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Transportation and Cost Issues in Modular Construction for IBS (Industrialized Building System)

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Abstract
Modular construction (MC) is one of the IBS construction method which can improve the quality of product, reduce the construction cost and reduce construction period. But the usage is still lack in Malaysia due to issues arise in handling and managing the MC. Most of the issues are related to transportation and cost. Due to this, the aim of this research is to improve the transportation and cost issues in managing the MC for IBS industry. In order to achieve this aim, the objective of research is to investigate the transportation and pertinent cost involved in MC, to identify issue related to delay in delivering the component to site and to suggest a way to overcome the issues and problems related to it. Scope of this research are focused on construction player in Selangor since Selangor is the most develop state in Malaysia. All data are collected from journal and questionnaire survey that has been responded by randomly selected construction player that involve in managing the modular component. The results revealed that long distance between factory and site will increase the risk of cost and safety of transportation. In conclusion, proper planning in estimating the distance and delivery time of MC system is the key for success.

Keywords: Modular Construction, Transportation, Cost

Introduction
Industrialized Building Systems (IBS) is a construction process where the building components will be produced in or on the premises, transported and assembled using the appropriate machines and equipment on site with minimum personnel. Modular construction (IBS) in Malaysia could be a new innovation that contribute to sustainability and improve the safety of the site within the built environment. But incorrect manufacturing, handling, transporting, managing, mounting and assembling the components on site, will give a big problem or failure in IBS systems. This can be due to the factor that (Thanoon et al., 2003) highlighted in which the completely prefabricated construction system requires high building accuracy.
Problem Statement
Transportation is one of the main important things in handling and managing the modular construction to transport or delivery it to site. The big size of component lead to several problems that faced by construction industry. Based on Ang & Kasim (2013), because of the large size of the component, transportation may require a large machinery and equipment to transport and move the component from manufactures to the site. Some routes have become difficult to navigate or adhoc improvements must be made. Besides, the cost of maintenance and operating also will be highly increase (Azman et al., 2011). This is one of the factors that make contractors’ afraid in dealing with IBS construction instead of the conventional construction. Damage to the modular components is another common problem that occurred when transporting it to site. This is the risk and cost. The defected component either can still be repair and use or rejected since it cannot be used anymore. And the cost, time and process of repairing and dealing with damage components on-site will increase (Pasquire & Gibb, 2002). Delay in delivering to site is another common big issue in modular construction. This may cause a loss of operating time for installation (Nor et al., 2018). And lead to late of project completion and increase the cost of construction (Nor et al., 2018). This is maybe due to poor planning, poor coordination, and poor management of IBS components.

Aim and Objectives
The aim of this study is to improve the transportation and cost issue in IBS modular construction. In order to achieve the aim, the objectives of study are:

- To investigate the transportation and pertinent cost involved in Modular construction
- To identify issues related to delay in delivery of modular components
- To suggest and recommend the way to reduce the transportation and cost issues in managing the modular construction system

Scope of Study
This research will focus on construction players that involve in handling and managing modular component in Selangor. This research will be evaluated based on their experience and perspective regarding the issues in transportation and delivery process which is by using the quantitative method. 200 respondents will be involved in this study and it is the randomly selected from any construction players in Selangor.

Literature Review
IBS is characterized as a technique in which components are manufactured and managed off site environment, transported, positioned and installed in a structure where the additional work is minimal (Hamid et al., 2008). The Industrialized Building System was introduced in the post-independent system since the early 1960s. According to Kamar et al (2012) construction has begun using IBS as a way to improve productivity and quality, reduce the safety and health risks of workers on site, reduce the problem of dependence on foreign workers unskilled and skilled workers, and achieve the enormous aim of reducing overall construction costs. The government initiated its first IBS projects following a 1964 visit (Din et al., 2012), in order to cut down the time required for delivery and to build affordable and high-quality houses. The project is on 22.7 acres of land at Jalan Pekeliling, Kuala Lumpur. The project consisted of 17 storey of seven blocks of 3,000 apartments and 40 stores. The ‘Danish’ system is a large panel pre-fabricate concrete walls and planks have been applied to the work of JV Gammon
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and Larsen and Nielsen in this project. The duration is from 27 months, including the construction of the casting yard, between 1966 and 1968. Since then until now, many construction players had used IBS components as an option for their project. And, there are many types and categories of IBS available nowadays.

Modular Construction

Modular construction (MC) is one of the popular IBS systems that being used today. According to (Musa et al., 2016), modular construction is a construction method to construct a building using three-dimensional or modular units, which are assembled and produced in a factory. Modular construction is a three-dimensional or room unit that is built using the same materials (light gauge steel frame, timber frame, concrete, and composites) and designed to the same standards. The three-dimensional or room units may form complete rooms, parts of rooms, or separate highly serviced units such as toilets or lifts. The three-dimensional units are fully fitted out before being transported to the site and stacked onto prepared foundations to form buildings. Modular construction speeds up the project construction schedule, reduces wastages, enhances the quality of building products and promotes sustainability.

Musa et. al (2016) said, the three-dimensional units have to be mass produced identically (multiple repeated units) with the same design and materials in a plant in order for modular construction to be economic and cost-effective. Further reduction in commissioning, defect and low repair costs is achieved by modular construction. The quality materials and use of QA / QC management can be obtained. Moreover, cost saving can be obtain by decreasing the amount of waste on site since its factory based and environment controls. The usage of MC also can reduce the reliability for foreign construction workers by removing about 80% of the building activities at the site. According to (Aziz & Abdullah, 2015), such offsite buildings make the solution cost-effective and fast.

Advantages of Modular Construction

Based on the research made by Musa et. al. (2016), he stated that there are 6 characteristics of modular construction that gives benefits to the construction industry. Those are

1) High-quality, identical three-dimensional or room size volumetric units

According to (Musa et al., 2016) Identical or standard three-dimensional or volumetric units in room size is the main feature of the modular building. The volumetric units are made of mass in a controlled factory and production plant that produce high quality and less waste modules. Moreover, Aziz et al (2015) also added that quality of material is better than conventional building because it is not affected by weather conditions. As well as manufacturing facilities or plants with individual inspections and testing protocols, there are rigorous quality assessment programs or quality control programs (QA / QC), to promote a high quality of buildings. The production of modular units at the factory, on the other hand, at every stage produces less waste.

2) Faster project schedule Modular construction

According to (Musa et al., 2016) The modular construction takes away the building site mostly during the construction phase. Slow, less productive plant activities are replaced by quicker and efficient plant processes. Modular buildings are constructed at the same time as construction sites, allowing projects to be completed in half the time of the traditional
method. Off-site construction also means that construction process is much less vulnerable to delay due to poor weather conditions (James, 2019)

3) Encourage sustainability in the construction surrounding
There are many regulations to reduce environmental impact had been enforced by the government but not all construction parties are followed to it (Lee JH, 2019). So, off site construction of modular units can be the best solution to encourage sustainability in the construction surrounding. In a controlled environment such as a factory, production of modular units and building can minimize environmental impact, reduce waste, decrease site activity and disturbance significantly and promote sustainability inherently. The modular design reduces demand for raw materials and reduces the energy required to create a building on site.

4) Systemization and storage
Modular construction can reduce the labour and material cost (Musa et al., 2016). The transportation of modular units is also subject to the country’s road department. Due to the size and weight of modular unit the logistical transport and the installation need to be planned early. A just-in-time (JIT) delivery schedule (James, 2019) should be implemented and it is not recommended or practical to store the units on site before erection. The units must be installed in the desired location immediately upon their arrival of the modular unit.

5) Safety
The usage of MC also can reduce the number of fatal injuries in traditional on-site construction. This is because, the workers work in a controlled setting (off site/factory) and are not exposed to the hazards of extreme weather and other construction site dangers such as those related to noise and air quality.

6) Ease Reconstruction
Modular construction facilitates redesign work or renovation work. Select the appropriate three-dimensional or modular units for the redesign plan and install them on the present building afterwards (Musa et al., 2016). It can be removed, renovated, and relocated for new use to another place.

Methodology
A collection of data analysed in this paper is obtained through literature review from other authors in the aspect of handling and managing the modular construction in Malaysia. Secondary data such as books, articles, journals, newspapers, web page, reports, thesis, and conference proceeding were also the sources of information of this paper. Primary data is gathered through questionnaire survey that had been distribute to more than 120 numbers of construction player that had an experienced in dealing with MC unit. The analysis attempts to review the definitions, characteristics, issues, and factors that contribute towards the transportation and cost of modular unit.

Analysis and Findings
From the questionnaire survey that had been done online, all data collected will be analyse and discuss in several sections. Which are (1) Transportation and Cost Factors Involve in Modular Construction, (2) Issues Related to Delay In Delivering the Modular Components (3)
The Suggestion and Recommendation to Reduce The Transportation and Cost Issues in Managing The Modular Construction System. The responds rate of survey is 55.8% and most of the respondents are construction player that had an experienced in handling the MC.

Transportation and Cost Factors Involve in Modular Construction

| NO | TRANSPORTATION AND PERTINENT COST IN MODULAR CONSTRUCTION | MEAN   | STD. DEVIATION | RANK |
|----|-----------------------------------------------------------|--------|----------------|------|
| 1  | Modular construction required a lot of heavy crane for lifting | 4.2985 | .75908         | 3    |
| 2  | Modular construction required high skill and expert workers for erection and lifting | 4.2985 | .60340         | 4    |
| 3  | Transportation of modular construction required expert and skill driver | 4.2687 | .75040         | 5    |
| 4  | Modular construction requires a lot of larger truck or lorry for transportation | 4.3433 | .64084         | 2    |
| 5  | Long distance of site will increase cost of the transportation | 4.3881 | .65030         | 1    |
| 6  | Transportation of modular components increases the maintenance of lorry/truck/trailer | 4.0896 | .82996         | 7    |
| 7  | Transportation of modular component increases the cost of lubricant and fuel | 3.9851 | .89599         | 9    |
| 8  | Large machinery and transport used lead to the changing of site design | 3.8955 | .87272         | 10   |
| 9  | Transportation require special escort during delivery for safety purpose | 4.0448 | .80590         | 8    |
| 10 | Route restrictions and permitting required to transport the modular component | 4.2388 | .65342         | 6    |

Issues Related to Delay In Delivering the Modular Components

| NO | ISSUES RELATED TO DELAY IN DELIVERY OF MODULAR COMPONENTS | MEAN   | STD. DEVIATION | RANK |
|----|----------------------------------------------------------|--------|----------------|------|
| 1  | Lorry has a technical problem during delivery            | 3.7761 | .99728         | 9    |
| 2  | Lorry was used to supply materials to other company      | 3.6716 | .94369         | 10   |
| 3  | The problems of transportation arise due to traffic accidents during transportation process | 3.9701 | .85227         | 8    |
| 4  | Difficult site topography can be difficult to the delivery process | 4.2239 | .73487         | 2    |
| 5  | Difficulty to reach to construction site also become an issue among driver | 4.0448 | .76738         | 6    |
| 6  | Extreme weather condition will affect the transportation process | 4.0149 | .86151         | 7    |
| 7  | Late payment by client will delay the manufacturing process as well as delay the delivery of component to the construction site | 4.1642 | .80898         | 4    |
| 8  | Improper planning is the factor to the inaccurate time in delivery the component | 4.2687 | .68716         | 1    |
| 9  | Delay of delivery the component effected by roadway congestion | 4.1791 | .79631         | 3    |
Lack of communication and misunderstanding between different organization 4.1045 .87272 5

Ways to Reduce The Transportation and Cost Issues in Managing The Modular Construction System

| NO | SUGGESTION AND RECOMMENDATION                                                                 | MEAN  | STD. DEVIATION | RANK |
|----|------------------------------------------------------------------------------------------------|-------|----------------|------|
| 1  | Proper study and planning in estimating the delivery time of MC system.                         | 4.373 | .64751         | 1    |
| 2  | Strengthen the cooperation /relationship between contractor and manufacturers / suppliers       | 4.253 | .70374         | 5    |
| 3  | Improvement in communication and integration among the MC system players                        | 4.238 | .62980         | 8    |
| 4  | Type of lorry, crane and machinery must suit with the size / weight of MC system (not too big and not too small) | 4.253 | .70374         | 6    |
| 5  | Conduct training courses for MC system to improve skill and knowledge of industry players       | 4.238 | .65342         | 7    |
| 6  | Regular Inspection and checking to transportation plant and machinery to avoid any problems    | 4.313 | .72214         | 3    |
| 7  | Manufacturer should improve information technology (IT) to have a quality transportation process | 4.149 | .76384         | 10   |
| 8  | Manage the supply chain which will give better price and guarantee supply by manufacturer      | 4.179 | .73702         | 9    |
| 9  | Involvement of manufacturers and contractors at the early stage (design stage)                  | 4.268 | .56628         | 4    |
| 10 | Strict quality control and close monitoring during the process of transportation, erection and installation | 4.328 | .72589         | 2    |

Conclusion and Recommendation

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Please use the pre-defined styles for headings. First heading: Times New Roman, bold, 12 pt, before 13pt, after: 13pt. Second heading: Times New Roman, bold, 12 pt, before 10pt, after: 10pt

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Fonts

Papers should use 11-point Times New Roman font. The styles available are bold, italic and underlined. It is recommended that text in figures is 10 pt.

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Table 1

| Title of Example Table |
|------------------------|
| Header | X | Improved |
|-------|---|----------|
| Item  | 4 | Yes      |
| Item  | 2 | Yes      |
| Item  | 4 | Yes      |
| Item  | 3 | Yes      |
| Item  | 2 | Yes      |
| Item  | 2 | No       |

Figure 1 Verification, Validation and Qualification

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Equations should be typed with indent 1.27 pt, and numbered consecutively starting with (1) set flush right. To set the style, type **Equation** in the **Style** box, or from **Style Menu**. But this style only sets the tab stop position. To put the equation to the right just press the **Tab** button one time. And to type the equation number, press the **Tab** button once again from the right side of the equation.

\[
K_r = \left(1 - \frac{R^2 \tau}{\epsilon_\alpha + v \tan \delta} \right)^4 k_1 \tag{1}
\]

For numbering, use ordered numbers (1), (2), (3), and so on. Do not order by Chapter i.e (1.1), (1,2), (1,3). For referring an Equation in the body text, please use “Eq. (1)”.

References

References in the text should be designated by brackets and should be constructed from the names of the first and second author and the year of publication, e.g. Setiawan (2009); Zhao and Dittrich (2009); Smith et al (1983), or if the author is referenced in the running text like “... already at the beginning of the 20th century, Dewey (1916) stated ...”. The references should be ordered by the last names of the first authors. For how to write the references please see the examples in the References section of this template is based on APA style.
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