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Towards Achieving Zero Wastage Material in Construction Industry

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Abstract: Construction industry is seen as a profit-oriented industry especially in Malaysia, as it gives positive impact towards the economy of a country. However, a massive amount of construction waste material is resulted through the rising number of construction and demolition activities. A substantial amount of waste is generated at all phases of construction from site preparation to demolition of existing structures to its final product. Therefore, the aim of this study is to accelerate the transition from a severe waste problem to zero construction waste in the Malaysian Construction Industry. In order to achieve the aim of this research, this study is specifically emphasized on the current waste handling practices, the challenges that have prevented Malaysia from implementing this proposed concept into practice and provide industry-wide solutions needed to achieve zero material waste. A quantitative approach is used to obtain data in which a set of questionnaires require construction industry players to respond. The result indicates that construction practitioners are aware with the current waste situation, but it still needs improvement as seen by the data collected, which demonstrates that this concept has numerous benefits for both the construction industry and environment. On the basis, the zero-waste concept should be taken into account for every construction project and in-depth plan is necessary for the implementation of this concept to be successful. This study will also assist industry experts better understanding and support the zero construction waste practises in Malaysia.
Keywords: Zero Wastage, Wastage Material, Construction Industry

Introduction

Higher demand in building and infrastructure project has led to the income of a nation. However, the unprecedented rate of construction development has increased the amount of construction waste generated (Siew, 2019). Waste management is the most challenging sector in most of the country, and it has been a focus of concern since the early 1800s (Liyanage et al, 2019). Construction waste material is defined as the end of life of a product that has no residual value resulting to unused and unwanted material from the construction project. Malaysia has executed numerous of construction projects not only focusing on construction sector but also in tourism and manufacturing sectors. The dramatical growth of construction output has led to the increasing in the consumption of construction material which led to the increasing of construction wastage in Malaysia. Waste management is a serious environment issue because it may destroy the habitat and ecosystem and creating pollution to earth and should not be taken lightly. Therefore, construction waste is still recognized as pressing issue in Malaysia (Siew, 2019) due to its rapid development. An information from Solid Waste and Public Cleansing Management Corporation of Malaysia stated by Saadi et al. (2016), reveals that 8 million tonnes of construction are approximately wasted per year that are generated from construction projects.

The statistics show that wastage in Malaysia is in critical condition. Waste management issue has been widely discussed among the construction players. However, there are still lack of action has been made to overcome this global issue.

Zero construction wastage material is an approach in eliminating wastage material that occur from construction activities. Waste that are known as unwanted materials can be considered as resources that are useful through an innovative method of zero waste concept. According to Liyanage et al (2019), zero waste is the best approach for construction and demolition waste management in construction industries. Malaysia should follow the footsteps of certain developed countries that have met their objective of zero construction waste. This paper will indicate the factors that contribute to construction waste, as well as the barriers and strategies for putting the concept into action in order to reduce and eliminate the existing waste issue.

Problem Statement

Construction activities produce inert (eg, construction debris, rubble, earth, bitumen, or concrete) and non-inert materials (eg, timber, bamboo, packaging waste or other organic materials) which are often disposed (Saadi et al, 2016). A data given by Construction Industry Development Board (CIDB) in their report on "Laporan Akhir Kajian Sisa Binaan" (2018)stated that a total of 271,948 tons of construction waste had been produced but only 13.7% was recycled. It shows that no proper waste management practice had been applied by

the construction industries. According to Wong et al (2019), the increased amount of concrete waste is driven by Malaysia's rapid development because of its high concrete consumption.

Attitude and behaviours of some low qualified contractors have affected the smoothness of the execution of work and lead to various method to material waste. Most of the low qualified contractor frequently encounter cash flow problems and rely on low experience labour (Mahamid, 2020). Low experience labour will result in making more mistakes in construction works that can increase the construction wastage and lack of knowledge to calculate and forecast construction material quantities using software. Stakeholders making last- minute design modifications during construction activities will also generates to a high construction waste since the materials purchased will not fit the new design.

Liyanage et al (2019) stated that open dumping and land filling methods has been practiced in most of Asia's developing countries to dispose waste. Construction wastes in Malaysia are usually dumped at a municipal solid waste landfills that have been provided by the municipal council as it is one of the easiest ways for responsible contractor to dump the waste. However, Saadi et al. (2016) mentioned some of the contractors refuse to dispose waste to the designated landfill due to the distance between site location and landfill site may too far. Therefore, illegal dumping activities are often made to avoid paying landfill fees and to save cost on transportation and time to dispose the waste (Wong et al, 2019). Illankoon et al (2019) also confirmed that higher landfill fees lead to higher environmental costs as a result of illegal disposal. This will threaten not only the environment, but also the social and economic well-being of a country.

Aim and Objectives

This study aimed to accelerate the transition in Malaysian Construction Industry from massive construction waste issue to zero construction waste. The objectives of study are:

1) To identify the best practices for construction practitioners to follow in accordance with government regulations to reduce construction waste material in Malaysia.
2) To determine the challenges that have prevented Malaysian contractor from implementing zero construction waste.
3) To promote ways in achieving zero wastage material in the construction industry.

Literature Review

Construction Waste is defined as materials that are unwanted or being generated during construction or demolition activities, including improvement, preparatory, repair or alteration works. Waste refers to substances that have outlived their usefulness and discarded by the user.

Type of Construction Waste

Unused material arising from the construction activities are considered as construction waste. According to Saadi et al (2019), construction wastes are the resources in generating a product, but the output has no value in the end. Construction, demolition and land-clearing activities all produce construction waste, which may include, but not be limited to the following:

Acoustic ceiling tiles	Glass containers	Metal	Window glass
Asphalt	Earthworks	Dirt	Land-clearing debris
Bricks	Drywall	Stones	Paint
Carpet and pad	Fluorescent lights	Wood	Plaster
Concrete	Cardboard	Plastic from packaging	Steel

Table 1: Type of construction waste (CIDB, 2008)

Besides that, based on the pie chart below, it shows the common composition of waste disposed from construction activities.

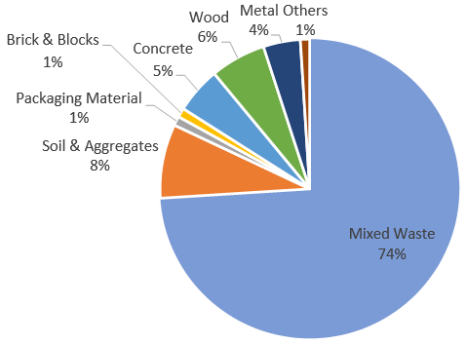

Figure 1: Composition of Construction and Demolition Waste (C&D)
(Source: Sustainable Construction Waste Management by CIDB Malaysia)

Waste that is not being used or recycled, it have high probability be dumped especially in illegal dumping areas that can cause harm to the environment. Major problem caused by C&D waste is landslides at final disposal sites, which can endanger the life of population (Ferronato and Toretta, 2019). According to Jalaei et al, (2019), C&D waste would not only cause environmental issues, but it will also incur additional management costs.

According to the CIDB's Guidelines of Construction Waste Management, construction waste can be classified into six types. Firstly, improper procurement will place excessive amount of orders for materials. Next, poor design will result in errors and inconsistencies during the early project phase within the drawing sets of fabricators (Won & Cheng, 2017). Damage to the materials during transportation and on site will necessitate the purchase of more materials. Insufficient material documentation on-site by the site manager or supervisor, as well as excess material left on-site after the works are completed can lead to a rise in amount of waste. Lastly, vandalism might also result in waste, causing the progress of the project to be inefficient.

Strategies to achieve Zero Waste Construction Material

Governments enact policies and regulations concerning recycling and reuse of building materials with the objective of minimizing waste and adverse environmental impact (Ge et al, 2017). The objective of the enforcement Act 672, which was gazetted on 30th August 2007 is to establish uniformity of law relating with management and regulation of solid waste and public cleansing in Peninsular Malaysia (SWCorp, n.d.).

Technologies

Technologies involves the engagement of software and hardware to assists in the management of C&D waste during the planning, design, construction, and demolition phases of a projects, hence increasing the productivity and profitability of a project (Won and Cheng, 2017). Therefore, it is crucial to utilise the technology such as BIM to reduce the C&D waste. BIM is a 3D digital information modelling system that can communicate, produce and link the data attributes to model elements by enhancing it with the visual of 3D design throughout the construction project life cycle. This technology helps in reducing the lacking of human power by providing more accurate information. However, BIM alone will not be sufficient enough to reduce the waste. It requires a waste minimization planning agenda or brief. BIM is widely proven as an effective and efficient approach in reducing construction waste because it integrates three-dimensional components of building design with external factors such as geographic location and local design conditions into a database (Jalaei et al, 2019).

Besides that, the software measures the accurate quantities of construction materials needed for particular activities and the project schedule. BIM is a platform that is capable of not only measure the quantities required to construct a building but also allows for the measurement of virtual waste. Won and Cheng (2017) agree that BIM facilitates Just-in-Time delivery of materials and equipment. It benefits in preventing the construction materials from being stored on-site for a long period of time which might result in damage such as material deterioration and inventory problems. As a result, material handling on-site will be more efficient and the redundant material quantities can be eliminated.

Reuse and Recycle

Recycling is widely regarded as a sustainable alternative since it decreases disposal volume and costs, converts waste into resources, lowers health and environmental concerns and extends landfill life (Yusop and Othman, 2019). Ge et al (2017) acknowledged that recycling and re-use of building material contributes in

reducing the generated waste and impact to the environment. Reuse is the activity of reusing resources, either for the original purpose or a new purpose, whereas recycling is the process of remanufacturing new materials utilising C&D waste as the raw material (Bao et al, 2020). Waste material can be reused in a variety of ways such as attaching an old door to a new panel as an example. Aggregate can be made from waste materials that have been recycled. It can be applied to a different project.

According to Bao et al (2020), C&D waste recycling can be divided into two types which are off-site and on-site recycling. Off-site recycling can be defined as recycling that takes place outside the construction site. Off-site recycling will require the transportation of waste to the facility centre. This method can be considered as environmentally friendly because the treatment will be performed in a controlled environment. On-site recycling eliminates the needs for transportation and minimizes the amount of time required because it takes place at the construction site itself. The procedure of sorting and segregation is carried out on-site. The management of on-site recycling method is less complicated compared to the off-site. In addition to visually inspecting the building components that can be constructed from reused or recycled materials, a BIM model can instantly calculate the amount of recycled and new construction materials utilized in the construction process (Won & Cheng, 2017).

Site Management

A well-planned site layout can facilitate material transportation and prevent unwanted incidents that normally occurred in construction site which is double handling of materials. As Hasmori et al (2020) agrees, inappropriate handling of construction materials is one of the causes that trigger the waste formations during a construction project. This is due to construction personnel mishandling materials during the construction process and inaccurate scheduling of the material. Unloading construction supplies also requires tremendous care to avoid harm to the material. Incompetent workers and supervisors may contribute to substandard workmanship.

Construction supplies should be stored as close as possible to the construction site (Liu et al, 2020) to prevent any damage. This is due to the longer the distance of material to be transported, the more likely the materials are to be harmed. Following the construction waste reduction objectives, Liu et al (2020) stated that using the equipment for normal operation and using skilled construction workers will have major impact on the waste reduction. The percentage of supplies that will be wasted is less with great handling.

The C&D waste are unavoidable, but it varies greatly depending on the method and strategies used to manage it. Lack of on-site material control is the second highest most influential contributor to material waste generation (Adewuyi & Odesola, 2015). Reducing waste generation can be applied by adopting fundamental strategies including limiting the waste output on site, decreasing the number of design changes and use implement effective transportation management. It is essential for the site supervisors to standardise the construction processes in order to avoid the necessity for the structure to be disassembled and require reworked activities as it can cause the project to have double work and wastage. This can result in enabling the maximum utilisation of building raw materials and a reduction in construction waste accumulation (Liu et al, 2020).

Waste Management Manager and Plan

An interview conducted by Huang et al (2018) with construction company managers revealed that the majority of the collected C&D waste have been mixed up and contaminated because it has not been properly separated or sorted. The statement can be agreed by Ferronato and Toretta (2019) by stating that C&D waste comprising of cement, bricks, steel and plastics are commonly mixed on the construction sites. This will result in a decrease in the efficiency for the waste to be reduced or recycled and increase the probability of the waste to dumped in the landfill. As a result, every construction site must appoint a person who is responsible to deal with the waste such as designated environmental officer or waste manager to monitor the construction site.

The waste materials must be segregated according to their composition from waste material to the greatest extent feasible with the assistance from the environmental officer. Each waste produced throughout the construction process will have its type and quantity to be recorded and allow the waste to be managed in an appropriate manner. This can result in any waste generated on-site will be handled incompliance with the duty of care regulations.

Material	Quantity	Disposal Method	Handling Procedure
Asphalt	300tons	Ground on site, reuse as fill	
Wood Framing	8tons	Recycle–Wood Recycling Northwest	Separate ‘clean wood’ In clean woodbin
Decorative Wood, Beams	200bd. Ft.	Salvage–Timber Frame Salvaging	Remove by hand, store on-site, palletize for pickup

Scrap Metal	7tons	Recycle	Deposit material in container

Table 2: Example report for expected waste materials, disposal method and handling procedures
(Source: Guidelines on Construction Waste Management by CIDB Malaysia)

The appointed environmental officer will have the authority to conduct site inspections at regular intervals and issue directions on waste management and disposal. The waste management plan should be disclosed to the stakeholders and staff prior to the commencement of construction activities to ensure that those who are involved with the construction activities can cooperate with the requirement of waste management plan. Additionally, waste management training programme can also be undertaken to raise their understanding of C&D waste which would be generated. This can help to prevent the waste generated from becoming out of control.

Methodology

Quantitative research methods had been used for this study. A total of 110 had been distribute to various parties involved in construction industries. The questions are formed based on the research aim and its objectives. A combination of open and closed-ended questions is used. Open-ended questions will extract the respondents' opinion based on their personal experiences and perceptions. And for the close-ended questions, answer choices should be kept reasonably narrow so that the respondent can easily make up their mind and does not have difficulty keeping multiple options in mind at once. Google form is used to perform the survey since it is the fast and the best method to deliver the questionnaire via email.

Analysis and Findings

The data was gathered through a questionnaire that was distributed to contractors, engineers, quantity surveyors, project managers, and other construction players throughout Malaysia. Number of questionnaires distribute is depends on how big their responsibility at site and size of the population. Only 67 no of questionnaires had been complete and returned. The rate of returned survey responses is shown in the table below.

Type of Respondent	Number of Questionnaire Distributed	Number of Questionnaire Returned	Rate of Responses from respondent	Percentage from Questionnaire Returned
Contractor	50	35	70%	52%
Others	20	12	60%	18%
Quantity Surveyor	20	11	55%	16%
Engineer	15	7	47%	10%
Site Manager /Project Manager	5	2	40%	3%
TOTAL	**110**	**67**	**61%**	**100%**

Table 3: Rate of returned survey response

The table demonstrates the rate of responses is acceptable. The total of responses is 67 respondents out of 110 respondents which result in 61%. Therefore, the data collected is acceptable and can be used for data analysis.

Section A: Demographic Information

State and Territories	Frequency	Percentage
Northern Region: Perlis, Kedah, Penang & Perak	12	17.91%
East Coast Region: Kelantan, Terengganu & Pahang	8	11.94%
Central Region: Selangor, Kuala Lumpur & Putrajaya	28	41.79%
Southern Region: Negeri Sembilan, Melaka & Johor	12	17.91%
East Malaysia: Sabah, Sarawak & Labuan	7	10.41%
TOTAL	**67**	**100.00%**

Table 4: State and Territories of Respondents Currently Working

Working Experience	Frequency	Percentage
Less than 5 years	15	22.39%
6 – 10 years	13	19.40%
11–15 years	7	10.44%
16–20 years	4	5.97%
21–25 years	8	11.94%
More than 25 years	8	11.94%
TOTAL	**67**	**100.00%**

Table 5: Working Experience in Construction Industry

Table3 shows the region where the respondents are currently working. The central region makes up a quarter of the pie chart with 28 respondents out of 67. While in table 4, it shows that 41.8% of the respondents have working experience less than 10 years. And more than half of the respondents have an experience more than 10years in construction industry.

Familiarity	Frequency	Percentage
Yes	49	73.10%
No	18	26.90%
TOTAL	**67**	**100.00%**

Table 6: Familiarity in Handling Construction Waste

Experience	Frequency	Percentage
Yes	38	56.70%
No	29	43.30%
TOTAL	**67**	**100.00%**

Table 7: Experience in Managing Construction Waste

Table 5 and table 6depict the familiarity and experience of respondents in handling construction waste. It shows that most of the respondents (73.1%) are familiar and had a good experience (57%)in managing construction waste. But the number of respondents that have no experience in waste management is also quite high. So, it can be concluded that nearly 50% of construction players did not apply a proper waste management practice at construction site.

Section B: Current Waste Management Practices in Construction Industry

Statement	Likert Scale					Mean Score
	1	2	3	4	5	
Waste minimization starts from early construction stage	7	7	22	21	10	3.30
Reuse the unwanted construction material	8	7	16	22	14	3.40
Recycle the construction waste	14	10	14	22	7	2.97
Treating the waste in the treatment facility	13	16	17	14	7	2.79
Dumping the wastes in the designated landfill	7	1	13	28	18	3.73
Dumping the construction wastes at unlawful area	22	9	13	14	9	2.69

Table 8: Common Waste Management Practices at Site

The most frequent practises practiced by Malaysian construction player is by dumping the wastes in designated landfill with the highest mean score 3.73. It shows that most of the construction player did not practice a proper waste management procedure and they simply dump everything at the landfill area. And sadly, the result also shows that only 22 numbers (32.8%) of the respondents did not dump waste at unlawful area. Other than that, only a small number of respondents that apply recycling the construction waste and treating it in the treatment facility.

There are also some other ways that being practices by the respondents in treating the construction waste at site. As per listed below:

Respondent	Description
R7	Use as part of fill material
R10	Reduce the optimize material requirement
R20	5R – refuse, reuse, recycle, reduce, and repurpose
R23	Crush the waste
R27	Manage surplus material to be reuse
R33	To crush
R37	Dispose material appropriately
R39	Hybrid recycling
R42	Draw construction site waste management plan
R46	On site separation
R50	Outline the waste disposal strategies
R60	Donate good construction materials
R61	Crush the materials

Table 9: Replies on the Other Techniques of Handling the Waste

Section C: The Barriers in Implementing Zero Construction Waste Management

Statement	Likert Scale					Mean Score
	1	2	3	4	5	
Zero Construction Waste Management will give a huge burden to SMEs (Small and Mid-Size Enterprise) as it requires a large fund to be invested.	1	2	7	22	35	4.31
Lack of fundamental in construction wastes data may influence the failure in adopting Zero Construction waste management.	0	0	2	27	38	4.54
Insufficient Malaysian policy strategy in managing construction waste.	0	1	6	26	34	4.39
Zero Construction Waste Management is difficult to attain due to a lack of awareness about Construction Waste.	1	1	5	31	29	4.28
Poor coordination among the parties involved	0	1	5	30	31	4.36
In efficient procurement strategies led to the barriers of implementing Zero Construction Waste Management on site.	0	2	6	29	30	4.30

Table 10: Barriers in Implementing Zero Construction Waste Concept

The highest level of agreement by the respondents is the 'lack of fundamental construction wastes data may influence the failure in adopting Zero Construction Waste management' with mean score of 4.54andno respondents disagree with this statement. The second highest issues is regarding the insufficient Malaysian policy strategy in managing construction waste. But, as an overall, it shows that all the barriers listed was strongly agree by the respondents since the mean score is more than 4. Any other barrier added by respondents are listed in the table below:

Respondent	Description
R5	Lack of awareness across the board
R9	Lack of awareness and enforcement
R26	Poor attitude
R29	Lack of recycle, reuse, and repurpose company which practices and operates construction waste
R30	In sensitivity of players towards the environment
R33	Government policy
R39	High cost of transportation
R49	Inadequate storage to segregate the waste
R51	Expensive technologies

R52	Inadequate utilization of waste disposal site
R58	Unwillingness to pay fees to dispose waste
R60	Unwillingness to pay fees to dispose waste
R61	Inadequate funding
R63	Financial constraints
R64	Low level of equipment
R66	Ineffective enforcement

Table 11: Replies on the Other Barriers in Implementing Zero Construction Waste Concept

Section D: Success Factors of Implementing Zero Construction Waste Management

Statement	Likert Scale					Mean Score
	1	2	3	4	5	
Government should provide more initiative and subsidise a portion of investment to implement this concept to help most of the companies especially SMEs.	1	0	3	20	43	4.55
Categorising potential building waste that can reuse aids in the realisation of Zero Construction Waste Management.	0	0	2	30	35	4.49
Malaysian Construction Industry should learn from other developed countries to achieve Zero Waste in Construction.	0	2	4	23	38	4.45
Encourage the usage of waste minimization practices provided by CIDB guidelines.	0	1	5	24	37	4.45
Technologies can help to connect parties involved and coordinating them effectively.						
a. Accurate databases of construction waste generated can improve documentation	2	0	7	19	39	4.39
b. Real-time GPS tracking can track the garbage collection vehicle to combat unlawful waste dumping	2	3	8	23	31	4.16
c. RFID tags to gather the waste information and data	2	2	15	24	24	3.99
Public-Private Partnership (PPP) procurement approach will allow government to collaborate with private entities to jointly solve the construction waste problem.	0	5	10	25	27	4.10
More campaign on zero construction waste management campaigns to increase the awareness and educate the stakeholders and parties involved in construction industry.	0	0	3	21	43	4.60

Table 12: Success factors in implementing zero construction waste

"Strongly Agree" gives the highest number of respondents for all questions in section D. 43 respondents strongly agree and no respondents contribute in strongly disagree and disagree to have campaign on the 'zero construction waste management to increase the awareness of parties involved in construction industry' which makes the statement is the highest mean score of 4.60.This indicates that the campaign must be carried out in order to raise awareness. Many construction professionals are still unaware of the significance of waste management.

Any other opinions from the construction players on the success factors that will positively contribute to the adoption of zero construction waste management in Malaysia are listed in the table below.

Respondent	Description
R2	The mindset of Malaysian construction players that need to be alter in order to achieve zero waste in construction as now many of them are still thinking like old ways
R6	Impose fines to those errant contractors
R7	Reward program
R18	The construction method. Moved away from the conventional construction methods to IBS system.

R22	Collaboration with database technology company and waste recycle industry players – initiate by the Government
R26	Consider construction waste as problems to the country and need to be emphasized as it keeps on generated year by year which can be harmful not only to the environment but the whole world
R29	All team members need to sit down and monitor this waste management properly. Planning, on-site monitoring, and head of members need to make sure this implementation is success.
R34	Technology improvement
R35	Waste management specifically to be part of the scope of works in the contract documents
R41	Strong support from the construction workers
R45	Incentive to those who participate in the zero-waste concept
R46	Efficiency or productivity of resources
R48	Tools to evaluate the contractor's waste management performance
R50	Makes waste reduction on site as practices
R51	Hire waste manager for every construction project
R53	Use IBS instead of conventional method
R54	Incentive to whom that applied
R60	Imposing fines
R61	Consider some trash that can be renewable
R63	Create a system where all contractors need to submit site drawings and pictures of how they handle their construction waste for every project, every month until the completion date.

Table 13: Replies on the success factors to adopt the zero waste concept

There are some of the respondents suggested to move the construction method from conventional to IBS. Muhaidin et al. (2018) endorse this viewpoint, stating that IBS components are useful as an efficient waste-reduction construction method. Respondents also suggested an incentive or reward programme for people who participate in the zero-construction waste concept. This will encourage the contractor to join the programme because they will be rewarded. The reward can occur in many forms, such as a cash incentive programme in which the contractor receives cash rewards if the concept is successfully implemented. Lastly, strong support from the construction workers is essential. This not only makes the concept feasible, but it also promotes helpful interactions in the workplace. If only a few parties involved in the construction support the idea, it will be impossible to implement.

Conclusion

Based on the analysis gathered from all three (3) objectives of the study, it has been demonstrated that the aims of this research were achieved. Recommendations are made in order to provide solutions. Although the industry has yet to fully embrace construction waste management, the analysis shows that the concept can provide numerous benefits for both construction industry and the environment.

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