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Performance Factors of Industrialised Building System (IBS) and Conventional Method toward Sustainable Construction

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Abstract: The Industrialised Building System (IBS) was introduced as a replacement for the conventional system and in response to the government's ideas for sustainable development. IBS provides advantages such as labour savings, high quality, and faster completion time. In contrast, conventional methods are vulnerable to flaws in terms of quality, effectiveness, and reliance on foreign workers. However, many industry players are still unwilling to abandon the conventional way. The study's objectives are to investigate the issues and challenges associated with IBS and conventional methods, to identify performance factors associated with IBS and conventional methods, and to analyse the issues/challenges and performance of IBS and conventional methods in terms of sustainability. A total of 36 questionnaires were analysed using the Statistical Package for Social Science (SPSS) software, with a 5-point Likert scale used to determine the respondents' level of agreement. According to the findings of this study, conventional methods and IBS face five and 23 issues and challenges, respectively. The performance factor is made up of six components: cost, quality, time, social, environmental, and economic. These components were also discussed in the data analysis. This result of this study helped provide awareness to industry players on the IBS system through performance analysis for IBS and conventional methods.

Keywords: Industrialised Building System, Conventional Method, Issue and Challenges, Performance

1. Introduction

Construction defined as human activity consists of planning, designing, constructing and maintaining work [1] which has been around for a long time and one of the largest industries nowadays [2]. Basic construction activities are always associated with three factors: time, cost, and quality [3]. Previous research has shown that the concepts of cost, quality, and time are highly interdependent, proving that they are distinct and important concepts in project management. Construction activity was contemplated sustainable if it meets the basic principles of social, economic, and environmental

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sustainability [4]. Sustainability is associated with concepts of a healthy built environment that focus on resource efficiency and a balanced ecology life cycle. Sustainable construction integrates green building concepts with eco friendly goals in minimising environmental impact of buildings. There are numerous advantages to adopting sustainability construction, including reduced cost, enhanced productivity, waste reduction, improved health, and better material utilisation. Construction activity has grown in importance as a source of national income in Malaysia. There are two types of construction methods: conventional and industrialised building systems (IBS). The conventional method of construction refers to the completion of construction work at the proposed location, which includes works such as the installation of a wood or plywood formwork, reinforcement steel, and cast, which are set up directly on the construction site. Furthermore, IBS is a building method in which components are manufactured in a factory and then positioned and assembled into structures with minimal additional site work. IBS is an acknowledged alternative to the conventional construction for improving long-term outcomes [5].

Many construction industry players continue to be opposed to the use of this good sustainable method of construction in their works. They might very well continue to use conventional method because it is convenient for them and does not necessitate skilled workers, and they do not want to risk adopting the IBS method. Furthermore, contractors find it difficult to transition to this system due to variable demand for building types, high financing rates, and low labour costs [6]. Adopting a new system necessitates a significant and ongoing budget, as well as time set aside for employee training and the purchase of specialised equipment and machinery [7]. The use of conventional methods can raise the overall cost of a construction project due to increased labour, raw materials, and transportation costs [8]. However, IBS provides numerous benefits to industry participants, including faster completion time, reduced waste material on the job site, labour savings, and high quality [9]. Despite the fact that IBS technology has been in use in Malaysia for a long time and that numerous previous studies have demonstrated the benefits of using IBS, the use of IBS, particularly in the private sector, remains low at 15% compared to 70% in government projects [10].

Therefore, the objective of this study is to explore on the issues and challenges of IBS and conventional method by using quantitative method which is questionnaire. Besides, identification of the performance factors of IBS and conventional method is the next objective of this study. In addition, the issues and challenges and the performance factors of IBS and conventional method have been analysed by descriptive analysis using Statistical Package for Social Science (SPSS) software.

2. Methodology

The methodology for this study consists of questionnaire design, determination of sample size, pilot study and descriptive analysis.

2.1 Questionnaire design

A refined questionnaire is vital to ensure the data collected is useful for the study [11] which it must be contractor-friendly [12]. Questionnaire allow for a large number of respondents and a range of variables can be quantitatively analysed [6]. In this study, the questionnaire was designed based on literature review on previous study. The questionnaire have been divided into three parts as follows:

a) Part A: Demographic information includes the chosen respondent's factual profile information and position in the organisation, education qualification, work experience in the construction and IBS fields, and so on.
b) Part B: Issues and challenges of industrialised building system (IBS) and conventional method towards sustainable construction. This section was designed to identify the major issues and challenges that respondents had encountered.
c) Part C: Performance factors of industrialised building system (IBS) and conventional method towards sustainable construction. This part was to investigate the performance on six factors which are cost, quality, time, social, environment and economy between conventional method and IBS.

2.2 Sample size of questionnaire

The sample size must be determined after the target population has been identified. The questionnaire was distributed to contractors with grade 7 (G7) specialisation in IBS consisting of prefabricated concrete system. G7 contractors were chosen because they are consistently and actively involved in the construction industry while also being skilled in both methods of construction. Based on Krejcie and Morgan table [13], the sample size for this study is 34 respondents (propotional) based on 39 population size of contractors G7.

2.3 Pilot study

The pilot study was carried out before the final version of the questionnaire draft was approved. Its aim was to ensure that all of the questions and instructions are clear, and to assess the suitability of the question before distribution process occur [11]. The response rate required for adequate precision in data collection has been set at around 10 – 15 in order to carry out the pilot study [14] which expert in the field of study should be involved in the pilot study. A pilot study can be used to assess the dependability and validity of a questionnaire. [15]. Cronbach's Alpa is a common method for testing the instrument's internal reliability; if the value is greater than 0.60, the instrument is considered internally consistent [16]. In other word, when the value is close to 0, the responses are not very reliable, but when it is close to 1, they are quite reliable.

2.4 Descriptive analysis

In this study, the data collected was analysed in two analysis which are mean score and standard deviation. The mean score have been arranged by the ranking value from highest to lowest for the issues and performance factors of conventional and IBS method of construction in Johor Bahru. In this research questionnaire the formula that have been used to obtain mean score [17] is as follows:

$$\text{Mean Score} = \frac{\sum R}{\text{N}} \quad Eq.1$$

Where;
R = Total Mean Score of each scale (5 point likert scale)
N = total number of respondents

Standard deviation is a widely used measure of variability that represent the degree of deviation from the average score. A low standard deviation indicates that the data points are close to the average score, whereas a high standard deviation suggests that the data comprise a wide range of values [18]. The equation of standard deviation [19] can be derived as:

$$\text{SD} = \sqrt{\frac{\sum(X-\bar{x})}{n-1}} \quad Eq.2$$

where;
X = observation value
$\bar{x}$ = mean
n = sample size

3. Results and Discussion

The study was conducted within the contractor G7 in Johor Bahru, which specialises in prefabricated concrete systems. There were 39 questionnaires distributed among contractor companies via Google Form.

3.1 Demographic

Background information on the respondents has been gathered in order to obtain a clearer and more complete picture of the study. Figure 1,2,3 and 4 show the demographic consist of gender, position in

organization, working experience in conventional construction industry and working experience in Industrialised Building System (IBS) respectively.

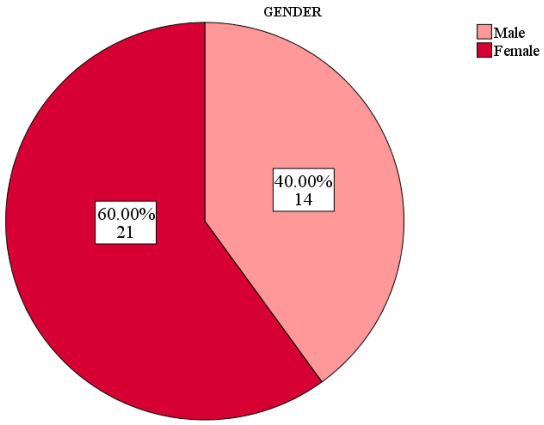

Figure 1: Gender

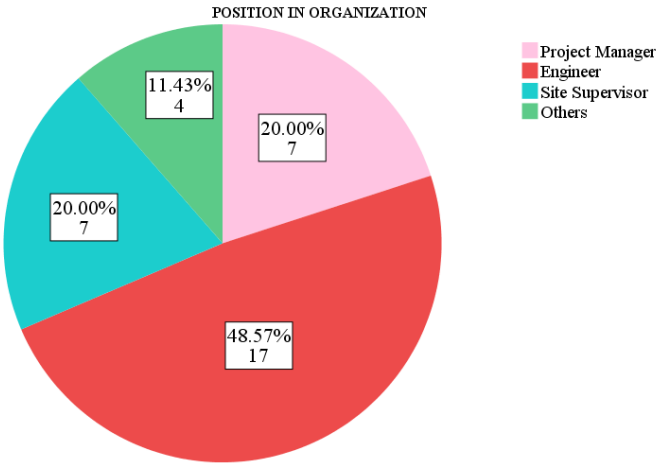

Figure 2: Position in Organization

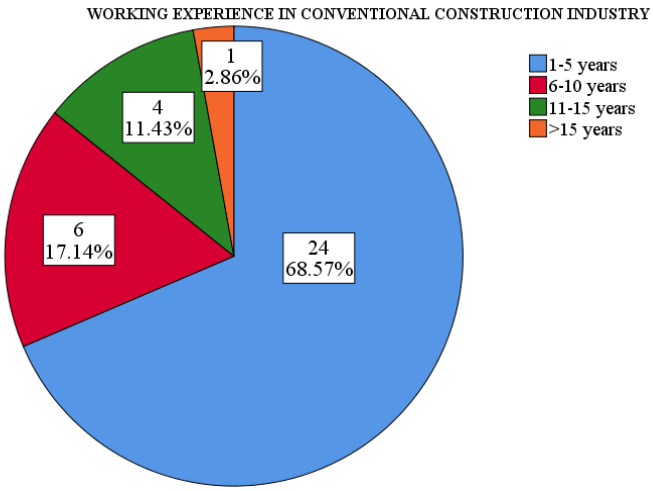

Figure 3: Working Experience in Conventional Construction Industry

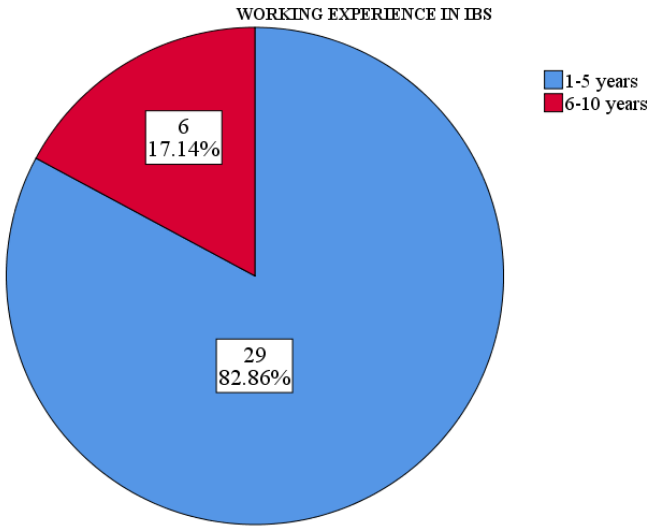

Figure 4: Working Experience in Industrialised Building System (IBS)

3.2 Issues and challenges of Industrialised Building System (IBS) and conventional method towards sustainable development in construction

Table 1 illustrate the issues and challenges of conventional method while Table 2 show the issues and challenges of IBS that have been obtained based on literature review and expert opinion on pilot study. There are five and 23 issues and challenges of conventional method and IBS respectively.

Table 1: Issues and Challenges of Conventional Method

No	Issue and Challenges of Conventional Method
1	The number of workers in construction activity
2	The completion time of construction activity
3	Waste of material in construction site
4	The quality of the workmanship skills
5	The maintenance expenses on the building

Table 2: Issues and Challenges of IBS

No	Issue and Challenges of Industrialised Building System (IBS)
1	The availability of professional skilled workers in construction site
2	The cost of skilled labour
3	The number of manufacturers for IBS components
4	The willingness of contractors to convert from conventional method to IBS
5	The necessitation for construction precision on IBS construction
6	The availability of centralised research and development (R&D) of IBS in Malaysia
7	The adequacy of government promotion in the implementation of IBS
8	The comfortableness of building occupancy due to acoustic performance of IBS wall
9	The cost of maintenance/repair
10	The jointing of building components (beam-beam, beam-column, etc.)
11	The adequacy on ventilation system of the IBS building
12	The flexibility to make changes to building after have been installed
13	The cost of renovation
14	Installation for plumbing and electrical works in IBS building
15	The cost of material and installation
16	The significant initial investment
17	The convenience of authority's approval and financing dealing

18	The accessibility on knowledge related to IBS
19	The communication and cooperation among key stakeholders in early stage of project
20	The adequacy on comprehension of the IBS design
21	The cost of transportation
22	The cost of IBS component
23	The sufficiency of regulation for IBS construction

3.3 Performance factors of Industrialised Building System (IBS) and Conventional Method towards sustainable construction

Table 3 indicates the performance factors of IBS and conventional method that have been identified by reviewing previous literature and the feedback of pilot study. There are six factors that have been determined and for every of the factors there are some items that have been discovered. There are five items under cost factor and three items each for quality, time, social, environment and economy factors.

Table 3: Performance Factors of IBS and Conventional Method

No	Performance Factors for Industrialised Building System (IBS) and Conventional Method
1.0	Cost
1.1	Saving in overall cost project
1.2	Saving in material cost
1.3	Saving in labour cost
1.4	Saving in equipment cost
1.5	Saving in structure/component cost
2.0	Quality
2.1	The satisfaction on the condition of finishes
2.2	The flexibility in performing renovation work
2.3	The requirement to have many maintenance works on building
3.0	Time
3.1	Time of completion
3.2	Time of installation structure/component
3.3	The material delivery time
4.0	Social
4.1	The availability of safety and health environment
4.2	The efficiency of cleanliness and organised site and also comfortableness of building occupant
4.3	The capability to avoid noise pollution and traffic disruption
5.0	Environment
5.1	Effectiveness of the global greenhouse gas emission
5.2	Effectiveness of energy efficiency
5.3	The capability to reduce waste of material
6.0	Economy
6.1	The capability of initial investment of stakeholder
6.2	Interest payment in construction depend on the time taken for building occupation
6.3	The depreciation of building cost depends on the quality of product

3.4 Analysis the issues/challenges and performance factors of IBS and conventional method towards sustainable construction

Table 4 demonstrates that the completion time of construction activity is the most critical issue and challenge, as respondents agreed that conventional methods require more time to complete a project, which may result in an increase in project cost. The least critical issue and challenge is the building's maintenance expenses, which respondents also agree are one of the issues and challenges for the

conventional method. This is due to the fact that conventional methods produce poor finishes, which result in higher building maintenance costs.

Table 4: Issues and Challenges of Conventional Method

No.	Issue and Challenges of Conventional Method	Mean	Std. Deviation	Rank
2	The completion time of construction activity	4.31	0.796	1
1	The number of workers in construction activity	4.03	0.618	2
3	Waste of material in construction site	3.97	0.891	3
4	The quality of the workmanship skills	3.94	0.968	4
5	The maintenance expenses on the building	3.63	0.973	5

Table 5: Issues and Challenges of IBS Method

No.	Issue and Challenges of IBS Method	Mean	Std. Deviation	Rank
2	The cost of skilled labour	4.11	1.022	1
22	The cost of IBS component	4.09	0.818	2
19	The communication and cooperation among key stakeholders in early stage of project	4.06	1.056	3
6	The availability of centralised research and development (R&D) of IBS in Malaysia	3.97	0.923	4
1	The availability of professional skilled workers in construction site	3.94	0.765	5
23	The sufficiency of regulation for IBS construction	3.89	0.932	6
5	The necessitation for construction precision on IBS construction	3.89	1.051	7
7	The adequacy of government promotion in the implementation of IBS	3.83	1.361	8
8	The comfortableness of building occupancy due to acoustic performance of IBS wall	3.80	0.868	9
18	The accessibility on knowledge related to IBS	3.80	0.868	10
20	The adequacy on comprehension of the IBS design	3.74	1.268	11
3	The number of manufacturers for IBS components	3.71	0.860	12
13	The cost of renovation	3.66	1.327	13
9	The cost of maintenance/repair	3.63	1.165	14
17	The convenience of authority's approval and financing dealing	3.63	1.165	15
10	The jointing of building components (beam-beam, beam-column, etc.)	3.57	1.145	16
15	The cost of material and installation	3.54	1.094	17
11	The adequacy on ventilation system of the IBS building	3.49	1.121	18
16	The significant initial investment	3.49	1.222	19
12	The flexibility to make changes to building after have been installed	3.43	1.290	20
14	Installation for plumbing and electrical works in IBS building	3.40	1.168	21
4	The willingness of contractors to convert from conventional method to IBS	3.37	1.114	22
21	The cost of transportation	3.09	1.422	23

Based on Table 5, respondents agreed that the most critical issue and challenge for the IBS method is a lack of skilled labour. This is due to the fact that the IBS method necessitates the use of workers who specialise in the manufacture of IBS, as it is a precise construction. Because of a scarcity

of skilled labour, the demand for skilled labour on IBS will drive up labour costs. Meanwhile, respondents agreed that the least issues and challenges of IBS is the cost of transportation. This is due to the fact that IBS components are typically transported on a large scale, which reduces the journey trip to the construction site as well as the cost of transportation.

Table 6: Performance Factor of IBS and Conventional Method

No	Performance Factors	Industrialised Building System (IBS)			Conventional Method		
		Mean	Std Deviation	Rank	Mean	Std Deviation	Rank
1.0	Cost						
1.1	Saving in overall cost project	4.29	0.750	2	3.23	0.770	4
1.2	Saving in material cost	3.97	1.071	4	3.31	0.796	3
1.3	Saving in labour cost	4.46	0.741	1	3.17	0.985	5
1.4	Saving in equipment cost	3.69	1.323	5	3.49	1.011	1
1.5	Saving in structure/component cost	4.20	1.132	3	3.37	0.808	2
2.0	Quality						
2.1	The satisfaction on the condition of finishes	4.23	0.808	1	3.60	0.914	2
2.2	The flexibility in performing renovation work	3.14	1.264	3	3.94	1.136	1
2.3	The requirement to have many maintenance works on building	3.34	1.235	2	3.43	1.195	3
3.0	Time						
3.1	Time of completion	4.49	0.853	1	3.06	1.211	3
3.2	Time of installation structure/component	4.31	1.078	2	3.06	1.211	2
3.3	The material delivery time	3.91	1.040	3	3.43	1.008	1
4.0	Social						
4.1	The availability of safety and health environment	4.46	0.780	2	4.11	1.132	1
4.2	The efficiency of cleanliness and organised site and also comfortableness of building occupant	4.51	0.702	1	2.94	1.083	2
4.3	The capability to avoid noise pollution and traffic disruption	4.46	0.886	3	2.77	0.877	3
5.0	Environment						
5.1	Effectiveness of the global greenhouse gas emission	4.26	0.919	3	2.66	1.162	3
5.2	Effectiveness of energy efficiency	4.46	0.741	1	2.74	1.120	1
5.3	The capability to reduce waste of material	4.40	1.006	2	2.66	1.083	2
6.0	Economy						
6.1	The capability of initial investment of stakeholder	3.83	1.071	1	3.63	0.942	1
6.2	Interest payment in construction depend on the time taken for building occupation	3.80	1.052	2	3.00	0.874	3
6.3	The depreciation of building	3.63	0.942	3	3.57	0.948	2

No	Performance Factors	Industrialised Building System (IBS)			Conventional Method		
		Mean	Std Deviation	Rank	Mean	Std Deviation	Rank
	cost depends on the quality of product						

From Table 6, for cost factor, most respondents agree that the conventional method can save money on equipment because it still relies on manual labour for the majority of the work, which may not save money on labour. Respondents strongly agreed, on the other hand, that the IBS method can save money on labour but not on equipment because the implementation of IBS reduces manual labour on the job site. Next, in term of quality factor, respondents strongly agree that there is flexibility in performing renovation work for the conventional method. On the other hand, the majority of respondents strongly agree that the IBS method provides satisfaction with the condition of the end product or finishes. This is due to the fact that the IBS components were manufactured in a factory. Besides, in term of time, respondents strongly agree that the conventional method's material delivery time has the greatest impact. This is because a delay in material delivery can have an impact on project completion, causing the project's duration to increase. Respondents strongly agree that the IBS method significantly reduces the time required to complete a single building construction project. As a result, it validates the previous study's finding that precast technology can save 20 to 35 percent of time [20]. Furthermore, for social factor, respondents agree that the conventional method provides a safe and healthy environment. Then, respondents strongly agree that the IBS method can achieve the efficiency of cleanliness and organisation of the site, as well as the comfort of building occupants, because the IBS method allows for a cleaner, well-organized site with less building waste. Meanwhile, in term of environment factor, on the conventional method, the majority of respondents are neither agreeing nor disagreeing with these items. This demonstrates that conventional methods are ineffective at achieving energy efficiency. However, as the mean score obtained is on the same rating (4.26 to 4.46), the majority of respondents strongly agree that the IBS method is more effective in terms of energy consumption, material waste reduction, and high effectiveness on global greenhouse gas emissions. Lastly, in term of economy factor, the majority of respondents agree that the conventional method is capable of having a high initial stakeholder investment because it allows the owner to have a higher return on investment. As the mean score sits on the same rating (3.63-3.80), the respondents agree that the IBS method is capable of having a high initial stakeholder investment, lower depreciation of building costs, and lower interest payment due to faster time for building occupation.

4 Conclusion

A study was conducted among G7 contractors company located on Johor Bahru to compare the performance between two method of construction which are Industrialised Building System (IBS) and conventional method. A literature study had been done to gain in depth understanding about the construction industry in Malaysia. Throughout the study, issue and challenges of the two method of construction have been explored. The performance of these two methods of construction had been divided into six factors which are cost, quality, time, social, environment and economy. The objectives of this study were met based on the data results obtained. The findings of this study will benefit construction practitioners by taking into account the issues and challenges in construction methods. Also, aided in raising awareness of the IBS system among industry participants through performance analysis for IBS and conventional methods.

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