CORRELATION OF PEAK WIND LOADS AT BATTEN-TRUSS CONNECTIONS

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PEAK WIND LOADS ON BATTEN TO TRUSS CONNECTIONS ON A TYPICAL GABLE ROOF HOUSE WERE EXAMINED USING A 1/50 SCALE WIND TUNNEL STUDY. THE DISTRIBUTION OF PEAK LOADS FOR VARIOUS WIND DIRECTIONS WAS DETERMINED AND THE CROSS-CORRELATION OF LOAD TIME HISTORIES WERE CALCULATED TO SHOW THE TIMING OF PEAK LOADS AMONGST NEIGHBOURING CONNECTIONS.

BACKGROUND

Wind loads on roofs fluctuate significantly, both across their surfaces and in time. Whether neighbouring connections experience high loads at the same time determines if they too can be overloaded; potentially causing a progressive failure to initiate.

WIND TUNNEL STUDY

A 1/50 scale wind tunnel study was conducted to determine the correlations of these load fluctuations on batten to truss connections. Pressure time history data for 24 runs of 30 seconds model scale (10 minutes full scale) were recorded for each wind direction at 500Hz.

Depending on wind direction, loads at roof corners and edges experience the highest uplift loads. These loads are characterised by 'peak events' of load more than 3.5 standard deviations from the mean lasting about 0.5 to 2.0 seconds. Loads are highly fluctuating, and peak events can occur for several of these connections around the same time.

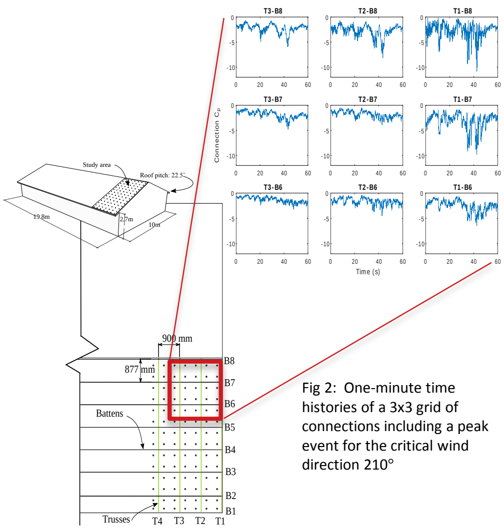

Fig 2: One-minute time histories of a 3x3 grid of connections including a peak event for the critical wind direction 210°

Fig 1: The 1/50 scale model in the Cyclone Testing Station boundary layer wind tunnel

CORRELATION OF SIGNALS

To assess the timing and correlation of these load histories, the correlation coefficient as a function of lag time (τ) of one signal relative to the other, or cross-correlation was determined:

$$r_{ij} = \frac{1}{T * \sigma_{pi} * \sigma_{pj}} \int_0^T p_i'(t) * p_j'(t+\tau)\, dt$$

Where,
p_i' and p_j' are the fluctuating components of the pressure at locations i and j.
σ_p is the standard deviation of fluctuating load
And T is the time over which the signal is analysed

The cross-correlation can be used to determined whether load fluctuations are experienced at the same time or if there is a lag between signals as negative pressures propagate across the roof surface. A peak in correlation at zero lag time indicates that the fluctuations occur at the same time. A peak at a negative lag time indicates that the fluctuation arrives at the location slightly later than at the critical connection.

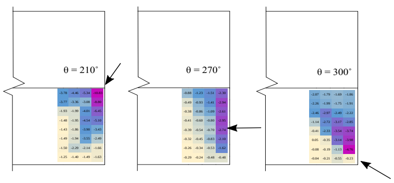

Fig 3: Individual time steps showing location of peak events occur for various wind directions

CONCLUSIONS

- Load histories between neighbouring connections are correlated and are sensitive to wind direction.
- Critical wind directions that cause the highest uplift loads are not necessarily those that experience the highest correlations amongst neighbouring connections.
- For different wind directions, loads at connections to the left, right or diagonally across from the critical connections are more correlated, suggesting that the path that a progressive failure takes is dependent on wind direction and the location on the roof where it initiates.

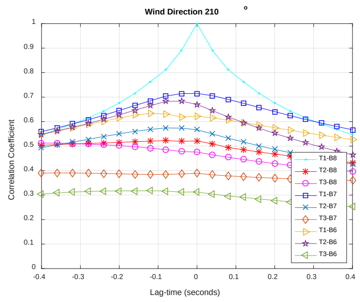

Fig 4: Cross-Correlation to connection T1-B8 for the critical wind direction 210°

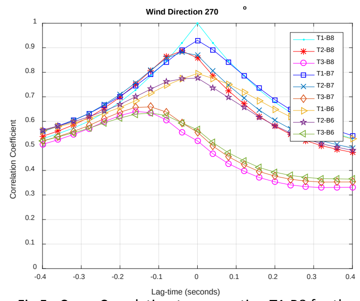

Fig 5: Cross-Correlation to connection T1-B8 for the wind direction 270°. Loads at neighbouring connections are more correlated than for direction 210°. Connections further along to roof experience these fluctuations about 0.1 seconds later

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