J2.15

NUMERICAL SIMULATION OF AIR FLOW AND GAS DIFFUSION IN MICRO-SCALE REGION WITH RAMS AND HYPACT CODES

Ryohji Ohba* and Tomohiro Hara
Mitsubishi Heavy Industries, Nagasaki, Japan
Silvia T. Casterri and Domenico Anffossi
CNR, Torino, Italy

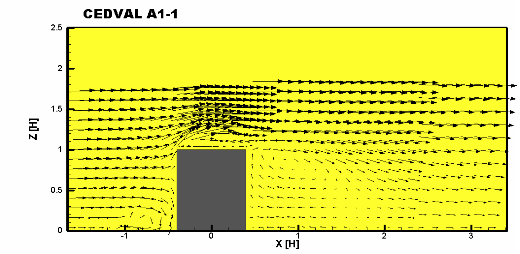
1. INTRODUCTION

RAMS and HYPACT codes were originally developed for the simulation of meso-scale phenomena, using the sigma coordinate and the Mellor-Yamada turbulence model. We implemented two new functions into the RAMS 4.2 of the non-hydro-static model to simulate the air flow and gas diffusion around building and terrain in micro-scale region; one is a scheme to approximate a building with a drag force in momentum equation, and to improve the turbulence model.

2. SIMULATION OF BUILDING

The momentum equations were modified to approximate the effect of building with air drag force: $C_{d_i} \cdot \frac{1}{2} u_i |u_i|$ .This method has been used for the simulation of obstacles in the engineering field of fluid dynamic code, since long years ago, such as MAC method by Welch et al. (1965) and so on. The drag coefficient Cd is defined to be an arbitrary big value. We need not to adopt Body-Fit-Coordinate (BFC) around a building and not to define a special boundary condition along the surface of the building.

Our calculated results were compared with the wind tunnel data measured by Schatzmann et al. (http://www.mi.uni-hamburg.de/cedval/). Wind vectors around a building shows the reversed vortex behind a building and good agreement with each other, as shown in Figs.1 and 2.



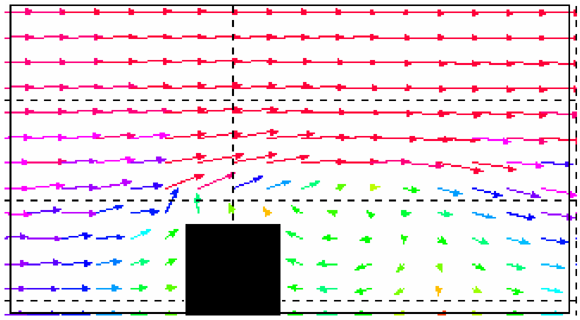


Fig. 1 Wind vectors around a building in vertical plane, where upper is wind tunnel and lower RAMS

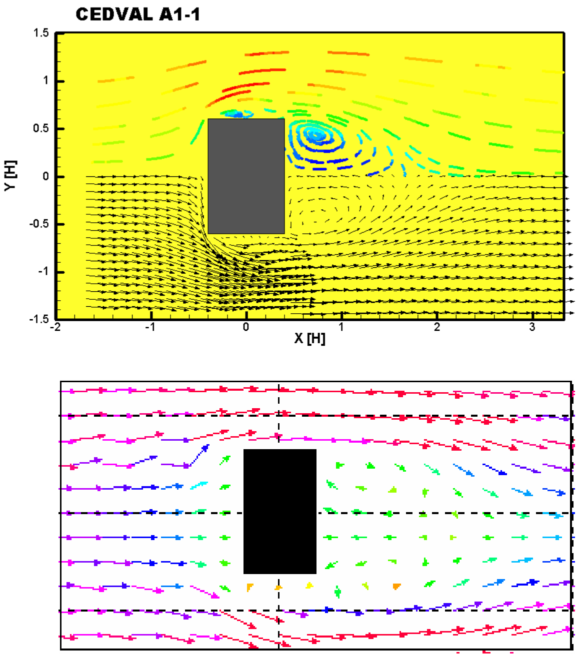


Fig. 2. Wind vectors around a building in horizontal plane, where upper is wind tunnel and lower RAMS

3. Improvement of turbulence model

Next, we calculated the air flow over a 3D hill by the Mellor-Yamada turbulence model level 2.5 and the new model developed by Castelli (2001), and compared the experimental results with our wind

*Corresponding author address: R. Ohba, Nagasaki R&D Center, MHI, Nagasaki 851-0392; e-mail: ohba@ngsrdc.mhi.co.jp

tunnel under neutral stability.

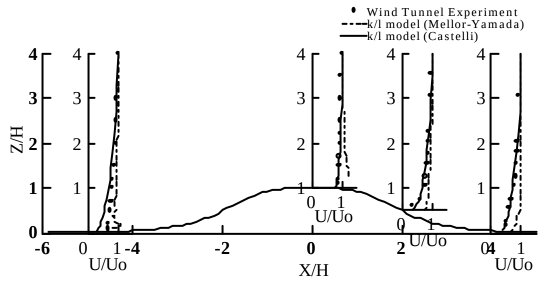


Fig. 3 Wind velocity profiles of RAMS with two kinds of turbulence models and wind tunnel results, where solid line is Casterri's model, broken line Y-M model and circular symbol wind tunnel

It was found from these comparisons that the new turbulence model by Casterri shows good agreement with wind tunnel data for wind velocity and total kinetic energy. The fundamental equation of Casterri's turbulence model is a full 3-D for k and l, while Mellor-Yamada model of level 2.5 neglects horizontal derivative terms.

Next, we calculated gas diffusion over an isolated hill by using the results of RAMS. HYPACT code simulates gas diffusion with Lagrangian particle model. Particle positions are shown in Fig. 4.

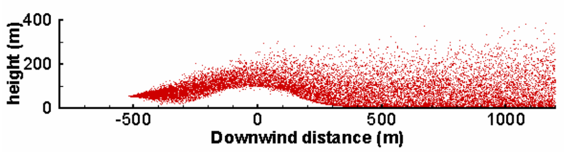


Fig.4 Particle positions over isolated 3D hill under neutral condition

Axial ground-level concentration were calculated from the number density of particles inside each mesh and shown in Fig.5. There are some discrepancies between wind tunnel and RAMS results with Castelli (k-l) and Mellor-Yamada models.

4. EMERGENCY RESPONSE SYSTEM

We developed a new emergency response system for accidents of nuclear power stations in Japan, by using the improved RAMS code for the simulation of building effect and the turbulence model. The calculated results of temperature, wind direction and wind speed agreed well with observed meteorological data (AMEDAS) near Ohi nuclear site, as shown in Fig. 6.

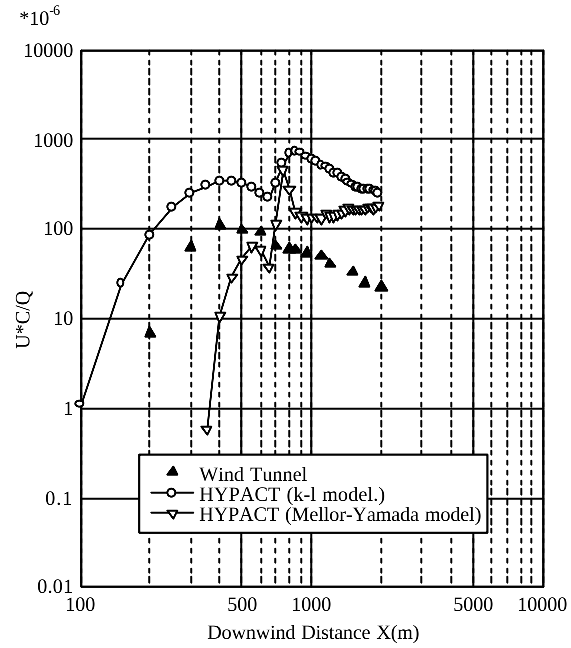


Fig. 5 Axial ground-level concentration along downwind distance over isolated hill

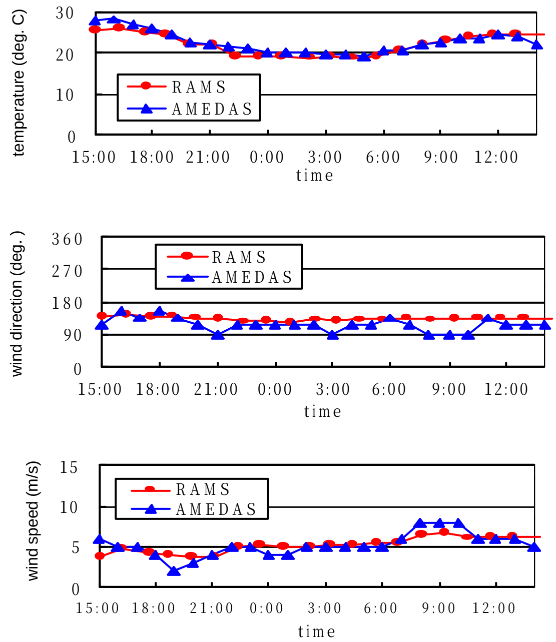


Fig.6 RAMS and observed data (AMEDAS) in Ohi site, Japan

5. References

Castelli, S. T., 2001: Turbulence Closures in Neutral Boundary Layers over Complicated Terrain, Boundary-layer Meteor., Vol.100, No.3, 405-419

Welch, J. E. et al., 1965: The MAC method, Los Alamos Scientific Laboratory Report, LA-3425