



PRESSURE-VELOCITY CORRELATION STUDY ON 1: 50 SCALE MODEL OF THE TTU WIND ENGINEERING RESEARCH FIELD LAB BUILDING

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ABSTRACT

In order to more fully understand the relationship between the incident wind velocity and surface pressures acting on a low-rise structure, an experimental study is being conducted in the LSU Wind Tunnel Laboratory at Louisiana State University. Correlations of simultaneously acquired flow and surface pressure measurements will be investigated. Results of this study will be compared with similar analysis of full-scale data from the Wind Engineering Research Field Laboratory (WERFL) at Texas Tech University.

The WERFL is a unique facility for obtaining full-scale pressure measurement on low-rise buildings, a detailed description of which is given by Levitan and Mehta [1]. Full-scale pressure coefficients (C_{pmean} , C_{ppeak} and C_{prms}) on the mid-plane and roof corner from data obtained at WERFL were reported by Levitan et al. [2] and Mehta et al. [3], respectively. Wind tunnel studies have been carried out at many laboratories over different geometrical scale models ranging from as large as 1:10 to as small as 1:100 [e.g., 4-5]. In general, mean pressure coefficients obtained from these model-scale studies are in good agreement with the full-scale data. Many of the wind tunnel studies were not able to accurately replicate rms and peak pressure coefficients for all pressure tap locations.

Wind loads on structures are often described in terms of a quasi-steady theory. A full-scale study was done by Letchford [6] to examine the pressure-velocity cross correlation in order to evaluate the performance of the quasi-steady theory. Although the theory is found not to be valid in separated flow regions (mid -plane region), significantly high cross-correlations have been observed between the upstream

velocity fluctuations and point pressures adjacent to the separation line. The current experimental study has the goals of determining if Letchford's full-scale observations will also be found in a wind tunnel simulation of the same building, and to further investigate the nature of the relationship between upstream velocities and surface pressures at different points on the building.

The boundary layer wind tunnel at Louisiana State University is an open circuit, suck-down tunnel, with a 1.32 m wide by 1 m tall by 2.5 m long test section. The upwind boundary layer development section is comparatively short 4.88 m long. Carpet, spires and trip fences were used to create an appropriately scaled down simulation of the full-scale atmospheric surface (boundary) layer at WERFL. The mean wind tunnel velocity at one roof height was around 10 m/s and the longitudinal turbulence intensity was 18 %. Mean velocity and turbulence intensity profiles were measured using single hot-film probes with a TSI Constant Temperature Anemometry system (IFA-300). The mean vertical velocity profile and turbulence intensity profile matched reasonably well between the simulation and the field data as shown in Fig. 1 and Fig. 2 respectively. Longitudinal integral scale (0.4 m) in the simulation was deficient by a factor of approximately five compared to full-scale data (2 m), a characteristic typically not matched in wind tunnel studies. The "Taylor" time scale and micro-timescales were 0.04s and 0.005s respectively at one building height.

A 1:50 scale geometrical model of the WERFL building (having full-scale dimensions of 9.1 m by 13.7 m by 4 m high) was constructed of plexiglas. It was furnished with pressure taps of 1.58 mm in diameter. The positions of selected taps were

determined from the field information provided by Levitan et al [1, 2]. The reference velocity and the static pressure were monitored using pitot static tube mounted at the roof height of the building model. Local velocity was measured using a Constant Temperature Anemometry System with an appropriately calibrated hot-film probe. The pressure was measured using a 16-channel Scanivalve pressure measuring system via short tubing with restrictors. The frequency response characteristics of the pressure measuring system were nearly flat in gain and linear in phase delay up to 100hz. This setup was used to measure the pressure time histories at taps located along the mid-plane section and the roof corner region of the model. The simultaneous velocity and pressure measurement from the hot-wire system and the Scanivalve system is made possible by triggering the two systems simultaneously with the aid of a Lab View virtual instrument.

A series of tests are currently being conducted in which cross-correlations between the longitudinal component of wind velocity (at various locations upwind of the building model) and the surface pressure along the mid-plane section and roof corner region of the model will be studied. The hot-film probe measuring the velocity fluctuations is mounted 87 cm upstream from the center of the model, and at model roof height. This corresponds with the location of the roof height anemometer mounted on the meteorological tower at the WERFL, for winds coming from the west. Results of the model tests will be compared with similar analysis of field measurements reported by Letchford [6]. Raw data

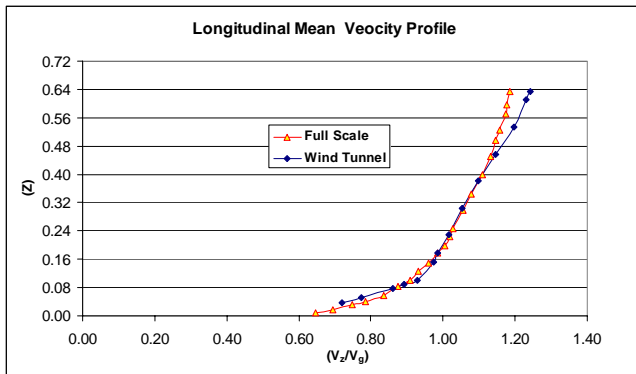


Fig. 1 Longitudinal Mean Velocity Profile

for several additional runs where the meteorological tower was directly upwind of the building has been

supplied by Texas Tech University. The wind-surface pressure correlations will also be analyzed for this dataset and compared to wind tunnel results.

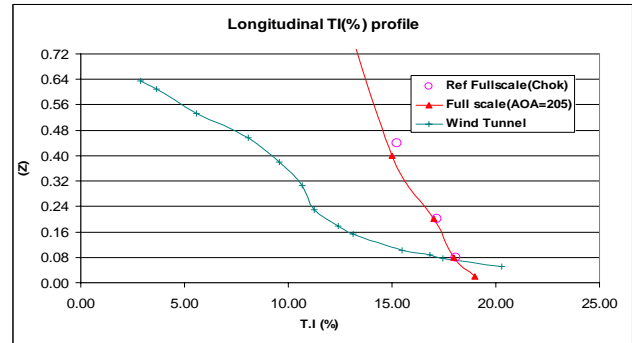


Fig. 2 Longitudinal Turbulence Intensity (TI) profile

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