

Construction Cost Comparison Between Conventional and Formwork System for Condominium Project

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Abstract-Based on recent scenario, Malaysia has emerged towards industrialization in all aspects of development. Most significantly, construction industry in Malaysia has transformed into a transitional paradigm changed, from the conventional system technology towards a more systematically, mechanized and industrialized forms, which adopted the latest and modernized technology. The transformation and innovation of this technology has evolved out of a tremendous backlog in the construction of the commercial and residential buildings. Apparently, the so-called 'Industrialised Building System' (IBS) is one of the major constituents in the construction systems. This system has been regulated and varied in a completely different manner compared to the conventional construction system, thus effected the design, construction method statements and most importantly the cost implications (CIDB, 2000). A case study was carried out by the researcher. The data required for this case study was generated through interviews. From the results of the case study, it undertaken can be concluded that the Industrialised Building System is better construction cost saving as compared to the conventional system.

Keywords: *construction cost comparison; conventional system; industrialised building system*

I. INTRODUCTION

Malaysia, which is one of the countries that is emerging towards industrialization in all aspect of development, was already achieved tremendous increase in the sector of construction industry. The industry apparently grew so rapidly in early 1990s and as new develops country at that time, Malaysia seriously emphasizing the necessity of industrial economic as its major income resource. The overwhelming demands by the government to obtain their financial resources through the sector significantly assured and increased the demands for the construction workers. This can be seen by the 50 percent increase in the number of the foreign workers brought into the country. But in late of 1990s decade, the industry started to slowdown and this major problem

contributed to a very large number of backlogs in the construction projects and the retrenchment of workers as well. Hence, a study to improve productivity in the construction site industry and a research to resolve the problem which causing the backlogs need to be done. And hopefully by the implementation of the research, it will be able to recover all the difficulty occurred and indirectly improve the stability of the construction sector [1].

The use of the industrialized building system (IBS) has been signified to have a various advantages over the conventional method. A few examples of the advantages are the reduction of the site labours, less wastage, less volume of building materials increased environmental and construction site cleanliness. Apart of that, IBS also provide a safer and more organized construction site, and reduces the completion time of construction. All these indirectly signify that the IBS is much more economical in terms of construction cost than the conventional system, even though the construction cost involves all matters either initially or throughout the building's life. And the focus of this study will be on generating a construction cost comparison projects using conventional construction method and the projects using IBS. And subsequently provide information as a guideline for the construction cost comparison for both systems.

II. CLASSIFICATION OF INDUSTRIALISED BUILDING SYSTEM

Industrialization in this study basically means the industrial methods employed, referring to the prefabrication, mechanization and standardization. The IBS can be defined as a system, which is used in industrial production that utilizes techniques either in the production of components or assembly of buildings or both [2].

Basically IBS is a term in building industry, which indicates the industrialized process by which components of a building are conceived, planned and fabricated, transported or erected at site. It also signified as a term given to building technology where modern systematized methods of design, production planning, and control as well as mechanized and automated manufactures are applied.

The main purpose of the system is to reduce the building into number common constituent parts, where most of it can be prefabricated or manufactured in long-term production runs, frequently away from the construction site and on-site installation. Such components with standard dimension and specific characteristic are then delivered to site and re-arrange according to certain standards to form structured buildings. In other words, it is a building system in which structural components are manufactured at the factory, on or off site, transported and assembly into a structure with minimal addition of site works.

Modular Coordination is to decrease the inconsistency of dimensions of building components, which obviously means the interdependent arrangement of the basic dimensions of the building with a primary unit accepted as a module. By conception a relatively large basic dimension unit (basic module) and by limiting the dimensions of building components to recommend preferred sizes it allows to an easy adaptation of prefabricated components to any layout and their interchange ability within the building. This was to be attained by defining the location of each component in the building with reference to a common modular grid rather than a reference to other components. Eventually, it would lead to cost efficiency in design, manufacture and construction [3].

Building system is a method of construction, which frequently used in the construction industry. And generally this building system can be divided into 4 major parts [4].

A. Conventional construction method.

The system depends mostly on the timber or plywood formwork for construction of building. It is defined as components of the building such as beams, column, slabs, foundation, that are prefabricated on site through the processes of timber formwork installation steel reinforcement and cast in-situ [5]. Since the method uses wooden formwork, it's been signified that the method is much more expensive via the usage of labours, raw material, transportation and the time duration of the construction.

B. Full-fabricated construction system

By using this highly skilled labour method, it will reduce the amount of the site labour involved in the construction operations and in the same time increases the productivity of

the industry. It also might reduce the duration of a project considering certain circumstances [6].

C. Cast in-situ construction method (Formwork system)

For a country which insufficient in skilled labour, this type of method is the most appropriate. Basically this method required no heavy machinery and the process is by using formwork as a mould, where wet concrete is poured into a temporary system. The temporary system also acts as a temporary support for the structures [4].

D. Composite construction method.

This method basically inspired by the prefabricated method and the cast in-situ method. The other name for this type of method is the partial prefabricated system. In this method, certain elements that can be standardized are prefabricated in the factory while others are cast-situ. The composite construction method has a wider range compared to the conventional and fully prefabricated construction.

Method of construction cost comparison between conventional and industrialised building system in construction industry

Referring to the large number of studies that have carried out and published, there are 3 signified principal approaches for comparing costs of building projects [7]; [8].

1. Comparison standardized identical buildings

Same drawings and specification, not representative

2. Comparison of standard buildings with local modifications

Representative when modifications for local circumstances

3. Comparison of functionally similar building.

Representative but not comparable

So, to achieve the best results in order to recognize the best system, the evaluation has to identify these parameters in terms of comparison.

1. Cost

Cost of work may be classified as follows [9]:

1. Material costs
2. Labour costs
3. Equipment cost
4. Overhead costs
5. Profit

The primary value of these classifications is that they help us examine and analyse construction cost. If a cost does not fit into one of the classifications, the classifications are not necessarily wrong; there might be more of them. But fewer classifications are more manageable and too many defeat their purpose.

2. Speed

Which system eventually require shorter construction period?. Since construction costs are incurred over the entire construction phase of a project, it is often necessary to determine the amounts to be spent in various periods to derive the cash flow profile, especially for large projects with long durations. Consequently, it is important to examine the percentage of work expected to be completed at various time periods to which the cost would be charged.

In general, the work on a construction project progresses gradually from the time of mobilization until it reaches a plateau; then the work slows down gradually and finally stops at the time of completion. The rate of work done during various time periods (expressed in the percentage of project cost per unit time) is shown schematically in Figure 1.0 in which ten time periods have been assumed. The solid line A represents the case in which the rate of work is zero at time $t = 0$ and increases linearly to 12.5% of project cost at $t = 2$, while the rate begins to decrease from 12.5% at $t = 8$ to 0% at $t = 10$. The dotted line B represents the case of rapid mobilization by reaching 12.5% of project cost at $t = 1$ while beginning to decrease from 12.5% at $t = 7$ to 0% at $t = 10$. The dash line C represents the case of slow mobilization by reaching 12.5% of project cost at $t = 3$ while beginning to decrease from 12.5% at $t = 9$ to 0% at $t = 10$.

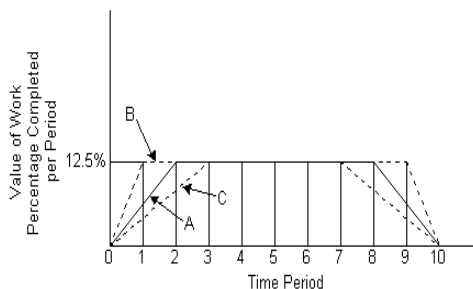


Figure 1.0 Rate of Work Progress over Project Time

The value of work completed at a given time (expressed as a cumulative percentage of project cost) is shown schematically in Figure 1.1. In each case (A, B or C), the value of work completed can be represented by an "S-shaped" curve. The effects of rapid mobilization and slow mobilization are

indicated by the positions of curves B and C relative to curve A, respectively.

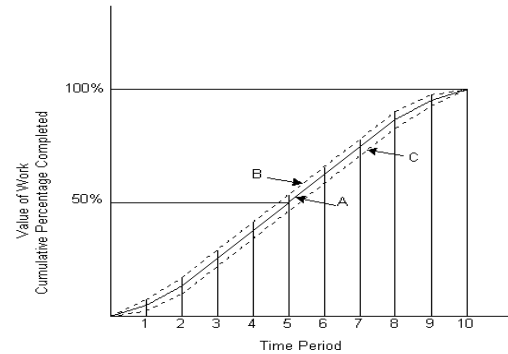


Figure 1.1 Value of Work Completed over Project Time

While the curves shown in Figures 1.0 and 1.1 represent highly idealized cases, they do suggest the latitude for adjusting the schedules for various activities in a project. While the rate of work progress may be changed quite drastically within a single period, such as the change from rapid mobilization to a slow mobilization in periods 1, 2 and 3 in Figure 1.0, the effect on the value of work completed over time will diminish in significance as indicated by the cumulative percentages for later periods in Figure 1.1. Thus, adjustment of the scheduling of some activities may improve the utilization of labour, material and equipment, and any delay caused by such adjustments for individual activities is not likely to cause problems for the eventual progress toward the completion of a project.

3. Labour

Which system eventually use less labour?. Labour rates include all labour cost, both the direct and indirect costs. Direct labour costs are wages and other payment made to workmen. Indirect labour cost are other payments made by a contractor on the employee's behalf, and these include fringe benefits and statutory payments. The wage rate is the direct cost per hour. The labour rate is the total of direct and indirect cost per hour [9].

4. Quality

Which system eventually contributes to a high quality of construction building?. In this term, the contractor has to know that the design and appearance may greatly influence the design and choice of materials and method of construction, and there by affect the building cost. This is particularly true in the case of residences and of retail buildings in which appearance is a means of attracting the customer [9].

II. RESEARCH METHODOLOGY

Since the data needed consist of the overall construction cost for a particular construction project, interviews with some of the selected respondents regarding the main objective of the topic were conducted for the data analysis stage.

An overall data of the construction cost for the conventional and the industrialized building system were collected from the chosen consultant company. This data is basically for the analysis of comparison for the two different types of the construction system. It would indirectly strengthen the information obtained through the interview that need been done.

III. RESULT AND DISCUSSION

Several interviews were conducted to a several construction participants with the objective of having their opinion regarding the construction cost comparison between conventional system and IBS. The criteria on selecting the sample are based on their role in the construction industry as purposive sampling. Some of them were representative from suppliers, consultants and also contractors with experienced on construction industry approximately more than 5 years. Therefore the data collected is surely relevant for the objective of this research.

Therefore, from the interviews that have been conducted, there were a lot of responses that shows different opinions regarding this research. And those opinions that have been indicated by the respondents actually based on their preferred construction system.

A. *Opinions on advantages of conventional system method are :*

1. The system is more flexible when it comes to a complex design of structure.
2. It is more convenient since the method is familiar to all contractors in Malaysia.
3. The method is widely used and easier in any aspect of construction.
4. Better negotiation chances in tendering stage.
5. Flexible in choosing alternative building materials at lower cost.

B. *Opinions on disadvantages of conventional system method are:*

1. The system requires a large amount of labour workers.
2. Produce a large number of wastage on site.

C. *Opinions on advantages of IBS method are:*

1. The enhance equipments used are more durable.

2. When it comes to a construction of repetitive or mirror units in large number, the system is considered as the best solution.
3. It is easy to assemble.
4. The system can be classified as more cost efficiency when the construction industry facing a lack number of labour or raw material.

D. *Opinions on disadvantages of IBS method are:*

1. Require high working capital for renting and purchasing the equipments of IBS.
2. Expensive components price charged by the supplier.
3. In Malaysia, the experienced contractor on designing using this method is still in small amount.

A. *Case Study*

The selected project for this case study is actually a project on development of a condominium (260 units). The condominium is basically consisting 3 blocks of dwelling unit, which are block 5, block 6, and block 7. These 3 blocks will be constructed in 11 level heights that locate 88 units of residential area, a ground level car park area plus 2 levels for mechanical and electrical equipments. But for block 7, the number of residential area that will be constructed in actually 84 units. Other facilities compiled are a unit of surau, a unit of guard post, two playing courts, playground and a unit of disposal area. The site location is in Shah Alam, Selangor Darul Ehsan.

Based on document contract of this project, the type of contract which being utilized initially is the traditional/conventional type. At first, the total cost tendered by the contractor for this particular project was estimated about **RM25, 301,911.54** and the tender document was treated as in Bill of Quantities. Then, because of the increases of certain construction materials such as steel bars and BRC, reinforcement concrete and also sands for plastering, rendering and concreting, the new revised tender cost have been tendered to a new amount **RM25, 999,709.02**. But since the revised tender cost was quite high, the Client has asked to the contractor to reduce the tendered cost to a lower revised amount. Thus, new costing revisions have been made on purpose of to alter all these circumstances, which could channel the contractor to propose a more economical price.

After a few discussions among themselves, they have decided to submit their proposed amount at a new revised sum of **RM25, 799,709.02**. This amount is subjected to the terms and conditions of the tender document, upon which the tender is based. For this new revised tender price, the scope of works shall be demarcated in terms of the building works (dwelling unit) shall be constructed using the formwork system method (IBS) while the other construction works is still based on conventional method. And as in the new tender document, it will be treated as lump sum in relation to their proposed IBS drawings and the type of contract is changed to design and build concept. The Client has accepted this new amount;

therefore an official contract document is made for the explanation of this new revised cost of contract.

B. The advantages of IBS for the project

There are several advantages that can be seen by using this formwork system, which are;

1. Using lightweight prefabricated formwork made of steel
2. Can be easily erected and dismantled.
3. Low skill requirement.
4. Can be quickly constructed.
5. Low maintenance.
6. The structure is durable.
7. Cost savings.
8. Capable to adapt to any design and plans of architects.
9. Can contribute to the high quality buildings.
10. Faster completion of a project
11. Reduce wastages

C. The advantages of IBS compared with conventional construction method

Through to the IBS manufacturer brochure and website, the advantages of IBS compared with conventional system are as below;

1. The lightweight of the system usually avoids the need for strengthening or adjusting the existing building. Therefore, the building system is suitable for on-top construction.
2. Suitable for any architectural design and layout.
3. Reduce the need for labour at building site.
4. Plastering work can be neglected since the joints between two elements can easily be filled with both plaster and skim coated with paint, wallpaper or plaster.
5. Suitable to inclement weather.
6. As shoring for formwork operations and afterwards as working scaffold for roof assembly, all scaffolding tasks could be carried out cost-effectively with a single system.
7. Adaptable and inexpensive system equipment for walls, columns and slabs.
8. The stop end angle is ideal for beam formwork intersections and -corners and beam branching. Beams up to a height of 60 cm can be shuttered without anchoring.
9. Can point out to a safe working platform, a safe access and the use of pallets increase the output of the personnel.

10. Allows alteration or renovation to be carried out properly with minimum restriction.
11. The castings of all panels are carried out on site. The construction site is tidy with minimum debris created during construction period.

Obviously the main objective of this case is basically to compare the differences in terms of construction cost between these 2 systems, which are conventional/traditional system and IBS (formwork system). In the other word, this case study should consider a study regarding the cost comparison of these 3 blocks of condominium. For the conventional system the estimation is based on bill of quantity condition while for the IBS is treated as lump sum in relation to the tender drawings. The costs that will be shown are signified according to the elements of the building which already being finalized in final summary section.

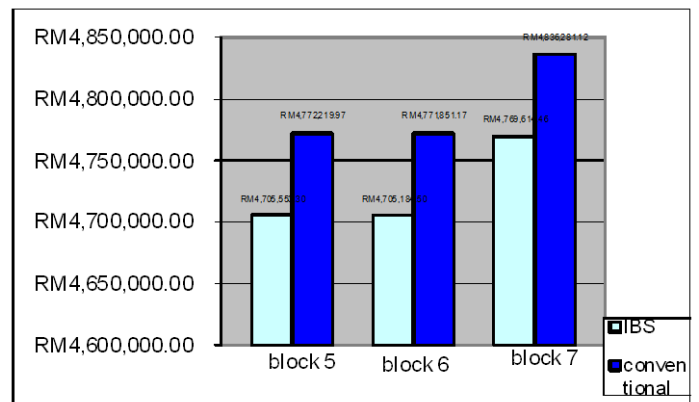


Figure 1.2: Cost Comparison for each block between Conventional System and IBS (Dwelling unit)

As illustrated in figure 1.2, the construction cost of block 5 (dwelling unit) for IBS is RM4,705,553.30 while for conventional system is RM4,772,219.97. For block 6 the cost is RM4,705,184.50 for IBS and RM4,771,851.17 for conventional system. While for block 7, IBS cost is about RM4,769,614.46 and conventional system is valued in about RM4,836,281.12.

Thus, the figure apparently shows that the construction cost for dwelling unit for each block is cheaper by using the IBS compared to conventional system. The cost difference for both systems is about RM66, 666.67.

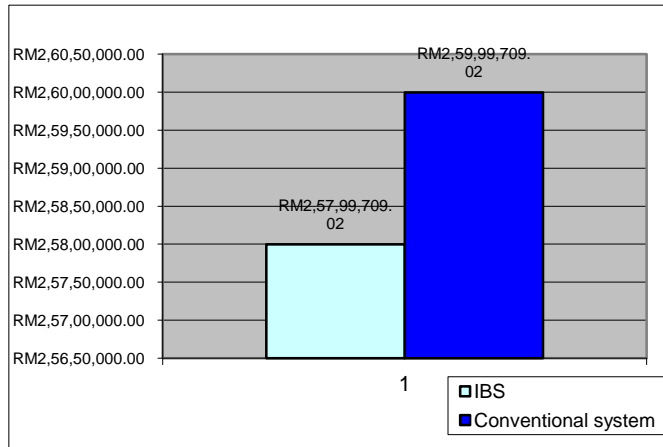


Figure 1.3: The construction cost difference between the two systems.

Above Figure 1.3 apparently shows that the overall construction cost for conventional system is RM25, 999,709.02 while the cost for IBS is RM25,799,709.02. So it can be concluded that the construction cost by using conventional system method is much more expensive than using the IBS. The cost difference is RM 200,000.00.

IV. CONCLUSION

From the above opinions, it can be concluded that the conventional system is still the main system that frequently used in Malaysia construction industry. The main reason why all contractors preferred this system is because the system can adapt any types of design of building. This is because of the flexibility by using the material such as timber, which can be obtained easily in this tropical country. Since the system is frequently used for most projects in this country, therefore the knowledge and experiences regarding the system is quite wide compared to IBS. This indirectly channelled to the conveniences of negotiation on the tendering stage of a project. Usually at the tendering stage, the clients might ask the contractor to reduce the cost amount, thus the conventional system surely contributes a very smooth negotiation among them.

All these are adequate to the familiarity of the building system among the contractor in the implementation stage. However, the system also required a large amount of labour worker needed for the system that indirectly contributes to an increase of construction cost to a particular project. Other than that, the increases of wastage production is also main problem that the contractor have to face in order to reduce the cost of evacuating all unnecessary material on site such as used timber and etc.

As for the case study analysis, the cost of IBS for dwelling unit of each block is lower than the cost of conventional system. This is because, by utilizing the enhanced formwork, the construction of a high-rise building can be done easily and faster. Based on the data from the case study, the IBS cost for framing element is higher than the cost for conventional system while for the external wall and windows and internal wall and windows elements, the cost recorded is lower.

These circumstances occurred because by utilizing IBS, the framing works required the construction of wall indirectly. The system is quite difference with the conventional system which for the framing works, its only considering the construction of the structure element of the building such as beams and columns. The material of the formwork itself is also durable and not only that, it also light in weight because it is made of lightweight enhanced steel. Besides that, the steel made formwork is easy to erect and allocate a small amount of skilled labour to operate the functions. The formwork can be used repeatedly until the end of the construction time. All these obviously could channel to a safe, fast and also a better quality construction. However, if the construction system using the conventional system is implemented, it may cause a lot of negative circumstances. It is because the system actually required a large number of skilled labours to construct timber formwork for the construction of one particular level. This may cause to an extension of construction period for the project. The small turnover of timber formwork also could cause to a large usage of timber plywood. And these apparently will cause an enormous number of wastage on the site.

Thus, the IBS that being selected for the construction can be said the most appropriate system for a high-rise building since the system could provide a cheaper overall construction cost of the project. This is because it can reduce the amount of construction works since the system is appropriate when it comes to a construction of repetitive or mirror units in large number.

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