Technical Guide for Air Ventilation Assessment for Developments in Hong Kong

1. This Technical Guide assists project proponent to undertake Air Ventilation Assessment (AVA) to assess the impacts of the proposal on the pedestrian wind environment. The assessment should follow this Technical Guide as far as possible and a report should be submitted to the proponent departments / bureaux or authorities on the assessment findings.

2. Every site is different. The assessor is strongly advised to approach the assessment intellectually and discretionally taking into account different site conditions. Working with experienced practising wind engineers throughout the assessment process is strongly recommended.

Indicator

3. Wind Velocity Ratio (VR) should be used as an indicator of wind performance for the AVA. It indicates how much of the wind availability of a location could be experienced and enjoyed by pedestrians on ground taking into account the surrounding buildings and topography and the proposed development. Given the general weak wind conditions in Hong Kong, the higher the wind velocity ratio, the less likely would be the impact of the proposed development on the wind availability.

4. Wind VR is defined as V_p/V_∞ (V pedestrian/V infinity). V_∞ captures the wind velocity at the top of the wind boundary layer (typically assumed to be around 400 m to 600 m above city centre, or at a height wind is unaffected by the urban roughness below). V_∞ is taken as the wind availability of the site. Vp captures the wind velocity at the pedestrian level (2 m above ground) after taking into account the effects of buildings and urban features.

Expert Evaluation / Initial Study / Detailed Study

5. It is always useful and cost effective for the assessor to conduct an early round of **Expert Evaluation**. This provides a qualitative assessment to the design and/or design options and facilitates the identification of problems and issues. The Expert Evaluation is particularly useful for large

sites and/or sites with specific and unique wind features, issues, concerns and problems. The following tasks may be achieved with Expert Evaluation:

(a) Identifies good design features.

(b) Identifies obvious problem areas and propose some mitigation measures.

(c) Defines "focuses" and methodologies of the Initial and/or Detailed studies.

(d) Determines if further study should be staged into Initial Study and Detailed Study, or Detailed Study alone.

6. In exercising expert knowledge and experience, the assessor should refer to the "Urban Design Guidelines", Chapter 11 of the Hong Kong Planning Standards and Guidelines downloadable from the Planning Department's (PlanD) website at http://www.pland.gov.hk.

7. The Expert Evaluation could lead to an Initial Study or directly to a Detailed Study depending on the nature of the development. The **Initial Study** will refine and substantiate the Expert Evaluation. The following tasks may be achieved with the Initial Study:

(a) Initially assesses the characteristics of the wind availability (V_∞) of the site.

(b) Gives a general pattern and a rough quantitative estimate of wind performance at the pedestrian level reported using Wind VR.

(c) Further refines the understanding (good design features and problem areas) of the Expert Evaluation.

(d) Further defines the "focuses", methodologies and scope of work of the Detailed Study.

8. It is sometimes necessary to reiterate the Initial Study so as to refine the design and/or design options.

9. With or without the Initial Study, the **Detailed Study** concludes the AVA. With the Detailed Study, the assessor could accurately and "quantitatively" compare designs so that a better one could be selected. Detailed Study is essential for more complex sites and developments, and where key air ventilation concerns have been reviewed and identified in the Expert Evaluation / Initial Study. The following tasks may be achieved with the Detailed Study:

(a) To assess the characteristics of the wind availability ($V\infty$) of the site in detail.

(b) To report all VR of test points. To report Site VR (SVR) and Local VR (LVR) when appropriate (as outlined in paras 27 to 30). To report, if any, wind gust problems.

(c) To provide a summary of how the identified problems, if any, have been resolved.

Site Wind Availability Data

10. It is necessary to account for the characteristics of the natural wind availability of the site. As far as possible, the design should utilize and optimize the natural wind.

11. For the Expert Evaluation, it is advisable to make reference to the Hong Kong Observatory Waglan Island wind data, as well as reasonable wind data of nearby weather stations. Expertly interpreted, it is possible to qualitatively estimate the prevailing wind directions and magnitudes of the site necessary for the evaluation.

12. For the Initial Study, it is necessary to be more precise. Either "simulated" site wind data, or "experimental" site wind data, as described in paras. 13 and 15 below, respectively, could be used.

13. Using appropriate mathematical models (e.g. MM5 and CALMET), it is possible to simulate and estimate the site wind availability data (V∞). Typically the site wind rose of V∞ could be obtained[1].

14. For the Detailed Study, it is necessary to be even more precise. "Experimental" site wind data, as described in para 15 below, should be used.

15. Using large scale topographical model (typically 1:2000 to 1:4000) tested in a boundary layer wind tunnel, more precise wind availability and characteristics information in terms of wind rose, wind profile(s) and wind turbulence intensity profile(s) of the site could be obtained. Hong Kong Observatory Waglan Island wind data should be referenced to for the experimental study.

Tools

16. Wind tunnel is recommended for both the Initial and the Detailed Studies, and most particularly for the Detailed Study. The conduct of the wind tunnel test should comply, as far as practicable, with established international best practices, such as, but not be limited to:

(a) Manuals and Reports on Engineering Practice No. 67 : Wind Tunnel Studies of Buildings and Structures, Virginia 1999 issued by American Society of Civil Engineers.

(b) Wind Engineering Studies of Buildings, Quality Assurance Manual on Environment Wind Studies AWES-QAM-1-2001 issued by Australasian Wind Engineering Society.

17. Computational Fluid Dynamics (CFD) may be used with caution, it is more likely admissible for the Initial Studies. There is no internationally recognized guideline or standard for using CFD in outdoor urban scale studies. The onus is on the assessor to demonstrate that the tool used is "fit for the purpose".

[1] Project proponents may write to PlanD to obtain the MM5 data translated into site wind availability data (V∞) of the Territory for Expert Evaluation and Initial Study.

18. Should the assessor wish to use other forms of tool for the assessment not described above, the onus is on the proponent to demonstrate that the tool to be employed is "fit for the purpose". The scientific suitability, as well as the practical merits of the tool to be used must be demonstrated.

Simplification of Wind Data for the Initial Study

19. In general, the characteristics of the site wind availability data should be reported in 16 directions. This is necessary to work out the Wind Velocity Ratio.

20. For the Initial Study, if using CFD, it may be appropriate and cost effective, to reduce the number of directions in the study. This is reasonable especially for sites with only a few incoming prevailing wind directions. The assessor must demonstrate that the probability of wind coming from the reduced set of directions should exceed 75% of the time in a typical reference year. Wind profile(s) for the site could also be appropriated from the $V\infty$ data developed from simulation models (e.g. MM5 and CALMET) and with reference to the Power Law or Log Law using coefficients appropriate to the site conditions.

21. For the Detailed Study, no simplification is allowed. Wind from all 16 directions and their probability of occurrences must be accounted for, and wind profiles(s) obtained from wind tunnel experiments should be used to conduct the study, and when calculating the Wind Velocity Ratio.

Project, Assessment and Surrounding Areas

22. The testing model for the Initial and the Detailed Studies should cover the Project, the Assessment and the Surrounding Areas.

23. The Project Area is defined by the project site boundaries and includes all open areas within the project that pedestrians are likely to access.

24. A key aim of AVA is to assess a design's impact and effects on its surroundings. The Assessment Area of the project should include the project's surrounding up to a perpendicular distance H from the project boundary, H being the height of the tallest building on site. Occasionally, it may be necessary to include an assessment area larger than that defined

above so that special surrounding features and open spaces are not omitted.

25. For the model, it is necessary to include areas surrounding the site. The Surrounding Area is important as it gives a reasonable and representative context to the Assessment Area. It "conditions" the approaching wind profiles appropriately. If the Surrounding Area is not correctly included and modeled, the wind performance of the Assessment Area will likely to be wrongly estimated. The Surrounding Area of up to a perpendicular distance of 2H from the project boundary must be included. Sometimes it may be necessary to enlarge the Surrounding Area if there are prominent features (e.g. tall buildings or large and bulky obstructions) immediately outside the 2H zone. Other than the method recommended, wind engineers can advise alternative extent of the surroundings to be included on a case-by-case basis, especially when there are nearby prominent topographical features.

Test Points

26. Test points are the locations where Wind VRs are reported. Based on the VR of the test points, the resultant wind environment of the project can be assessed. As each site is unique, it is impossible to be specific about the number and distribution of the required test points; but they must be carefully and strategically located. Three types of test points may be specified for assessment: Perimeter, Overall and Special.

27. Perimeter test points are positioned on the project site boundary. They are useful to assess the "immediate" effect of the project to the Assessment Area. Test points at around 10 m to 50 m center to center (or more if larger test site is evaluated) may be located around the perimeters of the project site boundary. Test points are normally not necessary at perimeter(s) where there is no major air ventilation issues e.g. waterfront area with ample sea breeze, inaccessible land such as green belt. Tests points must be located at the junctions of all roads leading to the project site, at main entrances to the project, and at corners of the project site. This group of perimeter test points will provide data for the **Site Air Ventilation Assessment**. Typically about 30 to 50 perimeter test points well spaced out and located will suffice.

28. Overall test points are evenly distributed and positioned in the open spaces, on the streets and places of the project and Assessment Areas where

pedestrians frequently access. This group of overall test points, together with the perimeter test points, will provide data for the **Local Air Ventilation Assessment**. For practical reasons, around 50 to 80 test points may be adequate for typical development sites.

29. Special test points may be positioned in areas that special localized problems are likely to appear (e.g. wind gust problem for exposed sites). These special test points should not be included in the Site and Local Air Ventilation Assessments, as they may distort the average VRs. They independently may provide additional information to assessors.

Reporting

30. For the purpose of the AVA, Wind Velocity Ratios of all test points should be individually reported. They help to identify problem areas. Two ratios may also be reported, they give a simple quantity to summarise the overall impact on the wind environment for easy comparison:

(a) For the **Site Air Ventilation Assessment**, the Site spatial average Velocity Ratio (SVR) of all perimeter test points (para 27 refers) may be reported. This gives a hint of how the development proposal impacts the wind environment of its immediate vicinity.

(b) For the **Local Air Ventilation Assessment**, the Local spatial average velocity ratio (LVR) of all perimeter and overall test points (paras 27 and 28, respectively refer) may be reported. This gives a hint of how the development proposal impacts the wind environment of the local area.

The local air ventilation considerations should always take precedence over the site specific air ventilation considerations. For exposed sites, concerns of wind gust should be reported.

31. The AVA report should contain the following key sections. The technical merit, as well as the results of the AVA of the project must be demonstrated:

(a) An introductory section of the details of **the project**.

(b) A section on results of the **Expert Evaluation**. Concerns and potential problems should be identified. Focuses and methodologies of further studies should be defined.

(c) A section on the characteristics of the **Site Wind Availability** to be used for Initial Studies and Detail Studies. Methodologies used to obtain the information must be explained in detail.

(d) A section on the **Methodology of the Initial Study**. The tool used for the studies must be explained in detail. It is important for the assessor to demonstrate and to justify that the tool and work process used is technically "fit for the purpose".

(e) A section on results and **key findings of the Initial Study**.

(f) A section on **Methodology of the Detailed Study**. The tool used for the studies must be explained in detail. It is important for the assessor to demonstrate and to justify that the tool and work process used is technically "fit for the purpose".

(g) A section on results and **key findings of the Detailed Study**.

(h) A section on Evaluation and **Assessment**. Summarise findings, highlight problems and outline mitigation measures, if any.

32. Based on the reported VR, the assessor would compare the merits and demerits of different design options. The following considerations on the reporting of SVR and LVR may be useful to note:

(a) In the general weak wind conditions in Hong Kong, for the AVA, the higher the values of the spatial average VR, the better the design. Comparing performances of design options using the spatial average VR (both SVR and LVR) is recommended (para 30 refers).

(b) The **Site Air Ventilation Assessment** (SVR) gives an idea of how the lower portion of the buildings on the project site may affect the immediate surroundings. When problems are detected, it is likely that design changes may be needed for the lower portion of the development (e.g. the coverage of the podium) (para 30(a) refers).

(c) The **Local Air Ventilation Assessment** (LVR) gives an idea of how the upper portion of the buildings on the project site may affect the surroundings. When problems are detected, it is likely that design changes may be needed for the upper portion of the development (e.g. re-orientation of blocks and adjustment to the extent of the towers) (para 30(b) refers).

(d) For very large sites, or for sites with elongated or odd geometry, it may be necessary to work out the SVR and LVR to suit the size or geometry. For example, say for an elongated site, it might be useful to sub-divide the site into smaller sub-sections to work out the spatial averages. It is possible that the development may have a high VR at one end and a low VR at the other end.

(e) It is necessary to examine VR of the individual test points of SVR and/or LVR to ensure that none is way below the spatial average. When this happens, it indicates possible stagnant zones to be avoided.

(f) On the other hand, no individual VR should be obviously above the spatial average SVR and/or LVR. When this happens, it indicates wind amplification, and the possibility of wind gust and pedestrian safety concerns. Further assessments and mitigation measures may be required.

(g) Where large differentials in individual VRs are reported, the spatial average SVR and/or LVR should be interpreted more carefully to avoid overlooking problem areas due to averaging of the individual VRs.

(h) In addition to SVR and LVR, and beyond the key focus of AVA in this Technical Guide, VR of special test points, if positioned, may be analysed. The results from these additional test points will identify potential wind problems in areas of special concerns.