FULL SCALE HOUSE TESTS IN THE NATURAL WIND

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Introduction

This paper describes a project that is still very much within its formulation period. A number of practical considerations have given rise to the realisation that there is still a significant need for information on both the magnitude and dynamic characteristics of loads on structural connections within housing. Some roof sheeting and fastening methods currently approved for use in cyclone prone areas, having been subjected to cyclic load testing based on AS1170 Pt. 2 - 1981 and TR440 (Dept. of Construction) are ostensibly the same as methods that performed poorly in cyclone 'Tracy'. The concern was reinforced by observations of roof sheeting failures incorporating fatigue cracking observed in damage investigations following cyclone 'Kathy' (Boughton and Reardon 1984). Estimated maximum wind speed for this event was estimated at between 46 ms^{-1} and 52ms^{-1} corrected to 10 m height in Terrain Category 2. This gives maximum loads of approximately 67% of design loads.

Other concerns have been raised when trying to relate foundation failures experienced in the Cyclone Testing Station's house testing project with observed damage in tropical cyclones. These concerns suggest that current static and dynamic design loadings underestimate peak loads on fasteners carrying loads attracted by small areas and overestimate total loads on structures. However, these subjective judgements could not be regarded as adequate grounds for criticism of codes or wind tunnel derived results. Clearly some measurements of loads on full scale houses during high velocity winds will give some basis for comparison with wind tunnel studies and code requirements.

It is unfortunate that little reliable data was obtained from the Aylsbury experiments, and that most full scale experiments to date have been performed with incident wind speeds less than 30 ms^{-1}. The current proposal is that an Australian house be built in a location regularly subjected to high velocity winds and instrumented to monitor structural effects and wind data to use as a comparison with current design aids.

Purpose of Tests

It is proposed that the magnitude and frequency of forces on various structural elements be measured at different wind speeds and over long periods. These can then be related to wind speed and used in conjunction with anenomograph records of high wind events to compare with currently accepted cyclic load specifications.

The wind characteristics and topography would also be accurately documented to allow wind tunnel models of the test house to be evaluated and compared with experimental results. Internal pressure variations could also be simulated by incorporating window openings into the structure.

Location of Test House

In order to obtain a relatively large number of periods of record at high wind velocities, a location is required where gale force and higher wind velocities are regularly experienced. For this reason, the environs of Wellington, New Zealand is proposed as the test site. The relatively narrow Cook Strait between the North and South Island of New Zealand tends to funnel winds due to pressure differences between the Tasman Sea and southern Pacific Ocean. This causes regular high winds in the Wellington area. Typically Wellington has 33 days per year when the wind gust velocity is 27 ms^{-1} or more. By locating the house on a flat topped hill near the town, the Jackson Hunt relationship (Reid 1983) indicates this velocity could increase to 35 ms^{-1}.

This will give frequent high velocity winds and also a location close to a research establishment that is prepared to co-operate in the experiments. Scientists at the Building Research Association of New Zealand in Wellington have indicated support for the proposal.

Anemometry

There are quite a number of issues here with which help in determining parameters would be appreciated.

(i) Frequency of Measurement: Because digital data storage will be used, the frequency of measurement could prove quite crucial. After discussions with Mr Hawkins of CSIRO on his experience with measurements on 1/3 scale buildings, 50 Hz has been chosen. Higher frequencies could affect the choice of instrumentation for the project.

(ii) Duration of Continuous Measurement: This parameter determines the amount of RAM required for the data aquisition system. Based on 50 Hz readings with 8 channels per microprocessor, 64 k of RAM gives 150 seconds of reading. 16 channels gives 75 seconds and considerable savings in instrumentation costs.

(iii) Type of anemometer: A hot film anemometer may be too fragile for use in outside conditions, and cup and related mechanical devices do not have quick enough response times to monitor small scale turbulence. Assistance in choosing suitable types of anemometers is therefore requested.

(iv) Anemometer placement: At present, the following locations are proposed. By placing instruments on an adjacent tower at heights of 30, 20 and 10 metres, an estimate of the wind profile can be obtained. Free standing anemometers at eaves height adjacent to but clear of the structure and 3 velocity transducers actually on the eaves will give an indication of the wind velocities incident on the house. It is recognised that the eaves mounted devices will return speeds influenced by the aerodynamics of the structure, but it is hoped that they will enable correlations to be made between wind speed at the structure and forces on it.

(v) Importance of "standard" boundary layer simulation: While every effort will be made in selecting and/or modifying a site to produce terrain category two boundary layer conditions, it is recognised that a perfect matching may not be realised. Given that the vertical profile, turbulence spectrum, wind velocity and direction and topography can be accurately recorded, what will be the effect of an incorrect vertical profile of velocities, turbulence scale, or roughness simulation?

Response Measurement

At present, it is planned to monitor structural response using strain gauged fasteners that have stiffnesses comparable with the conventional fasteners in the structure. Laboratory tests will be performed to calibrate these fasteners and determine the extent to which structural load sharing effects make the forces recorded different from the actual loads on the structure. Using the fastener instrumentation, the actual fastener loads for the structure can be determined fairly cheaply. Using this system 20 roof sheeting fasteners, 20 batten fasteners and 24 truss tie down details could be monitored. A similar system could be used to determine total uplift at the base of the walls. In monitoring vertical panel loads, six 3 m x 2.4 m wall panels, and six various window sized panels could be instrumented, with load cells giving the total lateral force on the house. Considerable development is needed in this area, and it is anticipated that a full year will be required to produce and test suitable load cells for all locations. Together with the wind speed monitoring equipment, this will give a total of about 100 instruments to monitor at any given time.

Instrumentation

At present it is proposed to use a two level microprocessor data aquisition and storage system. The first level will provide a power supply for each instrument and independent amplifiers which will allow the range of each to be set. 8 or 16 such conditioners will be incorporated into a single unit which will house a microprocessor, analog to digital converter and 64 k of RAM. These units will provide buffered data storage for 150 seconds or 75 seconds or record.

These first level systems will be connected via parallel data transfer busses to the second level microprocessor system that triggers each of the first level units to read every 1/50th of a second and when each 64 k storage buffer is full, down loads all the information from the first level units to be stored on hard disk. The down loading may take 2 or 3 seconds, so that the hour or so of record obtained, would consist of 75 or 150 second continuous records separated by 2 or 3 second gaps.

The instrumentation could be activated when the velocity at eaves height reached a certain trigger level, and by using multiple hard disk packs, many hours of sampling could be achieved.

Analysis of Results

In order to free the hard disks for further data aquisition, it is proposed that once full they are removed from the house and the data transferred to a mainframe computer in Wellington. There the velocity data would first be analysed and checked for consistency of gustiness and direction. Any that do not appear conducive to further analysis could be discarded, and then further analysis performed to reduce the quantity of information performed, and present preliminary findings immediately. This will enable faulty instruments to be located and fixed, and any other experimental modifications deemed necessary, effected.

Closing

This brief paper broadly outlines a project that has been proposed for possible implementation over a three year period. At present the project is undergoing evaluation for technical feasibility and desirability. If that is proved then it will undergo technical development studies and be accurately costed. After that funds will be sought for its implementation and construction will commence.

References

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