Hong Kong Housing Authority

Detailed Air Ventilation Assessment for Public Housing Development Project Batch C3

Proposed Public Housing Development at Ma On Shan Area 86B

Issue 1 Revision 1

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Proposed Public Housing Development at Ma On Shan Area 86B

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Executive Summary

In April 2009, Ove Arup & Partners Hong Kong Ltd was commissioned by the Housing Authority to undertake an Air Ventilation Assessment Detailed Study for Ma On Shan Area 86B. The study was carried out in collaboration with the CLP Power Wind/Wave Tunnel Facility of the Hong Kong University of Science and Technology, to assess the air ventilation performance of areas both within and surrounding the development site for the benefit of the occupants and pedestrians.

Overall Wind Performance

The following table summarizes the Air Ventilation Assessment study result of the Site and its surrounding Area. For easy reference, the average Velocity Ratio values at the seafront spots are taken as the reference wind condition, which indicates the ventilation performance for seafront without any obstacles, e.g. 0.20 under annual prevailing condition and 0.22 under the summer condition. As a result, the site and its surroundings have access to good wind environments with average Velocity Ratio values greater than 0.2 both under summer and annual prevailing wind conditions.

	Overall Assessment Area VR Results			
	Site Velocity Ratio (SVR)		Local Velocity Ratio (LVR)	
	Annual	Summer	Annual	Summer
Proposed Scheme	0.20	0.21	0.20	0.21

Wind Performance of Functional Area and Surrounding Area

The wind performance of several functional areas in Ma On Shan Area 86B has been analyzed to identify potential wind gusts and stagnant zones at the main pedestrian circulation areas.

The proposed scheme has carefully considered the wind availability and its surrounding topography and the functional areas are planned with good air ventilation performance, providing Velocity Ratio values around or greater than 0.2 under annual and summer prevailing wind conditions.

In addition, the proposed scheme offers more evenly distributed wind performance to surrounding areas, with annual average Velocity Ratio values ranging from 0.19 to 0.23.

1 Introduction

1.1 Background of the Study

In April 2009, Ove Arup & Partners Hong Kong Ltd (Arup) was commissioned by Housing Authority to undertake an Air Ventilation Assessment Detailed Study (the Study) for Ma On Shan (MOS) Area 86B. The study was carried out in collaboration with the CLP Power Wind/Wave Tunnel Facility of the Hong Kong University of Science and Technology (WWTF), to assess the air ventilation performance of the areas both within and surrounding the development site for the benefit of the occupants and pedestrian.

1.2 Objective of the Study

The Objective of the study is to evaluate the air ventilation performance of the proposed master layout design scheme for the Public Housing Development at Ma On Shan (MOS) Area 86B using the methodology for Detailed Air Ventilation Assessment.

The wind tunnel testing techniques used for this study has satisfied the quality assurance 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 (2006).

1.3 Scope of the Study

The main scope of the Study is to carry out an AVA Detailed Study to assess the ventilation performance of the proposed development at MOS Area 86B and surrounding environment.

The deliverable of the study is to evaluate the ventilation performance of the development site as well as the surrounding areas.

2 Study Background

2.1 Site Characteristics

The Proposed Public Housing Development at MOS Area 86B is situated in the north-eastern part of the New Territories, lying in between Heng On and Tai Shui Hang. The proposed development site is bounded by Hang Tai Road, Ma On Shan Road, Hang Chi Street, Sai Sha Road and Hang Yiu Street. The location and surrounding site condition is illustrated in Figure 1.

The MOS Area 86B development has its strategic location and the development scale. It is crucial at early design stage to define an effective urban planning for good air ventilation.

Figure 1 Ma On Shan Area 86B Development Site

2.2 Design Scheme

The proposed Public Housing Development in MOS Area 86B comprises:

- three 41 storey site specific design domestic blocks;
- outdoor parking spaces for light good vehicles and private cars; and
- two single storey retail complexes.

The design scheme for the Ma On Shan Area 86B is shown in Figure 2 below:

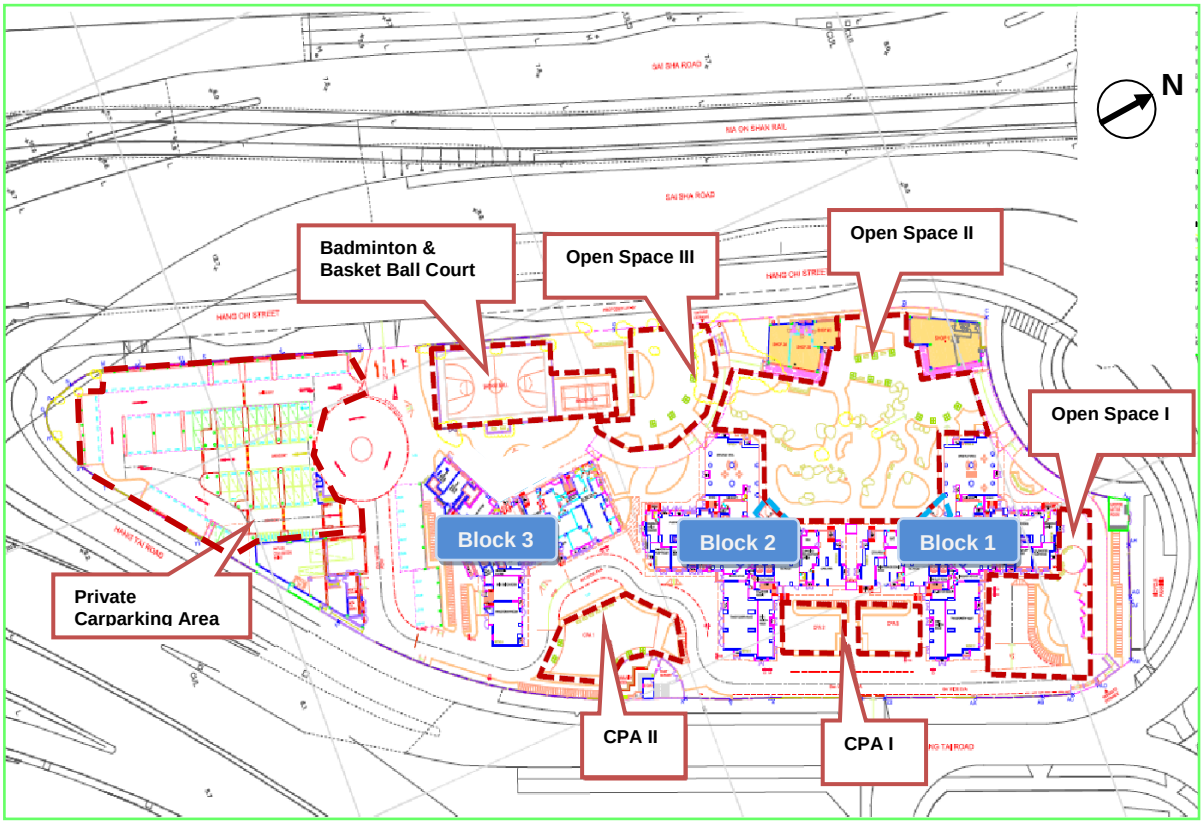

Figure 2 Master Layout for the Proposed Scheme

3 Methodology for the Study

3.1 Site Wind Availability Study

Physical Model of the Study Area

A 1:2000 scale topography study was conducted in WWTF's low speed test section to determine the effectiveness of topography on local wind conditions at the proposed site developments. The physical model for wind availability study has been shown in the Appendix from Figure 8 to Figure 11 in Appendix A.

Measurements were taken at 9 different height levels above the site, and at 22.5° intervals for the full 360° azimuth, using a miniature dynamic pressure probe (Figure 3) to determine the vertical profiles of mean wind speed, turbulence intensity, mean yaw and pitch angles of winds at the proposed development site.

For this study, all buildings and structures within the site boundary were removed for all measured wind directions in the wind availability study.

Experimental Equipment and Procedures

A miniature dynamic pressure (Cobra) probe was used to take measurements of the longitudinal, lateral and vertical components of wind speed, at 22.5˚ increments for the full 360˚ azimuth, i.e. for sixteen wind directions, and at nine heights to determine profiles of mean wind speed and turbulence intensity above the Study Areas.

Figure 3 Hardware of the miniature dynamic pressure (Cobra) probe

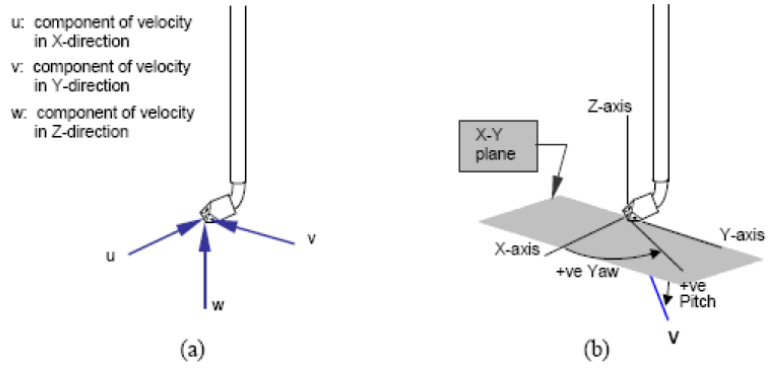

Figure 4 Usage of the miniature dynamic pressure (Cobra) probe

The results were used to determine the vertical profiles of mean wind speed, turbulence intensity and mean yaw and pitch angles of winds at the proposed development.

Mean wind speeds were measured in 1:2000 scale topographical model and matched with a larger scale model to be used for the detailed air ventilation assessment studies through a wind speed scaling factor (F), averaged over a range of heights that were considered likely to influence pedestrian level wind conditions, as shown in Equation (1).

$$F = \left[\frac{V_z}{V_{500,\text{open},i}} \right]_{\text{site wind availabili ty model}} \left[\frac{V_{ref}}{V_z} \right]_{\text{detailed model}} \quad (1)$$

where:

V_z = mean wind speed measured at a height z;

V_{ref} = wind speed measured at the reference height (z_{ref}) in the larger scale tests; and

$V_{500,open,i}$ = directional mean wind speed at 500 mPD above open terrain for the i-th wind direction.

The measured site wind characteristics were combined analytically with WWTF's probabilistic models of the annual and summer non-typhoon wind climate of Hong Kong, corrected to an appropriate height, for use in the subsequent air ventilation studies. Deviations in the mean wind direction determined in the 1:2000 scale topography study were averaged over a range of heights that were considered likely to influence pedestrian level wind conditions. If the average mean wind direction deviated by more than ±11.25° from the approach wind direction, those winds were treated as having shifted to an adjacent sector. Therefore, the probability of occurrence of the corresponding approach wind direction was added to that of the adjacent sector and the directional probabilities of occurrence were adjusted accordingly.

Experimental Results

Based on the wind tunnel test results, a number of representative approach wind conditions were identified for the tested site to rationalize and characterize the effects of the various topographical and terrain features for the 16 measured wind directions as illustrated in Appendix A2.

3.2 Detailed AVA Study

For the Detailed AVA study, a 1:400 scale model of the Project Area, Assessment Area and Surrounding Area (Figure 14 to Figure 17 in Appendix A3), was fabricated in accordance with plans, drawings and information supplied by Hong Kong Housing Authority (HKHA). The detailed model had a radius of approximately 580m and included all known existing and committed developments, as well as topographical features within the modelled region.

The testing points in the detailed wind tunnel model (1:400) were installed in Project Area and Assessment Area. Furthermore, additional test points were employed in order to study the ventilation performance in more detail, as shown in Appendix A4. Test points were categorised as either perimeter test points, overall test points or special test points in accordance with Planning Department's Technical Guide for Air Ventilation Assessment for Developments in Hong Kong (2006).

- **Perimeter test points** were located at regular intervals around the boundary of the Project Area, including the junctions of all roads leading to the project site, at main entrances to the project site and at the corners of the project site.
- **Overall test points** were distributed on streets and in open spaces within the Assessment Area that were readily and frequently accessible by the public.
- **Special test points** were located in areas where localised wind issues were expected, such as in stagnant zones or in regions with the potential for strong winds, or at locations where the pedestrian level wind environment was of special interest.

4 Detailed AVA Study Result Analysis

4.1 Overall Wind Performance

The annual and summer overall wind velocity ratios for all the test points at the Proposed Scheme are shown in Figure 19 and Figure 20 in Appendix A5, respectively. As summarized in the following table, the average VR of the site and its surrounding are quite similar, with value of 0.20 and 0.21 under annual and summer prevailing wind conditions.

To further evaluate its wind performance, test points at relatively exposed seafront locations are taken for easy comparison. The wind performance of seafront location are represented by test points O25 (0.21annual / 0.24summer), O37 (0.20annual / 0.22summer) and O60 (0.18annual / 0.20summer). The average VR values for seafront are 0.20 and 0.22 respectively under annual and summer prevailing wind conditions.

To conclude, the site and its surrounding area can enjoy good wind environments with average Velocity Ratio (VR) values greater than 0.20, which is similar to seafront areas where no obstacles exist.

	Overall Assessment Area VR Results			
	Site Velocity Ratio (SVR)		Local Velocity Ratio (LVR)	
	Annual	Summer	Annual	Summer
Proposed Scheme	0.20	0.21	0.20	0.21
Seafront VR	0.20	0.22	0.20	0.22

Table 1 Overall Assessment Area VR Values for the Proposed development at MOS area 86B

4.2 Wind Performance of Site Functional Areas

The wind performance at specific functional areas within the development site is also assessed.

The test points representing the wind performance of the functional areas in MOS Area 86B for the Proposed Scheme are illustrated in Figure 5.

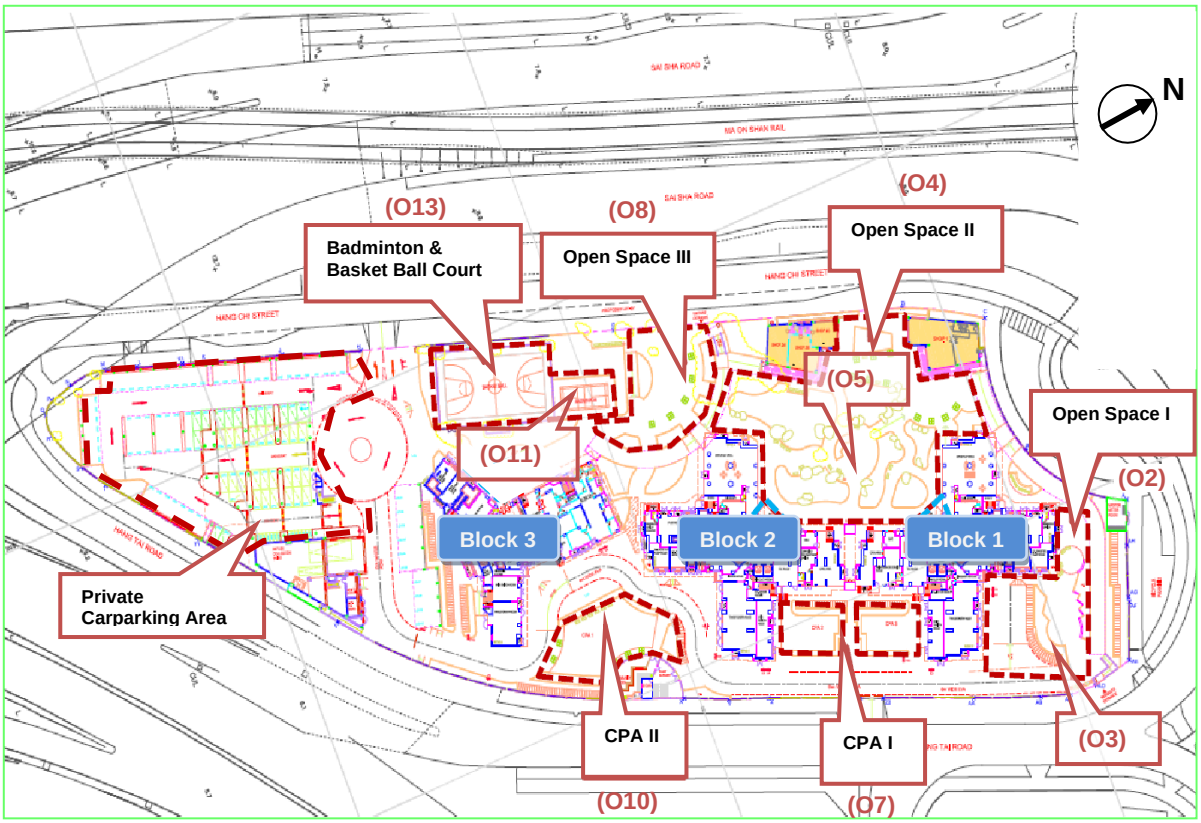

Figure 5 Functional Areas and Test Points for the Proposed Scheme

	Annual	Summer
	Proposed Scheme	Proposed Scheme
MOS Area 86B Overall		
	0.20	0.21
MOS Area 86B Functional Areas		
Open Space I (O2)	0.26	0.24
Open Space I (O3)	0.23	0.24
Open Space II (O4)	0.21	0.22
Open Space II (O5)	0.21	0.21
CPA I (O7)	0.19	0.23
Open Space III (O8)	0.20	0.21
CPA II (O10)	0.19	0.22
Ball Court Area (O11)	0.18	0.23
Ball Court Area (O13)	0.19	0.24

Table 2 VR values for the Functional Areas of Proposed Scheme

The VR values in Table 2 indicate the wind performance for each functional area in MOS Area 86B site under annual and summer conditions. It is concluded that:

- For most functional areas, VR values are 0.18 or above;
- Open Space I (O2, O3) is likely to attain relatively high VR value under the annual prevailing wind condition. However, this area is not designed as sitting area, the wind condition is acceptable for pedestrians.

4.3 Wind Performance of Surrounding Areas

The Surrounding Assessment Areas are subdivided into several representative zones according to their geographical locations and characteristics as shown in Figure 6. Wind performance of each focus area is summarized in Table 3.

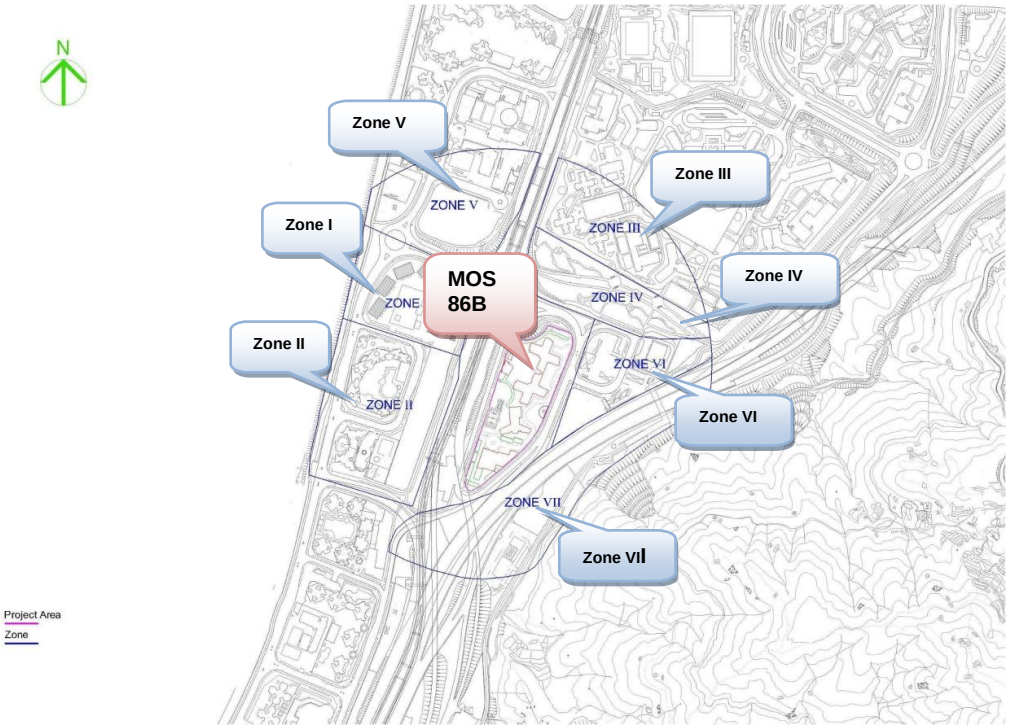

Figure 6 Focused Assessment Areas for the MOS 86B AVA Study

	Average Velocity Ratio (VR)	
	Annual	Summer
Zone	Proposed Scheme	Proposed Scheme
Zone I	0.21	0.23
Zone II	0.18	0.20
Zone III	0.18	0.20
Zone IV	0.18	0.22
Zone V	0.19	0.20
Zone VI	0.16	0.19
Zone VII	0.19	0.20

Table 3 Average VR values of Assessment Zones

The average VR values for the assessment zones surrounding the development are shown in Table 3.

In general, the Proposed Scheme has provided building setback from site boundary to minimize its impact to the surrounding area's air ventilation. The VR values of the assessment zones are around 0.18 (except Zone VI of 0.16 which is recommended to be verified by on-site measurement).

5 Conclusion

The AVA Detailed study for the proposed Public Housing Development at Ma On Shan Area 86B was carried out to evaluate the wind performance of the site and its surrounding areas.

Results indicate that the development site and its surrounding enjoy good wind environments with average Velocity Ratio (VR) values around 0.20 both under summer and annual prevailing wind conditions.

The functional areas have been designed with generally good air ventilation performance, providing VR values ranging from 0.18 to 0.26 under annual and summer prevailing wind conditions.

Appendix A

FIGURES

A1 1:2000 scale topographical model for Ma On Shan Study Area

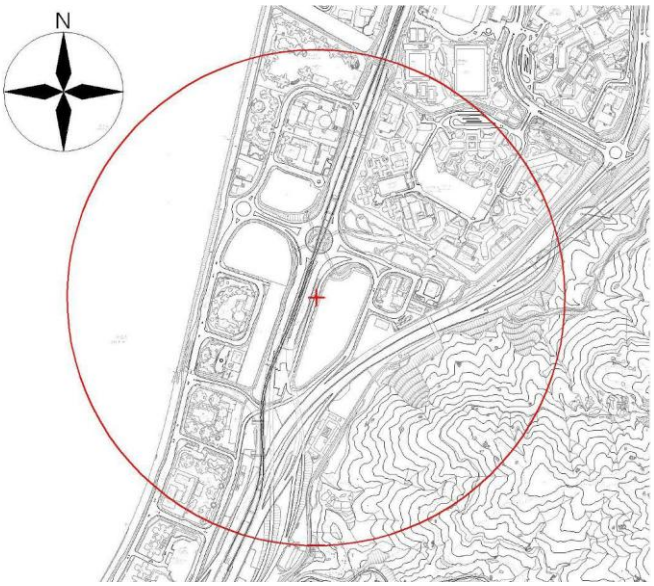

Figure 7 Ma On Shan Study Area

Figure 8 1:2000 scale topographical model in the low speed test section (north wind direction, 360°)

Figure 9 1:2000 scale topographical model in the low speed test section (east wind direction, 90°)

Figure 10 1:2000 scale topographical model in the low speed test section (south wind direction, 180°)

Figure 11 1:2000 scale topographical model in the low speed test section (west wind direction, 270°)

A2 Wind Availability result for Ma On Shan Area 86B

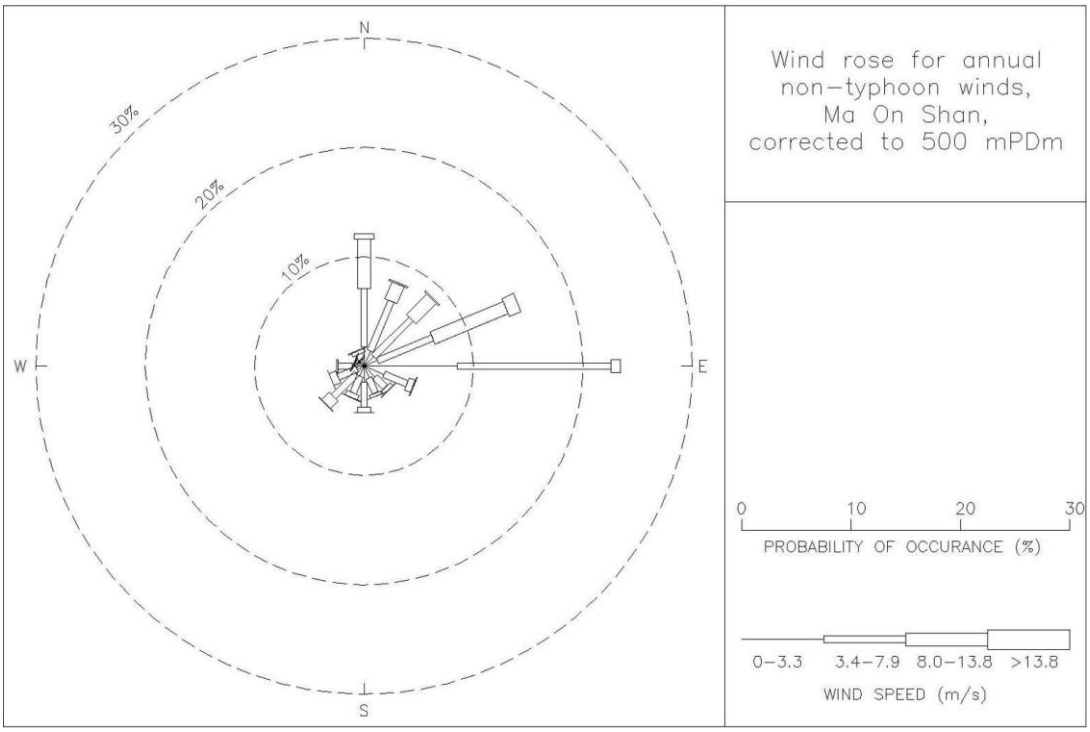

Figure 12 Wind rose for annual, non-typhoon winds for Ma On Shan Area 86B, corrected to 500 mPD

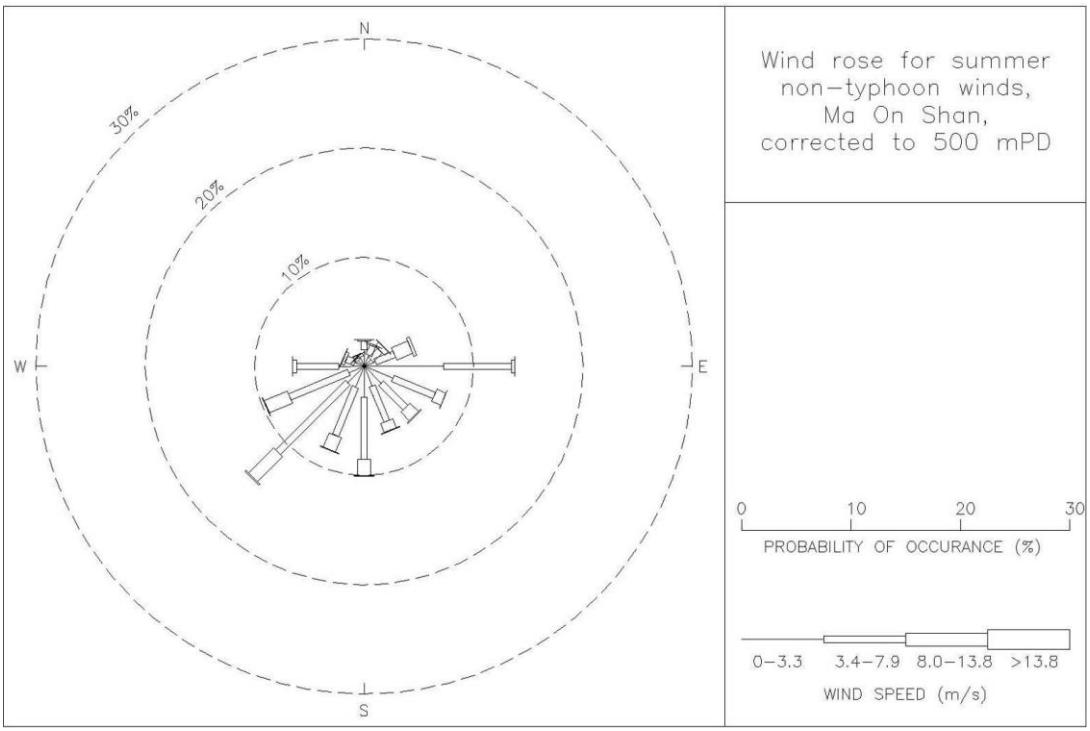

Figure 13 Wind rose for summer, non-typhoon winds for Ma On Shan Area 86B, corrected to 500 mPD

A3 1:400 scale physical model of the proposed development at Ma On Shan Area 86B and surrounds

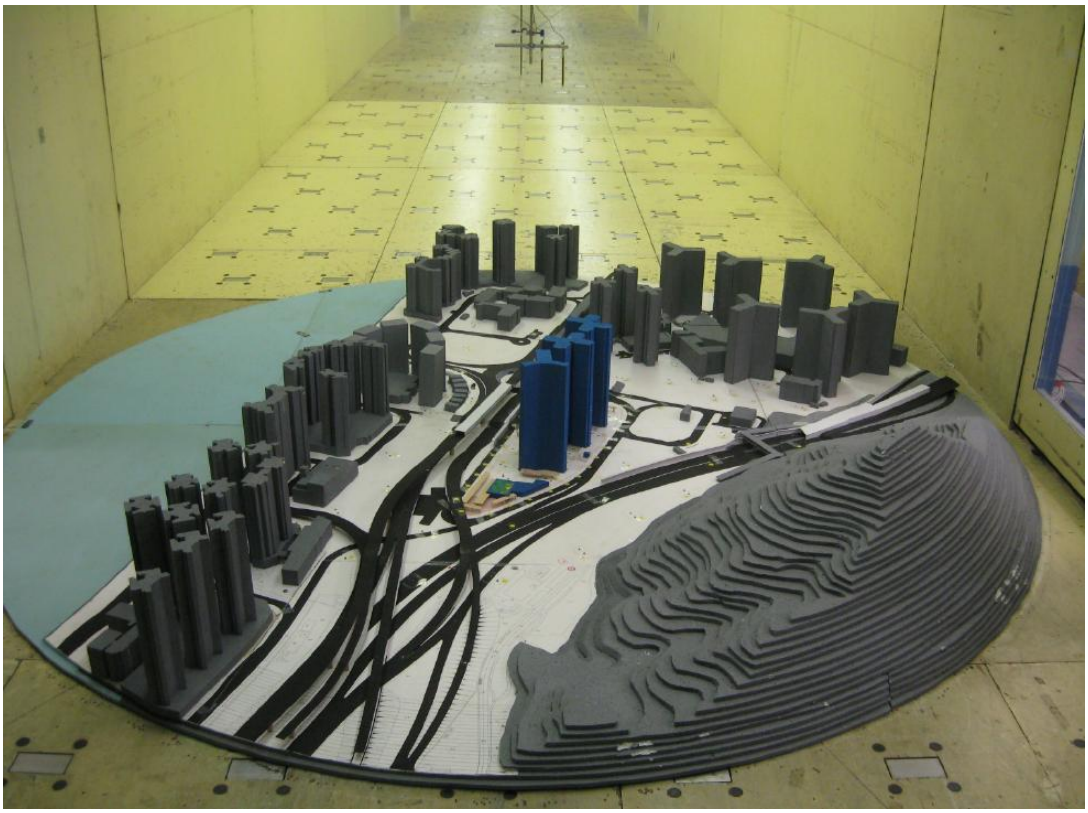

Figure 14 1**:400 scale physical model of the proposed development at Ma On Shan Area 86B and surrounds, downstream view of north wind direction**

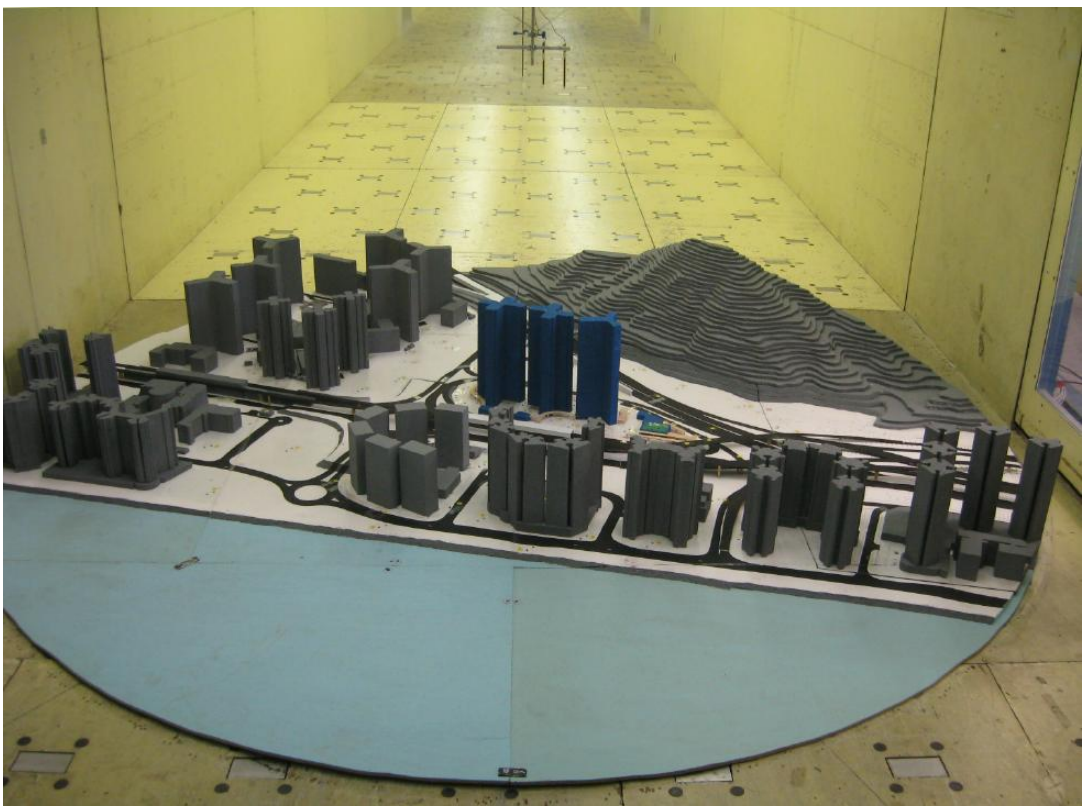

Figure 15 1:400 scale physical model of the proposed development at Ma On Shan Area 86B and surrounds, downstream view of east wind direction

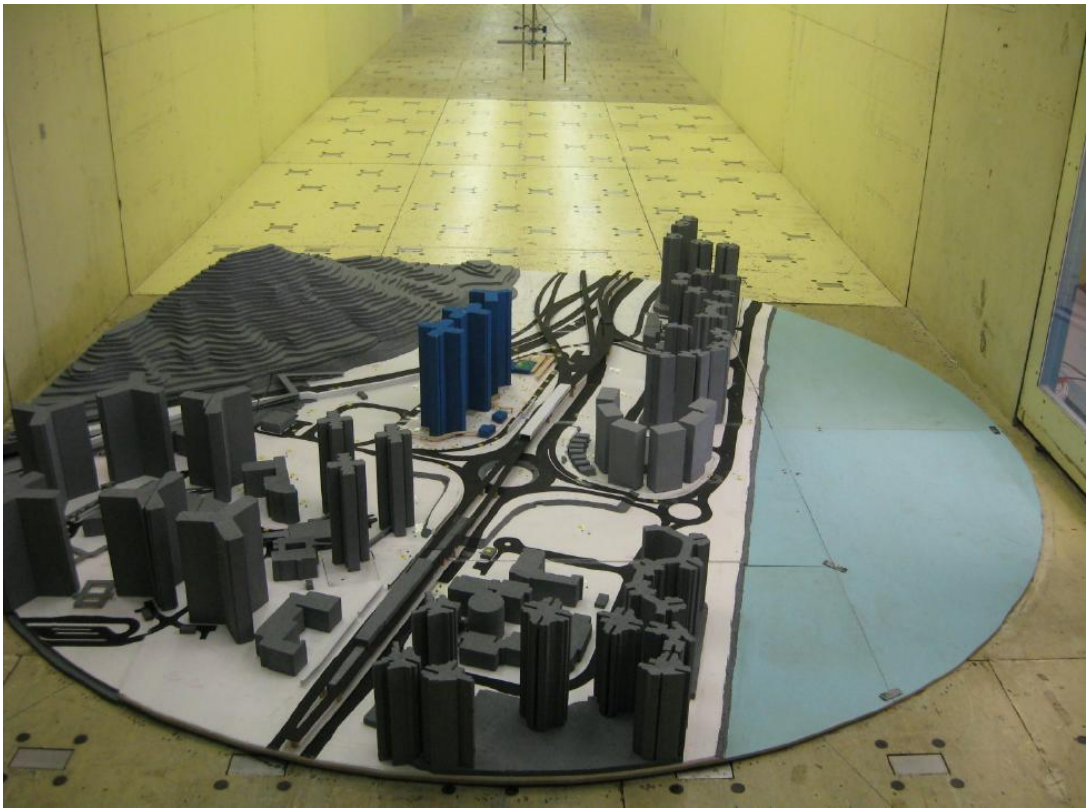

Figure 16 1:400 scale physical model of the proposed development at Ma On Shan Area 86B and surrounds, downstream view of south wind direction

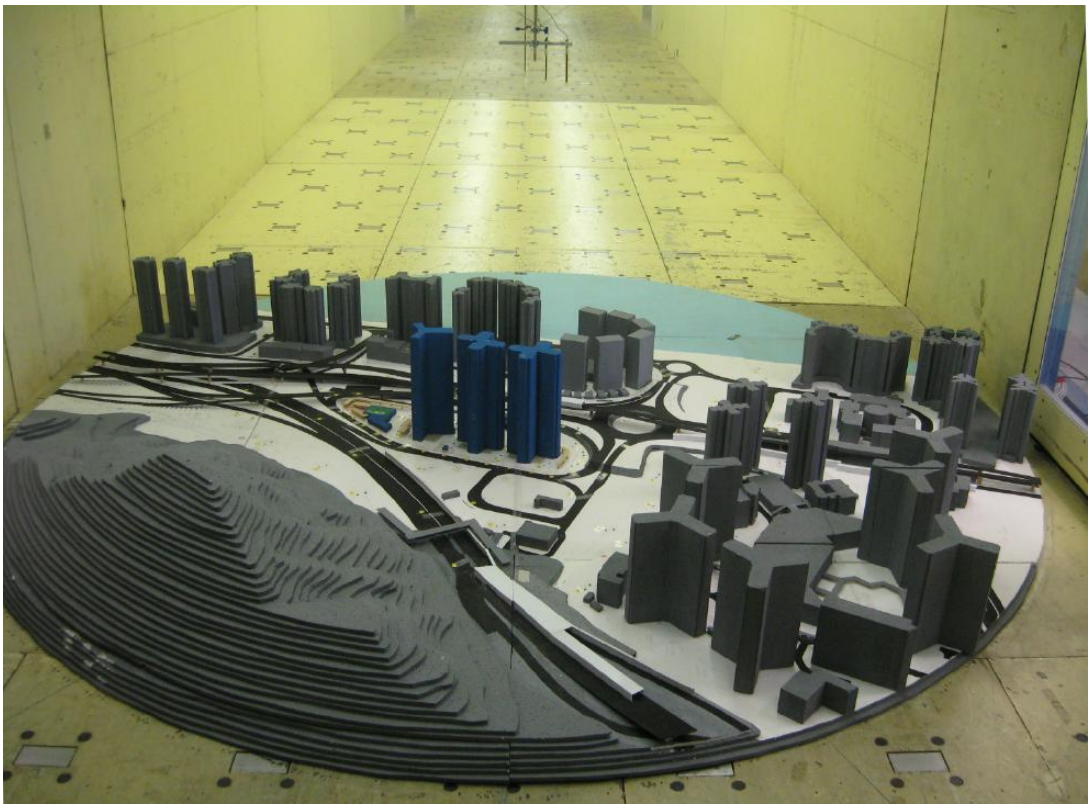

Figure 17 1:400 scale physical model of the proposed development at Ma On Shan Area 86B and surrounds, downstream view of west wind direction

A4 Test points locations for the Ma On Shan Area 86B Study

Figure 18 Test point locations for the MOS Area 86B Study

A5 Overview of Pedestrian Level Wind Performance

Figure 19 Annual overall wind velocity ratios for all test points

Figure 20 Overall wind velocity ratios for all test points in summer time