Construction Safety Management of Building Project Based on BIM

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ABSTRACT: Being as an important part of construction project, the quality of construction design has great influence on investments, progress and quality of the whole construction project. In order to improve the overall quality of China’s construction project, technology as well as management level, the informatization of technology and management must be implemented throughout the construction industry. Documentary research method, investigation and induction are used to analyze the qualities of knowledge and project management which are required to construction design management and the adaptability of applying BIM in it; the present paper analyzes problems appeared in management of progress early warning and proposes the adaptability of applying BIM into progress early warning. At last, the application of BIM technology into construction safety management is researched. And a model framework of construction safety management based on BIM is established. Combine with case study, the paper constructs a visual safety management platform through BIM modeling, 4D construction simulation and collision detection technology. Dynamically rehearse construction progress and manage the hidden dangers such as falling and collision during actual construction progress. And control safety risks through optimization of construction scheme and formulating defense system and emergency measure. Avoid or reduce safety accidents, achieving safety management.

KEYWORDS: Construction safety management; Building information model; Building engineering.

INTRODUCTION

In current construction market in China, the competition between contractors is increasingly fierce. Construction companies with poor management ability, often try to obtain construction contract by malicious bidding. These construction companies have weak risk tolerance and resilience, which increases the uncertainty of construction process and raises risk. And these risks will undoubtedly cause the delay of construction progress. How to use BIM technology and a large amount of data analysis and selection to make risk early warning for construction progress is a major issue which must be faced and be solved by construction companies. In recent years, popularization and application of construction industry both at home and abroad of BIM have been given great encouragement. A series of software based on BIM provided by companies such as Bentley, Autodesk, Google, and Graphisoft have been produced with BIM standard topped by American Institute of architects. And various BIM consulting firms and BIM training institutions have gradually emerged. However, now BIM is still not used to solve the problem of early risk warning for progress of construction project.

BIM MODELING TECHNOLOGY

BIM modeling technology is only used in construction stage to ensure the construction safety management. The implementation of each stage of the construction project is closely related to each other, and only different participation in different stages can constitute a whole project. And only considering from the overall perspective, implementation and management of the project are likely to make overall goals of the project more excellent. So if BIM technology is used at design stage to construct, structure, pipeline design, and model, it can be directly used at construction stage. Information data, design results and building model in design stage are used to guide safety management according to the needs at construction stage and it will save a lot of time and cost. And more detailed and accurate project information is conducive to construction safety management.

Application of Modelling Technology at Design Stage

A lot of BIM software can be used at design stage such as Revit Architecture of Autodesk company, Revit Structure, and Archi CAD of Graphisoft company. Among them, Revit is characterized by using a central database to store and edit information of an independent building models. In this Revit building information model platform, all drawings, 2D and 3D views and other data information are information expressing forms of a common basic building model database. This feature is very favorable for information coordination management. For example, if a certain
design parameters is modified, then the related plan, profile, model view, progress will be automatically updated, which will save a lot of time and cost and avoid design conflict. Moreover, if changes of the design plan or error correction information in construction process can timely and accurately be delivered to construction companies, measures can be taken to avoid unnecessary losses. Using the three-dimensional model established by Revit software can construct a 3D building information model to display the effect figure of the accomplished project, including construction, structure, pipeline and mechanical and electrical information as shown in Figure 4.1. And the model established by Revit, through file output converter, can be converted into NW format which can be used in the Manage Navisworks software to carry out the designs such as collision and conflict detection, and optimization design. It can also provide the basis and basis for the construction of the information model database at construction stage.

Application of Modelling Technology at Construction Stage

The 3D model which is established at design stage can be directly used at construction stage to construct a comprehensive information model database of the project. One of the advantages is to obtain comprehensive information and data of the design stage and provide a basis and support for safety, cost, progress, quality objectives realization in construction stage; Second is to save modeling cost. If two dimensional design is taken during design stage, the project needs to be made accordance with BIM in construction stage. And different professional models such as building, structure, electrical, fire, and equipment need to build which is very complex and cost high, and is not conducive to the optimization of the overall objectives; Third is to realize the collaborative management of information integration and sharing. Information can be shared at design stage and construction stage and make mutual feedback. Different professional models are carried out collision detection, 4D construction simulation, and construction animation by Manage Navisworks so that security risk in construction process can be found in advance which provides a convenient for the construction safety management, and reduces rework phenomenon. And the established integrated information database contains detailed information of the project components. In the model, any component can be selected to check its characteristics which provides guidance for construction.

The 4D Virtual Construction Technology

Construction is a large and complex dynamic system, including many processes with complex relationship which will directly affect the overall process of project construction. Virtual construction process, through simulation technology, combines 3D model and project progress plan to make a 4D construction simulation. It can detect problems that may occur in the actual construction process in advance and optimizes the construction scheme. Besides, it can identify and classify dangerous area to avoid the safety accident, as shown in Figure 1.

Before the virtual construction simulation, a detailed construction organization design and construction progress plan should be worked out first. The construction organization design plays a vital role in the whole project. It is a important technical basis and economic index which directly guide project implementation. Construction progress plan makes a reasonable order and time arrangement for construction process according to project requirements and existing human power, mechanical, materials and other resources. And then use BIM modeling technology to establish a virtual construction model and geometric model. And the construction scheme can be made a real-time interactive simulation for its optimization. as shown in Figure 2.
Collision Detection
Reasonable construction space, site planning and complete project management system can reduce collision and conflict in construction process to a certain extent. But this method in the construction management process is very passive, and can not accurately predict what conflicts may produces at which stage or which process. And safety accident prevention measures, to a large extent is made based on experience or data statistics of past similar project.

The implementation of the project is a complex dynamic process which contains many three-dimensional cross operations. And in construction process, unsafe situations such as collisions of structure, equipment, and machinery often occur due to the unreasonable design or conflicts of time arrangement and space layout at construction site, as shown in Figure 3.

SPECIFIC APPLICATION OF CONSTRUCTION SAFETY MANAGEMENT
Identify and label all kinds of dangers such as falling, collision mainly through the 3D model and 4D construction simulation and make inter communication among construction workers, technical personnel and management personnel about safety management plans. Under the support of 3D and 4D visualization technology, carry out effective safety management of construction site and activities. This case mainly analyzes how to use BIM technology to make construction site planning, and analyzes tower crane safety management and protections from high-altitude falling combing with virtual construction technology.
Construction Site Planning

Figure 4 is the showing picture of simulating a simple construction site. The simulation of construction site reflects building materials accumulation region, the main building, and two tower cranes to meet construction requirements. The position of tower crane can be determined according to their simulating moving trajectory to avoid conflicts and collisions in their working area. The established three-dimensional model clearly show the construction site environment, making it easy for management personnel to grasp all information about construction site. Reasonable planning of construction site can avoid safety accidents such as mechanical conflicts during construction process, collision damage on workers brought by machines, collapses caused by overloaded foundation pit that is made by unreasonable mechanical material parking position. And combined with the construction simulation and actual project construction progress, dynamic planning of construction site can be made at any time. Reasonable planning of moving paths of vehicles and machines at different time and operators’ activities area can effectively reduce hidden dangers such as lifting injury accident, objects hitting and collapses during construction process. If there exist serious hidden dangers in the construction process, safety areas can be graded which can be reflected in site model. List dangerous sources in danger area, and then control the emergence of dangerous sources in this area. Meanwhile combine the visualized model and communication with field operators about safety management, guarantee construction safety.

Construction Process Simulation

Figure 5 is a picture of simulating construction process (use simple sketch to simulate construction process whose results and data cannot be as the basis for the practical engineering construction). In the model, moving trajectory of tower crane in the construction process can be clearly seen. And combined with the measurement tools, whether the distance between machines and machines and structures, as well as working space of construction personnel can meet safety requirements can be realized. According to construction simulation results, adjust construction scheme which have hidden danger of collision, and then carry out construction simulation again. Optimize construction scheme in
this way repeatedly until it completely satisfy the safety construction requirement. The visualized scene simulation results provided by 3D model and 4D construction simulation enable the management personnel mastering all the information about the project. And it makes it convenient for management personal to optimize construction scheme, analyze possible dangerous factors in construction process, and make visualized information exchange.

Figure 5. Simulation of construction process.

Safety Management of Tower Crane

Several tower cranes need to run at the same time at large and complex project construction sit. And installation position and working area of tower crane are very complex. Once a mistake is made, the implementation of a correction scheme will also be very troublesome, resulting in great difficulty in safety management of tower crane at construction site. Meanwhile cost, schedule and safety goals will under great influence. When determine the position of tower crane, not only the needs of the construction should be met, but also the security issues should taken into consideration. Crane safety management is mainly to clarify tower crane’s running track and the radius of gyration in each stage of construction process to ensure that both the distance between tower cranes and that between tower cranes and buildings meet the security needs and avoid collision accident. Through the simulation of tower crane’s running area, clarify crane’s radius of gyration, influencing region and the rage of its swing arm at a certain construction stage. Combined with the construction progress and tower crane’s climbing height, carry out real-time collision detection. And according to the test results, clarify tower crane’s activities area before actual construction. Management personnel according to the results, make tower crane safety management plan in the next construction stage, and communicate timely with workers at construction site which can reduce security risks caused by
construction personnel’s untimely receiving information of tower crane running. Figure 6 is a simulation figure when two tower cranes are running at the same time.

![Figure 6. Simulation of tower crane’s moving trajectory.](image)

**EVALUATIONS ON EFFECTS**

Through the 3D building model and 4D construction simulation, the application of BIM technology in engineering construction process is demonstrated, and the advantages and the application effect of BIM technology in construction safety management can be summarized as the following points:

1. The 3D model established by the 3D modeling technology contains all the engineering information which are mutual connected, making it easy to share and modify, reducing the workload of information processing;

2. In the construction preparation stage, through the established 3D model of the construction site, make reasonable planning of construction site layout, simulate the impact of construction site environment on the construction process, and clarify the key content and the corresponding control measures of safety management in the construction process;

3. using 4D virtual construction technology to simulate construction process, cannot only optimize the construction scheme, but also enable the project management personnel finding out the risks which may influence construction progress or lead to the safety accidents during project implementation process. And management personnel can formulate the corresponding control measures, such as establishing a comprehensive anti fall protection system model. Avoid safety accidents such as collisions, machine hitting, personnel falling in the construction stage caused by unreasonable construction scheme or site;

4. The visual characteristics of the 3D model and 4D construction simulation strengthen communication between the project management personnel and construction personnel on the safety plan and emergency plan. And it enables information integration and sharing, reducing the occurrence of accidents which is conducive to the implementation of security plans and security risk control.
CONCLUSIONS AND OUTLOOK

Conclusions

(1) BIM technology is applied to the construction safety management of construction safety management. Through the analysis of characteristics of the current construction accidents, construction safety management status and management difficulties, as well as the researches the feasibility and effectiveness of applying BIM technology in the construction safety management, the paper proposes that apply BIM technology into construction safety management process. Combined with theoretical research and practical application, this paper expounds the function and significance of BIM technology in the control of construction safety accidents.

(2) Construction safety management model based on BIM. Through the application research on BIM modeling, construction simulation, collision detection technology and combined with the safety management principles, the framework of the construction safety management model based on BIM established. Use BIM technology to systematize construction safety management and provide the basis and reference for building engineering projects to use BIM technology in construction safety management, which has strengthened the engineering practice significance.

(3) Case demonstration. The specific application of BIM technology in the construction safety management. Use BIM modeling technology to build 3D, 4D models, and simulate the construction site environment, construction machinery, the main project and so on. Combined with the construction progress plan, carry out 4D dynamic construction simulation, forming a visual management platform. Through the visual and dynamic simulation of the site environment and construction process, the effect of different construction schemes can be compared and optimized. Before the actual construction, find out and deal with of the security risks and collision in construction process and site, improving the safety level during construction process. The visual characteristics of 3D and 4D model make it convenient for different participants to communicate with each other about the safety plan and emergency plans, strengthening the effect of construction safety management.

Outlook

The construction safety management of construction projects based on BIM can make positive function, but at present, the research and application of BIM technology in China is still at initial stage, with immature technology and limited application scope. Only using it in the construction stage will lead to high cost of application, and can not reflect the functions of BIM as information, coordination, and integration. This paper studies the construction safety management base on the application of BIM technology still exist many deficiencies, and has great limitations which still need chitinous further research and improvement. So the technology research and development, standard setting and application promotion are still needed. The main problem that still needs further studies include:

(1) There are many kinds of safety accidents in the construction site, and so do control and management measures, this paper is aimed at security incidents with a higher frequency in recent years to study the improvement of BIM technology. Therefore comprehensive application of BIM technology in the construction management needs to be further studied.

(2) The application of BIM in building construction safety management have not been combined with three management objectives namely cost, progress, and quality project. Only by planning and management from the overall project, using BIM technology in the whole life cycle of the project, and managing progress, cost, quality, safety and other objectives, real information and collaborative management mode can be established to optimized the overall project objectives.

(3) The actual development of the construction site is not exactly consistent with the simulation results. If it can be combined with the mobile computing technology, the management personnel can carry out the construction simulation, collision detection, and hazard identification. And they can according to the simulation results and testing report make adjustment on the deviation, making simulation results in accordance with the actual situation. Construction safety management which has realized the combination of virtual environment and the site environment is more conducive to safety risk control in the construction process.

REFERENCES


