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Research on Risk Management of Engineering Projects Based on Building Information Model (BIM) Technology

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Abstract: With the rapid development of the construction industry, the application of BIM technology has gradually become key to improving the efficiency of construction management. This paper, focusing on the issues existing in the risk management of engineering projects, conducts research and discussion based on BIM technology. Through in-depth analysis of the application of BIM technology in the risk management of engineering projects, combined with case studies, the advantages and roles of BIM technology in risk management are explored. The research results show that the application of BIM technology can effectively improve the efficiency and accuracy of engineering project risk management, reduce the possibility of risk occurrence, and provide important support for the smooth implementation of engineering projects. This paper also discusses the specific application of BIM technology in risk management and analyzes and proposes solutions to the challenges that may be encountered in the implementation process. Through the research of this paper, BIM technology provides good ideas and methods for the risk management of engineering projects and has a certain reference value for improving the management level of engineering projects and ensuring the smooth implementation of engineering projects.

Keywords: BIM Technology, Risk Management, Construction Engineering, Information Sharing, Collaborative Design.

1. Introduction

Currently, risk management in engineering projects is facing many problems and challenges. Traditional risk management methods suffer from information asymmetry and poor communication, leading to an incomplete understanding of project progress and potential risks by all parties. There is a serious phenomenon of information silos among project participants, with each party often only having a one-sided understanding, making it difficult to reach a consensus. In the risk management process, data collection and analysis are inefficient, leading to an inability to identify and respond to risks in a timely manner.

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In the face of these various problems and challenges, the application of BIM technology has become an inevitable choice to change the status quo. BIM technology, with its characteristics of information sharing, collaborative design, and visualization, can effectively solve the problems existing in traditional risk management. BIM technology can achieve real-time information sharing and collaborative work, allowing all parties to view project data and information at any time, communicate and consult in a timely manner, and ensure that all participants are on the same information platform. Risk management based on BIM can achieve information sharing and management throughout the entire lifecycle, with risk data and information at all stages of the project being recorded and tracked, which is conducive to forming a complete risk management system.

The visualization function of BIM technology can also help project participants more intuitively understand the project situation and risk status, promoting scientific and rational risk management decision-making. Through the application of BIM technology, project managers can more comprehensively identify and assess risks, formulate targeted risk response strategies, and improve the efficiency and quality of project management.

The central theme of this study revolves around the practical application of BIM technology in the expansion project of Oslo Airport, with a particular focus on its role in project risk management. Employing a literature analysis method, this research delves into the actual application and benefits of BIM in project risk management by closely examining the materials related to the Oslo Airport expansion and conducting an extensive review of the theoretical and practical studies of BIM technology.

The study begins with an introduction to the background and overview of the Oslo Airport expansion project. It then proceeds to analyze the application of BIM technology from five detailed perspectives: digital drawing management, on-site application, safety risk management, team collaboration and communication, and resource optimization and cost control. These perspectives encompass the entire construction process, from the design phase to the construction phase, and comprehensively reflect the potential of BIM technology in enhancing project management efficiency, reducing errors and rework, improving construction accuracy and safety, optimizing team communication, and controlling costs.

Finally, the research concludes with a summary of the findings and recommendations for future construction project management. The integration of BIM technology in the Oslo Airport expansion project has demonstrated its transformative impact on various aspects of construction management, offering valuable insights for the industry's progression towards more efficient, safer, and sustainable practices.

2. The Application Value of BIM Based Engineering Project Risk Management

From the above analysis, it can be seen that risk management of engineering projects based on BIM technology has important research and application value [1]. By introducing BIM technology, risk management can be information-based, intelligent, and efficient, which is conducive to improving the level and benefits of engineering project management. Therefore, strengthening the application research of BIM technology in the risk management of engineering projects is of great significance for promoting the development of the field of engineering management in China [2].

Research on risk management of engineering projects based on BIM technology can play an important role in improving project management efficiency [3]. Traditional project management methods often rely on manual drawing and paper documents, which are inefficient and prone to delays and inaccuracies in information transmission. By introducing BIM technology, the project team can achieve instant updates and viewing of information through shared model data, improving communication efficiency and collaboration. Team members can share information in real-time on

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the same platform, solve problems quickly, thereby improving the efficiency and effectiveness of project management.

Research on risk management of engineering projects based on BIM technology can also help reduce project risks [4]. BIM technology can predict risks at different stages of the project through modeling and simulation and provide corresponding risk response measures. In the design phase, collision detection and conflict analysis can be used to identify and avoid design issues. In the construction phase, progress management and resource optimization can be used to reduce construction risks. Through comprehensive risk management, the risks of project changes and delays can be effectively reduced, ensuring that the project is completed on time and with quality.

Research on risk management of engineering projects based on BIM technology can also improve the quality of the project. BIM models can integrate design and construction information into one platform, achieving "design once, use multiple times," avoiding errors caused by repeated entry and transmission of information. Through BIM technology, the quality of the project can be controlled and supervised comprehensively at different stages, identifying and solving quality issues in a timely manner, ensuring that the project quality meets the requirements.

Research on risk management of engineering projects based on BIM technology is of great significance for improving project management efficiency, reducing project risks, and improving project quality [5]. Through BIM technology, real-time information sharing and collaboration can be achieved, improving project management efficiency; modeling and simulation can predict and respond to project risks, reducing project risks; design and construction information can be integrated, improving project quality. Therefore, further research and promotion of risk management methods for engineering projects based on BIM technology are of great significance, helping to improve the success rate and benefits of engineering projects.

3. The Risk Problems Existing in the Current Engineering Project

3.1. Security Risks

Safe construction is the key to the success of the entire construction project, and it is also the basis for all subsequent work. The problems posed by effectively mitigating security risks are the most important part of risk management. These risks include falls from working at height, pinching or crushing during heavy machinery operations, electric shocks from electrical installations, and cutting or puncture injuries from construction materials [6]. Many construction sites have a large number of high-altitude hazards. At the same time, there are certain risks in the operation of the equipment, such as improper operation of large equipment may cause equipment damage and even casualties. In addition, building collapse accidents are also common, and the root cause of them is the neglect of detailed and comprehensive safety prediction before construction and strict and serious safety management during construction. The common safety construction management measures in the project are manually solved, such as allowing workers to receive safety training, providing safety belts at the construction site, or arranging equipment operators to conduct regular safety inspections on the equipment. When a critical situation occurs, whether the risk can be avoided altogether is still an uncertain answer.

3.2. Technical and Quality Risks

Technical and quality risks are the focus of the entire risk management work, and they are also the most common risks in construction practice. First of all, whether the engineering design meets the project requirements and whether there are technical problems that need to be solved are the problems that need to be considered before the construction of each project. Often, in complex design schemes, collisions occur when the design of electromechanical pipelines, structures, and other systems is

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inaccurate, which can lead to a series of problems such as construction rework and delays. In the construction of construction projects, there are sometimes engineering and technical problems that do not conform to their own technical professional capabilities, such as the use of new technologies and new materials that have not been practiced, which leads to test failures, engineering accidents, and even casualties. At present, qualitative analysis methods are included in the analysis methods of technology and quality risks, that is, the probability and impact of technical risks are predicted through expert discussions, empirical analysis and other methods. The second approach is quantitative analysis, which is an accurate quantitative analysis of risk through familiar models and simulation calculations. The two methods should be closely combined to minimize the impact of technical risks on engineering projects.

3.3. Environmental Risks

In civil engineering construction, environmental safety risks are a factor that cannot be ignored, and these risks mainly originate from the characteristics of the natural environment and the construction site itself. On the one hand, risks in the natural environment include extreme weather conditions such as heavy rain, typhoons, extreme heat or cold, which can lead to flooding on the construction site, damage to equipment, or damage to workers' health [7]. On the other hand, the project construction site is often carried out in an open-air environment, so it is inevitable that during the construction period, a variety of environmental problems such as air pollution, noise pollution, and light pollution will be caused by the transportation and processing of materials and the use of machinery. It will not only affect the entire stage of the site, construction and completion acceptance of the building, but also the nearby residents and the ecological environment will also suffer some adverse effects. Therefore, reasonable planning of the transportation time of materials and orderly arrangement of the location of machinery and equipment can reduce the environmental impact of the whole project to a certain extent. However, due to the differences in construction technology, materials and equipment, the environmental pollution problems generated are also different, so sometimes only artificial judgment is planned through inherent experience, and corresponding solutions are not taken for different environmental problems and causes.

3.4. Problems in Construction Risk Management

In most construction projects, in order to control the project cost, the construction unit did not formulate corresponding safety protection measures, and did not set up safety signs in strict accordance with relevant regulations, which could not ensure the life safety of employees [8]. In terms of risk management, many enterprises still continue to use the methods of accumulating experience, and the management strategies used are very simple, without the use of advanced management technology and the planning of reasonable and effective management processes, and lack the ability to resist risks. In addition, many engineering projects do not set up a risk management department and plan its functions in the organizational structure of the project department. Therefore, whether there are corresponding control measures and organizations in the construction project is the key to the effectiveness of construction risk control.

4. BIM Technology and Risk Management

4.1. The Use of BIM Technology in Project Risk Identification and Risk Analysis

BIM technology can help management teams efficiently, accurately, and comprehensively identify and analyze risks in project risk management.

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BIM technology can integrate comprehensive data of projects through drawings and form an integrated building information model based on it. By examining the model, various information about the building can be obtained, including project features, process parameters, component methods and so on. By presenting the model in a visual way, managers can grasp the overall situation of the project and complete data analysis, accurately identify potential risk factors, conduct risk assessments, and formulate response measures [9].

By utilizing BIM technology, managers can optimize decision-making and simulate construction, progress, and safety. Using BIM technology to reproduce actual work, conducting rehearsals of different plans, comparing data for resource allocation, cost planning, and optimization of plan design, helping decision-making teams make technically feasible and economically reasonable decisions.

4.2. The Use of BIM Technology in Project Risk Assessment and Risk Control

BIM technology can integrate various information of construction projects, establish three-dimensional, four-dimensional, and five dimensional models through information, and visually display the overall characteristics of the project.

The application of BIM technology can achieve real-time sharing and communication of information, promote collaborative work efficiency between various parts, and improve the accuracy and timeliness of integrated information [10].

4.3. Limitations of BIM Technology in Project Risk Assessment

China's development is still in its infancy, and the application of BIM software independently developed by China is not widespread. The standards and specifications related to BIM technology are not yet perfect, which brings certain uncertainties in practical applications due to differences in software, projects, and regions. The introduction and development of BIM technology require a significant investment of resources and a long return on investment cycle, which is difficult for some companies to afford in terms of cost and benefit.

5. Oslo Airport Case Analysis

5.1. Project Background

Oslo Airport is Norway's primary international airport and transportation hub. In recent years, passenger and cargo volumes have rapidly increased, exceeding the capacity of existing facilities. To enhance operational capacity and service levels, an expansion project was initiated in 2013 and completed in 2017. The project included the addition of 115,000 square meters of terminal space and a new runway, with a total budget of approximately 14.6 billion NOK. These new facilities encompass modernized passenger terminals and gates, as well as new runways and taxiways to improve aircraft takeoff and landing efficiency and safety.

The main objective of the expansion project was to enhance the airport's service capacity and operational efficiency by incorporating advanced construction and management technologies. The project also included environmental and sustainability measures, such as the use of renewable energy and energy-efficient equipment, to minimize the environmental impact of the expansion. These measures aimed to ensure that Oslo Airport could meet future traffic demands while becoming a model of environmental protection and sustainable development.

5.2. Project Overview

To address the complexity of the large-scale project and improve work efficiency and construction accuracy, the project team decided to fully adopt Building Information Modeling (BIM) technology.

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BIM technology provides an integrated digital platform, enabling the project team to precisely plan and simulate the entire construction process by creating detailed 3D BIM models during the design phase. The BIM model contains all detailed information about the building, including structural, piping, electrical, and mechanical systems, allowing various professional teams to collaborate and coordinate on a unified platform.

During the construction phase, the project team utilized software such as Tekla BIM sight, significantly reducing the use of paper drawings. This digital transformation ensured that all team members could access and use the latest design information in real-time, thereby reducing errors in information transmission, improving project management efficiency, and enhancing construction quality. BIM technology not only improved work efficiency but also enhanced overall construction precision and quality, enabling the Oslo Airport expansion project to be completed on schedule and meet high standards of service and operational requirements.

5.3. The Role of BIM in Project Risk Management

5.3.1. Digital Drawing Management

In the Oslo Airport expansion project, Tekla BIM sight software transformed paper drawings into digital models, simplifying document management and reducing the use of paper files. All team members could access the latest design information and update design changes in real-time, reducing errors caused by untimely drawing updates.

5.3.2. On-Site Application

The BIM model enabled real-time information sharing and updates on the construction site, improving construction accuracy and efficiency. The 3D model guided rebar placement, ensuring the precise positioning of each component and reducing rework. Additionally, BIM models were accessed on-site via tablets or BIM kiosks, providing instant reference and decision support.

5.3.3. Safety Risk Management

The visualization capabilities of the BIM model allowed the construction team to identify and address potential risks in advance, ensuring construction safety. The system automatically generated and updated safety checklists and construction schedules, ensuring all safety measures were strictly implemented and monitored. For example, the model highlighted high-risk areas, requiring workers to exercise caution and follow safety protocols.

5.3.4. Collaboration and Communication

BIM technology facilitated collaboration between designers, engineers, and construction teams, reducing communication misunderstandings and information loss. BIM workstations or “BIM kiosks” were set up on-site, allowing all stakeholders to access and view the latest BIM models and construction information. During construction meetings, team members could view and discuss the 3D model in real-time, understanding design intentions and construction requirements, thereby improving collaboration efficiency and decision-making quality.

5.3.5. Resource Optimization and Cost Control

Through the BIM model, resource optimization and cost control were achieved. The project team used precise material calculations and demand forecasts to reduce waste and overspending. Real-time budget and cost information helped the project management team better control project costs. BIM

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technology predicted material demand, optimized procurement plans, avoided material surplus or shortage, and through detailed cost analysis, adjusted the project budget in real-time, ensuring the project was completed within budget.

The application of BIM technology in the Oslo Airport expansion project significantly enhanced risk management. The visualization and real-time information-sharing capabilities of BIM enabled the project team to identify and address potential risks in advance, reducing errors caused by untimely or inaccurate information transmission. Automatically generated and updated safety checklists and construction schedules ensured strict implementation and monitoring of safety measures. Moreover, BIM technology improved collaboration efficiency and construction precision, ensuring the project was completed on schedule and met high standards of service and operational requirements.

6. Conclusion

This study, through case analysis of the application of BIM technology in the expansion project of Oslo Airport, demonstrates the significant role that BIM technology plays in project risk management. The results indicate that BIM technology, through applications in digital drawing management, on-site application, safety risk management, collaboration and communication, and resource optimization and cost control, has significantly improved the efficiency and safety of project management. Digital drawing management simplifies the documentation process, reduces the use of paper documents, and enhances the timeliness of document updates, thereby reducing errors caused by outdated drawings. On-site applications facilitate real-time information sharing and updates, improving construction accuracy and efficiency, using 3D models to guide construction and reduce rework. Safety risk management leverages the visualization capabilities of BIM models to identify potential risks in advance, ensuring construction safety. BIM technology also promotes collaboration and communication among teams, reducing misunderstandings and information loss. Lastly, in terms of resource optimization and cost control, BIM technology helps project teams effectively control costs through precise material calculations and demand forecasting, avoiding waste and cost overruns. These achievements confirm the significant value of BIM technology in enhancing the quality and efficiency of construction project management.

The significance of this study lies in showcasing the practical application and benefits of BIM technology in modern construction project management, especially in risk management. It offers the construction industry an effective tool for reducing errors, improving construction safety, optimizing resource allocation, and controlling costs. Moreover, the findings of this study have an important enlightening effect on promoting the wider adoption of BIM technology within the industry. They serve as a reference for other construction projects, encouraging more project teams to adopt BIM technology to improve the overall efficiency and quality of project management and elevate the standards and efficiency of the entire construction industry.

Looking ahead, with further technological development and an increased understanding of BIM technology within the industry, its application in project risk management is expected to become more extensive and in-depth. BIM technology may integrate with more advanced technologies, especially artificial intelligence and big data analysis, to further enhance the intelligence and automation levels of project management, improving efficiency and quality. At the same time, with the rise of sustainable construction, the application of BIM technology in environmental impact assessments and green building design will also become a focus of future research. Additionally, as BIM technology becomes more widespread, more standardized processes and training are expected to emerge, gradually improving industry standards and education systems to adapt to the changes brought about by BIM technology, thereby helping project teams to utilize BIM technology more effectively.

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Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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