BACKGROUND & OBJECT OF RESEARCH

In CFD analyses of urban area, power law is widely used for inflow boundary condition. Although this law is experimentally obtained, its relevance is assured by previous observations. However, this law is applicable just only for a profile averaged by long enough timescale. For instance, we have found that ten-minute or one-hour averaged profiles which are recorded by a Doppler Lidar System (DLS) still have considerable differences with the power law. Therefore applicability of the power law as inflow boundary condition is limited by the range of averaging timescale. In addition, the air flow at the ground level is still remained to be determined under instantaneous profile (which is far from a smooth curve such as the power law).

METHODOLOGY

We carried out a CFD analysis of model case. In this analysis we employ actual profiles obtained by DLS as inflow boundary condition. We used instantaneous profiles (ten minutes average) which measured during April to June 2014, and compared following two cases. In addition, from result of CASE1, we can know mean and deviations of wind environment due to the change of wind profiles. Comparing CASE1 and CASE2, on the modeling inflow condition, we can evaluate how the averaging operation affects the analysis of the air flow at the ground level. From this research, the relevance of the power law is also evaluated in terms of the range of averaging timescale.

CONDITIONS

Inflow Boundary Condition

Inflow Boundary Conditions are given by following methods. Equations are based on the thesis “All guidelines for practical applications of CFD to pedestrian wind environment around buildings” (Tomina ga et al.).

Velocity:

\[
\bar{u}(z) = \frac{U(z)}{1 - z/H}
\]

Where \( U(z) \) is model constant (=0.1), \( z \) is obtained from DLS.

Kinetic Energy:

\[
\epsilon(z) = \frac{1}{2} \bar{u}^2(z) \cong \epsilon(z) \cong \frac{\epsilon(z)}{\epsilon(z)} \cong \frac{1}{2} \bar{u}^2(z)
\]

Where \( \epsilon(z) \) is model constant (=0.09).

RESULTS

These sets of results are presented in these figures. First results show the transition processes of velocity, kinetic energy, dissipation rate, and pressure in one of the profiles(Fig. 8). The second set of results are comparison between case A & B(Fig. 9). The third result is the standard deviation of these profiles(Fig. 10). According to Fig. 8, it is observed that the transition of the profile of velocity is so few. But when it comes to kinetic energy, dissipation rate, and pressure, especially near the ground surface, there are some differences. It is seen from Fig. 9 that ensemble averaging operation barely affect to the velocity (As indicated by the green plots, difference of velocities is less than 1%). However, as shown on Fig. 10, deviation between each profile and averaged profile can take a high difference.

CONCLUSION

We could reach the conclusion that ensemble averaging operation of inlet profile itself doesn’t affect the CFD analysis. However, deviation between each profile and averaged profile can make a big difference.

Nowadays, CFD analyses are conducted for urban planning or designing. In most cases, actual inflow profiles are hardly available and the power law is still remained as an effective method to model the inflow. However, inflow condition affects significantly to computational result of air flow. Therefore contribution of this research is to let people know the impact of inflow modeling on the urban wind environment. Relevance of attempt to adjust the fluctuated profiles to k-e model still has been unproven. And each profiles certainly have a big differences from power law. So this remains an ongoing applying challenge. The author continue to pursue the present method attempted in this study.