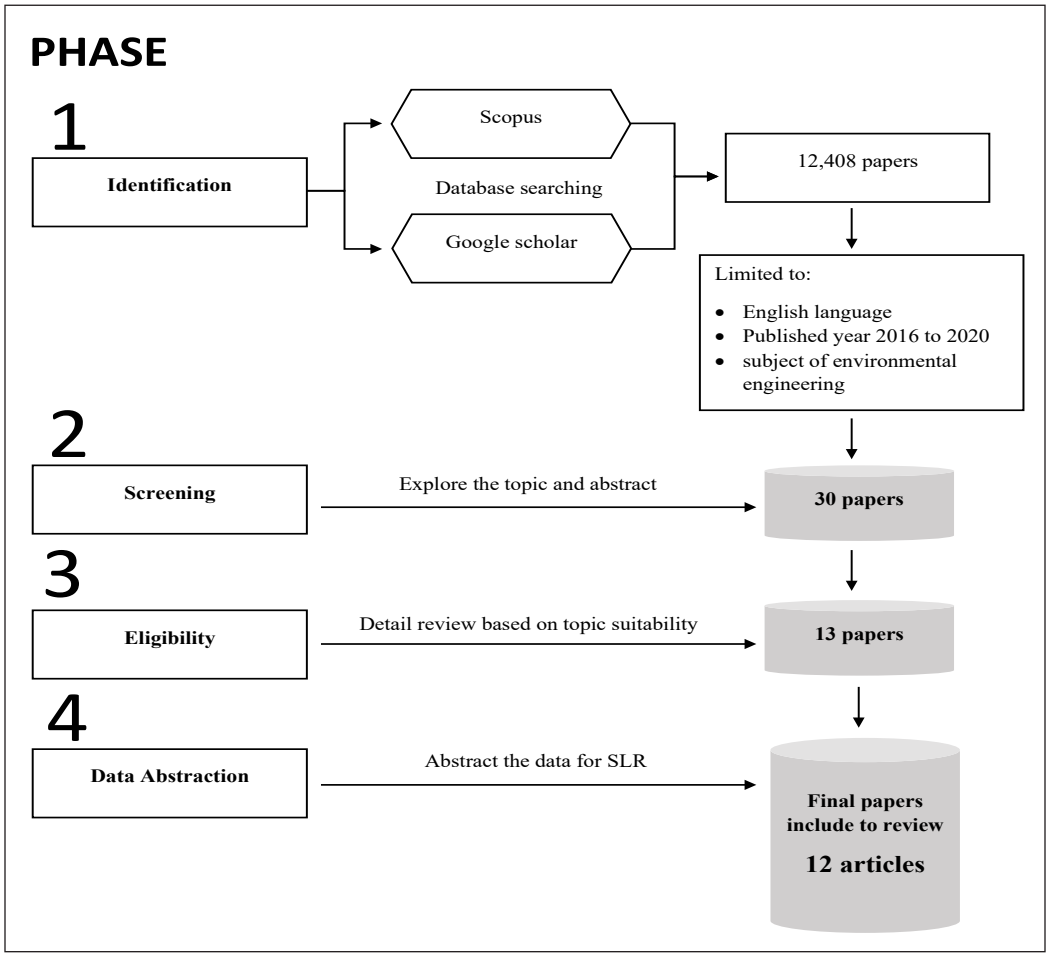

Figure 2. Phases in the SLR method

Phase 1: Identification

This phase was where a rigorous search of topics related to waste management strategies in GB practice was conducted. Appropriate databases and keywords for article selection should be determined, and many databases can be chosen to extract a wide range of articles while minimizing selection bias. Wijewickrama et al. (2021) mentioned that related words, such as synonyms, related terms, and variations of the main keywords, were all searched for to obtain a thorough reading of the existing literature. Two databases were used to identify the literature: Scopus and Google Scholar. There were 12,408 articles discovered using the search string shown in Table 3, and these were limited to English language articles from 2016 to 2020 that covered the subject of environmental engineering. The search string was established based on enriching keywords, as shown in Table 2.

Table 2
Result of identification process

Title	Main Keywords	Enriched Keywords
Strategies in Managing Waste for Green Building in Malaysia	• Strategies in managing waste • Construction waste • Green building	Strategies in managing waste= Method Way Plan Construction waste= Construction and demolition waste Solid construction waste Construction debris Construction solid waste Sustainable construction waste management Green building= Sustainable building Eco-Friendly Building

Table 3
SLR search string

Databases	Keywords
Scopus	TITLE-ABS-KEY ("sustainable waste management" OR "green waste management" OR “eco-friendly waste management" AND "construction waste" OR "construction solid waste" OR "construction and demolition waste")
Google Scholar	(("strategy*" OR "method*" OR "plan*" OR “way" OR "plan*") AND ("managing" OR "controlling" OR "handling") AND ("construction waste" OR "construction solid waste" OR "construction and demolition waste" OR "construction debris"))

Phase 2: Screening

In this phase, the identified literature was screened according to the suitability of their strategies in managing waste for green building practice. Wijewickrama et al. (2021) remark

that the screening includes exploring the topic and abstract of the papers. The purpose of the screening process was to sort out irrelevant articles from the SLR. At this phase, 30 manuscripts were reviewed, and only 13 were found to be eligible for this paper's review.

Phase 3: Eligibility

In the eligibility phase, the 13 screened literature were further reviewed to ascertain their suitability for the research topic. After being thoroughly analyzed, only 12 papers were selected for the SLR. The content of another study proved to be unrelated to the paper objective.

A systematic review was tabulated based on an item checklist that covered the author(s), the title of publication, year of publication, the country where the study was conducted, as referred to in Table 4.

Table 4
Papers' information

Year	Country	Title	Author
2016	India	Impact of the Construction Waste on the Cost of the Project	Surendra et al.
2016	Hong Kong	Time-based Construction Waste Management Planning Using Building Information Modelling (BIM)	Won & Cheng
2016	Malaysia	A Review of Construction Waste Management and Initiatives In Malaysia	Saadi et al.
2017	Malaysia	Contractors' Perspective on Material Waste Reduction in Kuala Lumpur	Osman et al.
2018	Zambia	Towards Sustainable Construction Waste Minimization and Management in Zambia and Beyond	Mulenga
2018	India	An Analytical Approach for Assessing the Construction and Demolition Waste In Construction Industry By Using Standard Practices.	Reddy et al.
2018	Malaysia	Waste Minimization Strategy and Technique: Towards Sustainable Waste Management	Noh & Mydin
2019	Kazakhstan	A Comprehensive Construction and Demolition Waste Management Model using PESTEL and 3R for Construction Companies Operating in Central Asia	Turkyilmaz et al.
2019	Sri Lanka	Towards the Adoption of Zero Waste Concept in the Construction Industry: A Review of Existing Strategies	Liyanage et al.
2020	Egypt	Achieving Sustainability Through Reducing Construction Waste During the Design Process: A Value Management Perspective.	Othman & Abdelrahim
2020	Malaysia	The On-Site Waste Minimization Practices for Construction Waste	Hasmori et al.
2020	Nigeria	Waste Minimization Strategies at The Design Phase: Architects' Response	Olanrewaju & Ogunmakinde

Phase 4: Data Abstraction

Table 4 shows the systematic review tabulated in the data abstraction phase based on the data from the 12 selected literature. The data abstracted were grouped into three main strategies of managing waste for green building: (i) reduce, (ii) reuse, and (iii) recycle using the thematic method.

ANALYSIS

Descriptive Information

This section explains the papers selected for the SLR. All 12 papers were collected from two databases: Scopus and Google Scholar. The relevant papers were selected from the last four years (2016 to 2020). According to Caldera et al. (2020), the country the author originates from should be used as the publication's geographical location. In Table 4, 3 authors out of the 12 were recorded from Malaysia, followed by two (2) from India, and one (1) from each of the following countries: Hong Kong, Zambia, Kazakhstan, Sri Lanka, Egypt, and Nigeria. It meets the criteria set by the author where all papers discussed waste management. According to varieties of the author's country, the author is biased by looking at the Malaysian aspect and covered worldwide.

Strategies for Managing Waste Relative to Green Building

The method used to analyze the data are (i) the thematic method and (ii) content analysis. Maguire and Delahunt (2017) define thematic analysis as the procedure for discovering patterns or themes in the data collected. The use of these themes to address the analysis about an issue by identifying relevant or intriguing trends in the data. According to Stemler (2015), the content analysis assesses the pattern based on a high level of value according to category.

Table 6 shows the literature review analysis conducted on the strategies for managing waste in green buildings. Based on the data gathered in Table 5, the strategies were arranged according to the frequency with which they were discussed as practices in GB management. It applies the content analysis method. These waste management approaches were then compiled and arranged according to which of the three main strategies of waste management theme—reduce, reuse, or recycle—they fell into. The analysis was conducted with a frequency of 4 and above, considered 'high,' as the total frequency was 8 (Table 6: most frequent strategies shaded in light grey). Besides, each of the approaches was grouped according to the development phase that involves the planning stage, executing (construction period), and demolition.

Based on the SLR data on strategies for managing waste in the green building shown in Table 6, the most frequent strategies adopted fell, firstly, into the category of reduce, followed by reuse, and then recycle.

Table 5
Checklist of the strategies for managing waste

Strategies in Managing Waste	Development Phase	Waste management Approach	Surendra et al. (2016)	Won & Cheng (2016)	Saadi et al. (2016)	Osman et al. (2017)	Mulenga (2018)	Reddy et al. (2018)	Noh & Mydin (2018)	Turkyilmaz, et al. (2019)	Liyanage et al. (2019)	Othman & Abdelrahim (2020)	Hasmori, et al. (2020)	Olanrewaju & Ogunmakinde (2020)	Frequency (f)
		Authors													
		Checklist													
Reduce	**Planning (P)**	Using prefabricated materials.				√	√		√	√				√	**5**
		Applying building information modeling (BIM) technology to avoid errors and reworks		√						√				√	**3**
		Implementing eco-friendly designs/ materials			√		√				√				**3**
		Life cycle assessment									√				**1**
		Implementing value management in identifying the unnecessary costs										√			**3**
		Designing according to standard	√												**1**
	Executing (E)	Minimizing design changes			√	√			√				√	√	**5**
		Adoption of proper site management techniques	√			√	√	√	√	√			√		**7**
		Good site coordination and communication	√		√	√	√	√	√				√	√	**8**
		Correct scheduling of purchases and deliveries	√		√	√			√						**4**
		Proper storage of materials on-site / Providing convenient containers for material storage and retrieval	√			√								√	**3**
		Materials supplied at the right quantities and volumes	√		√	√	√	√	√				√	√	**8**
		Ensuring the right dimensions and quality of materials	√			√	√	√						√	**5**
	Other	Use of more efficient construction equipment				√		√		√					**3**

Table 5 *(continue)*

Strategies in Managing Waste	Development Phase	Waste management Approach	Authors: Surendra et al. (2016)	Won & Cheng (2016)	Saadi et al. (2016)	Osman et al. (2017)	Mulenga (2018)	Reddy et al. (2018)	Noh & Mydin (2018)	Turkyilmaz, et al. (2019)	Liyanage et al. (2019)	Othman & Abdelrahim (2020)	Hasmori, et al. (2020)	Olanrewaju & Ogunmakinde (2020)	Frequency (f)
			Checklist												
		Implementing value management in identifying unnecessary costs										√			**1**
		Employing a waste management officer				√		√							**2**
		Good supervision				√		√							**2**
		Developing awareness among laborers and workers (e.g., Proper handling of materials)			√	√			√				√		**4**
		Constructing the building according to the design and instructions are given by the factory						√						√	**2**
		Employment of skilled workmen			√	√			√				√		**3**
		Training of construction personnel	√		√	√			√						**4**
		Government initiative	√		√										**2**
Reuse	**Executing (E) & Demolition (D)**	Reuse and recycling of some waste materials on-site	√		√	√	√		√	√				√	**7**
Recycle	**Executing (E) & Demolition (D)**	Recycling of some waste materials on-site	√		√	√	√			√				√	**7**
		Off-site recycling techniques			√				√	√			√	√	**5**

Table 6
Analysis of the strategies for managing waste relative to green building practice

Strategies for Managing Waste	Development Phase	Waste Management Approach	Frequency (f)	Green Building Practice
REDUCE	E	Good site coordination and communication	8	Sustainable Operation
	E	Materials supplied at the right quantity and volumes	8	Sustainable Operation
	E	Adoption of proper site management techniques	7	Sustainable Operation
	E	Ensuring the right dimensions and quality of materials	5	Sustainable Operation
	P	Using prefabricated materials	5	Resources Management
	E	Minimizing design changes	5	Sustainable Operation
	E	Correct scheduling of purchases and deliveries	4	Sustainable Operation
	E	Developing awareness among laborers and workers (e.g., Proper handling of materials)	4	Sustainable Operation
	E	Training of construction personnel	4	Sustainable Operation
	E	Proper storage of materials on-site/Providing convenient containers for material storage and retrieval	3	Sustainable Operation
	E	Use of more efficient construction equipment	3	Sustainable Operation
	E	Employment of skilled workmen	3	Sustainable Operation
	P	Applying building information modeling (BIM) technology to avoid errors and reworks	3	Sustainable Operation
	E	Implementing eco-friendly designs/ materials	3	Resources Management/ Environmental Health
	E	Employing a waste management officer	2	Sustainable Operation
	E	Good supervision	2	Sustainable Operation
	E	Constructing the building according to the design and instructions are given by the factory	2	Sustainable Operation
	O	Government initiative	2	Sustainable Procurement
	O	Implementing value management in identifying unnecessary costs	1	Sustainable Operation
	P	Lifecycle assessment	1	Repair and Maintenance Management

Table 6 *(continue)*

Strategies for Managing Waste	Development Phase	Waste Management Approach	Frequency (f)	Green Building Practice
	P	Design according to standard	1	Sustainable Operation
REUSE	E & D	Reuse of some waste materials on-site	7	Resources Management / Environmental Health
RECYCLE	E & D	Recycling of some waste materials on-site	7	Resources Management / Environmental Health
	E & D	Off-site recycling techniques	5	Resources Management / Environmental Health

Notes. The most frequently appearing strategies are shaded in light grey.

Reduce

The most prominent strategies in reducing waste are shown in Table 6. The highest-ranked activities under 'Reducing Waste' are good site coordination and communication; and materials supplied at the right quantities and volumes, both of which have scores of f=8. They are closely followed by the adoption of proper site management techniques; and the reuse and recycling of some waste materials on-site, with scores of f=7. The strategies of f=5 include ensuring the right dimensions and quality of materials, application of prefabricated materials, and minimizing design changes. Meanwhile, scheduling purchases and deliveries, purchasing sufficient raw materials, developing awareness among the labor force; and training construction personnel all have scores of f=4. As of the nine (9) most significant activities listed, eight (8) of them are the activities that take place during the construction management stage and involve implementing sustainable operation under GB practices.

The lowest frequency strategies in the reducing waste category are implementing value management, lifecycle assessment, and standard design application, all of which scored f=1.

Reuse

Table 6 presents the frequency for reusing some waste materials on-site, which is f=7. This activity usually occurs during construction management and involves applying resource management/environmental health to GB practice.

Recycle

The recycling of some waste materials on-site and off-site recycling techniques have scores of f=7 and f=5, respectively, as shown in Table 6. These activities usually occur during execution and involve applying sustainable operation/environmental health in GB practices.

FINDINGS AND DISCUSSION

Papers were collected worldwide to obtain the best findings; however, Malaysian authors' papers were the highest in quantity. Therefore, only papers from the past four years were selected to analyze the latest techniques in GB for this SLR. The strategies used in managing C&D waste relative to GB are necessary during a building's planning, execution, and demolition. The findings from the analysis are presented in the framework in Figure 3.

Based on the framework shown in Figure 3, it can be deduced that reducing waste is the main strategy that should be employed in managing C&D waste. The proper design, with the right technology and materials used, can help reduce the amount of C&D waste generated, which relates to the resources management aspect of GB. Besides that, good site coordination, correct planning on the quantities of materials supplied, and clear communication between stakeholders are the most crucial factors of reducing waste, which relate to the sustainable operations aspect of GB. These findings are supported by Othman and Abdelrahim (2020), which stress that selecting the best technology and materials can minimize waste. On the other hand, Akdağ and Beldek (2017) mention that C&D waste can be reduced by improving the supply chain to enhance the interface between site operations and the supply chain; and employing a JIT style of operations.

The second strategy used to manage waste is finding ways of reusing waste material on-site. This strategy is supported by Ng et al. (2017) and Akdağ and Beldek (2017), which both state that reusing on-site waste can reduce a contractor's expenditure by avoiding disposal costs. Recycling is the final strategy, encouraging contractors to recycle C&D waste either on-site or off-site. According to Akdağ and Beldek (2017), recycling can create certain new materials. Reusing and recycling materials saves time and money and protects the environment, which is the main concern of green buildings.

Figure 4 presents the application of C&D waste management and GB practices throughout the development phase, as Latief (2017) mentioned. During the planning stage, waste can be reduced by utilizing the right technology and materials related to proper resource management under GB practices. Planning is the activity that happens before construction begins or during the design stage of a construction project.

Execution, which happens during the construction phase, is where one would apply all three strategies: reduce, reuse, and recycle. The reduction of waste can be achieved by good site planning and coordination with well-trained workers who can relate to sustainable operations and resource management. The reuse and recycling of construction waste will reduce the quantity of waste produced and protect the environment from pollution, which is related to the environmental health aspect of GB. During demolition and alteration, reuse and recycle strategies are applicable, thus relating to resource management and environmental health.

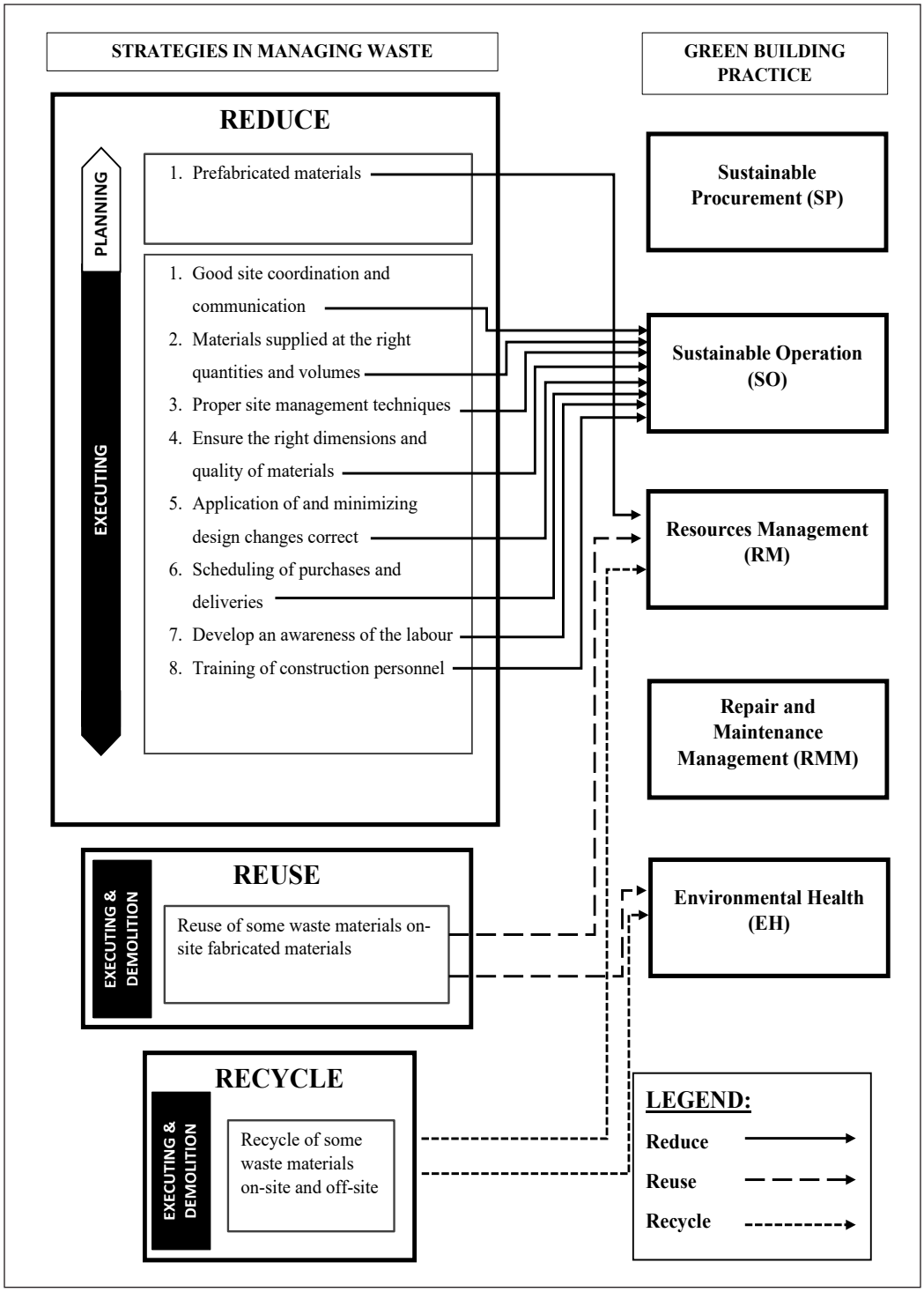

Figure 3. Framework on the strategies of managing waste relative to GB practices

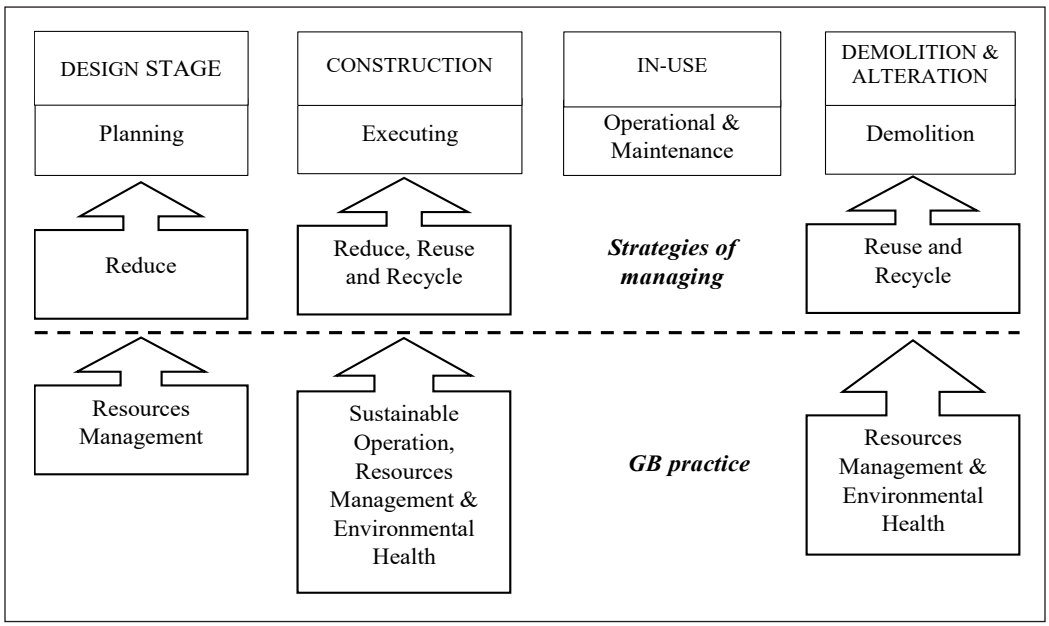

Figure 4. Strategies for managing waste relative to GB practices in accordance with the development phase

CONCLUSION

Construction waste contributes to economic waste, for example, in terms of time and money. However, this SLR only focused on managing solid C&D waste for planning, executing, and demolishing a building. The strategies for managing C&D waste have reduction as their main strategy, followed by reuse and recycling. As for GB practices, C&D waste is dealt with in sustainable operations, followed by resource management and environmental health. Other activities should be taken into consideration, although the SLR's frequency results for these strategies are low. Those strategies are the application of building information modeling (BIM), the implementation of value management, and the usage of eco-friendly materials. The application of BIM during the design and construction stages is in-line with the Industry Revolution 4.0 (IR 4.0) plan and the overall digitalization of construction. Value management is able to identify unnecessary and excessive design choices made during the design stage, whereas eco-friendly materials will offer protection toward the environment and one's health.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support provided by the 'Unit Pengurusan Penyelidikan' Universiti Teknologi MARA, Seri Iskandar, for the approval of research without grant for this research topic. The authors also thank Dr. Norul Wahida Wahid, from the Infrastructure University Kuala Lumpur, for their valuable contribution to this research.

REFERENCES

Aghili, N., Mohammed, A. H. B., & Sheau-Ting, L. (2016). Key practice for green building management in Malaysia. In *MATEC Web of Conferences* (Vol. 66, p. 00040). EDP Sciences. https://doi.org/10.1051/matecconf/20166600040

Akdağ, H. C., & Beldek, T. (2017). Waste management in green building operations using GSCM. *International Journal of Supply Chain Management, 6*(3), 174-180.

Caldera, S., Ryley, T., & Zatyko, N. (2020). Enablers and barriers for creating a marketplace for construction and demolition waste: a systematic literature review. *Sustainability, 12*(23), Article 9931. https://doi.org/10.3390/su12239931

Dwaikat, L. N., & Ali, K. N. (2018). The economic benefits of a green building–Evidence from Malaysia. *Journal of Building Engineering, 18*, 448-453. https://doi.org/10.1016/j.jobe.2018.04.017

Hasmori, M. F., Zin, A. F. M., Nagapan, S., Deraman, R., Abas, N., Yunus, R., & Klufallah, M. (2020). The on-site waste minimization practices for construction waste. *In IOP conference series: materials science and engineering* (Vol. 713, No. 1, p. 012038). IOP Publishing. https://doi.org/10.1088/1757-899X/713/1/012038

Latief, Y., Berawi, M. A., Basten, V., & Budiman, R. (2017). Construction performance optimization toward green building premium cost based on Greenship rating tools assessment with value engineering method. In *Journal of Physics: Conference Series* (Vol. 877, No. 1, p. 012041). IOP Publishing. https://doi.org/10.1088/1742-6596/877/1/012041

Liyanage, K. L. A. K. T., Waidyasekara, K. G. A. S., & Mallawarachchi, H. (2019). Towards the adoption of zero waste concept in the construction industry: A review of existing strategies. In *Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok* (pp. 2414-2424). IEOM Society International.

Maguire, M., & Delahunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *All Ireland Journal of Higher Education, 9*(3), 1-14.

Mohammed, M., Shafiq, N., Abdallah, N. A. W., Ayoub, M., & Haruna, A. (2020). A review on achieving sustainable construction waste management through application of 3R (reduction, reuse, recycling): A lifecycle approach. In *IOP Conference Series: Earth and Environmental Science* (Vol. 476, No. 1, p. 012010). IOP Publishing. https://doi.org/10.1088/1755-1315/476/1/012010

Mesa, J. A., Fúquene-Retamoso, C., & Maury-Ramírez, A. (2021). Life cycle assessment on construction and demolition waste: A systematic literature review. *Sustainability, 13*(14), Article 7676. https://doi.org/10.3390/su13147676

Mulenga, M. N. (2018). Towards sustainable construction waste minimization and management in Zambia and beyond. *Rwanda Journal of Engineering, Science, Technology and Environment, 1*(1), 1-10. https://dx.doi.org/10.4314/rjeste.v1i1.5S

Nawi, M. N. M., Osman, N. N., Osman, W. N., Zulhumadi, F., & Riazi, S. R. M. (2018). Environmental study on methods of handling construction waste for achieving sustainability in Malaysian construction projects. *Ekoloji, 27*(106), 1041-1046.

Ng, L. S., Tan, L. W., & Seow, T. W. (2017). Current practices of construction waste reduction through 3R practice among contractors in malaysia: Case study in penang. In *IOP Conference Series: Materials Science and Engineering* (Vol. 271, No. 1, p. 012039). IOP Publishing. https://doi.org/10.1088/1757-899X/271/1/012039

Noh, N. M., & Mydin, M. A. O. (2018). Waste Minimization Strategy and Technique: Towards Sustainable Waste Management. *Analele Universitatii'Eftimie Murgu', 25*(1), 91-98.

Olanrewaju, S. D., & Ogunmakinde, O. E. (2020). Waste minimisation strategies at the design phase: Architects' response. *Waste Management, 118*, 323-330. https://doi.org/10.1016/j.wasman.2020.08.045

Osman, N. A., Hashim, M. A. S., & Jye, H. P. (2017). Contractors' perspective on material waste reduction in Kuala Lumpur. *Pertanika Journal of Science & Technology, 25*(S), 47-54.

Othman, A. A. E., & Abdelrahim, S. M. (2020). Achieving sustainability through reducing construction waste during the design process: A value management perspective. *Journal of Engineering, Design and Technology, 18*(2), 362-377. https://dx.doi.org/10.4314/rjeste.v1i1.5S

Reddy, S. Y., Mahindra, K., & Asadi, S. S. (2018). An analytical approach for assessing the construction and demolition waste in construction industry by using standard practices. *International Journal of Civil Engineering and Technology (IJCIET), 9*(3), 475-488.

Saadi, N., Ismail, Z., & Alias, A. (2016). A review of construction waste management and initiatives in Malaysia. *Journal of Sustainability Science and Management, 11(2), 101-114.*

Shaffril, H. A. M., Krauss, S. E., & Samsuddin, S. F. (2018). A systematic review on Asian's farmers' adaptation practices towards climate change. *Science of the Total Environment, 644*, 683-695. https://doi.org/10.1016/j.scitotenv.2018.06.349

Schafiei, M. W. M., Abadi, H., & Osman, W. N. (2017). The indicators of green buildings for Malaysian property development industry. *International Journal of Applied Engineering Research, 12*(10), 2182-2189.

Stemler, S. E. (2015). Content analysis. In *Emerging Trends in the Social and Behavioral Sciences: An Interdisciplinary, Searchable, and Linkable Resource* (pp. 1-14). Wiley. https://doi.org/10.1002/9781118900772.etrds0053

Surendra, B. S., Manoj, H., & Madhav, K. (2016). Impact of the Construction Waste on the Cost of the Project. *International Journal of Engineering Research, 5*(SP 1), 126-128. https://doi.org/10.17950/ ijer/ v5i1/ 028

Turkyilmaz, A., Guney, M., Karaca, F., Bagdatkyzy, Z., Sandybayeva, A., & Sirenova, G. (2019). A comprehensive construction and demolition waste management model using PESTEL and 3R for construction companies operating in Central Asia. *Sustainability, 11*(6), Article 1593. https://doi.org/10.3390/su11061593

Wijewickrama, M. K. C. S., Chileshe, N., Rameezdeen, R., & Ochoa, J. J. (2021). Quality assurance in reverse logistics supply chain of demolition waste: A systematic literature review. *Waste Management & Research, 39*(1), 3-24. https://doi.org/10.1177/0734242X20967717

Won, J., & Cheng, J. C. (2016, July 6-8). Time-based construction waste management planning using building information modeling (BIM). In *16th International Conference on Computing in Civil and Building Engineering (ICCCBE 2016)* (pp. 561-568). Osaka, Japan.