Air Ventilation Assessment System for High Density City

An experience from Hong Kong

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ABSTRACT: Hong Kong was hit by Severe Acute Respiratory Syndrome (SARS) in 2003. The Hong Kong Government then set up a Team Clean Committee to critically examine the city for healthy living. The Planning Department, HKSAR initiated a study titled: "Feasibility Study for Establishment of Air Ventilation Assessment System". The study eventually led to a methodology of Air Ventilation Assessment (AVA). Unlike many countries with guidelines for dealing with strong wind conditions, AVA is a guideline for weak wind conditions specifically designed to deal with congested urban conditions. The AVA basically establishes a method for project developers to objectively assess their designs. The Government of Hong Kong adopted the system, published a Technical Circular in 2006, and implemented the system with the following note: "In accordance with the Joint Housing Planning Lands Bureau (HPLB) / Environment Transport Works Bureau (ETWB) Technical Circular No. 1/06 on Air Ventilation Assessment, all major government projects falling within the categories specified in the Technical Circular are required to undertake AVA." The government also set up an AVA project register. This paper reviews the experience learnt with the completed AVA project studies. It provides an insight to guide further actions and studies that will led to version 2 of AVA.
Keywords: planning, high density city, thermal comfort, ventilation

INTRODUCTION

High density city design is a topical issue. High density living is increasing an issue that planners around the world have to confront with.

Hong Kong is a high density city with a population of 8 millions living on a piece of land of 1,000 square kilometres. The urban density of Hong Kong is close to 60,000 persons per square kilometre. The site development density can be up to 3000 persons per hectare. (Figure 1)

Figure 1: A congested living condition of urban Hong Kong.

The recent event of Severe Acute Respiratory Syndrome (SARS) in 2003 has brought the Government of Hong Kong to the realization that a "quality" built environment should be an aim for Hong Kong. The government Team Clean report highlights the need to establish methods for air ventilation to guide future planning actions [1]. It initiated a study titled: "Feasibility Study for Establishment of Air Ventilation Assessment (AVA) System" in 2003 [2] [3] [4]. The study eventually led to a methodology of Air Ventilation Assessment (AVA) [2]. Unlike many countries with guidelines for dealing with strong and gust wind conditions, AVA is a guideline for weak and stagnant wind conditions specifically designed to deal with the congested urban conditions of urban Hong Kong. The AVA system basically establishes a study method for project developers to objectively assess their designs based on the use of Wind Velocity Ratio (VRw).

The Government of Hong Kong adopted the system, published a Technical Circular in July 2006, and implemented the system with the following advisory note: "In accordance with the Joint Housing Planning Lands Bureau (HPLB) / Environment Transport Works Bureau (ETWB) Technical Circular No. 1/06 on Air Ventilation Assessment (AVA), all major government projects falling within the categories specified in the Technical Circular are required to undertake AVA."

AVA IMPLEMENTATION

The Joint Housing, Planning and Lands Bureau and Environment, Transport and Works Bureau Joint Technical Circular (TC) [no. 1/06] is titled "Air Ventilation Assessments". The purpose of the TC is to set out the guidance for applying air ventilation assessment (AVA) to major government projects.

In the Background section of the TC, it states, "In the Team Clean report published in August 2003, Government undertook to examine the practicality of stipulating air ventilation assessment (AVA) as one of the considerations for all major development or redevelopment proposals and in future plan making. In the "First Sustainable Development Strategy for Hong Kong" promulgated by the Office of the Chief Secretary for Administration in May 2005, a strategic objective to promote sustainable urban planning and design practices has been set out amongst other objectives with special regard to issues such as buildings affecting view corridors or restricting air flow."

The government of Hong Kong has pleaded to subject all public housing projects, planning studies for new development areas and comprehensive redevelopment areas, preparation of new town plans and major revision to town plans to AVA. It has also encouraged quasi-government organisations and he private sector to apply AVA to their projects on voluntary and need basis. The following detail project implementation requirements have been stated. Projects needing AVA studies include:

(a) Planning studies for new development areas;
(b) Comprehensive land use restructuring schemes, including schemes that involve agglomeration of sites together with closure and building over of existing streets;
(c) Area-wide plot ratio and height control reviews;
(d) Developments on sites of over 2 hectares and with an overall plot ratio of 5 or above;
(e) Development proposals with total Gross Floor Area exceeding 100,000square metres;
(f) Developments with podium coverage extending over one hectare;
(g) Developments above public transport terminus;
(h) Buildings with height exceeding 15 metres within a public open space or breezeway designated on layout plans / outline development plans / outline zoning plans or proposed by planning studies ;
(i) Developments on waterfront sites with lot frontage exceeding 100 metres in length; or
(j) Extensive elevated structures of at least 3.5 metres wide, which abut or partially cover a pedestrian corridor along the entire length of a street block that has / allows development at plot ratio 5 or above on both sides; or which covers 30% of a public open space.

In addition, the TC states the following notes, "In assessing the need for AVAs for individual projects, the proponent departments / bureau or authorities should also take into account the following**:"**

(a) Whether there are existing / planned outdoor sensitive receivers located in the vicinity of the project site falling within the assessment area. The sensitive receivers should include pedestrians or open space users;
(b) Whether there are known or reasonable assumptions of the development parameters available at the time to conduct the AVA;
(c) Whether alternative designs are feasible or alternative locations are available for the project if the AVA to be conducted would reveal major problem areas;
(d) Whether there are other overriding factors which would prevail over air ventilation considerations in the determination of the project design;
(e) Whether the desirable project designs for better air ventilation may compromise other important objectives for the benefits of the public;
(f) Whether the public has raised concern on air ventilation in the neighbourhood area of the project; and /or
(g) Whether the project is already in advanced stage to incorporate the AVA.

The TC does not specify a standard to achieve. It is basically a methodology so that designs can be compared and optimised.

VELOCITY RATIO (VR) AS INDICATOR

Wind Velocity Ratio (VR) is 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. Wind VR is defined as Vp/Vinf (V pedestrian/V infinity). Vinf 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). Vinf 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.

EXPRET EVALUATION

It is always useful and cost effective for the AVA 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. (Figure 2)

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.

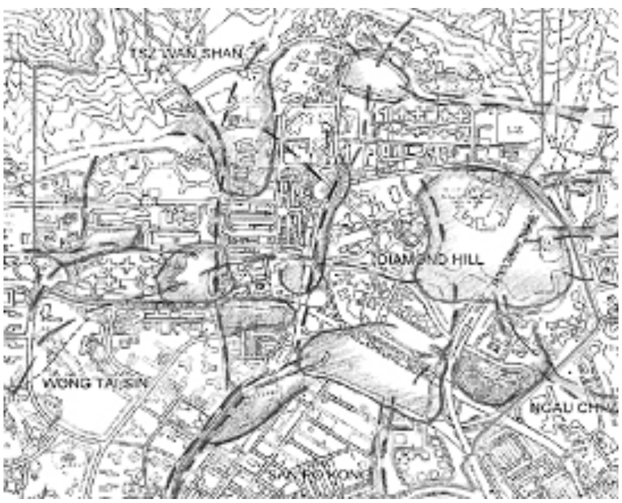

Figure 2: An expert evaluation of city air paths for planning.

INITIAL AVA STUDIES

The Initial Study refines and substantiates the Expert Evaluation (Figure 3). The following tasks may be achieved with the Initial Study:

(a) Initially assesses the characteristics of the wind availability (Vinf) 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.

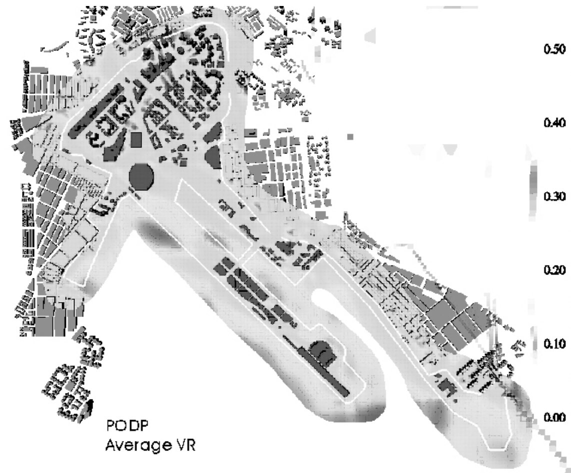

Figure 3: An AVA Initial Study of a city area of 300 hectares in Hong Kong using CFD.

DETAIL AVA STUDIES

With the Detailed Study, the assessor could accurately and "quantitatively" compare designs so that a better one could be selected (Figure 4). 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 (Vinf) of the site in detail.
(b) To report all VR of test points. To report Site VR (SVR) and Local VR (LVR) when appropriate. To report, if any, wind gust problems.
(c) To provide a summary of how the identified problems, if any, have been resolved.

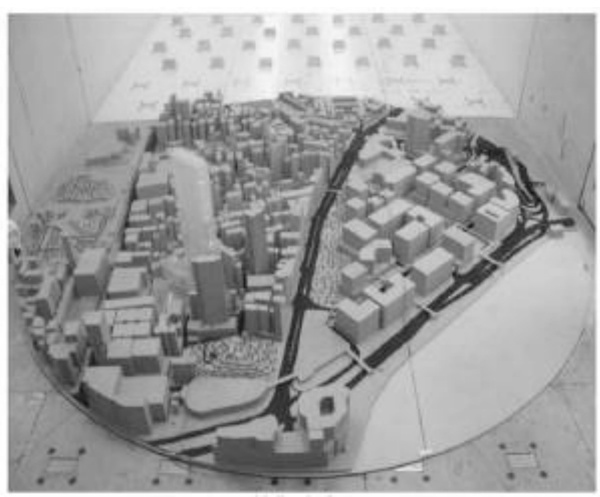

Figure 4: A design undergoing AVA Detail Study using wind tunnel.

SITE WIND DATA

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.

For the Initial Study, it is necessary to be more precise. Either "simulated" site wind data, or "experimental" site wind data, could be used. Using appropriate mathematical models (e.g. MM5 and CALMET), it is possible to simulate and estimate the site wind availability data (Vinf).

For the Detailed Study, it is necessary to be even more precise. "Experimental" site wind data should be used. 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

Wind tunnel is recommended for both the Initial and the Detailed Studies, and most particularly for the Detailed Study. 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" [5] [6] [7].

STUDY AREAS

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

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

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

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. Two types of test points may be specified for assessment: Perimeter and Overall.

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.

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.

AN APPLICATION

The Hong Kong Government intended to build their Headquarters on the waterfront of the busy and congested central business district. AVA Detail Studies was needed. A series of topographical model wind tunnel tests were conducted to establish the site wind characteristics. (Figure 5)

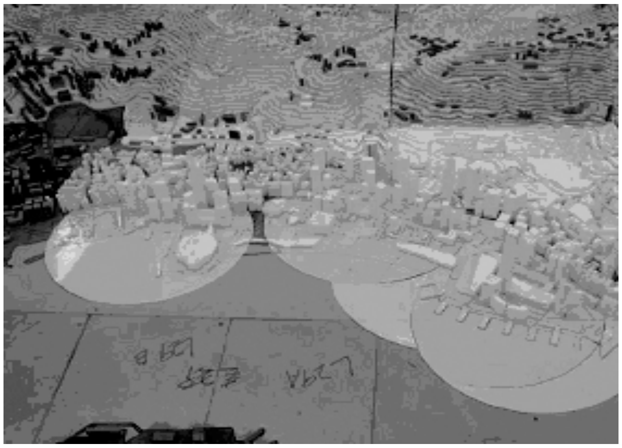

Figure 5: An AVA Detail Study using 1:2000 topographical model in wind tunnel. (Courtesy Professor Kenny Kwok, Hong Kong University of Science and Technology)

The site wind information was given to the 4 completing architect teams. They were required to conduct AVA Detail Studies based on the test point diagram as shown in Figure 6. The focus of the study had been the traffic interchange south of the building site. There had been concerns that the new government building would block urban air ventilation that could affect the interchange.

Figure 6: Test point distribution map of the AVA Detail Studies. The outer circle denote the surrounding area, the middle circle denotes the assessment area where test points are located; and inner circle is the site boundary of the design, test points are located on it. There are also a number of special test points on the waterfront. (Courtesy Planning Dept, HKSAR)

AVA Expert Evaluation stated that no bulky slab like building should be placed in front (north) of the interchange. Sufficient gaps and air paths must be maintained. The winning design by Rocco Design Architects did just that – and perhaps more. Based on the AVA Initial Studies using CFD, two thinner towers were proposed. This was linked with a high level bridge structure resulting in an arch like structure with a very large hole in between (Figure 7, 8 and 9).

AVA Detail Studies were further conducted to obtain the velocity ratios of the test points. This was to ensure that VRs before and after the proposed buildings are not too different, and that the interchange would not be adversely affected.

The final design is illustrated in Figure 10. It shows a continuous green lawn from the waterfront, through the archway, and towards the traffic interchange. The architects aptly dubbed it "Door Always Open" to signify the "transparency" of the government. The public seemed to accept it not realisation that it was all about air ventilation.

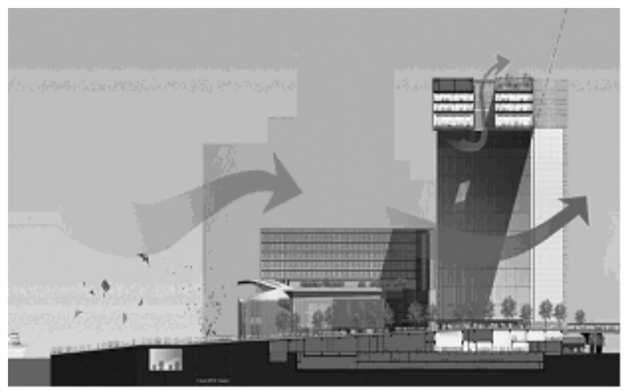

Figure 7: A north south section of the winning design showing air ventilation from the waterfront penetrating the archway towards the interchange on the site's south. (Courtesy Rocco Design Architects Ltd.)

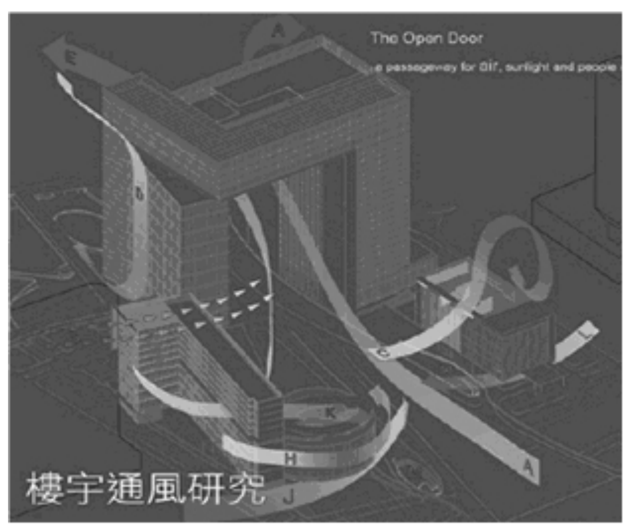

Figure 8: A visualisation of wind flow around the proposed building. (Courtesy Rocco Design Architects Ltd.)

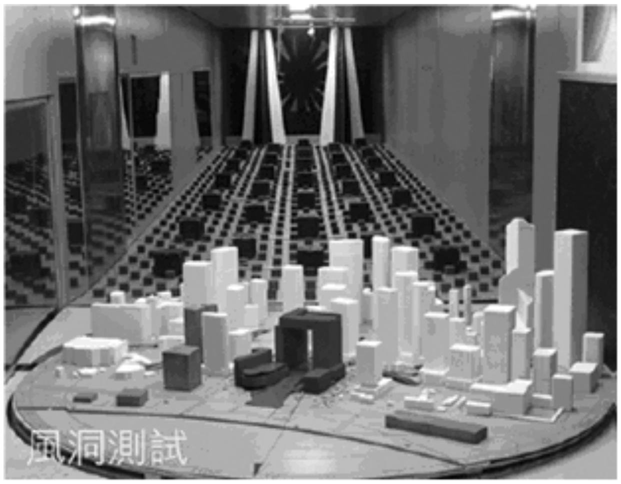

Figure 9: AVA Detail Studies using 1:400 model in a wind tunnel. (Courtesy Rocco Design Architects Ltd.)

Figure 10: The winning design of the Hong Kong Government Headquarters to be completed by 2012. (Courtesy Rocco Design Architects Ltd.)

THE POLICY FORWARD

Since early 2008, the government has mandated that all government sale sites be subjected to AVA investigation in order to establish the land sales guideline and the development potentials of the site (Figure 12 and 13). This allows a fair 'game play' with the property developers.

KEY LESSONS

The exercise demonstrates that it is possible to apply the AVA Technical Circular and its methodology to evaluate the pedestrian air ventilation environment using VR as an indicator. However, it has been found that the process was not straight forward, and that it required careful expert intervention through the process. In short, it was not a "follow the rule book" exercise.

Apart from the project proponents' wind experts, the Hong Kong government appointed an expert team to assess and double checked the work done. The assessment team, headed by Professor Edward Ng of Chinese University of Hong Kong, examined the AVA studies of all 4 competition entries. Firstly, the assessment team needed to detail examine the slightly different work process of different wind tunnel engineers and to normalise the data. They also needed to evaluate results of each of the test points and report any anomalies due sometimes to the way the models were made and the test points are positioned.

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