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HPC-BASED LES FOR WIND FORCES ON BUILDING IN TOKYO

Tetsuro Tamura[1], Tsuyoshi Nozu[2], Makoto Tsubokura[3] and Keiji Onishi[3]

[1] Tokyo Institute of Technology, 4259-G5-7, Nagatsuta, Yokohama, Japan, tamura@depe.titech.ac.jp
[2] Institute of Technology, Shimizu Corporation, Etchujima, Koto-ku Tokyo, Japan
[3] RIKEN Advanced Institute for Computational Science,
7-1-26, Minatojima-minami-machi, Chuo-ku, Kobe, Japan

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In order to accurately predict the wind pressure on actual building with a complicated shape, we introduce LES(Large eddy simulation) based on BCM(Building Cube Method) which is formulated on very fine Cartesian mesh system(Onishi et al., 2013). Houses and buildings were not modelled and directly reproduced their shapes, because the aerodynamic problems require the correct estimation of local flow field in the canopy layer close to the ground. Initially we have used the combined model which consists of the structured-grid for the accurate turbulence structures in the urban canopy, and the unstructured-grid for the exact wake patterns around the specified building inside the densely arrayed buildings. However recent high-performance computing technique has developed distinctly, so high-resolution computation becomes able to be applied to flows around a complicated configuration such as actual urban area. In this case we have to deal with buildings, vegetation and street etc. as a part of numerical model. Actually LES using the Cartesian coordinate encounters the incorrespondence of directions between the street lines and the discretized mesh lines. Very fine mesh system by BCM can solve this problen supported by the external forcing technque at the boundary named IBM(Immersed Boundary Method). Also, in this numerical scheme, computational process is so simple that the parallel algorithm and the memory access obtain the perfect efficiency. It is strongly expected that these advantages make it possible to efficiently simulate the flow around very complicated shapes with various scales consisting of a large variety of urban parts. In this study, we have exhibited the results by combined model and their predictive limitation, also have applied LES by BCM to the wind load estimation of a high-rise building at straightforward and inclined wind directions to the main streets.

We firstly show the LES results by the combined model(Tamura & Nozu, 2012) concerning wind flows and pressures on the specified building in the center of Tokyo. Figure 1 illustrates the numerical model where the limited area including the specified building and its circumstances are clipped for the unstructured grid. At the surrounding boundary of the unstructured grid domain the physical quantities obtained by LES on the Cartesian coordinate grid system, are given based on the one-way method. The intended urban area has an aspect with widespread layout of high-rise buildings, including the target building. The wind direction NW is slightly inclined to the main streets. Figure 2 illustrates the wind velocity field in a city where the flow makes its way through buildings. In comparison of wind pressure coefficients on the specified building between LES results and experimental data for wind direction NW in Figure 3, both results have unsymmetrical shape for spatial distribution, and are in reasonably good agreement with each other. Figure 4 indicates an acceptable consistency of experimental and LES results for various types of pressure coefficients.

Figures 5 and 6 depict the numerical model for the BCM and 3D contouring surfaces of Q values. We can recognize the 3D vortical structures in the wake of buildings. Conical vortex is reproduced on the roof clearly. These local flow structures are expected to provide the appropriate pressure distribution.

In conclusion, using the LES model overlaid by the unstructured grid system, the appropriate turbulence structures at inflow and among a pack of tall buildings can be simulated. It is confirmed that the combined model estimates the wind load on the high-rise building with convincing accuracy even at inclined wind direction to the main streets. BCM can reproduce the 3D vortical structures around the building in the urban canopy.

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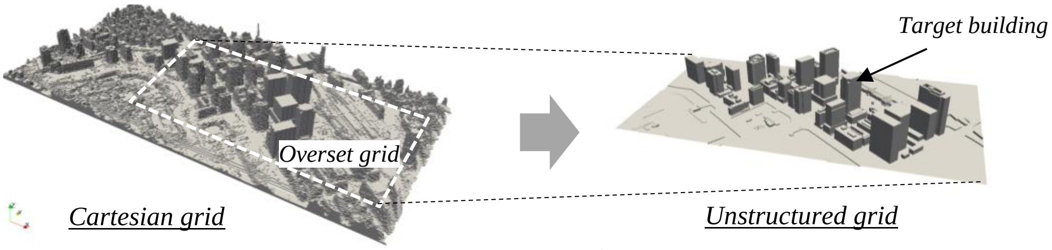

Fig. 1 Computational domain of combined model.

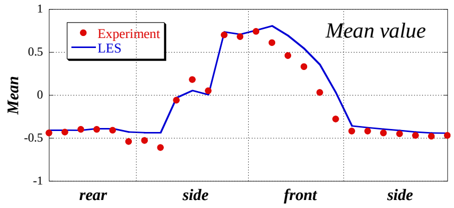

Fig. 3 Mean pressure coefficient.

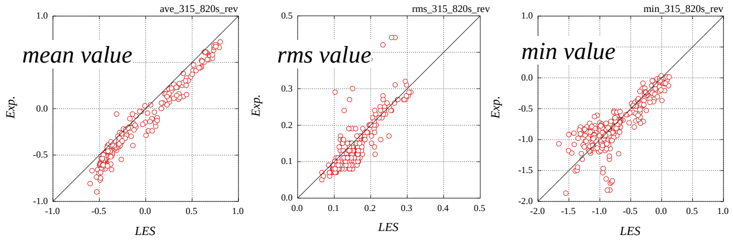

Fig. 4 Correlation between the pressure coefficient of LES and Experimental results.

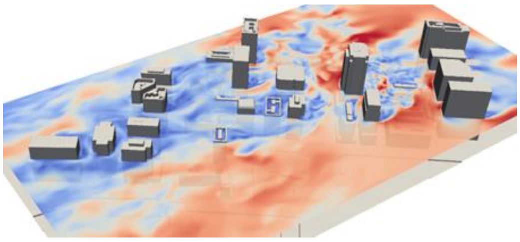

Fig. 2 Computed wind velocity field.

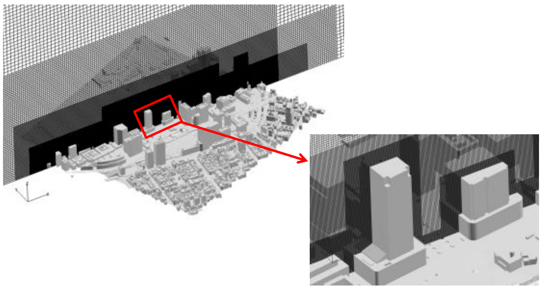

Fig. 5 Numerical model of BCM.

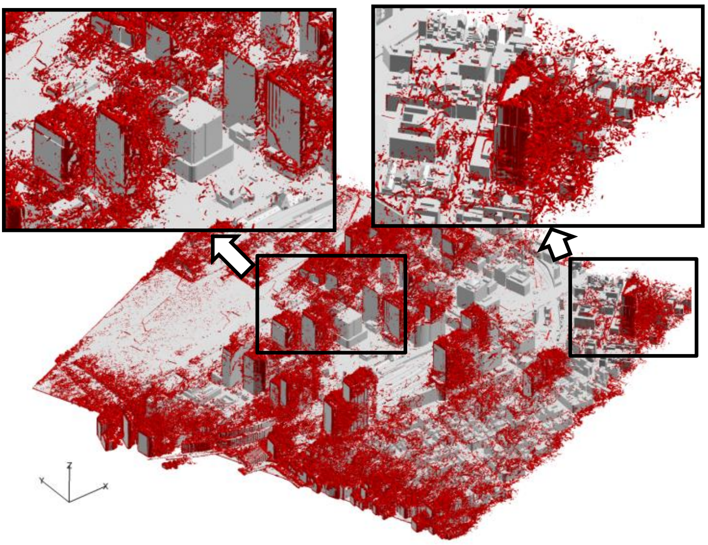

Fig. 6 Computed vortical structures in the urban canopy.