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Cost comparison on industrialized building system (IBS) and conventional method for school construction project

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Abstract: Industrialized Building System (IBS) can be defined as one of construction method that can upgrade the quality and productivity of the construction by using better or less machineries, equipment, materials, and extensive project planning. IBS can be classified into many types, depending on each country. Five types of IBS that were commonly used in Malaysia for structural elements such as wall, roof truss, beam, column, and slab are precast concrete system, reusable formwork system, steel framing systems, prefabricated timber framing systems, and block work systems. One of the barrier for IBS implementation in Malaysia that are currently facing by most of construction industry players is the negative thought of implementing IBS is not cost effective compared to conventional method. Hence, the study which focused on school construction project was done to determine the cost comparison based on technical data collection and analysis between IBS which using half slab with conventional method for slab structure and also to determine the perception from the industrial players on IBS and conventional method through questionnaire surveys. From the results obtained, the difference (in percentage) for both construction methods which also can be said as the percentage of reduction in cost for the calculated floor slab is 11.9%. This shows that IBS offers a good reduction in cost compared to conventional system.

Key words: Industrialized building system, construction method, school construction project, cost comparison

1. Introduction

Construction sector in Malaysia is one of important and productive sector. As a developing country, this sector plays a major role for the economic growth and also to upgrade the quality of life and living standard of Malaysian (Khan, 2014).

In year 2006, the expenditure due to the funding of building construction and improvements of infrastructure such as schools, hospitals, and government living quarters by the Federal Government was RM35.8 billion compared to year 2007 which was RM 40.6 billion (CIDB, 2008). The increasing of the expenditure was partly due to increasing price of the building construction materials.

As the Malaysian construction sector keep on expanding, it is going through a transitional change to a more systematic and mechanized system, prefabrication technology and upgrading the skills of workers compared to conventional technologies as a trend towards the global competition (Haron, 2005; Chan, 2011). Rahim et al. (2013) explained four major parts of construction methods that usually were used in the construction industry which are conventional method, full fabrication method, cast in-situ method (formwork system), and composite construction method.

1.1. Conventional construction method

Conventional construction method has been widely practiced globally and locally by the construction industry players. This method can be defined as fabricating components for the building on site through process of installation timber or plywood formwork and steel reinforcement (Haron, 2005; Lou, 2012).

Aishah and Ali (2012) explained in details on the conventional construction method in which this method is divided into two components. The first part is the structural system which is the cast in-situ of the frame such as column, beam and slab. The cast in-situ of the frame are undergoing by four operations which are the erection of timber formwork and scaffolding, installation of steel bar, pouring of fresh concrete and disassemble of formwork and scaffolding.

Some of the researcher stated that by using the conventional construction method, it will cost more in the whole construction project in such cost for the labor, raw material and transportation besides slow down the overall time duration for the project (Haron, 2005; Rahim, 2013).

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1.2. Industrialized Building System (IBS)

Haron et al. (2005) and Marsono et al. (2006) defined IBS as one of the construction method that can upgrade the quality and productivity of the construction by using better machineries, equipment, materials and extensive project planning while Abdullah et al. (2009) stated that IBS can be classified as modern construction method, pre-building system, advance automation and volumetric construction.

With the implementation of prefabrication in the construction, this method help in increasing the sustainability of the project in which lower the total construction time and shortened the overall construction time including enhanced in occupational health and safety, material conservation and also less construction site waste (Chen et al., 2010).

There are lots of other terms has been used to express the development of building industrialization in which the exact term or definition depends on the personal experience and comprehension where this is still in poorly clarified (Anuar et al., 2011). Pan (2006) described the other terminologies that have been used globally as shown in Table 1.

Table 1: Categorization of terminologies (Source: Pan, 2006)

Terminology	Category Term
OS	Offsite Production (OSP)
	Offsite Manufacturing (OSM)
	Offsite Fabrication (OSF)
	Offsite Construction
PRE	Pre-assembly
	Prefabrication
	Prefab
MM	Modern Methods of Construction
	Modern Methods of House Construction
	Modern Methods of House Building
Building	System Building
	Non-traditional Building
	Industrialized Building

According to Construction Industry Development Board (CIDB), IBS can be defined as a construction technique that utilizes techniques, products, components or building systems that involve on-site installation and prefabricated components.

1.3. IBS in Malaysia

In Malaysia, prefabricated construction has started almost 40 years ago but there was no proper plan formulated by the Government for the industrialization of construction until the inception of the IBS Roadmap 2003-2010 by CIDB (2003).

As to remain competitive in the era of globalization of construction sector and to align the construction technology development with the IBS Roadmap, government has promoted the usage of IBS in the local industry with the collaboration of CIDB as the scenario for the local construction industry during that time is low in quality and productivity (Rahman, 2006).

IBS was first implemented in Malaysia in early 1960's when Ministry of Housing and Local Government of Malaysia visited several European countries and evaluated their housing development program (Thanoon et al., 2003). After their successful visit in 1964, the Federal government built some pilot projects using the IBS such as 3,009 units of flat in Jalan Pekeliling, Kuala Lumpur in 1966 comprising seven blocks of 17 stories flat, and 3000 units of low-cost flat and 40 shops lot and 3,741 units of flat in Jalan Padang Tembak:, Pulau Pinang in 1967 (Badir et aI., 2002). The project at Jalan Pekeliling was awarded to Gammon and Larsen Nielsen using Danish System of large panel of pre-fabricated system. The project only took 27 months to complete, which was from 1966 to 1968 including the time taken in the construction of the RM 2.5 million casting yard at Jalan Damansara (CIDB, 2006; CIDB, 2003; Thanoon et al., 2003).

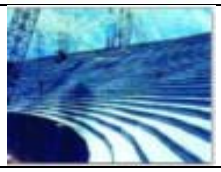
1.4. Classification of industrialized building system (IBS)

IBS can be classified into many types, depending on each country. According to CIDB, there are five types that were commonly used in Malaysia for structure elements such as wall, roof truss, beam, column, and slab. Table 2 shows the structure elements that available based on types of IBS System and Table 3 is the summary of the five main types of IBS and its components based on CIDB website.

Table 2: Types of IBS and structure elements (Source: CIDB)

System	Structure Elements	
Precast concrete system	Column Beam	Wall Slab
Reusable formwork system	Column Beam	Wall Slab
Steel framing systems	Column Beam	Roof Truss
Prefabricated timber framing systems	Column Beam	Roof Truss
Block work systems	Column Beam	Wall

Table 3: Types of IBS and its components in Malaysia (Source: CIDB)

Types of IBS		Components
	Pre-cast Concrete Framing, Panel and Box Systems	Pre-cast columns, beams, slabs, 3-D components (balconies, staircases, toilets, lift chambers), permanent concrete formwork, etc.
	Steel Formwork Systems	Tunnel forms, beams and columns moulding forms, permanent steel formworks (metal decks, etc.)
	Steel Framing Systems	Steel beams and columns, portal frames, roof trusses, etc.
	Prefabricated Timber Framing Systems	Timber frames, roof trusses, etc.
	Block Work Systems	Interlocking concrete masonry units (CMU), lightweight concrete blocks, etc.

2. Barriers on implementation of IBS in Malaysia

Since Industrialized Building System (IBS) was introduced in 1960's, which is reaching almost five decades of implementation, there are some of the construction industry players that is still not adapting this new modern method of construction in their construction projects. During the earlier stage of adaptation of IBS in Malaysia, the industry players faced problems regarding to the lack of IBS suppliers and lack on active IBS component manufacturers. Due to the limited number of suppliers, the demand seems to increase more than the supply which this situation turn into the increasing price on IBS components and therefore, it contributes to the barriers for implementing IBS in Malaysia. This is supported by Khalfan et al. (2008) which stated that Malaysia does not have enough manufacturers for IBS components. Plus, the demands of IBS components are also at slow rate and it making things becoming worst.

Construction Research Institute of Malaysia (CREAM) in 2007 has summarized the barriers that were faced by the industry players in order to implement IBS method in Malaysia. The summary reported that the obstacles to implement IBS such as it is not popular among the design consultants, lack of knowledge among designers; the need for mind-set change; lack of support and slow adoption from the private sector; lack of push factor from responsible bodies; volume and economy of production in scale to IBS components; monopoly of bigger contractors limiting opportunities to other contractors; low IBS construction components available in the market; IBS requires on-site specialized skills for assembly of components; lack of special equipment and machinery; lack of local RandD on technologies and testing facilities; mismatch between readiness of industry with IBS targets; insufficient capacity for contractors to secure project; and a sustainability issue with the government to lead during a downturn. There are also strong resistance from conventional contractors to change their existing ways, as well as the difficulty to meet the design and manufacturing requirements.

The challenges of the implementation of IBS in Malaysia were not only faced by the government but also it creates challenges to the construction industry players that have the guts to get involved in IBS construction. In general, most of the industry players have been influenced by a negative thought which the implementation of IBS is not cost effective compared to conventional method.

2.1. IBS and cost

IBS helps in decrease the expenditure and increase the future profits for the stakeholders and developer in such way that by implementation of the IBS, the cost of the labor and materials can be reduced (Yunus et al., 2011). From the past research, the difference between IBS and conventional does not have much differences in term of material saving but IBS has benefit in term of quality of project, easy to handle and also labor saving compared to conventional method (Azam and Zanarita, 2012).

Thus, this research was done to investigate the actual cost comparison between IBS and

conventional method and it was focused on social amenity which is school building. The collection of data and information was based on two schools which are SMK Idris Shah at Kinta in Perak and SMK Tinggi Klang in Selangor which they were located and can be categorized as schools in central region of Malaysia.

For the purposed of this study, the cost comparison was focused on material type for ground floor slabs which using conventional method and it has been designed as the suspended type of slab and the other part of the comparison focused on the first floor slab which using IBS method and half slab as it main IBS materials. The total area of each floor is 405m^2 with the dimension of 54m x 7.5m. The structure for each level having the same design and dimensions for both schools as the same contractor has been appointed for the project of the both schools.

3. Methodology

3.1. Survey

In the survey data collection, questionnaire has been used and structured questionnaire survey has been distributed out to the construction industry players and researcher, who have been involved in IBS projects to investigate their knowledge and perception towards IBS.

To make the survey can be easily reached by the respondents; the survey was also conducted online. The link of the questionnaire survey was shared through email and other electronic devices application. Some of the survey was mailed to the Public Work Department in Putrajaya via hardcopy.

From the survey data collection, all the data were presented in the table form or graph form to have more understanding and the relationship of each questions such as respondent's opinion, number of project involved using IBS and awareness of advantages on using IBS can be easily observed.

3. 2. Technical data

To have more understanding on the construction costs which uses IBS method, the evaluation of the existing school data had been carried out. The technical data such as bill of quantities, construction drawing, and the work programme of the selected school projects has been collected and evaluated as these technical data had provided the necessary information on the school building information.

For the construction of the slab by using IBS material which is half slab, few elements were considered in the calculation of the cost per area or per volume of the slab which are:

1. Concrete for topping
2. Half slab panel
3. Formwork for topping
4. Fabricated reinforcement bar/ BRC
5. Grouting

As for the conventional method, only three elements are taking into the calculation of the cost construction which are:

1. Slab concrete
2. Reinforcement bar
3. Formwork

The elements chose for both construction methods are based on construction of slab structure scope of work. This is to ensure that the comparison was made based on "apple to apple comparison" and not with other works or materials which was not in the similar scope.

4. Results and discussion

4. 1. Survey

This section gather all information related to the analysis and relationship from the respondents by the questionnaire which related to the perspective of IBS and conventional method. There were 110 of respondents answered the questionnaire surveys.

From the survey by questionnaire, position of the respondents was divided into several parts which are Engineer, Architect, IBS Researcher, Project Manager and IBS Manufacturer. It was found that 64% of the respondents are Engineers, 14% are the developers, 9% from IBS researchers followed with 5% from manufacturers while 4% from project managers and quantity surveyor.

Only important findings in the survey analysis are extracted and presented in this paper.

4.1.1. Level of awareness on IBS advantages

Fig. 1 below shows the rating given by the respondents on the level of awareness on IBS advantages in terms of cost and time reduction compared to conventional method. Based on answer by respondents, 55% of the respondents agreed that IBS has advantages in terms of cost and time reduction. 26% of the respondents strongly agreed and that makes a total of 81% respondents aware on the advantages of IBS in terms of cost and time reduction. However, only 5% of the respondents disagreed on the advantages of IBS. The rate given is based on respondent's experience in the construction industry.

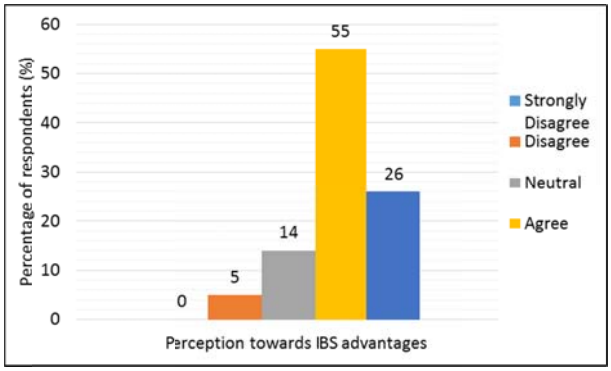


Fig. 1: Level of awareness on IBS advantages in terms of cost and time compared to conventional

4.1.2. Perception on IBS towards cost

Fig. 2 illustrates the difference in percentage that IBS offer in terms of cost reduction compared with the conventional method. 32% from the respondent agreed that IBS can reduce the construction costs from one to five percent (%) if compared to conventional method. 36% of them agreed that IBS can reduce six to ten percent of the construction costs compared to the conventional method. That makes most of the respondents agreed that IBS can reduce up to 10 percent of the construction costs. Only 9% of the respondent agreed that IBS can reduce more than 20 percent of the construction costs. This shows that IBS still can reduce the construction costs even though it is only few percent but IBS also can reduce up to 20 percent if the system used is very suitable for the construction.

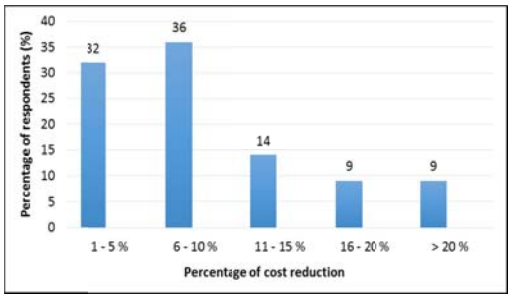


Fig. 2: Perception on percentage of cost reduction for IBS method

4.1.3. Perception on IBS towards time

Fig. 3 shows the difference in percentage that IBS offer in terms of time reduction compared to the conventional method. 36% from the respondent had responded to a reduction of 11 to 15 percent of the construction time using conventional method. Comparing to cost reduction stated previously, IBS has a positive feedback for the time reduction. In addition, for the percentage of more than 20 percent, from the respondent, 23% of them were agreed to this percentage of reduction of time for IBS method. This shows that IBS offers quite a large reduction of time compared to conventional method. Meanwhile, for one to five percent and six to ten percent, both having the same percentage of respondents which are 18% respectively that agrees to the percentage reduction; last but not least, 5% of the respondents said that IBS offers 16 to 20 percent of time reduction if compared to conventional system.

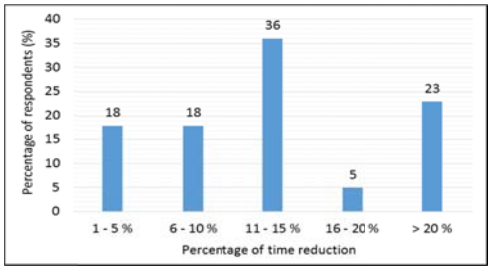


Fig. 3: Perception on percentage of time reduction for IBS method

4.1.4. Suitability for school construction

In this subjective question, respondents were asked whether IBS method is suitable or not for school construction projects. Respondents were then asked to give their reason or opinion on their answer based on their experience. Fig. 4 below shows the respondent's answers.

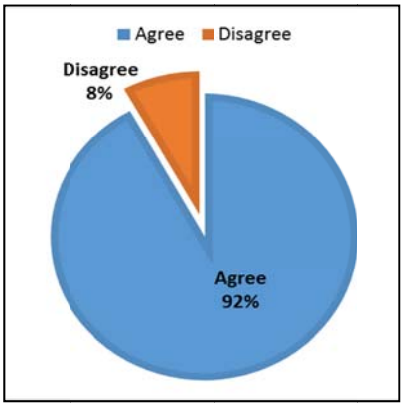


Fig. 4: Perception on IBS suitability for school construction project

From the respondent's feedback, only 8% stated that IBS are not suitable for the school construction while most of the respondents agreed that IBS is suitable for the school construction for the structural beam, columns and wall panel. Some of the respondents suggested that block work system, skeleton framing system, and steel formwork can be used but majority of the respondents suggested precast concrete system as the most suitable IBS materials to be used for the school construction.

4.2. Cost comparison analysis

This section will show the analysis of cost comparison of the school construction based on the construction method used which are conventional method and IBS method (half slab). The cost evaluation for both methods are based on materials used to complete the one floor slab of the ground floor which uses conventional (cast-in-situ) method and first floor which uses IBS method (half slab) on each schools.

The details of the area and the price are provided from the technical data such as bill of quantities, the construction drawings, and work programme of the school construction project.

Table 4 shows the distribution of the construction materials used for conventional construction method and the summary of cost calculation. The materials used as stated in the bill of quantities for this project are the concrete slab (Grade 30), prefabricated reinforcement bar (BRC) which uses A8 type, and conventional formwork (wood). The total cost to complete the one floor slab using conventional method is RM 56,068.38.

Table 4: Summary of Cost calculation for conventional method

N0	Item	Quantity Unit	Price	Total (RM)
1	Slab Concrete	137.7 m^3	RM220/m^3 RM20/ m^3	30,294.00 2,754.00
2	BRC (A8)	58 pieces 810 m^2	RM90/piece RM1.40/ m^2	5,220.00 1,134.00
3	Formwork	446.82 m^2	RM28.60/ m^2 RM8.70/ m^2	12,779.052 3,887.334
			Total	56,068.386

The same method has been used to collect the details of the construction information for IBS method which based on the technical data provided. Table 5 shows the summary of calculation and breakdown of the materials used for IBS method using pre-cast concrete slab panel which is half slab. The total cost to complete one floor slab using IBS pre-cast concrete slab is RM 49,398.10.

Table 5: Summary of Cost calculation for IBS method

N0	Item	Quantity Unit	Price	Total (RM)
1	Slab Pre-Cast Panel (half slab)	405 m^2	RM94.20/ m^2	38,151.00
2	BRC (A7)	29 pieces 405 m^2	RM80.00/piece RM1.40/ m^2	2,320.00 567.00
3	Concrete (G30)	30.375 m^3	RM220/ m^3 RM20/ m^3	6682.50 607.50
4	Grouting	123 m	RM8.70/m	1,070.10
			Total	49,398.10

Therefore, from the results obtained, the difference in percentage of both construction method and it can be said as the percentage of reduction in cost for the calculated floor slab is 11.9%. This shows that IBS offers a good reduction in cost compared to conventional system. This percentage might not looks huge in number for this study but in a bigger picture of any new school construction project which approximately having higher cost, it will give big number of cost savings. Furthermore, this study just focused on its materials used and not the reduction of machineries and labors which according to Ramli (2014) IBS method can significantly reduce the number of labors and machineries involved in the construction project.

5. Conclusion and recommendation

Despite all the obstacles and barriers that was faced by the construction industry players as well as the government bodies to ensure the implementation of IBS in Malaysia run smoothly and successfully, Malaysia still standing bravely to chase the continuously innovates the construction industry with this new modern method of constructions. The challenges arise has slowly been overcomes by the construction industry players to achieve a high quality standardization of IBS in Malaysia and fully utilizing the IBS system in all the construction projects following the IBS Roadmap 2011 – 2015 missions. In addition, based on the survey made by CIDB from May 2008 until October 2010, it has reportedly stated the positive impacts and the effectiveness of IBS implementation in government projects.

Based on the cost evaluation made, it can be concluded that IBS has shown the advantages in the cost reduction on slab structure of the school construction project. The costs calculated were based on the construction of ground floor slab which is conventional method and the first floor slab which used half slab (IBS method) to complete the construction. The cost difference is 11.9% of reduction on IBS method compared to conventional method.

As stated in the earlier chapter, IBS has offer the reduction of unskilled workers, especially foreign workers on the construction site. Since conventional method has depended intensely on the usage of general workers, IBS has been introduced in Malaysia to overcome the dependency of foreign workers in the construction industry. Therefore, this study can be a starting point for any researchers to investigate more on the advantages of IBS compare to conventional method which then can be used as a benchmark for construction industry players to realize and widely use IBS as their construction method.

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