Research and Application of Project Safety Management Based on BIM

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Abstract. In order to improve project safety management, this paper investigates the application of BIM in safety management of a project from four aspects: risk identification, risk management, safety education and site management. It draws the following conclusions: when BIM is combined with the construction schedule to integrate the spatial and time information into a visual 4d (3d+ time) model, the identification to evaluation of safety risks at different construction stages will be realized; when BIM is combined with GIS to integrate the geographic information of safety risks into a BIM model, the display of risk locations and early warnings will be possible; when BIM is combined with the construction plan to carry out process simulation of complex nodes, it enables to evaluate the feasibility and rationality of the construction plan and to conduct technical disclosure to project personnel; when BIM is combined with tilt photography, it enables an optimum planning and layout of the construction site, thereby reducing safety risks resulting from insufficient construction space.

Keyword: project safety management, risk identification, safety disclosure, BIM

1 Introduction

With the increasing complexity of construction sites and the continuous expansion of the scale of construction projects, traditional safety management methods, such as advance safety training and in-process safety checks, have been unable to meet the needs of project safety management. With the emergence of BIM (Building Information Modeling) technology and on the basis of its advantages of visualization, animation, coordination, simulation, etc.， it is possible to present the requirements and content of safety management in a three-dimensional form, which will prompt project managers to timely and intuitively discover hidden safety risks at the construction site, and then timely investigate and rectify the risks. At the same time, this technology can also be used to conduct three-dimensional safety disclosure and notification, safety warnings and etc., which will help to improve the level of project safety management. Due to its great significance in project safety management, it is gradually becoming one of the main approaches to safety management [1-4]. This article, based on project practice, will explore the application of BIM in project safety management.

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2 Visual presentation of hazards with BIM

The finding, correction and closed-loop tracking of safety risks are the daily tasks in project safety management. Due to the complexity and large quantities of these hidden risks, it is difficult for project managers to fully grasp their distributions and types on the spot and hard to take targeted measures. Manual closed-loop tracking is not only inefficient, but also works poorly [5]. Through combining the BIM technology and network information technology, a safety risk management information system based on BIM and network information can be developed, which enables to realize visual presentation and statistical analysis of the locations of hidden hazards, thereby providing decision-making support for project safety management.

According to the construction design drawings of a building, we can set up a lightweight BIM model of the building with given attributes (such as pile length, pile diameter, elevation, pile type, pile number and other information of the pile foundation). The HTML language can be used to develop the safety risk management system, and when the geographic information of discovered safety hazards is connected to the BIM model, the model will be able to operate on a web page [6]. Its technical route is shown as in Figure 1. The locations of potential hazards will be displayed in the BIM model and project managers will be able to inspect specific content of the risks, remind relevant personnel to pay attention to safety and eliminate potential risks in time when passing the site. The relevant content is shown as in Figure 2.

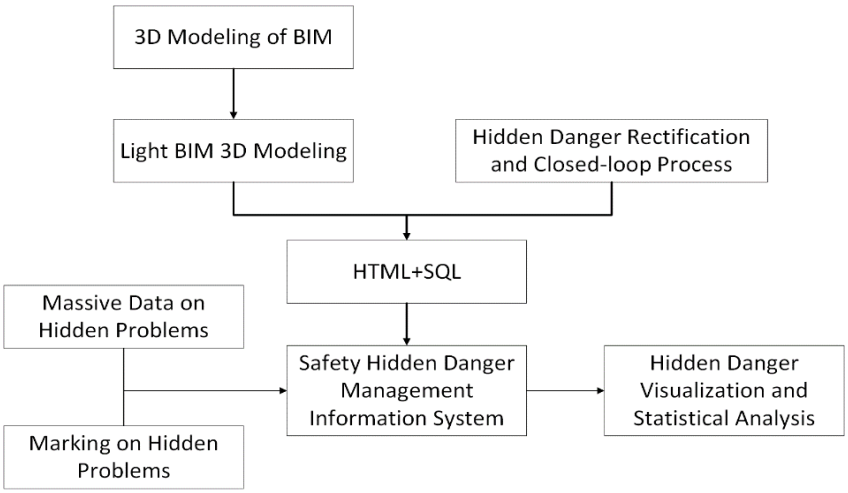

Fig. 1 Technical route

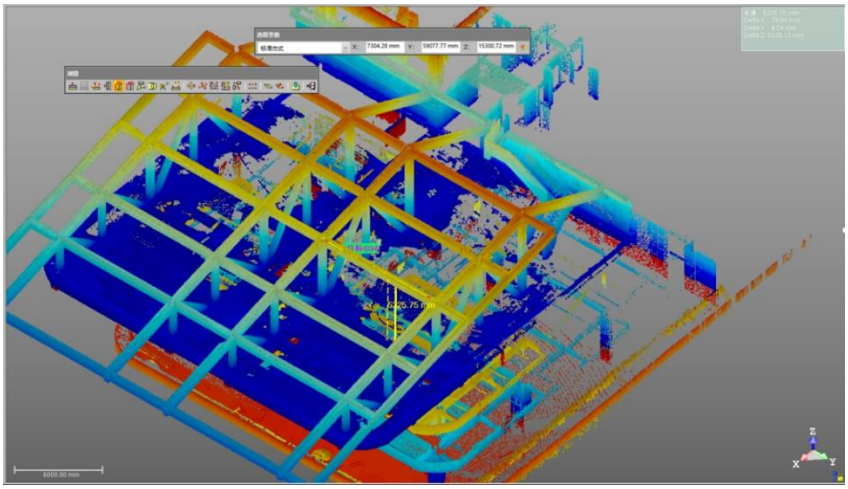

Fig.2 Safety hazard management (Chinese Version)

3 Risk identification based on BIM

Risk identification prior to project commencement is often carried out by project safety management personnel, who usually organizes experts in the fields of construction, technology, safety management and etc. to brainstorm on the basis of the project's environmental characteristics and construction process steps, and then forms an initial risk identification and evaluation list with major identified hidden dangers and proposed targeted measures on it. However, in actual operation, the work is often completed by project safety personnel themselves with reference to relevant information. Subject to the personnel's knowledge and experience in project safety management, they might conduct risk identification incompletely and inaccurately, having missed some important hazards and proposed less targeted or operable control measures. The technology of virtual construction based on a BIM model can eliminate the deficiencies derived from the personnel involved in the work of risk source identification but less experienced in construction process or procedure. Besides, the model can present the process one by one through three-dimensional visualization, which will improve the effectiveness and accuracy of hazard identification [7-8].

Based on the construction drawings of a project, the application of BIM technology enables virtual construction of the project. When the BIM model is correlated with the construction schedule of the project, the spatial and time information will be integrated into a visual 4D (3D + time) model, which can intuitively and accurately show the construction process of the entire building. The construction process will then be virtualized on computer according to time attributes, which enables the safety management personnel to participate in the virtual construction process at different stages, to make a comprehensive analysis of the organization and management of the personnel, materials and machinery, to identify potential safety risks in advance and formulate and implement preventive measures. The technical rout is shown as in Figure 3. The 4D Building growth model shown as in Figure 4.

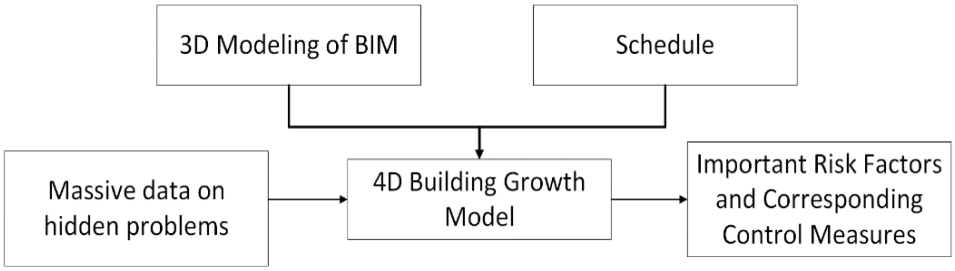

Fig.3 Technical route

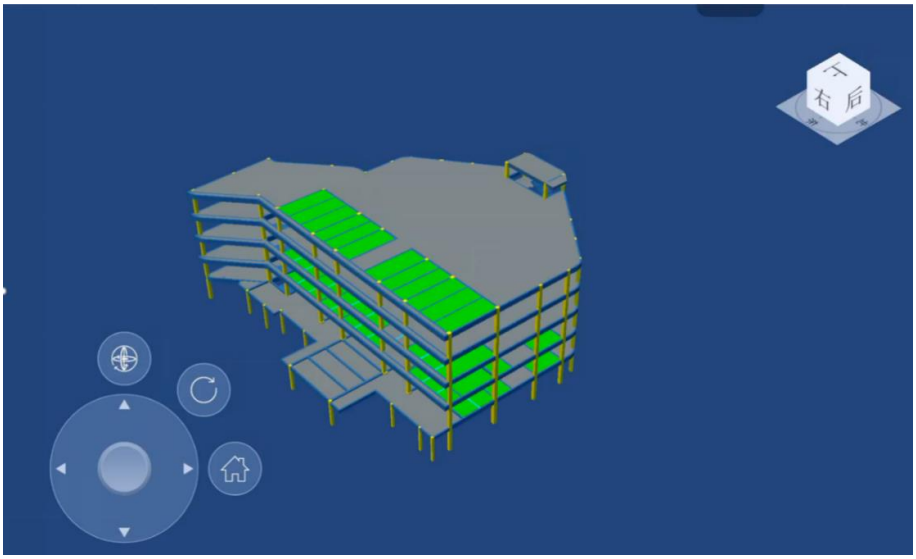

Fig.4 4D Building growth model (Chinese Version)

4 Disclosure of safety scheme

Through BIM-based virtual construction, a complicated safety scheme can be displayed three-dimensionally and the process of construction can be dynamically simulated. For example, a 3D model can be used to conduct safety disclosure in works with complex nodes or section works with high complexity and danger [9-11], and the safety management points during construction can be visually shown, which will help the personnel on site to have a more comprehensive understanding of the control points, construction priorities, safety precautions and other matters in the construction plan of the clarification work, and improve the personnel's safety management level.

By using the BIM model in combination with VR technology, virtual reality of the model can also be realized so that the person who has been conducted disclosure to will be able to experience the dangers personally, thereby enhancing safety awareness.

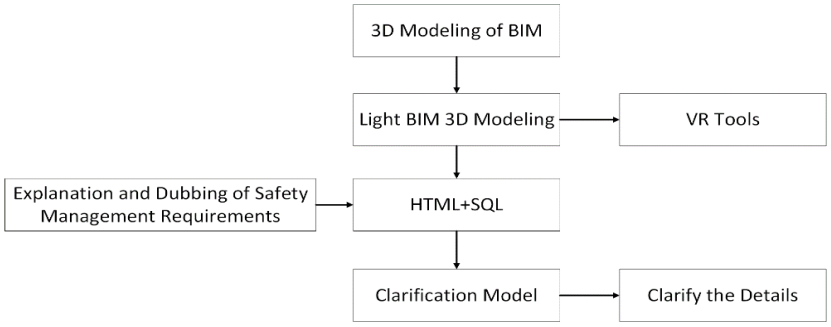

Fig.5 Technical route

Fig.6 Safety hazard management by BIM

Fig.7 Disclosure model of formwork support system

Fig.8 Animation of technical disclosure by VR

5 Construction site planning based on BIM

Due to the impact of construction environment or other factors, the area in cities available for engineering construction projects is continuously shrinking, which raises the complexity of construction environment for engineering enterprises, increases safety risks during construction process, and makes the land available for projects more and more scarce [12].

Therefore, on the premise of construction safety, it is necessary to rationalize the layout of the material storage site, construction equipment and on-site facilities. Based on BIM technology and tilt photography, a 3D real-scene model of the site of a project can be built to display the image of the project and surrounding real scene from a full perspective, and then an accurate model of the project land will be obtained. With the combination of tilt photography and three-dimensional BIM modeling, the virtual layout of the on-site material storage yard, construction equipment and on-site facilities can be respectively conducted on computer according to different construction stages, which will intuitively show the spatial location relation of the construction site, office area and living area, providing references for the optimization of on-site material stacking, mechanical equipment, and driving routes, improving the utilization rate of the construction site. Thus, it enables to obtain an optimal planning of the project construction site and ensure safe and civilized construction on site.

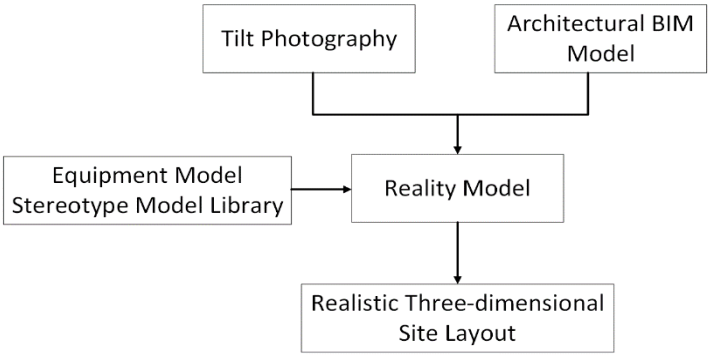

Fig. 9 Technical route

Fig. 10 Tower crane and traffic route planning for construction site

Fig. 11 Comparison of virtual layout and actual layout of construction site

6 Conclusion

In this paper the application of BIM technology in safety management was discussed from four aspects, including hidden risk identification, hidden risk management, safety education, and site management. In addition, it proposed a technical route and completed the following contents on the basis of project practice:

- Visual presentation of safety risks based on BIM and information system. Visual presentation of hidden safety hazards can be realized with the combination of a lightweight BIM model and information system.
- A BIM-based hidden risk identification method was studied. It associated the BIM model with the construction schedule, integrated the spatial and time information into a visual 4D (3D + time) model, and realized identification and evaluation of risk sources at different construction stages through virtual construction.
- A method using BIM model to carry out safety disclosure of a complicated and hazardous engineering project was proposed.
- It was proposed to use BIM and tilt photography to achieve an optimal planning of the construction site, thereby reducing security risks due to insufficient construction land.

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