FULL SCALE MEASUREMENTS OF WIND INDUCED ACCELERATIONS OF THE BRISBANE AIRPORT CONTROL TOWER

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Introduction

Motion from wind action is now being considered in the design of most tall buildings. However, determination of acceptable levels for human occupancy is complex, and the existing data base of human perception of horizontal motion in buildings is small.

In this project, it is intended to log occupants perception of the motion of the tower continuously, along with measurements of the accelerations of the tower and the incident wind velocity. This data will be used to relate the perceptions of building motion to actual accelerations and evaluate current acceleration acceptance criteria.

At this stage the instrumentation and data acquisition system has been installed in the tower. This paper describes the system and presents some preliminary results.

Brisbane Airport Control Tower

The Brisbane airport control tower is a 70 m high cylindrical concrete tower designed by Cameron and McNamara in 1983 (Refer Fig. 1). It consists of a 7 m diameter cylindrical shaft supporting a cone turret with a maximum diameter at the top of the turret of 17.5 m. There are five levels in the turret, including the roof top. The control room at level 10 is the main level which is always habitated. The roof is surrounded by a parapet 1.46m high.

Instrumentation and Data Acquisition

A schematic of the instrumentation system is shown in Figure 2.

The anemometer is a R.M. Young propeller anemometer and is mounted on a pole 7.53m above the roof top level and offset 0.6m from the centre of the tower in a NNW direction. This position was set so that the anemometer is beneath the lightning protection system and to avoid the lightning rod at the centre of the tower.

From wind tunnel tests, it was deduced that the wake from the tower extended approximately 5m above the centre of the tower, and that the undisturbed free stream flow was reached approximately 12.5m above the centre of the tower. Hence, at 7.53m the anemometer is in an accelerated flow region. The wind tunnel tests found that this position resulted in speed up ratios of 1.1 for mean wind speed and 1.02 for turbulence intensity.

The accelerometers are Lucas Novasensor models and are installed in the crawl space directly below the control room. They are aligned in N-S and E-W orientations.

Data from the anemometer and accelerometers is passed through a 50 Hz low pass filter and is logged onto a 486 PC computer using a Burr Brown 98C Board and Viewdac data acquisition software[1]. The system is set up on a fifteen minute cycle similar to that described by Denoon and Kwok[2]. For 14 minutes and 50 seconds, four channels of data are collected at 20 Hz and stored on a RAM disk. In the final 10 seconds, statistics for that period are calculated and written to summary file. If either the mean or peak velocities or accelerations exceed prescribed thresholds, the detailed data are copied to the hard disk for permanent storage. The summary and detailed data are regularly downloaded via modem.

Preliminary Results

The data acquisition system has been installed and collecting data since April 1994. The mean velocity threshold has been set at 15 m/s and ten detailed data files from three wind events have been collected during this time (Refer Table 1). Wind speeds have been reduced to a standard 10m elevation using AS1170.2[3] and adjusted by the speed up ratios from the wind tunnel test. From an analysis of over 30 years of daytime half hourly, 10 minute observations at 10m at the Brisbane Airport, the one year return period mean half hourly velocity is 15.39 m/s. Data collected to date has a maximum 15 minute mean speed of 10.51 m/s; significantly smaller than the one year return period event. The peak resultant acceleration collected to date is 0.0291 m/s^2. This seems consistent with the design criteria set for this tower (Refer Table 2).

Analysis of data recorded on 13/4/94 for fifteen minutes from 15:42, using Dadisp[4] software, are presented in more detail on the plots on the following page. The wind records are shown in figs. 3 and 4. Acceleration response was plotted for the full 15 minute period and the largest accelerations extracted (refer Figs. 5 and 6). The spectral analysis (refer Figs. 7 and 8) shows the dominant mode of vibration at 0.547 Hz. This compares well with the calculated first mode natural frequency of the tower of 0.55 Hz. The tower is not responding at its second mode of vibration, calculated as 1.8 Hz.

Conclusions

Continuous long term full scale measurements of wind velocity and tower acceleration are being undertaken in order to relate with the perceptions of the building motion of the occupants of the building, and to compare with the predicted response from wind tunnel and analytical design procedures. The instrumentation and data acquisition system has been installed and data is being collected. Preliminary results have been presented.

References

1. Keithley Asyst,"Viewdac Data Acquisition Program",1992.
2. R.O. Denoon and K.C.S. Kwok, "Full scale measurements of wind-induced response of an 85m high concrete control tower", AWES 3rd workshop on wind engineering, session proceedings, 1993.
3. Australian Standards, SAA Loading Code Part 2: Wind Loads AS1170.2,1989.
4. DSP Development Corp.,"Dadisp Worksheet, Data analysis and display software",1991.

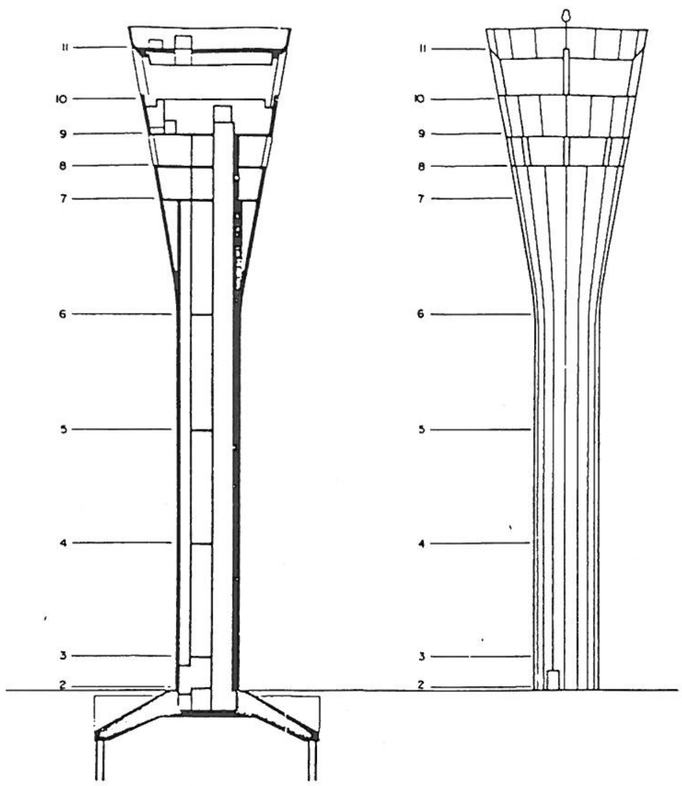

Figure 1 Elevations of Brisbane Airport Control Tower

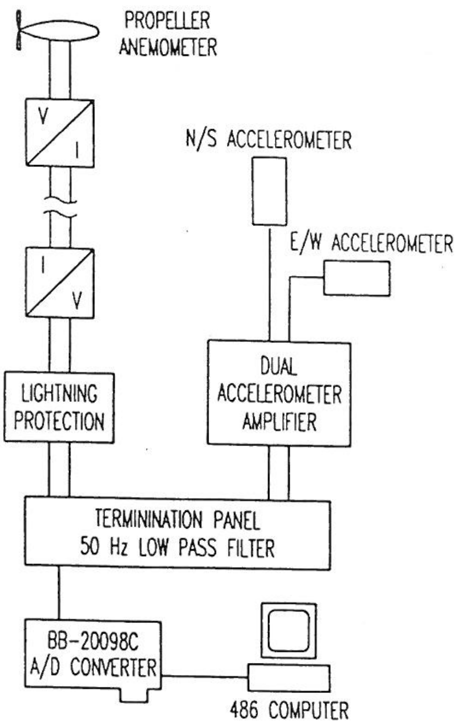

Figure 2 Instrumentation System

Date	Time	Wind Speeds and Direction from anemometer			Turbulence Intensities		Accelerations					Equivalent 10 m wind speed	
		Ave. Speed m/s	Peak Speed m/s	Ave. Direction degrees	Iu %	Iv %	N/S peak m/s2	N/S rms m/s2	E/W peak m/s2	E/W rms m/s2	Resultant peak(m/s2)	Ave. Speed m/s	Peak Speed m/s
-Mar-94	15:12	15.36	20.30	212.73	0.11	0.14	0.0086	0.0023	0.0081	0.0022	0.0118	10.34	15.14
Mar-94	15:27	15.51	18.95	211.24	0.10	0.09	0.0121	0.0029	0.0087	0.0027	0.0149	10.44	14.97
-Apr-94	11:57	15.10	19.10	80.20	0.13	0.08	0.0185	0.0040	0.0140	0.0030	0.0232	10.17	15.90
13-Apr-94	14:57	15.50	20.50	90.20	0.13	0.11	0.0120	0.0038	0.0160	0.0044	0.0200	10.44	16.38
13-Apr-94	15:27	15.00	20.40	84.90	0.15	0.12	0.0140	0.0028	0.0150	0.0041	0.0205	10.10	16.84
13-Apr-94	15:42	15.60	21.60	89.50	0.16	0.13	0.0220	0.0049	0.0190	0.0038	0.0291	10.51	17.71
13-Apr-94	15:57	15.60	20.60	94.60	0.15	0.11	0.0170	0.0043	0.0190	0.0034	0.0255	10.51	17.45
13-Apr-94	16:12	15.10	20.20	88.40	0.14	0.13	0.0210	0.0050	0.0150	0.0039	0.0258	10.17	16.40
31-Jul-94	11:42	15.18	21.59	78.31	0.14	0.15	0.0184	0.0041	0.0177	0.0039	0.0255	10.22	16.52
31-Jul-94	11:57	15.06	20.97	83.55	0.14	0.10	0.0202	0.0046	0.0139	0.0037	0.0245	10.14	16.35

Table 1 Summary of detailed data collected to date

	Return Period (Years)		
	1	5	100
Mean Hourly Wind Speed (m/s)	22	26	45
3s Gust Wind Speed (m/s)	36	42	72
Limiting Accelerations (m/s2)	0.0980	0.1470	-

Table 2 Design Criteria

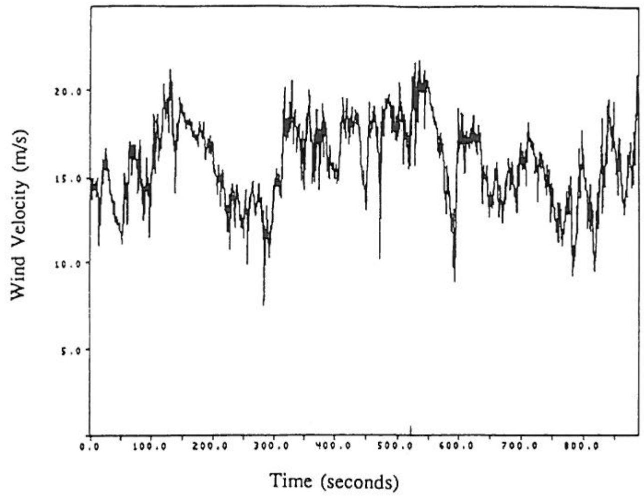

Figure 3 Wind Speed Record

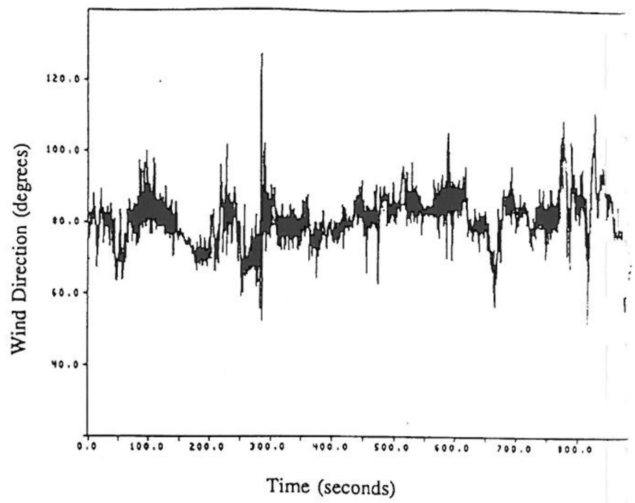

Figure 4 Wind Direction Record

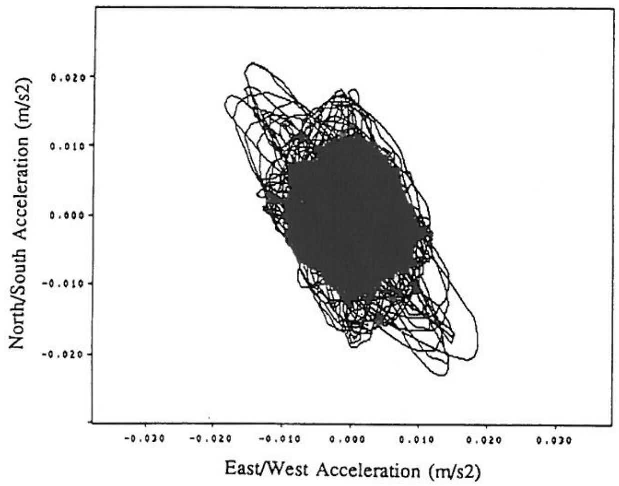

Figure 5 Acceleration Response Record

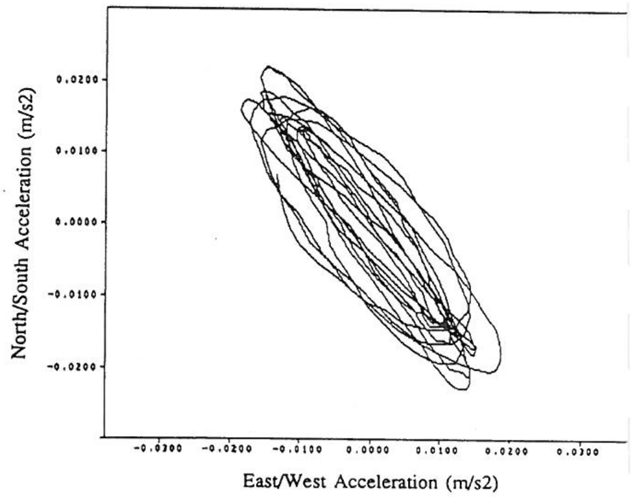

Figure 6 Extract from Acceleration Response Record

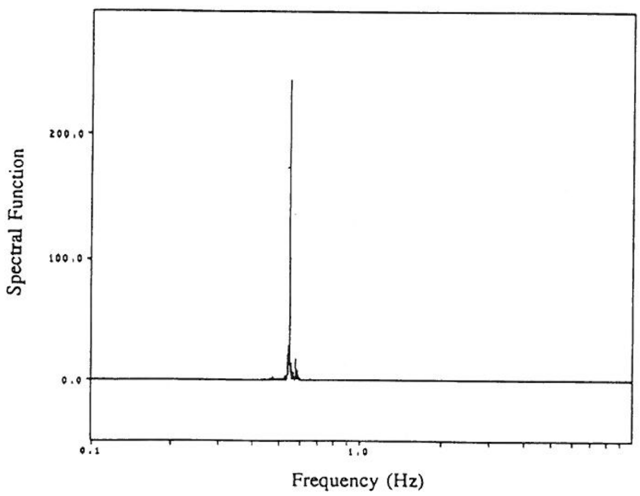

Figure 7 Power Spectrum for North/South Accelerations

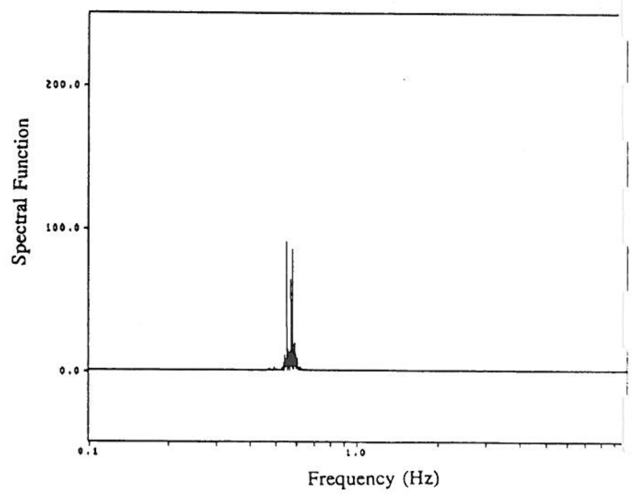

Figure 8 Power Spectrum for East/West Accelerations