AN APPLICATION OF BUILDING INFORMATION MODELING (BIM) IN CONSTRUCTION SCHEDULE MANAGEMENT – A CASE STUDY OF OLALANI RIVERSIDE TOWER PROJECT

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Abstract - This study focuses on the research and application of Building Information Modeling (BIM), specifically BIM 4D – the integration of time (schedule) into a 3D model – to enhance the effectiveness of construction schedule management. Through theoretical analysis, assessment of current practices, and practical application of BIM 4D at the Olalani Riverside Tower project in Danang city, the study highlights the significant potential of this technology in visualizing construction methods, monitoring progress, facilitating coordination, and improving accuracy in project execution. This research has cleared up the effectiveness of applying BIM in construction schedule management to a specific project, demonstrating benefits in areas such as enhanced visualization of construction methods, optimized scheduling and resource allocation, improved coordination among project stakeholders, and effectiveness in communication efforts. Consequently, it contributes to reinforcing and promoting the broader adoption of BIM and a more robust digital transformation in the construction industry.

Key words - BIM; BIM 4D; schedule management; construction simulation; Revit; Fuzor; Microsoft Project

1. Introduction

In recent years, thanks to rapid advances in science and technology - particularly the Fourth Industrial Revolution - Building Information Modeling (BIM) has emerged as a major trend in the construction industry. BIM represents a transformative shift in addressing long-standing issues related to productivity, efficiency, and safety in construction [1]. The term “Building Information Modeling” refers not only to the digital model itself but also to the process of information modeling throughout the project lifecycle.

Based on years of practical application in many countries, BIM has proven to be an effective tool for managing and sharing information among key project stakeholders, including owners, architects, design consultants, and construction contractors. Recognizing the importance of BIM in enhancing the Vietnamese construction sector, the government has issued guidance on BIM implementation, aiming to establish standards that are suitable for Vietnam’s socioeconomic conditions and to encourage broader participation from private enterprises.

On March 17, 2023, the Prime Minister of Vietnam approved Decision No. 258/QĐ-TTg, officially endorsing the roadmap for implementing BIM in construction activities [2]. Construction schedule management is a critical component of the project management process. It plays a decisive role in project success, as it enables the allocation of resources such as equipment, materials, and labor over time to ensure that the project is completed on schedule and within a budget. Beyond simply defining task sequences, effective scheduling allows stakeholders to assess project feasibility, estimate preliminary costs, optimize resource utilization, and monitor progress to ensure work is proceeding efficiently and aligned with the client's goals. Inadequate schedule planning can lead to project delays and budget overruns. BIM technology has been applied to improve performance in construction schedule management [3].

The emergence of BIM has transformed project management practices, helping managers perform their tasks more efficiently. The development of the fourth dimension (BIM 4D) - which incorporates time-related data into the 3D model - allows for simulation and optimization of the construction process, delivering measurable benefits. According to Candelario-Garrido, BIM 4D simulations are 40% more effective than traditional planning methods [4]. Furthermore, the visual nature of BIM 4D enhances understanding of construction processes, facilitates clearer communication, and fosters better collaboration among all project stakeholders.

In this study, Autodesk Revit and Fuzor were used as BIM tools, the most professional building design tools in construction. Revit software assists in creating sustainable building architectural models. Then Fuzor software plays the role of integrating the project's 3D model with the approved construction schedule to create the BIM 4D model of the project. The study provides a solution for applying BIM to construction schedule management and evaluates the suitability of the BIM 4D approach in a specific project application. The second contribution of this study is to advance domain knowledge and support the professional community in promoting digital transformation within the construction industry, aligning with the progress of Industry 4.0.

2. Research methodology and Case study.

2.1. Research methodology

To generate an effective BIM 4D construction schedule simulation, the overall process is outlined in Figure 1, encompassing three key stages: Firstly, the complete 3D building models (containing geometric and material information) along with the construction method model are meticulously developed in Autodesk Revit. Subsequently, the construction schedule is established in Microsoft Project, with quantity data extracted and directly linked from the 3D model, then exported to XML format for integration. This entire process ensures comprehensive synchronization and visualization.

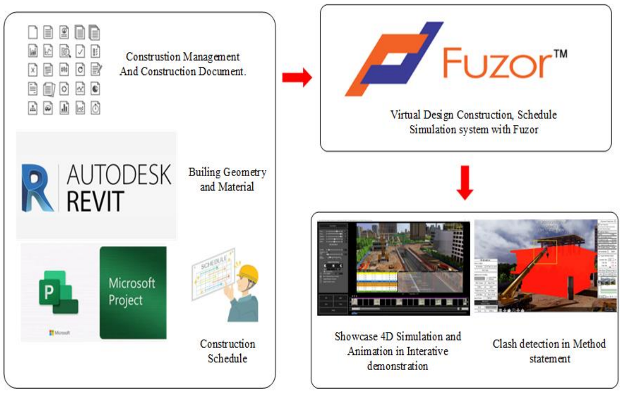

Figure 1. 4D simulation with Autodesk Revit, Microsoft Project and Fuzor

Based on the technical documentation from the design unit, the design drawings are issued. Revit is used to create a 3D model of the project with a predefined Level of Development (LOD). This main model is divided into three component models, including: The Structural-Architectural Elements Model, the Construction Method Model, and the Construction Site Layout Model. Based on the work volume extracted from the model, the contracted work volume, and the approved preliminary construction methods, the construction schedule is created and then converted into XML format in preparation for data import into Fuzor.

After combining the component models with schedule information using Fuzor, the resulting output is a 4D animation of the construction project. From this animation, users can visually manage the schedule, check for conflicts, and make appropriate adjustments to optimize the schedule and construction methods.

2.2. Case Study

The three-level basement structure of the high-rise building at the Olalani Riverside Tower project in Da Nang city, which serves as the illustrative case study for this research, is comprehensively showcased in Figure 2. Located alongside the Han River, this high-rise residential building features a basement floor area of 5566 m² and a basement level height of 3.2m. The structure is designed as monolithic reinforced concrete with resistance to seawater corrosion. The construction method implemented for the underground portion involves open excavation combined with diaphragm walls and a strutting system to implement BIM 4D for this project, the entire BIM model is divided into three main component models: the Underground Structure Model (Figure 2), the Excavation and Strutting System Construction Method Model (Figure 3), and the Overall Construction Site Organization Model. (Figure 4)

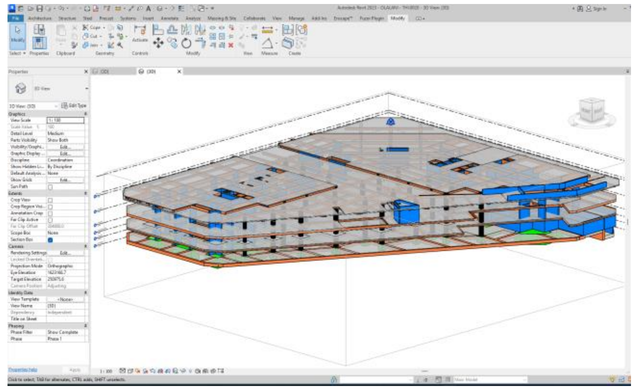

Figure 2. 3D Structure model with Autodesk Revit

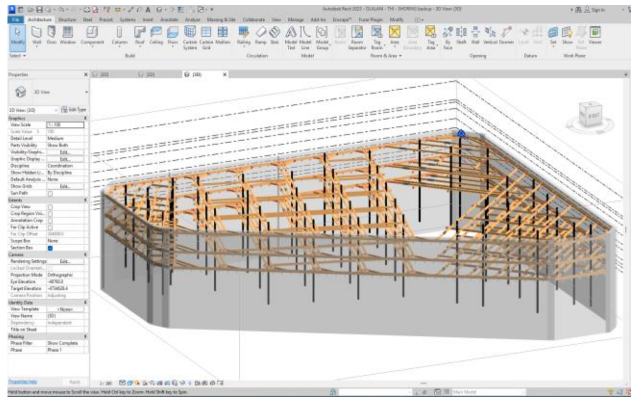

Figure 3. 3D method statement model with Autodesk Revit

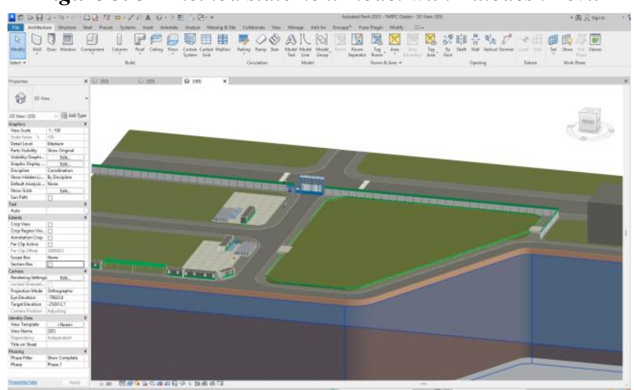

Figure 4. 3D construction site layout model with Autodesk Revit

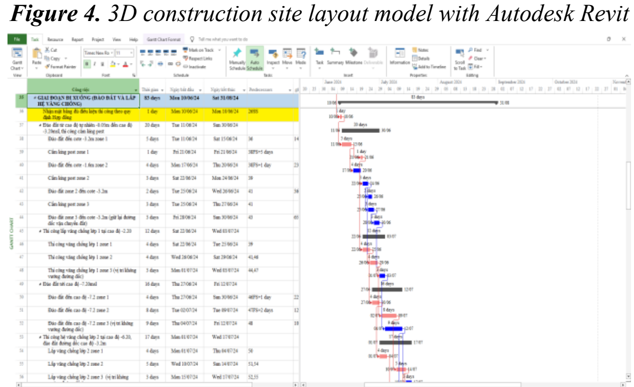

Figure 5. Construction schedule with Microsoft Project

The established construction schedule is detailed, as presented in Figure 5. Its initiation was based on estimated quantities derived from component 3D models and preliminary construction methods approved by the investor. Subsequently, with key milestones defined, more detailed tasks for individual components are meticulously added and refined to ensure logical continuity and practical feasibility during implementation. Finally, the completed schedule is exported to XML format, ready for integration into Fuzor software for the subsequent 4D simulation steps.

Once the necessary data and models have been prepared, Fuzor is used to perform BIM 4D simulation. This software allows for the connection of 3D models with the detailed construction schedule, thereby creating a visual simulation of the construction process as it unfolds over time. The results of this simulation provide significant practical benefits, enabling stakeholders to easily visualize the project's progress, the sequence of work execution, proactively identify potential conflicts, and effectively optimize the construction plan, while also enhancing professionalism in project communication.

Figure 6. *Combined models with Fuzor*

The process of integrating component models, subsequent to their import into Fuzor software, to create a comprehensive overall model is illustrated in Figure 6. This consolidated model encompasses the main structure, construction methods, and the overall construction site layout. It will serve as the primary working environment for performing 4D animation operations. Any modifications made to the component models will also be synchronously updated from Revit to Fuzor.

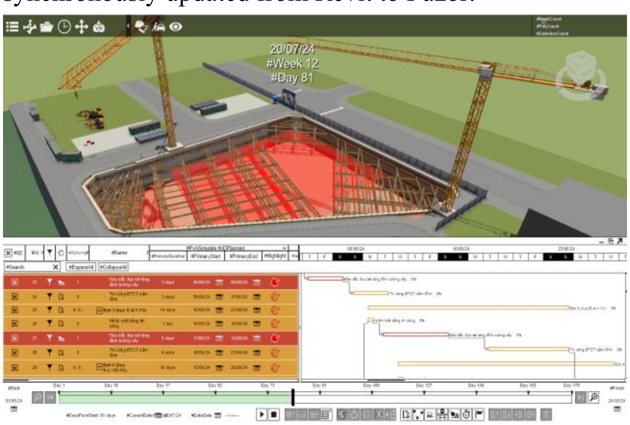

Figure 7. *Assign work components into Loaded Schedule with Fuzor*

The process of integrating the construction schedule, prepared in XML format, into Fuzor software is illustrated in Figure 7. Within the Fuzor environment, structural components to be constructed and elements related to the method statement are linked to specific schedule tasks in the project timeline. Once time-related information has been assigned to each component, a preliminary 4D simulation model is generated, visually representing the project's evolution over time.

The process of assigning animation direction and the construction order for components within Fuzor is visually illustrated in Figure 8. Following the integration of time-related information, establishing the construction sequence becomes crucial, ensuring that the animation realistically and accurately reflects the actual construction progress. This, in turn, leads to a more precise identification of potential spatial and temporal construction conflicts.

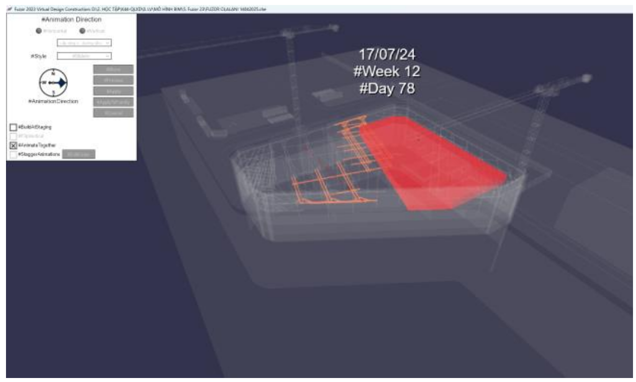

Figure 8. *Assign animation direction and construct order of components with fuzor*

During the implementation of BIM 4D, to optimizing the construction plan, the contractor takes a proactive role in reviewing and detecting early potential conflicts regarding both spatial constraints and the construction sequence. Through this process, valuable adjustments and recommendations can be promptly provided to all relevant stakeholders, playing a pivotal role in ensuring the project's timeline and superior quality are maintained (Figure 9).

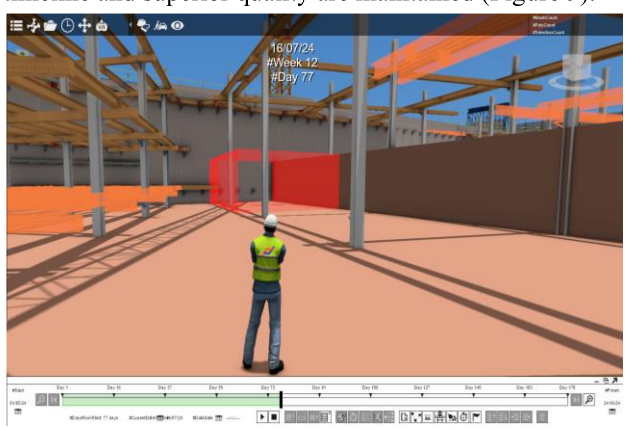

Figure 9. *Construction phase conflict checking process*

3. Result analysis

3.1. Effectiveness in Visualizing Construction Methods

The very high effectiveness of BIM 4D in visualizing the entire construction methodology is demonstrated in Figure 10. This encompasses its capability to clearly display the complete project model with the overall site plan, detail each construction step sequentially and by area, and provide a real-time simulation that allows viewers to perceive changes across both space and time.

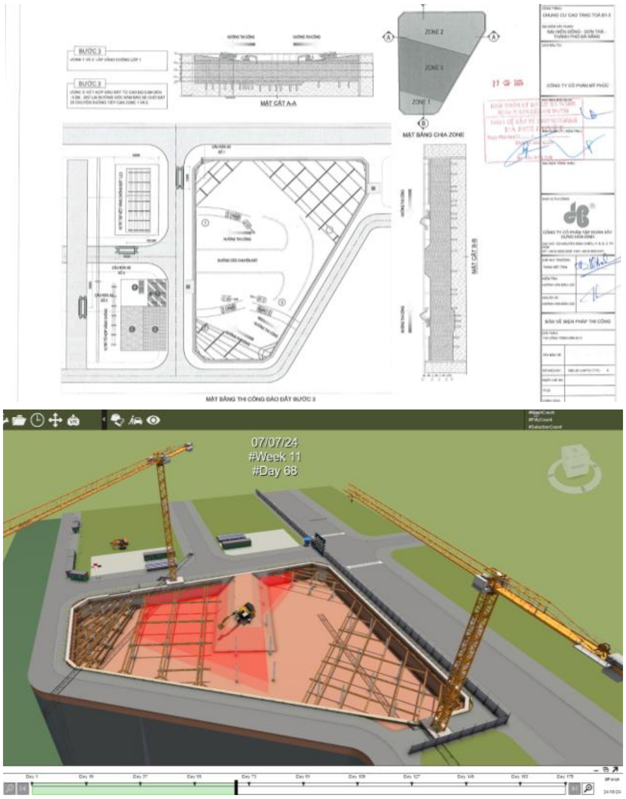

Figure 10. *Comparison between reviewing construction methods using 2d drawings and 4d animation*

3.2. Effectiveness in Optimizing Methods and Schedule

Thanks to the application of BIM 4D, the site management team can easily check for schedule conflicts such as overlapping or illogical tasks. This allows for early resolution and the development of specific solutions.

Furthermore, BIM 4D enables the testing of various construction organization scenarios and the selection of the optimal approach.

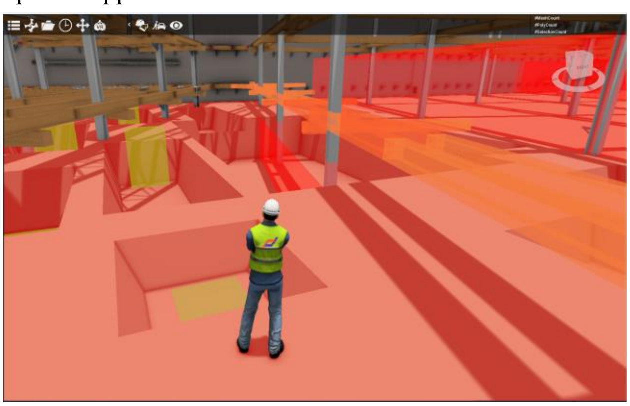

Figure 11. *Adjusting the excavation and strutting construction scope to align with the structural construction schedule*

To accelerate the construction schedule of the pit's foundation, the excavation scope of the third layer in Zone 1 was extended into Zone 3, allowing for the early installation of the third layer of struts at this location. This strategic adjustment, illustrated in Figure 11, facilitates the structural construction of Pit Zone 1 without further delays, thereby shortening the schedule of this Pit Zone construction by 7 days.

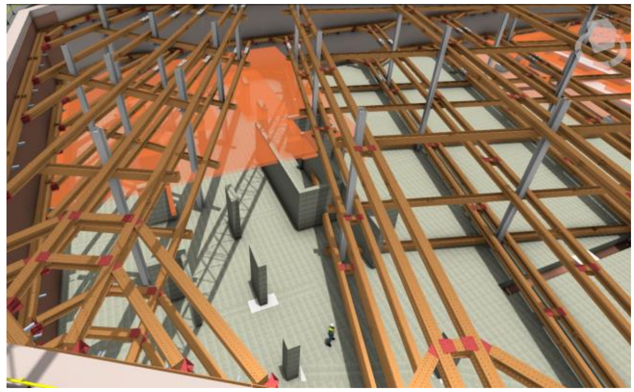

Figure 12*. Conflict between strut removal time and wall structure construction*

The conflict between the construction of the elevator core walls in Zone 1 and the third layer of the strutting system is clearly illustrated in Figure 12. To avoid impacting the B2 floor's completion schedule, this elevator core wall necessitates earlier construction. This, in turn, requires the recalculation of a reinforced support system to allow for the premature removal of the struts without awaiting the B3 basement floor concrete to reach its full strength. Early conflict detection and resolution enabled the author to find solutions swiftly with relevant stakeholders, significantly reducing the typical 2-3 working day delay usually incurred when conflicts arise close to the construction phase

3.3. Effectiveness in Construction Coordination and Collaboration

BIM 4D animation facilitates communication and discussion among project stakeholders, such as the Investor, Supervision Consultant, and Contractor, on a visual model instead of relying on static schedules and dry 2D drawings.

Thanks to dynamic visual data and logical sequence simulation, it helps stakeholders make quick and accurate decisions, enhancing the efficiency of resource and work coordination on the construction site.

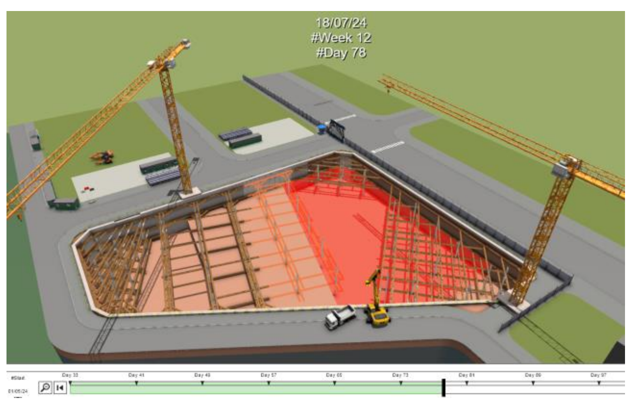

Figure 13. *Coordinating excavation work, soil transportation routes, and strut installation*

During the strut installation in the ramp area, the original soil transportation route was disrupted and necessitated redirection to an internal road running along the riverbank. However, at the commencement time, this alternative route was not yet complete. Figure 13 clearly illustrates this situation, simultaneously demonstrating how, thanks to the BIM 4D simulation, the coordination between the contractor and the Investor in determining the handover time for the internal road became significantly clearer and more efficient. The visualization of the schedule on the model helped both parties easily agree on the completion milestone for the construction infrastructure, thereby ensuring the excavation progress committed by the contractor.

3.4. Effectiveness in Communication Efforts

The application of BIM 4D not only effectively supports schedule management but also brings significant practical value to site operations and information dissemination. In particular, BIM 4D becomes a useful visual tool in training, helping foremen and workers easily understand the construction process, while also assisting site engineers in visualizing the execution sequence. The vivid simulation with dynamic images not only helps participants quickly grasp the content but also creates enthusiasm during technical briefings.

Furthermore, BIM 4D contributes to enhancing professionalism in communicating and presenting project information to stakeholders:

- Presenting tender documents visually and comprehensibly: Utilizing BIM 4D simulations clearly illustrates the construction organization methods and project schedule with dynamic visuals instead of relying solely on tables and dry text. This helps contractors make a strong impression on the Investor and enhances their competitiveness when participating in bidding.

- Presenting progress reports vividly and easily trackable: Instead of traditional text-based reports, BIM 4D allows for the display of actual progress directly on the 3D model, visually illustrating each completed and upcoming item. This enables stakeholders to easily understand the situation and make quick, accurate decisions.

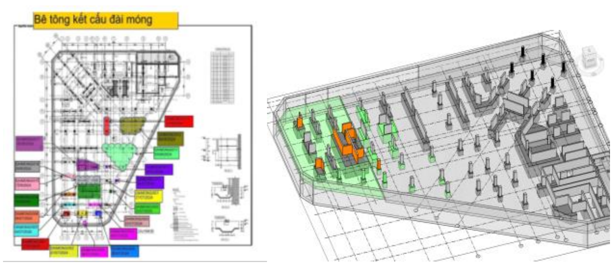

Figure 14. *Comparison illustrating traditional and bim-based work progress reporting*

Figure 14 illustrates the difference between the traditional method of reporting work progress and the application of BIM. While the traditional approach relies on coloring and marking completed areas on static 2D drawings, BIM offers a significant advancement by embedding the necessary information directly into the 3D model. This integration not only helps stakeholders easily grasp the actual situation visually but also allows for quick access to relevant detailed data, optimizing communication effectiveness and decision-making within the project.

4. Conclusions

The application of the Building Information Model (BIM) 4D in construction schedule management for the case study project has clearly demonstrated the efficiency and practicality of this technology within the context of a construction industry increasingly demanding accuracy, transparency, and resource optimization.

BIM 4D is not merely the integration of a 3D model with the time element; it is a comprehensive support tool for planning, construction monitoring, and multidisciplinary coordination. Through its ability to simulate the construction sequence in real-time, project stakeholders can easily visualize the entire implementation process, identify spatial and temporal conflicts early on, and assess the rationality of the proposed schedule. This is particularly beneficial in large-scale, multi-basement, multi-item projects like the applied case study, where there are high demands for construction progress, accuracy, and coordination between architectural, structural, mechanical, electrical, and plumbing (MEP), and construction disciplines.

Furthermore, the use of BIM 4D enhances transparency and professionalism in progress reporting, construction method presentations, and communication with stakeholders, including the investor, supervision consultant, and regulatory authorities. This reduces risks arising from errors in the planning process, limits on-site conflicts, and improves the ability to control the overall schedule and make timely adjustments when changes occur.

The practical application in the real-world project confirms that BIM 4D has significantly contributed to the modernization of construction schedule management, transforming it from a manual process to a more digitalized, visual, logical, and proactive one. This is also a step in line with the digital transformation trend in the construction industry, helping to enhance the competitiveness and sustainable development of domestic construction enterprises.

Therefore, expanding the application of BIM 4D, not only in the case study project but also in future construction projects, is entirely necessary and highly feasible. This requires synchronization in awareness, implementation capabilities, and technological infrastructure among all parties in the construction value chain, from design consultants to contractors and investors.

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