EFFECTS OF BUILDING-HEIGHT HETERGENEITY ON AREA-AVERAGED TRANSFER VELOCITY IN THE STREET SURFACE -WIND TUNNEL EXPERIMENTS USING SALINITY CHANGE TECHNIQUE

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1. INTRODUCTION

As a parameterization of turbulent fluxes in urban canopy layer, the resistance network in the canyon has been studied with heat balance method (Kawai and Kanda 2003), with naphthalene sublimation technique (Barlow and Belcher 2002), and with our water evaporation technique using filter paper (Narita 2003). This filter paper method is useful to examine the effect of canyon geometry on transfer velocity in two-dimensional models and also to compare the local difference of transfer velocity between the kinds of surfaces in homogeneous cubic array. About heterogeneous building arrangements, however, it is difficult to investigate the spatial-averaged transfer velocity using this technique because of a problem of edge effects and spatial representativeness. In this study, an experimental method to estimate the area-averaged transfer velocity was newly devised and tried to clarify the effect of heterogeneity of building height in wind tunnel experiments.

2. SALINTY CHANGE TECHNIQUE

In this method (Narita et al. 1986), the water evaporation rate is measured not by weight loss but by salinity change of saltwater. A square vessel (600 × 600mm) with 50mm depth was buried in wind tunnel working section as the rim-top matched to surrounding surface. The building models are arranged within it, then fill the vessel with saltwater to bathe the foot of them (Figure 1). After half and hour, stop wind tunnel fan, and remove the building models from the vessel. Then, stir the saltwater in the vessel sufficiently, and take it into four sample bottles. The salinity of these samples were measured with inductively coupled salinometer (accuracy : 0.003‰) as well as samples of initially pored saltwater. From the salinity-change, evaporation rate was calculated as follows.

\[ hS = (h - E)S' \]

\[ E = h(S' - S)/S' \]

where \( E \) is evaporation depth (mm), \( h \) is initial salt water depth (mm), \( S \) is initial salinity (‰), and \( S' \) is final salinity (‰). Accuracy of evaporation measurement is estimated as follows.

\[ \delta S = S' - S \]

\[ \delta E = \delta hS/S' + h(\delta S/S') \]

Experimental condition is \( S'\approx35‰, \ h=50mm \), and if measuring error is assumed \( \delta h=0.5mm \), and \( \delta(\delta S)=0.0042 \‰ \), then \( \delta E/E \) becomes 2.5% when \( E=0.4 \ mm \). In this technique, measuring term is not the weight loss but concentration change, so handling mistakes like spill-water doesn’t bring about fatal error.

3. RESULTS

3.1 Area-averaged \( Wt \) in constant building-height

Figure 3 shows model arrangements under building height constant. The basic model dimension is 60mm (=D) cubic. Series 1s-(array number) are building density variation (\( \lambda_p \) : plane area density of building). Case 1s-6, 2s-3, and 3s-2 are variation of model dimension under constant \( \lambda_p \). The area-averaged \( Wt \) was measured in three kind of model height (H) : 0.5D, D, and 1.5D for every arrangements.

The results were summarized in Figure 4, as a change due to the street canyon geometry (W/H). In the variation within same plane size arrangement, \( Wt \) has a slight peak in \( W/H=1.0-1.5 \). On the contrary, the effect of model assembling was not simple, and variation patterns were different for model height.
3.2 Effects of building-height heterogeneity

To create building-height heterogeneity, concerning the regular cubic array, we make a replacement of several cubic models by half height or one and half height models (Figure 5). Here, all arrangements have same average height and same $\lambda_p$. Figure 6 shows the difference of the $W_t$ of street due to the deviation of the model height is at most 40%. This means that morphological modeling of complicated city structure by regular cubic array to which has equivalent average height and $\lambda_p$ is not appropriate for the estimation of area-averaged transfer velocity.

4. CONCLUDING REMARKS

Though salinity change technique is available for only about street surface not including wall and roof surfaces, it is excellent in area-averaged investigations especially for the heterogeneous morphology. Using this technique, it was confirmed that the vertical heterogeneity of buildings has much greater effects on area-averaged transfer velocity than that of horizontal variation under building-height constant.

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