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Policies and technical guidelines for urban planning of high-density cities – air ventilation assessment (AVA) of Hong Kong

Edward Ng*

Department of Architecture, Chinese University of Hong Kong, Shatin, NT, Hong Kong

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ABSTRACT

In 2003, Hong Kong was hit by severe acute respiratory syndrome (SARS) from which many people died. The Hong Kong Government subsequently set up a Governmental Team Clean Committee to investigate possible urban design policies. Team Clean charged the task to the Planning Department, HKSAR. In 2003, it initiated a study titled: "Feasibility Study for Establishment of Air Ventilation Assessment (AVA) System." A number of focused studies were conducted. It eventually led to the technical methodology and guidelines of the air ventilation assessment (AVA) system. Unlike many countries with guidelines for dealing with gust wind problems, 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. In 2006, the government of Hong Kong officially adopted the system and required all major publicly funded development projects to undertake the assessment. The scientific and implementation processes leading to the AVA system are reported in this paper.

1. Introduction

Hong Kong is one of the most densely populated cities in the world. (Fig. 1) High-density living has the advantages of efficient land use, public transport and infrastructure, as well as the benefits of closer proximity to daily amenities. The "sunk cost" of high-density living is that it is more difficult to optimize urban design for the benefits of the natural environment – daylight and natural air/wind ventilation. Good planning and building designs are critically important.

In Hong Kong, it is opined that air ventilation in the densely populated city is generally not optimized; stagnant or slow air movements in streets and urban spaces are often experienced. It is important to initiate steps to improve the situation. Design and assessment tools are beneficial to assist the government, planners, engineers, architects, designers and industry stakeholders to better optimize air ventilation for the city. In 2003, after Hong Kong was hit by the severe acute respiratory syndrome (SARS) from which many people died, there were calls from the community for measures to improve the quality of our urban living environment. Among the recommendations in the Team Clean Final Report [1], it was proposed 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 planning.

The Planning Department of the Hong Kong Government was requested by Team Clean to discuss among government departments and consult relevant professional institutes and stakeholders on the standards, scope and mechanism for application of an air ventilation assessment (AVA) system. The Planning Department initiated a study titled: "Feasibility study for establishment of air ventilation assessment (AVA) system". In 2003, the research contract was entrusted to a team of researchers at the Department of Architecture, Chinese University of Hong Kong.

An underlying spirit of the study is to develop more science-based urban interventions – conceptually described as a form of "urban acupuncture" – for enhanced, long-term quality of life in the high-density urban context of Hong Kong. The study focuses on the fundamental mission: how to design and plan the city fabric for better natural air ventilation?

2. Study objectives

The primary objective of this study was to explore the feasibility of establishing some protocols to assess the effects of major planning and development proposals on external air movement for achieving an acceptable macro wind environment.

3. Health, comfort and SARS

Although the study was initiated by the Team Clean report, the study concentrated on what town planning could influence by taking SARS as a wake up call to establish the feasibility of an air

* Tel.: +852 2609 6515; fax: +852 2603 5267.
E-mail address: edwardng@cuhk.edu.hk

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Fig. 1. An urban skyline of Hong Kong with densely packed high rise buildings (30 to over 80 storeys) very closely built next to each others. The hills at the back further block the summer prevailing wind to the city.

ventilation assessment (AVA) system for planning with a view to improving the general living environment, quality and sustainability of the city.

Health and comfort are inter-related. Psychological and physiological thermal comfort is conducive to health. The World Health Organization (WHO) has since 1948 defined it as: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Whereas health (the immediate effects of the environment on a human's well being) is a consideration, the study should not neglect the long-term well being of the inhabitants of the city which has a lot more to do with comfort, both physiologically and psychologically.

4. Study methodology and main tasks

"Find the problem, else we risk solving the wrong one". This was the opening sentence of Professor Mat Santamouris when he was invited to be an expert reviewer during early stages of the study. The methodology and main tasks are summarized as follows:

(A) A desk top study of related works and study examples around the world – not just scientific investigations, but also policy measures.
(B) A review to understand the current urban conditions of Hong Kong, and to identify issues and problems.
(C) Explore the possibility of establishing performance criteria needed for considering the impact of development on the wind environment.
(D) Define the critical issues and explore the feasibility of developing a practical and cost-effective assessment methodology.
(E) Examine the practicality of an effective implementation mechanism, and 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.

The key policy outcomes of this study include (1) to advise on the framework for analyzing the urban fabric in relation to the planning context of Hong Kong; (2) to identify the key factors in planning terms that would have a bearing on air ventilation; (3) to identify the key factors for consideration in determining the circumstances under which air ventilation assessment should be required having regard to the prevailing planning context; and (4) to advise on implementation approaches and the corresponding implementation mechanisms.

5. Review

A quick literature survey was conducted. There are a lot of scientific studies dealing with the wind environment and modelling [2–4]. It was very quickly established that although many countries have codes and design guidelines for gust and strong wind problems [5,6], few seem to have touched on the issue of urban air stagnation and city air ventilation problems. Notable exceptions are studies dealing with air pollution and dispersion [7,8], for example Professor Chris Baker's group at Birmingham University [9,10]. In Japan, The Tokyo Metropolitan Government has an environmental map so that designated areas for the implementation of measures can be identified and used as a guide for redevelopment projects [11] (Fig. 2). In Germany, there is a legal requirement that developments should not worsen the climatic conditions of the site. Urban climatic maps have been produced (Fig. 3). They have been used to guide planning and development decisions. In the city of Kassel, the climatic map has been translated into a planning evaluation map. This map further identifies possible action for planners to reference [12,13]. Using this guiding map, which has factored the dynamic characteristics of the wind movement in the city to alleviate the adverse effects of urban heat islands, planners can decide if a development might block the wind to the city, and if a project proponent should be given permission, or is required to do further tests to provide justification. The review also identified ad-hoc studies in Hong Kong dealing with the wind environment for extreme high-density conditions. But in Hong Kong, weak wind studies are still rare.

6. Review of Hong Kong's urban issues

To shorten the study period, the existing 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 opinion, the following key comments were received.

6.1. Breezeway/air path

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

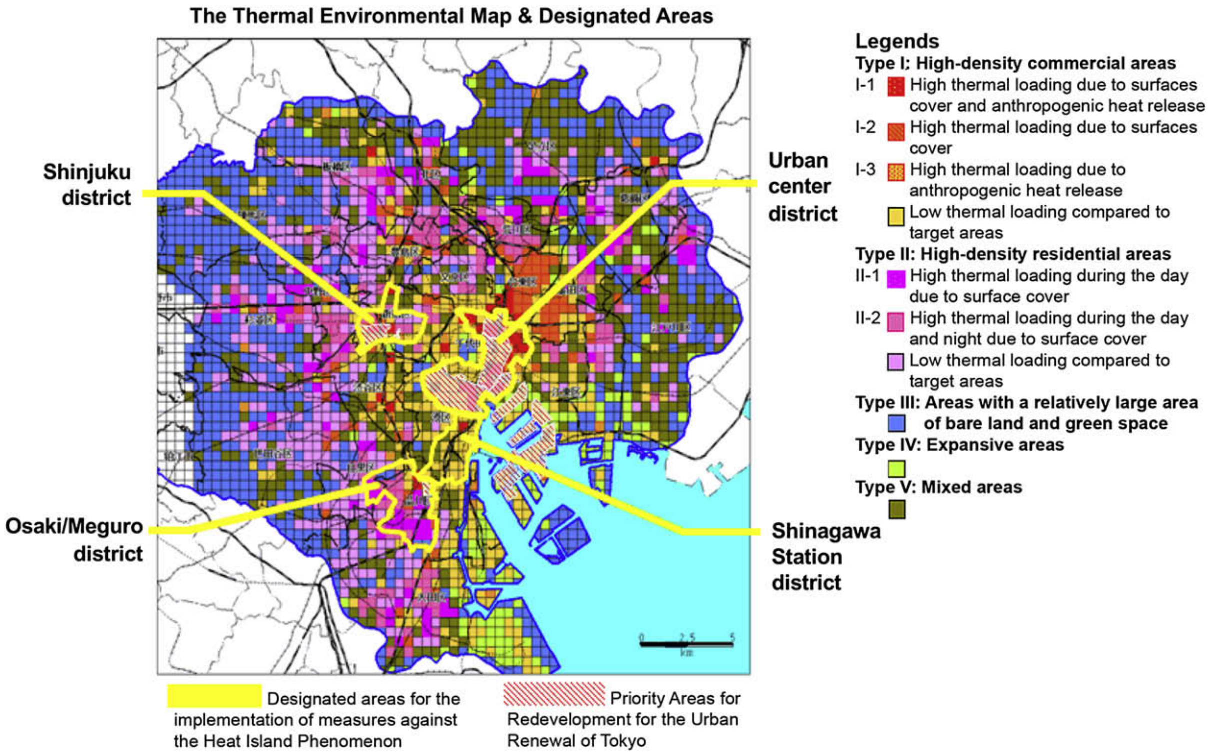

Fig. 2. Tokyo environmental map.

routes, and widening of the minor roads connecting to major roads. Also avoid obstructing the sea breeze. Any localized wind problem along the waterfront should be dealt with locally and not affect the overall air ventilation of the city.

6.2. 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 the pedestrian wind environment. 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 the 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).

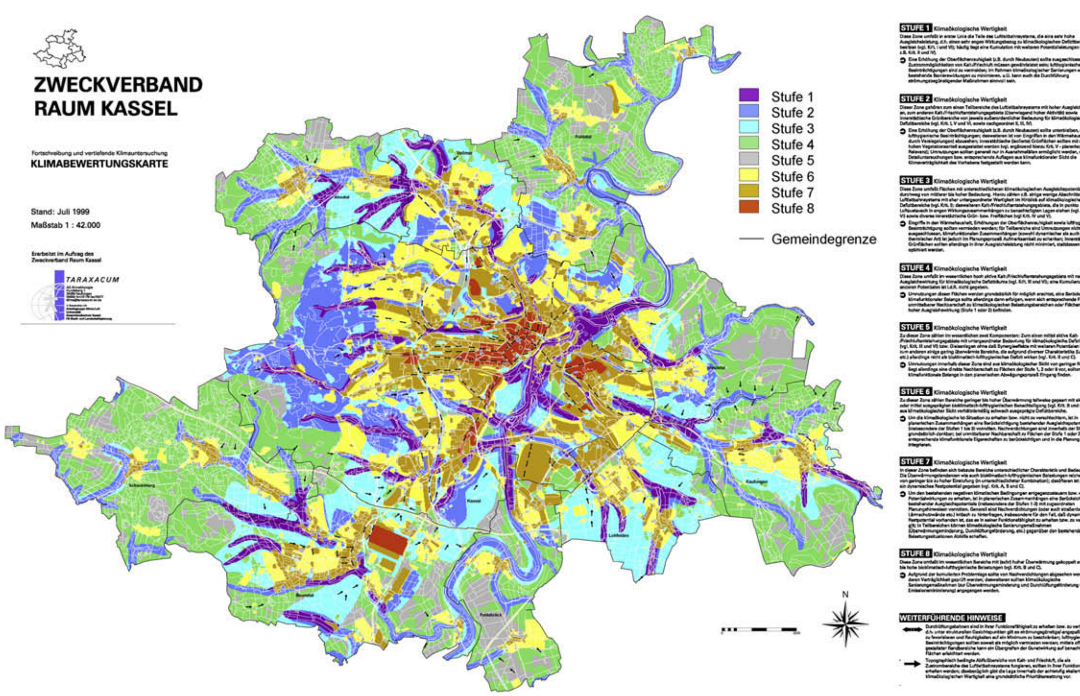

Fig. 3. Planning evaluation map by Professor Lutz Katzschner of Kassel University.

6.3. Building disposition

Proper orientation and layout of the buildings with adequate gaps between buildings are needed. Stagger the arrangement of the blocks such that the blocks behind are able to receive the wind penetrating through the gaps between the blocks in the front row. In the case of a new town, to avoid obstruction of the sea breeze, the axis of the buildings should be parallel to the prevailing wind. In order to maximize the wind availability to pedestrians, towers should preferably abut the podium edge that faces the main pedestrian area/street so as to enable most of the downwash wind to reach the street level.

6.4. 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 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 strategies in view of the common deep urban canyon situations in Hong Kong.

6.5. Building permeability

The provision of permeability/gaps 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 pedestrian comfort), but also help to remove pollutants and heat generated at ground level. The channelling effect created by the void also helps to improve 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 façades 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 mid-floor.

6.6. A need for planning to optimize air ventilation

It was in general expertly opined that unlike most cities in the world, wind gust may not be a problem in Hong Kong. On the contrary, wind stagnation and blockage is a major problem. And for the tropical climatic conditions of Hong Kong where wind in the summer is a welcome quality, it was opined unanimously that "the 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 minimizing the stagnant zones at the pedestrian levels.

7. Wind for comfort

Outdoor thermal comfort could be achieved when the following factors are balanced: air temperature, wind speed, humidity, activity, clothing and solar radiation. For designers, it is possible to design our outdoor environment to maximize wind speed and minimize solar radiation to achieve comfort in the hot tropical summer months of Hong Kong. Typically, the desirable environment for pedestrians is a balance between air temperature, solar radiation and wind speed. A higher wind speed might be needed if a pedestrian is only partly shaded, likewise, a lower wind speed might be desired if the air temperature is lower.

Givoni has conducted researche on outdoor comfort in two very different locations – Japan and Israel. Like Hong Kong, they have hot and humid summers: based on his findings, he developed formulas to predict the thermal sensation of people outdoors as a function of air temperature, solar radiation, and wind speed. According to the results of both studies, relative humidity (RH) has been shown to have a statistically insignificant effect on comfort perception [14,15]. Based on his formulas and the meteorological data of Hong Kong, a comfort outdoor temperature chart for urban Hong Kong was developed (Fig. 4). The *x*-axis of the chart is the outdoor air

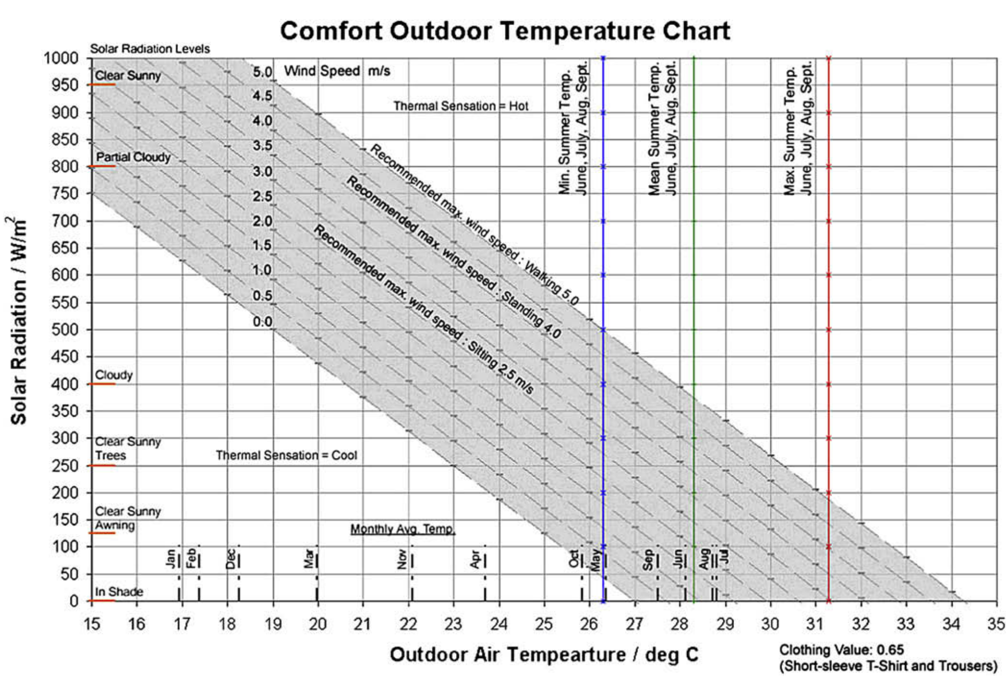

Fig. 4. Comfort chart based on researches of B.Givoni and Hong Kong meteorological data.

temperature and the *y*-axis is the level of solar radiation. The shaded area represents the neutral comfort region which could be obtained by a proper combination of air temperature, solar radiation and wind speed. The chart provides a guide to the kind of wind environment that is desirable in Hong Kong. For example, under Hong Kong's summer air temperature of 28 °C, a person standing under shade would be comfortable if a light breeze of 1.0 to 1.5 m/s is available.

Based on an examination of the Hong Kong Observatory's published wind data in the urban areas of Hong Kong, a mean roof top (at approximately 100 m above ground) urban canopy layer (UCL) wind of some 2.5 m/s is available. Based on the power law extrapolation, a mean wind of some 6 to 8 m/s at the boundary layer of 500 m can be predicted. With wind tunnel and CFD studies of urban areas of Hong Kong, urban wind velocity ratio (a ratio of pedestrian level wind at 2 m and boundary level wind at 500 m) of 0.3 near the waterfront and in open spaces, and 0.05–0.1 in streets and congested urban spaces can be expected. As such, one immediately sees the need for planning of the city to optimize the site wind availability so that at the pedestrian level of 2 m above ground, wind is available, especially in streets and congested urban spaces. [16]

Taking into account the above "wind for thermal comfort" considerations, various climatic and urban factors, and given Hong Kong's high-density conditions, it was opined that, for planning considerations, optimizing or maximizing air ventilation through the city fabric is the focus of air ventilation assessment (AVA). In general, "the more air ventilation the better" is the approach – save some isolated gust problems that in most cases could be dealt with locally. Given the natural wind availability of the site, a high probability of a gentle breeze at pedestrian level is a useful criterion. Taking into account the general high-density urban morphology of Hong Kong, and the macro wind availability, it is recommended that the city fabric should in general be as permeable and porous as possible. As such, the air ventilation assessment system should be developed to encourage this permeability to happen.

To easily assist design and assessment, the above generic wind criterion has to be further appropriated. Practically, it is important for the study to develop a simple design indicator in order to "relate the desirable pedestrian level wind environment and the urban form". Based on this indicator, designers and planners will have an objective basis to evaluate and optimize their designs.

8. Technical guide for air ventilation assessment (AVA)

A key objective of the study is not scientific, but to try 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. Fundamentally, it is important to ensure that buildings and their planning do not block the ambient background wind synoptically. Localized thermal wind is therefore a relatively minor consideration from a practical planning point of view.

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). V_p is the wind velocity at the pedestrian level (2 m above ground) after taking into account the effects of buildings. V_p/V_∞ is the wind velocity ratio (VR_w) that indicates how much of the wind availability of a location could be experienced and enjoyed by pedestrians on the ground taking into account the surrounding buildings. As VR_w is solely affected by the buildings of the location, it is a simple indicator one might use to assess the effects of proposals. The higher the value of VR_w, the less the impact of buildings on wind availability (Figs. 5 and 6).

Based on VR_w as an indicator, the methodology of the assessment procedures and scope needs to be identified. The assessment area, the surrounding area, the location of test points and the definition of site wind availability need to be specified (Fig. 7).

Although CFD could be used for some urban wind studies, the study concluded that the a wind tunnel is a more reliable tool. Wind tunnel work is robust and is known to give reliable results for structure and for pedestrian wind studies [5,6].

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

Along the boundary of the site, a number of perimeter test points will be planted. They could be about 10–50 m apart, depending on the site condition, surrounding the test site and 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 will be 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 detailed study, one test point per 200–300 m^2 of the assessment area would typically suffice, except when doing a 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 pavements, open spaces, piazzas, concourses and so on, but exclude back-lanes or minor alleyways. For streets, the tests point should be located on their

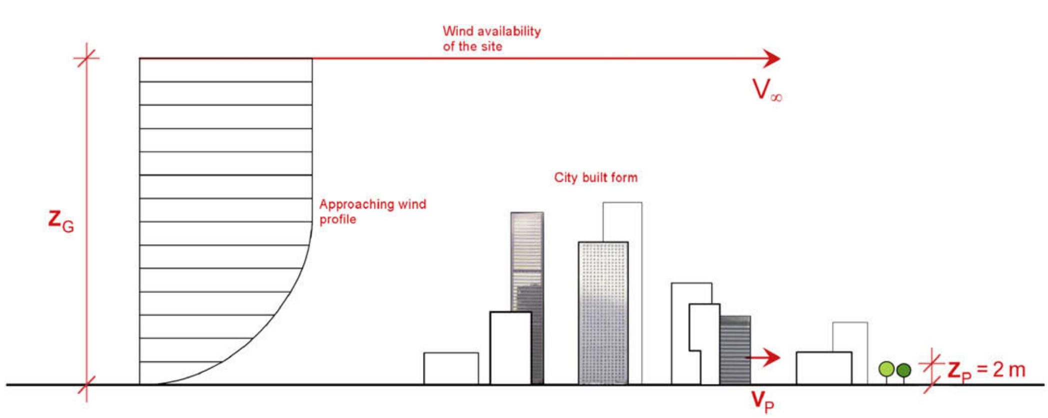

Fig. 5. The concept of VR. Using VR, it is possible to factor the effects of developments to the wind environment.

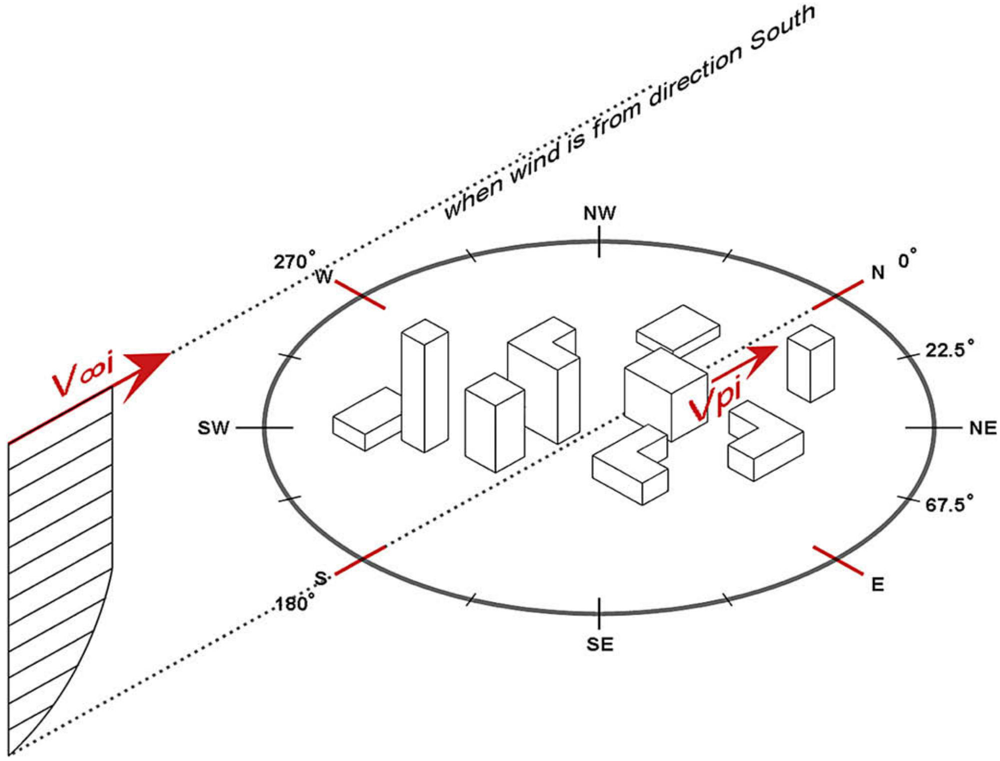

Fig. 6. For air ventilation assessment, sixteen wind directions are considered [VRi=Vpi/V∞i]. The VR of each direction (VRi) will then be factored with the probability of wind coming from that direction to become the wind velocity ratio (VRw) of the test point.

centre-lines. 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 and, 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. The SVRw and VLRw give an overall picture of how the designs impact the pedestrian level wind environment. Planners, designers and wind engineers can examine further the VRw of individual test point to further examine in detail focused areas of their designs. If needed, the directional VRi of the test point could be further investigated when mitigation measures are necessary. It must be stressed that AVA is predominantly a weak wind deign protocol. For wind gust and wind amplification, there are already international guidelines one could follow.

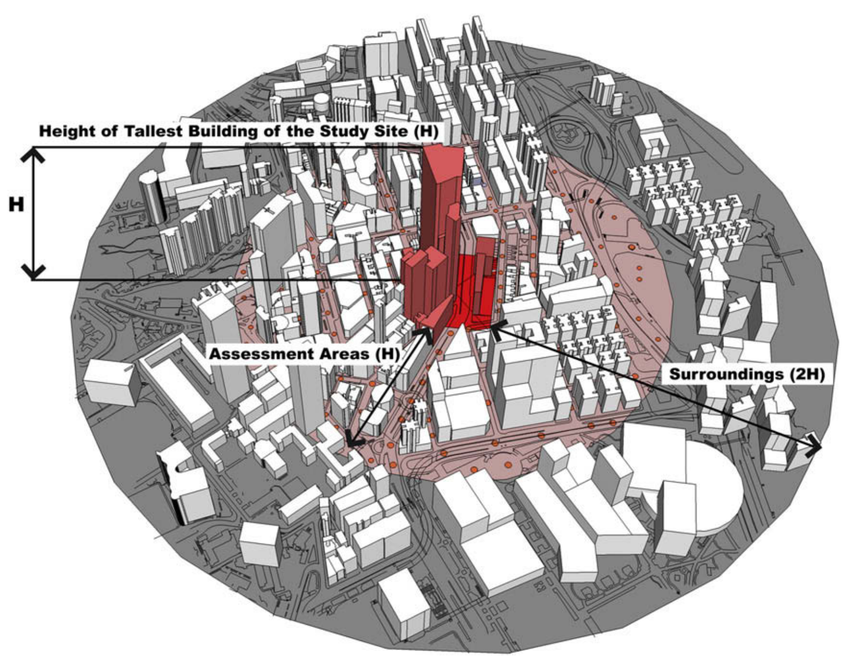

Fig. 7. The assessment area and the surrounding area defined by the height of buildings on site.

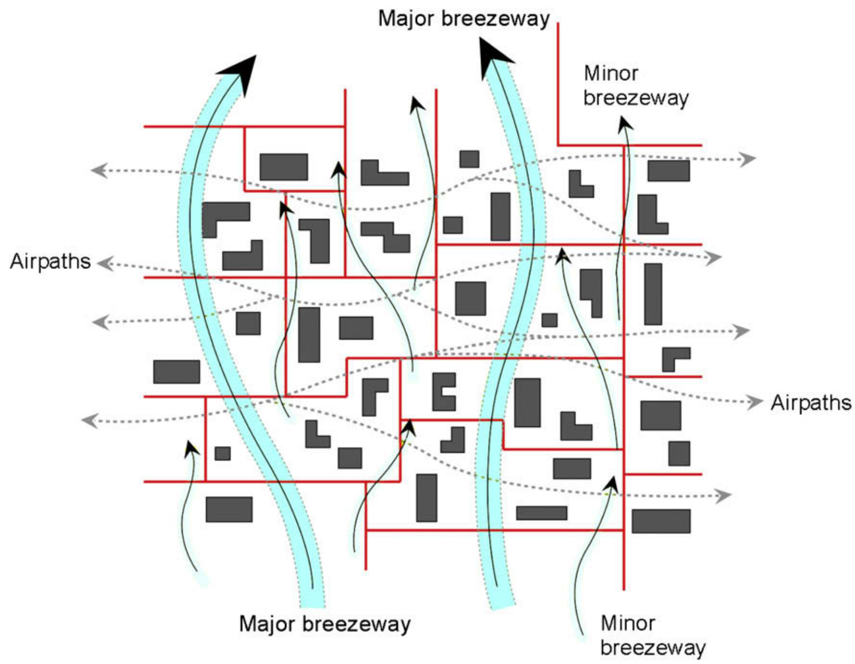

Fig. 8. Breezeway/air path.

9. Policy implementation

The implementation of an AVA system would depend on how robust the AVA system is and how important AVA is considered to be by the decision makers amongst all factors in the consideration of development proposals. In view of the time required for further scientific researches on different aspects of the urban climate and its correlation with urban geometry, the study recommends that AVA be implemented in four key stages[17]. The key stages are as follows:

9.1. Stage A: initial performance-based evaluation

If AVA were to be introduced as mandatory, then it would have to go through a much more lengthy process of testing and validation, when a more definitive local benchmark standard could be established. Hence, the study recommends an initial "advisory" AVA system to start with. The study also recommends that the government/quasi-government organizations lead by undertaking AVA, where practicable, under any one of the following circumstances:

- Preparation of new town plans and major revision of such plans.
- Development that deviates from the statutory development restriction(s) other than minor relaxations.
- Erection of building structure within a designated breezeway.
- Urban renewal development that involves agglomeration of sites together with closure and building over of existing streets.
- Development with shielding effect on waterfront, particularly in confined airsheds.
- Large-scale development with a high density, e.g. site area over 2 ha and an overall plot ratio of 5 or above, development with a total GFA of 100,000 m^2 or above.
- Massive elevated structures over a road in dense urban areas.
- For developments situated in an exposed location where there is no apparent shielding from the approaching wind, an assessment of the potential occurrence of windy conditions that may affect the safety of pedestrians should also be included.

It is recommended that AVA be carried out for different design options to identify better design scenarios and potential problem areas, based on velocity ratio as an indicator. A design having a higher velocity ratio would be considered as a better design than one having a lower velocity ratio. At this stage, only the better design option is known, but whether the better design option meets a standard cannot be known. The aim is to move "towards a better future" rather than for precision. The proponents initiating the proposals should be responsible for conducting, overseeing and self-appraising the AVA.

As for private projects, AVA is encouraged as a good practice guide at the initial stage. To encourage private project proponents to carry out AVA, incentives may be provided by the government through performance labelling, or other schemes.

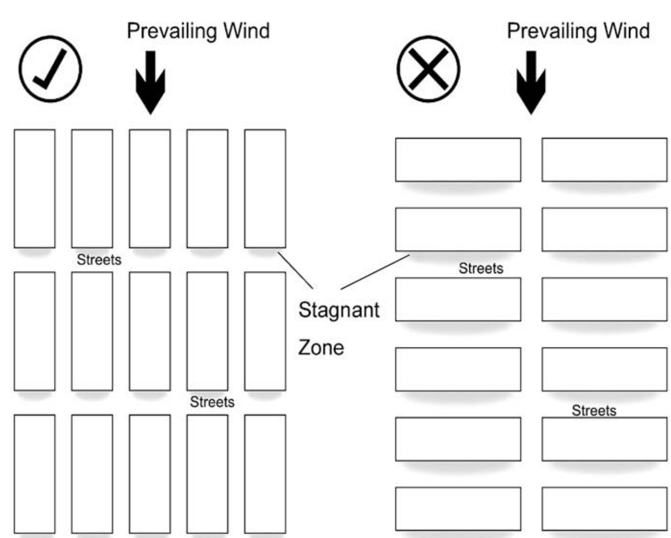

Fig. 9. Orientation of street grids.

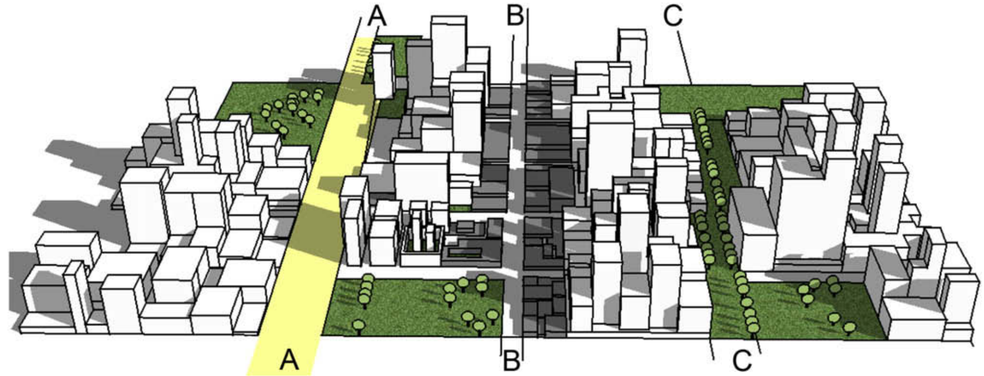

Fig. 10. Linkage of open spaces.

The study also considers it appropriate that a set of qualitative guidelines and the need for AVA be promulgated through revision of the Hong Kong Planning Standards and Guidelines (HKPSG). Some of the qualitative guidelines recommended in the study for better air ventilation in the city are already included in Chapter 11 of the HKPSG, and hence, they only reinforce or complement the existing guidelines. The approach to the initial AVA system recommended in the study is only a facilitating tool and not the primary decision making tool.

9.2. Stage B: urban climatic map

This stage would involve the preparation of an urban climatic map for Hong Kong. It would involve collating relevant data on meteorology, topography, urban fabric, land use pattern etc. for Hong Kong [18]. The resultant urban climatic map would identify the areas which are more in need of attention and improvements from an air ventilation perspective, e.g. highlighting locations poor in wind circulation or sensitive to wind variation, and where important breezeways and open spaces should be protected or reserved.

9.3. Stage C: performance-based evaluation (with standards)

This stage would establish the existing general wind performance condition of Hong Kong. This would serve as a benchmark standard that major projects should try to achieve, if possible, for optimum wind performance. This would allow direct comparison of air ventilation performance against a known criterion, rather than revealing only the better or worse design options (as in Stage A). The criterion established would provide a yardstick for evaluation of development projects where air ventilation is a major concern and projects have to be justified through the existing institutional framework (such as town planning, land grant/lease and building control and/or environmental impact assessment). Technical specifications for conducting AVA would need to be prepared to ensure there is no dispute in the AVA requirements and vetting process.

9.4. Stage D: quantitative guidelines

This stage would develop quantitative design guidelines to facilitate early designs of development proposals. Projects are assessed against pre-set design criteria, design parameters, ratios or indices concerning developments, such as site/district openness and building mass geometry (street width to building height ratio, variation in building height within site, permeability of the building facade etc.). These quantitative design guidelines have to be derived through iterative empirical tests by varying different design scenarios and assumed conditions to validate their magnitudes of impact on the wind environment. Development schemes that are designed in accordance with the quantitative design guidelines would be deemed to satisfy air ventilation requirements, without the need to go through the performance-based AVA testing. This would be less time consuming and more cost-effective, as compared to the performance-based approach in which the performance can only be tested after the design is generated.

At the completion of stages B, C and D, a widely accepted assessment method and a set of definitive assessment standards and criteria could be established in detail. It would then enable the government to ascertain the types of project/circumstances that should warrant an AVA. With definitive assessment standards/criteria and the availability of an urban climatic map, it would provide a stronger case for more extensive application to private projects, and for consideration of a regulatory approach, if necessary.

10. Qualitative urban design guidelines

Before further stages of AVA are developed, based on the advice of international experts, the following design guidelines provide useful design reference for better air ventilation. The qualitative

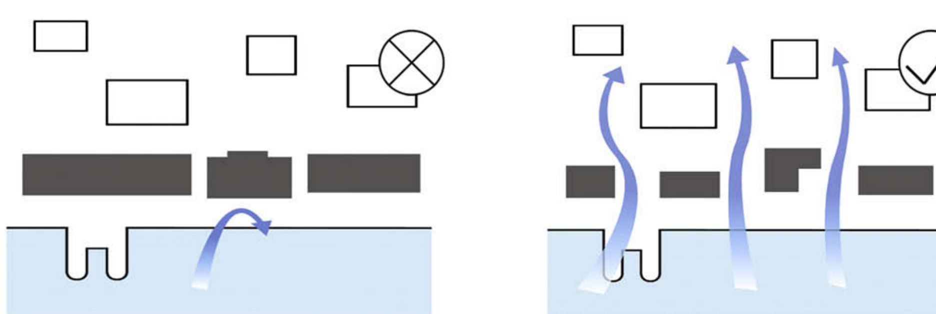

Fig. 11. Waterfront sites.

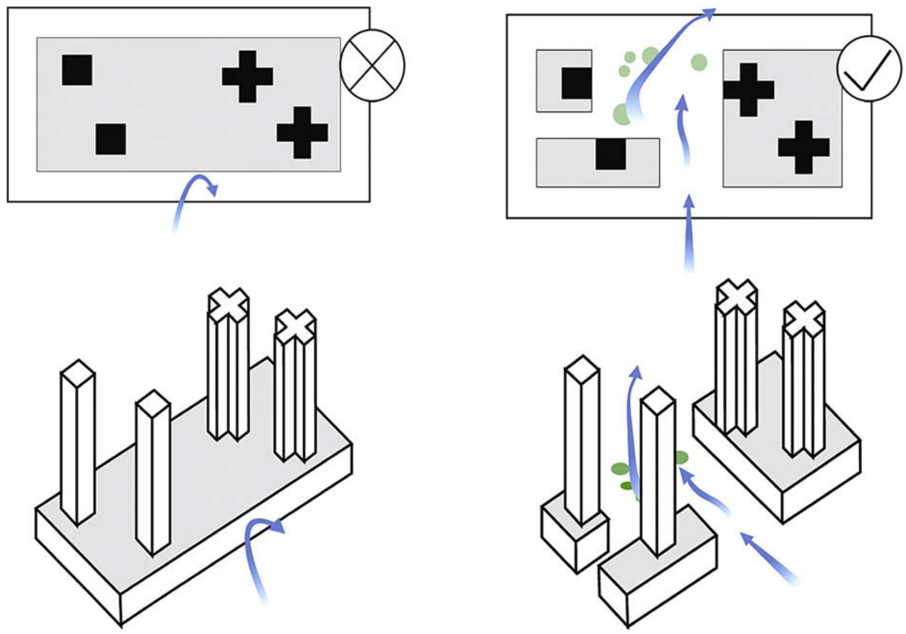

Fig. 12. Non-building area.

guidelines also provide designers with a strategic sense of how to start off their design. By observing the guidelines, there would be a higher probability that the resultant design would be better for the wind environment. This could later be confirmed with the air ventilation assessment tests, if necessary.

10.1. Breezeway/air path

It is important for better urban air ventilation in a dense, hot–humid city to let more wind penetrate through the urban district. Breezeways can be in the form of roads, open spaces and low-rise building corridors through which air reaches inner parts of urbanized areas largely occupied by high-rise buildings. Projecting obstructions over breezeways/air paths should be avoided to minimize wind blockage (Fig. 8).

10.2. Orientation of street grids

An array of main streets, wide main avenues and/or breezeways should be aligned in parallel, or up to 30° to the prevailing wind direction, in order to maximize the penetration of prevailing wind through the district (Fig. 9).

10.3. Linkage of open spaces

Where possible, open spaces may be linked and aligned in such a way as to form breezeways or ventilation corridors. Structures along breezeways/ventilation corridors should be low-rise as shown in Fig. 10. Air path A–A linking open spaces with a breezeway; air path B–B linking open spaces with low rise buildings; and air path C–C linking open spaces with a linear park.

10.4. Waterfront sites

Waterfront sites are the gateways of sea breezes and land breezes due to the sea cooling and sun warming effects. Buildings along the waterfront should avoid blockage of sea/land breezes and prevailing winds (Fig. 11).

10.5. Non-building area

The tendency for many developments to maximize views in certain directions and site development potential often results in congested building masses and minimum spaces between buildings to meet Hong Kong's building (planning) regulations. Large sites with compact developments particularly impede air movement. Development plots should be laid out and orientated to maximize air penetration by aligning the longer frontage parallel to

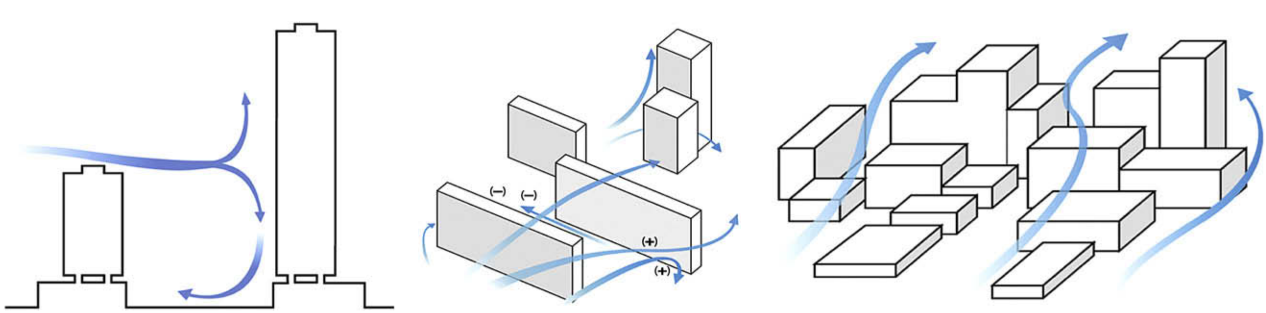

Fig. 13. Building heights.

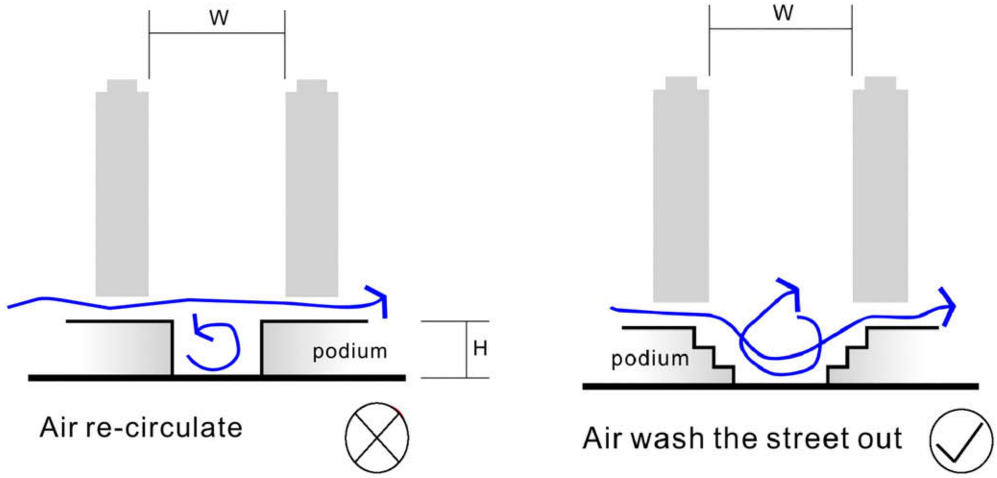

Fig. 14. Scale of podium.

the wind direction and by introducing non-building areas and setbacks where appropriate (Fig. 12).

10.6. Building heights

Height variation should be considered as much as possible on the principle that the height decreases in the direction that prevailing wind comes from. The stepped height concept can help optimize the wind capturing potential of the development itself (Fig. 13).

10.7. Scale of podium

The 100% site coverage for the non-domestic part of developments up to some 15 m high as permitted under the building (planning) regulations often results in large podia. For large development/redevelopment sites particularly in existing urban areas, it would be critical to increase permeability of the podium structure at street levels by providing some ventilation corridors or setback in parallel to the prevailing wind. Where appropriate, a terraced podium design should be adopted to direct downward airflow, which can help enhance air movement at the pedestrian level and disperse the pollutants emitted by vehicles (Fig. 14).

10.8. Building disposition

Where practicable, adequately wide gaps should be provided between building blocks to maximize the air permeability of the development and minimize its impact on the wind capturing potential of adjacent developments. The gaps for enhancing air permeability should preferably be in a face perpendicular to the prevailing wind. Towers should preferably abut the podium edge that faces the relevant pedestrian area/street so as to enable most of the downwash wind to reach street level.

10.9. Shading, greenery and cool materials

Tall trees with wide and dense canopies should be planted along streets/entrance plazas/setback areas for maximizing pedestrian comfort – reducing the urban heat island effect. Blockage to air movements at the pedestrian level by additional planting should be avoided. Use of cool materials in the pavements and building facades to decrease absorption of solar radiation is encouraged. Cool materials are characterized by high solar reflectivity and if possible by a high level of emission. For streets, the use of paving material with a high percentage of white aggregates should be considered. A large water body can also serve as a cool sink.

10.10. Projecting obstructions

Massive projecting obstructions, such as elevated walkways, may adversely affect the wind environment at pedestrian level. Signage should preferably be of the vertical type in order to minimize wind blockage, particularly in those areas with a high density of projecting signs over streets (Fig. 15).

Fig. 15. Projecting obstructions.

11. Conclusions

The study recommendation and proposed implementation actions echo one of the key initiatives proposed in "A First Sustainable Development Strategy for Hong Kong" promulgated by the Office of the Chief Secretary for Administration in June 2005, that is, to promote sustainable urban planning and design practices. The study opines that there is a need to find ways to improve air ventilation and the pedestrian wind environment of our city. Given Hong Kong's dense urban conditions, wind is beneficial. In general, "the more wind the better" is the guiding approach. Velocity ratio (VR_W). has been proposed to be the indicator for air ventilation assessment. This would provide an objective basis for evaluating and comparing design options.

The "Technical Guide for Air Ventilation Assessment for Developments in Hong Kong" proposed by the study allows design options to be compared on a scientific and objective basis with respect to the effect on air ventilation. An advisory approach to implementation with the government taking a lead is recommended. A technical circular, based on the technical guide, setting out guidance for applying air ventilation assessments to major government projects was promulgated in July 2006 [19]. In addition, Chapter 11 of HKPSG on urban design guidelines has been expanded to incorporate guidelines on air ventilation based on the recommendations of this study in August 2006 [20].

The AVA study is unique and highly original. As such one must regard it as a first step in the direction of understanding the wind environment. For more understanding of the problems, further studies and researche are essential and strongly recommended, namely: Stage B – Urban climatic map; Stage C – Benchmarking; and Stage D – Quantitative guidelines.

Last but not least, improving air ventilation for a better wind environment is only one of the many considerations towards sustainable development in Hong Kong. In planning, one must attempt to balance other equally if not more important considerations and as far as possible synergize needs to result in an optimized design.

To further the recommendation of the air ventilation assessment study and for enhanced and long-term improvement of the wind environment, in July 2006, the Planning Department commissioned a consultancy on the Urban Climatic Map and Standards for Wind Environment - Feasibility Study. This further study is scheduled to be completed in Jun 2010. The study has again been entrusted to researchers of the Chinese University of Hong Kong with the collaboration of many local and overseas experts and specialists. The study will draw together expertise and experience from academics, scientists, meteorologists of the Hong Kong Observatory, planners, architects and various construction industry stakeholders. Apart from drafting an urban climatic analysis map and a planning recommendation map for Hong Kong with reference to the German experience [21,22], field studies, user surveys, wind tunnel tests, mesoscale MM5 wind simulations, computational fluid dynamics simulation tests will also be conducted.

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