International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972

Volume 6 Issue 17 (June 2024) PP. 246-265
DOI 10.35631/IJIREV.617019

INTERNATIONAL JOURNAL OF INNOVATION AND INDUSTRIAL REVOLUTION (IJIREV)
www.ijirev.com

BARRIERS TO BUILDING INFORMATION MODELLING (BIM) IMPLEMENTATION AMONG CIVIL AND STRUCTURAL CONSULTANTS IN MALAYSIA'S CONSTRUCTION INDUSTRY

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Article Info:

Article history:
Received date: 15.10.2023
Revised date: 01.11.2023
Accepted date: 15.06.2024
Published date: 30.06.2024

To cite this document:

Ya'acob, M. R., Isa, C. M. M., Rahman, S. H. A., & Salleh, S. (2024). Barriers To Building Information Modelling (BIM) Implementation Among Civil And Structural Consultants In Malaysia's Construction Industry. *International Journal of Innovation and Industrial Revolution, 6* (17), 246-265.

DOI: 10.35631/ IJIREV.617019

Abstract:

Digitalization technology through Building Information Modelling (BIM) in the construction industry is a key focus in the Malaysian government's Strategic Plan for 2021-2025. Despite the introduction of BIM in 2007 with the aim of achieving 80% implementation by 2025, its adoption among civil and structural (C&S) engineering consultants remains limited. This paper presents the findings of a preliminary study conducted through a questionnaire survey administered to thirty (30) C&S consultants, aimed at identifying the barriers to BIM implementation in government projects. Several statistical analytic approaches, including validity, normality, reliability tests, and factor analysis, are used to identify the crucial specific factors impacting weak BIM adoption among C&S engineering consultants in Malaysia. The instrument reliability was tested, yielding a Cronbach alpha value of 0.91. The results indicate that issues such as coordination of construction activities within BIM, lack of clear BIM policies, legal concerns, data exchange interoperability, high costs associated with BIM investment, demanding software requirements, and difficulties and complexities in using BIM software are the main obstacles hindering the adoption of BIM among the C&S consultants. Therefore, establishing a systematic BIM process is expected to mitigate these challenges. This study contributes to the existing BIM literature within the construction industry context by providing insights to enhance the BIM implementation processes.

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Keywords:

Building Information Modelling, Civil, Structural, Engineering Consultants, Barriers.

Introduction

BIM in Malaysia's context is a modelling technology and associated set of procedures to produce, exchange, evaluate, and use of digital information models throughout the life cycle of construction projects (Construction Industry Development Board Malaysia, 2016). The BIM process will encompass every stage of a construction project, including planning, design, construction, and maintenance until the building or infrastructure is designated for refurbishment, rehabilitation, or demolition. The integration of Building Information Modelling (BIM) into the design process benefits engineering consultants working on construction projects in terms of time used, cost estimation, and product delivery quality. The digitization of the design process in BIM allows all information on design work to be kept as part of project deliverables in three-dimensional (3D) modelling. As a result, any collaboration effort amongst project stakeholders may be readily discussed, managed, and monitored using a real-time online system in Common Data Environment (CDE) such as BIM360 by Autodesk. The Construction Industry Development Board (CIDB) was driving the BIM deployment in Malaysia to be generally embraced by 2020 (Construction Industry Building Development Board Malaysia, 2013). It is adopted to boost efficiency in the Malaysian construction sector in compliance with the CIDB Malaysia Strategic Plan initiative, which runs from 2015 to 2020. According to the Malaysia BIM Roadmap, construction projects in Malaysia must employ BIM technology from the year 2020 onwards, which includes the private-sector-funded projects. As a result, BIM adoption in Malaysia has increased by 45% in 2019 compared to 17% in 2016. The findings also revealed that 74% of respondents are more aware of BIM, an increase from 45% in 2016. BIM adoption has started to show a favourable trend, with 49% of respondents using BIM in their building projects. Major businesses have the greatest adoption among implementers. This considerably increases BIM adopters over previous research findings (Construction Industry Building Development Board Malaysia, 2020).

With the presence of Industrial Revolution (IR) 4.0, digitalization has become one of the key contributions to construction modernization. CIDB continues the initiative with a new five-year strategic plan in the Construction 4.0 Strategic Plan (CSP), which runs from 2021 to 2025 and aims to improve the construction sector's performance, reduce negative environmental effects, and promote high-paying jobs for Malaysians. In 2007, the Design and Build Project for the National Cancer Institute building construction in Putrajaya, owned by the Ministry of Health of Malaysia and implemented by *Jabatan Kerja Raya* (JKR), marked the commencement of BIM application in Malaysian government projects. JKR, Malaysia's principal technical government agency, has also increased the use of BIM in other types of contracts, such as conventional consultant projects. Through its Strategic Plan 2021-2025, JKR has targeted the adoption of the BIM method to achieve 50% by 2021 and 80% by 2025. With a 10% annual increase through 2025, JKR would ensure that the method is employed in 50% of government projects costing RM10 million or more (*Jabatan Kerja Raya Malaysia*, 2020).

However, according to current findings by Zahrizan et al. (2013), Yasser Yahya et al. (2020) and Idris et al. (2021), BIM adoption in Malaysia remains low. There are only 20 Building

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Information Modelling (BIM) projects worth more than RM50 million or more within the Eleventh Malaysia Plan (11th MP) (Construction Industry Development Board Malaysia, 2020). Based on statistics from Unit BIM JKR, only 5 of these projects are currently on conventional consultants' contracts and expected to be completed by 2021, while the rest are under Design and Built contracts.

In comparison to architectural firms that have successfully employed 3D modelling in their design processes, engineering consultancies such as civil and structural, mechanical, and electrical firms are projected to have more barriers when using BIM. A recent study by Idris et al. (2021) reveals that Malaysia is still far from the position it should be in BIM implementation due to a lack of awareness, costs, slow adaptation, the lack of a clear guideline to assist organisations and policymakers towards BIM implementation transformation, and BIM was not mandated in sufficient time. According to Yasser Yahya et al. (2020), most Malaysian construction businesses are unaware of BIM technology. Meanwhile, the results of a study conducted by Samad et al. (2018) express that BIM in Malaysia is still hampered by a lack of understanding and willingness to change. In Muñoz-La Rivera et al. (2019) report, structural engineering companies (SECs) currently have a few deficiencies that impede their processes and interactions, decreasing their productivity, lacking collaborative and interconnected processes, and not including current work methodologies such as BIM. However, there is a gap of study where no research is discussed about the BIM implementation barriers that focus specifically on the Civil and Structural engineering consultant services area.

Furthermore, the Consultant Service Agreement (CSA) produced by the Ministry of Finance (MOF), Malaysia (*Kementerian Kewangan Malaysia*, 2018) that is currently used in the JKR conventional consultant contract did not clearly mention the guidelines for C&S consultants in a government project, BIM process in C&S design process from Level of Details (LOD) 300 done by consultants to contractor continue up to LOD 500, CDE for sharing platform, submission of drawings to local authorities, and BIM process transition LOD 500 by the contractor. With the lack of a transparent BIM process, C&S consultants are unable to execute the BIM project independently and must rely on modelers from external firms or third parties. Indirectly, the cost of project implementation will rise whether it is borne by the consulting firm or the project owner himself. As a result, engineering consultants in Malaysia are projected to face challenges in implementing the BIM mandated by government agencies as an obligatory project under Rancangan Malaysia ke 12 (RMK-12) by JKR.

Hence, the objective of this study is to gather the most recent information on the critical barriers influencing BIM implementation, specifically among civil and structural engineering (C&S) consultant's services in Malaysia, through a structured questionnaire survey.

Literature Review

The transformation in the construction industry must be enhanced further to promote economic growth in the construction sector effectively. The Construction Industry Transformation Program (CITP) 2016-2020, administered by the CIDB, has been designated as the national agenda for transforming the construction industry into more sustainable and cost-effective. As part of this CITP transformation, BIM has been implemented in construction as one of the advantageous technologies in the industry. Since 2017, CIDB has established MyBIM to serve as the construction industry's primary resource for support services and training to expedite BIM adoption in Malaysia. The construction industry works hard with CIDB to promote BIM

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implementation to enhance professionals' and organisations' awareness and encourage them to adopt and implement BIM in their work environment. It is projected that labor productivity will increase by 3.6% in RMK-12 (*Unit Perancang Ekonomi*, 2021) due to the implementation of BIM in the construction industry. In addition, CIDB (Construction Industry Development Board Malaysia, 2021) in media statement on 21 March 2021, reported that construction productivity increased by 60% in CITP and will continue its success with the Construction 4.0 Strategic Plan (CSP) for the next five years (CIDB Strategic Plan 2021-2025).

BIM is one of the 12 important technologies listed in the Revolution of Construction 4.0 to improve current and future technologies for the construction industry to achieve higher productivity, better safety, and a more sustainable approach – incorporating whole life cycle analysis (Construction Industry Development Board Malaysia, 2020). As the largest technical department in a government agency, JKR is responsible for ensuring the successful construction of public building and infrastructure initiatives in Malaysia. According to *Arahan Perbendaharaan 182, Kementerian Kewangan Malaysia* (2008), all non-technical departments must acquire development project services from JKR or *Jabatan Pengairan dan Saliran* (JPS). In accordance with the Industrial Revolution 4.0 (IR 4.0), JKR has been systematically implementing BIM since 2007 to improve the value of product delivery for its construction projects. Therefore, in the JKR Strategic Plan 2021-2025 (*Jabatan Kerja Raya Malaysia*, 2020), the organization has already mandated the implementation of BIM in projects with a value of RM 10 million or more, with 50% of total projects in RMK-12 predicted to implement BIM with an annual increase of 10%.

According to the CIDB (Construction Industry Development Board Malaysia, 2013) BIM steering group, BIM is a modelling technology and related set of procedures for producing, communicating, and analysing digital information throughout the building life cycle. Meanwhile, JKR described BIM as the process of developing and managing an informed 3D model throughout the life cycle of a project's execution, where this digital model is utilised for objectives by multiple parties to boost the efficiency of comprehensive asset management (Jabatan Kerja Raya Malaysia, 2021). BIM is one of the technologies used in building projects to minimise any potential variation orders (VO). The variation orders might be the result of design modifications caused by clashes amongst multiple disciplines in the project team. The addition of VO will indirectly raise the project's cost. Furthermore, by integrating BIM technology, the process of creating drawings and measuring quantities may be accelerated using 3D modelling tools and software such as Autodesk Revit, Civil 3D, and Cost X. Moreover, improved project visualisation in terms of 3-dimensional (3D) against the standard approach in 2-dimensional (2D) before construction physically on-site also may be explored.

Despite the benefits, recent research reveals that BIM implementation is still in its infancy as shown the current BIM barriers in Table 1.0. Ahlam and Rahim (2021) revealed that there is no clear discussion on risk factors which might hinder the early process of BIM adoption. Meanwhile, McAuley et al. (2020), Bosch-Sijtsema et al. (2021) and Waqar et.al. (2023) identifies critical BIM barriers as technical adoption barrier, behavioral barrier, implementation barrier, management barrier, and digital education barrier, indicate that BIM deployment is still hampered by a variety of constraints. According to international academicians, Porwal and Hewage (2013), Muñoz-La Rivera et al. (2019), Saka & Chan (2020) and Mahamadu et al. (2020), poor BIM implementation is attributed by lack of financial and technical support from organisations investment in software, hardware, and infrastructure, as well as an ambiguous

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BIM method, standard, and procedure. Similarly, Zahrizan et al. (2013) reported that Malaysian construction industry players are having difficulties implementing BIM because they do not know where, when, and how to start as there is no national BIM standard and guideline for them to follow. The construction players have difficulties understanding how BIM could be executed among parties (Idris et al., 2021). In addition, Yasser Yahya et al. (2020) conducted a survey which revealed that most construction companies are lack of awareness about BIM technology in Malaysia. The level of BIM implementation and team awareness only increased when the organization practices BIM in its daily works (Idris et al., 2021). The research by Idris et al. (2021) from 268 responses received revealed that only 13% of the participants from both public and private sectors are using BIM in their organization, and this is a negative sign that Malaysia is still far from the position it is supposed to be in BIM implementation. The research listed a lack of awareness, implementation costs, slow adaptation, and unavailability of a clear guideline to assist organizations and policymakers toward BIM implementation (Idris et al., 2021) as the causes of the slow implementation of BIM in Malaysia. In summary, local researchers Zahrizan et al. (2013), Samad et al. (2018), Yasser Yahya et al. (2020), Idris et al. (2021), and Manzoor et al. (2021) identified several reasons for poor BIM implementation in Malaysia, which includes lack of awareness, high costs, slow adaptation, and the lack of a clear guideline to assist organisations and policymakers.

According to Alreshidi et al. (2017), the factors influencing the efficiency of BIM are classified into five categories based on interviews with BIM experts, academicians, practitioners, and technicians. These categories are ICT factors, socio-organizational factors, practitioner factors, BIM process factors, and financial and legal factors. Recent studies by Idris et al. (2021) have shown that, on the surface, the BIM process, along with other elements, has a substantial effect on BIM implementation. The complexity of the BIM process, involving detailed and often cumbersome procedures in creating and managing BIM models, can pose a significant barrier due to the substantial time and effort required (Ismail et al., 2019; Cheng & Lu, 2021). As a result, this study will further assess the BIM process as a factor impacting BIM deployment because no previous research has done a survey target sample that focused on civil and structural engineering (C&S) consultants in Malaysia.

Table 1.0. The Current BIM Barriers

Barrier	Description	Sources
High Initial Costs	Substantial investment in software, hardware, and infrastructure needed for BIM implementation. Particularly prohibitive for SMEs.	Saka & Chan (2020); Mahamadu et al. (2020)
Lack of Awareness and Training	Insufficient knowledge about BIM benefits among clients and subcontractors. Inadequate training programs hinder effective implementation.	Eadie et al. (2020); Zhang et al. (2021)
Cultural Resistance	Industry's preference for traditional methods leads to resistance against adopting new technologies like BIM.	Ganah & John (2021); Oti et al. (2020)
Organizational Challenges	Lack of support from top management, shortage of BIM experts, and doubts about ROI. Organizational leaders hesitate to invest without clear evidence of immediate benefits.	McAuley et al. (2020); Bosch-Sijtsema et al.

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		(2021); Waqar et. Al (2023)
Legal and Contractual Issues	Absence of contractual requirements for BIM implementation, insufficient governmental support, and issues related to data ownership and interoperability between software programs.	Ahmed et al. (2019); Park & Kim (2020)
Complexity of BIM Process	The detailed and sometimes cumbersome processes involved in creating and managing BIM models can be a barrier due to the extensive time and effort required.	Ismail et al. (2019); Cheng & Lu (2021)

Based on the literature review, a conceptual framework is developed to understand the factors influencing Building Information Modelling (BIM) implementation among civil and structural engineering (C&S) consultants in Malaysia, as shown in Figure 1. The main components of the framework include the Construction Industry Transformation Program (CITP), BIM adoption initiatives, benefits of BIM implementation, barriers to BIM implementation and factors influencing BIM implementation.

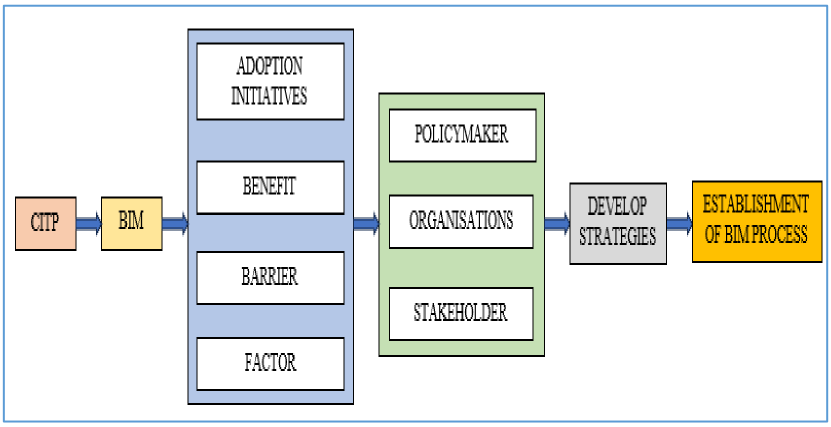

Figure 1. The Conceptual Framework

The construction industry is experiencing a significant transformation by technological advancements and the need for increased efficiency. At the forefront of this change is Building Information Modelling (BIM), a technology that digitally represents the physical and functional characteristics of a facility. BIM serves as a shared resource of information throughout a facility's lifecycle, from inception onward. This essay explores a structured framework for establishing the BIM process within the construction industry, highlighting adoption initiatives, key stakeholders, and strategic development. The CITP is the national agenda for transforming the construction industry in Malaysia to be more sustainable and cost-effective. BIM implementation offers various benefits, including increased productivity, enhanced project visualization through 3D modelling, and minimized variation orders (VO). BIM technology facilitates design modifications, accelerates drawing creation and quantity measurement, and improves project visualization compared to traditional 2D approaches. Despite the benefits, some barriers include financial and technical support limitations, lack of clarity regarding BIM methods, standards, and procedures, low awareness, high costs, slow adaptation, and the absence of clear guidelines for organizations and policymakers. Factors

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influencing efficient BIM implementation encompass the technical aspects, organizational dynamics, individual competencies, and the overall BIM process.

The conceptual framework in Figure 1 provides a comprehensive understanding of the factors that impact BIM implementation among C&S consultants in Malaysia. It highlights the significance of CITP, BIM adoption initiatives, benefits of BIM implementation, barriers to implementation, and the factors influencing efficiency. By considering these factors, policymakers, organizations, and industry stakeholders can develop strategies to overcome barriers and enhance BIM implementation processes in the Malaysian construction industry. At the heart of the framework are the adoption initiatives, which include benefits, barriers, and factors influencing BIM adoption. The benefits of adopting BIM are numerous. It fosters better collaboration among project stakeholders, enhances project visualization, increases accuracy in construction documents, and boosts overall project efficiency (Charef et al., 2021). However, adopting BIM is not without its barriers. High initial costs, resistance to change, a shortage of skilled personnel, and technical difficulties are significant barriers that must be addressed (Darko et al., 2020). Policymakers play a pivotal role in this framework by creating and enforcing policies that encourage or mandate BIM adoption. Government bodies and regulatory agencies set the necessary framework and regulations for BIM implementation, providing a supportive environment for its widespread use (Liu et al., 2020). Their involvement is crucial in overcoming the inertia that often accompanies the adoption of new technologies.

Organizations within the construction industry, including C&S engineers, is the primary users of BIM. Their active participation and support are essential for successful BIM implementation. These organizations need to invest in training programs, technology, and process changes to effectively integrate BIM into their operations (Alreshidi et al., 2018). Additionally, stakeholders, such as clients, end-users, suppliers, and other entities affected by the construction process, must be engaged. Effective stakeholder engagement addresses concerns and garners support for BIM initiatives, ensuring all parties are aligned with the objectives of the BIM process (Alhumaidi et al., 2020).

Developing strategies to overcome barriers is a critical step in the framework. This involves creating comprehensive plans that address the specific challenges faced by organizations in adopting BIM. Strategies may include investing in workforce training, advocating for policy changes, creating incentives for early adopters, and fostering a culture of innovation within the industry (Durdyev et al., 2022). These strategies are designed to facilitate a smooth transition to BIM, ensuring organizations can fully exploit its potential benefits. The ultimate goal of this framework is the establishment of a robust BIM process. Achieving this goal signifies that the industry has successfully navigated the challenges associated with BIM adoption. Establishing the BIM process leads to improved project outcomes, enhanced efficiency, and greater collaboration among all stakeholders involved in the construction lifecycle (Boje et al., 2020). In conclusion, the structured framework for establishing the BIM process within the construction industry highlights the importance of comprehensive adoption initiatives, the critical role of policymakers, the active participation of organizations, and the strategic engagement of stakeholders. By addressing barriers and BIM process, this framework aims to integrate BIM into current design, driving significant improvements in project delivery and lifecycle management concentrate on C&S consultancy.

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Methodology
A quantitative research design was employed to investigate the barriers to Building Information Modelling (BIM) implementation among civil and structural (C&S) engineering consultants in this study. A non-probability convenient sampling method was utilized to select the target respondents. The sample was drawn from the registered C&S engineering consultants listed on the Board of Engineers Malaysia (BEM) (Board of Engineers Malaysia, 2022) website as of March 31, 2022. The reason for selecting this sample is that all engineering consultants in Malaysia must be registered with BEM under the Registration of Engineers Act 1967 under registration qualifying codes as a Body Corporate, Multi-Discipline, Sole Proprietor, or Partnership. Thus, the sampling frame consisted of 1,905 engineering consulting organizations registered in the Civil and Structural discipline. According to Krejcie and Morgan (1970), a sample size of 321 respondents was determined to be appropriate. However, for this pilot study, a smaller sample of 30 respondents was randomly selected for analysis. The data collection process involved contacting the selected respondents via email, phone calls, and an online survey using Google Forms was conducted within 3 months after obtaining approval from the Ethics Committee. The survey questionnaire was designed based on a 5-point Likert scale to assess the level of relevance for each viewpoint, ranging from 1 (insignificant) to 5 (very significant). The questionnaire was developed from twenty (20) BIM hurdles adapted from previous research, as described in the literature section. The collected data were analysed using various statistical analytic approaches. First, the validity and normality of the data were assessed. Next, reliability tests were conducted to ensure the consistency and stability of the questionnaire. Factor analysis was performed using IBM SPSS software to identify the crucial specific factors influencing the weak adoption of BIM among C&S engineering consultants in Malaysia. The component matrix after rotation was examined, and the purpose and results of each method are explained in the results section.

Result

Respondents
In total, thirty (30) respondents completed questionnaires for this pilot project from targeted C&S consultant registered from current BEM website representing a response rate of 9.4 from 321 target samples C&S engineering consultant. 82% of respondents were registered with BEM, which 28 respondents choose civil discipline, meanwhile 21 from the total 30 respondents choose both civil and structure discipline, as shown in Figure 2 and Figure 3, respectively.

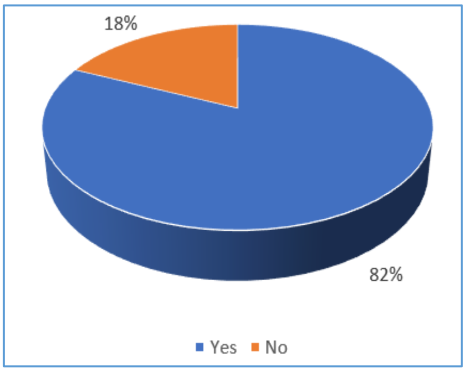

Figure 2. BEM Registration of Respondents

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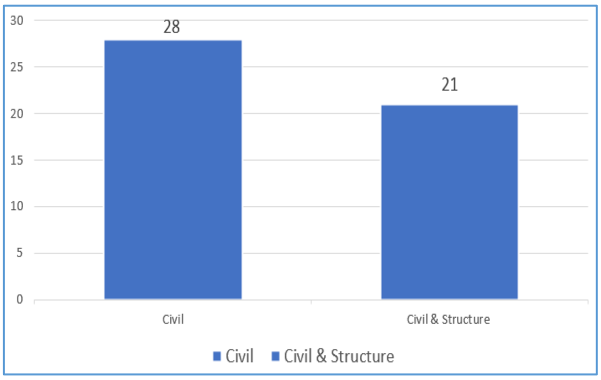

Figure 3. The Respondents Background Discipline.

Profiles of Respondents

This pilot study involved 73% male and 27% female respondents from various states in Malaysia, including Selangor, Kuala Lumpur, Negeri Sembilan, Johor, and others, accounting for 45%, 33%, 12%, 3%, and 18% of the sample, respectively as shown in Figure 4 and Figure 5. The sample questionnaires were received from individuals with diverse educational backgrounds and various job positions in the civil and structural (C&S) engineering field in Figure 6. Meanwhile, Figure 7 represents the sample, including directors, lead C&S engineers, senior C&S engineers, and C&S engineers.

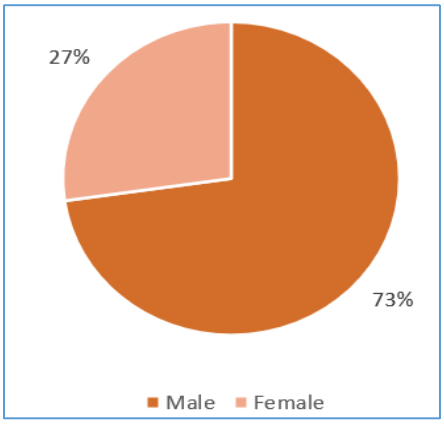

Figure 4. The Respondent's Gender

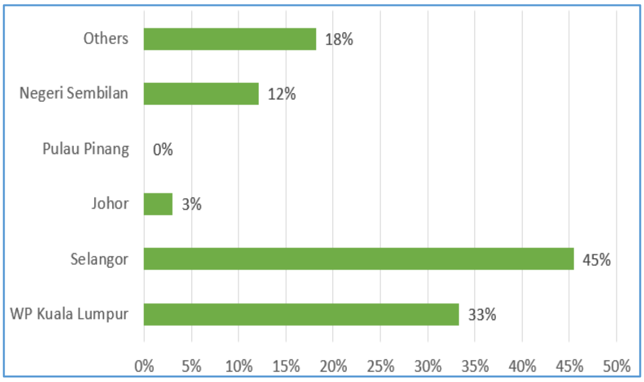

Figure 5. The Respondent's Origin State.

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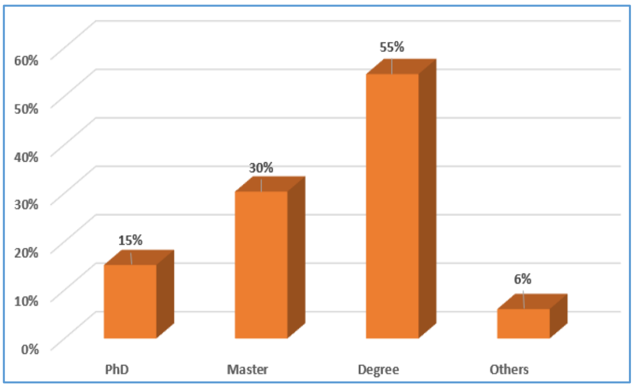

Figure 6. The Respondent's Education Background.

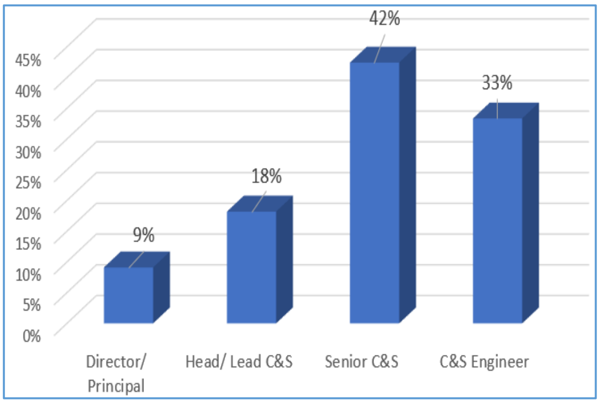

Figure 7. The Respondent's Job Position.

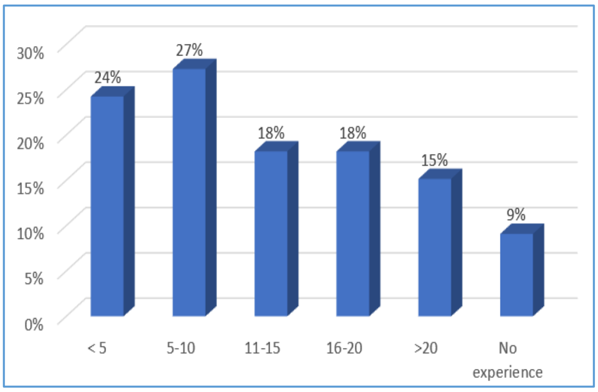

Figure 8. The C&S Design Experience.

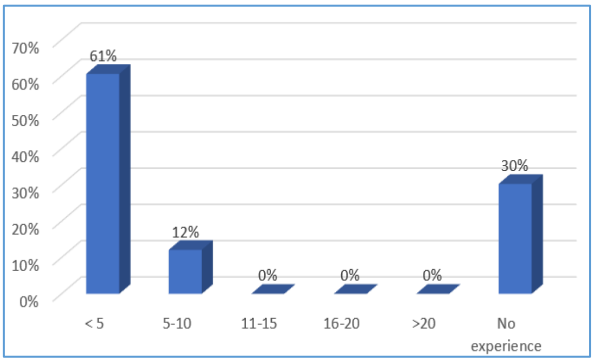

Figure 9. The BIM Experience.

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Figure 8 shows that the highest respondent with C&S design experience within 5-10 years was 27%, and only 9% do not have experience. However, the result shows that 61% of respondents have BIM experience minimum of less than 5 years compared to no experience of BIM about 30%, as shown in Figure 9.

Reliability Test

A reliability test using Cronbach's coefficient was conducted to measure the internal consistency of the BIM barriers under study. Table 1 shows the results for reliability test carried out on factors modified from the rotated component matrix.

Table 1. Reliability Test of BIM Barrier Factor for C&S Engineering Consultant.

Cronbach's Alpha	N of Items
0.910	20

The result shows that the factors listed in Table 4 is acceptable and reliable to be considered in the BIM barriers by the respondents with Cronbach's Alpha value of 0.91 (>0.7).

Mean Score Ranking of BIM Barriers

The mean score for each of the BIM barriers was calculated by using descriptive statistics. The objective was to determine if there were any BIM barriers with a mean score of less than 3. The lowest observed mean was 3.30, while the highest was 4.20. Both are larger than 3, confirming that the mean of the data is accurate and that there are no irregularities in the data. Table 2 shows the mean score ranking of BIM barriers of C&S engineering consultants, including mean, standard deviation (SD) and ranking.

Table 2. Mean Score Ranking of Barriers Factor.

BIM Barrier	Mean	Ranking	SD
B1	3.63	10	1.033
B2	3.30	11	1.264
B3	3.97	4	1.066
B4	3.67	4	.884
B5	4.10	2	.712
B6	3.83	6	.874
B7	3.67	9	.959
B8	3.87	5	.860
B9	3.97	4	.964
B10	4.20	1	.805
B11	4.07	3	.907
B12	3.83	6	.913
B13	3.87	5	.860
B14	3.83	6	.834
B15	3.77	8	.935
B16	3.80	7	.805

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B17	4.07	3	.785
B18	4.10	2	.662
B19	3.77	8	.728
B20	4.07	3	.691

Validity Test

The Kaiser-Mayer-Olkin (KMO) and Bartlett tests were used to validate the parameters examined for BIM barrier decision making in this study. Kaiser and Rice (1948) noted that KMO static fluctuates between 0 and 1 and recommends accepting values larger than 0.5, indicating that the sample fits the essential conditions for factor analysis (Hair et al., 2010). Table 3 displays the Barlett test of sphericity and KMO values for testing validity on certain parameters.

Table 3. Barlett and KMO Tests on BIM Barriers for C&S Engineering Consultant.

Independent Variable	Bartlett	KMO
BIM Barriers	0.00	0.571

The findings demonstrate that all KMO values are larger than 0.5. Furthermore, a substantial amount of Barlett value of 0.000 (p<0.001) is detected for all BIM barriers.

Normality Test

The normality of the variables for this pilot study was established by evaluating the data distributions for skewness and kurtosis. The standard error is the range of possible error occurs in data (Good standard error value < 1.0).

Table 4. Normality Tests for BIM Barriers

BIM Barrier	Skewness		Kurtosis	
Variable	Statistic	Std. E	Statistic	Std. E
Process	-0.473	0.427	-0.646	0.833
Knowledge	0.350	0.427	-0.721	0.833
Policy	0.371	0.427	-0.639	0.833
Cost	-0.544	0.427	-0.544	0.833
Technology	-0.471	0.427	-0.174	0.833

The standard errors for skewness and kurtosis are 0.427 and 0.833, respectively, as shown in Table 4. Both results suggest that the standard errors are good (<1.0). As a result, the normality assumption was fulfilled for each variable, indicating that all BIM barrier factors are normally distributed.

Factor Analysis

Factor analysis was used in this study to examine for groups among the inter-correlations of a set of variables in which the data may be reduced or summarized using a smaller set of factors or components (Pallant, 2013). In addition, Sekaran (2003) stated that factor analysis demonstrates which of the items or factors that are most appropriate for each dimension to establish construct validity. In this study, the analysis used twenty (20) factors and detected structure in the relationship between the factors which require factor rotation (Norusis, 2005).

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Each factor belongs only to one of the five (5) groups of specific barriers: process, knowledge, policy, cost and technology. Table 5 shows the component matrix after rotation with a value of factor loadings of more than 0.5 (Kaiser & Rice, 1948).

The barriers were categorized into five (5) groups. First, the barriers are related to the BIM implementation process itself. The identified factors are the lack of BIM standards, lack of BIM best practices, absence of a defined BIM workflow, time constraints associated with BIM adoption, and difficulties in coordinating BIM activities. These factors highlight the challenges in establishing efficient and effective BIM processes within organizations.

Second, in terms of knowledge and experience, the factors in this group pertain to the knowledge and experience aspects of BIM adoption. They include the need of BIM experience, insufficient BIM knowledge, inadequate BIM training opportunities, absence of clear BIM policies, and the lack of incentives to encourage BIM adoption. These factors suggest that a lack of expertise and awareness hinders the successful implementation of BIM among civil and structural consultants.

Third, the policy group addresses barriers associated with the broader organizational and industry policies. It includes factors such as reluctance to change, difficulties in using BIM software, the absence of a strong demand for BIM, and the need of legal contractual requirements for BIM implementation. These factors underline the need for supportive policies and frameworks to promote and enforce BIM adoption in the industry.

Fourth group is the cost factor that focuses on financial constraints and investment considerations associated with BIM adoption. The factors identified include the unwillingness to invest in BIM, financial limitations, and high capital expenditure (CAPEX) costs. These factors highlight the financial challenges and perceived costs that act as barriers to BIM implementation.

Table 5. Rotated Component Factor Analysis for BIM Barrier Factors for C&S Consultant.

Factor	Group				
	1	2	3	4	5
B9 - Lack of BIM standard	.856				
B10 - Lack of BIM best practice	.846				
B11 - No BIM workflow	.844				
B8 - Time barrier of BIM	.793				
B12 - BIM coordination difficult	.789				
B18 - Lack of BIM experience		.831			
B17 - Lack of BIM knowledge		.775			

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B20 - Lack of BIM Training		.732			
B16 - Lack of BIM clear policy		.698			
B15 - Lack of BIM incentive		.610			
B19 - Reluctance to change			.764		
B4 - BIM software difficult			.746		
B13 -Lack of BIM demand			.735		
B14 - No legal contractual of BIM			.579	.503	
B7 - Unwillingness to invest				.743	
B6 - Financial constraint				.724	
B5 - High cost on CAPEX				.720	
B1 - Interoperability data exchange					.851
B3 - High specification of hardware					.799
B2 - Current software not compatible					.756

1 – Process, 2 – Knowledge, 3 – Policy, 4 – Cost, 5 - Technology

Finally, the technology group encompasses barriers related to the technical aspects of BIM adoption. It includes factors such as interoperability issues in data exchange, high hardware specification requirements, and software incompatibility. These factors underscore the importance of addressing technological challenges to ensure seamless integration and interoperability of BIM systems. By categorizing the barriers into these five groups, this study provides a comprehensive understanding of the diverse challenges faced by civil and structural consultants in the Malaysian construction industry when implementing BIM. These findings can guide policymakers, industry stakeholders, and organizations in developing strategies and interventions to overcome these barriers and facilitate successful BIM adoption.

Ranking of BIM Barriers

Table 6 shows the summary of findings on the BIM barrier factors extracted from Table 5 which are ranked based on the five highest factor loadings.

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Table 6. Ranking Of BIM Barriers Based on Loaded Factor.

Ranking	BIM barrier factors	Loaded factor
1	Lack of BIM standard	0.856
2	Interoperability data exchange	0.851
3	Lack of BIM best practice	0.846
4	No BIM workflow	0.844
5	Lack of BIM experience	0.831

Discussion

This section examines the findings based on the key barriers impacting poor implementation of BIM among civil and structural engineering (C&S) consultants in Malaysia. The collected thirty (30) samples achieved the objective of the research which is to obtain feedback from civil and structural engineering consultant respondents. As for demographic background, the highest number of respondents were senior C&S engineers with degree qualifications based in Selangor. This represents that the data is reliable to be analysed as a pilot project because the majority of the respondents are from a developed state which has high level of construction developments for a good BIM exposure. This can be proven by the results of the reliability test conducted on twenty (20) BIM barriers factors which obtained a high Cronbach's Alpha result of 0.91, above the minimum of 0.7.

One of the significant findings of this study is the BIM implementation among the civil and structural engineering consultants in Malaysia are still in a very low level even though the respondents have years of experience in C&S design, as shown in Table 7 and Table 8. Most of the respondents who represents their organisations, are minimally used BIM and the team are not practicing its concept. This results in a delay in the diffusion of BIM implementation.
The benefits of BIM have influenced the construction sector to include BIM into construction projects. The primary purpose of BIM implementation in construction is to enhance productivity and efficiency. However, the three most crucial barriers that were found are significantly affect the implementation of BIM among the C&S engineering consultants. Table 1 shows the three highest ranking of BIM barrier based on mean value which is B10:4.2 (Lack of BIM best practice) followed by B5:4.1 (High cost on CAPEX), B18:4.1 (Lack of BIM experience) and B11:4.07 (No BIM workflow), B17:4.07 (Lack of BIM knowledge), B20:4.07 (Lack of BIM Training). Meanwhile, based on the factor analysis test in Table 4, there are 5 barriers group namely process, knowledge, policy, cost and technology has been identified. The barriers identified by the respondents aligned with findings from prior research by Roslan et al. (2019) and Yaakob et al. (2016). These studies categorized the elements that impede the adoption of Building Information Modelling (BIM) in the Malaysian construction industry into four overarching groups: i) People, ii) Technology, iii) Process, and iv) Policy.

Table 6 which represents the ranking of BIM barriers based on loaded factor addressed the first five most common BIM barriers factors: lack of BIM standard, interoperability data exchange, lack of BIM best practice, no BIM workflow and lack of BIM experience. Due to these findings, three of these BIM barriers factors were identified under the ‘BIM process’ (Group 1) from Table 4, which proven the significance of BIM process as one of the major influences in the BIM implementation for C&S engineering consultants. Although this study focuses on the C&S engineering consultant discipline, the finding aligns with the study by Idris et al. (2021), who reported that the BIM process is the main component that causes the slowness of

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BIM implementation in Malaysia. This circumstance is likely a negative perception for the C&S engineering consultants, as it causes the assumption that BIM C&S design work is prone to delays due to a lack of experience in executing BIM in the project, thus declining to implement BIM. The survey responses also proved that BIM process significantly influences the BIM implementation for C&S engineering consultants in Malaysia, revealing that 76% have agreed with the statement, as shown in Figure 10. Furthermore, 94% of the respondents agreed that having a proper process guideline for C&S engineering consultants can help to implement BIM, compared to 3% moderate and 3% is not agreed. Hence, there emerges a clear necessity to establish standardized BIM processes and adoption guidelines tailored for the Malaysian context, as emphasized by Azhar (2011).

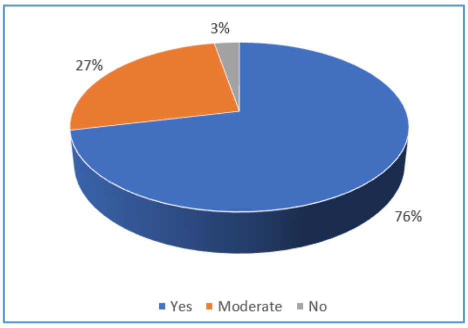

Figure 10. The Significant BIM Process in BIM Implementation

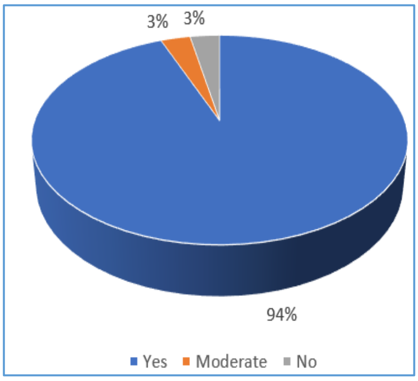

Figure 11. Requirement of Proper Process in BIM Implementation

Conclusion

BIM is considered a catalyst for innovation in the construction industry. Based on the pilot study data, there is obvious and strong evidence that the BIM process is one of the significant barriers among C&S engineering consultants in using BIM. Therefore, organizations such as C&S engineering consultants should understand the effective process for implementing BIM projects. Consequently, with 321 targeted C&S engineering consultants registered with BEM, it is reasonable to continue this investigation with a larger sample. Future research can help to develop a BIM process and framework, particularly for C&S engineering consultants, to use BIM as a source of reference in the organization's existing work process without relying on the services of external modelling businesses in the future. C&S engineering consultant as an important engineering consultant in the construction process shall find solutions to overcome the BIM obstacles, particularly the BIM process, which therefore enhances the country's course towards IR4.0. Various studies show that BIM has been implemented in a fragmented environment to produce models whereas BIM implementation in construction is still

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 6 Issue 17 (June 2024) PP. 246-265
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inefficient. Therefore, in this study, it is recommended that intensive workshops to promote BIM should illustrate the process of the BIM implementation rather than only promoting BIM awareness and the implementation benefits. The opinions of expert personnel on BIM implementation and its benefits shall be discussed and recommendations shall be taken into consideration accordingly. A few case studies illustrating the whole system process and its usefulness in improving work environment are essential to build concrete confidence for adoption. As a matter of fact, professionals are facing difficulties practicing the technology and improving technical and implementation skills. This research recommended civil and structural engineering consultants to initiate the adoption of BIM and encourage professionals to develop their skills in BIM implementation. This pilot study aimed to investigate barriers to improve Building Information Modelling (BIM) implementation among civil and structural consultants for government projects in the Malaysian construction industry. It addressed the limited adoption of BIM despite its potential benefits and government initiatives for technology digitalization. A quantitative research design utilized a non-probability convenient sampling method with 30 registered consultants from the Board of Engineers Malaysia. Data collection involved a questionnaire survey with a 5-point Likert scale while the statistical analyses, including factor analysis in SPSS IBM to identify the key factors impacting weak BIM adoption. The findings of this study shed light on the barriers to BIM implementation among civil and structural consultants in the Malaysian construction industry. The identified barriers were categorized into five groups: process, knowledge and experience, policy, cost, and technology. The study revealed challenges in establishing efficient BIM processes, acquiring sufficient knowledge and experience, implementing supportive policies, managing costs, and addressing technological issues.

Limitations and Recommendations

This study has a few limitations. It is also important to highlight that this finding only represents the level of BIM implementation in the last quarter of 2022 when the data were collected. First is the small sample size that limits the generalizability of the findings to the entire population of civil and structural consultants in Malaysia. Second, the study focused on government projects, and the barriers identified may differ in other sectors or project types. Third, the study is based only on self-reported data from questionnaire surveys, which may be subject to respondent and social desirability biases. Finally, the study did not explore the specific strategies or interventions that can be implemented to overcome the identified barriers. Thus, several recommendations for future research and the main study can be made: (i) A larger-scale study can be conducted with a more representative sample that would provide a more comprehensive understanding of the barriers to BIM implementation. (ii) Exploring the barriers and strategies in different sectors and project types would offer a broader perspective on BIM adoption challenges. (iii) Future research could explore into the specific interventions and strategies that can be implemented to address the identified barriers. In addition, qualitative research methods such as interviews or case studies could provide deeper insights into the experiences and perspectives of civil and structural consultants regarding BIM implementation. (iv) Investigating the long-term impact and outcomes of successful BIM adoption, including its effects on project performance, productivity, and sustainability, further contributes to the body of knowledge in this area.

Acknowledgement

I would like to express my sincere gratitude to everyone who has contributed to the completion of this work. First and foremost, I would like to thank my main supervisor and co supervisor,

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DOI 10.35631/IJIREV.617019
Prof. Dr. Ir. Che Maznah Mat Isa, Dr. Siti Hamidah Abdull Rahman respectively for their invaluable guidance, support, and encouragement throughout this project. Their expertise and insights have been instrumental in shaping this research. I am also grateful to my colleagues and friends, whose support and constructive feedback have been crucial in refining my ideas and improving the quality of this work. Special thanks to Dr. Salmaliza Salleh for her constant motivation and assistance during challenging times. I extend my appreciation to the participants and industry professionals who provided their time and valuable insights, contributing significantly to the depth of this study.

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