

Wind Engineering Joint Usage/Research Center FY2025 Research Result Report

Research Field: Outdoor Environment
Research Year: FY2025
Research Number: 252013
Research Theme: Investigation of the Wind Environment in an Intervening Area at Podium Level under Various Wind Directions and Corner Modifications

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Budget [FY2025]: Yen 300,000

- *There is no limitation of the number of pages of this report.
- *Figures can be included to the report and they can also be colored.
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1. Research Aim

Pedestrian-level wind (PLW) conditions in the inter-building areas above the podium are determined by the interaction of incoming boundary-layer flow and the local geometric characteristics at building edges. In modern podium-type developments, parapets and low protective edge walls are commonly included along podium perimeters for safety and aesthetic reasons. Despite the small size relative to the overall building height, these features introduce geometric discontinuities that may modify near-surface velocity distribution, shear layer formation, and localized acceleration patterns within pedestrian areas. Recent research on pedestrian-level wind conditions have thoroughly investigated the effects of building height, spacing, and orientation. However, there is a lack of research that addresses the parametric influence of parapet configurations, specifically podium top corner modifications, on the PLWE within the intervening space above the podium. This study investigates the wind environment at podium level, specifically addressing the influence of parapets, building heights, and various wind directions on flow fields. Wind tunnel experiments are performed with two distinct parapet heights, three varying building heights, and wind orientations. This research aims to evaluate these dynamics to enhance podium-level designs, thereby improving comfort, safety, and environmental quality, and contributing to the development of efficient and resilient urban environments.

2. Research Method

Fig. 1 illustrates the dimensional specifications of the base model, characterized by height H , along with the parapet dimensions employed in the wind tunnel experiments. The model (1:400) comprises two buildings, each measuring $0.55H \times H \times 0.75H$ (length x width x height), positioned over a podium with dimensions of $2H \times 1.5H \times 0.25H$ at the bottom. In this setting, $H = 0.2$ m denotes the total height of the model, measured from the wind tunnel floor to the top of the building, inclusive of the podium. The parapet heights are differentiated between $0.025H$ and $0.05H$, respectively. The model used in this study includes three varying building heights denoted as H , $1.5H$, and $2H$ (see Fig. 2). The experiments are performed in a wind tunnel at Tokyo Polytechnic University, Japan, measuring 19 m in length, 2.2 m in width, and 1.8 m in height.

The approaching flow profile is measured by the I-type hot wire anemometer (HWA) at a position $5H$ upstream from the turntable center, while incidental flow is assessed in the center of the turntable when the building model is not present. Additionally, thermistor anemometers are positioned in the intervening area that measure the average wind speed. The thermistors are located 5 mm above the podium's top (2 m at full scale), representing the height of the pedestrians. Four wind directions, $\theta = 0^\circ, 30^\circ, 60^\circ, \text{ and } 90^\circ$, are evaluated

by rotating the turntable in a clockwise manner. The building's location illustrated in Fig. 1 is at $\theta = 0^\circ$.

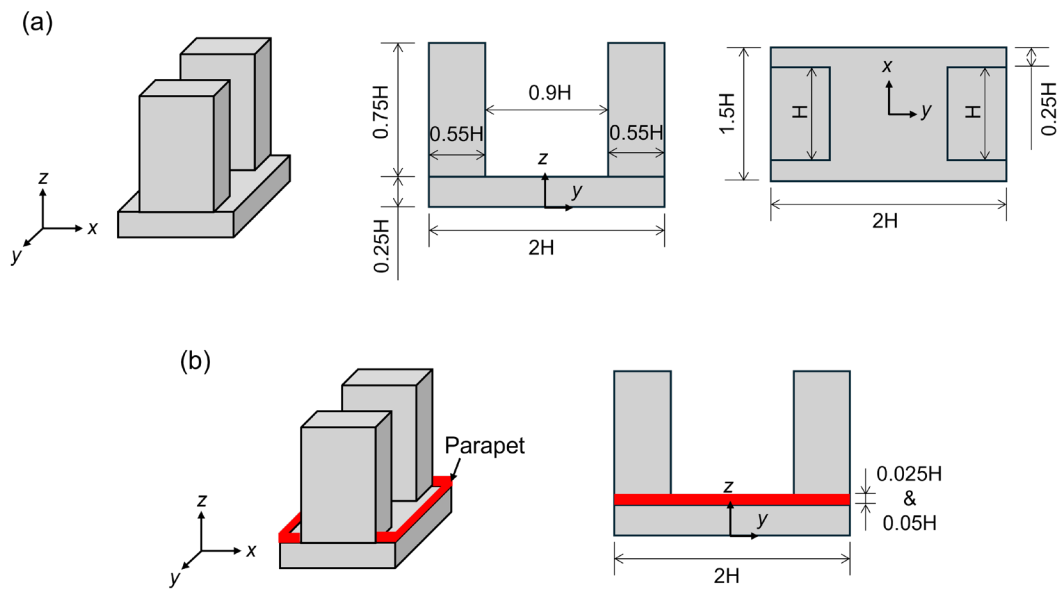


Fig.1 Schematic representations of the building model with (a) base model and (b) parapet dimensions. The flow is oriented in the x -direction..

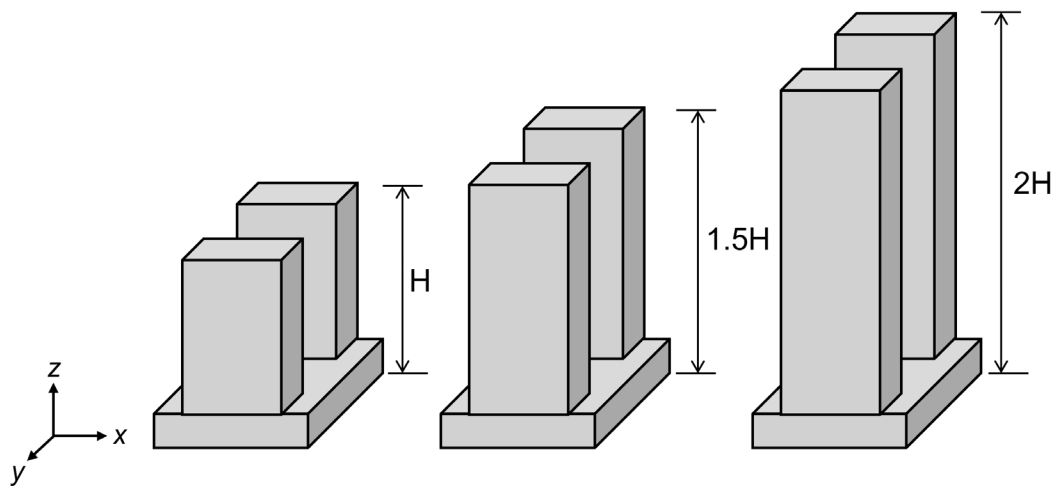


Fig. 2 Variation in building heights from the base model of H up to $1.5H$ and $2H$.

3. Research Result

3.1 Approaching and incidental flow conditions

Fig. 3 illustrates the vertical profiles of wind speed and estimated turbulent kinetic energy (TKE) for both the approaching and incidental flows. Fig. 3(a) depicts the normalized

approaching wind speed obtained through the application of the power law with an exponent of 0.25, corresponding to urban areas featuring mid-rise structures (category IV). The mean wind speed is denoted by U , while U_H indicates the mean wind speed at height H , as measured at the location of the approaching flow. Despite small acceleration observed at the wind tunnel surface due to the lack of roughness elements, the profile above $0.5H$ generally remained aligned with the approaching flow. The TKE is estimated on the assumption that k is approximately equal to σ_u , where σ_u denotes the standard deviation of the streamwise velocity, as the I-type HWA is insufficient for measuring multiple velocity components (Fig. 3 (b)).

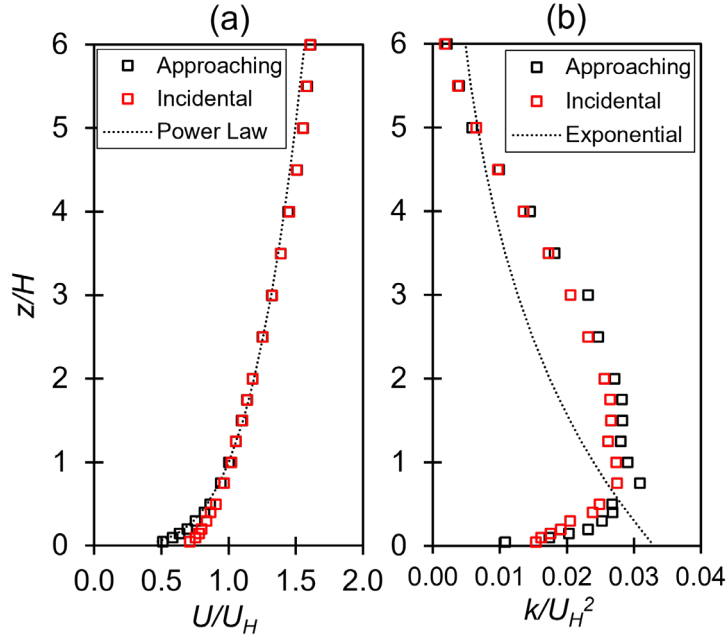


Fig. 3 Vertical profiles (a) wind speed and (b) estimated turbulent kinetic energy for approaching flow; empty black square at $x/H = -5.0$ and incidental flow; empty red square at $x/H = 0.0$.

3.2 Wind comfort criteria

The wind conditions within the intervening space are evaluated employing the wind speed ratio K , as defined in Eq. (1).

$$K = U_i / U_{ref} \quad (1)$$

U_i represents the wind speed at the pedestrian level at point i , measured within the intervening space, while U_{ref} denotes the wind speed at height of $2H$ at the undisturbed approaching flow. The Eq. (5) is defined at the pedestrian-level which is essential for assessing the wind environment at street level. While the evaluation height in this study is higher than street level, which is at podium level, the same concept of wind speed ratio is applied. The calculated K values are categorized according to the wind comfort criteria as presented in Table 1.

Table 1
Wind comfort criteria based on Zhang et al. (2017)

K	Classification	Remarks
<0.3	Low wind speed (LWS)	Calm conditions; potential for uncomfortable situations
0.3-0.7	Acceptable wind speeds	Suitable for walking and sitting
0.7-1	High wind speed (HWS)	Discomfort, unsuitable for prolonged stationary activities
>1	Unacceptable wind speeds	Hazardous conditions

3.2.1 Effects of building heights under without parapet conditions

Figs. 4 and 5 depict the distribution of the wind speed ratio K in the intervening space for different wind directions in the absence of a parapet at the podium top edge. For parallel ($\theta = 0^\circ$) and oblique ($\theta = 30^\circ$) wind directions, generally, an increase in building heights leads to a wider region of HWS, hence constraining the acceptable and LWS zones within the intervening space. At $\theta = 60^\circ$, the HWS strength intensifies and horizontally expands in the streamwise direction in the windward region. Furthermore, the LWS region extends toward the leeward side, indicating the presence of stagnant flow. The distributions are more uniform with moderate to low K values throughout the entire intervening space when the wind direction is perpendicular ($\theta = 90^\circ$), most likely because of increased blocking effects.

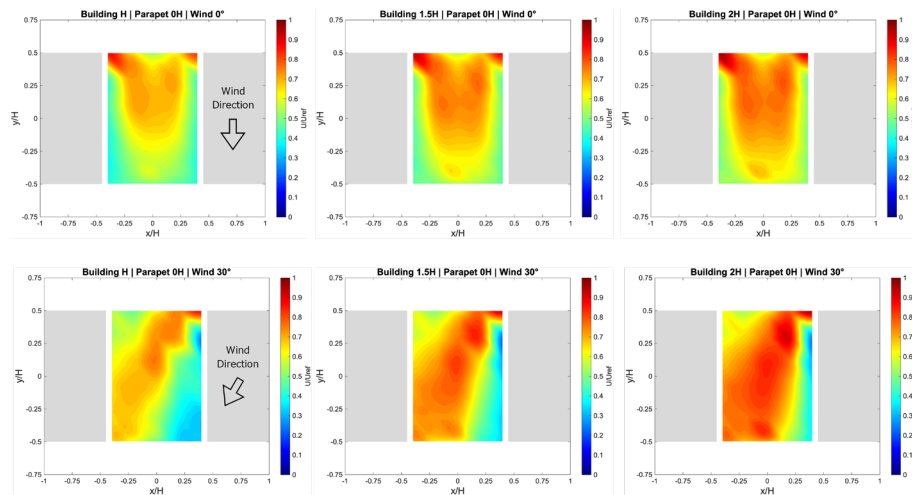


Fig. 4 Distribution of wind speed ratio K for wind directions $\theta = 0^\circ$ and 30° over different building heights without parapet scenarios.

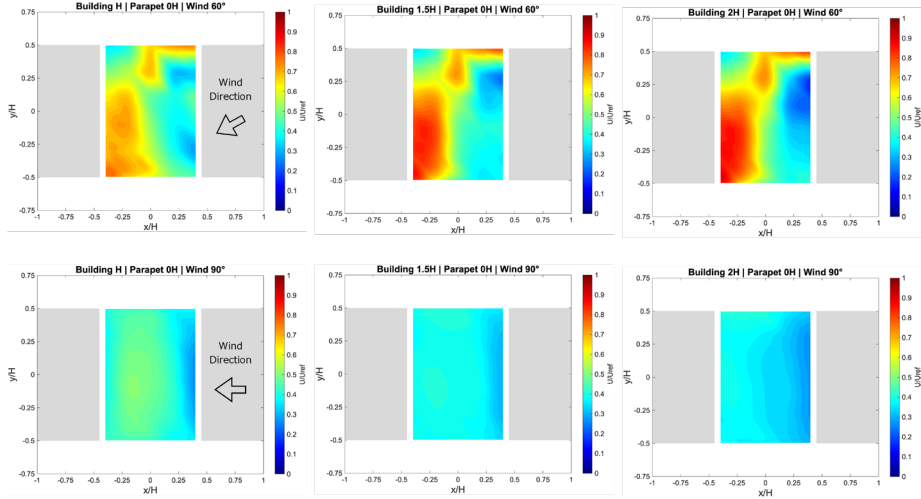


Fig. 5 Distribution of wind speed ratio K for wind directions $\theta = 60^\circ$ and 90° over different building heights without parapet scenarios.

3.2.2 Effects of building heights under parapet ($0.025H$) conditions

Figs. 6 and 7 show the wind speed ratio K distributions under parapet height $0.025H$ conditions. In comparison to the without parapet scenarios, installing parapet height depicts no significant differences across all wind directions suggesting a limited effect of parapet towards modifications of flow within the intervening space.

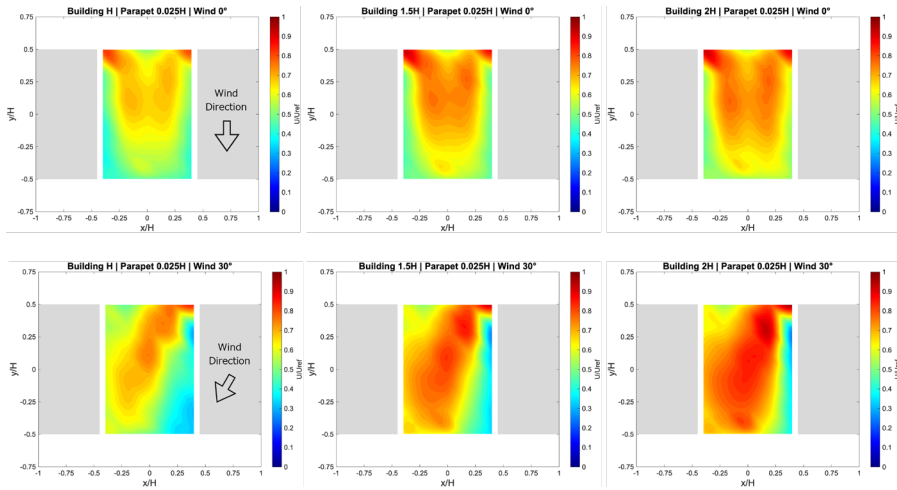


Fig. 6 Distribution of wind speed ratio K for wind directions $\theta = 0^\circ$ and 30° over different building heights with a parapet height of $0.025H$ scenarios.

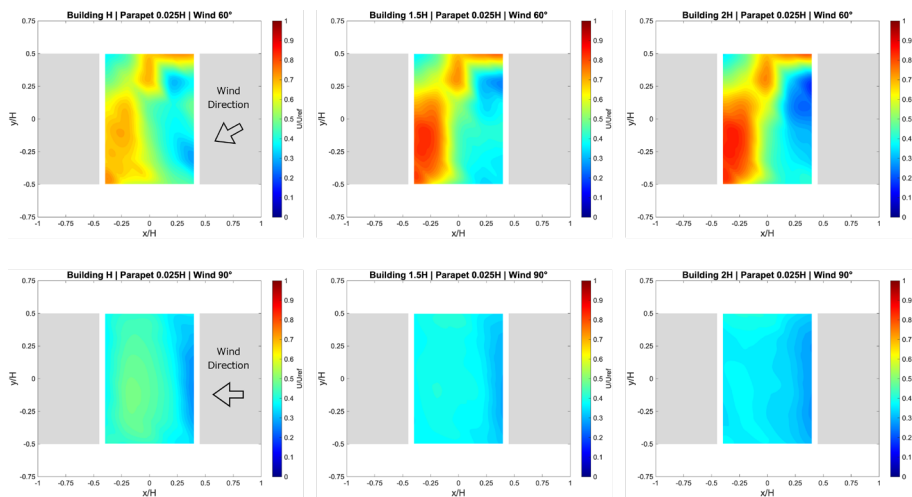


Fig. 7 Distribution of wind speed ratio K for wind directions $\theta = 60^\circ$ and 90° over different building heights with a parapet height of $0.025H$ scenarios.

4. Published Paper etc.

[Underline the representative researcher and collaborate researchers]

[Published papers]

1. Not available
2. Not available

[Presentations at academic societies]

1. Not available
2. Not available

[Published books]

1. Not available
2. Not available

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5. Research Group

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6. Abstract (half page)

Research Theme Investigation of the Wind Environment in an Intervening Area at Podium Level under Various Wind Directions and Corner Modifications
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Summary • Figures

The present investigation experimentally evaluated the effects of different building heights, wind directions, and parapet heights on the wind conditions in the area between two parallel buildings over a podium. Although the data reported in this paper are limited, further longitudinal studies are being conducted to include the findings into a comprehensive comparative analysis aimed for peer-reviewed publication. However, the following conclusions are made in light of the results presented in this work.

- 1) Increasing building heights expands the high wind speed (HWS) zones and confines the low wind speed (LWS) area within the intervening space for wind directions $\theta = 0^\circ$ and 30° . At $\theta = 60^\circ$, the HWS expands in the streamwise direction in the windward areas, while the LWS zones also increase in the leeward region.
- 2) The installation of the parapet at the podium edge has minimal impact on the flow modifications within the examined area.

