

Study on the influence of sunlight and ventilation on outdoor activity space of residential district

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Abstract: Outdoor activity space in residential districts is an important place for daily leisure activities of urban residents, whose comfortable level is directly affected by sunshine environment and ventilation environment. In this study, three residential areas represented in Hangzhou were selected. First, models were established to analyze the sunlight environment, and the suggestions were proposed to improve the sunshine conditions based on the research results. Secondly, the CFD wind environment simulation analysis method is adopted to analyze the ventilation environment of the three residential areas and discuss the solutions to the corresponding problems. The research conclusion can provide reference for the planning and design of outdoor activity space in urban residential districts.

1.Introduction

Outdoor activity space is the space environment which can provide residents' major leisure activity site between various residential buildings and public buildings in dwelling areas. Outdoor activity space plays an irreplaceable role in the life of urban residents, mainly as follows:

1) The activity space in residential area is an important place for leisure and fitness activities which is the basic physiological needs of residents. Most residential buildings have small indoor space and non-independent outdoor space attached. Residents need to rely on public spaces of residential areas for leisure and fitness activities.

2) The privacy design of the urban residential buildings meets the demand of the residents' privacy protection and result in the unfamiliar neighborhood relationship at the same time. Outdoor public space is the main place for residents to communicate and obtain information through the recreational activities such as chat, chess and cards etc^[1].

3) The outdoor activity space also plays an important role in children's play area and elderly's rest area.

The comfort level of the outdoor activity space in residential area is directly affected by the climate environment due to the absence of architectural shielding^[2]. The interaction between the building group arrangement and the external environment such as ventilation and sunshine has a greater impact on the outdoor activity space. This paper will point out the existing problems and explore the corresponding solutions so as to provide reference for the planning and design of outdoor activity space in residential areas based on the analysis of several residential areas in Hangzhou from the perspectives of sunshine environment and ventilation environment.



2. Selection of research objects

Three representative residential areas in Hangzhou were chosen according to the types of residential buildings and the scale of residential areas.

Residential district I: A high-rise residential district (Figure 1) is composed of 11 high-rise buildings with 960 households covering an area of 4.2 hectares. All the buildings are 17 storeys. There are two floors shops on the east and west sides of the residential area.

Residential district II: A multi-storey residential district (Figure 2) is composed of 42 multilayer buildings and 4 high-rise buildings with 1300 households covering an area of 7 hectares. The height of the buildings is mainly 6 floors of multi-storey and 12 floors of high-rise buildings. There is a kindergarten in the community and a middle school in the north of the residential area. There are ground apartments for commercial use in the west side of the residential area.

Residential district III: A large mixed residential district (Figure 3) with 5206 households covering an area of 58 hectares. The buildings heights from 6 to 17 floors. There is a primary school in the residential area and a relatively large green square in the center of the district. The north side of the residential area is part of the bottom business buildings.

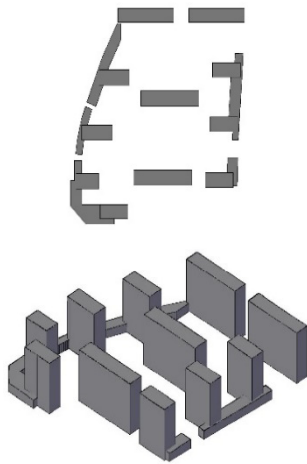


Figure 1. A high-rise residential district in Hangzhou

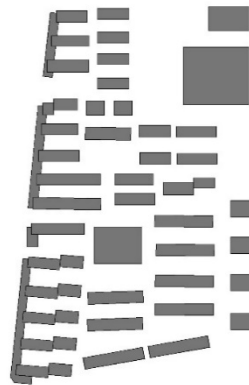


Figure 2. A multi-storey residential district in Hangzhou

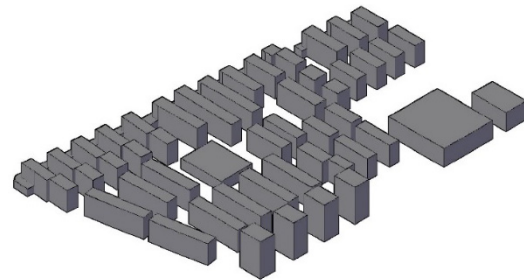


Figure 3. A large mixed residential district in Hangzhou

3.Sunlight analysis

The sufficient sunshine in winter plays an important role in the comfort level of outdoor activity because of the cold temperature in Hangzhou. The duration of the first floor sunshine should meet the demand according to the present national standard specifications for design and planning of residential district. There is not mandatory of sunlight standard time for outdoor activity space which caused inadequate consideration about the sunshine for most of the outdoor activity space position chosen^[3].

Here are the results of three residential area sunshine simulation analysis in Hangzhou, the time of sunshine simulation analysis is set as the Great Cold day and the calculation height is set as the 0.5 meters from the ground which is the common outdoor seat height. The basic rules of simulation calculation are as follows: the range of outdoor activities time is from early 9:00 to late 15:00, the average activity duration is 1 hour and the minimum continuous sunshine time is 20 minutes considering the general outdoor activities laws in winter.

The results are shown in the figure: the blue region is the area with sunshine time less than 1 hour, the yellow region is the area with sunshine time greater than 1 hour, and the area in the pink dotted line is the outdoor activity space.

As can be seen from the sunlight analysis diagram, the sunshine time of the two small activity spaces on the west side is more than 1 hour while the two main outdoor activity spaces in the middle have significantly less sunshine time in winter (Figure 4) of the residential district I. Only one outdoor activity space in the residential district II can have more than 1 hour of sunshine time in winter (Figure 5). The sunshine time of outdoor activity spaces in residential district III is basically meet the requirement that is more than 1 hour in winter (Figure 6).

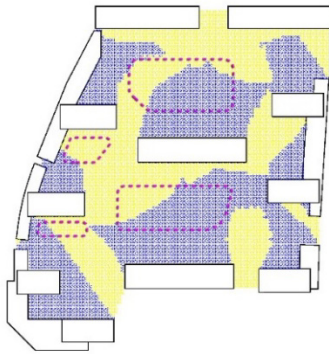


Figure 4. Sunlight analysis of Residential district I

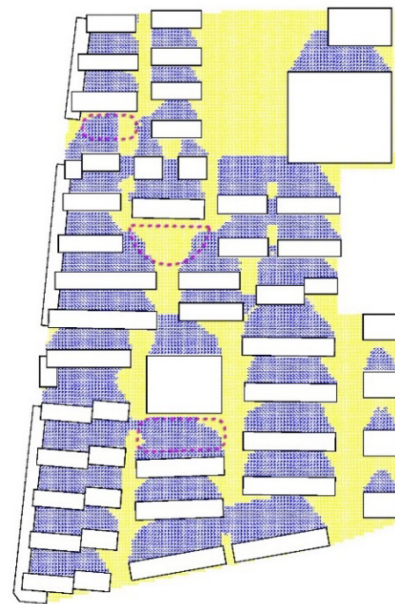


Figure 5. Sunlight analysis of Residential district II

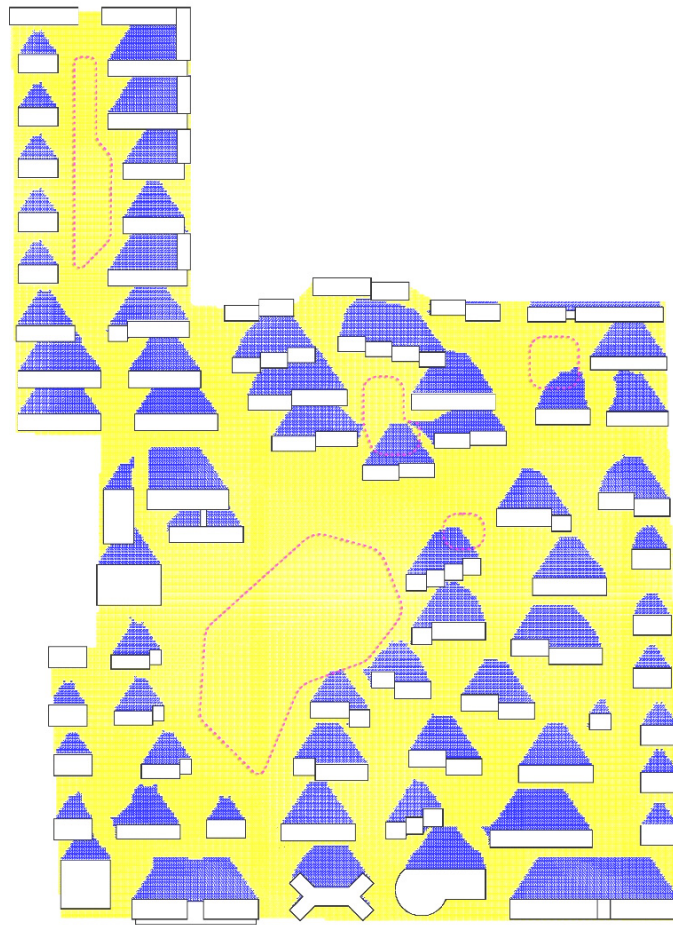


Figure 6. Sunlight analysis of Residential district III

The following conclusions can be deduced from the sunlight analysis:

1) In the residential district III, each independent outdoor activity space has a larger scale and the surrounding buildings have less influence on the sunshine correspondingly due to the large scale of the residential district and centralized setting of the activity spaces at the residential center and cluster center^[4]. While the outdoor activity spaces of residential district I and II are small and scattered, which is greatly obstructed by surrounding buildings.

Generally, designers prefer to set dispersed outdoor activity space to meet the principle of homogeneity and the requirements of residents' nearby activities. However, such dispersed activity spaces can hardly satisfy the winter sunshine time from the above examples. The most people are likely to choose activity space with 5-10 minutes walking distance to their room through the preference investigation at the same time. For example, the usage of the center activity space is the highest in the residential district III which is 10 minutes walking distance from the farthest building. Therefore, the centralized design of the outdoor activity space in residential areas should be chosen as far as possible.

2) In order to meet the requirements of the plot ratio, the sunshine blocking side (the north toward of the buildings) is chosen to plan the outdoor activity space in residential district I and II. The distance between north and south buildings in most residential areas can only meet the demands of sunshine time of the north buildings' ground floor and the winter sunshine time is very few at the building north toward which is the sunshine blocking surface. Therefore, it should be avoided when designing the outdoor activity space location.

The outdoor space design is mostly after achieving the overall layout of the residential area in current planning. The selection of the outdoor activity space is very difficult because of the building group arrangement basically determined and the explicit position of the sun shade. The design of the outdoor activity space should be done with building group arranged simultaneously. Appropriate location will be selected combination with the sunlight analysis.

4. Ventilation analysis

Ventilation environment directly affects the safety and comfort of outdoor activity space. On the one hand, good ventilation in summer and wind prevention in winter can bring more comfortable feelings to residents. On the other hand, good ventilation environment can promote the diffusion of pollutants, ensure air quality and avoid the spread of viruses. The climatic features of Hangzhou which is located in the lower reaches of the Yangtze River are hot in summer and cold in winter. The daily maximum temperature has exceeded 40 degrees in summer of the past two years. Outdoor ventilation is particularly important in summer.

The outdoor wind speed is closely related to human feelings. It is equivalent to almost no wind condition when the outdoor wind speed is less than 1 m/s, and when the wind speed is greater than 5 m/s, it will affect people's activity^[5] according to the related research. The ventilated environment with the wind speed between 1-5 m/s can be thought to make people feel comfortable in the after analysis.

According to the meteorological statistical data, the prevailing wind direction of Hangzhou in summer was SSW with an average wind speed of 2.14m/s, and the prevailing wind direction in winter was NNW with an average wind speed of 2.08m/s^[6]. CFD numerical simulation method was adopted to analyze the wind environment 1.5 meters above the ground. The wind environment simulation results of the three residential districts indicated the maximum wind speed in winter less than 5m/s, and the wind prevention effect was good. Therefore, the next part is mainly about the simulation results of the prevailing wind direction in summer.

CFD software was used for wind environment simulation, and the simulation results were shown in the figure. All wind directions in the figure were from left to right, and all data were obtained at a height of 1.5m. and the area in the pink dotted line is the outdoor activity space.

Residential district I: The wind pressure difference in the residential area is small and the internal ventilation effect is poor because of the blockade effect due to the wide windward face of the first row building. Two large outdoor activity spaces in the middle of the residential area have low wind speed and large no wind zone. The wind cannot flow out smoothly due to the shielding of many bottom shops. The eddy was generated on the leeward side of the buildings at the south of the residential district which can be seen from the wind speed vector map. The eddy zone is just located in the main outdoor activity space. This residential area is completely oriented south to north, with a small windward angle and a large number of bottom shops which constitute the wind obstruction. While 4 outdoor activity spaces are located on the leeward side, with poor ventilation and lower wind speed (Figure 7 to Figure 9).

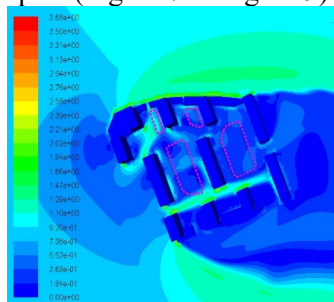


Figure 7. Contour of wind velocity

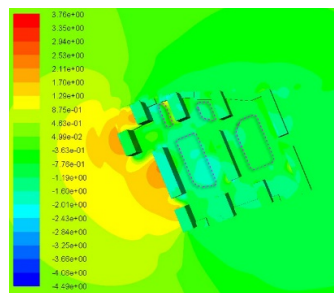


Figure 8. Contour of wind pressure

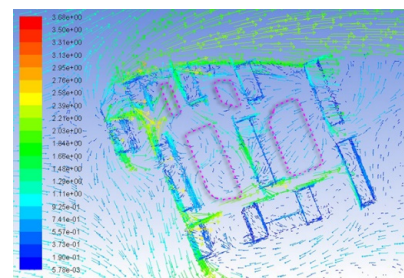


Figure 9. Vector of wind velocity

Residential district II: The simulation result shows that the wind pressure difference in the residential area is small. Due to the passage formed by the arrangement of buildings facing the wind, the ventilation effect of the area around the passage is good, and the wind speed of the outdoor activity space near the passage has significantly increased. While the residential buildings are all multi-story with small space between each other, the effect of wind speed increase formed along the passageway didn't spread to the interior of the residential area, and the overall ventilation effect of the residential area is poor. The pedestrian height has a low wind speed due to the west side is covered by bottom shops and the wind cannot flow smoothly into the district. The ventilation of the other two outdoor activity spaces is poor because of the location on the leeward side additionally (Figure 10 to Figure 12).

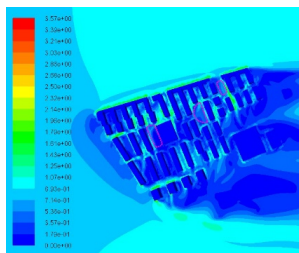


Figure 10. Contour of wind velocity

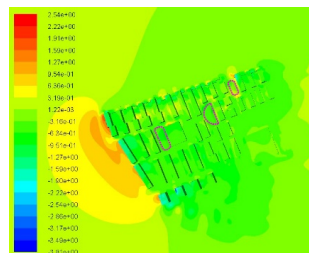


Figure 11. Contour of Wind pressure

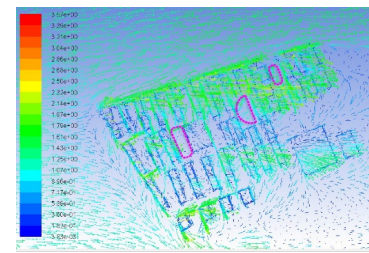


Figure 12. Vector of wind velocity

Residential district III: The simulation results show that the ventilation in the northwest of the residential area is much better than that in the southeast. The reason for this difference is related to the way the buildings are arranged. The northwest building arrangement forming a ventilation channel parallel to the prevailing wind direction which strengthened the wind speed. However, the windward building's height and wide face, the floor shops obviously hindered the ventilation in the southeast. Therefore, the outdoor activity spaces in the northwest have good ventilation effect. The outdoor activity space in the center of the residential area have poor ventilation effect with the wind speed basically below 1m/s. It is related to the large area here and the wind speed gradually decreases after a certain distance of wind flow. The wind can basically flow smoothly in the district based on the wind vector chart due to the large scale and the many open space of the residential district (Figure 13 to Figure 15).

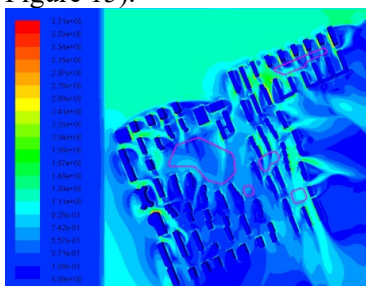


Figure 13. Contour of wind velocity

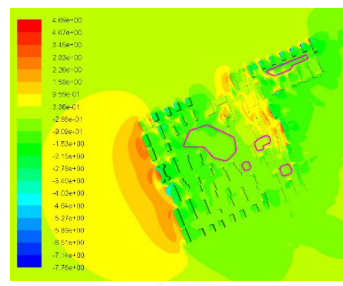


Figure 14. Contour of wind pressure

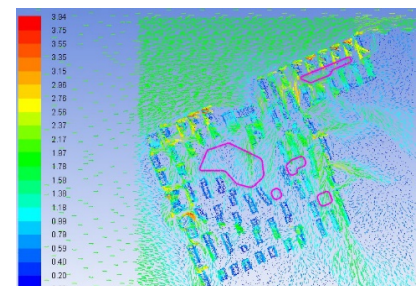


Figure 15. Vector of wind velocity

The following conclusions can be deduced from the ventilation analysis:

1) The obstruction effect to ventilation is more obvious if the surface of building is too wide. It should be avoided to arrange outdoor activity space on the leeward side of the building with wide surface.

2) It is generally recognized that the high-rise residential ventilation effect is little influenced by the bottom shops because of the high level wind flow can bypass the shops. While floor shops is very important influence to the ventilation of pedestrian height based on the simulation results. The bottom shops should be tried not to set in the direction of the prevailing wind direction in summer to ensure good ventilation of outdoor activity space.

3) The passage along the prevailing wind direction in summer can be properly considered to increase the wind speed when the residential buildings are arranged. The outdoor activity spaces can be arranged as close to ventilation corridors as possible.

4) Proper layout of open space can help wind flow through the residential area. However, larger open space can reduce wind speed. Channels can be properly set to increase wind speed under the circumstance.

5.Epilogue

In the planning and design of outdoor activity space in residential districts, the comfort level of outdoor activity space can be improved, and the utilization rate can be promoted to meet the needs of residents' life combined with the analysis of sunshine environment and ventilation environment, and take the influence of various factors into consideration.

References:

- [1] Yang bao-jun. The loss and revival of urban space[J]. Urban Planning Forum. 2006(6):9-15.
- [2] Ding Ke. Daylighting, noise, ventilation and other physical environment of residential outdoor impact research in hot summer and warm winter area[J]. Guang Dong Architecture Civil Engineering, 2015(8):32-34.
- [3] Chen Ming, Yang zhao-qing. Research on the sunshine analysis optimizing outdoor activity places in residential area: a case study of the residential planning in Red Lotus Lake area of Ezhou City [J]. Huazhong Architecture. 2014(2):40-44.
- [4] He ling-hua, Wei Gang. Built community environment renovation for senior people[J]. Planners. 2015(11):23-28.
- [5] Zhang sheng-wu. Research on wind environment residential districts in Hangzhou based on numerical simulation [D]. Hangzhou: Zhejiang University, 2016.
- [6] Wang Qin. Comprehensive analysis and construction method of urban-scale ventilation corridors [D]. Hangzhou: Zhejiang University, 2016.