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Some advances on the aerodynamics of a system composed by a rectangular bluff body with a screen at a relatively small distance

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Abstract

Understanding the wind effects on permeable building envelopes represents a quite challenging task. Previous two-dimensional studies on section models proved that their presence may interfere with the original "supporting body" aerodynamics. This work presents some advances concerning turbulence and wind direction effects.

1 Introduction

The request to reach high aesthetic and energetic standards make the building envelope one of the crucial elements in the design of a modern building. From a wind-loading point of view, a permeable building envelope can be considered as an additional layer fixed to one or more faces of the main building structure, which creates an internal cavity somehow connected to the exterior. In order to properly define the wind loads acting on such building facades, it is necessary to measure and/or evaluate both the external and internal pressures. Since the internal cavity is connected to the exterior, the (possible) wind-driven internal and external flows may mutually interacts and the study of the resulting fluid-dynamic system may prove difficult. One of the most complicated aspects to take into account concerns the reliability of the study of such geometries on scaled models, being the internal cavity gaps usually of an order of magnitude lower than the building itself. Moreover, the cavity between the building face and the external layer can be connected to the exterior in several ways, and compartmentalized with horizontal and/or vertical sub-structures. As shown in Giachetti's PhD thesis (2017) different configurations may lead to, at least in the two-dimensional case study, different aerodynamic behaviours of the systems. Despite the many works carried out on permeable building envelopes (*e.g.* Gerhardt and Janser, 1994, Inculet and Davenport, 1994, Lou *et al.*, 2012,), the inadequacy of current wind loading codes clearly shows that the flow mechanisms acting on the system "building + façade" in certain configurations are not fully understood, stressing the necessity of exploratory two-dimensional studies.
The current study focuses on a system with a laterally-opened airtight screen fixed in front of a square prism distanced between 1/10 and 1/40 of the cross-wind section dimension. Results of the ongoing two- and three-dimensional experimental investigations are presented, especially those concerning the effect of the wind angle of attack and the turbulence effect.

2 Experimental set-up

The experimental campaign was carried out in the CRIACIV Atmospheric Boundary Layer (ABL) wind tunnel, installed in the wind engineering laboratory of the University of Florence.
Tests were performed in smooth and turbulent flow. Investigations were carried out in the two-dimensional flow condition on section models, and ongoing tests are dealing with a turbulent ABL approaching flow. The two-dimensional models, characterized by a cross-flow section D = 0.12 m and a length of 1.24 m, were mounted vertically in the 2.4 × 1.6 m test section and confined between

circular end plates. The three-dimensional tests are focused on a square prism with a 1:1:5 side ratio. The ABL reproduced is characterized by a flow exponent typical of the urban environment ($\alpha \approx 0.3$). The screens were made of stainless steel foils of 1mm. The models were equipped with pressure taps and force balances. For instance, two High Frequency Force Balances (HFFB) were placed at the section-model extremities behind the end plates, while 44 pressure taps were installed around the middle section. Due to the limited screen thickness, it was not possible to install pressure taps around it. In the present work, the wind direction perpendicular to the screen is referred as $\alpha = 0°$. The models were fixed to the wind tunnel through an opportune rotating system in order to perform tests at different angles of attack up to $\alpha = 180°$.

3 Preliminary results

In Figure 1 there are reported the mean pressure coefficients around the middle section of the two-dimensional models for $\alpha = 0°$, respectively for the smooth (Figure 1a) and the turbulent (Figure 1b) approaching flows. Despite the problems encountered reproducing an uniform turbulent approaching flow by means of wooden grids (see Giachetti, 2017), the difference between the internal pressures and the external one in correspondence of the cavity extremities seems to indicate a screen aerodynamic interaction similar to that encountered in smooth flow. Moreover, preliminary studies conducted by varying the angle of attack seems to indicate that for any direction the wind drives an internal air flow in the cavity. These results are also promising for an extension of the study to a more realistic three-dimensional case study.

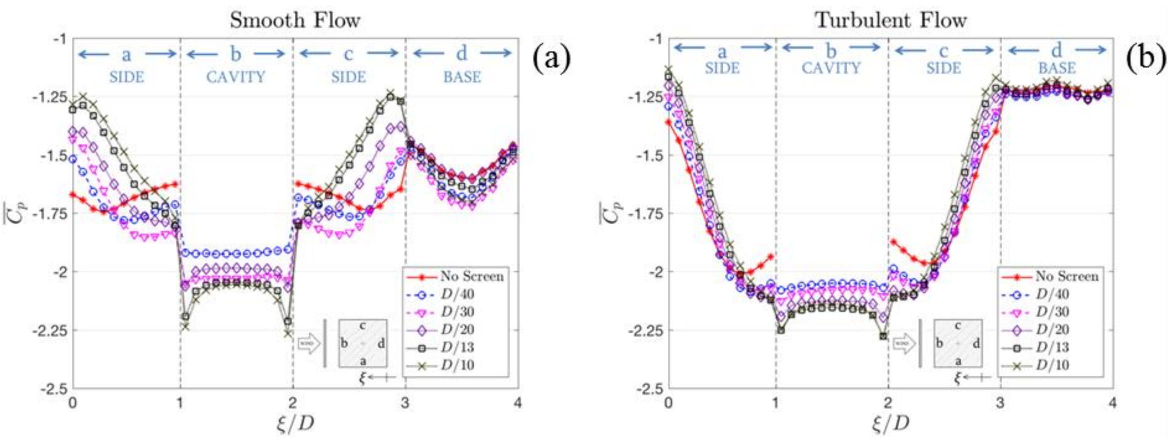

Figure 1. Mean pressure coefficients around the middle section of the system composed by the square section and the airtight screen in smooth (a) turbulent (b) flow (characterized by a turbulence intensity of 13-15%).

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