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The scale-model outdoor experimental study of both wind-driven and buoyancy-forced flow regimes in idealized 2D street canyons

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Wind and buoyancy are the two driving forces of urban ventilation and urban turbulence. As wind-thermal interaction and flows are not easy to measure in a real city, in this study, scale-model field measurements were performed to study urban flow regime and turbulent characteristics in the suburb of Guangzhou, China in summer of 2016 and 2018. The outdoor experiment site is 4800 m^2 with concrete floor and far away from the surrounding buildings in most prevailing wind directions. The influence of the surrounding buildings under nine wind directions (S, SSE, SE, E, SW, W, NW, NNW and N) was evaluated by wind tunnel experiments. Result confirms that in most cases surrounding constructions have no distinct influence on the uniformity of the coming flow for the whole experimental field, except northerly winds. Two thousand scaled square concrete building models (building width B=50cm, building height H=120cm and wall thickness is 1.5cm) are arranged in aligned west-east rows which are long enough (street length L=12.5m) and perpendicular to the main prevailing wind direction during test time. Concerning different heat capacity, two types of west-east street canyons were investigated: the *Empty* models, which consist of hollow building models, and the *Sand* models make up of same building models but filled with sand producing bigger heat capacity. Besides, both of them are arranged with three aspect ratios of H/W=1, 2 or 3 (W=0.4m, 0.6m and 1.2m), which resulted in different shading and solar radiation conditions. Twenty 3D Supersonic Anemometers and hundreds of thermal couples were fixed to monitor the thermal environment and turbulent flow characteristics in diurnal cycles.

Similar with realistic situations in urban areas, the street canyons are subjected to differential wall heating and overlying wind during the measurement period. Smoke visualization and the velocity profiles confirm that the complicated flow regimes occurring with the interaction of buoyancy-driven and wind-driven forces. For example, only one main vortex exists in street canyon with aspect ratio of 2 and 3 when wind is large and buoyancy force is not important. However two main vortexes may appear when wind is relatively small and buoyancy force cannot be neglected. A buoyancy parameter $B = g\alpha\Delta TH/U_{ref}^2[1 + (H/L)^2]$

was used to quantify the relative importance of buoyancy force and wind-driven flows, in which $g\alpha\Delta T$ represents the horizontal gradient of buoyance and L stands for the street width. As overlying wind is weak ($B >> B_c$=0.05), the heating of building walls may induce thermally driven circulation. When the street canyon is dominant by the wind ($B < B_c$), the canyon velocity u scaled by the reference velocity U_{ref} (u/U_{ref}) is approximately constant. And when both the overlying wind and buoyancy force are important, u/U_{ref} and buoyancy parameter B shows a relationship as $u/U_{ref} = r_3 + r_4B^{1/2}$, where $r_3$and r_4 depends both on heat capacity and street canyon aspect ratio.

Keywords: Thermal capacity; Wind-thermal interaction; Street aspect ratio; Scale model; Outdoor field experiment

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