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Full-scale Wind Measurements in the City of Melbourne

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Abstract

Continuous full-scale wind speed measurements in areas of high pedestrian traffic within the Melbourne CBD are being undertaken in order to evaluate the effect of the streetscape and urban features on the localised wind environments. Initial results are analysed and some comparisons with Computation Fluid Dynamics (CFD) simulations are made.

Introduction

Wind in the urban environment tends to be a complex phenomenon, highly dependent on the geometry of the built form within the city structure.

Global Wind Technology Services (GWTS) was engaged by a Victorian planning authority to provide advice on the regulation of building design for pedestrian wind effects. In order to develop the GWTS response, several studies were conducted including full-scale pedestrian-level wind measurements at ten locations in the Melbourne Central Business District.

The purpose of this study was to investigate the effects of the urban features on the localised wind environment in areas of high pedestrian traffic within the Melbourne CBD and how the measured wind environment is perceived. A comparison of wind measurements at different Bureau of Meteorology weather stations was made for the same recording period.

Full-scale study description

Study area

The study area of the full-scale wind measurements is within a distinct locality known as the Hoddle Grid, located to the north of the Yarra River. It is bounded by Flinders Street, Spring Street, La Trobe Street and Spencer Street.

Weather Station Locations

The location of each weather station was chosen dependent upon the following factors:

- Areas of particular interest
- Government regulations
- The degree of practicality and functionality available at the site.

Ten locations throughout the Melbourne CBD were selected by City of Melbourne to record full-scale wind measurements. Popular areas with high volume pedestrian traffic and knowledge of windy locations were the driving force in pinpointing the public spaces that should be investigated.

The weather station locations were developed in consultation with a City of Melbourne representative. It became clear during these consultations that the most practical, publically owned structures suitable for the installation of weather stations were street signs. Most, if not all, other structures (e.g. light poles, power poles, buildings, tram stops etc.) were privately owned or privately operated and would have required lengthy application processes to gain permission for installation.

Analysis of the proposed 'weather station to street sign assembly' was undertaken by GWTS to demonstrate the structural integrity of the street signs when in use. Acknowledgement and compliance with Clause 8.16 of the Road Encroachment Operation Guidelines for the City of Melbourne also helped to influence and gain the confidence of the Melbourne City Council prior to setup (City of Melbourne, 2003). The relevant guidelines were as follows:

- The weather stations will not encroach within 450mm from the face of the curb
- A minimum footpath width of 1050mm from the face of any adjacent building will be maintained
- A minimum height of 2700mm from the surface of the footpath to the weather station will be maintained
- Installation will be conducted during off-peak times
- High visibility vests will be worn for the duration of the installation.

At first inspection of each site, the practicality of installing, running and monitoring the weather station was then considered. The proposed weather stations would be wirelessly connected to the internet so it was essential that the location be within close proximity to a power source and internet connection, to host the data logger and transmit live data to the internet, with a clear line-of-sight to the weather station.

The City of Melbourne assisted greatly in this process by contacting nearby businesses and asking if they would contribute to the study by allowing the weather station data loggers to be installed on their premises and use their internet connection and mains power.

(1) State Library Forecourt	(2) Federation Square Plaza
(3) The Age Forecourt	(4) Hardware Lane
(5) Bourke/Spencer Street	(6) Bourke Street Mall
(7) Bourke/Queen Street	(8) Bourke/Russell Street
(9) Bourke/Spring Street	(10) Little Collins Street

Figure 1. Weather station locations.

Instrumentation

Each outdoor sensor consists of an Ambient Weather WS-1001-WIFI Observer linked wirelessly to a data logger and modem. The data logger is based on an Ambient Weather processor and was programmed to provide live online updates for a 16-second period at a frequency of 915 MHz via a wireless Wi-Fi remote monitoring system. The weather station specifications for the recorded data are provided below in **Table 1** for the parameters relevant to the current paper.

Measurement	**Range**	**Accuracy**	**Resolution**
Wind direction	0 - 360°	±1°	1°
Wind speed	0 – 45 m/s	±1 m/s or 10% (whichever is greater)	0.04 m/s

Table 1. Basic performance index of urban wind environment sensors (Ambient Weather, 2014).

Before beginning the full scale measurements, a sample Ambient Weather WS-1001-WIFI Observer was calibrated against a pitot tube in the Monash University Boundary Layer Wind Tunnel and was found to be within the stated accuracy of the instrument.

Selection of mounting poles

It was found that most mounting pole solutions are either quite costly, cumbersome to ship/transport or are not compatible with the surroundings of a busy urban environment. It was also found that the major use of weather stations is for personal/recreational use, and therefore, the mounting solutions that are provided with the instruments are designed to reside in a safe environment, without the threat of theft or vandalism.

GWTS therefore opted to source steel pipe sections (48.3mm OD x 3.2mm wall thickness) to attach to street signs and to mount the weather stations on.

After the street signs had been selected, the heights of each individual street sign were recorded to determine the minimum height requirements of the mounting poles that were to be attached to the street poles. A 300mm clearance from street signs was deemed adequate to avoid interfering effects. Due to the variation in heights among street poles, the length of each of the mounting poles was specific to each location. This resulted in a slight variation of weather station mounting heights, however, all ten mounting heights were between 3000mm and 3900mm above the local ground level.

Installation of poles and weather stations

The poles were fastened securely to street signs using stainless steel band-clamps. Stainless steel ‘Band-it’ band clamps are frequently used for similar applications (e.g. attaching street signs and surveillance cameras) and environments and are compliant with OH & S regulations.

Two 4 hour sessions, using a team of three people, were required to attach the poles to the street signs. Installation was carried out in off-peak times, from 8pm-12pm, to allow for easy car park access and to reduce disruption to pedestrians.

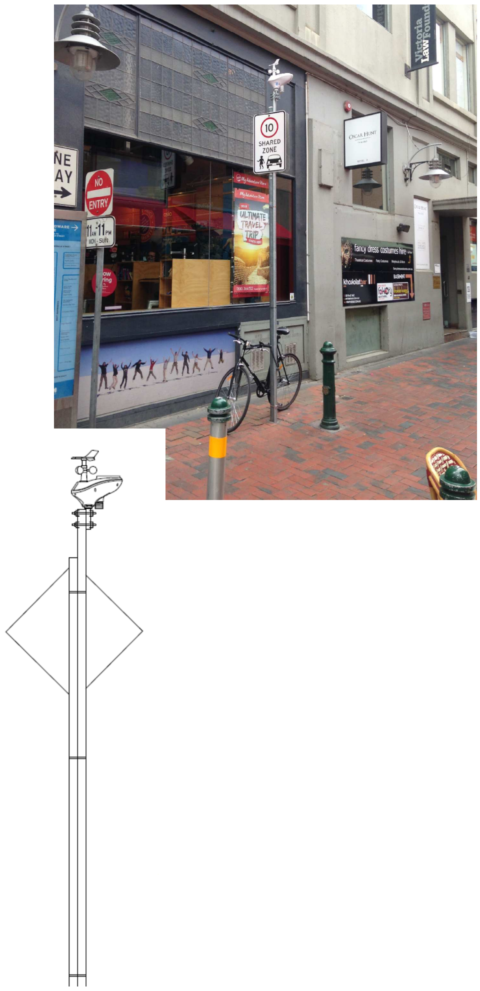

Figure 2. Installed weather station in Hardware Lane.

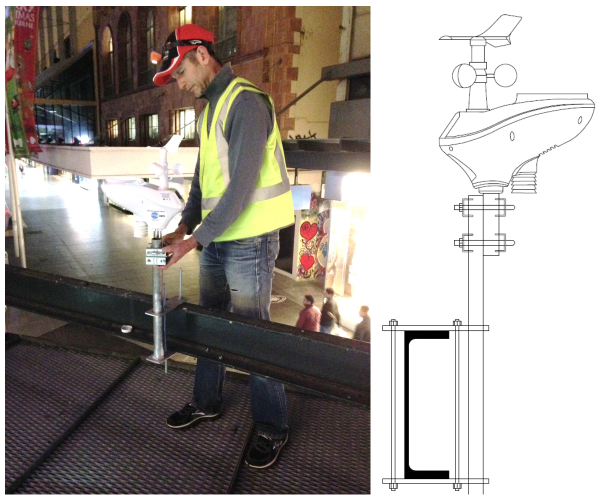

Figure 3. Installation work on the Bourke Street Mall information centre rooftop.

Installation of data loggers

Data loggers were then installed in the local businesses as arranged by City of Melbourne. In some circumstances, the private or public businesses were willing to provide access to their personal internet connection. In cases where this was not possible, a source of Wi-Fi was required. For ease and practicality, GWTS used Pocket Wi-Fi devices to provide a constant internet connection for the duration of the assessment. It should be noted that most Pocket Wi-Fi devices expire after 30 days and must have data replenished within this time period.

Monitoring and extracting data from personal weather stations

The period of recording has consisted to date of approximately six months from the 12th December, 2015 to the present. The live data for wind speed and wind direction is stored and monitored on the weatherunderground.com cloud-based online service. The data is presented as a continuous series of 5 minute averages and maximum gusts.

Collection of comparison data

Historical wind data for the Melbourne region was analysed to establish the frequency and magnitude of wind at different Bureau of Meteorology weather stations. The selected stations are Melbourne International Airport, Essendon Airport, Moorabbin Airport, Laverton RAAF, Fawkner Beacon and Melbourne Olympic Park. The frequency and directionality of these stations were determined from the historical wind data and plotted as wind roses.

Method of comparison

Wind roses for each weather station location were plotted to reflect the modified wind directionality according to the local built up area and location of the instruments. They were then compared with the historical wind data for the Melbourne Airport. It was intended to identify similarities and differences between the directionality of wind flow in an urban environment compared to a large open field.

A Computational Fluids Dynamics (CFD) analysis was conducted for the region surrounding Location 6 (Bourke Street Mall) to verify the direction of wind flow throughout the Melbourne CBD.

Results

Effect of built environment on wind direction

The period of Dec 2015 to Jan 2016 was considered at the Bourke Street Mall location. The most frequent wind direction according to the weather station in the Mall was west. However, during this period, the most frequent wind direction from the airport data was south.

A visualisation of this local wind directionality, based on a CFD simulation for the area around Bourke Street Mall, is shown in **Figure 4.** Here we can see that winds from the south are channelled through the streetscape to produce westerly winds along the Bourke Street Mall (the weather station at Location 6).

The wind data recorded by GWTS reflects the wind patterns that occur at pedestrian level within a built environment. They may therefore capture wind tunnel effects through alley ways, accelerated winds around building corners, channelling of wind through narrow streets, downwash at the bases of buildings, the effects of trees and altered wind directions due to the built environment.

Figure 4. CFD analysis of westerly winds on Bourke Street Mall produced by wind approaching from the south

Discussion

The following points were considered to be noteworthy:

- Locations were determined on the basis of convenience rather than the ideal location to record climatological parameters. A healthy balance of the two must be achieved.
- Selecting a location that offers a wireless connection may sound attractive at first, however, lack of control over the network may become an issue throughout the duration of the project.
- Weather underground uses a method of averaging data that is currently unknown to the authors.
- Analysis of the anemometer records is an ongoing task and the project is expected to run for a minimum of one year. The effects of seasonal changes on wind are hoped to be captured and the full-scale measurements shall then provide a good data base.

Conclusions

Continuous full scale wind measurements within the Melbourne CBD are being undertaken to investigate the pedestrian level wind environment. From conducting full-scale wind measurements at 10 locations in the city of Melbourne within the specified time period, the authors have found that:

- The wind data recorded by GWTS reflects the wind patterns that occur at pedestrian level within a built environment
- The effect of the built environment on wind direction recorded by the weather stations show good agreement with CFD simulations.

Although the full-scale measurements in this study were conducted using relatively low-precision instruments, they are considered to be valuable as full-scale measurements for pedestrian level wind in the built environment are uncommon. It is therefore encouraged by the authors that more full-scale pedestrian level wind assessments are conducted to reduce uncertainty in the results derived from this individual experiment.

Acknowledgements

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References

City of Melbourne (2003) Road Encroachment Operation Guidelines, Melbourne City Council

Ambient Weather (2014) Ambient Weather WS-1001-WiFi OBSERVER Solar Powered Wireless WiFi Weather Station User Manual, Ambient Weather LLC, Version 1