CFD Wind-resistant Design of Tall Building in Actual Urban Area Using Unstructured-grid LES

Masaru YOSHIKAWA
Research Engineer
Taisei Corp.
Yokohama, JAPAN
masaru.yoshikawa@sakura.taisei.co.jp

Masaru Yoshikawa, born 1973, received master's degree of engineering from Tokyo Metropolitan Univ., Japan.

Tetsuro TAMURA
Professor
Tokyo Institute of Technology
Yokohama, JAPAN
tamura@depe.titech.ac.jp

Tetsuro Tamura, born 1954, received doctoral degree of engineering from Tokyo Institute of Technology, Japan.

Summary

Computational Fluid Dynamics (CFD) is expected to be adopted as an applicable technique for evaluating wind load of buildings. In this research, the unsteady flow in a real urban district is simulated by Large Eddy Simulation (LES) using unstructured grid system. Moreover, focusing on a high-rise building located in the center of the area, the fluctuating wind pressures on the building are validated by comparison with the experimental data.

Keywords: CFD; LES; unstructured grid; wind-resistant design; tall buildings.

1. Introduction

In order to evaluate wind load for wind-resistant design of buildings, wind tunnel experiments are generally carried out using the models of buildings. On the other hand, recent development of CFD techniques has enabled us to simulate the complicated flow such as the wind in actual urban area ([1]-[4]). For evaluation of wind load on buildings, LES is effective to simulate the fluctuating wind pressures on buildings. In this research, the unsteady flow field in the real urban model is numerically simulated by LES using unstructured grid system, and the availability for wind-resistant design of buildings is examined.

2. Computational model

A real urban district in a large city is employed as the computed model. Figure 1 shows the configuration of the urban model and computed wind directions. In this study, focusing on a high-rise building located in the center of this area (bldg.A, H=180m), the fluctuating velocities and pressures are examined by LES.
Three-dimensional incompressible Navier-Stokes equations are used as governing equations. For subgrid scale model of LES, the standard Smagorinsky model is employed. The computational domain is divided using unstructured grid system. The unstructured grid systems are superior to conventional structured grid system in terms of not only the adaptability to configuration but also the flexibility to mesh density required for each location in the computational region. In this study, the tetrahedral cells generated automatically are employed as the unstructured grid system (figure 2).

3. Computed results

Figure 3 shows the horizontal distribution of the instantaneous vorticity at the height of 100m for wind direction [b]. As the computational model has enough resolution and the urban configuration is reproduced accurately using unstructured mesh, fine turbulent structures can be observed around buildings.

In order to evaluate the applicability of LES for wind-resistant design, the wind pressures on bldg.A are obtained and compared with those by the wind tunnel experiments. Figure 4 shows the horizontal distributions of pressure coefficients (mean value C_p and fluctuating value C_p'). On the whole, the computed values coincide well with experiments.

4. Conclusions

1) LES can evaluate the characteristics of complicated flow such as the fluctuating velocities around the real buildings in urban area.
2) Unstructured grid system is available and effective to formulate the computational model for real urban area in terms of the adaptability to complicated configuration of buildings and the flexibility to mesh resolution.
3) As the computed wind pressures on a high-rise building coincide well with the experiments, the unstructured-grid LES is expected to be adopted as a practicable technique for wind-resistant design of buildings.

References

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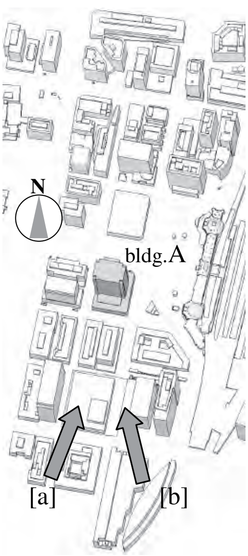

Fig.1: Computed model and wind directions

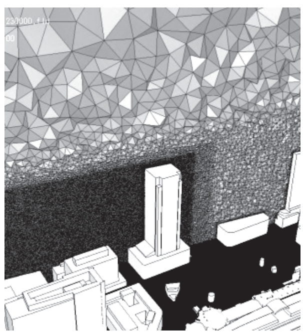

Fig.2: Unstructured grid system

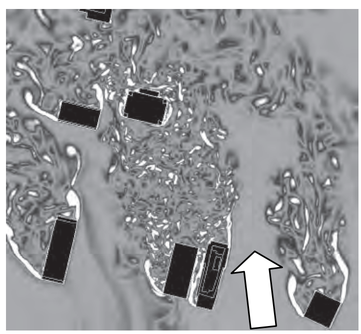

Fig.3: Instantaneous vorticity for wind direction [b]

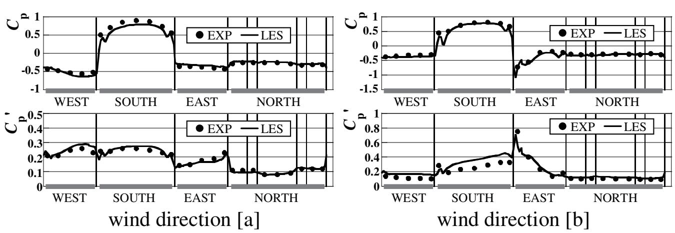

Fig.4: Horizontal distributions of pressure coefficients