

6.0 Conclusion

For a conclusion, this study found out that the prefabrication method is the most efficient and effective method in waste minimization especially it did not generate or produce much timber waste compared to conventional waste. Therefore, there are still many improvement needed in adoption of prefabrication method in the construction industry. Waste index (debris) for Project A is the highest ($0.4702 \text{ m}^3/\text{m}^2 \text{ GFA}$) followed by Project B ($0.2479 \text{ m}^3/\text{m}^2 \text{ GFA}$) and Project C ($0.1494 \text{ m}^3/\text{m}^2 \text{ GFA}$).

There are three main type of materials usually consists in construction waste generated at construction site. They are steel, concrete and timber. Timber is the main construction waste produced in construction site which adopts conventional method (Project C) whereas there is no record for projects adopting prefabrication method (Project B and Project A) steel waste generated at Project A (prefabricate method) is the highest **3.6228 x 10 %** ,followed by Project B (prefabricate method) and Project C (conventional method) **6.80%** and **4.9826 %** respectively. This research found that steel wastes are generated because of excessive order, error calculation, cutting error due to the unplanned design changes and unusable pieces when the steel bars are cut.

Mechanical problem such as tower crane breakdown, mechanism of concrete pump and hacking off concrete are among the main sources contribute to concrete waste generation at construction site. Size of building project also affects the amount of wastage level and waste index. For example, Project A and Project C are both commercial building projects but the wastage level of steel for Project A is higher than Project C. This is due to the size of project where the size area of Project A is bigger than Project C.

Recycle and reuse materials are one of the best alternatives in minimizing waste generation at construction site. For steel waste, even though it is required a lot in construction project and wastage level generated from it is high, but this material can be recycled or reused.

Steel waste can be reused for another projects or returned to the vendor for recycle. Other material which has the potential in recycling activity is cement packaging, scaffolding, bracket and air conditioner conducting. However, for cement packaging, only high quality of packaging of cement can be recycled such as Sika brand.

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Finally from this study, it can be concluded that the formula/calculation of Poon et al., (2001) is the most suitable to be applied and used for measurement of waste quantification in Malaysian construction industry.

6.1 Recommendation

In practicing sustainable development to preserve environment in a long term, it is advised that all construction projects should use recycle product such as SIKA brand (cement) and PERI formwork that can be recycled 10-15 times.

Plastic packaging which is still in good condition must not be disposed along with debris. It should be given back to supplier for recycle or reuse in project site for other purpose such as protector cover.

Subcontractor should be provided with training and seminar to provide them with information about construction waste management skill and build environment awareness so that, they will be more alert and make less technical mistake when handling materials in order to avoid production of construction waste during their work such as doing cement mixing.

All construction contractors in Malaysia should be recommended to use steel forms or PERI formworks instead of timber formworks. This is due to the durability of the steel forms, because they can be reused over 100 times for the next project and scrapped for recycling. Besides, steel forms can produce a better quality of concrete works compared to timber formworks. Even though the cost to purchase or rent the steel forms is much higher than timber, but it can be cheaper in long run particularly with their recycling potential. CIDB may be able to encourage contractors and to support the contractors to apply steel forms instead of timber forms.

Subcontractors who are responsible to purchase new construction materials themselves are advised to be in charge of the cost of both purchasing new materials and disposing any waste material from their construction activities. This will give them a direct financial incentive to use materials efficiently with minimum wastage level.

Regular inspection and scheduled maintenance service at tower crane should be emphasized by all contractors. This can avoid high amount wastage of concrete deposited at construction site.

6.3 Limitation of study

- 1) Essential data that need for calculation of construction waste not usually can be gained from project sites. This is due to the fact that quantification of waste is not under Quantity surveyor scope of work or there are no officer assigned to manage the entire construction waste disposal at construction site.
- 2) Each project site cannot provide standard information and data for calculation of construction waste such as cumulative order quantity and cumulative workdone for each material. Some sites can give the details of the data needed by monthly but some can just give the overall data. This will make it difficult to evaluate the quantifications waste precisely according to the phases or construction activities. Therefore, only overall comparison can be made.

- 3) Each project has different data record keeping system even though the projects are conducted (undertaken) by same main contractor. Most data such as cumulative order quantity are keeping by subcontractor and sometimes the data needed seems like private and confidential and difficult to obtain.
- 4) Only three construction materials such as timber, concrete and steel can be observed at these sites because data for other materials are not recorded.
- 5) During the research and data collection period, only one building project that used conventional method is available to observe. This has limit the data and comparison for construction waste generation using conventional method which should be gained from at least two projects site.