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Construction safety management based on building information modeling technology

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Abstract. With the progression of society, urban construction has been rapidly advancing, yet the incidence of construction safety accidents has surged. In order to effectively prevent construction safety incidents, construction safety management has become increasingly significant. To achieve the safety management of construction projects, Building Information Modeling (BIM) technology is introduced. It can help construction safety management departments better understand every link in the entire construction process. In this paper, an integrated analysis of BIM technology and the current state of construction safety is presented, aiming to explore the problems existing in the current construction safety management and provide construction personnel and management staff with a comprehensive understanding of predictable risk factors, effective preemptive measures, safety inspections, identification of safety hazards, and other associated issues, thereby guaranteeing the occupational safety and security of construction personnel and property. Consequently, the accident prevention model undergoes a transformation from a reactive approach to a proactive one.

Keywords: Bim Technology, Construction, Safety Management, Risk Factor Analysis.

1. Introduction

In traditional methods of construction safety management, people have demonstrated a lack of safety consciousness, assuming that wearing appropriate helmets, safety belts, insulated shoes, and insulated gloves would sufficiently safeguard construction safety [1-3]. As a result, the management of construction safety poses a significant challenge within the construction industry, with considerations ranging from three-dimensional visualization, construction structure, and consumption of building materials, to the safety of personnel involved. It is imperative to acquire and compile information in order to minimize the incidence of adverse events within construction. A novel technology known as Building Information Modeling (BIM) offers a solution by facilitating the virtual, three-dimensional digitization and management of physical and functional features of construction projects [4]. This technology has the characteristics of information collection and three-dimensional virtual modeling, and it can build quantitative modeling and data information base, so as to manage the whole project visually and dynamically. In recent years, BIM technology has been recognized as an important technology adopted by construction experts in the 21st century construction industry, and it is regarded as a basic professional technology that construction experts must learn and master today and in the future. It is convenient for the safety management of the whole life cycle of the construction project. Through the analysis and summary of the advantages brought by BIM technology and the current situation of

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building construction safety management, the best safe construction method based on BIM technology is found. This paper can help the construction personnel and management personnel to more intuitively understand the safety hidden dangers in the construction process so that accident prevention can be transformed into an anticipatory control mode.

2. BIM attributes and current state of construction safety management

2.1. Characteristics of BIM

Harmonization is crucial in the development of construction engineering projects as multiple professional fields are involved. However, under conditions of information asymmetry, incompatibility issues often arise, resulting in the frequent emergence of safety problems during project execution. BIM technology can effectively address these challenges by ensuring seamless coordination and collaboration among personnel from various construction engineering fields, thereby mitigating information asymmetry. BIM technology facilitates communication among workers from different professional domains, ensuring efficient information exchange and averting safety concerns caused by information asymmetry in the construction process [5].

Visualization plays an essential role in the construction project as it aids in achieving precise construction. To ensure accurate construction, the builder must possess a visual construction model. Visualization of construction organizations entails the process of creating a three-dimensional model of the construction project, allowing it to be virtually represented on the computer. The utilization of BIM technology enables a comprehensive display of intricate construction structures on a computer platform. The integration of building visualization technology empowers construction project managers and builders to proactively identify potential issues in the construction process and take timely preventive measures to mitigate safety risks.

Simulation is a pivotal component of BIM technology, carrying substantial significance. There are numerous large-scale construction projects that are extremely intricate and require effective identification and swift management of various perilous factors. Neglecting these dangerous factors or failing to handle them expeditiously can significantly increase the construction risks associated with such projects. With its capabilities, BIM technology facilitates the efficient simulation of the site layout, environmental conditions, and geological considerations of the construction project. The utilization of BIM-driven simulations enables construction project personnel to swiftly and comprehensively comprehend the various potential safety risks prevalent at the construction site, empowering them to promptly enact corresponding proactive measures. As a result, the safety management effectiveness of construction projects is enhanced.

2.2. The current status of safety management in construction

Conventional security preparation, relying heavily on frequent human surveillance, is an operation that demands significant labor and time, consequently provoking inefficiency. In contrast, the integration of safety planning and project execution planning enables clear communication of what, when, where, and why safety measures are required. Unfortunately, the association between safety scheming and job execution technique enforcement frequently falls short, as contractors only utilize two-dimensional drawings and on-site observations in identifying hazard prevention techniques. Since their methods are manual and solely based on personal experience, they are prone to errors, making the transmission of safety knowledge solely through regulations challenging due to the subjective decision-making of responsible authorities. Even so, existing safety rules, regulations, and best practices have been proven to have a positive impact, with indicators such as the Total Recordable Accident Rate (TRIR) published by the Construction Industry Institute signaling a trend towards zero accidents in the construction industry [6].

2.2.1. Insufficient implementation of safety supervision. Numerous safety incidents have transpired within the realm of construction enterprises primarily due to inadequate monitoring and management.

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Some of those in charge of construction projects place greater emphasis on timeliness and the rate of advancement as opposed to safety precautions, which impedes the effective implementation of safety protocols and ultimately results in failed safety supervision. On-site investigation into safety management in the chosen regions of construction engineering implies a lack of genuine concern, with supervision frequently conducted solely through targeted inspections. This hinders the ability to fully comprehend site operation, as well as the extent to which guidance and supervision are effectively disseminated. Ultimately, this contributes to heightened safety risks during later phases of construction, subsequently promoting the likelihood of safety incidents.

2.2.2. Outdated safety management techniques. With the increasing complexity of the construction environment and the mounting difficulty in construction, the reliance on conventional construction safety management methods alone can no longer meet the demands of contemporary construction safety management. The majority of construction enterprise managers have encountered the issue of an aging workforce, who heavily depend on their own individual experiences to carry out construction site management. Consequently, their management approaches are considerably outdated, and the formulated construction safety management plans, to some extent, lack scientific components aligning with actual construction practices. Consequently, security concerns can easily arise. Furthermore, in previous security work, a substantial amount of information was conveyed through written communication or verbal admonishments, resulting in low communication efficiency. Even during safety inspections, the absence of prompt communication results in delays in implementing improvement measures, thereby causing inefficiencies in safety management.

2.2.3. Deferred education for safety management. It is apparent from recent safety incident reports that the deficiency of safety knowledge among managers and construction laborers is a significant contributing factor to accidents such as falls from heights and mechanical injuries. Due to an excessive focus on profits, managers of many construction firms lack the necessary comprehension of safety management, resulting in deficient implementation of safety education and training for employees at all levels. As a result, employees' understanding of safety protection and operation procedures is insufficient. Additionally, some companies overlook employee safety training due to time constraints, leading to the involvement of untrained staff in certain working conditions, thereby leading to non-compliance with regulations and, subsequently, safety incidents. With the passage of time, these safety issues threaten to substantially impact the progress of construction projects.

3. The construction safety system integrated with BIM technology

As illustrated in Figure 1, the BIM framework, developed upon real architectural structures, adeptly employs the singular linear model alongside specialized engineering measurement software. Subsequently, meticulous calibration and harmonization procedures are conducted [7]. The BIM framework encompasses all the construction prerequisites, in scenarios where the construction of diverse disciplines collide either temporally or spatially; subsequently, it can be suitably modified [8]. Construction companies are capable of achieving precise cutting, construction, and administration through the utilization of BIM technology, thereby enabling a harmonious management process between enterprises. Yet, it is imperative to acknowledge that the primary objective of constructing models under BIM technology is to establish a foundation for safety overseeing. This requires the ability to abstract information from any architectural drafts and unite those modifications to promptly update the corresponding drawings.

In the domain of engineering construction, the utilization of BIM technology is capable of discerning and categorizing risk factors, delineating geographical areas of potential peril, and optimizing the design process.

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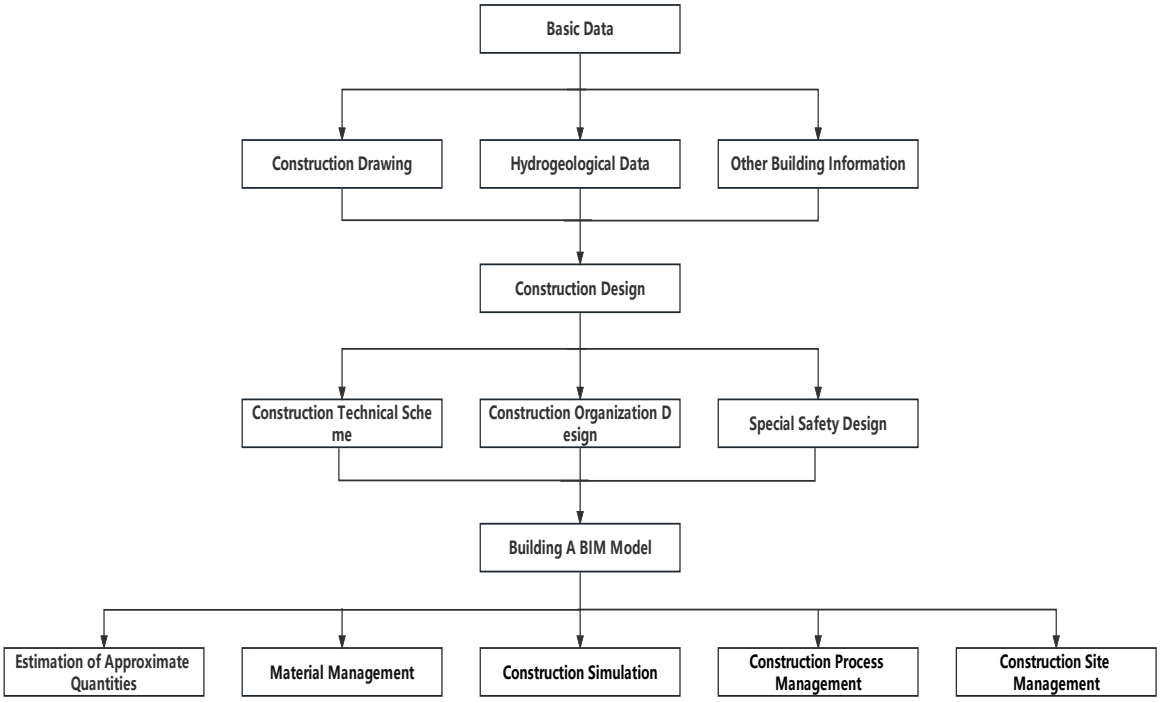

Figure 1. The BIM method.

3.1. Identification of risk factors within the context of building construction: an academic exploration

Through the integration of pre-construction preparatory data, expert opinions, and BIM model planning information, the qualitative and quantitative risk units of the construction site are segmented. Subsequently, the risk sources are exhaustively identified based on the information from the risk source database for comprehensive analysis, as visually depicted in Figure 2.

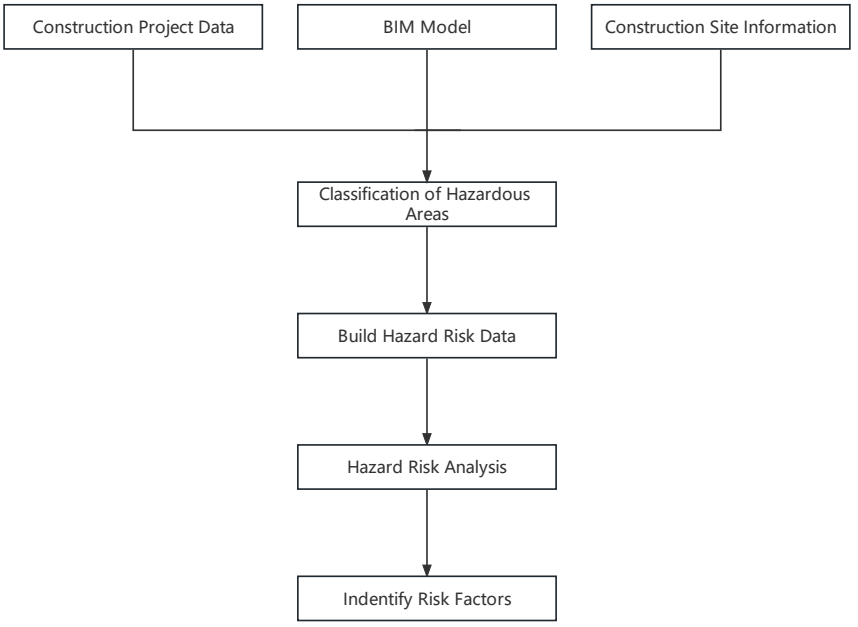

Figure 2. Risk Analysis Process of BIM Model.

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3.2. Division of construction hazard zones

Once the risks in the site have been identified, dividing the area of risk becomes essential. This can be achieved by employing BIM simulation to pinpoint areas that pose potential risks, such as the perimeter of the building and the entrance. Subsequently, enhanced safety measures, such as protective fencing and safety nets, can be implemented in these areas. As the risk and safety zones are subject to change, the dynamic nature of BIM is utilized to periodically evaluate the effectiveness of the zoning system and facilitate the dynamic updating of risk zones. By conducting risk level assessments, the evaluation of risk zones and risk levels are combined to offer guidance in the selection of appropriate risk levels.

3.3. Confirmation of an optimal construction plan

The incorporation of information models for diverse construction disciplines is seamlessly integrated into BIM models by means of computer technology, thereby culminating in the creation of building models consisting of disparate component units. These models are subsequently imported into the Revit software platform to facilitate real-time implementation and simulation. In the event of any conflicts that may arise, a comprehensive report is generated and dispatched to the client, who then proceeds to optimize the spatial arrangement of machinery and structures based on the findings delineated within the report, thus ultimately determining the most optimal construction plan. The systematic procedure for ascertaining the most optimal construction plan is visually depicted in Figure 3.

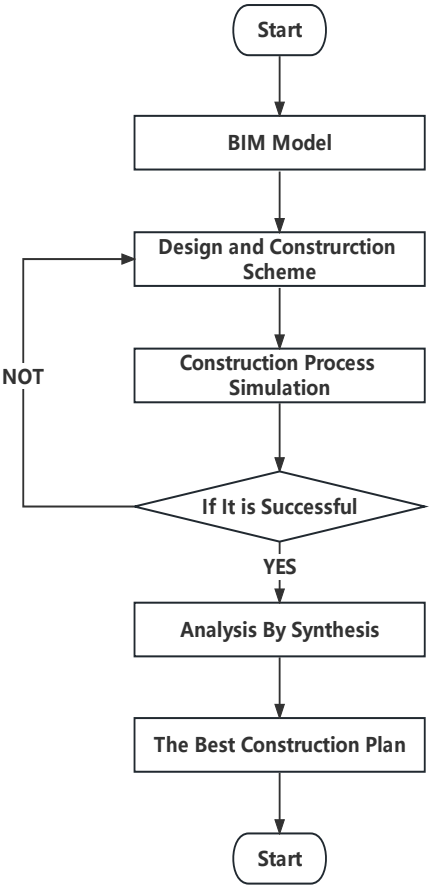

Figure 3. The best construction scheme datermines the process.

4. Conclusion

BIM technology has become prevalent in the realm of construction project safety management and boasts its own unique advantages, yet there are still certain concerns and inadequacies that require

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further research and enhancement. Presently, BIM technology serves as an indispensable component of construction safety management, effectuating a significant boost in construction productivity, comprehensive construction outcomes, and the well-being of construction personnel. Its capabilities encompass the timely detection of various challenges and the provision of substantial data resources for technical personnel to draw from, ultimately leading to reduced construction expenditures and lessened occurrences of safety mishaps.

In this paper, a thorough analysis of the existing BIM technology and the current state of construction safety reveals the inadequacy of safety supervision, obsolescence of safety management approaches, and deficient safety training. Addressing these concerns entails the collection of core data, creation of BIM models, identification of risk factors, subdivision of at-risk zones, optimization of designs, identification of optimal construction plans, and presentation of anticipated risk factors to construction and management crews, facilitating the implementation of preventive measures, conducting safety inspections, and proactively eliminating safety hazards to safeguard the lives and property of construction personnel.

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