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Wind-induced structural response of a building with movable porous screens

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SUMMARY
Wind tunnel study was conducted for a proposed residential development featuring movable porous screens that residents can reposition around their balconies. Because these screens can occupy a wide range of possible layouts, the investigation focused on understanding how different screen arrangements influence the building's wind-induced structural response. Among the many potential configurations, two cases were selected for testing: a "closed" screen layout, where the screens nearly envelop the façade including the corners, and an "open" layout, where the façade remains largely exposed to the oncoming wind. The results indicate that while the most notable variations in bending moments occur in the along-wind response, the torsional moment exhibits the greatest overall sensitivity to the screen configuration.

Keywords: structural wind loading, porous façade screens, wind tunnel testing

1. INTRODUCTION

The use of porous panels is becoming increasingly common in residential buildings as a means of shading interior spaces. These systems help reduce reliance on air conditioning and electrical cooling during warm seasons, and their effectiveness can be enhanced when the panels are operable, allowing residents to adjust their position throughout the day. However, operability introduces a virtually unlimited range of possible screen layouts around the building, each of which may influence the building's aerodynamic behavior.

Wind tunnel test was carried out for a residential tower with balconies to assess the impact different screen arrangements might have on the wind-induce structural response. Two configurations of sliding screens were modelled and tested: a "closed-screen" configuration, in which the sliding screens almost fully enclose the building's balconies, including corners; and an "open-screen" configuration, in which the facade remains largely exposed to the wind. It was uncertain whether the additional screens, by creating a more uniform corner geometry along the building height, would intensify vortex-shedding excitation, even if porous. Similarly, it was uncertain whether the presence of additional screens, despite the building's unchanged effective width, would augment the along-wind loading.

The wind tunnel study was carried out using the High Frequency Force Balance (HFFB) technique at 1:300 geometric scale, in the presence of all surroundings within a full-scale radius of 360m, in RWDI's 2.7m × 2.1m wind tunnel facility. Meshes with 50% porosity were used to simulate the sliding screens. The results of the test configurations are compared and the differences discussed.

1.1.Study building

The study building is a residential tower approximately 116 m tall. Its plan is an almost square cross-section measuring 26.5 m × 24 m over most of its height, increasing to roughly 29.5 m × 26 m when the projecting balconies are included. These balconies wrap around all corners and three elevations of the tower. A simplified cross-section is presented in Fig. 1, illustrating the open-screen configuration on the left and the closed-screen configuration on the right. The southern corners remain screened in both arrangements. Additionally, the effective wind-exposed area in the X and Y directions is essentially unchanged between configurations due to the presence of solid balcony separators extending from the façade to the balcony parapets.

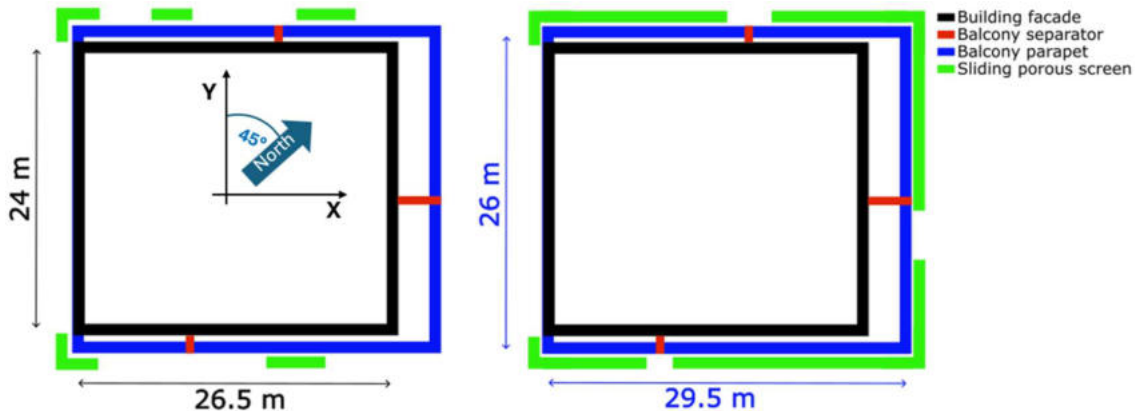

Figure 1. Building geometry and screen test configurations

The building dynamic characteristics and exposure are summarized in Table 1. The design wind speed was 57 m/s (0.2-second gust) at 10 m in open terrain.

Table 1. Building dynamic properties and exposure

	X	Y	Z
Frequencies (Hz)	0.166	0.169	0.368
Damping (%)	3	3	3

Exposure	Wind Direction (°)
Suburban	30 to 100; 240 to 320; 350; 360
Light Urban	10; 20; 110 to 230; 330; 340

The immediate surroundings as modelled were relatively empty for winds from 0° to 110°, whereas the remaining sectors are built-up, with the most substantial and tallest neighboring buildings occurring between 120°–150° and 300°–350°.

2. RESULTS

The wind tunnel results for both configurations of screens layout are presented and compared in terms of bending and torsional moments, mean and peak loads. Note that the influence of wind directionality is not accounted for in these comparisons.

2.1.Bending Moments

Fig. 2 shows the mean and peak loads of the bending moments for the closed-screen configuration in blue and the open-screen configuration in red.

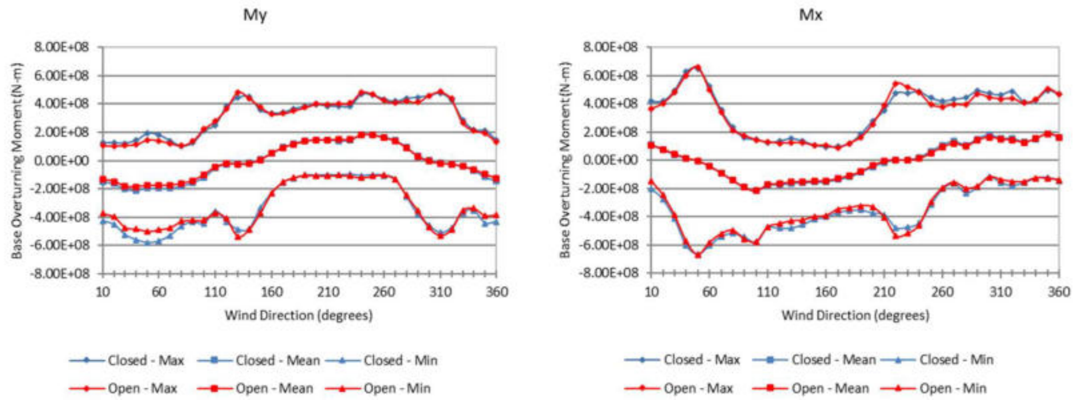

Figure 2. Bending moments mean and peak loads

When examining the along-wind loads, the largest differences occur in the M_y response around 50° for both mean and peak values. At these wind directions, the closed-screen configuration includes additional screens at both windward corners, leading to an increase in peak loads of approximately 16%. Conversely, the M_y along-wind response at 230° is nearly identical between configurations, which is expected given that the upwind corners and elevation remain unchanged. Some differences in the along-wind response for the Mx are observed around 130° and 320°. For these directions, only one windward corner gains extra porous screens, as the other corner is screened in both configurations. However, these differences are too small in magnitude to support any definitive conclusions.

The across-wind response is particularly pronounced for Mx at 50°, a direction characterized by suburban exposure and an open fetch immediately upwind of the site. Notably, the addition of corner balcony screens does not produce a reduction nor an amplification of the response. In contrast, a noticeable variation is apparent at 220°, where the open-screen configuration results in increased loading. Because the upwind corners and elevation remain unchanged for this direction, the findings suggest that the screens at the leeward corners could have a mitigating effect on the vortex-shedding. The across-wind M_y response remains nearly identical between the two configurations.

It is important to note that while the M_x response is dominated by across-wind loading at 50°, with very similar values for both configurations, the M_y response shows a different governing behavior: for the closed-screen configuration, the highest M_y load occurs in the along-wind direction at 50°, whereas for the open-screen configuration the peak M_y load is driven by across-wind effects at 130°, and is approximately 10% lower.

The response behavior described above applies to the specific wind speeds and dynamic properties considered, and it can vary substantially with changes in these parameters. The Australian/New Zealand Standard (AS/NZS 1170.2:2021) specifies 500-year return-period regional wind speeds between 45 and 57 m/s (0.2-second gust) for non-cyclonic regions, while the American Standards (ASCE 7-22) provides natural frequencies typical for concrete moment-resisting frame buildings. To examine how the response varies with building natural frequency and design wind speed, results were compared for reduced frequencies ranging from 0.069 (10% below the baseline) to 0.121 (corresponding to a 45 m/s wind speed and a natural frequency of 0.21 Hz per ASCE 7-22).

Across this range, the dominant response behavior remains broadly consistent with the baseline, except for the moment about the My in the closed-screen configuration. In this case, the across-wind loading at 120° decreases as the reduced frequency increases, eventually allowing the along-wind loading at 50° to become the dominant response mechanism, similarly to the open-screen configuration.

2.2.Torsional Moment

Overall, the biggest differences between the two configurations are observed for the torsional moment. Fig. 3 presents the mean loads on the left and the peak loads on the right.

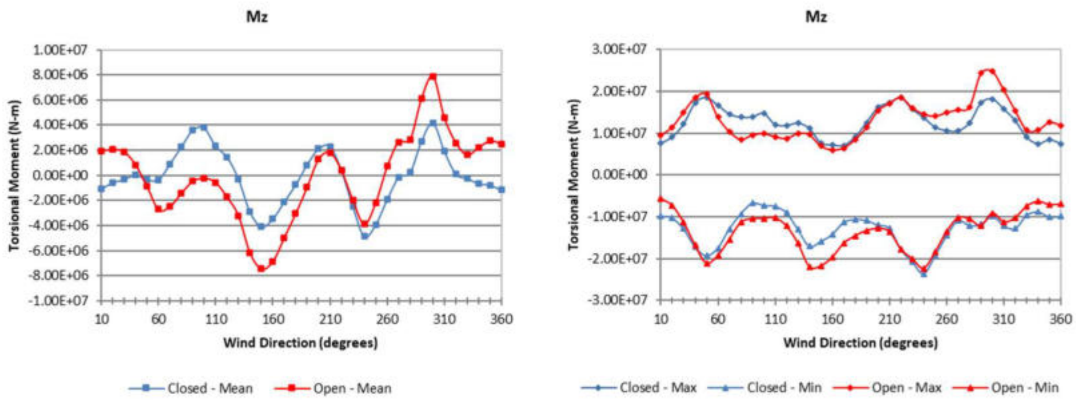

Figure 3. Torsional moment mean and peak loads

For angles of attack between 130° to 320°, the closed-screen configuration mean torsional response resembles that of a regular square section. It is nearly zero when the wind is aligned with the axis of symmetry, and it increases/decreases rapidly for adjacent wind directions as the center of pressure shifts away from the axis, producing an uneven pressure distribution. This behavior arises from the added symmetry provided by the additional screens. For the remaining wind directions, the porous screens are asymmetric and the balconies project more prominently, both of which influence the torsional response. In the open-screen configuration, a similar pattern is observed between 210° and 240°, where the upwind corners and elevation remain unchanged. However, the torsional response at 150° and 300° increase substantially. At these angles, the unevenness of the pressure distribution is amplified by geometric asymmetry, with corner balconies on one side and sharp corners on the opposite side.

The peak torsional loads follow a similar trend. Notably, the peak at 240° increases significantly more than those at 150° and 300°, driven by a stronger resonant response. As a result, the overall peak torsional load is of similar magnitude for both test configurations, but it originates from different wind directions, which may lead to substantially different design values once combined with local wind directionality.

3. CONCLUSIONS

The wind tunnel investigation demonstrates that operable porous screens can alter the aerodynamic behavior of a residential tower. In the case study, the closed-screen configuration tends to increase along-wind bending moments at specific wind directions due to the added solidity at windward corners, while the open-screen configuration exhibits more pronounced across-wind effects for certain orientations. The most significant differences arise in the torsional moment, where the closed-screen arrangement behaves more like a regular square section, whereas the open-screen case shows amplified torsional peaks driven by geometric asymmetry. Although the overall peak torsional loads are similar in magnitude between configurations, they occur at different wind directions, which may lead to different design values once combined with local wind directionality. These findings highlight the need for careful consideration of screen positions, as different layouts may lead to different wind-induce responses.

REFERENCES

ASCE 7-22. Minimum Design Loads and Associated Criteria for Buildings and Other Structures. New York: American Society of Civil Engineers, 2022.

AS/NZS 1170.2:2021. Structural design actions, Part 2:Wind actions. Joint Australian/New Zealand Standard, Third Edition, 2021