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wind-induced loads & vibrations

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TECHNICAL BULLETIN ONE

Issue No. 1 March 1993

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Full-scale / model-scale comparisons of the wind pressures on the Texas Tech University Experimental Building

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One of the valid concerns held by structural engineers regarding wind tunnel testing is the reliability of pressure data obtained in the wind tunnel. Engineers need to know what level of confidence can be placed in wind tunnel test results. Ideally, the degree of reliability would be represented as a safety factor. With a high degree of reliability, a lower safety factor is required, facilitating the rationalisation of the structure, with possible cost benefits.

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Since 1982, a number of studies have been conducted to establish the reliability of the wind tunnel testing procedure. These included comparative studies between full-scale and model-scale data of wind pressures based on a reference buildings such as the Aylesbury or Silsoe Buildings.

Recently, Texas Tech University (TTU) set up an experimental building which is situated in a flat terrain with no obstructions in any direction. This building is built on a large turn- table, allowing it to be rotated to simulate different wind directions. The building's situation and manoeuvrability make it ideal for comparative studies with model scale tests. Significant full-scale data of the TTU building has already been accumulated by Leighton Cochran of Colorado State University (CSU).

WINDTECH has carried out a series of studies of wind pressures on scale models of the TTU building, in their boundary layer wind tunnel. This Bulletin presents the results of these studies compared with the TTU full- scale measurements, and CSU's model-scale measurements. The effect of the scale of the model is also discussed.

Modeling of the TTU Experimental 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 is given by Levitan and Mehta (1992).

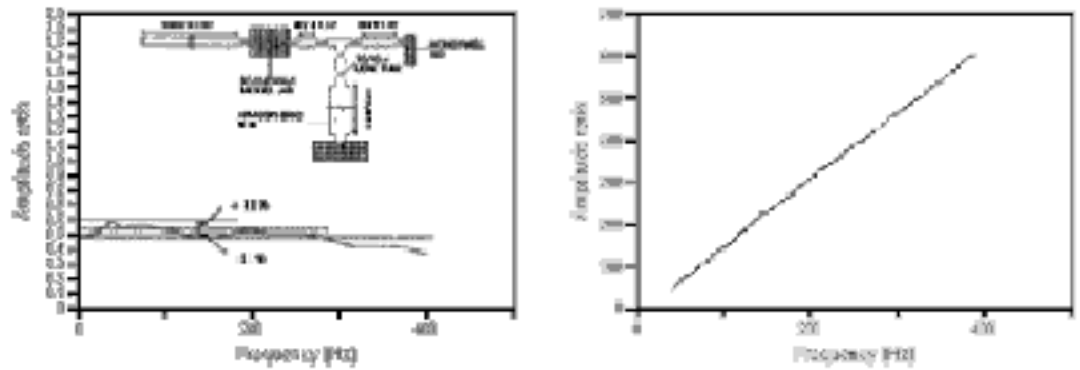
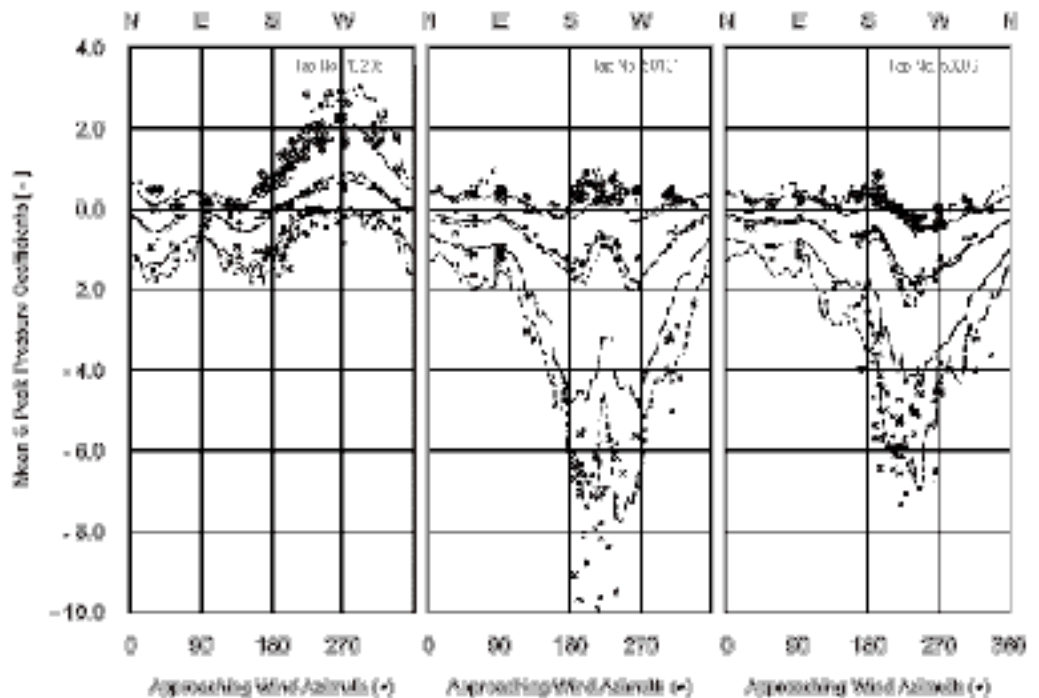


Figure 1 : Frequency response of the pressure measurement system.

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.

This is equivalent to the local wind structure. Model scales of 1:100 and 1:50 were tested in Windtech's boundary layer wind tunnel. The appropriate boundary layer flows were produced for the respective model scales using a combination of spires, tripboards and rough-ness blocks.

The velocity scale for the 1:50 scale model was 1:1.25 and 1:1 for the 1:100 scale model tests. The sample length used to test the respective models is determined by the time scale, which is a function of the velocity and length scales. A sample length of 30 seconds was used to test the 1:50 scale model and 18 seconds for the 1:100 scale model. These two respective time periods correspond to 30 minutes sampling time in full-scale.



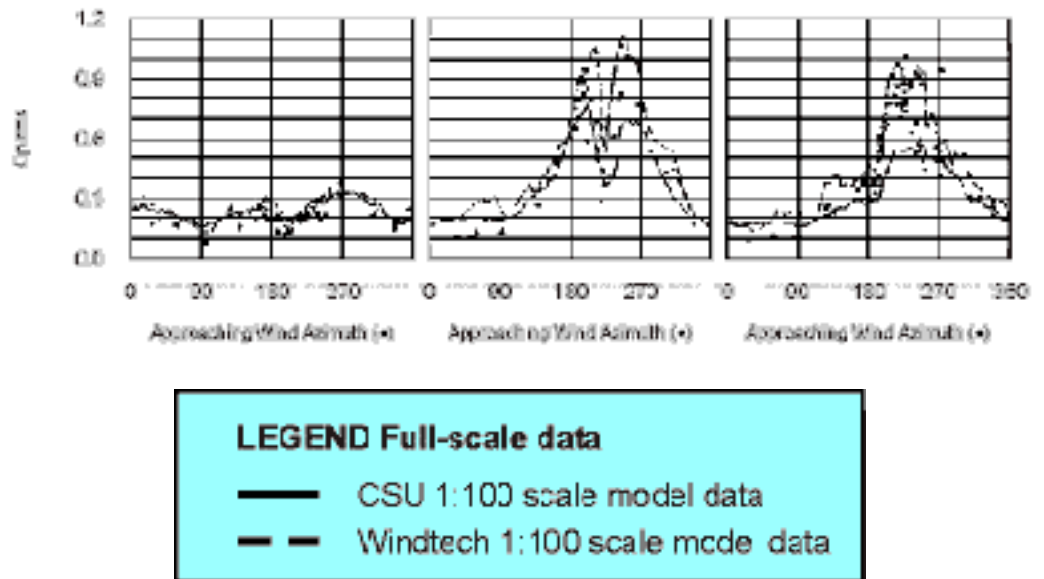


Figure 2 : Comparison of TTU full-scale data with 1:100 scale model data by Windtech and CSU

Data Acquisition and Analysis

The pressure taps on the TTU building have a universal and systematic classification. Three pressure tap locations were selected for this comparative study. The tap numbers are 50101, 50209 and 40226. Tap number 50101 is located at a corner of the roof, at a distance of 0.305 m from either wall. Tap number 50209 is located near the edge the longer side of the roof, 0.61 m away from the longer wall and 2.7 m from the shorter wall. Tap number 40226 is located at the centre of one of the longer walls. These tap locations are considered representative of the various types of pressure signals.

The pressure measurement system used vinyl tubing to connect the tap locations to a Type J48 Scanivalve pressure scanning switch. This system is based on the leak tube arrangement, which was able to eliminate all resonant frequencies, with a uniform response up to 295Hz. Calibration was by the CSIRO in Melbourne.

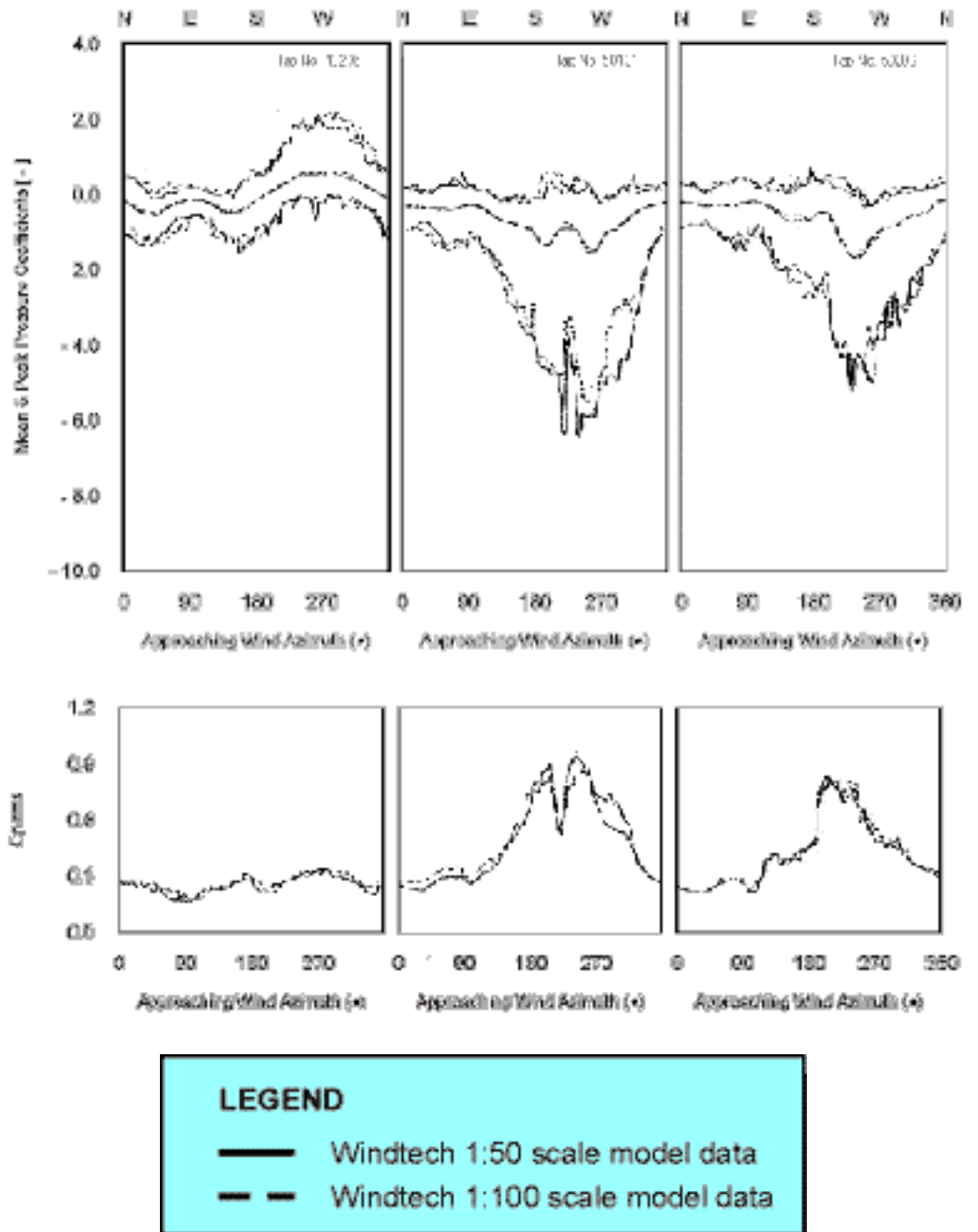


Figure 3 : Comparison of 1:100 scale and 1:50 scale data by Windtech

The pressure scanning switches are connected to Honeywell 163 pressure sensors. Figure 2 shows the frequency response of the pressure measurement system used for this study.

The pressure signal was digitised using a Hewlett Packard 3561A Narrow Band Real Time Analyser. 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 and Cermak (1992).

Peak pressures were analysed using the standard Upcrossing technique. Research

has shown that the peak pressures obtained using this technique are more repeatable than simply adopting the extreme peak value. This technique has been found to provide highly reliable results for sample lengths of 30 minutes duration or more.

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 roof height.

The Effect of Scaling

Figure 3 illustrates the difference between WINDTECH's 1:100 scale and 1:50 scale model data. With a minor exception, all results are very close. This implies that the model scale data is not greatly affected by scaling. Results also confirm that the effect of Reynold's number (which is a function of scale) is not critical in the modeling of wind flows around straight- edged buildings.

Conclusions

In this study, it was possible to confirm the accuracy of WINDTECH's pressure measurement system. It can also be said that WINDTECH's model scale data replicate the full-scale data better than any other data published to date.

Comparison of 1:100 scale and 1:50 scale measurements indicate that the effect of scale is not significant.

A more detailed comparative study is currently being carried out. This study will concentrate on the modeling of pressures near the roof corner and at various wall locations.

References

Levitan, Marc L. and Mehta, Kishor C., 1992, "*Texas Tech field experiments for wind loads, Part 1: building and pressure measuring system*", Journal of Wind Engineering and Industrial Aerodynamics, vo1.43, pp.1565-1576.

Cochran, L.S. and Cermak, J.E., 1992, "*Full- and model-scale cladding pressures on the Texas Tech University experimental building*", Journal of Wind Engineering and Industrial Aerodynamics, vo1.43, pp.1589-1600.



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