The European Proceedings of
Multidisciplinary Sciences
EpMS

FUTURE ACADEMY

ISSN: 2421-826X

https://doi.org/10.15405/epms.2019.12.21

ICRP 2019

4th International Conference on Rebuilding Place

A REVIEW ON THE CONSTRUCTION METHOD IN MINIMISING CONSTRUCTION WASTE IN MALAYSIA

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Abstract

Economic and development growth are mainly supported by the construction industry. Consequently, the escalation and advancement in the building industry had produced massive wastes, affecting the environments' quality. The problem highlighted is supported by previous studies which proved that it is one of the main concerns to be resolved in future. This paper is based on a review of the construction waste and its scenario in Malaysia. Based on the data collected from previous studies, it can be identified that wood is the main waste materials that are generated in the construction industry due to the high usage of wood in the conventional method of the formwork system. The high amount of construction waste generated also resulted in more illegal waste dumping impacting the environment in Malaysia. This paper discusses on the construction technique that can help in minimising construction waste. Industrialised Building System (IBS) is one of the methods which apply prefabrication and factory-produced construction in Malaysia. It is one of the efforts reducing the production of construction debris on site due to the structural components being produced in a regulated space such as a factory rather than on the construction site. RBM Building System and the new digital IBS is one of the other construction methods that are improvised from the previous IBS which maximise the potential of minimisation of waste construction.

Keywords: Construction materials, construction waste, construction method, minimising waste, industrialised building system.

https://doi.org/10.15405/epms.2019.12.21
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Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

1. Introduction

Sustainability is one of the important concepts in various disciplines. As stated by Ragheb, El-Shimy, and Ragheb (2016) green architecture which is also known as sustainable architecture or green building is a concept which is friendly to the environment in term of the science and style of the building. One of the criteria in a sustainable design concept is the minimisation of waste at all phases of the building development, from the construction, use, and operation. Hyett, and Edwards (2001) stated that sustainable construction practice involves any of the construction players such as architects and engineers to design buildings with minimal number of resources so that future generations have their share of reserves. This was the basis of sustainability concept advocated by the World Commission on Environment and Development (1987) report on sustainability which transpires that development should meet the needs of current society without compromising on the need of future generations. At the same time, the design should not influence the environment in negatives ways such as pollution from the waste products in building construction. Yearly, it takes a total of three billion metric tons of raw materials to produce building materials around the globe (Calkins, 2009). Moreover, after the food industry, buildings consume the second largest of raw materials (Halliday, 2008). As building construction materials consumes a large percentage of raw materials, one of crucial step in the construction industry is to adopt the life cycle approach i.e. the life cycle analysis of building materials, an appropriate method in evaluating building materials environmental impact from cradle to cradle (Abdul Samad & Yahya, 2016).

In Malaysia, the construction industry is among the primary industries that are crucial to the economy (Hussin, Rahman, & Memon, 2013). The development of the construction industry is very crucial because it is part of the major sector that driving Malaysia to achieve the mission in becoming a developed nation. However, the rapid evolvement of the construction industry has negative impacts, especially towards the quality of the environment. It is because the quality of the environment is affected by the great amount of construction debris (Saadi, Ismail, & Alias, 2016) which contributes approximately 41% of the solid waste generation in Malaysia (Mei & Fujiwara, 2016).

However, the amount and rate at which construction waste produced on site can be reduced by the appropriate application of the construction method. Off-site construction such as prefabrication and modularisation (Alazzaz & Whyte, 2015) which can be in the form of components, penalised, and modularised elements can be implemented in the structural, enclosure, service and interior partition system. (Smith, n.d.). It is reported that this construction method can limit at about half of the waste output in a project (Oakley, 2017). This paper will be reviewing the off-site construction method in term of the advantages and how it can minimise the number of debris produced when using this method.

2. Problem Statement

Construction industry has become one of the problems contributing to the pollution of the environment due to waste production. Construction waste generation is growing in number and has been contributed to illegal dumping activities (Rahim et al., 2017). The problem statements of this paper are:

- The abundance of construction debris ends up at the landfill
- The construction method in reducing construction waste

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3. Research Questions

The research questions for this paper are:

- What is Malaysia's scenario in relation to construction waste that they are currently facing?
- What is the construction method in minimising the production of construction waste?

4. Purpose of the Study

The purpose of this study is to:

- Determine the contributing causes to the waste generation in the construction site in Malaysia.
- Generate a list of construction methods to minimise discarded material in the construction site.

5. Research Methods

The objectives of this paper guide the methodology of this study. This study is started by reviewing the previous studies related to this study regarding the production of construction waste and technologies that can be applied to counter the problem of waste generation. Based on the previous studies, this paper will discuss and analyse the latest technologies that are suitable to be applied in the construction which is suits to manage the debris production

6. Findings

The findings of this paper are defined in two categories which are the current scenario of production of construction waste and the construction methods that can be implemented in a project to minimise construction waste.

6.1. Construction waste and the scenario in Malaysia

Wood, concrete, metal, bricks and plastics are some of the examples of the construction wastes that have been produced in Malaysia. Asaari, Halim, and Isa, in 2004 stated that wood is the major contributor of waste composition, which is about 63.84%. Plywood and engineering wood are the main components which were used as the formwork during the construction process. Table 1 shows the overall composition of the construction waste.

Table 01. Composition of the construction waste

Type of the Materials	Percentage of the Total Amount for Institutional Project (%)	Percentage of the Total Amount for Residential Project (%)	Percentage of the Total Amount for commercial Project (%)	Total (%)
Concrete	12.32	25.11	25.74	15.45
Metals	9.62	10.04	10.16	9.73
Bricks	6.54	13.76	13.91	8.24
Plastics	0.43	1.86	1.58	0.96
Woods	69.10	47.60	46.67	63.85
Others	2.00	1.64	2.94	1.77

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Based on the three projects, woods were the main contributor to construction debris on site due to the usage of the materials in the formwork system. The conventional formwork from timber is good in term of the economy but not for the environmental (Alashwal & Abdullah, 2017). There are several options of modern formworks system such as aluminium formwork (MIVAN system) and industrialised system of on-site construction of tunnel formwork (Karke & Kumathekar, n.d.) which can reduce the dependency of the wood materials in formwork system. Offsite formwork also is the other alternative which can assist in decreasing material debris because of human error.

The better understanding of sources of construction wastes is also important to find the ways in and minimising and handling it. Nagapan and Rahman (2011) mapped the 63 causes of aspects that are contributed to construction waste produced in many countries based on the 20 scholarly studies selected. The study is done by using a matrix of sources of construction waste. This study shows that seven significant factors in the production of construction waste which are (1) often design adjustment, (2) wrong material storehouse, (3) climate factors, (4) lousy planning, (5) ordering flaws, (6) employee' fault and (7) waste materials on site. Frequent design changes are the main significant factor in causing to the number of debris on site. In 2016, Ikau, Joseph, and Tawie, (2016) were also identified the factors that influencing of waste generation in Malaysia. Based on their study, the main factors that influencing the production of debris are (1) minimal knowledge and experience in handling construction waste, (2) incorrect purchased of materials, (3) damage of the materials due to inappropriate storage conditions and (4) rework. From the factors listed above, it shows that every single phase of the construction process has the possible of contributing to the generation of construction waste. An appropriate waste management plan has to be taken seriously, and it should start at the beginning of the project so that it is well-planned, and every phase is going through the waste management system.

The generation of construction wastes also contributes to the environmental problem. It is a serious issue in Malaysia, especially when the increased quantity of construction debris is one of the factors that cause illegal dumping activity (Rahim et al., 2017). Perbadanan Pengurusan Sisa Pepejal dan Pembersihan Awam (SWCorp) has detected that waste management process is inadequate and the construction industry does not take waste management as a serious issue based on the eight hundred fifty-one of illegal dumping area that available in Malaysia (Rahim, et al., 2017).

6.2. Construction method in minimising construction waste

The construction method is one of the ways that can help in decreasing the quantity of debris generated on-site. Selection of method of construction is very important because it may affect the construction process such as time of construction, design of the building and materials used for the projects. Industralised Building System (IBS) is one of the construction methods that have been used in Malaysia since 90s. However, as stated by chairman of Construction Industry Development Board (CIDB) Malaysia, IBS construction method had a slow uptake and still 20 years behind in adopting it in the construction industry (The Malaysian Insight , 2018). Even the evolution of IBS is slow, but it still has the improvement that appropriates to the technologies in Malaysia.

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6.2.1. Prefabricated and modular design by Industralised Building System (IBS)

In Malaysia, Industrialised Building System (IBS) refers to the prefabrication and implementation of industrialised construction (Kamar, Hamid, Azman, & Ahamad, 2011). In their study also stated that IBS is also described as the recent method of construction which have the offsite manufacture and pre-assembly. In 1960s, it has undergone tremendous evolutions since it was first trialled in Malaysia. (Yew, 2018). The concept of IBS construction is that the structural components are produced in a regulated facility such as a factory rather than manufactured it on the construction site. CIDB (2003) classify IBS in six classifications which are steel formwork system, precast concrete framing, panel and box systems, steel framing system, prefabricated timber framing system and block work system.

There are many advantages to the use of IBS in comparison to traditional construction method. That is why the Malaysia Government supports IBS by giving the mandate of 70% of the government development to use IBS components (Azman, Ahamad , Majid, & Hanafi, 2012). In their study also mentioned the roles of IBS in reducing, reuse and recycle (3Rs) which is related to minimisation of the construction waste. The application of IBS in a project can help in minimising the wastage production, green environment, less usage of materials, less number of labour, quality control and reduce the time of construction. It is also better than conventional construction method in terms of waste products as 94% of the waste produced can be repurposed, which is relatively higher than the 73% obtainable from traditional construction methods (Begum, Satari, & Pereira, 2010).

However, there are also constraints in using IBS. Mariam et al. determined the main constraints in application of the IBS such as (1) shortage of the academic curricula regarding IBS and modular coordination (MC), (2) unskilled worker, (3) high initial cost to establish a factory, (4) storage area and (5) architect unfamiliar with the modular design. By identifying the constraint of using IBS, the improvement of the current scenario should be applied to increase the higher potential of using IBS in Malaysia such as educational concerning IBS should be improved and there should be a training course for IBS application in the project.

6.2.2. RBM Building System

RBM Building System is a construction technology introduced by RBM Building Machinery Trading Sdn Bhd. It is founded in 1995 and recognised as a smart building technique which is improvised from the conventional method practices especially in minimise material wastage and consistency of quality. In 2009, RBM presented the most excellent and innovative 3 in 1 Foam Concrete Machine model for advance IBS industry to emphasise the speed, quality, and sustainability of the construction (RBM , 2016).

3 in 1 Foam Concrete Machine, Formwork System, Skim Coat Machine and green insulated technology are the advance integrated system in RBM Building System. Due to the flexibility and efficiency of this program, it will reduce the materials cost up to 60%. It is also considered as green and smart building technology because RBM remarkably changes recycled materials into an astonishing building wall that have better thermal and acoustic insulation that comply to fire requirement of four hours fire-rated wall. (RBM, 2016). There are several projects that used this system during the

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construction process such as Prime Minister Office in Putrajaya, Pavillion Kuala Lumpur, and Shahbury in Putrajaya.

- 3 in 1 foam concrete machine

  RBM Building Machinery in 2016 stated that 3 in 1 Foam Concrete Machine (RBM-2000) is a multifunction machine which fulfills the green and energy efficiency requirement. This machine comes with foam generator that can generate up to 600 liters of foam per minutes. It is also having a built-in conveyor to process concrete from the raw materials. This machine can be used to form solid wall, solid partition wall, spray plastering, infill reinforcement chipping concrete, floor screeding and repairing works. With this con-friendly machine, the construction will be faster because no brick and plastering work is needed which can save materials cost up to 60%.
- Formwork system

  Instead of using timber as in conventional method, metal is used as the main material for formwork system in RBM. This material can be recycled the usage for cast structure and wall. Because of the material used is recyclable, this formwork system can reduce the dependency of new raw material in the construction.

6.2.3. Digital IBS

Digital IBS is a new sophisticated IBS production by Gamuda Sdn. Bhd. which is fully digitalised that increase the overall quality of the building components and optimising the usage of construction materials such as steel, cement and steel (Yew, 2018). It is the first digital IBS in Malaysia and was first introduced on a large scale in 2016 in their brand-new IBS factory in Sepang, Selangor. Figure 1 shows the Gamuda IBS factory and the robotic technology in the manufacture of building components.

Digital IBS cooperates with the Building Information Modelling (BIM) digital design system. BIM is an online design tool which allows sharing and transferring information such as data related to the drawing and materials supply in the project. This system is accessible to all relevant parties such as architects and engineers. By having all the data in one platform, the error and design issues such as piping, plumbing and the ducting system can be resolved before the construction process is happening (Yew, 2018). So, any errors and design clashes are solved before the BIM system send the data to the robotics production system (Gamuda, 2018). This system eliminates any problem before the construction process that is normally associated with the conventional construction methods and reduce the wastage to less than 1% (Singh, 2018).

The latest digital IBS is also improved from the previous IBS, which it is not limited to the typical prefabricated panel that is limited, especially in term of design. With the latest digital tools, architects can explore more due to the flexibility of the design that is not restricted to the standard prefabricated panel. It can be customised in various type of design and facades in the similar area, even in the linked houses as in Figure 2 (Yong, 2018).

Digital IBS is a method which is faster than the conventional method. It is because the installation of the panels is like ‘Lego’ which is easier for the workers. One floor per week is estimated for the installation process which can reduce the construction period for 12 months (Gamuda, 2018). In addition,

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digital IBS has flexible design approaches. The digital tools used can customised the panel in various design instead of the standard dimension from the previous IBS (Yong, 2018). It also introduces sustainable construction approach which is safe, reduces sound pollution and construction wastage. Construction waste generated from the Digital IBS is less than 1% which is very low (Gamuda, 2018). This method also guarantees the components produced strong and sturdy as it is fully testes and Sirim-certified and it have better resistance to fire and has better sound and heat insulation (Yong, 2018).

7. Conclusion

Construction waste generated from construction activity affects the environment. This study finds that timber, namely plywood and engineering wood, generates the most construction material waste in Malaysia (conventional formwork system). To combat this, there are options in reducing dependency on wood materials in formwork systems such as aluminium formwork (MIVAN system) and the industrialised system of the on-site construction of tunnel formwork. Using the correct method of construction can assist in decreasing the production of construction waste. IBS is prefabrication and industrialised construction concept applied in Malaysia. To increase its effectiveness, it needs to have more diverse application and be implemented in more projects. However, there are constraints of IBS in Malaysia, such as less knowledge of IBS due to a shortage of the academic curricula, unskilled labour and limited design approaches (modular design).

IBS in Malaysia is improved as the new technologies have been invented in this industry. RBM is one of the examples of advance IBS application that comes with a multi-function 3 in 1 Foam Concrete Machine. The concrete is produced from the machine and poured straight to the formwork which can shorten the construction time and reduce the material waste. With this technology, there is no need for ready mix concrete truck and also require small number of workers. Mobile crane is also not required because this machine can pump up to 125-meter building height. This system simplifies the standard construction method and minimises the potential cause of material wastage.

Gamuda Sdn. Bhd. also coming out with digital IBS which has been improvised especially in the flexibility in the standard component's size. Due to the digital tool used, designers have the flexibility in designing and not restricted to the standard prefabricated panel dimension. In addition, construction waste can be minimised less than 1% due to the digital tool used which is very precise in construction in a controlled environment.

In conclusion, construction waste can be minimised with the right method chosen depending on the type of project. There are several requirements to be looked into in choosing the appropriate type of construction especially to achieve the construction waste minimisation. Digital IBS is the method which has the lowest construction waste produced in the market. However, the source of production is limited because it is very new and at the same time it requires high initial cost for production and transportation. RBM is also a good option as it is constructed on-site. If the project has a repetitive, standard design such as linked home or apartment with require less flexibility in term of design, RBM is the best option for the construction method.

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Acknowledgments

This research is conducted under the Fundamental Research Grant (FRGS) (Grant no: 203/PPBGN: 6711708) awarded by the Ministry of Education Malaysia.

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