Wind loads on louver walls

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1 INTRODUCTION

Louvered panels / screens are often used as components and claddings for buildings and other structures or as free-standing sign boards, such as highway signs. Currently, the design of louvered panels as building components are guided by specifications which were primarily developed to assess wind loading on walls of buildings. For example, in the "Minimum Design Loads for Buildings and Other Structures" ASCE 7-05 [1], the net drag force acting on a louvered panel is determined based on external and internal pressure coefficients, which depend on categorisation of the buildings as open, partially enclosed or enclosed, based on the porosity of the wall receiving positive pressure and that of the remainder of the building envelope. The effect of the exact porosities of the wall of interest and of the other surfaces of the building, nor the effect of the shape and distribution of the openings in the walls are considered. This is questionable for the case of louvered panels, which have a solid surface area when projected onto a plane normal to horizontal wind, yet provide significant openings for through air-flow.

In addition, ASCE 7-05, currently do not have specific provisions for wind loading of porous sign boards and consequently designers often have to design louvered sign boards utilizing solid board data. Even when a standard, such as the Australian/New Zealand Standard (AS/NZS 1170.2:2002) [2], specifies pressure coefficients for porous panels, these pressure coefficients are again based on tests of porous panels which differ from louvered panels. Due to these considerations, a series of exploratory tests were conducted in a wind tunnel to directly measure and assess the wind force acting on a louvered panel both as part of a building model representing a generic low-rise building and as a free-standing porous board. The drag coefficients obtained from these tests are compared with those specified by ASCE 7-05 and AS/NZS 1170.2.

2 EXPERIMENTAL DETAILS

Experiments were conducted in the Texas Tech University Boundary Layer Wind Tunnel with cross section of 1.84 m wide and 1.26 m high, and an upstream fetch of 17 m for generation of the desired boundary layer. The model studied is a plastic louvered panel; 254 mm wide, 193 mm high and 28 mm deep. It has 6 blades of 3 mm thickness inclined at an angle of 45°. **Error! Reference source not found.** shows the front and side views of the louvered panel model. This panel is nominally a 1 to 25 scale model of a full scale louvered panel. For a typical design situation, with the dimensions shown, the panel has a free area ratio of 42%.

The porosity of the panel can also be characterized by the pressure loss coefficient, K, which is defined as:

$$K = \frac{P_u - P_d}{\rho U^2 / 2} \tag{1}$$

where P_u and P_d are the static pressure upstream and downstream of the porous panel, ρ is air density, and U is the mean velocity of the approaching wind. The measured coefficient was 11.8. The full-scale louvered panel with the same porosity ratio but slightly different louver blade configuration yielded a pressure loss coefficient of 10.3. These values compare favourably with loss coefficients for other porous materials, [3].

Fig. 1. A wall of the generic building model composed of louvered panels

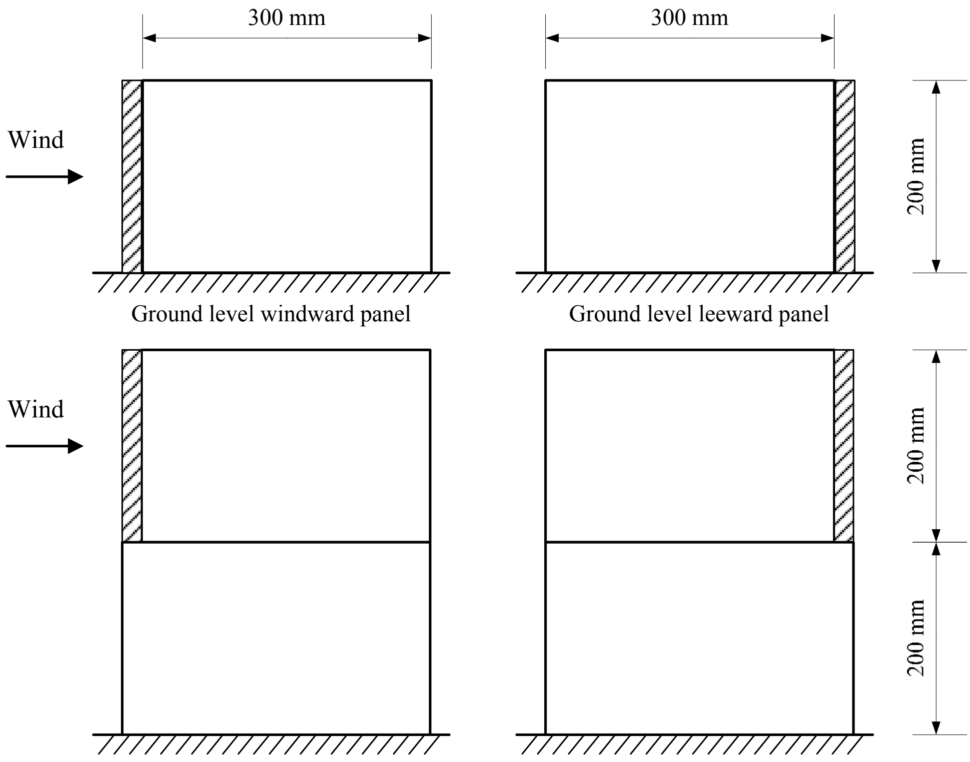

Fig. 2. Tested louvered panel configurations (Porosity of the wall opposite the louvered panel varied)

For all tests conducted to measure the net drag coefficients on the louvered panel as a component of a building, two dummy panels with the same blade configuration and of the same height but half the width of the panel model, shown in Fig 1, were installed on each side of the instrumented panel model. These two dummy panels were not instrumented. They were fixed to the rest of the building model, which was in turn fixed to the wind tunnel floor. The three panels formed a complete wall of a generic building model, nominally 12.7 m wide, 5 m high and 7.5 m deep at full-scale. The louvered panel model in the center of a wall was completely supported by a six-component load cell (ATI Industrial Automation, inc. Gamma series, calibration SI-32-2.5) for force measurement. Fig 2 shows all four test configurations with the louvered panel being a component of a building wall. For tests of free-standing louvered panels, only the front wall section of the model was in place. For all tests conducted, wind speeds were measured by a Cobra probe (Turbulent Flow Instrumentation, series 100) located at the same height as the top of the instrumented louvered panel and in the plane of the model, away from its direct influence.

A total of eight configurations were tested: Four tests were conducted with the wall formed by the louvered panels at the wind tunnel floor level and four tests at an elevated level on the top of a fully-enclosed base of the same height and width as the generic building model. At each level, the louvered panel was tested both on the windward side and the leeward side of the building model. The wind was always normal to the front face. These configurations represent generic scenarios for when louvered panels are used on walls of low-rise buildings. For each louver model configuration, the porosity of the wall opposite the louvered panel was varied, ranging from completely open to fully closed with various wall porosities in between. This allowed the investigation of the effect of the porosity on louver wall loads. For the porous walls opposite the louvered panel, the openings were formed by circular holes that are mostly evenly spaced.

3 RESULTS & DISCUSSION

The tests were conducted in boundary layer flow simulated to represent exposure category C specified by ASCE 7-05 and terrain category 2 specified by AS/NZS 1170.2. Both mean- and pseudo-steady drag coefficients were estimated based on the study. Figs. 3 and 4 show the net pressure (drag) coefficients of the louvered panel in the building model for two configurations. It is seen that for all louvered-panel configurations, when the porosity of the wall opposite the panel is greater than 50%, the mean and pseudo-steady drag coefficients were close. When the porosity of the opposite wall was below 50%, however, the two force coefficients differ significantly for each test configuration, which is not unusual for situations where the mean coefficient tends to zero. Table 1 lists the experimentally estimated drag coefficients of free-standing louvered panel with its front face on the windward side and the leeward side, together with the drag coefficients for the same panel when it is part of the generic building tested.

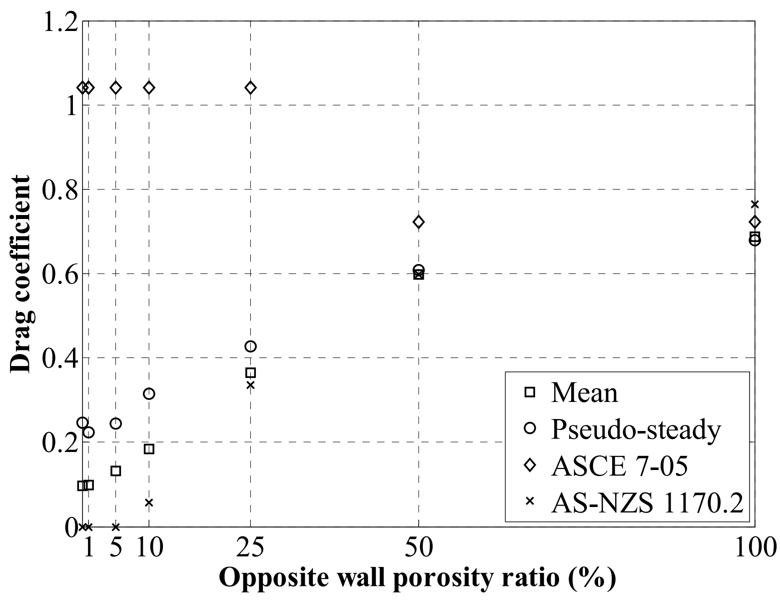

Fig. 3. Drag coefficients for windward louvered panel at wind tunnel floor level in a building model.

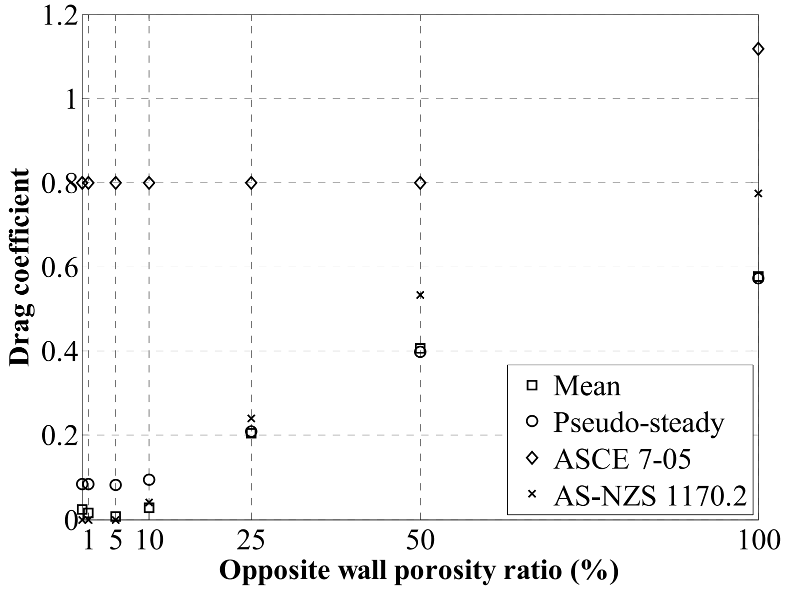

Fig. 4. Drag coefficients for leeward louvered panel at wind tunnel floor level in a building model.

Table 1. Drag coefficients of free-standing louvered panel and of panels in generic buildings with 100% opposite wall porosity

Configuration		*Drag coefficients*		
		Free-Standing Panel		*Panel in Generic Building with 100% Opposite Wall Porosity*
		Test Result	*AS/NZS 1170.2 Provisions*	*Test Result*
Ground	*Front wind*	*1.09*	*.81*	*0.68*
	Back wind	*0.66*	*.81*	*0.57*
Elevated	*Front wind*	*1.16*	*n/a*	*0.72*
	Back wind	*0.81*	*n/a*	*0.70*

The outcome of the study suggests that the wind loading on louvered panels can be significantly different from both ASCE 7-05 and AS/NZS 1170.2 provisions with ASCE 7-05 in particular providing very conservative net loads across the louvered panels for configurations with small opposite wall porosity ratios. This difference can be directly attributed to the way internal pressure coefficients are handled in each standard.

4 REFERENCES

[1] ASCE. (2005). *Minimum design loads for buildings and other structures (ASCE7-05)*, American Society of Civil Engineers, Reston, VA, USA.

[2] Standards Australia (2002). Australian/New Zealand Standard, Structural Design Actions, Part 2: Wind Actions, AS/NZS 1170.2:2002

[3] Letchford, C.W., Row, A., Vitale, A., & Wolbers, J.,(2000) Mean wind loads on porous canopy roofs, *Journal of Wind Engineering and Industrial Aerodynamics,*84, 197-213.