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LETTER TO THE EDITOR

Influence of Upstream Buildings on the Distribution of Pollutants in Street Canyons based on Three-Dimensional BIM Model

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In order to reduce the influence of upstream buildings on street valley pollution, an analysis of the influence of upstream buildings on the distribution of pollutants in street canyons based on three-dimensional BIM model is proposed. Based on the three-dimensional BIM model, the street valley of four building layout planes is given, and the height of the buildings on the two sides of the street valley is analyzed by numerical simulation and is 15m. The numerical simulation uses FLUENT-6.3.26 as the basic program to simulate the velocity of air flow and the concentration field of pollutants in the solution area. The diffusion equation of pollutants is represented by QUICK scheme. The experimental results show that the swirl in the middle street valley of layout 3 is beneficial to the diffusion of pollutants.
BIM model; Upstream building; Gorge; Pollutant distribution

1 Introduction

With the continuous development of human society, the contradiction between human beings and the environment is becoming more and more obvious. Traffic pollution is an important source of urban environmental conditions. The diffusion of traffic pollutants in cities is mainly affected by the layout of ground buildings, wind and atmospheric turbulence, among which the layout of urban buildings plays a major role in the process of atmospheric turbulence. (Fu et al. 2018).

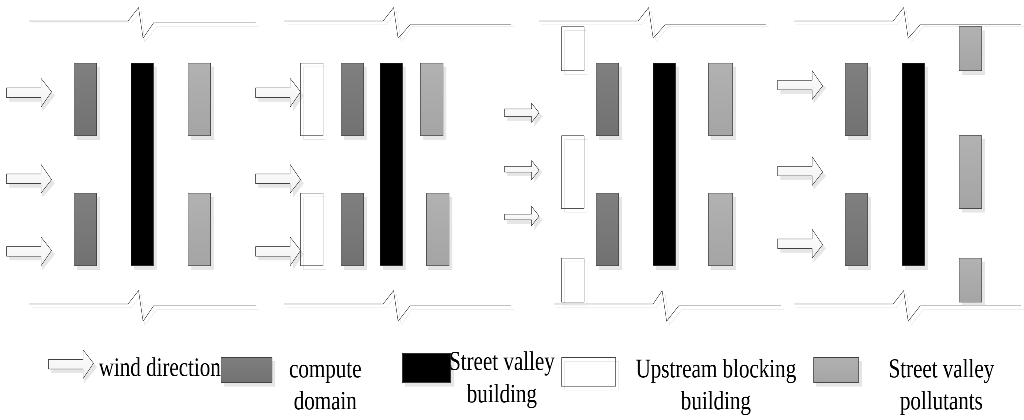
Jun Xing, Jie Dong, Xinzhe Wang published an article in 2019 in the journal Ekoloji, Issue 107, entitled “Design of Extraction Model for Copper Ion Pollution Information Based on Big data Analysis.” With the development of the social and economic level, people’s demand for the city gradually rises, and various natural landscapes have emerged. River landscape attracts attention to the effective utilization of rivers. The changes of climate, vegetation and land use pattern play a decisive role in the ecological water demand of river landscape. It is predicted that the ecological water demand of river landscape will continue to decline in 2019, 2020 and 2030. The natural runoff of the river can meet the ecological water demand of the river. There is a serious ecological deficit in the annual flood meeting, which requires ecological replenishment of rivers. On the basis of this analysis, the influence of upstream buildings on the distribution of pollutants in street canyons is analyzed based on three-dimensional BIM model.

Kumar, Huang far East and Li Qinyi have studied the migration and transformation of pollutants in street canyons, but due to the limitations of various conditions, There is no extensive application of modern BIM technology to study the effects of pollution source location on airflow movement and pollutant diffusion in street canyons. (Kirazli et al., 2017)Many people have studied the different characteristics of the air microenvironment in street valleys. According to the numerical simulation results of Xie et al., the street valley layout has a direct effect on the wind field in the street valley, and the diffusion of pollutants is mainly affected by the vortex structure in the street valley. Gu et al. The study shows that the uneven building layout is more conducive to the diffusion of pollutants in the microenvironment. The results of Wang et al. show that the concentration of pollutants in non-isolated street valleys is much higher than that in isolated street valleys. Zhao Baoqin's research shows that with the increase of building height, it is difficult to spread the pollutants, which increases the concentration of pollutants near the surface of the canyon. The results of He Zeneng et al show that the canyon form is more effective for the migration and diffusion of pollutants in the canyon, while Yassinl6J thinks that the appropriate top shape of the building is more beneficial to the diffusion of pollutants in the street canyon. (Bian et al. 2018).

In this paper, the three-dimensional BIM model is used to analyze the influence of different pollution sources on the air flow movement and the convective diffusion of pollutants in the canyon under different roofs in the street canyon.

2 Idea Description

Based on the three-dimensional BIM model, the street valleys composed of four kinds of building layout planes are given, as shown in figure 1. The layout 1 and layout 4 are isolated in the form of isolated streets that are common in the prior art, that is, there is no upstream barrier building; the difference is that the layout 1 is a determinant street valley and the layout 4 is a staggered street valley. The remaining 4 layouts are the variants of the layout 1 and the layout 4, respectively, that is, there is a barrier building upstream of the street valley (Wang et al.2017).



(a) layout 1 (b) layout 2 (c) Layout 3 (d) layout 4

Figure 1 Street valley model composed of different building layouts

In practice, the higher the height of the buildings on both sides of the street valley, the stronger the air flow pattern in the street valley is restricted and influenced by the buildings on both sides. The interference and influence of upstream barrier building on street valley flow field is smaller, (Zhang et al. 2018). In this paper, the common multi-storey buildings are taken as the research object, and the height of the buildings on both sides of the street valley is equal and 15 m is analyzed by numerical simulation.

In the simulation, the computational domain entrance condition is set to the velocity entrance, to describe the velocity profile through user-defined functions. The outlet is regarded as fully developing turbulence, so the boundary condition is set as free outflow (Outflow), because the simulated building is symmetrical distribution, so the symmetric boundary condition (Symmetry) is set. For the building wall and the ground of the calculation domain, there is no slip boundary, and the sliding boundary condition is used for the top and the side of the calculation domain.

The numerical simulation uses FLUENT-6.3.26 as the basic program to simulate the airflow velocity and pollutant concentration field in the region by three-dimensional simulation (Liang and Chen 2018). In order to eliminate the end effect caused by the limited area as much as possible, the following treatment is done in the simulation. The upwind first row building distance is 12 upstream boundary, and the end row building distance from the downstream exit of 17H building top to the top of the free edge interface 5H is three-dimensional simulation, in order to save the calculation cost and ensure the reliability of the results, according to the analysis of the existing research, the turbulence model takes the standard $k-\varepsilon$ model, the finite volume method is used for discrete control equations. In order to ensure the accuracy of the calculation. The second order upwind scheme is used for the discretization of the governing equation, and the QUICK scheme is used for the pollutant diffusion equation. The scheme is used for the discretization of the governing equation (Cen and Yu 2017).

3 Results

Based on the above analysis, the influence of the appearance of the upstream barrier building on the flow field and concentration field in the street valley is evaluated according to the estimation of the relative size of the flow and pollutant concentration in the upstream barrier building. η_V 、 η_C 、 η_I represent the average wind speed, the average concentration of pollutants and the change rate of turbulence intensity are defined respectively.

$$\eta_V = \frac{V_0 - V_i}{V_0} \times 100\% \tag{1}$$

$$\eta_C = \frac{C_0 - C_i}{C_0} \times 100\% \tag{2}$$

$$\eta_I = \frac{I_0 - I_i}{I_0} \times 100\% \tag{3}$$

In the form, V_0 、 V_i represent the average airflow velocity when there is no and no building upstream of the street valley building, respectively, m/s; C_0 、 C_i represent the dimensionless average concentration of pollutants in the upper reaches of the street valley without and when there is a building, respectively. I_0 、 I_i indicate the turbulence intensity when there is no and no building in the upper reaches of the street valley, respectively. When $i=1$, the upper reaches of the street valley block the parallel arrangement of the building, and when $i=2$, the blocking building is misarranged.

Figure 2 shows the statistical calculation results of velocity and concentration change rate in different areas of street valley with different blocking buildings.

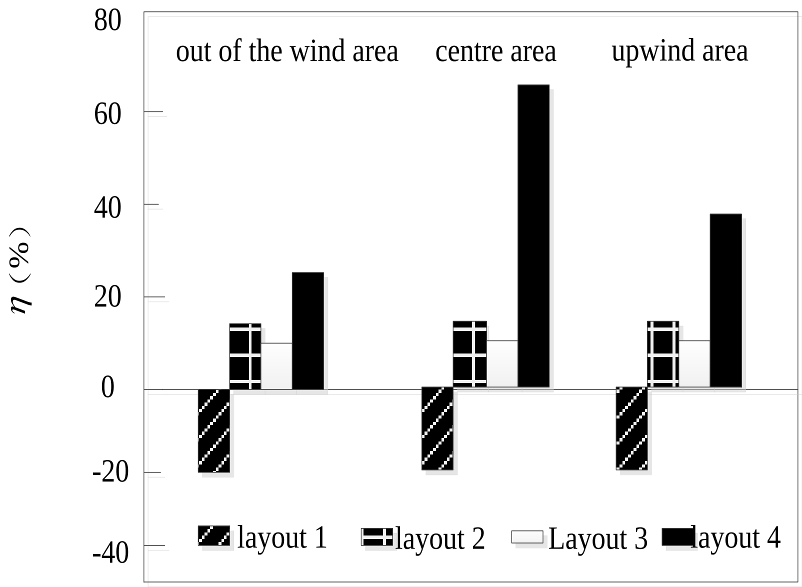


Figure 2. Change rate of air flow velocity, turbulence intensity, and concentration at the same time in the upstream building layout of the determinant

It can be seen from figure2 that the effect of the barrier building on the average wind speed in the windward area of the parallel street valley is very small, but the effect on the average wind speed in the back wind area and the central area exceeds 10%, and the effect of the layout 2 is slightly larger than the layout 3. It can also be seen from figure 2 that the reduction rate of the concentration of the blocking building to the street valley is much greater than the change rate of the average velocity, and the change rate of the concentration of the upstream barrier building to the street valley area to the street valley center area is about 15% at the time of layout 2. Layout 3 is more than 15%, among which the decrease of pollutant concentration in the central area of street valley is the most significant. The upstream building in the layout 2 is dominated by the increase in the wind speed in the street, and the barrier building of the layout 3 has little influence on the wind speed of the whole area of the street, but the effect of the reduction of the concentration of the pollutants is obviously larger than the layout 2, this is because the factors that affect the diffusion of contaminants in the street are also important factors in addition to the velocity of the gas flow. As can be seen from figure 2, the inner vortex of the street in the layout 3 facilitates the diffusion of the contaminants.

4 Discussion

Effects of upstream buildings on flow and concentration distribution in typical locations in street valleys: The upstream blocking buildings outside the street valley have obvious influence on the air flow and pollutant distribution in the street valley. When there are blocking buildings, although the rotation effect of air flow in the valley is weakened, the vortex current is limited to the street valley, which makes it difficult for pollutants to spread out of the street valley from the height direction. There will be a strong return vortex in upstream blocking buildings and street valley upwind buildings.

When there is an upstream blocking building, the numerical images of flow and pollutant distribution in two kinds of street valleys, determinant and staggered, which show that the existence of buildings outside the street valley will change the characteristics of velocity and local vortex in the street valley. And affect the diffusion and removal effect of pollutants in the street valley.

In determinant street valleys, no matter how the upstream barrier buildings are arranged, the concentration of pollutants in the street valleys will be reduced. In this paper, the reduction rate is about 20-60%. Therefore, in the study of pollution characteristics of determinant street valleys, the concentration of pollutants in street valleys will be overestimated if the existence of upstream buildings is not taken into account.

5 Conclusion

The problem of the migration and diffusion of the pollutants in the street canyon has become one of the hot spots in the field of environmental engineering. In order to control the problem of the diffusion of the pollutants in the street and the life of people, this paper mainly adopts the method of the three-dimensional BIM model. The influence of different roof and different pollution sources on the flow vortex motion in the street canyon, the distribution of the distribution of the wall concentration of the building is studied, and the simulation results are compared and analyzed. The next research direction is that the presence of upstream blocking buildings has obvious influence on the flow field and concentration field in the street valley, and the influence on turbulence intensity distribution is similar. Due to the change of the average wind speed and the vortex characteristics in the street valley, the effect of the barrier building in different arrangement on the average concentration of the pollutants in the street is obviously larger than the average wind speed.

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Research subject of higher education teaching reform in jilin province - research and practice on teaching reform of BIM 3d architectural drawing course for international students.

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