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Bridging Critical Risks and Digital Solutions: BIM Applications in IBS Projects

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KEYWORDS

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ABSTRACT

Industrialised Building System (IBS) is central to Malaysia's construction modernisation but still faces critical risks that hinder project success. Building Information Modelling (BIM) is promoted as a digital enabler, yet its systematic application in IBS risk management remains underexplored. This study uses a quantitative approach with 120 Grade 7 contractors in Kuala Lumpur to examine the relationship between critical IBS risks and BIM feature applications. Findings reveal that design, coordination, and technical risks are the most critical. BIM is widely applied for technical, operational, and design functions, but less in cost and safety domains. Correlation analysis confirms strong relationships, particularly between design risk and design-related BIM features ($r = 0.985$, $p < 0.001$). The study highlights the need for structured, risk-driven BIM frameworks to ensure resilient IBS implementation in Malaysia.

1. INTRODUCTION

Malaysia's construction industry is shifting towards sustainable and standardized methods(Jamalluddin et al., 2022). IBS offers efficiency and quality improvements, but projects are still vulnerable to risks such as design inconsistencies, technical errors, and coordination breakdowns (Feng et al., 2023; Nur-E-Alam et al., 2024). At the same time, BIM provides digital solutions for project planning, scheduling, and cost control, yet its role in systematically mitigating IBS-specific risks is not fully established(Bernabe et al., 2023). This research aims to:

1. Identify the most significant critical risks in IBS projects.
2. Examine the extent of BIM feature adoption in managing these risks.
3. Analyse the correlation between IBS risk domains and BIM applications.

2. METHODOLOGY

This study employed a quantitative descriptive-correlational design to examine the relationship between critical risks in IBS projects and BIM feature applications. Data were collected via a structured questionnaire distributed to Grade 7 contractors in Kuala Lumpur, identified from the CIDB MyBIM database (27 December 2024).

The questionnaire comprised three sections: (A) demographic information, (B) perceptions of IBS critical risks, and (C) BIM feature usage, measured on a five-point Likert scale. Content validity was confirmed by six experts (three academics, three BIM practitioners), and reliability was ensured with Cronbach's alpha values above 0.7.

Simple random sampling was applied to select respondents from 235 contractors, with 120 valid responses obtained through Google Forms. Data were analysed using descriptive statistics (mean, standard deviation) and Pearson correlation to explore relationships between risk categories and BIM strategies, with significance set at $p < 0.05$.

This methodology provides reliable, generalisable insights into BIM's role in IBS risk management in Malaysia.

3. RESULTS AND DISCUSSION

3.1 Respondent Demographics

The survey participants comprised a group of industry professionals with solid technical knowledge and relevant field experience. Base on Table 1, the gender distribution showed 67.5% male and 32.5% female respondents, which is in line with the overall trend of Malaysia's construction sector that is still largely male-dominated. Most respondents were in the 31–40 age bracket (50.0%), followed by 41–50 years (30.0%), reflecting a relatively mature sample with broad industry exposure.

From the perspective of academic qualifications, the majority of respondents had at least a bachelor's degree (69.17%), while 18.33% held a master's degree, and a small fraction (1.67%) possessed a doctorate. This educational attainment corresponds well with the technical requirements of the research, especially in relation to BIM utilisation and risk evaluation.

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Table 1 Demographic Profile of Respondent

	Frequency	Percentage
Gender		
Male	81	67.50
Female	39	32.50
Total	**120**	**100 %**
Age		
21-30	15	12.50
31-40	60	50.00
41-50	36	30.00
51 and above	9	7.50
Total	**120**	**100 %**
Highest Education qualification		
Certificate	0	0
Diploma	13	10.83
Bachelor Degree	83	69.17
Master Degree	22	18.33
PhD	2	1.67
Total	**120**	**100 %**
Experience in Construction Industry		
Less than 5 years	27	22.50
6-10 years	28	23.33
11-15 years	32	26.67
More than 15 years	33	27.50
Total	**120**	**100 %**
Experience in IBS Construction Projects		
Less than 5 years	84	70.00
6-10 years	31	25.83
11-15 years	2	1.67
More than 15 years	3	2.50
Total	**120**	**100 %**
Experience in BIM technology in the project		
Less than 5 years	105	87.5
6-10 years	8	6.67
11-15 years	2	1.67
Total	**120**	**100 %**

About 87.5% of respondents had less than five years of BIM experience, showing that digital tools are still new in Malaysia. However, their industry background and education indicate they are capable of giving useful insights on managing IBS risks with BIM.

3.2 Identifying the Most Significant Critical Risks in IBS Projects

The first objective was to determine the main risks in IBS project delivery. Analysis of seven categories using mean scores from a five-point scale showed that Design (4.48), Coordination (4.39), and Technical (4.31) risks ranked the highest, all at a very high level. Meanwhile, Cost (4.14), Manpower (4.15), Material (4.12), and Safety & Health (4.02) risks were also significant but only at the high level.

Table 2 Descriptive analysis for most significance critical risk in IBS project

Independent Variables	Mean	Std. Deviation	Mean Value
Design Risk	4.477	0.321	Very High
Technical Risk	4.314	0.293	Very High
Manpower Risk	4.150	0.325	High
Material Risk	4.123	0.414	High
Coordination Risk	4.387	0.320	Very High
Safety and Health risk	4.017	0.399	High
Cost Risk	4.140	0.411	High

These findings from Table 2, align with earlier studies showing that design errors, weak coordination, and technical issues are common barriers in IBS projects. Since prefabrication needs accuracy, mistakes in design can cause costly delays during assembly. Coordination risks highlight the need for smooth collaboration among all stakeholders, while technical risks reflect the challenge of shifting from conventional practices to new systems.

The consistent ranking of these risks shows a shared industry experience and the importance of stronger risk management in IBS projects.

3.3 Evaluating BIM Features Application Strategies

The second objective examined how BIM features are used to address key risks in IBS projects. Respondents rated their application of BIM across eight categories. Results in Table 3 showed that Technical (4.59), Operational (4.56), Managerial (4.55), and Design (4.49) functions were most widely adopted, all at the very high level. In contrast, Safety (4.13), Quality (4.14), Cost (4.11), and Structural (4.11) features were applied less often, though still considered high.

The strong ratings for technical and operational BIM use show that the industry values BIM in handling complex construction activities, especially prefabrication. Its ability to visualize designs, simulate processes, and improve scheduling fits well with IBS needs. Managerial functions such as communication and information

tracking are also commonly applied, reflecting BIM's role not only in design but also in overall project management.

Table 3 Descriptive analysis for BIM features application strategies

Dependent Variables	Mean	Std. Deviation	Mean Value
Cost	4.113	0.334	High
Management	4.553	0.411	Very High
Design	4.486	0.438	Very High
Structural	4.112	0.404	High
Operational	4.563	0.401	Very High
Technical	4.518	0.411	Very High
Safety	4.128	0.311	High
Quality	4.137	0.370	High

The industry mainly applies BIM for technical and operational tasks such as prefabrication, visualization, simulation, and scheduling, with added use in communication and information management. However, its limited use in safety and cost functions despite the potential of 4D and 5D tools suggests gaps in training, system integration, and adoption, underscoring the need for stronger BIM skills and targeted digital investment in IBS risk management.

3.4 Correlation Between Critical Risks and Bim Feature Strategies

The third objective examined how critical risks in IBS projects align with BIM feature applications. Pearson's correlation analysis indicated several strong and statistically significant relationships. The strongest was between Design Risk and BIM design applications ($r = 0.985$, $p < 0.001$), highlighting BIM's central role in addressing design-related challenges. Coordination Risk ($r = 0.911$) and Technical Risk ($r = 0.832$) also showed robust correlations, reflecting the close link between project complexity and digital coordination tools. Material Risk ($r = 0.613$), Cost Risk ($r = 0.656$), and Manpower Risk ($r = 0.524$) demonstrated notable associations, while Safety and Health Risk recorded only a moderate correlation ($r = 0.417$).

These findings suggest that BIM is well integrated into design, technical, and coordination processes but remains underutilized in safety management. The weaker link to safety indicates a gap between BIM's potential and its current practice, likely due to limited awareness or insufficient training. From an industry perspective, this underscores the importance of strengthening BIM adoption in safety, cost, and workforce planning. For policymakers, the results provide empirical support for embedding BIM-based risk strategies into IBS project guidelines.

4. CONCLUSION

This study shows that key IBS risks specially design, coordination, and technical can be reduced through strategic use of BIM. However, uneven application in areas like safety, cost, and structural risks highlights the need for stronger policies, targeted training, and industry readiness to ensure more consistent and resilient project delivery.

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