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Net pressures on the roof of a low-rise building with wall openings

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Abstract

This paper deals with an investigation of the characteristics of net pressures on two significant roof areas of a low-rise building with two different dominant wall openings. Wind tunnel boundary layer studies were conducted on a corner and a gable-end roof area of a 1:50 geometric scale model of the Texas Tech University (TTU) test building with a corner and a central wall opening. Mean and peak pressure coefficients, RMS values for the pressure coefficient fluctuations about their mean, as well as roof external pressure—internal pressure correlation coefficients were obtained for the entire 360° wind azimuth range. Frequency domain studies were also conducted for a few selected point roof pressure situations from which the frequency-dependent roof external pressure—internal pressure phase difference functions, root coherence functions and the spectral density functions were obtained. The results show that the mean, RMS and peak net pressure coefficients are particularly enhanced relative to the coefficients for the roof external pressure in the $\pm 50^{\circ}$ wind range. Zero-time-lag correlation coefficients of up to -0.64 were obtained in agreement with results from past studies, while root coherence values of up to 0.7 were also recorded. It is demonstrated that the provisions of both the Australian/New Zealand wind loading code—the AS/NZS1170.2:2002, and the American wind loading code—the ASCE7-02, are sometimes non-conservative in the

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prediction of mean and peak net roof pressure coefficients. These are believed to be due to non-conservative internal pressure coefficients allowed for in these codes.

Keywords: Net pressure; Roof pressure; Dominant openings; Internal pressure; Helmholtz resonance; Correlation; Coherence; Wind loading code; AS/NZS1170.2:2002; ASCE7-02

1. Introduction

It is well known that high wind speeds in windstorms (eg. in tropical cyclones) generate flying debris that can act as missiles and cause damage to windows and doors of buildings, creating an opening. Consequently, the characteristics of building internal pressure induced through such an opening and the manner in which it combines with external pressure across the envelope become issues of prime concern. If an opening is created fairly rapidly (ie. suddenly), then there is the possibility of a significant overshooting of internal pressure in the resulting transient response. In the steady-state response on the other hand, the phenomenon of Helmholtz resonance can lead to peak internal pressures higher than those predicted from the quasi-steady theory, as well as enhanced fatigue characteristics indicated by higher RMS values of fluctuating internal pressure. The phenomena of transient overshooting and Helmholtz resonance were first demonstrated by Holmes [1], and a number of investigators [2–6] have since increased our understanding of the characteristics of building internal pressure in the presence of dominant openings.

While an understanding of the behaviour of internal pressure is important in itself, its impact upon the loads on the building envelope is of greater significance. Internal pressures in the presence of dominant wall openings can contribute quite significantly to the overall loading on the roof, and subsequently to the fixings that not only hold the envelope but the entire building together. For a single windward opening, mean internal pressure will be the same as the positive external pressure at the opening. Its combined effect with external pressure across the envelope provides relief on the windward wall, however, it complements external suctions on other walls and in particular on the roof, to increase their overall loading. This situation is illustrated in Fig. 1, in which internal pressures have been assumed to be uniform over most of the building interior. The mean level of the net

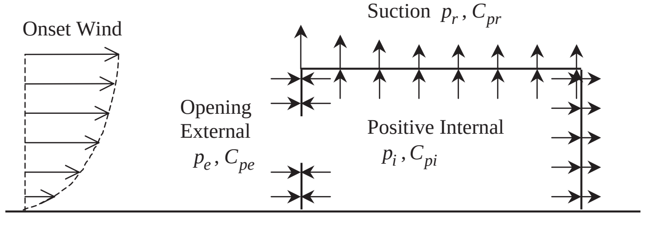

Fig. 1. Envelope pressures under a dominant windward wall opening.