

Contractors' Perspective on the Benefits of Implementing Industrialized Building System (IBS)

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Abstract

Construction industry is considered among the most crucial sectors in developing countries where it is capable to drive a nation towards progressive development as it provides a positive platform to other industries. Implementation of Industrialized Building System (IBS) has been acknowledged as an effective measure to increase capability within the industry as compared to the conventional methods. The purpose of this study is to present the benefits of implementing IBS from contractors' viewpoint. Questionnaire forms were distributed to 683 construction firms registered under the Construction Industry Development Board of Malaysia operating in the states of Penang, Selangor, Kuala Lumpur and Johor. A total of 254 questionnaire forms were returned duly completed. The collected data was analysed using the Conformity Index. Three main benefits gained by implementing IBS from the contractors' perspective are (1) IBS increases the productivity of construction works, (2) IBS reduces concrete mixing activities at construction sites and (3) IBS reduces the overall duration of construction work. These results indicate that the contractors are focusing more on completing construction works with the help of IBS implementation at construction sites. Also with IBS, it is able to minimize the problem of site mismanagement/disorganization through a significant reduction of in-situ wet concrete works.

Keywords: *Construction, Industrialized Building System, productivity*

1.0 Introduction

The construction industry has often been referred to as a backward industry, and has been unceremoniously regarded as being stricken with the '3D Syndrome' (Dirty, Dangerous and Difficult). A number of construction projects are at a relatively alarming state, based on inefficiencies of labour productivity, integration, quality and inconsistent costing. Other industries or sectors such as manufacturing and aerospace have however extensively evolved in terms of product quality, productivity and performance. This has allowed these sectors to progress competitively when compared with other less productive industries, specifically the construction industry [1].

The construction industry is seen as a fundamental industry in Malaysia, and is one of the indicators of the nation's economic growth. It serves to provide the necessary infrastructure for numerous industries, both from the economic and social standpoint. As such, the construction industry needs to be more effective and efficient in providing basic infrastructure to enhance the quality of life of the nation's populace in terms of providing safe and user-friendly road systems, railways, communication facilities and others [2]. It is crucial for the government to recognize the importance of the construction industry as it is capable to trigger other industries. However, it has been reported that the current state of the Malaysian construction industry is still not capable enough to meet demands from the various other sectors. This is due to insufficient quality, productivity and safety, and high dependency on inexperienced foreign labour. In view of this, the Industrialized Building System (IBS) may offer some solutions in reducing the gap between these high demands and the current low quality supply exhibited by the construction industry.

IBS was introduced by Le Corbusier circa 1914-1915 in Switzerland [3]. This intensive approach is adapted from the massive production systems of the manufacturing industry with the aim of reducing the low performance of the construction industry. The government of Malaysia has recently emphasized this approach to reduce the influx of foreign labour in both public and private sectors. This is seen as a strategic approach that is in line with Vision 2020 which is the Malaysian blueprint towards achieving the status of a developed nation by the year 2020. This effort is also a comprehensive attempt to improve the performance of the construction industry. Based on this scenario, the objective of this paper is to determine the main benefits gained by contractors through implementing IBS in construction sites.

2.0 IBS Implementation

IBS is an innovative process that utilizes mass produced industrialized systems, incorporating both off site and in-situ production through a controlled manner. It comprises logistic and installation aspects, which involve well-coordinated productions aspects through systematic plans and integration [4]. Therefore, IBS is a building process composed of components, techniques, products and building systems. The building systems comprise processes of providing prefabricated building components and installation works which are carried out at the construction site.

In general, there are many benefits that a stakeholder can gain by implementing IBS when compared with in-situ conventional building systems. According to Idrus [5], IBS has proven to be economical since it saves costs, reduces incompetent labour, reduces building materials and is comparatively efficient, safe and cleaner with improved quality. Bon and Hutchinson [6,7,8,9] have emphasized that IBS provides benefits which include enhanced building quality, long term profits, and satisfying customer demands in terms of affordability, comfort and flexibility. The implementation of IBS has encouraged production of good quality materials within a shorter duration, with lower material and labour costs [10,11]. While IBS is able to increase productivity and efficiency in the construction industry, within the Malaysian context, its main objectives are more towards enhancing the overall quality of construction products and reducing dependency on foreign labour [12].

The transformation from labour-dependent conventional building systems to a more technology facilitated IBS is currently being implemented by the Malaysian government and is gradually creating positive impacts to the nation. IBS has proven to produce effective and efficient components or products that are competitive within the challenging global markets. The Ministry of Urban Wellbeing, Housing and Local Government (formerly known as the Ministry of Housing and Local Government) had initiated the implementation of IBS as early as during the 1960s in Malaysia. This effort was initiated after several site visits and performance assessments of buildings in a few European countries. In 1964, the government commissioned two pioneer projects using the IBS approach. The first project was located along Pekeliling Road on a 22.7 hectare site. It comprised of 4 blocks of 4 storey buildings and 7 blocks of flat housing units (with 17 levels each) which housed a total of 40 units of shops and 3,000 units of low-cost flat housing. The firm of Gammon/Larsen Nielsen was chosen to construct this project using the industrialized prefabricated panel system, a technology imported from Denmark. The second project was constructed in Penang, comprising 6 blocks of flat housing units (with 17 levels each) and 3 blocks of flat housing units (with 18 levels each). The total number of units consisted of 3,699 residential units and 66 units of shops along Rifle Range Road. The firm of Hochtief/CheeSeng was responsible to construct the project by using a prefabricated system from France.

Previous studies have carried out comparisons between conventional building systems and the IBS projects based on the aspects of cost, productivity and quality. The first pioneer project had shown an increased percentage in cost (8.1%) through the use of IBS, as compared to conventional construction systems. The second project, however, showed a decreased cost percentage (2.6%) when compared to conventional methods. In terms of efficiency, both projects required at least 27 months to install the components from the prefabrication factories. Evaluation has shown that IBS has higher and better quality

than conventional systems. All in all, IBS was seen as having the potential to be extensively implemented as this approach was evidently perceived to be acceptable within the construction industry. These two pioneering projects were considered to be the projects that paved the initial path for subsequent IBS implementation.

The Malaysian government through its designated agency, the Construction Industry Development Board (CIDB) took subsequent steps to further develop plans and strategies to refine IBS implementation in Malaysia. A roadmap was drafted and developed by the CIDB IBS Steering Committee in 2003 based on a '5M Strategy' (Manpower, Materials-Components-Machines, Management-Processes-Method, Monetary and Marketing). The roadmap was created to develop the construction industry and achieve a wider use of building systems by 2010. The IBS Roadmap 2003-2010 was planned to reduce dependency on foreign labour by emphasizing policies that encourage investment in technology, techniques and building methodology. CIDB further enhanced its initial roadmap via the IBS Roadmap 2011-2015 to encourage industry players to use the IBS approach. CIDB has also emphasized on four sub-objectives in their policy, which are quality, efficiency, workmanship and sustainability. This emphasis is mainly to accomplish a sustainable IBS industry as well as a more competitive construction industry in Malaysia.

3.0 Research Methodology

The purpose of this study is to determine the benefits that contractors can gain by implementing IBS at construction sites. Towards this end, a questionnaire was developed to facilitate data collection. The questionnaire comprised of two sections; the first part is to determine the background of the respondents and the second section focuses on evaluating the benefits of IBS in the construction industry. A Likert Scale (ranging from 1-5) was employed to evaluate the acceptance levels of IBS among the respondents, where, '1' represented 'highly agree' while '5' represented 'highly disagree'. A pilot study was carried out to test and subsequently refine the questionnaire [13], in order to assist the enumerators during the final data collection process [14].

A total number of 683 firms, all of which registered with CIDB, formed the population of respondents for this study. These firms mainly operated in four major states within Peninsular Malaysia, namely, Penang, Selangor, Kuala Lumpur and Johor [15]. These four states recorded the highest growth in terms of the national Gross Domestic Product (GDP), compared to the rest of the states in Malaysia [16]. Data collection via the distribution of the questionnaires was carried out before the returned data was subsequently analysed, interpreted and discussed prior to concluding the findings based on the main objective of this study. In the end, three out of the thirteen benefits listed (representing 23% of the total benefits) were discovered to be the main benefits of IBS implementation within the context of this study. In comparison to previous research, for instance in a study by [17], for the installation of on-site prefabricated components, 10 out of 42 factors (representing 24%) were categorised under the main factors that contribute to labour productivity; whereas, in another study, Jarkas and Bitar [18] have categorized 10 out of 45 factors as the main factors affecting construction labour productivity in Kuwait. As such, comparatively, this study demonstrates a similar trend as exhibited by other research on the common subject matter of construction productivity.

The 2 main quantitative analyses utilized in this study were descriptive analysis and mean analysis. Cronbach's Alpha was also applied to test the reliability of the garnered data. A conformity index was then later used to rank the benefits that a contractor can gain by using IBS at construction sites, based on the following formula:

$$\text{Conformity Index (CI)} = \frac{5n_1+4n_2+3n_3+2n_4+n_5}{5(n_1+n_2+n_3+n_4+n_5)} \quad \text{Equation 1}$$

where,

n_1 = number of respondents who responded 'highly agree'

n_2 = number of respondents who responded 'agree'

n_3 = number of respondents who responded 'neutral'

n_4 = number of respondents who responded 'do not agree'

n_5 = number of respondents who responded 'highly disagree'

4.0 Findings and Discussion

4.1 Demography

From the 254 questionnaire forms returned duly completed (representing a 37% response rate), more than half of the respondents were found to have a Bachelor's degree (65%). In terms of work experience, the range of years reported by the respondents is as follows (in descending order based on the percentage of respondents): 12 to 17 years (34%), 6 to 11 years (28%), less than 5 years (16%), 18 to 23 years (5%) and 24 to 29 years (1%). It was also discovered that less than half of the respondents (41%) have had 6 to 11 years of experience in implementing the IBS approach. Approximately half (48%) of the respondent have 5 years or less experience in IBS. The remaining respondents were those with IBS experience for more than 30 years (11%). A majority of the respondents (69%) were focused only on implementing IBS in local projects, while a few (2%) had utilized IBS on international projects. The remaining respondents (29%) were found to have concentrated on both international and local projects. 68% of the respondents were discovered to have experience in implementing IBS in less than six projects, as compared to 82% of the respondents who had carried out 6 to 20 projects.

4.2 Main Benefits of IBS Implementation

The Cronbach's Alpha Reliability Test was performed after all the data from the respondents were compiled. A significantly high value of 0.8739 was obtained. This indicates that this data can be utilized to analyze the importance of the relevant factors. The listed factors were ranked 1 to 13 according to importance as indicated by the index calculation of Equation 1. Using the conformity index, the overall analysis of the listed benefits gained by contractors via IBS implementation were obtained. The mean score and the response frequency are as presented in Table 1.

Table 1: Ranking based on the conformity index of the benefits gained by contractors from IBS implementation

Benefits Gained by Contractors via IBS Implementation	The frequency of benefits received by the contractors through IBS implementation at construction sites					Conformity Index (CI)	Mean	Position
	1	2	3	4	5			
IBS improves the production of construction	104	112	30	5	3	0.843307	4.22	1
IBS reduces concrete mixing activities	92	132	18	9	3	0.837008	4.19	2
IBS reduces construction duration/time	95	118	31	5	5	0.830709	4.15	3
IBS components fabricated in factories reduced the usage of raw materials on site.	69	154	23	5	0	0.828685	4.14	4
IBS helps in reducing the usage of foreign labour	88	125	23	13	5	0.818898	4.09	5
IBS decreases construction waste	70	145	32	2	5	0.814961	4.07	6
Standardized IBS components have enabled a more uniform quality in building design	97	99	27	28	3	0.803937	4.02	7
IBS increases building quality	49	119	74	9	3	0.759055	3.80	8
IBS increases the level of effective construction management	48	134	45	22	5	0.755906	3.78	9
Local IBS components help reduce costs of projects	48	129	45	24	8	0.745669	3.73	10
IBS helps in reducing health risks at construction sites	51	98	83	19	3	0.737795	3.69	11
IBS increases safety levels at construction sites	45	99	86	19	5	0.725984	3.63	12
IBS is able to reduce building defects	41	97	93	20	3	0.720472	3.60	13

[©] **Note:** 1 – highly agree; 2 – agree; 3 – neutral; 4 – do not agree; 5 – highly disagree; CI – Conformity Index

This analysis shows that there are three main benefits received by the contractors through IBS implementation at construction sites. These main benefits are as follows:

- (1) IBS increases productivity at the construction site (CI = 0.843307);
- (2) IBS reduces concrete mixing activities at construction sites (CI = 0.837008); and
- (3) IBS reduces construction duration/time (CI = 0.830709)

4.3 IBS Increases Productivity at the Construction Site

According to Koss and Lewis [19], the term ‘productivity’ originates from the Latin word, *producere* where ‘*pro*’ is to advance or develop and ‘*ducere*’ means to lead. A more comprehensive definition of ‘productivity’ can be related to the quantitative aspect between outputs and inputs. In terms of IBS, outputs are referred to any IBS components that are installed based on the specifications of the construction drawings, whereas inputs are the total man-hours required to complete that IBS activity [3]. Productivity levels can be improved by increasing output while sustaining or reducing the input. All the

respondents agreed that improved productivity is the main benefit that they can gain by implementing IBS at construction sites. This benefit recorded a CI of 0.843307 which is 0.006299 more than the second main benefit of reducing concrete mixing activities at construction sites.

The main function of the construction industry has always been to enable the provision of effective physical assets and infrastructure systems. Both of these elements are crucial in ensuring Malaysia's progressive achievement towards being a developed country. IBS is able to create finished construction products (outputs) in a faster and efficient rate, while simultaneously reducing the dependency on foreign labour (input) at construction sites. Thus, the implementation of IBS is evidently critical in paving a new direction by propelling Malaysia towards a successful Vision 2020.

4.4 IBS Reduces Concrete Mixing Activities at Construction Sites

According to Mindess and Young [20], concrete-related operations comprise of four processes which are i) transportation ii) placement iii) assembly and compression iv) smoothing and refining the surface according to the specifications listed in the contract. Badir [21] categorized the structured building system of IBS as i) a framework structure based on concrete mixture by using aluminium or steel (to mould the materials) ii) a prefabricated system; and iii) a composite system (a combination of other systems where concrete is mixed in-situ with the use of prefabricated slabs). However, architects and engineers in Malaysia have mainly often chosen the system utilizing prefabricated IBS components in their construction projects [3, 22].

The implementation of IBS will definitely reduce concrete mixing activities as a majority of these conventional concrete casting activities will now be conducted under a controlled environment within factories. The reduction of these wet concrete works is one of the main advantages that will be gained by contractors through IBS implementation. In this category, the conformity index recorded is 0.837008 (out of the full value of 1.000000). The difference in CI value between this benefit and the subsequent third main benefit is 0.006299.

4.5 IBS Reduces Construction Duration/Time

Time management is crucial as construction workers are normally paid according to their working hours. Thus, by managing time efficiently, it can optimize the cost for salary and wages. In addition to this, any delay in construction activities will affect the overall scheduled implementation of a project. This is due to the fact construction activities are usually linked either in succession or in a simultaneous manner within the overall project work schedule. A delay in a certain activity will negatively affect the next corresponding activity, and subsequently affect the entire project timeline.

The efficiency and effectiveness of the whole project can be increased through IBS implementation at construction sites. This is because IBS helps to optimize time and reduce labour costs. By implementing IBS, the duration for activities that require concrete mixing work may be significantly shorter when compared to conventional methods. The CI value for this benefit was recorded at 0.830709.

5.0 Conclusion

IBS implementation is able to maintain a consistent level of quality in construction projects by meeting the demands of contractors and clients. The three main benefits of IBS implementation that were identified through the course of this study are, increasing construction site productivity; reducing the time for in-situ concrete mixing activities; and reducing the overall construction duration. The common denominator among these three main benefits is the capability of IBS implementation to reduce the time frame for construction product completion. At the same time, IBS implementation is also able to create a better construction site working environment, as there would no longer be massive in-situ wet concrete works. It is evidently clear that the capacity of this industry can be enhanced using the IBS approach. This will allow this industry to generate better products that will be subsequently utilized by other industries and sectors. This in turn will spur a positive economic growth that will ultimately benefit developing nations such as Malaysia. IBS will significantly reduce the reliance on in-situ concrete mixing activities that have long dominated conventional construction work methods and will consequently enable contractors to complete their works in a far better timeframe to the satisfaction of their clients.

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