High performance computing of wind-induced pressures on various domes under real conditions

Tetsuro TAMURA*, Yong CAO, Yuki NAGAO, Hidenori KAWAI, Koji NISHIGUCHI[a], Makoto TSUBOKURA[a]

*Department of Architecture and Building Engineering, Tokyo Institute of Technology
Yokohama, 226-8502, Japan, tamura.t.ab@m.titech.ac.jp
[a] Riken Center for Computational Science, RIKEN

Abstract

In this study, in order to accurately estimate pressures acting on the roof of various shaped dome for wind resistant design, high performance computing (HPC) was performed using the K computer (Japanese supercomputer). Design wind loading on a dome should be obtained under real conditions such that the Reynolds number (Re) is in the supercritical regime from the fluid mechanical sense and the flexible roof is oscillating in the strong wind. Thus far the wind tunnel experiment has been performed using the roughened model instead of real roof surface for assuming to realize the supercritical regime. However this kind of imitation causes the different wind loading, because basic supercritical condition shows more drastic change of wind pressures on a curved roof. Recent advancement of HPC has made it possible to compute the supercritical flow around a bluff shaped object [1]. Also, by the sophisticated numerical technique [2] for the fluid and solid interaction problem, large deformation of flexible roof can be solved under the unstable state of aero-dynamical oscillation. The objective of this study is to numerically clarify wind flows and pressures around the various shaped dome and discuss adequacy for the estimation of wind load under the real conditions.

Figure 1(a) shows the mean pressure distributions on stream-wise center-line of a hemisphere in various turbulent boundary layers. Good agreement can be recognized between numerical and experimental data, when Re is set to the sub-critical regime. Unsteady flow characteristics are observed in Figure 1(b): horseshoe vortex system, shear layer instability, large-scale wake oscillations. Also, for the case of fluid and solid interaction problem on the flexible large spanned dome, an Eulerian finite volume formulation using a particle-in-cell method is employed. To avoid numerical dissipation of material interfaces and history-dependent variables of solid, a set of Lagrangian particles represent the solid region and carry history-dependent variables [2].

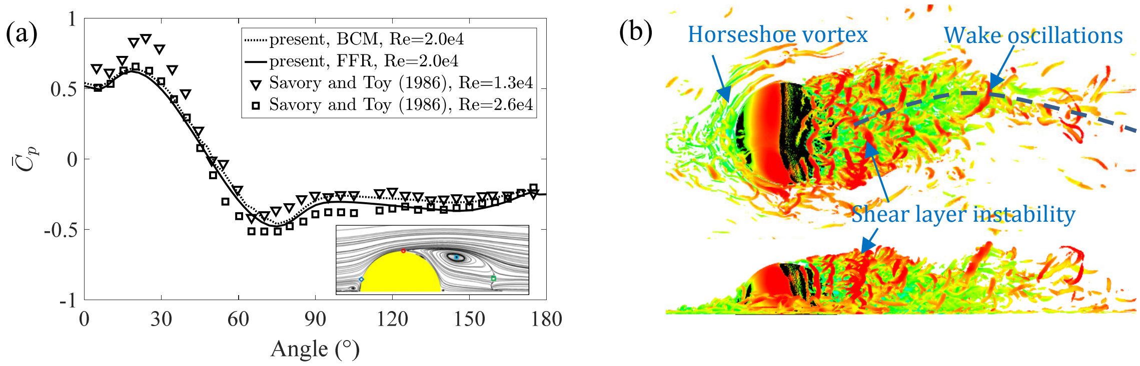

Figure 1 (a) Pressure distributions on stream-wise center-line. (b) Unsteady flows obtained by FFR.

References

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