Application and Research of Architectural Wind Environment Simulation in the Design Phase of the Project

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Abstract. In the general layout and plane design of the building, the wind environment of the building is of great significance to improve the comfort of the living, the indoor air quality and the quality of people's life. The outdoor and indoor wind environment of the building shall be simulated in time to avoid vortex or dead angle in the human activity area of the site and no wind in the room. This paper discusses the important role of wind simulation in the architectural design stage through the reasonable optimization of the architectural scheme, in order to play a positive complementary role in improving the living environment in the scheme design stage.

Keywords: Building wind environment; Phoenics; Simulation; Scheme design.

1. Introduction

As one of the important influencing factors of urban environment, wind is often ignored by urban planners and architects in the design process. The neglect of outdoor wind environment and natural ventilation of urban buildings may lead to the bad local wind environment of building groups and the reduction of indoor and outdoor comfort. In the early stage of architectural design, the wind environment is simulated and analyzed, and the appropriate adjustment is made to get the optimal design scheme, which can avoid the trouble caused by the wind problem in the later stage. Therefore, the prediction analysis and optimization design of wind environment by architects should be an important part of the process of architectural design. The past design neglect of wind environment can not be ignored.

Architectural wind environment design is particularly important in the conceptual design stage. In the conceptual design of architectural scheme at this stage, architects do not have a qualitative judgment basis and standard for the design of wind environment, which is always based on their own experience and human feelings. This situation leads to the unreasonable design of wind environment in many practical projects. Especially in residential buildings, unreasonable wind environment design will bring inestimable consequences. However, it is very unlikely to change this situation in time after finding the problem, so the actual project can only be optimized through the later wind environment treatment measures. However, the cost will increase and the results achieved will not be as good as the design results of the project after making the appropriate wind environment design strategy in the conceptual design. This paper discusses the important role of wind simulation in the architectural design stage through the reasonable optimization of the architectural scheme, in order to play a positive complementary role in improving the living environment in the scheme design stage.

2. Research Background

2.1 Environment Introduction

This paper takes a group in the bidding scheme of a high positioning residential quarter in Chang'an District, Xi'an City, Shaanxi Province as a case study. The residential quarter is located in the south of Chang'an District, Xi'an City, Shaanxi Province. The annual temperature in Xi'an is characterized by hot summer and cold winter. Therefore, the special meteorological data for thermal environment analysis of Chinese buildings is used to analyze the meteorological data in Xi'an. The coldest month of the year is January, the hottest month is July, and the appropriate time period for indoor thermal environment regulation by ventilation is May to September.

The relative humidity of Xi'an is about 67% - 68% in summer, 65% in winter, 66% in spring and 74% in autumn.

2.2 Software Introduction

PHOENICS flair module is a CFD special module designed by Cham company for architecture and HVAC specialty. It is widely used in the calculation of indoor and outdoor wind and thermal environment and comfort, air conditioning design, heat island effect, pollutant concentration diffusion prediction and fire subway simulation. Its market share in the field of building ventilation simulation in China has expanded year by year, which has exceeded 80%. Therefore, in the design stage, Phoenix 2009 is used as CFD simulation software in this simulation report to simulate and analyze the wind environment of the building complex.

2.3 Scheme Introduction

The terrain of the community is high in the southeast and low in the northwest, with great relief. In the unit design, townhouses are the main part. The community covers a total area of 91355.72 square meters, a total construction area of 81227.58 square meters, a commercial area of 2454.5 square meters, and a cultural area of 2073.15 square meters. As the north is a main road with large flow of people, business will be placed on the north side in the scheme design. Three different schemes have been made for this group by using Phoenix software.

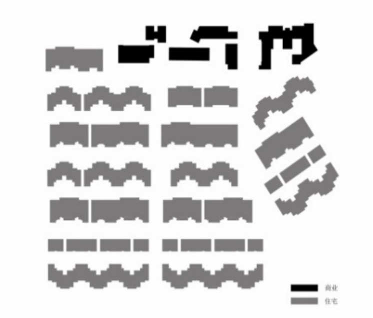


Figure 1. Design Scheme I

Figure 2. Design Scheme II

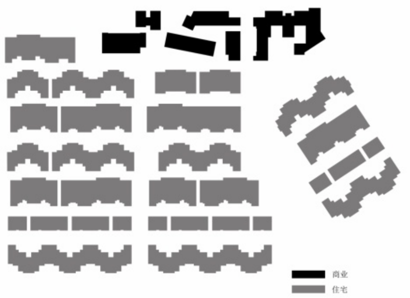


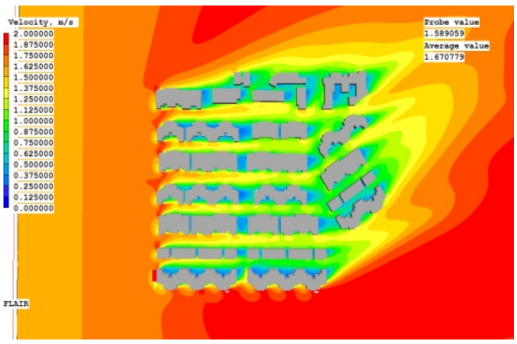
Figure 3. Design Scheme III

Photo Source: Self Drawn by the Author

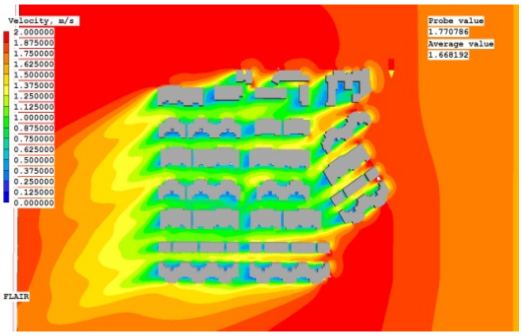
3. Simulation Analysis Process

3.1 The First Mock Exam Analysis.

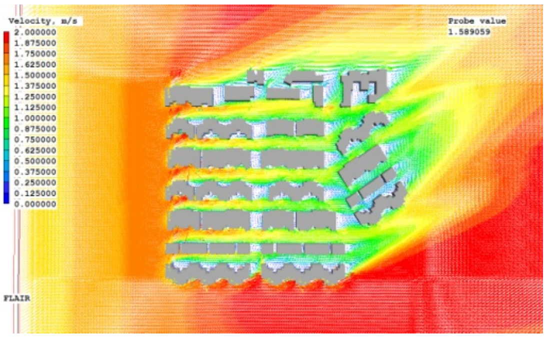
In scheme I, the plot ratio is relatively high and economical, and the space between buildings in the design is relatively small, especially the distance between the local buildings on the right and the main buildings is narrowed to make the buildings in the group more centralized and land-saving, as shown in the following figure:



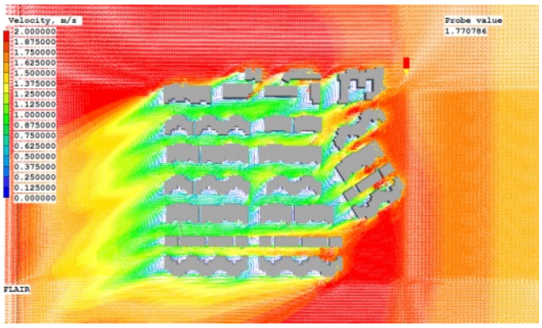
(a)Wind speed chart of southwest wind in summer



(b) Wind speed chart of northeast wind in summer



(c)Wind speed vector map of southwest wind in summer

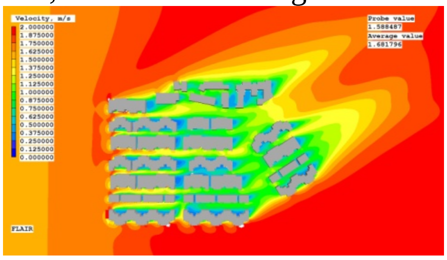


(d) Wind speed vector map of northeast monsoon in summer
Figure 4. Image Source: sSelf Drawn by the Author

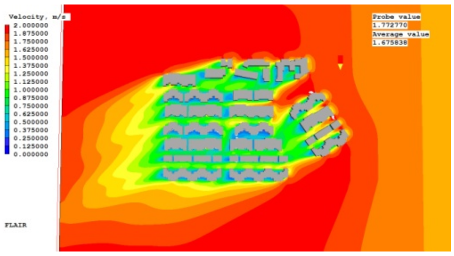
It can be seen from the figure that in summer, as the slab building on the south side of the community is perpendicular to the incoming wind direction, the downdraft formed by the impact of the wind on the building flows back near the ground, and there is no obvious eddy formation on the windward side of the building. When the incoming wind enters the residential area through the passage between buildings, due to the sudden narrowing of the air passage, the wind speed increases, forming a "narrow pipe effect", where the highest wind speed is close to 2 m / s. At the same time, at the corner of the building, the wind also accelerates when it goes around the corner. From the perspective of the whole community, the wind speed in the main pedestrian areas is controlled at 0.5-1.5 M / s. In addition, there is no obvious air flow dead zone and eddy current around the building, which is conducive to the natural ventilation in summer. The amplification coefficient of wind speed at the height of 1.5m is less than 2, which meets the demand of comfortable environment in pedestrian area. By analyzing the wind speed vector diagram, it can be seen that there are vortex area and no wind area at the corner of the building, and the flow field around the building is evenly distributed, which is conducive to outdoor heat dissipation and pollutant dissipation.

3.2 Scenario Two Simulation Analysis

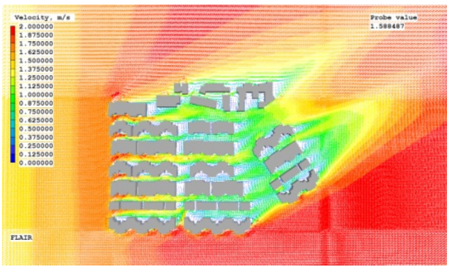
The plot ratio of scheme II is the smallest, which increases the width of the road in the community compared with scheme I, but the reduced building spacing, the greening between the road and the house is smaller, which is relatively economic, and the commercial part is also closer, which is more compact and practical, as shown in the figure below:



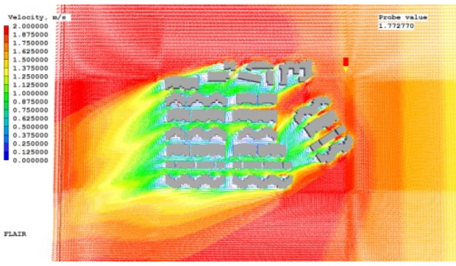
(a)Wind speed chart of southwest wind in summer



(b) Wind speed chart of northeast wind in summer



(c) Wind speed vector map of southwest wind in summer



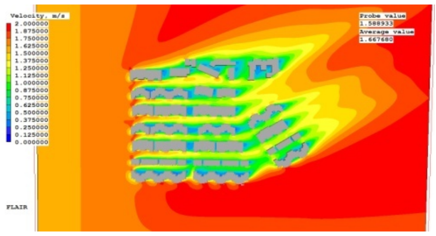
(d) Wind speed vector map of northeast monsoon in summer

Figure 5. Image Source: sSelf Drawn by the Author

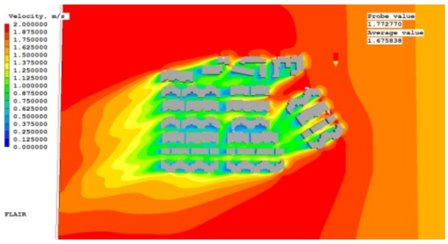
It can be seen from the figure that the main problem of scheme I is roughly the same. At the same time, at the corner of the building, when the wind bypasses the corner, it also produces acceleration. In addition, there are obvious air flow dead zone and eddy current around the building, which is not conducive to the natural ventilation in summer. Can not meet the needs of comfortable environment in residential areas. By analyzing the wind speed vector diagram, we can see that there are many whirlpool areas and no wind areas around the corner of the building, and the flow field around the building is not evenly distributed.

3.3 Scenario Three Simulation Analysis

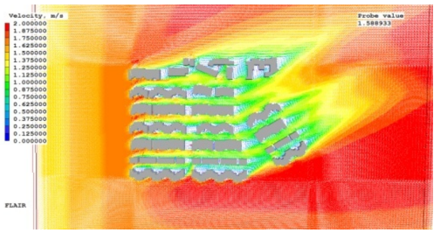
Compared with the first two schemes, the third floor of the scheme has the largest space, more evacuation, wider roads in the community, and more clear privacy and functionality of the residence. However, it is not economical to waste space compared with the first two cases, as shown in the figure below:



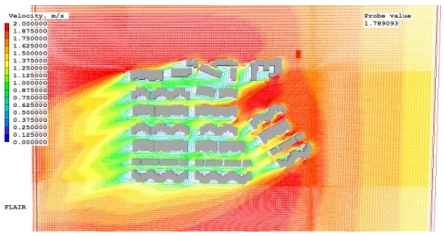
(a)Wind speed chart of southwest wind in summer



(b) Wind speed chart of northeast wind in summer



(c)Wind speed vector map of southwest wind in summer



(d) Wind speed vector map of northeast monsoon in summer

Figure 6. Image Source: sSelf Drawn by the Author

In the analysis of the 1.5m high wind speed map in summer, it can be seen that the summer wind blows from the northeast and southwest corner under two different working conditions. In the whole residential area, there is basically no excessive wind speed, which is more suitable for residents to walk and rest here. There is no obvious air flow dead zone and eddy current around the building, which is beneficial to the natural ventilation in summer. It can meet the needs of comfortable environment in residential areas. By analyzing the wind speed vector diagram, it can be seen that there are few whirlpool areas and no wind areas around the corner of the building, and the flow field around the building is evenly distributed, which is conducive to outdoor heat dissipation and pollutant dissipation.

4. Site Wind Environment Simulation and Scheme Layout Shape Optimization

Based on the above separate analysis of each scheme, the results are compared as follows:

Compared with the southwest wind speed map of scheme I and scheme III in summer, the overall wind speed of scheme I is not uniform, and there are vortices at the corner of the building; compared with the southwest wind speed map of scheme II and scheme III in summer, the above problems exist, and scheme II has a great impact on the nearby communities, with the most vortices. Compared with the wind speed map of West northeast in summer of scheme I and scheme III, the overall wind speed of scheme I is relatively uniform, but there are many vortices at the corner of the building; compared with the wind speed map of northeast in summer of scheme II and scheme III, the overall wind speed of scheme II is uneven, and there are too many vortices at the corner of the building.

Through building wind environment simulation, a comprehensive comparison of wind speed and wind speed vector diagram in the residential area of the three schemes is made. The third scheme is superior to the first and second schemes. Combined with other architectural design points, the final design scheme of the residential area is selected as the third scheme.

In the conceptual design stage, the architectural wind environment design mainly includes two levels: the first level is the planning level, which focuses on the external environment of the building, including the site, the relationship with the surrounding buildings, group layout, etc. This level is also the basis of the wind environment design. By optimizing the relationship between the building groups, the relationship between the building and the dominant wind direction, the relationship between the building and the surrounding buildings, and the relationship between the building and the site, we can ensure the ventilation while weakening the impact of local adverse wind environment, and avoid the impact of local strong wind on the comfort at the pedestrian height. In addition, the adverse wind environment can be improved by combining auxiliary spaces such as water body, courtyard, atrium, open space, and auxiliary structures such as plants and windbreak walls. So as to create a comfortable and safe external overall wind environment, improve the utilization rate of outdoor space, and lay the foundation for the single building wind environment.

The second level is the single building level. The idea of this level is to reasonably select the building shape to make it conducive to the wind environment, reasonably select the form and materials of the building envelope, and reasonably use the building auxiliary structure that is conducive to the wind environment. It not only controls the wind environment in the overall situation, but also improves the wind environment in some parts, creating comfortable indoor wind environment and thermal environment. So as to improve air quality, thermal comfort and energy saving.

The main problems of natural ventilation of high-rise buildings are high-altitude wind pressure and high-altitude turbulence, especially the huge wind pressure on the upper part of high-rise buildings may lead to destructive effect, so it is difficult to achieve direct natural ventilation. In addition to reducing the wind pressure, there is also a proper pressure difference between the air inlet and the air outlet on the skin. Double skin can be used as buffer layer to provide comfortable natural ventilation for high-rise buildings. The curtain wall of the scheme can be opened either in the forward direction or in the lateral direction. The opening mode is selected according to the different requirements of ventilation, and the air volume is controlled by the louver as the improved mode of double skin to realize the controllable wind environment. The measurement standard of indoor comfort is determined by many factors. As one of them, the wind environment cannot be measured to a fixed value. It will change with the change of other factors. Therefore, the plane layout and indoor wind environment are not discussed in this plan.

To sum up, the wind environment simulation mentioned in this paper can be more applied to the preliminary planning stage of architectural design scheme and the deliberation stage of scheme shape. In the design scheme stage, through the comparison and analysis in the early stage, the most appropriate scheme can be screened out more accurately, many design detours can be avoided, and various schemes in different situations can be quickly analyzed through drawings The advantages and disadvantages, give a strong proof. In many cases, unnecessary arguments and quarrels can be avoided. The simulation of wind environment for different types of houses can also be further discussed. In the design stage, it can be further involved in our design. Such research will bring us obvious help and effect in the formulation and selection of the scheme. Therefore, it is suggested to pay attention to this part and promote it accordingly.

5. Conclusion

The above research is only suitable for the stage of architectural concept and scheme design, through the computer simulation of wind environment to find the optimal design method, and the simulation accuracy can meet the architect's scheme decision in this stage. Through this study, it is not difficult to find that taking the requirements of wind environment in the national green building evaluation standard as a reference, making full use of the building wind environment simulation technology, comparative analysis, adjustment and optimization of different building schemes, making the building have a more reasonable and comfortable outdoor wind environment, good natural ventilation effect, improving the building's heat insulation, cold insulation and heat dissipation performance, so as to Reduce the energy consumption of building operation and practice the concept of green building.

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