ISSN: 2710-0588

BIM-based Fire Evacuation Simulation Study

Chen Huang

School of Southwest Minzu University, Chengdu 610000, China

*2475297790@qq.com

Abstract

The frequent occurrence of fire accidents has caused many safety problems for people, and improper evacuation often results in casualties. As a building information visualization tool, BIM model has the advantage of unique digitalization and information storage function, which can reflect the structure of building model and the location and distribution of stairs and rooms. It can provide real building information for fire and other emergencies, and the evacuation effect is better when combined with personnel evacuation software.

Keywords

BIM; Pathfinder; Evacuation Simulation.

1. Introduction

The frequent occurrence of fire accidents has caused great safety problems for human beings. From the investigation of fire accidents in residential and dense places, it is found that a large part of the causes of human casualties is due to the untimely evacuation in case of fire. Due to the unfamiliarity of the evacuated people with the internal access intersections of buildings and the lack of relevant firefighting awareness, they are unable to obtain the correct route to the safety exits for evacuation in time in case of fire, and the firefighters are unable to carry out rescue and fire fighting work quickly, resulting in serious casualties and property losses[1].

Traditional evacuation relies on posting fire evacuation diagrams inside buildings and organizing field fire drills. 2D fire evacuation diagrams lack specificity and local paths may fail when a fire occurs, so a single evacuation plan cannot meet the evacuation needs of people in multiple fire scenarios. Organizing fire drills in the field requires a large amount of human and material resources, and there are safety hazards such as trampling accidents. Therefore, a large number of computer simulation-based evacuation research efforts have emerged in recent years. Computer simulation-based personnel evacuation has many advantages over traditional evacuation work, which are mainly reflected in: (1) unlimited simulations can be realized for different fire scenarios (different settings of fire starting point, personnel composition, etc.), and multiple evacuation plans can be obtained; (2) low cost, without consuming a large number of d human and material resources; (3) simulation results can provide guidance for building layout optimization in the design stage or existing building renovation or renovation of existing buildings in the design phase [5]. In addition, human behavior in emergency situations can have an impact on the choice of evacuation paths, which in turn has an impact on evacuation time and efficiency, etc. It is unrealistic and unethical to study human evacuation behavior in a burning building; therefore, it is important to integrate the evacuation behavior of people in emergency situations into the evacuation simulation process of public buildings and optimize the interior layout design of buildings based on the simulation results [2][3].

ISSN: 2710-0588

2. Releted Technologies

2.1. BIM Technologies

BIM (Build Information Model), that is, "building information model". C.I.M in 1974, a kind of building information carrier from two-dimensional flat to three-dimensional space of building information expression, in recent years in the design and construction phase of rapid development. Its core is to use digital technology to reflect the complete and real information of the building by establishing a virtual 3D model of the building. This information not only reflects the geometric information, professional attributes and state of the building, but also includes the state information of non-constructed objects such as time and motion information[4].

2.2. WebGL Technologies

WebGL (Web Graphics Library) is a Web 3D graphics protocol released by the Khronos Group, which is based on OpenGLES2.O, and is bound to JavaScript, providing a free, open, cross-platform Web-3D graphics rendering API. Compared with OpenGL and traditional Web3D applications, WebGL does not require plug-ins, can call computer GPU resources for accelerated 3D rendering, is compatible with most browsers such as Google, IE, Safari, Firefox, etc., and can better display of 3D models and scenes, and realize the light weight and visualization of BM models.

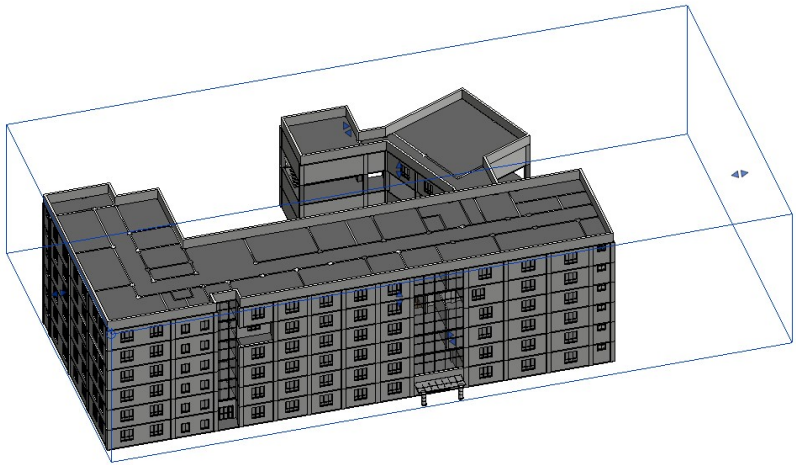
2.3. Pathfinder

Pathfinder is an intuitive, easy-to-use, new intelligent emergency evacuation assessment system developed by Thunderhead Engineering, Inc. It uses technology from the fields of computer graphics simulation and game roles to perform graphical virtual walkthroughs of individual movements in multiple groups so that individual escape routes and escape times can be determined in the event of a disaster. PATHFINDER is an intuitive and easy-to-use new intelligent emergency evacuation and escape assessment system.

3. Model Building

3.1. BIM Model Building

The study selected the first experimental building in Wuhou Campus of Southwest University for Nationalities as an example model, which has 6 floors, one elevator and three staircases. CAD drawings were drawn according to the structure of the laboratory building, and the BIM 3D physical model was established according to the CAD drawings through Revit software as the basic 3D model for simulating evacuation, as shown in Figure 1.



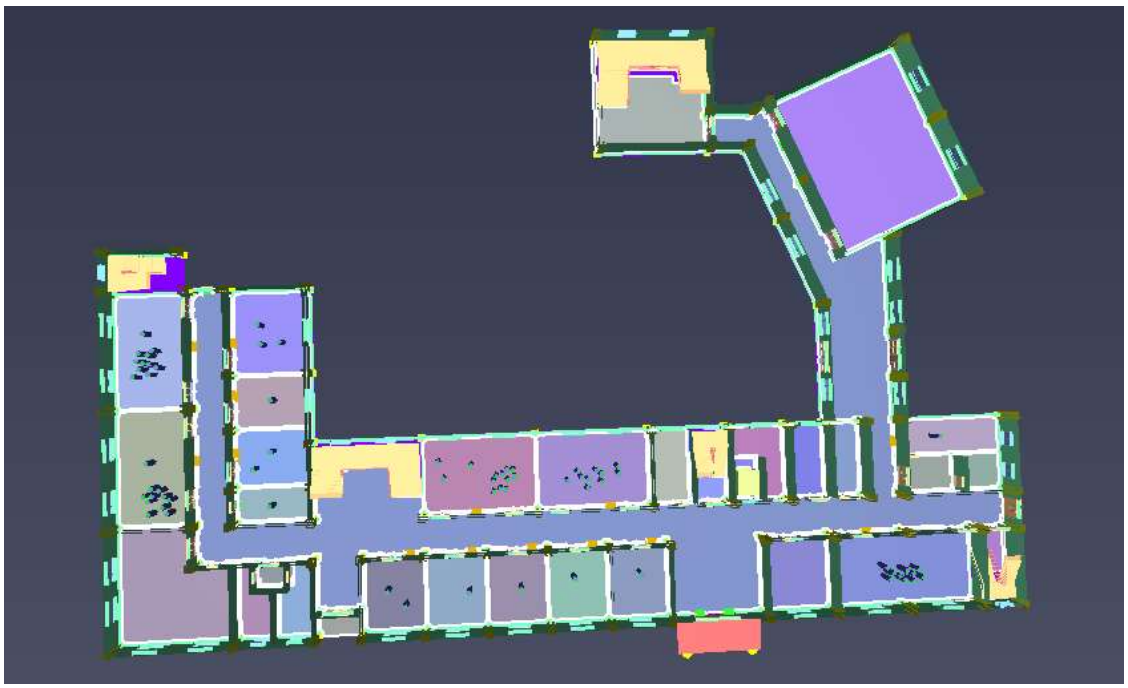
Figuer 1. The basic 3D model for simulating evacuatio

ISSN: 2710-0588

3.2. Pathfinder-based Evacuation Model

Open Revit to load the model, export DWG format, export settings only retain the building model (hide the structure, mechanical and electrical, etc.), import the exported model into Pathfinder. create the floor elevation of the analysis model, this building has six floors, the floor height is 3m. select the floor just created Floor3.0m and Floor6.0m and the floors above, and hide them, at this time in the 3D view only show the elements at 0~3m. Pathfinder also provides a function to identify the plane to generate room button [extract floor from imported geometry], click the button in the left toolbar, and then click the floor in the model in turn, the program can automatically generate Room. Click the button [AddaNewDoor] in the red box in the left toolbar, and set the width of the door in the upper menu bar to finish drawing the door at the corresponding position in the model. When the door is arranged between two Rooms, the two Rooms are connected and people can enter and exit the door during the evacuation simulation; when the door is arranged at the edge of a Room, the door is the evacuation exit and people will evacuate out of the building to this place during the evacuation simulation. After finishing the drawing of Room and Door, a simple evacuation analysis model is completed[5][6].

To ensure that the model can reflect the scenario during evacuation in a concise and intuitive way, the model needs to be simplified, leaving only the structures necessary for the evacuation simulation. Firstly, the walls, columns and other components that hinder the observation of the evacuation process are removed from the model, and secondly, the rooms are extracted and different color modules represent different rooms (e.g., restrooms, cable rooms, power distribution rooms, etc.), and the doors and stairs necessary for evacuation are added to the rooms, with the green doors representing the safety exits. The simplified evacuation model is shown in Figure 2.



Figuer 2. The simplified evacuation model

4. Simulation

4.1. Determination of Constraint Parameters

The determination of the constraint parameters mainly includes the determination of the number of evacuees and evacuee indicators.

ISSN: 2710-0588

(1) According to the Revit model, the actual evacuation area of each floor of the laboratory building is about 1500 square meters. There are 21 rooms on each floor, six large laboratories, two restrooms, three staircases, and one elevator. There are 4 safety exits in the whole building.

Assuming there are 20 people in the large lab, a total of 6 x 20 = 120 people. Other small labs count 6 people, 15 x 6 = 90 people. A total of 210 people per floor, the laboratory building, six floors of a total of 1260 people.

(2) the classification of the evacuation process and the speed of movement of personnel will have an impact on the evacuation time. Young and middle-aged people are predominant in the laboratory building, and the speed of personnel is constantly changing due to the influence of psychological and environmental factors[7].

4.2. Simulated Evacuation

Simulation was performed according to the design parameters, and the total number of evacuees was 1260, and the total evacuation time was measured to be 154.8s.

4.3. Analysis of Simulation Results and Design Deepening

(1) The above simulation results show that the time required for evacuation is greatly extended during the period of maximum personnel flow. The emergent situation can easily lead to a safety accident.

(2) To solve the above problems, this experiment sets up a new exit on the other side of the building, and when the alarm sounds a fire alarm, the fire exit opens automatically, and the evacuation simulation is carried out at this time, and the evacuation time is greatly reduced[8][9].

5. Conclusion

In this paper, we combine examples, apply Revit software to establish 3D BIM models of experimental buildings, use Pathfinder simulation to simulate the dynamic process of safety evacuation of experimental buildings, verify the practicality and feasibility of modeling and simulation technology, and draw the following conclusions.

(1) Through the combination of Revit modeling and Pathfinder evacuation simulation, the temporal and spatial changes of the safety evacuation of the experimental building can be vividly displayed in a visual way.

(2) Through the simulation of evacuation process, it is found that the bottleneck of evacuation is mainly reflected at the staircase. With the evacuation to proceed, the number of people here saturated, there is serious crowding phenomenon.

(3) By changing the evacuation conditions, if additional safety exits and other measures are installed, the evacuation effect is significant.

References

[1] Lin Chen. Comparative study on evacuation strategies and applicability of commonly used personnel evacuation simulation software[D]. Anhui University of Technology, 2020. DOI:10.26918/d.cnki.ghngc.2020.000894.

[2] Guo Baoliang. Path planning research of fire emergency evacuation intelligent system[D]. Hebei University of Science and Technology, 2020. doi:10.27107/d.cnki.ghbku.2020.000067.

[3] Zhang Bo. BIM-based simulation and design optimization of fire evacuation in public buildings[D]. Dalian University of Technology, 2021. DOI:10.26991/d.cnki.gdllu.2021.000148.

[4] Wang Kao. Building fire evacuation path planning based on BIM and optimized ant colony algorithm[D]. Xi'an University of Architecture and Technology, 2020. DOI:10.27393/d.cnki.gxazu.2020.000545.

ISSN: 2710-0588

[5] Ma Yana. Simulation study of building fire safety evacuation based on BIM technology[D]. Lanzhou University of Technology,2021.DOI:10.27206/d.cnki.ggsgu.2021.000604.

[6] Cheng, Lina. Study on the simulation of emergency evacuation of subway station fire based on Pathfinder[D]. Lanzhou Jiaotong University,2014.

[7] Yu Heng. Research on fire safety evacuation in subway stations based on fire dynamics and crowd evacuation simulation[D]. South China University of Technology, 2020. DOI:10.27151/ d.cnki. ghnlu.2020.000030.

[8] Zhang, H. S. Research on lightweight indoor emergency evacuation simulation system for fire scenarios[D]. Shandong University of Science and Technology, 2020. DOI:10.27275/ d.cnki. gsdku. 2020.001740.

[9] Liu Y, Liu Z-M. Simulation study of crowd evacuation in small and medium-sized stadiums based on Pathfinder[J]. Low Temperature Building Technology, 2021, 43(4):5.

[10] Shao ZG, Wang XH, Yu DH. A study on safe evacuation simulation of subway stations based on Revit and Pathfinder[J]. Journal of Qingdao University of Technology, 2021.