EXPERIMENTAL SITE WIND AVAILABILITY STUDY FOR TUEN MUN EAST AREA, HONG KONG

INVESTIGATION REPORT WWTF011-2008

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CLP Power
Wind/Wave Tunnel Facility

The Hong Kong University
of Science and Technology

EXECUTIVE SUMMARY

At the request of Scott Wilson Ltd**,** a study of wind availability and characteristics at two locations in the Tuen Mun East Area was conducted under "Agreement No. CE 47/2006 (TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study" by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology. The study was undertaken in accordance with the requirements stipulated in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). The study was also conducted in accordance with the recommendations of Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005) and Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2005).

A 1:2000 scale topographical model study was undertaken to determine the effects of local topography and the surrounding urban environment on mean wind direction, mean wind speed and turbulence intensity at two locations in the Tuen Mun East Area, in accordance with the instructions of Scott Wilson Ltd on 18 March 2008: Position 1, located in Perowne Height close to Tai Lam Country Park, and Position 2, located at the eastern side of Siu Sau Village and south-east of Position 1.

A miniature pressure probe was used to take measurements of three components of wind speed, i.e. in the longitudinal, lateral and vertical directions, at 22.5º increments for the full 360º azimuth, i.e. for sixteen (16) wind directions, and at nine (9) heights to determine profiles of mean wind speed and turbulence intensity above the study area. The results will be used as input boundary conditions for subsequent detailed air ventilation assessment (AVA) studies. The 1:2000 scale topographical model included the surrounding area up to a distance of approximately 10 km from the study area.

The topographical model study results were combined with WWTF's statistical model of the Hong Kong wind climate, based on measurements of non-typhoon winds taken by Hong Kong Observatory at Waglan Island during the period of 1953 – 2000 inclusive, to determine wind roses corresponding to annual mean wind speeds at the study area.

In general, the directional characteristics of winds at 500 m at Positions 1 and 2 are similar to those for non-typhoon winds approaching Hong Kong, with one significant yaw angle was measured at Position 1 for wind from 22.5°. At a height of 50 m above Position 1 and an elevation of 50 mPD at Position 2, winds from the north-east and north-west quadrants were significantly affected by the Tai Lam Country Park to the north of the study area, causing significant reductions in the magnitudes of mean wind speed and changes to the directional distribution in the corresponding directions. Winds approaching from southerly directions were the least affected due to the area's relatively open exposure in those directions.

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1. INTRODUCTION

At the request of Scott Wilson Ltd**,** a study of wind availability and characteristics at two locations in the Tuen Mun East Area was conducted under "Agreement No. CE 47/2006 (TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study" by the CLP Power Wind/Wave Tunnel Facility (WWTF) at The Hong Kong University of Science and Technology (HKUST). The study was undertaken in accordance with the requirements stipulated in the Australasian Wind Engineering Society Quality Assurance Manual, AWES-QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). The study was also conducted in accordance with the recommendations of Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005) and Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2005).

There are a total of 14 study sites in the nominated Tuen Mun East Area that is bounded by the Tuen Mun River Channel and Hoi Wong Road to the west, the Tai Lam Country Park to the north, Tai Lam Chung Nullah to the east and the coast to the south, as shown in Figure 1.

A 1:2000 scale topographical model study was undertaken to determine the effects of local topography and the surrounding urban environment on mean wind speeds and turbulence intensities at two locations, agreed with Scott Wilson Ltd on 18 March 2008 and also indicated in Figure 1, within the Tuen Mun East Area:

- In Perowne Height (Position 1 in Figure 1); and
- At the eastern side of Siu Sau Village (Position 2 in Figure 1).

The topographical model study results were combined with WWTF's statistical model of the Hong Kong wind climate, based on measurements of non-typhoon winds taken by Hong Kong Observatory at Waglan Island during the period of 1953 – 2000 inclusive, to determine site-specific annual wind roses for hourly mean wind speeds that are intended to be used for a subsequent detailed air ventilation assessment (AVA) of the study area.

2. ANALYSIS OF THE HONG KONG WIND CLIMATE

Waglan Island, located approximately 5 km southeast of Hong Kong Island, has been used by Hong Kong Observatory (HKO), formerly The Royal Observatory, Hong Kong, for the collection of long-term wind data since December 1952. Due to its location, relative lack of development over the past 50 years and its generally uninterrupted exposure to winds, data collected at Waglan Island is considered to be representative of winds approaching the Hong Kong region and the highest quality available for all wind engineering purposes for Hong Kong. Wind speed and direction measurements at Waglan Island are essentially free from the interference effects of nearby developments that were clearly demonstrated by Melbourne (1984) in a comparison of wind speed measurements taken at both Waglan Island and Hong Kong Observatory in Tsim Sha Tsui. The study of Melbourne (1984) also demonstrated that anemometer position corrections are required to account for the effects of the location and height of an anemometer station, the surrounding topography and buildings, even for those stations that are considered suitable for wind engineering applications.

Waglan Island wind records have been analysed previously in studies of the Hong Kong wind climate, most notably by Davenport et al. (1984), Melbourne (1984) and Hitchcock et al. (2003). Melbourne (1984) conducted wind tunnel model studies to determine directional factors relating wind speeds at each anemometer location to the wind speed at a height equivalent to 50 m in the freestream flow and concluded that:

- Measurements taken during the period 1 January 1964 to 11 July 1966 inclusive were directly and adversely affected by the effects of building on which it was mounted; therefore, records from that period were excluded from that study.

- The anemometer correction factors for mean wind speeds show some sensitivity to the modelled approach flow but they are not strongly dependent on the modelled approach profiles.
- The largest magnitude speed-up effects occur for winds approaching from approximately 67.5°, 180°, 270° and 360°.
- The largest magnitude slow-down effects occur for winds approaching from approximately 112.5°, 225° and 315°.

In the study conducted by Hitchcock et al. (2003), wind tunnel tests were undertaken to correct wind records for position and topographical effects at the four anemometer locations used since 1952, with the exception of the location used during the period 1 January 1964 to 11 July 1966 inclusive. In that study, thermal (hotwire) anemometer measurements were taken at 22.5° intervals for the full 360° azimuth relating wind speeds at anemometer height to wind speeds at a height equivalent to 200 m in the freestream. The directional characteristics of the former anemometer sites were found to be similar to those discussed by Davenport et al. (1984) and Melbourne (1984), whereas the current anemometer site is much less affected than its predecessors, due mainly to its additional height.

Correction factors were determined and subsequently applied to non-typhoon wind data collected at Waglan Island to determine a probability distribution of directional mean wind speeds for Hong Kong. The annual wind rose for mean wind speeds at a height equivalent to 500 m above Waglan Island is presented in Figure 2 and indicates that, on an annual basis, prevailing and strong non-typhoon winds approaching Hong Kong occur mainly from the north-east quadrant and, to a lesser extent, the south-west.

In Figure 2, mean wind speeds are divided into four categories (0 – 3.3 m/s, 3.4 – 7.9 m/s, 8.0 – 13.8 m/s and greater than 13.8 m/s) that are indicated by the thickness of the bars for the 16 cardinal wind directions. The length of the bars indicates the average percentage of occurrence per year. For example, Figure 2 illustrates that, on an annual basis, east winds occur approximately 24% of the time and hourly mean wind speeds exceed 13.8 m/s approximately 6% of the time at a height of 500 m.

3. WIND TUNNEL STUDY

The wind tunnel test techniques used in this investigation were consistent with the procedures and recommendations of the Australasian Wind Engineering Society Quality Assurance Manual, AWES QAM-1-2001 (2001) and the American Society of Civil Engineers Manual and Report on Engineering Practice No. 67 for Wind Tunnel Studies of Buildings and Structures (1999). Those requirements cover the satisfactory modelling of the turbulent natural wind, the accuracy of the wind tunnel models, experimental and analysis procedures and quality assurance.

3.1 Modelling the Natural Wind

Air moving relative to the Earth's surface has frictional forces imparted on it, which effectively cause it to be slowed down. These forces have a decreasing effect on air flow as the height above ground increases, generally resulting in mean wind speed increasing with height to a point where the effects of surface drag become negligible. In wind engineering, a convenient measure of the thickness of the atmospheric boundary layer is commonly referred to as the gradient height which will vary depending on the surrounding surface roughness over which the air will flow. Obstacles to air flow can vary from relatively large expanses of smooth, open water, to vegetation such as forests, built-up environments such as city centres, and large, rugged mountain ranges. The resulting gradient heights typically vary from several hundred metres to in excess of 1000 m.

Winds within the atmospheric boundary layer are also usually highly turbulent or gusty. Turbulence intensity is a measure of the gustiness of wind due to eddies and vortices

generated by frictional effects at surface level, the roughness of the terrain over which air is flowing and convective effects due to opposing movements of air masses of different temperature. In typical atmospheric boundary layer flow, turbulence intensity generally decreases with height. Closer to the ground, at pedestrian level for example, the magnitude of the turbulence intensity can be very large due to the effects of wind flowing around buildings and other structures.

In conducting wind tunnel model studies of wind characteristics and wind effects on and around tall buildings and other structures on the surface of the Earth, it is necessary to adequately simulate the atmospheric boundary layer. WWTF's boundary layer wind tunnel test sections can be used to simulate atmospheric boundary layer flow over various types of terrain, ranging from open terrain, such as open water, to urban or mountainous terrain.

WWTF comprises two long fetch boundary layer wind tunnel test sections as shown in Figure 3. The 28 m long high speed test section has a 3 m wide × 2 m high working section and a maximum freestream wind speed of approximately 30 m/s. The 40 m long low speed test section has a 5 m wide × 4 m high working section and a maximum freestream wind speed of approximately 10 m/s. Various terrain simulations can be modelled in either test section at length scales ranging from approximately 1:5000 to 1:50.

The wind in the low speed test section of the WWTF can be modified through the use of devices such as spires, grids, and fences to model different scale atmospheric boundary layer flows. For the current study, WWTF's low speed test section was calibrated, by using appropriate combinations of roughness elements, to simulate the characteristics of winds approaching Hong Kong through mean wind speed and turbulence intensity profiles

corresponding to wind flowing over open water. The mean wind speed profile of the wind flow approaching the study area was simulated in accordance with the power law expression, defined in Equation (1), specified in Planning Department's Feasibility Study for Establishment of Air Ventilation Assessment System – Final Report (2005).

$$\frac{\overline{u}(z)}{\overline{u}_{ref}} = \left(\frac{z}{z_{ref}} \right)^{\alpha} \qquad (1)$$

where:

$\overline{u}(z)$ = mean wind speed at a height z (m/s);

$\overline{u}_{ref}$ = mean wind speed at a suitable reference height (m/s);

z = height above zero plane displacement height (m);

z_{ref} = a suitable reference height (m);

α = a power law exponent, which is a constant commensurate with the terrain roughness, taken as approximately 0.15 for this study.

The turbulence intensity profile of the approaching wind flow was simulated in accordance with Terrain category 2 stipulated in Australian/New Zealand Standard AS/NZS 1170.2:2002, i.e. corresponding to non-typhoon wind flow above rough open water surfaces.

The simulated mean wind speed and turbulence intensity profiles were generally within ±10% of the target mean speed and turbulence intensity profiles defined and are presented in Figure 4. The spectrum of longitudinal turbulence of the approaching wind flow measured at a height equivalent to 500 m in prototype scale is presented in Figure 5.

3.2 Physical Model of the Study Area

WWTF has a 1:2000 scale topographical model of the New Territories, Kowloon and Hong Kong Island fabricated at 20 m contour intervals from information acquired from the HKSAR's Survey and Mapping Office, Lands Department. The relevant sections of the topographical model were updated to include all known current buildings and the major topographical features in the urban landscapes of Hong Kong Island, Kowloon Peninsula and the New Territories. For all wind directions tested, the wind tunnel model included surrounding areas within a distance of up to approximately 10 km from the study area.

The topographical model was updated to include greater detail within a zone from 1000 m up to approximately 1500 m from the measurement positions. In accordance with information supplied by Scott Wilson Ltd during a period from 4 October 2007 to 15 November 2007, all known existing and relevant future buildings and structures at the time of testing were included in the model to represent their effects on wind flow approaching the study area. Beyond the 1500 m radius, the topographical model included roughness representative of the surrounding areas. A representative view of the 1:2000 scale topographical model used in the current study is shown in Figure 6.

3.3 Experimental and Analysis Procedures

The terrain surrounding the study area comprises complex mixtures of open water, urban and built-up environment, and mountainous areas in the New Territories and Kowloon Peninsula. Winds approaching the modelled region were scaled to simulate non-typhoon winds flowing over open water and the topographical model was used to determine the modifying effects of the surrounding complex terrain on the wind speed and turbulence intensity above the two test locations in the nominated study area.

Position 1 was located in the vicinity of the mountainous region in Tai Lam Country Park. The mountainous topography around Position 1 was included in the topography study, but all buildings within a radius of 1 km were removed from the topographical model as their effects will be directly accounted for by their inclusion in the later more detailed 1:400 scale AVA studies.

Position 2 was located at a region of less significant topography. When wind speed measurements were taken at Position 2, all buildings and topography within a radius of 1000 m were removed from the topographical model for all measured wind directions. All buildings and topography within the radius of 1000 m will be included in the proximity model for the more detailed 1:400 scale AVA studies to be conducted later, to directly account for their effects on the wind flow around Position 2.

Wind tunnel measurements were taken at each test location using a miniature dynamic pressure probe, a Cobra probe manufactured by Turbulent Flow Instrumentation Pty Ltd, at 22.5° intervals for the full 360° azimuth (i.e. 16 wind directions, θ), where a wind direction

of 0° or 360° corresponds to an incident wind approaching the study area directly from the north, 90° corresponds to an incident wind approaching the study area directly from the east, etc. For each wind direction tested, mean wind speeds and turbulence intensities were measured at heights equivalent to 25, 50, 75, 100, 150, 200, 300, 400 and 500 m at prototype scale above the local ground level of Position 1 (i.e. approximately 40 mPD) and at 25, 50, 75, 100, 150, 200, 300, 400 and 500 m at prototype scale above Hong Kong Principal Datum at Position 2.

4. EXPERIMENTAL RESULTS AND DISCUSSION

For each wind direction tested, the results of the 1:2000 scale topography study for Positions 1 and 2 are presented in graphical format in Figures 7 to 22 and Figures 23 to 38, respectively and in tabular format in Appendices A and B, respectively. In Figures 7a to 38a, the normalised wind characteristics include mean wind speed profiles and turbulence intensity profiles. Mean wind speed profiles were determined by normalising the local mean wind speeds with respect to the mean wind speed of the approaching wind flow measured at a height equivalent to 500 m, as defined in Equation (2). Vertical profiles of turbulence intensity, defined in Equation (3), are also presented in Figures 7a to 38a. Yaw and pitch angles, i.e. the lateral and vertical deviations respectively, of the local mean wind direction relative to the approaching mean wind direction, are presented in Figures 7b to 38b inclusive. The sign conventions used to define yaw angles and pitch angles are provided in Appendix C.

The profiles of longitudinal mean wind speed and turbulence intensity will be used as input conditions for the more detailed AVA studies of the Tuen Mun East Area.

$$\text{normalised wind velocity} = \frac{\overline{V}_z(\theta)}{\overline{V}_{500,\text{approach}}(\theta)} \qquad (2)$$

$$\text{turbulence intensity} = \frac{\sigma_{V,z}(\theta)}{\overline{V}_z(\theta)} \qquad (3)$$

In Equations (2) and (3):

$\overline{V}_z(\theta)$ = mean wind speed at a height z (z = 25, 50, 75, 100, 150, 200, 300, 400 or 500 m in prototype scale above the local ground level of Position 1 or above Hong Kong Principal

Datum for Position 2) for an approaching wind direction θ (θ = 22.5º, 45º, 67.5º, 90º, 112.5º, 135º, 157.5º, 180º, 202.5º, 225º, 247.5º, 270º, 292.5º, 315º, 337.5º or 360º);

$\overline{V}_{500,approach}(\theta)$ = mean wind speed of the approaching wind at a height equivalent to 500 m in prototype scale for an approaching wind direction θ;

$\sigma_{V,z}(\theta)$ = the standard deviation of the fluctuating wind speed V_z for an approaching wind direction θ.

Winds approaching the Tuen Mun East Area from northerly directions are affected by the hilly topography of Tai Lam Country Park and are typically characterised by relatively high turbulence intensities and significant reductions in mean wind speeds for the lower portion of the corresponding profiles. Winds approaching from southerly directions flow over Lantau Island and its two largest peaks, Lantau Peak (934 m) and Sunset Peak (869 m), and then above the fetch of open water between Lantau Island and the Tuen Mun East Area. However, as Lantau Island is further from the Tuen Mun East Area than the topography in Tai Lam Country Park, hence it has less influence on the local wind characteristics at the two test positions.

4.1 Wind Characteristics at Position 1

For Position 1, reductions in mean wind speeds and corresponding enhanced turbulence intensities were measured for winds approaching from 22.5º to 45º and 292.5º to 360º as shown in Figures 7a to 8a and 19a to 22a, respectively. For those directions, Position 1 was located downstream of the Tai Lam Country Park, with the hilly topography particularly affecting wind conditions in the lower 200 m of the measured profiles.

Relatively lower turbulence intensities and higher mean wind speeds were measured for winds approaching from 67.5º to 270º, as indicated in Figures 9a to 18a, highlighting the influence of the open water fetch between Lantau Island and the Tuen Mun East Area.

The topographical model study measurements were also used to determine directional factors for the 16 measured wind directions, relating the mean wind speeds at heights equivalent to 50 m and 500 m above the study area to the mean wind speed of the approach flow at a reference height of 500 m. These directional factors were then applied to WWTF's Hong Kong non-typhoon wind climate model, derived from HKO's Waglan Island wind data as discussed in Section 2 of this report, to determine site-specific wind roses pertaining to annual hourly mean wind speeds at heights of 50 m and 500 m above Position 1. The annual wind roses are presented in Figures 39 and 40 for heights of 50 m and 500 m above Position 1 (i.e. approximately 90 mPD and 540 mPD) of the Tuen Mun East Area, respectively.

The measured wind speeds at a height of 500 m above Position 1 were within ±10 % of the approaching mean wind speed at a height of 500 m for all measured wind directions except 360° and 22.5°. Furthermore, a significant yaw angle was measured for a wind direction of 22.5º at a height of 500 m above the local ground level of Position 1. These effects are reflected in the wind rose presented in Figure 40 in which the directional characteristics for wind directions of 360° and 22.5° are significantly different to those of the annual wind rose for Waglan Island presented in Figure 2.

The annual wind rose corresponding to a height of 50 m above the local ground level of Position 1 of the Tuen Mun East Area presented in Figure 39 demonstrates further reductions in the overall magnitudes of wind speed with respect to reference wind speeds of the

approach flow at a height of 500 m. Significant yaw angles were also measured for winds approaching from 315º, 337.5º and 360º, resulting in significant changes to the directional distribution of the wind rose at 50 m presented in Figure 39.

4.2 Wind Characteristics at Position 2

For Position 2, high turbulence intensities and reductions in mean wind speeds were measured for winds approaching from 22.5º and 292.5º to 360º, as shown in Figures 23a and 35a to 38a, respectively. For those directions, Position 2 was located downstream of the hilly terrain in Tai Lam Country Park which enhanced the turbulence intensities, particularly in the lower 200 m of the measured wind profiles.

Relatively lower turbulence intensities and higher mean wind speeds were measured for winds approaching from 45º to 270º, as indicated in Figures 24a to 34a, highlighting the effects of the fetch of open water between Lantau Island and the Tuen Mun East Area on winds from those directions.

A comparison of the annual wind rose for Waglan Island presented in Figure 2 to that for Position 2 of the Tuen Mun East Area at a height of 500 mPD in Figure 42 illustrates that the measured wind speeds for all measured wind directions, except 337.5°, were within ±10% of the approaching mean wind speed at a height of 500 m. No significant yaw angles were measured at a height of 500 mPD.

In contrast, the annual wind rose corresponding to height of 50 mPD above Position 2, presented in Figure 41, indicates both significant reductions in the overall magnitudes of

wind speed with respect to those at a height of 500 m and significant changes of directional distributions for winds approaching from 112.5º and 337.5º.

5. CONCLUSIONS

A study of wind availability and characteristics of the Tuen Mun East Area was conducted by the CLP Power Wind/Wave Tunnel Facility at The Hong Kong University of Science and Technology under "Agreement No. CE 47/2006 (TP) Planning and Engineering Review of Potential Housing Sites in Tuen Mun East Area – Feasibility Study" administered by Scott Wilson Ltd.

A 1:2000 scale topographical model study was undertaken to determine the effects of local topography and the surrounding urban environment on mean wind speeds and turbulence intensities above the study area. The topography study results were subsequently combined with a statistical model of the Hong Kong wind climate, based on measurements of non-typhoon winds taken by Hong Kong Observatory at Waglan Island, to determine directional wind characteristics and availability at two test positions in the Tuen Mun East Area.

In general, the annual prevailing wind characteristics corresponding to strong non-typhoon winds at a height of 500 m above the Tuen Mun East Area were similar to the overall characteristics of non-typhoon winds approaching the Hong Kong region, although a significant yaw angle was measured for wind approaching from 22.5° for Position 1. At a height of 50 m, winds from directions of 315° to 360° for Position 1 and winds from directions of 112.5° and 337.5° for Position 2 were significantly affected by the surrounding topography, causing significant changes to the wind roses at that height. Significant reductions in the measured magnitudes of wind speed are believed to be caused by the hilly topography of Tai Lam Country Park to the north of the Tuen Mun East Area. Winds

approaching from southerly directions were the least affected due to the area's relatively open exposure in those directions.

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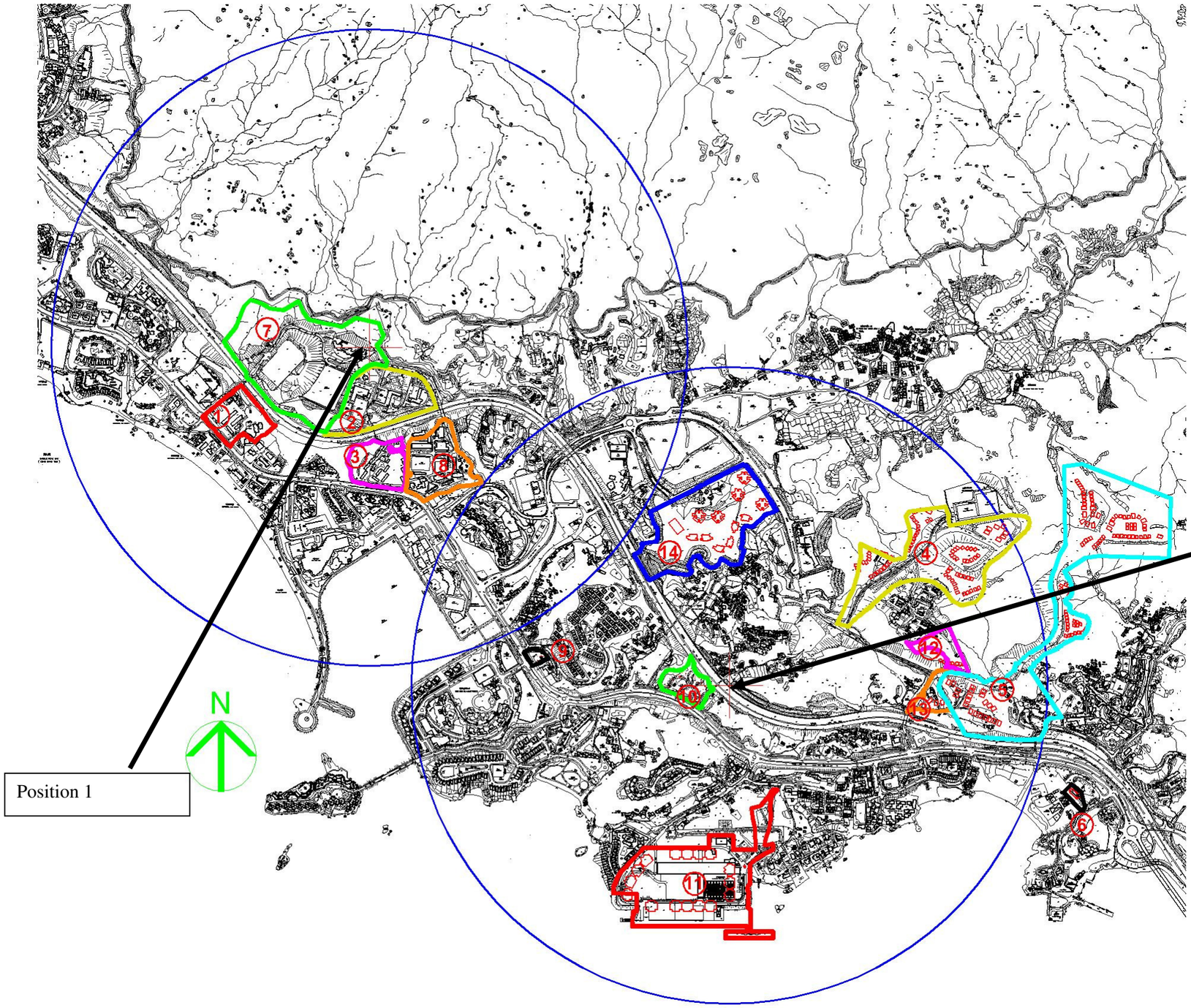

Figure 1: Tuen Mun East Area

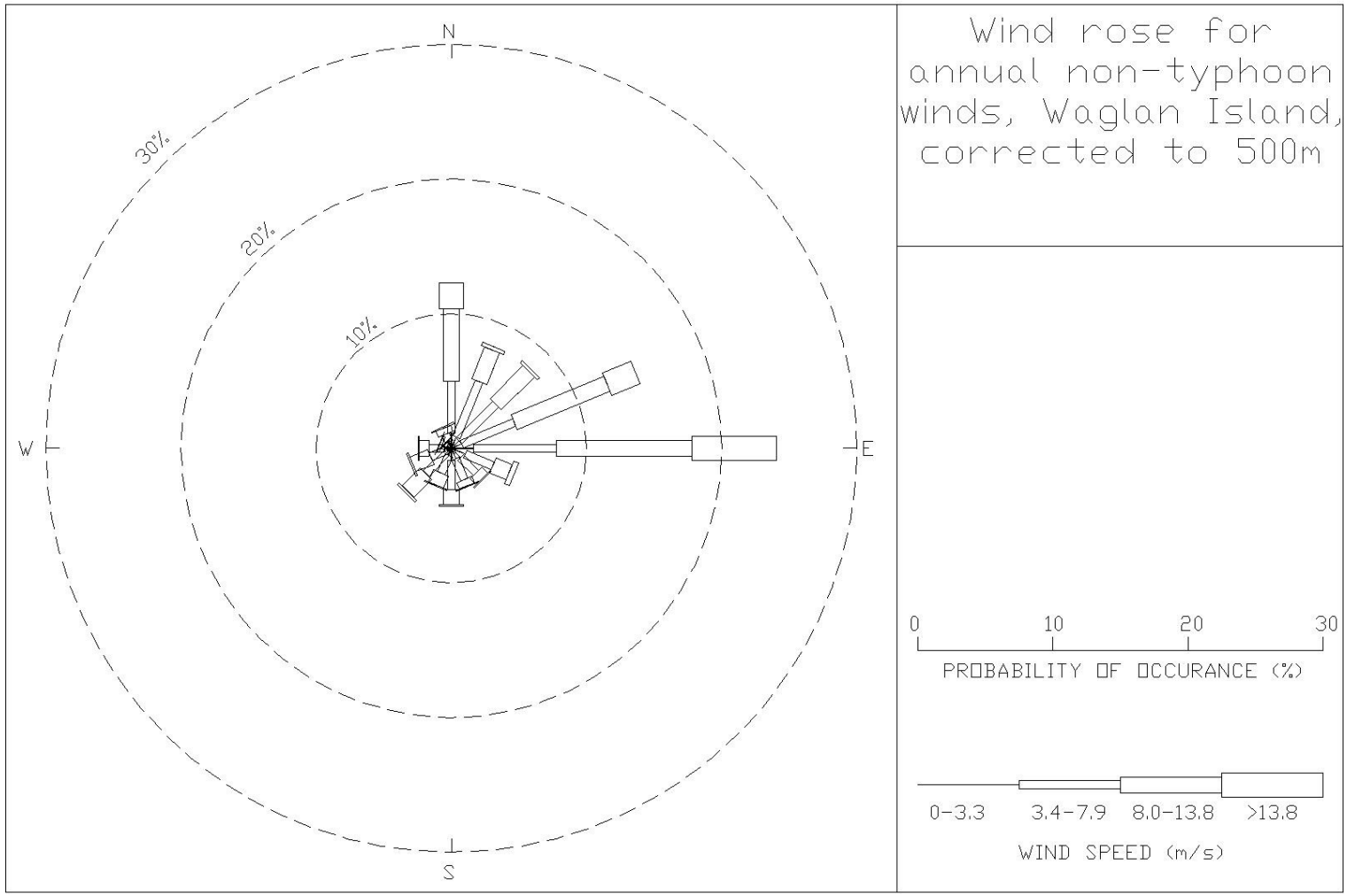

Figure 2: Wind rose for annual, non-typhoon winds, Waglan Island, corrected to 500m, 1953-2000

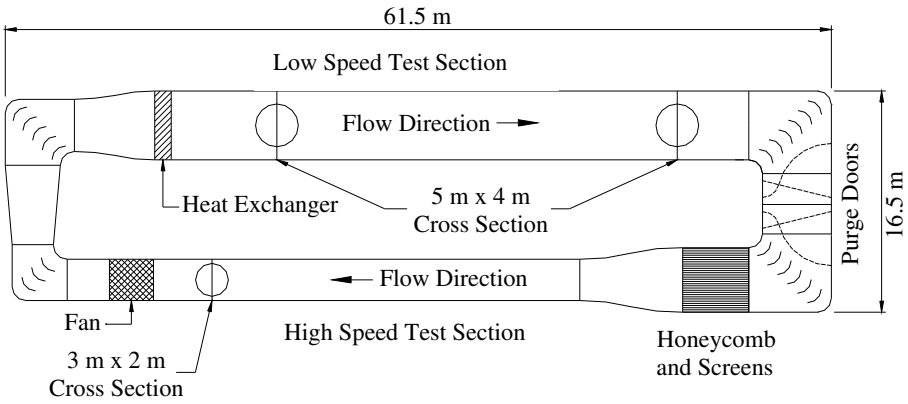

Figure 3: Test sections at the CLP Power Wind/Wave Tunnel Facility

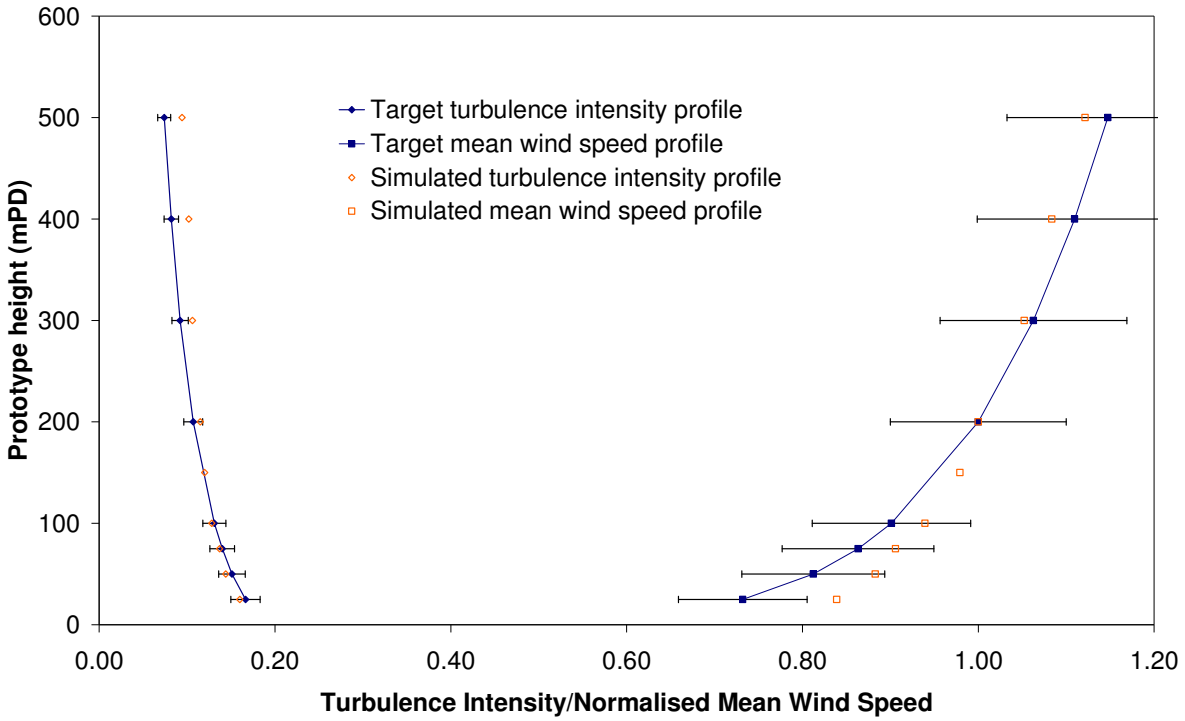

Figure 4: Simulated mean wind speed and turbulence intensity profiles – approach wind

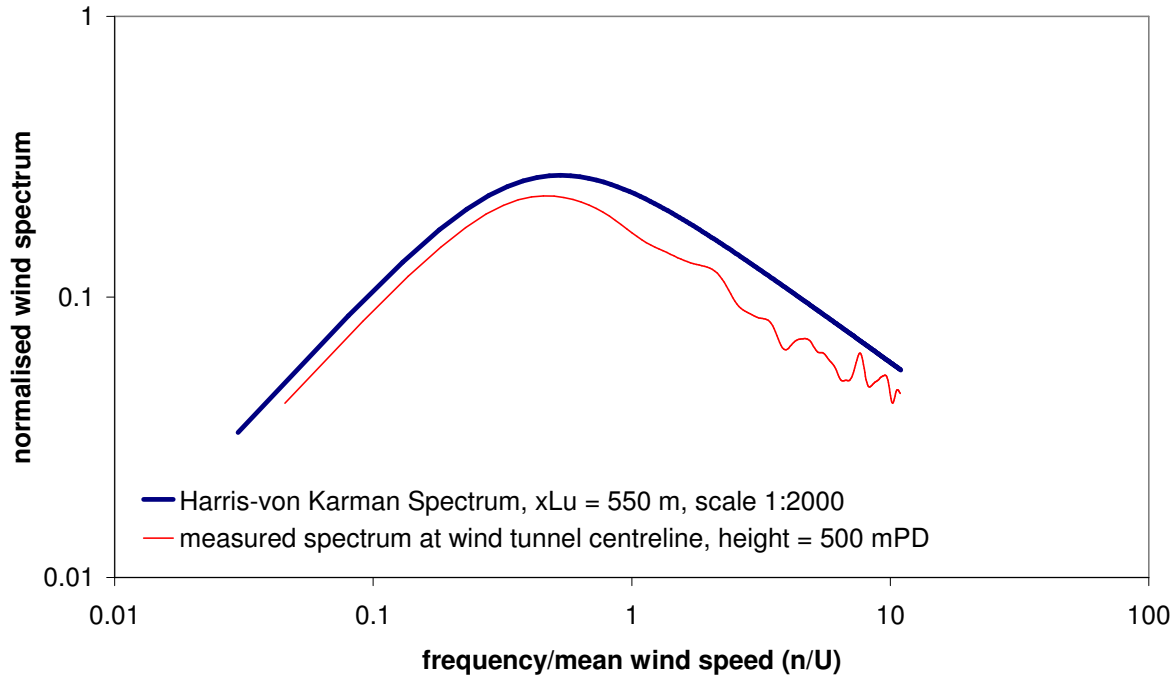

Figure 5: Longitudinal turbulence spectrum – approach wind

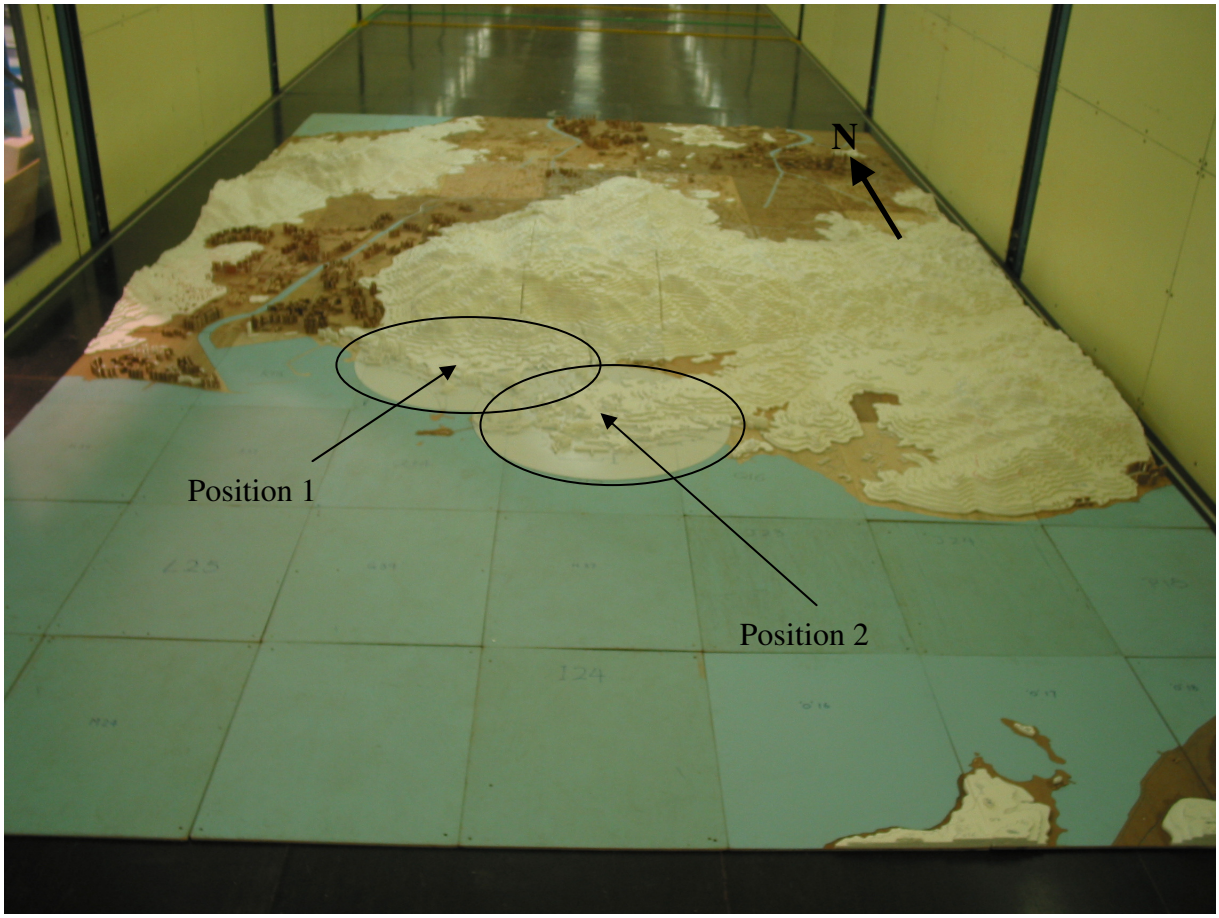

Figure 6: A 1:2000 scale topographical model of the Tuen Mun East Area, Hong Kong in the low speed test section of the CLP Power Wind/Wave Tunnel Facility

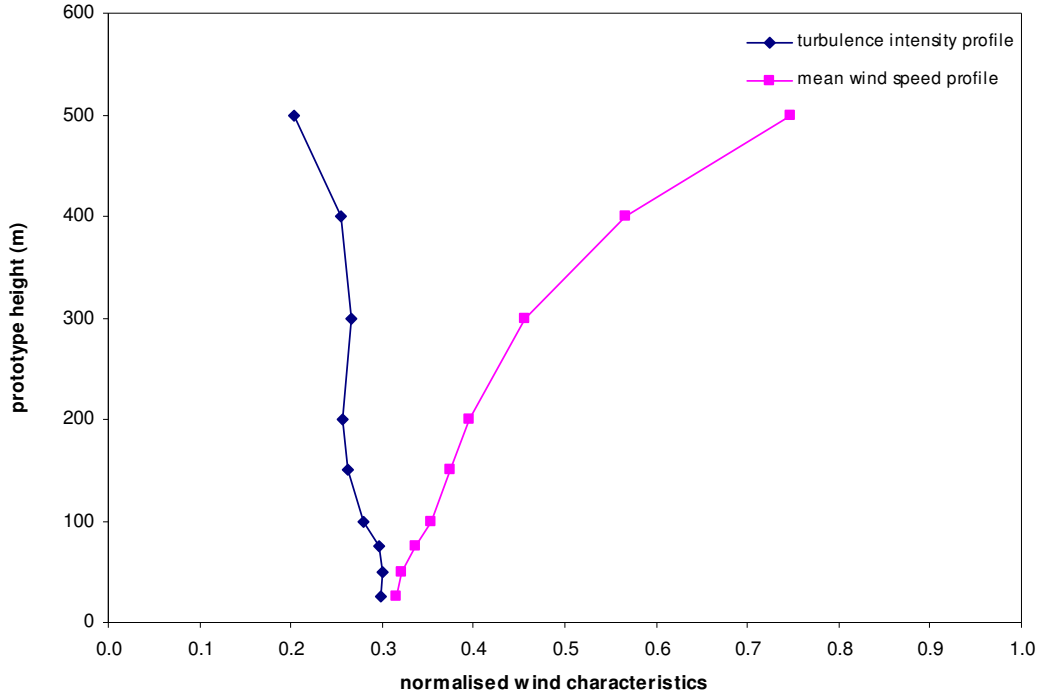

Figure 7a: Wind characteristics, Position 1, Tuen Mun East Area, 22.5º

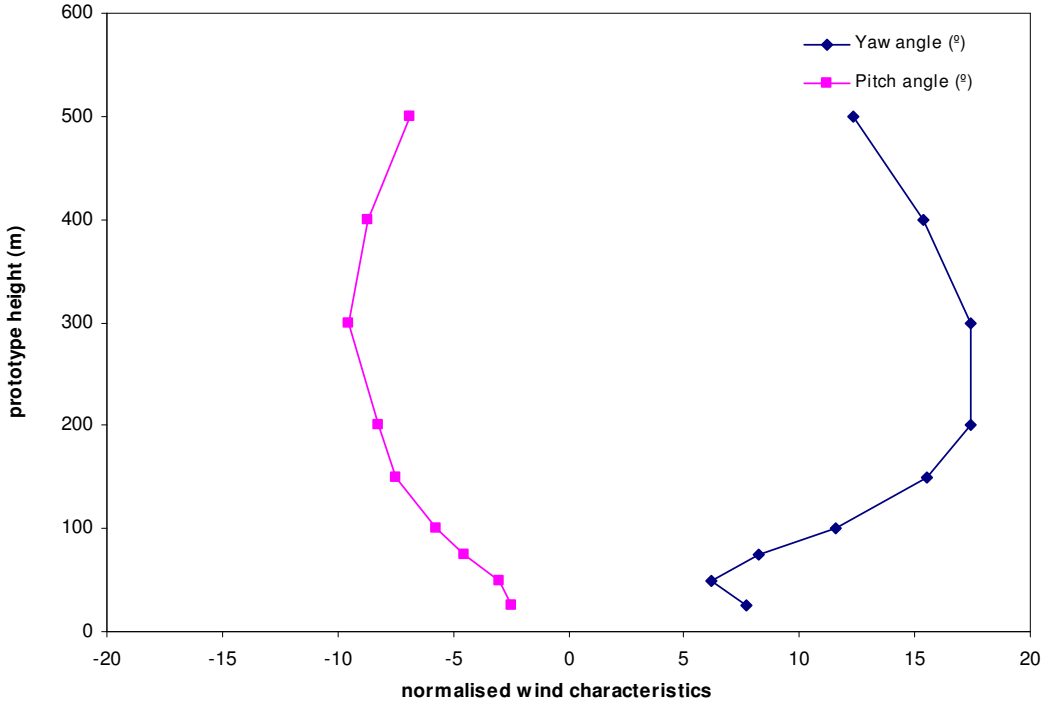

Figure 7b: Mean wind direction, Position 1, Tuen Mun East Area, 22.5º

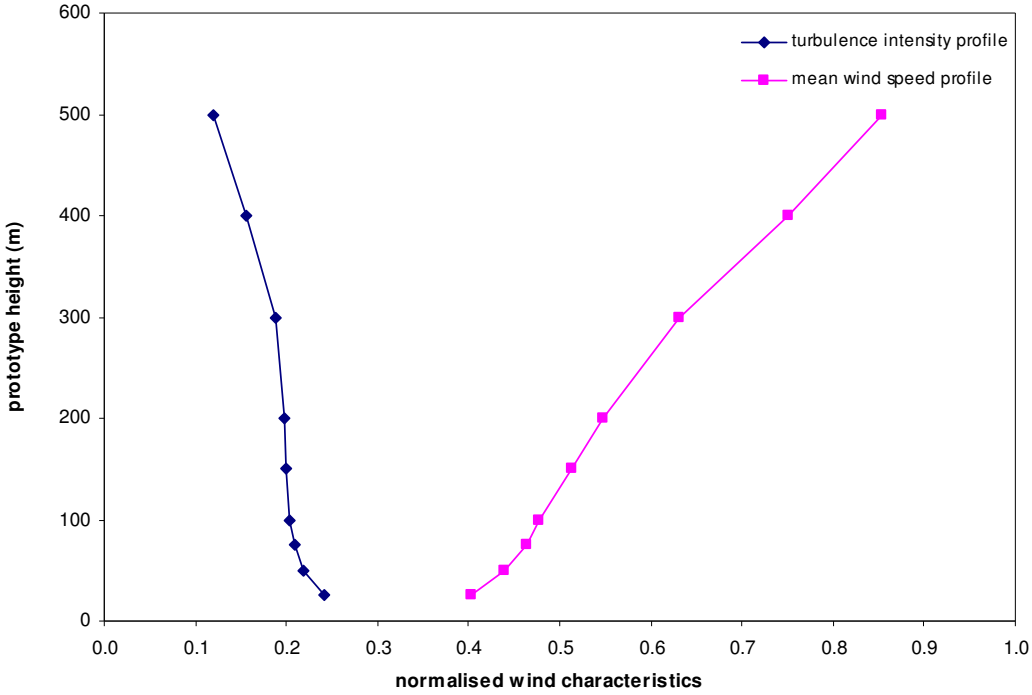

Figure 8a: Wind characteristics, Position 1, Tuen Mun East Area, 45º

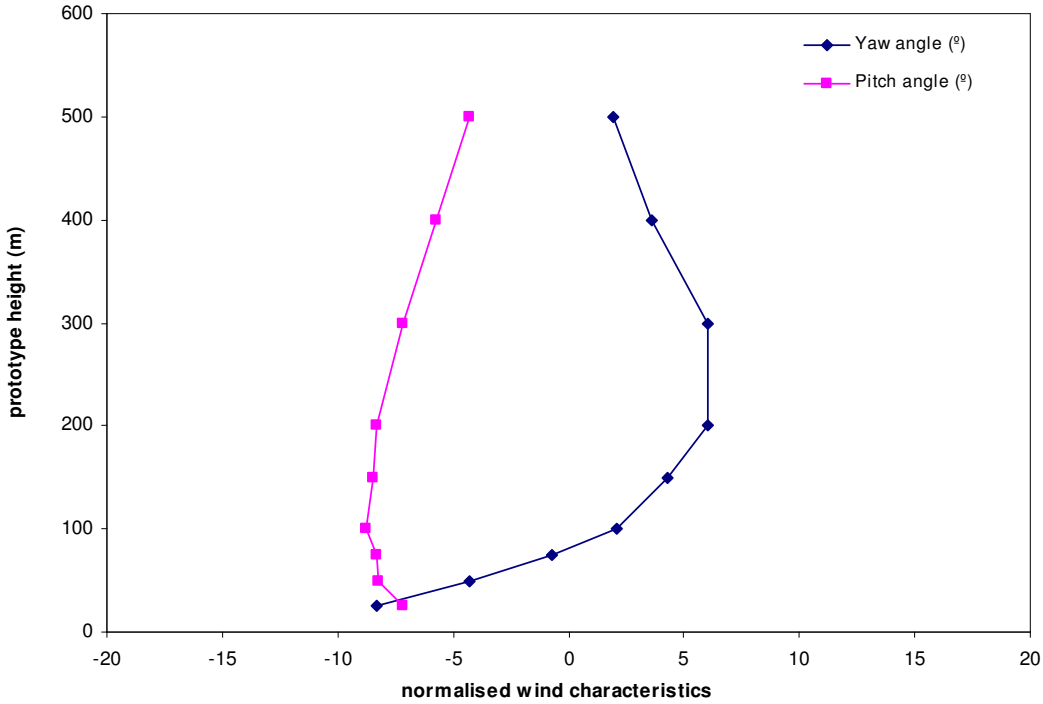

Figure 8b: Mean wind direction, Position 1, Tuen Mun East Area, 45º

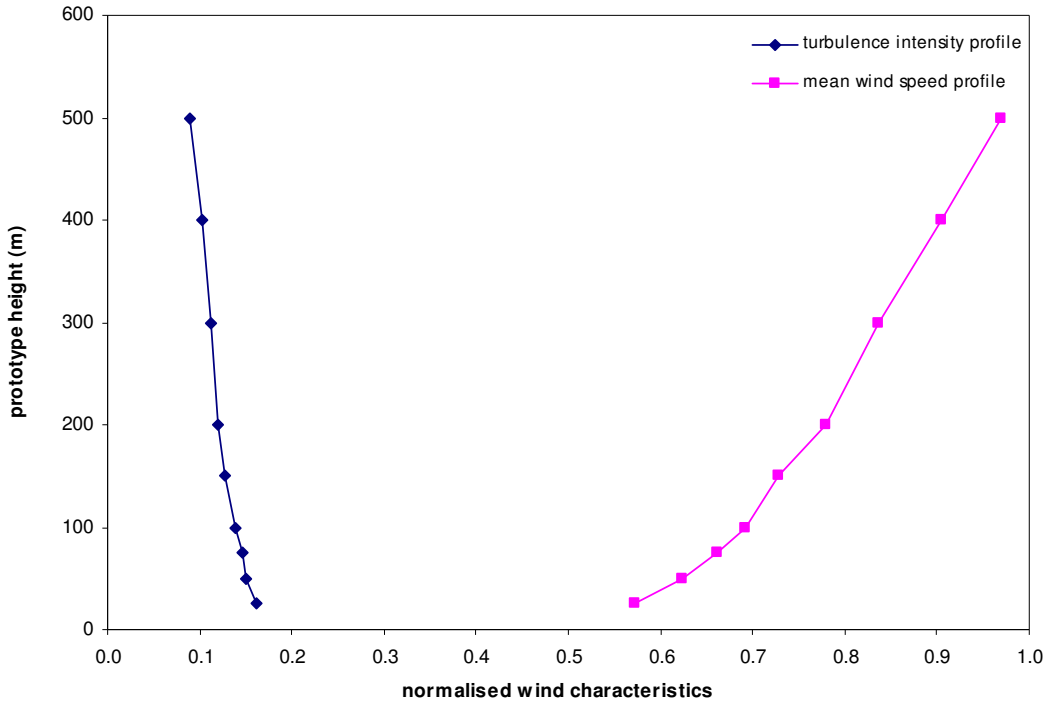

Figure 9a: Wind characteristics, Position 1, Tuen Mun East Area, 67.5º

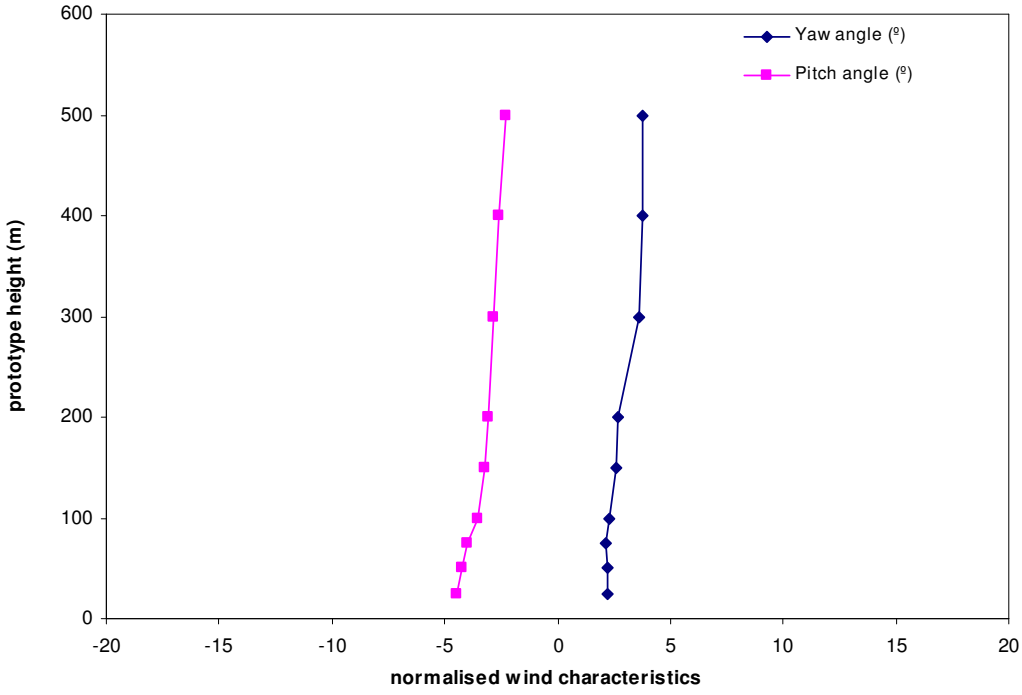

Figure 9b: Mean wind direction, Position 1, Tuen Mun East Area, 67.5º

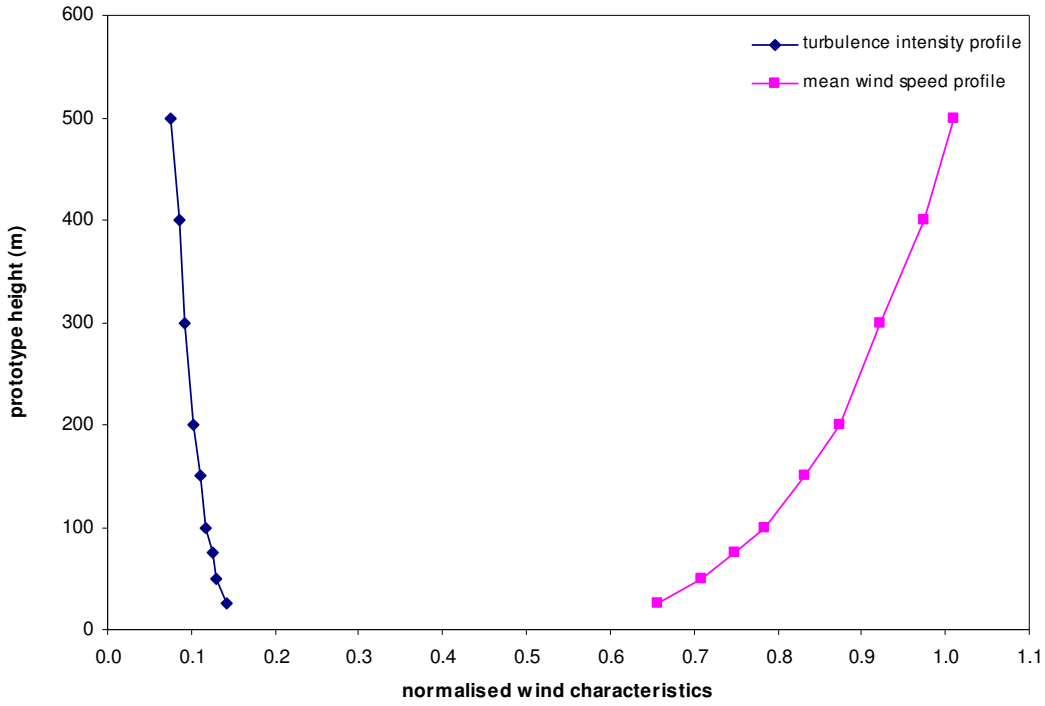

Figure 10a: Wind characteristics, Position 1, Tuen Mun East Area, 90º

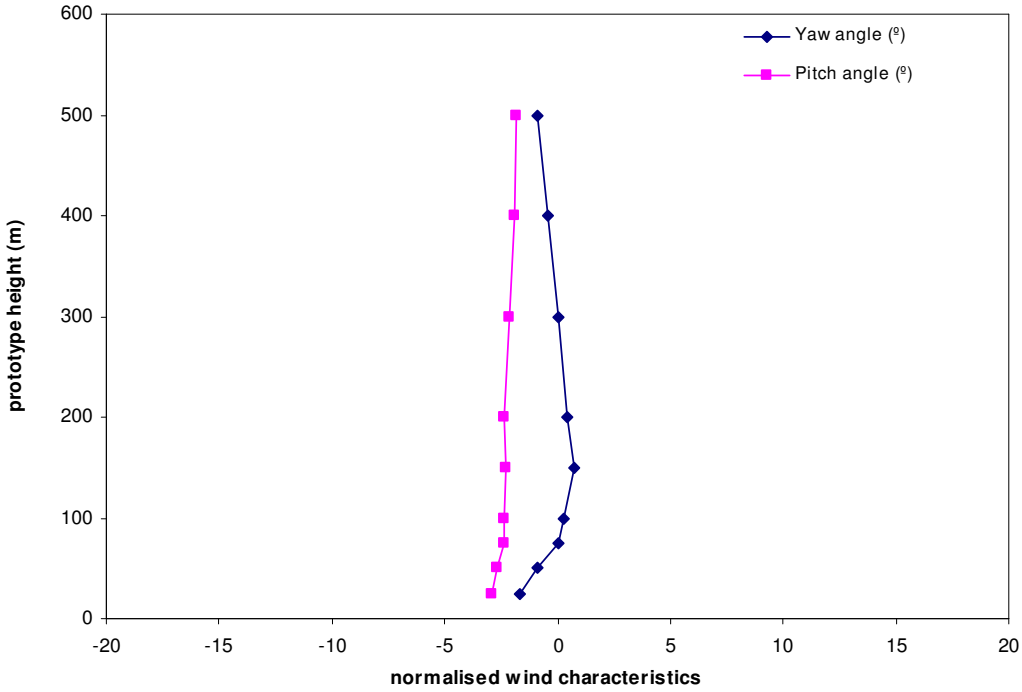

Figure 10b: Mean wind direction, Position 1, Tuen Mun East Area, 90º

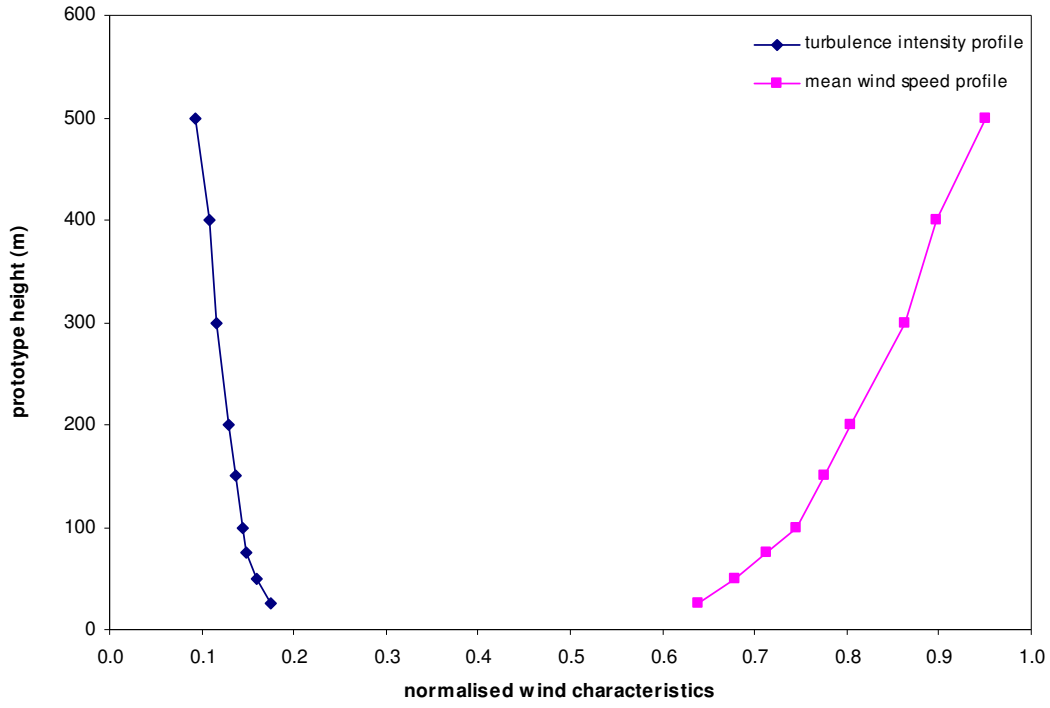

Figure 11a: Wind characteristics, Position 1, Tuen Mun East Area, 112.5º

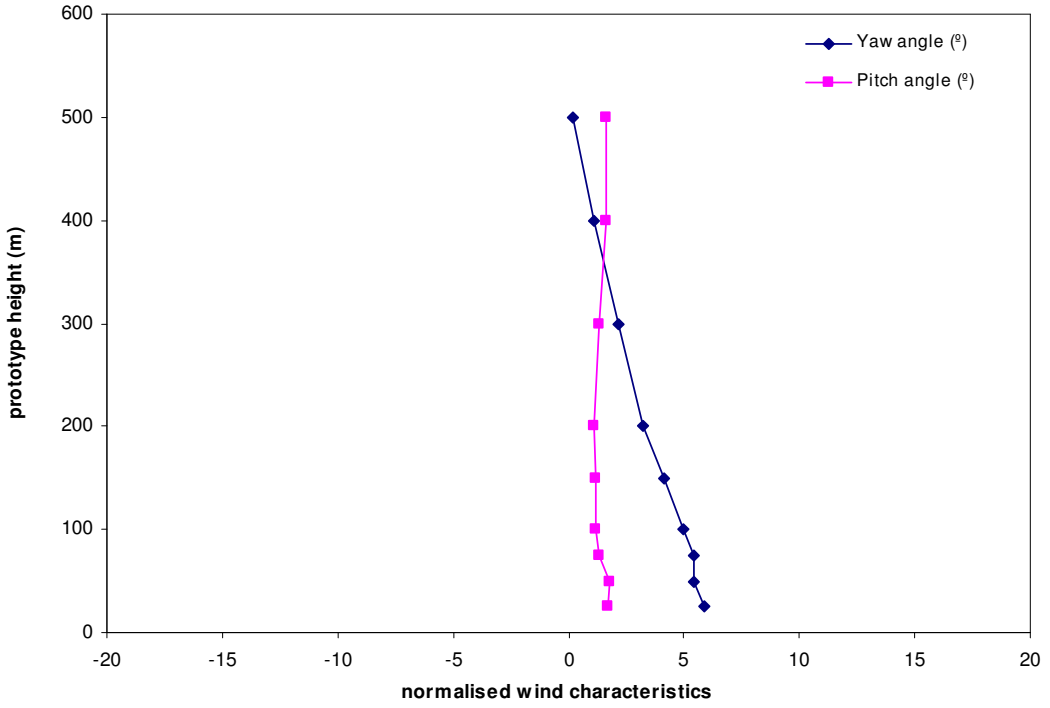

Figure 11b: Mean wind direction, Position 1, Tuen Mun East Area, 112.5º

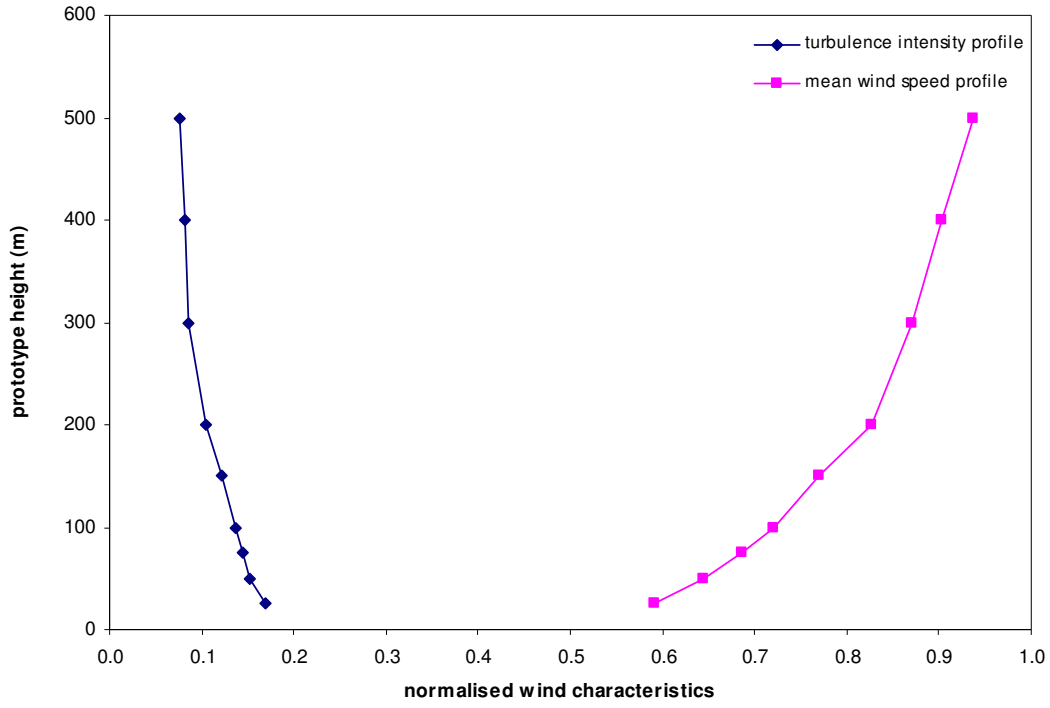

Figure 12a: Wind characteristics, Position 1, Tuen Mun East Area, 135º

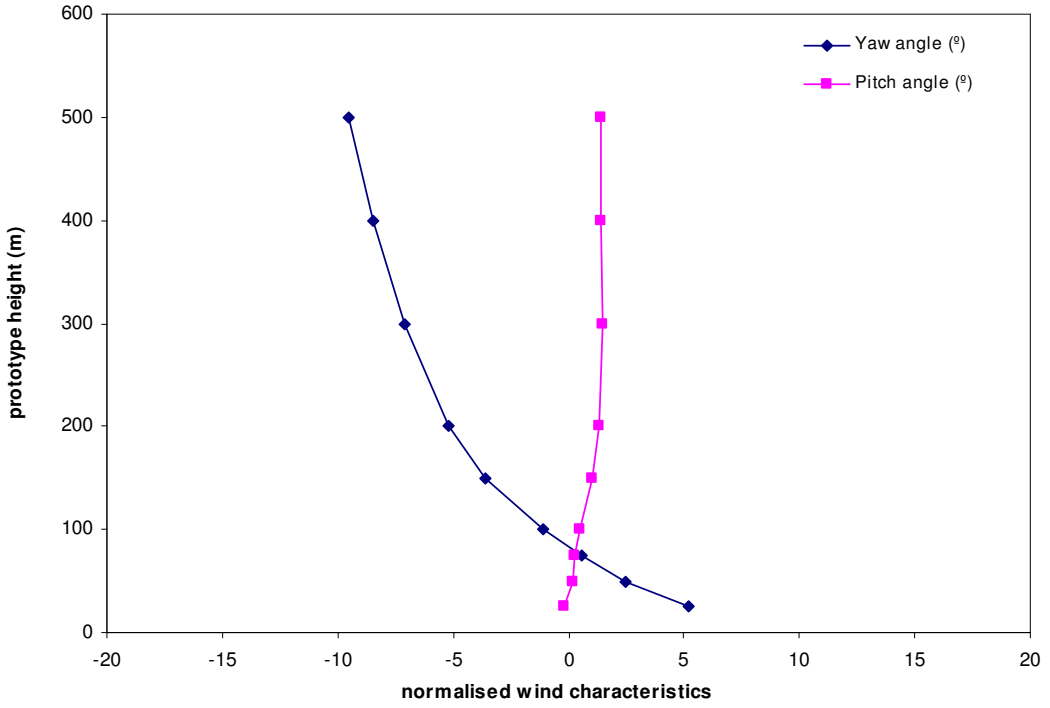

Figure 12b: Mean wind direction, Position 1, Tuen Mun East Area, 135º

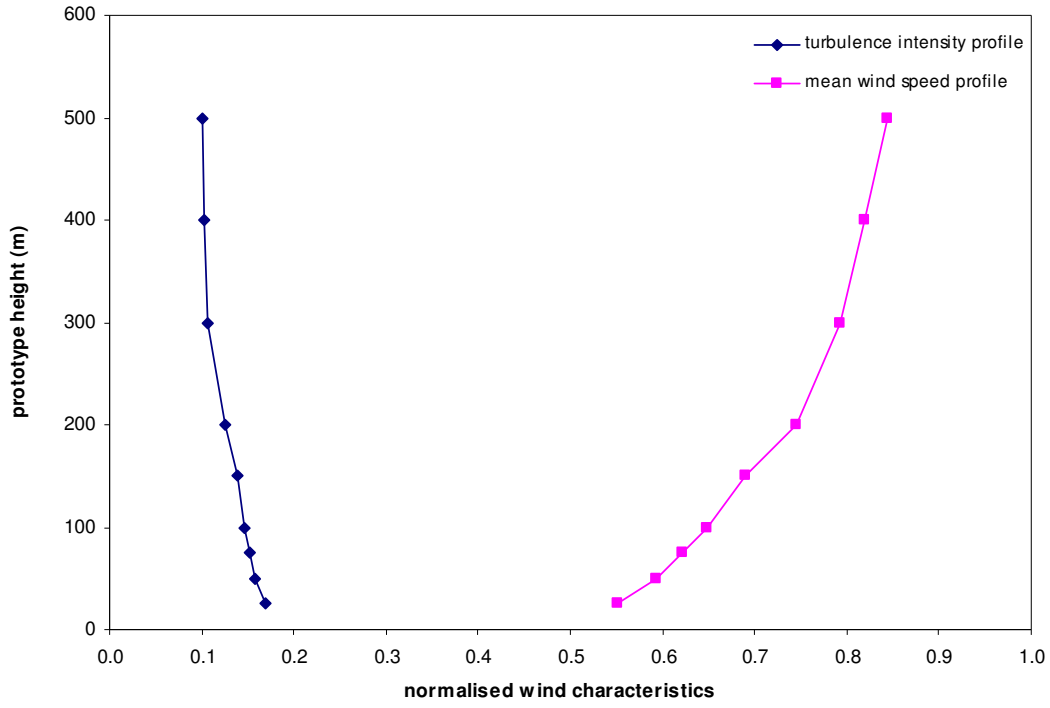

Figure 13a: Wind characteristics, Position 1, Tuen Mun East Area, 157.5º

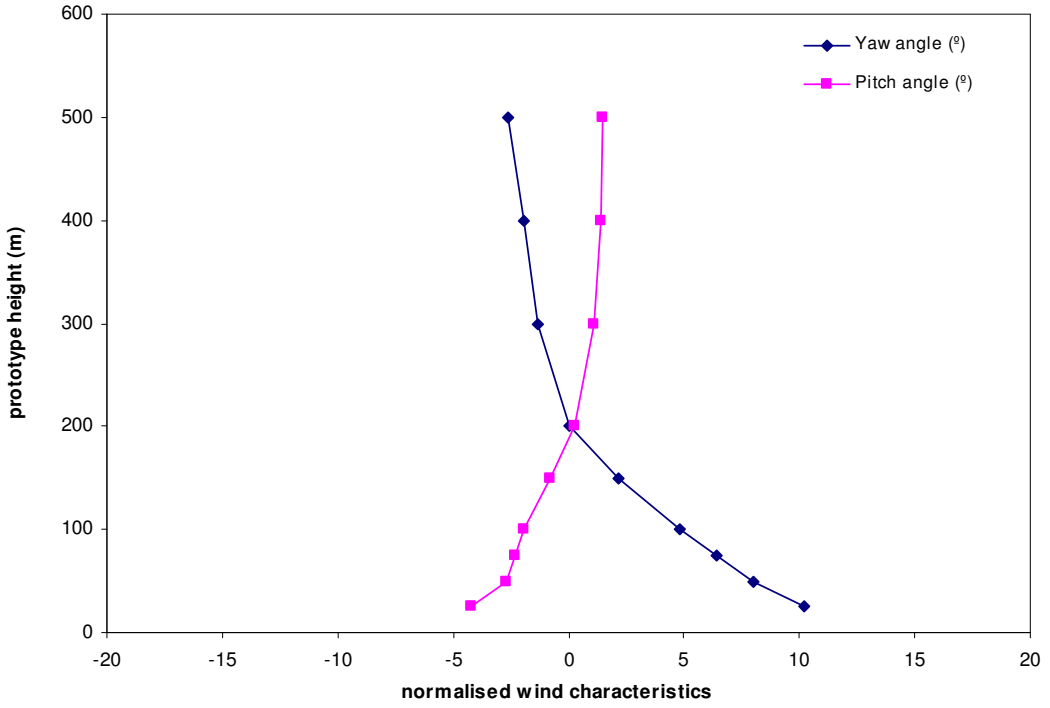

Figure 13b: Mean wind direction, Position 1, Tuen Mun East Area, 157.5º

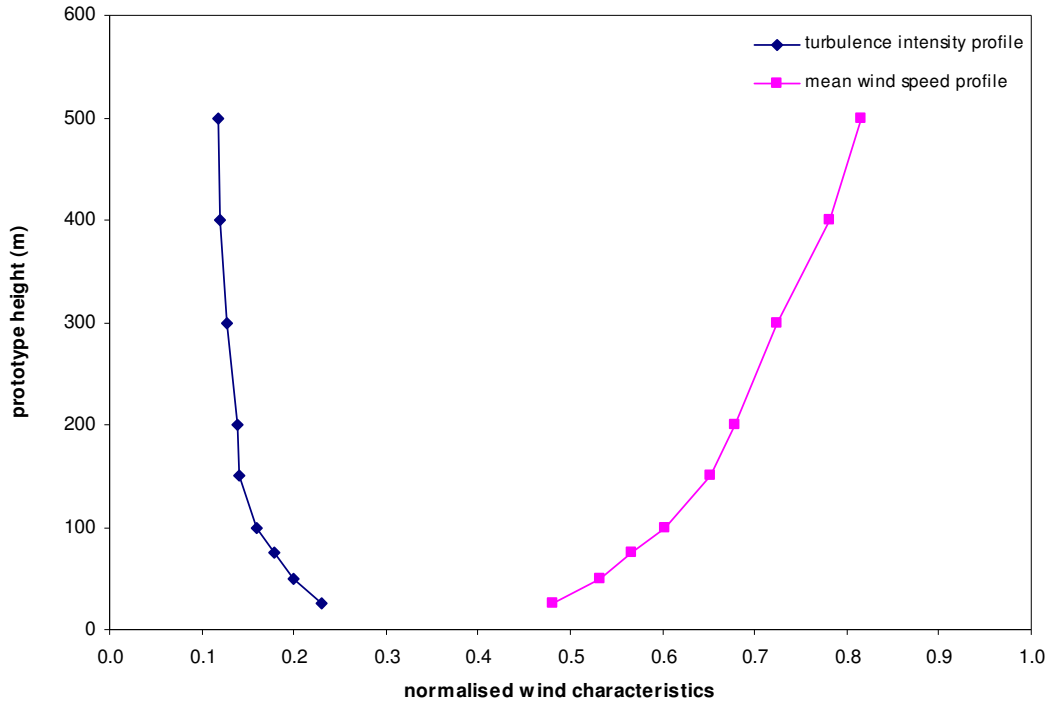

Figure 14a: Wind characteristics, Position 1, Tuen Mun East Area, 180º

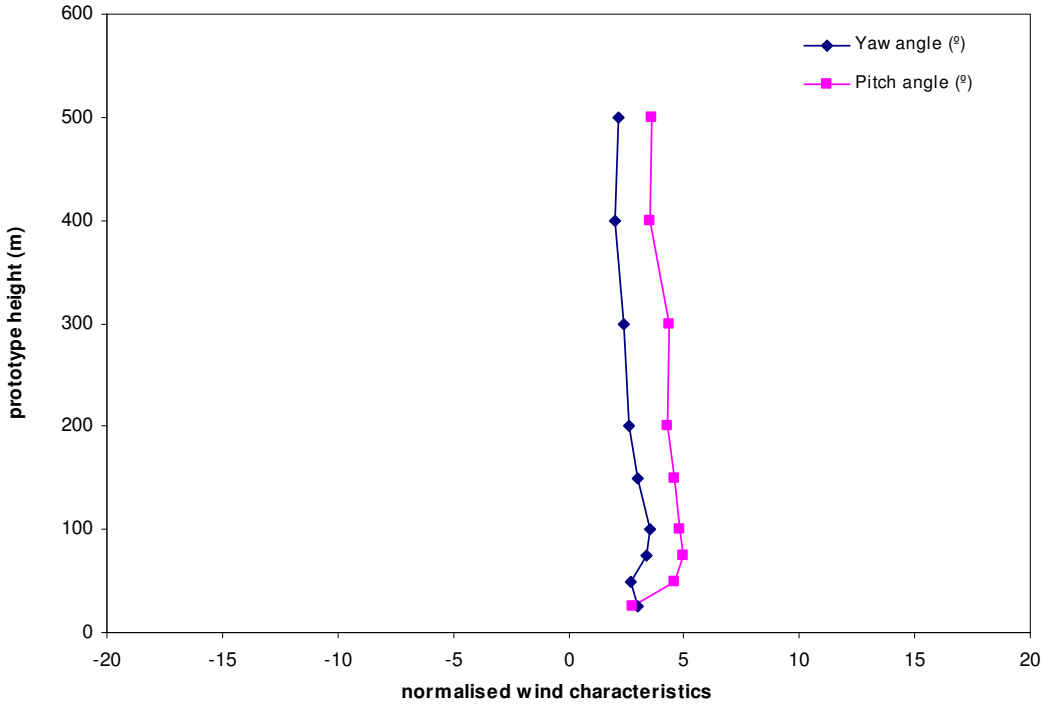

Figure 14b: Mean wind direction, Position 1, Tuen Mun East Area, 180º

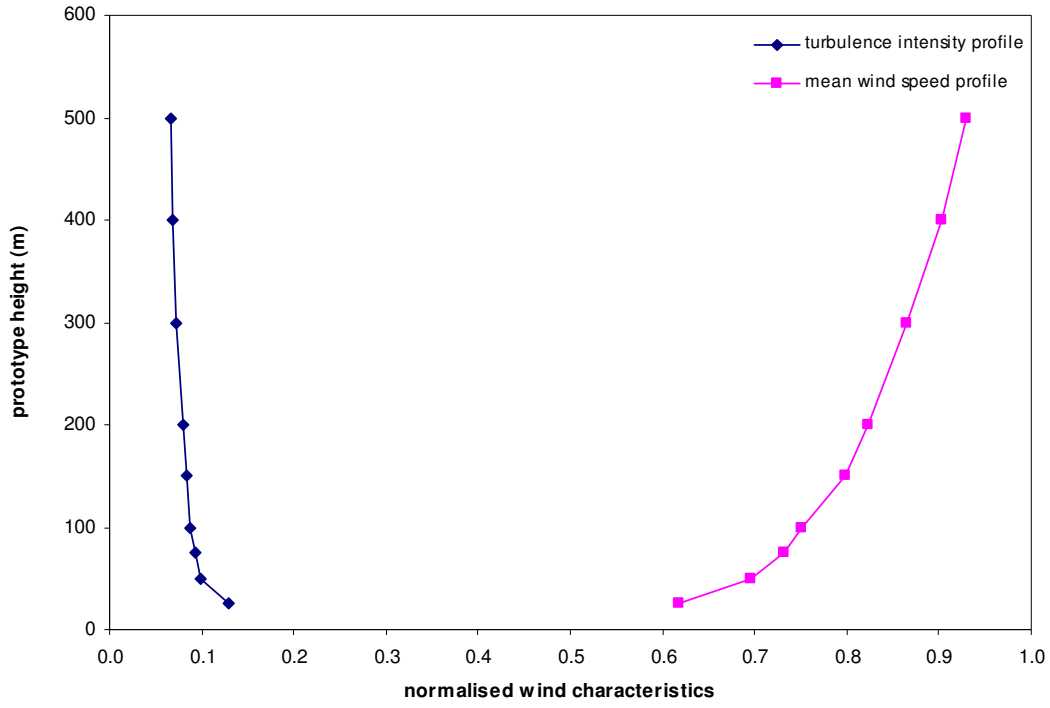

Figure 15a: Wind characteristics, Position 1, Tuen Mun East Area, 202.5º

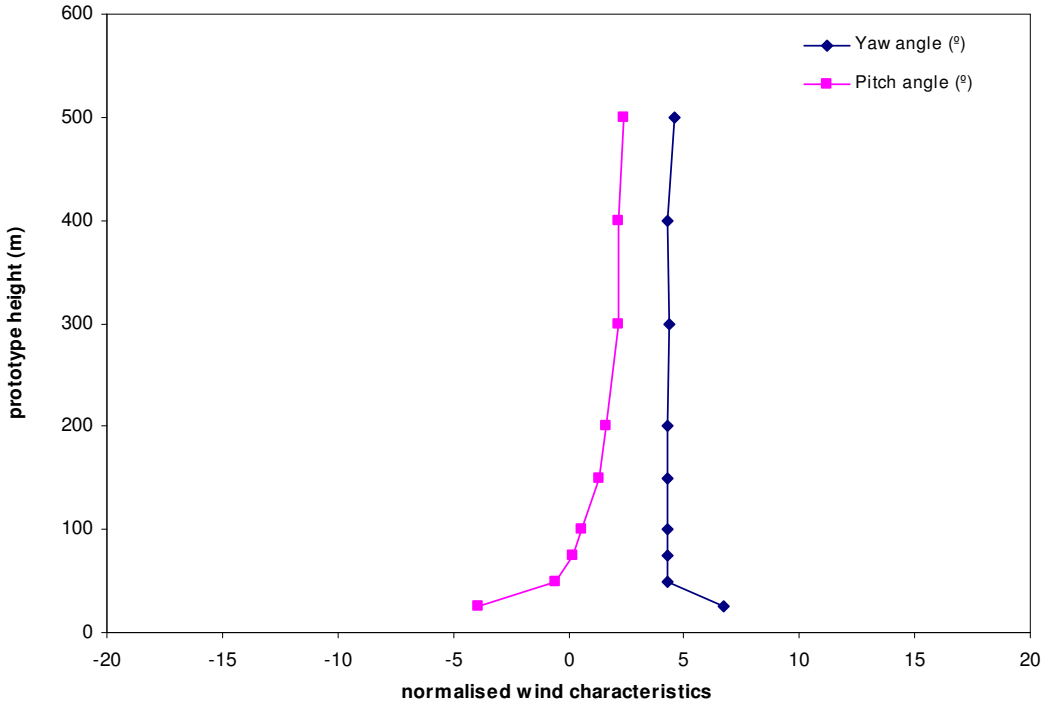

Figure 15b: Mean wind direction, Position 1, Tuen Mun East Area, 202.5º

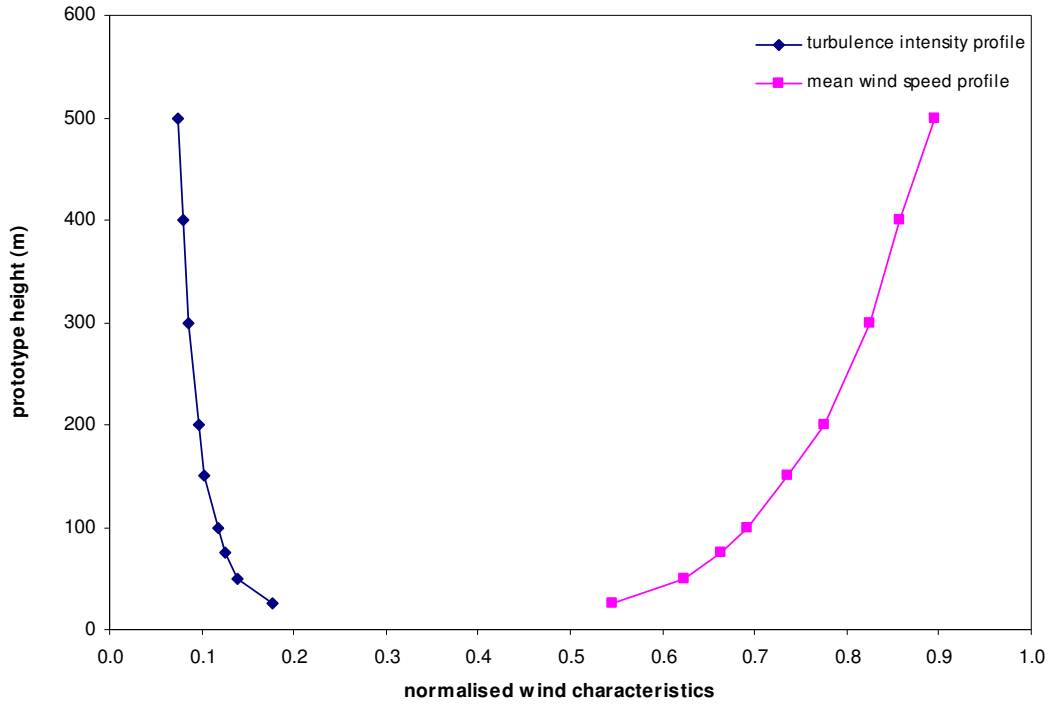

Figure 16a: Wind characteristics, Position 1, Tuen Mun East Area, 225º

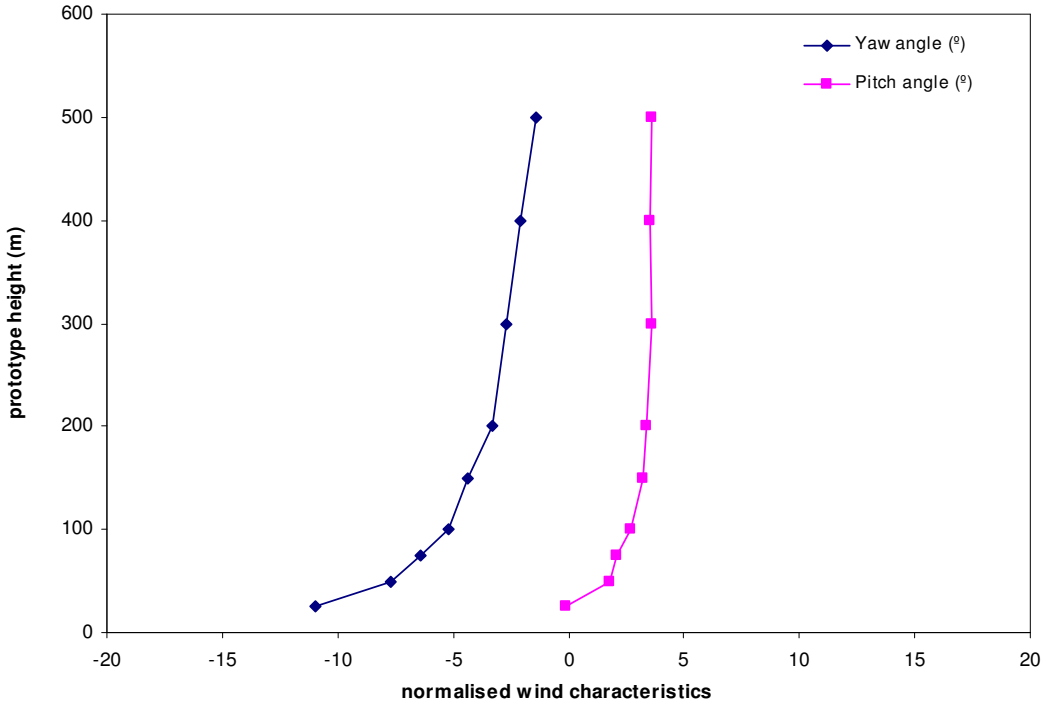

Figure 16b: Mean wind direction, Position 1, Tuen Mun East Area, 225º

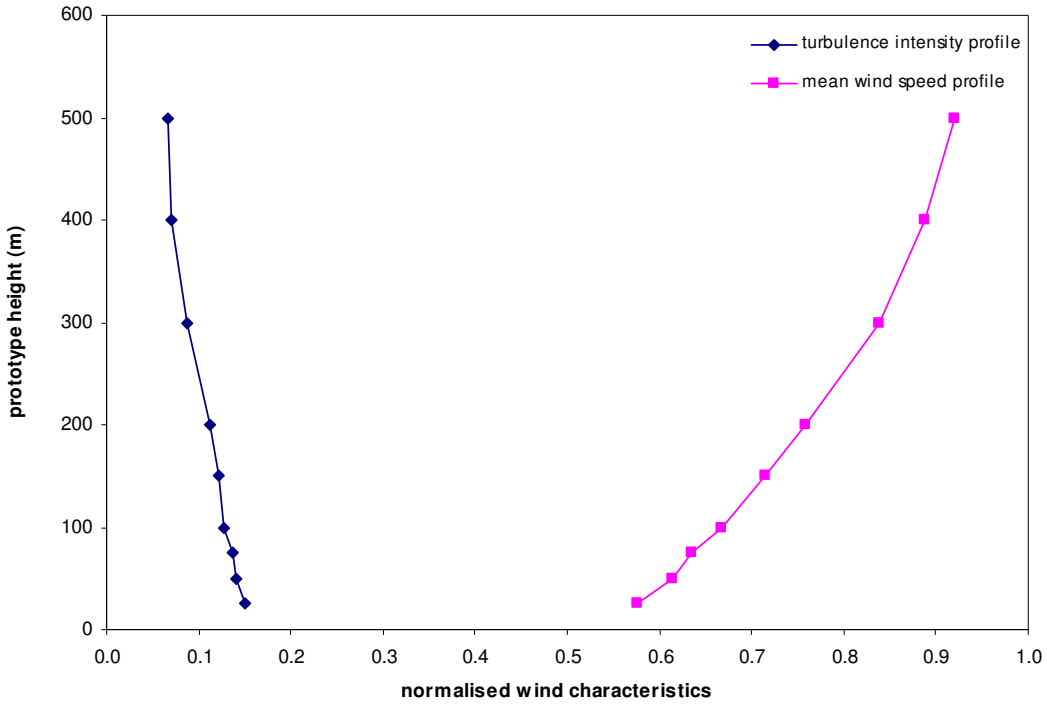

Figure 17a: Wind characteristics, Position 1, Tuen Mun East Area, 247.5º

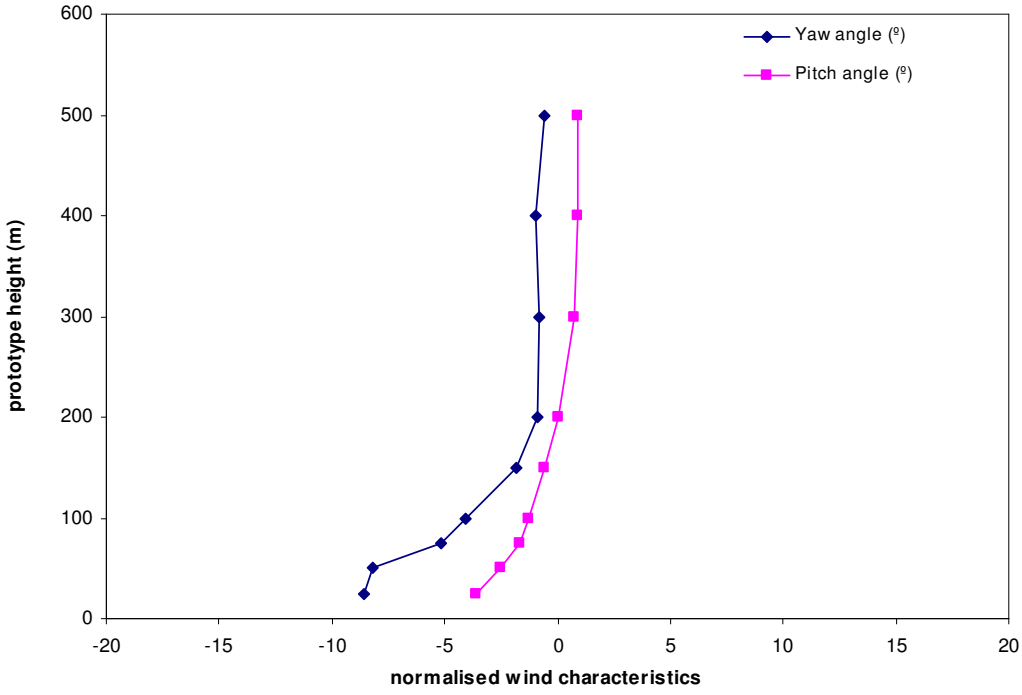

Figure 17b: Mean wind direction, Position 1, Tuen Mun East Area, 247.5º

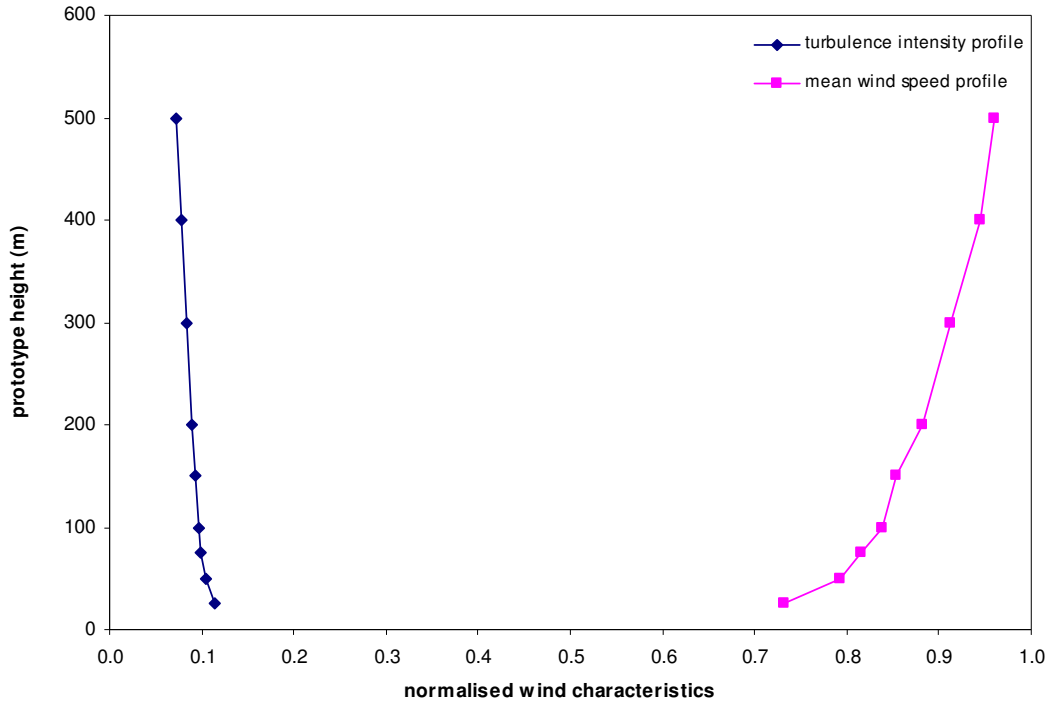

Figure 18a: Wind characteristics, Position 1, Tuen Mun East Area, 270º

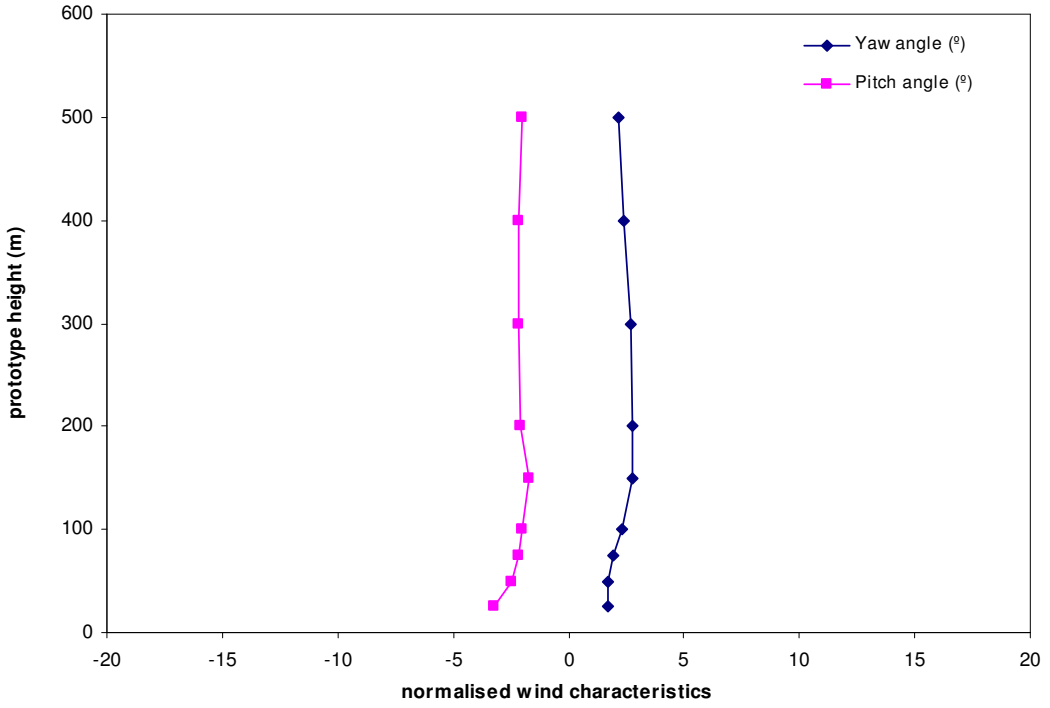

Figure 18b: Mean wind direction, Position 1, Tuen Mun East Area, 270º

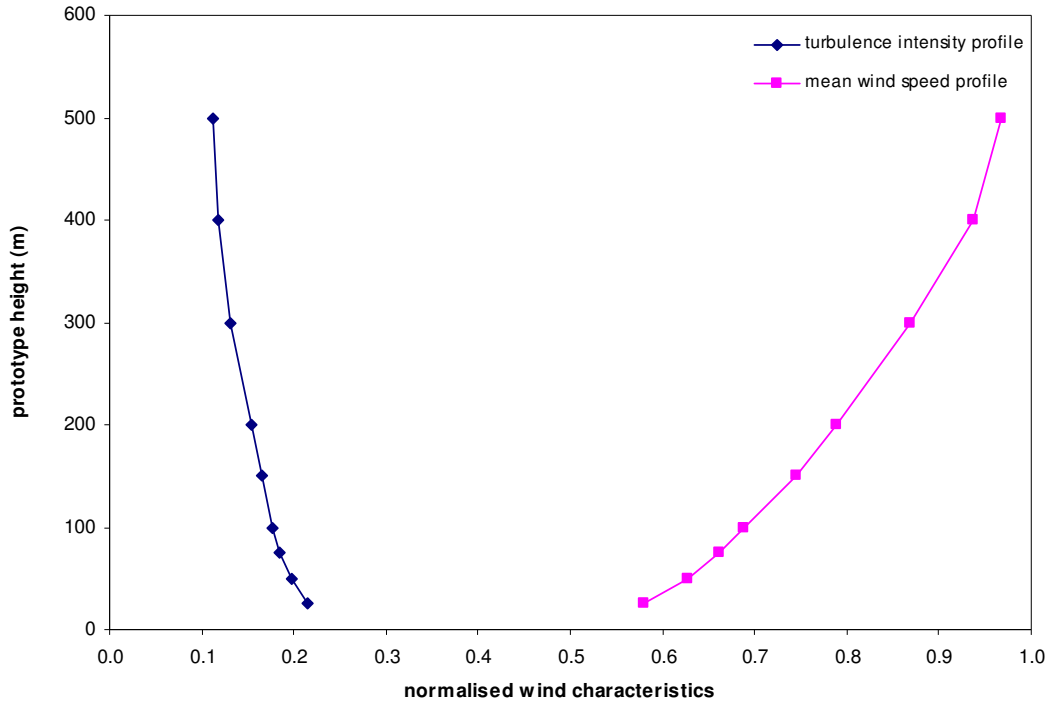

Figure 19a: Wind characteristics, Position 1, Tuen Mun East Area, 292.5º

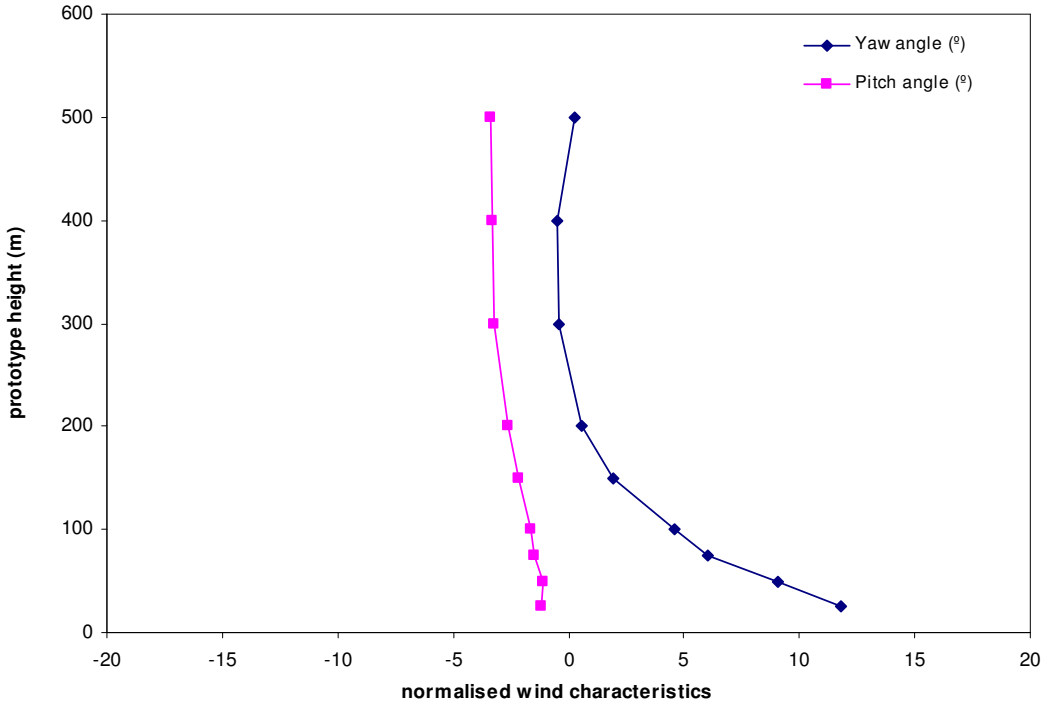

Figure 19b: Mean wind direction, Position 1, Tuen Mun East Area, 292.5º

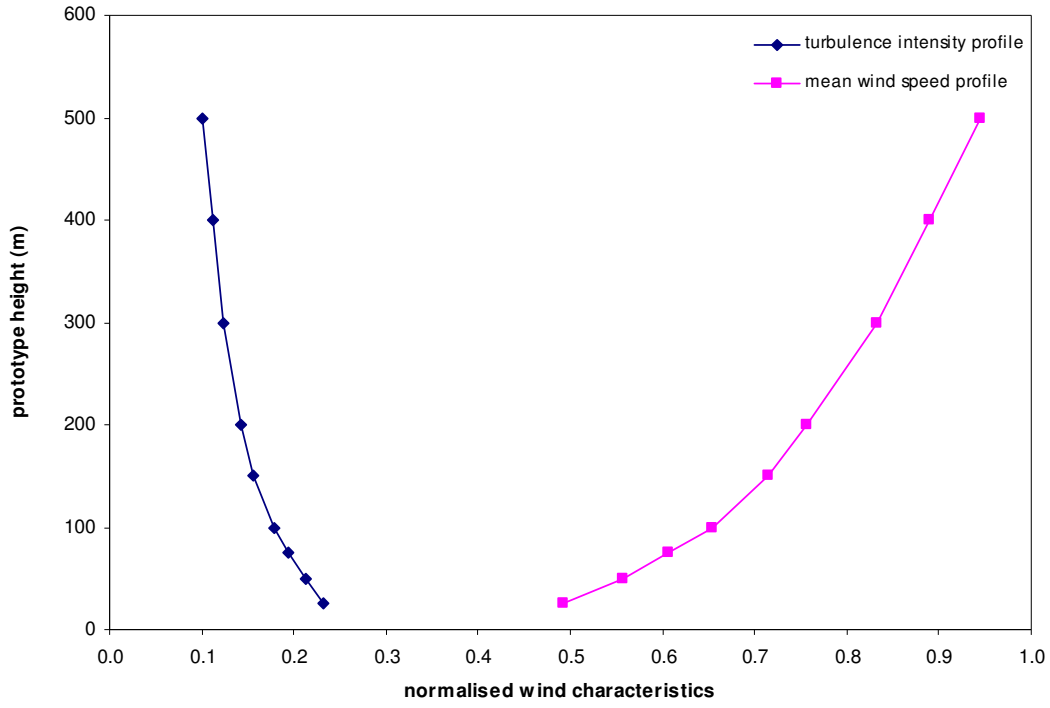

Figure 20a: Wind characteristics, Position 1, Tuen Mun East Area, 315º

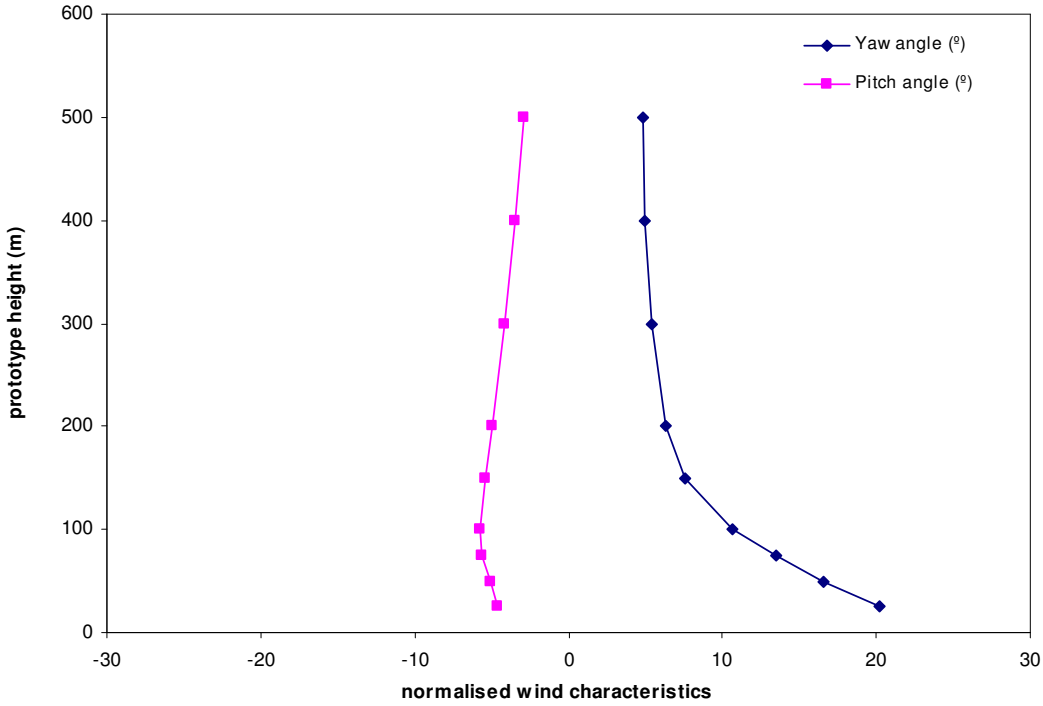

Figure 20b: Mean wind direction, Position 1, Tuen Mun East Area, 315º

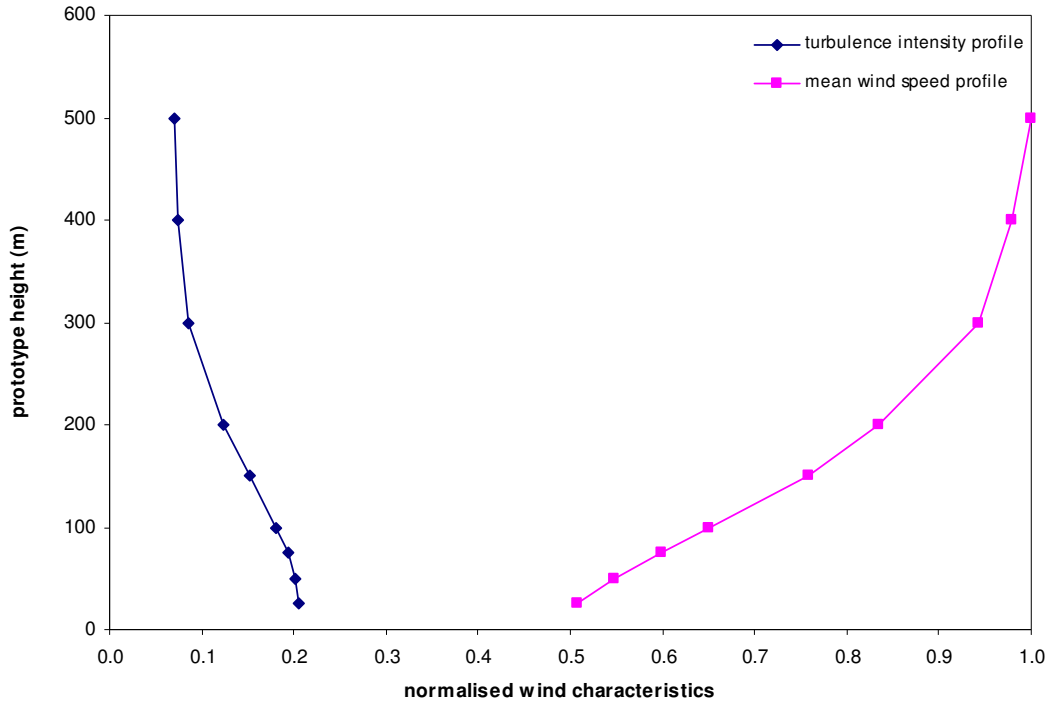

Figure 21a: Wind characteristics, Position 1, Tuen Mun East Area, 337.5º

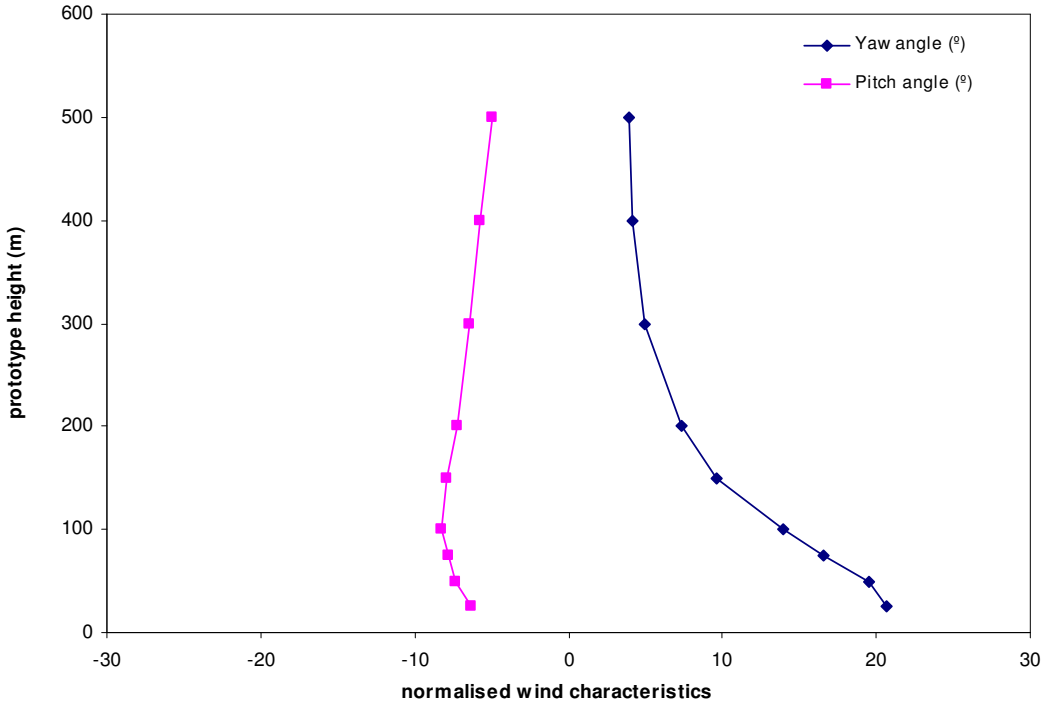

Figure 21b: Mean wind direction, Position 1, Tuen Mun East Area, 337.5º

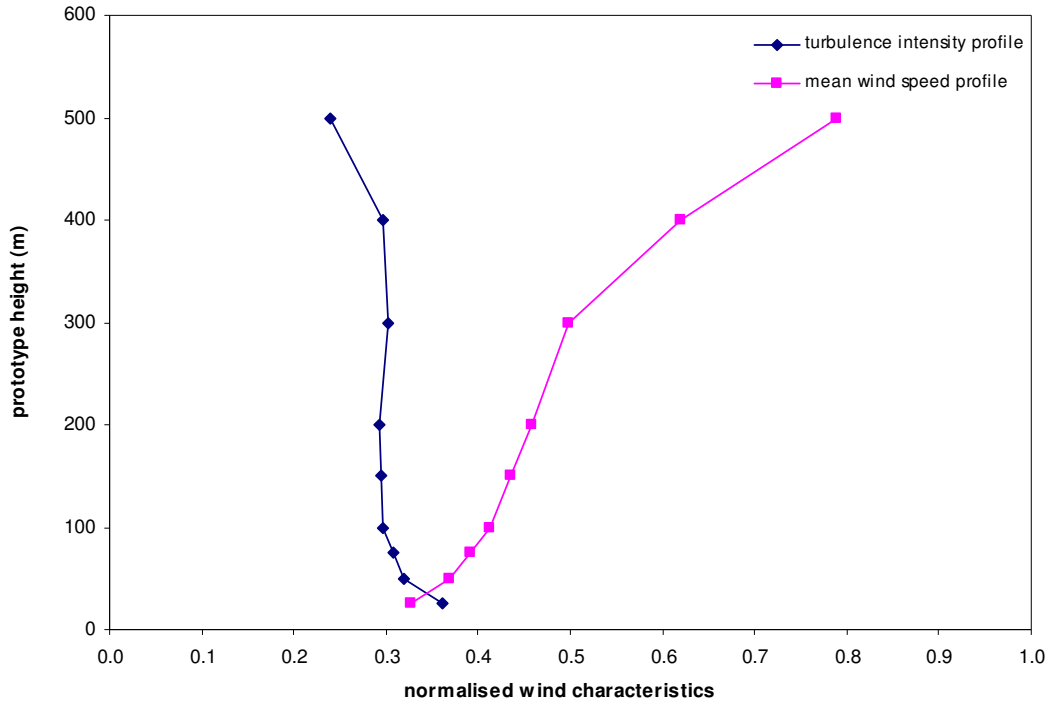

Figure 22a: Wind characteristics, Position 1, Tuen Mun East Area, 360º

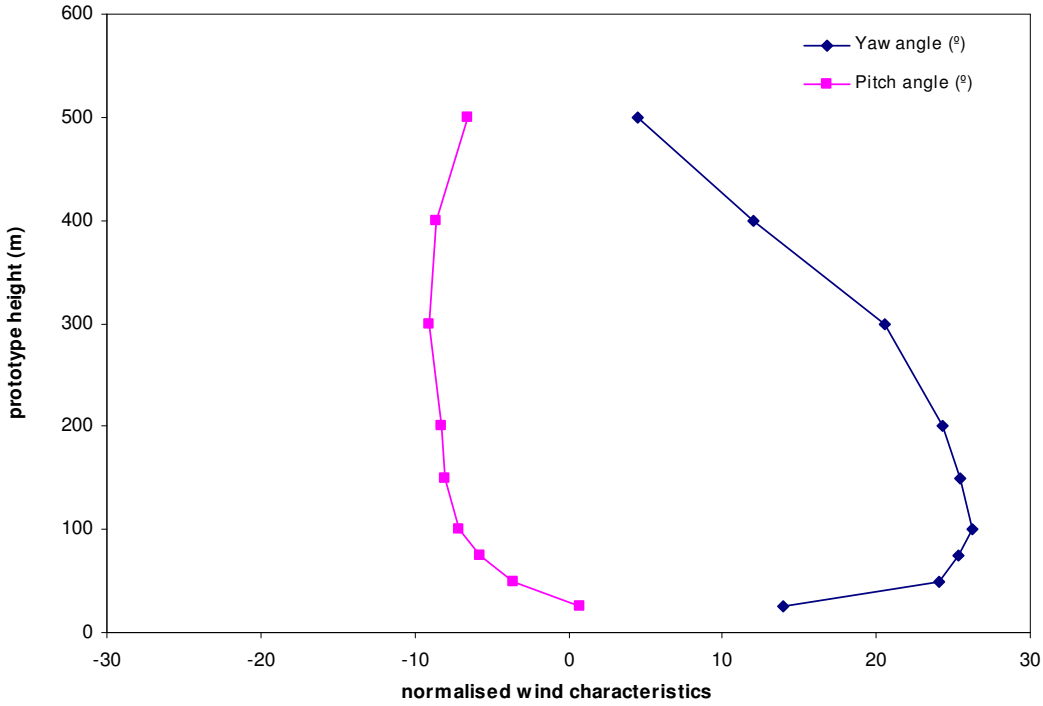

Figure 22b: Mean wind direction, Position 1, Tuen Mun East Area, 360º

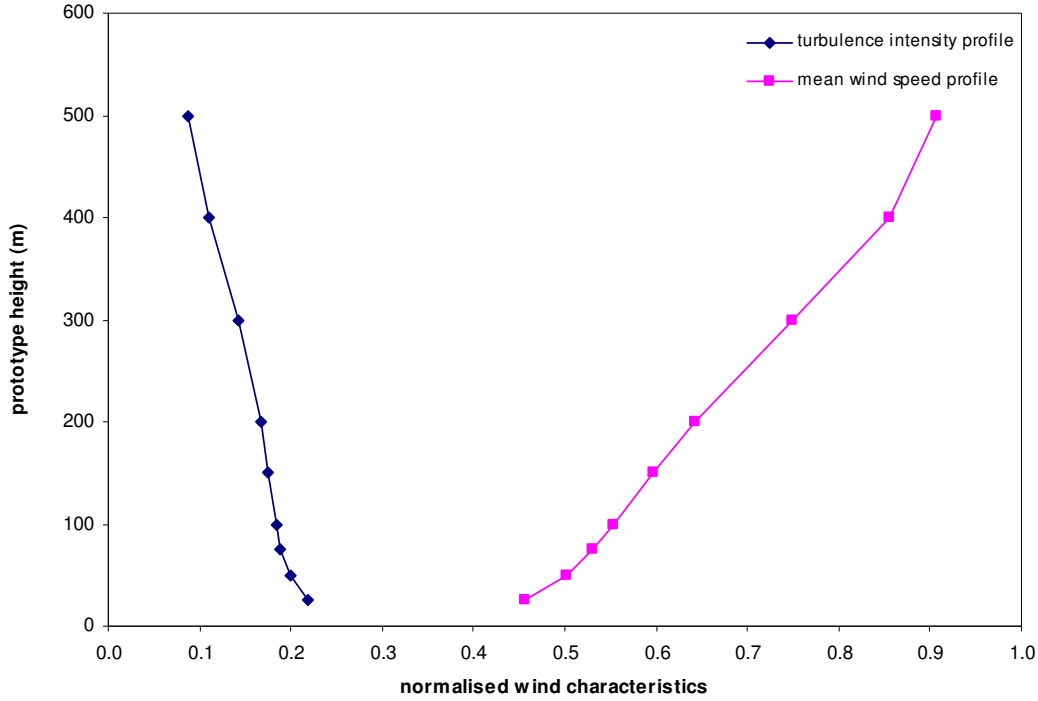

Figure 23a: Wind characteristics, Position 2, Tuen Mun East Area, 22.5º

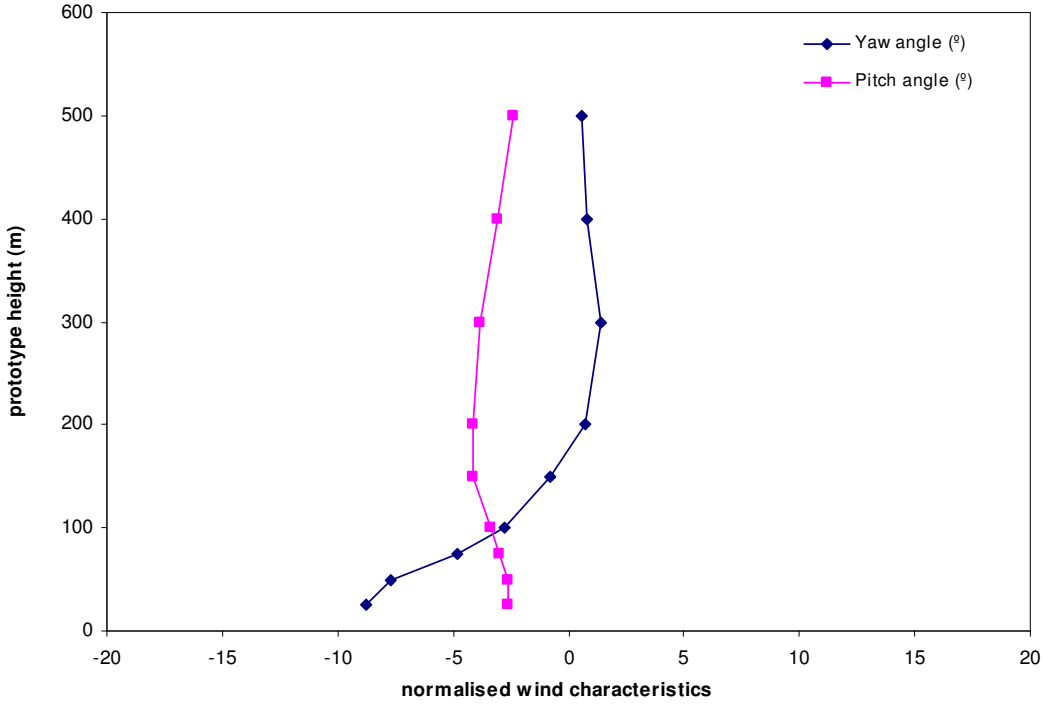

Figure 23b: Mean wind direction, Position 2, Tuen Mun East Area, 22.5º

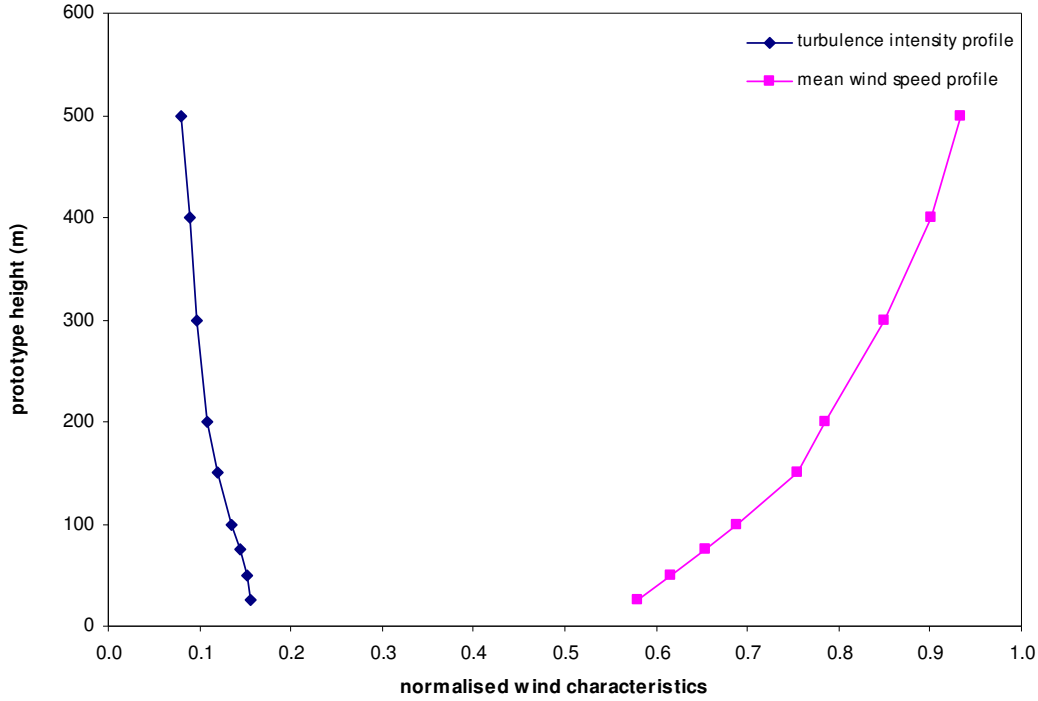

Figure 24a: Wind characteristics, Position 2, Tuen Mun East Area, 45º

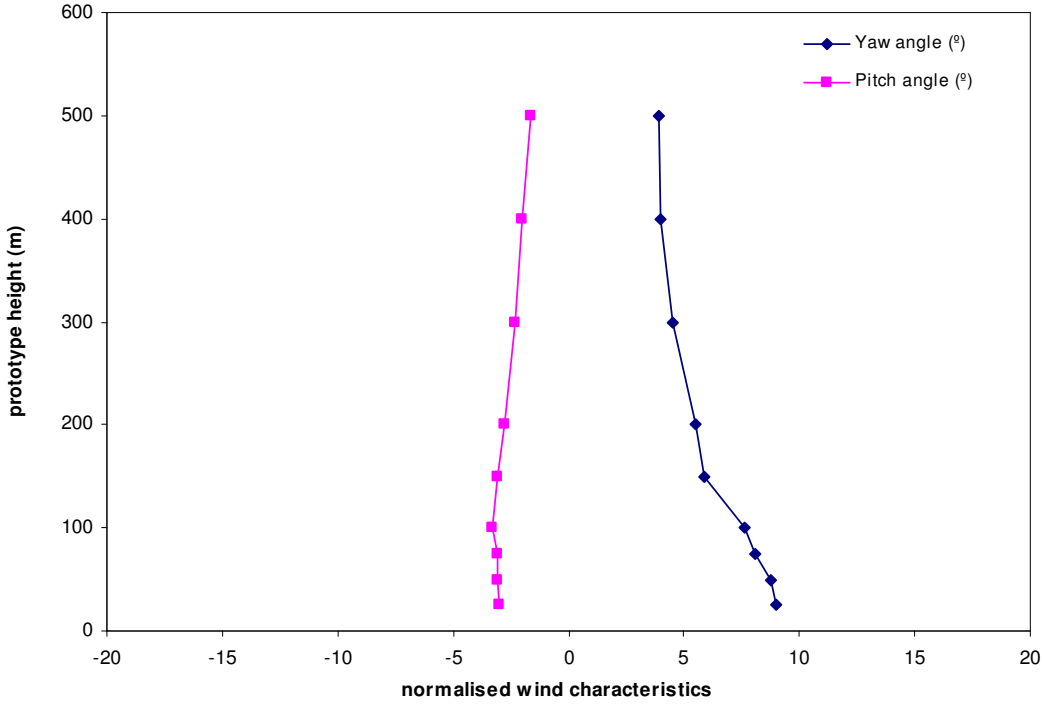

Figure 24b: Mean wind direction, Position 2, Tuen Mun East Area, 45º

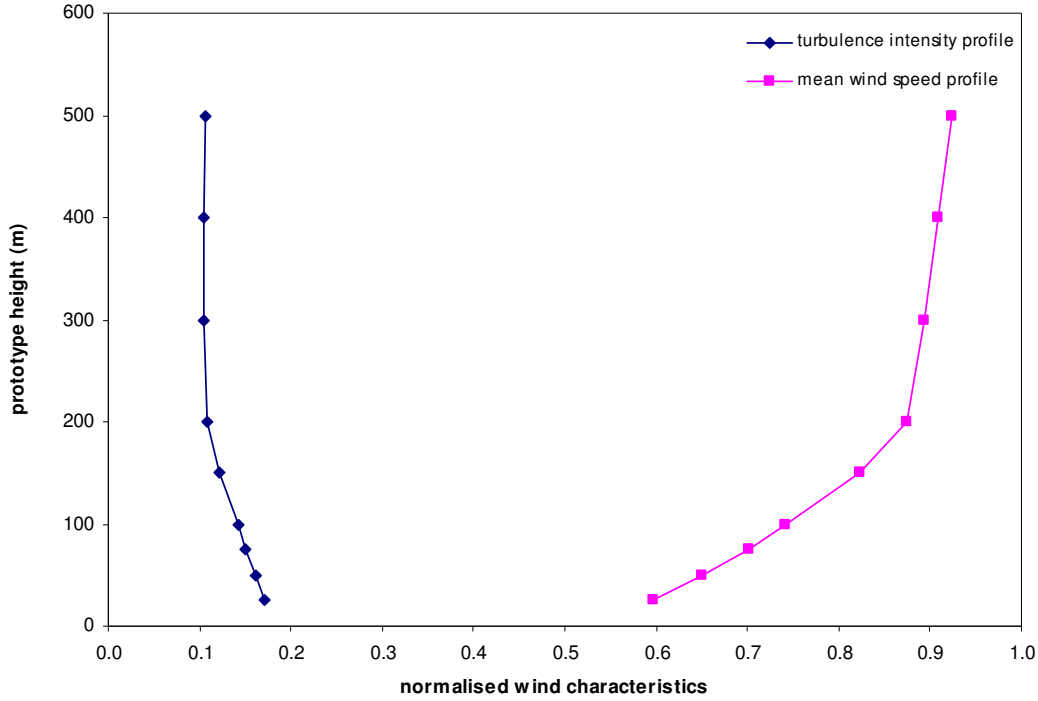

Figure 25a: Wind characteristics, Position 2, Tuen Mun East Area, 67.5º

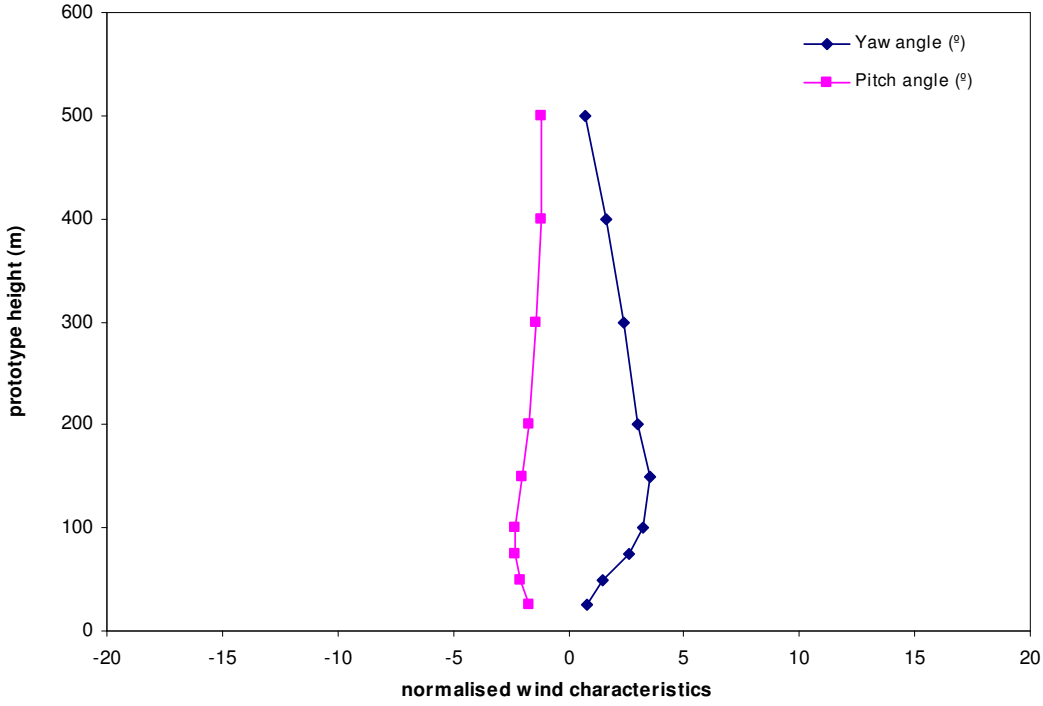

Figure 25b: Mean wind direction, Position 2, Tuen Mun East Area, 67.5º

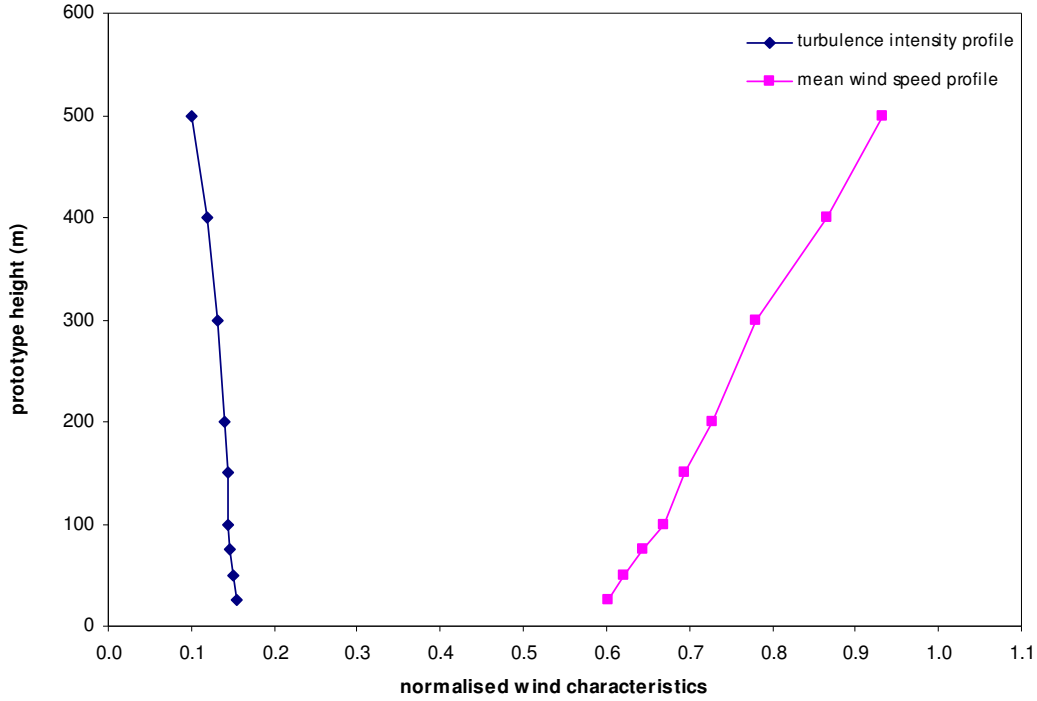

Figure 26a: Wind characteristics, Position 2, Tuen Mun East Area, 90º

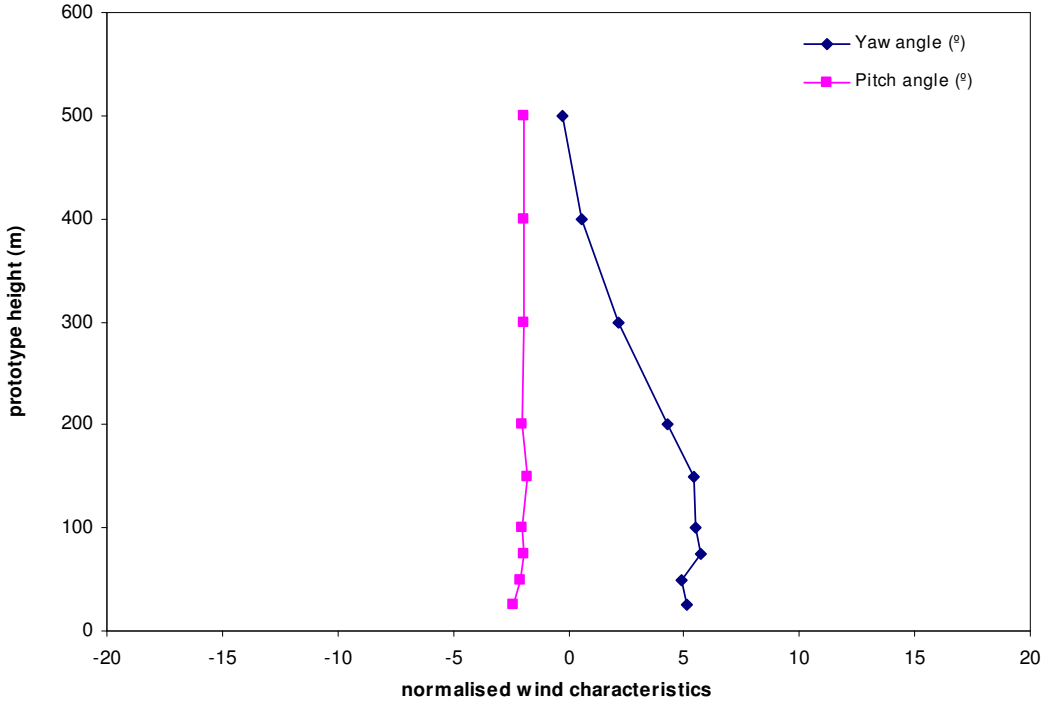

Figure 26b: Mean wind direction, Position 2, Tuen Mun East Area, 90º

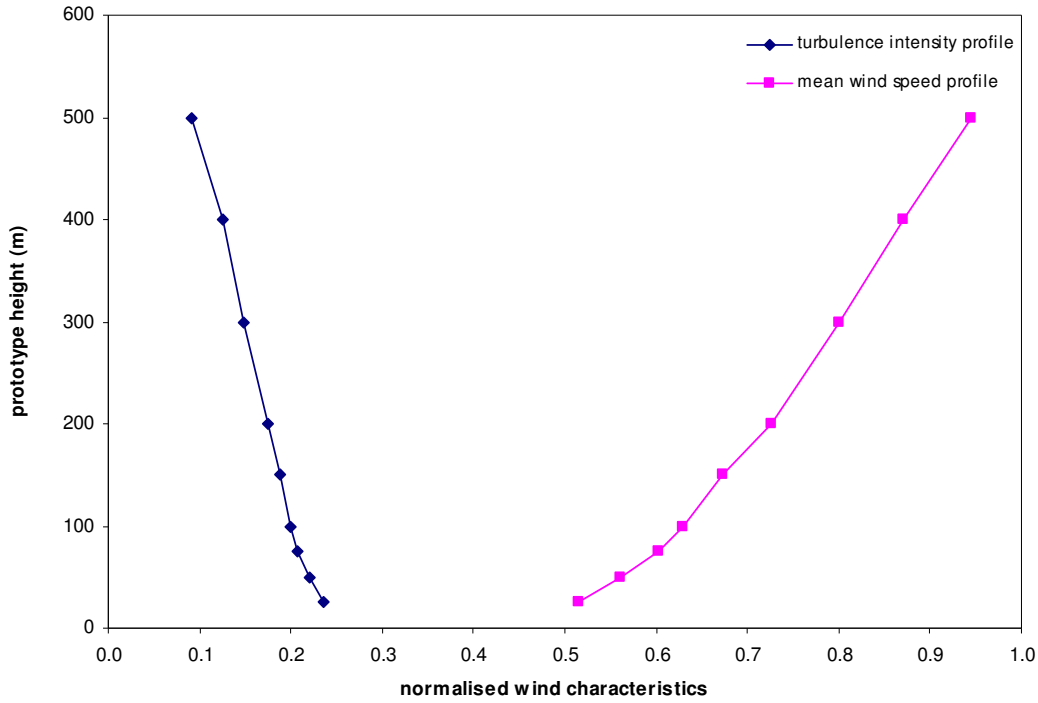

Figure 27a: Wind characteristics, Position 2, Tuen Mun East Area, 112.5º

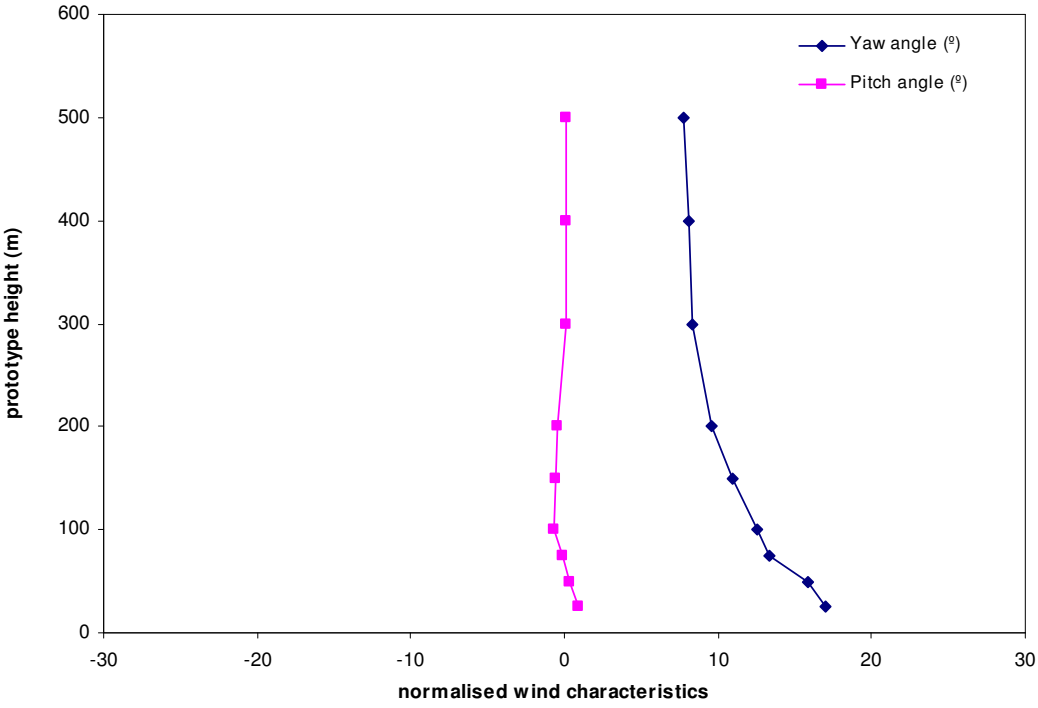

Figure 27b: Mean wind direction, Position 2, Tuen Mun East Area, 112.5º

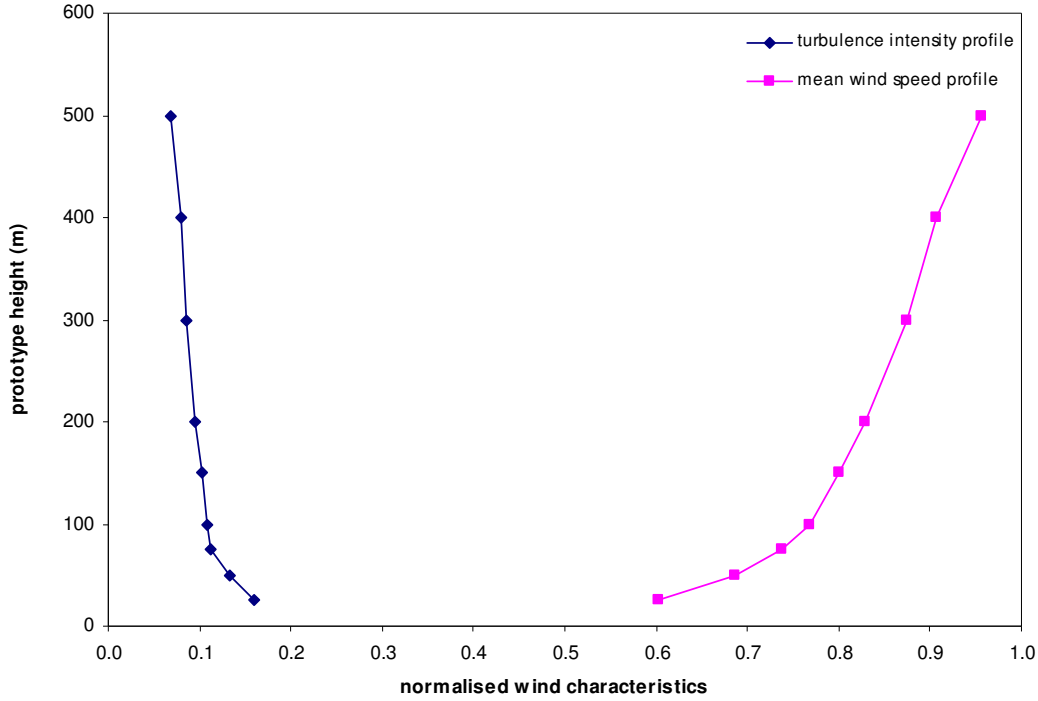

Figure 28a: Wind characteristics, Position 2, Tuen Mun East Area, 135º

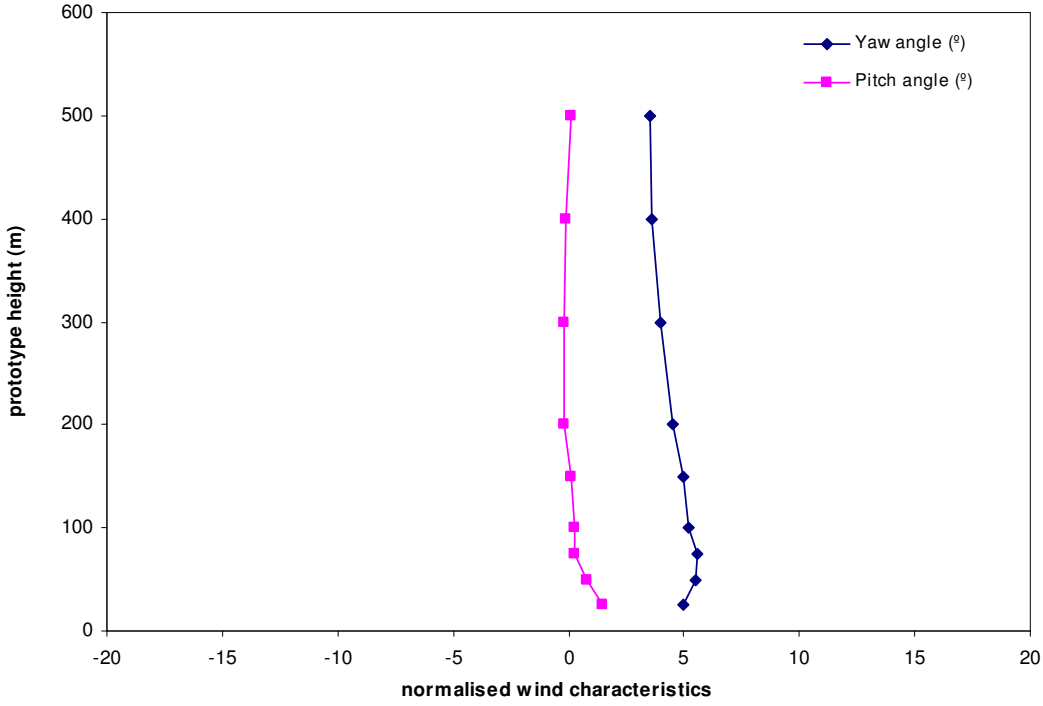

Figure 28b: Mean wind direction, Position 2, Tuen Mun East Area, 135º

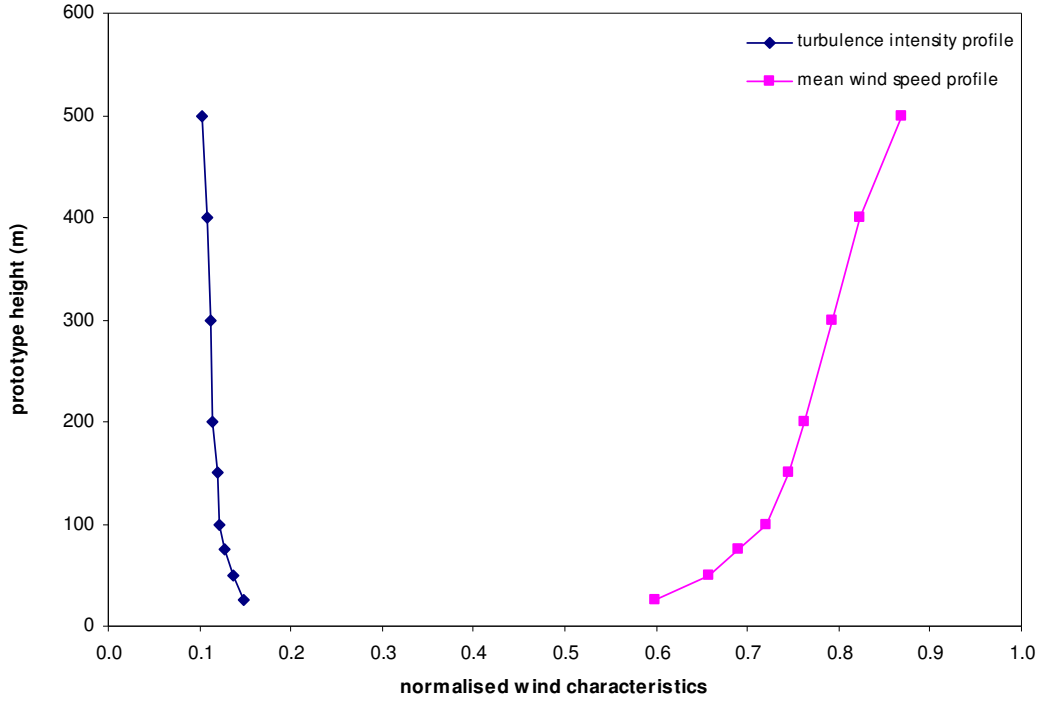

Figure 29a: Wind characteristics, Position 2, Tuen Mun East Area, 157.5º

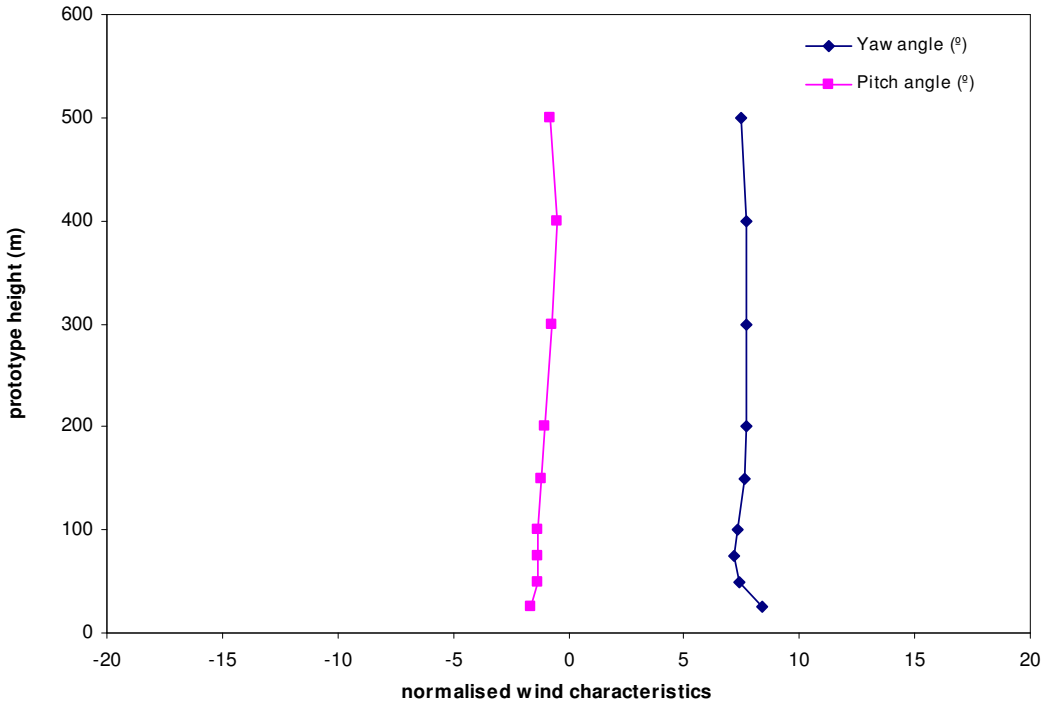

Figure 29b: Mean wind direction, Position 2, Tuen Mun East Area, 157.5º

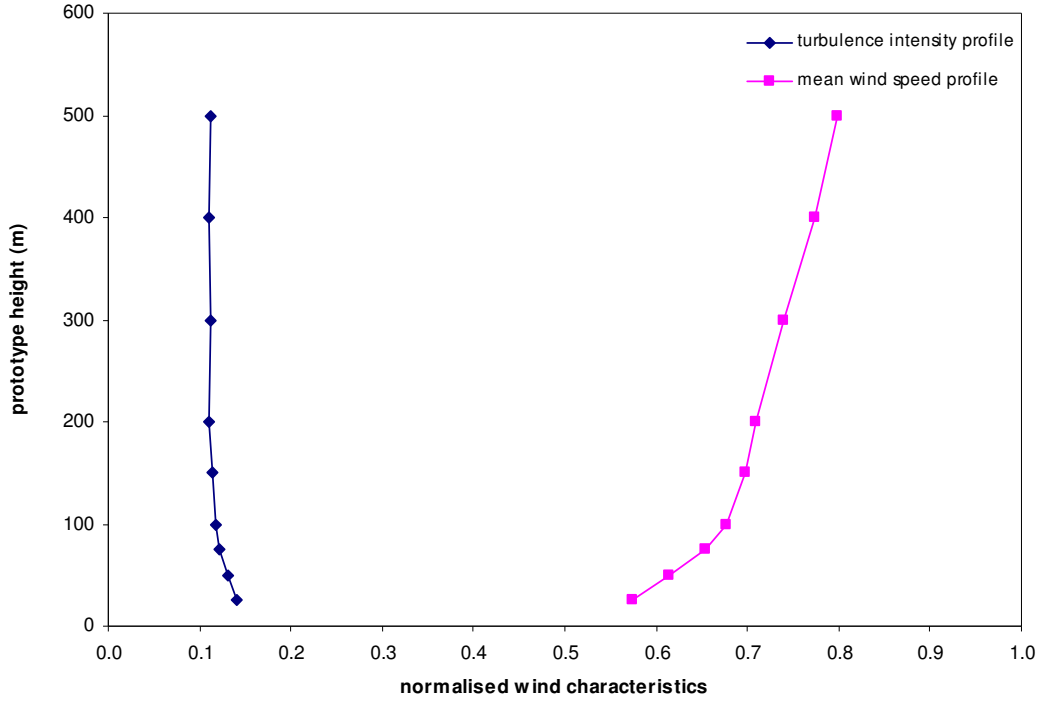

Figure 30a: Wind characteristics, Position 2, Tuen Mun East Area, 180º

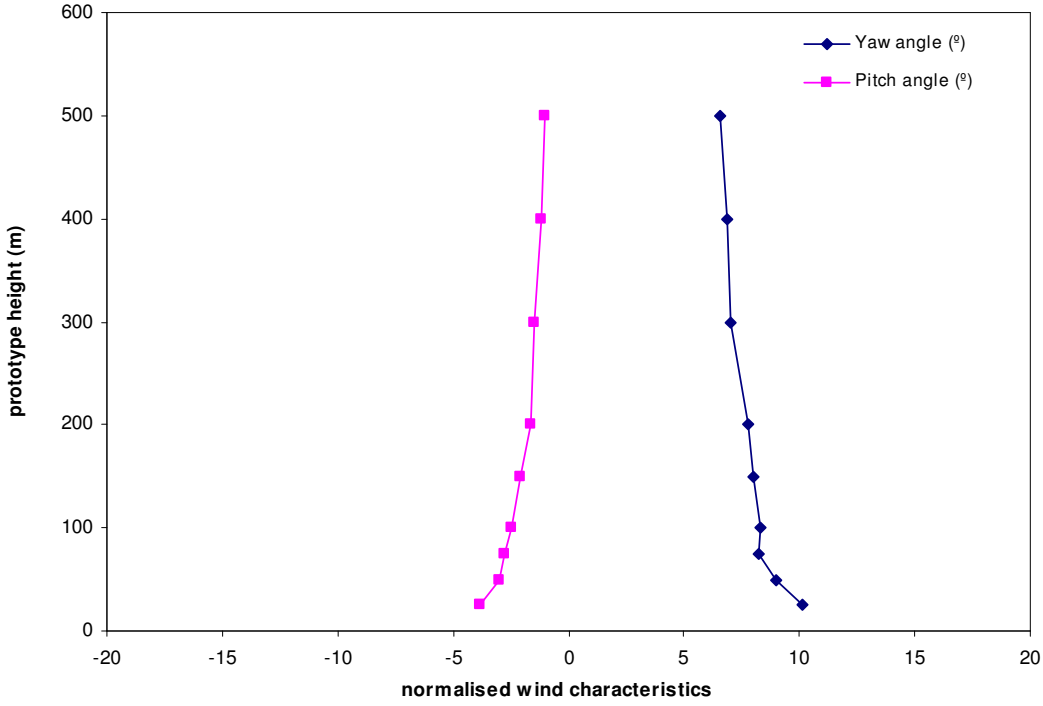

Figure 30b: Mean wind direction, Position 2, Tuen Mun East Area, 180º

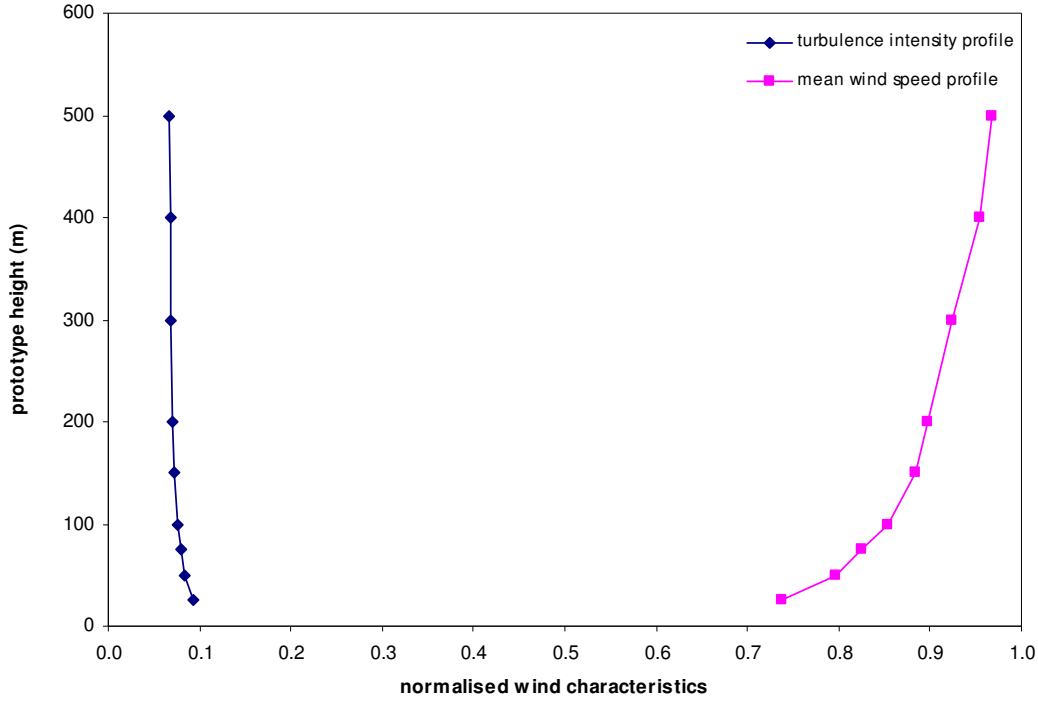

Figure 31a: Wind characteristics, Position 2, Tuen Mun East Area, 202.5º

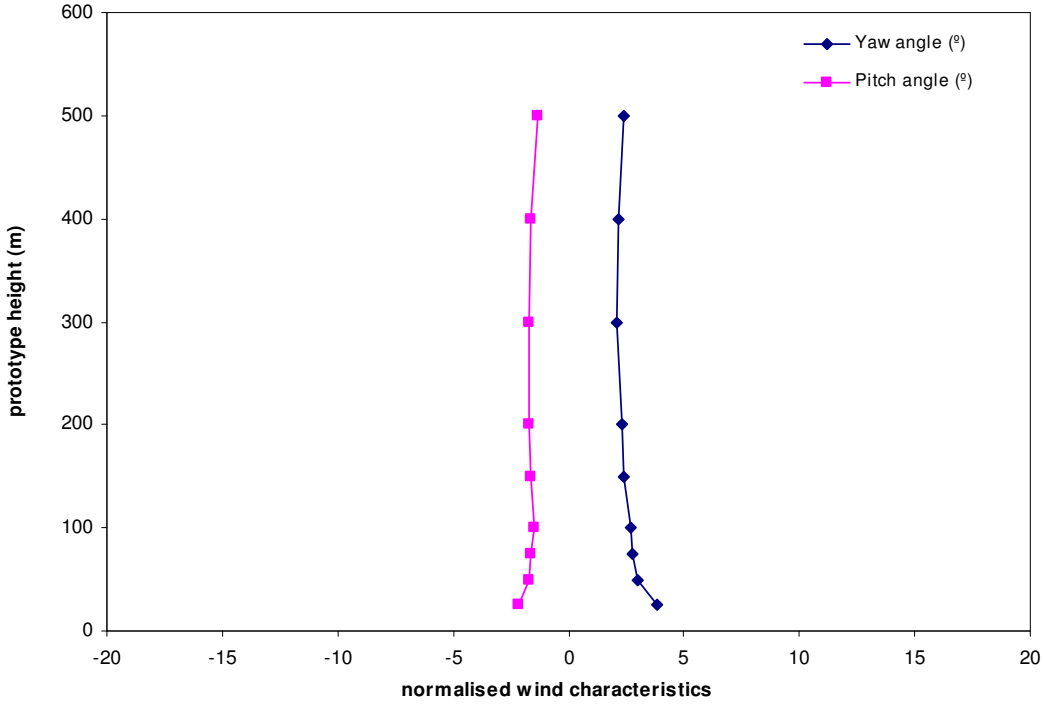

Figure 31b: Mean wind direction, Position 2, Tuen Mun East Area, 202.5º

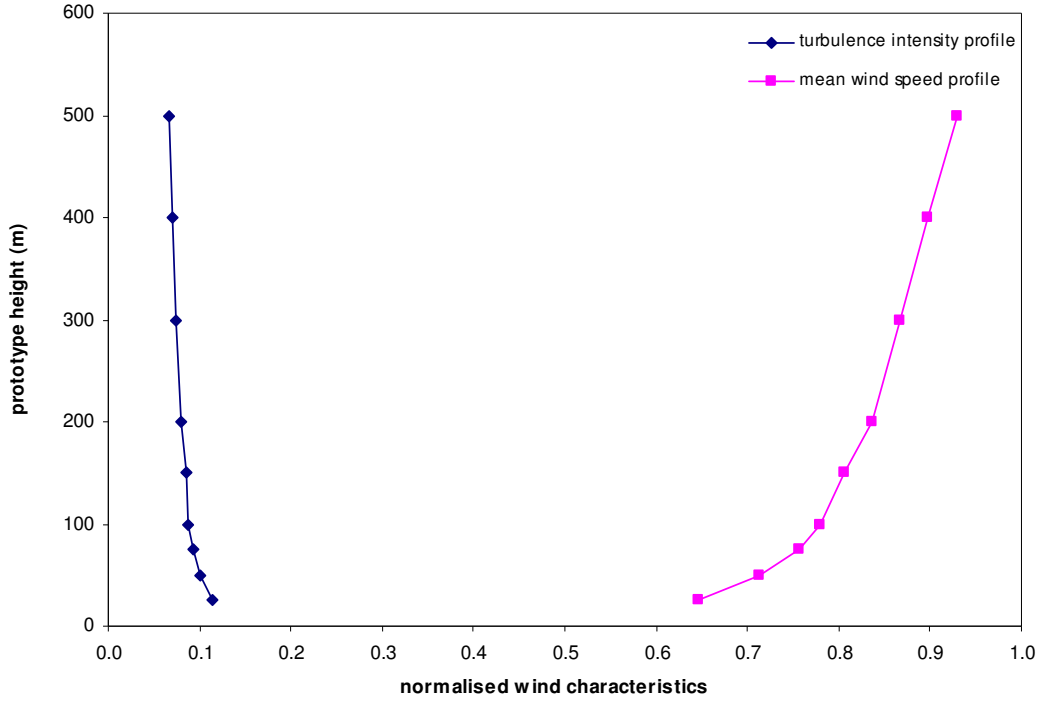

Figure 32a: Wind characteristics, Position 2, Tuen Mun East Area, 225º

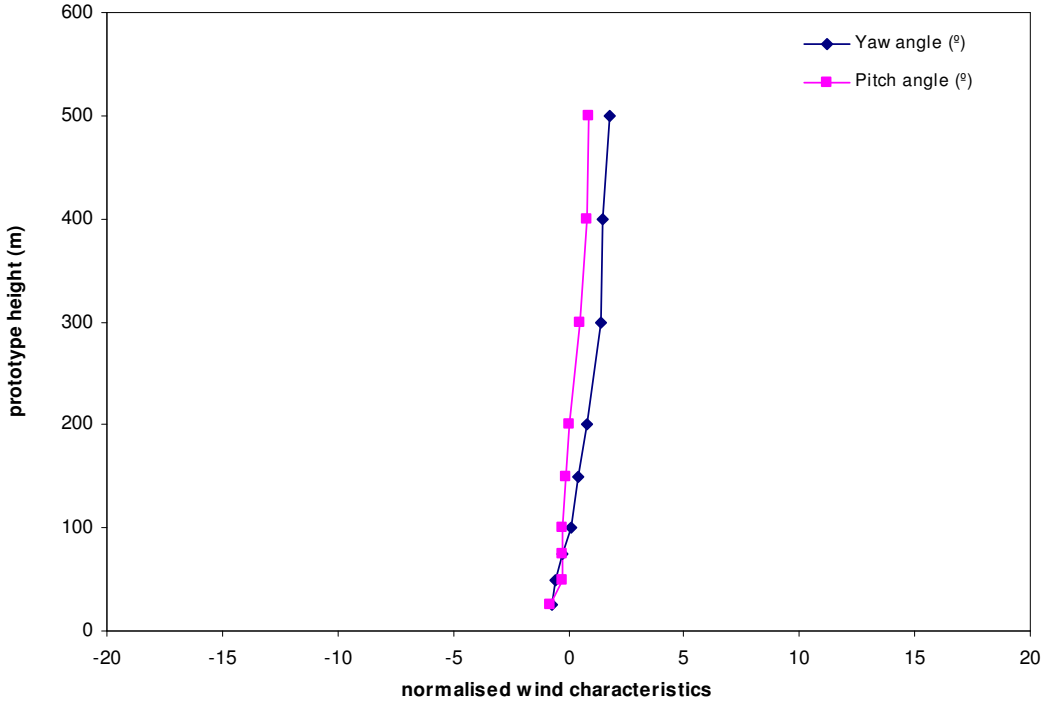

Figure 32b: Mean wind direction, Position 2, Tuen Mun East Area, 225º

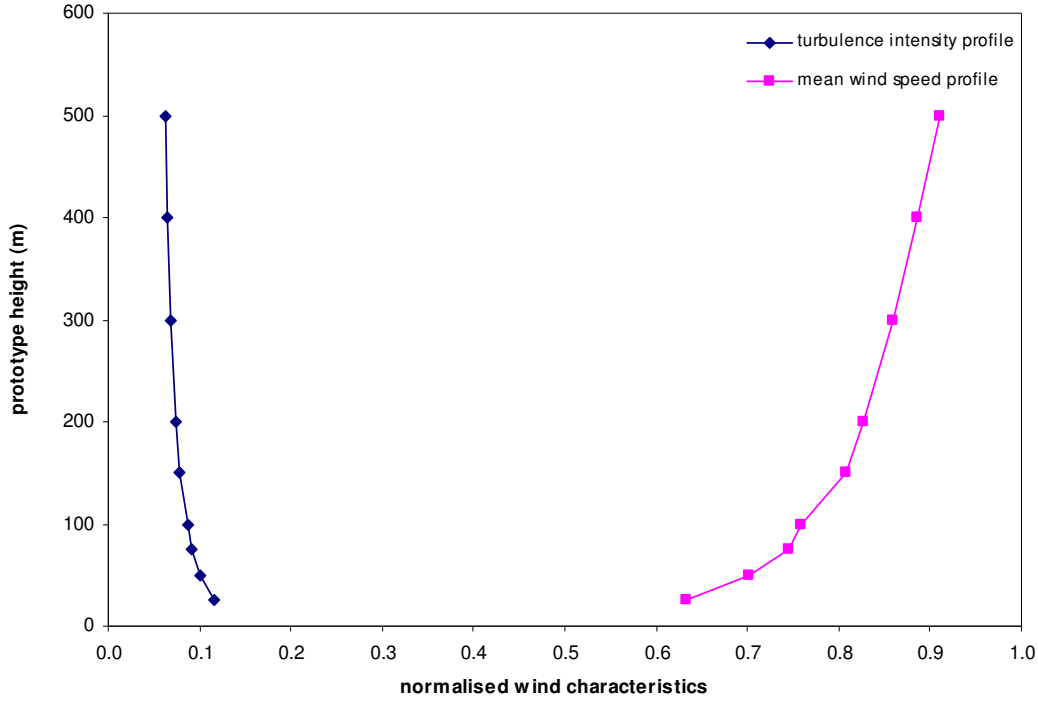

Figure 33a: Wind characteristics, Position 2, Tuen Mun East Area, 247.5º

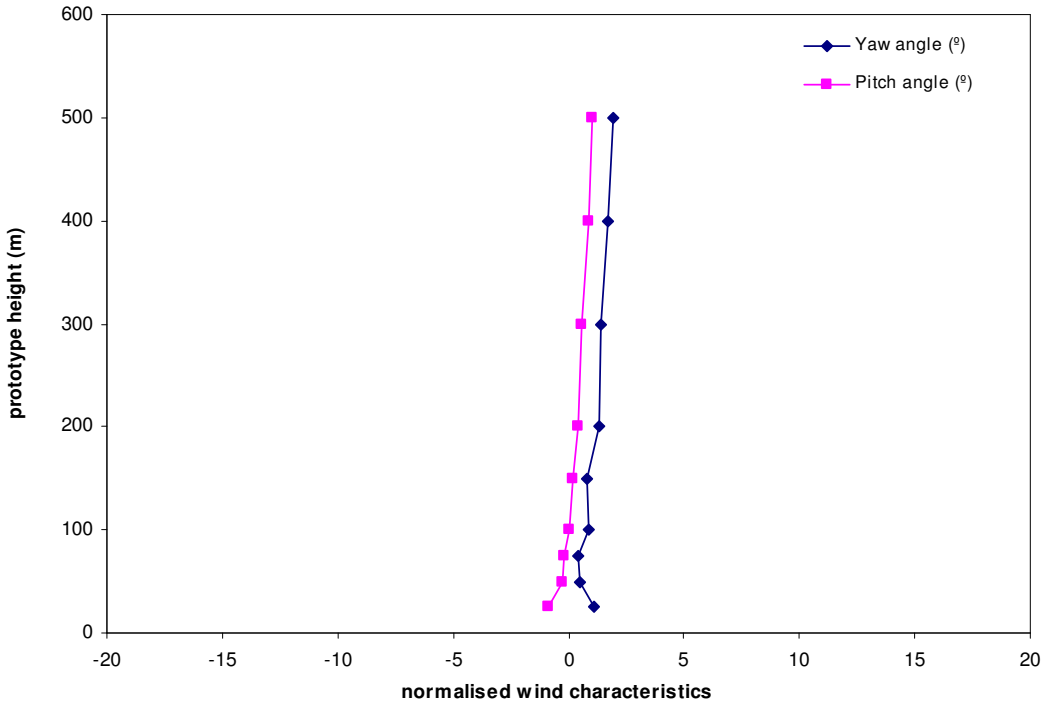

Figure 33b: Mean wind direction, Position 2, Tuen Mun East Area, 247.5º

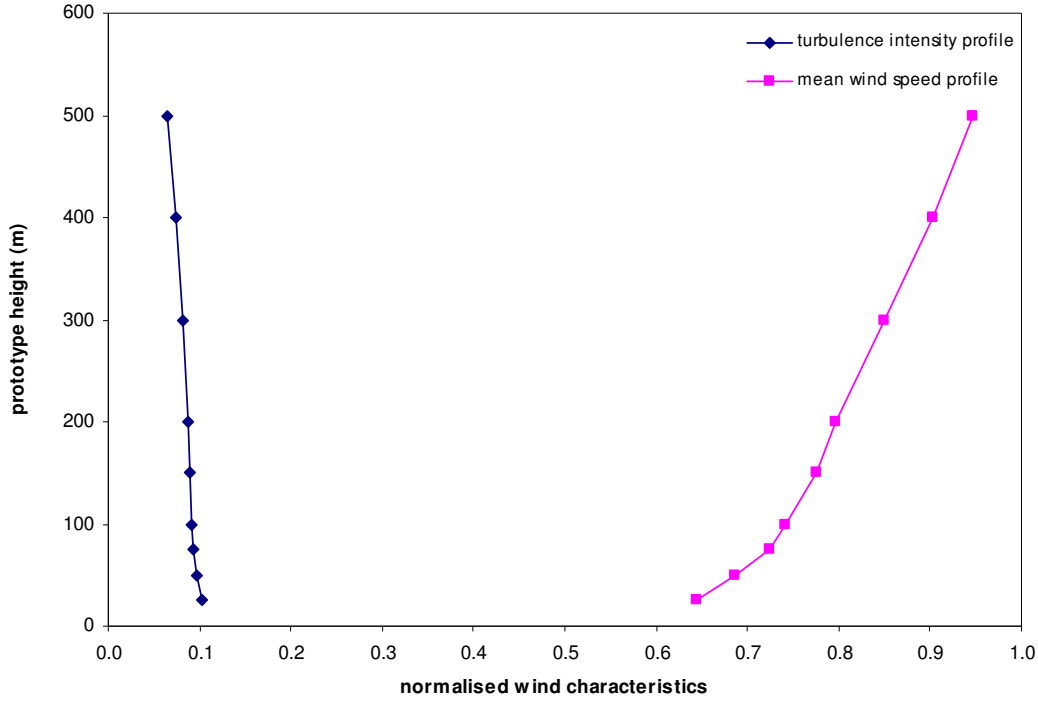

Figure 34a: Wind characteristics, Position 2, Tuen Mun East Area, 270º

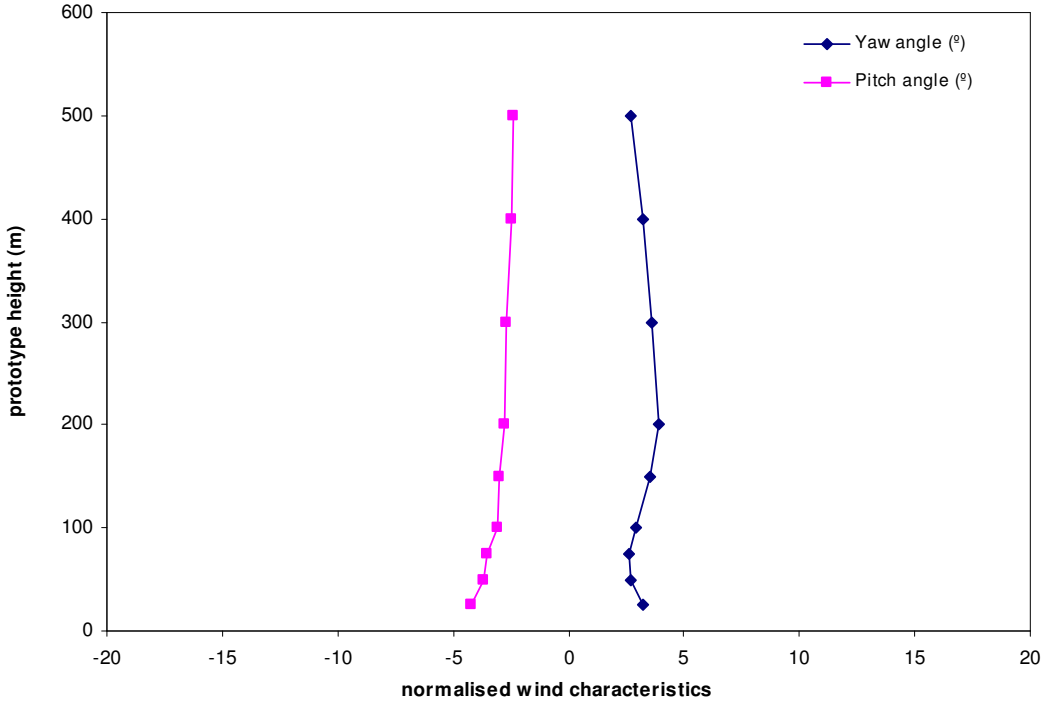

Figure 34b: Mean wind direction, Position 2, Tuen Mun East Area, 270º

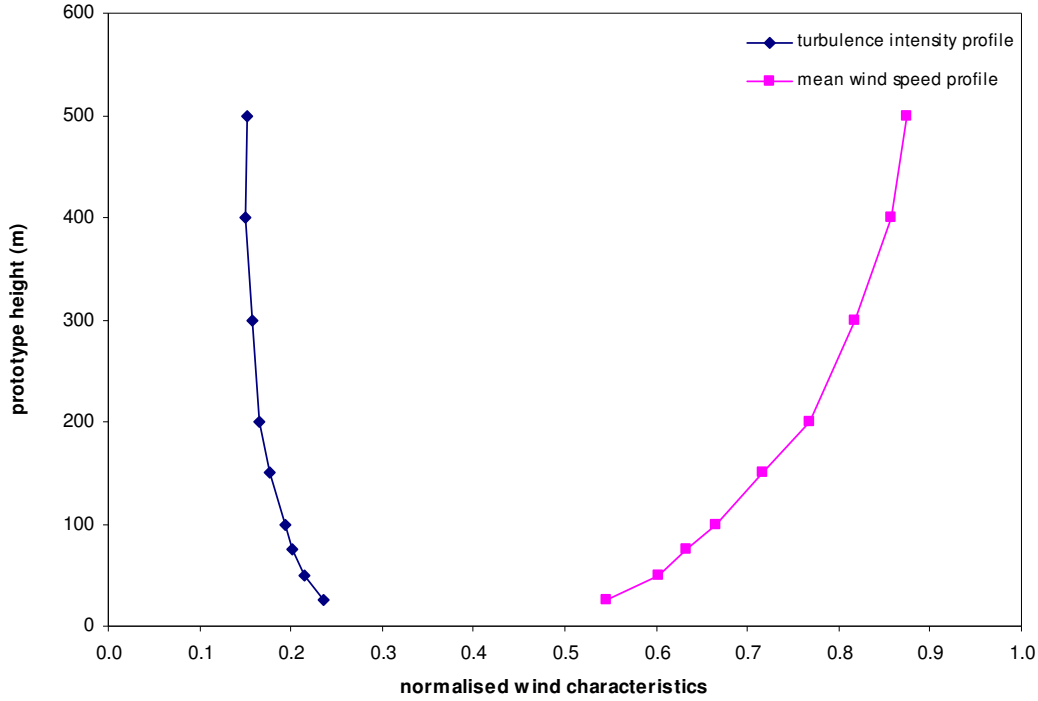

Figure 35a: Wind characteristics, Position 2, Tuen Mun East Area, 292.5º

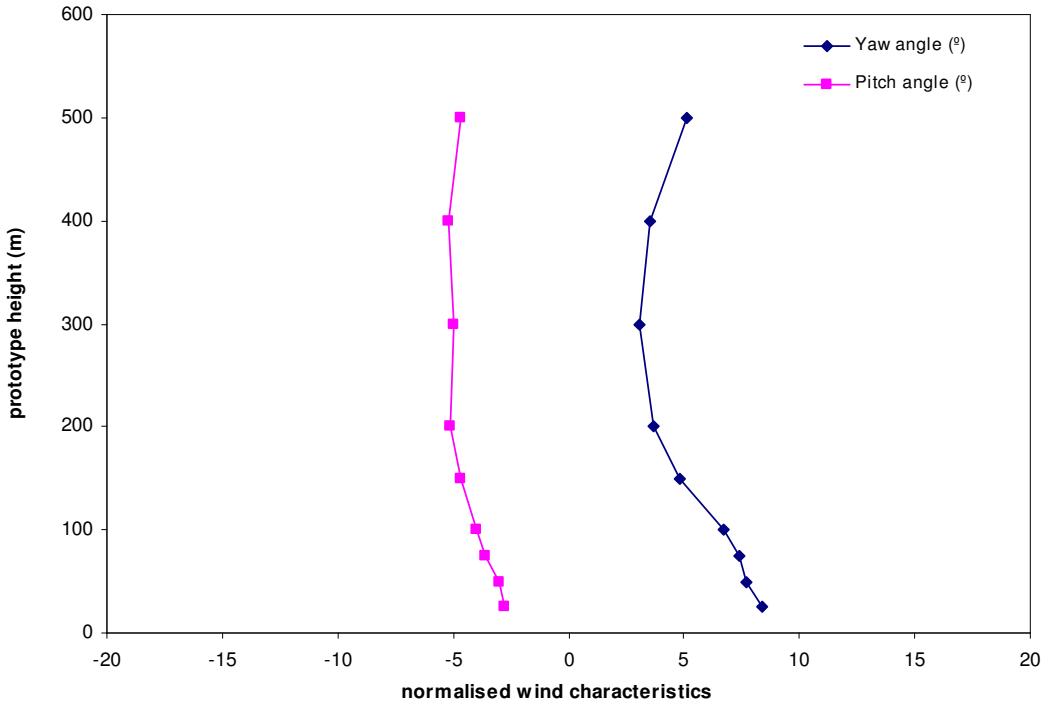

Figure 35b: Mean wind direction, Position 2, Tuen Mun East Area, 292.5º

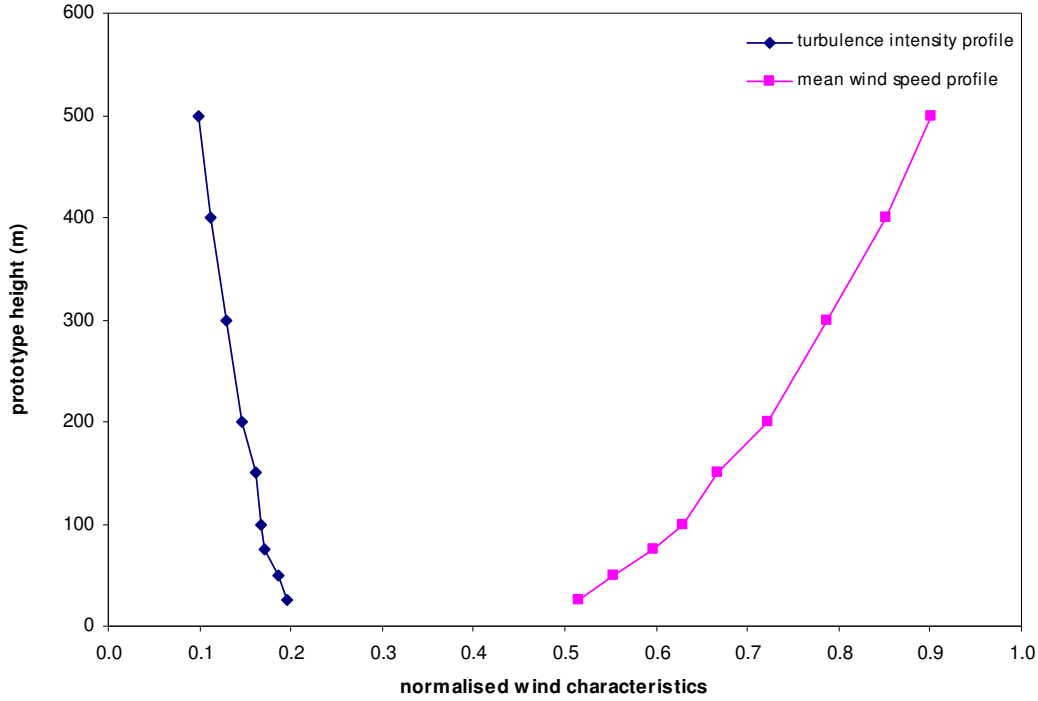

Figure 36a: Wind characteristics, Position 2, Tuen Mun East Area, 315º

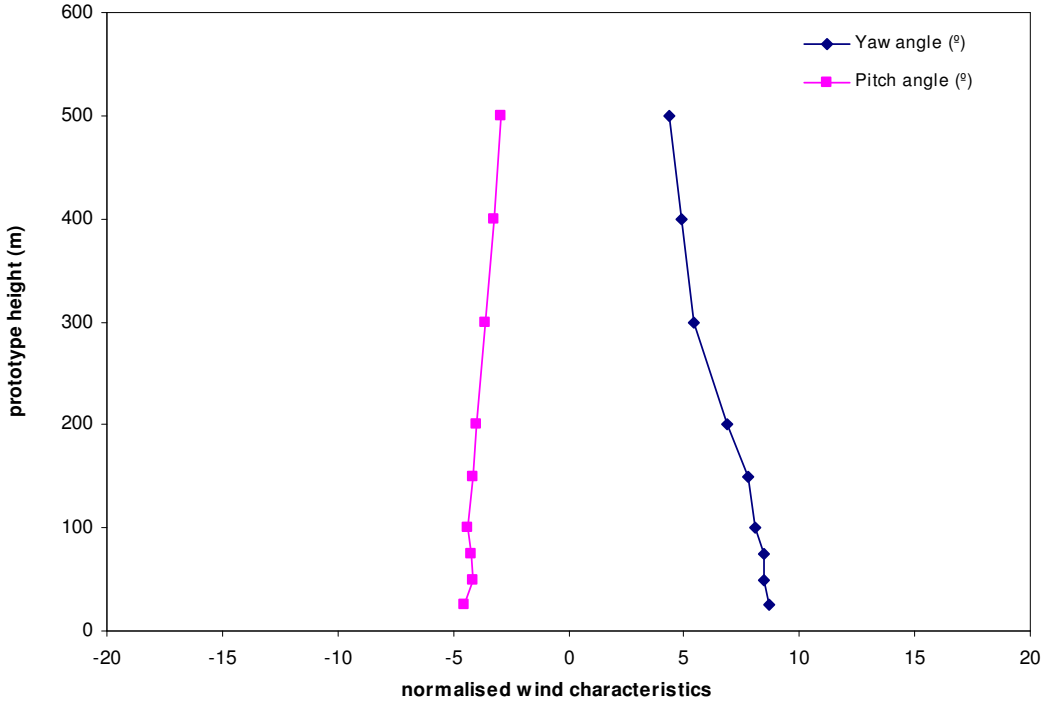

Figure 36b: Mean wind direction, Position 2, Tuen Mun East Area, 315º

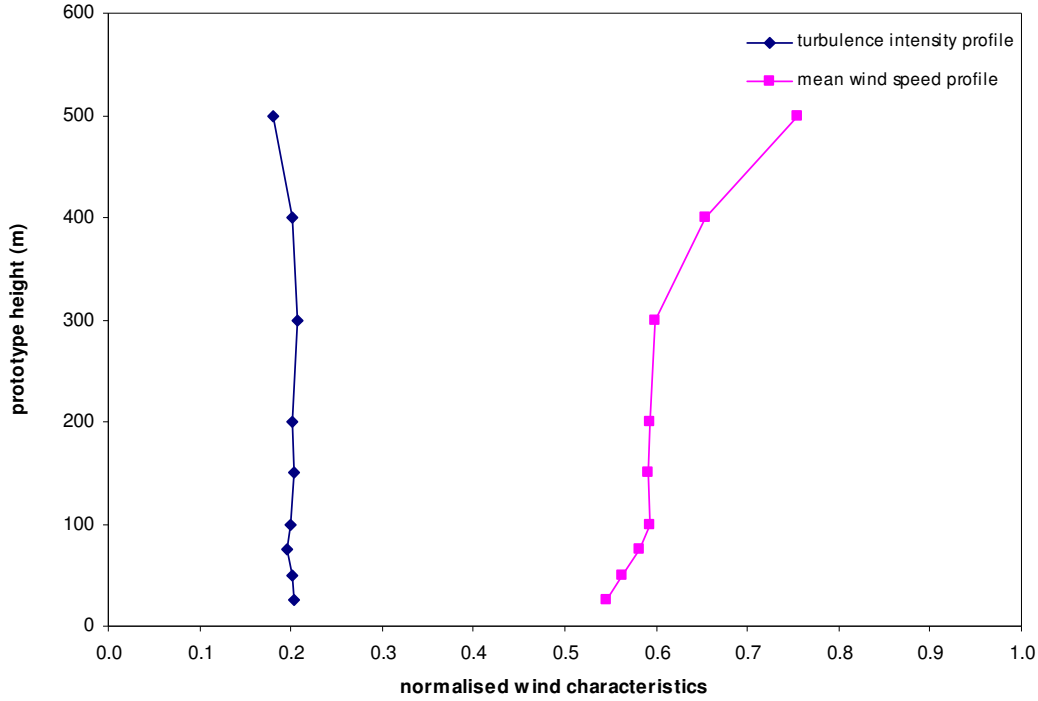

Figure 37a: Wind characteristics, Position 2, Tuen Mun East Area, 337.5º

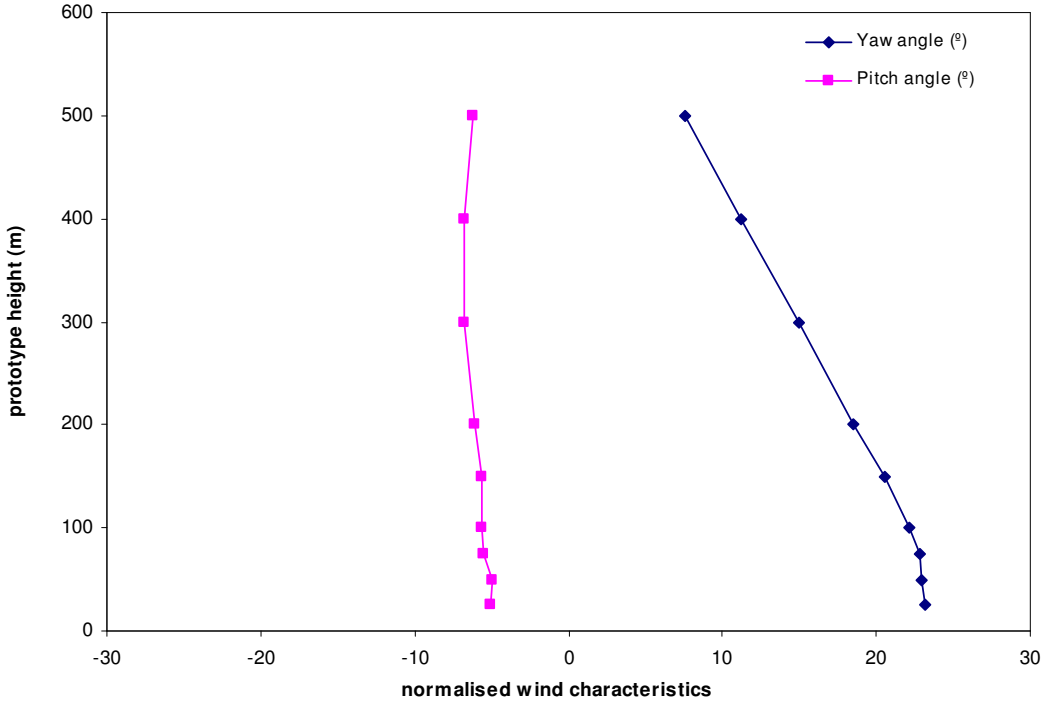

Figure 37b: Mean wind direction, Position 2, Tuen Mun East Area, 337.5º

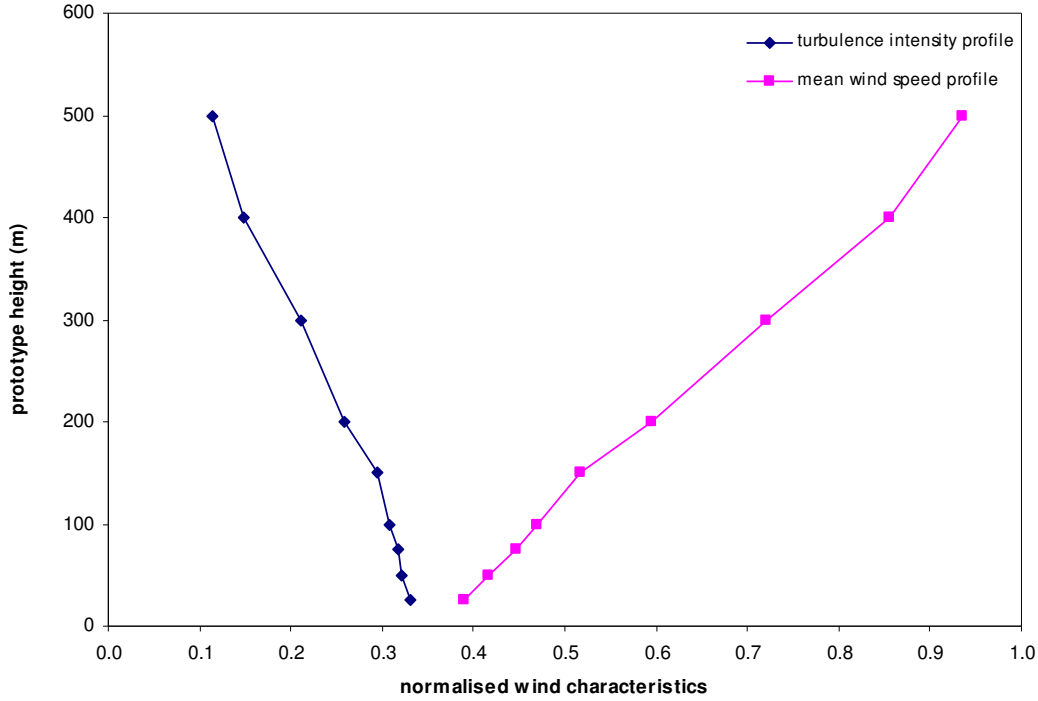

Figure 38a: Wind characteristics, Position 2, Tuen Mun East Area, 360º

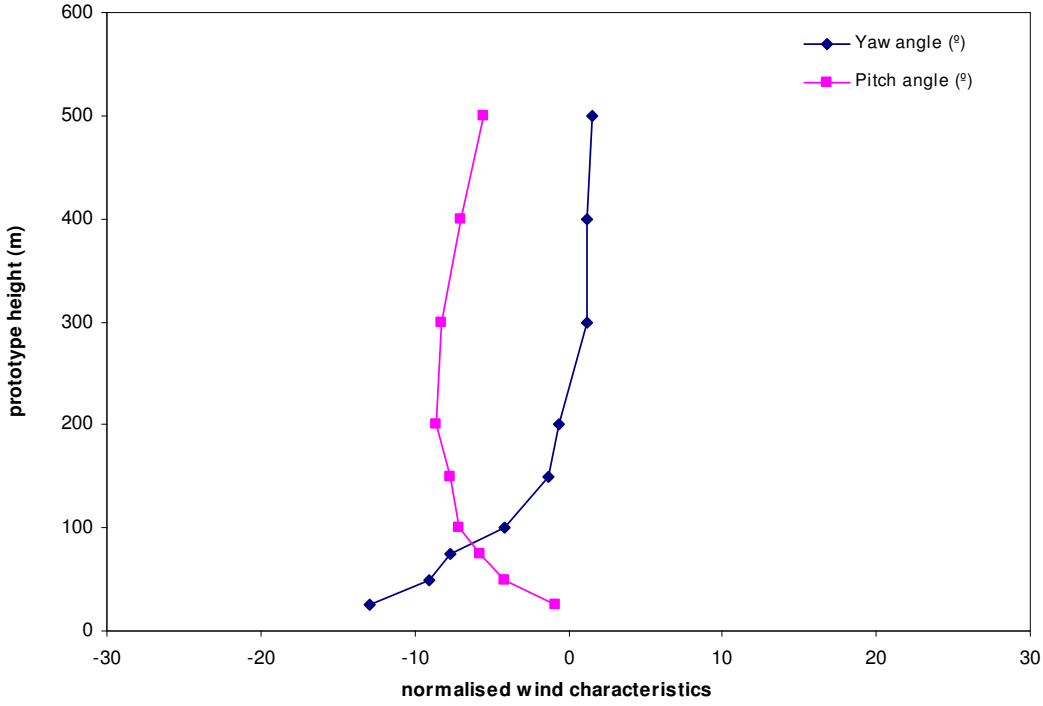

Figure 38b: Mean wind direction, Position 2, Tuen Mun East Area, 360º

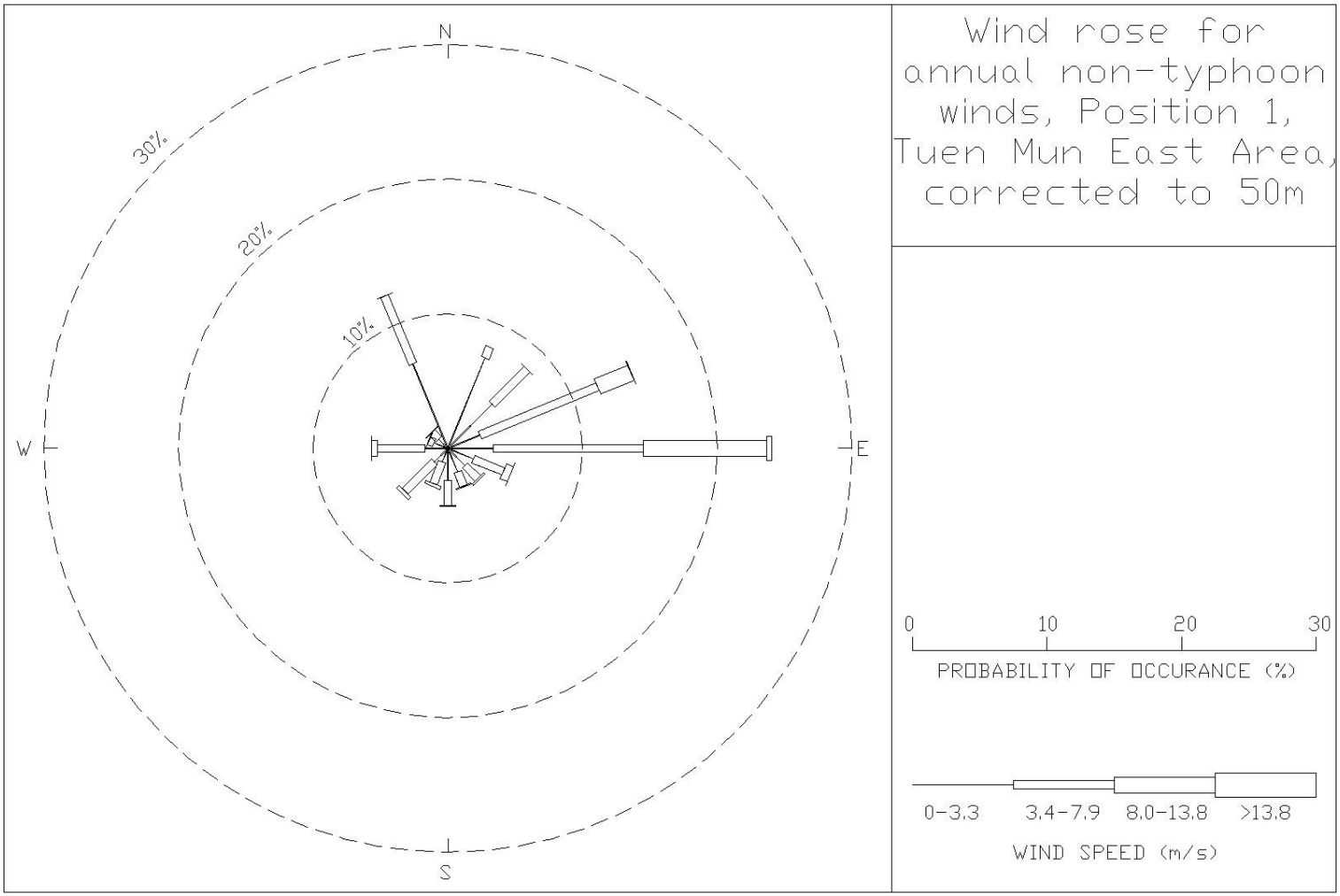

Figure 39: Wind rose for annual, non-typhoon winds for Position 1 of the Tuen Mun East Area, corrected to 50m

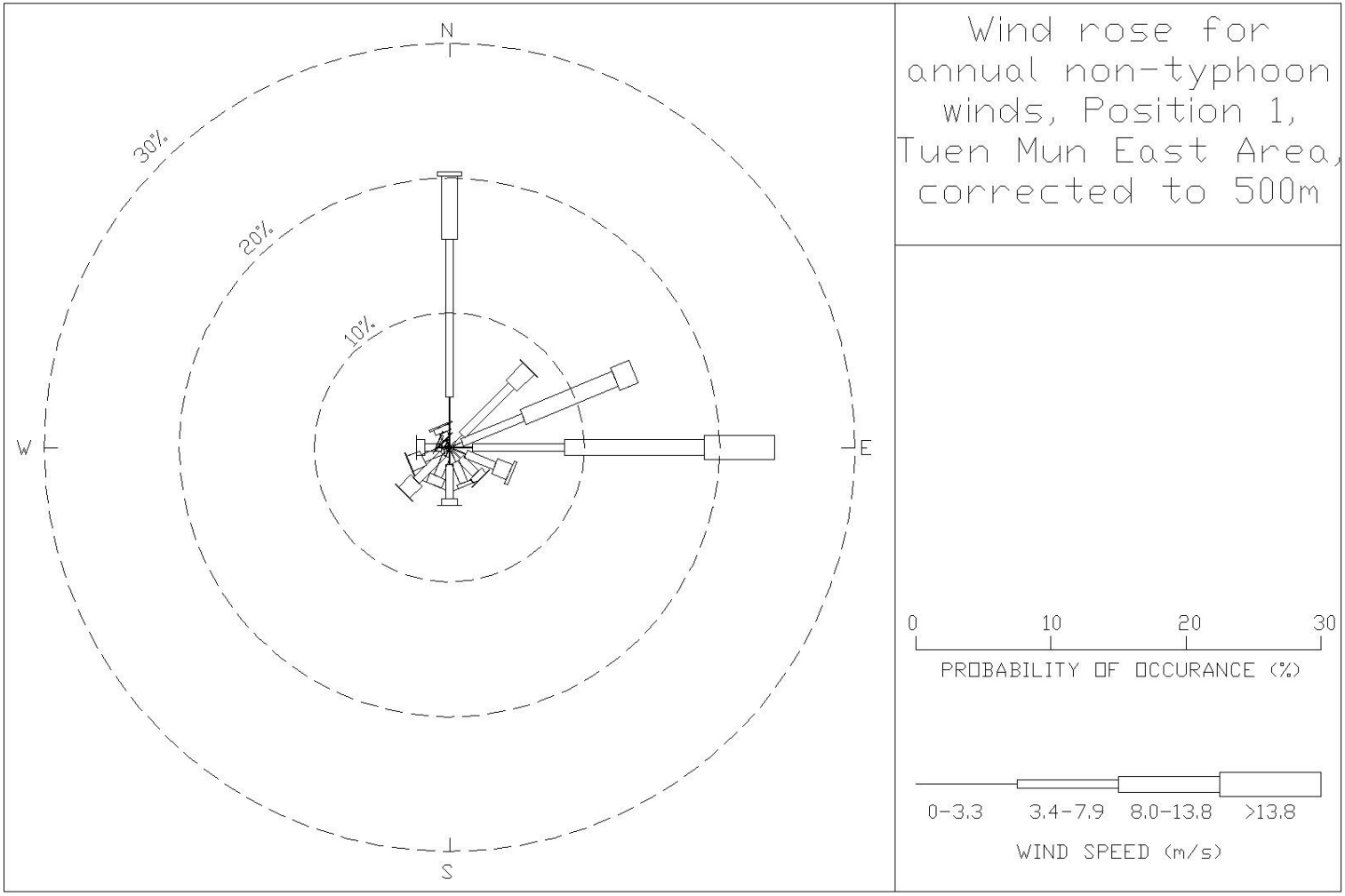

Figure 40: Wind rose for annual, non-typhoon winds for Position 1 of the Tuen Mun East Area, corrected to 500m

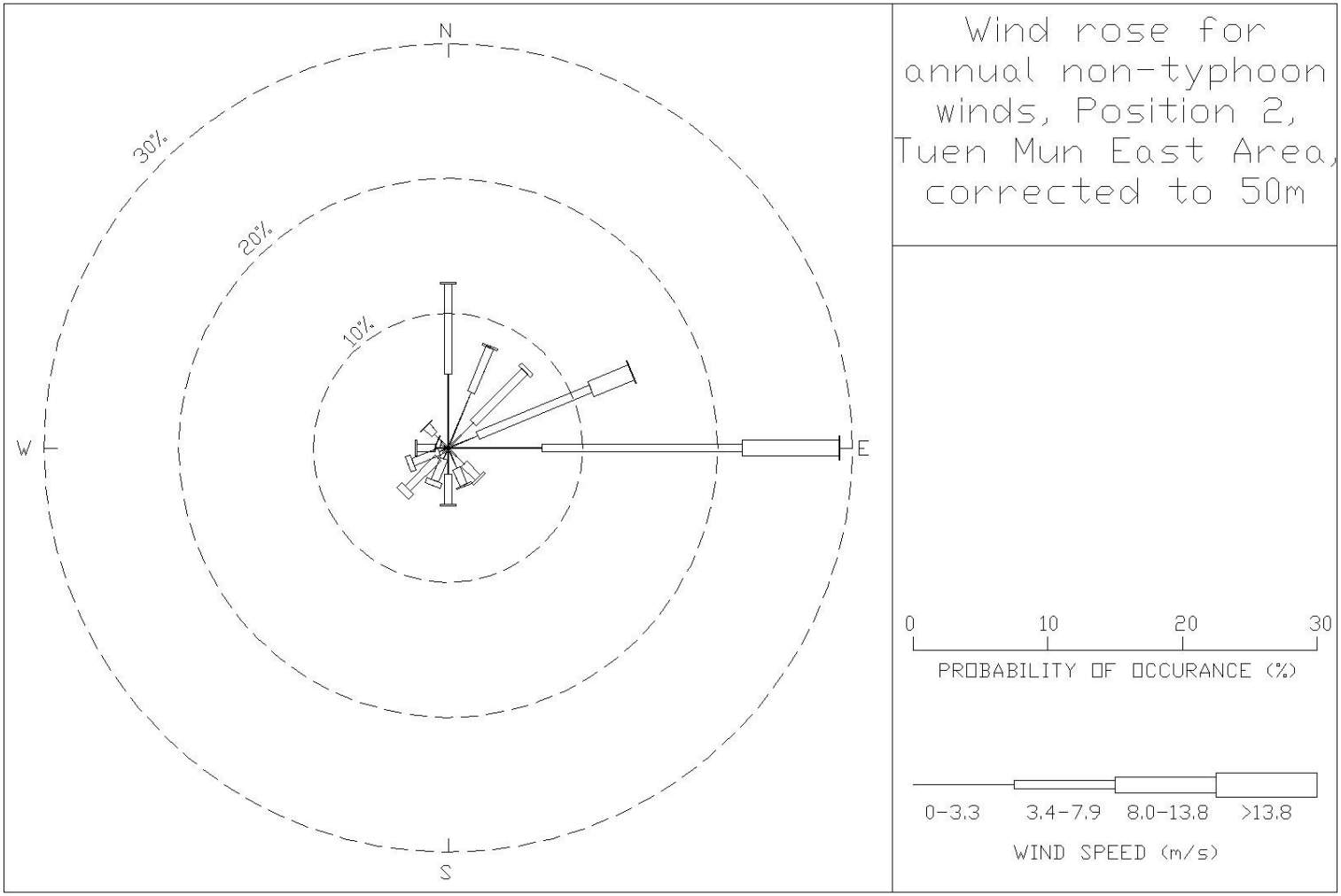

Figure 41: Wind rose for annual, non-typhoon winds for Position 2 of the Tuen Mun East Area, corrected to 50m

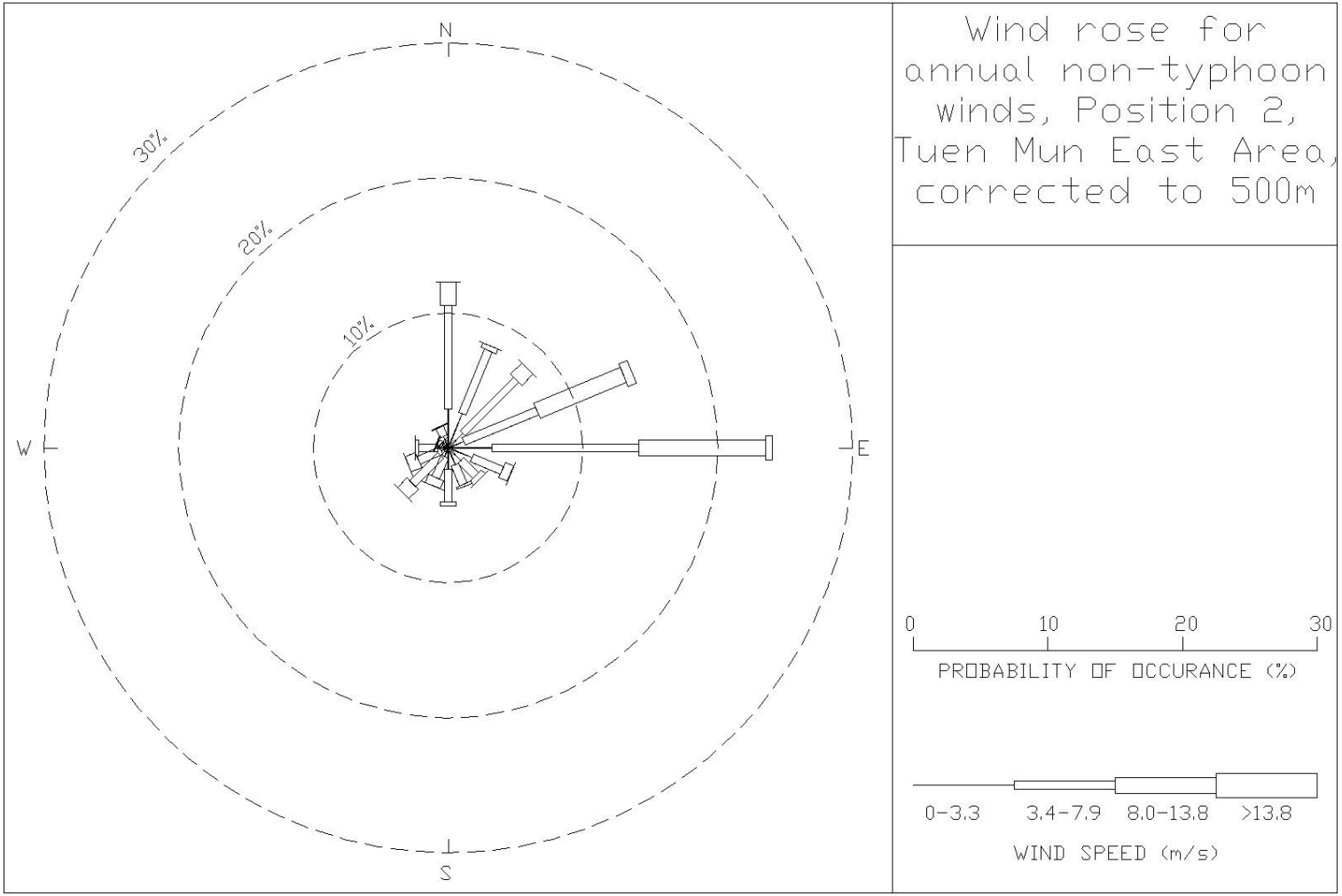

Figure 42: Wind rose for annual, non-typhoon winds for Position 2 of the Tuen Mun East Area, corrected to 500m

APPENDIX A: TABULATED RESULTS FOR POSITION 1, TUEN MUN EAST AREA

Table A1: Site wind characteristics, Position 1, Tuen Mun East Area, 22.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.32	29.9	7.7	-2.5
50	**0.32**	30.1	6.2	-3.0
75	0.34	29.6	8.2	-4.5
100	0.35	28.0	11.6	-5.7
150	0.38	26.3	15.5	-7.5
200	0.40	25.6	17.4	-8.2
300	0.46	26.6	17.4	-9.5
400	0.57	25.5	15.4	-8.7
500	**0.75**	20.4	12.3	-6.9

Table A2: Site wind characteristics, Position 1, Tuen Mun East Area, 45º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.40	24.2	-8.3	-7.2
50	**0.44**	21.9	-4.3	-8.2
75	0.46	21.0	-0.7	-8.3
100	0.48	20.4	2.1	-8.8
150	0.51	19.9	4.3	-8.5
200	0.55	19.8	6.0	-8.3
300	0.63	18.8	6.0	-7.2
400	0.75	15.5	3.6	-5.7
500	**0.85**	11.9	1.9	-4.3

Table A3: Site wind characteristics, Position 1, Tuen Mun East Area, 67.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.57	16.2	2.2	-4.5
50	**0.62**	15.1	2.2	-4.2
75	0.66	14.6	2.1	-4.0
100	0.69	13.9	2.3	-3.5
150	0.73	12.7	2.6	-3.2
200	0.78	12.0	2.7	-3.1
300	0.84	11.3	3.6	-2.8
400	0.91	10.2	3.8	-2.6
500	**0.97**	9.0	3.8	-2.3

Table A4: Site wind characteristics, Position 1, Tuen Mun East Area, 90º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.66	14.3	-1.7	-2.9
50	**0.71**	13.0	-0.9	-2.7
75	0.75	12.5	0.0	-2.4
100	0.78	11.7	0.3	-2.4
150	0.83	11.1	0.7	-2.3
200	0.87	10.2	0.4	-2.4
300	0.92	9.3	0.0	-2.1
400	0.97	8.6	-0.4	-1.9
500	**1.01**	7.5	-0.9	-1.8

Table A5: Site wind characteristics, Position 1, Tuen Mun East Area, 112.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.64	17.4	5.9	1.7
50	**0.68**	16.0	5.4	1.8
75	0.71	14.9	5.4	1.3
100	0.74	14.4	5.0	1.2
150	0.78	13.6	4.1	1.2
200	0.80	12.9	3.2	1.1
300	0.86	11.6	2.2	1.3
400	0.90	10.8	1.1	1.6
500	**0.95**	9.4	0.2	1.6

Table A6: Site wind characteristics, Position 1, Tuen Mun East Area, 135º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.59	17.0	5.2	-0.2
50	**0.64**	15.3	2.5	0.2
75	0.69	14.5	0.6	0.3
100	0.72	13.7	-1.1	0.5
150	0.77	12.2	-3.6	1.0
200	0.83	10.4	-5.2	1.3
300	0.87	8.5	-7.1	1.5
400	0.90	8.2	-8.5	1.4
500	**0.94**	7.6	-9.5	1.4

Table A7: Site wind characteristics, Position 1, Tuen Mun East Area, 157.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.55	16.9	10.2	-4.2
50	**0.59**	15.7	8.0	-2.7
75	0.62	15.2	6.4	-2.3
100	0.65	14.6	4.8	-1.9
150	0.69	13.8	2.2	-0.8
200	0.74	12.5	0.0	0.3
300	0.79	10.6	-1.3	1.1
400	0.82	10.3	-1.9	1.4
500	**0.84**	10.1	-2.6	1.5

Table A8: Site wind characteristics, Position 1, Tuen Mun East Area, 180º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.48	23.0	3.0	2.8
50	**0.53**	19.9	2.7	4.6
75	0.57	17.8	3.4	5.0
100	0.60	16.0	3.5	4.8
150	0.65	14.1	3.0	4.6
200	0.68	13.8	2.6	4.3
300	0.72	12.7	2.4	4.4
400	0.78	11.9	2.0	3.5
500	**0.82**	11.7	2.2	3.6

Table A9: Site wind characteristics, Position 1, Tuen Mun East Area, 202.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.62	13.0	6.7	-3.9
50	**0.70**	9.9	4.3	-0.6
75	0.73	9.4	4.3	0.2
100	0.75	8.8	4.3	0.6
150	0.80	8.4	4.3	1.3
200	0.82	8.0	4.3	1.6
300	0.86	7.2	4.4	2.2
400	0.90	6.9	4.3	2.2
500	**0.93**	6.6	4.6	2.4

Table A10: Site wind characteristics, Position 1, Tuen Mun East Area, 225º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.55	17.6	-11.0	-0.1
50	**0.62**	13.8	-7.7	1.8
75	0.66	12.5	-6.4	2.1
100	0.69	11.8	-5.2	2.7
150	0.74	10.3	-4.4	3.2
200	0.78	9.6	-3.3	3.4
300	0.83	8.6	-2.7	3.6
400	0.86	8.1	-2.1	3.5
500	**0.89**	7.4	-1.4	3.6

Table A11: Site wind characteristics, Position 1, Tuen Mun East Area, 247.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.58	15.0	-8.6	-3.6
50	**0.61**	14.1	-8.2	-2.5
75	0.64	13.6	-5.2	-1.7
100	0.67	12.8	-4.1	-1.3
150	0.72	12.1	-1.8	-0.6
200	0.76	11.2	-0.9	0.0
300	0.84	8.8	-0.8	0.7
400	0.89	7.1	-1.0	0.9
500	**0.92**	6.6	-0.6	0.9

Table A12: Site wind characteristics, Position 1, Tuen Mun East Area, 270º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.73	11.5	1.7	-3.2
50	**0.79**	10.4	1.7	-2.5
75	0.82	10.0	1.9	-2.2
100	0.84	9.8	2.3	-2.0
150	0.85	9.3	2.8	-1.7
200	0.88	9.0	2.8	-2.1
300	0.91	8.3	2.7	-2.2
400	0.94	7.8	2.4	-2.2
500	**0.96**	7.3	2.2	-2.0

Table A13: Site wind characteristics, Position 1, Tuen Mun East Area, 292.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.58	21.5	11.8	-1.2
50	**0.63**	19.7	9.1	-1.1
75	0.66	18.4	6.0	-1.5
100	0.69	17.7	4.6	-1.6
150	0.74	16.5	1.9	-2.2
200	0.79	15.4	0.6	-2.6
300	0.87	13.2	-0.4	-3.2
400	0.94	11.7	-0.5	-3.3
500	**0.97**	11.3	0.3	-3.4

Table A14: Site wind characteristics, Position 1, Tuen Mun East Area, 315º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.49	23.2	20.2	-4.6
50	**0.56**	21.3	16.6	-5.1
75	0.61	19.3	13.5	-5.6
100	0.65	17.9	10.6	-5.7
150	0.71	15.5	7.6	-5.4
200	0.76	14.2	6.3	-5.0
300	0.83	12.4	5.4	-4.2
400	0.89	11.3	5.0	-3.5
500	**0.94**	10.0	4.8	-2.9

Table A15: Site wind characteristics, Position 1, Tuen Mun East Area, 337.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.51	20.6	20.7	-6.3
50	**0.55**	20.1	19.5	-7.3
75	0.60	19.4	16.6	-7.8
100	0.65	18.0	13.9	-8.3
150	0.76	15.2	9.6	-7.9
200	0.83	12.3	7.3	-7.2
300	0.94	8.6	4.9	-6.4
400	0.98	7.4	4.2	-5.7
500	**1.00**	7.0	3.9	-5.0

Table A16: Site wind characteristics, Position 1, Tuen Mun East Area, 360º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.33	36.1	14.0	0.7
50	**0.37**	31.9	24.1	-3.6
75	0.39	30.8	25.3	-5.7
100	0.41	29.7	26.2	-7.1
150	0.44	29.4	25.5	-8.0
200	0.46	29.2	24.3	-8.2
300	0.50	30.2	20.6	-9.1
400	0.62	29.6	12.0	-8.6
500	**0.79**	23.9	4.5	-6.6

APPENDIX B: TABULATED RESULTS FOR POSITION 2, TUEN MUN EAST AREA

Table B1: Site wind characteristics, Position 2, Tuen Mun East Area, 22.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.46	21.9	-8.8	-2.6
50	**0.50**	19.9	-7.7	-2.6
75	0.53	18.9	-4.8	-3.0
100	0.55	18.4	-2.8	-3.4
150	0.60	17.4	-0.8	-4.1
200	0.64	16.8	0.7	-4.1
300	0.75	14.3	1.4	-3.8
400	0.86	11.0	0.8	-3.1
500	**0.91**	8.8	0.6	-2.4

Table B2: Site wind characteristics, Position 2, Tuen Mun East Area, 45º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.58	15.6	9.0	-3.0
50	**0.62**	15.2	8.8	-3.1
75	0.65	14.5	8.1	-3.1
100	0.69	13.5	7.6	-3.3
150	0.75	12.0	5.9	-3.1
200	0.79	10.9	5.5	-2.8
300	0.85	9.7	4.5	-2.3
400	0.90	8.9	4.0	-2.0
500	**0.93**	8.0	3.9	-1.6

Table B3: Site wind characteristics, Position 2, Tuen Mun East Area, 67.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.60	17.1	0.8	-1.7
50	**0.65**	16.1	1.5	-2.1
75	0.70	15.1	2.6	-2.3
100	0.74	14.3	3.2	-2.3
150	0.82	12.1	3.5	-2.0
200	0.88	10.8	3.0	-1.7
300	0.89	10.4	2.4	-1.4
400	0.91	10.4	1.6	-1.2
500	**0.92**	10.7	0.7	-1.2

Table B4: Site wind characteristics, Position 2, Tuen Mun East Area, 90º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.60	15.4	5.1	-2.4
50	**0.62**	15.1	4.9	-2.1
75	0.64	14.7	5.7	-1.9
100	0.67	14.5	5.5	-2.0
150	0.70	14.4	5.4	-1.8
200	0.73	14.0	4.3	-2.0
300	0.78	13.2	2.2	-1.9
400	0.87	12.0	0.6	-1.9
500	**0.93**	10.0	-0.3	-1.9

Table B5: Site wind characteristics, Position 2, Tuen Mun East Area, 112.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.51	23.5	17.0	0.9
50	**0.56**	22.1	15.8	0.3
75	0.60	20.8	13.4	-0.1
100	0.63	20.0	12.5	-0.7
150	0.67	18.8	10.9	-0.6
200	0.73	17.5	9.6	-0.4
300	0.80	14.8	8.3	0.1
400	0.87	12.5	8.1	0.1
500	**0.94**	9.2	7.8	0.1

Table B6: Site wind characteristics, Position 2, Tuen Mun East Area, 135º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.60	16.0	5.0	1.5
50	**0.69**	13.3	5.5	0.8
75	0.74	11.3	5.6	0.3
100	0.77	10.8	5.2	0.3
150	0.80	10.2	5.0	0.1
200	0.83	9.5	4.5	-0.2
300	0.88	8.5	4.0	-0.2
400	0.91	8.0	3.6	-0.1
500	**0.96**	6.9	3.5	0.1

Table B7: Site wind characteristics, Position 2, Tuen Mun East Area, 157.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.60	14.8	8.4	-1.6
50	**0.66**	13.7	7.4	-1.3
75	0.69	12.8	7.2	-1.3
100	0.72	12.2	7.3	-1.3
150	0.75	11.9	7.6	-1.2
200	0.76	11.5	7.7	-1.0
300	0.79	11.3	7.7	-0.7
400	0.82	10.8	7.7	-0.5
500	**0.87**	10.2	7.5	-0.8

Table B8: Site wind characteristics, Position 2, Tuen Mun East Area, 180º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.57	14.0	10.1	-3.8
50	**0.61**	13.1	9.0	-3.0
75	0.65	12.2	8.2	-2.8
100	0.68	11.7	8.3	-2.5
150	0.70	11.4	8.0	-2.1
200	0.71	11.0	7.8	-1.6
300	0.74	11.2	7.0	-1.5
400	0.77	11.1	6.9	-1.2
500	**0.80**	11.3	6.6	-1.0

Table B9: Site wind characteristics, Position 2, Tuen Mun East Area, 202.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.74	9.3	3.8	-2.2
50	**0.80**	8.4	3.0	-1.7
75	0.83	8.0	2.8	-1.6
100	0.85	7.6	2.7	-1.5
150	0.88	7.3	2.4	-1.6
200	0.90	7.0	2.3	-1.7
300	0.92	6.9	2.1	-1.7
400	0.95	6.8	2.2	-1.6
500	**0.97**	6.7	2.4	-1.3

Table B10: Site wind characteristics, Position 2, Tuen Mun East Area, 225º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.65	11.4	-0.7	-0.8
50	**0.71**	10.1	-0.6	-0.3
75	0.76	9.3	-0.3	-0.3
100	0.78	8.8	0.1	-0.3
150	0.81	8.5	0.4	-0.1
200	0.84	7.9	0.8	0.0
300	0.87	7.4	1.4	0.5
400	0.90	7.0	1.5	0.8
500	**0.93**	6.6	1.8	0.9

Table B11: Site wind characteristics, Position 2, Tuen Mun East Area, 247.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.63	11.6	1.1	-0.9
50	**0.70**	10.1	0.5	-0.3
75	0.75	9.2	0.4	-0.2
100	0.76	8.8	0.9	0.0
150	0.81	7.9	0.8	0.2
200	0.83	7.4	1.3	0.4
300	0.86	6.8	1.4	0.6
400	0.89	6.4	1.7	0.9
500	**0.91**	6.2	1.9	1.0

Table B12: Site wind characteristics, Position 2, Tuen Mun East Area, 270º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.65	10.3	3.2	-4.2
50	**0.69**	9.8	2.7	-3.7
75	0.72	9.3	2.6	-3.5
100	0.74	9.1	2.9	-3.1
150	0.78	8.9	3.5	-3.0
200	0.80	8.8	3.9	-2.8
300	0.85	8.2	3.6	-2.7
400	0.90	7.4	3.2	-2.5
500	**0.95**	6.5	2.7	-2.4

Table B13: Site wind characteristics, Position 2, Tuen Mun East Area, 292.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.55	23.5	8.4	-2.8
50	**0.60**	21.4	7.7	-3.0
75	0.63	20.2	7.4	-3.6
100	0.67	19.3	6.7	-4.0
150	0.72	17.6	4.8	-4.7
200	0.77	16.6	3.7	-5.1
300	0.82	15.7	3.1	-5.0
400	0.86	15.0	3.5	-5.2
500	**0.87**	15.2	5.1	-4.7

Table B14: Site wind characteristics, Position 2, Tuen Mun East Area, 315º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.52	19.5	8.7	-4.5
50	**0.55**	18.6	8.5	-4.1
75	0.60	17.2	8.5	-4.2
100	0.63	16.7	8.1	-4.4
150	0.67	16.1	7.8	-4.1
200	0.72	14.7	6.9	-4.0
300	0.79	13.0	5.4	-3.6
400	0.85	11.2	4.9	-3.2
500	**0.90**	9.9	4.4	-2.9

Table B15: Site wind characteristics, Position 2, Tuen Mun East Area, 337.5º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.55	20.3	23.2	-5.1
50	**0.56**	20.1	22.9	-4.9
75	0.58	19.5	22.8	-5.5
100	0.59	20.0	22.1	-5.6
150	0.59	20.4	20.5	-5.6
200	0.59	20.2	18.5	-6.1
300	0.60	20.8	15.0	-6.8
400	0.65	20.2	11.2	-6.8
500	**0.76**	18.0	7.6	-6.2

Table B16: Site wind characteristics, Position 2, Tuen Mun East Area, 360º

Prototype scale height (mPD)	Normalised mean wind speed	Turbulence intensity (%)	Yaw angle (º)	Pitch angle (º)
25	0.39	33.1	-12.9	-0.9
50	**0.42**	32.2	-9.0	-4.2
75	0.45	31.7	-7.7	-5.8
100	0.47	30.8	-4.1	-7.1
150	0.52	29.4	-1.3	-7.7
200	0.60	25.9	-0.6	-8.6
300	0.72	21.1	1.2	-8.2
400	0.86	14.9	1.2	-7.0
500	**0.93**	11.4	1.5	-5.5

APPENDIX C: AXIS SYSTEM OF THE COBRA PROBE

The following figures show the standard axis system of the Cobra Probe:

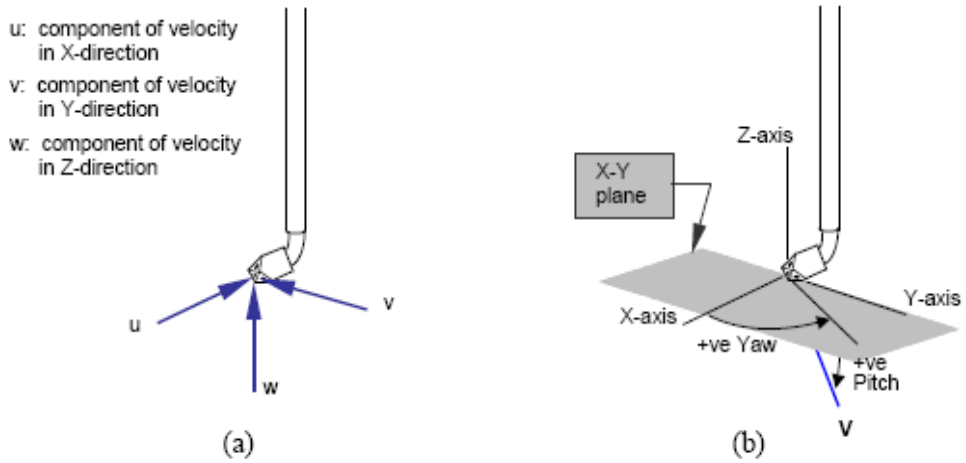

Figure C1: (a) Flow axis system with respect to the Cobra Probe head;
(b) Positive flow pitch and yaw angles

Note: Yaw angle is technically 'azimuth' (rotation angle about the z-axis); Pitch angle is technically 'elevation' (the angle between the flow velocity vector V and the X-Y plane).