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Research Article

Investigation on the effectiveness of using building information modeling (BIM) tools in project management: a case study

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Abstract: Building information modeling (BIM) has brought a technological shift in the area of construction programs, resulting in a significant rise in project management performance and affordability. In Bangladesh, designers have to deal with numerous issues in implementing BIM technology as technological expertise is insufficient in this area. Therefore, the paper focuses on implementing BIM across the project life cycle and assesses its effectiveness on a construction project with respect to the Bangladeshi construction industry. For this, a 3D model simulation of a three-storied residential building is developed and all semantic data (material properties, construction details, schedules, cost of the material, etc.) is stored with the model. In addition, BIM-centered integrated project delivery techniques are analyzed for clash detection, structural analysis, scheduling (4D), and cost estimation (5D) during the planning and construction phase. The outcome of the study indicated that BIM is effective in raising whole process performance, giving precise quantity takeoffs, optimizing schedules, reducing overall project uncertainties, structural defects, and expenses. The constitutional framework of this study can lead to increased efficiency, effective communication, as well as rarer mistakes in the construction project of Bangladesh. In addition, it can be an effective tool for managing medium- and large-scale projects since it can help to boost profitability, cut expenses, and enhance time management.

Keywords: Building information modeling (BIM), project management, case study, scheduling, cost estimation, clash detection.

1. Introduction

The architecture, engineering and construction (AEC) infrastructure has declined slightly by 20% over the last 50 years due to a variety of underlying concerns, including delays, funding issues, and negligible efficiency (Linderoth, 2010). However, the economic growth in non-farm enterprises has enhanced by around 150% (Agenda, 2016). The difficult issue of information management in project management needs continuous decision-making to maintain current plans with continually updated design materials (Pan & Zhang, 2021). Consequently, a wide range of information and communication technologies (ICTs) are being adopted into the industry to handle information management difficulties, enhance teamwork and coordination, and accomplish progressive implementation. (Lu et al., 2015). As a result of the development of new software programs, the integration of technical developments in construction management in terms of budgetary control, cost reduction, design, drafting, and scheduling is consistently increasing.

Building information modeling (BIM) is an ICT-based technique that enables proactive model-based management of construction projects (Bryde et al., 2013). The Building Information Model (BIM) has created new possibilities for the entire construction life cycle. Hybridization strategies for managing project data and planning project execution are the outcome of a technology revolution (Çıdık et al., 2017). BIM is a method of communicating project decisions involving concerns such as design, visualization, collaboration, and simulation of many applications through the use of digital data. BIM features include managing building information and documents (Datta et al., 2023), integrating project process and circulation with reliable statistics, computation, and process flow assessment (Bryde et al., 2013; Martins et al., 2020), embracing lean and productive development (Jin et al., 2017), establishing a supportive working platform (Xu et al., 2017) and enhancing value management (Park et al., 2017).

Several research into the impact, benefits, and implementations of BIM in the construction sector have previously been carried out in various areas (Datta et al., 2022; Hossain & Ahmed, 2019). Yet, the implementation of BIM tools in many areas of the Bangladeshi construction sector, such as safety (Hossain & Ahmed, 2019), preventing delay management (Nafe Assafi et al., 2022) and energy performance (Rana et al., 2020), has been investigated, but the potential project management of a residential building using BIM tools are yet to know. That is the primary cause of the Bangladeshi construction industry's continuing struggle with a variety of project management-related issues. Since project management is a crucial component of every successful construction project, it is essential to understand how BIM affects managing construction projects along with what needs to be done to ensure BIM has the greatest impact. Consequently, the goal of this study is to apply BIM technologies to residential building construction projects in Bangladesh and identify the effectiveness that BIM has introduced to the industry over the conventional approach in terms of project management. The methodology covers the entire process of applying the BIM approach to the construction industry.

2. Literature review

In developing countries like Bangladesh, the construction industry is a valuable asset since it boosts its economic production. Because the construction industry is subject to unpredictability, managing such difficulties without missing anything is a worry. As a result, the construction sector is making strong efforts to cut capital expenditure, project duration, and waste. As a result, a variety of project management solutions have been employed, all of which contribute to a better knowledge of the targeted outcomes through optimal coordination and collaboration among project participants (Datta et al., 2021). BIM is widely mentioned as a key factor in the construction sector's expansion and success. It's a procedure comprising the production and management of digital illustrations of structural and logical features of locations and supported by a number of techniques, tools, and agreements. Martins et al. (2020) defined BIM as a method for planning, implementing, and maintaining a plan in which a visual representation of the development stages is used to promote electronic data interchange and interoperability. Conversely, Sacks et al. (2018) classified it as a simulation system that includes a range of tools for creating, communicating, and assessing design concepts.

At any stage during the project's lifespan, BIM can be utilized by the client to evaluate requirements, the creative team to analyze, organize, and implement the plan, the contractor to monitor the project's execution, and the facility management to maintain throughout maintenance and decommissioning periods (Grilo & Jardim-Goncalves, 2010). The AEC business is information-dependent, with a huge volume of data produced and communicated during the design process (Y. Chen & Kamara, 2011). Any set of data connected to the model components in the BIM, such as dimensions, placement, budget, timelines, energy calculations, and liabilities, is referred to as "Information" in the context of BIM. It connects information systems across the project lifecycle, integrates all phases of project management utilizing digital tools, and blends modeling and execution through visualization implementation. The efficacy of BIM is increasing because of cloud-connected solutions that allow construction companies to operate and collaborate in new ways (Mutis & Mehraj, 2022).

Several studies on the impact, implementation, and applicability of BIM in construction projects have already been performed. Hanif et al. (2017) evaluated two divisions in the same project with varying levels of BIM collaboration to highlight the important impact of BIM on design collaboration, whereas Lu et al. (2015) considered two scenarios with and without BIM to quantify the effects of BIM on program performance. Furthermore, X. Wang and Chong (2015) and Vilutiene et al. (2021) evaluated the BIM at various stages of the project and concluded that BIM integration is important for operations. Bryde et al. (2013) examined how BIM is used in projects that resulted in better scheduling, cost, and product quality, as well as increased teamwork and coordination. Cao et al. (2017) concluded that owners' encouragement for using BIM technologies could enable for more stakeholder participation. Inyim et al. (2015) also reported that BIM allowed team members to manage all information, allowing them to make informed decisions during the design and construction phases. BIM is a collaboration method that combines overall management skills around a single model in the construction industry.

2.1 3D to 5D BIM

The level of detail in three-dimensional (3D) modeling is crucial because BIM gives exceptional accuracy when the data is integrated into the model with the required level of detail (Biagini et al., 2016). Resource qualities, project features, system parameters, constituent features, operational expenses, and supplier details must be included in the model (Jalaei & Jrade, 2015). According to K. Chen et al. (2018), 3D models should include geometrical, architectural, topographical, structural, and other data. With the help of a 3D model, clash detection is used to avoid and alleviate construction site disagreements before they occur, lowering construction costs, reducing rework, and increasing efficiency (Zhang et al., 2018). In addition, the planning simulations might be integrated with the compound model and linked to the project schedule to analyze the impact of transitory objects and evaluate conflicts (Eldeep et al., 2021).

During the conceptualization, implementation, and maintenance phases, companies use a variety of scheduling systems such as Bar Charts, Critical Path Methods, and Gantt Charts (Lee & Shvetsova, 2019). BIM allows one to integrate structural elements in 3D models with activities in the schedule, resulting in a 4D model that gives a clear image of the operations and helps in developing project interaction (W.-C. Wang et al., 2014). The primary benefit of 4D models is their capacity to better oversee and regulate the construction, allowing them to save money and resources while also maximizing asset use. BIM software (such as Navisworks) provides project modeling, which is important for viewing the 3D model in real-time throughout construction (Heigermoser et al., 2019).

However, a 5D model is one that incorporates financial information into the BIM model (Datta, Sobuz, et al., 2023). Capital budgeting, along with quantity takeoff, is the most essential financial component of construction projects. It gives a clear view of the project before it starts, and if the cost exceeds the budget, the concept can be changed. In this scenario, the 5D BIM technique is beneficial since calculations save time and work right away. These calculations are made by inputting the unit cost of each element (Jrade & Lessard, 2015). When all relevant data is present inside the simulation, BIM delivers accurate computations.

2.2 BIM tools

There are a variety of Building Information Modeling tools available, which illustrate the production and execution of computer-generated n-dimensional simulations, which encompass infrastructure design, implementation, and management. It assists designers, engineers, and builders in visualizing and assessing potential concepts, implementation, and technological difficulties in a virtualized world. The MEP, structural, architectural, and 3D modeling tools are among the BIM tools used at various phases, as well as their primary roles and manufacturers, as shown in Table 1 below.

Till date, numerous studies on the application of these BIM tools in the construction industry have been conducted in a number of domains, including energy performance, construction safety, delay management, and so on . However, the utilization of BIM resources in project management is not yet widely embraced, which is one of the main reasons why the Bangladeshi construction sector keeps struggling with various project management-related challenges. Each successful project requires effective project management, so it is critical to comprehend why BIM can make influences in project management. As a result, the aim of the present research is to evaluate the efficiency of BIM tools in residential building construction projects along with the comparison to the traditional project management methodology.

3. Materials and methods

This study presents a case study to demonstrate how BIM leads to more efficient construction projects and evaluate its effectiveness on a construction project in Bangladesh. It was designed to select a project that did not employ BIM tools throughout the planning or construction stages. This decision was made in order to have a better understanding of the inherent practical issues that come with BIM simultaneous implementation and see if BIM might be used as a communication tool.

The residential building construction at Khulna in Bangladesh set the criteria and applied to reach this research conclusion. The research flow diagram is presented in Figure 1. Through a case study, this research focused on introducing BIM interactions to a project and exploring the potential profits of this integration. The design cycle included architectural function 3D workflow, as-built before construction, structural analysis, MEP analysis, clash detection, scheduling, and cost estimation. The whole process was conducted by using BIM tools, as presented in Table 1. On the other hand, the execution cycle centered on direct manufacturing from BIM and modification orders. It was carried out after investing in a real-life project that demonstrates BIM's contribution to a project in order to share key lessons learned in a visible manner. This study belongs to a potential development of an innovative technique of modeling the data in BIM projects.

Table 1. BIM tools used in this study.

Segments	Primary function	Related software	Manufacturer
3D modeling	Create a 3D model using a data set of quantities, expenses, and timelines (Biagini et al., 2016)	Autodesk Revit 2018	Autodesk
Structural analysis	Concrete structural framing and design (Gilemkhanov et al., 2018)	Autodesk Robot Structural Analysis 2018	Autodesk
MEP modelling	Mechanical, electrical, and plumbing incorporation in the 3D model (Zhang et al., 2018).	Autodesk Revit 2018	Autodesk
Clash detection	To determine the conflicts prior the construction stage (Eldeep et al., 2021). Check geometrically the design	Autodesk Revit 2018	Autodesk
		Autodesk Navisworks 2018	
Scheduling (4D Model)	Time estimation and visualization of the project according to the schedule (Martins et al., 2020).	Autodesk Revit 2018	Autodesk
		Autodesk Navisworks 2018	
		MS Project 2018	Microsoft
Cost estimation (5D Model)	At the design stage, it provides a quantity takeoff and cost estimate. It's a look at what to expect before starting the construction stage and how to stay focused in the early phases. Creates financial decisions (Martins et al., 2020).	Autodesk Revit 2018	Autodesk
		Microsoft Excel 2018	Microsoft
Design review	Mismatch analysis and management during construction using a BIM-based integrated solution (Nawari, 2020)	Autodesk Design Review 2018	Autodesk

4. Case study

A three-storied residential building project at Khulna division in Bangladesh was completed on 1460 sqft land, with a time of 22 months. The residential building has one unit at each floor. As of September 2020, the building was accomplished using only 2- dimensional drawings with a total cost of around 84 lacs tk (BDT). The project was managed by Sailors Construction, where the first investigator was employed at the time and served as a design consultant for this project. Around two months were taken for the design stage, followed by the local authority's approval (about two months), and then an 18-month construction period. There were no BIM management tools employed on this project.

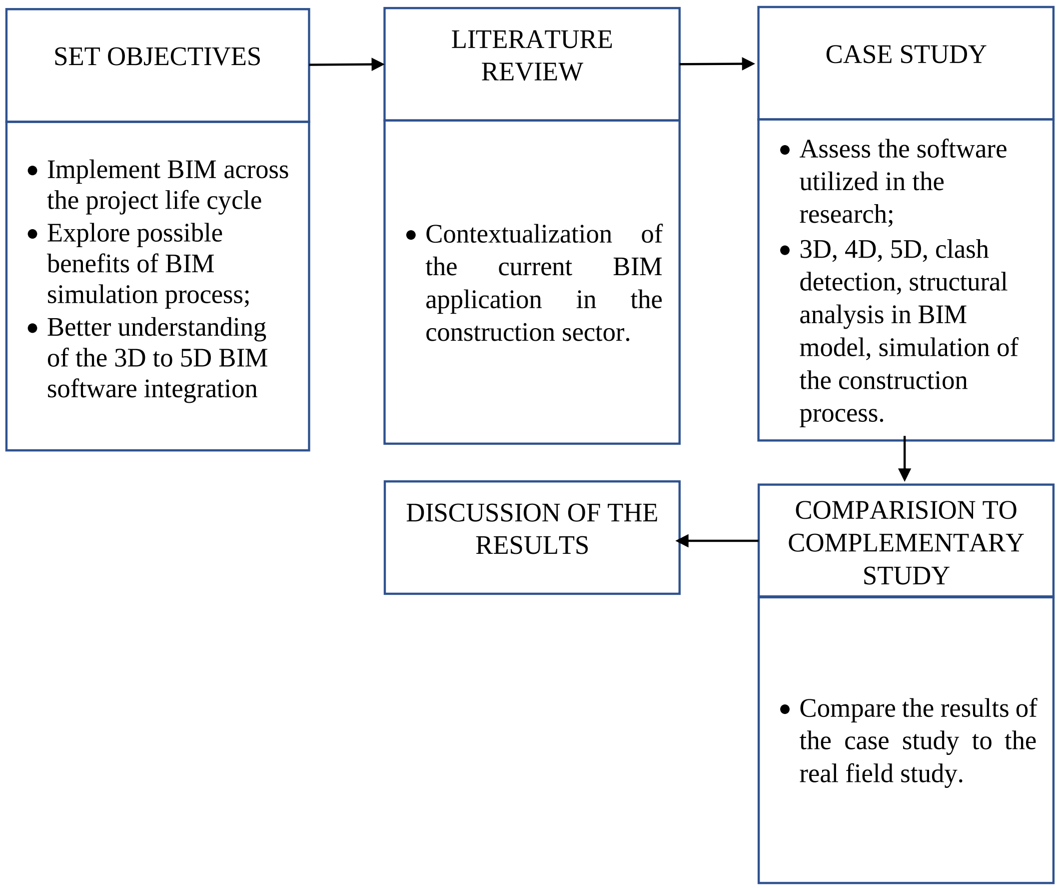
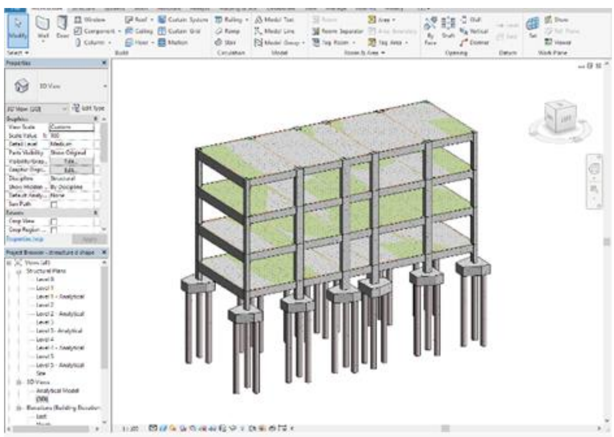


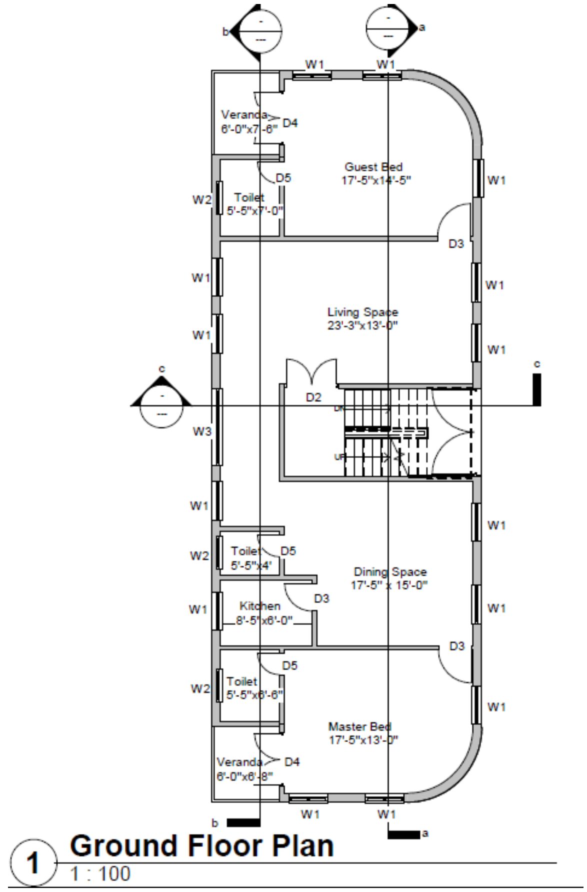
Figure 1. Research flow diagram of this study.

A comparison of 2D drawings and the 3D BIM model is shown in Figure 2. The researchers tested their theory by converting typical 2D CAD drawings for a residential project into a complete 3D incorporated BIM model, which allowed for successful 3D modeling. Revit Architecture, Autodesk Robot Structural Analysis, Revit Structure, Autodesk Design Review, MS project, and Navisworks manage tools were used to redesign the project. The project is being split to achieve the study's objectives, and the most important aspects of each stage have been appraised and incorporated into the program. The 3D model was formed employing Autodesk Revit in accordance with the MEP features. The Revit model was transferred to Navisworks for Clash Detection, whereas MS project was used to create the scheduling, which was then integrated into Navisworks. Then, the quantity takeoff was formed in Revit and converted to Excel immediately, while the Revit model was attached with Autodesk Robot Structural Analysis for undertaking the structural analysis. After the design, the site inspection was conducted, where Autodesk Design review was used for clarification of the design elements. Approximately one month was spent for modeling the project.

(a)



(b)



(c)

Figure 2. Comparison among: a) 3D Architecture, b) 3D structural drawing, c) 2D drafting: floor plan.

5. Results and discussion

5.1 3D system workflow

Traditionally, the information flow in the residential project was operated by incorporating 2D CAD. In the design phase, the preliminary design was followed by an evaluation by the customer and a rework period. After the client has evaluated and confirmed the concept design, the schematic design process begins. Similarly, there is a review and revision process for the schematic design. The design team moved on to the comprehensive design phase after receiving the owner's approval for the schematic design. When comparing the conventional 2D CAD process to the newly produced BIM-based model, various wastes can be removed, and several benefits are gained from the new 3D model.

Enhanced visualization: With a physical model, 3D models were developed and stored in 3D Revit, enabling the client and contractors to navigate, view easily, and envision the project's specifications, even also having the option of using the relevant information.

Time wastage due to waiting: To use the newly developed BIM model, the designers would not have to wait in line for each other. Consequently, data will be transmitted early and readily through the model, allowing interdisciplinary teams (Architecture, Structural, and MEP Engineers) to work on designs at the same time. According to the case study, BIM cut the time necessary for the design process in half by eliminating the waste of time in the prior design method.

Decrease steps: In the traditional 2D CAD paper-based method, minimizing redundant processes allows for increased consistency. It also minimizes the time it took for details of drawing, printing, and delivery. Collaborative work in the BIM model will bring new opportunities to save time, such as clash detection and off-site prefabrication, which could help to avoid any implementation complications.

Nonstop information flow: Due to early data transmission between users in a BIM-based design, information will be updated. This allows the design to be adjusted, modified, and evolved in as little time as possible. Players will be able to communicate more efficiently and information will flow more smoothly due to the clear representation of design. Previously, Eldeep et al. (2022) also studied on the information flow process model of the BIM and achieved it as a lean management tools in an university project.

The client can take part early in the design process with the new BIM model, avoid delay design decisions by pulling any data related to design from the model. This procedure will save much time for the repetition of work. Being continuously engaged with the development of design, the client can provide early feedback so that the value of function will be optimized throughout the project's life cycle.

5.2 As-built before construction

The precast pile was the structural system used in this residential construction. The technique of putting a precast pile in place is to raise the actual measurements from the field, which determines the exact measurements of the precast pile, and then submit the pile's detailed drawings. The subcontractor started off-site prefabrication of the precast piles after the consultant approved the design and shop drawings. Then, as indicated in Figure 3(a), it was transported and installed on the job site. This process needed three weeks to be completed.

The three-week wait in planning and installing the precast pile is immediately apparent as a waste of time. As the BIM model is able to rectify data and dimensions of the project, it may reduce time consumption and waste. After finishing the structural design in Autodesk Robot, the design team and the precast pile subcontractor should begin an iteration phase. The BIM model will be used to facilitate information sharing and exchange. The column size, beam dimensions, slab thicknesses, and surface loading types were forecasted and estimated prior to establishing the Robot model as presented in Figure 3(b). The contractor will receive the BIM model, determine the precast pile numbers and dimensions, and make the precast pile drawings. Next, the designers re-integrate the precast pile elaborate design with the previous version and look for any problems. Then the model will be simple to synchronize the pile caps carried by the precast piles during the execution phase. Using this method, the structural design and the comprehensive design of other trades and related tasks, will be completed ahead of schedule. The as-built model will be completed before the implementation begins, so detailed drawings will be merged.

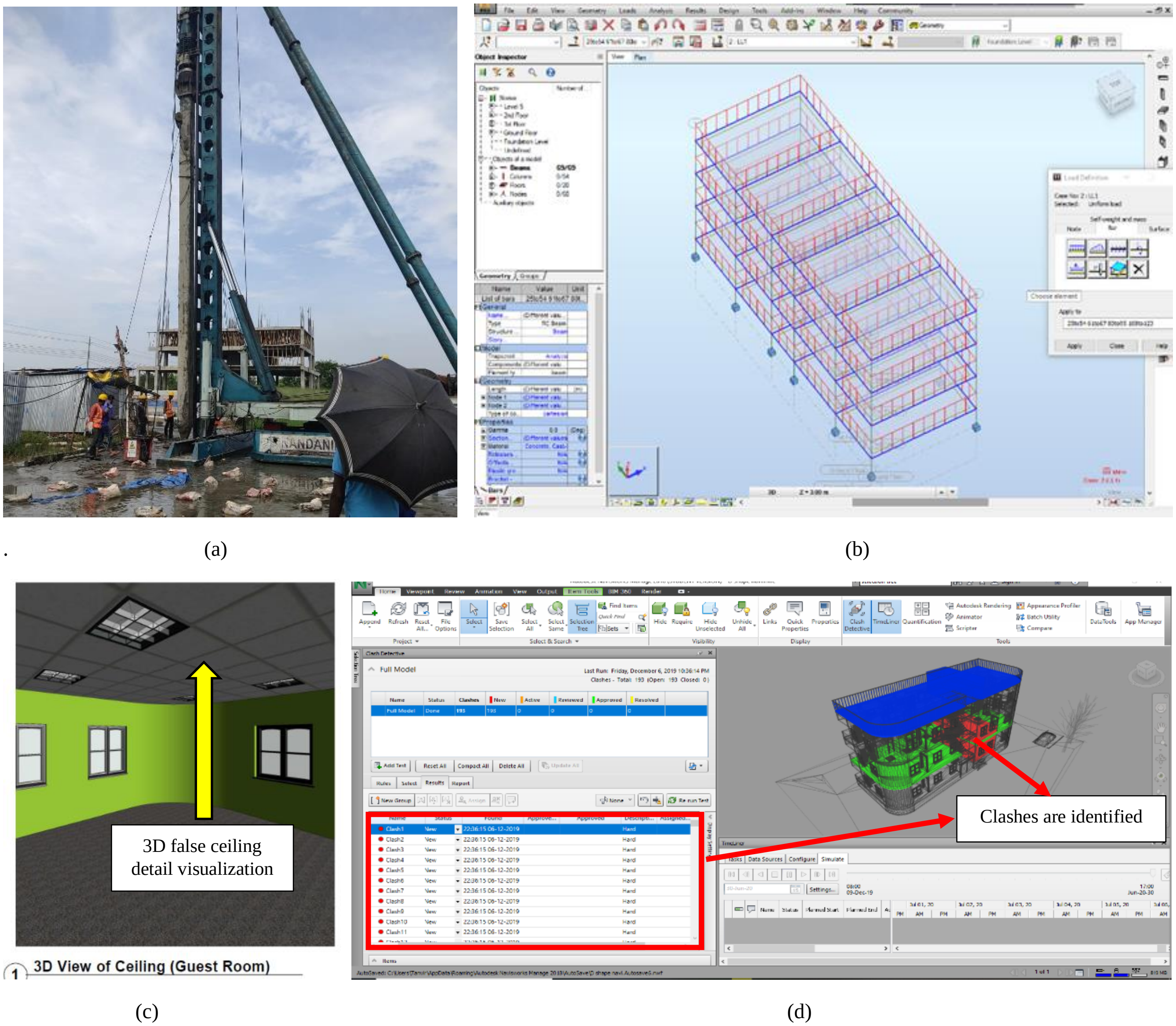


Figure 3. As built prefabrication: a) installation of on-site precast piles, b) autodesk robot structural analysis, c) 3D false ceiling detailling, d) clash detection.

The casting of the pile could be completed three weeks ahead of schedule and without any alterations due to the BIM model and process. The BIM model can help save up to one and a half months for a residential project using As-built before construction/prefabrication by minimizing time waste. This method can also be used to quickly install additional parts, for instance, HVAC, electrical, and plumbing systems. Furthermore, disturbances in the workplace will be reduced, and the mobility of people and items will be limited. This will improve site security and morale, as well as the crew's confidence and professionalism in their work. According to Tserng et al. (2014), schedule management linked with the BIM method is becoming increasingly important to improve the general contractor's use of visual construction management during the construction phase. Their investigation introduces a unique system dubbed the Construction BIM-assisted Schedule Management (ConBIM-SM) system for local contractors in Taiwan to improve visualization of the revised as-built schedule for the construction contractor.

Many on-site activities, such as structural concrete, architectural features (walls, doors, ceilings, etc.), mechanical, electrical, and plumbing can all be included in the BIM model for this project. The 2D CAD drawing, for example, lacked false ceiling detailing and did not describe numerous aspects needed to install false ceiling elements on-site. Figure 3(c) illustrates all of the features of the false ceiling with all important measurements and heights which were generated in the BIM model. This image represents a detailed visualization experience before commencing the project works and it would be possible with the help of BIM technologies.

5.3 Clash detection

The clashes for the project were detected using the Revit and Navisworks tools. Customers can use Navisworks to access and integrate 3D models, move them about in real-time, and analyze them using various techniques like as comments, viewpoints, and so on. Over 100 clashes and flaws, reflecting collisions between various parts and components of the project, for example, architectural elements, RCC structure, mechanical, electrical, and plumping, were detected and resolved. Figure 3(d) shows some clashes which are found between individual components in the 3D model. Some of the discovered clashes between individual components in the 3D model are shown in Figure 4. It can be seen that collisions between mechanical works and air conditioning ducts as well as stair riser and tread mismatches caused major problems on the construction site of this project. Because several and diverse parties such as Architects, Civil, and MEP engineers undertake the project's design work, design errors are frequent in the AEC business. These errors in the design could result in rework and construction waste. By finding and correcting design faults, design reviews, and conflict detection are BIM-based solutions for decreasing construction and design waste. The 3D model properly illustrates the linkages between each part and allows for cross-industry collaboration. It is estimated that employing a BIM model for a home project would save a minimum of three weeks and 400,000tk (BDT) in the project due to design flaws. Furthermore, the traditional design stage could have been modified from a faulty to a quasi-integrated design process.

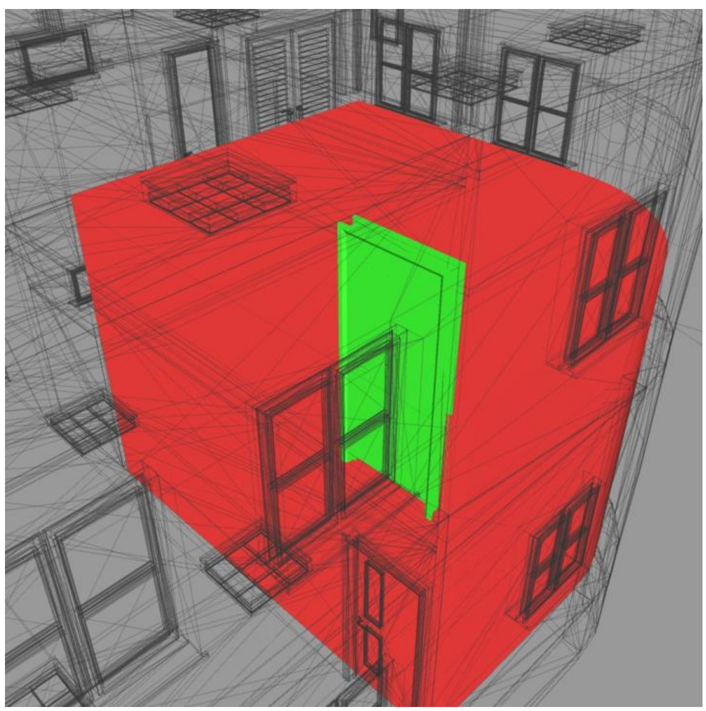


Figure 4. Clash detection of the real field project by Navisworks.

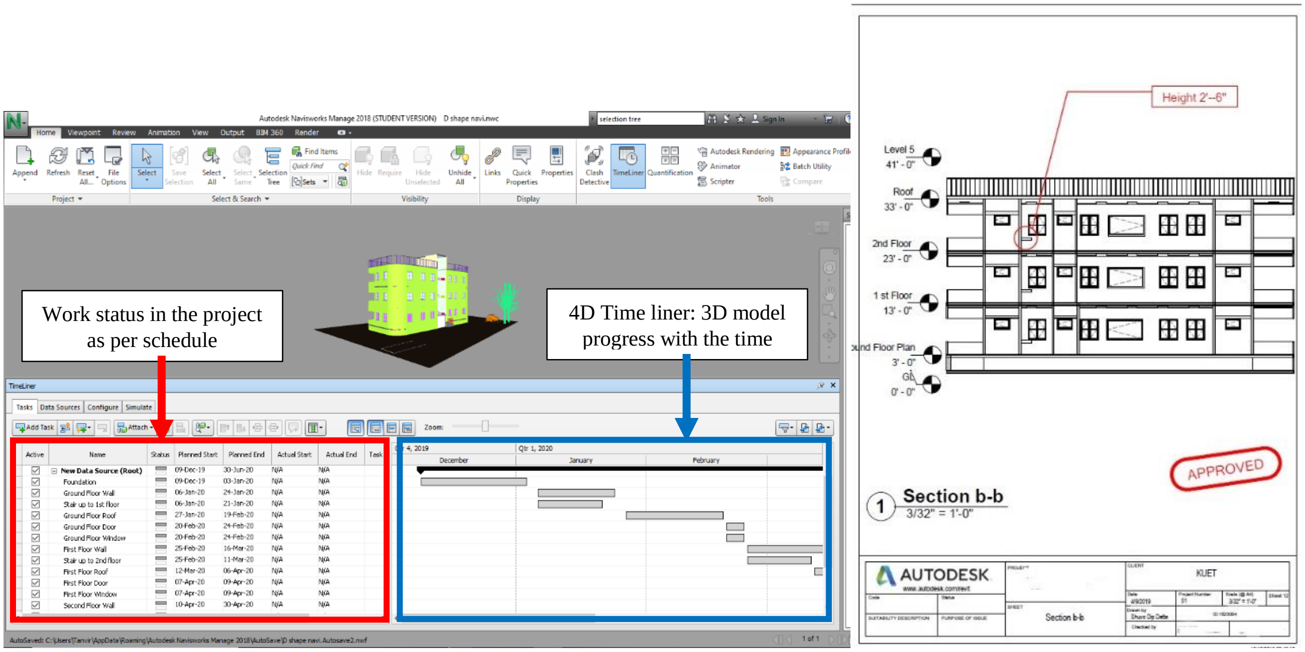
5.4 Implementation of 4D BIM

When compared to the creation of 3D BIM projects, the development of a 4D-BIM project required several additional processes. Figure 5(a) presents the 4D timeliner of the project using Autodesk Navisworks Manage. In this image, we can see the work progress with time implying whether the project was within the schedule or not. The schedule planning and modeling teams must work together to ensure consistent design products. According to the study, despite the fact that 4D BIM has important advantages for project performance, it is not commonly applied, especially in developing countries. This study looked into the benefits and drawbacks of using different BIM platform software to integrate schedule, cost, and time, as well as environmental impacts: Autodesk Revit for making 3D-BIM models, Microsoft Project for elaborating schedules, and Autodesk Navisworks for developing construction simulations. Due to improper scheduling, the project timetable was shattered during onsite construction. In this project, project schedule variance is computed as a percentage difference between the building's planned and real construction durations, where the superstructure construction work takes 13.91 percent longer due to manual scheduling. Changes in design solutions in structures throughout the construction phase were the cause of the increased duration. A viable option is using cloud-based 4D BIM to adjust the schedule and decrease schedule variance issues. Therefore, the authors attempted to integrate the 4D BIM model into the cloud-based system.

When designing and installing the drop panel, there was a delay of three weeks, which, is an example of a waiting time waste. Due to the fact that the created BIM model includes exact information and measurements about the building, this type of waste may be eradicated and removed from the structure. A new technique should be taken to reduce this waste; After finishing the structural design, an iterative process should be established between the design team and the subcontractor. The sharing and exchange of information will be the foundation of this process, which will make use of the BIM model. The subcontractor will receive the model, extract the quantities and measurements of drop panels, and produce the design and details of the panels. Following this step, the design team will combine the detailed design with the initial model and check for any conflicts that may arise. It will then be simple to synchronize the execution phase with the design phase in order to have accurate drop panels. By employing this strategy, the structural design will avoid any kind of uncertainty as well as the thorough design of other trades and related operations. The as-built model will be ready before commencing implementation; hence, the design and shop drawings were merged.

5.5 Implementation of 5D BIM

Quantity takeoffs provide answers to questions like how much equipment is used and how much it costs through data, comments, and solutions. As a result, the ability to generate takeoffs efficiently is a huge plus. The difficulties and benefits of adopting 5D BIM have also been compared to the findings of this study. According to the findings, 5D BIM may have benefits over conventional estimation methods in terms of increasing collaboration among project team members, increasing project understanding for best cost and time assessment, increasing visualization of construction details, integrating 3D with time and cost, and minimizing change orders. However, it has been difficult to implement 5D BIM in real construction fields for various reasons. The belief of the companies that their software provides more accurate performance than BIM, Lack of guidelines for coding objects within the information of the project and shortage of qualified employees to navigate the BIM are the main obstacles. In addition, to the provided timetable parameters, Revit may estimate quantified numbers for computing the overall cost. To compute the overall expenditure of the project, the bill of quantities must be entered.



(a) (b)

Figure 5. a) 4D time liner using Autodesk Navisworks Manage, b) RFI assessment by BIM engineer.

5.6 Change order and BIM model inspection

The case study project has 12 change orders and approximately 55 RFIs (Contractor Requests for Information). Figure 5 (b) presents the RFI reply of the BIM engineer, where the visualization on clarification was emphasized. Owner-initiated changes have emerged as the project's most major source of change. It was observed that the owner visited the site frequently during the project's execution. A lot of the owner's adjustments were required to do the project. A few alterations were made, such as the quantity and location of balconies, the quality of finishes, and room proportions. Around 7 change orders were handled to accommodate the owner's requests. It was also analyzed how those changes would affect the project's schedule and budget. As a result, the timeline was extended and the associated costs were adopted. As the client did not have any clear vision of the project at the planning stage, he made those revisions. He did not get any idea when he saw the 2D project plans. After the beginning of construction works, when the plans were executed at the field, the client started prompting modifications. However, during the design stage, if the owner saw a 3D or 4D model, he would give his feedback.

BIM inspection was intended to test the results of BIM models before using them in ongoing maintenance. By checking the validity and consistency of BIM models, this proposed management reduces the risk of mistakes and misconceptions when using updated BIM models for service and maintenance.

5.7. Cost and schedule breakdown

Figures 6 and 7 represents the cost and schedule breakdown of the project using the traditional approach and BIM tools. It can be seen that the project cost was reduced significantly when BIM was implemented. There were some inappropriate designs, and clashes in the design which were identified through using BIM before the project started. These clashes could improve the cost if the project were commenced without identifying these. But using Navisworks over 100 clashes and flaws, for example, architectural elements, RCC structure, mechanical, electrical, and plumping, were detected and resolved. On the other hand, there were several client change orders which were solved before the implementation phase since the client got a real 3D experience of his building. With the implementation of BIM tools, the project cost was reduced by almost 400,000 tk (BDT) whereas the time was reduced 1 month.

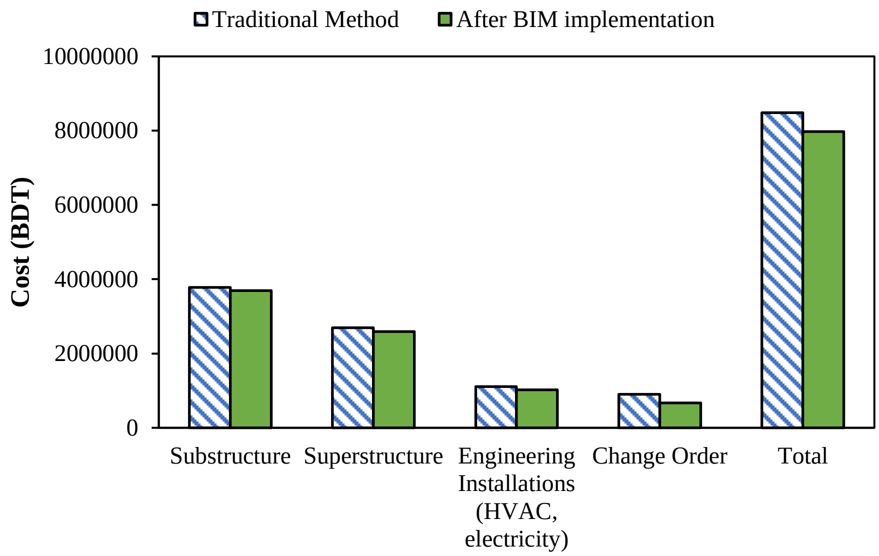


Figure 6. The total distribution of the budget of the whole construction project implementing traditional and BIM tools.

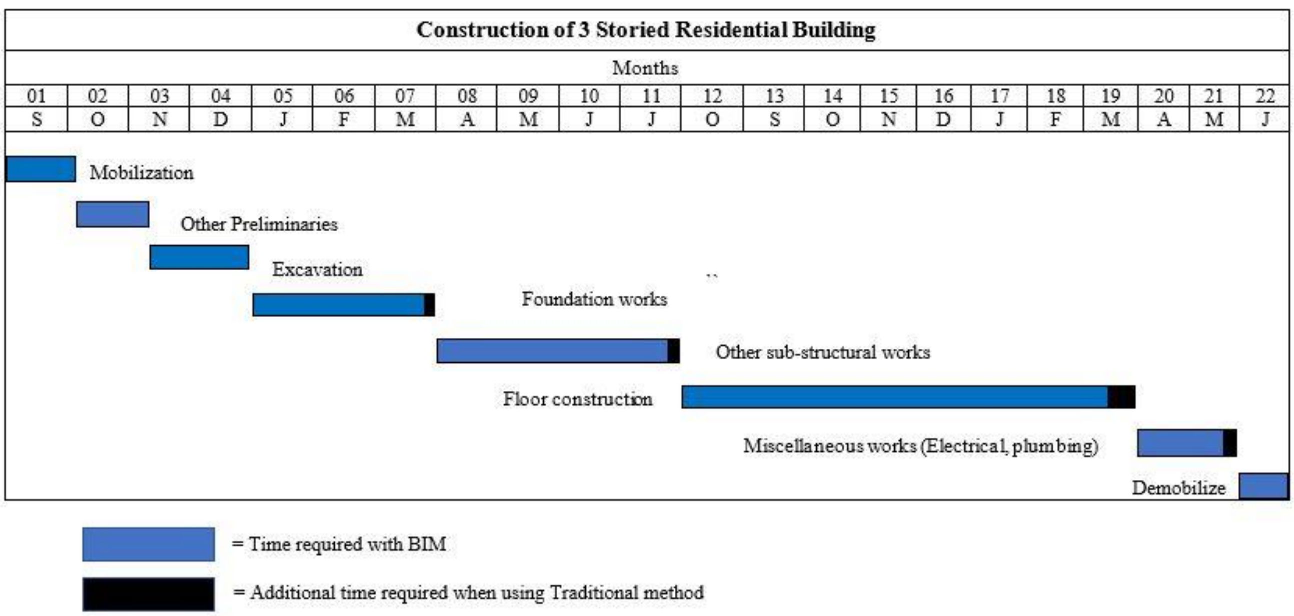


Figure 7. The total distribution of the schedule of the whole construction project implementing traditional and BIM tools.

6. Practical implications

The primary contribution of this study lies in its investigation of the BIM-based building design process from a stakeholder's perspective. As opposed to past studies that mostly focused on BIM-based building design procedures, machine-readable formats for rules and regulations, etc., this research takes a more practical approach. According to the study, it can be difficult for municipalities or other public regulatory bodies to adopt BIM for the building design process in Bangladesh. However, management support, the advantages of a BIM-based building design system, employee involvement early on through training programs, and BIM awareness can all act as catalysts for successfully implementing a BIM-based building design process. The use of a single case study and a qualitative methodology has made it possible to fully comprehend the phenomena being studied (BIM adoption for building design processing and compared with the traditional method). As a result, a rich, diverse picture of the organizational setting has emerged, which is important for advancing our knowledge in this recently developed field of study. However, because this study is based on a single case study, rather than a comparative analysis of multiple case studies, which would need to account for the differences in organizational cases, it may also limit the generalizability of its findings to other industries and countries. On the other hand, this allows for greater depth than a comparative analysis of multiple case studies, which would need to account for the differences in organizational cases. This investigation used a qualitative approach to enable an understanding of stakeholders' perceptions of the context of the implementation of BIM-based process for building design, which in turn led to the derivation of a list of factors that affect it. Other existing studies on BIM adoption factors in the AEC industry have primarily employed quantitative methods. Future research is also encouraged in order to lessen the difficulties associated with BIM-based building permit procedures, for instance through the development of decision support systems for BIM-based building permit processes and multiple criteria evaluations.

7. Conclusions

BIM can reduce many wastes during construction, including inappropriate design, communication gaps, and unanticipated modifications in designs during construction. BIM enables the development of a precise prediction that is rich in data and free of clashes, allowing for better decision-making at various stages of the construction process.

According to this study, integrating BIM into design work greatly enhances project efficiency. BIM was able to cut the time required for design progression in half by reducing the time spent for waiting. The BIM model additionally includes information from Autodesk Robot Structural Analysis, Autodesk Navisworks Manage, and MS project. By installing the precast pile just in time and eliminating the waiting time waste, the BIM model enables saving up to one month for the project. Besides, BIM-based techniques, such as design reviews and collision detections, are used to reduce design and construction waste by eliminating design issues discovered during construction. Using the BIM model to find clashes is predicted to save at least one month and 400,000 tk (BDT) in design errors and client change orders.

Despite the fact that it is nearly impossible to eradicate all changes that may occur on any project, this study finds that BIM can reduce the cost and duration of change orders. The greatest significant reduction in change orders was observed when BIM was implemented on the project. Around 9 out of 12 change orders (more than 75%) connected to owner and design-related changes can be avoided using the BIM model, making the project more linear. As a result, BIM-based models save time and money when compared to traditional construction methods.

7. Limitations and future study

This study is an exploratory attempt to implement BIM tools in the construction of residential buildings in Bangladesh while evaluating the positive impacts of BIM in project management over the traditional approach.

However, this case study has a few limitations in evaluating 6D and 7D benefits by utilizing BIM. Further studies regarding this topic may employ additional details, variables, scheduling algorithms, as well as optimization techniques to carry out projects on schedule while staying within budgets. In addition, further studies can be done by utilizing BIM technology in large infrastructure projects to evaluate 3D to 7D effectiveness in the construction industry.

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