APPLICATION OF WIND TUNNEL EXPERIMENT AND CFD SIMULATION ON ESTIMATION OF WIND ENVIRONMENT INSIDE AND OUTSIDE A LARGE-SCALE BUILDING COMPLEX WITH AN ATRIUM SPACE

T. Kurabuchi[1], N. Kobayashi[2], A. Arashiguchi[1] and T. Anai[1]

[1] Dept. of Architecture, Faculty of Engineering, Science University of Tokyo, JAPAN
[2] Dept. of Architecture, Faculty of Engineering, Tokyo Institute of Polytechnics, JAPAN

ABSTRACT

For a large-scale building complex planned to be built in urban area, airflow around buildings and airflow inside a ventilated atrium of the building complex were estimated by CFD (Computational Fluid Dynamics) simulation, and wind and thermal environment were evaluated. The accuracy of CFD simulation was assessed by comparison with wind tunnel experiment. It was found that CFD tends to underestimate the air velocity near the ground surface compared with the results of wind tunnel experiment. In the area closer to the building, where relatively fine mesh was used, it was confirmed that both results agreed well with each other. Wind environment around the buildings was statistically evaluated using meteorological data of the area under study. It was found that the evaluation results obtained by CFD corresponded well to the results of wind tunnel experiment. Further, the effects of shutters and skylights installed for environmental control of the atrium were assessed according to the values of SET* (Standard New Effective Temperature, Gagge et al.) associated with the change of air velocity. As a result, it was confirmed from the results of both CFD and wind tunnel experiment that air velocity of the atrium may increase and comfortableness may be improved in summer season by opening shutters, while the effects of opening the skylights were relativery low.

KEYWORDS

CFD, Cross Ventilation,
Model experiments, Thermal comfort

INTRODUCTION

In case a large-scale building complex is planned to be built in urban area, it is necessary to study the influence of the planned building on the environment in the surrounding area and also the influence of the surrounding environment on internal environment of the planned building. As an example of the former case, the change of wind environment around the building often becomes an important issue. On the other hand, with regard to the influence of the surrounding environment on the building, it has been generally practiced to introduce local meteorological data in the calculation of thermal designing of the building. However, in view of the protection of global climate as earnestly discussed in recent years, there is a growing tendency to promote energy saving, particularly for large-scale buildings in Japan. It is frequently practiced to introduce passive approach such as ventilation instead of using air handling equipment for the environmental control of atrium and the like. Therefore, there is now the necessity stronger than ever to study the influence of the conditions around the building on internal environment of the planned building.

For detailed evaluation of these problems, wind tunnel experiment has been frequently performed, but this usually means the increase of cost and time required for the evaluation. As an alternative approach, it would be helpful to save time and cost if CFD could be utilized. Unfortunately there have been very little study which has dealt with the accuracy of estimation when wind environment inside or outside the actual building are evaluated according to CFD simulation. In the present study, we performed evaluation based on the results of wind tunnel experiment and CFD on a large-scale building complex. Reliability of CFD was assessed by comparing the results of these two approaches on the evaluation of wind environment inside and outside the

CONCLUSIONS

The results of the present study may be summarized as follows:

On a large-scale building complex which is planned to be built in urban area, wind environment around the building was evaluated by comparing the results of CFD simulation and the results of wind tunnel experiment. The results generally agreed well with each other. In particular, estimation accuracy was high in the regions around the building under study where relatively fine meshes were used.

The effects of shutters and skylights installed for environmental control of atrium were evaluated according to the difference of calculated results of SET* associated with the change of air velocity. It was confirmed in the results of CFD and wind tunnel experiment that comfortableness would be increased in summer season in the atrium when shutters were opened, while the effects of opening the skylights were relatively low.

REFERENCES

Gagge, A. P., Stolwijk, J. A. and Nishi, Y. (1971) An Effective Temperature Scale Based on a Simple Model of Human Physiological Regulatory Response, *ASHRAE Trans.*, 77

Launder, B. E., and Spalding, D. B. (1972) Mathematical Models of Turbulence, *Academic Press*

Leonald, B. P. (1979) A Stable and Accurate Convective Modeling Procedure Based on Quadratic Upstream Interpolation, *Computational Method in Applied Mechanics and Engineering,* vol.19

Murakami, S., Iwasa, Y. and Morikawa, Y. (1983) Investigation of Statistical characteristics of Wind at Ground Level and Criteria for Assessing Wind-Induced Discomfort. *J. of Archit. Plann. Engng. AIJ* No.325

Nakamura, Y. and Hiraoka, H. (1986) Numerical Analysis of Thermal Load on a Human Model in an Urban Canyon of Two-Dimensional Rectangular Cavity Type. *J. of Archit. Plann. Engng. AIJ* No.369

Patankar, S. V. (1980) Numerical Heat Transfar and Fluid Flows, *McGraw-hill Book Company*

Takakura, S. and Suyama, Y. (1992) Numerical Simulation of Flowfield around Buildings in Urban Area. *J. of Wind Engineering,* No.52

Van Doomaal, J. P. and Raithby, G. D. (1984) Enhancements of the SIMPLE Method for Predicting Incompressible Fluid Flows, *Numerical Heat Transfer*, vol.7