COMPARATIVE STUDY OF THE TEXAS TECH BUILDING

A.W. Rofail

Windtech Wind Engineers, Sydney.

The recently established Texas Tech University (TTU) Experimental Building, has been established to facilitate the collection of comprehensive directional full-scale data. Significant full-scale data has already been accumulated by Leighton Cochran of Colorado State University (CSU). This present study presents a comparison between the model-scale measurements in Windtech's boundary layer wind tunnel and full-scale measurements, as well as model-scale measurements at CSU. Wind tunnel data obtained by Windtech was found to be in good agreement with full-scale data. This paper attempts to explain the reason for the good agreement.

MODELLING OF THE TTU BUILDING

This building is essentially a rectangular prism and has dimensions 30 x 45 x 13 ft. (9.1 x 13.7 x 4.0 m). A description of the TTU Experimental building was given by Levitan and Mehta (1992). Model scales of 1:100 and 1:50 were tested in Windtech's boundary layer wind tunnel.

The wind structure modeled in the wind tunnel was based on the AS170.2-1989 definition of a wind structure for a category 2 (open country) terrain. The line of the mean velocity profile, as estimated by AS1170.2-1989 is approximately equivalent to a power- law exponent of 0.15. This is considered the equivalent of the local wind structure as described by Levitan and Mehta (1992). The longitudinal turbulance profiles were also closely matched.

The normalised power spectral density function for wind speed at the full-scale height of 10 m, at 1:50 scale, matched an integral length scale of 40m. The CSU wind model is reported to have an integral length scale of 60 m at a 10 m height. (Cermak and Cochran, 1991). The corresponding full-scale value was approximately 100m.

A sample length equivalent to 30 minutes in full-scale time was used for both model scales.

DATA ACQUISITION AND ANALYSIS

Three pressure tap locations were selected for this comparative study. These are considered representative of the various types of pressure signals (i.e., windward, leeward and separated and reattached flows). The tap locations measured were 50101, 50209 and 42206. The location of these taps is described in Figure 1, below.

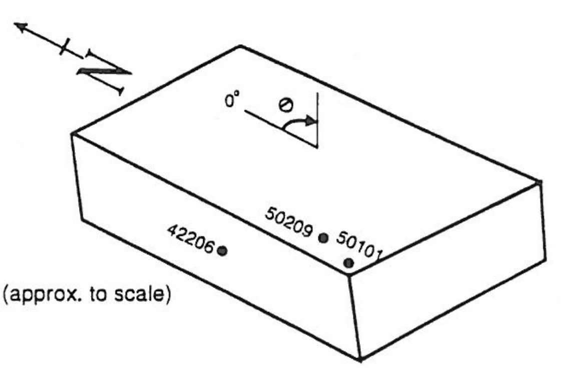

Figure 1: Locations of pressure taps on the TTU model.

The pressure measurement system was based on the leak tube system and was calibrated by using the method reported by Holmes and Lewis (1987). The pressure measurement system had a flat response (to within 11 percent) to 295 Hz. No resonant peaks were detected beyond that range. The signal was low pass filtered at 400 Hz and sampled at 1000 Hz. For the 1:100 scale model, these frequencies correspond to full-scale values of 4 Hz and 10 Hz, respectively. These match exactly with the actual full-scale situation, as reported by Cochran et al (1992).

Peak pressures were analysed using the standard Upcrossing technique. In this method the number of crossings by the pressure signal are registered at the various pressure levels and are fitted to a Poisson function, which permits a linear distribution. Fisher Tippet Type I parameters are derived from the line of best fit and a statistical extreme value is obtained by the following relationship;

Extreme Value = U + 0.5772/a

Where U and 1/a are the mode and dispersion of the Upcrossing distribution, respectively and 0.5772 is the Euler constant.

Results are presented in the form of pressure coefficients. A pressure coefficient is defined as the ratio of the local point pressure to the mean velocity pressure at the building height.

RESULTS AND CONCLUSIONS

The 1:100 scale model data by Windtech and CSU are compared with full-scale measurements in Figure 2. Figure 3 presents a comparison between Windtech's 1:100 and 1:50 model scale data.

The mean pressure coefficient data are generally in good agreement with the full-scale data for both the Windtech and CSU results.

Windtech's rms pressure coefficients as well as the peak pressure measurements are in very good agreement with full-scale data. Generally, peak pressure coefficients are generally within 10 percent of full-scale data. The only exception to the above are the peak negative pressures from tap 50101 and between azimuths of 200 and 245 degrees, where Windtech's results under-estimate the full- scale data by approximately 25 percent. This is a significant improvement over the CSU results.

Although the Upcrossing method may have some advantages in terms of repeatability of results, the statistical extremes derived from this method are unlikely to be the cause for the large variation between the Windtech and CSU results. A comparative study by Rofail and Kwok (1992) found that the various methods of analysis had a negligible effect on the peak pressures.For the 1:100 scale tests, both Windtech and CSU results are based on a velocity ratio of 1:1. This eliminates the possibility of a Reynolds Number effect. The sampling frequency of the CSU data was 1800 Hz and therefore is not the cause for the discrepancy. The modeling of the wind velocity and turbulance profiles as well as the wind spectra have been has been discussed and generally indicate that the variation between wind tunnel and full-scale is generally acceptable, particularly since the TTU is a low-rise building.

The only test parameter which remains is the difference is the frequency response of the pressure measurement system and the low- pass filtering frequency between the Windtech and the CSU setup. As reported above, the frequency response of Windtech's pressure measurement system was within $\pm$11 percent upto 295 Hz, with no resonant peaks beyond this range. In addition, there was no significant attenuation upto 400 Hz. The signal was low-pass filtered by a HP3561A Real-Time Signal Analyser at 400 Hz. This compares with 250 Hz, in the CSU case.

Recent work reported by Letchford et al (1992, Figure 8) indicates that for separated flows, a definite relationship exists between the Reduced Velocity and the attenuation of the maximum peak pressures, even at high cut-off frequencies. The reduced velocity is defined as the velocity at reference height divided by the smaller horizontal dimension and the cut-off frequency.

In the case of the TTU model data obtained by Windtech, for areas of separated flow, the setup for the 1:50 scale and 1:100 model data would result in minimum peak response ratios of 0.97 and 0.85, respectively. The corresponding figure for the CSU 1:100 scale model setup would be 0.73, indicating considerably higher attenuation of the maximum peaks in cases of separated flow (such as obtained from tap 50101 between azimuths 200 to 245 degrees). This trend matches closely with that predicted by Letchford et al (1992).

A study by Bienkiewicz and Sun (1992) of the surface flow pattern for the above case confirms that this flow is separated flow. On the other hand, the effect at tap 50209 between the same wind azimuths is a result of secondary separation. A line of reattached flow runs from the windward corner between the two tap locations.

These levels of attenuation of peaks account for a large part (possibly half) of the difference between wind tunnel and full-scale results. Furthermore, the corresponding results for these three cases

The data presented above indicate that the frequency response of the pressure measurement system and the low-pass filtering frequency largely influence the accuracy of the TTU model-scale pressure data for peak pressures in areas of separated flow.

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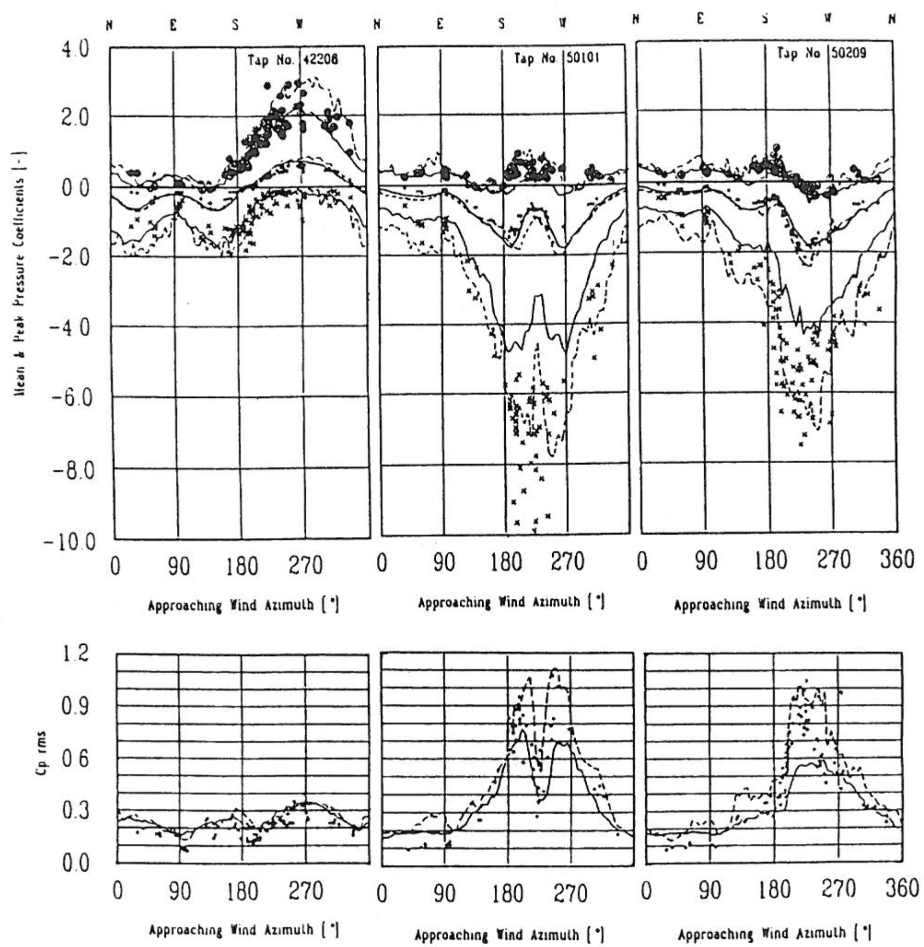
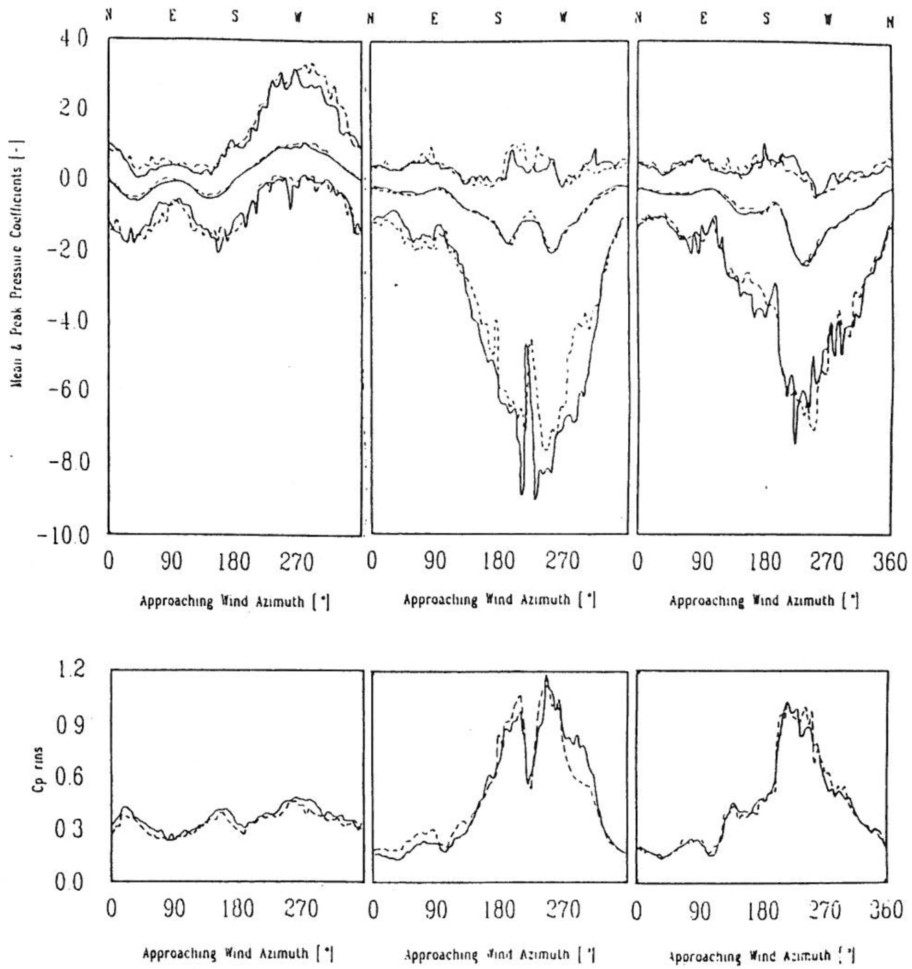


Legend: {symbols} Full-scale data
______ CSU 1:100 model scale data
\- - - - - - Windtech 1:100 model scale data

Figure 2: Comparison of TTU full-scale data with 1:100 scale model data by Windtech and CSU.



Legend: ______ Windtech 1:50 model scale data
\- - - - - Windtech 1:100 model scale data

Figure 3: Comparison between 1:100 scale and 1:50 scale data by Windtech.