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Hong Kong Housing Authority

Environmental Study for Kiu Cheong Road East HOS

Air Ventilation Assessment – Expert Evaluation

June 2013

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1 INTRODUCTION

1.1 Background

1.1.1 AECOM Asia Company Ltd. has been commissioned by the Hong Kong Housing Authority (HKHA) to undertake an Air Ventilation Assessment (AVA) Study – Expert Evaluation for the Kiu Cheong Road East HOS to examine the air ventilation performance of its building design qualitatively and formulate effective and practicable measures enhancing the air ventilation as part of the continuous design improvement process.

1.2 Objectives of the AVA Study

1.2.1 The objective of this study is to investigate the wind ventilation performance of the development schemes using methods of Air Ventilation Assessment with reference to the "Housing Planning and Lands Bureau – Technical Circular No. 1/06, Environment, Transport and Works Bureau – Technical Circular No. 1/06" issued on 19th July 2006 (the Technical Circular) and "Technical Guide for Air Ventilation Assessment for Development in Hong Kong – Annex A".

1.3 Purpose of this Working Paper

1.3.1 This Expert Evaluation Report aims to report the following items:

- Identify the existing site wind environment surrounding the Kiu Cheong Road East HOS Area qualitatively;
- Identify possible problems and issues in the terms of air ventilation for the Development Options;
- Identify existing good design features that shall be retained and improved design features that will enhance pedestrian wind comfort; and
- Recommend the scope, methodology and details of initial study for further air ventilation assessment stage.

2 SITE WIND ENVIRONMENT

2.1 Wind Availability

2.1.1 The Subject Site, Kiu Cheong Road East HOS, is located in Yuen Long District, to the near south of the West Rail Tin Shui Wai Station. The Site falls within the Approved Ping Shan Outline Zoning Plan (OZP) No.S/YL-PS/14. **Figure 2.1** shows the location of the Subject Site.

Figure 2.1 Study Area – Kiu Cheong Road East HOS

2.1.2 The natural wind availability is crucial to investigate the wind ventilation performance of the Subject Site. The Hong Kong Planning Department (PlanD) has released a set of wind availability data of different locations in Hong Kong using MM5 mesoscale model for AVA studies. The set wind availability data can be obtained at the official website of Planning Department (http://www.pland.gov.hk/pland_en/misc/MM5/index.html).

2.1.3 For the Subject Site in the current study, the data from grid (15, 36) as shown in **Figure 2.2,** is used as the site wind availability data for wind analysis.

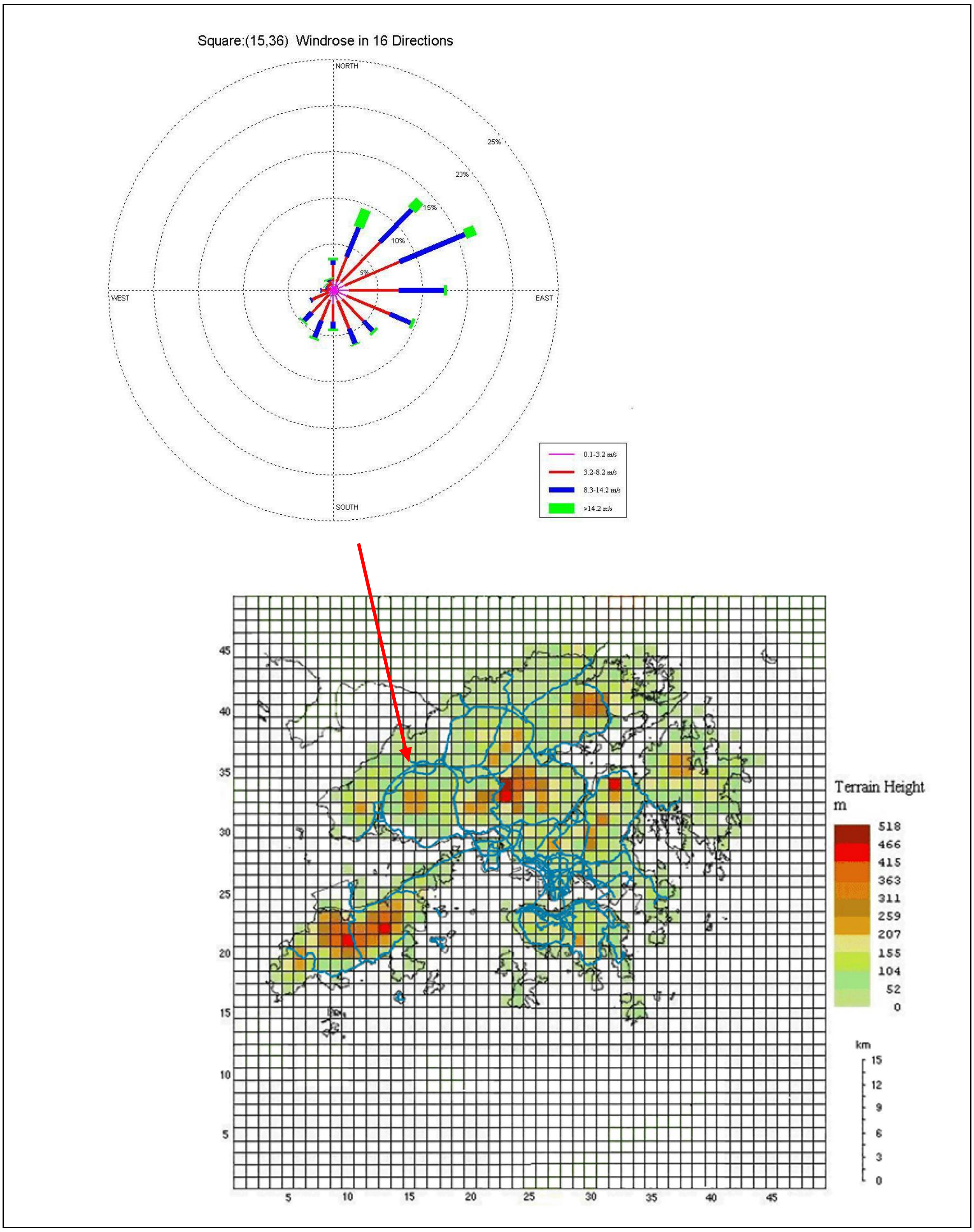


Figure 2.2 Wind Rose from PlanD website obtained from MM5 model (Grid 15, 36)

2.1.4 In the report, an annual wind rose and monthly wind roses during 1986 to 2012 from the Lau Fau Shan Weather Station are presented and shown in **Figure 2.3** and **Figure 2.4**. Also, the annual wind rose in year 2011 from the Wetland park automatic weather station which is close to the study area is also presented in **Figure 2.5**.

Table 2.1 Annual Wind Frequencies Table from MM5 model (Grid 15, 36)

Wind Direction	% of Annual Occurrence^
0º (N)	3.50%
22.5º (NNE)	**9.30%**
45º (NE)	**13.5%**
67.5º (ENE)	**16.9%**
90º (E)	**12.5%**
112.5º (ESE)	**9.50%**
135º (SE)	**6.40%**
157.5º (SSE)	**6.30%**
180º (S)	4.30%
202.5º (SSW)	5.60%
225º (SW)	4.70%
247.5º (WSW)	2.80%
270º (W)	1.40%
292.5º (WNW)	0.90%
315º (NW)	1.00%
337.5º (NNW)	1.30%

^ Percentage of occurrence directly extracted from wind probability table

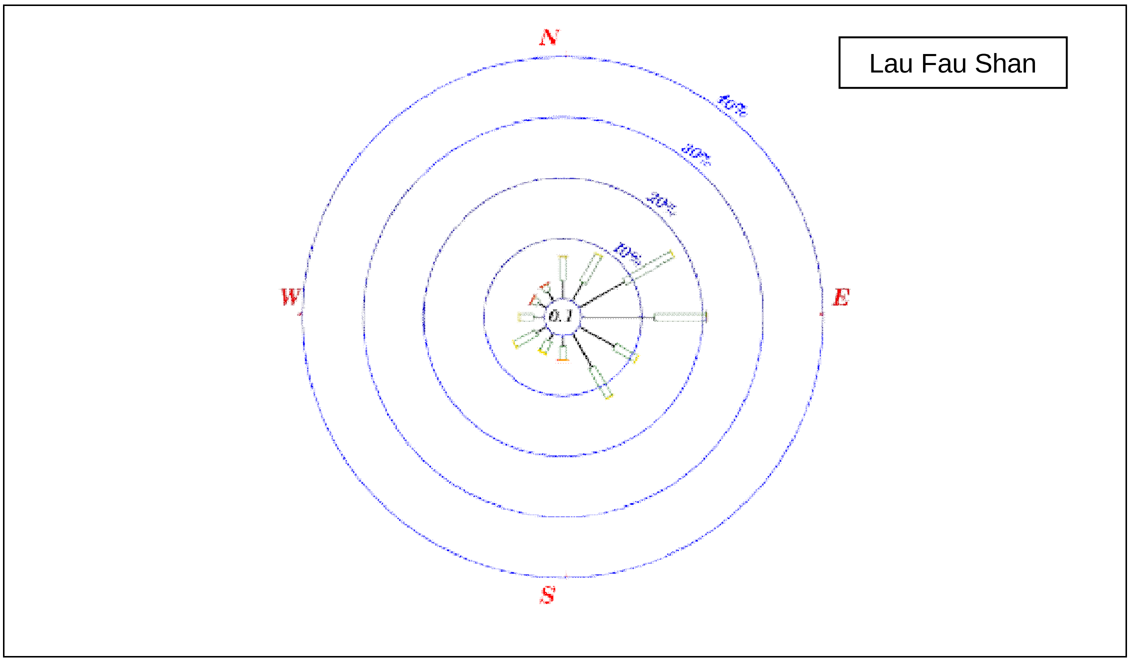
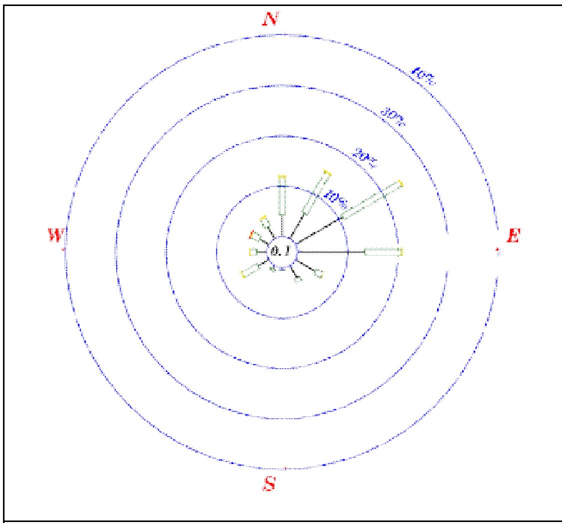


Figure 2.3 Annual Wind Rose from Lau Fau Shan Automatic Weather Station, 1986 to 2012



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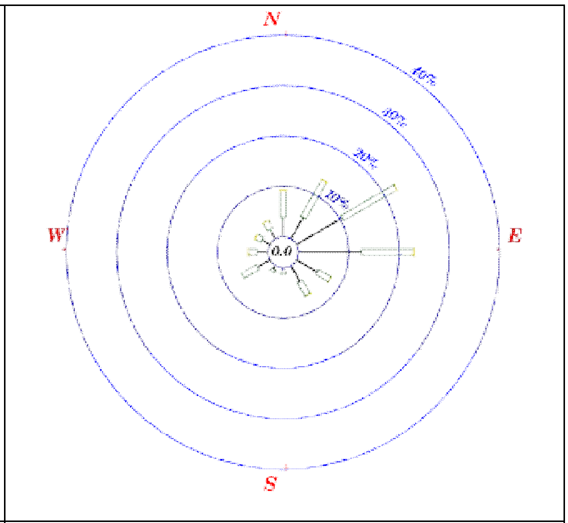

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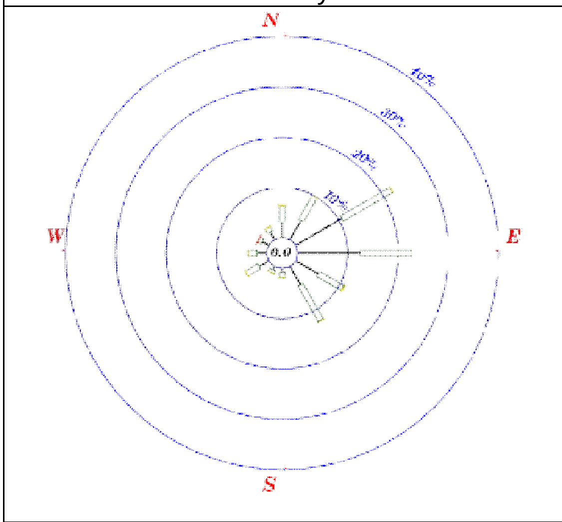

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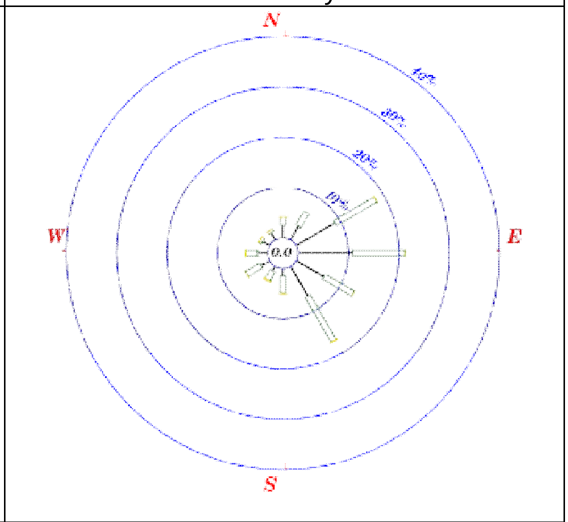

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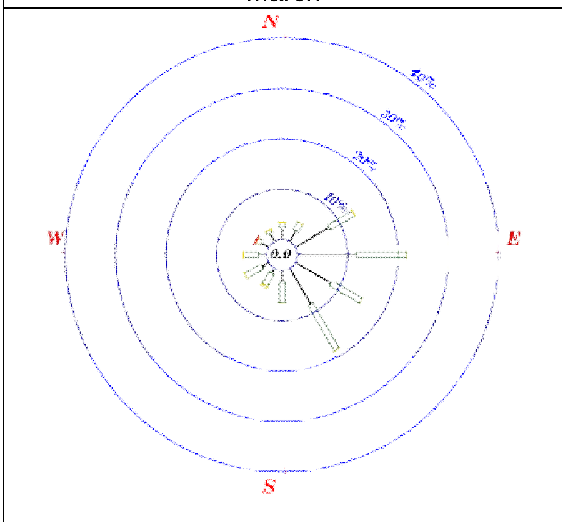

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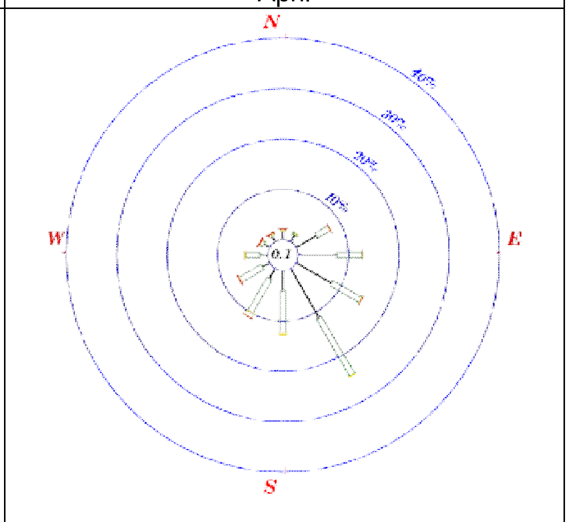

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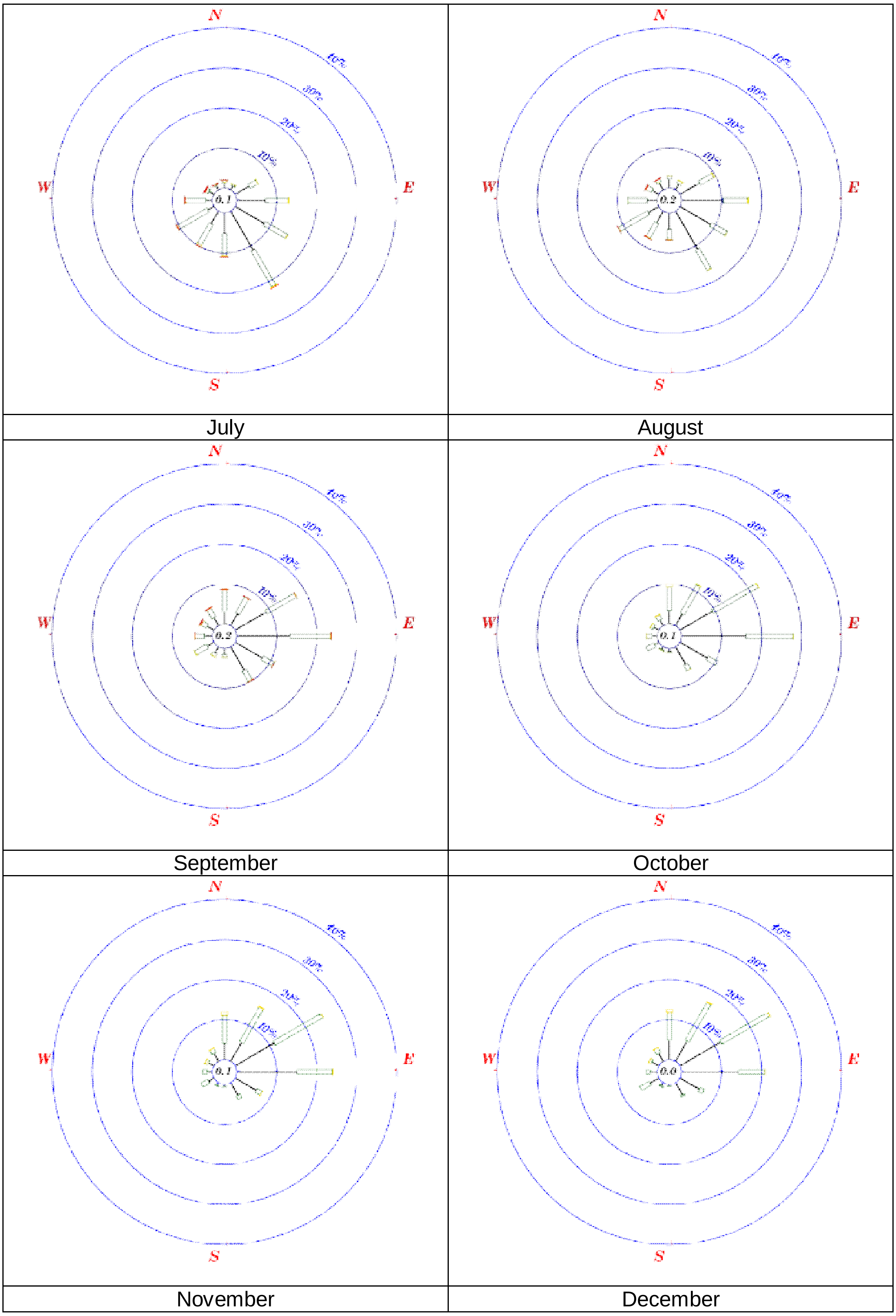


Figure 2.4 Monthly Wind Rose from Lau Fau Shan Automatic Weather Station, 1986 to 2012

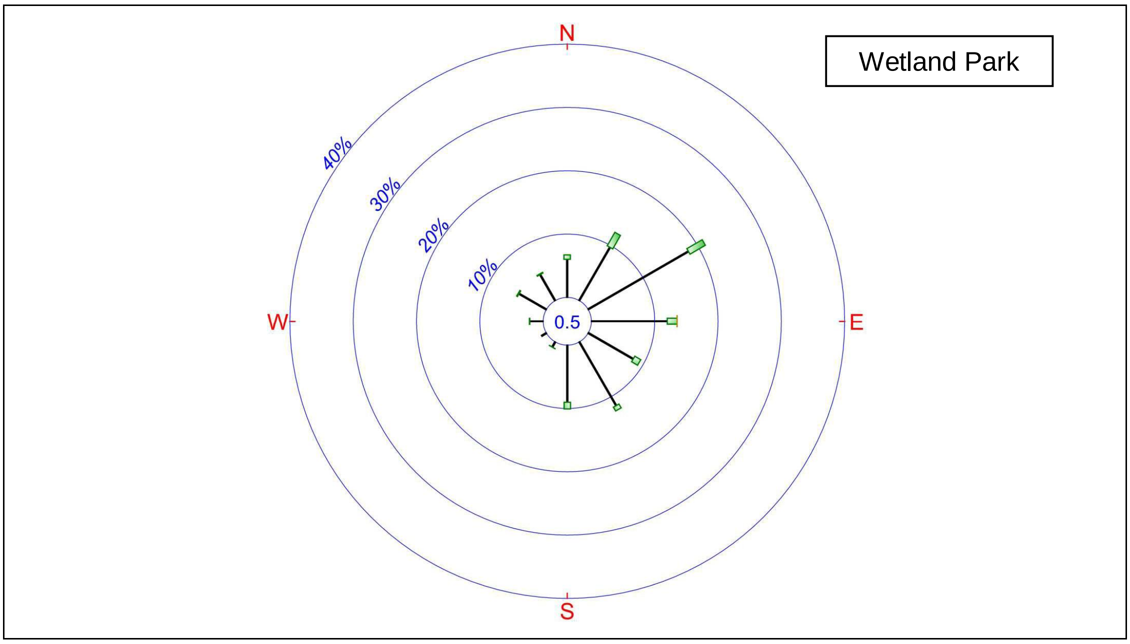


Figure 2.5 Annual Wind Rose from Wetland Park Automatic Weather Station, 2011

2.1.5 The MM5 natural wind availability data and the HKO data are compared in this report in order to identify the annual and summer prevailing wind directions for analysis on the existing wind environment of Ping Shan Area.

2.1.6 From the wind rose obtained from the Planning Department's website (see **Table 2.1**), it is noted that the occurrence of wind from E, NE and ENE directions occupy over 42% of the annual wind direction. According to the wind probability table provided together with the wind rose analysis result, northern-easterly wind and east wind are the most predominant winds in the area and both contributes over 12% of the time in a year.

2.1.7 In addition, from the annual wind rose obtained from the Lau Fau Shan Automatic Weather Station (see **Figure 2.3**), it is noted that the occurrence of wind from E, NE directions each occupies over 15% of the annual wind direction.

2.1.8 From the summer wind roses (June to August) for Lau Fau Shan in the year of 1986 -2012 as shown in **Figure 2.4**, the wind directions from the E, SE, SSE are the major dominant ones for the summer season in which these directions possesses occurrence percentage of over 15%.

2.1.9 Further observing the annual and summer wind rose in the year of 2011 for Wetland Park Automatic Weather Station which operated by Hong Kong Observatory as shown in **Figure 2.5**, E, NE and ENE directional winds are also the major annual dominant ones while winds from the south eastern quadrants are also dominant ones.

2.1.10 Therefore, the winds from the north east quadrant are considered to be the annual prevailing wind for the Kiu Cheong Road East HOS study area. Apart from that, the summer non-typhoon wind rose from the Lau Fau Shan Automatic Weather Station suggests that summer prevailing wind is coming from the south eastern quadrant. As a result, the prevailing wind for the study area is considered to be E/NE/ENE (annual) and E/SE/SSE (summer).

2.2 Topography and Building Morphology within Study Site and Surroundings

2.2.1 **Figure 2.6(a)** shows land use of the subject area and its surroundings while **Figure 2.6(b)** is the aerial photo of the study area and the surroundings.

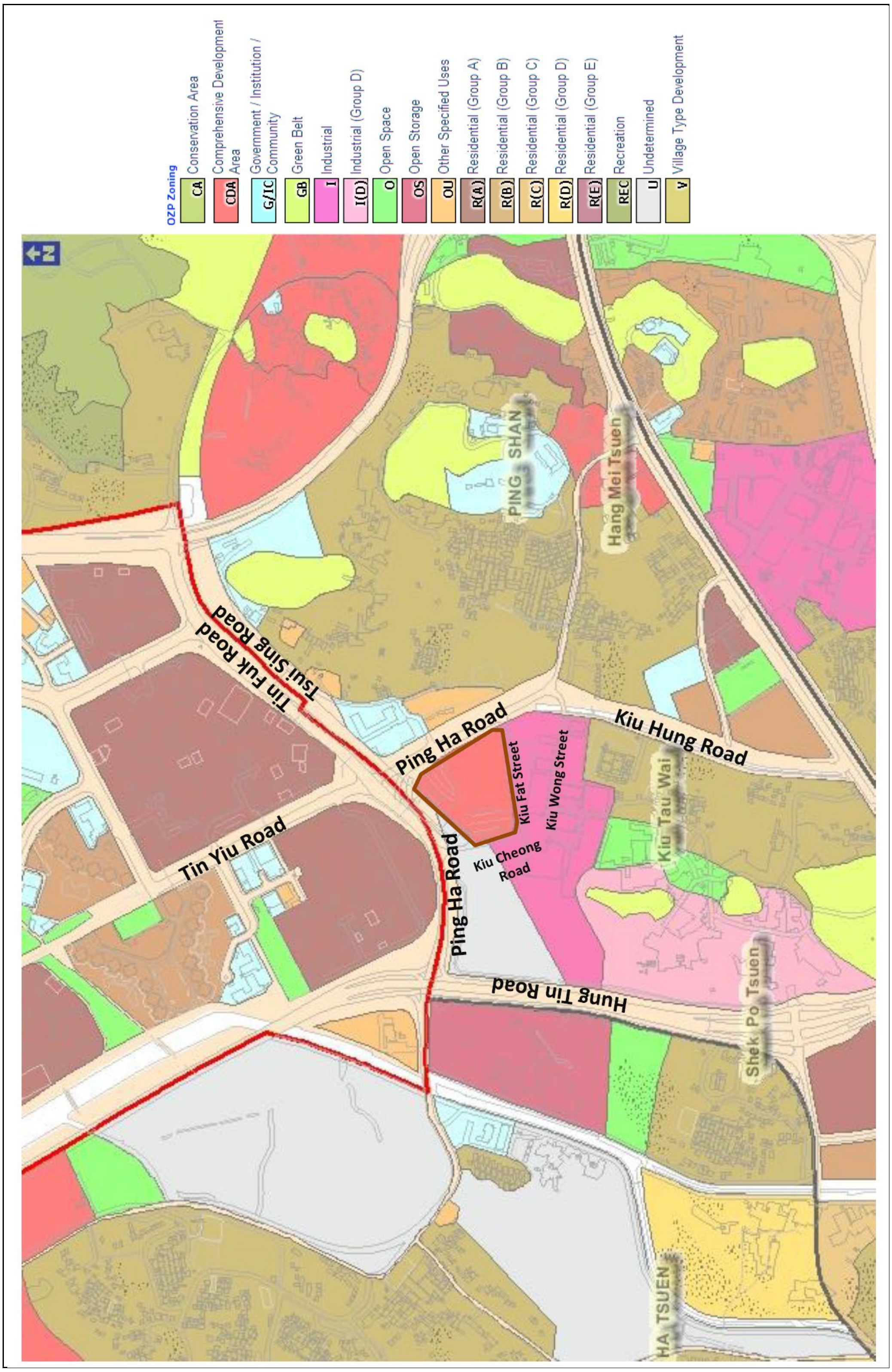


Figure 2.6(a) Land use of the Development Site and its Surrounding Area

1. Ting Shing Court	2. Lions Clubs International Ho Tak Sum Primary School	3. Qes Old Students Association Branch Primary School	4. Tang Ancestral Hall
5. Yu Kiu Ancestral Hall	6. Tin Shui Wai Station	7. Twghs Kwok Yat Wai College	8. Elle Garden Block
9. Yeung Hau Temple	10. Hung Shing Temple	11. Ping Shan Heritage Trail	12. Crown Motors Limited
13. Ying Cheong Industrial Building	14. Lai Tak Group Building	15. Open Storage Areas	

Figure 2.6(b) Location of the Study Area and its Surrounding Area

2.2.2 The Subject Site, Kiu Cheong Road East HOS area, is located in Yuen Long District. West Rail Tin Shui Wai Station is located at the north east of the Subject Site. The terrain in the immediate vicinity of the Subject Site is flat with some village houses, residential areas and Industrial areas. The Kiu Cheong Road East HOS area falls within the Approved Ping Shan Outline Zoning Plan (OZP) No. S/YL-PS/14. **Figure 2.6** shows the major land use of the subject site and its surrounding areas.

2.2.3 The Subject Site circled with the red line as shown in the **Figure 2.6** is bounded by Ping Ha Road to the north and east, Kiu Fat Street to the south and Kiu Cheong Road to the west. The subject site area possesses a Comprehensive Development Area (CDA) land use type which will expect to be developed and constructed into residential building blocks.

2.2.4 To the northwest area of the Subject Site are mostly residential areas with minor commercial and GIC land uses with medium building density. The major buildings in that location are Tin Shing Court Residential Blocks, and two primary schools (Lions Clubs International Ho Tak Sum Primary School and Qes Old Students Association Branch Primary School).

2.2.5 Apart from the residential buildings to the northern/north western portion of the study area, there are some major industrial building blocks in the south vicinity of the subject site, including Crown Motors Limited, Ying Cheong Industrial Building and Lai Tak Group Building. The major industrial blocks are marked in **Figure 2.6(b)**.

2.2.6 To the immediate east of the subject site, there is Ping Shan Heritage Trail, there are some historic spots including but not limited to Yeung Hau Temple, Tang Ancestral Hall, Yu Kiu Ancestral Hall and Hung Shing Temple etc. These historic spots are marked in **Figure 2.6(b)**.

2.2.7 Apart from that, some Village type blocks (about 1- 3 storey high) are sparsely located in the east and southeast part of the subject area, these village houses include but not limited to Sheung Cheung Wai, Hang Tau Tsuen Village, Tong Fong Tsuen Village, Ping Shan Sin Tsuen Village etc.

2.2.8 To the northeast of the site, there is the West Rail Tin Shui Wai Station, residential type of Ping Wu Garden Blocks, Elle Garden Block and Twghs Kwok Yat Wai College. To the west and south western part of subject site, there is large area of open storage with low building density and low building height range.

2.3 Wind Environment of Existing Scenario

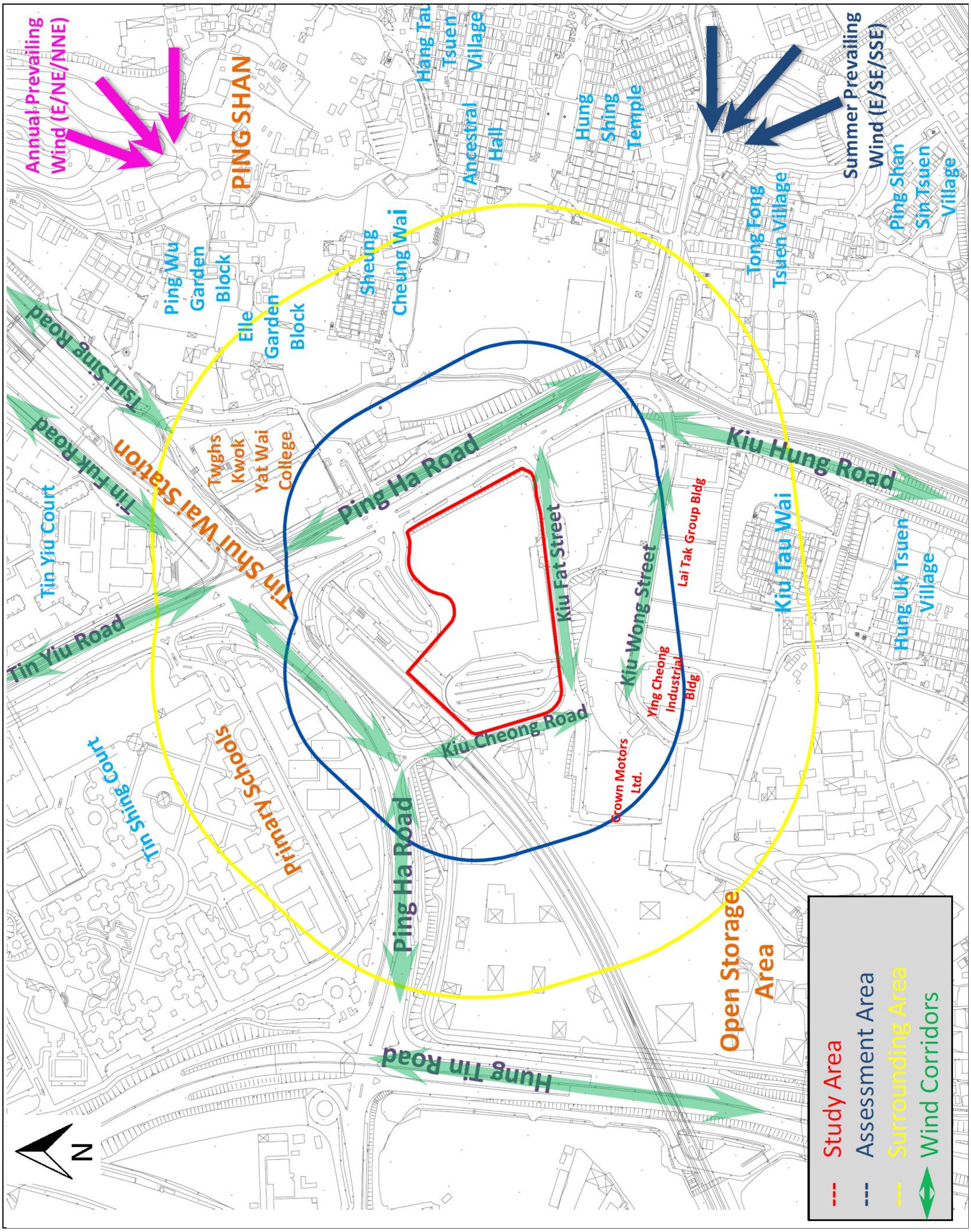
2.3.1 In accordance with the wind availability data, the Subject Site relies on easterly, north easterly and east north easterly winds for ventilation during in a year. Summer prevailing wind is coming from the east, south east and south southern east direction. Therefore, any blockage to these prevailing winds should be avoided as far as possible.

2.3.2 Tsui Sing Road, Tin Fuk Road acts as wind breezeways under the north easterly annual wind direction. Apart from these two major roads, Kiu Fat Street and Kiu Wong Street also acts as wind breezeways under the easterly wind directions as shown in **Figure 2.7**.

2.3.3 As shown in **Figure 2.7**, Ping Ha Road and Tin Yiu Road serve as two major wind breezeways under the summer prevailing wind directions (i.e. the south east directions and south southeast directions respectively.)

2.3.4 In addition, Ping Ha Road and Tin Yiu Road mentioned in paragraph 2.3.3 above creates linkage to Tin Fuk Road and Tsui Sing Road which links up the wind breezeway to promote air ventilation to the subject site and its vicinity areas.

2.3.5 Major wind breezeways are marked in **Figure 2.7** as green arrows which include but not limited to Tsui Sing Road, Tin Yiu Road, Ping Ha Road, Kiu Hung Road, as well as Kiu Fat street and Kiu Cheung Road which surrounded the subject site. These wind breezeways will enhance and promote ventilation performance at the surrounding areas of the subject site.



Notes:

- Width and Length of arrows **do not** have any special meanings and just for illustration purpose

Figure 2.7 Breezeways movement through Subject Site

2.3.6 To the vicinity of the subject site, there are large area of open storages located on the south western side with low density and height; these storage containers are expected not to create blockages to the wind from the south western quadrant and will not lead to significant ventilation issues towards the subject site.

2.3.7 Clusters of village houses are located at various directions from the subject site. These village houses include Kiu Tau Wai and Hung Uk Tsuen Village to the south, Tong Fong Tsuen Village and Ping Shan Sin Tsuen Village to the south eastern direction, Hang Tau Tsuen Village and Sheung Cheung Wai located to the east. Although these village houses exists in high density, they are low in building heights (2-3 storeys in height) plus the relatively flat terrain, therefore annual and summer prevailing wind are not expected to be blocked by these village houses, thus satisfactory wind ventilation performance is expected.

2.3.8 The low density residential buildings such as Elle Garden Block and Ping Wu Garden block which is located at the north eastern direction of the subject site is relatively low in building heights, thus the annual prevailing wind from the north eastern quadrant towards the subject site is not expected to be blocks by these existing developments.

2.3.9 To the northern and north western direction of the subject site are medium packed residential building blocks named Tin Shing Court and Tin Yiu Court, these residential blocks are approximately over 100mPD in height. These high rise developments might partially block the winds from the north western quadrants towards the subject site and may create slight air ventilation issues to the immediate surrounding areas.

2.3.10 Therefore, generally, it is expected there will not be significant air ventilation issues to the vicinity areas due to the development of subject site. However, in order to quantitatively assess the wind environment of the study area and its surrounding areas, an initial Air Ventilation Assessment will be carried out in a later stage.

2.4 Design Option and Merits

2.4.1 The development option is shown in **Figure 2.8** below. As shown in the figure, three residential building blocks are proposed to be built. The heights of these building blocks are approximately 110mPD in height.

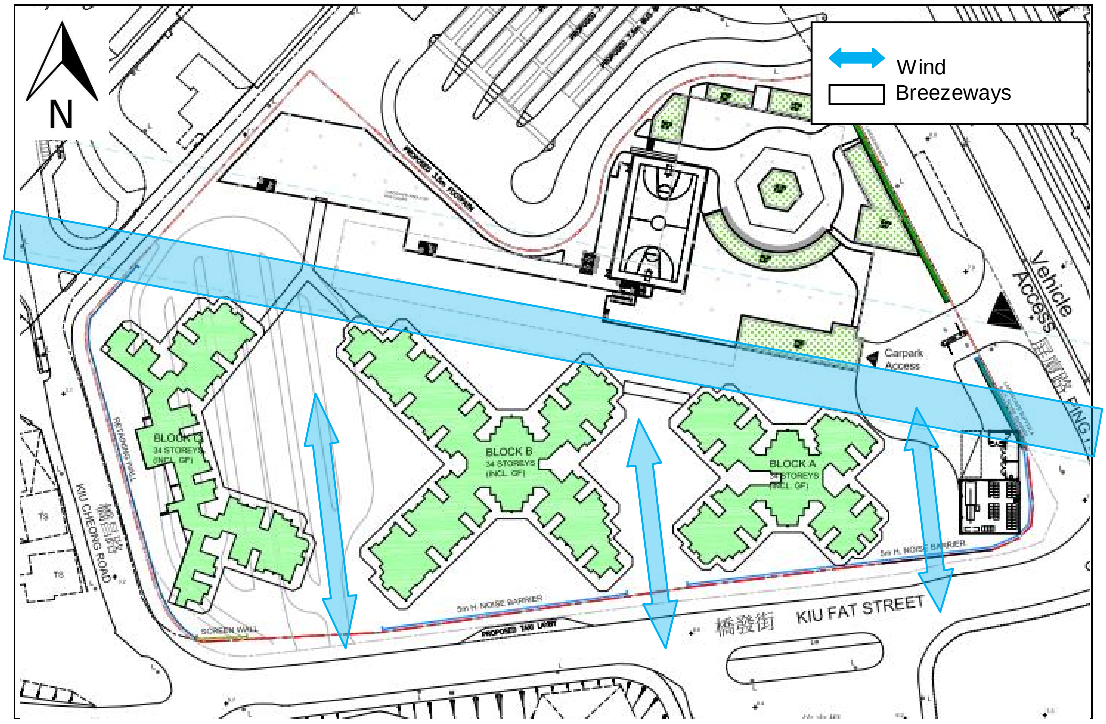


Figure 2.8 Design Option and Merits

2.4.2 The development blocks are designed and situated more to the southwards portion in which leaves some open spaces to the northern portion. This will create an east western breezeway (marked in **Figure 2.8**) which will be effective in enhancing ventilation under the annual eastern prevailing wind.

2.4.3 There exist satisfactory wide building separation gaps between the building blocks to allow air flow through these tall buildings. These separation gaps would increase air permeability and hence enhance air ventilation performance.

2.4.4 Further possible wind performance improvement includes:

- Creating a breezeways in the east-west orientation in the form of linked open spaces
- Aligning the longer frontage of any future development in parallel to the prevailing wind direction to avoid wall effects and blockage of the prevailing winds
- Providing some ventilation corridors or setback in parallel to the prevailing wind so as to improve the wind permeability
- Providing adequate wider gaps between building blocks to maximize the air permeability of the redevelopment
- Stepping building height profile to divert winds to lower levels as shown in **Figure 2.9** below

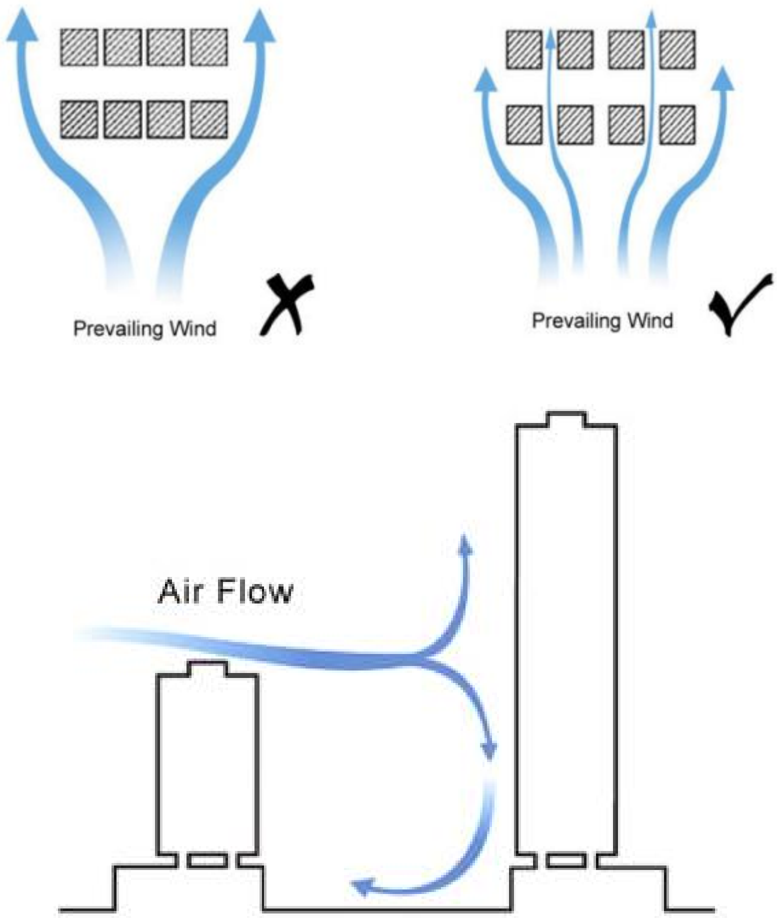


Figure 2.9 Stepping height profile to divert winds to lower levels

3 METHODOLOGY FOR AVA INITIAL STUDY

3.1 Set-up of the numerical simulations

3.1.1 Referring to the Technical Guide for Air Ventilation Assessment for Development in Hong Kong (HPLB and ETWB, 2006), assessment will be conducted by means of 3-dimensional CFD model. The well-recognized commercial CFD package ANSYS ICEM-CFD (ANSYS, 2011a) and ANSYS FLUENT (ANSYS, 2011b) will be used in this exercise. FLUENT model had been widely applied for various AVA research and studies worldwide. The accuracy level of the FLUENT model will be very much accepted by the industry for AVA application.

3.1.2 For the initial AVA study, wind environment surrounding the Project Area should be simulated using CFD under 8 most prevailing wind directions (which represent occurrence of more than 75% of time). Wind Velocity Ratio which is obtained at various test point locations (distributed evenly and randomly at major areas within the study area and junctions of road) are used as a wind ventilation performance indicator.

3.1.3 A 3-dimensional CFD model will be constructed to capture all major components such as topographical features and buildings within and in the vicinity of the Project Area that would likely affect the wind flow. The methodology described in the Technical Guide will be adopted for this assessment. According to the Technical Guide (HPLB and ETWB, 2006), the Assessment Area and the Surrounding Area should include the project's surrounding up to a perpendicular distance of 1H and 2H respectively from the project boundary, H being the height of the tallest building on site. For the purpose of this assessment, a larger Assessment Area and Surrounding Area will be adopted so that special surrounding features and developments would not be omitted.

3.1.4 The CFD model should maintain major features and contain information of the surrounding buildings and site topography in which the information are obtained from the Geographical Information System (GIS) software.

3.2 Solution parameters and boundary conditions

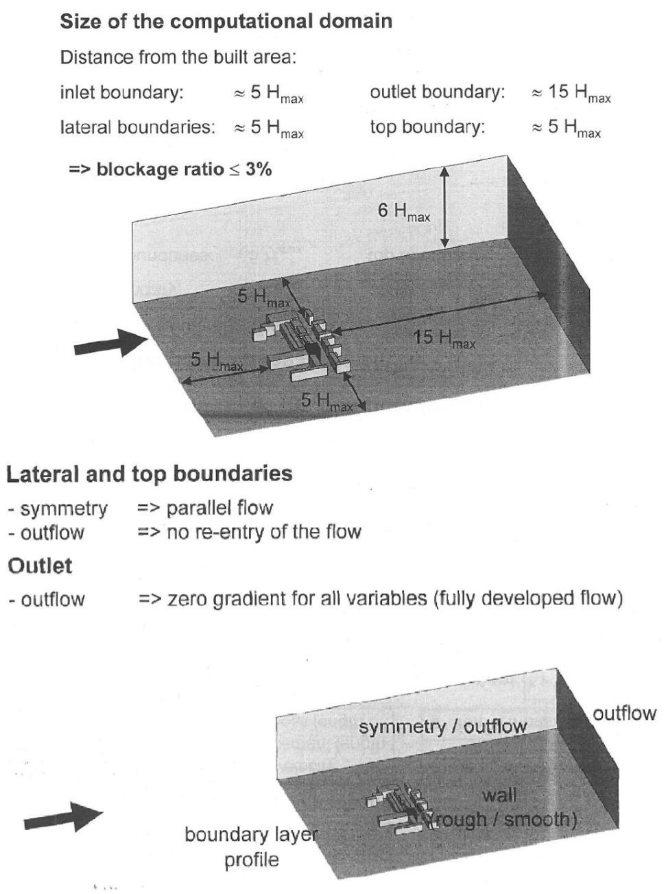
3.2.1 The total number of cells for this study would be anticipated to be in the range of about 3,000,000 to 4,000,000 cells in tetrahedral mesh. As polyhedral mesh cells counts can often be much smaller than comparable tetrahedral meshes with equivalent accuracy as well as improve mesh quality and manner of convergence. Grids may be converted to polyhedral mesh, if necessary.

3.2.2 The horizontal grid size employed in the CFD model in the vicinity of the Project Area was taken as a global minimum size of about 2m and increased for the grid cells further away from the Project Area. Besides, four layers of prism cells (each layer of 0.5m thick) were employed above the terrain. The grid expansion ratio in this study will be at most 1.2. In addition, the blockage ratio will not be larger than 3%.

3.2.3 Turbulence Model: As recommended in COST action C14, realizable k-epsilon turbulence model will be adopted in the CFD model to simulate the real life problem. Common computational fluid dynamics equations will be adopted in the analysis to capture the temporal and spatial fidelity of the atmospheric wind flow on a three-dimensional basis.

3.2.4 Variables including fluid velocities and fluid static pressure will be calculated throughout the domain. The CFD code captures, simulates and determines the air flow inside the domain under study based on viscous fluid turbulence model. Solutions will be obtained by iterations. The convergence for the simulations will be the scaled residuals drops below $1x10^{-4}$.

3.2.5 The size of the computational domain will set according to the conceptual diagram shown below. The inflow boundary is set as an inlet velocity boundary condition with a distance of at least 5H away from the built area where H is the tallest building height in the built area. The lateral and top boundaries are set as symmetry boundary condition with a distance of at least 5H from the built area and the outflow boundary located at least 15H from the built area.



Pressure velocity coupling	Coupled Scheme
Pressure Term	Second Order Scheme
Discretization - Momentum	Second Order upwind Scheme
Discretization – Turbulent Kinetic Energy	Second Order upwind Scheme
Discretization – Turbulent Dissipation rate	Second Order upwind Scheme
Wall Treatment	Standard Wall Function

3.2.6 Wind Directions: In the CFD model, the average wind speed of individual prevailing wind direction identified for the Project Area will be adopted for simulation of air ventilation performance for each direction. According to the Technical Guide (HPLB and ETWB, 2006), wind environment surrounding the Project Area will be simulated using CFD under 8 most prevailing wind directions (which represent occurrence of more than 75% of time).

3.2.7 Vertical Wind Profile: Wind environment under different wind directions will be defined in the CFD environment. According to the Technical Guide Para 20, wind profile for the site could be appropriated from the V_∞ data developed from MM5 and with reference to the Power Law or Log Law using coefficients appropriate to the site conditions. In this assessment, vertical wind profile condition is determined using the Log Law:

$$\text{Log Law} \quad U_z = \frac{u^*}{\sigma} \ln\left(\frac{Z}{Z_0}\right)$$

where U_Z : wind speed at height z from ground

u^* : friction velocity

σ : von Karman constant = 0.4 for fully rough surface

Z : height z from ground

Zo : roughness length

3.3 Assessment Criteria

3.3.1 Wind Velocity Ratio (VR): VRs, per aforesaid technical circular (HPLB and ETWB, 2006), are defined as VR = V_P/ V_{INF} where V_{INF} is the wind velocity at the top of the wind boundary layer and it would not be affected by the ground roughness and local site features and VP is the wind velocity at the 2m pedestrian level. VRs will be adopted as the indicator of the wind performance at pedestrian level, taking into account of surrounding buildings, topography and the project site. Per the velocity ratio method (CUHK, 2008), the analyzed CFD results will determine the extent to which the proposed development impacts over the wind environment of its immediately vicinity and local areas.

3.3.2 The SVR and LVR are worked out so as to understand the overall impact of air ventilation on the immediate and further surroundings of the subject site. SVR is the average of VR of all perimeter test points while the LVR is the average of all overall test points and perimeter test points.

3.3.3 Test Points: Both perimeter test points and overall test points will be selected within the Assessment Area in order to assess the impact on the immediate surroundings and local areas respectively. Overall test points will be evenly distributed over surrounding open spaces, streets and other parts of the Assessment Area where pedestrian can or will mostly access. Detailed selection of test points and grouping of test points into different focus areas, including major streets, for subsequent analysis and comparison of the ventilation performance of different options of development schemes will be provided and agreed with PlanD upon the obtainment of different development scenarios. The selected test points will be evenly and randomly distributed within the Project Area for the purpose of the AVA studies. All test points are elevated at 2m above ground.

4 SUMMARY AND CONCLUSIONS

4.1.1 Qualitative assessment of the wind environment regarding the existing environment of the Kiu Cheong Road East HOS Area has been carried out. A quick and broadbrush description of the existing wind situation has been included in this report. Apart from that, major wind breezeways have also been identified.

4.1.2 According to the MM5 model result obtained from the website of the Hong Kong Planning Department, the 1986-2012 averaged annual wind data from Hong Kong Observatory at the Lau Fau Shan Automatic Weather Station and the Wetland Automatic Weather Station, it is proposed that the annual prevailing wind comes from the E/NE/ENE directions while the summer prevailing wind comes from the E/SE/SSE directions. Therefore, any blockage to these prevailing winds should be avoided as far as possible.

4.1.3 3 residential building blocks with about 110mPD are proposed to be built, situated more to the southwards portion in which leaves some open spaces to the northern portion, which creates an east western breezeway and wide building separation gaps. This will be effective in enhancing ventilation under the annual eastern prevailing wind.

4.1.4 Tsui Sing Road, Tin Fuk Road acts as wind breezeways under the north easterly annual wind direction. Apart from these two major roads, Kiu Fat Street and Kiu Wong Street also acts as wind breezeways under the easterly wind directions. In addition, Ping Ha Road and Tin Yiu Road serve as two major wind breezeways under the summer prevailing wind directions.

4.1.5 Ping Ha Road and Tin Yiu Road also creates linkage to Tin Fuk Road and Tsui Sing Road which links up the wind breezeway to promote air ventilation to the subject site and its vicinity areas.

4.1.6 Major wind breezeways include but not limited to Tsui Sing Road, Tin Yiu Road, Ping Ha Road, Kiu Hung Road, as well as Kiu Fat street and Kiu Cheung Road which surrounded the subject site. These wind breezeways will enhance and promote ventilation performance at the surrounding areas of the subject site.

4.1.7 It is not expected to have significant air ventilation issue due to the new development because of the relatively flat terrain of the surroundings and relatively low density building existing developments. In order to quantitatively assess and compare the air ventilation performance of the existing environment and the expected wind situation after various proposed developments options, an initial AVA study using Computational Fluid Dynamics Approach will be carried out in later stage.