FULL-SCALE STUDIES OF ENVIRONMENTAL WIND CONDITIONS AROUND HKUST

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Introduction

Although Hong Kong is better known for its history of typhoons, the effects of non-typhoon winds on its environment, in terms of both human comfort and air pollutant dispersion, are receiving increasing attention from governmental authorities, planners, developers and citizens. This Paper presents the results of preliminary studies of environmental wind conditions at a number of locations around the campus of the Hong Kong University of Science and Technology (HKUST).

Site description

The HKUST campus occupies a 60-hectare site on the northern end of the Clear Water Bay peninsula in East Kowloon. The campus is situated on fairly steep slopes, a typical feature in Hong Kong. Campus buildings situated along the shoreline are terraced so that buildings on all levels have unobstructed views of the sea. The main academic building is aligned north-south such that a large number of open spaces are exposed to strong north-easterly winds which prevail during the winter months. This exposure, coupled with winds accelerating up the steep slopes, has drawn critical comments from staff and students alike about the discomfort caused by strong winds.

Measurement program and equipment setup

During teaching semester time, the HKUST campus provides a large population of willing students and staff for a questionnaire based assessment of their reactions to environmental winds. A preliminary exploration around the campus quickly identified a number of high-wind "hot spots" of which three locations, Atrium, Footbridge and Café as shown in Fig. 1, were chosen for the study. Both the Atrium and the Footbridge are heavy traffic areas with the Atrium linking the University's teaching facilities and student amenities including the library, academic concourse, sports hall and various cafeterias, and the Footbridge leading to undergraduate, postgraduate and staff living quarters.

During each measurement and survey period, a laptop computer linked to an ultra-sonic anemometer with an averaging time of 1 second was used to continuously record the wind speed at 1.5 m above the ground level. A typical wind record is shown in Fig. 2. Pedestrians were intercepted and interviewed approximately 2 m downwind of the anemometer. Each pedestrian was asked to rate the wind condition at the time according to the following 7 comfort level scale:

a) Almost no wind at all, I would have preferred more wind to feel more comfortable.
b) I wasn't specially aware of the wind / the wind was 'just right'.
c) It wasn't uncomfortable, but the wind was rather strong.
d) The wind was strong, and I feel uncomfortable.
e) The wind was strong, and I feel very uncomfortable.
f) The wind was very strong, but I didn't feel endangered.
g) The wind was strong enough to be dangerous.

Each interview took approximately 60 seconds and the pedestrian's response to the questionnaire was matched to the maximum gust wind speed recorded within that 60 seconds period. During the survey period, general observations of the effects of wind on pedestrians and the nearby environment were also made and noted.

Results and discussions

To date, six measurement and survey periods, shown in Table 1, have been completed from which approximately 200 questionnaires were obtained and analysed. In order to identify trends, the data were grouped into 2 m/s wind speed bands within which the percentage

distributions of each comfort level were determined. It is not surprising that the higher the wind speed, the lower the comfort level.

By further grouping according to comfort level such that levels a) and b) are considered to be acceptable, c) and d) uncomfortable, e) and f) very uncomfortable, and g) dangerous, the corresponding wind speeds were found to be approximately 0-3 m/s, 3-7 m/s, 7-12 m/s and greater than 12 m/s respectively. A summary of this analysis is shown in Fig. 3. These specific wind speed bands are reasonably similar, except the "dangerous" threshold, to the four bands: 0-5 m/s, 5-10 m/s, 10-15 m/s and greater than 15 m/s, suggested by Murakami et al. (1980). This discrepancy is believed to be different interpretation of "dangerous". The current study identified a perceived danger while physical dangers were observed in Murakami's studies. The much larger samples Murakami tested also suggest the results may be statistically more reliable. Furthermore, their test methods reflects more accurately the reaction of pedestrian to the sudden onset of wind gusts, that is the wind speed gradient, such as when a pedestrian steps out of a building or walks around the sheltered side of a corner into the exposed side. This "effective gust" approach was recently identified and described by Denoon et al. (2000). The results of a recent study of wind conditions on subway railway platforms due to train movements (Kwok et al., 2000) also suggest that the suddenness of the wind gusts, that is the wind speed gradient, associated with a train arriving at or leaving the platform is a more important parameter, in terms of passenger comfort while standing on the platform.

Concluding remarks

The HKUST campus, with its topography and layout, known windy conditions and a willing population of students and staff, provides an interesting setting to investigate the effects of strong winds on people engaging in various activities. This paper presents the results of some preliminary measurements carried out at the Atrium, Footbridge and the Café. More measurements and pedestrian surveys are planned for those three areas, the sports field and BBQ area along the shoreline where more leisurely activities take place. The Café will be studied in more details to assess the impact of wind on its operation as an outdoor eating area.

A scale model of the HKUST campus is under construction and will be tested in the CLP Power Wind/Wave Tunnel Facility to assess the overall impact of strong winds on the ground level wind environment in and around the campus. Wind tunnel test results will also be compared with the results of the full-scale studies in progress.

References

1. Denoon, R O, Kwok, K C S, Wood, G S and Phillips, A G, "Issued in the design of sports stadia for environmental wind effects", 1st International Symposium on Wind & Structures, Korea, January 2000.
2. Kwok, K C S, Lam, T P and Lee, Y C, "Full scale studies of wind conditions on subway railway platforms due to train movements", Proceedings of 8th AWES Workshop, Scarborough, Perth, February, 2000.
3. Murakami, S, Uehara, K, Deguchi, K, "Wind effects on pedestrians: new criteria based on outdoor observation of over 2000 persons", Wind Engineering, Proceedings of 5th International Conference On Wind Engineering, Fort Collins, July 1979, pp. 277-288.

Table 1 Summary of wind velocity during six measurement and survey periods

Location	Date	Max. gust wind speed (m/s)	Mean wind speed (m/s)	Mean wind direction
Atrium01	20/1/2000	14.5	5.9	East
Atrium02	6/12/99	8.7	4.5	North
Café01	10/1/2000	10	6.0	East
Café02	10/1/2000	7.7	5.5	East
Footbridge01	20/1/2000	14.3	5.6	East
Footbridge02	18/1/2000	11.4	2.9	North

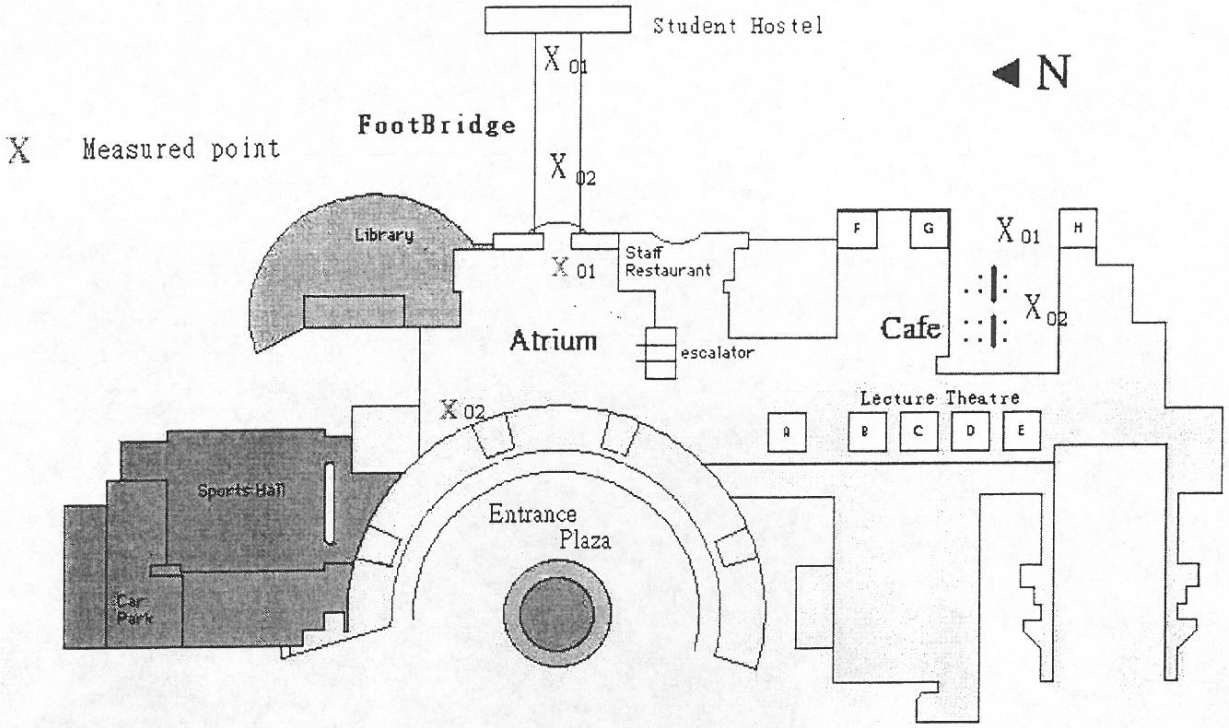


Fig.1 Layout of HKUST campus buildings and positions of wind speed measurement and survey

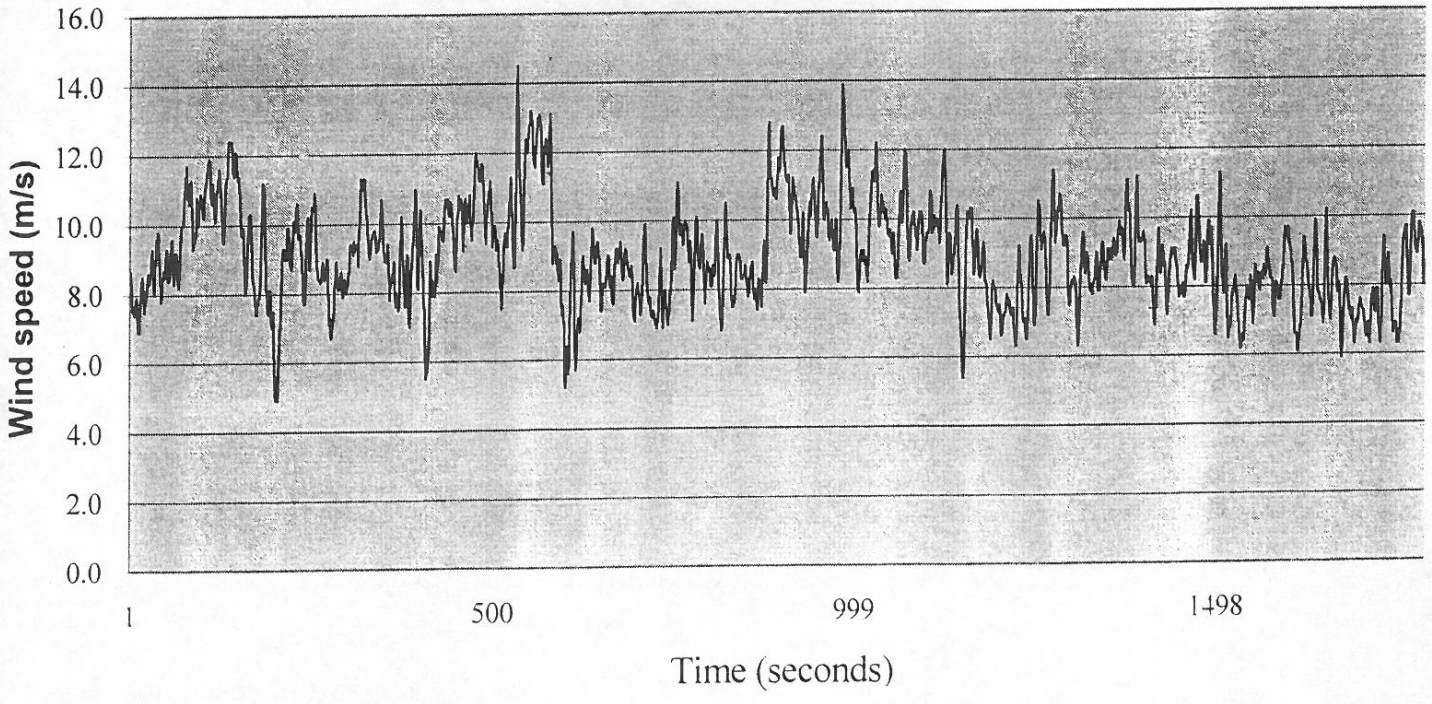
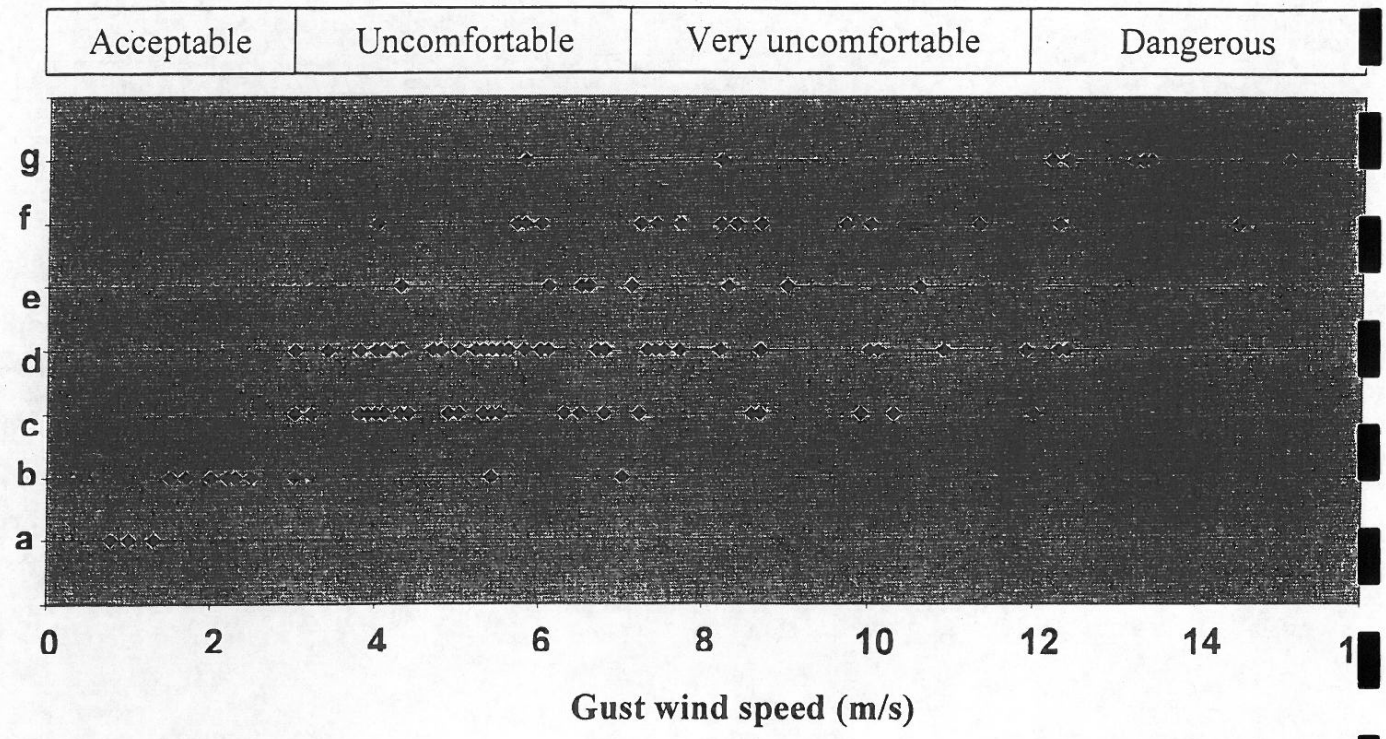


Fig. 2 Wind recorded at Atrium at 9 p.m. on 20 January 2000



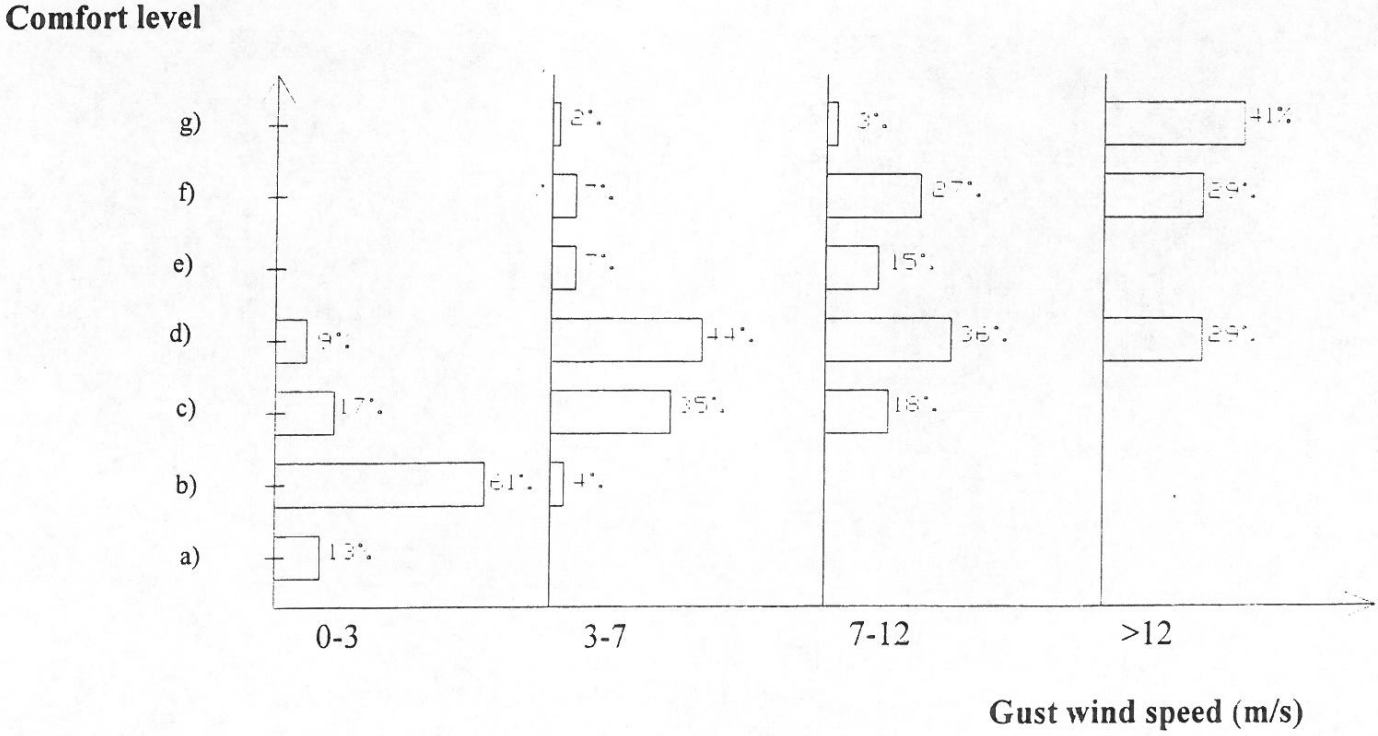


Fig. 3 A summary of the effects of wind on pedestrians