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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

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 / volumetric units are fully fitted out before being transported to the site and stacked onto prepared foundations to form buildings. Below is the summary of the manufacturing process of modular units at the factory before being delivered to site.

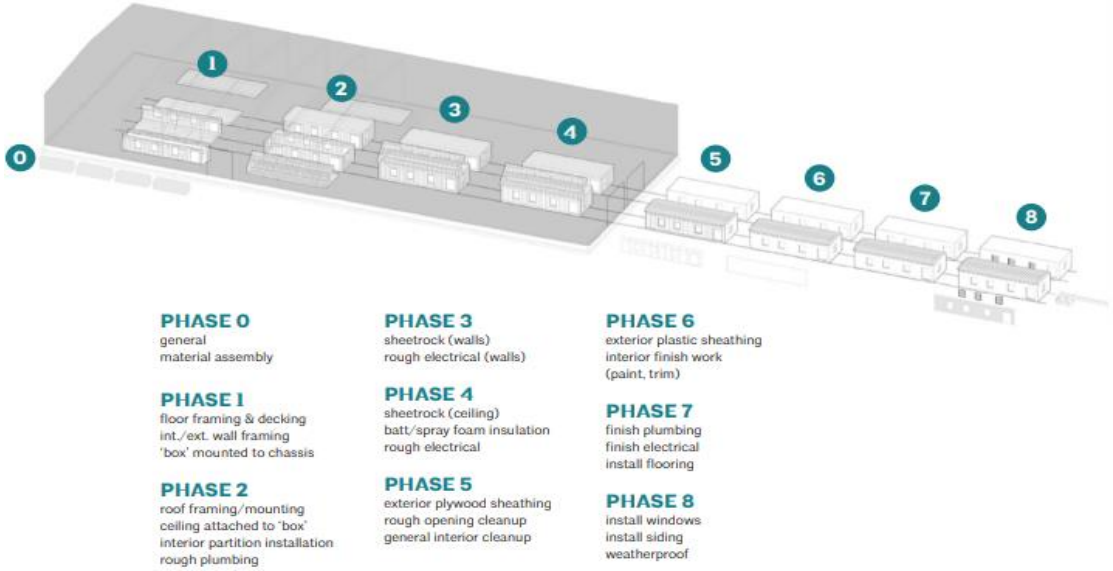

Figure 1: The manufacturing process of MC (Sources: Wilson (2019) Materials Practice Guide Modular Construction)

Figure above show the common general sequence of manufacturing the building modules, different manufacturers may have different process / works involve. Musa et. al (2016) said, the three-dimensional / volumetric 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.

Modular construction speeds up the project construction schedule, reduces wastages, enhances the quality of building products and promotes sustainability. 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 obtained 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, 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.

Transportation of Modular Units to Site

In order to ensure that the crane can easily erect and transport the MC to the site, the significant value for each component of pre-cast concrete of MC should not exceed 7 ton. Heavy duty cranes are hard to find in Malaysia. The radius limited to modular components being transport to site is 50 km. Meanwhile, the study made by Warszawski (1999) on the suitable distance from the new potential development area to the fabrication plant should be the distance with a variance from 0km to 100km. In addition to the effectiveness of the distance to transport the IBS part to the site, pre-cast concrete should also be available in partial dimensions in which 'plug and play' can be used to convert large-scale pre-cast concrete. The principal reason why the MC producer opts to produce partial sizes of pre-cast concrete is to increase the efficiency of the construction, make it easier to transport it to the building/site and reduce costs to hired transport.

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

For the first section, (base on table 1.0 below) it shows that some of the possible factors that related to transportation that could give significant impact towards the cost of using modular construction for a building.

Table 1
Transportation and Pertinent Cost 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

Base on the table below, the highest mean score is on the item no 5 (4.3881), which is more than 90% of the respondents agree that the long distance between the construction site and the manufacturing factory is the main factors that could contribute to the high cost of MC. The long distance from the factory to the site leads to delivery delays and becomes a transport problem. Long distance from the site may take long to reach the destination and increase transportation costs directly (Oleiwi et al., 2010).

Factor that rank no 2 is on the modular construction requires a lot of larger truck or lorry for transportation, with 4.3433 mean score. This absolutely will increase the overall cost of project due to the low availability of large truck and the high pay of the driver itself. So, in order to avoid this situation from happen the manufacturer tend to produce partial size for components to save the transportation cost of size truck, enhance the effectiveness of erection, suitable weight to carry, easy transport to the site construction and economic value crane to erect the component. Rank no 3, about 87% of the respondents agrees that modular construction required a lot of heavy crane for lifting. Base on Azman et al (2011), contractors must also decide volumetric unit base on the appropriate weight crane. The safety and proper erection are necessary in order to ensure the units is not faulty, and that high precise installation is essential.

And the rest of factors that rank from no 4 to 10, most of it also have a high mean score; which is above average (3). So, it can be concluded that, all the transportation issues above is the main driving force and restriction in the utilisation of MC. It is fundamental to have a proper planning on the mechanism that will use for carrying the heavy load of MC and for making a clear width measurement to pass the federal road and travel through the city road and its low

density area (Azman et al., 2011). This is an important part of the transportation network. Jabar et al (2013) also stated that transportation issues are including problems relating to the size and weight limitations, routing limits, enabling and availability of lifting equipment. When the components reach the construction site, additional elevator planning is required. Considering transportation, the units design, cranes and availability of the design will have an impact on construction schedules.

Based on (Nawi et al., 2011), the majority of IBS manufacturers are located in industrial areas like Klang Valley, Seremban and Butterworth. Within a construction project budget, this situation would indirectly increase the cost for logistics and transportation if it is located far away within rural areas, particularly the northern and eastern coastal regions of Malaysia. In light of this, the unfortunate entrepreneur shall incur additional transport and logistical costs to procure the distribution of the modular components at such a location. These challenges are between the designers, contractors and producers, and its need better coordination and integration among the related IBS players.

Issues Related to Delay In Delivering the Modular Components

Based on Nawi et al (2019) delayed delivery of materials is among the factors underlined by the manufacturer, contributing to the delay of the project. So, the second findings of this study is on the problems or issues that related to the cause of delay in delivering the modular components to the site. The data gathered from the questionnaire survey being stipulated in table below.

Table 2
Issues on Delay in Delivering the Modular Construction

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
10	Lack of communication and misunderstanding between different organization	4.1045	.87272	5

Based on data, the highest mean score is 4.2687; which is on the improper planning of component's delivery time. Many risk and uncertainty that could happen when delivering the MC. Sometimes the truck is having a technical problem and at the same time this truck also

being used to supply material for other companies. This will lead to the delay / changing of delivery schedule and will affect the total cost of construction.

Other than that, difficulty to reach to construction site also become an issue among driver. Base on the delivering issues that rank no 2, 46% of the respondents agree and 38% strongly agree that difficult site topography will lead to the delay on delivering the modular components. When this situation occurs, the truck driver might think; (1) is it safe for me to deliver the MC? (2) can the truck carry and deliver the large and weight component to the site safely? Not all driver willing to take the risk. This may lead waste of time on finding the competent driver and to find the area or accurate destination to deliver the MC (Oleiwi et al., 2010). It will also rise the cost of transportation and delay of delivery the component.

Rank no 3 is an issue on traffic congestion. Traffic congestion is widely viewed as an increasing problem in several urban areas around the world, particularly mega-cities, because the overall volume of vehicle traffic is still growing faster than the overall transport system capacity in many areas (as reflexively reflected by vehicle-kilometers of travel) (Oleiwi et al., 2010).

No 4 (with 4.1642 mean score) is on the late payment by the client. Late payment by client / contractor will delay the manufacturing process as well as delay the delivery of component to the construction site. It is important for the client to make sure that the payment being done before the delivery schedule to avoid this situation from happen. Problem with the requirement of the manufacturer was identified as one of the obstacles to the adoption of MC in the Malaysian construction sector (Fikri, 2005). In current practices, the contracting contractor awarded is payable as an initial payment by the customer between 10% and 25% of the overall amount of the contract value. However, initial expenditure in an IBS project is anticipated by the contractor, to be paid to manufacturers before progress is made. MC manufacturers are normally required to advance about 75% of the capital to manufacture the IBS components before delivering these components to construction site (Fikri, 2005). Such contractors must support this initial bill. The contractor's late payment may delay the supply of production components.

Some other issues is on the lack of communication and misunderstanding between different organization (5), driver’s difficulty to reach to construction site (6), extreme weather condition will affect the transportation process (7), traffic accidents during transportation process. The accidents happened whether from the other vehicles or the trailer itself that can delay the delivery to the site (8), lorry has technical problem during delivery (9) and lastly on the lorry was used to supply materials to other company.

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

The third findings are on the ways to minimise or reduce the transportation and cost issues in managing the modular construction system. All data gathered is listed in table 3.0 below.

Table 3.0
Ways to Reduces Issues Related to Modular Construction

NO	SUGGESTION AND RECOMMENDATION	MEAN	STD. DEVIATION	RANK
1	Proper study and planning in estimating the delivery time of MC system.	4.3731	.64751	1
2	Strengthen the cooperation /relationship between contractor and manufacturers / suppliers	4.2537	.70374	5
3	Improvement in communication and integration among the MC system players	4.2388	.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)	4.2537	.70374	6
5	Conduct training courses for MC system to improve skill and knowledge of industry players	4.2388	.65342	7
6	Regular Inspection and checking to transportation plant and machinery to avoid any problems	4.3134	.72214	3
7	Manufacturer should improve information technology (IT) to have a quality transportation process	4.1493	.76384	10
8	Manage the supply chain which will give better price and guarantee supply by manufacturer	4.1791	.73702	9
9	Involvement of manufacturers and contractors at the early stage (design stage)	4.2687	.56628	4
10	Strict quality control and close monitoring during the process of transportation, erection and installation	4.3284	.72589	2

From the result, 91.1% of the respondents agree that there should have a proper study and planning on the delivery time of MC. Since MC is applying the JIT (just-in-time) practice, every single component of MC must arrive on site at the exact stipulated time to avoid any delay in completion time of the project. The contractors and all design teams must arrange properly on when is the best date and time for the MC to be out from the factory for delivery. Most of possible risk could be reduce if the design team had strategized and plan from the early stage of the project.

The 2nd (4.3284 mean score) and 3rd (4.3134 mean score) rank are on the strict quality control and close monitoring during the process of transportation, erection and installation; and regular inspection and checking to transportation plant and machinery to avoid any problems. So, it can be said that close monitoring is important to ensure the quality of the product and transportation process run smoothly without any issues or problems. Which also could avoid any waste from occur and save the overall cost of construction.

Then, followed by the involvement of manufacturers and contractors at the early stage (design stage) of construction with mean score of 4.2687. Thereafter the fifth rank is to strengthen the cooperation / relationship between contractor and manufacturers / suppliers with score mean 4.2537. For the rank at sixth, 87% of the respondents have responded that the type of lorry, crane and machinery must suit with the size / weight of MC system (not too big and not too small). This is due to the issues on high cost to hire a large truck to deliver the MC to site.

The result indicates the lowest ranking for the suggestion and recommendation is on the manufacturer should improve information technology (IT) to have a quality transportation process with score mean 4.1493. This shows that this suggestions is not the best solution, since there is less issues that related to IT in transporting the MC. The second lowest that respondent responded is manage the supply chain which will give better price and guarantee supply by manufacturer as the rank at ninth with mean score of 4.1791.

Conclusion and Recommendation

Modular construction is still lack adapted among construction industry especially in Malaysia due to problems and issues that arise in managing the modular construction.
The government should encourage the used of modular construction by providing or make construction using modular system for public construction such as school and others public facilities. The development by government such as for housing also used modular construction system to increase the involvement of construction industry in managing modular construction system.

Based on the research many issues regarding the cost of transportation due to delay in transportation. To reduce the issue the construction industry where involve in modular construction include manufacture should improve the quality of management and quality control in transportation system. The great planning and management can achieve the target and improve the quality of the product.

Some of the delay due to congestion and accident on road, this problem is normally happened in Malaysia while Malaysia record one of the top country that have accident cases. The government should improve the quality of the road by designing the systematic road and construct more highway that can separate the huge transport and normal vehicles. This study is to establish the transportation and cost issue in modular construction for IBS. This research is more focus to cost in transportation. Maybe for the next research can study on important of management in supply material of modular construction.

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