Application of BIM for Safety Management During Construction

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ABSTRACT

BIM has been rapidly recognized to change the process how construction projects are delivered. This paper discussed the implementation of BIM technology for safety management and visualization in construction. The process of the safety management model based on BIM through dynamic analysis approach are proposed. In addition, potentials and limitations of BIM-based safety management were discussed. We expect this research to extend the study and adaptability of BIM in safety management on sites.

Keywords: Building information model (BIM), safety management, 4D, Visualization technology

INTRODUCTION

The construction industry is an essential national backbone, especially for developing countries. Despite advances in technology and implementation of robust safety management, occupational safety and health (OSH) incidents continue to cause persistent suffering to the construction industry and its workers in China. Building information modeling (BIM) has recently experienced rapid technological advancement and gained prevalence in the architectural, engineering, and construction (AEC) industry. Despite its great potential, the advancement of BIM in China is still in a relatively infant stage, with a relatively high percentage of construction projects still sitting on the sidelines of BIM implementation[1].

BIM is a 3D-based framework designed to integrate and digitize complete building information so as to express all the building components and their relationships. The goal of BIM has existed for at least 30 years and various standards have been published[2]. Existing literatures provided individual aspects of BIM, such as the need for data exchange standards, the future potential and inter-organizational usage of BIM. It has also been realized that BIM can be utilized to promote safety management, and combine safety with other construction planning processes. Benjaoran and Bhokha introduced an integrated system for safety and construction management using an existing 4D computer-aided design (CAD) model[3]. Guo et al. developed a conceptual...
framework of adopting virtual prototyping technology to aid in construction safety management. It consists of three components: modeling and simulation, the identification of unsafe factors, and safety training[4]. Zhou et al. explored the implementation of visualization technology for safety management and safety assessment in metro construction[5].

However, a more advanced and efficient method needs to be explored to achieve both safety hazard identification and visualization along with the construction progress.

The paper conducts an extensive review on these new developments. Then it presents the process of the safety management model based on BIM through dynamic analysis approach. The final part of the paper discuss the use of BIM and BIM-related technologies for safety management and outlines the existing challenges and gaps that slow down or prevent its broad adoption.

**DYNAMIC ANALYSIS FOR SAFETY MANAGEMENT BASED ON 4D MODELING**

For 4D visualization, Autodesk Navisworks is used widely. Revit models are converted from Navisworks (see Figure 1). Other tools can be used together with Navisworks for integrated 4D scheduling and visualization that include Microsoft Project and Visual Basic for Applications (VBA) programming[6]. The process of the safety management model based on BIM through dynamic analysis approach are described in detail as follows.

**4D modeling**

1) 3D modeling of the building; 2) create Work Breakdown Structure (WBS) and corresponding schedules according to prearranged construction scheme; 3) divide the 3D models into construction segments in accordance with WBS; and 4) link segments with corresponding WBS nodes and schedules.

**Build up the 4D construction information model**

1) Enrich the 4D model by appending project properties (e.g., resources, budget quota, and site layout); 2) extend construction information by linking elements to material properties, control parameters for meshing, activity-based loads, etc.; and 3) establish the 4D construction information model by organic and automatic integration of the abovementioned information.

**4D construction simulation and management**

1) According to different time intervals (days, weeks, or months) and schedules (planned schedule or actual schedule), the construction process can be sequence- or reverse-simulated. 2) Through 4D schedule management, construction schemes can be modified and controlled. Furthermore, schedule tracing and analysis are available by comparing planned and actual schedule data. 3) By setting up several sets of resource stencil, construction quantities, resource requirements, and estimated cost can be computed automatically and precisely by 4D resource management. 4) The 4D site management function can assist managers in accomplishing efficient site space utilization by linking 3D facility entities to the construction schedule, which is similar to other construction elements.
4D construction analysis

1) At any time point during 4D construction simulation, according to the selected schedule, elements that have been constructed, use of resources, and design codes, etc., construction analysis models can be automatically generated and stored in text files or database. 2) Through data transfer interface, these models can be imported to construction analysis systems for mechanical computation. 3) The results can be transferred back to construction managers or designers by data files, or to the 4D construction information model. 4) The results can also be used for further safety performance analysis and evaluation by calculating performance indicators, which are guide factors for warning and forecast of safety problems. 5) With site-measured data, the evaluation of safety performance can be adjusted, implementing whole process tracking of construction safety performance.

DISCUSSION

Undoubtedly safety may be present in the different stages of the project and product lifecycle and the performance of safety management has a direct influence on whether the project can be fulfilled successfully on-time and within budget. When a contractor is appointed, the analysis of safety continues but now with the assistance of specialists in construction. A construction project is normally divided into a number of subprojects for managing safety at a sub-project level by considering different activities and processes individually. To implement safety management, specialists who play facilitating roles during the safety management process need to attend the project control meetings and keep tracking progress, and give advice on specific construction activities. However, the project team, especially the managers, is required to be responsible for the application of the safety management cycle. It is extremely important to point out that many people will be involved in the safety management during the lifecycle, so that any updated safety information, decisions and changes should be recorded and communicated effectively. Therefore, BIM-based safety management is expected to facilitate efficient safety communication and support the dynamic development process of a project.
CONCLUSIONS

This study describes a methodology that assists the detection and visualization of workspace safety problems on a construction project. BIM was used to detect workspace congestion to determine potential on-site safety hazards. BIM-based 4D models could be utilized to help site safety management in construction phases. The result showed that workspace safety problems could be visually identified and managed, using the system and methodology presented in this paper. These methodologies can be used for the active BIM system which may be a representative construction safety management tool.

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REFERENCES