PRESSURES ON A 1/10 SCALE MODEL OF THE TEXAS TECH BUILDING

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INTRODUCTION

The Texas Tech Field Experiment [1,2], the main part of which comprises detailed wind pressure measurements on a small steel building, has attracted considerable interest from both wind-tunnel and computational modellers. The experimental building is 4.0 metres high, with plan dimensions of 9.1 metres by 13.7 metres. Amongst the full-scale data analysed and published are point pressure measurements along the centre line for wind normal to the building axis [3], and pressures from an array of nine pressure tappings near the upwind corner of the roof for oblique wind directions [4].

This paper will present results from a large (1/10 geometric scale) model of the Texas Tech Building tested in the new large wind tunnel at Monash University. This large model size gives an intermediate Reynolds Number between full scale and the smaller model tests and enables the effect of this parameter to be investigated.

THE MODEL AND WIND TUNNEL

A 1/10 scale model of the Texas Tech Building was constructed from medium-density fibreboard, internally reinforced at the corners with timber members. The exterior surface was smooth and painted with a matt acrylic paint. Stainless steel pressure tappings were installed at positions corresponding to measurement positions provided on the full-scale building [1]. The internal diameter of the pressure tappings of 0.8 mm, matched exactly the full scale pressure tapping diameter at the scale of 1/10. Pressures were measured with 800 mm long lengths of vinyl tubing of 1.5 mm internal diameter connected to 'Scanivalves' with externally mounted Honeywell pressure sensors. This system, when combined with an analogue low-pass filter gave a near-flat amplitude frequency response up to about 30 Hertz. The system matched quite well, at a frequency scaling of 10:1, the full-scale frequency response in the M01 and M04 modes [1], in which data was sampled at 10 Hertz.

The results described in this paper were obtained from tests carried out in 1995 in the upper environmental working section of the large closed-circuit Wind Tunnel at Monash University. Preliminary tests to establish the instrumentation system and measurement procedure were carried out, in late 1994, in the open jet working section in the lower part of the same wind tunnel. The upper section is 12 metres wide, 4 metres high and 40 metres long, and the wind tunnel is powered by two axial flow, variable speed fans mounted in parallel, and with a maximum combined power consumption of 1 MW. At the height of the model, the mean wind speed during these tests was about 9 m/s, giving a Reynolds Number based on the model height, of about 2.5×10^5. A simulated atmospheric boundary layer was generated by strips of steel channel section laid across the wind tunnel section normal to the flow. The mean velocity and longitudinal turbulence intensity profiles at the centre of the test section are shown in Figure 1. The mean velocity profile indicates a roughness length of around 0.02 mm, i.e. equivalent to 0.2 mm in full scale. This is just below the range obtained in the full-scale tests [2,4]. The turbulence intensity of 0.22 at the height of the top of the building model (0.4 m) is, however, well within the range of the full-scale data.

Measurements were carried for 89 measurement points for wind directions in the quadrant from 180 to 270 degrees. Data was sampled at 1000 Hertz for 100 seconds for each direction. Pressure coefficients were corrected with respect to the mean dynamic pressure at the top of the model (0.4 m.), and were measured with reference to a floor static pressure plate located 2.3 metres from the centre of the model at a position equivalent to the full-scale pressure 'box' [1].

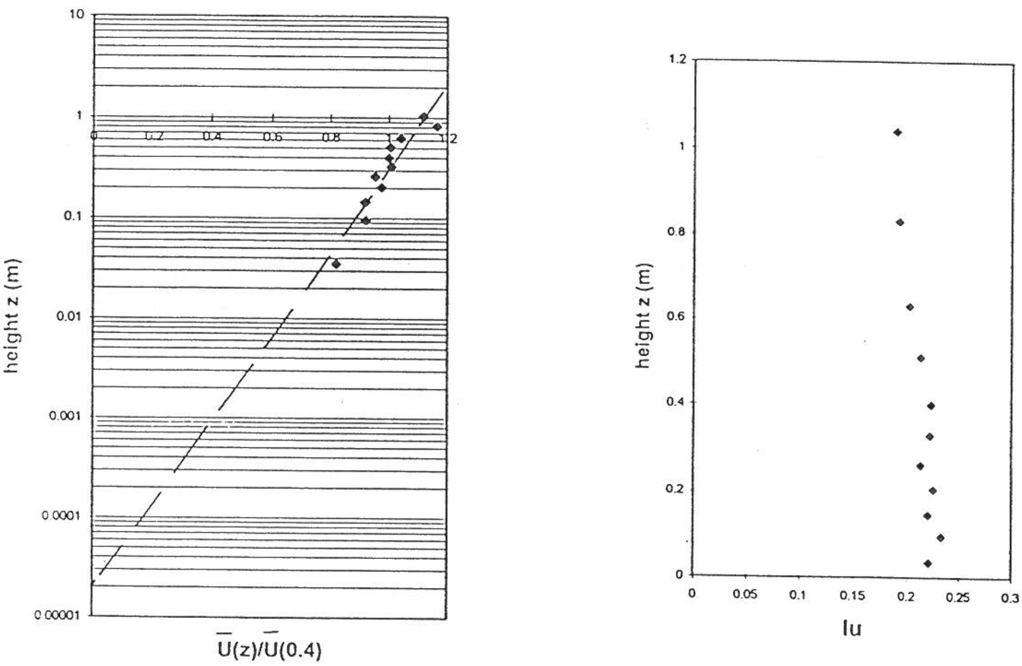

Figure 1. Mean velocity and turbulence intensity profiles.

RESULTS

Two pressure tappings for which small scale wind-tunnel model tests significantly under-predicted the full-scale r.m.s. and peak negative pressures [5], are designated 50101 and 50501 in the field experiments. These tappings are located near the corner of the roof [1], and the discrepancies occurred for a narrow range of mean wind directions (200–250 degrees) for which the wind blows obliquely on to this corner. These directions are associated with the intermittent formation of conical vortices along the edges of the roof at the corner.

The results for these two tappings for the present 1/10 scale tests are plotted in Figures 2–5 and compared with the full-scale (M04) data. The mean and minimum peak pressure coefficients are shown together in Figures 2 and 4, and the r.m.s. fluctuating pressure coefficients are shown in Figures 3 and 5. The peak values are single measured peaks recorded in a 100 second sample time in the wind tunnel, equivalent to approximately 15 minutes in full scale; thus these values are directly comparable with the full-scale values.

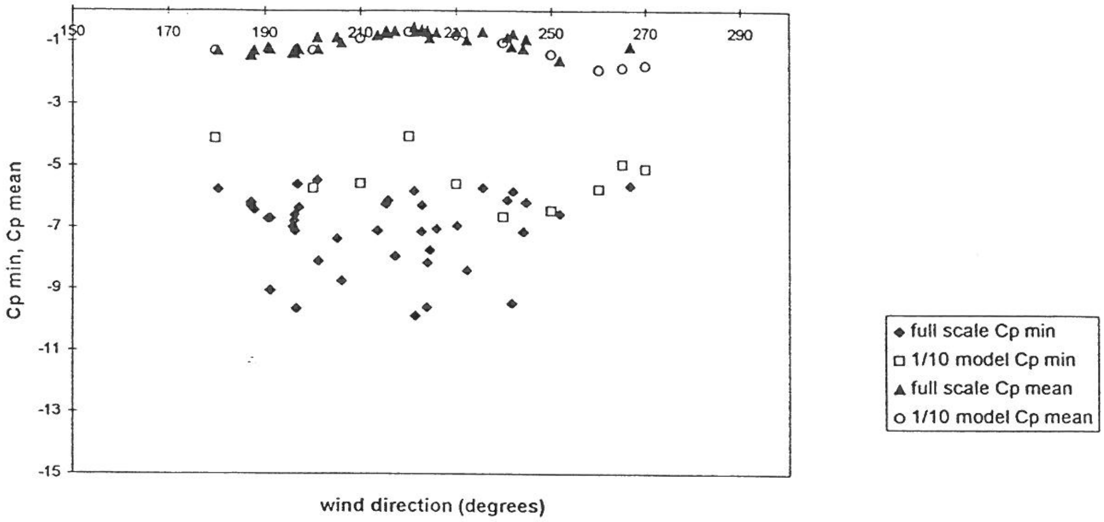

Figure 2. Mean and minimum pressure coefficients – Tap 50101.

The mean and r.m.s. pressure coefficients show excellent agreement with the full-scale values for both pressure tappings. In the case of tap 50501, mean coefficients with magnitudes greater than –2, and r.m.s. coefficients greater than 1 were recorded in both model and full-scale for a large range of wind directions.

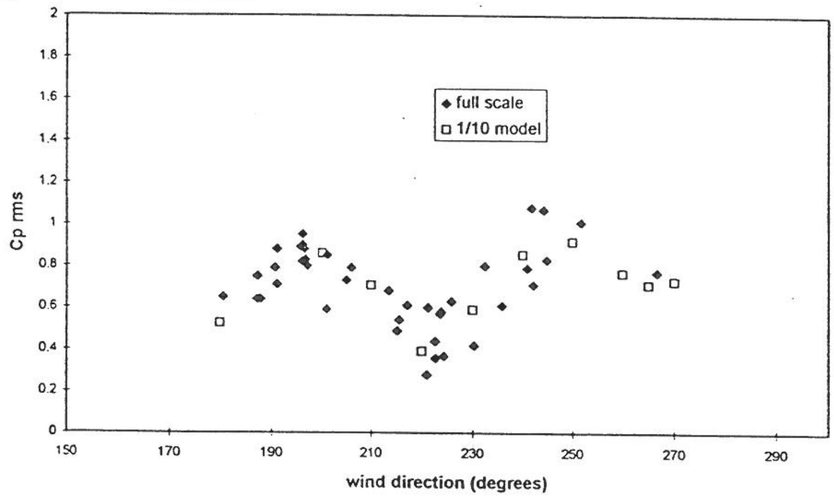

Figure 3. R.m.s. fluctuating pressure coefficients – Tap 50101.

Disregarding the inevitable sampling error which occurs when a single recorded peak is used, the comparison between the model and full-scale minimum pressure coefficients (Figures 2 and 4) is also good. The 1/10 model peak values are on average about 20% less than the corresponding full-scale values. However, the gap between the 1/100 scale results and full scale reported by Cochran and Cermak [5], and others, was much larger. Apparently, the larger Reynolds Number used in the present tests, although still less than the full scale value by a factor of 10, enables the small scales of turbulence in the corner vortex regions to be generated. These scales may contribute significantly to the magnitude of the peak pressures. Another paper [6] will discuss the effect of length scales in the approach turbulence on roof pressures on the Texas Tech building.

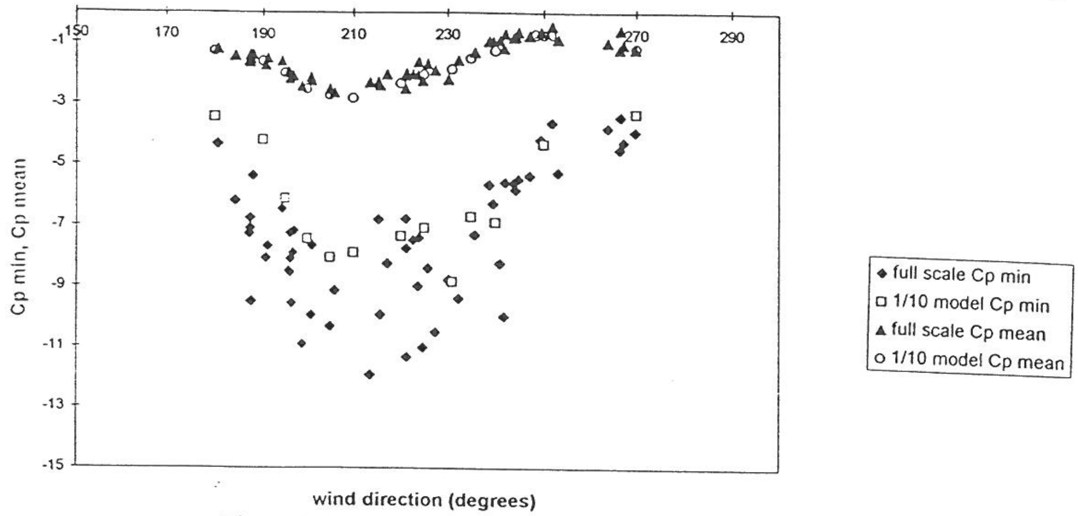

Figure 4. Mean and minimum pressure coefficients –Tap 50501.

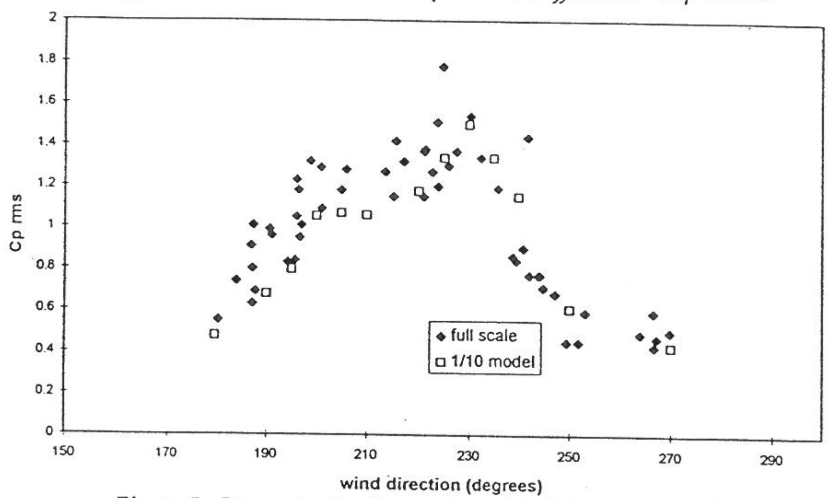

Figure 5. R.m.s. fluctuating pressure coefficients – Tap 50501.

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