Balconies Influence on Buildings Natural Ventilation: Pressure coefficients determination through experimental trials in wind tunnel

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Abstract
Facade elements may impact the performance of natural ventilation in buildings. This research investigated the influence of balconies on the natural ventilation performance of a high-rise building located in Sao Paulo’s city center, by analyzing its envelope wind pressure coefficients. Wind tunnel experiments were performed in the atmospheric boundary layer wind tunnel from the Instituto de Pesquisas Tecnológicas (IPT), Sao Paulo, by using reduced scale models with and without balconies of different lengths and depths, in order to obtain envelope wind pressure coefficients for different wind directions. Results were used to generate isoline graphics, by applying Origin software. Results show that balconies are obstruction elements to natural ventilation, once its presence caused a reduction of the wind pressure difference between inlet and outlet openings. However, there were no significative changes on the natural ventilation performance by using two different depths of balconies.

Key words: Natural ventilation; wind pressure coefficient; balcony.

Introduction
The atmospheric boundary layer (ABL) wind tunnel is commonly used to perform natural ventilation analyses of reduced scale building models¹, such as wind pressure coefficients (Cp). The building envelope Cps describe the wind pressure by a dimensionless quantification of the relative wind pressure in reference to the undisturbed dynamic pressure². It is proved that balconies influence the envelope wind pressure distribution, however, detailed information about how façade’s geometries alterations modify the Cps are still necessary³. This research aimed to investigate the influence of balconies on the natural ventilation performance of a high-rise building located in Sao Paulo’s city center, by analyzing its envelope wind pressure coefficients.

Results and Discussion
The tested building was 34,1 m height, 22 m length and 11 m depth. Image 1 shows the floor plan. A total of 12 scenarios of different balcony sizes were tested, being three of them analyzed in this paper: no balconies, 0,5 m depth balconies and 2,0 m depth balconies. Being the balcony length 5 m and the banister height 1,1 m. A 1:50-scale model was built and tested for wind directions varying in 15° ranges (Image 2). A total of 128 pressure intakes were placed at the four facades. A small difference between 0,5 and 2 m depth balconies was observed: 0,5 m depth balconies showed constant Cp values of approximately 0.6 at windward façades, while 2 m depth balconies showed a wider variation, reaching 0.8 at the central area and -0.4 near the edges.

Image 3 shows the wind pressure coefficients for the building with no balconies, 0° wind direction. The Cps of windward façades were predominantly positive, while in leeward façades the Cps were negative. Also, the absence of balconies resulted in higher Cp values for windward facades. Being tested, three different floor levels were analyzed: first, second and third. Firstly, the building was analyzed with no balconies in the windward and leeward facades. Then, we placed 0,5 m depth balconies in the windward facades and left the leeward facades the same. Then, we placed 2,0 m depth balconies in the windward facades and left the leeward facades the same. Finally, the building was analyzed with 0,5 m depth balconies in both windward and leeward facades. This research aimed to investigate the influence of balconies on the natural ventilation performance of a high-rise building located in Sao Paulo’s city center, by analyzing its envelope wind pressure coefficients.

Conclusions
Balconies were identified as obstruction elements to natural ventilation, mainly in higher and lower floors of the building. However, there were no significant changes on natural ventilation performance by using two different depths.

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Notes:
2 CASTAÑO, H. F. M. Impacto de dispositivos de sombreado externos e muro na ventilação natural e no desempenho térmico de uma habitação de interesse social. Dissertação (mestrado), Universidade de São Paulo, 2017.

Images:
- Image 1: Building floor plan.
- Image 2: Small-scale model.
- Image 3: Wind pressure coefficients for scenario 1.