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Analysis on Wind Environment in Winter of Different Rural Courtyard Layout in the Northeast

Huang Meng[a], Wang Jiao[b]* , Jin Hong[a] ,Li Anna[a]

[a]*Harbin Institute of Technology, No.66 of Xidazhi Street, Harbin150000, China*
[b]*China Southwest Architectural Design and Reseach Institute, No.866 of the North Section of Tianfu Avenue, Chengdu610041, China*

Abstract

Through to survey the northeast region in China, summarized four kinds of typical rural courtyard layout forms. Using Fluent software to simulate the wind velocity of different layout forms, combined with the assessment criteria of wind velocity ratio, considering factors such as the wind shadow area and the numbers of eddy current, to analyze advantages and disadvantages of wind environment in existing courtyard.

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Keywords: Courtyard;Wind speed; Fluent software simulation;

1. Introduction

Screened from more than 2,000 the satellite images of towns and villages in the northeastern region, and ultimately selected 33 villages in the territory of Heilongjiang, Jilin, Liaoning and Inner Mongolia to do the research. Each village takes at least 30 residents at random, the number of valid questionnaires is 896. Each questionnaire contains courtyard plan, which as this study courtyard sample.

* Corresponding author. Tel.: +13604512338; fax: +0-000-000-0000 .
E-mail address: sheshouzuo_wj@126.com

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1.1. Courtyard elements

According to the function in the courtyard, elements can be divided into four categories: production, life, entertainment and vegetation. Production function including poultry and livestock breeding, vegetable planting, store tools and food, or agricultural vehicles parking, and the corresponding elements are livestock shed, vegetable garden, warehouse and garage. Through the questionnaire data statistics, the proportion of vegetable garden and warehouse is larger, accounted for 34% and 33% of the overall production function elements. Life functions include accommodation, washing, drying, toilet, etc., and the corresponding elements are main room architecture, outdoor toilet, and the open space of the courtyard. The proportion of outdoor toilet is larger, accounted for 50% of the overall life function elements.

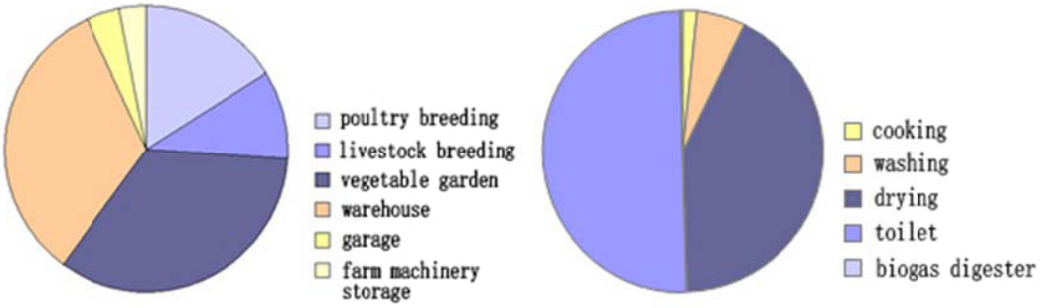


Fig. 1. the percentage of production function elements and life function elements.

Entertainment function mainly refers to the leisure activities within the courtyard, such as enjoying the shade, playing cards, etc. Through questionnaire survey, respondents enjoy the shade in the courtyard as the main leisure activities, and there is no recreational facilities for respondents such as seats, arbor. Respondents said they enjoyed the shade in the main room shadow, no fixed area.

Vegetation mainly refers to grow vegetables and crops in the vegetable garden, but tall woody plants in the yard, and residents also don't want to plant trees in the yard, the reason is that planting trees have no spare space, also don't want to sacrifice the area of the garden for planting trees.

In addition, there is a more important element-fence. Fence as a borderline of the courtyard, is the exterior protected construction, which makes the whole courtyard to form a private space.

1.2. Shape and scale of courtyard

For the type research purpose, the 896 samples according to aspect ratio are divided into three types: Square courtyard, aspect ratio is approximately equal to 1; Rectangular courtyard, aspect ratio is less than 2:1; Bar yard, aspect ratio is greater than or equal to 2:1. Rectangular courtyard accounted for about 47.7% of the total number of samples, is currently common courtyard type in the northeast rural. The size of Rectangular courtyard, is generally between 400 m2 to 900 m2. In this paper, in order to ensure the research are universal, defined the rectangular courtyard 18 m wide (east-west) * 30 m long (north-south).

1.3. Courtyard layout form

The courtyard layout form is determined by the location of the courtyard elements. The location of the vegetable garden is determined according to the location of the main house and warehouse. Because of its peculiar smell, outdoor toilet usually locates at the downwind, according to the prevailing northwest wind in the northeast, generally in the southeast of the courtyard. So the main house and the warehouse both determine the courtyard layout form.

According to the position of the main room, the courtyard can be divided into three types: Front yard, Back yard,

Front-back yard. According to the survey questionnaire statistics, 78.7% of respondents adopted Front-back yard. In the northeast, countryside gives priority to Front yard and Front-back yard, mainly because of the lighting problem of the inside courtyard, and Back yard usually locates in the north of main road. For Rectangular courtyard in this paper, Front yard and Back yard is rare, and Front-back yard is common.

The warehouse is mainly used to store grain and production equipment. For the convenience of residents to take production equipment, shortening the distance between main house and warehouse, so the warehouse is closed to the main house commonly. The position relationship between them can be divided into two types: one is that the warehouse parallels to the main house, named "一" shape. The other is that the warehouse is perpendicular to the main house, named "L" shape. When there are two warehouses, they are respectively arranged on both sides of the main house, named "U" shape.

To sum up, this paper studies the courtyard layout forms can be divided into the following four types: A. the main house and the warehouse are parallel; B. the warehouse perpendicular to the main house is located on the left side of the main house; C. the warehouse perpendicular to the main house is located on the right side of the main house; D. the warehouses perpendicular to the main house are located on the left and right sides of the main room, as shown in Figure 2.

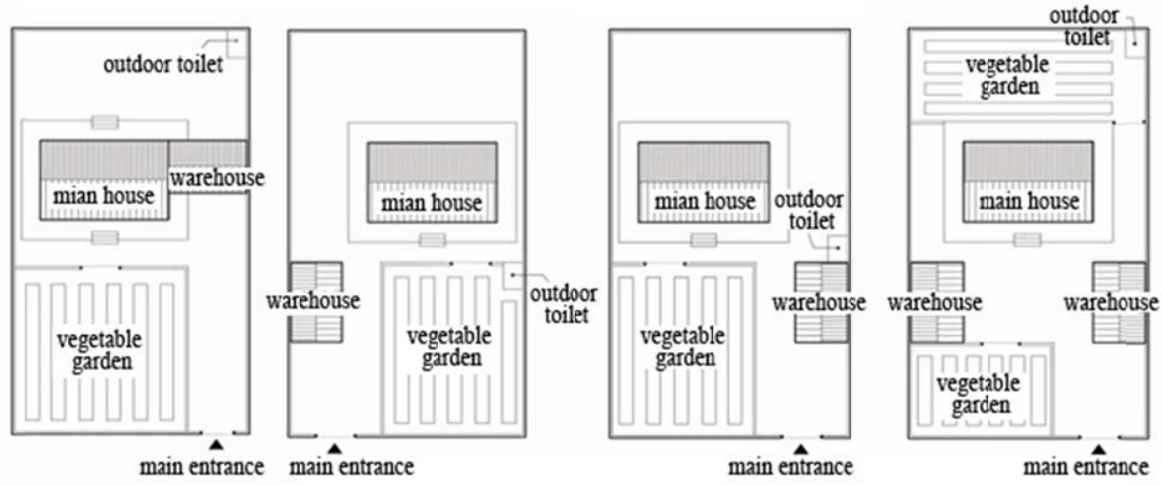


Fig. 2. Courtyard layout types.

2. Methods

According to the domestic and foreign study on wind environment simulation software application, verification, and various kinds of contrastive analysis of the simulation software, this article selects the Fluent software as the wind environment simulation analysis software (solver), Gambit software as modeling software (pretreatment), Tecplot software as late data processing software.

2.1. Modeling

Mathematical model: As the k - epsilon model is mainly suitable for indoor air flow, so choose improved k - epsilon model of Fluent software, namely the RNG k - epsilon model. By comparing the wind pressure numerical calculation results with field measured values, Jin Xinyang et al.(2006) concluded that the RNG k - epsilon numerical prediction results of the model is good, can basically reflect typical complex flow characteristic of flow around bluff body structure, so can adopt RNG k - epsilon model to study the wind flow under the building blocks. Geometric model: the geometric models used in the simulation according to the survey results simplified, retain only the main house, warehouse and fence. Main house size is 6 m (width) * 10 m (length) * 4.5 m (height). Warehouse size is 4 m (width) * 6 m (length) * 4 m (height). Fence is 1.5 m high. Figure 3 shows the courtyard model for the

simulation ("U" shape courtyard for example). Because the height of the plants in vegetable garden is less than 1.5 m, the garden has a little influence on the pedestrian high wind speed, negligible. Outdoor toilet is small, and the influence on the wind speed is not obvious, so can also be omitted. In order to reduce the influence of boundary condition of simulation area for buildings, build an open outdoor space that is close to the atmospheric layer. The direction of the wind is 5 times the length of the courtyard, and under the direction of the wind is 10 times the length of the courtyard, 5 times the height of buildings (Shao Teng 2012).

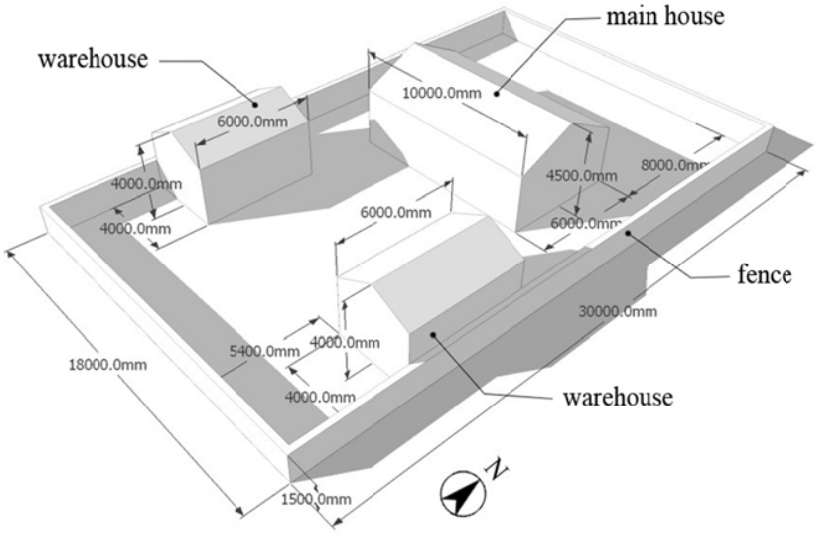


Fig. 3. Courtyard model for the simulation.

2.2. Boundary condition

In simulation, need to define three boundary types: Velocity Inlet, Pressure Outlet, Wall.

Velocity Inlet: the research object (the entire courtyard) submerged in the atmospheric boundary layer, mechanical turbulence and thermal circulation movement are weaker, so define the parameter of the wind speed elevation is 0, and ignore the surface wind speed. In this paper, the entrance wind speed is 3.00 m/s.

Pressure Outlet: the boundary conditions can solve the problem about the reflux export convergence difficulty, and turbulence intensity is 2%, the viscosity ratio is 5(Li Yunping 2007).

Wall: the surface of the building and the ground adopts no slip wall condition, because the distance between the simulation region and the top of the building is far away, and when setting the entrance speed, only defines the horizontal direction of the wind. So the normal direction of the wind speed value is 0(Krishna 1995).

3. Results and discussion

Based on comparing different layout courtyard wind velocity vector diagram simulated by Fluent software can be seen that, in general, the wind speed inside the courtyard is lower than the outside. The average wind speed is 1.28 m/s or so, compared with the outside courtyard wind speed reduces 1.72 m/s. It shows that the block effect is obvious, but significant difference exists among the wind speed distribution in different layout courtyard.

As shown in Figure 4, "—" shape yard, the wind speed between the windward side buildings and fence is larger, and the wind speed ratio is about 1.02. The leeside of the buildings forms the wind shadow, and the wind shadow area is about three-quarters of the construction area, and the wind speed ratio is about 0.19. Due to the Corner wind, the wind speed at the lower left of the main house increases rapidly, and the wind speed ratio is about 1.13. Looking

at the wind pressure diagram, as shown in Figure 5, wind pressure at the building windward side is bigger, and should strengthen the windward surface heat preservation and air tightness measures of the doors and windows.

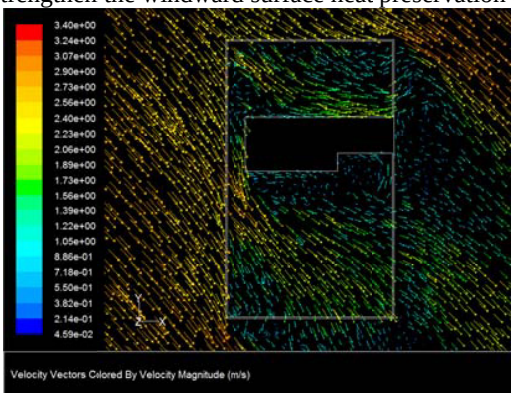


Fig. 4. "—" shape yard wind speed distribution vector diagram (left)

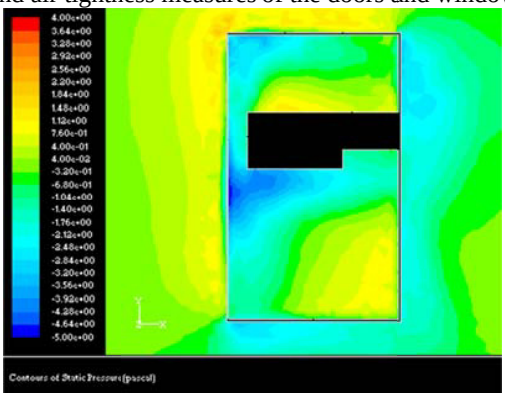


Fig. 5. "—" shape yard wind pressure distribution contour diagram (right)

As shown in Figure 6, "L" shape courtyard 1, the wind speed between the windward side of the main house and the fence is larger, and the wind speed ratio is about 0.99. The leeside of the main house and the warehouse forms wind shadow, and the wind shadow area is about three-quarters of the construction area, and the wind speed ratio is about 0.14. Due to the Corner wind, the wind speed at the lower left corner of the main house increases rapidly, and the wind speed ratio is about 1.03, accompanied by low eddy current. Looking at the wind pressure diagram, as shown in Figure 7, the wind pressure on the upper left corner of the main house is bigger, and should strengthen the part heat preservation measure.

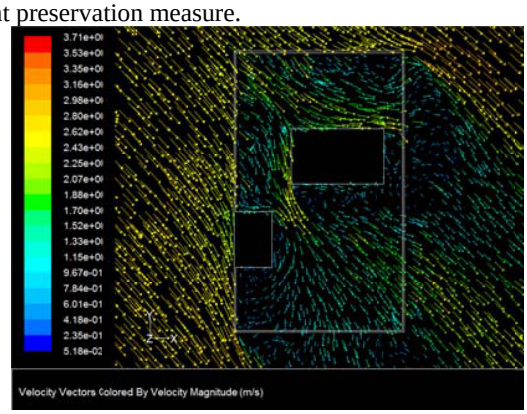


Fig. 6. "L" shape yard 1 wind speed distribution vector diagram (left)

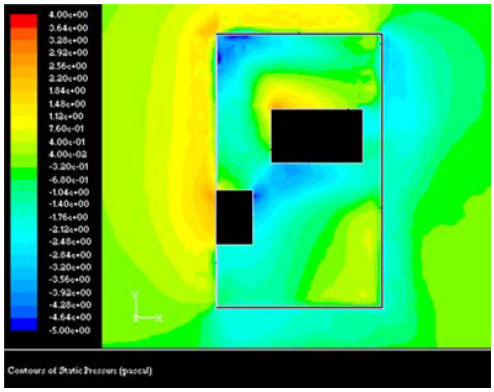
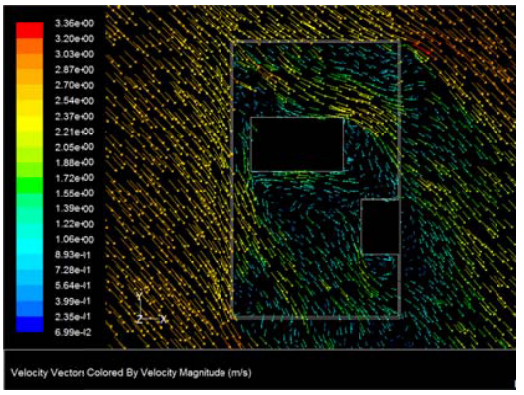


Fig. 7. "L" shape yard 1 wind pressure distribution contour diagram (right)

As shown in Figure 8, "L" shape courtyard 2, the wind speed between the windward side of the main house and the fence is bigger. Because the main house blocking effect is weak, the wind speed increases, and forms the Corner wind at the upper right corner of the main house, and the wind speed ratio is about 1.07. The leeside of the main house forms wind shadow, the wind shadow area is about 1.2 times construction area, and the wind speed ratio is about 0.09. Due to the main house close to the left side of the fence, the wind speed increases rapidly, and forms slit wind, and the wind speed ratio is about 0.92, accompanied by low eddy current.

Looking at the wind pressure diagram, as shown in Figure 9, the wind pressure on the windward of the main house is bigger, and should strengthen the windward surface heat preservation and air tightness measures of the doors and windows.



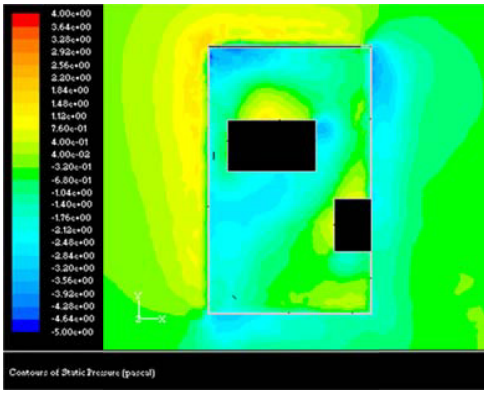
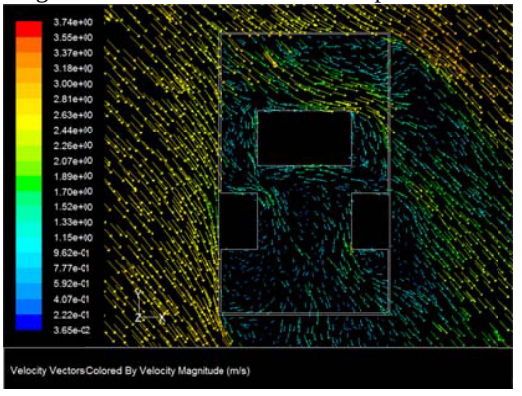


Fig. 8. "L" shape yard 2 wind speed distribution vector diagram (left) Fig. 9. "L" shape yard 2 wind pressure distribution contour diagram (right)

As shown in Figure 10, "U" shape yard, the wind speed between the windward side of the main house and the fence is larger, the wind speed ratio is about 1.03. The surrounding area between the main house and the warehouse forms the wind shadow, and the wind speed ratio is about 0.11, accompanied by low eddy current. Due to the Corner wind effect, the wind speed is larger, and the wind speed ratio is about 1.10. Looking at the wind pressure diagram, as shown in Figure 11, the wind pressure on the windward of the main house and the warehouse is bigger, and should strengthen the windward surface heat preservation and air tightness measures of the doors and windows.



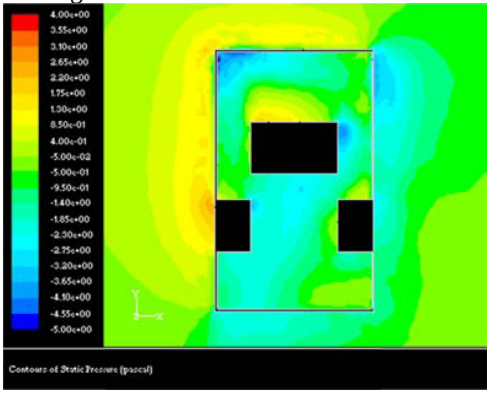


Fig. 10. "U" shape yard wind speed distribution vector diagram (left) Fig. 11. "U" shape yard wind pressure distribution contour diagram (right)

According to the maximum wind speed ratio and the wind shadow area, the optimal wind environment ranking as follows: "L" shape courtyard 1 > "L" shape courtyard 2 > "U" shaped courtyard > "—" shape courtyard, as shown in Figure 12.

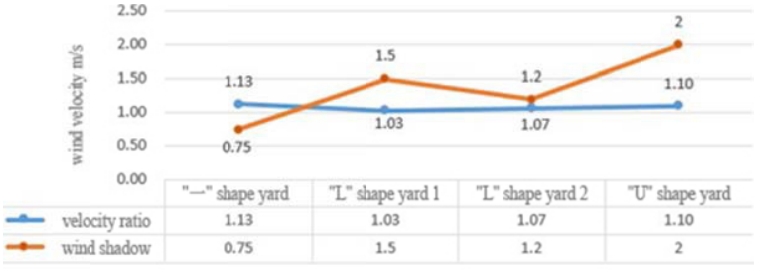


Fig. 12. Different layout types courtyard wind environment contrast.

4. Conclusions

Through the above analysis result, the courtyard layout types have a direct impact on the wind velocity distribution inside. The wind environment in "L" shape courtyard and "U" shape courtyard is better than "一" shape courtyard, namely the higher the surround close degree, the lower the wind speed. The more windward side buildings, the more wind shadow area in the courtyard, the greater to provide a good space of outdoor activities for the residents. However, the high surround close degree is prone to form low eddy current, which can lead to dirt, and affect the healthy outdoor environment. Comprehensive considering the wind speed, the wind shadow area and the number of eddy current as the evaluation criteria, "L" shape courtyard 1 has the best wind environment.

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