SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Progress and Prospects: Building Information Modelling (BIM) in Malaysia's Construction Industry

Mohd Mawardi Mohd Kamal[1], Normadiana Mohammad Hanapi[1,*], Awang Nasrizal Awang Ali[2]

[1] Civil Engineering Studies, College of Engineering Universiti Teknologi MARA, Pahang, Malaysia
[2] Civil Engineering Studies, College of Engineering Universiti Teknologi MARA, Sarawak, Malaysia

ARTICLE INFO

Article history:
Received 5 April 2026
Received in revised form 25 May 2026
Accepted 5 July 2026
Available online 18 July 2026

Keywords:
Building Information Modelling (BIM); Construction Safety; Technology Adoption; Malaysian Construction Industry; Risk Management

ABSTRACT

Building Information Modelling (BIM) is a combined approach of technologies and processes that revolutionizes how buildings are designed, constructed, and managed virtually, enhancing collaboration. As the leading digital tool in construction, BIM is critical in improving workplace safety by identifying hazards and risks, thus elevating project safety standards. The study investigates the influence of BIM on safety and health in Malaysia's construction sector, focusing on its adoption by local firms and identifying specific health and safety issues related to its use. Data from the Department of Safety and Health (DOSH) and interviews with industry professionals informed our analysis. A quantitative methodology was adopted to pursue empirical investigation, wherein surveys were disseminated among contractors, consultants, and project managers. Data analyzed using SPSS revealed a significant increase in BIM usage in Malaysia's construction industry, rising from 13% to 48% among public and private sector respondents. This highlights a growing appreciation for BIM's benefits in construction. BIM is a crucial risk management tool in construction, notably reducing fatal accidents by enabling spatial clash detection, hazard anticipation, and implementing fall protection strategies. It also offers detailed parametric data for a building's entire lifecycle. Despite its effectiveness in large projects, BIM still faces challenges in broader adoption. High operational costs and time investment deter its implementation. Small to medium-sized enterprises often overlook BIM's long-term benefits, perceiving it as a cost rather than an asset. Barriers also include a lack of expertise, awareness, and stakeholder collaboration.

1. Introduction

Building Information Modelling (BIM) is a collaborative process that combines design and management, involving various construction professionals to create a unified 3D model. Its capacity to reduce costs and time while boosting productivity has led to its growing adoption [1 The Director of Malaysia's Public Works Department originally advocated using BIM in 2007, recognising its benefits for cost savings and averting design flaws during planning. BIM improves collaboration among industry specialists such as architects, engineers, and contractors, allowing for more efficient

* *Corresponding author.*
E-mail address: normadiana@uitm.edu.my

https://doi.org/10.37934/araset.61.5.161173

problem-solving in construction projects.Health and safety (H&S) are paramount in construction, an industry known for its hazardous nature due to complex onsite activities [2]. BIM extends beyond design and management as a safety tool for hazard identification and planning in the preconstruction phase [3]. It facilitates the virtual construction of buildings, reducing ambiguities and enhancing safety through risk modeling and assessment. BIM's uses include worker safety training, design for safety, accident analysis, and maintenance safety management [4].

This study examines BIM's development, global application, and implementation in Malaysia, focusing on its role in improving construction safety. Its primary objective is to assess BIM's integration within Malaysian construction companies and explore its advantages for the country's construction sector.

2. Literature Review

2.1 Background of BIM

Header Building Information Modelling (BIM) is an integrated process involving consistent and accurate information management from a project's design stage to its operation [5]. BIM transcends traditional contractor use, benefiting architects and civil engineers [6]. Azhar et al. [7] describe BIM as a multifaceted platform for n-D modeling, improving communication and collaboration in the Architecture, Engineering, and Construction (AEC) industry. It spans from 3D modeling to scheduling, costing, and facility management, integrating technology with operational processes and significantly transforming the industry. The national BIM standard defines it as a digital representation encompassing an object's physical and functional characteristics. It is a reliable decision-making resource throughout a project's life cycle, from inception to demolition [8]. BIM's usage and interpretation vary across users and organizations, reflecting its flexibility in different project phases, including preconstruction, construction, and post-construction [9].

2.2 Implementation of BIM in International Developing Countries

Architectural design practices remained relatively static until the mid-nineteenth century, with engineers relying on conventional methods [10]. BIM has revolutionized construction practices, gaining widespread adoption globally in developed and developing nations. A McGraw Hill Construction study also highlights BIM's rapid global expansion [11].

BIM implementation varies in depth and function across projects, represented by levels ranging from 0 to 6, each indicating a different degree of maturity and data integration [12]. Originating in the 1990s, BIM has become integral to industrialized nations' AEC sectors. Since implementing the National BIM Policy Programme in the 1990s, the United States has been at the forefront, particularly at level 3 of BIM usage. Following suit, the United Kingdom (UK) mandated joint 3D BIM for projects by 2016 and aspired for level 2 BIM implementation under its Digital Built Britain initiative.

Finland's HUT-600 project in 2002 pioneered integrated BIM projects. Since 2016, Australia has mandated BIM for government-supported projects, guided by the Department of Planning, Transport, and Infrastructure. Singapore's Building and Construction Authority initiated the Corenet project in 1990, though its advancement was slower than expected. Conversely, Hong Kong is in the growing stages of BIM adoption, with the Hong Kong Institute of Building Information Modelling (HKIBIM) established in 2009 [13].

2.3 Implementation of BIM Adoption in the Malaysian Construction Industry

The National Building Specification (NBS) was surveyed to assess the implementation of Building Information Modelling (BIM) in the United Kingdom, Malaysia, Canada, Japan, and Denmark. The survey revealed that the utilization of BIM varied among these countries, with Denmark exhibiting the most extensive implementation rate [14]. The rising demand for large-scale projects, municipalities' transition to digital platforms, government incentives that support BIM, and standards set by semi-government organizations are just a few factors driving Denmark's BIM business growth [16]. Figure 1 shows the level of Malaysia's BIM implementation compared to the global BIM implementation in 2016.

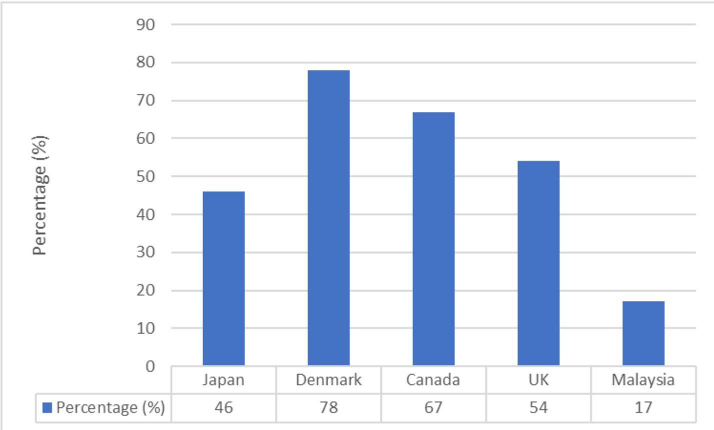

Fig. 1. Malaysia's BIM adoption compared to some other countries

Figure 2 showcases the comparative BIM adoption rates in Malaysia and the UK. The UK leads with a higher % adoption rate at 69%, compared to Malaysia's 49% [15]. This disparity is attributed to the UK's early BIM adoption and its 2016 mandate for BIM implementation. The UK's global leadership in BIM usage, service delivery, and standard development further consolidates its position [16]. In Malaysia, a notable awareness of BIM within the construction industry indicates a widespread familiarity with its applications. As reflected in the latest data compared to the BIM Report 2016, the growth in Malaysia's BIM adoption rate highlights the evolving landscape and potential for BIM's future expansion within the Malaysian construction industry.

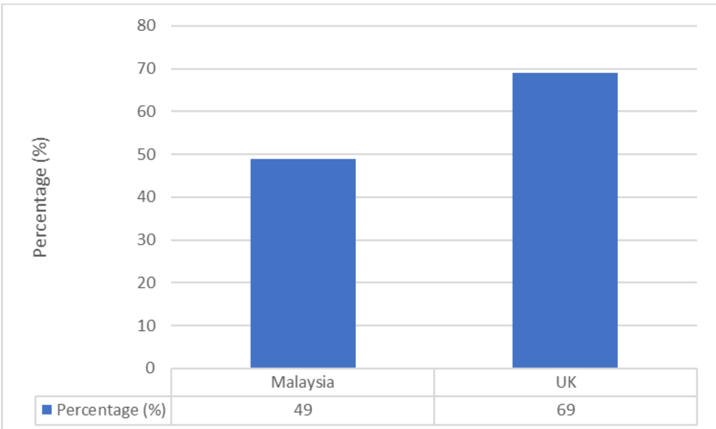

Fig. 2. Analysis of BIM Implementation in Malaysia and the UK in 2019

2.4 BIM for Construction Safety Planning

The construction sector is notably afflicted with workplace accidents, often leading to severe injuries and high fatality rates [17]. This issue is starkly highlighted compared to other industries, such as manufacturing [18]. Figure 3 shows that in the past five years, approximately 1,129 Malaysian construction workers have suffered fatal or severe injuries on the job. As reported, this equates to an average of one fatality every two working days in the construction industry [18], based on statistics from the Department of Safety and Health (DOSH), Malaysia. Despite increased attention to safety management, the construction industry continues to see a worrying rise in fatal accidents, outpacing other sectors, as shown in Figure 4. This trend highlights the industry's need for adequate safety measures and interventions.

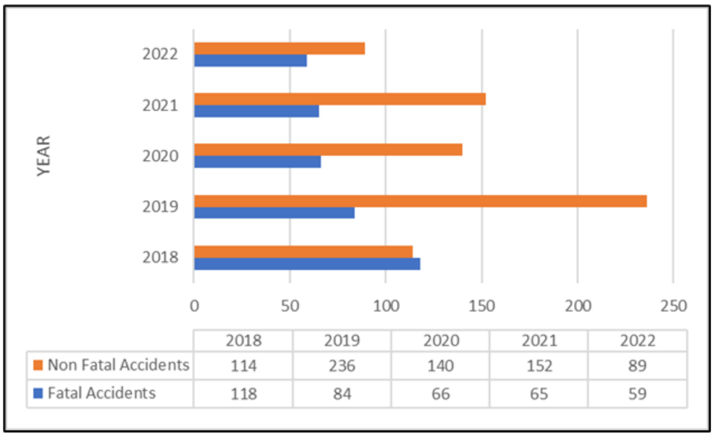

Fig. 3. The data on both fatal and non-fatal incidents in the Malaysian construction industry spans the years 2018 to 2022

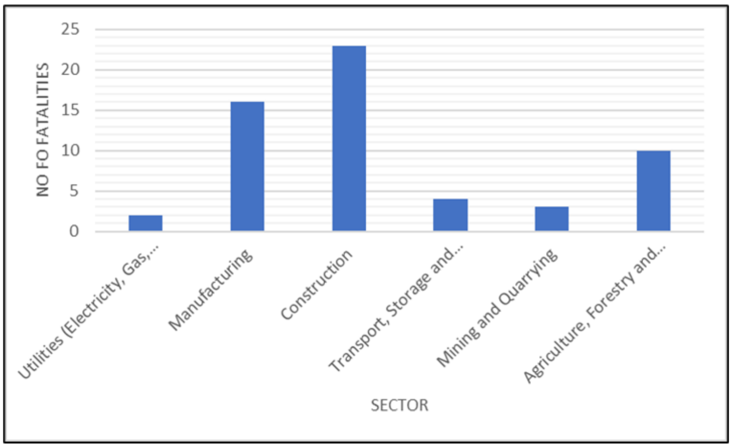

Fig. 4. Fatal accident count by sector in Malaysia (January-May 2023)

The analysis of Malaysia's building industry accident statistics reveals a high and persistent rate of incidents, highlighting an urgent need to revise safety protocols in construction. Construction safety performance is influenced by factors like workforce, skill shortages, limited experience, resource availability, safety attitudes, and project size, value, budget, and schedule constraints [19]. Poor work planning, inadequate equipment, insufficient training, ineffective communication, and lack of leadership impede safety effectiveness [20].

Challenges in safety measures are often due to poor coordination among designers, engineers, and safety coordinators [21]. Workers and managers may lack safety awareness, leading to accidents and economic losses [19]. This calls for innovative solutions to address these safety concerns in the construction sector.

BIM acts as a pivotal tool for improving H&S practices in construction. It enables better understanding and mitigation of site accidents, enhancing safety planning and hazard identification. BIM is essential for detecting construction-related physical and spatial conflicts [22]. Four-dimensional (4-D) BIM aids in visualizing, analyzing, and mitigating project hazards throughout the construction lifecycle [21]. Integrating BIM with laser scanning can identify risks like falls and cave-ins, creating detailed site models [23].

Zhang et al. [24] conducted a study to create an automated BIM system that can identify potential fall hazards at construction sites based on the construction schedule. The system aims to assist in labor-intensive modeling and planning tasks related to fall prevention and enhance workers' safety awareness by visually representing the potential hazards. After modeling the fall protection railing component, the railings will be mounted on the structure using a BIM model [25]. The researchers could see various falling risks or hazards throughout the 3D view that were not visible while performing the entire process utilizing the manual 2D plan view [26]. Meanwhile, the 4-D offers the project contractor and all site practitioners complete and better data on where and when the railings will be removed or installed during the development [25]. Figure 5 shows safety railings along the borders of cast-in-place slabs and guardrail posts placed in pre-designed holes.

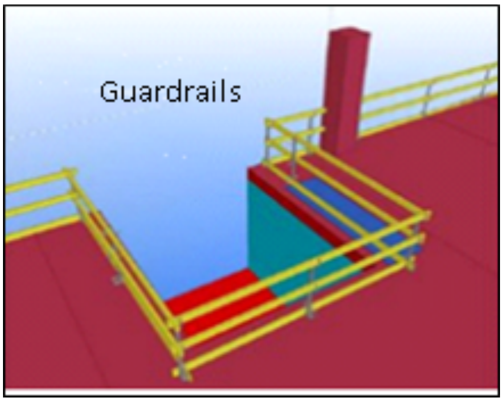

Fig. 5. An example of fall protection planning in BIM

In addition, scaffolding accidents among construction workers also contribute to the highest rate of fatal accidents [27]. Scaffolding systems, formwork, and shoring systems are examples of temporary structures that aid in installing bulk materials. BIM's automated safety verification and risk management capabilities are instrumental. It is a base for BIM-related technologies and risk analysis during project development [28].

Kim and Teizer [29] devised a rule-based system that autonomously designs scaffolding systems for proactive management in BIM. A regulation was formulated based on the existing procedure for developing and implementing scaffolding systems. The suggested computational methods autonomously identify both geometric and non-geometric characteristics in building models and generate a design for a scaffolding system that can be utilized by a practitioner onsite. The system initiated a comprehensive analysis to accurately determine the areas that require scaffolding and produced the relevant scaffolding design using BIM. BIM can also function as a rule-checking software tool during planning and design, optimizing safety and design [28]. By incorporating data on hazardous materials, BIM models enable scenario visualisation, aid designers in decision-making and methodology selection and provide safety enhancements for construction tools [30].

3. Methodology

This research assesses the utilisation of BIM in Malaysia and its benefits for construction health and safety. The methodology involved a literature review, a survey questionnaire, and validation through semi-structured interviews. The literature review, conducted online, explored global BIM deployment using various sources, including journals, international conferences, and government publications, focusing on McGraw Hill Construction's 2014 BIM reports [31]. Primary data was collected via a modified questionnaire distributed to construction experts through an online Google Form. The study employed convenience sampling, as suggested by Rowley [32], due to the diverse and widespread backgrounds of construction workers. This approach was chosen for its suitability in reaching respondents across various regions. Potential respondents, including contractors, consultants, and project managers, were identified using the Construction Industry Development Board (CIDB) database.

Out of the 300 questionnaires distributed, 168 responses were received, yielding a 56% response rate. This sample size, well above the minimum of 30 for statistical analysis [33], is considered adequate for drawing statistical inferences. Odeyinka et al. [34] state that a 20–30% response rate is typically sufficient in construction industry surveys. Data analysis was conducted using SPSS 29 software, employing descriptive statistics such as mean score, percentage, frequency, and correlation.

4. Result and Discussion

4.1 Respondent Profile

Table 1, using frequency distribution, presents the demographics of the survey participants from the Malaysian construction industry, including quantity surveyors, architects, and project managers, among others. The majority of respondents were contractors (48%), followed by architects (24%), civil and structural engineers (15%), and others (13%). This variety in professions ensures diverse perspectives on BIM adoption within the industry.

Table 1
Demographic Profile of Survey Respondents

Item	Respondents	Percentage (%)
Gender	Male	54%
	Female	46%
	Total	100%
Age	25-30 years	20%
	31-35 years	24%
	36-39 years	31%
	>40 years	25%
	Total	100%
Education Qualification	Master's Degree	21%
	Bachelor's degree	60%
	Diploma	19%
	Total	100%

Table 1 (*contined*)
Demographic Profile of Survey Respondents

Item	Respondents	Percentage (%)
Work Experience	<5 years	12%
	6-10 years	32%
	11-15 years	29%
	>15 years	27%
	Total	100%
Designation	Architect	24%
	Contractor	48%
	C & S Engineer	15%
	Others	13%
	Total	100%

Regarding experience, 12% of respondents had less than five years in the construction industry, while 88% had over five years of experience. This indicates that most responses were from seasoned professionals, likely providing depth and practical insights. Educational qualifications of respondents varied, with 19% holding diplomas, 21% with master's degrees, and the majority (60%) possessing bachelor's degrees, reflecting substantial academic backgrounds. The predominant age group was 31 to 39 years (55%), suggesting that most respondents had considerable life and professional experience, likely contributing to richer insights into the building industry.

4.2 Classification of Respondent's Sector

This study categorised respondents based on their sector affiliation, revealing that 60% were from the private sector, while 40% represented the public sector. The higher private sector participation might be influenced by the Malaysian government's mandate for BIM implementation in general construction projects with budgets over RM100 million [35]. This directive likely sparked increased interest in BIM among private sector professionals, especially following the CIDB's recommendation to mandate BIM in specific personal projects by 2020 [36].

BIM is increasingly vital in Malaysia for managing complex and high-risk construction projects [37]. However, challenges exist, particularly among local contractors in Grade 1 (G1) to Grade 6 (G6) classification, due to limited IT adoption and the financial costs associated with acquiring BIM tools and training [38]. To mitigate these challenges, the Malaysian government has introduced a grant program under Multimedia Super Corridor (MSC) Malaysia, offering to fund for BIM training to undergraduates, organizations, and individuals [39].

4.3 Awareness of the BIM Process's Implementation

For top management in construction, understanding the installation and processing of BIM is critical for making informed decisions on adopting BIM technologies in projects. While BIM implementation is complex, requiring information from diverse sources, comprehending the process can facilitate overcoming these challenges. This study evaluated participants' knowledge of the BIM implementation process, revealing that many are familiar. However, the proportion of professionals with a high understanding of technology applications and processes is still lower than expected, with an overall awareness level of 88%.

The study also explored respondents' awareness of BIM concerning the Construction Industry Transformation Programme (CITP). Findings show that awareness of BIM within CITP has increased from 33% to 66%, indicating that a majority are informed about CITP's BIM initiatives. The increasing awareness of BIM in Malaysia indicates its growing importance in advancing the construction sector. This trend suggests a future with more widespread implementation of BIM standards [15].

4.4 BIM Adoption in the Malaysian Construction Industry

The integration of BIM in Malaysian construction is significantly influenced by an organization's readiness to incorporate technology. Figure 6, illustrating BIM adoption rates, indicates a relatively low implementation level in the private and public sectors. This low uptake is attributed to a lack of understanding, cost concerns, awareness issues, and resistance to shifting from traditional practices.

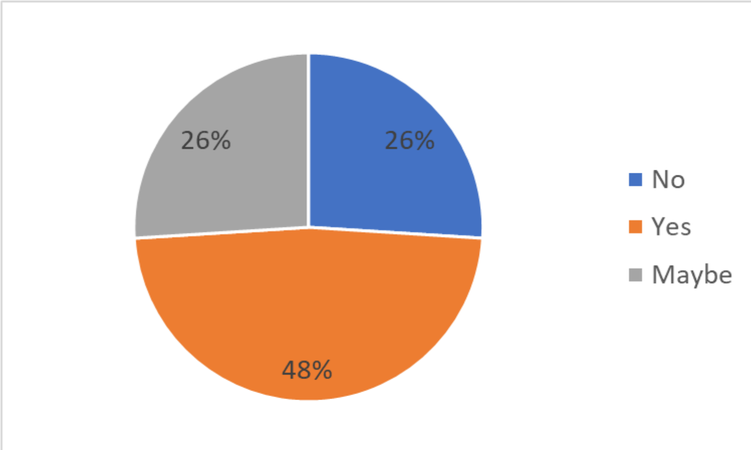

Fig. 6. Application of BIM in organizations

Policy-related challenges further complicate BIM implementation. A significant hurdle is the absence of clear policies for BIM deployment, leading to its slow and ineffective adoption. Latiffi et al. [39] highlight the confusion caused by personal BIM guidelines created by industry participants, contributing to a fragmented approach since 2013. Previous surveys corroborate that BIM adoption remains minimal due to these persistent issues [36, 38]. Additionally, around 26% of respondents from both sectors are unaware of their organizations' BIM usage, reflecting a general lack of understanding about the technology.

4.5 Frequency of BIM Application in Organisations

Figure 7 presents the frequency of BIM application in respondents' organizations, categorized as never, rarely, sometimes, often, and always. The data shows that 22% of participants have never used BIM in their construction projects, while 18% used it rarely. Notably, the cumulative percentage of respondents using BIM sometimes, often, and always is 60%, suggesting a significant level of engagement with BIM technology in the Malaysian construction industry.

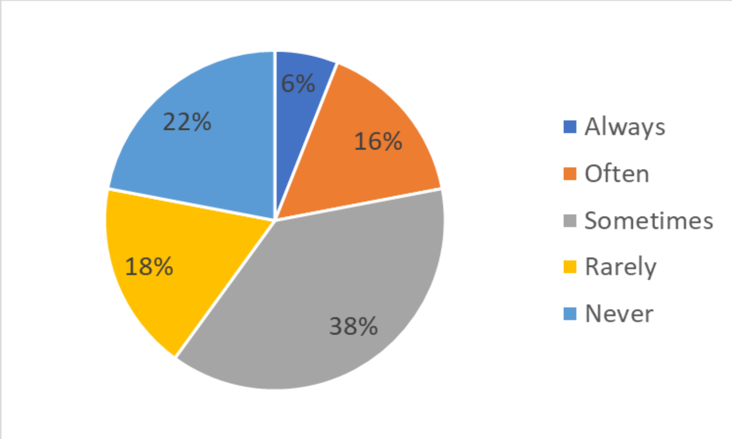

Fig. 6. Frequency of BIM application in organizations

This usage level indicates a growing implementation of BIM, with practical application as key to overcoming implementation challenges and understanding the technology's optimal use. It is recommended that construction organizations begin adapting to BIM and encourage regular use among their teams. Such practice will facilitate the integration of BIM into their operational frameworks. The statistic reflects an increasing recognition of BIM's value and significance in construction projects.

4.6 Benefits of BIM in the Construction Industry

Adopting BIM brings diverse benefits across the construction lifecycle, varying with different roles and project goals. Respondents rated potential BIM benefits, with the findings organized in Table 2 by mean scores. The primary benefit identified is effective cost planning in the design phase (mean score of 4.00), followed by better trade coordination to prevent rework (mean score of 3.68) and minimization of construction phase changes (mean score of 3.58). Additionally, BIM was recognized for enhancing onsite collaboration and communication (fourth-ranked, mean score 3.46), improving construction safety (fifth-ranked, mean score 3.38), and reducing project lifecycle duration to avoid delays (sixth-ranked, mean score 3.26).

Table 2
Benefits of BIM in the Construction Industry

No	Benefits	Mean	Ranking
B1	The planning stage allows for more effective construction cost estimation.	4.00	1
B2	BIM allows you to coordinate trade and subcontractors better, detecting any MEP, internal or external clashes before construction begins	3.68	2
B3	Visualize the project in preconstruction. Gaining a comprehensive perspective from the outset reduces the need for costly and time-consuming modifications in the future.	3.58	3
B4	Improve onsite collaboration and communication.	3.46	4
B5	BIM can make buildings safer by finding hazards before they become problems and planning and visualizing how things will work on the job site.	3.38	5
B6	BIM allows design and documentation to be done at the same time. As a result, BIM saves time by shortening project cycles and avoiding construction schedule delays	3.26	6

Interviews further validate BIM's role in boosting productivity, efficiency, cost-effectiveness, and time saving and enhancing safety and management in the construction sector. The trainer highlighted the ongoing expansion and improvement of BIM applications across the construction industry. However, there is a perceived gap in evidence or comprehensive case studies supporting BIM's cost and time-saving benefits across all project stages. The interviewee highlighted the significance of showcasing the advantages of BIM, such as heightened productivity, efficiency, cost and time reductions, and excellent safety and management, to promote wider acceptance within the construction sector. An alternate strategy might involve implementing a mandate that necessitates the use of Building Information Modelling (BIM), ensuring its thorough execution. This approach would provide a more complete understanding of the project from the outset, thereby reducing the need for costly and time-consuming modifications in the future.

4.7 Implementing BIM to Improve Safety Performance

This section examines the impact of BIM on improving H&S in construction, analyzing the key factors that influence its effective implementation. The validity and correlation of the data are presented in Table 3.

Table 3
Correlation Summary

Factors to implement BIM	Correlation Coefficient, r	Correlation Strength
Construction has an inadequate safety record compared to other industries	0.587	Strong
Sharing safety knowledge is challenging with only safety regulations	0.511	Strong
Contractors are often entirely responsible for construction site safety	0.541	Strong
Factors affecting occupational safety include project delivery technique, work system, and size of the construction site	0.653	Strong
By examining safety history, traditional safety analysis estimates risk scenarios and adjusts schedules	0.471	Medium
Poor work planning, equipment, miscommunication, training, and leadership can all impact health and safety.	0.529	Strong
Accidents result from human behavior, the site environment, and poor safety management	0.539	Strong
Safety is affected by skilled labor, resources, experience, safety attitudes, project size, time, and money.	0.513	Strong
BIM manages onsite design and safety and controls the ideal timeline	0.569	Strong
BIM authoring tools use VR for virtual danger assessment, professional training, and safety design.	0.560	Strong
BIM automatically creates temporary structures and assesses their safety	0.472	Medium

Table 3 shows that the p-value for all factors is less than 0.001, well below the standard significance level of 0.05. This indicates a strong relationship between all the factors examined. However, some factors displayed Pearson correlation values ranging from 0.31 to 0.50, denoting a moderate correlation. Despite this, the overall correlation results are considered positive and indicate significant relationships. The top three factors identified for the effective implementation of Building Information Modelling (BIM) in construction to enhance safety performance are related to occupational safety. These include the project delivery method, the work system, and the size of the construction site, collectively scoring 0.653 in importance. Most respondents agreed that the project delivery technique and the project's complexity not only affected the quality of the project but also led to safety. For instance, adopting BIM in construction projects can assist in clash detection. BIM modeling allows for the simple and successful creation of complicated designs and arrangements and the education of project participants on various project difficulties. For safety reasons, construction workers must be aware of the real things and safety threats around them. In addition, Augmented Reality (AR) technologies help them achieve this understanding effectively. Most respondents agreed that construction has an inadequate safety record compared to other industries(0.587). Implementing a 3D BIM model enhances construction safety by enabling more detailed safety planning, offering more apparent site layouts, and visualizing updated plans and site information. The third reason BIM can be considered a tool to enhance health and safety is that it manages onsite design and safety and controls the ideal timeline(0.569). The 3D BIM model enables safety specialists to identify potential hazards and devise appropriate mitigation strategies effectively.

5. Conclusions

This research assessed the adoption of Building Information Modelling (BIM) in Malaysia's construction industry. Collaborating with the Construction Industry Development Board (CIDB), the initiative aims to raise BIM awareness and encourage its use. The survey indicated that 48% of participants from both public and private sectors are utilizing BIM in their organizations. A notable finding is that 22% of participants have never used BIM, while 18% have used it rarely. However, 60% of respondents reported using BIM at least sometimes, indicating a positive trend.

The frequency of using BIM directly influences the development of skills and team knowledge. Applying BIM leads to more effective implementation, while sporadic use limits its benefits. The study suggests that merely offering training or seminars is insufficient; practical application is crucial. The study also found that 26% of participants were unsure if their organizations use BIM, highlighting a gap in awareness and understanding.

To foster quicker adoption, the study recommends practical workshops demonstrating BIM's real-world application rather than just discussing its theoretical advantages. The study concludes that for BIM to be effectively integrated into organizational practices, theoretical knowledge and hands-on experience are essential. However, the study faced limitations due to its online survey method, leading to a lower-than-expected response rate. Future studies could delve deeper into how BIM's advantages influence organizational decisions to adopt it, potentially adopting a broader methodology for data collection.

Acknowledgment

Thank you to those who have assisted in completing this study, especially the directly or indirectly involved respondents.

References

[1] Bui N, Merschbrock C and Munkvold BE, "A Review of Building Information Modelling for Construction in Developing Countries" Procedia Eng, 164, 2006, 487–94, 1847

[2] Alaloul, W.S.; Saad, S.; Qureshi, A.H. Construction Sector: IR 4.0 Applications. In Handbook of Smart Materials, Technologies, and Devices; Springer International Publishing: Cham, Switzerland, 2021; pp. 1–50. ISBN 9783030586751.

[3] Y. D. Mohammed & M. B. Ishak. (2013). A study of fatal and non-fatal accidents in construction sector.Malaysian Journal of Civil Engineering, 25(1), 106-118.

[4] J. A. Gambatese, J. W. Hinze, & C. T. Haas. (1997). Tool to design for construction worker safety. Journal of Architectural Engineering, 3(1), 32-41.

[5] Associated General Contractors of America, "The Contractor's Guide to BIM" AGC Research Foundation, 2005

[6] A. N. Boukara and A. Brief, "Introduction to Building Information Modeling", 2015

[7] Azhar S, Khalfan and M, Maqsood T, "Building Information Modeling (BIM): Now and Beyond" Australas. J. Constr. Econ. Build,12(4):15–28, 2012

[8] NBIMS, National BIM Standard - United States, Version 3-Scope, 1–5,2015.[Online]. Available: https://www.nationalbimstandard.org/

[9] Furneaux, C. and Kivit, R. BIM: Implications for Government. CRC for Construction Innovation. Brisbane Australia. Net Pty Ltd., pp. 10-31, 2008

[10] H. Yan and P. Damian, "Benefits and barriers of building information modeling", The 12th International Conference on Computing in Civil and Building Engineering, 2008

[11] McGraw Hill Construction, The business value of BIM for construction in major global markets, 2014

[12] Asc Technology: BIM Levels (BIM Level 0-6) & Level of Development. Retrieved August 9, 2023. [Online]. Available:LinkedIn,https://www.linkedin.com/redir/redirect?url=http%3A%2F%2Fwww.asctechno.com&url hash=NcyL&trk=about_website

[13] K. D. Andy, K, W. Wong Francis and N. Wong Abid," Architectural Engineering and Design Management" 6, 288–302, 2010

[14] NBS. NBS International BIM Report. Retrieved 2016. [Online]. Available: https://www.thenbs.com/knowledge/nbs -international-bim-report-2016

[15] National BIM Report 2019. National BIM Report. The Definitive Industry Update, 1–28. Retrieved 2019. [Online]. Available: https://doi.org/10.1017/CBO9781107415324.004

[16] Paul, S. BIM adoption around the world: how good are we? 2018 Retrieved May 6, 2020. [Online]. Available : https://www.geospatial world.net/article/bim-adoption-around-the-world-how-good-are-we/

[17] A. P. Chan et al. (2008). Work at height fatalities in the repair, maintenance, alteration, and addition works. Journal of Construction Engineering and Management,134(7), 527-535.

[18] M. O. H. R. Department of Occupational Safety and Health (DOSH), Malaysia. (2019). Department of occupational safety and health (DOSH), Malaysia. Ministry of Human Resources, Malaysia.

[19] Pham, K.-T.; Vu, D.-N.; Hong, P.; Park, C. 4D-BIM-based workspace planning for temporary safety facilities in construction. Int. J. Environ. Res. Public Health 2020, 17, 3403

[20] Cortés-Pérez, J.P.; Cortés-Pérez, A.; Prieto-Muriel, P. BIM-integrated management of occupational hazards in building construction and maintenance. Autom. Constr. 2020, 113, 103115

[21] Rodrigues, F.; Baptista, J.S.; Pinto, D. BIM Approach in Construction Safety—A Case Study on Preventing Falls from Height. Buildings 2022, 12, 73.

[22] Lu, Y.; Gong, P.; Tang, Y.; Sun, S.; Li, Q. BIM-integrated construction safety risk assessment at the design stage of building projects. Autom. Constr. 2021, 124, 103553

[23] Mihĭ c, M.; Vukomanovĭ c, M.; Završki, I. Review of previous applications of innovative information technologies in construction health and safety. Organ. Technol. Manag. Constr. Int. J. 2019, 11, 1952–1967

[24] Zhang, S., Sulankivi, K., Kiviniemi, M., Romo, I., Eastman, C.M., & Teizer, J. 2015. BIM-based fall hazard identification and prevention in construction safety planning. Safety Science, 72, 31-45.

[25] Zhang, S., Sulankivi K., Kiviniemi M., Romo I., Eastman C., and Teizer J., (2015). "BIM-based fall hazard identification and prevention in construction safety planning." Safety Science, Vol.72, pp. 31-45.

[26] Azhar, S., Behringer, A., Sattineni, A., and Maqsood, T. (2012). "BIM for Facilitating Construction Safety Planning and Management at Jobsites." CIB W099 International Conference on Modelling and Building Health and Safety. Singapore.

[27] Hoła A., Sawicki M., & Szóstak M. (2018). Methodology of Classifying the Causes of Occupational Accidents Involving Construction Scaffolding Using Pareto-Lorenz Analysis. Applied Sciences, 8(48), 1-11.

[28] Zou, Y.; Kiviniemi, A.; Jones, S.W. A review of risk management through BIM and BIM-related technologies. Saf. Sci. 2017, 97,88–98

[29] Kim, K., & Teizer, J. 2014. Automatic Design And Planning Of Scaffolding Systems Using Building Information Modeling. Advanced Engineering Informatics. 28(1): 6680.

[30] Ruikar, D. Using BIM to mitigate risks associated with health and safety in the construction and maintenance of infrastructure assets. WIT Trans. Ecol. Environ. 2016, 204, 873–884.

[31] McGraw Hill. 2014. The Business Value of BIM for Construction in Major Global Markets. SmartMarket Report. Retrieved 2014. [Online]. Available: http://static.autodesk.net/dc/content/dam/ autodesk/www/solutions/building-information-modeling/construction /business-value-of-bim-for-construction-in-global-markets.pdf

[32] Rowley. J, "Designing and using research questionnaires", Management Research, Vol. 37 No. 3, pp. 308-330, 2014
[33] Tennent.J, "The Economist Numbers Guide: The Essentials of Business Numeracy", Profile Books, London, 6 Ed
[34] Odeyinka, H.A, Lowe, J. and Kaka, A., "An evaluation of risk factors impacting construction cash flow forecast", Journal of Financial Management of Property and Construction, Vol. 13 No. 1, pp. 5-17, doi: 10.1108/13664380810882048, 2008
[35] PWD and CIDB, "BIM Execution Plan," 2018.
[36] Bernama, "CIDB recommends mandatory use of BIM in certain private sector projects," New Straits Times. Retrieved 2018 [Online]. Available: https://www.nst.com.my/news/nation/2019/03/470468/ cidb-recommends-mandatory-use-bimcertain-private-sector-projects.
[37] Jabatan Kerja Raya (JKR) . Laporan Tahunan JKR 2011, pp 28-29. Retrieved March 12, 2013.[Online]. Available:http://www. jkr.gov.my/var/files/File/dokumen/laporan_tahunan_jkr_2011.pdf
[38] Utusan Malaysia 2012. Projek IKN siap tiga bulan lebih awal. Retrieved March 12, 2013.[Online]. Available: http://www.kkr.gov. my/en/node/29133
[39] Latiffi. A, A. Mohd .S & Rakiman, "Product lifecycle management in the era of internet of things" revised selected papers. IFIP Advances in Information and Communication Technology Doha, Qatar, October 19-21, 467, 149–158, 2015