THE VENTED FACADE AND UNWRITTEN ANECDOTES

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1.0 Introduction

The authors have written a number of commercial and research papers in recent years on the implications on design of facade venting in high rise apartment buildings. During the course of this work they have come across many anecdotes about the effects of facade venting on occupancy comfort and safety, most of which cannot be written down because of the need to protect the innocent and the guilty, not to mention possible deformation action. However it is important within a workshop forum of wind engineers to at least air some of these problems so that lessons from the past do not get lost with the passage of time. As background to this discussion, and to provide some technical background, a few excerpts from previous work will be set out.

Apartments in tower buildings are naturally ventilated through balcony doors, openable windows, louvres and wintergardens with a combination of windows and louvres. All have the ability to significantly change the internal pressure throughout a building, whether venting is to a windward, leeward or stream-wise face. To date anecdotal evidence with apartment buildings up to about 100m in height is that problems have been limited to difficulty in opening doors and slamming with wrist injuries and door jamb failure, deformation and popping of balcony doors and windows on sides adjacent to balcony doors (possibly due to use of standard units designed for lower buildings). There has been no known failure of internal partition walls and floors. The leap to super-tall apartment buildings has the potential to double design and serviceability loads on facades and internal components beyond general current experience. This situation can no longer be ignored at a design level even though the probability of occurrence of extreme loads is low, because to realise such loads requires an external door or window to be left open

2.0 Potential Design Pressures due to Venting

For the first part of this discussion no account will be taken of the probability of occurrence of various openings. Quite simply, if there is the potential for a door or window to be open its effect on loading a facade or internal component in the most adverse circumstances must, at least, be considered. The possible mitigating effects to be taken into account would be the lack of correlation between peak windward facade positive pressures and leeward and streamwise facade negative pressures, with wind direction and time, and the effect of venting to large internal volumes.

The analysis technique used was based on wind tunnel model pressure measurements. All facade pressures were recorded as a digital time series for each wind direction. The process then proceeded through a sequence as follows:

(i) Identify internal pressure on a path to give high differential pressures across a facade element or internal component and relate this path to two external facade pressure locations.

(ii) Identify the range of wind directions likely to give the worst-case peak differential pressures.

(iii) Obtain a differential pressure time series being the digital difference between the two external pressure time series and analyse this new, differential, pressure time series for mean, standard deviation and peak minimum and maximum design pressures across the element under consideration.

An example of this process is shown with three pressure time series in Figure 1. Figures 1(a) and 1(b) show pressures measured on a windward and streamwise face. The former reflects the positive pressure due to fluctuating turbulence in the approaching wind flow and the latter reflects the more intermittent negative pressures measured under the separating and re-attaching shear layer. Figure 1(c) shows the differential pressure between the two times series in Figures 1(a) and 1(b) as a function of time

3.0 Pressure Paths and Generalised Pressure Ratios

Figure 2 illustrates typical pressure paths that would relate to scenarios of balcony doors being open or exposed to internal pressures effected by a window open on another side. An example of the calculation of the ratio between the windward face external peak pressure and the internal pressure that may be realised behind this face can be calculated for several cases as follows (for Figure 2(a));

Worst case pressure difference between peaks = 1191 + 2789 = 3980 Pa
Digital difference between two facade pressures = 3326 Pa   Ratio = 0.84

4.0 Some examples of Facade and Internal Pressures

The internal pressures that give rise to the worst case design pressure require that one or more doors or windows be left open. The simplest scenario is that of the additional loading on a facade panel due to an opening on the other side, or around the corner of the same room. This requires that only one external door or window be left open or fail. Then follows the less probable sequence of requiring two external doors or windows to be left open to cause an additional load on internal partitions, doors and floors, facades not covered by the single opening scenario, along with the opening or venting through an internal lobby door for some pressure paths. In this paper the risk levels associated with these scenarios, and the effect of large internal volumes will not be considered. In Figure 3 examples of facade design pressures are given for a sealed facade and for the same facade with critical openings. In Figure 4 an example of the possible design pressures across internal partition walls is given for the same critical facade openings.

5.0 Problems and Anecdotes

The following problems will be discussed with anecdotal evidence:

Door and window failures
Injuries to people
Wind noise, door closure problems and lift doors jamming
Objects blowing away.
Negatively and over-pressurised fire escapes.

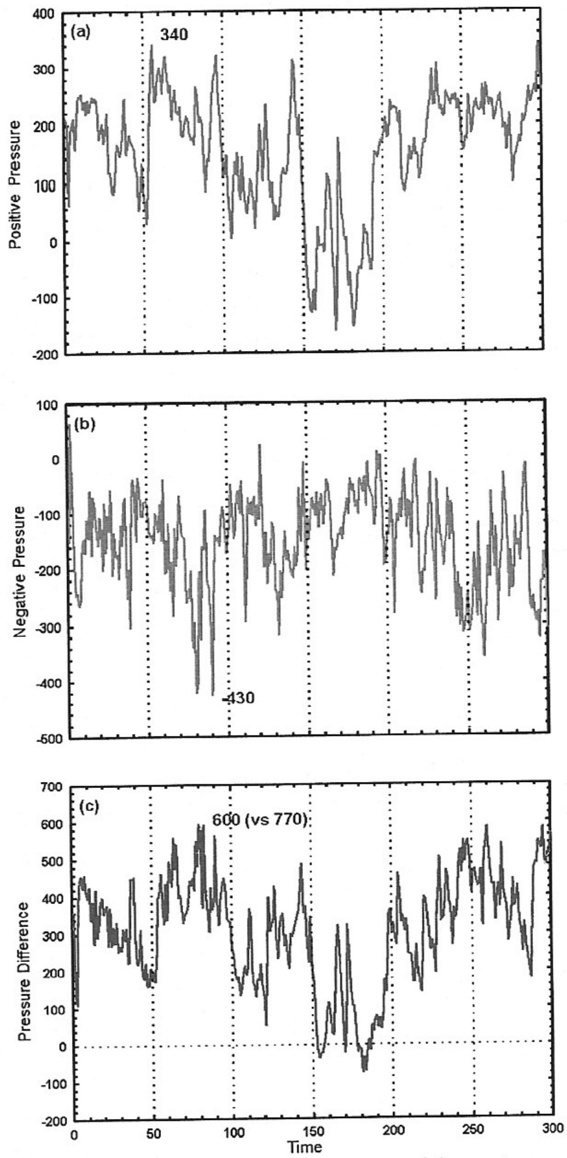

Figure 1: Example of pressure measurements on an (a) upstream and (b) windward faces of a building and (c) the difference between them as a function of time.

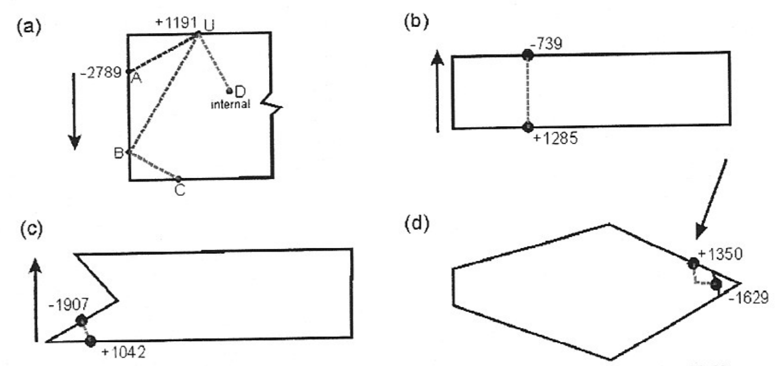

Figure 2: Typical pressure paths for a vented facade building

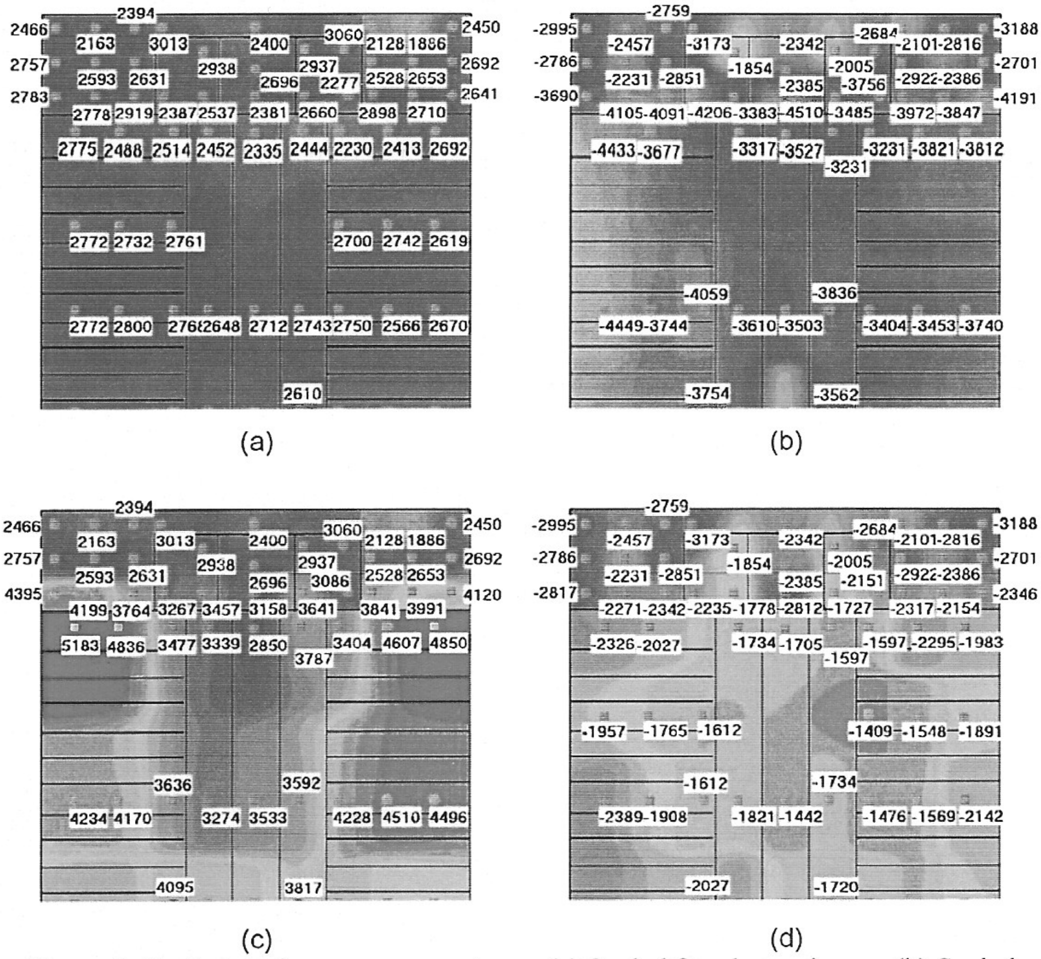

Figure 3: Typical design pressure contours, (a) Sealed facade maximum, (b) Sealed facade minimum, (c) Vented facade maximum, and (d) Vented facade minimum

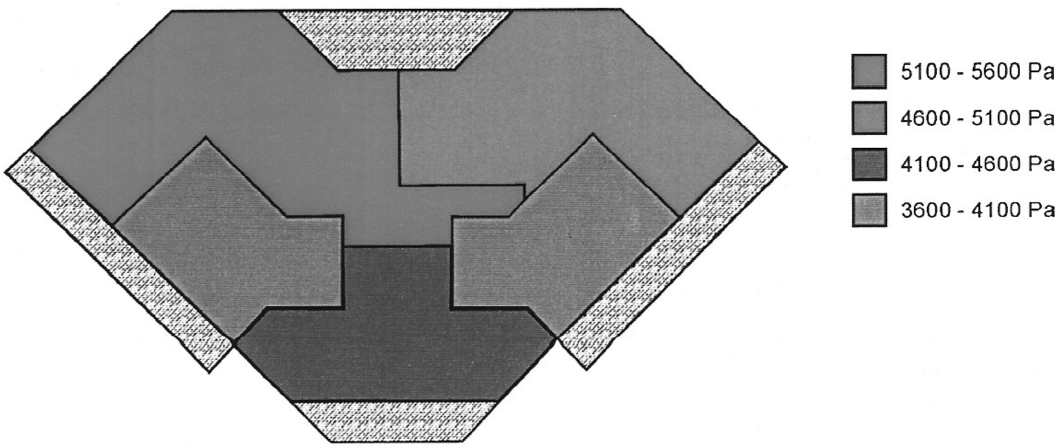

Figure 4: Possible design pressures across internal partition walls