Challenges of BIM Technology and Lean Theory in the Construction Industry in Vietnam

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ABSTRACT

Vietnam's construction industry is in the development stage. Construction problems and especially the issue of construction quality are considered and analyzed from numerous aspects. Currently, building information modeling (BIM) technology plays a major role in the development of the construction industry. Companies, governments, experts, and training providers aim for the widespread adoption of BIM. BIM development stages are being continually edited and oriented to suit each development point. Moreover, lean construction philosophies are gradually being applied to construction implementation based on BIM technology. This philosophy helps ensure construction quality and enhances BIM processes in construction projects. The current study has initially analyzed construction quality needs with the lean philosophy applied in BIM technology. The basic challenges are identified and management solutions are proposed for construction projects to meet customer needs.

Keywords-BIM; lean; quality; management; construction

I. INTRODUCTION

The construction industry plays a vital role in economic development. Meeting quality in construction is also an aspect that needs careful consideration and evaluation [1]. The construction market in Vietnam is on continuous development Technologies and sciences related to the construction sector are also regularly updated and applied. However, in construction, there are many unnecessary losses and material waste. The issue of incorrect estimations in construction reveals that the project scale is inappropriate and that there are inefficiencies in the building structure. For instance, it is common for homeowners to demolish walls and change the interior space of a building after receiving apartments and townhouses from the investor. Additionally, issues arise from changes in the planning and project structure [2]. Moreover, the existing conflict among the architecture, structure and construction fields, may lead to ineffective performance in the construction industry [3]. The waste in construction accounts for up to 12% of the total project cost (Figure 1). Thus, these wastes can be considered and analyzed before investing in construction, leading to more optimized project costs [3]. Today, with new construction technologies and improved project management processes, BIM technology has emerged as a comprehensive solution in construction [5]. In Vietnam, since 2016, the government has established policies and roadmaps for BIM development derived from research topics, projects, and legal or sub-legal documents, such as the Decision 2500/QD-TTg issued by the Prime Minister on addressing to applying BIM in construction, project management, and operation. Additionally, Decision 203/QD-BXD, issued by the Ministry of Construction, established the National BIM Steering Committee. Until now, the application of BIM has been affirmed by Decision 258/QD-TTg of the Prime Minister,

which was issued on March 17, 2023, and outlines the roadmap for the stages of applying BIM in construction.

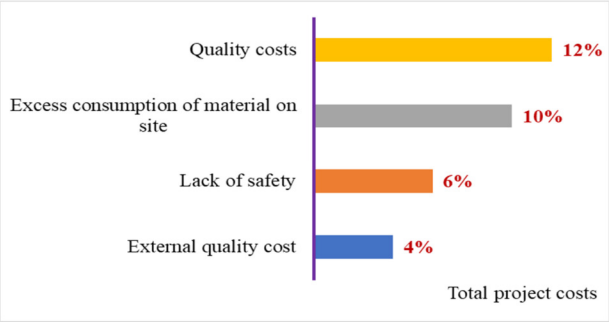

Fig. 1. Waste in the construction industry (data from [4]).

Thus, BIM has become an essential technology in construction. It helps construction work become more streamlined. Construction quality is more assured, particularly in terms of transparency in construction project management [6, 7]. These issues are of particular concern. Lean construction is a project management process that ensures efficiency in terms of quality, cost-effectiveness, and safety within the construction environment. In particular, BIM helps design projects comprehensively with a multidimensional perspective. Hence, the application of 4D and 5D BIM has established construction implementation processes. As a result, solutions for the construction progress can be provided in compliance with the construction process and resource appropriate establishment [8]. BIM assists in connecting units, namely investors, designers, and contractors, in the construction industry. At the same time, ensuring the construction process is streamlined, and construction quality is consistent with user needs [9]. This study is based on a survey of solutions for developing the construction industry in Vietnam. In particular, BIM technology is proposed as a future development tool.

II. BACKGROUND TO STUDY BIM

BIM technology in Vietnam has been applied and put into practice. However, there are still many research and analysis issues. The basis for BIM implementation in Vietnam can be seen in the following aspects:

A. Legal Documents

- Construction Law-Law 50/QH13/2014 (June 18, 2014) mentioned basic principles in construction investment and project management activities using BIM technology (Article 4 and Article 66).
- Circular 12/2021/TT-BXD (August 31, 2021) of the Ministry of Construction promoting construction norms and costs for applying BIM is specified in Section 1, Part I, Appendix VIII.
- Decision 348/QD-BXD (April 2, 2021) on the publication of General Instructions for applying BIM.
- Decree 10/2021/ND-CP (February 9, 2021) on investment cost management in construction, showing the application of BIM and costs for BIM (Article 6 and Article 31).
- Decree 15/2021/ND-CP (March 3, 2021) on construction investment project management, demonstrating project management using BIM (article 66).
- The Prime Minister has approved the roadmap to apply BIM in construction activities in Decision 258/QD-TTg (March 17, 2023). Phase 1 from 2023 to 2025 has to do with applying mandatory BIM to works of level 1 and above, and phase 2 from 2025 onwards has to do with applying BIM to works of level 2 and above.

B. Demand for BIM

Research demonstrates that BIM understanding is quite high (63.3% in Vietnam [10] and 46.2% in Malaysia [11, 12]). If the BIM level is at level 2 or higher, in most countries, the BIM adoption rate ranges from 42% to 90% (Figure. 2). Meanwhile, the survey shows interest in BIM at 64%, and 90% of companies require BIM skills, as exhibited in [12].

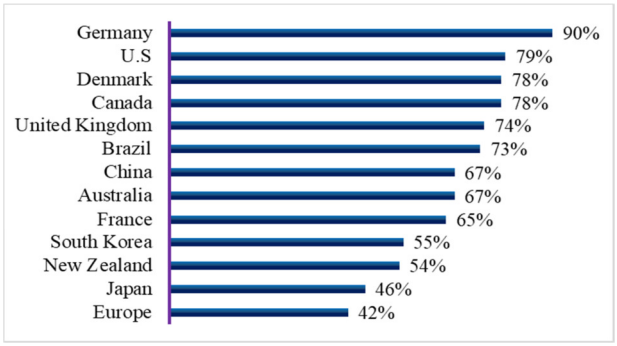

Fig. 2. Rate of BIM use in construction (data from [13, 14]).

Surveys of recruitment information in popular job markets show high demand for BIM. Recruiting candidates with BIM knowledge in construction is an advantage.

C. Efficiency at Work

Clash detection, as one of the BIM functions, has been widely utilized to improve construction quality. The conflict detection rate was 76% and the error reduction was reported by 73% of the people surveyed, as evidenced in [15]. Furthermore, shaping and analyzing connections in BIM is more convenient, especially in locations with complex steel structures. Material statistics is also an excellent tool for the evaluation of construction projects. The material statistics in BIM are conducted based on the building structure and the building simulation layers. The more accurate the construction simulation is, the more detailed is the level of material statistics. Regarding material inventory time, BIM technology outperforms experts' estimations (saving 87% of implementation time [12]). Considering statistical accuracy, BIM achieves absolute accuracy according to construction simulation. Therefore, BIM technology achieves transparency from the design stage to the construction process [16]. In addition, the Return on Investment of BIM projects (BIM ROI) is extremely attractive, ranging from 39.9% to 140% [17].

BIM helps simulate the entire building. It can review and optimize the building performance [18], in which dynamic

simulation can visualize what structure the building will have after construction. Relationships in BIM are also considered favorable. Parties involved in the project can directly evaluate structural changes based on BIM, hence, coordinating adjustments from the investor, design consultants, construction contractors, and managers. This coordination helps improve the project construction process faster and in accordance with reality [19].

III. LEAN CONSTRUCTION

Lean theory originates from production activities in factories [20]. This lean thinking was introduced in the 1900s [2, 29]. Applying lean theory in construction is a mindset of meeting customer needs, eliminating waste, and adapting to the environment and the times. The potential of lean in construction is highly appreciated (Figure. 3) and it has many practical benefits for construction companies [21].

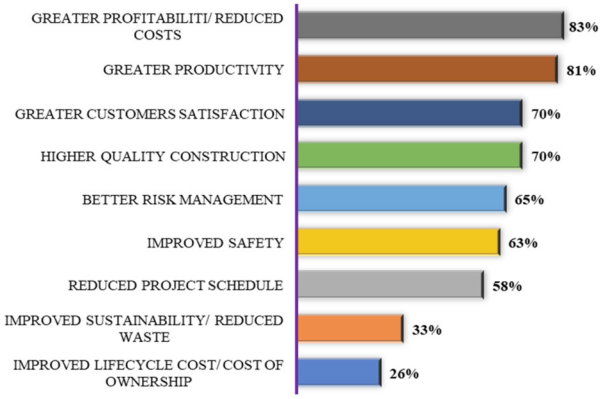

Fig. 3. Potential benefits of applying lean philosophy in construction (data from [21]).

Lean construction is a production philosophy which aims to achieve optimization in construction ranging from effectively using resources, materials, and construction time. To serve lean theory, construction scheduling methods have been proposed with different types of diagrams, such as horizontal diagrams, oblique diagrams, network diagrams, etc. Each scheduling method has its advantages and disadvantages. In general, it has helped clarify construction management issues, utilizing resources in accordance with needs. However, it is still not possible to fully satisfy the lean theory.

Moreover, to meet lean skills, it is necessary to have a huge and orderly information source. Regarding document employment, managers will be required to memorize documents, drawings, and decisions about the project. It is also necessary to fully grasp the partners participating in the project, the order of work, and implementation methods. Thus, the manager needs a lot of auxiliary human resources and the auxiliary personnel's capacity is also required to be at a high level, leading to increased project management costs, while the quality of work is sometimes not smooth and accurate.

Surveys related to companies applying lean theory in construction (Figure. 3) show that saving project costs is very common (83% of companies agree) and shortens construction progress (58% of companies agree). In addition, general contractor companies (Figure. 4) can reduce both operating costs (36% of respondents agree) and labor accidents (35% of respondents agree) [21].

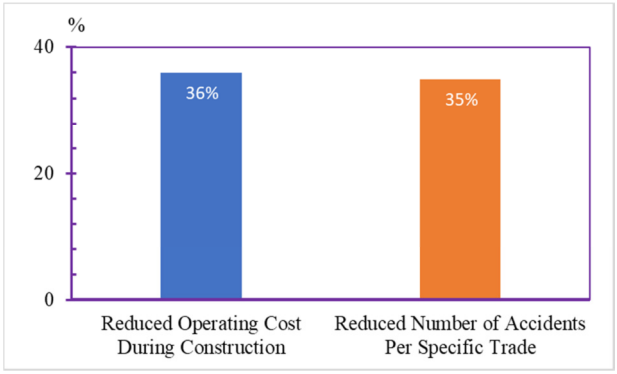

Fig. 4. Measurement of profits generated by the lean construction (data from [21]).

Meanwhile, BIM is a construction visualization tool that stores information about each item in that construction. With BIM 4D/5D, integrating time into the project will increase the level of convenient project information management. Construction components that have been completed and will be implemented soon can be fully simulated by BIM. If combined with other project management software, such as Oracle Primavera P6 [22, 23], the arrangement of work content will be in appropriate sequences and shorten meetings and negotiations on implementing construction work in the future. Research conducted for construction projects has revealed that when applying BIM and lean theory (Figure. 5), it helps reduce the contract price by 11% and the entire project construction time by 25% [24].

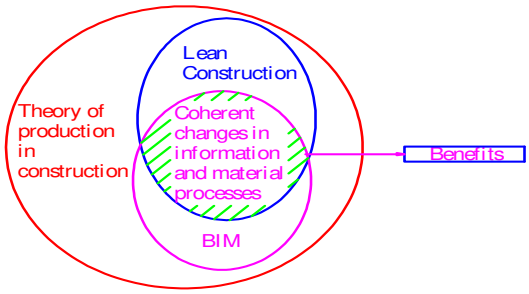

Fig. 5. Integrating lean theory and BIM [24].

Lean theory is a work implementation direction, not a method, tool, or process for improving construction quality. Therefore, integrating lean construction theory into BIM will be a suitable technique on the basis of the current conditions in ensuring construction quality [9, 21].

IV. CONSTRUCTION QUALITY

The quality of a construction project is measured by the ability in meeting the technical, aesthetic, safety, and

environmental sustainability requirements of the project, while also meeting construction regulations and standards, as well as regulations in relevant legal documents and economic contracts. To certyify quality, in addition to meeting construction standards (according to national regulations the needs of construction product users should be met. For instance, the lack of early customer involvement in construction has led to an unnecessary increase in work. Numerous users have had to remove the entire interior of the house to rebuild it. Surveys concerning this problem have been encountered in apartments and some townhouses or villas. Thus, the initial cost of completing the apartment and the cost of users to demolish and refinish it will cause waste. Meanwhile, regarding the process of refinishing, construction management still has many places without strict supervision. Demolition of structures and walls still occurs regularly, and leaks and seepage in toilet areas arise again. These are still consistent with the original quality claims. However, meeting user needs is still lacking.

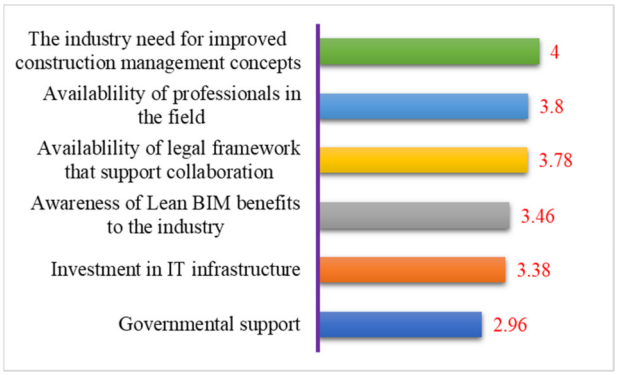

Fig. 6. Challenges of lean theory in BIM-based construction (note: challenges increase from 0 to the highest 5. Data from [23]).

Streamlining construction based on BIM technology, in addition to active support from the government, will bring commensurate benefits. On the contrary, it will face challenges, namely lack of experts and large initial investment (Figure. 6). Thus, construction quality can be improved based on BIM technology, in which the integration of compact theories helps make the project completion process more transparent and clearer. The tasks, investment costs, and resource usage in each phase are fully illustrated before construction begins.

V. MANAGEMENT OF CONSTRUCTION QUALITY BASED ON THE LEAN THEORY IN BIM TECHNOLOGY

In order to use the lean theory in construction and BIM technology, some proposed solutions for quality management are provided:

- Management of Project Quality Based on Government Planning:

Based on the government's construction development planning, construction planning must meet current needs and sustainable development in the future. The relationship between housing planning and urban infrastructure is a problem that needs to be balanced. At that time, the quality of the project will respond to the needs of sustainable use. Planning issues based on BIM technology will provide clearer management and more suitable construction structures for functions and operating capacity enhancement. This promotes urban development with a longer vision and is consistent with the government's development support for construction quality management. Construction quality management in Vietnam is based on national standards and issued in the form of legal documents. These standards provide general regulations for all construction projects in terms of project design, construction, acceptance, operation management and maintenance. Urban planning and construction documents are reviewed and evaluated periodically every 5 years, with appropriate adjustments being made according to the specific development conditions of each region.

- Management of Construction Quality Based on National BIM Standards:

Vietnam's BIM planning is built and oriented for each period. Starting from 2017, BIM development plans have been implemented (The government directly requires some projects to apply BIM). Currently, BIM planning is divided into 2 periods from 2021 to 2025 and from 2026 to 2030, with mandatory regulations on applying BIM for projects ranging from level 2 and above (Decision No. 258/QD-TTg). With this development plan, the conditions for BIM development become clear and BIM application projects have a greater legal basis concerning implementation and management. In particular, this plan offers clarity and transparency in project management. In addition to the mandatory application of BIM for projects, the Government has issued general BIM application guidelines for all projects (Decision No. 348/QD-BXD), which describe in detail the processes of BIM project application. National and international conferences on BIM are held annually. The comprehensive assessment of BIM development stages is also regularly conducted by ministerial-level management agencies. The government often implements and closely monitors BIM development agreements with companies.

- Management of Construction Quality Based on the Lean Theory in BIM Technology:

This constitutes coordination within the same environment. If the designs are changed, the construction repairs processes and stances from different perspectives, entailing investors, construction units, managers, etc. This covers all technical needs, construction and post-construction management, project performance, and suitability to customer needs (Figure. 7). BIM is a tool that connects the fragmentation between opposing segments in construction projects, unifying the coordination of general resources and resources for real-time tasks. Since then, the project has met technical, environmental, and planning space standards. The lean construction in BIM always focuses on all processes, entailing design, construction, and operations management, and each stage has an appropriate management process according to BIM technology with a lean construction philosophy. The end of the production process is a product that meets customer needs, eliminates waste, and maximizes profits. This will respond to the sustainability requirements of the project. Applying lean theory to

construction is a new concept, and there is no in-depth training on this subject in Vietnam. Besides, BIM technology is currently not fully promoted in construction. As a result, significant waste in construction persists without a comprehensive solution provided to reduce it. In the field of high-rise building construction, it is common for customers to need to make repairs before using their apartments. Customers often spend between 10% and 20% of the total apartment cost to repair and redo the interior before moving in. This is so common that all apartment complexes form many groups specializing in building and perfecting apartments according to the homeowner's wishes. Thus, lean theory applied in BIM technology will bring good management effects in construction.

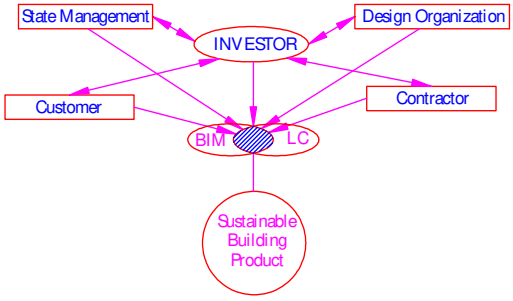

Fig. 7. Structure of BIM project management based on the lean theory in construction.

VI. CHALLENGES IN IMPLEMENTING THE LEAN CONSTRUCTION THEORY IN BIM TECHNOLOGY

The Lean theory and BIM bring many benefits in the construction field, such as helping to monitor working processes, reducing accidents in the construction, more accurate forecast of project completion time, reducing errors in the construction and ensuring the most optimal customer investment. To ascertain benefits in construction, possible challenges when applying lean thinking in BIM technology in Vietnam are expressed in the following aspects:

- Common Data Environment (CDE) is not unified: The system of CDEs when applying BIM has not been unified. Management units, investors and contractors still encounter difficulties when applying the CDE system. Moreover, coordination still faces many challenges, especially in how to choose CDE appropriately. In Decision No. 348/QD-BXD, only CDEs systems are listed, but there is no general consensus in government management. This problem can be seen through the Sadora high-rise building project (Ho Chi Minh city, Vietnam). This study reveals that 20% of surveys lack data consistency and 50% of surveys lack project information [24].
- The Lean theory in construction has not been perfected and plays a leading role in the construction industry: The concept of lean theory in construction has not been fully exploited and construction management is not fully simulated in BIM technology. Project management is still mainly based on paper documents [12], the determination of construction progress is predicted for each stage without generalization for the entire process.
- Customer inconvenience in using the product: In many high-rise building projects, customers often have to demolish and renovate the apartment upon handover, increasing costs and affecting the structure of the project. Adding or changing product functions during construction is still limited, this is because right from the initial stage there is no customer participation in the project design and the interaction between customers and investors and construction units is difficult. Therefore, there is a lot of waste in construction (73% of the survey said that detecting waste is very necessary [27]).
- Project management using BIM technology is still limited: Most project management relies on 2D paper records, which are authenticated with signatures and seals [26]. Therefore, when applying BIM, it is difficult to authenticate the legality of the project using the model of BIM technology, which makes it challenging to apply BIM technology for the entire life cycle of a construction project. To ensure the legality of projects in BIM technology, it is necessary to have a common data management environment in which legality is recognized, only then will BIM technology truly play a central role in a construction project and the lean theory can promote efficiency in production.
- Skilled workers in BIM in construction: Currently, the lack of the skilled workers [27] in BIM technology is limiting the development of BIM [26]. BIM human resources are lacking in both the construction companies and state management agencies [28]. Units specializing in BIM have not been deployed in state management agencies, so the application of BIM by consulting units occurs sometimes only for project demonstration purposes [26], while it has not been thoroughly applied to the main activities of the project. The Lean construction philosophies have not been fully understood and applied to projects using BIM technology. The building of an "e-government" in Vietnam has been promoted since 2020. However, information synchronization still faces many difficulties although construction management has been developed (such as 100% bidding management on the network from 2024 by website "www.muasamcong.mpi.gov.vn"). Nevertheless, meeting BIM application capacity is still limited and project management records have not become a synchronized system yet.

These challenges still play a major role in hindering BIM development in Vietnam. Overcoming these challenges is a positive and long-term transition process.

VII. CONCLUSIONS

Lean construction is a project management philosophy that ensures economic, technical, and sustainable use. This philosophy is thoroughly applied in construction with different project management methods, especially in construction scheduling solutions. However, the streamlining in construction when applied to BIM technology truly ascertains construction

quality for investors and managers and the satisfaction of customer needs.

The need to deploy BIM in construction has been proven through actual work, and it has been confirmed by legal documents.

The BIM application plan has been implemented by the Vietnamese government since 2017, it is divided into many different development stages and is managed by the National BIM Steering Committee. Up to now, the directions for BIM application are also clear (after 2026, level 2 and higher projects are required to apply BIM). Consulting firms, contractors and managers have also incorporated BIM technology into the strategy and existence of the construction industry.

BIM application directions are also clear. Consulting companies, contractors, and managers have also incorporated BIM technology into the strategy and existence of the construction industry.

Lean production based on BIM technology helps construction activities certify order in production, coordinate resources appropriately for each stage, and reduce waste (time and resources). It also ensures that the final product meets customer needs and maximizes investor benefits. In particular, waste in construction will be minimized. Lean philosophy in Vietnam is a new concept, not yet clearly formed. But there were solutions during the construction process for streamlining in construction to be met. The challenges of CDEs in BIM management, limited human resources, and unsynchronized management, have required access and development in many aspects of the construction sector in Vietnam.

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