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RESEARCH ARTICLE

Simulation Study of the Influence of Different Urban Canyons Element on the Canyon Thermal Environment

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Abstract The heat island effect is an important issue for large cities, especially those located in hot and moist climates. The phenomenon is more severe in urban canyons because surrounding high-rise buildings allow little ventilation and dissipation of heat caused by traffic. The primary goal of the present study is to investigate the thermal environment of a major street in Osaka by intensive measurement during the summer of 2006. Osaka is the second largest city in Japan and suffers from the most severe heat island effect. In addition, several fundamental renovations and a composite renovation for the improvement of thermal environment in the urban canyon are proposed, and the efficacies of these measures are verified by computational fluid dynamics (CFD) simulation. It was found that by modifying the heights of buildings along the street and the ground surface materials and increasing the quantity of vegetation, the thermal environment can be improved by a 2.0℃ reduction in standard new effective temperature (SET*) at maximum.

Keywords heat island, CFD simulation, thermal environment, urban canyon, urban renovation

List of symbols

a	density of leaf area (m^2/m^3) (= 0.4)
C_d	coefficient of resistance (= 0.5)
C_p	specific heat of air (J/kg·K)
E_s	transpiration rate ($kg/m^2·s$)
f_a	partial pressure of water vapor (kPa)
f_s	partial pressure of saturated water vapor (kPa)
g_i	acceleration (m/s^2)
K	coefficient of heat conduction (J/m·s·K)
lE	absorption of heat (W/m^2)
L	road width (m)
N_i	traffic rate (number of cars/s)
P	air pressure (N/m^2)
$\dot{q}$	heat generation ($J/m^3·s$)
q_b	specific heat generation of a building type (W/m^2)
q_{ci}	heat dissipation rate for car types (J/m)
Q_b	heat generation from a building (W/m^2)
Q_c	heat release from traffic (W/m^2)
S_b	total floor area of a building (m^2)
S	area of heat exhaust (m^2)
t	time (s)
T	air temperature (K)
T_0	reference temperature (K)
u_i	velocity (m/s)
x_i	space coordinate (m)
α_w	water vapor transfer coefficient conductivity ($kg/m^2·s·kPa$)
β	evaporation efficiency
ε	dissipation rate of turbulence (m^2/s^3)
η	ratio of vegetation coverage
κ	turbulent energy (m^2/s^2)
μ	coefficient of viscosity (kg/m·s)
ρ	density of air (kg/m^3) (= 1.176)

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