Quantification Study for Construction Waste Generation in Housing Project

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Abstract. One of the main contributors to the waste generated in the Malaysian construction industry is housing projects. The construction waste has increased over years, creating environmental problems and profit loss to contractors. Limited data are available to date in Malaysia, especially in terms of sources, types and quantity. The aim of this study is to explore the causes and contributory factors that cause waste generation in selected housing project followed by quantification of common waste generated at sites. Site observation and interviews with labors and site management was conducted in determining the waste sources and waste management practices. Management and workers were the main causes of waste generated in this study.

1. Introduction

The quantification of pollution from building is one of the daunting challenges relevant to the products used on site. The behaviors towards successful practice in waste management are far from what they have hoped to be. Among the determining factors in implementing waste minimization by design are the attitude of designers and their perceived behavioral control [1]. According to Oyedele [2], the insufficient knowledge about the waste stream is one of the main barriers to becoming a recycling society. Waste generation is the primary beginning of this issue. So, this problem must be correctly handled at all stages [3]. Nevertheless, the waste generation data systems are also not well defined. Data such as labourer and their work area, productivity, management, policy etc. need to be explored on the waste contribution factors. In the previous study, particularly in the Malaysian housing projects, the causes, processes and flow of waste produced on the basis of the flow of each material operation was not found either.

Improper data recording of waste will contribute to the difficulties in benchmarking global waste system performance. This was supported by Bilal et al., (2017) who reported that data on building materials such as expense, measurements, alternative materials and potential for waste remained uncaptured. Several studies have proposed that contractors should be liable for quantifying the waste produced at sources, according to Llatas [4]. However, no significant steps are currently being made, either by the company or the contractor. The most important phase in capturing waste data is to measure the waste produced at the sites. Even if it is impossible to obtain the exact amount of waste, quantification of the waste is required. If the contractors are unable to predict the exact amount of waste, the disposal costs are likely to rise, and this will have a significant impact on the project budget.
2. Methodology
This study begins with observation at the site. Observational studies gather a range of information about one's conduct. The phenomena observed in this study were: physical action (workers and supervisor's attitude towards waste, control/ causes of waste), verbal behavior (workers and supervisor's opinion about waste reduction/ causes of waste), physical object (amount of waste produced). Observation normally involves deviating from actions which monitor the participant's daily behavior [5]. Site observation may be designed as an evaluation of the construction site activities [6]. There were three locations identified in this analysis. The locations were Taman Ilmu Site, Seri Akasia Site and Seri Putera Site. Due to its easier access, most of the sites had been visited up to three to four times. The site supervisor will report the activities for certain materials, such as concrete and roof tiles, to the planned schedule.

The analyses start at the early stage of the operation and finish until the operation is through. During the observation, the discussion and interview activities with the workers and the site supervisor were conducted to obtain data relating to the activities. The data documented include those of the number of skilled and unqualified workers, their work experience, total order and structures [4]. The goal of site observation (direct observation) is to see the specific site waste processes applied in the site studies chosen. That covers the worker's or administration behavior surrounding the introduction of site pollution. Observation was performed without the staff or managers realizing they had been observed implicitly during the sampling process. Hidden observation is necessary to get the true image of what is done on sites in this research.

3. Results and Discussions
The amount of waste generated is minimum in the initial construction phase. The main reason for that is the new materials used in the initial stage. The amount of waste will increase at project end [5]. The styles of materials described in this analysis included concrete, timber, steel, roof trusses, and roof tiles.

3.1. Concrete Waste
The form of concrete used for housing developments is ready mixed concrete. Most of the concrete waste was created from chutes into the framework during the transition. These situations was observed at Site Taman Ilmu, Seri Akasia and Seri Putera. Waste protection was done at Seri Akasia by providing a small pail for pouring concrete into the structure. The primary cause of this is the complex column configuration requiring a tiny section. A pail is used as another way to prevent waste at Taman Seri Akasia. At Taman Ilmu and Seri Putera, the contractors did not have health measures to prevent waste during the concreting operations. When the concrete was poured into the beams and columns at Taman Ilmu and Seri Putera, 13.93% and 9.12% of the total order produced by the contractor. Based on the CIDB Study [7], the amount of waste for chosen concrete building material is around 5 to 10 per cent. As reported by Lu et al. [8], the badly built formwork is one of the factors leading waste at sites. From the observation it can be summed up that some of the sites had some form of prevention of waste from concreting activities. Poor supervisory work resulted in concrete activities going beyond the scheduled time (sometimes till night) that affected the productivity of the worker. Slabs works created less waste than the columns. Slab waste ranges from 0.1 per cent to 0.34 per cent of total order. The percentage for each site is based upon the average data.

3.2. Timber
In the initial building process wood losses are fairly small. Toward project end, the wood waste will be increased. Cutting waste happened at the project's initial stage and rotting wood at the end. Cutting operations and rotting timber are the sources of wood waste at the test sites, as found during the study. Typically wood formwork can be used up to three or five times. The amount of wood waste generated from Site Taman Ilmu, Taman Seri Akasia and Seri Putera ranges from 35-49 m³ (10-15 per cent) per block. According to the CIDB Report (Hamid et al., 2015), the waste level for selected wood
construction material with timber formwork material and roof trusses is approximately 5% to 13% and 2% to 7% respectively. The waste level is based on the average data per block of houses.

3.3. Roof trusses
Waste from the roof trusses is created after construction stage of the framework. Site installation, cutting and fastening for roof trusses is creating waste production at the sites. As observed at the Taman Ilmu, Taman Seri Akasia and Seri Putera site, roof trusses waste generation occurred in three stages as follows.

Step 1 The truss of steel arrives on location
Stage 2 Site cutting and fastening begins
Stage 3 Installing truss and battens on the roof

The waste generation rates (WGR) for the Taman Ilmu, Taman Seri Akasia and Seri Putera sites as are 1.354, 1.223 and 1.264 kg/m² (range 5-10 per cent) respectively. WGR is based on the total waste data separated by the total field of operation for each location. Based on the CIDB Report [7], the value of wastage of roof trusses in construction sites is about two to seven per cent.

3.4. Roof Tiles
Roof tiles are a part of valuable on-site materials. Waste generation for roof tiles can be broken down into four levels. The stages manage this content from the lorry to the sites, raising the roof tiles onto the wall, mounting and cutting to match the initial design. Due to the cutting to fit the size, the generation of roof tiles waste increases at the corner of a roof as compared to the centre. The causes of the waste generated from roof tiles can be summed up. The Taman Ilmu, Taman Seri Akasia and Seri Putera waste generation (WGR) rates (1.502, 1.988 and 1.354 kg/m²; 5-10 per cent). WGR is based on the total waste data separated by the total field of operation for each location. Based on the CIDB Report [7], the roof tiles waste value is approximately 5 per cent.

3.5. Sanitary and Drain Fittings
The installation work for pipe and sanitary fittings starts at the early stage of the project. Before the slab is concreted, the piping and sanitary pipe are installed at their correct position. Normally, the pipes for water and sanitary may be damaged during concreting or formwork activities. Cutting and handling waste is part of the waste contribution for the pipe and sanitary fittings. Involvements of skilled workers and proper monitoring are part of the factors that may reduce the pipe and sanitary fitting wastes. Based on the CIDB Report [7], it mentioned on the PVC pipe material of wastage, which is the wastage level, is about four to seven per cent.

3.6. Steel
Steel is the most valuable material used at construction sites. The steel waste was generated during the structural stage of construction. Steel is not considered as a waste because of the value of the material. The steel waste is collected and usually sold as a recyclable material. However, the recycled steel is sold at a lower rate. The control of steel waste is important during the cutting and bending activities. The use of skilled workers and management control is part of the waste control strategy that can be implemented. Based on the CIDB Report [7], it stated there are three types of material wastage during construction, which are reinforcement bar, wire mesh and steel formwork. The wastage level for the materials is about four to eight per cent, three to seven per cent and one to five per cent, respectively. Table 1 presents the summary of waste caused by material in Site Taman Ilmu, Seri Akasia and Seri Putera.
Table 1. Summary of Waste Causes by Material in Taman Ilmu, Taman Seri Akasia and Seri Putera.

| Materials          | Causes of Waste Generated                      |
|--------------------|------------------------------------------------|
| Concrete           | Poorly constructed formwork, Poor supervisory system, Improper Handling |
| Wood               | Cutting waste, Decay woods                     |
| Roof Trusses       | Poor Handling, Poor Installation, Cutting Waste |
| Roof Tiles         | Poor Handling, Poor Installation, Cutting Waste |

4. Conclusions

The research presents a realistic perspective of site waste implementation in Malaysian housing construction. The main kinds of waste, including concrete, timber, steel, roof trusses, roof tiles, and sanitary fittings are investigated individually in this research.

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