Construction Technology Safety Management under the Background of BIM and Information System Modeling

Yang Liu
Urban Vocational College of Sichuan, Sichuan, China, 610110

Abstract. The construction industry is the driving force and pillar of my country’s economic development. In recent years, due to the increasing difficulty of construction and long construction period, the traditional construction technology safety management mode is no longer suitable for modern construction projects. Construction safety accidents also occur frequently and threaten the personal safety of construction workers has caused a serious negative impact on construction enterprises. The application of BIM technology and building information system has created a new management model for construction safety management in the construction industry, greatly improving the level of engineering construction safety management, and also marking the construction industry's march toward a new era of technical information.

Keywords: BIM technology, Information system, Safety accident, Construction technology safety management.

1 Introduction

Traditional engineering projects usually adopt a multi-person safety management model, but this will make building information distributed, making information nodes difficult to manage and screen. In the process of safety management, there will be a lot of information messy and undetectable hidden safety hazards. Problems such as construction technology and safety management can not be timely and accurately supervised and managed, which reduces the quality of construction and endangers the lives and safety of workers. The application of BIM information system in the process of building construction technology safety management reduces the occurrence of safety accidents and opens up new ways for construction safety management.

Many scholars at home and abroad have conducted research on the safety management of building construction technology under the background of BIM and information system modeling, and the research progress is relatively smooth. For example, a researcher studied the application of BIM technology in building information integration. It is very effective to integrate construction information with the help of BIM technology. After analyzing the informatization situation of the domestic construction industry, based on BIM technology, through a series of strategic guarantees such as talent development, main body coordination, and information exchange, a management model for targeted construction projects has been established [1]. A research team designed an innovative framework based on virtual reality
technology to realize real-time data transmission from position sensors to visualization platforms, allowing users to be on the scene and dynamically monitoring the safety of the manufacturing process. They believe that the awareness of managers is in the construction. The safety of the management structure in the process is very important. In the early stage of construction, safety construction designers need to make detailed safety plans to enhance the safety of the construction process [2]. Although the research results of construction technology safety management based on BIM and information system modeling are good, construction safety accidents still occur frequently, and effective measures need to be taken to reduce the accident rate.

This article introduces the advantages of the application of BIM information system in construction technology safety management. The implementation purpose of construction technology safety management based on BIM information system analyzes the types and locations of construction safety accidents in a province from 2015 to 2019, and uses BIM Technical management of the construction technology safety of the construction industry, and promote the healthy development of the construction industry.

2 BIM information system and construction technology safety management

2.1 Advantages of BIM information system

First of all, BIM information system has the advantage of reducing risks. As we all know, the construction process of a building is affected by different factors and usually faces different risks during the construction process. Some risks may hinder the timely completion of the construction project. In the traditional building design stage, designers must check and compare the construction design, but in the later construction process, there are still a large number of design modifications, which poses a major risk to the construction project. With the help of BIM technology, because the 3D model of the construction project can be presented more intuitively, the design accuracy of the construction project has been significantly improved, which not only reduces potential risks, but also allows designers to generate the best design ideas.

Secondly, BIM information system has the advantage of visualization. Visualization is one of the most basic capabilities of BIM information systems, and it is also the most obvious feature that differs from traditional architectural models. Essentially, BIM technology uses a three-dimensional method to present the characteristics of a three-dimensional building. It can not only enlarge and rotate, but also modify and enhance it. This is very different from the traditional two-dimensional design function. The two-dimensional method can only express the basic and key features, and cannot intuitively present the design information, so that the designer cannot find design errors and problems in time, which affects subsequent construction progress [3].

Furthermore, the BIM information system has the advantage of information exchange. Compared with traditional methods, one of the most important properties of BIM technology is the huge amount of information it contains, which also reflects the shortcomings of traditional methods that cannot analyze large amounts of information. Due to the limited methods of storing information, traditional methods cannot store large amounts of information. In this case, errors and problems when transferring information are very common. With the help of the BIM information system, various information can be retained from the initial design stage of a construction project, and it can be sorted and integrated with the information in the next stage of construction and operation to realize the penetration and exchange of information, while also ensuring the continuity of information.
Lay a solid management foundation for construction projects. Finally, BIM information system has the advantage of parametric simulation. Parametric simulation is the cornerstone of a BIM information system and a prerequisite for realizing its series of advantages. In BIM technology, parametric modeling can be done through widgets and family libraries. This method can save the geometric and informal division parameter information of construction projects, which brings great convenience to designers [4-5].

2.2 The basic process of building construction technology safety management

Building construction technology safety management is the process of designing, formulating and implementing safety decision-making plans based on the identification and measurement of factors affecting safety. Construction companies must follow the principle of "prevention first" and take targeted accident prevention measures for all safety issues involved in the construction process to ensure the personal and property safety of the engineering company and ensure the safe progress of construction. Therefore, the safety management task of the construction stage is mainly to predict the factors that affect construction safety, so as to take accident control measures to prevent the occurrence of safety accidents. Among them, the key is to establish a clear prediction and control system for factors affecting safety, and to integrate and systematically manage the safety of structures. Figure 1 shows the basic process of building construction technology safety management. First, determine the safety goal, that is, determine the safety goal of the construction project according to the actual construction situation (such as whether the construction site is a living house or a commercial house), and establish environmental safety protection and conduct safety education and training before implementing the construction; secondly, identify the impact on-site operation activities safety factors, find out all the factors that affect the implementation of the construction safety goals of the construction project; then, the project management personnel formulate and review risk mitigation measures and accident emergency plans to prevent and control major risks to ensure that construction safety issues are effectively resolved. Finally, they analyzed and evaluated the implementation results of the safety risk control measures during the construction of the construction project, and continuously improved the control measures to finally achieve the goal of construction safety. The key step that must be carried out is to classify and identify the factors that affect safety, which is a prerequisite to ensure the smooth implementation of construction safety work [6-7].
Determine safety goals

Pre-planning of the venue

Security technical confession

Identification of major safety factors

Control of major safety factors

Supervision and inspection guidance

Keep improve

Achieve safety goals

Fig.1. The basic process of building construction technology safety management.

2.3 Implementation purpose of construction technology safety management based on BIM information system

(1) Transparency of security status
The construction process is a dynamic process, which leads to uncertainty in the safety status of the construction site. It is the uninterrupted goal of all safety management personnel to maximize the safety of the construction site. Checking the information on the safety status of the construction site is closely related to the possibility of a safety accident. It is always related to the safety of the construction site and is also the focus of safety management. The implementation of on-site safety management based on BIM information system can help managers to understand the on-site safety status in real time, accurately and efficiently, so as to achieve the goal of improving the transparency of safety status [8].

(2) Intuitiveness of safety management
The construction technology safety management based on the BIM information system will improve the intuitiveness of safety management. Even beginners with little knowledge of safety can directly assess the construction site through the 3D display in the on-site assessment and the inspection and review of the transportation model. The safety status of the system allows them to have a comprehensive and intuitive understanding of the entire process, and also enables safety managers to effectively control the construction site [9].

(3) Dynamic safety management
In the process of construction safety management, BIM technology can monitor construction safety management rules in real time at any time of the day. In addition, the construction site is designed and organized in a 3D virtual scene, and the detailed construction plan is constantly updated and improved. Through dynamic simulation to ensure the continuity of on-site safety management in time and space, discover deficiencies and failures in time, and realize the dynamic construction of safety management.

(4) Proceduralization of safety management
The application of BIM technology in the construction process has promoted the implementation of safety management throughout the entire process from construction to
completion. Add BIM technical data on the basis of the traditional management process, dynamically manage the entire construction process, standardize the management process, and complete the implementation of the construction safety management program [10-11].

2.4 BIM-based extraction of architectural topological relations

When extracting the spatial relationship within the building, each node in the topological graph is used as a starting point to calculate, and a series of spatial syntax variables are constructed [12]:

\[
CON(U_i) = \sum_{j=1}^{n} e_{ij} x
\]  

(1)

Among them, \( e_{ij} \) is the edges of nodes \( U_i \) and \( U_j \), \( CON(U_i) \) represents the number of edges starting from node \( U_i \), that is, the node connection value, and \( n \) is the number of nodes in the topological relationship graph.

\[
I(U_i) = \frac{n - 2}{2(MD(U_i) - 1)}
\]  

(2)

Among them, \( MD(U_i) \) is the average depth value of the node \( U_i \), and \( I(U_i) \) is the degree of integration.

3. Research on the safety management of building construction technology under the background of BIM and information system modeling

3.1 Research purpose

The BIM information system can use its visualization and simulation functions to detect certain safety issues in building construction, so as to prevent the emergence of safety accidents in the construction process in advance. This article attempts to explore how to use the building information system model to improve the level of construction safety management and effectively prevent and contain the occurrence of on-site safety accidents.

3.2 Research methods

This paper collects the frequency of accident types in construction safety in a province from 2015 to 2019, analyzes the location of safety accidents, and uses BIM technology to reduce the incidence of construction safety accidents.

4. Analysis of construction technology safety management

4.1 Statistics of construction safety accidents
Table 1. 2015-2019 Frequency of Construction Safety Accidents

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall from height (%)</td>
<td>32.75</td>
<td>35.61</td>
<td>41.98</td>
<td>44.57</td>
<td>45.12</td>
</tr>
<tr>
<td>Collapse accident (%)</td>
<td>12.33</td>
<td>14.06</td>
<td>13.48</td>
<td>13.26</td>
<td>10.74</td>
</tr>
<tr>
<td>Object strike (%)</td>
<td>17.28</td>
<td>13.41</td>
<td>15.50</td>
<td>12.76</td>
<td>11.08</td>
</tr>
<tr>
<td>Lifting injury (%)</td>
<td>6.77</td>
<td>8.35</td>
<td>10.61</td>
<td>8.18</td>
<td>11.27</td>
</tr>
<tr>
<td>Suffocation by poisoning (%)</td>
<td>14.64</td>
<td>12.87</td>
<td>16.34</td>
<td>11.22</td>
<td>9.69</td>
</tr>
</tbody>
</table>

As can be seen from Table 1, there are five main types of construction safety accidents in the province from 2015 to 2019. Among them, falling from height is the risk factor with the highest frequency of safety accidents during construction. Falling from height in 2019 is safe the accident rate is as high as 45.12%; the rate of collapse accidents remains within the range of 10%-15%; the rate of safety accidents hit by objects is within the range of 10%-20%; the incidence of lifting injuries is the lowest, only 6.77% in 2015; the accident rate of poisoning and suffocation dropped below 10% in 2019, but it is still above 10% in other years. Therefore, corresponding preventive measures should be taken for these high-frequency construction safety accidents to minimize the number of accidents.

4.2 Locations where construction safety accidents occur

It can be seen from Figure 2 that the main parts of the province's construction safety accidents are: openings and borders, tower cranes, scaffolding, formwork, foundation pits and so on. The most obvious of which is the highest accident rate at the entrance of the cave and the edge, which has become the most difficult point in the safety management of construction. For these frequently occurring parts of safety accidents, appropriate technical safety management measures should be taken, such as reinforcing the construction parts of the scaffold to reduce the frequency of safety accidents due to the instability of the scaffold.
5 Conclusion

This article analyzes the incidence of construction safety accident types in a province in recent years, and understands where the safety accidents occur. In general, the reasons for the frequent occurrence of safety accidents during the construction process can be attributed to the following factors: First, people pursue the differentiated operation of the project, improve the building quality requirements and the existing building height, which greatly increases the difficulty of construction and complex buildings. The structure makes the occurrence rate of safety accidents higher; and many builders only pay attention to the progress and cost when managing the project, but do not pay attention to the management safety measures, and even reduce the safety management cost to complete the construction project ahead of time, without taking any safety protection measures, resulting in frequent safety accidents during construction and production; third, construction safety management methods are relatively backward, and many construction companies still adopt traditional management methods. Nowadays, with the passage of time, the scale of the project and the difficulty of construction have been greatly improved. It is no longer possible to realize the safety management of the construction site only by improving the management system and strengthening the management. In response to these problems, the use of BIM information systems to manage construction safety can effectively reduce the incidence of safety accidents.

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