II - 21 EFFECTS OF NARROWNESS INDEX IN URBAN CANYON ON RADIATIVE HEAT EXCHANGE

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1. Introduction:

Radiation conditions, especially within the canopy layer of inner cities are complicated by the change of horizon, which affects the duration of sunshine and insolation by the urban surface materials and also radiative interactions occurred between buildings and front streets. This interaction is determined by the height of houses and width-orientation of the front street.The main objective of this study is to make relationship between the urban heating & cooling characteristics and narrowness index of the urban canyon. For this, energy balance of urban canyon system has to be determined.The narrowness index of the canyon is defined by the following equation.

$$N = \frac{Z_b}{W_s} \tag{1}$$

where N is the narrowness index, Z_b is the height of the building, W_s is the width of the adjacent streets. N is also an important factor for determining the view factor ψ. Characteristics of N and ψ are reciprocal of each other. Z_b is estimated from the following equation (Yamashita *et al*, 1990-91)

$$z_b = \Re n + c \tag{2}$$

where $\Re$ is estimating the height of one story of the building, n is the number of stories of the building(dimensionless) and c is the height of floor basement.

2. Numerical Model Description:

The model employed is simple and can not be handled in full range of conditions found in cities.The subsurface temperature profile is allowed to adjust to the computed substrate heat flux density and it is estimated by one dimensional Fourier equation, which is solved by finite difference Crank Nicholson method. The equation is as

$$\rho c \frac{\partial T}{\partial t} = k \frac{\partial^2 T}{\partial z^2} \tag{3}$$

The boundary condition is described by the equation (4) given below.

$$-k \frac{\partial T}{\partial z} = S(1-\alpha) + R_{Ln} - H \tag{4}$$

where ρc is the volumetric heat capacity of the surface material , k is the thermal conductivity of the surface, T is the surface temperature, S is the total shortwave radiation, α is the albedo, R_{Ln} is the net absorbed infrared radiation and H is the sensible heat.

R_{Ln} is estimated from the following equation;

$$R_{Ln} = \varepsilon_i \sigma \left[\sum_{\substack{j=1 \\ i \neq j}}^{N} \varepsilon_j \psi_{ji} T_j^4 + \varepsilon_a T_a^4 \psi_{sky-i} - T_i^4 \right] + \varepsilon_i \sigma \sum_{\substack{k=1 \\ k \neq i}}^{N} \sum_{\substack{j=1 \\ j \neq k}}^{N} \psi_{ki} (1-\varepsilon_k) \psi_{jk} \varepsilon_j T_k^4 \tag{5}$$

where i is the receiving surface, j and k are the emitting surfaces to the i, T_j, T_i, T_k are the surface temperatures, ε_i , ε_j, ε_k are the surface emissivities and ε_a is the atmospheric emissivity, T_a is the atmospheric temperature. Last term of the equation (5) is assumed to be neglegible in the 2-D canyon analysis. First and second terms are incoming infra-red radiations from the environment and from the sky respectively. Third term is outgoing infra red radiation from the surface and last term is that of alternate region. Sensible heat is estimated as (Swaid,1992);

$$H = h_c\left(T_a - T_i\right) \tag{6}$$

where h_C is the convective heat transfer coefficient.

3. Results and Discussion:

Results are compared with the Yoshida *et al* scheme (1990) shown in the Fig.1 where it is seen that the sensible heat exchange is rarely negative and is supported through the night by withdrawal of heat from the substrate. The diurnal patterns of energy budget components at the top of urban canyon are almost smooth, in which net radiation Q_t^* is symmetrical around noon while conduction heat flux Qg peaks at 14:00. The sensitivity test between calculated & measured net radiation and between net infrared radiation & sky-view factor are given in the Fig.2 and Fig.3 respectively and parametrization of R_{Ln}=-5.1711.59Ψ_{sky}+263.08$(\Psi_{sky})^2$(corelation factor r=0.92) is the best fit and also from Fig 2 it is evident that calaculated & measured net radiation flux comprised best fit. Exchange of infrared radiation interms of narrowness index are shown in the fig.4-6. It is seen that exchange of infrared radiation is higher in the case of smaller N and decrease gradually as N increases. The resulting lower surface temperatures coupled with large narrowness index cause net radiations to be larger throughout the day and lesser negative overnight.(In case of Qg and sensible heat downward is +ve)

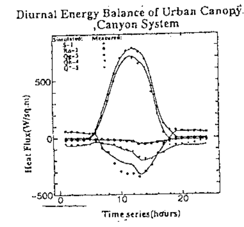

Fig. . 1.

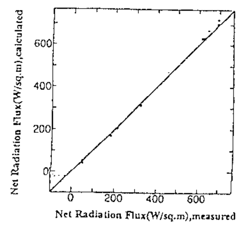

Fig.. 2

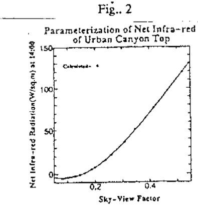

Fig.. 3

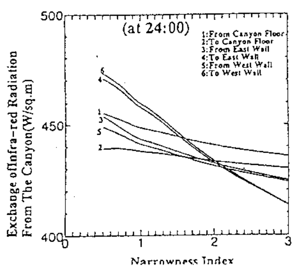

Fig.. 6

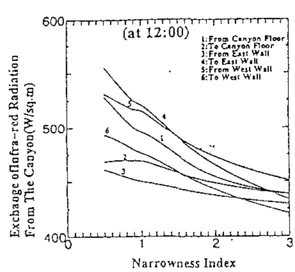

Fig.. 5

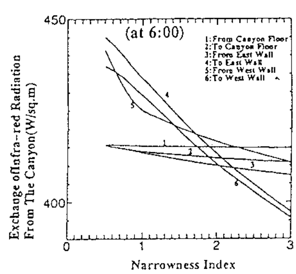

Fig. 4

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