Research on Building Fire Risk Management Based on BIM

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Abstract. Based on the current building development needs and the existing problems of fire risk management, this paper analyzes the specific application of BIM technology in building fire safety analysis, and also puts forward the direction of thinking, and then builds a BIM-based fire risk management system model framework, which can provide references and ideas for the informatization and intelligent development of building fire risk management.

1. Introduction
With the continuous advancement of urbanization construction in our country, the demand for living and working places in urban areas is increasing, which has brought about a large number of high-rise and super high-rise buildings, increasing the difficulty of fire prevention and safety management. However, the traditional fire risk management model completely relies on labor, and transmission of the data and information between each other is inefficient, which makes it difficult to meet the needs of the current development of building fire protection operation and maintenance[1]. Over the years when BIM (Building Information Model) technology was introduced into our country, its powerful visualization, simulation, and parameterization features have made its application in construction engineering increasingly mature. Among them, the fire performance analysis of buildings has gradually become the focus of BIM technology research and application, providing new ideas and methods for building fire safety work[2]. Therefore, analyzing and thinking about the application of BIM technology in building fire risk management is of great significance for improving the efficiency of building fire management and its own application development in the field of fire safety.

2. BIM technology overview
BIM (Building Information Model) is a 3D virtual model established in the computer using digital technology, which can realize information integration and dynamic management of the entire life cycle of the building.

The connotation and technical characteristics of BIM: (1) BIM can simultaneously record the geometric information and non-geometric information of the building, the geometric information such as the length, width and height of the building, and the non-geometric information such as the building components’ physical properties, material properties and fire performance[3]. (2) BIM uses the common IFC standard as the basis for information transfer between various primitives to achieve a high degree of correlation between the model and the corresponding data, and improve the efficiency of the use of the model[4]. (3) Using the real look and feel and good information display of the BIM model, relevant building simulations can be conducted to reduce the consumption of resources and
manpower. (4) The research on the secondary development of BIM software can break the limitation of use among different professions, and realize true information sharing and higher-level BIM applications[5].

3. Application and thinking of BIM technology in fire safety analysis

3.1. Establishment of 3D model

The fire safety analysis of a building is based on the fire protection information related to the building and its components, and has higher requirements on the accuracy of the building information model and the integrity of the information[6]. Therefore, it is necessary to focus on the information setting required for fire risk management, or create a dedicated family library, so as to lay the foundation for the subsequent fire simulation and later operation and maintenance. From the three perspectives of architecture, structure and MEP (mechanical, electrical and plumbing), the relevant components of the building fire safety analysis included in the entire construction cycle of the building are listed in table 1. Figure 1 is the input of the fire resistance information of building components during the Revit modeling process and figure 2 shows the operations for creating stretch and adding text when creating a hydrant family library in Revit.

![Figure 1. Information input of fire resistance of building components.](image1)

| Components related to fire safety analysis | Fire parameter information |
|-------------------------------------------|----------------------------|
| Architecture                              | Interior and exterior walls, doors, windows, Building classification, fire resistance level, fire protection zone, safety exit, fire distance, etc. |
| Structure                                 | Beams, slabs, columns, shear walls. |
| MEP                                       | Air duct, water pipe, strong and weak electricity, mechanical equipment. |
|                                           | Design parameters of fire water supply system, automatic fire alarm system, smoke exhaust system, etc. |

![Figure 2. Stretch creation and text addition in Revit family library.](image2)

3.2. Marking of building functional zoning

As the functions of buildings become more and more extensive, a building often contains several use units, various equipment and facilities and combustible materials. If stored or operated improperly, it will pose a great fire hazard. Before the building is put into use, by identifying the fire risk source inside the building, it is possible to roughly assess the area where the fire risk is greater. Combined
with the characteristics of intuitive and visual display of the spatial structure of the BIM model, different colors can be used to describe different functional partitions during modeling to achieve rapid positioning and view viewing of various functional areas, and spatial areas with large fire hazards. It can also be marked and warned in the same way to facilitate the fire safety supervision and inspection of key fire hazard areas during the operation and maintenance period[7]. Figure 3 is a functional zoning picture of a certain floor of a complex building marked in Revit.

3.3. Fire simulation and evacuation simulation
Due to the characteristics of visualization, simulation and optimization of BIM technology, many scholars have used it as an effective tool combined with the simulation of building fire simulation to improve the research efficiency of building fire and safety evacuation[8]. Figure 4 is a workflow diagram for the combination of BIM modeling software Revit and today's mainstream fire and evacuation simulation software Pyrosim and Pathfinder. Revit has a very good performance in the civilian market with the help of CAD. It can achieve the sharing and association of different professional information on buildings, structures and equipment.

However, there are still some problems in the analysis and management of building fire performance in the current BIM environment: on the one hand, although the current fire and evacuation simulation software can directly use the imported BIM model and information, reducing the trouble of repeated modeling, but in the process of model conversion, there will still be problems such as the loss of stored material information, which is not conducive to the accurate assessment of the development trend of fire; on the other hand, BIM-based fire simulation and personnel safety evacuation analysis are often unidirectional, and there is no feedback and storage to the BIM platform, which is easy to cause the information chain break, and it is inconvenient for the later operation and maintenance personnel to use the data when they carry out their work. Therefore, how to realize the quick and effective extraction of material parameters and other information in the BIM model through the secondary development of the BIM software, and integrate the useful information data analyzed in the relevant simulation software into the BIM platform is worthy of constant research.

4. BIM-based fire risk management system model
BIM technology promotes the concept of information transmission and sharing throughout the life cycle of engineering projects. Fire risk management information, as an important branch of them, should keep up with the pace of information technology. Consequently, it is necessary to systematically consider the fire risk management of the building based on the BIM data platform, so as to achieve the purposes of improving management efficiency and professionalism, promptly detecting the fire and rescue in time, and ensuring the safety of personnel and buildings.
According to the characteristics of the fire risk management process, this paper establishes a BIM-based fire risk management system which includes data collection, information model, data analysis, risk warning and data application. The system framework is shown in figure 5.

(1) Data layer: (for the entire system) Provide a huge database as the basis of the fire risk management information system, combined with visual monitoring, radio frequency identification, multi-data sensors and other big data emerging technologies to achieve data collection of various parameters. The content mainly includes three aspects: the collection of geometric information and non-geometric information of the building model, the collection of data on hazard sources in the building, and the real-time collection of the operational status data of each fire equipment. It is used to integrate a series of fire risk management information from building design, construction to use stage, to provide guarantee for the information exchange and cooperation of various parties.

(2) Model layer: The information model is a 3D visualization of data, and different information models are a collection of relevant information required for application functions of different modules. The establishment of a fire risk management system based on BIM technology requires the combination of two types of models. The first type is a three-dimensional information model based on BIM, which uses the characteristics of BIM technology information integration to achieve detailed statistics and rapid transmission of information, while providing a visual platform for fire risk management. The second type is the fire safety analysis information model, including the fire simulation model, evacuation simulation model and fire system information model, which can also be regarded as a fire emergency database. The data in the model is continuously recorded and updated over time. The relationship between them is complementary. The information between different software is transmitted or stored in BIM through the standardization of IFC data, and the information exchange between different modules is connected through the development of API interfaces.

(3) Analysis and early warning layer: data analysis is mainly to analyze the data received and stored by the model, mainly based on the specifications and set standards, to carry out data analysis of fire hazards (smoke concentration, air temperature and toxic gases) in the building. The processing and analysis of fire simulation data, and the detection of the operation and use status of fire fighting equipment. Based on the analyzed data, a warning can be given at the specific hazard source location of the BIM model, and a signal can be sent out in time to prompt the staff to deal with it as soon as possible.
(4) Application layer: The main purpose of system design is to realize fire risk management of buildings. Extract the required information from the corresponding information model, analyze, process and update, such as viewing emergency resource information and escape evacuation alternatives in the emergency information model, and regularly setting maintenance information query in the BIM model fire equipment database. The whole process of fire risk management is carried out around the core idea of performance-based fire prevention.

5. Conclusion
Based on the technical characteristics of BIM, this paper discusses and thinks about its active role in building fire safety analysis, and initially designs an application framework that combines BIM technology with fire risk management, aiming to solve the lack of informatization and systematic control of traditional fire risk management models. Nowadays, the world is in the era of technological innovation in the development of the Internet of Things and big data technology. Subsequent research will continue to combine BIM and emerging technologies to innovate research ideas for improving the fire safety level of buildings.

References
[1] Ma Guofeng, Song Xue. (2019) Research on BIM-based office building intelligent operation and maintenance management design. Science and Technology Management Research, 39:170-178.
[2] Chen Yuan, Ren Rong. (2016) Research on the application framework of building fire safety management based on BIM. Journal of Graphics, 37: 816-821.
[3] Liu Zhaoqiu, Zhang Ji. (2015) Structural analysis BIM model framework and data conversion application [J]. Industrial Architecture, 45: 178-183.
[4] Bai Jiaojiao. (2019) Development and implementation of emergency management module for subway station based on BIM. In: The Fifth National BIM Academic Conference. Chang Sha. pp. 68-73.
[5] Deng Tiejun, Ji Yunzhi, Deng Hongbo. (2019) Fire management information system of transportation hub project based on BIM technology. Journal of Railway Science and Engineering, 16: 542-549.
[6] Wang Yueqiang, Zhou Jin. (2019) Research on fire risk assessment based on BIM. Journal of the Armed Police College, 35: 9-13.
[7] Qi Baoliang, Lin Yupu, Yang Xiuzhi, Wang Qingqing. (2020) Automatic labeling method of room information in Revit three-dimensional model. Computer System Application, 29: 226-232.
[8] Wang Yin, Yi Saili. (2019) Fire Simulation of Urban Underground Comprehensive Pipe Corridor Based on BIM. Fire Science and Technology, 38: 1704-1707.