The 2022 World Congress on
Advances in Civil, Environmental, & Materials Research (ACEM22)
16-19, August, 2022, GECE, Seoul, Korea

Large eddy simulation of high-rise building under interference effect

*Han-Sol Lee[1)] and Thomas Kang [2)]

[1), 2)] *Department of Architecture & Architectural Engineering, Seoul National University, Seoul, Korea*
[2)] *tkang@snu.ac.kr*

ABSTRACT

For urban buildings, unexpected wind load can occur by interference effect from surrounding buildings. To prevent the increased wind load by interference effect, understanding the interference mechanism and its effect on response of building is needed. In this study, interference effect on high-rise building is discussed using computational fluid dynamics (CFD). Here, CFD is performed based on AIJ guideline (AIJ 2015), and large eddy simulation is used for turbulence model to capture the flow characteristic under interference effect. Wind pressure pattern on building and flow pattern is analyzed using modal decomposition, and mechanism of interference effects is discussed.

1. INTRODUCTION

Most of current design codes about wind load on building are based on isolated building. However, most of the buildings in urban region are not isolated, and surrounding buildings can cause the interference effect on the wind load. By effect of vortex shedding or Venturi effect, unusual wind load can act on the building. To prevent the increased wind load by interference effect, understanding the interference mechanism and its effect on response of building is needed.

Under the interference effect, unusual sequence such as bimodal distribution of probability distribution of the wind pressure on building can occur (Hui 2013, Liang 2020). Non-Gaussian distribution can mislead the peak wind load. In this study, numerical simulation using computational fluid dynamics (CFD) is performed to capture the interference effect and discuss the mechanism of unusual distribution of wind load.

2. METHODOLOGY

To simplify the interference situation, a case with two buildings where interfering building affects the incident wind on principal building is analyzed. Both principal and

---

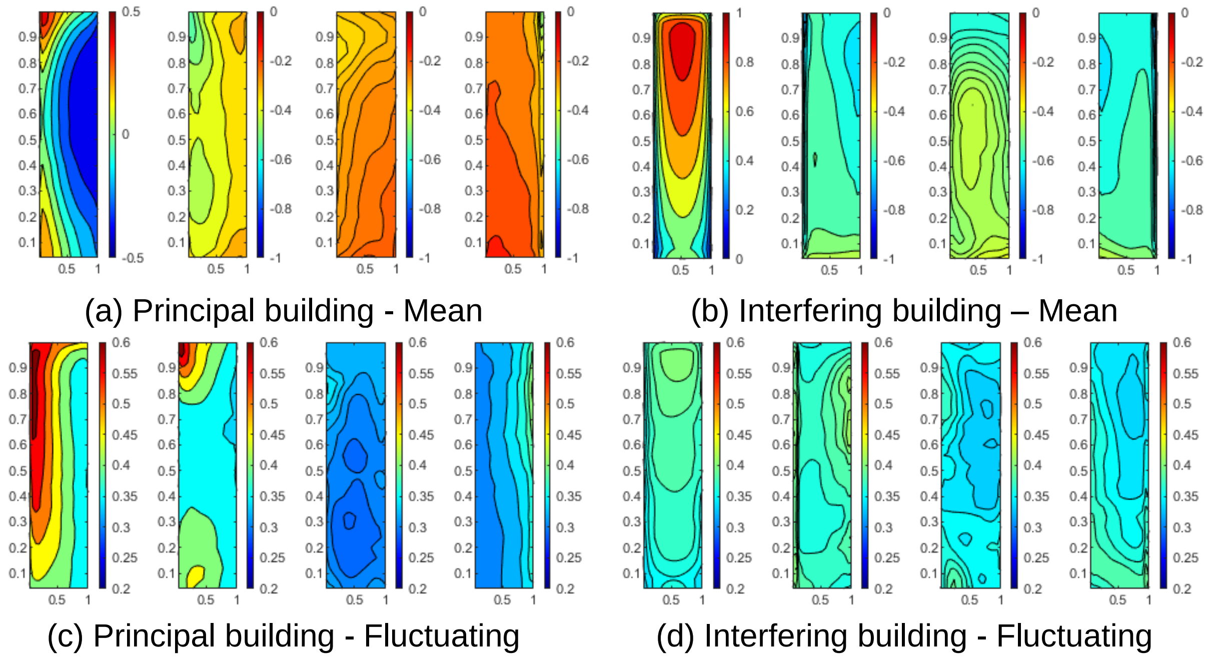
[1)] Graduate Student
[2)] Professor

interfering buildings have the same geometric shape and an aspect ratio of 5 with square section. Principal building is located at 2.5*B* in alongwind direction and 0.5*B* in crosswind direction from the interfering building, where *B* is width of the principal building. Distance between two buildings was decided based on the location where vortex shedding from the interfering building is expected to hit the principal building.

Numerical simulation using CFD is performed to capture the interference effect on the building and nearby flow. Large eddy simulation is used for turbulence model with WALES model. Time and length scales of domain are 1:80 and 1:400, respectively, which correspond to velocity scale of 1:5. Total domain size was decided based on the AIJ recommendation (AIJ, 2015), where 5*H* and 15*H* is defined from building to each inlet and outlet, respectively, and 10*H* and 4*H* as domain width and height. Here, *H* is height of the principle building. With a time step of 0.0005 second, total 12.5 second data with 25,000 steps was simulated. The first 5 second data was ignored for stabilization of wind flow, and 7.5 second data was used for further analysis, which corresponds to 10-minute data for real scale. Total 1.55 million meshes were used.

3. NUMERICAL SIMULATION

Fig. 1 shows the result of CFD analysis on the mean and fluctuating wind pressures on the interfering and principal buildings. A half side of front wall of the principal building shows large fluctuating wind pressure for both mean and fluctuating components, which are affected by vortex shedding from the interfering building.



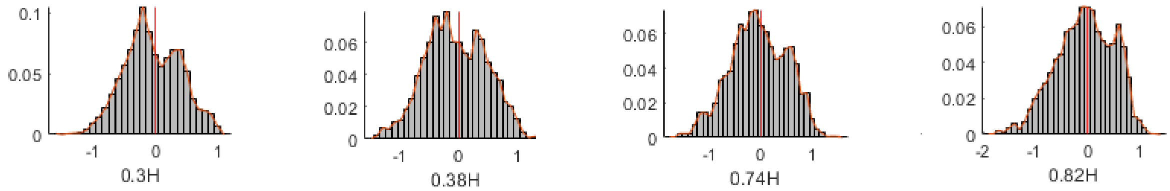
(a) Principal building - Mean (b) Interfering building – Mean

(c) Principal building - Fluctuating (d) Interfering building - Fluctuating

Fig. 1 Mean and fluctuating wind pressures on building

4. BIMODAL DISTRIBUTION OF WIND PRESSURE

As reported by previous studies, bimodal distribution of wind pressure is captured at the corner of the front wall of principal building. Fig 2 shows the PDF of wind pressure at the pressure tap on the front corner of principal building along the height.

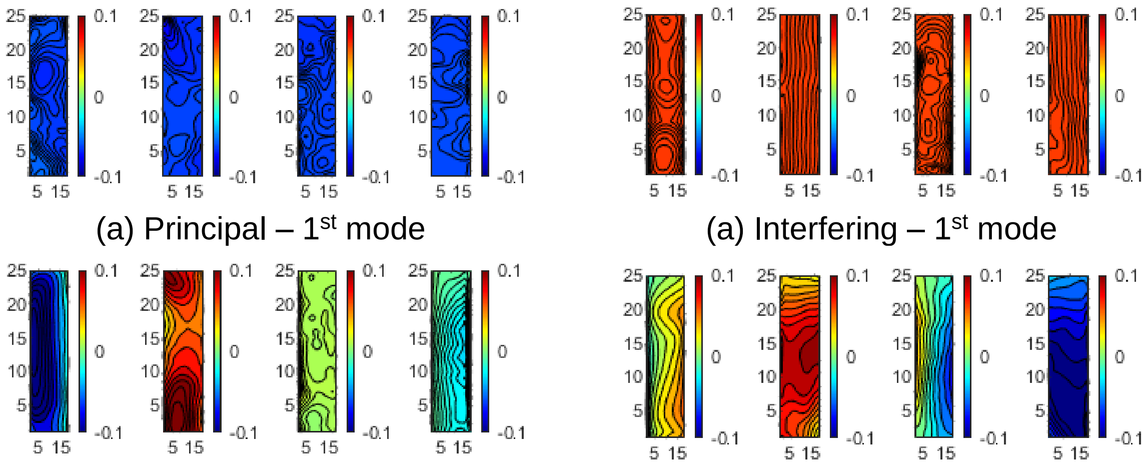


(a) 0.3*H* (b) 0.38*H* (c) 0.74*H* (d) 0.82*H*

Fig. 2 Observed bimodal PDF at corner of front wall of principal building

To analyze the bimodal distribution of wind pressure, modal analysis using proper orthogonal decomposition (POD) was conducted, which is quite efficient to capture the characteristic of fluctuating field (Tamura, 1999).

Fig. 3 shows the first two POD modes of wind pressure on two buildings. The first mode shows the effect of the fluctuating of incident wind flow, and the second mode shows the effect of vortex shedding at the interfering building.

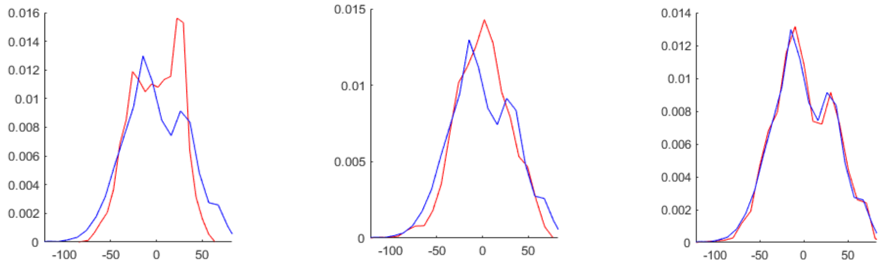


(a) Principal – 1st mode (a) Interfering – 1st mode

(c) Principal – 2nd mode (c) Interfering – 2nd mode

Fig. 3 POD mode shape of fluctuating wind pressure on building

To check if a certain mode occurs the bimodal distribution, wind pressure reconstruction was done with POD modes with each specific eliminating single mode. Fig. 4 shows the PDF of three cases with elimination of each mode. When second mode is removed, number of the peak of PDF is reduced from 2 to 1, while removing other modes do not affect having 2 peaks in PDF.



(a) (b) (c)

Fig. 4 PDF at height of 0.3*H* with elimination of (a) 1st ,(b) 2nd, and (c) 3rd POD mode

5. CONCLUSIONS

This study performed CFD analysis on the high-rise building under interference effect, and showed that CFD can be an efficient tool to capture the unusual distribution of wind pressure. With modal analysis using POD, eliminating single modes showed that vortex shedding from the interfering building causes the bimodal distribution of wind pressure.

In further study, effects of non-Gaussian distribution of wind pressure by interference effect on the peak wind load will be discussed. Because the equivalent static wind load is affected by not only the characteristic of wind pressure but also the response of building, structural analysis should also be performed.

ACKNOWLEDGEMENTS

This work presented in this paper was funded by the National Research Foundation of Korea (NRF) grant (NRF-2021R1A5A1032433).

REFERENCES

AIJ, 2015. “Recommendations for loads on buildings”, Architectural Institute of Japan, Tokyo, Japan.

Hui, Y., Yoshida, A., Tamura, Y. (2013), “Interference effects between two rectangular-section high-rise buildings on local peak pressure coefficients,” Journal of Fluids and Structures, **37**, 120-133.

Liang, Q.S., Fu, J.Y., Li, Z., Yan, B.W., Shu, Z.R., He, Y.C. (2020), “Bimodal distribution of wind pressure on windward facades of high-rise buildings induced by interference effects”, Journal of Wind Engineering and Industrial Aerodynamics, **200**, 104156.

Tamura, Y., Suganuma, S., Kikuchi, H., Hibi, K. (1999), “Proper orthogonal decomposition of random wind pressure field,” *Journal of Fluids and Structures*, **13**, 1069-1095.