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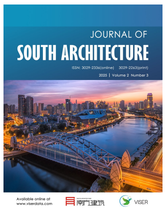

Research on Healthy Wind Environments of Settlements Based on Epidemic Control: A Case Study of the Lingnan Yuedao Settlement

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ABSTRACT: With the evolution of the coronavirus epidemic, the health problems of settlements have attracted broad attention. In the present study, a systematic study of the design of healthy wind environments of settlements based on epidemic prevention situations was carried out through a literature review, field investigation, on-site measurements, numerical simulations, and other methods. The necessity to design healthy wind environments in settlements was established based on the literature review focusing on coronavirus epidemic control and healthy settlements. A case study of the Lingnan Yuedao settlement was carried out through a field investigation and on-site measurements. The specific requirements were summarized by combining relevant guidelines and standards for the healthy wind environments of settlements. On this basis, numerical simulations, benchmarking judgments, and systematic analyses from community, group, and individual perspectives in the Yuedao settlement were performed with Phoenics software. It was found that all three levels suffer from numerous problems, such as poor ventilation, air pollution, etc. Subsequently, the optimization, simulation verification, and reassessment of these problems were conducted. Finally, it was concluded that the design of healthy wind environments in a settlement should be oriented to green spaces, intelligence, and health, with consideration given to local conditions and sustainable development while preventing and controlling the epidemic.

KEY WORDS: wind environment; healthy settlements; epidemic prevention; design

Introduction

The sudden outbreak of COVID-19 [1] forced people to adopt preventive measures such as home isolation to block the spread of the epidemic. During the epidemic, people stayed at home all day long, and health problems in settlements became particularly prominent, especially the guarantee of natural ventilation and air quality became the focus of people's attention. Therefore, the design of healthy wind environments in settlements has become the focus of this research. Taking the Lingnan Yuedao residential area as an example, through scientific analysis, quantitative verification, and systematic sorting [2], this research concluded that the design of healthy wind environments in a settlement should be oriented to green spaces, intelligence, and health, with consideration given to local conditions and sustainable development while preventing

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and controlling the epidemic [3,4].

1 Background

1.1 Coronavirus epidemic

Since the outbreak of the coronavirus epidemic in December 2019 [5], it has spread rapidly around the world. Wuhan was placed under lockdown at 10:00 on January 23, 2020 [6]. As a result, the daily activities of people across the country quickly shifted to a state of home isolation, and other countries around the world are actively learning from China's experience in epidemic prevention. There are three main ways to prevent infectious diseases: manage the source of infection, block the transmission route, and protect susceptible groups [7]. Home isolation can be regarded as one of the three effective ways to block the transmission route, and it is also the inevitable choice for the vast majority of people in the current context of epidemic prevention. However, based on the fear of the spread of the epidemic and people's fundamental demands, healthy settlement environments have become an inevitable requirement. Coronavirus primarily spreads through respiratory droplets and close contact. In relatively enclosed environments with prolonged exposure and high concentrations of aerosols, aerosol transmission is also possible [8,9]. Home isolation can effectively block the transmission route and greatly reduce the possibility of close contact transmission. However, for droplet and aerosol transmission, it is required to achieve a certain level of protection in the wind environment of settlements, and to use natural ventilation as much as possible to reduce the concentration of the virus in a unit space, thereby reducing the probability of infection [10]. The *Recommendations on Residential Architectural Measures for Home-based Prevention and Control of Coronavirus* compiled by the China Institute of Building Standard Design & Research in collaboration with experts from relevant departments, also confirmed the necessity of healthy wind environments in settlements. Among the 15 prevention and control measures, three explicitly emphasize the importance of natural ventilation and ensuring indoor air quality [11]. At the same time, relevant literature was searched in CNKI using the full-text keywords "ventilation" and "coronavirus," and a total of 2,104 academic journal papers were retrieved, among which those with the theme of "epidemic prevention and control" accounted for the highest proportion, reaching 32.23%. The importance of healthy wind environments in preventing epidemics has been demonstrated from three aspects: transmission mechanisms, policy requirements, and academic research. Therefore, this paper conducts research on the design of wind environments for preventing the epidemic based on healthy settlements.

1.2 Healthy settlements

From a spatial perspective, a healthy settlement is a residential area formed by the rational organization and planning of designed healthy buildings. Against the backdrop of the coronavirus epidemic, health is particularly important, especially for settlements where people stay around the clock. In fact, China's concern for healthy settlements can be traced back to Wu Liangyong's proposal in 1995: the human living environment should be designed to be harmonious with the environment and not detrimental to people's physical and mental health [12]. In 1997, Meng Qinglin proposed to promote the construction of healthy human settlements with scientific methods [13]. In 1999, the China National Engineering Research Center for Human Settlements organized experts from various disciplines to research housing and health issues [14]. In 2004, the first "Forum on Healthy Housing Theory and Practice" was held in Beijing [15]. In the same year, Zhong Jishou discussed the research trends of healthy housing at home and abroad, and proposed that the research on healthy housing should be systematic [16]. In 2008, Liu Yanhui and others proposed that healthy housing should use computer simulation technology to provide scientific data and conduct research based on regional climate characteristics [17]. The 10th International Green Building Conference in 2014 proposed that healthy buildings are the next generation of green buildings [18]. In 2016, the CPC Central Committee and the State Council issued the *Outline of the Healthy China 2030 Plan* [19]. In 2019, Wu Shuoxian proposed that "green buildings should be healthy buildings," emphasizing the importance of ensuring indoor air quality [20]. In 2020, Wang Jianguo proposed the concept of health-oriented development for urban planning in the context of the epidemic, addressing it from three dimensions: opportunity, prevention and control, and re-evaluation [21]. Meng Jianmin reflected on the architectural thinking triggered by the sudden outbreak. He first emphasized that the "health" factor should be prioritized, and also outlined specific requirements for ensuring ventilation and air quality [22]. Over the past 20 years, the development of healthy settlements in China has seen significant progress as people have increasingly prioritized their health. Relevant expert theories, national policies, and academic conferences have consistently emphasized the importance of healthy settlements. Concepts such as healthy settlements have evolved from early-stage broad, macro-level understandings to more precise approaches involving scientific analysis, quantitative verification, and systematic organization of the physical environment. In the context of preventing the epidemic, the healthy wind environment of settlements has become the primary issue that needs to be addressed in current healthy settlements.

2 Case study

The Lingnan Yuedao settlement is an area in the Shili Fangyuan real estate project developed by Fangyuan Group in Heshan City, Jiangmen, Guangdong Province, located in Lingnan. According to the *Standard of Climatic Regionalization for Architecture* (GB50178-93) [23], most of Lingnan is classified as a hot summer and warm winter area, with long summers and no winters, high temperatures, and heavy humidity. Ventilation should be the primary concern addressed in this area for healthy human settlements [24,25].

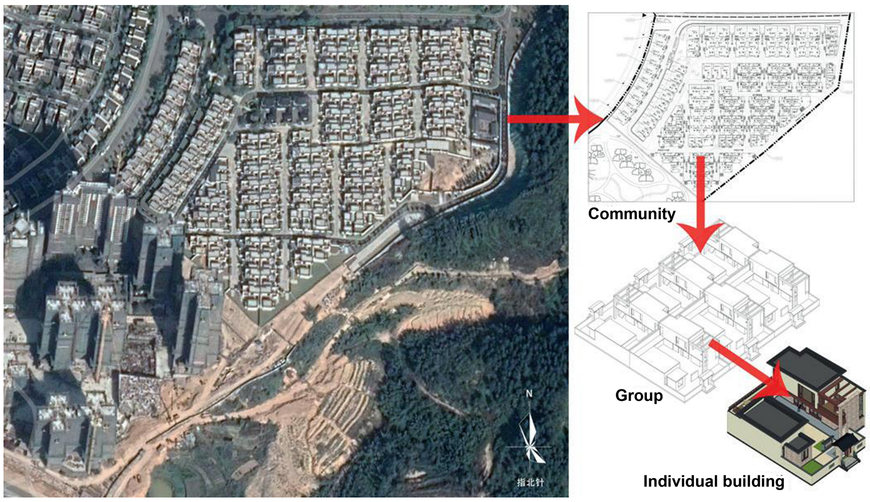

Figure 1 Settlements, groups and individual buildings in Yuedao

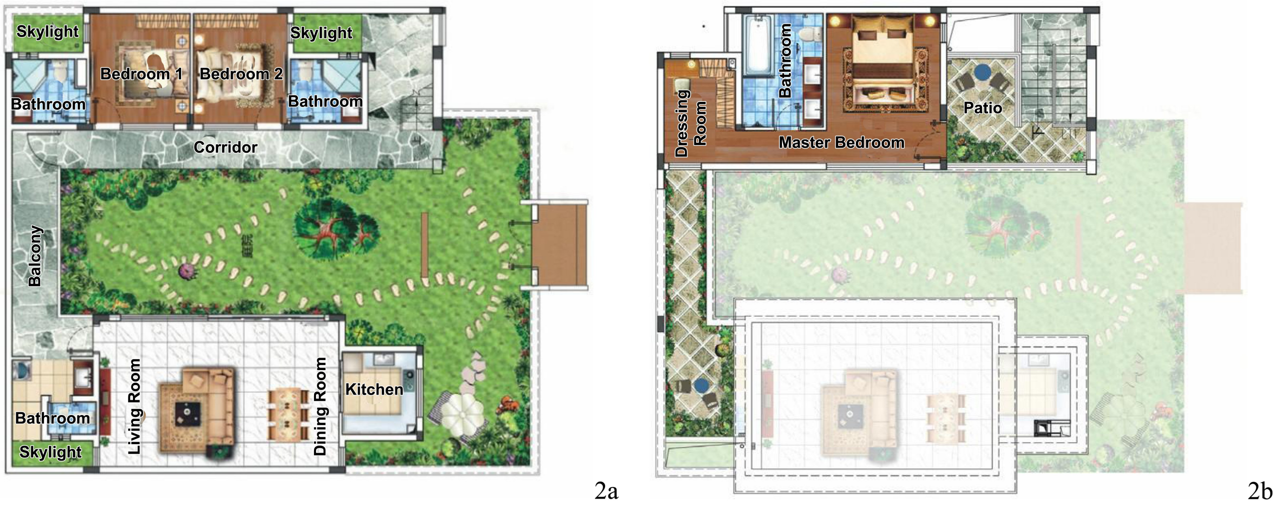

Figure 2 Plan of each floor of an individual building

The Yuedao settlement faces south as a whole and is divided into different residential groups by residential roads. Each group is composed of courtyard-style individual buildings as the basic elements. In terms of scale, the Yuedao settlement can be divided into three levels: community, group, and individual building (Figure 1). The individual buildings are mainly 135 m^2 in size and designed in a courtyard style, featuring two north-facing floors with three bedrooms and three bathrooms, and one south-facing floor comprising a living room, a dining room, a kitchen, and one bathroom (Figure 2). The courtyard units are linked by eave corridors, forming an enclosed courtyard. The buildings occupy a total footprint of 232 m^2, with a floor area ratio of 0.58. The group is composed of individual buildings mirrored from east to west and terraced from north to south, retaining the layout of independent courtyards and households. The community is based on groups, mostly consisting of 6 buildings, and is arranged in a road network.

For places with human activity, there is a need for epidemic prevention, and the relevant requirements for a healthy wind environment of settlements should be met. Following field investigation on the wind environment, the planning layout of the Yuedao settlement employs the Lingnan comb-style layout, which is well-suited to the local climate (Figure 3) [26]. The design of individual buildings utilizes partition walls to create narrow cooling alleys that enhance airflow (Figure 4). Each household also features a courtyard with a skylight (Figure 5), which fosters healthy wind environments. However, under the new requirements for developing healthy settlements, subjective judgments based on field investigation are insufficient to draw objective and scientific conclusions. Therefore, on-site measurements were conducted to assess ventilation rates in the kitchen and a bathroom of individual buildings (Figure 6). Using the CO_2 tracer gas decay method, the ventilation rates in the kitchen and a bathroom were measured at 6.4 air changes per hour (ACH) and 9.5 ACH, respectively, meeting the requirements of *The Standard of the Measurement and Evaluation for Efficiency of Building Ventilation* (JGJ/T 309-2013). Relevant information is shown in Table 1. However, multi-scale wind environment design research is limited by the measurement scope and time. Based on the requirements of relevant guidelines and standards, this paper conducts a study on the design of healthy wind environments in settlements through a systematic and scientific quantitative analysis of numerical simulations.

Figure 3　Comb-style layout

Figure 4　Cooling alley with partition walls

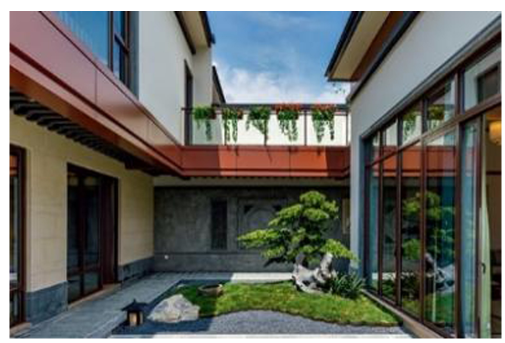

Figure 5　Courtyard with a skylight

Figure 6　On-site measurement

Table 1 On-site measurements information

Standard requirements		
Air changes per hour (ACH)	Kitchen≥3/h	Bathroom≥3/h
On-site measurement data		
Measurement date	May 26, 2019 15:43-16:07(kitchen)	May 26, 2019 16:51-17:05(bathroom)
Used measurement	AZ77535 CO_2 instrument, CO_2 cylinder, electric fan	
Tester range		
CO_2 concentration	0~ 9999ppm(ensured accuracy: 0~ 5000 ppm)	
Temperature	−10~ 60 ℃	
Humidity	0.1~ 99.9%RH	
Dew point temperature	−20.0~ 59.9 ℃	
Wet bulb temperature	−5.0~ 59.9 ℃	

3 Related requirements

The relevant guidelines and standards for healthy settlements in China mainly include the *Technical Essentials for Construction of Healthy Housing*[27], *Technical Specification for Construction of Healthy Housing* [28], *Evaluating System on Performance of Healthy Housing* [29], *Evaluating Standard on Performance of Healthy Housing* (Consultation Draft) [30], *Assessment Standard for Healthy Building* [31], *Evaluating Standard for Healthy Housing* [32], and *Healthy Communities Evaluation Criteria* are sorted out in chronological order (Table 2), and the latest requirements of each guideline or standard on the wind environment are sorted out and summarized in turn.

Table 2 Guidelines and standards for healthy settlements in China

Year	Standard name	Remark
2001	Technical Essentials for Construction of Healthy Housing	
2002	Technical Essentials for Construction of Healthy Housing	2002 revised edition
2004	Technical Essentials for Construction of Healthy Housing	2004 revised edition
2005	Technical Specification for Construction of Healthy Housing	CECS179-2005
2009	Technical Specification for Construction of Healthy Housing	CECS179-2009
2013	Evaluating System on Performance of Healthy Housing	Renamed 2009 version specification
2016	Evaluating Standard on Performance of Healthy Housing	Consultation Draft
2016	Evaluating Standard for Healthy Housing	Renamed standard version of 2013
2017	Assessment Standard for Healthy Building	T/ASC 02-2016
2017	Evaluating Standard for Healthy Housing	T/CECS462-2017
2020	Healthy Communities Evaluation Criteria	Effectiveon September 1

The *Technical Essentials for Construction of Healthy Housing* (2004 revised edition) Section 2.3.3 stipulates that living spaces should be naturally ventilated. The *Technical Specification for Construction of Healthy Housing* (CECS179-2009) Section 3.3.1 points out that the planning and layout of settlements should fully consider the dominant wind direction in the area. The wind environment of the site should be simulated and predicted under typical meteorological conditions, with pedestrian-level wind speeds at 1.5 m above ground around buildings, preferably less than 5 m/s. Section 3.3.3 further requires residential spaces to make full use of natural ventilation. The *Evaluating System on Performance of Healthy Housing* (2013 edition) Section 4.1.2 outlines that the wind environment of settlements must be conducive to pollutant dispersion, outdoor activity comfort, and natural ventilation during transitional seasons and summer. The simulation prediction of the wind environment in the site under typical meteorological conditions must meet the following requirements: in winter, the wind speed in the pedestrian area around the building at 1.5 m above the ground is less than 5m/s; in the transition season and summer, the outdoor wind pressure of the building is uniform, and the pressure difference between the front and rear surfaces of the building under typical wind speed and direction conditions is greater than 0.5 Pa. At the same time, the simulation boundary conditions and basic settings are based on the *Code for Green Design of Civil Buildings* (JGJ/T 229-2010). Section 5.4.2 requires the spatial organization of the residence should be conducive to indoor natural ventilation. The *Assessment Standard for Healthy Buildings* (T/ASC 02-2016) Section 3.1.2 stipulates that a healthy building must first be a green building, and the standard can be applicable to the evaluation of building clusters. In Section 6.2.11, it is suggested that passive adjustment measures such as natural ventilation should be adopted as much as possible, which can not only save energy and reduce emissions, but also better meet the needs of human comfort. The *Evaluating Standard for Healthy Housing* (T/CECS462-2017) Section 5.4.1 states that polluted gases from indoor spaces such as kitchens and bathrooms in residential areas should be discharged outdoors as quickly as possible to prevent them from entering other functional rooms indoors. Among them, the *Assessment Standard for Healthy Buildings* (T/ASC 02-2016) points out that healthy buildings must be green buildings, which, to a certain extent, reflects the development trend from green buildings to healthy buildings. Although the *Assessment Standard for Green Building* (GB/T 50378-2019) was updated in 2019, the control item 5.1.2 stipulates that the air and pollutants in areas such as kitchens and bathrooms should be prevented from spreading into other rooms. This principle is consistent with the requirements of the aforementioned other guidelines and standards.

In summary, healthy wind environments of settlements should meet the following requirements: (1) natural ventilation should be achieved as much as possible; (2) the dominant wind direction should be taken into account in planning and layout; (3) airflow from auxiliary rooms such as kitchens and bathrooms should not flow into main rooms such as living rooms and bedrooms; (4) in summer, the outdoor wind pressure is uniform, and the pressure difference between the front and back surfaces of buildings under typical wind speed and direction conditions should be greater than 0.5 Pa; (5) in winter, the outdoor wind speed in the pedestrian area at the height of 1.5m should be less than 5m/s.

4 Numerical simulations

Taking the Yuedao settlement as a case study, based on the specific requirements of the healthy wind environment outlined in relevant guidelines and standards, a numerical simulation method is used to simulate, analyze, and quantitatively assess the Yuedao settlement at three levels—community, group, and individual building [33, 34]. The *Evaluating System on Performance of Healthy Housing* (2013 edition) proposed that the simulation of the wind environment of settlements should be carried out in accordance with the relevant requirements of the *Code for Green Design of Civil Buildings* (JGJ/T 229-2010). However, to unify the fundamental requirements for calculating the green performance of civil buildings in China, the *Standard for Green Performance Calculation of Civil Buildings* (JGJ/T 449-2018) was issued and implemented in 2018. Therefore, the numerical simulation in this study was based on the updated standard [35], and utilized the recognized international mainstream software, Phoenics, to simulate the wind environment [36,37]. Numerical simulations can be divided into three steps: modeling, setting, and calculation.

The modeling was carried out using SketchUp software in the form of components at three scales—community, group, and individual building. These models were then imported into Phoenics software for calculation and setting [38]. The numerical method employed is the finite volume method [39]. According to the relevant standard, the computational domain was defined by a simulated building height H, with the inflow boundary and the top boundary set at a distance of at least $5H$ from the model, and the outflow boundary at a distance of no less than $10H$ (Figure 7) [40]. The blockage ratio of the cross-section orthogonal to the dominant wind direction was kept below 3%. The Yuedao settlement is located in the suburban region of Heshan, Jiangmen. For typical summer and winter meteorological conditions at the levels of community, group, and individual building, the reference parameters were set based on Appendix B of the *Standard for Green Performance Calculation of Civil Buildings* (JGJ/T 449-2018): a southeast-south prevailing wind with an average speed of 2.3 m/s in summer, and a northeast-north prevailing wind with an average speed of 2.7 m/s in winter. The wind speed gradient distribution power exponent (α) was selected as 0.16 according to the specification, and the turbulence calculation model adopted the standard k-ε model suitable for near-ground wind simulation [41]. The computational grid was then generated, and simulations were carried out until convergence was achieved [42].

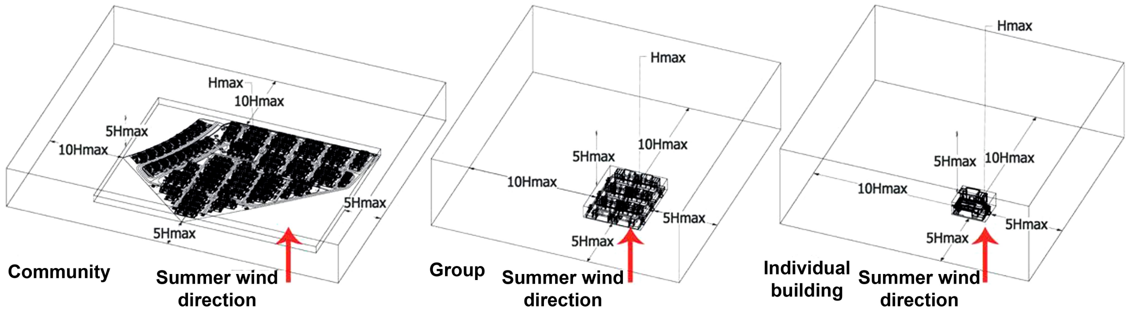

Figure 7 Model settings (summer conditions)

5 Simulation results

The simulation results of the wind environment are interpreted from three levels: community, group, and individual building. In terms of communities, the wind speed in summer ranges from 0.57 to 2.89 m/s. The ventilation of some houses on the leeward side is weak, forming astatic wind zone (Figure 8), which does not meet the requirements for natural ventilation in healthy settlements and needs to be optimized. The wind speed in winter is distributed between 0.44 and 3.5 m/s, which is less than 5 m/s. It will basically not affect human activities and meets the requirements (Figure 9).

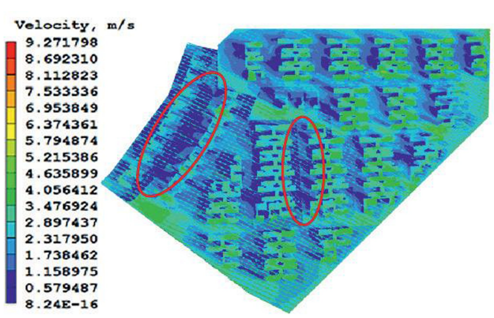

Figure 8 Wind speed within settlements in summer

In terms of the group wind environment, ventilation on the west side of the group is blocked, regardless of whether it is summer or winter, due to the north-south terraces, especially in the middle of the west side, where a large area of static wind appears (Figures 10-12). At the same time, the mirroring of the individual buildings creates the problem of air pollution caused by the airflow from the bathroom into the bedroom (Figure 13). After mirroring the individual building, the main entrance faces away from the dominant wind direction, which is not conducive to natural ventilation and requires optimization.

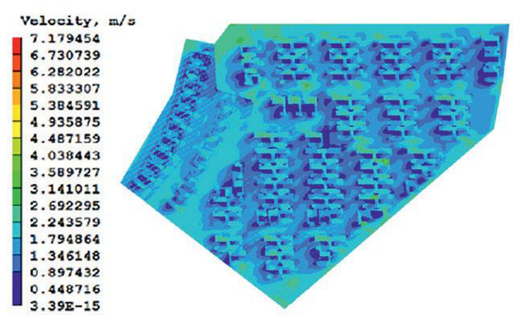

Figure 9 Wind speed within settlements in winter

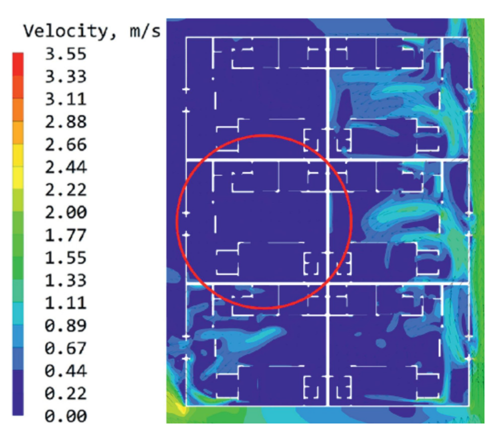

Figure 10 Wind speed on the first floor of the group in summer

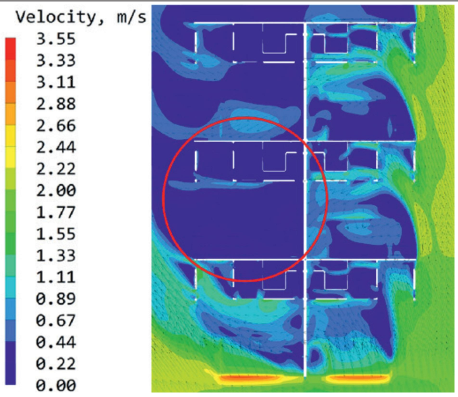

Figure 11 Wind speed on the second floor of the group in summer

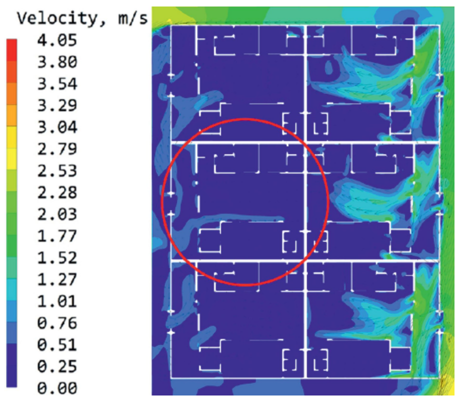

Figure 12 Wind speed on the first floor of the group in winter

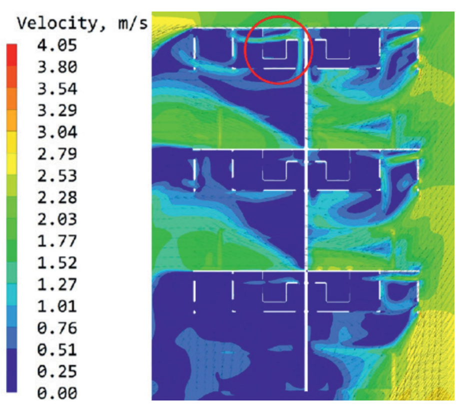

Figure 13 Wind speed on the second floor of the group in winter

In terms of the individual building wind environment, natural ventilation can be achieved on the first floor in summer, but the bathroom on the east side will affect the indoor air quality of the bedroom (Figure 14), and the wind environment on the second floor of the individual building is good (Figure 15); in winter, the first floor also has air pollution problems due to the auxiliary rooms located in the upwind direction (Figure 16), and the wind environment on the second floor is good (Figure 17), and the overall wind speed is between 0.01~3.95 m/s, less than 5 m/s.

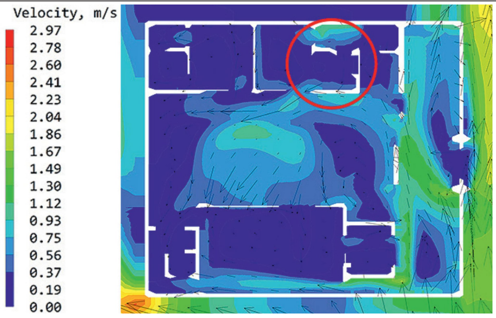

Figure 14 Wind speed on the first floor of the individual building in summer

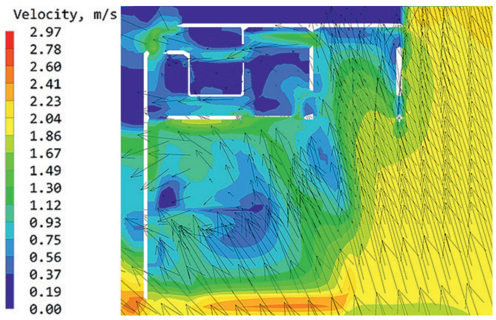

Figure 15 Wind speed on the second floor of the individual building in summer

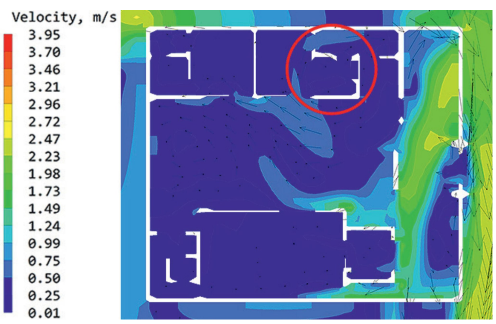

Figure 16 Wind speed on the first floor of the individual building in winter

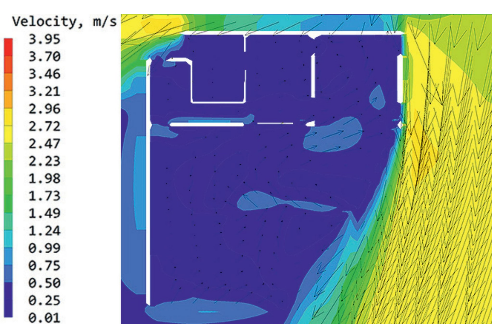

Figure 17 Wind speed of the second floor of the individual building in winter

6 Optimization analysis

The numerical simulation reveals that the subjective judgment of the wind environment in the Yuedao settlement, based on field investigation, lacks scientific validity, and on-site measurements have their limitations. The numerical simulation interprets the impact of the current planning and design of the Yuedao settlement on the wind environment in a quantitative way. Based on the need for optimization, problems are systematically solved at the three levels of community, group, and individual building.

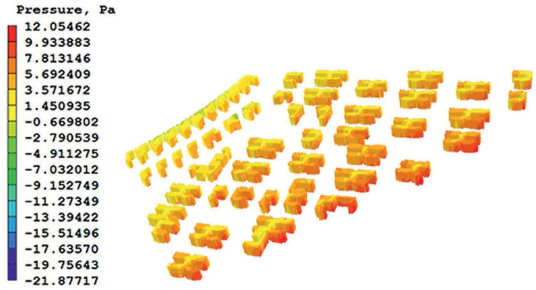

Figure 18 Wind pressure within the settlement in summer

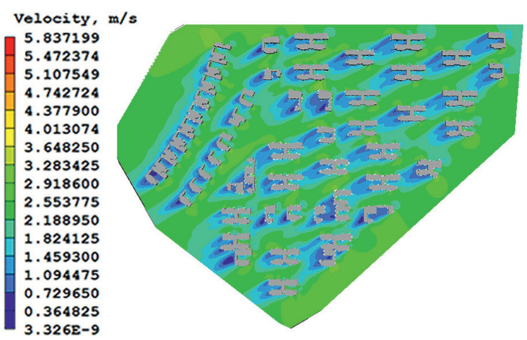

Figure 19 Wind speed within the settlement in winter

At the community level, there are local static wind areas in the summer that do not meet the relevant requirements for healthy wind environments in settlements, whereas the winter wind environment meets these requirements. In terms of community planning and layout, the overall orientation is north-south, and most of the groups are aligned with the dominant wind direction in summer. Taking into account factors such as solar exposure, it is possible to moderately disperse the groups within the comb-style layout to create more ventilation corridors without altering the overall orientation [43]. The summer wind environment has been greatly improved after simulation-based optimization. Under typical summer conditions, the pressure difference between the front and rear surfaces of buildings exceeds 0.5 pa, meeting the ventilation requirements (Figure 18). The winter wind speed ranges from 0.36 to 3.64 m/s (Figure 19), which is less than 5 m/s. The optimized community wind environment meets the relevant requirements of healthy settlements.

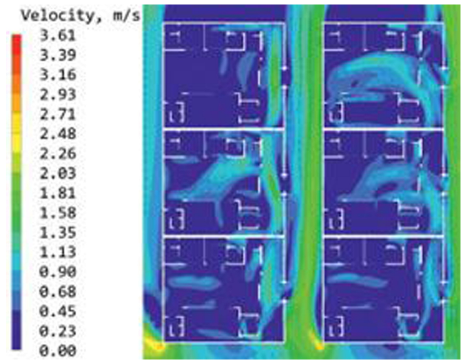

Figure 20 Wind speed on the first floor of the group in summer

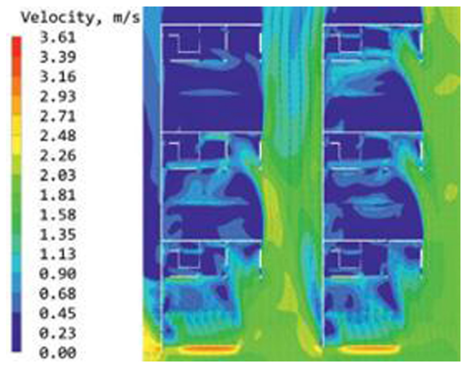

Figure 21 Wind speed on the second floor of the group in summer

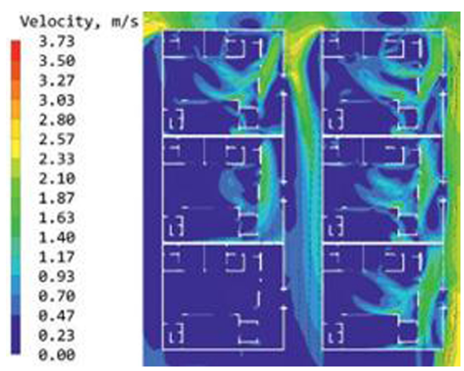

Figure 22 Wind speed on the first floor of the group in winter

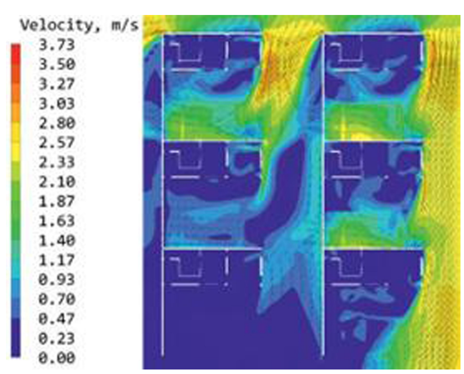

Figure 23 Wind speed on the second floor of the group in winter

At the group level, the main problem is the poor natural ventilation on the west side due to the mirroring of the individual buildings. Through design optimization, the mirror layout in the leeward direction was eliminated, allowing the main entrances of each building in the group to be oriented towards the dominant wind direction, thereby effectively solving the problem of static wind. The wind speed in summer is between 0 and 3.61 m/s, which is higher than before optimization. The wind speed in winter ranges from 0 to 3.73 m/s, which is less than 5 m/s, meeting the requirements (Figures 20-23).

At the individual building level, the main problem is that the bathroom located on the east side upwind causes air pollution to the bedroom. After optimization, openings were added to the partition wall to facilitate airflow. Without altering the original floor plan, theReturn Air Effect [44] redirected bathroom airflow directly outdoors. After optimization simulation, the summer wind speed is between 0.01~ 3.47m/s, which is higher than before optimization, and the ventilation effect is good. The wind speed in winter is between 0 and 4.18m/s, less than 5 m/s, which meets the requirements (Figures 24-27).

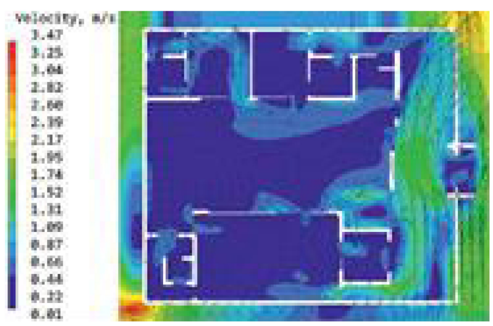

Figure 24 Wind speed on the first floor of the individual building in summer

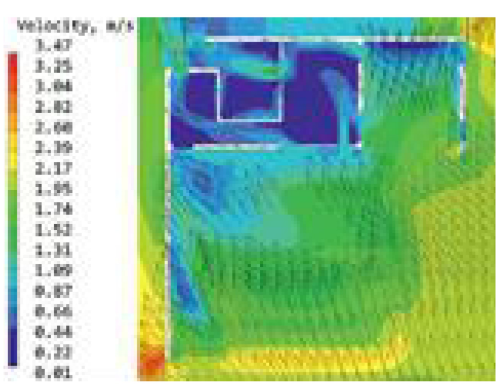

Figure 25 Wind speed on the second floor of the individual building in summer

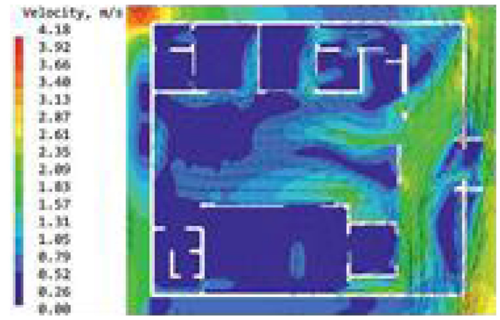

Figure 26 Wind speed on the first floor of the individual building in winter

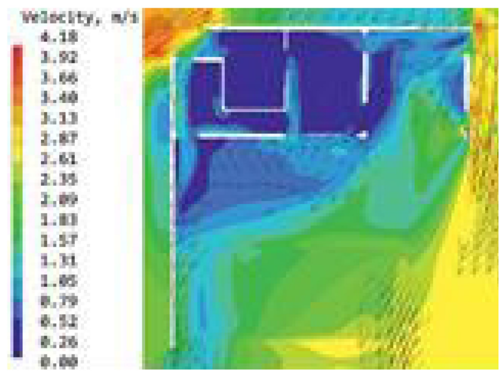

Figure 27 Wind speed of the second floor of the individual building in winter

Conclusion

This paper studies the design of healthy wind environments in settlements based on epidemic prevention. The literature review reveals that, within the research context of the coronavirus epidemic and healthy settlements, creating a healthy wind environment for settlements is crucial in preventing the epidemic. Therefore, the creation of healthy wind environments for settlements should be studied comprehensively, objectively, and scientifically. Then, taking the Lingnan Yuedao settlement as an example, a case analysis was conducted from three levels: community, group, and individual building. By sorting out the relevant guidelines and standards for healthy wind environments of settlements, the specific requirements for healthy wind environments of settlements were summarized. Then, according to the *Standard for Green Performance Calculation of Civil Buildings* (JGJ/T 449-2018), a numerical simulation was carried out using Phoenics software.

The simulation results show that the original comb-style layout at the community level was too dense, resulting in static wind areas in summer; at the group level, ventilation was blocked due to the terrace layout, the mirroring of individual buildings within groups caused air pollution problems, and the main entrances of some buildings deviated from the dominant wind direction; at the individual building level, auxiliary rooms such as bathrooms occupied the upwind direction, causing air pollution to the main rooms. After optimization simulation, the appropriate discretization of groups based on the comb-style layout is conducive to the formation of more ventilation corridors, thereby solving the problem of poor ventilation in summer at the community level. By canceling the mirror layout of individual buildings within the group, the main entrance of the building faces the dominant wind direction, solving the problem of static wind and air pollution in a large area. Holes are designed in the walls of individual buildings to effectively address the air pollution problem caused by the Return Air Effect without altering the floor plan.

Through the above analysis, we can conclude that the design of healthy wind environments of settlements based on epidemic prevention should be green, intelligent, and healthy, with consideration given to local conditions and sustainable development. Green design: First and foremost, a healthy building must be a green building. The *Assessment Standard for Healthy Buildings* (T/ASC 02-2016) stipulates that the evaluation of a healthy building must first meet the criteria of a green building, making green design the primary guiding principle. Intelligence, based on the requirements of healthy settlements and the current evolving scientific and technological methods, especially cutting-edge technologies such as big data, the Internet of Things, and artificial intelligence under the call of new infrastructure [45,46], quantitative methods such as monitoring and simulation of the physical environment of wind, light, heat, etc. in healthy settlements can avoid the risk of making subjective and wrong judgments that the wind environment in the Yuedao settlement is healthy through field investigation as mentioned above. Numerical simulations have shown that there is room for optimization at the three levels of community, group, and individual building. Therefore, intelligence should be the second level of guidance for the design of healthy wind environments in settlements. Health, as the fundamental human-centered demand, represents the core of residential design. Green design emphasizes energy conservation and environmental protection, while intelligent designs employ objective and scientific methods for evaluation and optimization. Ultimately, all approaches must return to addressing essential human needs. Especially in the context of epidemic prevention, health has become the third level of guidance in the design of healthy wind environments in settlements. Indeed, the guidance for the green, intelligent, and healthy design should also be implemented in the specific environment. For example, the Lingnan Yuedao settlement, a case study in this paper, is located in an area with hot summers and warm winters. Due to the diverse climate environments and project attributes, its comb-style layout is based on the climate adaptability of the Lingnan region [47, 48]. It may not necessarily apply to the design of wind environments in settlements of other regions or of different types. Therefore, the design of healthy wind environments in settlements based on epidemic prevention should adhere to the guiding principle of green, intelligent, and healthy design, with consideration given to local conditions and sustainable development.

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Sources of Figures and Tables

Figures 1-2: redrawn by the author based on data provided by Fangyuan Group.

Figures 3-27: photographed or drawn by the research team;

Table 1&2: Author's drawing.

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