EVALUATING THE MATERIAL WASTE REDUCTION BY USING PREFABRICATION IN BUILDING CONSTRUCTION IN KUALA LUMPUR

Nurul Aini Osman[1], Lee Na C.C.[2]
[1-2]INTI International University
[1]nurulaini.osman@newinti.edu.my
[2]Email

ABSTRACT Issues of construction waste are getting serious in the recent years. The generation of waste in the construction industry will soon affect the environmental issues. The rate of the wastage level is relatively high in Malaysia. The method of construction used in constructing a building is crucial as it can help to reduce the generation of material waste. In line with this, a study was carried out to analyse the types of material waste both in conventional and prefabrication method. Plus, an investigation for the level of material wastage between conventional and prefabrication method also been done. The scope of this study mainly focuses on the building contractor's firm registered under Construction Industry Development Board Malaysia (CIDB) in Kuala Lumpur area. The data were obtained and analysed by using frequency analysis, average index analysis and mean analysis. The results revealed that the average wastage reduction level was about 30% when the contractors implemented the prefabrication construction. This implies that an extensive use of prefabrication could considerably reduce construction waste generation in Kuala Lumpur.

Keywords: Construction Waste, Prefabrication, Construction

1. Introduction

The construction sector generates a massive amount of waste in the different phases of the construction process, from the extraction of the raw materials to the manufacture, the construction process, demolition and finally the disposal of the waste materials in landfills. For the last two decades, the construction industry has become increasingly aware of the importance of the environmental impacts associated with waste generated during both the construction of new buildings and the demolition of old structures. Nazirah defined sustainable construction as a way forward to the stability of the necessity to continue development without ignoring the responsibility to care for the natural environment whilst creating healthy, comfortable and economically prosperous places for people to live, work and play [1].

Sustainability as a performance issue forces us to take a much wider look in both times (full life cycle assessments) either space and costs than we used to do in traditional construction [2]. Therefore a lot of countries worldwide had done so much initiative in order to solve this issue. The most useful guidelines that had been implemented by most of the country were the Leadership in Energy and Environmental Design (LEED). This guideline been first setting up by United States Building Council on 1994 [3].

Kuala Lumpur is a compact city. It is the national capital and most populous global city in Malaysia. The population of the city is 1.6 million with a compact area of 234 km² [4]. The construction industry in Kuala Lumpur consumes a significant amount of building materials and produces large quantities of building waste every year [5]. Thus as a capital city of Malaysia, Kuala Lumpur has faced into construction waste problem due to the rapid development of construction industry.

In recent years, construction waste reuses and recycle have been promoted in order to reduce wastes and protect the environment. The Construction Industry Development Board of Malaysia (CIDB) granted a research fund to the Institute for Environment and Development (LESTARI) and Forest Research Institute Malaysia (FRIM) to conduct a project. This project namely as The Project on Waste Minimization and Recycling Potential of Construction Materials commenced on January 2002 and concluded in June 2005. The objectives were to propose better practices for construction waste management and promoting the recycled material to the contractors [6]. Through these project, they found out that most of the contractors were not implemented the reuse, reduce and recycle etiquette through the construction phase. Therefore, this cause to more of construction waste ended up in the landfill. In Kuala Lumpur itself, there have 11 numbers of the landfill for waste disposal [7].

As an ambitious to realise developed country status by 2020, Malaysia is challenged with the decoupling economic growth and waste generation. Therefore on the 10th Malaysia Plan, sustainable growth has been put as the central theme in order to achieve 2020 Vision [8]. In 2008, Malaysia's government launched the Green Building Index (GBI) which this guidelines intentions towards sustainability and green building resources [9]. This guideline performs a task similar to the other country worldwide index such as LEED. Not only have that, Malaysia also taken a way forward in realizing the Vision 2020 when a Construction Industry Master Plan 2006-2015 were introducing the seven strategic trust [10] such as Integrate the construction industry value chain to enhance productivity and efficiency, Strengthen the construction industry's image, Strive for the highest standard of quality, occupational safety and health, and environmental practices, Develop human resource capabilities and capacities in the construction industry, Innovate through research and development and adopt new construction methods, Leverage on information and communication technology in the construction industry and Benefits of globalisation including export of construction products and services.

In order to solve this waste issue, the Government of Malaysia had taken numerous steps but in the end, it still exists because of the ignorance and unwanted to participate in that problem solving. Most of the contractors neglected to implement the better practices of construction waste management [11]. To make this case worst when up to this date, there are no any significant mandatory requirements for the construction company to practice sustainable resources or implement construction waste management [12].

Source reduction is definite as any activity that reduces or eradicates the generation of waste at the source, usually within a process [13]. A studied in Hong Kong showed a reduction of 30% construction waste through full implementation of prefabrication in timber formwork, steel formwork and concrete works [14], [15].

Although prefabrication has been promoted in Malaysia for years, they still remain inactively [13], [11]. In contrast, they still contractors and developers rely on conventional methods involving in-situ concrete and timber formwork [11]. This has been proved when a survey had shown that 85% of contractors unaware of environmental impacts of construction waste and therefore most of them were refuse to implement the prefabrication methods [12].

Prefabrication has only recently been developed and been used commercially in the construction industry when the Public Work Department Malaysia (PWD) enforced of prefabrication usage with 15% minimization application throughout the construction phases [16].

There have been a lot of studied been done in order to show the benefits of prefabrication which linked to the waste reduction such as frozen design at the early design for better adoption of prefabrication [14], have better supervision through the construction phases [11], [17], reduce overall construction cost and

shorten the construction time [10], [18], environmental performance improves for waste minimization [3], [19] and increase the aesthetic value of the construction site and building [1], [20].

2. RESEARCH METHODOLOGY

The data collection processed consisted of the questionnaire survey and detailed case study analysis. The questionnaire aimed to establish the general perspective of construction method, causes and level of material wastage while the case study will provide the information on current industry practices.

A questionnaire was developed and administered to 300 contractors in the construction industry in Kuala Lumpur. This target population were based on the data provided by Construction Industry Development Board (CIDB) that registered under contractors in Kuala Lumpur. The sampling size calculated through formula by Bill (2004) as shown:

$$SS = \frac{Z^2 \times (p) \times (1-p)}{C^2} \quad \text{……(1)}$$

where, SS = sampling size, Z = value for confidence level (1.645 = 90% confidence level), P=percentage of population (0.5 used for sample size needed), C = confidence interval, expressed as decimal.

The survey was conducted over a period of 4 months in 2014. There were 61 respondents with 20% response rate. The questionnaire consist of 15 questions which consisted 3 section to address the following issues: (i) current construction method (ii) causes of construction waste (iii) waste reduction through prefabrication.
In the questionnaire, the respondents were requested to assign an appropriate rating on a scale of 1-5 points. The average index was calculated by the following equation:

$$Average\ Index = \frac{\sum aixi}{\sum xi} \quad \text{…..(2)}$$

where, ai = constant which represent of i,xi = variable represent the respondent frequency for i, i = 1, 2, 3

The mean of each factor was calculated by the following equation:

$$Mean\ of\ Factor, \bar{X} = \frac{\sum_i^k = lfixi}{\sum_i^k = lfi} \quad \text{….. (3)}$$

where, fi = a number of frequency and xi = medium point for each class of waste.

An investigation of five recent building projects in Kuala Lumpur from both public and private sectors was also conducted. The selected building projects were completed between 2014 and 2016, after implementation of prefabrication methods. The total amount of construction waste generated was estimated at each construction site through the record of the total number of truckloads of construction waste.

3. FINDINGS AND DISCUSSION

The main findings of this study are as follows:

3.1 Construction waste generation

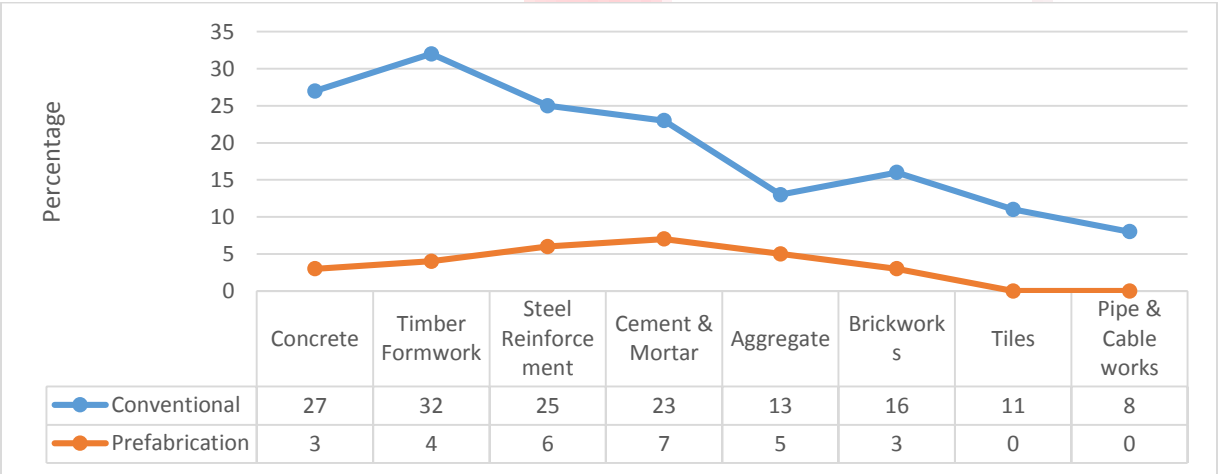
The survey revealed that following phases in construction stage causes most construction waste (in descending orders): (i) Operation (ii) Handling materials (iii) Design and procurement (iv) Inclement weather (v) Communication. Although all the respondents were all aware of the pressing waste management problem in Kuala Lumpur, operation through construction still leading the causes towards construction waste in site.

This indicates that waste generation on building sites may mostly be related to the construction method selection and the level of education and training of the workers. Wastes also arise as a result of design and procurement. The previous study showed that 'last minutes changes' may affect the cost and contributed towards a generation of waste [11].

3.2 Comparison between conventional and precast construction.

In this study, the results demonstrated that waste reduction was significant reducing through the implementation of prefabrication. It is interesting to note that 74% respondents agree that prefabrication method will reduce the construction waste through full implementation especially on the timber framework.

The main objectives of this study were to compare prefabrication with conventional construction with regards to waste reduction. As shown in Figure 1, resulted in construction waste generated in every building works. It showed that timber formwork produces a very high waste around 32% follow by concrete work with 27%. The results were also confirmed by a recent study which identified timber form works as the greatest major contributing construction waste [22].Most of the respondents believe that prefabrication gave more impacts in reducing construction waste especially in timber formwork and concrete work. They also believe that waste reduction and improved quality control were the most important when implementing prefabrication method in every building works. Prefabrication also contributed to a tidier and safer working environment on-site compared to conventional construction.



	Concrete	Timber Formwork	Steel Reinforcement	Cement & Mortar	Aggregate	Brickworks	Tiles	Pipe & Cable works
Conventional	27	32	25	23	13	16	11	8
Prefabrication	3	4	6	7	5	3	0	0

Figure 1: Comparison of material waste generation between conventional and prefabrication method

In order to determine the percentage of waste reduction between conventional and prefabrication method, mean analysis was used. As shown in Table 1, there significant differences between the means in conventional and prefabrication method for all material. Also, there great benefits of waste reduction when using the prefabrication method with a higher percentage of 57% in timber formwork and the lowest percentage reduction in pipe and cable works with 5%. There also has the previous study in Batu Pahat, Johor shown a significant value of the material waste [11].

Table 1: Percentage of material waste reduction

Material Waste	Mean ($\bar{x}$) of conventional	Mean ($\bar{x}$) of prefabrication	Percentage of reduction
Concrete	11.78	5.81	51%
Timber formwork	12.64	5.41	57%
Steel framework	9.29	7.97	14%
Cement and mortar	10.18	7.53	26%
Aggregate	9.97	5.34	46%
Brickwork	8.37	6.94	17%
Tiles work	7.01	6.51	7%
Pipe and cable work	6.30	6.00	5%

4. CONCLUSION

The study assesses the benefits of prefabrication in building and the comparison of each material wastage reduction with the conventional method. The results of the study show that waste reduction could be done when using prefabrication methods compared with conventional construction. From the case studies, the average level of reduction was 30% when adopting prefabrication method and reduction of 57% of timber formwork could be achieved.

In conclusion, a wider application of prefabrication techniques in building construction in Kuala Lumpur could significantly reduce construction waste generation. However, this study was only focused on five construction of residential buildings in Kuala Lumpur due to time constraint. Further studies should be conducted to assess a wider range of building types and examine the environmental impacts.

5. ACKNOWLEDGEMENT

The authors wish to express the greatest appreciation and utmost gratitude to the Inti International University and Construction Industry Development Board Malaysia (CIDB) for all the support in making the study success.

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