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PHOENICS-based Simulation Study on Winter Wind Environment in Outdoor Space of Old Communities—Taking Sanlihe Community of Beijing as An Example

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PHOENICS-based Simulation Study on Winter Wind Environment in Outdoor Space of Old Communities—Taking Sanlihe Community of Beijing as An Example

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Abstract. The quality of wind environment is closely related to the comfort of outdoor space, and the wind environment is an important factor affecting outdoor activities of urban residents in winter. Taking the old Sanlihe Community in Beijing as an example, this paper uses the PHOENICS simulation software to simulate the outdoor wind environment of the community in winter in a physical way, analyse problems existing in the outdoor environment in a more scientific way, and put forward optimization suggestions, so as to provide an objective basis for future practical transformation.

1. PHOENICS software

1.1. Introduction to PHOENICS software

PHOENICS is a CFD (Computational Fluid Dynamics) software[1]. It is also the world's first commercial software for computational fluid and heat transfer, which was developed by CHAM in 1981. It is widely used in 26 scientific fields, such as building environment science, aerospace, energy power, ship water conservancy and industrial design engineering, for physical simulation and analysis[2].

1.2. Advantages of PHOENICS software

Firstly, it is open to users to the extent possible, and allows them to modify or add users and models as needed. With the introduction of PLANT and INFORM functions, users no longer need to write FORTRAN source programs, and the function of GROUND program makes it more convenient for users to modify and add models. Secondly, PHOENICS can read the graphics files of Auto CAD software. In-Form: It is a user interface function, allowing the input of user's mathematical expression, IF-judgment and other functions. It is convenient for users to control the input of boundary conditions, initial conditions, physical properties of materials and other parameters. Its VR (virtual reality) colour graphic interface menu system is one of the easiest one among CFD softwares. It is also very simple in the definition of boundary conditions, and can automatically generate grids. Fourthly, PHOENICS is compatible with models of various formats. Models generated by SketchUp, AutoCAD, Rhino and Revit can be imported directly, which simplifies the process of modelling and improves the study efficiency. Fifthly, PHOENICS can directly output the wind speed diagram and vector diagram within the grid range, and can transform isoline map and adjust the value range of display according to the needs, so that the results are more abundant.

2. Characteristics of wind environment and climatic conditions in Beijing

2.1. Characteristics of wind environment in outdoor space

The wind environment in outdoor space is closely related to the comfort of the community. According to the relevant provisions in Assessment Standard for Green Building, the wind speed at a height of 1.5m above the ground around the residential building in winter should be less than 5m / s, as shown in Table 1. The wind speed has a direct relation with people's comfort[3].

Table 1.   Relation Between People's Comfort and Wind Speed.

wind speed (V)/(m.s^2)	People's feelings
V≤5	comfortable
5<V≤10	Untrue, action affected
10<V≤15	Very uncomfortable, seriously affected
15<V≤20	Insufferable
V>20	Danger

In addition, the wind speed will be affected by the surface friction, and the roughness of the ground is directly related to the friction. As shown in Table 2, according to the relevant specifications of China, the ground roughness values of different terrain are different. The downtown area of Beijing belongs to Class C terrain, and the roughness value a is 0.2.

Table 2. Surface Roughness Values of Different Terrains.

Classification	Terrain	a
A	Offshore sea, island, coast, lake	0.12
B	Fields, villages, jungles, hills, small and medium-sized cities with sparse houses and suburbs of large cities	0.16
C	Urban area with dense buildings	0.2
D	Urban areas with dense and high buildings	0.3

2.2. Climate and wind speed conditions in Beijing

Table 3. Monthly Average Temperature of Beijing.

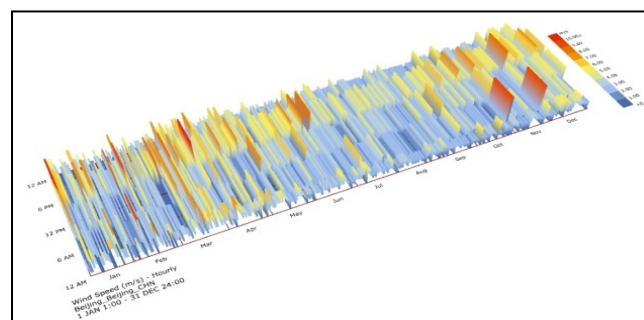| Month	1	2	3	4	5	6	7	8	9	10	11	12
Average air temperature	-3.7	-0.7	5.8	14.2	19.9	24.4	26.2	24.9	20.0	13.1	4.6	-1.5

Figure 1.   Diagram of annual wind speed in Beijing.

According to the division of architectural thermal climatic regions in China, Beijing belongs to cold region and has obvious climate characteristics of four seasons. It can be found in Dataset of Daily Surface Observation Values in Individual Years (1981-2010) in China issued by China Meteorological Administration that the annual average temperature of Beijing is 10°C-12°C, as shown in Table3.

In winter, the northwest wind prevails in Beijing, while in summer, the southeast wind prevails. In spring and autumn, winter wind and summer wind coexist, i.e. there are both northwest wind and southeast wind, but most of them are northwest wind. According to the data of China Meteorological Administration, the average wind speed in Beijing is about 3m/s in spring and 1.5m/s in summer. As a whole, the average wind speed in downtown area is about 2.5m/s. As shown in Figure. 1, Diagram of Annual Wind Speed of Beijing, the yellow and red parts represent high wind speed areas, while the blue and green parts represent low wind speed areas.

3. Old residential communities
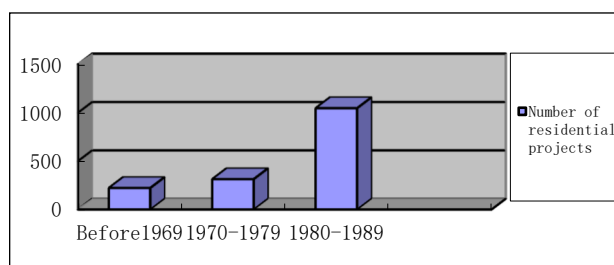
3.1. Old residential communities in Beijing

Figure 2. Statistics of Housing Construction in Each Stage in Beijing Source.

As shown in Figure 2, there are about 1,600 old communities built before 1990 and still in use in Beijing, accounting for about 2/5 of the total number of communities, with a total gross floor area of about 60 million square meters. Among them, about 230 projects were completed before 1969, with a gross floor area of about 10 million square meters; there were about 1,000 projects completed between 1980 and 1989, with a gross floor area of about 38 million square meters[4].

3.2. General situation of Sanlihe Community

Figure 3. Map of Sanlihe Community

As shown in Figure 3 this paper takes Sanli Henan community in Beijing as an example. It is located in the central urban area (Xicheng District) of Beijing. It is surrounded by Sanlihe Road, pedestrian road, Sanlihe East Road, Sanli Henan Seven Lanes and Sanli Henan cross street. It covers an area of 60.84 mu, mainly 54 buildings, with a total construction area of 72870 square meters, including a residential area of 67620 square meters and a green space rate of 30%.

4. Application of and suggestion on optimization of PHOENICS simulation software

In Beijing, where it is cold in winter, strong wind is the most unfavourable factor for outdoor activities. Therefore, the author uses PHOENICS software to simulate and analyse the winter wind environment of Sanlihe Community, providing reliable basis for the optimization strategy of the wind environment.
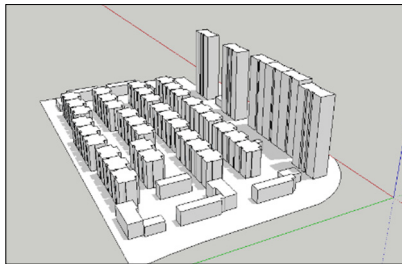
4.1. Modelling
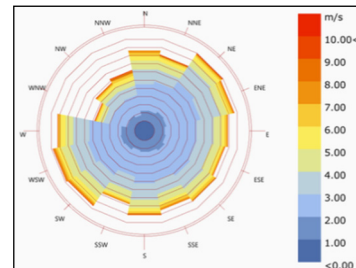

Figure 4. Model map of Sanlihe community.

Figure 5. Winter wind speed chart of Beijing.

Sanlihe Community is enclosed by roads on the west and south sides, and by buildings on the north and east sides. The number of floors of buildings in this plot is mainly 2-3, 6 and 18. Some of the buildings have stores settled on the ground floor, and the plot environment is complex and changeable. A CAD plan is drawn according to the Google map of the community, and a 3D model, which is then simplified, is established with SKETCHUP software. As shown in Figure 4, the outdoor wind simulation experiment model is exported to STL file and then imported to PHEONICS for quantitative wind environment simulation.

The experimental grid is set to 2mx2m, and the test height is determined to be 1.5m from the ground. According to the known conditions, i.e. the average wind speed in Beijing in winter is 2.5m/s and the wind direction is northwest, the wind direction, wind frequency, wind speed and other meteorological data are directly imported, as shown in Figure 5 Main Wind Frequency and Wind Speed Map of Beijing Downtown Area.
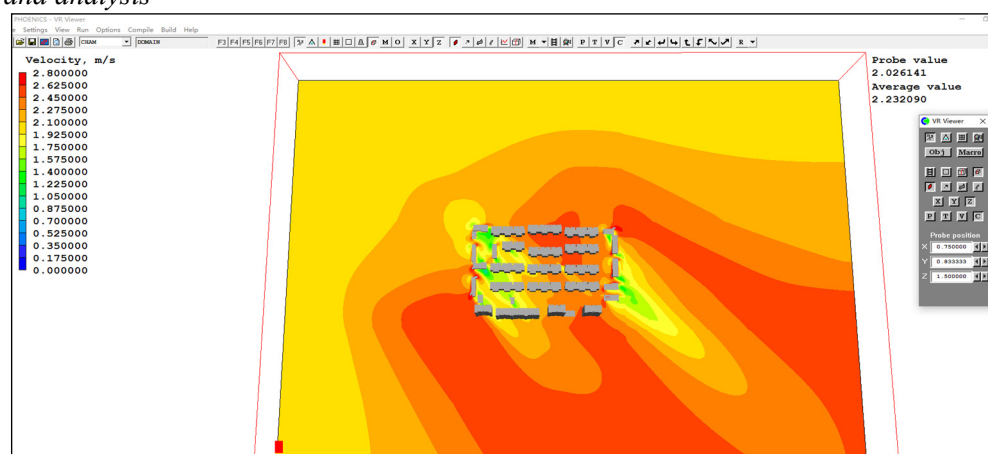
4.2. Results and analysis

Figure 6. Interface of Simulation of Winter Wind Environment on Winter Solstice in Sanlihe Community.

The winter wind environment simulation diagram of Sanlihe Community is obtained through the analysis with PHOENICS software, so as to analyse and assess the outdoor environment from the

perspective of wind environment (as shown in Figure 6 Test Result Interface of PHOENICS Software).
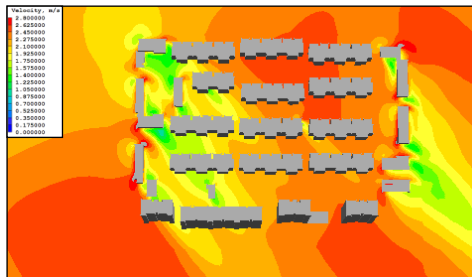

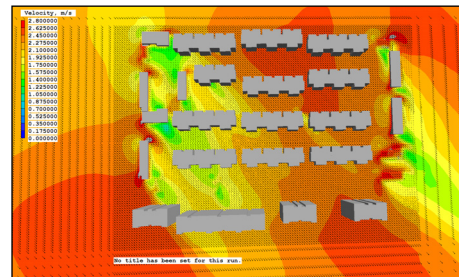Figure 7. Winter Wind Environment Simulation Diagram.

Figure 8. Winter Wind Environment Vector Diagram.

As shown in Figure 7 and 8, the wind environment and its vector diagram at 1.5m height in winter are obtained through the simulation and analysis of wind environment by PHOENICS. It can be seen from the figure that the closer the colour is to the yellow and red part, the greater the wind speed is, the highest is 2.8m/s. It is mainly concentrated in the north of Sanlihe Community, because there is less shelter near the main road in the north, and the residence here is relatively dense, which is easy to increase the air flow speed in some areas, forming a wind gap; the wind speed in the south and east of the site is about 2.1m/s-2.45m/s, and in the west, the wind speed is about 1.05m/s-2.1m/s. On the whole, the pedestrian level wind speed at 1.5m in the outdoor space of Sanlihe Community in winter is not more than 5m / s. Based on the wind prevention requirements in winter in Northern China, when the wind speed is low, it can prevent the loss of heat and feel more comfortable. Since there is no need to diffuse pollutants in Sanlihe Community, the lower the wind speed in winter, the more suitable for outdoor activities of residents.

4.3. Problem induction

Based on the field investigation in Sanlihe Community in Beijing and physical simulation of outdoor wind environment by using PHOENICS, it is found that the higher the wind speed is, the colder the residents will feel outdoors in winter, so windproofing measures should be taken to improve the comfort of the outdoor space.

4.4. Suggestions on optimization of outdoor space

Based on the above study, the author proposes the following strategies for the optimization of outdoor space of Sanlihe Community:

First, appropriate trees shall be selected according to the climate characteristics of Beijing, and trim them into proper shape and height. For example, evergreen trees shall be planted in places with high accumulated solar radiation to ensure cool places in all seasons; deciduous trees shall be planted in places with low accumulated solar radiation to ensure shade in summer and good sunshine after leaves fall in autumn and winter. In addition, heliophile shall be planted in places with strong solar radiation to create more space effects; ombrophyte shall be planted in places with weak solar radiation to prevent them from becoming negative spaces[5].Secondly, in terms of function, places with sufficient sunlight and good wind environment in winter shall be set as activity area, rest area and children activity yard for residents; the benches and sports facilities shall not be set at the location with high wind speed and no sunshine, so as to provide a more comfortable outdoor environment for residents.

5. Conclusion

By analysing the current situation of Sanlihe Community and PHOENICS simulation, it is found that its outdoor environment is not suitable for residents to participate in outdoor activities in winter, and suggestions on optimization are put forward for the problems found.

References
[1].James O P Cheung.Liu C H.CFD Simula-tions of Natural Ventilation Behavior in High-rise Buidings in Regular and Staggered Arrangements Atvarious Spacing.Energy and Buiding,2011,43(5):1149-1158.
[2].Zhiyong Tian,Jiankai Dong,Yiqiang Jiang,Numerical simulation of wind environment of an existing building group in Harbin.Building energy saving,2014,42(6):67-70.
[3].Ministry of Housing and Urban-Rural Development of the People's Republic of China.(2014) Assessment Standard for Green Building. China Academy of Building Research, Beijing.
[4].Jingzhao Zhao, Residential Design, China Construction Industry Press, Beijing, 1999.
[5].Li Yang,Application of CFD technology in wind environment analysis of residential area,Journal of Architecture,2010,(S1):5-9.