WIND ENGINEERING RESEARCH AT WORKS CENTRAL LABORATORIES

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INTRODUCTION

Works and Development Services Corporation (NZ) Ltd, or WORKS, came into being on 1 April 1988, having being created from the previous Ministry of Works and Development. Central Laboratories is a branch of WORKS, in which the work performed by the Aerodynamics Section includes research in wind engineering and the operation of a boundary layer wind tunnel. The following is a brief summary of the wind engineering research which we have performed since 1988. It is convenient to subdivide the work into several general areas of research.

PEDESTRIAN WIND COMFORT

"The Wind Environment in Wellington City - Full Scale Measurements and Comparisons With Wind Tunnel Tests"

A variety of wind speed recordings were obtained in the streets of Wellington on windy days, and subsequently compared with the equivalent wind tunnel measurements. There was good agreement between the full-scale and wind tunnel data, and the results provided useful evidence of actual conditions and the typical relationships between mean, r.m.s. and maximum gust speeds.

"Investigation of Measures Available for Improving Ground Level Wind Conditions Around Buildings"

Wind tunnel tests were performed on a 60 m high cubic building sited in a representative city model consisting of regularly spaced 30 m high city blocks. The effects of a wide variety of architectural modifications on the wind speeds in the streets were examined. Some notable observations included the large deterioration in wind conditions produced by a taller tower, and the mixed effects (speed increases and decreases) produced by a tower and podium design. This research is continuing this year.

"Wind Speed Comfort Criteria for Pedestrians"

Various published papers, and our own experiences, indicate that the 3-second gust criteria which we have used previously are not entirely adequate. So-called "effective" wind speeds, calculated from measurements of the mean speeds and turbulence, were found to be more appropriate. Also the proposed criteria vary depending on the density of pedestrian traffic, and whether pedestrian usage (e.g. of a park) is a matter of personal choice.

LOCAL WIND PRESSURES ON BUILDINGS AND STRUCTURES

"Review of Full Scale Wind Pressure Measurements on Buildings"

A literature survey of studies on full-scale pressure measurements was carried out, and several case studies were selected for detailed evaluation. Codified pressure coefficients were found to be suitably conservative for rectangular high rise buildings, in comparison with the full-scale measurements. For low-rise buildings, some substantial discrepancies were found between code values and the available full-scale data.

"Wind Induced Pressures on Low Rise Building - Review of the Draft New Zealand Wind Loading Code"

This study derived from the one above. It included a literature review of more recent full-scale pressure measurements on low rise buildings, and also wind tunnel test results. The new wind loading code pressure coefficients were found to be reasonably conservative. Topics found to require further work include the duration of high suctions, the choice of code values from full-scale or model-scale data, and loads on hip roofs.

"Wind Induced External Pressures on a Tall Building with Various Corner Configurations"

Wind tunnel pressure measurements were performed on the CAARC building. The effects of various corner configurations on the magnitude and distribution of the peak pressures were investigated. The planforms tested included rectangular and recessed corners, and two different sizes of bevelled and rounded corners. The highest negative peak pressures occurred on the large rounded corners. This research is continuing this year.

"Wind Tunnel Pressure Test Procedures for Cladding Design, and the Use of Directional Probability Analysis"

A new method of analysis was incorporated into the wind tunnel pressure test procedure used at Central Laboratories, which sums the measured probability of exceeding the design pressure for each wind direction, and hence calculates the total probability of exceedance. This is an improvement on the previous procedure, which simply assumed that the design pressure resulted from the highest combination of measured pressure coefficient and design wind speed for each direction. The new procedure typically produces a small reduction in the measured design pressure, particularly for locations where high suctions occur for a narrow sector of wind directions.

"Designing Cladding on Buildings to Resist Wind Loads, and the Benefits of Wind Tunnel Testing"

This report includes an analysis of the design cladding pressures for two office buildings, including the wind tunnel pressure test results. The measured pressures were, on average for the total cladding, about 30% lower than those from the code calculations using the draft New Zealand wind loading code, but the measured pressure also exceeded the calculated pressure in a few critical locations. The estimated total cladding costs using the design wind pressures from each of the two procedures were compared.

OVERALL WIND LOADS ON BUILDINGS AND STRUCTURES

"Determination of Damping in Tall Buildings"

This literature review describes the present understanding of damping, specifically with regard to tall buildings. It was found that relatively few careful systematic studies of the structural damping of tall buildings have been performed, and that there is a need for full-scale vibration tests of tall buildings in New Zealand.

"Development and Calibration of a High Frequency Base Balance to Measure Fluctuating Wind Loads"

A high frequency base balance was designed and built to be installed in the Central Laboratories wind tunnel, to measure 3 components of moments for rigid, lightweight building models. Calibration tests were performed using the CAARC building model at scales of 1:300 and 1:500. The measured r.m.s. and peak moment coefficients were found to be higher than those typically reported by other researchers, due to the higher levels of turbulence in the Terrain Category 3 atmospheric boundary layer simulation which was used.

"Design Guide for Wind Loading on Multi-Storey Buildings"

The available calculation methods for predicting the action of along-wind, across-wind and torsional forces on buildings were reviewed. Design guidelines were prepared, giving classification procedures for identifying wind sensitive buildings, methods for estimating the wind-induced displacements and accelerations, and worked examples.

"Dynamic Characteristics of Tall New Zealand Buildings"

The wind-induced motion of 6 tall office buildings in Wellington was measured during strong winds using 2 accelerometers installed on the top floors. These measurements were used to estimate the peak displacements and accelerations, natural frequencies in several modes, and the structural damping. For the tallest of the buildings (120 m), a careful study was also performed using a mechanical shaker to excite the building in several modes over a range of frequencies. The results from the wind-induced and mechanically-induced motion tests were compared.

"Development of a Low-Cost Rain Cover for Crops. Part 1 : Parametric Wind Tunnel Study"

Ultra-low-cost greenhouse-like structures are becoming increasingly common in New Zealand, particularly as rain covers over cherry orchards. These structures of clear plastic film supported by a wire framework are extremely vulnerable to wind and can require constant maintenance to repair damage. Few guidelines are available for optimising the designs to reduce wind loads. This report describes the effects of various design modifications on the motion of a flexible model. The research is continuing this year, when a similar series of pressure-measurement tests on a rigid model is planned.

"Effects of Edge Detailing on the Loading of Free Standing Roofs and Canopies"

A wind tunnel study was performed into the effects of adding deep fascias to canopy roofs, using the area-averaged pressure measurement technique. The canopies were similar to the style used for petrol stations, and included both pitched and troughed designs. The effects of wind direction and edge detailing were investigated, including the use of deep fascias placed entirely below, entirely above, and half above and half below eave height. It was found that fascias can reduce the net loading, the most effective fascia configuration being above eave height for pitched roofs, and below eave height for troughed roofs.

"Simulation of Wind Induced Building Motion"

This report reviewed occupancy comfort criteria for wind-induced motion of buildings, and previous research into simulation of building motion. A design study investigated different options for a bi-directional motion simulator, which would realistically reproduce motion due to wind and earthquake, and its potential benefits.

WIND SPEEDS

"Aspects of the Assessment of Design Wind Speeds for Building Sites in New Zealand"

This report includes design wind speed information for 40 New Zealand towns, to assist users of the new structural loadings code. The interpretation of the orographic lee and topographic multipliers is clarified. Also, the channelling multipliers are specified in detail for each town where they apply, by use of a series of channelling multiplier contour maps.

"A Topographic Wind Tunnel Model Study of Wellington City - Experimental Methods and Results"

A 5 m long, 1:2500 scale model of Wellington City and the surrounding hills was wind tunnel tested. The aim was to determine the influence of the complex topography on the wind climate and design wind speeds at various locations. Between 30 and 40 locations were examined for 8 wind directions, at 4 heights above ground level.

OTHERS

"Design and Installation of a High Speed Section for Central Laboratories Boundary Layer Wind Tunnel"

The main working section of the Central Laboratories wind tunnel measures 2.74 m wide by 1.22 m high, with a maximum flow speed of 12 m/s. A new high speed section was installed upstream of the main section, using an open jet design. The nozzle measures 1.2 m wide by 0.8 m high, and has a maximum speed of 33 m/s.

"Living With The Wind - An Introduction to the Problems Caused by the Wind, and Some Solutions"

This is a simple, relatively non-technical introductory guide to all aspects of wind engineering. It emphasises those aspects of designing for wind on which Central Laboratories is most often asked for advice. The material was selected from a wide variety of the published work of various authors.

"Development of a Wind Turbine Control System to Reduce Electricity Generation Costs for Isolated Communities"

A literature review was performed into recent advances in wind energy generation, particularly involving wind diesel systems. Central Laboratories has purchased an existing 40 kW wind turbine, which will be instrumented and used for the development of a wind diesel control system. This research is continuing this year.

CONCLUSION

The Aerodynamics Section of Central Laboratories, consisting of a small group of engineers and scientists, performs a wide variety of different research work in the area of wind engineering. Its aim is to establish and maintain a facility with a broad range of expertise, and to perform specific research of particular benefit to the community, as well as also providing a commercial consultancy service.

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