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APPLICATION OF BUILDING INFORMATION MODELING (BIM) FOR STRUCTURAL ENGINEERING

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ABSTRACT
In the field of civil engineering, i.e. structural engineering, have increasingly used the Building Information Modeling (BIM) approach in both professional practice and as the focus of research. However, the field of structural engineering, which can be seen as a sub-discipline of civil engineering, misses a real state-of-the-art on the use of BIM in this regard. The aim of this research is to review the experiences of early adopters of BIM which give an impact to structural engineering, its barrier and strategy to the construction industry in improving its performance.The quantitative method has been used. Questionnaires on five levels of Likert-Scale as a research instrument were used and floated to employees in Klang Valley, Kuala Lumpur and Seremban. Investigation was done through a survey where 80 questionnaire forms were distributed and 33 completed forms received back were analyzed with Relative Importance Index (RII) method. Results of study revealed the significant usage is that BIM's tools can provide a very effective and clear structural design process to ensure proper structural workflow. The significant barrier of implementation of BIM is social and habitual resistance to change. Training the construction staff and subsiding the price on BIM software are the effective strategies in enhancing the implementation of BIM

Keywords:
BIM, Structural Engineering, Barrier, Strategies, Construction Project, Application

INTRODUCTION

Building Information Modeling (BIM) in general, is the key to emerged technologies in the construction industry (Zezhou Wu et al., 2019). In general, BIM refers to the process and practice of virtual design and construction. BIM is being implemented in the current practices of construction projects, but the understanding of BIM varies among construction players is not well. According to Kerosuo et al. (2015) and Latiffi et al. (2017), this is due to the different capability levels of construction players in adopting and mastering the concept. Over the past decade, the BIM approach has increasingly been used in both professional practice and research relating to the fields of civil and structural engineering (Ciotta et al., 2021). It is more than just software, there are many more functions than basic software, primarily 3D building design that visualises all data of the building and organizes accordingly before the building is even constructed (Memon, 2014). Memon, et al. gives a list of five (5) main features of BIM such as visualization, coordination, simulation, optimization and plotting.

Building Information Modeling (BIM) is a technology that can change the entire design process, therefore the design phase and the related engineers involved will benefit from it (Habte et al.,2021). Despite the advanced technology that has been brought up by BIM, this paper aims to learn the impact and barrier that will be acquired throughout the implementation of BIM in a project and to overcome the matter

LITERATURE REVIEW

BIM-based workflows, innovative tools, combination platforms, and update information can be used throughout the entire life cycle of a facility and building (Grilo et al., 2010; Ciotta et al., 2021; Matameh et al., 2017; Habte et al., 2021). This has been a catalyst for innovation across the architecture, engineering and construction (AEC) industry (Azhar, 2011; Ciotta et al., 2021). According to Bilal et al., (2016) and Vilutiene et al., (2019), BIM models are 3D geometric encoded, in diverse proprietary formats with the potential to add time (4D) and cost data (5D) when attached to them. According to Vilutiene et al., (2019), most vendors offer BIM software that include the three required capabilities needed for structural engineering, which is geometry, material properties, and loading conditions for an analysis. Therefore, it all can be derived directly from a BIM model, stored, edited, and applied by such BIM software. For example, Autodesk Revit can supplement the physical representation of the objects commonly used by structural engineers (Sack et al., 2018; Vilutiene et al., 2019).

BIM is the effective tool collection that has strengthened the construction industry to design, build and manage (Ahmed, 2018). BIM has distinct advantages for the entire life cycle of the project even after its lifecycle but this advantage cannot be gained by the period due to failure to successfully implement BIM technology to the construction industry (Ahmed, 2018).

Ahmad (2018) define that the most important barrier to BIM application is social and habitual resistance to change, traditional method of contracting, training expenses and the training curve are too expensive, high cost of software purchasing and lack of awareness. Based on the report from Memon et al., (2014) research results, the top four (4) strategies to enhance the implementation of BIM are, provision of trial software, training of construction staff, introduction of BIM in university curriculum and subsidize the price of BIM software. According to Habte et al. (2021), structural engineers and the entire design team can use the common database provided by BIM in improving collaboration and communication between them. Changes can be tracked automatically by structural engineers and vice versa if it is made by other members of the design team (Habte et al; 2021).

METHODOLOGY

In this chapter, the research methodology for the study is described to obtain the relevant data. These data are analysed using Relative Important Index and all the results will be present in table form for easy understanding. In statistical analysis, data collection performs a very important aspect.

Primary data is fresh information gathered specifically for your reasons, straight from individuals who are aware of it. Primary data compilation methods differ on the basis of the study objectives as well as the sort and scope of the information being requested. The questionnaire study was therefore spread among the parties who had respected knowledge about this specific topic. Questionnaire survey was used to collect data because it covers a large number of respondents. The choice to use this method because this method is relatively inexpensive compared to others.

The questionnaires were structured in four (4) sections.

Section A: Demographic of the respondents
This section provides the background information of the respondents with their particular details.

Section B: BIM for structural engineering in construction projects.
This section of the questionnaire is to obtain information about how application BIM can improve in structural engineering. Likert scaling method was used to determine the total score obtained by

requirements at this section. A scale of 1 (Strongly Disagree) to 5 (Strongly Agree) is used to determine the degree of implementation towards the statement.

Section C: Barrier in the application of BIM for structural engineering in construction projects.
This section of the questionnaire is to obtain the information about barriers to implement the BIM system in the construction project A scale of 1 (Strongly Disagree) to 5 (Strongly Agree) are used to determine the respondent reaction

Section D: Strategies to overcome the barrier on BIM for structural engineering implementation in construction projects.
Section D question is about the questionnaire which is related to the strategies to overcome the barrier on BIM (Revit) implementation. A scale of 1 (Highly Ineffective) to 5 (Highly effective) are used to determine the respondent reaction.

The analysis from the result from objectives B, C, D is used in the Relative Importance Index (RII). As specified by Odeh and Battaineh (2002), RII is suitable method to determine the ranking of different factors from different group of respondents.

$$Relative\ Importance\ Index = \frac{\varepsilon w}{AN}$$

W is the weighting given to each factor by the respondents, ranging from 1 to 5. From '1' which is 'not effective / strongly disagree' to '5' which is 'strongly agree / very highly effective'.
A is the highest weight for example 5 in this study)
N is the total number of samples.
The Relative Importance Index (RII) ranged from 0 to 1 and from here the CSFs ranking is defined.

ANALYSIS AND DISCUSSION

This section indicates the characteristics of respondents from the survey. Issues covered include type of organization, role and position, years of working experience and working content. Out of 80 sets of questionnaires distributed, 33 sets of questionnaires were returned which were equivalent to 41.25%. The barrier through the minimum on returns of the questionnaire is mainly due to the limited respondent who is applying BIM in the construction project.

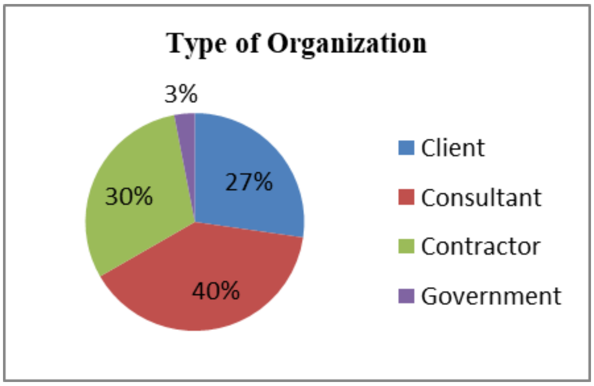

Figure 1 Type of respondent's organization.

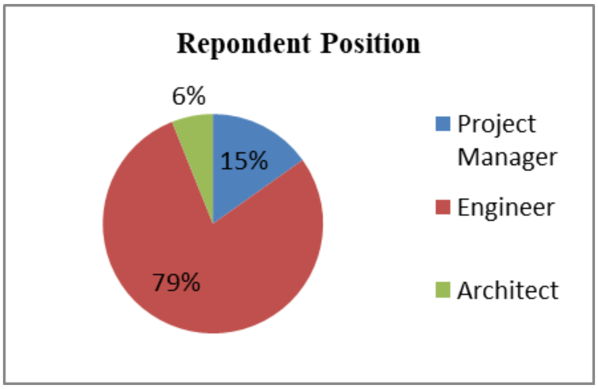

Figure 2: Respondent's position

Figure 1 demonstrates that 27% of respondents were clients, 40% of respondents were consultants, 30% of respondents were contractors and 3% were government servants. Among the responses were received, 15.15% of respondents were project managers, 79% of respondents were engineers and 6% of respondents were architects as presented in Figure 2. There are differences in the total years of working experiences respondents. These results showed that 27% and above of respondents have working experience more than 11-year experience as presented in Figure 3. Others, below18% of respondents have worked less than 10 years.

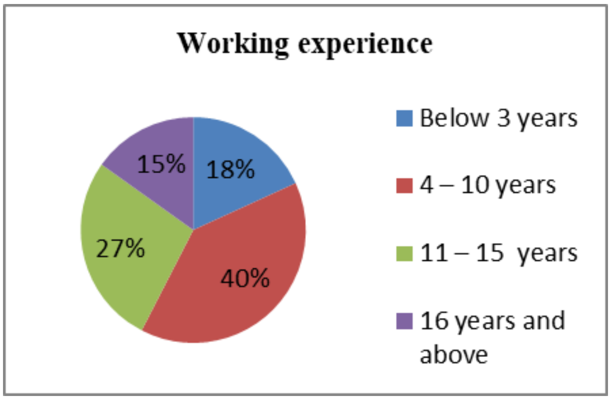

Figure 3: Respondent's working experience

Figure 4 shows that there are 70% of respondents using Revit below one years. 24% of respondents had working experience using Revit around 2 to 4 years. Only 3% of respondents had working experience using Revit for 5 years and above.

According to Table 1, results show most of the respondents agree that "BIM is a very significant element that brings benefits to the construction industry". This statement ranked in number 1 with RII as high as 0.812. Beside this, respondents also agree that "BIM's tools can provide a very effective and clear structural design process to ensure proper structural workflow", this statement is also ranked in number 1 with 0.812 RII as well.

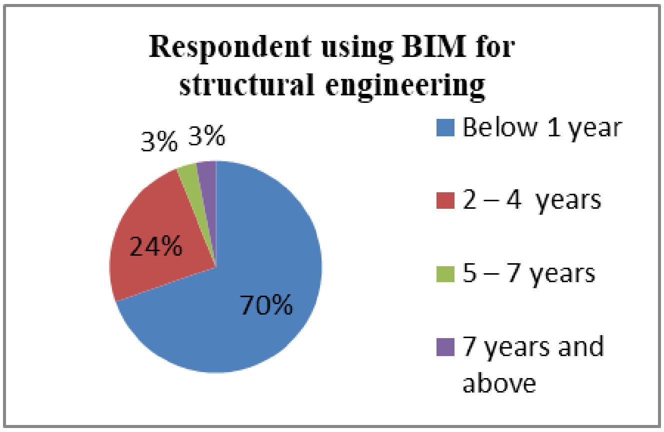

Figure 4: Respondent using Revit

Table 1: Application of BIM for structural engineering

BIM for structural engineering	RII	Rank
BIM can provide a very effective and clear structural design process to ensure proper structural workflow.	0.812	1
BIM is a very significant element that brings benefits to the construction Industry.	0.812	2
BIM can provide a 4D structural information model which includes the accounting of time and enriches all the basic information where it leads to better management of a project.	0.800	3
BIM provides structural analysis which can produce a detailed result required for all parties.	0.752	4
BIM is a structural tool that assists the structural engineer to optimize their structural design, comparing multiple solutions for sustainable design models.	0.745	5

Statement "BIM's can provide 4D structural information model which include the accounting of time and enriches all the basic information where it leads to better management of a project" had RII of 0.800 is 3rd in the ranking followed by BIM's tools provide structural analysis which can produce a detail result require for all parties. With RII of 0.752 and lastly the statement "BIM's structural tools assist the structural engineer to optimize their structural design, comparing multiple solutions for sustainable design models" had the RII of 0.745 and is ranked at number 5.

Table 2: Ranking and RII value on the barrier in the application of BIM for structural engineering

Barrier in the application of BIM for structural engineering	RII	Rank
Social and habitual resistance to change.	0.830	1
Training expenses and training curves are way too expensive if a company wants to implement BIM in a project.	0.806	2
High cost of BIM hardware and tools.	0.800	3
The lack of awareness about BIM.	0.764	4
The involved parties are familiar and adapted with the traditional methods.	0.752	5

In line with the result and findings on the study from Ahmed, (2018) as shows on Table 2, "Social and habitual resistance to change" taking number 1 in the ranking with the RII of 0.830. This indicates that the companies outside refuse to change their working pattern. "Training expenses and training curves are way too expensive if a company wants to implement BIM in a project." taking rank 2 with RII of 0.806 which means most of the respondents agree that the training curves and expenses are way too expensive to use BIM. Statement "High cost for the BIM hardware and tools" ranked at number 3 with RII of 0.800 is ranked at number 4 with RII of 0.764. Lastly with the statement "the involved parties are familiar and adapted with the traditional methods" with RII of 0.752.

Table 3: Strategies to overcome the barrier of a BIM implementation for structural engineering

Strategies to overcome the barrier of a BIM for structural engineering	RII	Rank
Training of construction staff	0.879	1
Subsiding the price of BIM software	0.879	2
Introduction of BIM in university curriculum	0.867	3
Provision of trial software	0.848	4
Mobilizing client on the important of BIM	0.842	5

Findings in Table 3 demonstrates that all of the strategies discussed are quite acceptable by respondents. All the RII value is very close. Strategies "training of construction staff" and "subsiding the price of BIM software" are the most agreed strategies which ranked in number 1 with the highest RII score 0.879. The training of construction staff" is supported by Memon, (2014) study. Besides, introduction of BIM in university curriculum is strategy number 3 with RII value of 0.867. Provision of trial software had an RII value of 0.848 and lastly mobilizing clients on the importance of the BIM is ranked at number.5. All the RII value is 0.8 and above it brings the meaning that these strategies are effective to overcome the barrier of adoption of BIM.

CONCLUSION

This research concluded that the application of BIM for structural engineering did bring advantages to the AEC industry. BIM brings benefits to the construction project about design, management, structural detailing and most significantly in terms of structural workflow. The rate of implementation of BIM in the construction industry is at a slow tempo and this provides a way for the application of Building Information Modeling (BIM) to encourage the faster performance of the construction industry (Ahmed, 2018). In another study by Shin (2017) and Carmo el al, (2022) focused on structural engineering, analysed that related issue inserted in a structural engineering environment aiming to make the best use of BIM collaborations in order to improve work efficiency and efficacy. Mora et al, (2022) state in their study finding that the scientific production proves that the integration of the structural project with the environments of BIM is a reality and both form a symbiotic relationship.

The elements that lead in to this issue are pointed out in this study such as (1) Social and habitual resistance to change, (2) Training expenses and training curves are way too expensive if a company wants to implement BIM in a project, (3) High cost of BIM hardware and tools, (4) Lack of awareness about BIM and (5). The involved parties are familiar and adapted with the traditional methods. So these issues need to be addressed hence if the government wants to see the construction industry to be able to compete globally. The need for continued support from the government will play a good role in increasing the momentum of BIM implementation in the construction sector. On the other hand, the countries are continuously starting to invest in supporting the implementation of BIM in construction projects (Government, 2012; Latiffi et al., 2017).

Construction stakeholders including owners, consultants and contractors should play their very own role by shifting the paradigm from using the traditional method to a more innovative method (Ahmed, 2018) and vice versa. It can be concluded that the construction industry can overcome the barrier to the implementation of BIM through the progressive participation of government agencies and all construction stakeholders (Ahmed, 2018).

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