

Influence of advertisement boards on urban street canyon thermal environment under different wind directions

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SUMMARY (10 PT)

Billboards (or advertisement boards) are widespread in urban street canyons, yet their impacts on the thermal environment remain unexplored. Addressing this gap, this study investigates how billboards affect mean flow and thermal conditions in a street canyon with an aspect ratio of 1 under different wind directions. Billboard effects are strongly wind-direction dependent. With winds perpendicular to the street (x -) axis, billboards reduce average canyon temperature by up to 21.6% by strengthening recirculation about the x -axis and enhancing vertical heat removal. In contrast, when winds align with the street, billboards increase average temperature by up to 57.6% by disrupting the helical flow about the x -axis and causing wake-induced heat accumulation. Centred billboards generally induce smaller temperature changes than side billboards due to weaker flow disturbance. These results show that billboard configuration can be optimized to regulate and modulate thermal conditions in street canyons.

Keywords: *Street Canyon, Computational Fluid Dynamics, Thermal Environment, Advertisement boards, Billboards*

1. INTRODUCTION

Mitigating the urban heat island (UHI) effect and improving outdoor thermal comfort is especially difficult in cities such as Hong Kong, which is characterized by high urban density, narrow street canyons, and widespread billboard installations. Much of Hong Kong's built-up area is composed of street canyons with height-to-width (H/W) ratios ranging from 0 to 4 (Peng et al., 2025a). These environments are highly susceptible to heat accumulation, and accurately modeling their thermal behavior is challenging due to their strong sensitivity to multiple influencing factors. Billboards are ubiquitous and particularly concentrated in commercial areas. Data from the September 2025 Hong Kong registry of legal and validated projecting billboards (Peng et al., 2025b) indicate that the city has 3,619 registered projecting billboards, averaging 13.4 billboards per km² of developed land. In the major commercial district of Yau Tsim Mong alone, 929 billboards are documented, yielding an exceptionally high density of 132.9 billboards per km². Nevertheless, despite their abundance, the effects of billboards on the ambient thermal environment remain unstudied.

2. CFD SIMULATIONS

This study examines the influence of billboards on mean airflow and thermal conditions within a street canyon of aspect ratio 1, considering varying wind directions and six distinct billboard configurations (Figure 1).

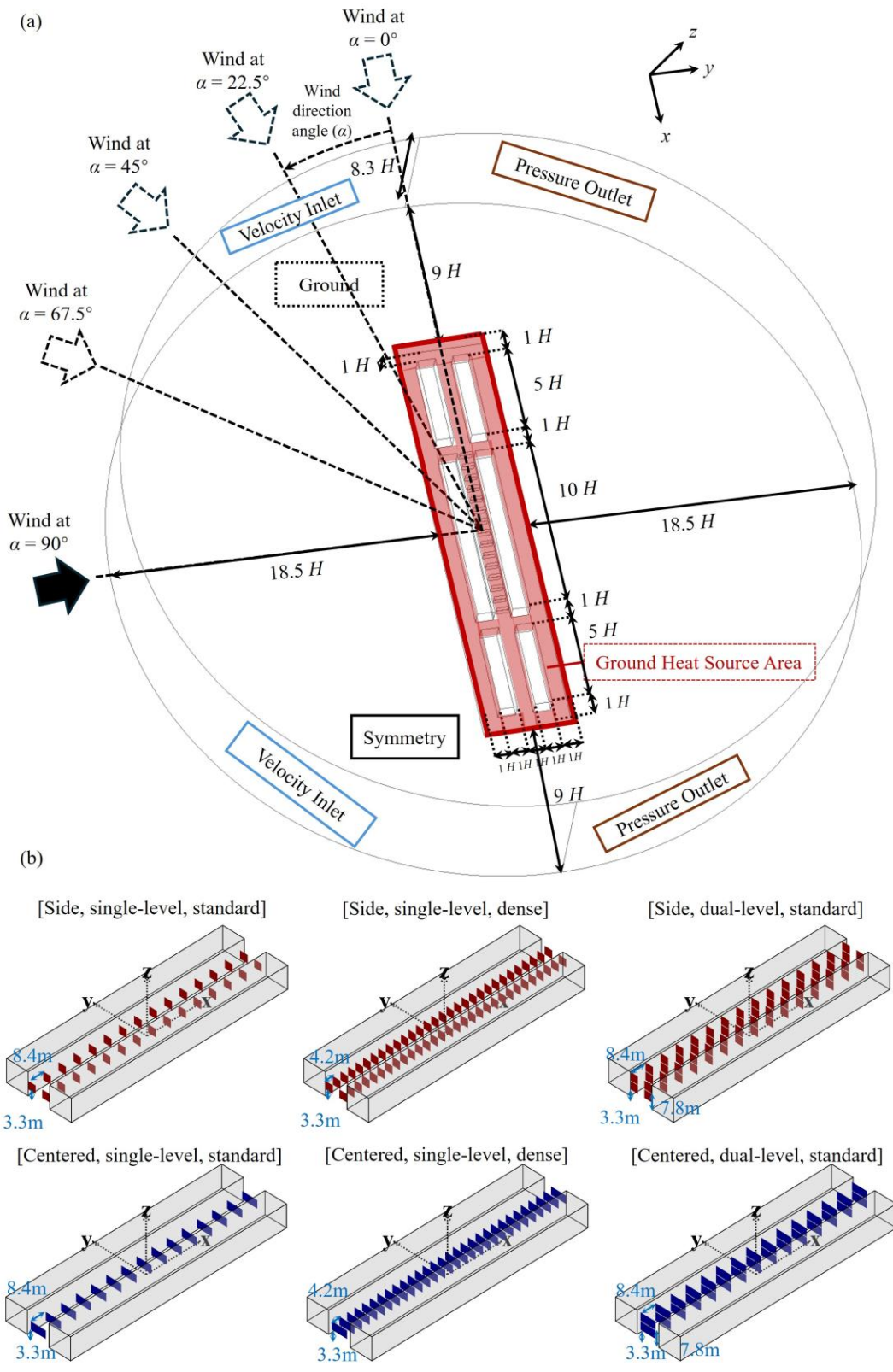


Figure 1 Geometry of (a) simulation domain at $\alpha = 90^\circ$ (b) six billboard layouts

3. RESULTS AND DISCUSSION

3.1. Average Street Canyon Temperature with Side and Centered Billboards

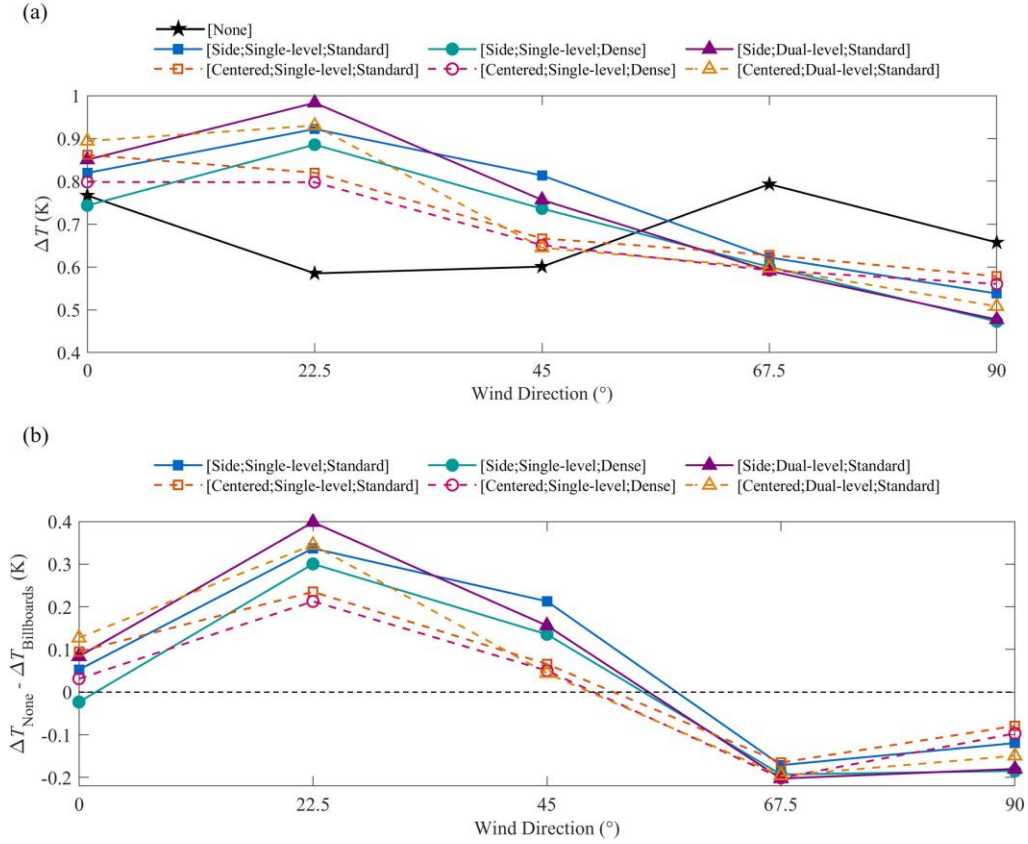


Figure 2 (a) Average temperature difference ($\Delta T = T_{\text{Street Canyon}} - T_0$, $T_0 = 300\text{K}$) within street canyon under different wind directions of 0° , 22.5° , 45° , 67.5° , and 90° . (b) Average temperature difference between the street canyon with billboards and the plain street canyon ($T_{\text{Billboards}} - T_{\text{None}}$) within street canyon under different wind directions of 0° , 22.5° , 45° , 67.5° , and 90° .

Figure 2 illustrates the temperature difference between street canyons with billboards and a plain canyon ($T_{\text{Billboards}} - T_{\text{None}}$) within street canyon under wind directions of 0° , 22.5° , 45° , 67.5° , and 90° . The introduction of billboards alters the canyon's thermal conditions in a wind-direction-dependent manner. At $\alpha = 90^\circ$ and 67.5° , billboards reduce the average canyon temperature, whereas at $\alpha = 45^\circ$, 22.5° , and 0° they generally increase it, with the exception of the [Side; Single-level; Dense] configuration at $\alpha = 0^\circ$.

In terms of configuration, side billboards induce stronger cooling than centered billboards at $\alpha = 67.5^\circ$ and 90° , but lead to greater heating at $\alpha = 22.5^\circ$ and 45° . When $\alpha = 0^\circ$, centered billboards result in more pronounced heating. Overall, across $\alpha = 22.5^\circ$, 45° , 67.5° , and 90° , centered billboards produce smaller temperature variations than side billboards.

3.2. Cooling Effect of Side and Centered Billboards at $\alpha = 90^\circ$ and 67.5°

The thermal influence of billboards strongly depends on wind direction. At $\alpha = 90^\circ$ and 67.5° , when airflow is primarily perpendicular to the street (x -axis), billboards markedly lower the

average canyon temperature by as much as 21.6%. This cooling occurs because billboards regulate and strengthen recirculation about the x -axis, thereby promoting vertical heat removal, as illustrated in Figure 3.

3.3. Heating Effect of Side and Centered Billboards at $\alpha = 0^\circ, 22.5^\circ,$ and 45°

At $\alpha = 45^\circ, 22.5^\circ,$ and $0^\circ,$ when winds are more aligned with the street axis, billboards significantly raise the average canyon temperature by up to 57.6%. This warming effect results from the disruption of the primary helical flow about the x -axis, leading to wake-induced heat accumulation within the canyon, as shown in Figure 3.

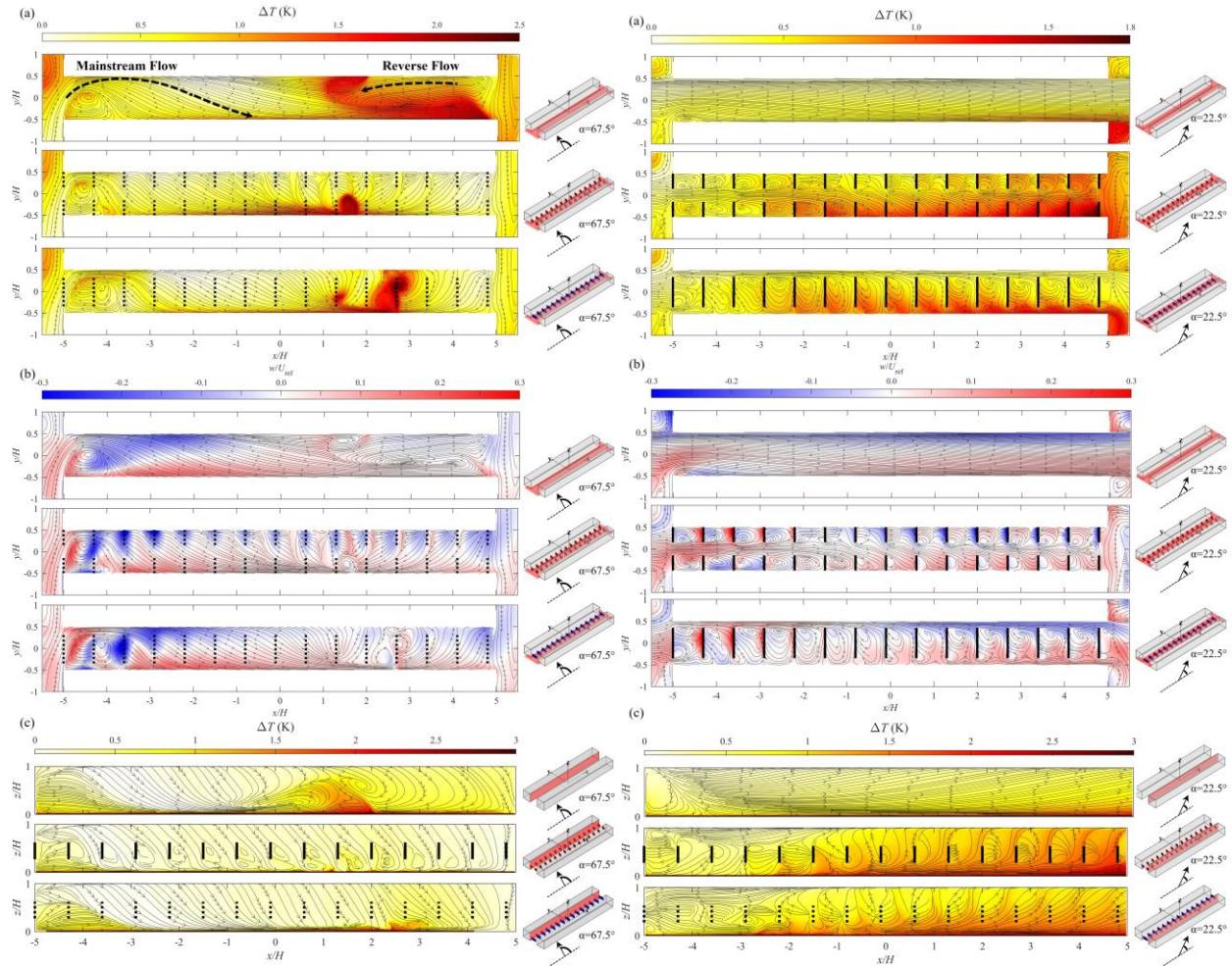


Figure 3 (a) Temperature difference ($\Delta T = T - T_0$) at pedestrian level (b) vertical wind component at pedestrian level (c) temperature difference ($\Delta T = T - T_0$) at the windward wall under wind direction of 67.5° (Left) and 22.5° (Right).

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