**Wind Engineering Research at Texas Tech University**

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## Abstract

A multi-disciplinary, multi-million dollar wind engineering research program is underway at Texas Tech University. This paper gives an overview of some of these research activities, including, full-scale studies of the effect of change of terrain on velocity profiles, using a C-130 Hercules to generate destructive winds over a mobile home, and damage documentation from the Fort Worth Tornado of 28 March 2000.

## Change of Terrain experiments

From March to May of 2000, a series of experiments were conducted in Lubbock, TX to examine the effect of change of terrain on wind profiles. The existing 50m WERFL tower together with two mobile WEMITE towers, extended to 15m, were deployed across a transition from single story suburban to open fields. Wind speed measurements at 5 heights (2, 4, 6, 10 & 15m) on the WEMITE towers, with the uppermost being a sonic anemometer, were collected. Profile parameters (d, $z_o$, and $u_*$) in each exposure were estimated from analytical methods and compared with field measurements. The effect of change of terrain was clearly evident in the profiles and a comparison was made with several existing models for calculating this effect, including the AS1170 model.

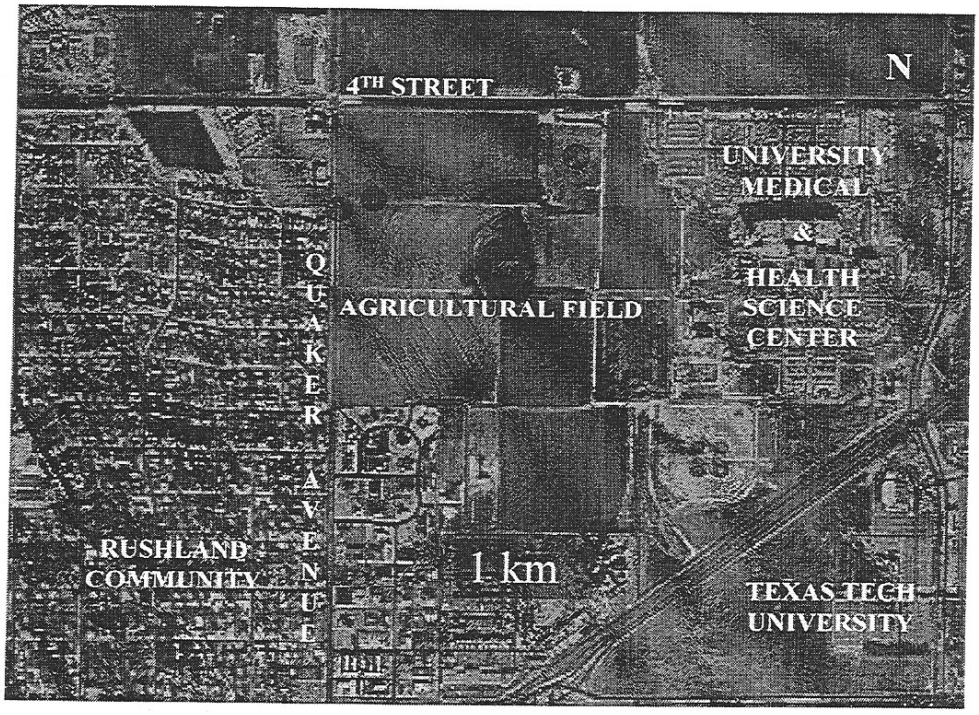


Figure 1. Experimental setup across terrain change in Lubbock, TX

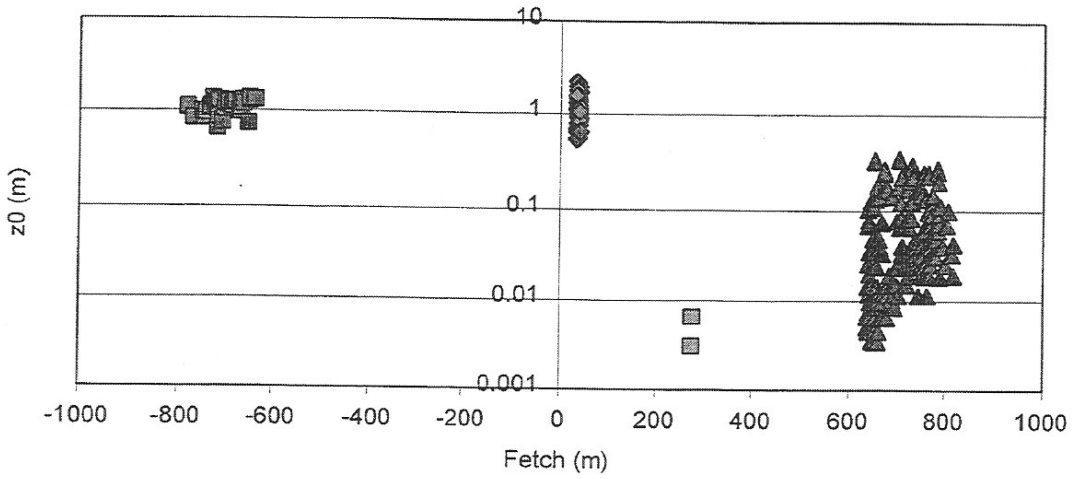


Figure 2. Profile calculated $z_o$ values across the change of terrain.

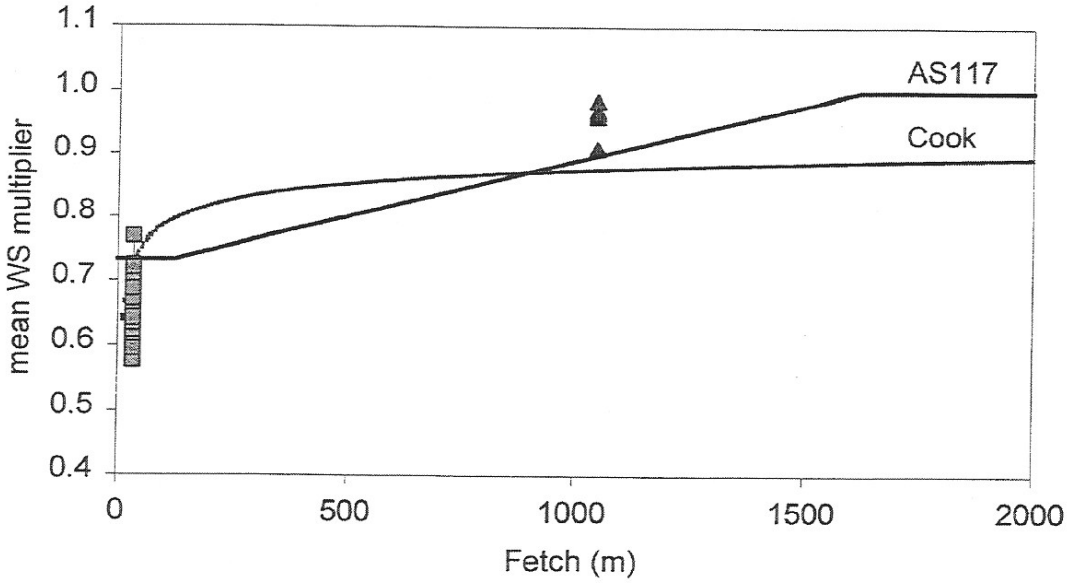


Figure 3. Mean wind speed multiplier for rough to smooth transition.

These preliminary results indicate that the change in mean speed for a rough to smooth transition has largely occurred for fetches beyond 1000m and that the AS1170.2 model appears to be more representative than the Cook model which requires a much longer fetch to reach equilibrium. The gust speed results were more scattered but clearly showed that equilibrium conditions are approached much more quickly for turbulence than for means.

## C130 Hercules experiment

In an effort to examine the ultimate behaviour of structures under controlled strong winds an experiment was undertaken at Texas Tech University in which a mobile home was subjected to the wash from a C130 Hercules aircraft. In a preliminary study, the wash from this large 4 turbo-prop engine aircraft was documented. A region of approximately uniform flow some 20m wide and 5m high from 30-40m downstream of the propellers was found. The maximum mean speeds reached were 110km/h (73mph) with gusts to ~150km/h (92mph) in an ambient wind of 8km/h. Longitudinal turbulence was somewhat suppressed in this uniform flow regime while lateral turbulence was severely reduced. Not unexpectedly the swirl from the 4 propellers lead to increased vertical turbulence. The correlation structure of the flow was also curtailed with most of the gust energy at high frequencies.

Subsequently, a mobile home, 18m (60ft) by 4.3m (14ft) and 3.7m (12ft) high was erected at Reese Airfield 16km west of Lubbock and a Hercules from the Texas Air National Guard flown in to conduct full scale tests to develop a testing protocol for such full scale tests. The mobile home was instrumented with some 20 pressure taps in two planes, centreline and adjacent to an end bay. Displacements were also measured at a number of locations within the home. Three anemometer towers with 2 levels of wind speed and direction instrumentation were strategically placed around the home. Over a two day period, the Hercules blew at the home from two wind directions, perpendicular to the long wall and the short wall respectively with a series of wind speeds ranging from just above ambient to gusts of approximately 160km/hr. Although structural loading information was of primary interest another component of the test was to examine the building permeability under strong wind conditions.

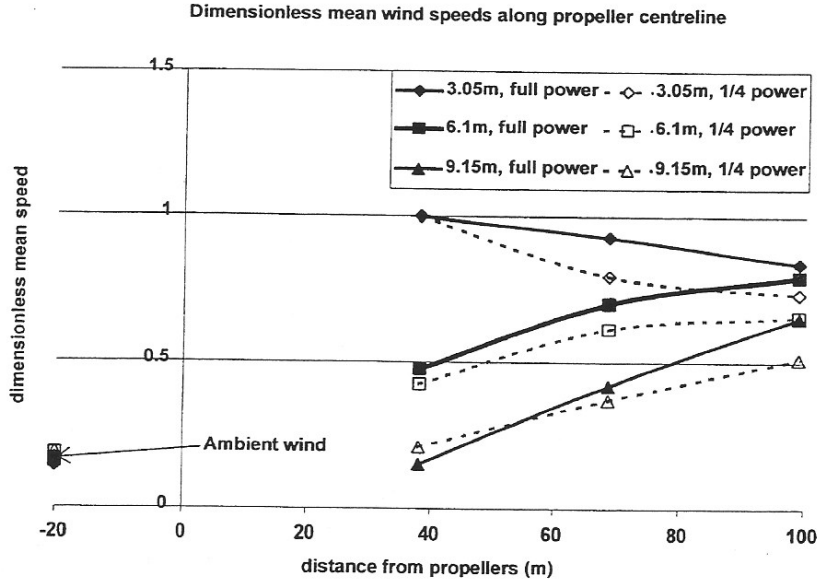


Figure 4. Variation of mean wind speed downwind of Hercules with speeds non-dimensionalized by 33m/s.

## Fort Worth Tornado

A tornado, designated as F2, passed through the downtown region of Fort Worth, Texas, in the early evening of Tuesday, March 28 2000. Severe damage to glass clad buildings in the downtown was reported. A second tornado from the same storm system touched down in Arlington some 15miles further east about 30 minutes later. A team from the Wind Science and Engineering Program at Texas Tech University spent two days conducting damage documentation and assessment on March 30 and 31.

Numerous buildings were damaged, accommodation complex's evacuated and electricity supply cut-off. Many areas of the downtown were closed for over a week as repair crews removed broken glass from high-rise buildings. The 6:30 timing of the event was fortuitous given that many of the office workers and shoppers had left the inner city for the day. Only one death can be attributed to actual structural failure that of a brick wall collapsing on a person sheltering behind.

Best estimates of *lower* bound wind speeds range from 80-100miles/hr in standard terrain at 10m height. It was anticipated that the wind speeds were not significantly greater than this, due to the relatively few buildings that suffered total collapse. Indeed, in terms of Fujita scale rating, there were few houses of good domestic construction that received F2 damage. Those engineered buildings that did suffer total structural failure have been assessed as having structural deficiencies rather than excessive wind speed leading to the failure.

Several low-rise buildings in the industrial area just to the west of the Trinity River suffered complete collapse and became significant sources of debris. This debris started a chain of destruction of the cladding and contents of the largely glass clad buildings that lay in the path of the tornado on its way through the downtown.

Breach of windward walls through debris impact in several builds lead to internal pressurization and subsequent failure of roofing and side-corner windows. This occurred on both low-rise buildings and on high-rise buildings. For the low-rise buildings, in one case an outer brick veneer wall was blown out while on another the complete roof system, deck and trusses was removed on a leading corner. In the case of the 35-story completely glass clad building over half of all windows were broken with many corner windows, despite the buildings' chamfers, broken. Despite this the internal partition wall forming a corridor around the lift core remained intact and became a pressure barrier.

### References

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