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Measuring the Performance of Industrialized Building System (IBS) Construction on Projects Towards Achieving IR 4.0 in Malaysia- Contractor's Perspective

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ABSTRACT

According to prolonged project completion times, excessive costs, and inadequate building products, the majority of construction projects are seen as underperforming. Alternatively, stakeholders are encouraged to move from conventional to Industrialized Building Systems (IBS) in line with today's technology. Previous studies show the performance of IBS practices in the Malaysian construction industry is still at a low level even though the government has diversified promotions and issued instructions for 70% of IBS use in government projects. These selection criteria affect contractors' performance of IBS practices and need to be done in a systematic way, along with current technology trends and sustainability. Content validity in IBS practice performance is an important step in instrument development. Content validity in IBS practice performance is an important step in instrument development. Therefore, this research aims to evaluate the content validity of the performance effectiveness of IBS practices by using the content validity index (CVI) and modified Kappa sensitivity. In an effort to accomplish the objectives of this study, a questionnaire was created using construct items that were taken from earlier research projects by various researcher. A panel of selected experts who are experienced in the field of IBS, such as CIDB, JKR and contractors have reviewed and evaluated pig instruments to ensure the relevance of each item. The final instrument contains 39 items that are valid and considered permanent and all items will be tested again in the next study. The results showed that the S-CVI/AVE for every item met every requirement and received an outstanding rating for every assessment.

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1. Introduction

The construction sector in Malaysia plays an important role in achieving Malaysia's status as a developed country. The pace of technological modernization nowadays has changed the construction industry, from industrial revolution 1.0 up to industrial revolution 4.0. Accordingly, the construction sector is undergoing changes towards sustainable technological practices.

Therefore, the application of IBS in construction projects can increase productivity, quality, and a conducive environment (Irwan Hafizy Md. Arif et al., 2020).

Malaysia is now rapidly developing, and a framework has been developed to improve construction technology in Malaysia, where the IBS 2003-2015 action plan has been framed as an alternative to replace conventional and towards sustainable development. The sustainability of IBS provides great opportunities in an open system and is able to compete with other countries (Tarja et al., 2018). The construction industry in Malaysia faces challenges in demand and supply for houses, whether low-cost houses or affordable houses that practice sustainable construction and green technology. Conventional construction methods seem unable to bear the increasing demand and supply (Abd Rashid et al., 2018). In construction, the success of a project can be achieved through efficiency practices. The Malaysian Construction Industry Development Board (CIDB) was established to encourage the use of IBS in construction projects. (Mohd Kasmuri et al., 2022). IBS is also defined as an innovation and industrial process, an element built using mass production, manufactured in an environment controlled by logistics, and assembled by each component based on schedule and task activity planning (Zairul, 2021).

The concept of the IBS practice performance framework is a strong connection to strengthen the effectiveness of IBS practice as an alternative to replace conventional practice. It is seen as a concept related to contractor practices in construction projects. The construction industry serves as a cornerstone of economic development, and the strategic integration of advanced technologies like Industrialized Building Systems (IBS) stands as a potent catalyst for progress. The government encourages contractors to adopt IBS, which is 70% in government construction projects and 50% in private projects (MOF, 2020).

Awareness of green and sustainable technology in construction projects is important because it helps reduce adverse effects on the environment. This is important among players in construction projects towards sustainability. An alternative to sustainability in practice on construction sites is to use IBS technology. This technology greatly benefits construction players because it produces sustainable materials that can create a safe environment. However, IBS construction methods in Malaysia are still at a low level (S. N. A. Abd Rashid et al., 2019). Productivity is an element used to measure the level of efficiency of stakeholders in implementing construction projects. Labor productivity is part of the issues that affect the performance of construction projects, such as cost, quality, and time (Nurhendi et al., 2022).

In Malaysia, the concept of prefabricated technology is known as the industrialized building system (IBS). IBS technology greatly aids local and international research especially in terms of cost, time and product quality. According to the Construction Industry Industrial Development Board's (CIDB) 4.0 construction strategic plan for 2020–2025, construction players are urged to use innovative and creative construction methods. This initiative reflects the commitment of the Malaysian government to address the IBS agenda (Zuhairi Abd Hamid; et al., 2020). The IBS trend needs to go through several transitions from conventional to hybridization stages. The government introduced IBS in 1960 but received little response from the industry. In 2008, a dramatic transformation in IBS practice only occurred after the government encouraged the use of IBS in the construction industry for government projects. Based on the statistical analysis from the 2003 survey and the 2008 IBS survey, particularly steel frame systems that are a popular use in government projects. It is inevitable for the government to take responsibility for this phenomenon and provide more capital investment for automation and robotics technology to make Malaysia progress in the transformation of the IBS construction industry (Riazi et al., 2020).

In the project IBS in Malaysia, contractors are divided into categories or grades according to a certain size, starting from small contractors (G3-G3) to medium-sized contractors (G4-G5) up to large-sized contractors (G6-G7). Due to the unfavorable working conditions and low wages of foreign workers, the majority of organizations prefer to hire foreigners over locals. Therefore, as part of efforts to reduce dependence on foreign workers, the government began the implementation of IBS technology in the organization. Each government activity must achieve at least 70% adoption of the IBS system (Construction Industry Development Board (CIDB), 2019).

The total number of IBS contractors by state and IBS expertise is displayed in Figure 1. IBS contractor statistics indicate that there were 11,400 fewer IBS contractors in 2023 than there were in 2022 (15,029 total). This demonstrates that conventional methods are still used in construction projects by contractors in Malaysia who are still not at 100% IBS in accordance. Furthermore, with 2295 IBS contractors, the nation of Selangor has the highest number of IBS contractors, indicating that IBS is used more frequently than conventional methods in Selangor construction projects.

The local and global labor productivity benchmarks reported in CITP 2016-2020 reflect the limited modernization of Malaysian construction methods and practices with the challenges of construction becoming increasingly serious as a result of using conventional methods. The Malaysian construction authorities are actively promoting new innovation and technology in modern methods of construction. The IBS roadmap for 2011-2015 targeted an overall adoption rate of 100 percent implementing IBS project, with an IBS score of 70 for public sector project and a score of 50 for private sector project. The IBS implementation chronology is as shown in Figure 2.

The Malaysian construction industry is a contributor to the country's development. Planning is an important element of sustainability towards the integration and adoption of IBS. Because the atmosphere of the construction environment in Malaysia is conducive and competitive, manpower is essential in construction projects. The Malaysian government took the initiative to encourage industry players to use modern construction methods to achieve a healthy and sustainable environment (Baharuddin et al., 2019). The Malaysian construction industry is a contributor to the country's development. Planning is very important because

the construction environment in Malaysia is conducive and competitive, but manpower is essential in construction projects.

The Malaysian government took the initiative to encourage industry players to use modern construction methods to methods to achieve robustness and sustainability. At the beginning of the work process to produce IBS components, the project cycle is taken into account, such as planning, controlling, and product quality, so that the waste of construction can be overcome and create a safe environment. IBS technology is able to maintain the quality of the building structure and reduce construction costs and time (Usman et al., 2019). As a major contributor to national development, the IBS project needs to confirm that the mechanism of IBS. In order to ensure the performance of IBS practice is more robust, stable, stakeholders need to switch from conventional systems to IBS systems (Yunus et al., 2020).

i) Supply Chain Management

Supply chain management is a method of changing the construction industry to achieve better success and overcome conflicts in the project team, ensuring accurate and clear communication with each other and effective coordination, collaboration, and integration as practiced in IBS project management. Supply chain management depends on a collaborative effort that aims to create integrated project delivery in a team, whether the project is developed in the long term or short term, that can benefit the parties involved in the construction project team (Riazi et al., 2020).

Supply chain management provides great opportunities for IBS performance management strategies with today's construction industry technology and innovation. The transition of supply chain management from conventional methods to greater value instead of focusing only on cost (Fauzi et al., 2017). Supply chain management can provide knowledge and information delivery that has the potential to overcome delays in construction projects in Malaysia in the future (Riazi et al., 2020).

ii) Lean management

IBS consists of integrated processes throughout the construction project. This process involves subsystems in manufacturing, components, and manufacturing processes (Yusof et al., 2024). The implementation of lean management in IBS can improve the performance of construction practices at construction project sites in Malaysia. In addition, it can save time by eliminating non-essential processes through effective performance management in construction projects (Yunus et al., 2020).

The IBS system is a device for the successful action of solving a problem. This is because the management pattern of IBS is different from conventional management, such as the implementation of IBS projects on site, work quality, and planning (Nawi et al., 2018). The IBS system is a device for the successful action of solving a problem. This is because the management pattern of IBS is different from conventional management, such as the implementation of IBS projects on site, work quality, and planning.

iii) Construction Activities

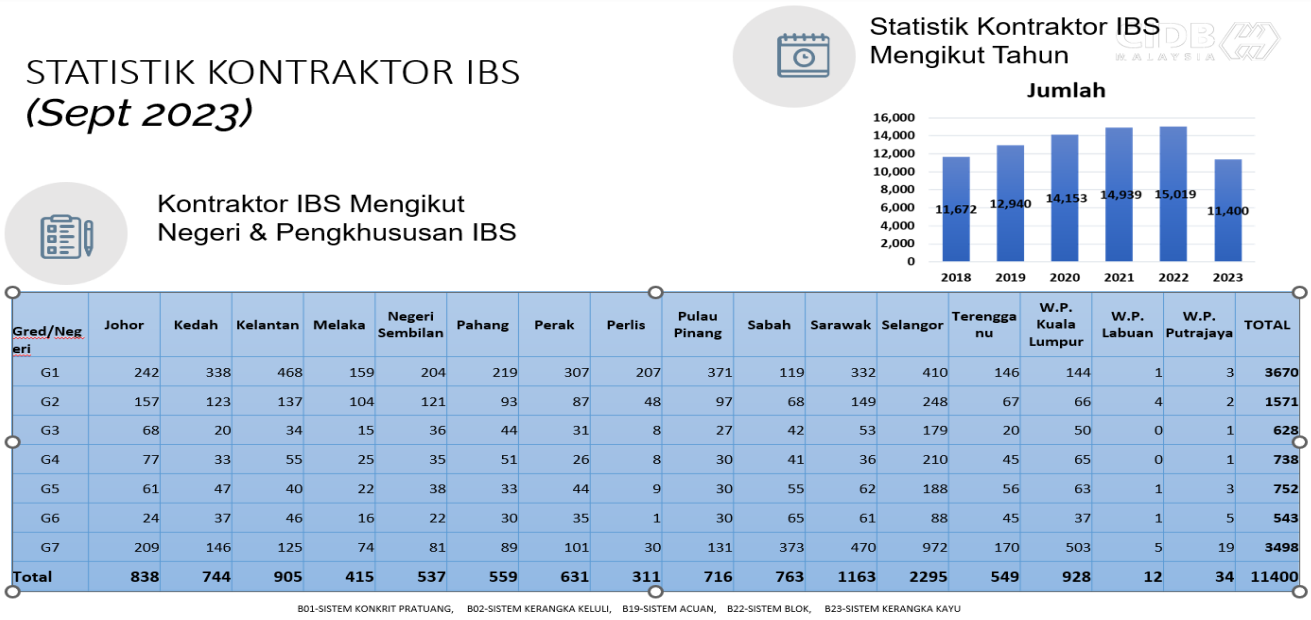
Finance is required for construction activities in order to purchase equipment, transport, steel molds, and pay laborers who assemble IBS components (Baharuddin et al., 2019). This impacts how IBS projects' performance practices change (Wuni & Shen, 2020). Purchasing machinery, creating molds, and importing equipment from overseas, as well as the expense of imprecise management techniques and ineffective IBS project implementation are some of the factors that contribute to high costs (Jaffar & Lee, 2020). The government took measures to adopt the IBS project, enabling all projects to satisfy the government project score target of 70% (MOF, 2020). It is essential that the authorities strive to establish the required rules for IBS initiatives. This is to guarantee that everyone involved in the project uses the most current developments and technologies.

iv) Knowledge and expertise

Knowledge and expertise in the IBS system are very important to perform construction projects (Jaffar & Lee, 2020). Successful implementation of IBS requires extensive knowledge of design, planning, and work processes (Baharuddin et al., 2019). Effectiveness in IBS project requires expertise and solid knowledge of relationships among stakeholders (Nawi et al., 2019). In addition, the challenge in the performance of IBS practice is a shallow knowledge of IBS, and research in IBS still lacks attention among researchers (Akmam Syed Zakaria et al., 2018). Effectiveness in IBS project practice requires expertise and solid knowledge of relationships among stakeholders (Nawi et al., 2019).

v) Integration Process

The integration process can simplify the work process in IBS because various skill resources that are not limited to one task have good potential in the IBS network as a whole in construction projects (Jaffar & Lee, 2020). The term "integration" has been defined as a culture that is especially sustainable and is integrated among parties. This culture is needed in various organizations that shape the delivery of projects more effectively through collaboration across all sub-systems, components, and efficient and quality manufacturing processes (Tajul Ariffin et al., 2017).



Gred/Negeri	Johor	Kedah	Kelantan	Melaka	Negeri Sembilan	Pahang	Perak	Perlis	Pulau Pinang	Sabah	Sarawak	Selangor	Terengganu	W.P. Kuala Lumpur	W.P. Labuan	W.P. Putrajaya	TOTAL
G1	242	338	468	159	204	219	307	207	371	119	332	410	146	144	1	3	**3670**
G2	157	123	137	104	121	93	87	48	97	68	149	248	67	66	4	2	**1571**
G3	68	20	34	15	36	44	31	8	27	42	53	179	20	50	0	1	**628**
G4	77	33	55	25	35	51	26	8	30	41	36	210	45	65	0	1	**738**
G5	61	47	40	22	38	33	44	9	30	55	62	188	56	63	1	3	**752**
G6	24	37	46	16	22	30	35	1	30	65	61	88	45	37	1	5	**543**
G7	209	146	125	74	81	89	101	30	131	373	470	972	170	503	5	19	**3498**
Total	**838**	**744**	**905**	**415**	**537**	**559**	**631**	**311**	**716**	**763**	**1163**	**2295**	**549**	**928**	**12**	**34**	**11400**

B01-SISTEM KONKRIT PRATUANG, B02-SISTEM KERANGKA KELULI, B19-SISTEM ACUAN, B22-SISTEM BLOK, B23-SISTEM KERANGKA KAYU

Figure 1 IBS Contractor statistic by state and year (CIDB, 2023)

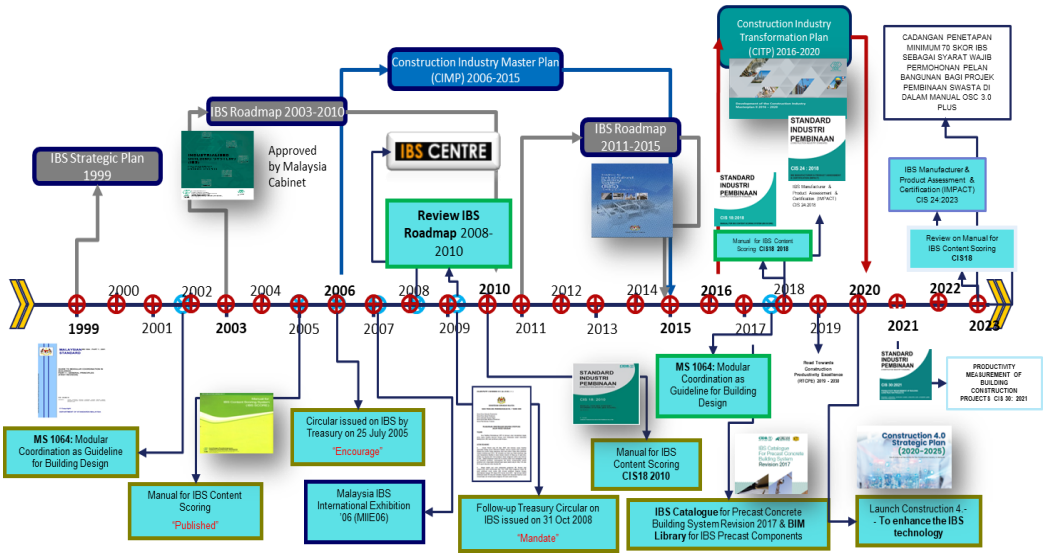


Figure 2 IBS chronology in Malaysia (CIDB, 2023)

Sample selection criteria and performance IBS are as below:

i. Criteria 1

Issues and challenges in IBS practice were selected as a research sample. According to Fauzi et al.(2017), irregular construction methods cause supply chain management to be weak and ineffective, even though various efforts have been made to improve the performance of IBS practices in Malaysia. In addition, the project does not meet the client's requirements due to the complexity of the work design process so that the contractor postpones the construction (Baharuddin et al., 2019). This criterion was taken into account in the selection of the sample because it highlights the issues and challenges in the performance of IBS practice today. The selection was made considering that nowadays many construction projects use IBS compared to conventional systems. However, how much of this performance actually gets utilized to fulfill the growing supply and demand in the current globalization era.

ii. Criteria 2

Numerous initiatives have been developed to raise the degree of IBS technique use in construction projects through the IBS road map. The aim of the IBS direction is to maintain the level of use for the IBS method with a 70 IBS score for a construction

project in the public sector and encourage the involvement of the private sector in the use of the IBS method with a 50 IBS score. But to what extent are IBS practices practiced in construction projects. Therefore, it is very important to ensure that the performance of IBS practices is well practiced in order to increase the value and integrity of IBS buildings (Dzulkalnine et al., 2017).

iii. Criteria 3

IBS practice only focuses on projects that use the IBS system in the Klang Valley. The state of Selangor was selected as a sample because of its main location, where many use IBS in construction projects. In terms of economy, Selangor is the most advanced and fastest-growing state, with an era of sustainable technology. In addition, Selangor is a state that uses IBS a lot in construction projects when compared to other states. Contractors can also easily obtain IBS components from IBS manufacturers. In terms of technology, it was found that the production of IBS components from various categories is abundant in the state of Selangor. According to Zahari and W. Muhamad Radzi (2021). Industrial Revolution 4.0 is a trend to increase the use of technology and automation in the construction sector. This revolution will bring changes to the construction industry, from the use of human labor to the use of robotics. In accordance with technology and automation to satisfy the demands of the client, how much are the practices of the stakeholders in the IBS project being modified.

2. Methodology

2.1 Description of Study Area

The methodology of research is the quantitative method used in this study. Therefore, this study will be divided into three main phases. The first phase is to identify the issues, problems and gaps that exist in the research area being studied. Gathering data whether primary or secondary is very important to help identify issues, problems, and gaps in the research topic being studied. In addition, interviews are conducted so that the problems studied will increase the value of the research. Unstructured interviews with authorities from JKR and CIDB were conducted to identify some issues so that the researcher could determine what factors needed to be studied.

2.2 Literature Review

The researcher consulted any journal related to the performance of IBS practices practiced in construction projects. This literature review is very important to make it easier for researchers to identify and understand the performance, trends, problems, or issues in IBS practice for the purpose of developing the framework concept. This phase is very important in determining the perception criteria and the challenges that exist in the practice of IBS at construction project sites in Malaysia. This phase can also help in the design of the main survey of this research.

2.3 Instrument Development

The instrument used in the study is a questionnaire. According to Brece (2013), with the use of questionnaire instruments, respondents more easily and confidently respond to the criteria studied. An instrument in the form of a questionnaire is easy to administer when it is well constructed, and the data is easy to process for analysis purposes. The questionnaire was developed by the literature review. The questionnaire used was adapted based on previous research relevant to this study. The instruments used must meet the criteria of reliability and validity (Aksah et al., 2023).

2.4 Expert Validation and Pilot Test

The sample of respondents consisted of nine (9) panel experts in field of IBS. This panel of experts was asked to review the questions and give their opinions, especially questions that are relevant or not to the study being conducted. Each item in the questionnaire was checked by a panel of experts. This is to determine whether the content is suitable for the conceptual framework of the questionnaire domain and current practices that are more sustainable. Table 2 is a list of expert panel members for this research.

Table 2 The panel expert

Expert	Position	Organization
Exp1	Civil Engineering	Public Work Department
Exp 2	Civil Engineering	Public Work Department
Exp 3	Civil Engineering	CIDB
Exp 4	Civil Engineering	CIDB
Exp 5	Civil Engineering	CIDB
Exp 6	Civil Engineering	Proven IBS
Exp 7	Civil Engineering	GP IBS
Exp 8	Contractor	TEP PRECAST
Exp 9	Contractor	GREEN IBS

According to Brece (2013), the questionnaire that was tested with a pilot test was to confirm the validity of the instrument used and measure the responses of the respondents. A pilot test is an initial study of the questionnaire to ensure that the instrument can be backed up for the actual study. Reliability refers to the phenomenon of measurement that provides consistent, stable, repeatable results and raises concerns about consistency (Mohammad et al., 2019).

Table 3.0 Pilot test respondents

Background	Respondent
Public Work Department	3
CIDB	3
Contractor	25
Total	31

Survey questionnaire with panel experts in the IBS project

The questionnaire was conducted by industry players involved in the IBS construction project. The goal of the survey is to develop and validate a framework for a better understanding of IBS practices and how they impact and contribute to a sustainable construction industry in line with Industrial Revolution 4.0. A total of 31 respondents, consisting of those with more than ten (10) years of experience in the field of IBS. The aim of this study is to determine the performance effectiveness of IBS practices in the construction industry in Malaysia.

Data for this study was obtained from respondents among the parties involved in the construction project. A 55-item questionnaire was developed in the Google Form applications and distributed via WhatsApps to 31 target respondents. The first part of the questionnaire aims to obtain the demographics of the respondents. It contains questions such as contractor company grade, position, academic qualifications, and experience in IBS projects. This data is analyzed using percentages. Part two asks respondents to choose the significance level of each factor using a five-point Likert scale consisting of 1 = strongly disagree, 2 = disagree, 3 = medium, 4 = agree and 5 = strongly agree. This data was analyzed using IBM SPSS to identify descriptive patterns. In the last section, respondents can suggest factors not listed in the survey based on their experience with the IBS project. By answering the questionnaire, the respondents have checked and verified all the factors.

3. Result and Discussion

3.1 Expert Validation and Pilot Test

Involvement of expert panels in studies conducted to obtain evidence of judgment. An expert panel is necessary to verify that the instrument has authentic content. The determination of the expert panel depends on the number of people who can be contacted and identified. Specific guidelines need to be followed in the sampling of panel experts. To measure the relationship between constructs and items, an expert panel is needed to evaluate each scale. Other studies suggest that the content validity process should involve 5 to 10 expert panels. For this study, a total of 9 panel experts evaluated the surveying instrument. Table 4.0 shows the results of I-CVI values for each item involved in the instrument. To adjust for agreement with the expert panel, a modified kappa (k) statistic was calculated. Items with I-CVI values greater than 0.78 and larger kappa scores were retained. Items with an I-CVI value lower than 0.78 should be considered for revision, combination, or rephrasing based on expert comments.

Table 4 Content validity decision

Item	Number in Agreement	Item -CVI	k	Evaluation
Time	8/9	0.89	0.89	Excellent
Robotic	9/9	1.00	0.89	Excellent
Completion period	8/9	0.89	1.00	Excellent
Labor cost	8/9	0.89	0.89	Excellent
Construction waste	9/9	1.00	1.00	Excellent
Cost	9/9	1.00	1.00	Excellent
Reusable mould	9/9	1.00	1.00	Excellent
Supply Chain	9/9	1.00	1.00	Excellent
Expensive	9/9	1.00	1.00	Excellent
Additional Cost	8/9	0.89	0.89	Excellent
Knowledge	8/9	0.89	0.89	Excellent
Transportation	7/9	0.78	0.78	Excellent
Communication	9/9	1.0	1.0	Excellent
Capital	8/9	0.89	0.89	Excellent
Awareness	9/9	1.00	1.00	Excellent
Unskilled workers	9/9	1.00	1.00	Excellent
Not uniform	8/9	0.89	0.89	Excellent
Technological Shift	8/9	0.89	0.89	Excellent
Machinery	9/9	1.00	1.00	Excellent
Operator	9/9	1.00	1.00	Excellent
Knowledge	9/9	1.00	1.00	Excellent
Method	9/9	1.00	1.00	Excellent
Productivity	9/9	1.00	1.00	Excellent
Activities	8/9	0.89	0.89	Excellent
Sustainable	9/9	1.00	1.00	Excellent
Innovation	8/9	0.89	0.89	Excellent
Less workers	9/9	1.00	1.00	Excellent
Unskilled workers	9/9	1.00	1.00	Excellent
Planning	8/9	0.89	0.89	Excellent
Foreign workers	7/9	0.78	0.78	Excellent
Environment	9/9	1.00	1.00	Excellent
Design	7/9	0.78	0.78	Excellent
Experience	8/9	0.89	0.89	Excellent
Integration	9/9	1.00	1.00	Excellent
Affordable housing	8/9	0.89	0.89	Excellent
Promotion	9/9	1.00	1.00	Excellent
Awareness 70% IBS	7/9	0.78	0.78	Excellent
Policy	7/9	0.78	0.78	Excellent
Levi	9/9	1.00	1.00	Excellent
Simple	9/9	1.00	1.00	Excellent
Intensive Government	9/9	1.00	1.00	Excellent
Expert	9/9	1.00	1.00	Excellent
Quality	9/9	1.00	1.00	Excellent
Trend	9/9	1.00	1.00	Excellent
Facilities	9/9	1.00	1.00	
Exactly	9/9	1.00	1.00	Excellent

Item	Number in Agreement	Item -CVI	k	Evaluation
Waste	9/9	1.00	1.00	Excellent
Guaranteed	9/9	1.00	1.00	Excellent
Flexible	9/9	1.00	1.00	Excellent

a* I-CVI: Item-level content validity index, number of expert panels rating item 3 or 4/total number of expert panels
b*k: kappa gives the correlation agreement, k= (1-CVI-pc), where pc (probability of chance occurrence) is calculated based on pc= [N! / A! (N-A)!] 5N, N= number of expert panels and A= number of agreeable to good relationship
c*evaluation criteria for kappa: Fair = k from 0.40 to 0.59, good = k from 0.60 to 0.74 and excellent= k>0.74

Demographic

Based on the questionnaire that was developed, the demographics of the respondents consisted of the grade of the contractor company, position in the organization, qualification achievements, and experience in IBS projects. A total of 31 respondents were answered consisting of 23 respondents from G7, 3 respondents from G6, 3 respondents from G5, 1 respondent from G3, and 1 respondent from G2. Based on their position in the organization, 10 respondents were engineers, 17 respondents were project managers, and 4 respondents were contractors while the achievement of academic qualifications consisted of 20 respondents from undergraduates and 11 respondents from masters. The category of respondent experience in the IBS project consists of 2 respondents with 1-5 years of experience, 4 respondents with 6-10 years of experience, 15 respondents between 11-15 years of experience, and 10 respondents with more than 15 years of experience.

Reliability test

This pilot investigation is a government projects. Questionnaires were distributed to respondents to determine the level of reliability of variables based on the questions presented. A total of 31 respondents, consisting of those with more than ten (10) years of experience in the field of IBS, are shown in Table 5 which illustrates the reliability test results of the pilot test. In this pilot test, it shows the high level of reliability between TOE constructs because Cronbach's alpha exceeds 0.600. Higher values indicate higher inter-item consistency.

For this study, the data collection process for the measurement of the performance of IBS practices is evaluated against the factors that influence the drivers and levels of IBS practices among industry players in construction projects. The selected study location is the state of Selangor. The justification for this selection is because Selangor is the state with the highest number of IBS contractors registered with CIDB. Not only that, construction projects that use IBS around Klang Valley are also the highest compared to other states.

Table 5 Reliability test for pilot test

Construct	Number of Item	Alpha Cronbach
Environment	5	0.952
Popularity	3	0.942
Government Policy	6	0.935
Social Culture	8	0.918
Productivity	6	0.889
Resources	5	0.839
Construction Cost	4	0.818
Challenges	10	0.778
Time	3	0.642

4. Conclusion

All in all, it can be seen that nowadays, conventional construction methods are often associated with unprofessional practices and delay the construction process. The adoption of IBS in construction projects promises a practice that increases productivity and the construction industry toward sustainability and the IR 4.0 industrial revolution that is able to compete with other countries to realize an image of professionalism. In addition, IBS has an interest in the construction industry. Therefore, new business models such as robotics and auto-performance practices are able to minimize the generation of construction waste, short time periods, and more economical construction costs. The development of this research allows for the improvement of IBS construction projects in the future by refining contractor practices in construction projects towards achieving sustainable development. Based on the pilot test, this study can be studied because the results of the reliability test show that the questionnaire items are reliable.

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