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Adopting Building Information Modelling (BIM) into Industrialised Building System (IBS) in Malaysian Construction Industry

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Abstract

Building Information Modelling (BIM) is the development of digital models used during planning, design, construction, and operation stages of a project. Some construction players doubt the practicality in implementing this new technology. Full adoption of Industrialised Building System (IBS) project is not an easy journey. In addition, the implementation of BIM technology into IBS system will put the client's expectation at risk as it is difficult to understand the complex software. Therefore, the aim of this research is to explore the adoption of BIM into IBS application in Malaysian construction industry. Among the objectives of this research are to investigate the implementation of BIM into IBS application, examine challenges in implementing BIM into IBS application and propose ways to improve the incorporation of BIM into IBS application by Malaysian construction industry players. Research data were collected through questionnaire survey and the results were analysed using SPSS software. The results showed vast majority of public and private sectors have some experience in handling IBS and BIM projects and these sectors are aware that BIM can facilitate IBS projects. However, the implementation of BIM into IBS application is still at the low level especially in private sectors. One of the challenges faced is its high cost, thus only large organisations can afford its implementation. To successfully improve the incorporation of BIM into IBS project, government should take some measures by organising awareness programs, restructuring IBS and BIM training programs, providing incentive, as well as promoting sustainability development and green construction. By doing that, the proposed measures are expected to increase the confidence of industry players to actively adopt BIM into more IBS projects in Malaysian construction industry.

Keywords

Building Information Modelling (BIM); Industrialised Building System (IBS); Implementation; Challenges; Strategies

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1 Introduction

Construction industry is one of the main sectors that provides important ingredients for the development of an economy. In realising the objectives, construction sector in Malaysia plays a pivotal role in attaining Malaysia as a developed country. In facing construction industry challenges. Thus, the designers and contractors should be attentive to the latest technologies offered[1]. Malaysian government through CIDB (Construction Industry Development Board) is seriously promoting the use of Industrialised Building System (IBS) in construction sector. Some benefits of adopting IBS in a project are shorter time taken to complete the project compared to the conventional method and it can also reduce the amount of construction waste. Through Construction Industry Transformation Programme 2016–2020, under trust no 2, focus area no 4, one of the main initiatives highlighted by CIDB is on the waste management, which could lead towards sustainable construction.

Industrialised Building System (IBS) seems to be the best method to achieve sustainable construction goals in maintaining sustainability in construction through efficient use of resources, improvements in the quality of constructed buildings, and waste minimisation. This can be achieved by addressing the need to further strengthen sustainable supply of affordable houses using prefabrication technology, in which it is believed to be able to produce and supply houses faster, in better quality, and reduced construction costs[2]. However, it found that the implementation of IBS in Malaysian construction industry is lacking due to the unwillingness of the stakeholders as they are not convinced with the IBS system and from various challenges faced in terms of the IBS workflow as well as cost overrun[3]. As a result, Building Information Modelling (BIM) is introduced to enhance the IBS performance related to time, cost, and quality matters[4]. BIM is proposed to be incorporated in the IBS workflow as it can provide support standardised prefabrication element.

Witnessing the uptake, the advanced technology of BIM is among the technology that has garnered great attention. This suggests that BIM provides the insight and tools for Architectural, Engineering, and Construction (AEC) professionals to effectively plan, from design, operation management, structural analysis data management, and construction workflow. In addition, BIM can simultaneously handle multiple resources and information. So, the complexity in IBS construction is due to the communication deficiency between manufacturing and construction industries which can be overcome by BIM[5]. However, most of the stakeholders are still unwilling to adopt BIM for IBS project since there is a lack of research on the benefits of BIM into IBS construction project renders them unconvinced with the IBS and BIM technology[3].

2 Literature Review

BIM is more than just an information database technology. BIM has the attributes of both approaches of strategy and process[6]. It provides an alternative to the traditional paper-based project design and management, in which the project performance can be measured. It is a process of creating an intelligent virtual model that integrates the project data from design to construction and operation. It gives architecture, engineering, and construction (AEC) professionals an insight to plan more efficiently in designing, constructing, and managing buildings and infrastructure that represents buildings virtually over the whole life cycle as semantically enriched, consistent, digital building models[7].

On the other hand, IBS is one of the technologies that can be defined as an innovative manufacturing method of building construction using mass-production concept of industrialised systems in the factory and observed with minimal additional site work[2]. The process of IBS includes installation aspects of prefabricated components, which are done in systematic planning with proper coordination. The components of IBS are produced in a controlled environment either on or off-site like in a factory[8]. Once completed, the components will be transported, placed,

and erected into a structure with minimal assembly and erection site work.

2.1 Implementation of BIM into IBS Applications Among Construction Key Players

Through its subsidiary Construction Research Institute of Malaysia (CREAM), CIDB has entered a strategic partnership with Gamuda Industrial Building System Sdn. Bhd. (Gamuda IBS) as the industry progresses towards IBS and BIM implementation in Malaysia that can cut down construction time, reduce construction wastage, as well as increase safety standards and more conducive worksite. At the same time, it also reduces dependency of foreign labour in construction projects[8].

Therefore, the collaboration made between CIDB and Gamuda IBS is a significant step for Works Ministry to spur the implementation of BIM design tools and IBS by the housing industry in Malaysia towards achieving the productivity goals of the Construction Industry Transformation Programme (CITP) 2016-2020, in addition to be in line with the industry as it gears itself toward Industry4WRD, the National Strategy for Industry 4.0 introduced by the Ministry of International Trade and Industry (MITI). Through this partnership, CREAM will leverage on Gamuda IBS's digital IBS factory, its processes, and activities, including design on the BIM platform; quantity taking and ordering of materials; robotics manufacturing and digital controls; digital tracking to detect and identify monitoring and delivery of panels; production strategy and management; quality of finishes product; and product verification for testing by relevant authorities.

In Malaysia, IJM Corporation Berhad (IJM) is leading the way for a fully integrated Industry 4.0 by establishing its 200,000 sq. ft IJM IBS Pusat Bina Bestari facility headquartered in the growing industrial hub of Bestari Jaya, Kuala Selangor to be completed by mid-2021[9]. In a 25-acre site with an annual capacity of 500,000 m^2 (equivalent to 3,000 homes), IJM IBS has capabilities to deliver end-to-end digital IBS starting from designing, costing, manufacturing, fabrication to delivery and on-site installation. Apart from that, IJM IBS is a smarter way of building a construction project that engages partners in using innovative pre-cast production technologies driven by Building Information Modelling (BIM), Internet of Things (IoT), robotics, cloud computing and big data.

New evolving technologies are modern production based for design and engineering, where designs and prototypes are transitioned from 2D to 3D models, making it much easier for key players to visualise. In particular, all key players involved in the construction industry are able to access the proposed design and alteration; hence, quickly decide on design and construction works using BIM platform through computers and software in constructing buildings; including quantity taking and ordering of materials; robotic manufacturing and digital control; management and production planning; quality of product; and product approval by the relevant authorities.

In China, the construction of Houshenshen Hospital near Wuhan is completed in less than 10 days (from 23 Jan to 2 Feb 2020); a life-saving hospital with a capacity of 1,000 beds, in response to the Wuhan Coronavirus outbreak. The hospital is an excellent example of IBS building, the bulk of structures were prefabricated in multiple locations off-site and then transported to the site and in addition, completely utilised BIM technologies[10]. Buildings built using this technology are of higher standards and consequently perform very well throughout project life cycle. On top of that, a lot of planning goes into constructing an emergency hospital, particularly due to Covid-19 in Wuhan, which does not have enough hospital to accommodate patients. This makes the organisation and manpower that put together Huoshenshan Hospital in Wuhan as a genuinely impressive accomplishment, that is impossible to be repeated[11].

2.2 Challenges of Implementing BIM into IBS Application

BIM and IBS have not been successfully implemented in Malaysian construction industry. Despite the Government's vigorous effort in promoting BIM and IBS through the Construction Industry Transformation Programme (CITP) 2016-2020, there has been no substantial improvement progress in BIM and IBS implementations in the industry. There are several problems faced in implementing BIM, as follows.

2.2.1 Technology

One of the obstacles in adopting BIM is the resistance from employees who are reluctant to learn new emerging technologies. In addition, interoperability between systems and software technical difficulties is considered a major risk in implementing BIM. This challenge occurs when a single software method is built to satisfy the needs of various disciplines[12].

The implementation of BIM usually requires new software and periodically requires hardware updates to run intensive processing software[13] and with this, high cost of investment will be incurred. There is a huge technological aspect involved in BIM implementation. Lack of interoperability due to lacking structured approaches in data sharing across different proprietary information systems and software is seen as a major obstacle. Hence, the selection of the most suitable software system is therefore highly important for organisations to improve their business and the opportunity to interact with other companies and efficiently share the knowledge.

2.2.2 Organisation

The failure to integrate BIM is resulted from the organisation itself[14]. Some organisations are hesitant to change their business method from traditional to BIM. Firstly, they are fearful to bear the risks because of high investment required and secondly, they are unsure of how to use BIM.

Researchers have been investigating the main factors plaguing the construction organisations which is the lack of experienced BIM workers within the construction organisation[15]. Employees in the company, however, fear that technology will take over their jobs and felt uncertain about change, particularly when digital technology is involved, and this occurs because not all new users of BIM understand how to handle technical changes. In general, implementing BIM required skilful and knowledgeable workers. The main concern that construction organisations are having is the lack of experienced BIM workers to administer it within the construction organisations[16].

However, many companies believe that the introduction of BIM and its awareness will somehow influence the existing business processes. In implementing new technologies that will alter their business processes, competitiveness will suffer because of transforming from decentralised to collective nature, putting the project outcomes and clients' expectations at risk. In Malaysia, contractor Grade 1 (G1) to Grade 6 (G6) are still not ready to incorporate BIM in their construction project due to a huge investment to acquire BIM software and consequently undergo training[17].

2.2.3 Financial

The financial issue would be one of the biggest obstacles to implement BIM. BIM probably requires new software and frequently requires hardware updates to run intensive processing software and provide personnel training[18]. Apart from that, it is often expensive to shift the workflow and work process from conventional to new technology.

As part of adopting BIM, continual efforts are expected from employees via education and training before being conversant. Needless to mention, learning process requires time, which incurs extra costs for the organisations.

2.2.4 Legal Issues

BIM are unlikely to cause substantial improvement in existing procurement practices unless the issues affecting its legal system have been clearly established and mandated to be used for procurement and contract management[19]. Legal issues concerning incompatibility of procurement system with BIM, arises when design-bid-build method are implemented in the contract. Usually, the essence of design-bid-build method is not good enough to be used because it hinders the successful implementation of BIM and addresses legal concerns on the lack of contract form, that explicitly specifies BIM practice[20].

Furthermore, the lack of clarity about the ownership of BIM data is the first hurdle to defend copyright laws and other legal channels[21]. There is no specific standard and protocol on the BIM mechanism and practice, no legal protections on intellectual property, cyber security, and ownership of the data model. The cooperation between project participants on the BIM platform is required to exchange their design information through a file format so that other project participants can access the data with their own data to create a federated BIM model. Liability arises through the exchanging of information between project partners and other project participants such as contractors and downstream contractors are at the greatest risk for file errors, loss of data or data misuse.

3 Research Methodology

This research uses quantitative approach, in which the questionnaire survey is being distributed to stakeholders of BIM and non-BIM users alike in Malaysian construction industry. The questionnaires for this research are structured in five sections as shown in Table 1.

Table 1. Sections of questionnaire.

Section	Description
A	Demographic background / Respondents background
B	Implementation of BIM into IBS application amongst Malaysian construction industry players.
C	Challenges of implementing BIM into IBS application amongst Malaysian construction players.
D	Ways of improvement incorporating BIM into IBS application amongst Malaysian construction players.
E	Recommendations or suggestion by the respondents

Close-ended questions were used for sections A and B, Likert scale was used for sections C and D, and lastly, open-ended question for section E. The Google Form questionnaire is designed and distributed via e-mail and various social media platforms such as LinkedIn, Twitter, Facebook, and others. A total of 103 respondents had participated in the survey. Summary of respondents' background is shown in Table 2.

Based on Table 2, most respondents were contractors (34%) and Quantity surveyors (27%). And majority of the respondents had more than 10 years of experience in the construction industry. So, it can be concluded that most of the respondents are experienced and had involved in numerous projects, either from the government or private clients.

Table 2. Respondents' background.

Respondents' background	Frequency	Percentage
Role in the construction industry		
Architect	11	10.7
Quantity Surveyor	28	27.2
Civil Engineer	11	10.7
Contractor	35	34.0
QAQC Engineer	3	2.9
Project Manager	7	6.8
M&E Engineer	1	1.0
Others	7	6.8
Number of projects involved		
Less than 10 projects	11	10.7
10 - 20 projects	28	27.2
21 - 30 projects	11	10.7
More than 30 projects	7	6.8
Working experience in the construction industry		
1 - 5 years	15	14.6
6 - 10 years	18	17.5
11 - 15 years	28	27.2
16 - 20 years	31	30.1
20 years and above	11	10.7
Type of project involvement		
Government	44	42.7
Private	48	46.6
Both (Government and Private)	11	10.7

4 Results and Finding

4.1 Implementation of BIM into IBS Application Amongst Construction Industry Players

Respondents are required to answer a series of questions related to BIM implementation either they are BIM users or non-BIM users. This section contains eight (8) questions asking the respondents to investigate the implementation of BIM into IBS project. Table 3 shows the respondents' experience related to IBS and BIM application.

It shows that most of the respondents 38.8% had experience in dealing with both BIM and IBS project. Unfortunately, 39.8% of the respondents use them separately.

Table 3. Respondent's experience in BIM and IBS projects.

Experience	Frequency	Percentage
BIM project/s only	27	26.2
IBS project/s only	13	12.6
Both BIM & IBS project/s	40	38.8
None for BIM and IBS project/s	23	22.3
Total	103	100.0

BIM practice	Frequency	Percentage
Yes, use BIM to manage IBS application	27	26.2
Use BIM but not for IBS application	41	39.8
No, I never practice any BIM or IBStechnology	35	34.0
Total	103	100.0

Table 4. Respondent's awareness on the application of BIM in IBS projects.

Existence of BIM technology of respondents	Frequency	Percentage
Not aware of BIM technology applied in IBS application and never use it	19	18.4
Aware of BIM technology applied in IBS application but does not use it	57	55.3
Aware and use BIM technology applied in IBS application rarely (1-3 times)	22	21.4
Aware and use BIM technology applied in IBS application frequently (more than 3 times)	5	4.9

For respondents' awareness on the existence of BIM for IBS application, majority of them are aware but did not apply it. From 82% of respondents that are aware of BIM technology's applicability into IBS projects, only 26% of the respondents from construction industry players that applied it. Moreover, 21.4% uses BIM for 1 to 3 times and 4.9% applied BIM for more than 3 times.

Based on Table 5, the frequently used BIM software by respondents is Autodesk Revit with 36.9% and followed by Cubic-cost with 29.0% as both Autodesk Revit and Cubic-cost are common BIM software. As for the reason of using it, the data indicates the highest BIM purposes preferred by respondents is for design purposes with 22.7%, followed by 19.9% for cost-estimation. Respondents also highlighted other purposes with 0.3% using BIM for preparing Bills of Quantities.

Table 5. Type of software and the purpose of using BIM in IBS project.

BIM purposes for respondents	Frequency	Percentage
Planning	56	19.6
Design	65	22.7
Construction	40	14.0
Maintenance	22	7.7
Demolition	12	4.2
Cost-estimation	57	19.9
I never used any BIM technology	33	11.5
Others	1	0.3
Total	286	100.0

BIM Software that being used	Frequency	Percentage
Autodesk Revit	65	36.9
Navisworks	8	4.5
Cubic-cost	51	29.0
Cost-X	14	8.0
Archicad	6	3.4
I never used any BIM software	32	18.2
Total	176	100.0

Based on Table 6, the highest percentage which is 24.5% of respondents are still not using any IBS project with/for BIM technology. In the meantime, the type of IBS usually being used with BIM was for precast concrete framing (20.4%) followed by blockwork system (18.1%). When the respondents were being asked whether they agree or not that BIM can facilitate in IBS construction project life cycle, majority of them agreed and strongly agreed (Figure 1). This shows that they have no doubt that BIM could facilitate in achieving better IBS project outcome. So, there must be a justification on why they were reluctant to apply BIM in IBS project.

Table 6. IBS Project with BIM application.

Types of IBS use with BIM	Frequency	Percentage
Precast Concrete Framing	44	20.4
Steel Formwork System	31	14.4
Steel Framing System	31	14.4
Prefabricated Timber Framing System	18	8.3
Blockwork System	39	18.1
Not used any IBS project with BIM	53	24.5
Total	216	100.0

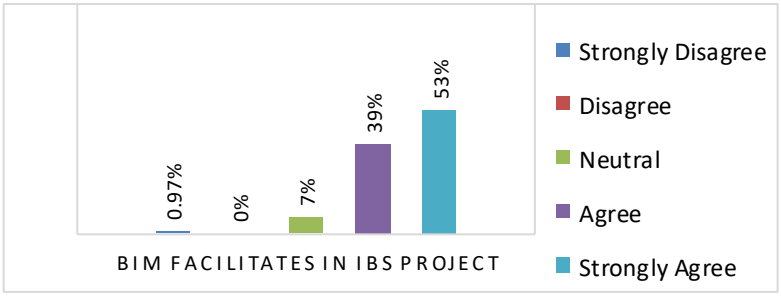

Figure 1. Respondent's agreement on the application of BIM in facilitating IBS projects.

4.2 Challenges of Implementing BIM into IBS Application

Under four main headings, the researcher had identified 16 challenges that could contribute to low application of BIM in IBS projects. Likert scale is used for this section, and the result from the survey is shown in Table 7.

From Table 7, the top ranked challenges are on the financial issues. The cost to implement BIM in the company is too high with the mean value being 4.48. The initial costs to adopt BIM technology and hardware are high. Therefore, large investment in updating the BIM software is between RM 9,000 to RM 50,000, and it is on a yearly rental basis[8]. It can be concluded that adopting BIM requires the company or firm to make a huge financial investment. Therefore, only large organisations can afford the costly technology which is the highest mean score for challenges on technology (4.43). The price for Building Design Suite Premium, an entry level software for BIM, is US$6,825[13]. With the current exchange rate being US$1.0 to RM4.21, makes the price in Malaysia to be RM28,749.00. Furthermore, the cost calculated only includes the purchase of the most basic BIM software. BIM is seen as an expensive technology to be adopted, but it has been proven to provide solutions to the above-mentioned construction problems. Thoroughly, high cost is involved through continuous effort of educating and training staff before becoming a BIM expert.

Another challenge with the same highest mean score 4.48 is that BIM could cause a greatest risk for file errors and loss of data. Based on literature, to incorporate BIM information with other project team, participants need to exchange their design through file format in creating a federated BIM model. There will be liability arising through exchanging information between project partners and other project participants such as contractor, quantity surveyor, downstream contractor, and other related parties[21]. Besides, lack of protection for intellectual property right is the second ranked of triggered legal issues because BIM models can be easily extracted and copied, thus intellectual property rights are determinative in BIM implementation[20].

Table 7. IBS Project with BIM application.

Challenges of BIM technology in IBS application amongst Malaysian construction players	Mean value	Standard deviation
Technology		
High cost for new technology and only large organisation can afford to own the technology	4.43	0.696
Regularly requires hardware upgrades	4.32	0.730
A requirement for detailed and precise models to fix the issue of interoperability	4.24	0.734
BIM coordination is difficult to adapt in complex design	4.23	0.846
Interoperability between application and software	4.15	0.733
Organisation		
The low number of skilled technical experts	4.43	0.709
Need to hire new workers who have skills and knowledge of BIM	4.43	0.762
Unwillingness of the top management in a company to use new technology	4.26	0.816
Unwillingness of companies to change from traditional to current construction culture	4.09	0.864
Unwillingness of staff to adopt BIM technology	4.04	0.917
Financial		
The cost to implement BIM in the company is too high	4.48	0.739
Large investments in updating software and hardware	4.44	0.621
High cost spent through continuous effort in educating and training staff	4.05	0.922
Legal Issues		
Greatest risk for file errors and loss of data	4.48	0.502
Lack of protection for intellectual property rights	4.46	0.556
Incompatibility of procurement systems with BIM	4.21	0.836

In terms of challenges from the organisation, the highest mean value is 4.43 under the statement of the low number of skilled technical experts in BIM implementation. One of the reasons is the low knowledge on BIM and most of respondents believe that majority of construction players in Malaysia do not know how, when, and what to start with. Moreover, unwillingness of top management, companies, and staffs to change from traditional to current construction culture was also a challenge for the organisations as it will incur additional cost and risk for later. Without the skilled expert of BIM technology in companies, they need to move forward to internalize a new working environment in their firm.

4.3 Ways of Improvement in Incorporating BIM Into IBS Application

For ways to increase the usage of BIM into IBS application, the researchers had categorised the seven improvements under three main headings.

Based on Table 8, the most suggested improvement as rated by the respondents is on the training, with the highest mean value of 4.67 by stating that CIDB should conduct more programmes and workshops for all key players to increase BIM awareness among them. To ensure the success of BIM implementation, CIDB are required to form several groups with specific tasks such as developing training module, organising seminar, talk, workshop, or colloquium and other relevant programmes. By enhancing education and training for them, this could help the practitioners from construction industry to improve their knowledge on BIM technology into IBS project and they are able to see how BIM would benefit them.

Table 8. Improvement in BIM application into IBS projects.

Improvement in BIM application into IBS projects	Mean value	Standard deviation
Training		
Awareness programme and workshop by CIDB Malaysia for all key players	4.67	0.512
Enhance education and training for staff	4.57	0.553
Government should mandate compulsory for key players to attend BIM campaigns and seminars	3.94	0.802
Government		
Both government and private sector need to apply BIM in promoting sustainable construction	4.63	0.505
Develop national BIM standard and guidelines	4.59	0.550
Construction Practitioners		
Client occupiers should ask for BIM capability during tendering	4.30	0.607
Key players must be ready to implement BIM in construction projects once it is requested by the client	4.25	0.682

The second highest mean value of 4.63 is on the role of government and private agencies to apply BIM in promoting sustainable construction. Moreover, the government should develop national BIM standard and guidelines specifically for construction industry player as a guide for them to use it in the construction especially in IBS project. Furthermore, in terms of construction practitioners, the client should ask for their BIM capability during tendering. With all these efforts, construction practitioners must always be ready to implement BIM technology in construction project to foster their business either as requested by client during tendering or not.

The lowest mean value of 3.94 is made under the statement of government should make it compulsory for key players to attend BIM campaigns and seminars to gain more knowledge related to the implementation of BIM technology. It is predicted that most of the respondents are not ready when BIM campaigns and seminars will be made compulsory and may feel like they are being forced to do so.

5 Conclusion

It can be concluded that majority of the construction players have an experience in dealing with BIM and IBS. However, they did not incorporate any BIM technology into IBS construction project although they strongly agreed that BIM technology can facilitate in obtaining better outcomes, especially in reducing the risk of discrepancies and variation. One of the biggest challenges faced by the industry players is on the high cost for new technology and only large organisations can afford to own the technology. Moreover, the number of BIM experts conversant with the technology is still low. So, it its crucial for Malaysian construction players to improve and promote the adoption of BIM into IBS project. Both public and private sectors need to play bigger roles to promote sustainable construction as it could expand the efficiency and productivity of current businesses. CIDB should organise more training or awareness programmes for all key players as it offers solution from the lack of BIM knowledge in the construction projects. In addition, the enforcement by Government is important to encourage any IBS project to incorporate BIM. Rating score should also be introduced for any projects that uses BIM technology which is similar to IBS score and incentives be given to projects that get a high score. Finally, BIM technology is there for all construction key players to use, and the incorporation of BIM into IBS can really reduce construction material wastage by correctly estimating the materials based on the BIM model.

Conflict of Interest

The authors declare that there is no conflict of interest.

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