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Building Cost Comparison Between Conventional and Formwork System: A Case Study of Four-storey School Buildings in Malaysia

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Abstract: The Malaysian construction industry is undergoing a transitional change from an industry employing conventional technology to a more systematic and mechanized system. This new system is now known as the Industrialized Building System (IBS). This new method of construction can increase productivity and quality of work through the use of better construction machinery, equipment, materials and extensive pre-project planning. This study becomes very necessary since there is yet no organized body, which can provide the necessary information on the building cost comparison between the conventional system and industrialized building system in Malaysia's construction industry. This study also addresses the building cost comparison of the conventional system and industrialized building system of formwork system. It provides the details building cost between the conventional system and the formwork system and indicates which of the two is cheaper. The data were collected through questionnaire survey and case study, which consisting of institutional buildings. Through the statistical test 't-test' it is shown that there is a significant difference in cost saving for the conventional system as compared to the formwork system (industrialized building system).

Key words: Conventional, formwork system, building cost, comparison

INTRODUCTION

The Malaysian construction industry is undergoing a transitional change from an industry employing conventional technologies to a more systematic and mechanized system employing the latest computer and communication technologies. This is vital for the future health of the industry, given the trend towards global competition and the advent of the k-economy.

The Industrialized Building System (IBS) has been introduced in Malaysia since the 60's by the use of pre-cast concrete beam-column elements. Since the demand of building construction has increased rapidly, it is necessary to innovate a construction method, which speeds up the building construction process. Abdullah *et al* [1] has listed the various types of building systems currently available in Malaysia. Few definitions of industrialized building system are also given by various authors[2]. To sum-up, in general, the IBS is a methodology whereby a local construction industry is driven towards the adoption of an integrated and encouraging key player in the construction industry to produce and utilize pre-fabricated and mass production of the building on their work sites. This will help to enhance the efficiency of a construction process, allowing a higher productivity, quality, time and cost saving.

The construction cost of a building using pre-cast components should be assessed in its overall context. The traditional method of costing by material quantities with a fixed factor for labor cost can lead to incorrect estimation. For example, if labor usage is halved, this will more than compensate for a 10% material increase. More importantly, there is saving in time. Also, If properly designed and executed, pre-cast can lead to much better quality of work. The overall cost impact of pre-cast has therefore to take all these factors into consideration. With the rising costs of labor and less assurance of dependable skilled manpower, the trend is that pre-cast construction will become increasingly competitive compared to cast-in-place construction[3].

Classification of Industrialized Building System:
Industrialization: The Oxford English Dictionary (1991) defines industrialization as "the process of industrializing or fact of being industrialized; also, the conversion of an organization into an industry". However, industrialization in this study means industrial methods employed, referring to especially, prefabrication, mechanization and standardization. The meaning of prefabricated, according to the same dictionary, is, "to manufacture sections of a building or similar structure, in a factory or yard prior to their assembly on a site". However, Prefabrication in this study is the assembly of buildings or their components at a location other than the building site.

The types of construction methods range from a conventional construction method to fully prefabricated construction method. Generally, the construction methods are classified here into four categories:

* Conventional construction method
* Cast-in-situ
* Composite method

* Fully pre-fabricated method.

Conventional Construction Method: Conventional building method is defined as components of the building that are pre-fabricated on site through the processes or timber or plywood formwork installation, steel reinforcement and cast in-situ. Conventional building is, mostly built of reinforced concrete frames[4]. The traditional construction method uses wooden formwork. It is much more costly for construction, which includes labor, raw material, transportation and low speed of construction time[5].

Cast-in-situ Construction Method: This system is suitable for a country where unskilled labor is limited. There is no heavy machinery or high technology involved. The system is technically applicable to almost all types of building. Formwork is used as a mold, where wet concrete, is poured into a temporary system. The temporary system also acts as a temporary support for the structures. The objective of in-situ method is to eliminate and to reduce the traditional site based trades like traditional timber formwork, brickwork, plastering and to reduce labor content. A carefully planned in-situ work can maximize the productivity, speed and accuracy of prefabricated construction. Cast in-situ method uses lightweight prefabricated formwork made of steel/fiberglass/aluminum that is easily erected and dismantled. The steel reinforcement is placed within the framework as they are being erected and concrete is poured into the mold. When the concrete is set according to the required strength the mold is dismantled. The workers can be trained easily to erect the molds and set the steel reinforcement. Its advantages over the traditional construction method are, its low skill requirement, can be quickly constructed, maintenance is low, the structure is durable and cost can be less[5].

Composite Construction Method: The objectives of the composite construction method (partially prefabricated) are to improve quality, reduce cost and shorten construction time. The concept of partial industrialized is derived from the composite nature of full industrialization and is used to describe a manufacturing or production strategy that selectively uses some industrializing aspects, while avoiding or postponing the use of others. The prefabricated construction method is combined in such a manner the features applied could be prominently demonstrated especially composing various works such as temporary facilities, building frames, building finishes and equipments[5].

Fully Prefabricated Construction Method: In this method of construction, all elements that can be standardized are prefabricated in the factory. Normally, this method would involve the assembly of pre-cast elements such as floor slabs, in filled walls, bathrooms, staircases, etc. Into place for incorporation into the main unit, columns and beams. This method of construction has reduced the amount of site labor involved in building operations and increased the productivity of the industry. Pre-cast building systems can reduce the duration of a project if certain conditions are met[6].

The last three construction methods are considered non-conventional construction methods. These types of construction are specifically aimed to increase productivity and quality of work through the use of better construction machinery, equipment, technology and materials. The main important point to consider here is the particular construction method most suitable for a particular project[7].

Method of Cost Comparison in Construction Industry: During the past decade a large number of such studies has been carried out and published. In the existing studies three principal approaches for comparing costs of building projects among countries can be distinguished[8-11]:

* Comparison of standardized identical buildings
* Comparison of standard buildings with local modifications
* Comparison of functional similar buildings

Comparison of Standardized Identical Buildings: With the first method exactly the same building work is priced on the basis of the same drawings and specifications. This is possible only in theory, largely as a result of national (or even regional) differences which exist in architecture, standards, availability of products, etc. The building and the costs will be comparable, but they are not necessarily representative.

Comparison of Standard Buildings with Local Modifications: Better representative can be achieved when modifications for local circumstances, like building codes, standards, specification levels, are taken into account.

Comparison of Functionally Similar Buildings: With the third approach, typical, functionally similar buildings are compared: this means building types, which are representative. Not only locally divergent circumstances and quality-levels are taken into account, but also various performances and aesthetic criteria, which reflect typical client requirements or tenant expectations for a building in that sector. The buildings and the costs are representative, but not necessarily comparable. Arguably 'apples' are being compared with 'oranges'[12]. A meaningful comparison must take into account all relevant (time-dependent and quantity-dependant) cost components, classified as follows[13]:

* Labour;
  - Direct
  - Indirect
* Materials
* Investment
* General expenses (site and plant)
* Transportation (for system construction only)
* Overhead

As for this study the method of cost comparison used standardized identical buildings and functionally similar buildings while the unit is cost per gross floor area.

Research Methodology: Data was collected by using mail questionnaire. To strengthen the finding of the survey and to assist in providing the information about the building cost comparison study, a case study was also conducted. However the major approach was used questionnaires, considering such factors on sample size, time, cost and efforts. Questionnaire method was chosen as the appropriate approach for this study. Questionnaire can reach a large number of respondents in different locations of the country at a relatively low cost, shorter time and less effort as compared to other data collection methods. The questionnaires were sent to the general manager, project manager, technical executive, managing director and project director. The questionnaires were mailed to the respondents, accompanied by a covering letter, self addressed and stamped envelope. The case study was conducted on a building cost comparison of 1 unit 4-storey of school building project carried out by the Public Works department, Malaysia, which uses conventional system and formwork system. Data gathered at a building cost of building systems in Malaysia were processed and analyzed using Statistical Package for Social Science (SPSS).

RESULTS AND DISCUSSION

Figure 1 shows building cost-saving in term of percentage. Forty two percent of the respondents agreed that the conventional construction method is more cost saving, 25% agreed that composite construction method are most cost saving, 21% agreed that formwork system are most cost saving. Last but not least only 12% agreed that prefabricated construction method is most cost saving.

The previous study showed clearly the advantages of using formwork system (cast in-situ). These were spared, quality and economics[5]. However, the results of the analysis revealed that the conventional construction method is more cost saving compared to the IBS method.

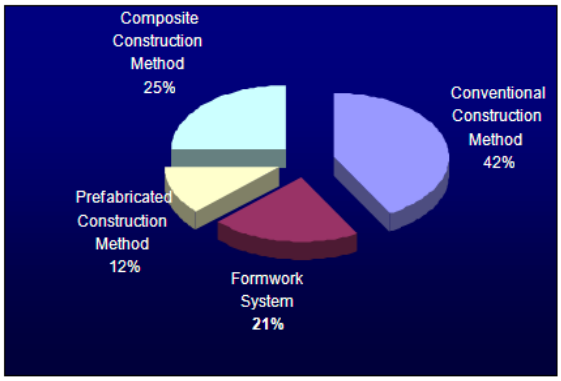

Fig. 1: Building Cost Saving

According to the reasons given by the respondents, the conventional system is more cost saving as compared to formwork system was because of better negotiations and chances to get the most competitive tender price appropriate to the developer's budget. There is also flexibility in choosing alternative building materials at a lower cost. Therefore, building cost can be reduced. As for the IBS, there are limited to a few manufacturers or specialized contractors. This contributed to the high cost of building due to higher licensing cost and they tend to be monopolized by the higher price of the building panel or other building components.

Formwork System Case Study: The selected industrialized building system case study is based on formwork system. This system is suitable for a country where unskilled labor is limited. There is no heavy machinery or high technology involved. The system is technically applicable to almost all types of buildings. Formwork is used as a mold, where wet concrete, is poured into a temporary system. The temporary system also acts as a temporary support for the structures. This In-situ method is to eliminate and reduce the traditional site based trades like traditional timber formwork, brickwork, plastering and to reduce labor content. Carefully planned in-situ work can maximize the productivity, speed and accuracy of prefabricated construction[5]. The main objective of this case study is to study the cost comparison of school building cost of 1 unit 4-Storey (academic block) project carried out by the Public Works Department, Malaysia, which uses a conventional / traditional system and formwork system. The conventional and formwork system building cost is based on analysis of the Elemental Cost Analysis (ECA) form. The formwork system is based on the combination of pre-fabrication and in-situ conventional construction, which features the utilization of permanent concrete form elements instead of conventional timber formwork.

Table 1: Mean Difference between 1 Unit Four Storey School Building of Conventional and Formwork System (IBS)

Paired Samples Statistics					
		Mean	N	SD	Mean SE
Pair 1	CONV	432.3940	20	73.4217	16.4176
	IBS	544.4355	20	69.8597	15.6211

Table 2: Significant of Difference between 1 Unit Four Storey School Building of Conventional System and IBS (Formwork System)

Paired Samples Test									
Paired difference									
		Mean	SD	Mean SE	95% confidence interval of the difference		t	df	sig.(2-tailed)
					Lower	Upper			
Pair 1	CONV- IBS	-112.0415	79.8209	17.8485	-149.3988	-74.6842	-6.277	19.000	

Building Cost Information: The main objective of this case study is to study the cost comparison of 4-storey school buildings, which used conventional/traditional system and formwork system. The conventional system building and the formwork system cost is based on elemental cost analysis form from the Public Work Department, Malaysia[14].

Cost Comparison: Table 1 shows the main difference between 1 unit four storey school building of conventional and formwork system for 20 numbers of data. The mean cost of conventional systems is RM 432 per square meter whereby the formwork system is RM 544 per square meter. The difference is RM 112 per square meter. Although the difference is RM112 per square meter the total of the square meter for 1 unit 4-storey school building is about 2000 square meters. This shows that there is a wide difference between IBS and Conventional. In layman's terms the IBS is very expensive. For example, if the government wishes to build 20 school buildings of the same IBS, this means the cost will be very high. Therefore, all efforts must be made to reduce this so as to ensure the future use of IBS method is feasible.

The t-test analysis is a statistical analysis to test the difference between two variables. The purpose is to show the significance level of the building cost comparison between 1 unit four storey school buildings using conventional system and formwork system.

The present study used a two-tailed test .The underlying reason for application of the two-tailed test over one-tailed test is to ensure that the result obtained is compatible. If only one-tailed test is used, then the result obtained might not be the same with that of a two-tailed test. If the result shows the difference between conventional and formwork system is not significant then, the study cannot conclude that formwork system is more expensive than conventional system. Perhaps, the formwork system is only expensive for certain numbers of buildings based on 20 numbers of data available.

Table 2 shows the result of the t-test conducted using IBS (formwork system) and conventional methods. It has been found that there is a 0.000 (last column) or 100% confidence level. This therefore, confirms that cost of building using formwork system method is expensive compared to the conventional method. The mean difference is RM 112 per square meter shows that formwork system is more expensive compared to conventional system. The highest building cost difference per square meter is RM 149 and the lowest difference is RM 75 per square meter.

This analysis, which was carried out was based on Elemental Cost Analysis Form (ECA) from the Public Works Department, Malaysia shows 1 unit 4-storey school building cost using conventional system and formwork system. The cost provided using the same type of contract.

With reference to Table 1, the mean cost of conventional systems is RM 432 per square meter, whereas the formwork system is RM 544 per square meter. The difference is RM 112 per square meter from 20 numbers of data. The results showed that the difference is significant with a 100% confidence level. Therefore, the conventional cost is cheaper, compared to formwork system. This finding is in coherence with the results already obtained in an earlier survey analysis.

CONCLUSION

According to the reasons given by the respondents, the conventional system is more cost saving as compared to formwork system (IBS) since it provides better negotiation chances so as to obtain the most competitive tender price appropriate to the developer's budget. There is also flexibility in choosing alternative building materials at lower cost. Therefore, building cost can be reduced. As for the IBS, there are limited to a few manufacturers or specialized contractors. This contributes to the higher cost of building for a higher licensing cost is levied on the IBS panel and they tend to be monopolized by the higher price of the building panel or other building components.

From the results of the case study, it can be concluded that the conventional construction system is more cost saving as compared to the formwork system (IBS). The case study results are also in coherence with the result of the survey analysis. Most of the organized body in the construction industry thought that the

building cost of IBS is more cost saving compared to conventional system. However, the present study proved the results was opposite to what was thought earlier.

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