WIND DRIVEN RAIN: A DATA COLLECTION FACILITY

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Summary

A facility has been established at CSIRO, North Ryde to collect simultaneous data of wind and directional rainfall intensity. The wind data are obtained from a cup anemometer and rainfall intensity data are collected from two specially designed and constructed rain towers. Other relevant weather information such as the wind direction, atmospheric temperature, pressure and relative humidity are also gathered. The weather data collection facility and the associated instrumentation are described here. A sample of the useful parameters that can be deduced from the collected rainfall data are also given.

1. INTRODUCTION

Wind and rain are, arguably, two of the fundamental design parameters for a building envelope system. The basic function of a building envelope is to protect the occupants of a building from natural elements such as rain, high speed wind, hail and fire. A poorly designed and/or constructed facade will permit the rain water to seep through the building and thus cause enormous damage to the building. Therefore, it is vital to design and construct the building facade with sufficient weather tightness. A well designed building envelope system will save significant amounts of money and energy associated with the repair/replacement of facade over a period of time.

The poor performance of building facades in severe weather conditions can be due to: poor design and/or inadequate techniques used for construction. A poorly designed facade is the result of deficiency of data available on combined rainfall intensity and wind speed for any particular site.

The work carried out by the Weather Performance group at the Division of Building Construction and Engineering, CSIRO is addressing both design and construction aspects of building facades. As a part of the work, a database containing combined wind speed and rain fall data is being established by collecting weather data at North Ryde.

The aims of this paper are: (i) to provide a description of the weather data collection facility and (ii) to show some examples of key parameters (eg. Vertical rainfall, horizontal rainfall, mean and gust wind velocity during rain, vertical rain velocity, raindrop diameter) that can be extracted from the collected data. It is hoped that these parameters will provide crucial input for the effective design of facades and minimise problems due to water leakage. In particular, they will enable the prediction of precipitation rates and the pressure distribution on building faces with more accuracy. As a whole, the database is also a pre-requisite for the laboratory assessment of the performance of a facade system.

2. EXPERIMENTAL FACILITY

The field data collection facility is located at Commonwealth Scientific Industrial Research Organisation's Division of Building Construction and Engineering at North Ryde. A photograph showing the facility is given in Figure 1. The facility consists of two rain towers, a 3 cup anemometer for wind speed, a wind vane for wind direction, and other instrumentation to measure the atmospheric pressure, temperature and humidity. All these instruments feed signals into a DT200 datataker from which data is unloaded at regular intervals to a portable computer. A brief description of the wind and rain measuring systems and the data acquisition system, and an example of the collected data and its analysis are given here.

2.1 Wind Data

The wind speed is measured using a high response, low-threshold 3 cup optoelectronic anemometer (Vaisala WAA 15) which is mounted on a mast of height 3 m. The specifications of the anemometer are given in the instruction manual of Vaisala (1988). The threshold of the anemometer is 0.4 m/s and the maximum speed that can be measured is 75 m/s. The anemometer uses a light emitting diode (LED) together with a phototransistor to measure the wind velocity. The output of the anemometer is a pulse and its frequency depends on the wind speed. The wind speed signal is connected to several datataker channels to allow the separate recording of mean and 3 second gust wind speeds.

The wind direction is measured using a low threshold (0.3 m/s), counterbalanced 3 cup optoelectronic wind vane (Vaisala WAV 15). The specifications of this instrument are given in instruction manual of Vaisala (1990). The wind vane can operate in speeds up to 75 m/s. The output of the wind vane is connected to an analog input channel of the Datataker DT200 via an interface board which converts the 6 bit digital code into a voltage output.

The other atmospheric data such as pressure, temperature and humidity are also measured using the Datataker DT200.

2.2 Rain Towers and Rainfall Data

The rain towers are square, 3 m tall and located 3 m apart. One of the towers is rotated by an angle of 45^{o} with respect to the other so that rainfall intensities from the eight cardinal directions (N, NE, ..., NW; angles are measured clockwise from N) can be measured.

The rainfall is measured using RG 13 type rain gauges which incorporate a tipping bucket mechanism. The rain falling on the tower is transported to the rain buckets via Teflon tubing. For an accumulation of 0.09 mm of rain fall, the contact in the tipping bucket mechanism closes once. The rain fall intensity is measured from the total number of contact closures. The output of RG 13 is connected to a digital input channel of DT200 which counts the number of contact closures. A scaling command in the BASIC program converts this to the amount of rainfall in millimetres. The program has two schedules to log data with and without rain.

3. DATA ANALYSIS

The rainfall data can be analysed in several ways; for example, in terms of all rainfall intensity or on the basis of the percentage of time during which the directional rainfall intensity exceeded a predetermined amount. However, to keep the analysis simple, the collected data has been grouped in to two main categories, data during rain and data without rain so that each category can be analysed separately. When no rain is falling, data collection is on hourly basis. During rain, data of wind and rain are collected on a minute by minute basis. Preliminary results for the rainfall data collected between June 1993 to June 1994 are presented here.

3.1 Directional Rain

The rainfall data are grouped into vertical and horizontal rain for each month. The vertical rain data are due to rain falling on the top face of one rain tower and the horizontal rain are due to the total rain falling on the 8 sides of the two rain towers. Figure 2 shows a bar chart of the total rain collected for each month between June 1993 and June 1994. In calculating the total rainfall intensity, only rain showers which last for more than one minute are included. No rain is shown for the months of December to February because the vertical rain gauge was blocked. It can be seen that, except for April and May, the vertical rainfall intensity is higher than horizontal rainfall intensity. For the months of June to October in the year 1993, the horizontal rainfall is lass than 50% of the vertical rainfall. The largest rainfall (both horizontal and vertical) occurred in April. This was due to a number of heavy showers over a period of four days, rather than a single shower. For the months of May and June 1994, the vertical and horizontal rainfall are of comparable magnitude.

The average rainfall (=Total Rainfall/Number of Rainshowers) when plotted (Figure 3) for each month showed a similar trend to that of the total rainfall. However, as the number of rainshowers in March 1994 are more than November 1993, there is a significant change in ranking for the two months.

3.2 Wind speeds during Rain

Wind speeds during rain are shown in Figure 4. The mean and 3 second gust wind speeds shown are those measured by the anemometer. The vertical raindrop speeds were calculated using the mean horizontal wind speed and the ratio of horizontal rainfall/vertical rainfall. For each month, the vertical raindrop speed is significantly higher than both mean and 3 second gust wind speeds. The highest raindrop speed of 11.8 m/s occurred in August 93. However, this speed seems to be higher than that physically possible for a raindrop as explained later.

3.3 Raindrop Diameter

Using the vertical raindrop speed, the raindrop diameters can be directly estimated. For the present data, the estimated raindrop diameters are shown in Figure 5 as a function of the vertical speed of rain. For the purpose of comparison, the data of Best (1950) are also plotted in Figure 5. It can be observed that there is excellent agreement between the present data and Best's data, except for the month of August 93 for which the vertical rain speed was estimated to be 11.8 m/s. This speed is inconsistent with the peak terminal velocity of about 9.1 m/s for raindrop diameters of about 6 mm given in the literature. Therefore the raindrop diameter could not be estimated.

4. CONCLUDING REMARKS

A rain tower facility for collecting the combined rainfall and wind speed data has been established at the CSIRO Division of Building Construction and Engineering. A brief description of this facility has been provided here. A database has been established using the collected data.

A relatively simple analysis of the rainfall data yielded a number of important design parameters. When incorporated in the design of a building envelope, these parameters are expected to increase the probability of water tightness and reduce operating and/or repair costs associated with the building envelope systems.

5. REFERENCES

Best, A. C. (1950), "The size distribution of raindrops", Quarterly J. Royal Meteorol. Soc., 76, 16-36.

Vaisala (1988) *Instruction Manual for Wind Measurement System Anemometer WAA 15, WAA15-T0346-1.2.*

Vaisala (1990) *Instruction Manual for Wind Measurement System Wind Vane WAV 15, WAV15-T0348-1.5.*

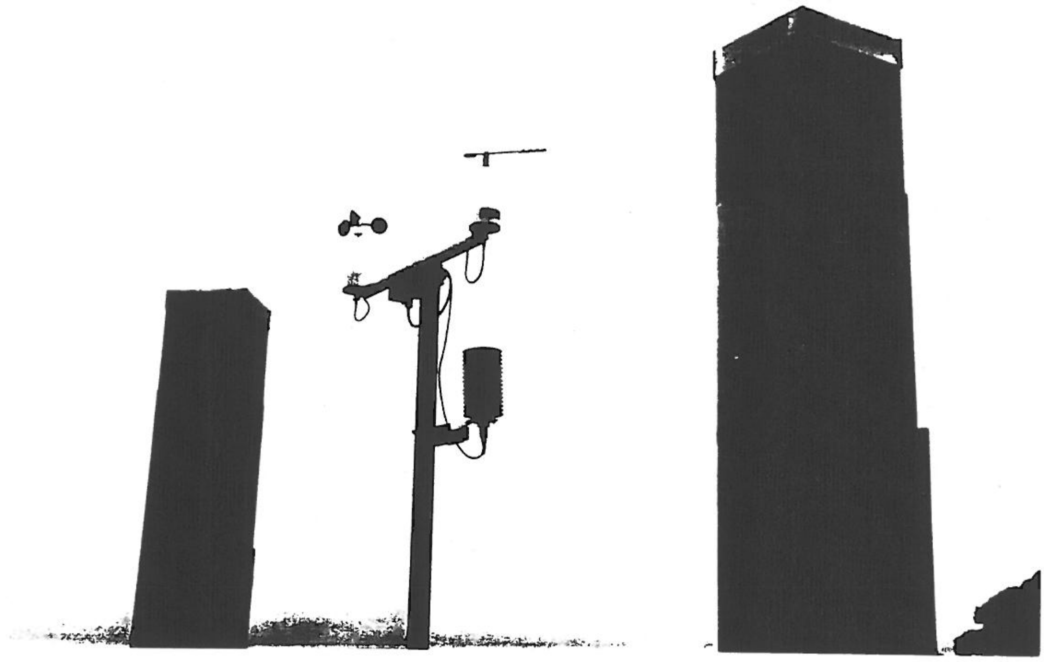

Figure 1 A photograph of the rain tower facility at CSIRO, North Ryde.

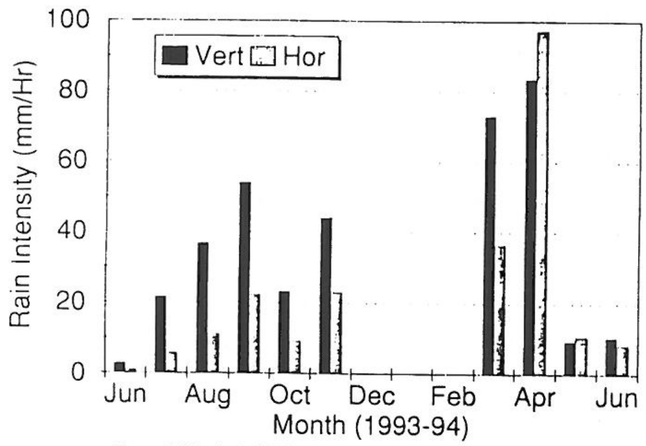

Figure 2 Total rainfall for each month during Jun 1993-Jun 1994.

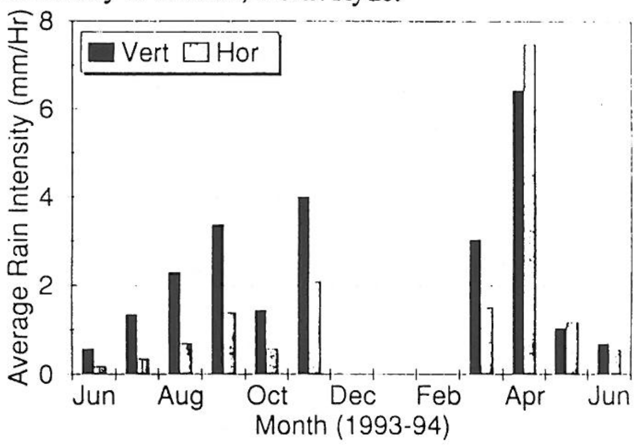

Figure 3 Average rainfall for each month during Jun 1993-Jun 1994

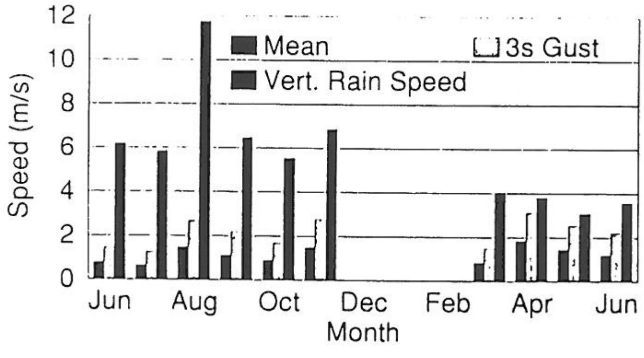

Figure 4 Mean wind speed, 3 second gust wind speed and vertical rain speed.

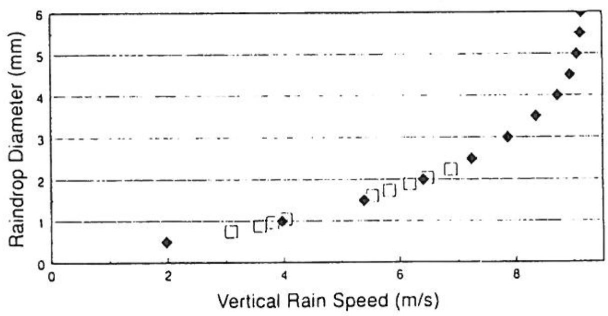

Figure 5 Raindrop diameter as a function of vertical speed of rain.