5.1 Comparison of waste index between Project A and Project B

Waste index is referred to amount of debris that was collected by licensed contractor for disposal at landfill divided by gross floor area (GFA) of the project. Both Project A and Project B adopt prefabrication method in construction activities but Project B is construction for residential building whereas Project A is a construction of commercial building. The data analysis from Figure 5.1 showed that waste index at Project A which is a commercial building is two times higher than Project B which is a residential buuilding. The values of waste index for Project B and Project A are 0.2479 m^3/m^2 GFA and 0.4702 m^3/m^2 GFA respectively.

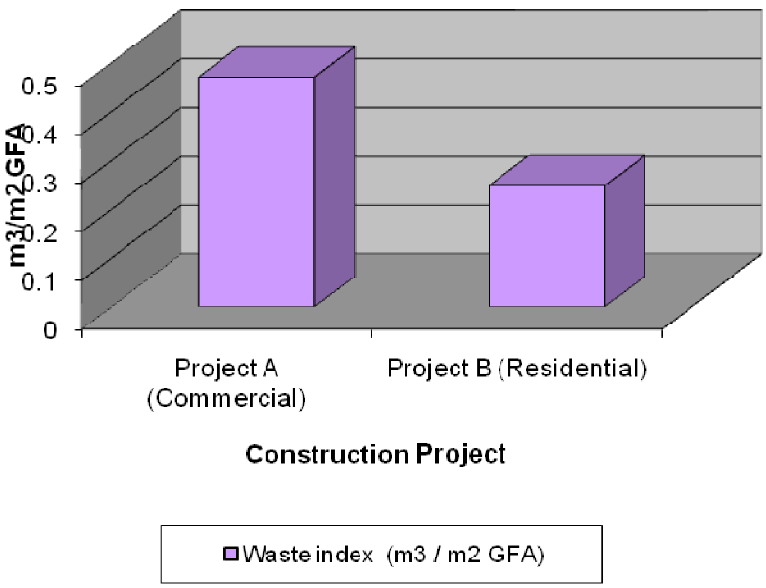

Figure 5.1: Waste index between two types of project with different type of building

From a research conducted by Poon (2001) on construction of commercial office and private housing projects which use prefabrication method revealed that waste index for both projects are 0.200 m^3/m^2 GFA and 0.250 m^3/m^2 GFA respectively. Therefore, from the comparison made using the data from this study and data from Poon (2001), it can be concluded that the value of waste index generated for Project A which is a commercial building (0.4702 m^3/m^2 GFA) is two times higher compared to waste index of commercial building in Hong Kong. As for the value of waste index at Project B which is a residential building (0.2479 m^3/m^2 GFA) it is slightly similar to waste index value of residential building in Hong Kong.

From data analysis, both Project A and Project B have different sizes of gross floor area (GFA). Project A has 2.51 acres with 39 storey while the size project Project B has 1.58 acres with 7 blocks, 21 storey and total 105 units. Size area of Project A is bigger than Project B. Consequently, Project A which is a commercial building and has bigger size area generates more debris compared to Project B which is a residential building and has smaller area project. According to Laeur (1993), there are many factors contribute to the variation of waste index such as structure type (e.g., residential, commercial or industrial building), structure size (e.g., low rise, high rise) and construction activities being performed. Therefore, the waste index results for Project A and Project B are different due to the differences of building structure type and size of GFA. For that reasons, it can be concluded that, size area and structure type of construction project are among the factors that influence amount of waste generated and percentage of waste index although both types of project adopt same methodology of construction.

Besides, storage method also is one of the factors of waste indexes generated at site. Project B generates less waste index compared to Project A. This is due to the storage construction material method at Project B. As mentioned earlier, storage material system at Project B is the best and effective system compared to Project A. Project B makes use of their basement floor to place all the construction material. Therefore, all the construction materials at Project B are stored in good condition and being covered. As a result, there are less damaged construction materials at Project B, indirectly give less amount of debris generated at Project B.

5.2 Comparison of wastage level between Project A and Project B

There are only two materials selected for wastage level calculation in this study for Project A and Project B which are steel reinforcement and premixed concrete. These two materials are selected because of two factors. Firstly, both materials are among the categories of materials that have a higher percentage of waste. Secondly, both materials are mainly used during the same stages of work (structure).

According to Poon (2001), recommended allowable wastage for both materials concrete and steel is only 4%. Figure 5.2 showed that the wastage level of concrete waste generated at Project A which is commercial building is 6.7609×10^{-4} % whereas for Project B which is a residential building is 2.69%. Wastage level for steel waste at Project A and Project B are 3.6228 x 10 and 6.8% respectively.

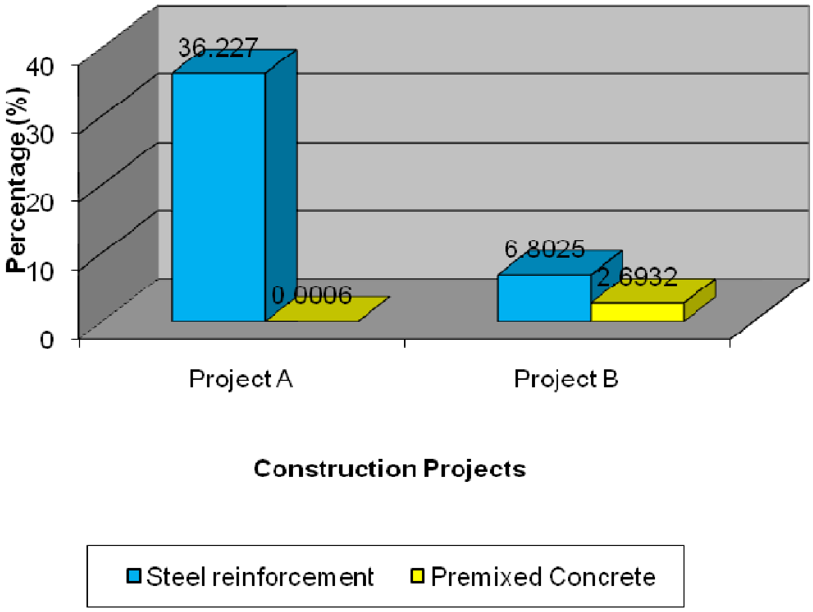

Figure 5.2: Wastage level of material between two types of project with different type of building

Based on the result, the wastage level for concrete for both project sites is acceptable where the percentage of concrete wastage is below 4% whereas, for the wastage level of steel reinforcement at both projects are surprisingly high and exceeded the allowable wastage (4%). However, most of steel reinforcement waste are reused or recycle in the next project or sold to the vendor to be remold. Furthermore, this type of waste gives less impact to environment compared to the other construction materials. From site observations and interview, concrete waste generated at Project B which is a residential building is due to huge extra order caused by calculation error and also technical mistake made by the site management. This is as shown earlier in Table 4.8 (Chapter 4)

However, concrete wastage level generated at Project B is still below allowable wastage limit. One of the quantity surveyors involved in this project revealed that each and every material ordered is normally will be counted ± 5% from the exact needed amount. This is conducted just as a safety precaution to prevent shortage of raw materials at site. Hence, better planning is needed to avoid the wastage from huge extra order in the future project.

5.2 Comparison between Project A and Project C

Project A and Project C adopted different method in construction activities in which Project A adopts prefabrication method while Project C adopts conventional method. However, both projects are classified under same type of building projects which is commercial building. Early assumption predicts that, Project A which is a commercial building adopts prefabrication method will generate less construction waste (debris) than conventional Project C which is a commercial building adopts conventional method. . However, from Figure 5.3, the result showed that waste index in project A is four times higher than project C. The values of waste index for Project A and Project C are 0.4702 m^3/m^2 GFA and 0.1494 m^3/m^2 GFA respectively.

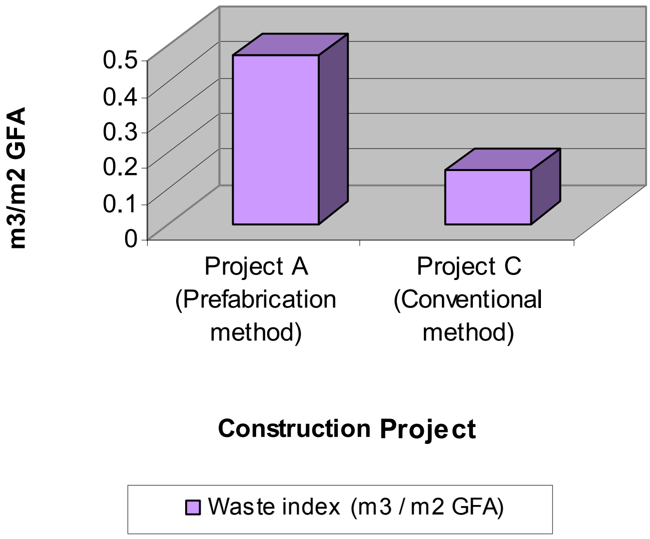

Figure 5.3: Waste index between two types of construction project with different method

Waste index for both projects, Project A and Project C showed that the different is four times higher while differences in percentage of waste index between both project is 68% which is surprisingly high. If compared to a study conducted by Poon (2001) for Hong Kong commercial building project which adopt prefabrication method, the waste index generated is only 0.2 m^3/m^2 GFA. Waste index calculation depends on the total number of loads of waste disposal. During this study, the trucks loads for waste disposal for Project A and Project C were 1015 and 156 trips respectively. The numbers of trip trucks loads are different among project sites because it depends on the construction activities and it is one of the factors that contribute to the differences of waste index for both projects. Generally, the total numbers of truck loads of trip explain the amount of debris dumped by the subcontractor from the projects. Increase in total of trips means a lot of debris is being generated by the construction activities.

However, size of project also is one of the factors that contribute to debris generation on site. Gross floor area for Project A is bigger than Project C. Therefore, waste index for Project A is higher because it generates more debris. This phenomenon can be related to the truckloads trips as mentioned earlier.

Design of the building is also one of the important variation values factor. Project A design is more to esthetic rather than Project C which has a standard design. This is supported by Hylands (2004) who identified that standardization of design for a building which can improve build ability and at the same time can reduce the quantity of off-cut activities on site. While Osmani et al., (2007) found that, the architects agreed that waste is a significant concern in construction but view of waste minimization is often a low priority in the design of projects.

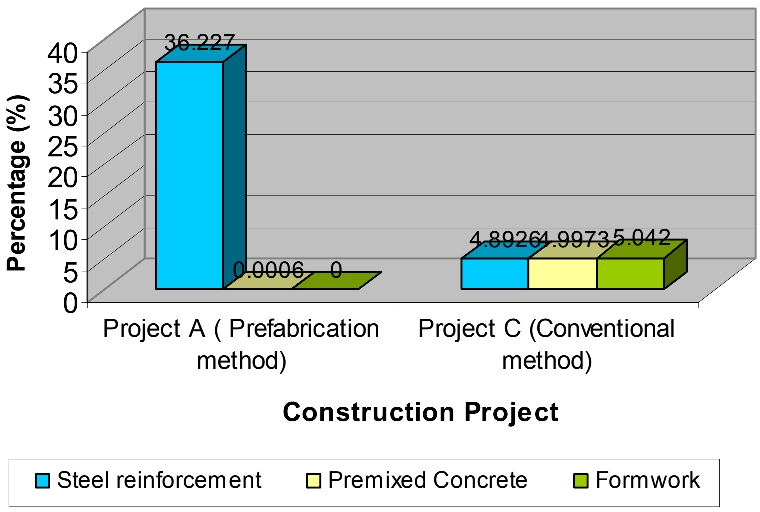

Figure 5.4: Wastage level of material between two types of construction project with different method

The Figure 5.4 shows the wastage level of concrete at Project A which adopts prefabrication method is much lower than Project C which adopts conventional method. Project A generates 0.0006% wastage level of concrete, while Project C generates 4.9973%. Moreover the wastage level of steel at Project A is nine times higher than Project C which is 36% for Project A and 4.8826% for Project C. As mentioned earlier, the wastage level of steel reinforcement at Project A is higher due to the error calculation and excessive order. While the wastage level of concrete waste generated at Project A is four times less than Project C. High generation of concrete waste at Project C is because of the technical problem due to the often breakdown by tower crane during concrete pouring process. In addition, adopting prefabrication method in Project A can enhance the quality levels of furnished products and less concrete waste generated during the concrete works.

However, size of project also can lead to the differences of wastage level for steel waste at Project A. Project A is 39 storey building with the aesthetic design, consequently it is the factor to the over ordering and error in calculation compared to Project C which is 30 storey building with a standard design. However, there is no data on formwork timber waste at Project A because Project A adopts PERI formwork compared to Project C which adopts conventional method. From the result, Project C generates high percentage of wastage level for timber formwork which is approximately over 4%. Moreover, the wastage level of timber formwork is the highest compared to both wastage level of concrete and steel at this project.

5.3 General comparison on wastage level of material among Project A, Project B and Project C.

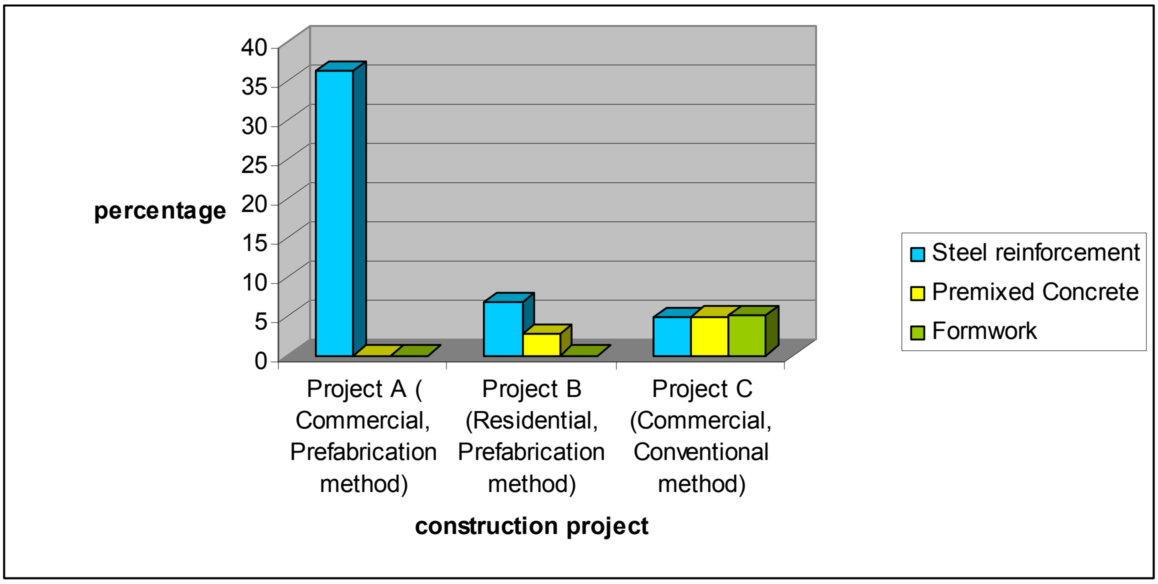

Figure 5.5: Wastage level of material at three construction projects

Figure 5.5 presents the main result of the percentage of waste for each site. The result indicates that there was a small variation in waste indices at different sites for the same material, but the wastage for steel reinforcement at Project A was nearly six times higher than Project B (Table 4.3). It was found that Project A has a good performance in controlling the waste of concrete, but poor performance in the consumption of steel reinforcement. In contrast, it was found that Project C had a good performance in controlling the waste of concrete and steel reinforcement. Result at Project A indicates that those contractors are able to control the waste of concrete, but are not able to extend this control to all materials on site. It can be concluded that the wastage level generated is still in allowable wastage level which is 4 – 5 % for concrete waste.

In this study, only Project C adopts conventional method in construction activities. The result shows that wastage level of formwork is about 5% compared to Project B and Project A which adopts prefabrication method, there is no record for wastage level for timber formwork because both project sites use PERI formwork in construction activities which can be reused 10 – 15 times casting compared to timber formwork only 2-3 times casting before it damaged (refer Table 4.5 in chapter 4)

Overall, these three sites show good performance in controlling the waste of concrete because the percentages of the concrete wastage are slightly the same; Project A 2-3%, Project B 0-1% and Project C 4-5%. According to Poon (2001), the average wastage level for concrete is about 4%, which is normal. However, it could be reduced to 3% if correct and proper handling of material at site is applied. Good performance was shown by these sites due to relatively high cost of the material used (refer Table 4.4 in chapter 4). In contrast, according to Carlos et al, (2002), most construction companies in Brazil assume that the waste of premixed concrete is minor.

From the results, it can be summarized that construction method, size of projects, type of building, construction activities, storage method system, human error and technical problem are the factors that can affect the amount of waste index (debris) and amount of wastage level generated at construction sites.

The calculation of waste index and wastage level of material are important element and should be emphasized more in construction industry in this country. Amount of waste index and wastage level of material construction generated for a construction project depend on various factors. Based on this study, as mentioned earlier, it can be concluded that construction method, size of projects, type of building, construction activities, storage method system, human error and technical problem among the main factors that identified in contributing to the generation of higher amount of waste index and percentage of wastage level for this study (Figure 5.6).

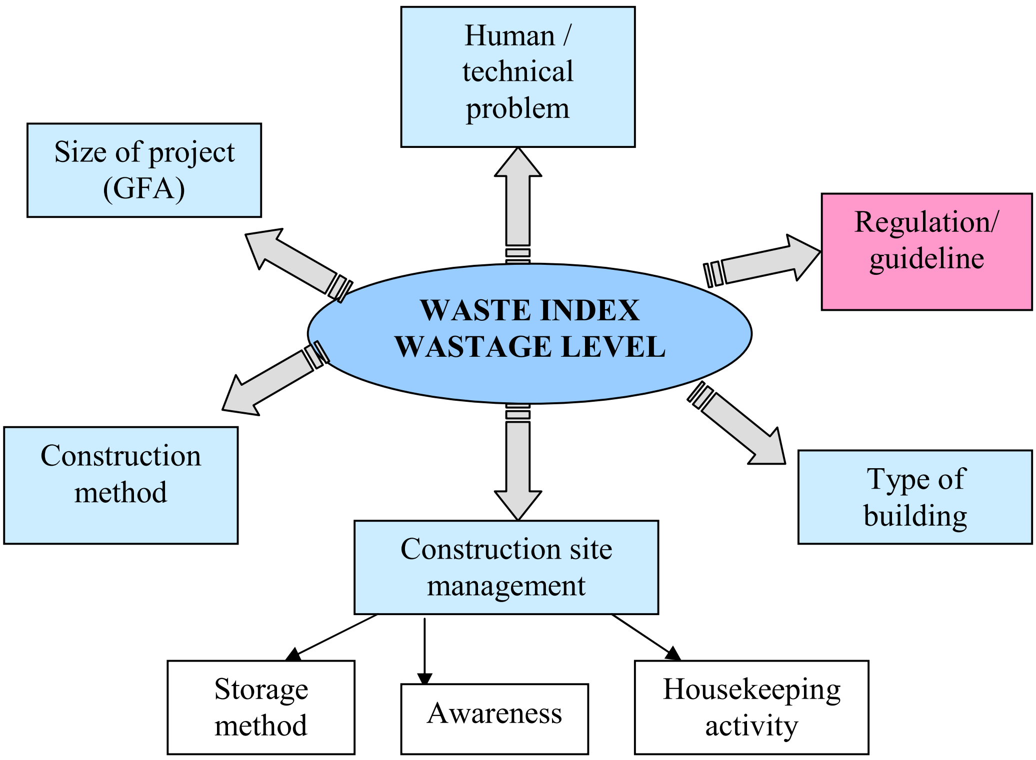

Figure 5.6: General factors affecting of waste index and wastage level on site

Identification of the waste index value for a construction project, indirectly we can know all the process and activities that were conducted at construction site are properly managed or otherwise. Construction site management is one of the element/ aspects that should be emphasized because it is one of the major sources of construction waste.

From author's view, workers and contractors in this construction industry are lack of awareness towards the importance of environmental conservation. Construction project costs become their main priority. For example, materials that had been separated at each floor during the housekeeping activities shall end up in a bin along with debris for disposal. Normally each project site only has one bin ($3m^3$) for debris disposal. This clearly shows that there is no material segregation activities conducted neither inert nor non inert waste. During the housekeeping activities only few materials are reused or recycled such as packaging of cement, air conditioner conduit, steel, plywood and others. Segregation activity conducted in order to identify waste material that should be moved down either through rubbish chute or tower crane/fork lift.

Regulation / guideline which are highlighted in pink (refer Figure 5.6) is another one aspect that can be considered as a factor contributing to the waste index and wastage level generation at construction site. It should be looked into to prevent and overcome this problem. In Malaysia, there are still no specific regulation and guideline related to construction waste. This regulation can guide the contractor to manage their site management towards environment. Moreover, this is also important for subcontractors conducting waste disposal activities because with new regulation and guideline, they will be alert more and illegal dumping activities can be avoided. If all parties are concerned about the implication amount of waste index and wastage level generated on site, this industry can support a lot of benefits towards other stakeholders such as government, contractors, public and the environment.

5.4 Benefits of this study

Proper and well management of construction waste can benefit our government in many ways. Without an efficient construction waste management, waste generated from construction site will be disposed at landfills, therefore contributing to the increase of waste at landfills. Construction waste management can reduce the amount of construction waste generated and indirectly will help government to minimize utilization of existing landfills without opening new landfills. Furthermore, this can reduce the cost for government to open the new landfill. In addition, the practice of construction waste management in Malaysia will help our government to create new jobs to people in this field. This also can show the world that Malaysia government is concern to the new technology and can be such as good example to the country in South-East Asia and indirectly can educate Malaysian about the importance of construction waste management for a long term impact. Indeed if we fail to manage construction waste properly it will contribute to the economic loss.

For contractors', they can save up their expenditure by practicing good construction waste management. Construction project cost can be reduced for the aspect of waste disposal and cost of purchasing new material by implementing recycling material at site. Practicing a proper construction also means the contractors are adopting a new effective constructions method and this can give contractors a positive image to the country and the community as a company that can manage construction waste efficiently. By well managing construction waste also can assist the contractors in stimulating the development of green technology for their construction activities.

Construction waste minimization also means more waste from construction site is recycled. Recyling of construction waste not only can reduce the cost for purchasing new materials but at the same time it also can conserve energy and land. Energy can be conserved by manufacture products from recycled materials instead of using a virgin one. This also can support the lifespan of landfills because recycling can reduce the amount of waste disposed at landfills. Moreover, not only energy and land conservation, construction waste minimization can also preserve natural resources. For example, the prefabrication method which uses PERI formwork compared to conventional method that use timber as their formwork. Adopting the new methodology can reduce the impact of global warming and reduce emission of green house gasses, thus it can prevent air and water pollution indirectly.

Construction waste production can contribute to contamination of hazardous and non hazardous chemicals. Hazardous chemical consists of organic compounds and heavy metals resulted from construction materials or improper disposal of demolition waste. Meanwhile non hazardous chemical which consists of chlorine, sodium and ammonia could be leaching from construction and demolition waste materials.

Nevertheless, these two types of contamination can affect surface and groundwater quality which is important in human life. Contamination of groundwater will affect not only to human health but also the environment.