

Research on Simulation Practice of Hospital Indoor Wind Environment Based on Bim Technology

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ABSTRACT. Thanks to the promotion of construction industrialization, BIM has been widely used in architectural planning and design, coordinated layout of pipelines, visualization and virtualization, etc., but its application in wind environment is rare. In this paper, Autodesk Revit is used as a 3D design platform to create hospital BIM model. In the process of modeling with Revit software, the building information model is defined by adding object elements and modifying parameters. The results show that the wind speed in winter in the patient area around the building does not exceed 4.0m/s, which does not affect the comfort requirements of patients; According to BIM model and building codes and standards, BIM simulation and reliability evaluation methods of building wind environment are established. The research results show that the method of interactive application based on BIM model can achieve good results in simulating indoor wind environment in hospitals, and through the interactive connection of models, BIM technology can be effectively used as an auxiliary reference and optimization design for designers in hospital planning stage.

KEYWORDS: Bim, Hospitals, Indoor wind environment, Simulate

1. Introduction

With the development of economy and society, the scale of urban population is increasing, and the scale and height of hospital buildings are increasing. Therefore, hospital buildings need to move in time, and incorporate scientific hospital ideas into them, especially in the aspects of hospital building planning and design, energy saving, indoor environment control, etc., so as to make hospital buildings have excellent indoor wind environment. BIM technology, as a new information technology, has been continuously promoted and improved in continuous development. BIM technology can carry out corresponding engineering information management in combination with the engineering cycle of building hospitals, and then complete the joint management of construction time, quality and cost, reduce the time of hospital construction, and effectively improve the technical level of engineering buildings [1]. How [2] has established solar simulation technology based on BIM development platform; Jiang et al. [3] applied BIM technology to establish a geological environment and fire response model; Therefore, taking the hospital as an example, this paper studies the simulation analysis method of indoor ventilation environment based on BIM technology.

2. Bim Modeling Method

For architectural design, Sketch up software can be used to build a preliminary model, and 3D geometry can be easily generated by topographic map, and 3D modeling of complex terrain can be realized. It can put the original information into the platform for collection, research and synthesis. In addition, the created model is 3D, not flat content. This software can use the integrated technology platform to complete higher-level dimensional research, and it can also be connected with many related technologies. It can also quickly obtain the detailed structure at any position, and optimize and adjust the scheme in time according to the wind environment simulation results. After integrating the architectural and hospital models with Revit, the Revit design model is read through Phoenix VR panel. Using Revit software, the standard layer model of each scheme is established, the height is set to 2 800mm, and the thickness of external wall and internal wall is drawn according to the dimensions given in the atlas. The floor slab is 100mm thick, and the size of the hole of doors and windows is accurately placed. The actual opening of windows is the size of windows. This paper mainly simulates and analyzes the summer working conditions when air conditioners are used more. The indoor wind environment simulation conditions of the model are set as follows: the wind direction is southeasterly (SSE), the wind speed is 3.00m/s, and the air pressure is one standard atmospheric pressure.

3. Reliability Analysis of Building Wind Environment

3.1 Random Factors of Wind Environment

Hospital environmental performance analysis is mainly in the preliminary design stage of building hospitals, and the analysis results are calculated to determine the feasibility of green design of hospitals. The air flow produced in different directions has obvious uncertainty. The wind load is often considered as certainty in previous studies, which leads to low reliability of calculation models. Indoor wind environment analysis mainly considers natural ventilation in summer and transition season under average wind speed condition, wind protection in winter and patient safety under 10% strong wind condition [4]. When the wind is close to the building model, it starts to decelerate obviously, but the degree of reduction is different in different areas. After determining the building wind environment simulation index, the calculation area is divided into hospital grids. The wind speed in the direction of building inflow is evenly distributed, and the wind speed in different height planes increases gradually along the direction of building height. Indoor air conditioning system is needed to meet the requirements of cold and heat load and air quality. In transition season, when indoor air quality is good, indoor natural ventilation can be used to improve air quality, which is both energy-saving and healthy. Avoid the influence of wall effect and the vertical component of wall is zero; The outer domain can be set as symmetric boundary condition; The model of outpatient department adopts wall boundary, and fluid flows through the wall without slippage.

Good indoor and outdoor ventilation design is very important for reducing air pollutants and human living comfort. On the windward side of the building model, the wind direction is still dominated by the current direction, and there is no big change; The realizable- $k-\varepsilon$ model is selected to set the Phoenix wind environment parameters. This analysis model can predict the divergence ratio of cylindrical jet and flat plate more reasonably, and analyze the flow separation and secondary flow characteristics of hospital wind flow. According to relevant engineering experience and simulated trial calculation, the selection criteria of calculation domain are as follows: taking the whole simulated building complex as a benchmark, the building is expanded by about 5 times before and after the building, and the height is expanded by 4 times, and the building complex is placed in the center of calculation domain. The simulated pressure distribution of indoor wind environment in our hospital under the dominant wind direction and wind speed in transition season is taken as the pressure boundary of indoor natural ventilation window. In the analysis or evaluation of building wind environment, these factors should be considered as random or fuzzy factors, and the evaluation based on these factors will give full consideration to the influence of various uncertain factors, thus providing scientific basis for architectural design.

3.2 Reliability Analysis Method of Wind Environment Comfort

In computational fluid dynamics, grid generation is very important, which is directly related to the success or failure of CFD calculation. There are many factors that affect air infiltration, such as door and window structure, orientation, indoor wind speed and direction, indoor and outdoor air temperature difference, building height and so on. Generally speaking, for buildings with low height, the effect of wind pressure is mainly considered in air infiltration, and the effect of hot pressing can be ignored [5]. Therefore, there is no large eddy area and no serious impact on hospital wind environment. The architectural layout forms a wedge-shaped open layout facing the wind direction, which is beneficial to hospital ventilation. The hospital wind field of BIM model is analyzed by Phoenix platform. Under the prevailing wind conditions in summer and winter, the hospital airflow speed, wind pressure and indoor wind speed amplification factor are calculated, and the simulation results are analyzed. Set the wind direction as north wind and the wind speed as 4.2 m/s, and intercept the flow field, wind speed and wind pressure at the height of 1.5 m for analysis. The distribution of tuyere position is beneficial to the formation of "through flow". At the same time, the airflow in some positions is blocked by the inner wall to generate vortex, which leads to higher local wind speed, while the wind speed in other parts is relatively small, and the airflow distribution in the region is uniform.

The indoor wind environment simulation of this project mainly uses the standard $k-\varepsilon$ model to solve the surrounding conditions. The general research in this part has a certain relationship with the continuity equation, momentum and energy equation. The general equations for indoor wind environment simulation are as follows [6]:

$$\frac{\delta(\rho\varphi)}{\delta t} + \text{div}(\rho\bar{U}\varphi) = \text{div}(\Gamma_{\varphi}\text{grad}\varphi) + D \quad (1)$$

φ in the general equation marked above is generally velocity and turbulence kinetic energy, and may be turbulent energy dissipation rate and temperature.

Different heights have different wind speeds, and the calculation formulas of height and wind speed are as follows:

$$V_h = V_0 \left(\frac{h}{h_0}\right)^n \quad (2)$$

In which: V_h is the wind speed at height h , m/s; V_0 is the wind speed at the reference height h_0 , m/s, and the wind speed at 10m is generally taken; n is the exponent.

Hospital environmental performance evaluation is not only unilaterally scoring and judging the green degree of hospitals, but also the evaluation indexes in its contents should be determined around the social and economic performance of the construction industry, in order to achieve the purpose of sustainable development [7]. Grid division is the key to model calculation. Good grid division can ensure the accuracy of calculation results and shorten calculation time. Grid quality is very important to simulation results. The increase of hospital wind speed is also beneficial to the flow of indoor fresh air, strengthening natural ventilation and taking away hospital pollutants to ensure the air quality in surrounding areas. This is mainly related to the small area of the indoor partition and the openable external window of the building, and there are many indoor obstructions through which the airflow passes, resulting in slow wind speed. Because the generalized uncertainty is extremely complex, this paper is limited to study the randomness of wind environment. Without losing generality, only the specific key random characteristics of wind environment, such as the influence of wind speed or wind pressure randomness on architectural design, are considered.

4. Simulation and Analysis of Indoor Wind Environment Performance in Hospitals Based on Bim

4.1 Build a Bim Model Platform

In this example, Autodesk Revit is used as a 3D design platform to create a hospital BIM model. In the process of modeling with Revit software, the building information model is defined by adding object elements and modifying parameters. The airflow in the hospital wind field is basically in the range of 0.1 ~ 4.2 m/s, and the indoor wind environment is in good condition, which ensures the dispersion of pollutants and the adjustment of thermal environment in the hospital. Set the wind direction as north wind and the wind speed as 5.0 m/s. The flow field, wind speed and wind pressure at a height of 1.5 m are intercepted and analyzed, mainly explaining the wind speed and relative change in the planning area and the wind pressure distribution in the building facade. According to the simulation results of indoor wind environment, two wards with positive and negative wind pressure on the southbound surface were selected as typical rooms for indoor air distribution simulation. Combined with BIM model and calculation and prediction method, a new index of building comfort, namely building comfort reliability, is put forward. The uncertainty of building wind environment is considered, in which the influence of random wind environment is mainly considered. The speed, stability and accuracy are calculated through various discrete schemes and numerical methods in the corresponding areas, and the best combination scheme is obtained through repeated simulation analysis and comparison. Finally, various practical problems are efficiently handled and various flow statistics problems are solved.

4.2 Simulation Analysis of Indoor Natural Ventilation

According to the simulation diagram of indoor wind environment in transition season, the indoor natural ventilation of hospital is simulated and analyzed. According to the analysis of simulation results, it can be seen that all hospitals in each scheme have good ventilation, the maximum indoor wind speed is 1.7m/s under natural ventilation conditions in summer, and the air velocity in areas where people often move indoors is guaranteed to be between 0-1.4m /s, which is beneficial to obtain good natural ventilation effect. The internal flow field moves upward from the 1st floor along the stairs, and then flows out from the exit of the 2nd floor. Vortex is generated in some areas of the 2nd floor due to the obstruction of the inner wall, resulting in higher local wind speed, while the wind speed in the L-shaped wing area is relatively low. The overall ventilation in the hospital is in good condition. The wind pressure in the north of the hospital is about 3 ~ 7 Pa, the maximum wind pressure is distributed on the windward side of the building, which is about 7 Pa, and the minimum wind pressure is distributed on the leeward side of the building, which is about 8 Pa. Therefore, whether a person is safe and comfortable at a certain location depends on the wind speed at that location and the surrounding wind speed distribution. Through wind speed simulation and analysis, we can get the location where people can get close to the ground, the average wind speed and airflow direction under the influence of different wind directions, and then calculate the comfort parameters. The simulated operating conditions are set as shown in Table 1:

Table 1 Simulated Working Condition

Season	Indoor average wind speed	Maximum wind direction	Maximum wind direction frequency
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Winter	0.81m/s	NE	8.6%
Summer	1.32m/s	S	14.7%
transition season	1.02m/s	E	12.1%

The simulation results of wind speed and direction are shown in Figure 1, in which the arrow indicates the wind direction, and the color from warm color (red) to cool color (blue) indicates the wind speed from large to small. It can be clearly seen from fig. 1: on the windward side, the wind speed decreases not obviously, and even enlarges at the corner; However, on the leeward side or in the places with irregular buildings, there will be obvious changes, and the wind speed will decrease sharply, even forming a windless zone.

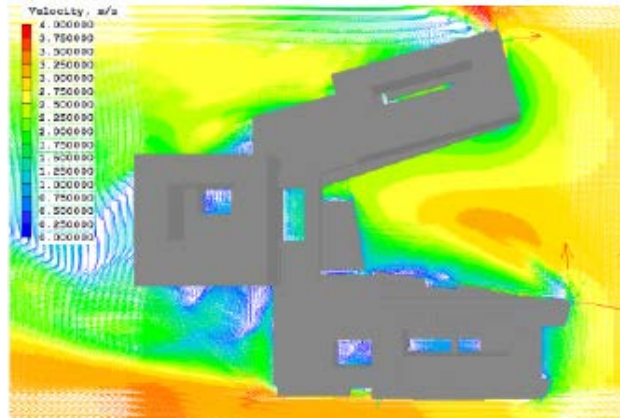


Fig.1 Wind Speed and Direction Plan Around a Hospital

Hospital ward is an important place for patients' treatment and rehabilitation. Because most patients are inconvenient to move, they have to stay in the ward almost all day. Therefore, a good indoor environment is very necessary. The windward room of the hospital is affected by the overall air pressure difference, which is easy to cause indoor cold air infiltration and condensation of cold bridge. Therefore, it is necessary to strengthen the tightness of doors and windows in this room, ensure that the thermal performance of cold bridge meets the relevant requirements, and take corresponding measures to ensure the indoor thermal environment in winter. Compared with the whole wind pressure cloud picture, the wind pressure at the entrance is larger, and there is an air flow at the stairway at the junction between the first floor and the second floor, which flows towards the air outlet, resulting in a larger wind pressure there. In the design, the angle between plane and dominant wind direction should be considered to facilitate indoor ventilation in northwest corner. Intermediate households are greatly affected by the shielding of elevators. In the numerical simulation analysis of hydrodynamics, different turbulence models should be selected for different fluid flows to simulate the real flow field values to the greatest extent. When the wind speed is 5.0~7.3 m/s, the wind environment at the pedestrian height has reached an uncomfortable level, but it will not affect people's normal activities. 7.3 m/s is to judge whether the wind speed is high enough to affect people's normal actions. The maximum indoor wind speed is the maximum inlet wind speed, and the minimum wind speed is about 0.1 m/s, which is the same as the second-floor speed field, and the wind speed in most indoor areas is 0.1 ~ 0.5m/s.

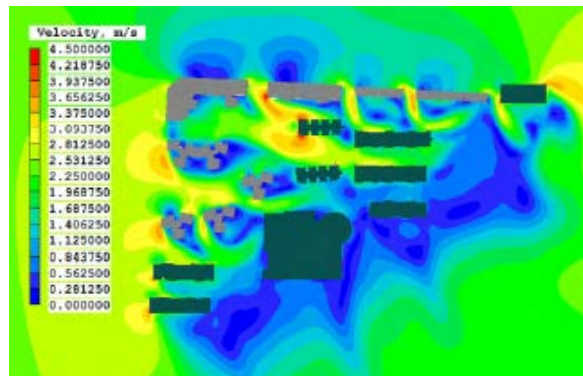


Fig.2 Environmental Wind Speed Nephogram When the Input Wind Speed is 2.5 m/s

According to the wind speed in the pedestrian area around the building is lower than 5m/s, and the amplification

factor of indoor wind speed is less than 2; Except the windward first row buildings, the wind pressure difference between windward and leeward surfaces of buildings shall not exceed 5Pa. Meet the requirements of human body and comfort. The maximum wind speed in hospital buildings in winter is 4.7 m/s, and the overall wind speed does not exceed 5 m/s, which does not affect the comfort requirements of patients. Because of the obstruction of the wall at the entrance, the wind pressure increases after the vortex is generated. The high internal wind pressure is caused by air convection, but the space as a whole meets the requirements of personnel for fresh air. Under various working conditions, the maximum wind speed around the hospital building is less than 5.0 m/s, and the wind speed amplification coefficient is less than 2, and there is no obvious vortex or dead corner around the hospital building; The wind pressure difference between windward side and leeward side in transition season and summer is greater than 1.5 Pa, which is beneficial to natural ventilation. When the external window is affected by indoor positive pressure, more and more hot air enters the room and is far away from the air supply outlet. The temperature near the external wall is obviously increased by the seepage wind, and the influence depth reaches about 1.7m, especially near the right hospital bed, which has reached 27°C; As shown in fig. 2, the high-rise building located in the southwest corner of the hospital has a maximum wind speed of 5.3m/s.

5. Conclusion

BIM technology has profoundly affected the development of architectural design industry, and its application value and advantages have become increasingly prominent at the beginning of design. In this paper, building engineering modeling activities are carried out based on BIM technology, and a simple Revit model is added to our corresponding tools for simulation research by using information interface transformation and gbxml format, and finally, in-depth exploration is carried out. From the simulation results, when the ward is located in different wind pressure areas in the building, the indoor design parameters should be properly adjusted according to the indoor wind environment. During the transition season, the wind speed of the main indoor functional rooms can be basically controlled at 0.1 ~ 0.54 m/s; The average natural ventilation frequency of hospitals is not less than 2 times/h. Because of the boundary conditions of building hospitals and the disturbance of surrounding environment, the analysis of wind environment and the evaluation of comfort reliability are complicated, which needs further discussion.

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