

# Key Challenges in the Pre-Contract for Building Information Modelling (BIM) Project

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## Abstract

The Malaysian construction industry is undergoing digital transformation through the Construction 4.0 Strategic Plan (2021-2025), with Building Information Modelling (BIM) playing a key role in enhancing project efficiency. BIM is a technology that enables the creation, communication, and analysis of digital models through a construction project's lifecycle. The pre-construction stage, which includes design, cost estimation, cost planning, and tender preparation, is critical to project success but often encounters data interoperability issues and communication breakdowns, leading to delays and cost overruns. Despite BIM's potential to improve collaboration, streamline processes, and enhance decision-making, its application remains limited due to reliance on traditional methods. Therefore, this research aims to examine BIM application during the pre-construction stage, identify key challenges, and propose strategies for its effective implementation. A mixed-method approach was employed, utilizing questionnaire surveys and interviews for data collection. The findings reveal that the high implementation cost is a significant barrier, limiting its widespread implementation. By addressing these issues, the Malaysian construction industry can accelerate its digital transformation, improving efficiency, collaboration, and competitiveness.

## 1. Introduction

The Twelfth Malaysia Plan (2021–2025) introduced the Construction 4.0 Strategic Plan to drive digital transformation in the construction industry. This initiative promotes BIM application across all project stages—pre-construction, construction, and post-construction—to enhance efficiency and project outcomes (Jaafar *et al.*, 2024; Latiffi *et al.*, 2016). BIM is a modeling technology and process used to generate, communicate, analyze, and utilize digital information throughout a construction project's lifecycle (Jaafar *et al.*, 2024; Latiffi *et al.*, 2016). Research by Hashim *et al.* (2023), Latiffi *et al.* (2013), and Hadzaman *et al.* (2016) shows that BIM plays a crucial role in the pre-construction stage for key decisions on design, cost, and planning. This stage is important for project success, involving planning drawings, material selection, technical design, cash flow analysis, tender document preparation, and scheduling (Bakar *et al.*, 2016; Kumar, 2017). However, significant challenges such as design changes, clashes, and poor constructability often lead to delays, cost overruns, and disputes (Elsayed *et al.*, 2024). Despite BIM's potential to mitigate these challenges and improve project efficiency, its adoption in Malaysia

remains slow (Feng, 2021) due to reliance on traditional methods (Wong & Gray, 2019), high training costs (Roseli, 2024), and a lack of standardized guidelines (Roseli, 2024). Additionally, construction stakeholders struggle with understanding and implementing BIM effectively (Musarat *et al.*, 2024), and strategies for its integration remain limited (Ershadi *et al.*, 2021). Interoperability issues between different BIM software platforms create further barriers, affecting seamless collaboration and data exchange (Ershadi *et al.*, 2021). Moreover, data security concerns limit BIM implementation, as construction firms hesitate to transition from conventional document storage to cloud-based digital models due to fears of cyber threats and unauthorized access (Mishra *et al.*, 2024). Communication breakdowns between stakeholders—caused by inadequate training, lack of BIM expertise, and insufficient coordination—further reduce its effectiveness in pre-construction planning (Lau *et al.*, 2018).

Advancing BIM application in the pre-construction stage can enhance efficiency, reduce project risks, and accelerate digital transformation in Malaysia's construction sector. However, Mishra *et al.* (2024) and Lau *et al.* (2018) highlight a lack of practical research on BIM implementation during this phase. Therefore, this research explores BIM application in the pre-construction stage, identifies key challenges, and proposes strategies for effective implementation.

## 2. Literature Review

### 2.1 Pre-Construction Stage

The pre-construction stage, as defined by the Royal Institute of British Architects (RIBA, 2020), involves establishing project objectives, refining requirements, and preparing initial designs to ensure a smooth transition to construction. This research refers to both the RIBA Plan of Work (2020) and Buku Panduan Pentadbiran Kontrak Kerja Raya Edisi Ketiga (PWD, 2010), as both outline similar activities. The RIBA Plan is widely recognized in the construction industry (Kirkham, 2013; Fung, 2015) and has been referenced in Malaysian studies (Rashid *et al.*, 2014). Meanwhile, the PWD guide remains a key resource for Malaysia's construction sector. Figure 1 illustrates the parallel activities in the pre-construction stage according to both references. Pre-construction activities lay the foundation for a successful project by defining key requirements, timelines, design concepts, and budget estimates.

#### 2.1.1 Project Brief

At the initial stage of a project, stakeholders define its purpose, scope, and key deliverables to ensure clear objectives. This includes identifying the type of project, whether residential, commercial, or infrastructure, and outlining functional requirements, expected capacity, and sustainability goals. Legal, regulatory, and zoning considerations are also addressed to ensure compliance with local building codes. Additionally, procurement strategies are planned, determining whether materials, labor, and services will be sourced through competitive bidding, direct, or negotiation. Effective early planning ensures smooth project execution, cost control, and regulatory compliance. Proper planning in this stage minimizes risks and streamlines project execution.

#### 2.1.2 Land Acquisition and Site Investigation

The Land Acquisition Plan ensures the selected site is suitable for construction. The process begins with site access and measurement to determine boundaries, levels, and contour lines. A site assessment is conducted to identify surface obstructions like existing structures or vegetation, while subsurface investigations detect hidden obstacles such as utility pipes and cables. Additionally, soil analysis is conducted to assess soil properties and bearing capacity, ensuring the land can support the planned structure. Proper site evaluation helps prevent construction delays, reduces risks, and ensures a stable foundation for the project.

#### 2.1.3 Preliminary Design and Site Layout

The design stage is of utmost importance in the construction industry, as it assures the project delivery with respect to guidance provided to both the project team and the client during the course of building (RIBA, 2020). The Pre-Preliminary Design and Preliminary Cost Estimate phase focuses on early planning, design, and cost assessment to ensure project feasibility. It begins with detailed architectural and engineering design, aligning structural and technical requirements with budget constraints. An initial cost estimation is conducted, followed by preliminary cost planning to track expenses and optimize resource allocation. Elemental Cost Analysis (ECA) further breaks down costs into specific components, helping stakeholders make informed financial decisions. This phase ensures efficient budgeting, cost control, and a solid foundation for the detailed design and construction stages.

### 2.1.4 Cost management

During the preliminary design and site layout phase, the project team develops an initial site layout plan and conceptual design based on project requirements. This stage includes a preliminary cost estimate to provide an early financial overview. Moving into the planning phase, the design is further refined, incorporating detailed architectural and engineering elements to ensure feasibility and functionality. Additionally, cost reviews are conducted to align the design with the project budget. In the design stage, engineering design and initial cost estimation are carried out, followed by cost planning and Elemental Cost Analysis (ECA) to evaluate cost distribution across different building components. These processes ensure that the project remains financially viable while meeting technical and design specifications.

### 2.1.5 Tender documentation

During the tendering process, the tender documents are prepared, outlining the project scope, standard specifications, and bill of quantities (BQ) to ensure clarity for bidders. If the project cost exceeds RM 500,000, tenders are invited through an open or selective bidding process; otherwise, quotations may be requested for smaller projects. Once bids are received, they are evaluated based on compliance, pricing, and technical capability, leading to a recommendation for the most suitable bidder. The successful contractor is then issued a letter of tender acceptance, formally notifying them of their selection. Finally, the contract documents are signed, officially binding both parties to the project's terms and conditions. The tender stage is the critical stage in which contractors or suppliers are selected based on the ability to provide the best combination of expertise, quality of work, cost-effectiveness, and timely completion (Ahmad *et al.*, 2021).

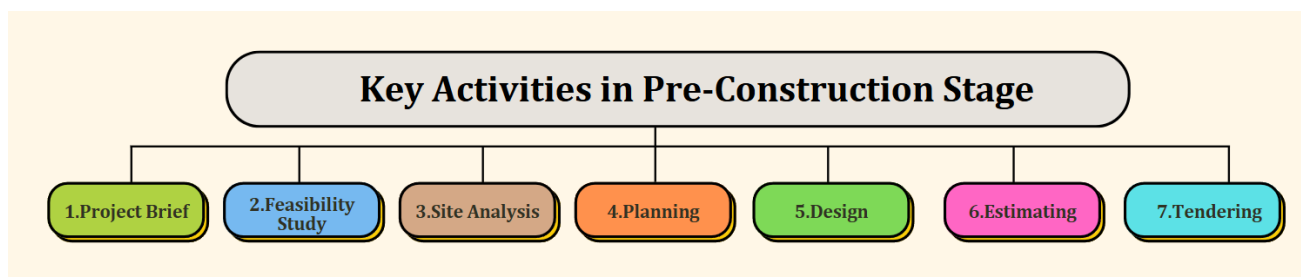


Fig. 1 Key Activities in Pre-Construction Stage (RIBA, 2020; PWD, 2010)

## 2.2 Overview of Building Information Modelling (BIM)

### 2.2.1 Definition of BIM

BIM is revolutionizing the construction industry by replacing traditional, fragmented practices with an integrated digital process. It is a technology-driven approach that utilizes various tools and technologies to generate, analyze, and manage digital representations of construction projects (Eastman *et al.*, 2011). BIM facilitates the creation, communication, and application of digital information models throughout the project lifecycle, improving efficiency and collaboration (CIDB, 2017)

### 2.2.2 BIM Application in the Malaysian Construction Industry

BIM was introduced in Malaysia by the Public Works Department (PWD) in 2007 with the publication of the BIM Standard Manual and Guidelines. In 2014, Malaysia hosted its first International BIM Day at the Putra World Trade Centre in Kuala Lumpur, marking a significant step in raising national awareness (Jamaludin *et al.*, 2022). By 2017, PWD had implemented BIM in 18 projects, with the National Cancer Institute of Malaysia in Sepang being the first public project to utilize BIM in 2010. Government initiatives have further bolstered BIM application. The Eleventh Malaysia Plan aimed to implement BIM in 10% of public projects valued over RM50 million. In early 2019, BIM became mandatory for public projects with budgets of RM100 million or more. By 2024, BIM applications had significantly increased, with PWD integrating BIM into 455 projects between 2021 and 2024, covering all stages from planning to construction. The PWD Strategic Plan 2021-2025 set objectives to achieve 50% BIM application by 2021 and 80% by 2025 (Abanda *et al.*, 2018 as cited in Yusoff *et al.*, 2023).

## 2.3 Pre-Contract for Building Information Modelling (BIM) Project

BIM applications can be applied to all construction project phases, which are the pre-construction phase, the construction phase, and the post-construction phase. However, Hadzaman *et al.* (2016) emphasize that BIM is especially valuable during the pre-construction stage.

### 2.3.1 BIM Application in the Project Brief Stage

The project brief usually includes the objectives of the client, the project scope, budget, and the client's specific requirements (Mundia, 2024). Creating a clear project brief can be a daunting task since it requires the clients to be able to completely understand and convey their own needs and what the needs of their end-users will be before it is communicated to the project team members (Xia *et al.*, 2012). According to Poirier *et al.* (2015) and Sackey *et al.* (2015), BIM has been a great tool in the process of briefing because it supports communication and collaboration among project team members during the early stages of construction. This potential is negated by the lack of clarity in the project brief; BIM cannot fix things that are not working due to a vague or incomplete brief (Vahabi *et al.*, 2022). Therefore, clear and well-defined project briefs are the basis for effective utilization of BIM, as they align the project objectives and requirements for data sharing and decision making. Consequently, the involvement of BIM at this stage is typically limited. Although BIM plays a significant role in later stages, particularly in detailed design collaboration and information sharing, it is not extensively utilized during the project brief stage. This stage emphasizes high-level strategic alignment and business needs, which can often be assessed without requiring extensive technical input (RIBA, 2013). A BEP can be one of the most important documents already at the project brief stage and integrated into planning an overall project strategy for BIM (Hadzaman *et al.*, 2016). Hadzaman *et al.* (2016) and Antunes & Elliot (2022) describe that defining a BEP within the project's brief stage clarifies how BIM will be incorporated into the project goals and establishes how information is to be shared among stakeholders.

### 2.3.2 BIM Application in the Feasibility Studies Stage

Feasibility studies are important in determining the economic, technical, technological, and functional viability of a possible construction project. Feasibility studies include investigations into whether a project should be continued or not based on factors like cost, time, resources, and possible risks (Yilmaz *et al.*, 2019). However, BIM is not used directly in the feasibility study stage, but it becomes prominently relevant as the project progresses into the next stages of development, such as programming and design (Yilmaz *et al.*, 2019). Apart from the complexity of the project, the other major factor that can be used to evaluate BIM suitability at the feasibility study stage is the availability of the necessary technological infrastructure and resources (Sacks & Pikas, 2021). Advanced software, as well as skilled personnel who can handle it, is required for implementing BIM. At this point in time, firms need to assess whether hardware and software are in place and whether BIM expertise resides within their teams. Where this lacks, external consultants may have to be engaged, thus adding to the cost of the project (Rajabi *et al.*, 2022).

### 2.3.3 BIM Application in the Site Analysis Stage

One of the key levels in any construction project is pre-construction because of the number of risks and uncertainties related to subsurface ground conditions-which is the most critical area of construction. Lau *et al.* (2018) continue to discuss the detailed data attributes that must exist during the pre-construction stage, particularly site analysis, to such an extent that major risks can, in reasonable terms, be anticipated. BIM technology is going to change the way site analysis is conducted significantly. It will provide site analysis in 3D, enabling the project team to base their decisions on precise positioning of the buildings and understanding the future site obstacles such as slopes, elevations, and surrounding structures (Hs, 2020; Ahsan, 2024). On the contrary, BIM fully depends on GIS for site analysis. With GIS and BIM in place, site analysis has become more precise since it can bring up the areas and the best possible places to erect future projects. Advanced systems that are designed to manage, analyze, and present spatial data, therefore, offer detailed geographical analysis by GIS. The use of GIS in construction is very important at the site planning and logistics levels, with spatial insights derived. GIS with BIM turns on better construction provision by a geographic analytic function that improves site management and supports logistics and route planning (Ahsan, 2024).

### 2.3.4 BIM Application in the Planning Stage

As reported by Kjartansdóttir et al. (2017), planning is the stage that defines how the construction project will be executed. This initial stage in pre-construction use of BIM is according to Schwabe *et al.* (2016). Site layout planning concerns the arrangement of all equipment, including crane towers and containers, while addressing safety and cost considerations. BIM helps architects and construction managers in making accurate 3-dimensional (3D) models of building designs. It has an even more significant role when the construction industry moves towards digital planning. During the planning stage, construction schedules are integrated with specific tasks by creating the 3D model objects using advanced 4D scheduling tools like Vico Office, Synchro, or Navisworks (Kjartansdóttir *et al.*, 2017). Another significant advantage of BIM is that it adds a time dimension to the 3-dimensional model, otherwise known as 4D BIM (Magill *et al.*, 2022), thereby enabling simulation of the construction process. It helps with complex project planning and visualizes the whole project or specific stages within it. It allows stakeholders to see how timing impacts workflow, plan versus actual schedules and identify timing conflicts (Ahmadi and Arashpour, 2020).

### 2.3.5 BIM Application in the Design Stage

The design stage is the vital stage in the pre-construction process that includes early ideas moving toward the developing plans and drawings. It includes the development of architectural, structural, mechanical, electrical, and other design elements for construction (Aziz *et al.*, 2024). Kurwi *et al.* (2021) highlight that the design stage is the stage where BIM is most applied, emphasizing its significant role in transforming the way design and planning processes are executed in construction projects. This also aligns with Eadie et al. (2013, as cited in Chi *et al.*, 2015), who note that BIM is most suitable for use in the design and pre-construction stages due to its ability to improve collaboration, enhance visualization, and reduce errors. BIM-generated 3D models output building aspects with accuracy and detail, providing possibilities for early identification and resolution of expected issues, and limiting the risk of costly rework during implementation (Adeyemi *et al.*, 2024). Architects and engineers can collaborate in the project design and visualization within a coordinated environment in 3D using tools such as Revit Architecture, Revit Structural, and Revit MEP (Hardin & McCool, 2015). In general, the creation of a 3D model ensures that all elements of the project relate cohesively and can be visualized in one model (Adeyemi *et al.*, 2024).

### 2.3.6 BIM Application in the Estimating Stage

Wahab and Wang (2021) highlight the long procedure of costing that involves a manual take off from hardcopy drawings along with 2D software takeoffs has rendered cost estimation very time-consuming. BIM offers more efficient updating of material take-offs, counts, and other measures compared to traditional methods, thus saving time (Gholizadeh *et al.*, 2018). Moreover, BIM technology can eliminate the need for repetitive, time-consuming tasks most often done by QSs and allow them to work on other services (Nagalingam *et al.*, 2013 as cited in Ismail et al., 2021). 5D BIM models, quick cost estimates become possible through automated quantity take-offs against accurate costs of modeled projects. This would, therefore, provide rapid feedback on costs during any design change that occurs (Fan *et al.*, 2015; Vitasek and Žák, 2018). It means, therefore, that with early cost decision and increased collaboration and communication, construction practitioners can ensure the overall monitoring of the budget of the project and reach higher productivity via enhancing control over costs (Shaqour, 2022). Abdul Rahman *et al.* (2019) assert that the integration of BIM within the design of a cost estimator enhances precision since, through the drawing synchronism, it automatically generates specifications and cost estimates as drawings are created in the BIM software. BIM 5D, supported by software such as Autodesk Navisworks, Autodesk Revit Architecture, Cost X, and Microsoft Excel, enhances cost estimation accuracy in construction projects (Aman & Suratkon, 2022).

### 2.3.7 BIM Application in the Tendering Stage

The tender stage somehow creates conditions of decision-making that are complex: industry fragmentation, differences of opinions, time pressure, unknown client needs, and changes in the design that make it very difficult to make decisions and will eventually affect the end project quality and reliability (Mohamad *et al.*, 2010). Hence, using BIM would significantly boost efficiency during tendering processes during the tendering stage of construction projects and standardize and refine tender processes for better arbitration of the conflict of interest among bidding parties (Miao, 2023). 3D model enables bidders to visualize the complexities of a project along with assessing its feasibility, making them take more informed decisions on their bids. This works by both timesaving and reducing misunderstandings, thus minimizing potential conflicts between the parties involved (Miao, 2023). Improved visualization is among the core benefits that make for the tendering of this project (COBIM, 2012).

## 2.4 Challenges In the Pre-Contract For Building Information Modelling (BIM) Project

There are numerous challenges to implementing BIM (Wong and Gray, 2019), especially in pre-construction projects. Based on literature findings, the issues encountered by the construction sector in Malaysia may be categorized into four categories, which are People, Cost, Technology, and Policy Challenges.

**Table 1** Summary of Literature Review of Challenges in BIM Application in Pre-Construction Stage

Challenges	Author
<b>People</b>	
Lack of BIM knowledge during the pre-construction stage	Radzi <i>et al.</i> (2024)
Resistance to change for new technology	Hasan <i>et al.</i> (2021) Umar (2021) Liu (2023)
The assumption that conventional methods pre-construction stage are better than new processes	CIDB (2020) Lee <i>et al.</i> (2022)
Insufficient BIM training is available	Umar (2021) Lee <i>et al.</i> (2022)
Lack of skilled and experienced workers to implement BIM	Lee <i>et al.</i> (2022) Radzi <i>et al.</i> (2024)
<b>Cost</b>	
High cost of software	CIDB (2020) Lee <i>et al.</i> (2022)
High cost of hardware	Lee <i>et al.</i> (2022)
High training cost	CIDB (2020) Al-Mohammad <i>et al.</i> (2022)
Lack of government subsidies	Imoni <i>et al.</i> (2024)
<b>Technology</b>	
Hardware incapable of running basic BIM software	Lee <i>et al.</i> (2022) Radzi <i>et al.</i> (2024)
Data security concerns	Hasan <i>et al.</i> (2021)
Issues of interoperability and data exchange	Ahmad Jamal <i>et al.</i> (2019) Radzi <i>et al.</i> (2024)
BIM software is complicated to use	Ahmad Jamal <i>et al.</i> (2019)
<b>Policy</b>	
Lack of clear policies that support BIM implementation in the pre-construction stage	CIDB (2020) Lee <i>et al.</i> (2022)
No established contractual framework for working with BIM in the pre-construction stage	Lee <i>et al.</i> (2022) Imoni <i>et al.</i> (2024)
There is no BIM in the pre-construction stage requirement in the industry	CIDB (2020) Lee <i>et al.</i> (2022)
Data ownership issues	Umar (2021) Lee <i>et al.</i> (2022)

## 3. Research Methodology

This research employs an exploratory sequential mixed methods design, initiating with quantitative data collection and analysis to gain foundational insights. Then, these initial findings inform the subsequent qualitative stage, enhancing the overall comprehension of the research problem. This integrated approach ensures a comprehensive understanding of BIM application during the pre-construction stage, addressing its challenges and proposing viable solutions. Quantitative data were collected through questionnaires, while qualitative insights were gathered via semi-structured interviews. A purposive non-probability sampling technique was utilized to select participants based on specific criteria aligned with the study objectives. The sampling frame was derived

from the MyBIM Centre and the Construction Industry Development Board (CIDB) in Malaysia, encompassing 74 BIM companies across various regions.

Meanwhile, questionnaires were distributed to all identified companies, targeting active BIM practitioners, resulting in 31 respondents. Additionally, 6 professionals with substantial BIM expertise were selected for semi-structured interviews. The qualitative data from the interviews underwent thematic analysis to identify key themes and patterns, offering deeper insights into the participants' perspectives. Then, the quantitative data from the questionnaires were analyzed using descriptive statistics, including frequency distributions and measures of central tendency, facilitated by the Statistical Package for the Social Sciences (SPSS). According to Evren *et al.* (2022), the mean categories are defined as follows:

- Low if the mean is  $\leq 2.50$
- Moderate if the mean is between 2.51 – 3.50
- High if the mean is  $\geq 3.5$

## 4. Result

### 4.1 BIM Application in the Pre-Construction Stage

#### 4.1.1 Questionnaire Survey

**Table 3** Summary of BIM Application in the Pre-Construction Stage

Pre-Construction Stage	Median	Mean	Significant Level
Design Stage	5	4.06	High
Planning Stage	4	3.87	High
Tendering Stage	4	3.71	High
Site Analysis Stage	4	3.65	High
Estimating Stage	4	3.58	High
Feasibility Study Stage	4	3.58	High
Project Brief Stage	4	3.39	Moderate

Table 3 provides a comprehensive summary of the application of BIM throughout the pre-construction stage. The analysis highlights seven distinct stages of BIM application, each of which was derived from the literature review presented. The stage that exhibits the highest mean value is the BIM application in the design stage, with a mean score of 4.06. Following closely is the BIM application in the planning stage, which has a mean of 3.87. The next highest mean value of 3.71 corresponds to the BIM application in the tendering stage. The application of BIM in site analysis comes in with a mean value of 3.65, indicating a high level of usage during this stage. Both the estimating and feasibility stages exhibit identical mean values of 3.58. Lastly, the project brief stage has the lowest mean value of 3.39.

#### 4.1.2 Interview

This section comprehensively discusses BIM application in the pre-construction stage through in-depth interviews with industry professionals.

**Table 4** Summary of BIM Application in the Pre-Construction Stage

No.	Project Brief	Feasibility Study	Site Analysis	Planning	Design	Estimating	Tendering
<b>R1</b>	"Limited BIM application in this stage"	"Government projects do not conduct feasibility studies. The project's requirements are only at the ministry level."	"The use of Geographic Information System (GIS) depends on the project. It is not compulsory unless the project requires environmental enforcement."	"Clients can only imagine the concept, but with flythroughs and walkthroughs of the model, they can make changes if needed. Clear visualization."	"BIM in this stage is where designers need to 3D model."	"Analysis is still done using software, but some items, such as the reinforcement bars, using 3D model presentation"	"The contractor will tender based on the 3D model as well as the 2D drawing from AutoCAD."

						s, are not practical as they require significant manpower and heavy models."	
<b>R2</b>	"BIM Execution Plan (BEP) document is important as it guides team members to follow a structured approach."	"For large-scale projects suitable for BIM."	-	-	"Design is done using a 3D model that consists of information."	"It is easy to change materials and assess the impact on total cost."	"Tendering using BIM becomes faster, with time advantages and cost reduction."
<b>R3</b>	"Focus is on design, inputting data into the software."	-	"It is not fully implemented in JKR."	"Digital twin allows for comparing the site work with the model."	"Stage uses BIM the most."	"Quantity takeoffs are faster and more accurate in the pre-construction stage."	"Large companies are investing in BIM technology."
<b>R4</b>	"BIM is used, part of BEP itself, one section specifies the project's site, the client, and the consultant"	-	"Some projects need a BIM 3D model complete with site analysis, some do not."	"4D planning is done during construction planning with detailed information."	"Design is compulsory for all consultants, M&E, architecture – 2017 in my company using BIM."	"Quantity Surveyor consultant in my company, whether large or small, depending on the project, is mandatory in 2020."	"In addition, using BIM in the tendering stage, we can generate costs based on National Construction Cost Center (N3C) cost data. We can ensure transparency."
<b>R5</b>	"During this stage, we figure out which software to use and what version is needed."	"Look at the design, it is feasible to produce; if it is not, it is necessary to send the worker for training."	"BIM department, it is crucial to use drones to capture images and videos from above. This helps in evaluating design ideas, alignment, and potential issues. Software like Civil 3D is used"	"Before construction, we do 4D simulation, using the CPM process at the site. But rare projects implement BIM in planning during the pre-construction"	"As a BIM Modeler, Revit is the most used 3D model."	"Cost estimation and budget management are handled through BIM data."	"The design model is submitted, and contractors receive the model, which they then update throughout the project."

			<i>for roadwork and earthworks."</i>	<i>stage because it is expensive and requires expertise."</i>			
<b>R6</b>	<i>"Project briefs are not really implemented in project BIM; however, BEP needs to be prepared during this stage".</i>	<i>"Risk analysis, which is a clashing element."</i>	<i>"Surely have, but I do not know any software to know the topography and everything."</i>	<i>"There is a 4D simulation."</i>	<i>"The most used BIM is the design stage."</i>	<i>"Quantity Surveyors typically use 5D BIM for cost estimation."</i>	<i>"To do tender, BIM modeler updates info, auto-generates new quantities to tender."</i>

## 4.2 Challenges in the Pre-Contract for Building Information Modelling (BIM) Project

### 4.2.1 Questionnaire Survey

**Table 5** Summary Results Challenges of BIM Application in the Pre-Construction Stage

Challenges	Mean	Median	Significant Level
<b>People</b>			
Lack of BIM knowledge during the pre-construction stage	3.94	4	High
Resistance to change for new technology	3.77	4	High
The assumption that conventional methods pre-construction stage is better than new processes	3.77	4	High
Insufficient BIM training is available	3.58	4	High
Lack of skilled and experienced workers to implement BIM	3.45	3	Moderate
<b>Cost</b>			
High cost of software	4.19	4	High
High cost of hardware	4.13	4	High
High training cost	4.03	4	High
Lack of government subsidies	3.94	4	High
<b>Technology</b>			
Hardware incapable of running basic BIM software	3.65	4	High
Data security concerns	3.29	3	Moderate
Issues of interoperability and data exchange	3.10	3	Moderate
BIM software is complicated to use	2.71	3	Moderate
<b>Policy</b>			
Lack of clear policies that support BIM implementation in the pre-construction stage	3.55	4	High
No established contractual framework for working with BIM in the pre-construction stage	3.42	3	Moderate
There is no BIM in the pre-construction stage requirement in the industry	3.16	3	Moderate
Data ownership issues	3.10	3	Moderate

The summary data presented in the table is based on the responses of 31 participants, with the results summarized using the mean values. For people related enablers, the lack of BIM-skilled and expert workers to implement BIM holds a high mean value with 3.94. Insufficient BIM training is available, and resistance to change for new technology of BIM application in the pre-construction projects shares the same mean value with 3.77. By looking at the mean value, cost enablers hold the highest mean of 4.19, which indicates that the primary challenges in BIM application during the pre-construction stage are the high cost of hardware. Next, for technological

challenges, the highest score means 3.65 for the hardware incapable of running basic BIM software. Finally, from the perspective of policy challenges, no established contractual framework for working with BIM applications during the pre-construction stage has the highest mean value of 3.55.

#### 4.2.2 Interview

Based on the results below in Table 6, the effective strategies mentioned by all respondents are a high-cost BIM implementation, competency issues, the mindset of individuals, and a lack of expertise. These interviews were conducted through Google Meet to validate the findings from the questionnaire.

**Table 6** Summary Results Challenges of BIM Application in Pre-Construction Stage

Challenges	No. of Respondent
High cost of BIM Implementation	R1, R2, R3, R5, R6
Competency issues	R1, R2, R4, R5, R6
Mindset of Individuals	R3, R4, R5, R6
Lack of expertise	R2, R5, R6

### 4.3 Discussions

#### 4.3.1 BIM Application in the Pre-Construction Stage

According to questionnaire results, most respondents have high agreement that BIM is utilized more in the design stage compared to other stages. This is also supported by the interview that also mentioned that the design stage is the most BIM applied in the pre-construction stage compared to other stages in the pre-construction stage. Both the questionnaire and interview have consistent results. This finding aligns with Kurwi *et al.* (2021), who highlight that the design stage is the stage in which BIM is most applied. This is also consistent with Eadie *et al.* (2013, as cited in Chi *et al.*, 2015), who note that BIM is most suitable for use in the design and pre-construction stages due to its ability to improve collaboration, enhance visualization, and reduce errors.

Meanwhile, the project brief stage is the least applied for BIM uses in construction projects. This, too, is a point of agreement with RIBA (2013), which states that while BIM plays its major roles in later-stage activities, such as detailed design collaboration and information sharing, it is not widely engaged in the project brief stage. Findings revealed that BIM application remains limited in this stage, with greater use observed in the design stage, while estimating and tendering stages still rely on 2D and 3D models. This contradicts Huang (2021), which states that BIM technology is widely applied in construction cost management. The integration of BIM with advanced technologies like GIS, drones, and digital twins is promising but costly, especially during the site analysis and planning stage. This contrasts with Schwabe *et al.* (2016), who emphasize the planning stage as crucial for introducing BIM in the pre-construction phase. This difference underscores the challenge of balancing BIM's long-term benefits with the immediate financial constraints in construction projects.

Lastly, the feasibility studies and project brief stages are identified as having the least application of BIM. This is primarily because these stages occur at the very early stages of a project; however, the conceptual 3D model produced during this stage. This, too, is a point of agreement with RIBA (2013), which states that while BIM plays its major roles in later-stage activities, such as detailed design collaboration and information sharing, it is not widely engaged in the project brief stage.

#### 4.3.2 Challenges in the Pre-Contract for Building Information Modelling (BIM) Project

From both the questionnaire survey and the semi-structured interviews, it can be concluded that several findings are consistent and correlated with each other. The researcher identified that the "high cost of hardware" and "high cost of BIM implementation" are interlinked, suggesting that cost remains a significant challenge in BIM application during the pre-construction stage. This finding is consistent with Radzi *et al.* (2024), who highlight the necessity for construction teams to invest in advanced and reliable hardware to support the demanding performance requirements of BIM software. Without the proper hardware infrastructure, BIM software may not function effectively, limiting its potential to streamline processes and enhance project outcomes. As such, the upfront cost of hardware becomes a major challenge, making it critical for organizations to plan and budget accordingly to ensure successful BIM application in the pre-construction stage. This consistent concern across both methods indicates that cost is a fundamental challenge of BIM application in the early stages of construction projects.

## 5. Conclusion

The research achieved its objectives by examining BIM applications and identifying challenges. The current trend of BIM application in the pre-construction stage indicates that it is primarily used during the design stage. However, its application in other stages, such as cost estimation and tendering, remains limited due to challenges like a lack of expertise and high implementation costs. These challenges significantly hinder the broader adoption of BIM in the pre-construction stage, with high implementation costs being a major barrier. The findings contribute to enhancing industry practices, supporting Malaysia's transition towards Construction 4.0 and aligning with the principles of IR 4.0 to foster a more efficient and innovative construction sector. This research is valuable to both academia and the construction industry, providing insights that can guide future studies and support industry practitioners in optimizing BIM application during the pre-construction stage.

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## Conflict of Interest

There is no conflict of interest regarding the publication of the paper.

## Author Contribution

The authors confirm their contribution to the paper as follows: **study conception and design:** Nurdina Sarah, Roziha Che Haron; **data collection:** Nurdina Sarah; **analysis and interpretation of results:** Nurdina Sarah; **draft manuscript preparation:** Nurdina Sarah, Roziha Che Haron, Md Asrul Nasid Masrom. All authors reviewed the results and approved the final version of the manuscript.

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