Air Ventilation Assessment 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. Subsequently, Hong Kong Government initiated a study titled: "Feasibility Study for Establishment of Air Ventilation Assessment (AVA) 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 system basically establishes a method for project developers to objectively assess their designs. The Government of Hong Kong has adopted the system and published a Technical Circular. The AVA system is introduced in the paper.

Key words: Urban Ventilation, Building design, City Planning

1. INTRODUCTION

The unfortunate events of Severe Acute Respiratory Syndrome (SARS) in 2003 brought the Government and inhabitants of Hong Kong to the realization that a "quality" built environment should be an aim for Hong Kong to become a city that we could proudly call home. Gradation of development height profiles, provision of breezeways, layout planning and disposition of building blocks to allow for more open spaces, greater building setbacks to facilitate air movement, reduction of development intensity, increase open space provisions especially in older districts and more greenery, are coined as possible measures to improve the built environment. There is a need to establish an objective assessment method of urban air ventilation to guide future planning actions. (Team Clean 2003) This paper summarises the research findings, and reports the Air Ventilation Assessment (AVA) Method that is now adopted in Hong Kong to guide developments. The research works were commissioned to researchers at Department of Architecture, Chinese University of Hong Kong in November 2003.

2. The AIR VENTILATION ASSESSMENT STUDY

"Find the problem, else we risk solving the wrong one". This was the opening sentence of Prof Mat Santamouris when he was invited to be an expert reviewer during the early stages of the study. The following methodology for the study was adopted.

(A) A desk top study of related works and study examples around the world – not just on scientific investigations, but also about policy measures.
(B) A review to understand the current urban conditions of Hong Kong, and to identify issues and problems.
(C) Explore the possibility to establish performance criteria needed for considering the impact of development on wind environment.
(D) Define the critical issues and to explore the feasibility to develop a practical and cost effective assessment methodology.
(E) Examine the practicality of an effective implementation mechanism, and to develop a methodology.
(F) Establish principles and good practice for the use of professionals and practitioners in the shaping of the built environment for a better wind environment.

3. A REVIEW OF THE EXISTING CONDITION

The existing city conditions in Hong Kong were evaluated based on expert qualitative evaluation. Professor Baruch Givoni, Professor Lutz Katzschner, Professor Shuzo Murakami, Professor Mat Santamouris, and Dr Wong Nyuk Hien were the five experts. With minor differences in opinions, the following key comments were received.

3.1. Breezeway / air path

As a general rule, the more air ventilation to the streets, the better it will be for these dense urban areas. The overall permeability of the district has to be increased at the ground level. This is to ensure that the prevailing wind travelling along breezeways and major roads can penetrate deep into the district. This can be achieved by proper linking of open spaces, creation of open plazas at road junctions, maintaining low-rise structures along prevailing wind direction routes, and widening of the minor roads connecting to major roads. Also avoid obstruction of the sea breeze. Any localised wind problem along the waterfront should be dealt with locally and not affect the overall air ventilation of the city.

3.2. Podium / Site Coverage

The effect of building layout (especially in terms of building site coverage) has a greater impact than that of building height on pedestrian wind environment. (Figure 5) Stepping building heights in rows would create better wind at higher levels if differences in building heights between rows are significant. The "podium" structures commonly found in Hong Kong are not desirable from the viewpoint of maximizing wind available to pedestrians. The podia with large site coverage not only block most of the wind to pedestrians (affecting comfort and air quality), but also minimize the "air volume" near the pedestrian level (affecting air quality).

3.3. Building Heights

Vary the heights of the blocks with decreasing heights towards the direction where the prevailing wind comes from. If not, it is better to have varying heights rather than similar / uniform height. Given the extremely high density of the urban fabric and narrow streets, a probable strategy for improving the air ventilation is by varying building heights for diverting winds to the lower levels. Nonetheless, assessment will be required to further quantify the actual performance of such potential in view of the common deep urban canyon situations in Hong Kong.

3.3. Building permeability

The provision of permeability / gap nearer to the pedestrian level is far more important than that at high levels. Create permeability in the housing blocks. Try to create voids at ground level to improve ventilation for pedestrians. This will improve not only the air movement at the ground level (thus improving the pedestrian comfort), but also help to remove the pollutants and heat generated at ground level. The channelling effect created by the void also helps to improve the ventilation performance for those residential units at the lower floors. Creation of openings in the building blocks to increase their permeability may be combined with appropriate wing walls that will contribute to pressure differences across the building facades and thus will permit the air to flow through the openings of the buildings. The wing walls have to be designed according to the known standards. For very deep canyons or very tall building blocks, mid-level permeability may be required to improve the ventilation performance for those occupants situated at mid-floors.

3.3. More the Better

It was in general opined that unlike most cities in the world, wind gust may not be a problem in most areas in Hong Kong. On the contrary, wind stagnation and blockage is a main problem. For the tropical climatic conditions of Hong Kong where wind in the summer is a welcoming quantity, it was opined unanimously that "more the better" should be the guiding spirit. That is to say, designs and developments should focus on not blocking the incoming wind, as well as to minimise the stagnant zones at the pedestrian levels.

4. AIR VENTILATION ASSESSMENT (AVA)

A key objective of the study is not purely scientific, but it is trying to find an objective protocol and methodology to guide planning practice. Planners have control of a number of design parameters. For example, site coverage, building bulk, building alignment and deposition, and so on. It is important to ensure that the planning of buildings does not block the ambient background wind. Localised thermal wind is therefore a relatively minor consideration from a practical planning point of view.

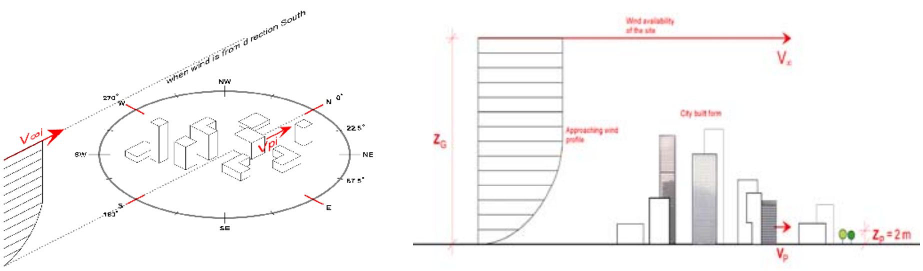

Figure 1: The concept of VR_w. Using VR_w, it is possible to assess the effects of project developments to the wind environment. 16 directions are considered. The VR_i of each direction will then be factored with the probability of wind coming from that direction to calculate the VR_w.

Wind Velocity Ratio (VR_w) is used as an indicator. V_∞ is the wind velocity at the top of the wind boundary layer not affected by the ground roughness, buildings and local site features (typically assumed to be a certain height above the roof tops of the city centre and is site dependent). Vp is the wind velocity at the pedestrian level (2m above ground) after taking into account the effects of buildings. Vp/V_∞ is the Wind Velocity Ratio (VR_w) that indicates how much of the wind availability of a site can be experienced and enjoyed by pedestrians on ground taking into account the buildings in between. As VR_w is solely affected by the buildings of the location, it is a simple indicator one may use to assess the effects of proposals – higher the value of VR_w, lesser the impact of buildings on wind availability. (Figure 1)

Based on the VR_w as an indicator, the methodology of the assessment procedures and the scope of work needs to be identified. The assessment area (radius from the boundary of the test site (r) =1 x the height of the tallest building (H) on the test site) of the , the surrounding area (r = 2xH), the location of test points and the definition of site wind availability based on the wind rose of the test site at V_∞ height need to be specified.

Although CFD could be used for some urban wind studies, the study concluded that the use of wind tunnel is the more reliable tool. Wind tunnel work procedures are robust and are known to give reliable results for wind studies for structure and for pedestrian winds. (Plate 1982, ASCE 1999 and AWES 2001)

Once VR_w of the tests points are measured inside a wind tunnel, project proponents are required to report 2 key ratios to represent their designs.

Along the boundary of the site, a number of perimeter test points are planted. They could be about 10 to 50 metres apart, depending on the site condition, surrounding the test site and are evenly distributed. Test points must be planted at the junctions of all roads leading to the test site, at corners, as well as at the main entrances of the test site. This set of test points is known as Perimeter Test Points. They will later provide data to calculate the Site Spatial Average Wind Velocity Ratio (SVR_w). This gives a hint of how the development proposal impacts the wind environment of its immediate vicinity.

Test points should also be evenly distributed over the assessment area of the model. For detail study, one test point per 200 to 300 square metres of the assessment area would typically suffice, except when doing rough initial study, or when the site condition is simpler. Test points should be positioned where pedestrians can or will mostly access. This may include pavement, open spaces, piazzas, concourses and so on, but exclude back-lanes or minor alleyways. For streets, the tests point should be located on their centerlines. Some of the test points must be located at major entrances, as well as identified areas where people are known to congregate. This group of test points will be known as Overall Test Points, together with the Perimeter Test Points, will provide data to calculate the Local Spatial Average Wind Velocity Ratio (LVR_w). This gives a hint of how the development proposal impacts the wind environment of the local area.

5. IMPLEMENTATION

The idea of Urban Acupuncture has been coined as a metaphor. The idea is to identify key “needle points” that are most effective for intervention. For example, for metro areas of downtown Hong Kong, it is almost impossible to re-plan. A better strategy would be to find the most effective counter-measures, as well as to look for the most critical sites. For example, to encourage gaps to appear, there could be a proposal to allow for trading of land rights and/or implementing of a bonus scheme. In July 2006, the Hong Kong government has decided initially that all government projects of a certain characteristics to go through the AVA. Some of the characteristics are:

- (A) Preparation of new town plans and major revision of such plans.
- (B) Development that deviates from the statutory development restriction(s) other than minor relaxations.
- (C) Urban renewal development that involves agglomeration of sites together with closure and building over of existing streets.
- (D) Development with shielding effect on waterfront, particularly in confined airsheds.
- (E) Large-scale development with a high density, e.g. site area over 2 hectares and an overall plot ratio of 5 or above, development with a total GFA of 100,000 sq.m. or above.

6. GUIDELINES, PRINCIPLES, POLICIES AND THE WAY FORWARD

In addition to the assessment methodology, the government has also incorporated some guidelines into their Hong Kong Urban Standard and Guidelines (HKPSG). This document provides guidance to designers and planners. An example is as shown in Figure 2.

The Hong Kong government has appointed a team of AVA advisors to oversee the implementation of the AVA methodology. A joint government bureau level technical circular has been issued in December 2006 to head start the AVA. Previous to that, the government has required the planning development of the old Kai Tak airport site

(328 hectares) to undertake the AVA. This is the first government piece of land trying out the new AVA methodology. Sebsequently, the new government headquaters builidng also went through the AVA (Figure 3).

Beyond the immediate policy implementation, the government has in Sept 2006 commissioned further studies to advance the AVA methodology. An urban climatic map of Hong Kong will be generated to strategically guide the design and planning decision making process. The study is planned to be completed in Aug 2010.

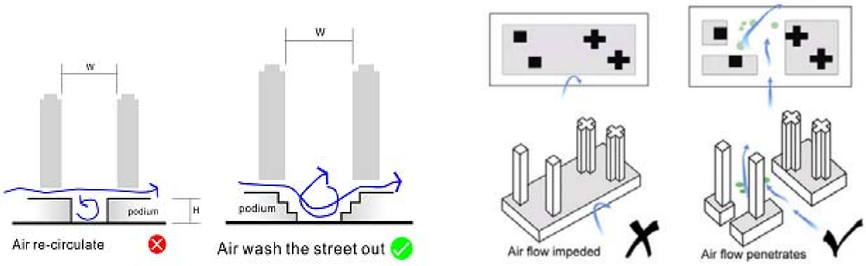

Figure 2: Two examples of the guidelines dealing with the shape of the podium.

Figure 3: (left) The 328 hectares old Kai Tak airport site designed to benefit from the south-east prevailing wind. (right) The Tamar Government Headquarters building.

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References

Team Clean (2003), Report on Measures to Improve Environmental Hygiene in Hong Kong, HKSAR, p. 87.

Plate, E.J. (1982), "Wind tunnel modeling of wind effects in engineering", in Plate, E.J. (ed.), *Engineering Meteorology*. Elsevier, Amsterdam, pp. 573-639.

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

AWES (2001), Quality Assurance Manual on Environment Wind Studies, AWES-QAM-1-2001.