EMS Annual Meeting Abstracts
Vol. 10, EMS2013-363, 2013
13th EMS / 11th ECAM

Influence of Atmospheric Boundary Layer Depth on the Ventilation Performance over Idealized Urban Surfaces

Y.-K. Ho and C.-H. Liu
The University of Hong Kong, Mechanical Engineering, Hong Kong, Hong Kong (yatkiuho@yahoo.com.hk)

The mechanism of flows and scalar transfer over urban areas is complicated by the random city surfaces in which a detailed investigation is required in its parameterization. Despite the collective effort made by the researchers on urban air pollution problems, our knowledge on the interaction between flows and aerodynamic resistance over cities is limited. Apart from the roughness effect induced by the bottom of the urban boundary layer (UBL), the local atmospheric environment conditions and the city-level air quality are closely correlated but their importance is apparently overlooked. Therefore, as a pilot attempt, this study is conceived to examine the effect of UBL depth on the street-level ventilation performance and its parameterization over hypothetical urban roughness.

Computational fluid dynamic (CFD) technique is employed and a series of CFD sensitivity tests are performed. Street canyon configurations of unity building-height-to-street-width (aspect) ratio with different values of UBL depth (in the range of 6h to 1200h, where h is the building height) are examined. The Reynolds-averaged Navier-Stokes (RANS) equations with the Renormalization Group (RNG) k- turbulence model are adopted in the numerical simulations.

The aerodynamic resistance and the ventilation performance are measured by friction factor f and air exchange rate ACH, respectively. Preliminary results show that the friction factor decreases with increasing UBL depth, that in turn affects the ACH subsequently. In particular, the turbulent component of ACH (ACH”) is linearly proportional to the square root of friction factor. This finding is in line with our previous studies in which a monotonic behaviour between ACH” and (square root of) friction factor is exhibited regardless the geometry of building elements. In view of the consistent results obtained, it is hypothesised that the aerodynamic resistance (measured by friction factor) could be used as a single parameter of urban area ventilation performance. Additional CFD tests are undertaken based on a broad range of aspect ratio and UBL depth.