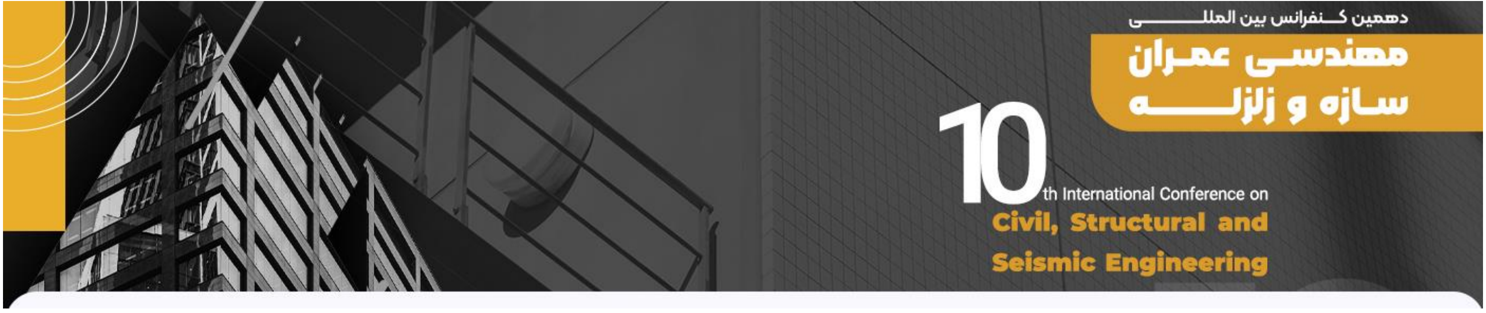

The influence of Building Information Modeling (BIM) technology on enhancing the project management

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ABSTRACT

Building Information Modeling (BIM) is regarded as one of the most significant and innovative technologies to emerge in the fields of engineering, architecture, and construction. The application of this technology facilitates the development of a precise digital virtual representation of the structure. Building Information Modeling (BIM) is a methodology employed in the planning, design, construction, and operational phases of facilities. This technology enables architects, engineers, and construction professionals to effectively visualize the structures to be constructed within a simulated setting. This article examines contemporary approaches, advantages, possible hazards, and the obstacles that lie ahead.

Keywords: *BIM, Technology, Construction, Intelligent management, Project management.*

1. *INTRODUCTION*

Building Information Modeling (BIM) represents a technologically advanced methodology for the creation, utilization, and management of critical design and project information related to buildings. This process facilitates the effective exploitation of data throughout the entire lifecycle of a structure, allowing for the visualization of this information through sophisticated three-dimensional digital models [1,2]. Although first conceptualized in the 1970s, creating building models was not commonplace, due to the expense and limited commercial availability of the necessary software, until the 1990s. As technological advancements progressed and became increasingly available, the methodologies for both the creation and analysis of three-dimensional digital models also evolved correspondingly. According to the definition provided by Oraee et al. [10], Building Information Modeling (BIM) is characterized as a comprehensive methodology that encompasses technological, agent-based, and managerial elements. The integration of Information and Communication Technology (ICT) within the construction industry led to significant innovations in the field [11,12].

BIM software is fundamentally based on three-dimensional parametric modeling, a technological approach that associates pertinent data with virtual construction elements such as walls, columns, electrical systems, and plumbing. This integration of information allows for the precise definition and management of the characteristics and functionalities of these building components [2]. This data may encompass various aspects, including geometric properties, relational geometric characteristics (such as being parallel to or offset from other elements), material attributes, design efficacy, supplier information, timelines, costs, and additional relevant factors [2]. BIM platforms facilitate the creation and visualization of object data within a precise three-dimensional building model, while BIM audit and analysis tools enhance the depth of information contained in the model through examination and augmentation. The significance of interoperability in Building Information Modeling (BIM) is rooted in its ability to facilitate smooth information exchanges across various disciplines. This capability not only improves communication and collaboration among project stakeholders but also theoretically leads to increased cost efficiency and reduced risk. Interoperability within Building Information Modeling (BIM) is primarily facilitated by the use of direct connections and open standards, notably the Industry Foundation Classes (IFC) [2]. Direct connections can be established when the Application

Programming Interface (API) of a particular application is capable of retrieving information that can be seamlessly converted into valuable data by the receiving API's translator [2]. Direct connections are typically provided between applications developed by the same manufacturer or through collaborative agreements between vendors. Industry foundation classes establish a flexible framework that facilitates seamless interaction and data exchange among various organizations. Project participants utilize their individual BIM software to generate an IFC model file, which is subsequently imported into the BIM software of the receiving party. The existing challenges in interoperability arise from the nature of the Industry Foundation Classes (IFC) as a loosely defined schema, which permits various interpretations and definitions of identical concepts. Groups of Building Information Modeling (BIM) specialists, along with various industry participants, are actively engaged in efforts to tackle this issue through the establishment of standards. The adoption of Building Information Modeling (BIM) significantly transforms various aspects of project execution, including workflows, the preparation of construction documentation, the delineation of project roles, and the communication between different disciplines involved in the project. Participation in projects utilizing Building Information Modeling (BIM) necessitates meticulous planning and improved collaboration, thereby compelling each participant to reassess their professional relationships and existing operational methodologies. Construction stakeholders frequently encounter significant obstacles in their efforts to complete projects while adhering to budgetary constraints, maintaining timelines, and meeting established quality standards [7,8].

2. Benefits of BIM

Building Information Modeling (BIM) serves as a digital representation that encapsulates both the physical attributes and functional features of a structure. Following the data collection phase, Building Information Modeling (BIM) projects require the establishment of a Common Data Environment (CDE) to facilitate centralized access to information for all individuals involved in the project. The implementation of Building Information Modeling (BIM) necessitates a transformation in the organizational culture, technological infrastructure, and operational procedures of a company. The adoption of Building Information Modeling (BIM) can significantly enhance the efficiency of construction projects by minimizing both time and costs, particularly when it replaces conventional 2D paper-based methods and non-parametric 3D techniques [2-5]. Numerous authors have explored the advantages of Building Information Modeling (BIM), highlighting several key benefits associated with its implementation:

- *Reduced conflicts during construction*
- *Enhanced communal comprehension of design objectives through superior visualization techniques.*
- *Reduced changes during construction*
- *Enhanced design outcomes can be achieved through comprehensive analysis, simulation, and performance benchmarking within Building Information Modeling (BIM) software, ultimately leading to superior quality in building construction.*
- *Improved coordination of construction documentation*
- *Increased collaboration and coordination*
- *Improved quality and safety*
- *Enhanced sustainability*
- *Improved facility management*
- *Improved synchronization of manufacturing processes and subcontractor activities, along with the automated production of fabrication and lifting schematics.*

It is evident that Building Information Modeling (BIM) possesses the capacity to provide numerous advantages to construction initiatives, which has consequently resulted in its growing adoption globally.

The successful application of Building Information Modeling (BIM) in collaborative projects necessitates the amalgamation of diverse information resources. Software interoperability refers to the capacity of multiple systems or components to communicate with one another and effectively utilize the information that is shared between them.

Generally, Building Information Modeling (BIM) software facilitates real-time collaboration among all participants involved in a construction project. This encompasses a range of professionals, including architects, engineers, contractors, and property owners. It facilitates a collaborative digital environment in which all stakeholders can simultaneously access identical information, thus contributing to the reduction of communication errors and delays. The implementation of Building Information Modeling (BIM) allows all *parties involved to assess and modify the design and construction strategies, leading to a more synchronized and effective construction workflow. So, Enhancing awareness is crucial for addressing the obstacles that hinder the adoption and implementation of Building Information Modeling (BIM), ultimately leading to the realization of its technological benefits [13].*

Building Information Modeling (BIM) facilitates the development of three-dimensional designs, thereby providing an improved visual depiction of the project. This enhances the comprehension of the various elements of the project and their spatial interconnections, facilitating the recognition of possible obstacles while also enabling the investigation of alternative solutions and opportunities throughout the planning stage.In addition, implementation of a collaborative virtual environment through Building Information Modeling (BIM) facilitates effective coordination among architects, engineers, contractors, and various other participants in the construction process. Finally, integrating cost information and construction timelines with the Building Information Modeling (BIM) framework enables project managers to make precise cost estimations, enhance the allocation of resources, and create more achievable schedules. This integration ultimately contributes to better management of both budgets and timelines throughout the project lifecycle. It has been demonstrated that the initial investment of time and effort in Building Information Modeling (BIM) is substantial; however, this investment is expected to yield quicker returns in complex projects compared to more conventional, repetitive projects.

3. Effect of BIM on project management

The growing intricacy of contemporary infrastructure and construction initiatives frequently renders conventional project management techniques inadequate, resulting in delays, budget excesses, and operational inefficiencies. Building Information Modelling (BIM) represents a transformative technology that significantly enhances the planning, execution, and management of civil engineering projects. Its capabilities streamline processes and improve efficiency, thereby redefining traditional methodologies in the field. On the other hand, Building Information Modeling (BIM) in the realm of construction project management represents a cooperative approach that encompasses the development and oversight of digital models reflecting both the physical attributes and functional specifications of a construction endeavor.

Building Information Modeling (BIM) represents a methodology that encompasses the creation and administration of digital models that accurately depict the physical and functional attributes of structures, as well as other tangible assets and facilities. This approach facilitates enhanced collaboration and efficiency throughout the lifecycle of a project, from design through construction and maintenance. In fact, BIM facilitates the project manager's ability to conduct swift evaluations of various scenarios and provide feedback to the owner, demonstrating the effects of design choices on both budget and timeline. Building Information Modeling (BIM) enables property owners to obtain a comprehensive digital representation of a building asset, integrating data collected throughout its entire lifecycle. When this information is incorporated into a real-time digital model, commonly referred to as a digital twin, facilities managers are equipped to leverage this transition to enhance the efficiency of various aspects of building operations.

Construction management constitutes a specialized professional service aimed at delivering comprehensive oversight to project owners regarding various critical aspects of a construction endeavor, including its timeline, budget, quality standards, safety measures, scope, and operational functionality. This management approach is versatile and can be effectively integrated with any method of project delivery. A BIM manager is a professional in civil engineering responsible for overseeing the implementation of all procedures related to Building Information Modeling (BIM) and Digital Construction throughout the phases of design, construction, and project handover. Digital Construction represents one of the two distinct workflows associated with BIM. Generally, BIM management involves the administration of Building Information Modeling processes and the application of BIM data to effectively manage Architectural, Engineering, and Construction (AEC) projects across their entire lifecycle. The process encompasses the structuring, execution, and ongoing management of Building Information Modeling standards, protocols, and workflows to facilitate seamless collaboration among stakeholders.

BIM (Building Information Modeling) management is based on five main principles, which are collaboration, communication, coordination, collation and exchange. As a result, implementation of Building Information Modeling (BIM) technology plays a crucial role in enhancing the management of construction projects. Accurate planning and scheduling is one of the methods of BIM to affect the overall productivity of the construction team – with less wasted time, more defined stages of construction, and figuring out possible prefabricated parts of the building beforehand. Better task scheduling. As a result, Building Information

Modeling (BIM) is essential in multiple stages of construction project management, offering a holistic and cohesive strategy for executing projects. An examination of the ways in which BIM improves each phase reveals its significant contributions to the overall process:

- *Accurate visualisation*
- *Design coordination*
- *Clash detection*
- *Rich data repository*
- *Efficient maintenance*
- *Lifecycle planning*

Several BIM tools and software such as Autodesk Revit, Autodesk Navisworks, Bentley Systems, Trimble Solutions and BIM 360, are widely used in construction project management, each offering unique features and benefits that enhance various aspects of project management. Autodesk Revit stands out as a premier Building Information Modeling (BIM) authoring software, specifically tailored for the design and documentation of architectural, structural, and mechanical, electrical, and plumbing (MEP) systems. Autodesk Navisworks serves as an all-encompassing platform designed for the integration of Building Information Modeling (BIM) coordination, the identification of clashes, and the simulation of construction processes over time, often referred to as 4D simulation. Bentley Systems provides a comprehensive range of Building Information Modeling (BIM) software solutions, which encompasses tools such as MicroStation, ProjectWise, and AECOsim Building Designer, each designed to address different facets of project management within a BIM framework. Trimble Solutions provides an array of Building Information Modeling (BIM) software applications, including Tekla Structures, Vico Office, and Trimble Connect, which are specifically designed to enhance structural design, facilitate construction management, and promote effective project collaboration. And finally, BIM 360, Autodesk's cloud-based platform, offers tools for BIM collaboration, document management, and project coordination. While Building Information Modeling (BIM) offers numerous advantages associated with its implementation, it is essential to acknowledge the potential risks that must be taken into account. The risks associated with projects can differ significantly based on a variety of factors; however, they typically encompass legal issues, financial uncertainties, and resistance to change among individuals involved. In conventional procurement practices, contracts primarily emphasize the rights and obligations of the parties involved. In contrast, the implementation of Building Information Modeling (BIM) necessitates a collaborative approach among all stakeholders, highlighting the importance of information sharing and teamwork. Consequently, the contracts typically employed in conventional procurement methods are unsuitable for application within the context of Building Information Modeling (BIM).

4. Effect of BIM on risk management

Risks represent unpredictable circumstances, and comprehending their implications can prove advantageous for any organization. Unanticipated events should be clearly identified, comprehended, and assessed to ensure that they are either mitigated, allocated to another party, or addressed in a manner deemed appropriate by the organization [3]. So, Risk managers must possess the capability to recognize the various components of risk, assess their significance, and effectively manage these risks as they arise. The objective of risk management is to enhance the likelihood and significance of favorable occurrences while simultaneously reducing the likelihood of adverse events affecting the project. The discussion of risks is a central theme in every team meeting, as the potential outcomes of risk-taking can lead to either success or failure. In fact, every project has a risk and risks must be managed [6]. Crooty [9] asserts that inadequate information quality is the primary factor contributing to subpar performance within the construction sector.

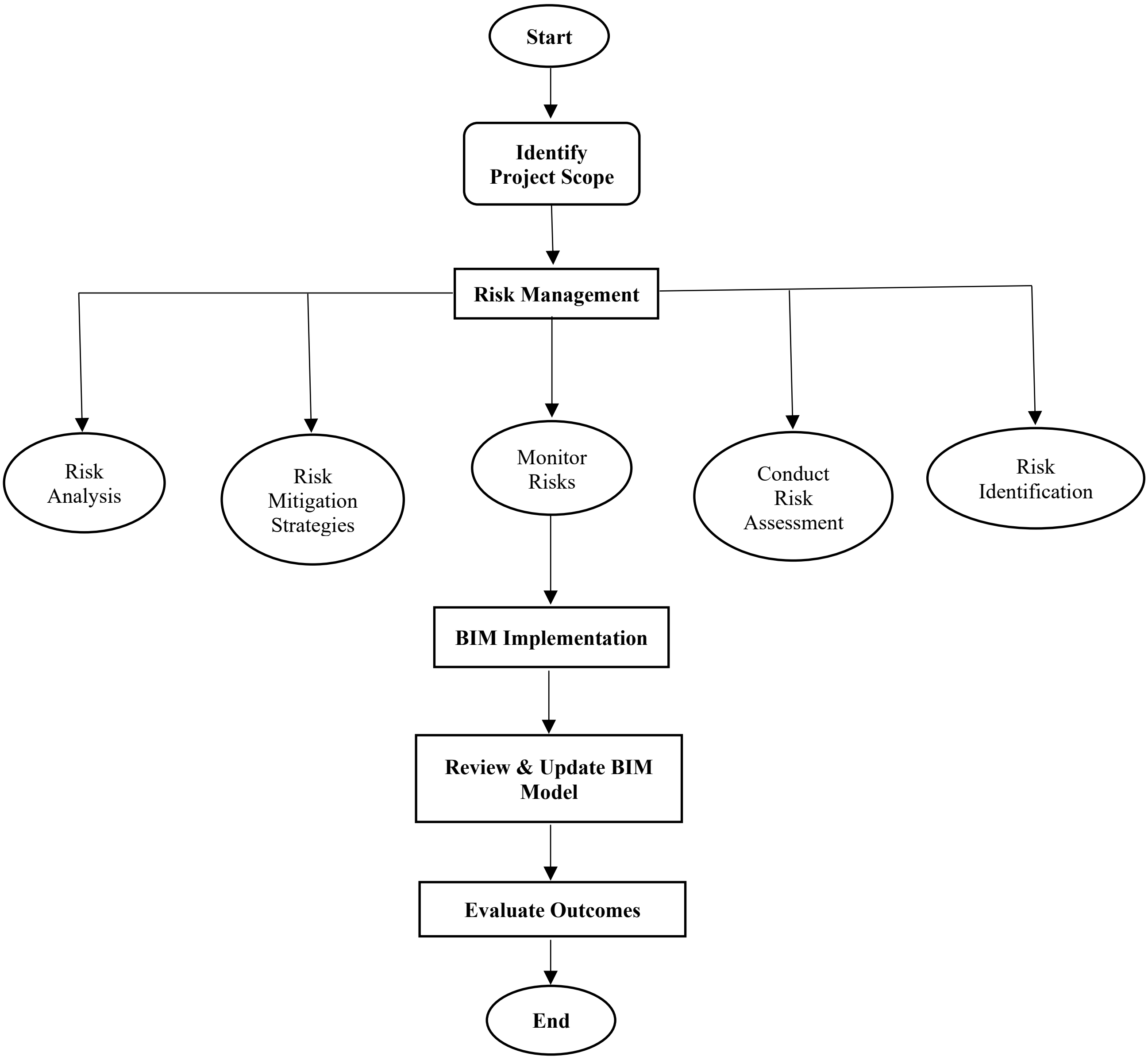

Fig.1. *The relationship between risk management and BIM implementation*

In the fields of architecture, engineering, and construction (AEC), the effective management of risk plays an essential role in guaranteeing the successful completion of any project. Evaluating a Building Information Modeling (BIM) ecosystem for potential hazards and risks prior to their emergence as issues contributes significantly to enhancing safety on construction sites. Risk management within the realm of civil engineering encompasses a range of activities, including the identification, analysis, assessment, and mitigation of potential risks that may affect the overall safety of a project. Civil engineering endeavors are characterized by their intricate nature, necessitating the collaboration of various stakeholders, the development of distinctive designs, and extensive financial analysis. The significance of risk management in civil engineering is paramount, as it serves a crucial function in mitigating unexpected challenges. In fact, the effective management of risks in civil engineering is crucial for the successful execution of construction projects. The process encompasses a methodical and comprehensive approach to recognizing, addressing, and alleviating the risks that subsequently influence the results of the project. The significance of risk management in civil engineering *endeavors is underscored by its capacity to eliminate delays, mitigate dangerous occurrences, and prevent budget excesses.*

As a result, Building Information Modeling (BIM) serves as an exceptional instrument for enhancing risk management within design and construction initiatives. The process facilitates the creation of a comprehensive digital model that encapsulates both the structural elements and their functional attributes. The utilization of diverse Building Information Modeling (BIM) tools enhances the processes of planning, drafting, and executing projects, thereby facilitating more effective risk management strategies.

Effective risk management in construction industry projects begins with conducting a thorough risk assessment. BIM tools enhance this process by offering comprehensive visual representations of the project, which assist in recognizing potential risks at different phases. Incorporating risk assessment during the initial stages of project planning enables project managers to formulate targeted mitigation strategies that address the identified risks. This procedure is consistent with the foundational tenets of risk management within the construction sector, facilitating the identification and mitigation of potential challenges prior to their advancement to subsequent phases. In addition, management of risk within construction projects places significant emphasis on safety, which is an essential component of the overall process. For this purpose, implementation of Building Information Modeling (BIM) has the potential to enhance safety management by facilitating the early identification of possible hazards during the initial phases of a project. Comprehensive three-dimensional models facilitate the visualization of site conditions, thereby enabling the effective planning of safety measures in response to those conditions. BIM also enhances safety training by enabling the development of virtual environments in which employees can engage in practice scenarios and gain a comprehensive understanding of safety protocols. The emphasis on safety corresponds with the overarching advantages of risk management within the field of civil engineering, as it mitigates the occurrence of accidents and improves the efficiency of project execution. In summary, as technological advancements progress, the significance of Building Information Modeling (BIM) in the realm of civil engineering risk management is poised to expand, offering increasingly sophisticated methodologies for risk mitigation and enhancing the overall value of construction initiatives. A further concern pertains to the stakeholders who stand to gain from the savings and profits associated with Building Information Modeling (BIM), as well as the party accountable for the expenses incurred during its implementation. Additionally, it is crucial to identify which entity will assume the risks associated with the adoption of BIM.

5. Conclusions

In summary, the influence of Building Information Modeling on the management of construction projects is significant and complex. As the need for expansive, intricate, and sustainable infrastructure initiatives escalates, it is essential for project managers to adopt Building Information Modeling (BIM) in order to maintain a competitive edge in the industry. Civil engineers who take the initiative to develop their skills and understanding of Building Information Modeling (BIM) will not only enhance their competitiveness in the employment landscape but will also establish themselves as pioneers in fostering innovation and improving operational efficiency within their organizations. In fact, the future of civil engineering project management is closely associated with the successful integration of Building Information Modeling (BIM). By fully leveraging their capabilities, project managers are equipped to adeptly manage the intricate challenges associated with contemporary construction projects, ensuring the delivery of outstanding outcomes. This proficiency not only enhances their effectiveness but also plays a crucial role in fostering the development of sustainable, resilient, and innovative built environments that significantly influence the surrounding world. Project managers have the opportunity to utilize these comprehensive models to replicate different scenarios, detect possible conflicts, and enhance the sequencing of construction activities. By adopting this forward-thinking strategy for addressing challenges, the likelihood of design mistakes is diminished, the need for rework is lessened, and overall project efficiency is markedly increased. The trajectory of Building Information Modeling (BIM) is anticipated to be marked by ongoing innovations, a rise in its utilization, and a more extensive incorporation of technology throughout the construction sector.

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