WIND PRESSURES ON THE CAARC STANDARD TALL BUILDING MODEL

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1. INTRODUCTION

It is common practice to determine design wind pressures for the cladding of large new buildings through specific wind tunnel testing of scale models of the buildings. Numerous such tests have been performed worldwide, and occasionally the resulting design pressures for a building can be found in published texts. The highest design pressures typically occur at locations where large peak suctions are measured. However, the distorting influences of different design wind speeds, velocity and turbulence profiles, building shapes, and surrounding buildings, make it difficult to compare results for different buildings or different wind tunnels.

There is surprisingly little published data for basic measured pressures on simple building shapes in idealised wind conditions. This paper therefore simply aims to add to the available data, and to highlight interesting features of the complex pressure distribution patterns which occur for even a very simple building shape.

2. TEST PROCEDURE

The reference building chosen for the tests was the CAARC building, which is a nominal simple rectangular block measuring 600 ft high x 150 ft wide x 100 ft deep. The primary boundary layer simulation chosen was terrain category 3 (z_o = 0.2 m) as defined in the current New Zealand and Australian wind loading codes. The boundary layer simulation is therefore not the same as some earlier comparative studies on the CAARC building (e.g. Melbourne [1]) which used wind simulations with less turbulence. The patterns of pressure distribution for the wide and narrow faces of the building are generally similar, but there are also some substantial differences between the two, particularly for the peak minimum pressures.

This study followed on from previous work on cladding pressures for several different building shapes, including the CAARC building [2]. Since our earlier study, changes in our test procedure have included an improved representation of terrain category 3 at 1:300 scale, and also the installation of an aerofoil-slatted ceiling in the wind tunnel. Therefore comparable results in the two studies are similar but not identical.

A total of 585 pressure taps were used to define the pressure contours on all four faces, with twice as many taps on faces 1 and 2 as on faces 3 and 4. The contour diagrams show several blank strips on faces 3 and 4 where we have no data. Mean, rms, minimum and maximum pressure coefficient contour diagrams were plotted for eight directions: 000, 005, 008, 010, 080, 085 and 090. A selection of these diagrams is included in this paper.

Wind tunnel mean speed at building roof height was 9.3 m/s. Sampling time for each tap was typically 72 seconds at 1000 Hz, using a pressure measurement system with flat response from 0 to 270 Hz. The peak Cp's were calculated using an extreme value analysis of the measured data for an effective sampling time of 44 seconds, which is equivalent to 1 hour for a nominal mean speed of 34 m/s at full scale.

3. RESULTS

The mean rms and minimum pressure coefficient distributions on all four faces for wind direction 000 are shown in Figures 1 to 3. Figure 4 shows the mean, rms and minimum pressure coefficients for wind direction 010 for face 2 only. Some notable features of the diagrams are as follows.

3.1 Mean Pressure Coefficients

The highest mean Cp is 0.89, which occurs on face 1 at around height H = 0.8 (where H is the height normalised by the total building height). Pressures on the side faces are fairly uniform for direction 000, but vertical contour lines become much more pronounced on face 2 for direction 010. The largest negative mean Cp is -1.30, which occurs near the top windward corner of face 2 for direction 010.

3.2 Rms Pressure Coefficients

At direction 000 the highest rms Cp is 0.49, which occurs at the trailing edge of face 2 at around height H = 0.7. A narrow strip of similar high rms Cp's at the trailing edge extends from around H = 0.4 to H = 0.9. At direction 010 the pressure contours again become more strongly defined on face 2. The trailing edge effect becomes weaker, and a small zone of very high rms Cp's develops near the top windward corner of face 2, with a peak value of 0.56.

3.3 Peak Pressure Coefficients

At direction 000 a narrow strip of large minimum peak Cp's at the trailing edge of face 2 extends virtually the full height of the building, reaching a value of -4.3 at around H = 0.6. A minimum Cp of -4.3 also occurs in a very small zone at the top windward corner. Elsewhere on face 2, minimum Cp's of between -3.3 and -3.6 extend over a large area for most of the building height, centred at around ⅓ of the face width from the windward edge. It is interesting to note that for the majority of the building height, the peak design pressures around the building perimeter occur at the trailing edges of the two side faces for directions close to 000.

At direction 010 the pattern on face 2 is largely similar, with the trailing edge peak again being a little weaker. However, the peak Cp in the small zone at the top windward corner has increased dramatically to -6.0. The largest measured peak Cp at the top corner was -6.4 for direction 008. (By comparison, the minimum peak Cp on face 1 was only -4.0, which occurred for direction 080.)

The largest positive peak Cp's (not shown in the diagrams) were 2.3 on face 1 at around height H = 0.85.

3.4 Effects of Increased Turbulence

The influence of increased turbulence was examined by comparing the results obtained for simulations of terrain categories 3 and 4 (C3 and C4 in the diagram) at two thirds building height (H = 0.66) for direction 000. These results are shown in Figure 5. The category 4 (z_o = 2 m) simulation was fairly approximate compared to that for category 3, as may be seen from the asymmetry of the category 4 results, but the measured turbulence intensity at H = 0.66 was correct (22% for category 4 compared to 16% for category 3). The pressure distribution patterns remain much the same, with the positive and negative peak Cp's increased by similar amounts due to the increased turbulence.

The peak minimum Cp at the top windward corner of face 2 was increased from -6.4 for category 3 to -8.3 for category 4.

4. CONCLUSIONS

A thorough study has been performed to measure the wind pressure distribution on the CAARC building for a representative range of wind directions. This paper has presented a selection of the results.

5. REFERENCES

[1] Melbourne, W.H. (1980): "Comparison of Measurements on the CAARC Standard Tall Building Model in Simulated Model Wind Flows", Journal of Wind Engineering and Industrial Aerodynamics, Vol. 6.

[2] Jamieson, N.J., Carpenter, P. and Cenek, P.D. (1991): "Wind Induced External Pressures on a Tall Building with Various Corner Configurations", Proc. 8th Int. Conf. on Wind Engineering, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 44.

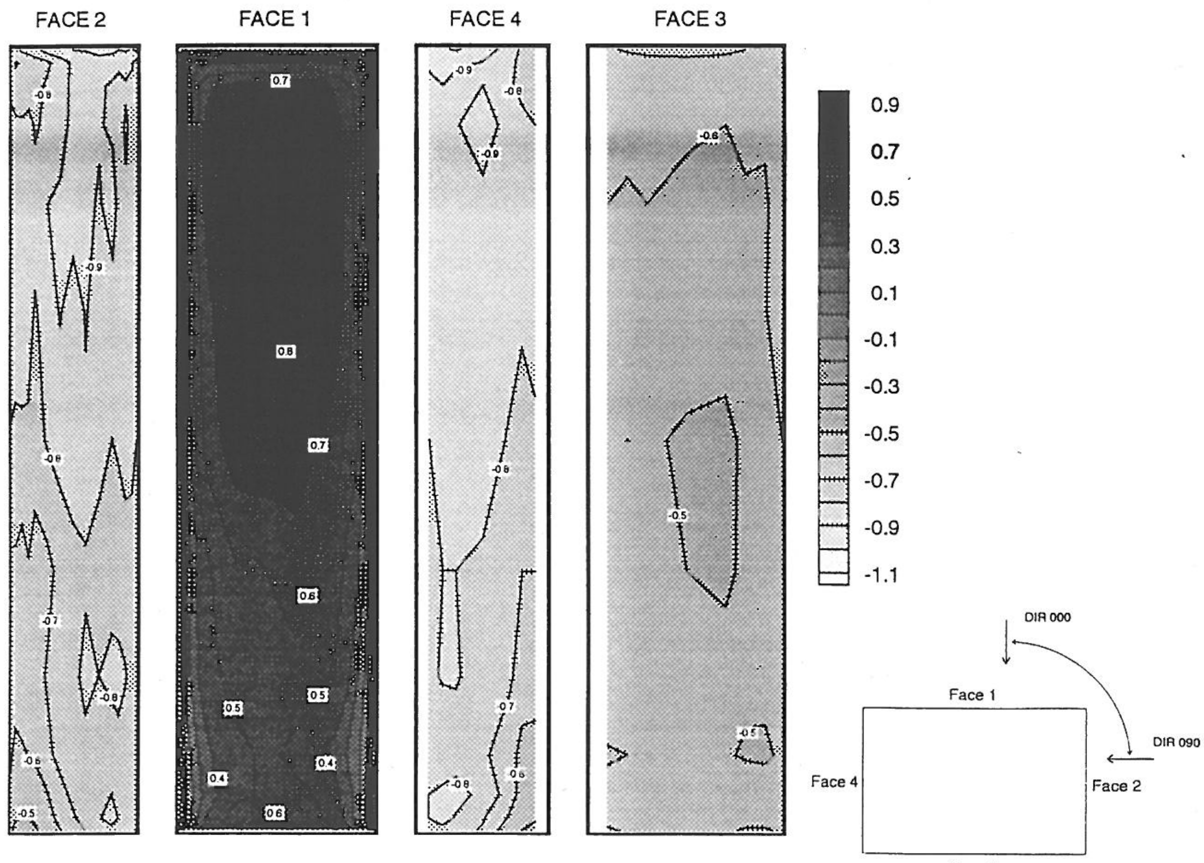
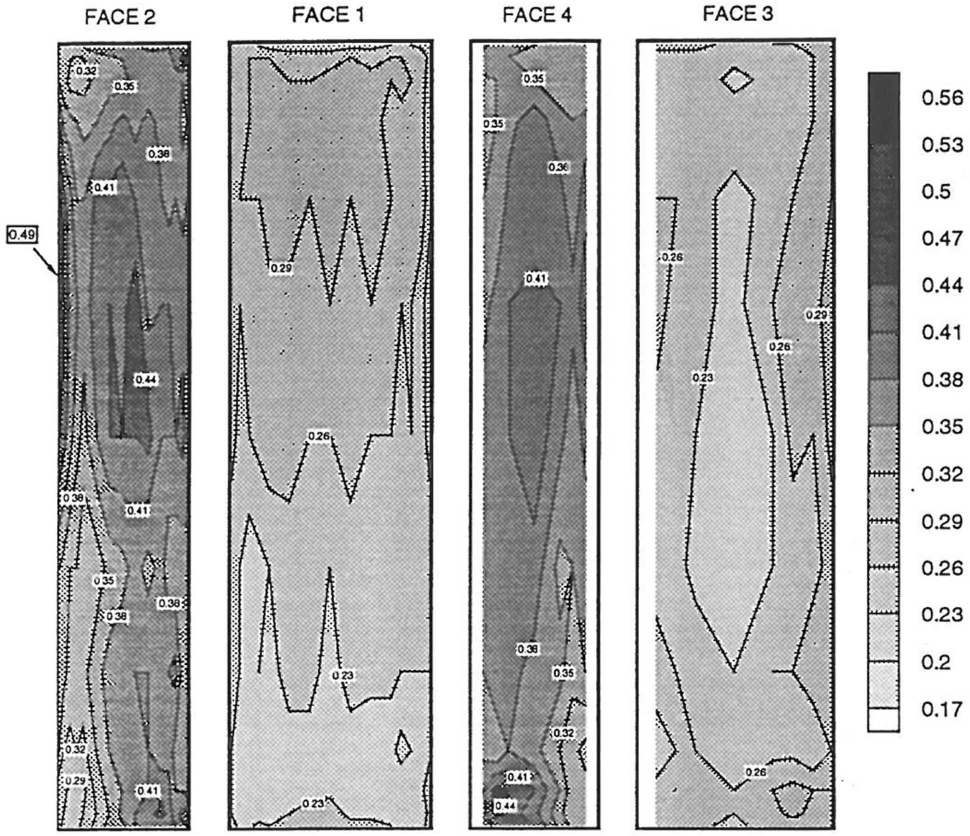


FIGURE 1: Mean Pressure Coefficients, Wind Direction 000



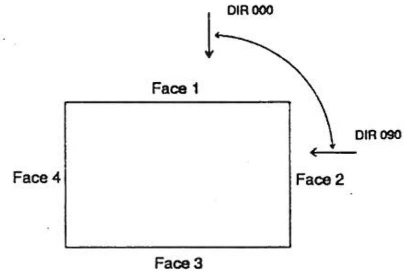


FIGURE 2: Rms Pressure Coefficients, Wind Direction 000

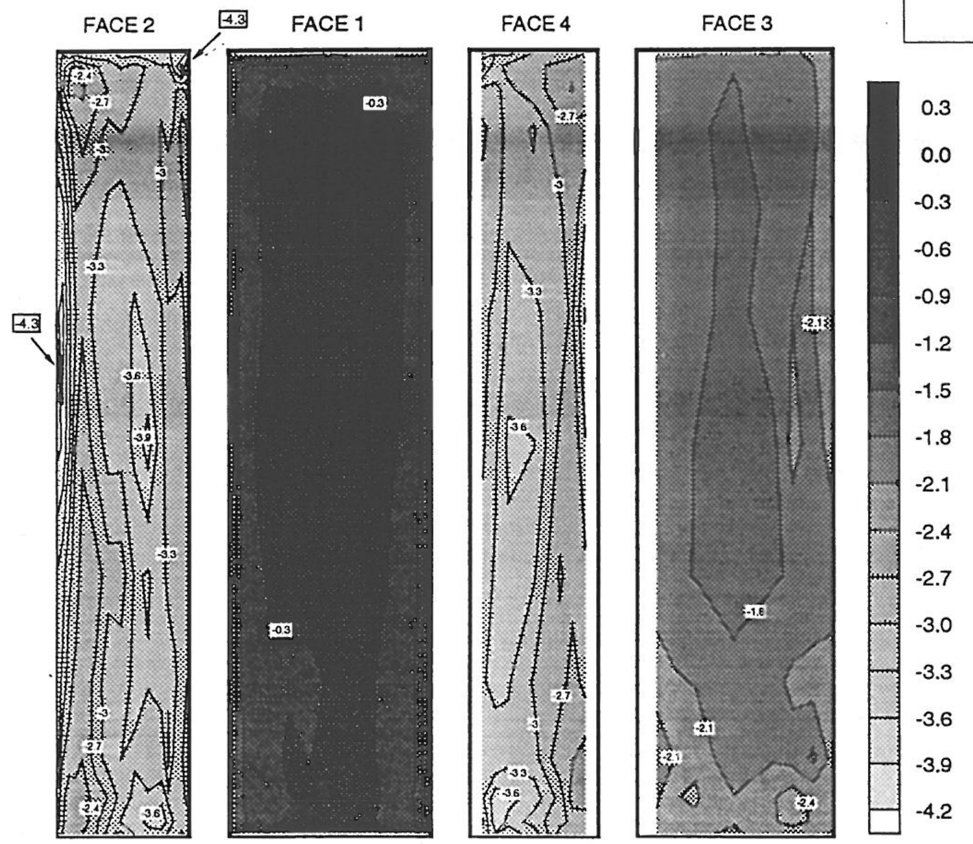


FIGURE 3: Minimum Peak Pressure Coefficients, Wind Direction 000

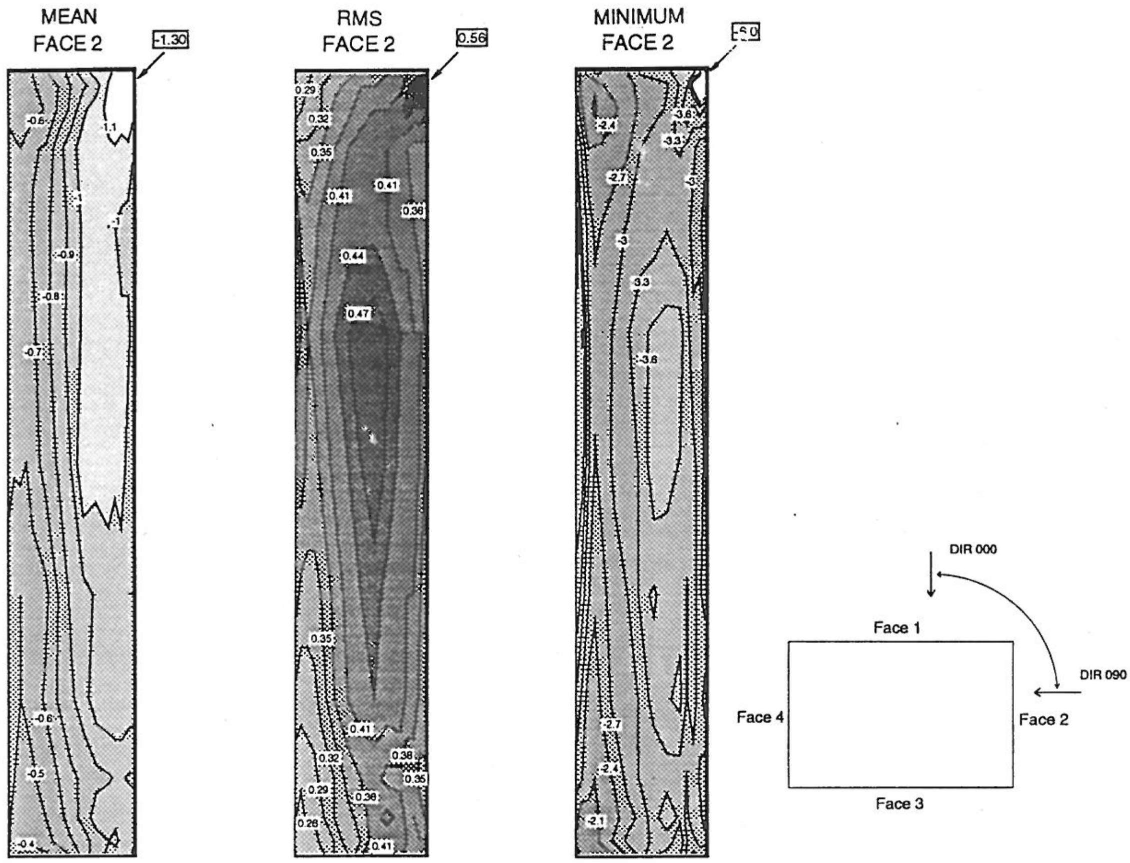


FIGURE 4: Mean, Rms and Minimum Pressure Coefficients, Face 2 Only, Wind Direction 010

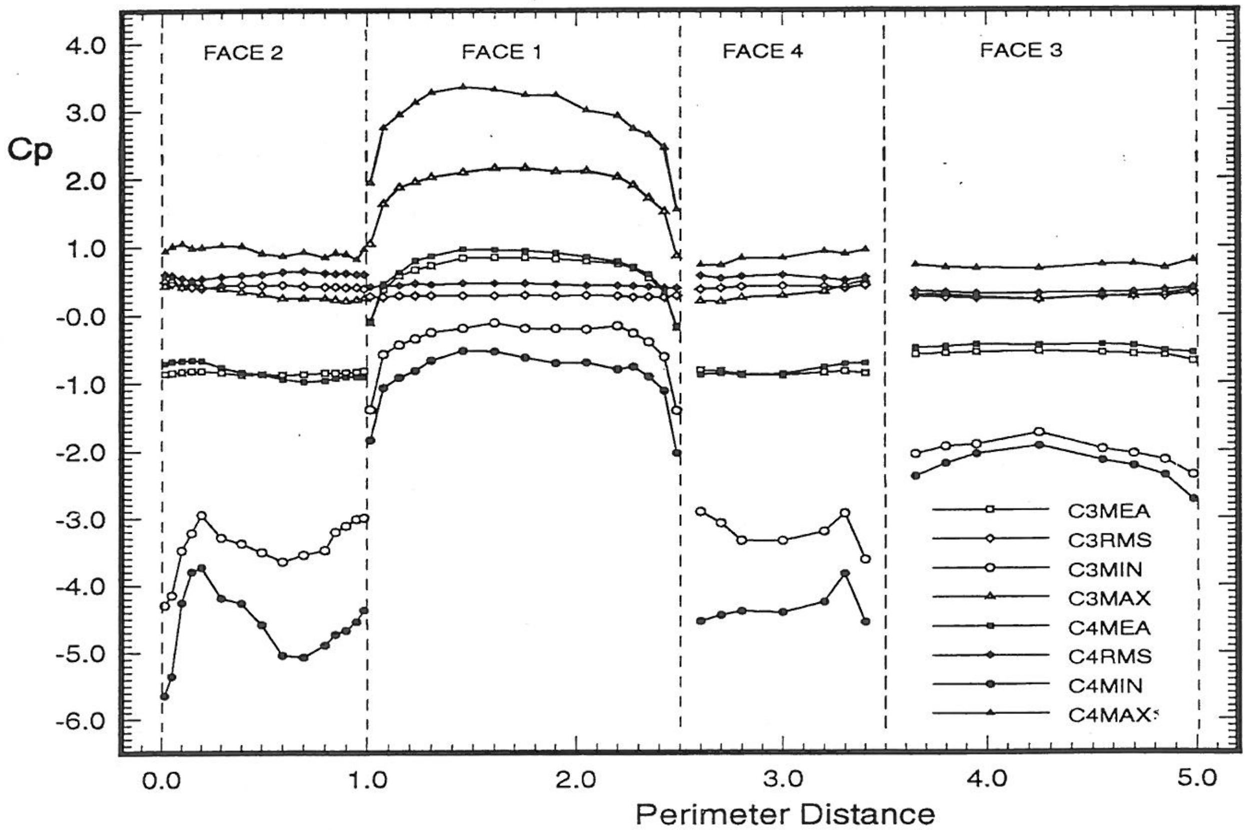


FIGURE 5: Comparison of Measured Pressure Coefficients for Terrain Categories 3 and 4, Two Thirds Height, Wind Direction 000