MODEL-BASED CONSTRUCTION WORK ANALYSIS CONSIDERING PROCESS-RELATED HAZARDS

Jürgen Melzner
Sebastian Hollermann
Silvia Kirchner
Hans-Joachim Bargstädt

Institute for Construction Engineering and Management
Bauhaus-Universität Weimar
Marienstraße 7A
99432 Weimar, GERMANY

ABSTRACT

The identification of job hazards, before they actually occur, is a challenge for the construction work planner as well as for the safety and health coordinator. The high-risk construction sector records the highest number of accidents among different industry sectors. In most cases, safety planning is purely based on checklists and manual description, which are not closely related to the actual and specific construction object. Modern technologies, such as Building Information Modeling (BIM), are offering an object-oriented planning approach toward a project’s lifecycle. This paper presents a research-in-progress project, where the BIM technology has been used to identify object-oriented and process-oriented job safety hazards. Here, the necessary construction processes will be derived from the “to build”-objects in the model. The proposed framework would be able to detect a safety hazard during the early phases of design and planning processes. The scope of research in this paper is limited to safety hazards in solid construction.

1 INTRODUCTION

The German Occupational Safety Act (ArbSchG § 1 Abs. 1) states that: “[...] safety and health of employees at work need to be secured and improved by the means of protective measures”. Therefore, a job hazard analysis (JHA) is useful for detecting hazards and risks present in the daily work at a construction site (U.S. Department of Labor 2002). This paper is concerned with such an analysis, where the implementation of theoretical input will be integrated into a 3D building model. Its aim is to organize the risks in such a manner that they could be associated to a building element in the building information model.

In Germany, more than 100 construction workers die every year at work. This shows that safety concerns have still remained a problem in the construction business. Safety planning in construction is a challenging task because of the large number of parties involved, the constantly changing conditions and the complexity of construction. The nature of construction projects are defined by separate stages of the planning process. It leads to unequal information distribution among the involved work planners. An objective evaluation of the safety planning methods regarding qualitative and quantitative factors could be significantly improved by application of innovative and integrated safety planning tools. Major safety hazards can be identified by reviewing the job accident report. This set of identified hazards constitutes the knowledge base. A thorough review of the detailed report on job accidents forms the basis for linking together objects, processes and accidents. This paper contributes to the process-driven job hazard analysis, with its implementation into the BIM. It also contributes to improvement of safety conditions at construction sites.
assigned to a building element type in a database. This will provide us in the much needed framework. By applying this system, the knowledge base will be checked against the building elements of the building model (Figure 3). The results can be seen in the software prototype.

Figure 3: Framework for the knowledge-based system.

5 EXECUTION OF HAZARD ANALYSIS AND RESULTS

In this research, the construction processes belonging to the four main categories are considered. The different construction processes, which are relevant for building construction projects, are allocated to the construction methods (Figure 4).

Figure 4: Construction methods and their related processes.
Hence, a direct connection between risk and building element is created. The system is tested on a high-rise building model (Figure 4).

The model represents an 87 meter high reinforced concrete building comprising 18 standard floors. This model represents the structure of the building, including different types of objects such as slabs, columns and walls.

Due to the similar floor structure, two floors were extracted from the model for demonstration. The two floors will be exported as the Construction-Process-Integration-XML-file (cpiXML). The cpiXML-file will be imported to ceapoint desiteMD. Out of that, the building objects will be exported to the table-based format with the following attributes: No, Name, RevitLevelName and cpID. After exporting this database, which includes the attributes mentioned before, the risks will check against the building elements and will automatically assign. The result of this connection is a graphical representation of the selected building element in the 3D building model and the arguments in the output table with the associated risks (Figure 5).

![Figure 4: View of the building information model.](image)

6.2 Results

The results of the research which are exemplary shown in Figure 5 display a comprehensive object-oriented construction job hazard analysis. By selecting an building object in the model such as a column in Figure 5 in an additional window will displayed all hazard witch can occur based on statistical evaluation. The lists of hazards shed light on the name of object and an unambiguous ID of the object. Furthermore it informs about the default construction method. In this case the assembling of a prefabricated concrete column is selected. Moreover, the type of selected building element and the probability of
occurrence according to Equation (1) of the associate risk is informed. The results indicate that Job Hazard Analysis can be integrated in the BIM processes. The performed research demonstrates flexible and project specific assessment tools for safety planning.

Figure 5: View of 3D building model with selected building element column (below) and associated risks in a table (above).

7 FUTURE WORK

In this research, the hazards caused by building geometry and construction environment have not been turned into risks because there are no statistical evaluations. Hence, a different approach must be applied. Since the building geometry is concerned with lines, areas and spatial dimensions, these factors are introduced under three categories: line-related, area-related and spatial-related hazards.

The line-related hazard categories include (Melzner et al. 2012a):

- distance from working area to the building edge,
- distance from working area to the lower level, and
- distance from working area to other objects.
The area-related hazards include:

• deepening in the floor,
• holes and openings in the floor,
• the area or level itself as work place,
• an inclined slope as work place, and
• changing floor elevations, e.g. from one level to the next level.

The spatial-related hazards include:

• ceiling height and
• atmospheric environment.

The hazards that are caused by the construction environment have neither to do with construction methods nor with building geometry. The construction environment describes the working area in which construction workers do their job or task. The German construction site regulations (BauStellV) deliver the input data in this regard, such as working near high levels of traffic, working close to high-voltage lines or working above (open) water. Future work will include the implementation of the geometric hazards, as mentioned before, to provide a comprehensive job hazard analysis tool.

8 CONCLUSION

This research identifies focal points of occupational accidents as well as risks and hazards influencing the safety of construction workers. This paper determines the job hazards related to construction process. After linking such risks to a 3D building model, the results are demonstrated with the commercial BIM software ceapoint desiteMD. The advantage of this approach is that after selecting the building element in the 3D model, the risk table displays the associated risks for the selected object. However, the risk analysis is methodologically limited to the process-driven hazard of building construction. This method, however, does not detect the hazards that may result from geometrical aspects and the construction environment.

This research demonstrates the application of a model-based job safety analysis. The framework supplies the project team with important information about the connection between construction method, building element and the related risks. Future research on this topic may include the expansion to different trades and an evaluation of a real construction safety process.

REFERENCES


