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Stakeholders' Perception on the Current Practices of Industrial Building System (IBS) Construction Technology

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ABSTRACT

The Industrialised Building System (IBS) has been adopted in the Malaysian construction sector to replace the conventional building approach. Despite the government's attempts to encourage IBS adoption, the use of IBS in Malaysian building projects remains low. This study aims to gather stakeholders' views on drivers, barriers, and strategies to improve IBS implementation in Malaysia. About 52 questionnaires were received from IBS stakeholders in Johor such as consulting firms, contractors and IBS manufacturers. Average Index Analysis was used to analyse the questionnaire data on the main factors: current drivers, factors when considering IBS construction, current barriers and strategies to increase IBS construction. From the questionnaire survey, among the main drivers of IBS construction in Malaysia are technology advancement, reduce completion time and improve quality and productivity. Stakeholders also perceived that supervision on continuous and regular improvements and IBS implementation needs planning for productive process among the main factors when considering IBS construction. Meanwhile, the main barriers for IBS construction perceived are high initial cost investment in projects related to IBS construction, lack of skilled workers and unable to adapt instant changes to design modification in IBS construction. Several main strategies were noted to enhance the IBS implementation such as improving the balance between supply and market demand, innovation in creating eco-friendly sustainable construction and factory production optimization for IBS items. The outcomes of the study could assist relevant parties to understand the current drivers and barriers of IBS construction, and further help them to enhance the IBS implementation in Malaysia.

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1. Introduction

In the state of a developing country, Malaysia has come to the realization that the construction industry plays a vital role in economic growth and enhances the quality of life, together with the standard of living of the Malaysian people. The construction industry is dynamic and has links to other parts of the economy, that would be the sector that provides the social and economic infrastructure for industrial growth and production [1]. Several organizations have implemented initiatives to encourage best practices within the construction industry's current constraints, while others have been attempting to drastically restructure and reengineer the industry in an effort to deal with the industry's previous failures and disruptive pressures [2]. Fortunately, there are a few alternative ways of building that have been slowly adopted by the market, which help keep costs down and schedules on track. One of the initiatives is Industrial Building System (IBS) construction. Industrialized Building Systems are construction methods that generate components in a controlled environment, either on or off site, and deliver, place, hoist, and assemble them into a building structure with little effort [3]. Industrialized building and new materials can change many aspects of construction.

Malaysia's low adoption of Industrialised Building Systems (IBS) demonstrates the lack of modernization of its construction processes and practices, despite the fact that IBS is a globally known method of increasing productivity. While the government has made great efforts to promote IBS adoption, adoption of IBS remains low in Malaysian construction projects [4,5]. One of the main barriers of the adoption is due to the lack of knowledge and skills among IBS construction players, i.e. architects, engineers and contractors [4,6-8]. Lack of information and skilled workers are the common obstacles to implementing IBS in Malaysia, directly addresses this issue as it relates to the country's construction industry. Furthermore, obstacles to widespread utilization of IBS included high costs and a shortage of design options [4,9]. Studies have shown that costs are heavily impacted by a wide variety of variables, from the time of project estimation until the time of project completion. Studies by the previous studies [10-13], and others have found the elements that significantly influence construction costs in different nations. They argue that these aspects have a direct bearing on the construction organizations' responsibilities for managing the cost, socio-cultural, economic, external, technological, and political settings in which they operate, all of which have an impact on the construction costs.

This study suggests that identifying the current drivers and barriers is crucial for stakeholders to enable construction organizations better comprehend the significant potential perspective of the barriers and drivers of IBS construction. Various stakeholders, such as developers, architects, engineers, contractors, and manufacturers, may have different opinions on IBS adoption, therefore it is critical to look at those stakeholders' objections. Even though there are numerous research has been done to examine the barriers to IBS uptake in Malaysia and other countries, most of the studies only obtained the opinions on the variables that restrict IBS uptake from the perspective of contractors only [6,11,14] and consultants only [4]. Other than that, most of the studies conducted on identifying the barriers of IBS implementation were done over a decade before and rather outdated [6,14,15].

Therefore, this study aims to investigate the current drivers and barriers of IBS implementation from the perspectives of IBS construction stakeholders, as well as the main strategies to enhance IBS implementation. This study focused on the state of Johor only since this this state recorded the second highest number of IBS projects for project value over RM 10 million in 2019, after Sabah [16].

1.1 Industrialised Building System (IBS)

In general, the definition of IBS has been quite similar among authors. System building or building system is any pre-engineered method of building that has a predefined scope and configuration limits. They can be volumetric, panel, stick build or hybrid. In Malaysia, IBS is defined as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and installed into a structure with minimal additional site works [1,17]. Kamar *et al.,* [18] revisited the term and developed a new definition of IBS to fit the current categorisation of IBS in Malaysia, which is – "an innovative process of building construction that incorporates: the concept of mass-production of industrialised systems; produces products at the factory or onsite within controlled environments; includes the logistical and assembly aspects of it; and is coordinated with thorough planning and integration." The transition from traditional construction techniques towards IBS in Malaysia has led to enhanced efficiency, cost savings, and improved quality [19]. They underscore the profound influence of technology in making IBS a feasible solution for the nation's fast-growing infrastructure demands.

2. Methodology

A quantitative research approach was adopted for this study through distributing the questionnaire survey form to IBS stakeholders in Johor, Malaysia. About 100 questionnaire forms were sent to IBS stakeholders such as consultants, contractors and IBS manufacturers through the online platform (google form) and face-to-face. After one-month period of data collection, the number of returned questionnaire was 52 (52% response rate).

The questions were closed-ended using a five-point Likert scale to represent the respondent's degree of agreement about the factors. The questionnaire consisted of six sections, as follows: Section A - demographic information of the respondent; Section B - stakeholders' perception on IBS usage in Malaysia, Section C - current drivers in IBS construction in Malaysia; Section D - factors when considering IBS construction in Malaysia; Section E - current barriers in IBS construction in Malaysia; Section F - strategies to enhance the implementation of IBS in Malaysia. In Section C to F, the respondents were asked to rate the level of agreement of the factors listed, based on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Most of the questions were built upon the previous study conducted in the United States by Razkenari *et al.,* [20]. The questionnaire was validated by 3 panels of the expert who had more than 10 years of experience in IBS construction. Minor improvements have been made according to expert panels' suggestions to ensure the questions fit with Malaysia environment. Further, a reliability testing was done by 10 selected respondents to check the reliability of the survey instrument. The result from Cronbach's Alpha reliability values for each section range between 0.843 and 0.974, suggesting that there is no change needed in the questionnaire instrument [21]. Next, the actual data collection started by distributing the questionnaire to the respondents who were working at construction sites in Johor. Average Index (AI) Analysis was used to analyse the returned questionnaire. The evaluation ranges to assess the level of agreement are shown in Table 1.

Table 1
Evaluation ranges for AI analysis

Average index	Level of agreement
1.00 ≤ Average Index ≤ 1.50	Strongly Disagree
1.50 ≤ Average Index ≤ 2.50	Disagree
2.50 ≤ Average Index ≤ 3.50	Neutral
3.50 ≤ Average Index ≤ 4.50	Agree
4.50 ≤ Average Index ≤ 5.00	Strongly Agree

3. Results and Discussions

3.1 Reliability Test

The returned questionnaires were analysed for Cronbach's Alpha test to check the reliability of the results and the overall consistency of a measure for the entire survey. Table 2 indicates the results of the reliability test for responses of Section B, C, D, E, and F, which indicate good internal consistencies.

Table 2
Cronbach's Alpha values

Section	Cronbach's Alpha value
Section B – Stakeholders' perception of IBS usage in Malaysia	0.843
Section C – Current drivers in IBS construction in Malaysia	0.974
Section D – Factors when considering IBS construction in Malaysia	0.953
Section E – Current barriers to IBS construction In Malaysia	0.924
Section F – Strategy to enhance the implementation of IBS construction in Malaysia	0.936

3.2 Section A - Demographic Information of Respondents

Table 3 shows the background of respondents. Out of 52 respondents, most of the respondents had Bachelor's Degree qualification, followed by Diploma and postgraduate degrees. Most of the respondents were from constructing companies, followed by IBS manufacturer and consultant. From respondents' background analysis, it is believed that the information provided by them would be reliable because the respondents were selected among those who had experience in handling IBS project and most of the respondents had working experience in construction for more than 5 years.

Table 3
Background of respondents

Description	Percentage of respondents (%)
Academic qualification	
Postgraduate (PhD and Master)	23
Bachelor's Degree	48
Diploma	27
SPM	2
Organisation	
Client	11
Architect	8
Engineering consultant	21
Contractor & sub-contractor	31
IBS manufacturer	25
Other	4
Years of working experience	
More than 20 years	18

15 - 20 years	17
10 – 15 years	29
5 – 10 years	21
Less than 5 years	15

3.3 Section B - Stakeholders' Perceptions Regarding the Use of IBS Construction for Market Demand in the Future

Stakeholders were asked to share their assumption on the market demand of IBS construction in the future. From Figure 1, majority of the respondents perceived that the demand of IBS construction will increase in the future. Twenty-seven percent (27%) of respondents voted the market demand for IBS construction will slightly increase, whereas the remaining 2% of respondents assumed it will remain the same as of current pace.

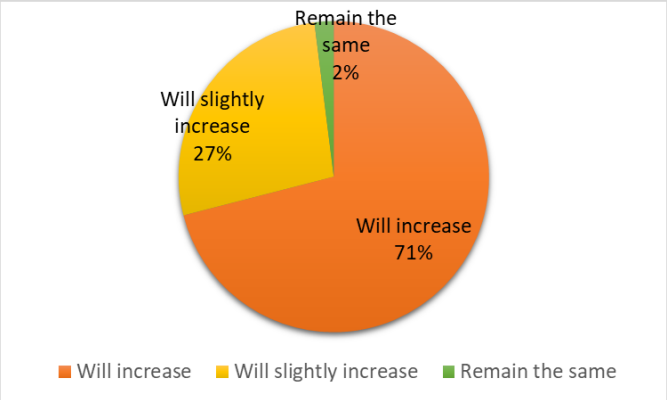

Fig. 1. Stakeholders' perception regarding the use of IBS construction for market demand in the future

3.4 Section C - Current Drivers in IBS Construction in Malaysia

Figure 2 shows the results of average index analysis and the ranking of current drivers of IBS construction in Malaysia. In general, most drivers had significant mean values above 4.00 across stakeholders' perspective.

The highest rank of current driver is 'IBS construction enhances the advancement of technology in Malaysia' with the AI value of 4.58. According to Nawari [22], the advancement of technology and new ideas for IBS building has made adoption an essential area of strategic research, to the construction industry's more widespread acceptance of technology, which proves that technology plays a vital role in construction. Technology has greatly impacted stakeholders, making this driver the most trustworthy when working on IBS projects.

This is followed by the factor of 'IBS construction reduces completion time'. Majority of the respondents chose agree and strongly agree to this factor, resulting the AI value of 4.42. According to Ali *et al.,* multiple studies have demonstrated that IBS can save construction time by 30% [4]. IBS projects are time efficient construction as supported by the stakeholder by giving good range of scales towards this driver in terms of IBS holds high potential in short period construction projects.

Next, the third rank of IBS driver is IBS construction enhances quality and productivity', with the AI value of 4.37. IBS projects priorities quality and productivity during building and manufacture. The stakeholder agrees to Wang *et al.,* [23] findings on incorporating Building Information Modelling (BIM) together with laser scanning and photorealistic rendering technology as the core concern of quality control for standardized IBS components [23].

Other than that, stakeholders also perceived that IBS construction projects are environmentally friendly, in agreement with Tam *et al.,* [24] who claimed that when compared to traditional projects, using IBS might minimize waste by approximately 74 percent for tiling, over 90 percent for concrete casting and reinforcement, and by 100 percent for plastering. Meanwhile, cost reduction is perceived as the least driver of IBS construction in Malaysia.

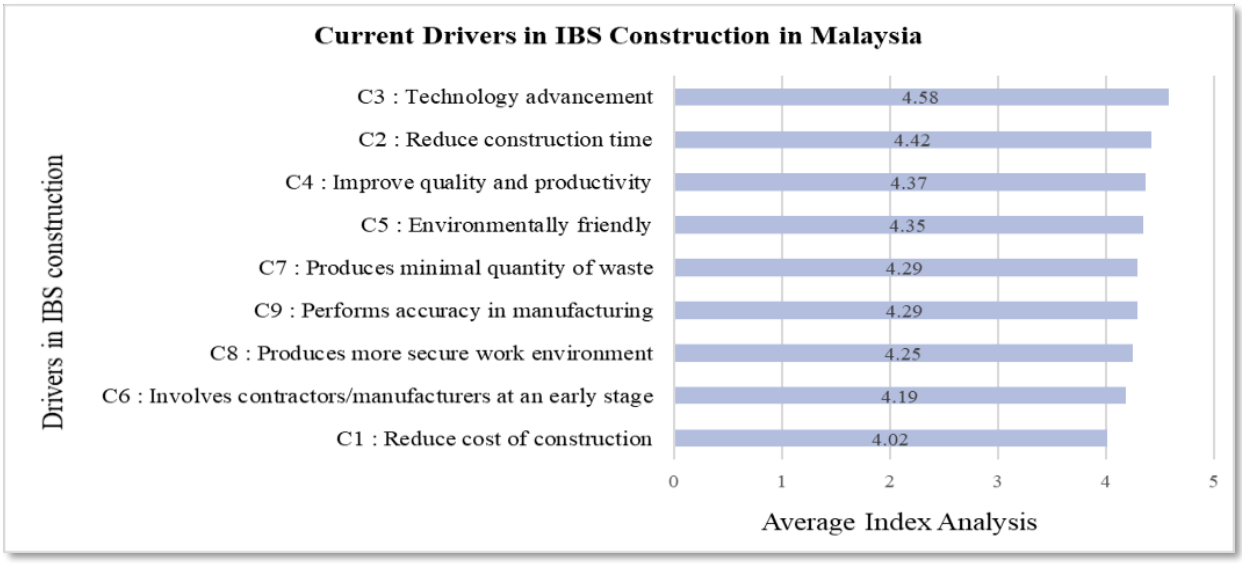

Fig. 2. Current Drivers in IBS construction in Malaysia

3.5 Section E - Factors When Considering IBS Construction

The respondents were also asked about their agreement on the factors when considering IBS construction. In general, most of the factors were evaluated with significant mean value (i.e. AI value of 4.00 and above), except one factor, which is 'focuses on integrated design implementation during construction' with the AI value of 3.98 (as shown in Figure 3).

The highest factor when considering IBS construction in Malaysia is 'supervision on continuous and regular improvements' with average index (AI = 4.38). According to Shen *et al.,* [25], although IBS is an attractive method for reducing construction time and saving materials, it still requires a lot of monitoring and direction from trained site managers to prevent mistakes. This research agrees with previous studies on supervision and improvements, prioritizing improvements or default checks for a smooth construction process [25].

Next, the second highest ranked factor is 'proper planning for productive process' with the AI value of 4.35. IBS stakeholders need production planning. This implies that the planning and production in the current state needs attention and more management steps in terms of planning. Planning defines the project's direction and eliminates any uncertainties imposed upon it. This results in improved project performance, coordination, and management. As the adage goes, practice and practice, and a successful implementation is dependent on the learning curve from previous initiatives. Consequently, constant learning permits the evolution of IBS methodologies and underlying principles. Practice makes perfect, and a successful implementation relies on past experiences [26]. Constant learning allows IBS methods and principles to evolve [27]. This research supports previous statements on production process planning, which is more accurate and reliable.

The third highest factor is 'standardizing the production item factor' with the AI value of 4.38. Stakeholder's perception regarding IBS construction shows agreement in terms of standardizing the

production items with specific measurements catalogue, materials, and design for standard amount of price, or in case of uniform design. In addition to reducing problems, site management promotes standardisation. This leads to reduction in project cost due things into consideration process.

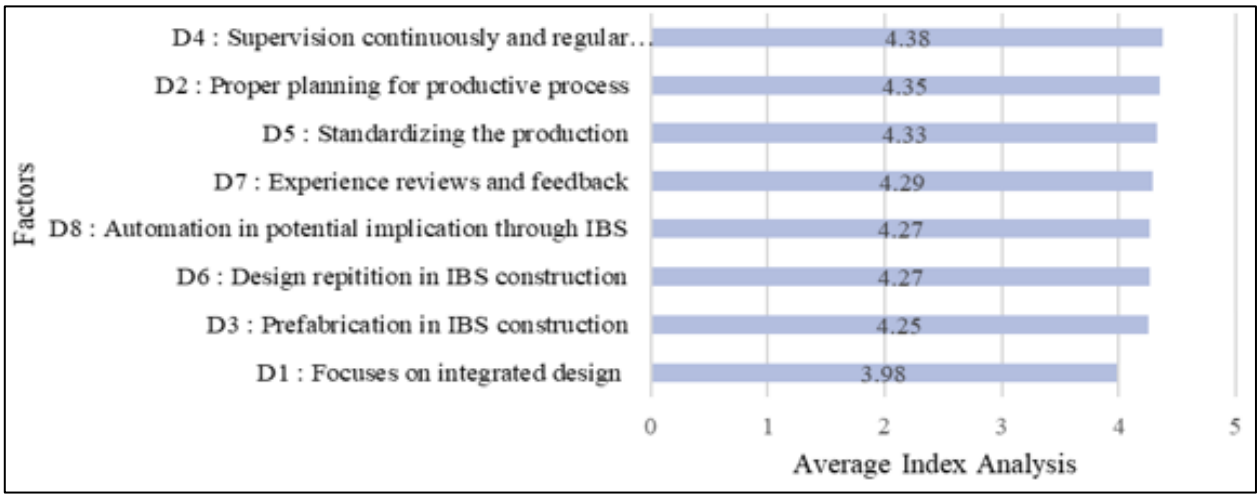

Fig. 3. Factors when considering IBS construction

3.6 Section E - Current Barriers in IBS Construction in Malaysia

Figure 4 shows the results of respondents' perceptions on the current barriers in IBS construction in Malaysia. Based on the results, the respondents seemed to agree and neutral with the barriers listed.

The finding indicates the most perceived current barrier is 'high initial investment cost' in projects related to IBS construction (AI = 3.94). This indicates that majority of the stakeholders agreed that IBS need huge potential of financial support to implement the construction. The initial cost of an industrialized building system is prohibitive for the stakeholders, who will be unable to afford it, which proves high mean value on the barrier issue by the stakeholders [27]. The contractors who usually try to make more money by cutting costs see IBS as an expensive, risky, and complicated choice. which clearly supports the finding of this research that IBS projects need potential financial arrangement for smooth construction procedure.

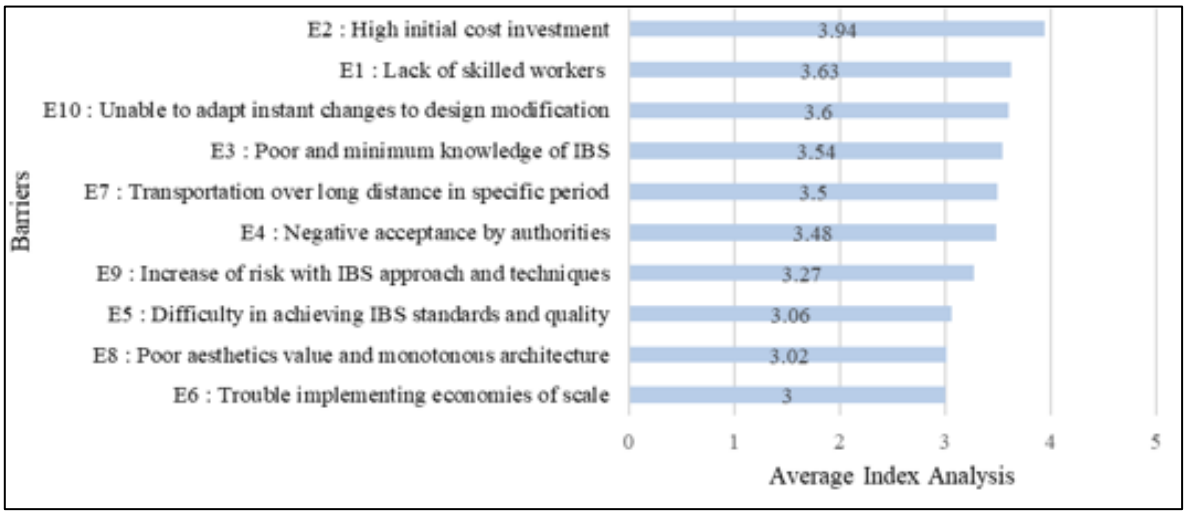

Fig. 4. Current Barriers in IBS construction

The second highest perceived barrier is 'lack of skilled workers in IBS construction (AI = 3.63). The construction industry, especially IBS construction, is hindered by a lack of skilled workers. This is in line with previous study by Kamar *et al.,* [6]. Further remarks were made that the deployment of the IBS system required a first-rate effort to replace current building practices and to teach the staff with specialized talents, such as assembling and coordinating [6].

Then next barrier is 'IBS construction unable to adapt instant changes to design modification' (AI = 3.60). This implies that stakeholders are still unsure of IBS construction, especially with design changes. Comparing to previous studies by Fateh *et al.,* [28], many authorities are unfamiliar with the IBS coordinating and standardisation idea associated with IBS manufacturing and application techniques. Other barrier includes 'poor and minimum knowledge of IBS construction' (AI = 3.54). This is due to the lack of understanding and awareness among industry's stakeholders, which make IBS is not a popular option for design consultants [3,4]. Other than that, lack of structural analysis and design of prefabricated components expertise among civil engineers and people involved in construction is one explanation for the low level of IBS adoption.

3.7 Section F - Strategy to Enhance the Implementation of IBS Construction in Malaysia

Figure 5 shows the results of respondents' perceptions on the strategies to enhance IBS construction in Malaysia. All respondents agreed that the nine strategies listed are significant to enhance the IBS implementation in Malaysia. Among the main strategies noted are 'improving the balance between supply and market demand', 'innovation in eco-friendly sustainable construction' and 'factory production optimization for IBS item'.

Majority of the respondents believed that stable and balanced analysis between manufacturer supply and market demand for construction should be managed to promote growth. According to Fateh *et al.,* [28], IBS requires contractors to take on the roles of solution provider and procedure supervisor, with the responsibility of managing the operation from the manufacturing line to the site. This will balance supply and market demand by cooperating with manufacturers and contractor teams. In addition, some IBS methods allow the use of wastes to be incorporated as building materials, thus preserve earth's scarce resources for future generations [29,30]. The author also emphasizes that IBS approach should require strong participation from institutions, industries, and organizations from the start of any precast R&D initiatives. R&D topics should include in-depth value chain research on IBS solutions as well as solving difficult problems like inventing new jointing systems and IBS materials [31,32].

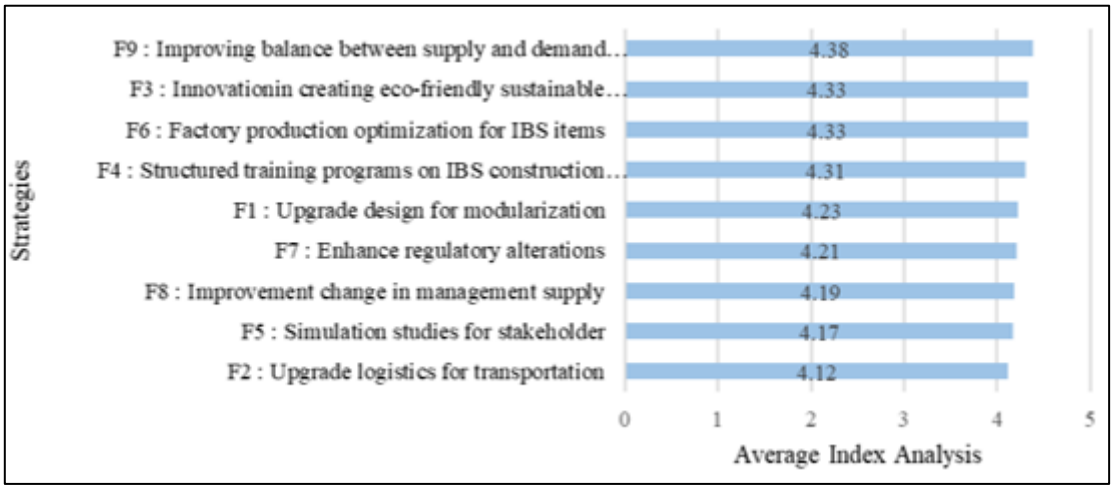

Fig. 5. Strategy to enhance the implementation of IBS construction in Malaysia

4. Conclusions

As a conclusion, the main current drivers for IBS construction in Malaysia perceived by the IBS stakeholders are 'IBS construction enhances technology', 'reduces the completion time' and 'improves quality and productivity'. Meanwhile, the main current barriers of IBS adoption identified are 'high initial cost investment in projects related to IBS construction', 'lack of skilled IBS construction workers' and 'unable to adapt instant changes to design modification'. In order to enhance the IBS adoption in Malaysian construction industry, several significant strategies had been postulated by the stakeholders, such 'improving the balance between supply and market demand', 'eco-friendly sustainable construction innovation' and 'factory production optimization for IBS items. The outcomes of the study could assist relevant parties to understand the current drivers and barriers of IBS construction, and further help them to enhance the IBS implementation in Malaysia.

This study has limitations that it only focused on Johor and did not represent the Malaysian construction industry as a whole. Further research can be widened up the national level for clearer picture of IBS usage in Malaysia and data generalization. The number of respondents should be increased for better validity and reliability of the data.

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