P11.7

COMPARISONS OF VARIOUS EXPERIMENTAL RESULTS ON THE CONVECTIVE HEAT TRANSFER COEFFICIENT OF URBAN SURFACES

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1. INTRODUCTION

The turbulent heat exchange between the atmosphere and urban surfaces can be expressed by the convective heat transfer coefficient (CHTC) *h* as shown in equation (1).

$$Q_H = h \cdot \left(T_S - T_{air}\right), \qquad (1),$$

Although the CHTC is the crucial parameters for estimation of the heat flux of urban areas in the Urban Canopy Models (UCMS), it is yet still poorly understood. In this paper, we compare the former experimental studies on the CHTC of building surfaces and surfaces with urban-like roughness.

2. Full-scale measurements on building surfaces

2.1 Horizontal roof

Figure 1 shows some of the full-scale measurements of CHTC for horizontal roofs of buildings. The curves of Urano and Watanabe (1983) and Hagishima and Tanimoto (2003) agree well in spite of the differences in roof size. The CHTC of Kobayashi (1994) has smaller values and smaller slopes than the curves in Urano and Watanabe (1983) and Hagishima and Tanimoto (2003). Except for Kobayashi and Morikawa (2000), the CHTC values are all in near agreement at wind speeds below 1 m s^{-1}. In contrast, the measurement of Kobayashi and Morikawa (2000) are significantly less than the other measurements at wind speeds below 2 m s^{-1}. The reason for this discrepancy is the thermal stability.

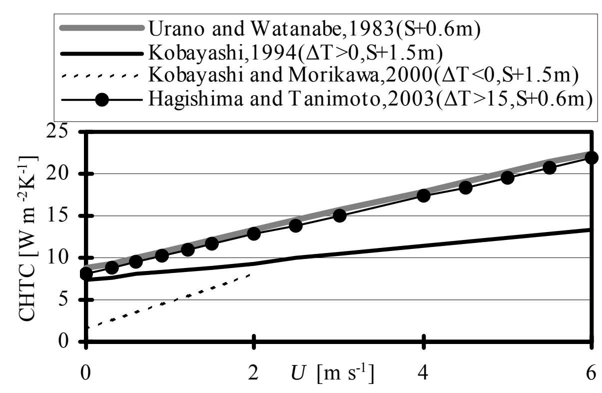

Fig.1 Relation between CHTC for horizontal building roofs and wind speeds. "S+1m" means that the wind speed was measured 1-m above the objective surface. $\Delta T = T_s - T_{air}$.

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2.2 Vertical walls

Figure 2 indicate the experimentally derived equation of CHTC defined by the wind speed for building walls. First of all, it is recognized that the effect of the wind direction on CHTC is small. In contrast, the position in relation to the wall has a relatively large influence on CHTC. The particular choice of target building also significantly affects CHTC.

3. Scale model experiment

Figure 3 shows the results of two scale model experiments in the wind tunnel and one full-scale measurement. The curves (M) is based on the data by Meinders et al. (1997). In this study, eight cubes, 15 mm on a side, are scattered at regular intervals on a straight line in a wind tunnel. The curves (N) indicate the data of the roof of the isolated cube by Narita et al. (2000) based on the evaporation method with filter paper. The curves (K) indicate the data of horizontal roof of a 3-story building by Kobayashi (1994).

For a given wind speed, the CHTC of scale model based on the mass transfer method is much larger than those based on the thermal balance method. The relations between the

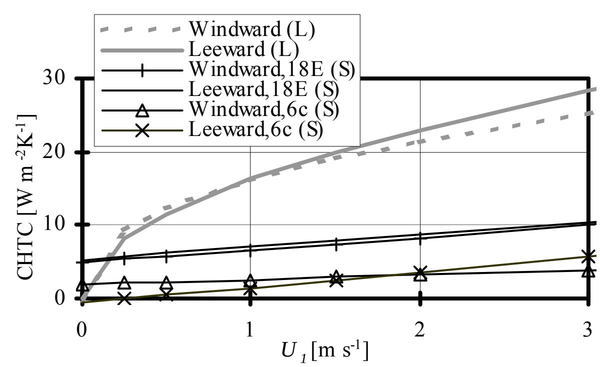
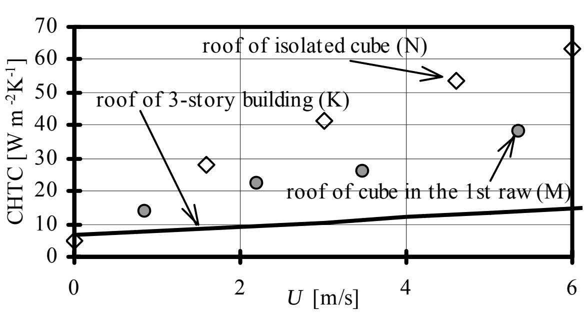


Fig.2 Relationship between CHTC of vertical wall of buildings and wind speeds at the height of 1-meter

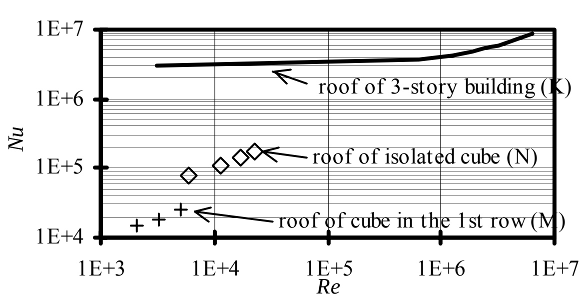
"18E" indicates the data observed at the edge of the wall of 18th floor and "6c" indicates the data observed at the central wall of the 6th floor. (L) and (S) indicate the data of Loveday and Sharples,1984, respectively.

Nusselt number and Reynolds number of them are also different. The CHTC from full-scale measurements are much smaller than those from smaller-scale measurements. The relation between the Nusselt number and Reynolds number of full-scale measurement is also much different from those of scale model experiments. Although these three results cannot be compared precisely because of the differences of both referential wind velocity and boundary condition, we would like to emphasize the disagreement of the relation *Nu*(*Re*) between full-scale measurement and scale model experiments.

Figure 4 shows the relation between the mass transfer coefficient (MTC) of 2-D canopy and the ratio of model height to street width H/W, which are taken from Narita et al. (2000) and Barlow et al. (2004). Each values of roof increase with the increase of H/W at the ratio H/W below 0.6, where the flow regime is assumed to be isolated flow or wake interference. Conversely, that is constant at the ratio H/W above 0.6, where the flow regime is assumed to be skimming. The MTC of the vertical windward wall generally decreases with the increase of H/W. In addition, the MTC of the vertical windward wall by Narita et al. (2000) is almost constant in the range of H/W=0.8 to 1. The MTC of the leeward wall decreases with an increase of H/W at the ratio H/W below 0.3 and above 0.7, which is classified as the isolated flow and skimming flow.



(a) Relationship between wind speed and CHTC



(b) Nusselt number - Reynolds number

Fig.3 Comparison between CHTC of scale model and full-scale building

(M) indicates the data of roof of cube by Meinders et al, 1997. (K) indicates the data of building roof by Kobayashi, 1994. (N) indicates the data of roof of isolated cube by Narita et al., 2000. The height of the referential wind speed is 8*H.

6. Conclusions

The several experimental researches on the CHTC of urban surfaces are compared. To improve a model of CHTC for UCMs, the further investigation under various thermal and geometric conditions are needed. In addition, comparison among several measurement results that are based on different scales and measurement methods is important.

Acknowledgments

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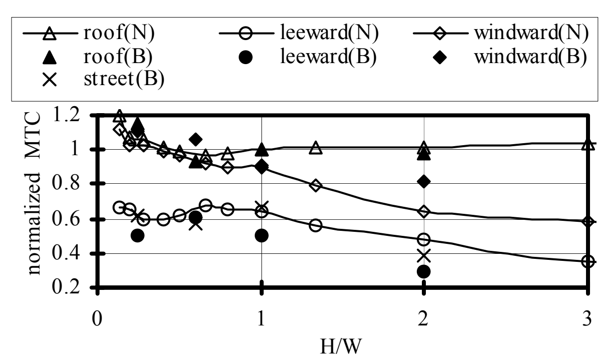

Fig.4 Measured MTC for various values of height to width ratios H/W.

(N) and (B) indicate the data from Narita et al ,2000 and Barlow et al., 2004, respectively. The transfer coefficients are normalized by the measured mass transfer coefficient for the roof with H/W=1.0.