HKGBC Guidebook on Urban Microclimate Study

Technical Seminar & Launching Event

Guidebook Introduction

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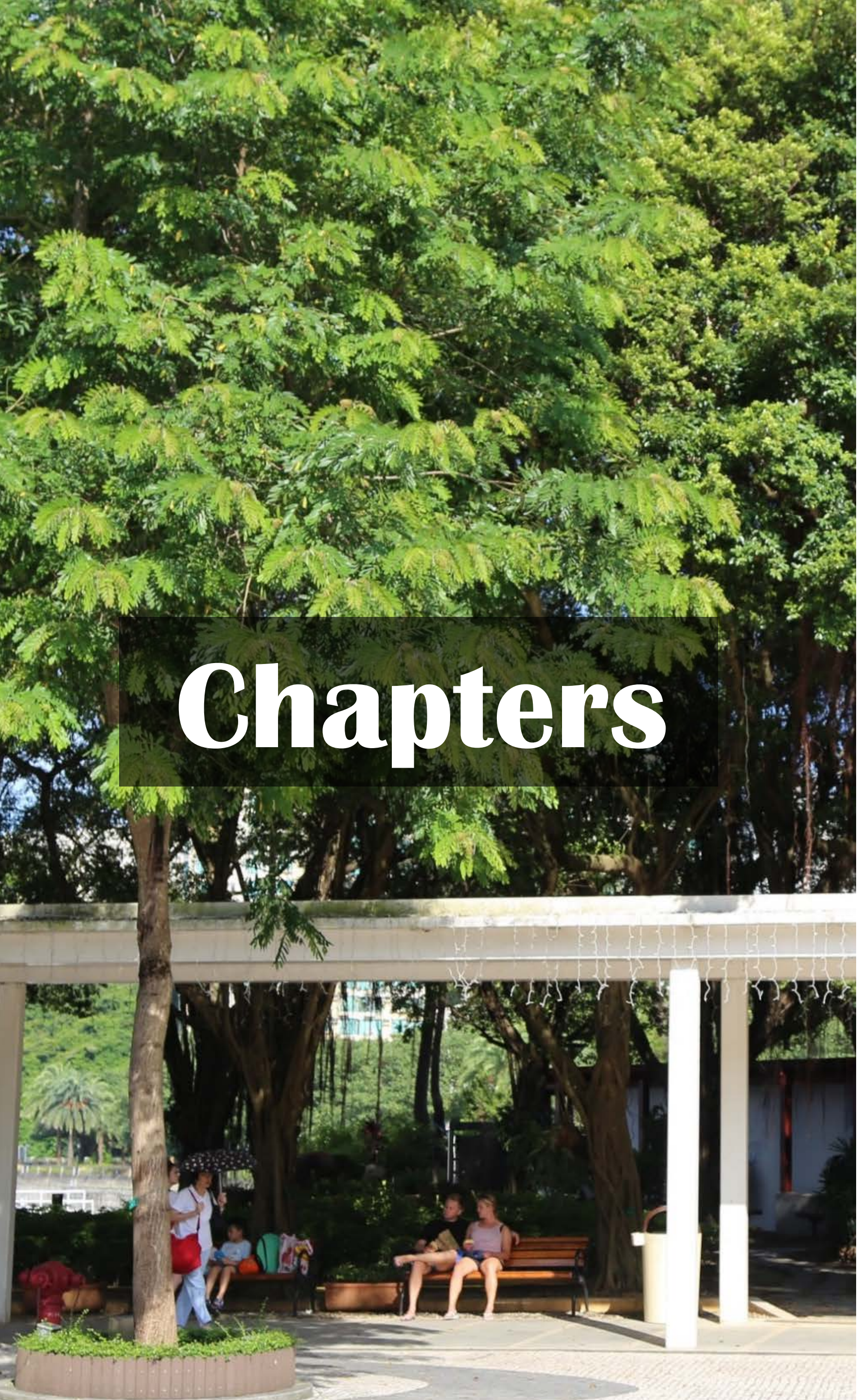
Objectives

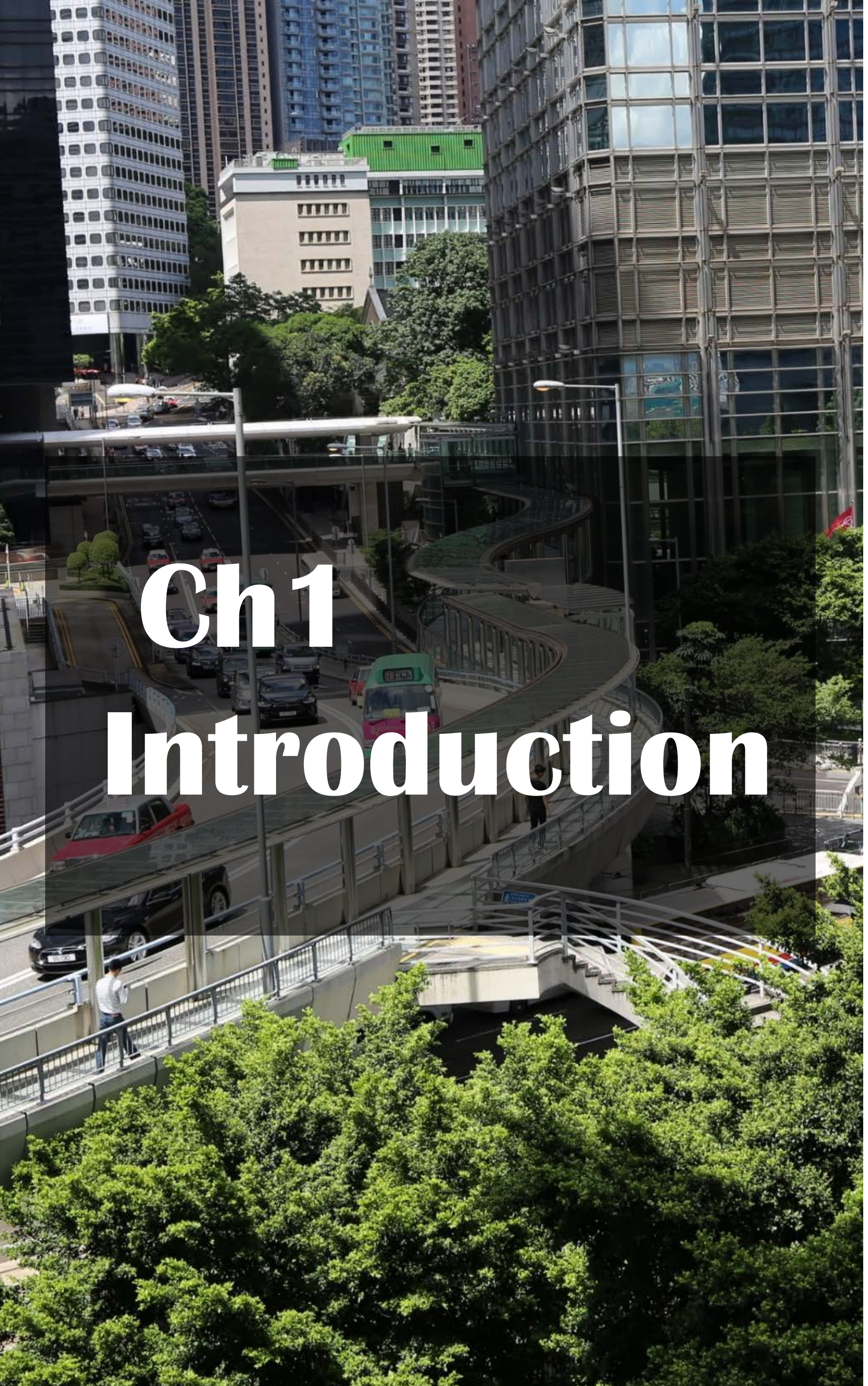
- To provide the knowledge of and inspiration for urban microclimate design for practitioners in the building industry

- The guidebook aims to be forward-looking, user-friendly and easily applicable.



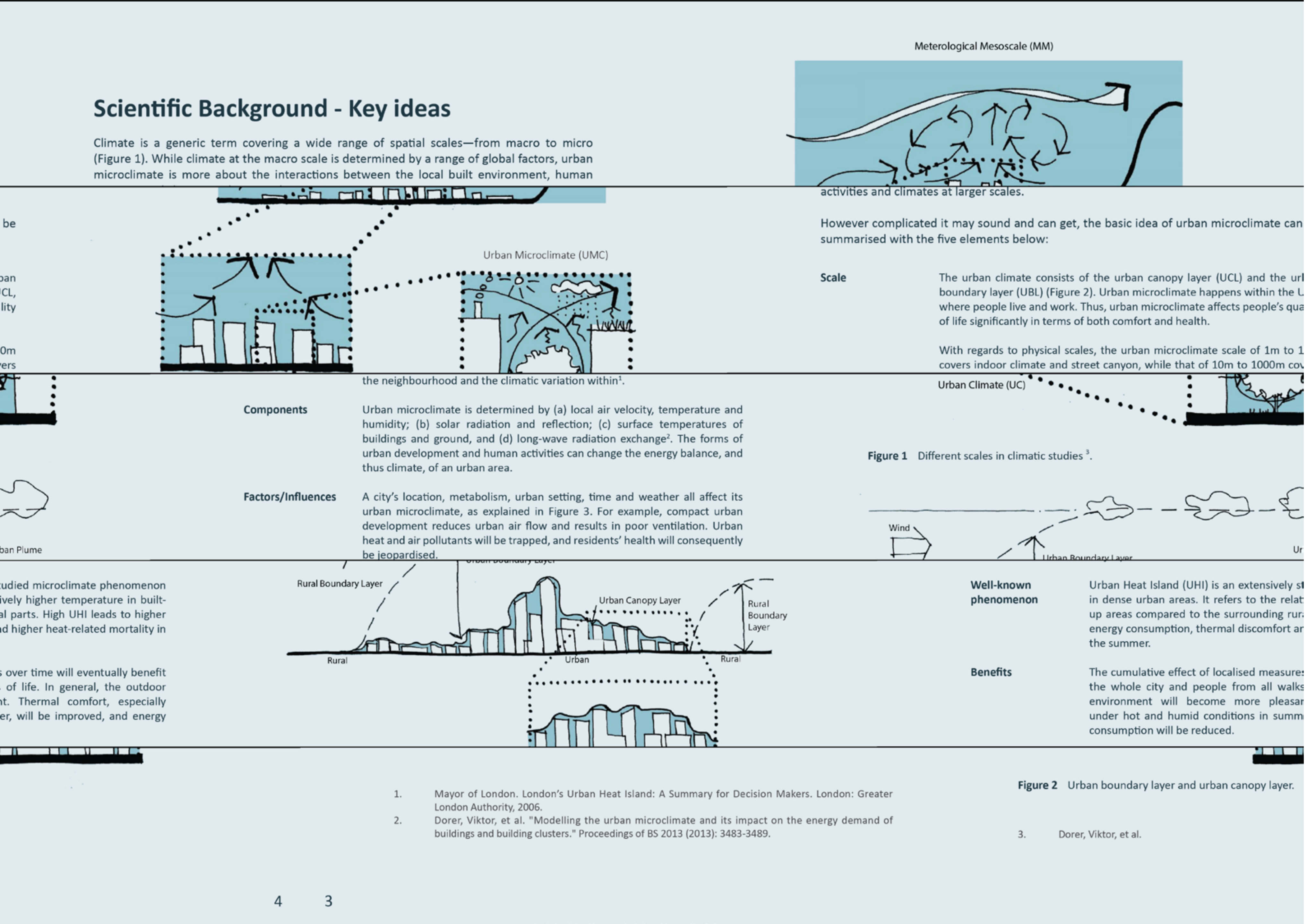
Chapters

1. Introduction
2. Guidelines for Urban Microclimate Design
3. Sub-tropical Urban Microclimate Design
4. Local Good Practices– Case Studies
5. Way Forward



Ch1 Introduction

- Scientific Background– Key Ideas
- Why Climate Change Matters
- Outdoor Human Thermal Comfort
- Hong Kong Context



Scientific Background - Key ideas

Climate is a generic term covering a wide range of spatial scales—from macro to micro (Figure 1). While climate at the macro scale is determined by a range of global factors, urban microclimate is more about the interactions between the local built environment, human

activities and climates at larger scales.

However complicated it may sound and can get, the basic idea of urban microclimate can summarised with the five elements below:

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Scale The urban climate consists of the urban canopy layer (UCL) and the url boundary layer (UBL) (Figure 2). Urban microclimate happens within the U where people live and work. Thus, urban microclimate affects people's qua of life significantly in terms of both comfort and health.

With regards to physical scales, the urban microclimate scale of 1m to 1 covers indoor climate and street canyon, while that of 10m to 1000m cov the neighbourhood and the climatic variation within[1].

Components Urban microclimate is determined by (a) local air velocity, temperature and humidity; (b) solar radiation and reflection; (c) surface temperatures of buildings and ground, and (d) long-wave radiation exchange[2]. The forms of urban development and human activities can change the energy balance, and thus climate, of an urban area.

Figure 1 Different scales in climatic studies [3].

Factors/Influences A city's location, metabolism, urban setting, time and weather all affect its urban microclimate, as explained in Figure 3. For example, compact urban development reduces urban air flow and results in poor ventilation. Urban heat and air pollutants will be trapped, and residents' health will consequently be jeopardised.

udied microclimate phenomenon
ively higher temperature in built-
al parts. High UHI leads to higher
d higher heat-related mortality in

s over time will eventually benefit
. of life. In general, the outdoor
nt. Thermal comfort, especially
er, will be improved, and energy

Well-known phenomenon Urban Heat Island (UHI) is an extensively st in dense urban areas. It refers to the relat up areas compared to the surrounding rur energy consumption, thermal discomfort ar the summer.

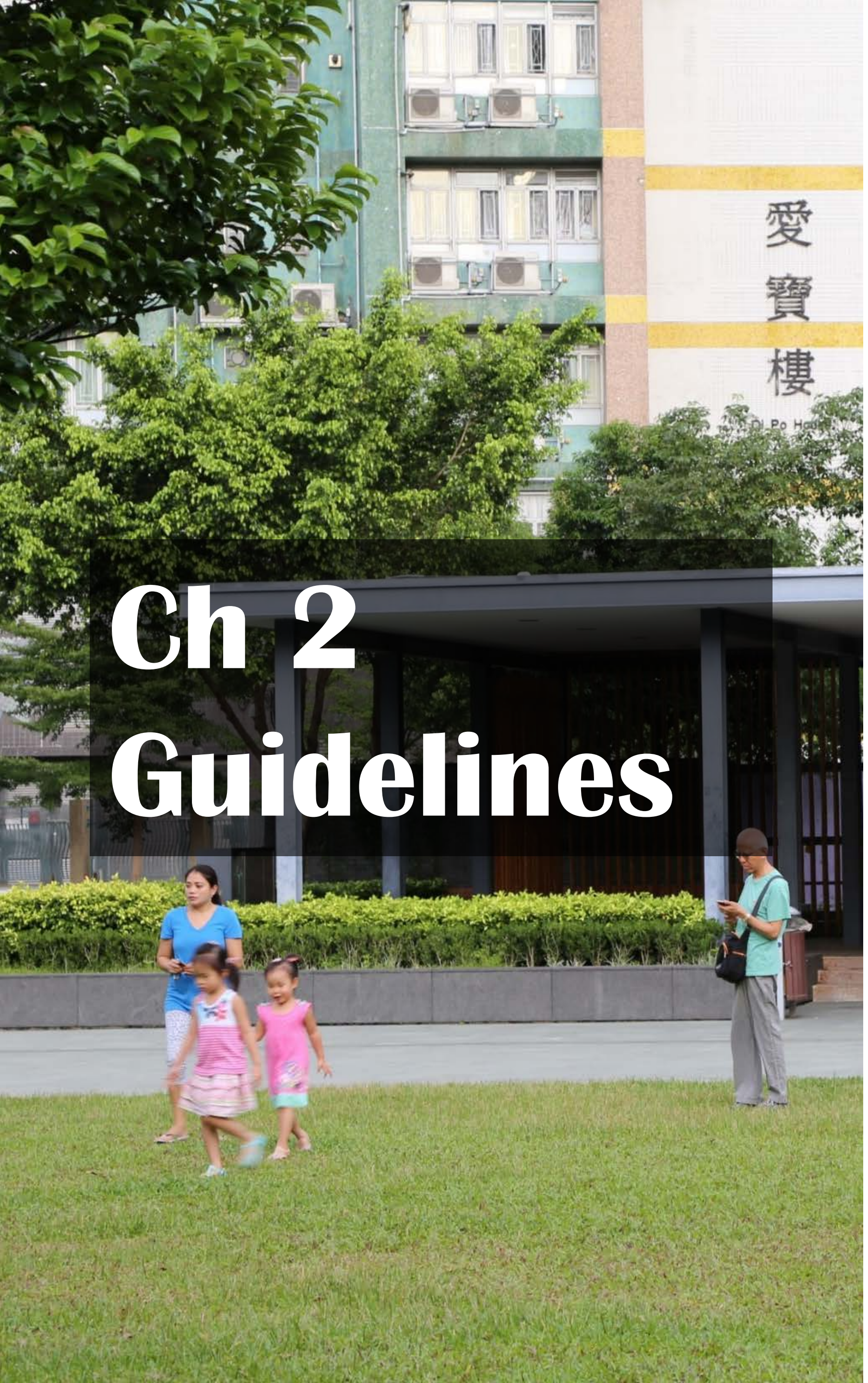
Benefits The cumulative effect of localised measures the whole city and people from all walks environment will become more pleasar under hot and humid conditions in summ consumption will be reduced.

Figure 2 Urban boundary layer and urban canopy layer.

1. Mayor of London. London's Urban Heat Island: A Summary for Decision Makers. London: Greater London Authority, 2006.
2. Dorer, Viktor, et al. "Modelling the urban microclimate and its impact on the energy demand of buildings and building clusters." Proceedings of BS 2013 (2013): 3483-3489.
3. Dorer, Viktor, et al.

4 3

- Scientific concept summarized in simple language
- Concept explained with lively illustration



Ch 2 Guidelines

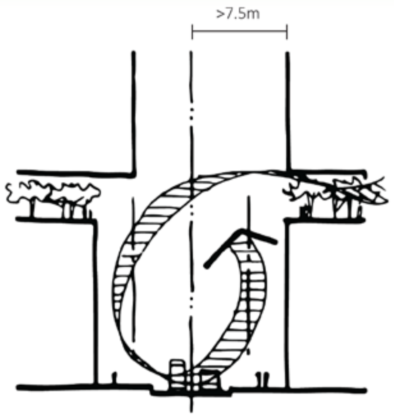
31 Strategies

Wind
- Increase ventilation with site planning
- Increase ventilation with building design

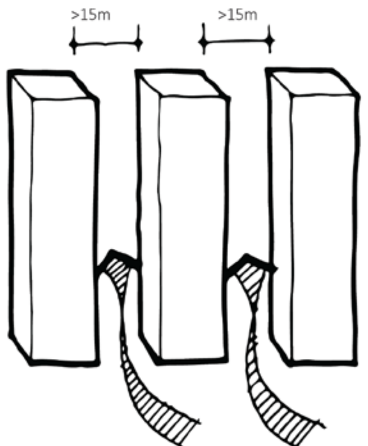
Thermal Radiation
- Reduce direct solar radiation
- Reduce surface temperature

Temperature
- Increase evaporative cooling
- Reduce heat accumulation
- Reduce heat release

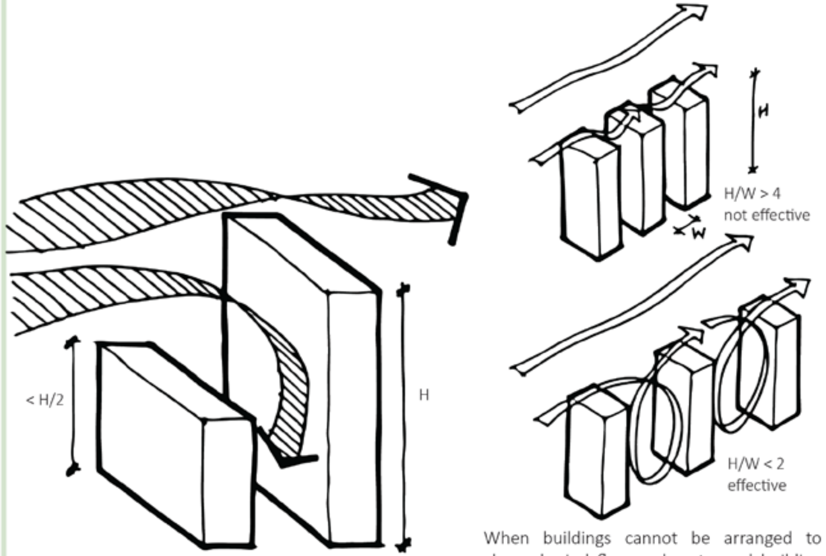
Precipitation
- Provide rain protection



05 Building setback



06 Increase permeability of building blocks/ No wall building



07 Stepped building height profile

When buildings cannot be arranged to channel wind flow and a stepped building height profile cannot be adopted, a height-width ratio of less than 2 is recommended.

Minor breezeways

05 Building setback

Intent

Prevailing winds often flow along wind corridors and breezeways at major roadways or through building gaps. Building setback increases the distances between buildings and enables a larger volume of prevailing wind flow, thereby enhancing the wind environment of a development and its surrounding areas. (Cross reference: HKPSG Ch.11- Widening/Building Setback)

Implementation

Set back buildings at existing major wind paths by leaving clear an area of least 7.5m wide from the centreline of the adjacent roadway. When building setback is widely adopted, the total additional space along the roadway will result in better ventilation.

06 Increase permeability of building blocks / No wall building

Intent

Wall buildings are characterised by long continuous façade blocking ventilation. Impermeable building blocks reduce prevailing wind flow through the development. Building separation enables air flow towards the downwind areas, improving the wind environment for the outdoor space on the downwind side. (Cross reference: HKPSG Ch.11- Gaps between Building Blocks to Enhance Air Permeability)

Implementation

Separate buildings by at least 15m to create minor breezeways. The continuous length of a particular façade should be less than five times the width of the street canyon along it to avoid wall building effect.

07 Stepped building height profile

Intent

In a high-density urban environment, closely clustered buildings give rise to a generally weak wind environment in the streets. However, if the building heights are varied, mid-to-high-level prevailing wind can be captured and diverted downwards to the pedestrian area by the downwash effect. Thus, the appropriate use of a stepped building height profile can potentially improve ventilation in an urban area. This is an alternative strategy when buildings cannot be arranged to channel or direct wind due to site constraints. (Cross reference: HKPSG Ch.11- Stepping Height Profile to Divert Winds to Lower Levels)

Implementation

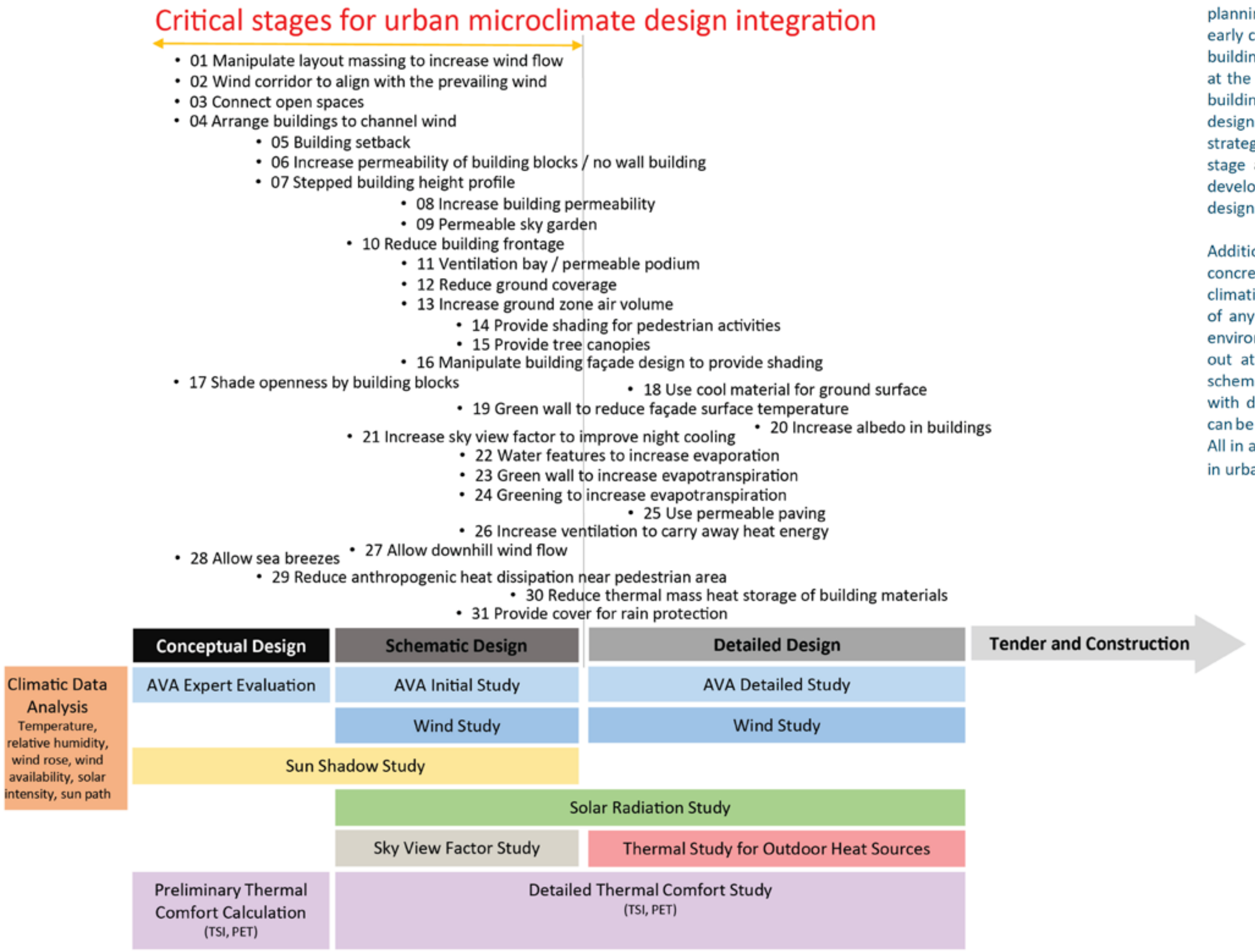
For a multi-building development, adopt a stepped building height profile by placing lower buildings on the windward side. For a single-building development, consider the heights of the adjacent buildings in the design. For effective application, the taller building should at least double the height of the shorter one. The façade of the taller building should abut the podium edge so the downwash wind can reach the street below.

Tips:
Downwash wind can at times become too strong and cause safety and comfort concerns. Wind environment at the pedestrian area should be carefully studied with detailed analysis beforehand to minimise possible issues.

Further reading:
Planning Department, Urban Climatic Map and Standards for Wind Environment-- Feasibility Study (Stakeholders Engagement Digest). Hong Kong: HKSAR Government, 2011.

- Easy-to-understand graphical presentation of strategies
- Intent and implementation of each strategy explained
- When necessary, extra tips and further reading provided

Integrated Design Process



The timing of implementation of the urban microclimate design strategies introduced in the Guidebook is critical. Very often, beneficial features cannot be applied properly because considerations were made too late. Strategies related to site planning and layout massing should be planned and applied at the early conceptual design stage. Those related to building design, building permeability and landscape design can be considered at the subsequent schematic design stage. Finally, strategies on building material selection can be implemented at the detailed design stage. As such, the majority of urban microclimate design strategies should be implemented before the detailed design stage and hence the most critical stages occur early in new development projects (i.e. conceptual design and schematic design stages).

Additionally, technical studies and analyses will facilitate the concrete design of urban microclimate strategies. Desktop climatic data analysis should be conducted at the very beginning of any design works, so the project team can understand the environment of the site. Qualitative analysis should be carried out at the conceptual design stage for site planning. At the schematic design stage, the building design should be fine tuned with detailed quantitative analysis. Computational calculations can be used to optimise and verify the microclimate performance. All in all, design for thermal comfort should be the ultimate goal in urban microclimate design.

- Reminds practitioners that urban microclimate design has to be considered early on, before detailed design begins

- The extent of time sensitivity varies from strategy to strategy

Linkage to BEAM Plus

BUILDING ENVIRONMENTAL ASSESSMENT METHOD (BEAM) provides building users with a single performance label that demonstrates the overall quality of a building, either new or refurbished, or one that is already in use. A building certified by BEAM Plus is safer, healthier, more comfortable, more functional and more efficient than a similar building that does not achieve the level of performance prescribed in BEAM.

BEAM Plus embraces a range of good practices in planning, design, construction, management, operation and maintenance of buildings, and is aligned with local regulations, standards and codes of practice. Urban microclimate design is addressed in several credits under different BEAM Plus rating schemes.

The following table summarises the linkage between the urban microclimate design strategies in the Guidebook and the BEAM Plus rating system, specifically BEAM Plus New Buildings Version 1.2, its newer Version 2.0[20] and Neighbourhood Version 1.0. Details of the linkage are further described in Section 4.3.1 and 4.3.2. Credit information such as credit intent, background and requirements will not be stipulated in the Guidebook. Please refer to the BEAM Plus New Buildings Version 1.2 Manual, BEAM Plus New Buildings Version 2.0 Manual and BEAM Plus Neighbourhood Version 1.0 Manual for details.

20. Disclaimer: The BEAM Plus NB V2.0 credits and summary presented in this chapter are based on the BEAM Plus NB V2.0 Upgrade Training Course held in July 2017. Please refer to the official release of NB V2.0 manual for any discrepancy.

		BEAM Plus New Buildings Version 1.2						BEAM Plus New Buildings Version 2.0								BEAM Plus Neighbourhood Version 1.0						
		SA P1	SA7a	SA7b	SA8a	SA8b	SA8c	SA P1	SA1	SA7	SA8	SA9	SA10	SA11	HWB3	CA3d	SA2a	SA2b	SA2c	SA7	OEQ1	OEQ2
Wind																						
Increase ventilation with site planning																						
1	Manipulate layout massing to increase wind flow				●		●				●	●	●								●	●
2	Wind corridor to align with the prevailing wind				●		●				●	●	●								●	●
3	Connect open spaces				●		●				●	●	●								●	●
4	Arrange buildings to channel wind				●		●				●	●	●								●	●
5	Building setback				●		●				●	●	●			●			●	●	●	●
6	Increase permeability of building blocks / no wall building				●		●				●	●	●								●	●
7	Stepped building height profile				●		●				●	●	●								●	●
Increase ventilation with building design																						
8	Increase building permeability				●		●				●	●	●								●	●
9	Permeable sky garden				●		●				●	●	●								●	●
10	Reduce building frontage				●		●				●	●	●								●	●
11	Ventilation bay / permeable podium				●		●				●	●	●								●	●
12	Reduce ground coverage				●		●				●	●	●				●	●			●	●
13	Increase ground zone air volume				●		●				●	●	●								●	●
Thermal Radiation																						
Reduce direct solar radiation																						
14	Provide shading for pedestrian activities					●					●		●			●			●	●	●	
15	Provide tree canopies	●		●				●	●	●	●		●			●			●	●	●	●
16	Manipulate building façade design to provide shading					●					●		●			●			●	●	●	●
17	Shade openness by building blocks										●		●								●	●
Reduce surface temperature																						
18	Use cool material for ground surface										●											●
19	Green wall to reduce façade surface temperature	●		●				●	●		●									●		●
20	Increase albedo in buildings					●					●											●
21	Increase sky view factor to improve night cooling										●									●		●
Temperature																						
Increase evaporative cooling																						
22	Water features to increase evaporation	●		●				●			●			●			●	●		●		●
23	Green wall to increase evapotranspiration	●		●				●	●		●									●		●
24	Greening to increase evapotranspiration	●		●				●	●		●			●			●	●		●		●
25	Use permeable paving		●								●			●								●
Reduce heat accumulation																						
26	Increase ventilation to carry away heat energy																					
27	Allow downhill wind flow																					
28	Allow sea breezes																					
Reduce heat release																						
29	Reduce anthropogenic heat discharge near pedestrian area								●													
30	Reduce thermal mass heat storage of building materials																					
Precipitation																						
Provide Rain protection																						
31	Provide cover for rain protection					●					●		●		●	●			●	●	●	

Table 6 Summary of the linkage between the urban microclimate strategies and BEAM Plus rating system.

Links to local credit system BEAM Plus

Ch 3 Overseas UMC Design

Singapore

Guidelines and South Beach

Japan

CASEBEE-HI, Osaki in Tokyo and ACROS Fukuoka Prefectural International Hall

Brisbane, Australia

Guidelines: Buildings that Breathe

Macau

New Reclamation Areas

CHAPTER 3.2

Japan

In Japan, urban microclimate efforts at the policy level are best reflected in its guidelines, assessment system, and the setup of 'model areas' to mitigate the urban heat island effect.

Guidelines for Architectural Design to Mitigate the Urban Heat Island Effect were issued by the Ministry of Land Infrastructure and Transport in 2004, followed by *the Comprehensive Assessment System for Building Environmental Efficiency on Heat Island Relaxation (CASBEE-HI)* in 2006.

They encourage owners, professionals and designers in the building industry to adopt mitigation measures. The Guidelines give recommendations on shading, surface cover, exterior construction materials, open and airy space and heat release from the building.

Related strategies:

- Wind corridor to align with the prevailing wind
- Connect open spaces
- Building setback
- Ventilation bay / permeable podium
- Reduce ground coverage
- Provide shading for pedestrian activities
- Manipulate building façade design to provide shading
- Greening to increase evapotranspiration

CASBEE-HI is part of the CASBEE family which looks at the Built Environment Efficiency. CASBEE-HI addresses the quality of the outdoor environment of a building site, the load of the surrounding environment and the planet as a whole. It evaluates building designs by their effects on urban ventilation, shadows, the choice of ground cover materials, the choice of wall materials, and building and anthropogenic heat emissions. The assessment of each item is conducted according to the building type (residential or non-residential), site conditions, and plot ratios.

Concrete implementation examples can be seen in the model areas established under the policy *Development of Measures against Global Warming and Heat Islands through Urban Renaissance Projects*. Thirteen areas in 10 cities were designated in 2005, where environmental and energy-saving measures were implemented to mitigate the UHI effect. The **Osaki/ Meguro** district in Tokyo is one such area.

The plan to transform the Osaki Station district dates back to July 2002, when it was designated an urban emergency redevelopment area under the Urban Renaissance Special Measures Law. The overall aim was to make the iconic Meguro River part of the area's environmental resources with emphases on UHI mitigation measures, creation of space for the area's community, development of guidelines, and their application to reduce the environmental loads from building projects.

Related strategies:

- Greening to increase evapotranspiration
- Use permeable paving

In the project, space is created along the Meguro river for residents to interact with water and enjoy Osaki's environmental attributes; wind paths are set aside by positioning buildings at a 45 degree angle to the river; water-retentive pavement is used to lower the temperature of the surface; trees and plants are erected along the road; green spaces are extended to the adjacent land to develop cool spots.

Following that, voluntary proposal *Osaki Station District Environmental-conscious Guidelines* was set forth in July 2005 to encourage developers to undertake environmental measures to mitigate UHI. An *Environmental-conscious Manual* was also developed to present examples to aid practitioners in the implementation of the guidelines.

Read more:

Yamamoto, Yoshika. "Measures to Mitigate Urban Heat Islands." Science and Technology Trends Quarterly Review 18.1 (2006): 65-83.

Link to strategies introduced in the last chapter

Explore what other places do to improve the outdoor urban environment

Case Study: ACROS Fukuoka Prefectural International Hall, Fukuoka, Japan

Originally a park in the city centre, the space was transformed into 15 stepped terraces of the ACROS Fukuoka Prefectural International Hall. The project presents itself as a powerful solution to reconcile a developer's desire for profitable use of a site with the public's need for open green space.

The city-owned site was the last large undeveloped plot in central Fukuoka. It was eventually designated to be developed under a joint-venture scheme, where part of the building's space would be devoted to public and municipal operations, and the remaining revenue-producing. As concerns were raised about the effect of the development on the adjacent Tenjin Central Park, the architect decided to design the space in a way that the same area of land taken up by the building will be given back to the public.

Hence, the building's green terraces are made assessable to the public as gardens for meditation and relaxation, while the top floor offers a panorama of the bay of Fukuoka and the surrounding mountains. Apart from plants, a stepped series of reflecting pools are set up on the terraces and connected by upwardly spraying jets of water. The resulting ladder-like climbing waterfall helps mask the ambient noise of the city beyond. Moreover, the façade of the building rakes outwardly and acts as an awning over the sidewalk to shade pedestrians.

Related strategies:

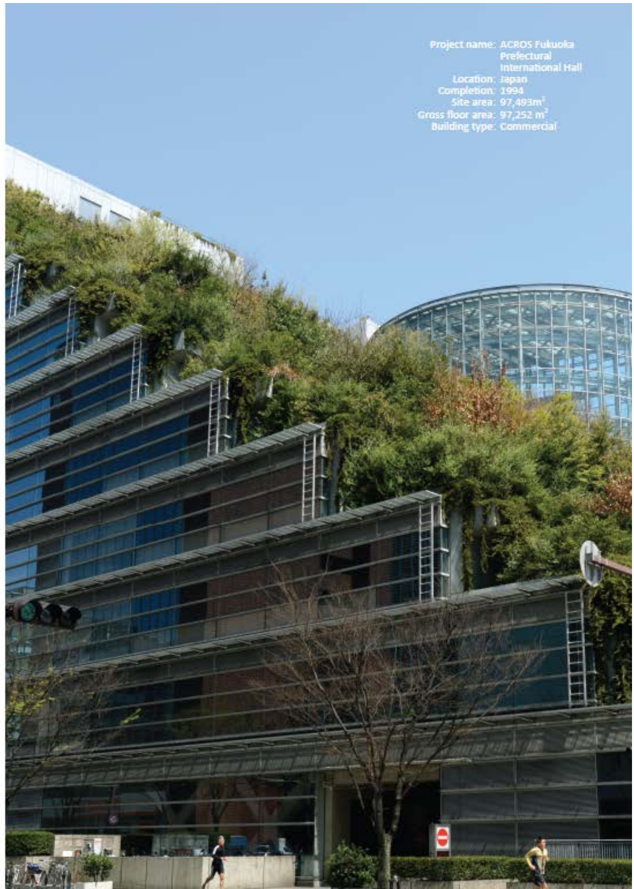
- Wind corridor to align with the prevailing wind
- Provide shading for pedestrian activities
- Green wall to reduce façade surface temperature
- Water features to increase evaporation
- Greening to increase evapotranspiration

The plant-covered building is proved to be effective in alleviating UHI in a study in 2000 by the Takenaka Corporation, Kyushu University, and Nippon Institute of Technology, which found a difference of 15°C between the surface temperatures of the concrete and the greenery.

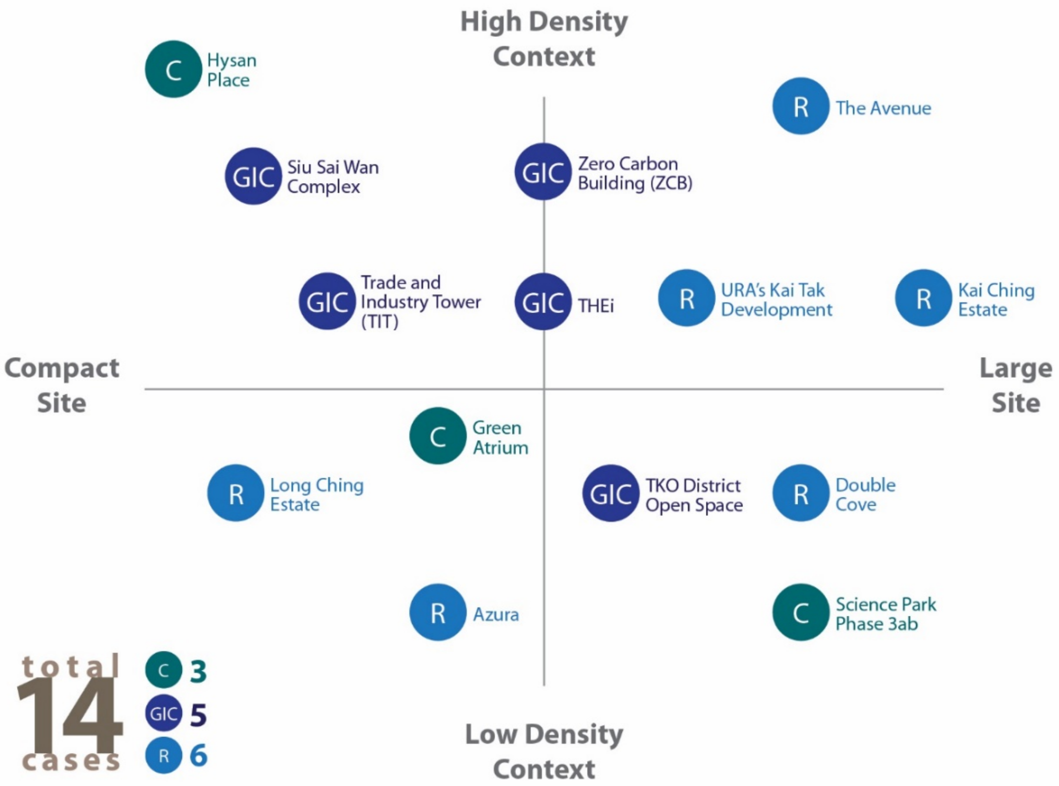
Read more:

Greenroofs. "ACROS Fukuoka Prefectural International Hall." 2015. Web. <http://www.greenroofs.com/projects/pview.php?id=476>.

The ambient air temperature of the surrounding is reduced due to evapotranspiration of vegetation.



Ch 4 Local Good Practice



For each case, 6 questions are asked:

1. Where is the project site?
2. What are the key microclimate features?
3. Why is it important to are for the microclimate there?
4. How were the microclimate conditions studied and improved?
5. When were the microclimate conditions and potential strategies taken into account in the process?
6. What are the expected achievements?

Each case explained with pictures and illustrations

HK CASE STUDY 1
LARGE SITE

Kai Ching Estate

Increase ventilation with site planning

Location: Kai Tak
Completion: 2013
Site area: 34,700m²
Gross floor area: 224,750m²
Building type: Public housing
Recognition: GBA2014 Merit

Where The large new-development site in Kai Tak faces the Victoria Harbour on one side and the old and dense districts of San Po Kong, Choi Hung and Kowloon Bay on the other.

What Prevailing wind and sea breezes.

Why The high density of its neighbouring districts means its master layout plan and building design must be carefully developed to minimise or even eliminate the impact not only on its own microclimatic conditions, but also its vicinity's. The wind environment is of particular concern.

How A microclimate study was conducted by the Housing Authority. The project has employed a range of urban microclimate strategies, which can be referred to on p. 68. Two features are of particular emphasis here:

Improving the wind environment:
- Manipulate layout massing to increase wind flow (Strategy 01);
- Increase permeability of building blocks/ no wall buildings (Strategy 06).

When The wind environment at the site and the surrounding neighbourhoods was considered at both the planning and design stages. At the planning stage, the layout massing was arranged to align with the wind corridors. At the design stage, the wind environment was further optimised with building design strategies. For example, openings were provided at the ground level and wings of domestic blocks were rotated to widen building separation. Thermal comfort at the open spaces with pedestrian activities was analysed and recommendations were made for areas of concern.

Achievements
- Capturing the incoming south-easterly prevailing wind and sea breezes;
- Improvement in the wind environment, maximisation of natural ventilation at the site, and increase in wind penetration;
- Improvement in residents' outdoor thermal comfort condition in summer.

Domestic blocks were positioned to capture the prevailing south-easterly and south-westerly wind for most of the year to maximise its ventilation performance.

Blocks were designed to have no bulky podium structures to reduce ground coverage and increase permeability for better ventilation at open spaces. The provision of large ventilation bays further improves the building permeability.

The site has a greening ratio of 30%, cooling the open space with evapotranspiration. Large trees were planted at the pedestrian areas to improve thermal comfort.

HK CASE STUDY 13
SINGLE BUILDING

Hysan Place

Increase ventilation with building design

Location: Causeway Bay
Completion: 2012
Site area: 4,435m2
Gross floor area: 65,960m2
Building type: Shopping mall/ office
Recognition: GBA2012 Merit
BEAM Plus NB V1.1 Platinum

Where The single-tower redevelopment project stands amid a cluster of high-rise buildings project in the densely populated district of Causeway Bay.

What Limited ventilation.

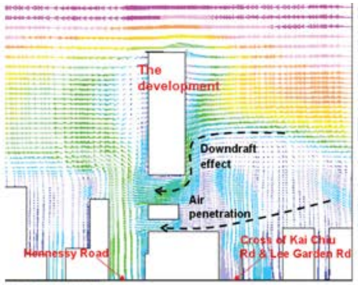
Why Although the project itself is a single office and retail-mall tower, the microclimatic conditions of the crowded district could be adversely affected if considerations were not duly given to the design. The wind environment is of particular concern.

How An AVA study was conducted by the developer and different design proposals were compared with CFD simulations to look for the best permeability and ventilation effect. The project has employed a range of urban microclimate strategies, which can be referred to on p. 68. A feature is of particular emphasis here:

Improving the wind environment:
- Increase building permeability at above-ground levels by constructing large openings in the building structure (Strategy 08).

When A CFD simulation was conducted during the schematic design stage to evaluate the wind environment at the development and its surroundings. The study assisted the project team in the quantification of the wind penetration effect of the urban windows.

Achievements
- Improvement in the wind environment and maximisation of natural ventilation;
- Increase in wind penetration;
- Greenery coverage at different heights.



CFD analysis was conducted to evaluate the effectiveness of the urban window design under major prevailing wind conditions.

The three openings in the building structure act as urban windows for wind to penetrate high up from the ground.

Sky gardens are elevated from the ground to avoid heat from the roadway. They are shaded by the building profile for better comfort.

Key features stipulated

Ch 5 Way Forward

- Science and Technology Development
- Policy, Practice and Design
- Public Awareness and Education

Science and Technology Development

- Past effort acknowledged
- Continuous support for research needed
- Adequate funding required

Policy, Practice and Design

- Concerted effort from the government important
- Policy encouragement needed to motivate developers
- Industry practitioners should play an active role

Public Awareness and Education

- More effort to produce easy-to-understand material to practitioners and laymen
- Bridge education gap between brief courses and PhD level knowledge pursuit


富裕地產
We make our City. Then our City makes us.