CFD Simulation of the Interference Effects of Wind Pressures in Building Groups

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Abstract. The effect of interference is a hot topic in structural wind engineering. In order to investigate the phenomena of this effect, some cases, including single interfered building, double interfered buildings and building matrixes, were simulated by the technique in the software Fluent. The simulation results show that, the windward pressures were dramatically influenced by the interfered buildings, and some rules between the distances and the pressures were discovered.

1 Introduction

Investigations of interference effects in structural wind engineering can be root to 1970s, when 3 of 8 cooling towers collapsed in UK. Researchers hold that this failure was mainly caused by the interference in the towers, which dramatically increased the wind loads on the cooling towers [1]. Following researches were focused on wind tunnel tests of rigid and aero-elastic models, which simulated interferences in some kinds of building group patterns. The results showed that, pressures in building faces were increased notably in rigid-model tests and the maximum torque can be three times enlarged by the interference effects [2]. From the 1980s, this effect became a hot topic in wind engineering researches. Investigations included summarizing the effect by statistics [3], consideration of local amplification by safety coefficients [4], torsion in non-central tall buildings [5], simulation and prediction of interferences based on artificial neural network [6-8], and simulation by computational fluid dynamics [9].

In this paper, some simulations by CFD method were completed. The results show some phenomena that the interference effects cause.

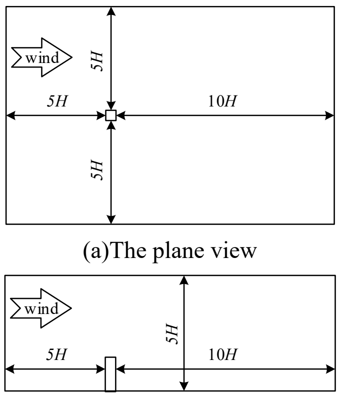
2 Modelling of CFD

Simulations in this paper were engaged by the software Fluent, which was widely used in solving fluid problems.

Turbulence model of realizable was adopt, which is a modification of standard model, and was considered an effective model to cope with the problems of flow in boundary layer.

2.1 Computing region

Computing region decides the time and accuracy of CFD simulations. The region in simulations are shown in figure 1. The parameter H is the height of buildings. From the buildings, the boundaries ware located 5H in windward, 10H in leeward, 5H in lateral, and 5H in height. This is a commonly used setting method in wind pressures in tall buildings simulation.



(a)The plane view

(b) The vertical view

Fig. 1. Geometry of computing region

2.2 Boundary settings

The windward boundary were set to velocity-inlet, in which the wind profile was set in formula (1), the turbulence profile was set in formula (2), and some turbulence parameters ,kinetic energy and dissipation ratio, were set in formula (3) and (4).

$$V(z) = V_{10}\left(\frac{350}{10}\right)^{0.16}\left(\frac{z}{450}\right)^{0.3} \quad (1)$$

$$I(z) = 0.15\left(z/H\right)^{-0.05-\alpha} = 0.15\left(z/H\right)^{-0.05-0.3} \quad (2)$$

$$k = \frac{3}{2}\left(uI_z\right)^2 \quad (3)$$

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$$\varepsilon = C_{\mu}^{3/4} \frac{k^{3/2}}{l} \tag{4}$$

In these formula, $C_{\mu} = 0.09$ .Parameter l is turbulence integral scale, and $l = 0.07L$, in which L are the typical geometry of buildings. The wind velocity profile, turbulence kinetic energy and dissipation rate were set by user-defined functions in Fluent.

The top and lateral boundaries were set to symmetry, and the leeward boundary was set to pressure-outlet. The faces of building and ground were set to wall, which were modified by roughness surface.

3 Interference by single building

In this part, CFD models of interference by single building were established. The distance of two buildings ranged from 100m to 1000m. The geometry of buildings was set to 300m in height, 50m in width and 50m in depth. As shown in figure 2, the distance, D, included 7 cases, they were 100m, 200m, 300m, 400m, 500m, 750m, and 1000m.

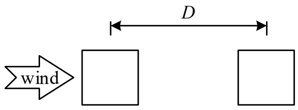
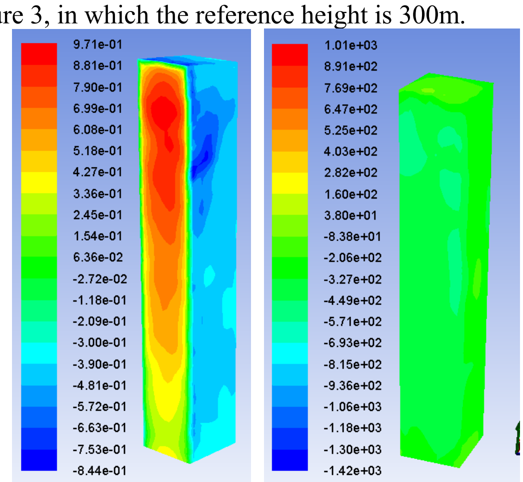
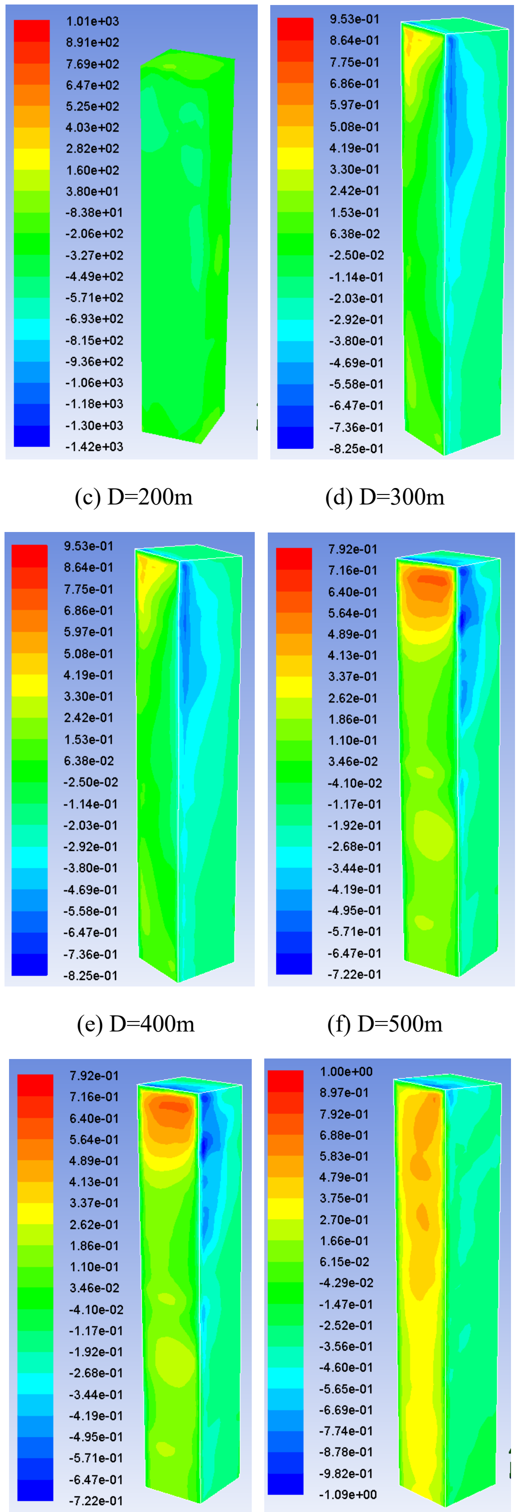


Fig. 2. Distance of interference

Contours in the windward surface are shown in figure 3, in which the reference height is 300m.



(a) non-interfered (b) D=100m



(g) D=750m (h) D=1000m

Fig. 3. Contours of windward surface under single interfered building

The results of wind pressure by single interference building show that, when the interference building is fairly closed, the windward pressures were mostly negative because the coming flow cannot act to the building's surface directly. We can see that in the case of D=100m, the windward pressure were all negative, and with the increase of distance, positive pressures emerged gradually in the top, and then the rest parts. When the distance become larger than 750m, the interference effects disappeared and became similar to the non-interfered case.

4 Interference by double buildings

Then the interference effects by double buildings were discussed. The geometry of buildings in computation were same with which in single interference, and the location were shown in figure 4, and the pressure contours in the windward surface were shown in figure 5.

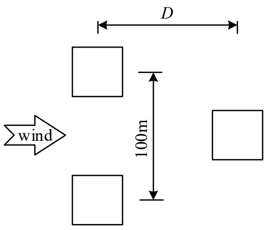
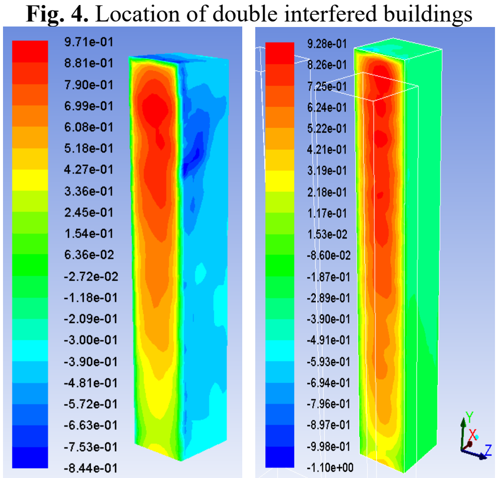
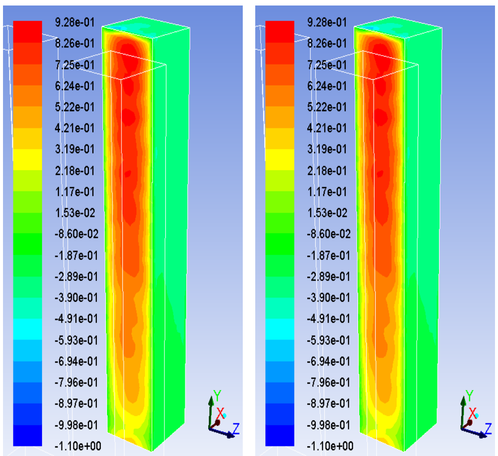


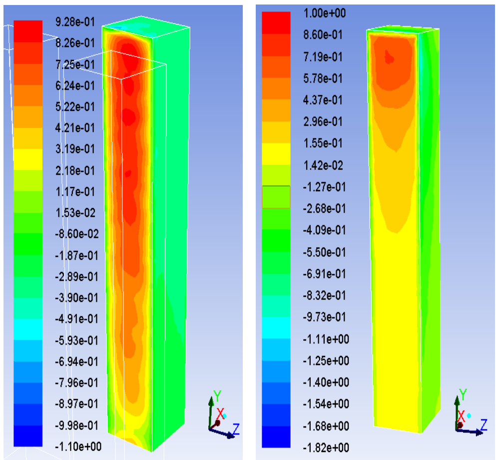
Fig. 4. Location of double interfered buildings



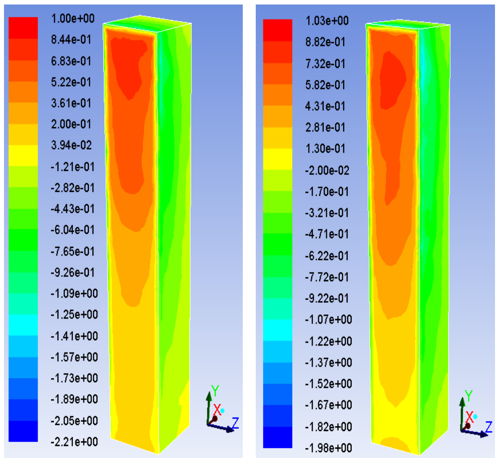
(a) non-interfered (b) D=100m



(c) D=200m (d) D=300m



(e) D=400m (f) D=500m



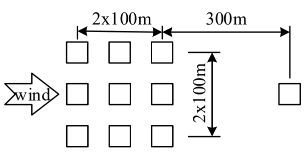
(g) D=750m (h) D=1000m

Fig. 5. Contours of windward surface under double interfered buildings

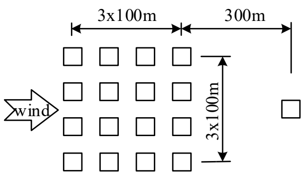
The results show that, when the interfered distance is closed, the flow can act directly to the windward surface though the double interfered buildings. Because of this, the windward pressures were almost same with which in the non-interfered case.

5 Interference by building matrix

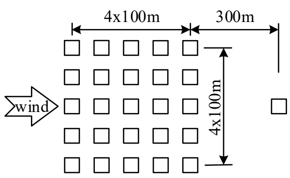
In this section, the interference effects by building matrixes were investigated, including matrix 3x3, 4x4, and 5x5. The locations were showed in figure 6, and the interfered pressures were showed in figure 7.



(a)Matrix 3x3

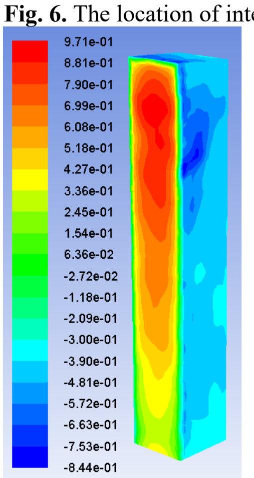


(b) Matrix 4x4

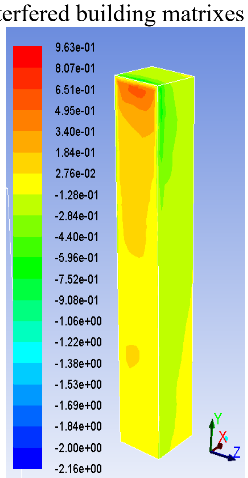


(c) Matrix 5x5

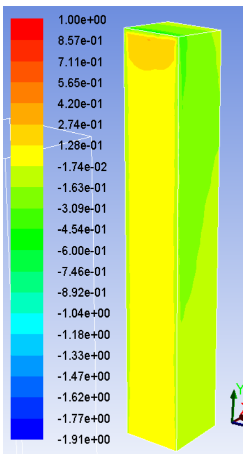
Fig. 6. The location of interfered building matrixes



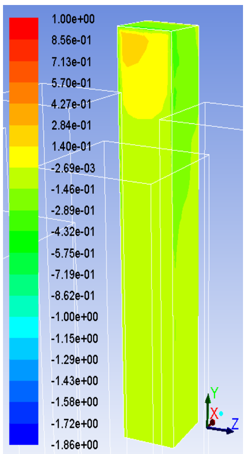
(a) non-interfered



(b) Matrix 3x3



(c) Matrix 4x4



(d) Matrix 5x5

Fig. 7. Contours of windward surface under building matrixes

In the figures, with the increase of number of interfered buildings, this effect became more notably, and the windward pressures gradually turned uniform.

6 Conclusions

In this paper, the interference effects were investigated by CFD simulation on some interfered cases. According to the results, some conclusions could be got as following:

(1) A single interfered building will cause the interference effects dramatically if the distance is small, and the effects will disappear when the distance increase beyond 750m.

(2) In the cases of double interfered buildings, the effects cannot be observed in much closed distance, and only emerged when the distance was far enough.

(3) In the cases of interference of building matrixes, the wind pressures would turn uniform with the increase of the number of interfered buildings.

Acknowledgements

This research is funded by Chongqing Research Program of Basic Research and Frontier Technology (No. cstc2015jcyjA30016), Research Foundation of Chongqing University of Science & Technology (No. CK2015B15, No. CK2016Z17).

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