A REVIEW OF STUDIES ON THE RELATIONSHIP BETWEEN URBAN MORPHOLOGY AND URBAN CLIMATE TOWARDS BETTER URBAN PLANNING AND DESIGN IN (SUB)TROPICAL REGIONS

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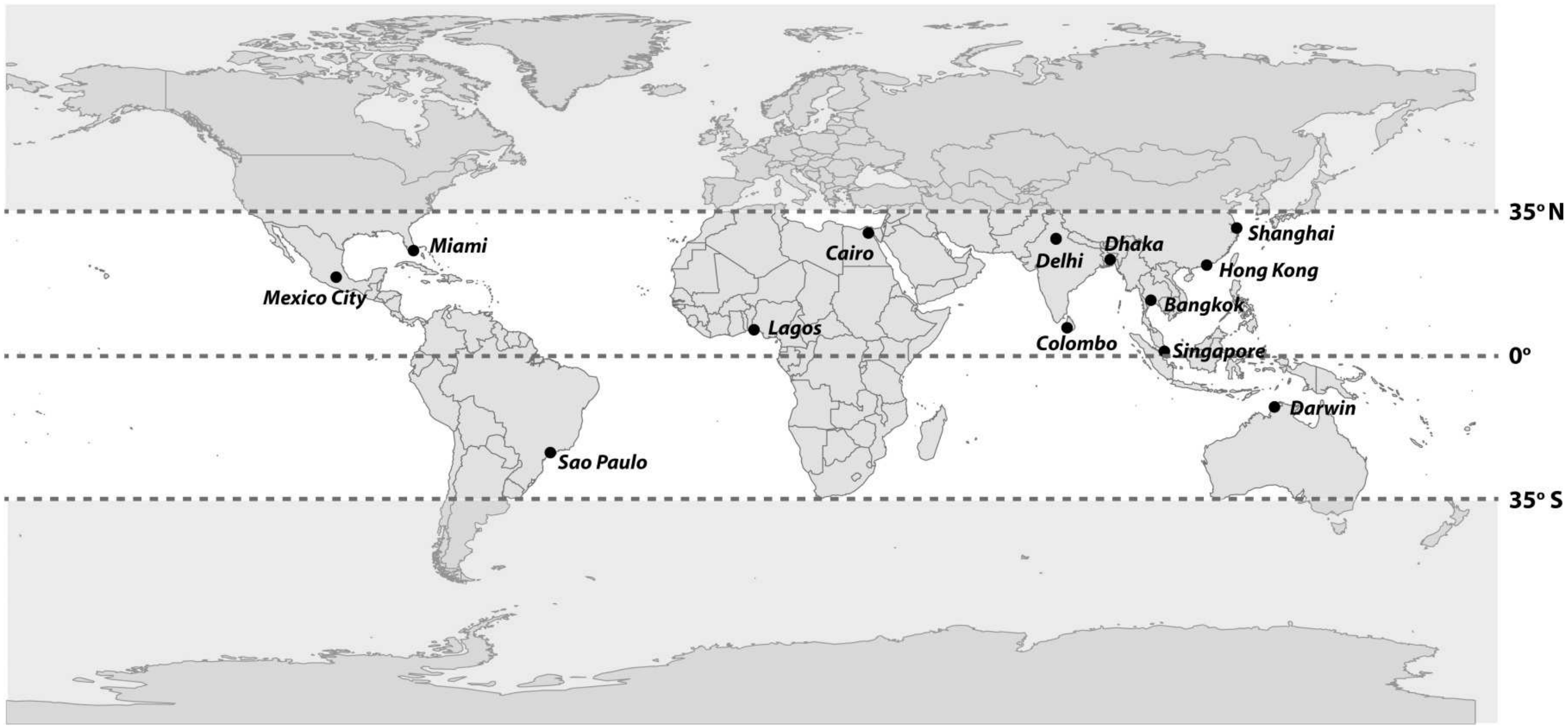
INTRODUCTION & BACKGROUND

Population increasing

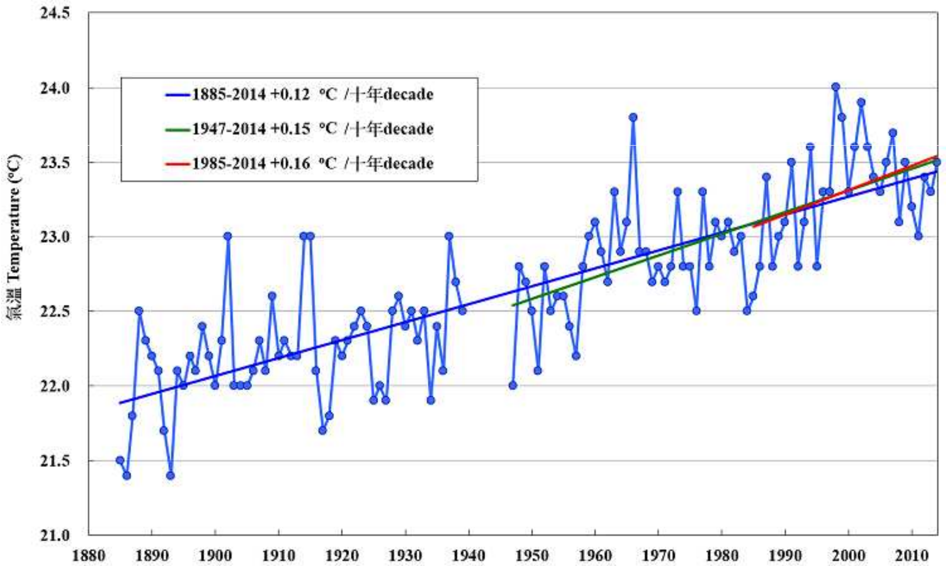


By 2050, mega-cities with more than 10 million people in the world, 22 of 37 in (sub)tropical regions (United Nations, 2012)

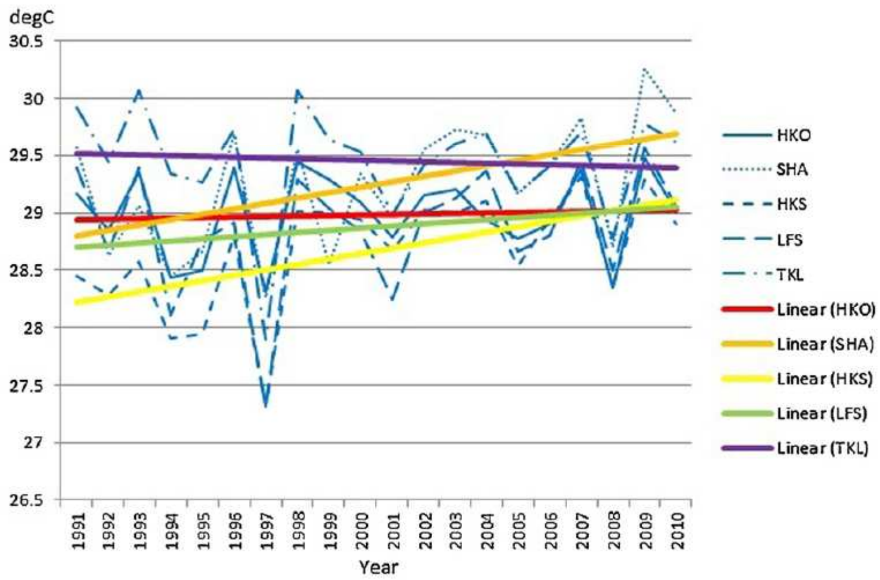
INTRODUCTION & BACKGROUND

Temperature Rising, UHI

Hong Kong



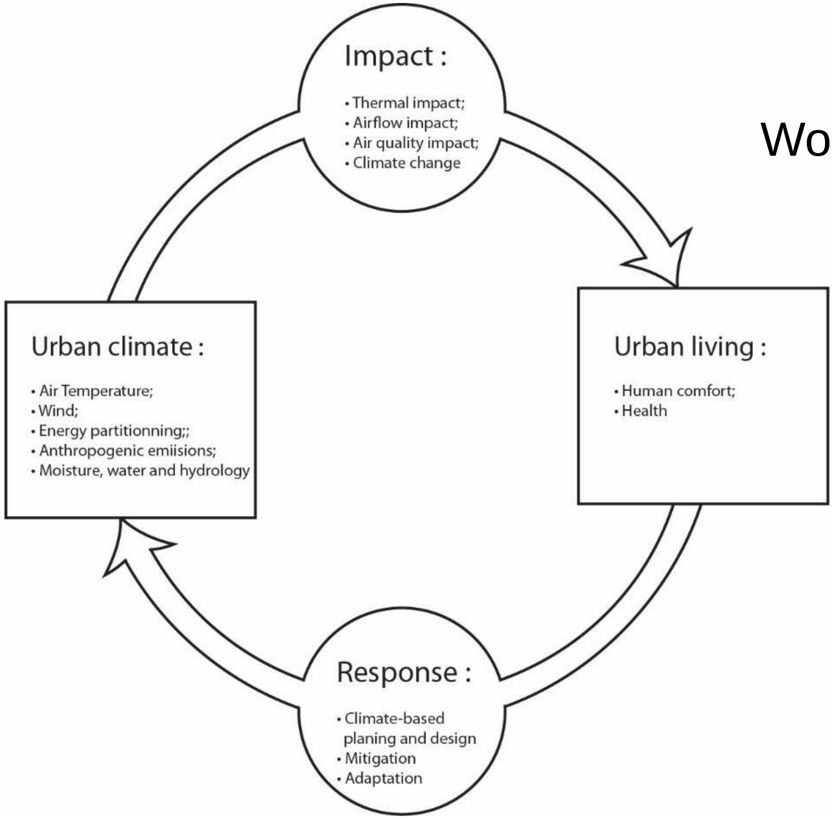
(source: HKO)



Source: Lau et al., 2013

Urban climate and urban living

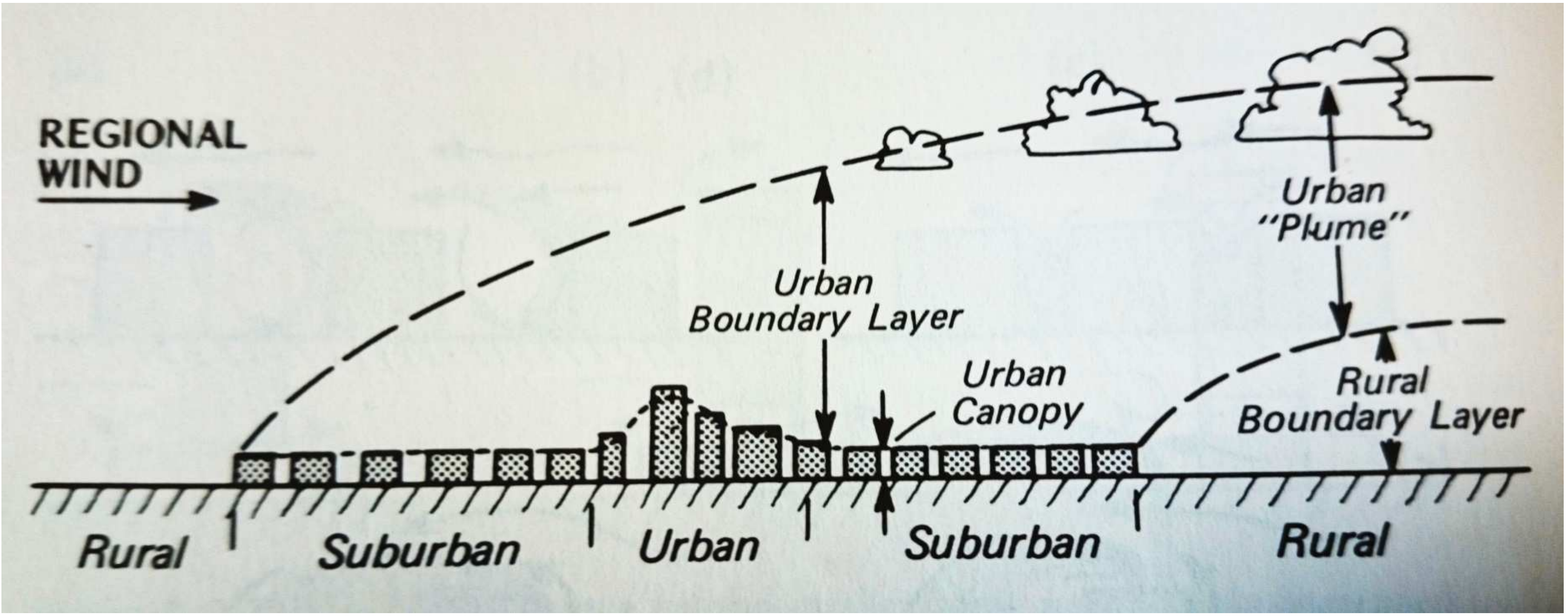
World Climate Conference-3



Framework of the understanding of the relationship between urban climate and urban living based on Grimmond et al.(2010) *and Mills et al.*(2010)*.*

URBAN CLIMATE AND URBAN MORPHOLOGY

Scientific understanding of Urban Climate and Urban Morphology



Schematic representation of the urban atmosphere illustrating a two-layer classification of urban modification (Oke, 1987)

Studies on urban forms affecting urban climate

Researchers	City	Climate	Spatial scale	Urban morphological parameters	Approaches
Emmanuel & Fernando (2007)	Colombo, Sri Lanka; Phoenix, Arizona	equatorial wet; sub-tropical dry	Micro scale	Density	Numerical simulation
Johansson & Emmanuel (2006)	Colombo, Sri Lanka;	equatorial wet;	Micro scale	H/W, SVF, Orientation	Numerical simulation, Field measurements
Ali-Toudert et al. (2005); Ali-Toudert & Mayer (2006)	Beni-Isguen and Ghardaia ,Algeria	sub-tropical dry	Micro scale	H/W	Numerical simulation, Field measurements
Johansson (2006)	Fez, Morocco	sub-tropical dry	Local scale	H/W, Orientation	Field measurements
Fahmy & Sharples (2009)	Cairo, Egypt	sub-tropical dry	Local scale	compactness factor	Numerical simulation
Middel et al. (2014)	Phoenix, the United States	sub-tropical dry	Local scale	LCZ classification	Numerical simulation
Krüger et al (2011)	Curitiba, Brazil	sub-tropical highland		SVF	Numerical simulation, Field measurements
Chen et al.(2012)	Hong Kong	sub-tropical humid	Local scale	SVF	GIS-based simulation
Ng et al.(2011)	Hong Kong	sub-tropical humid	Local	Frontal area density, Ground coverage ratio	Numerical simulation
Yuan & Ng (2012a)	Hong Kong	sub-tropical humid	Local	Different building morphologies	Numerical simulation
Hwang et al (2011); Lin et al. (2012)	Huwei Township, central Taiwan	sub-tropical humid	Local	SVF	Numerical simulation, Field measurements

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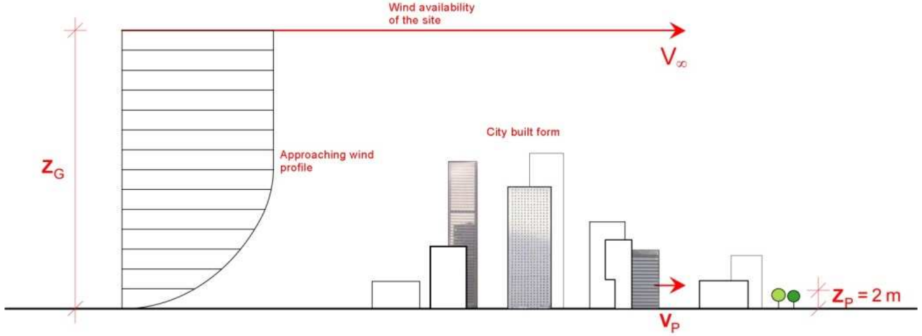
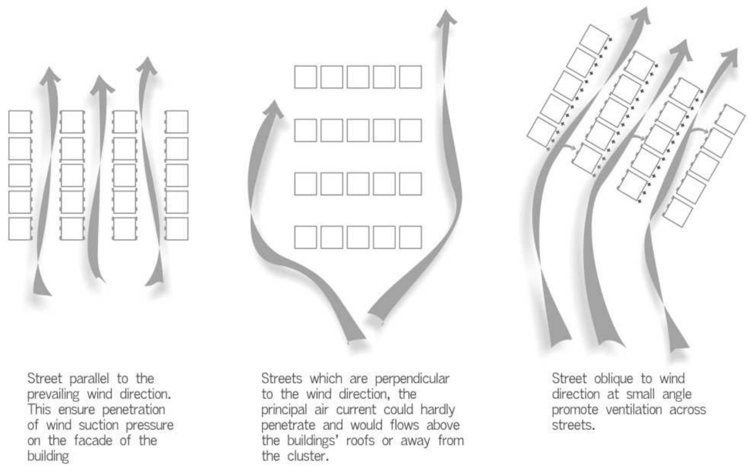
Scientific understanding



Planning and Design



(source: HKPSG)

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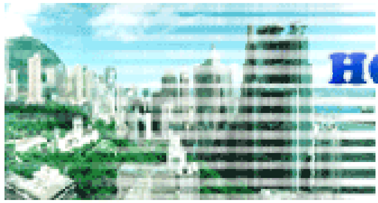
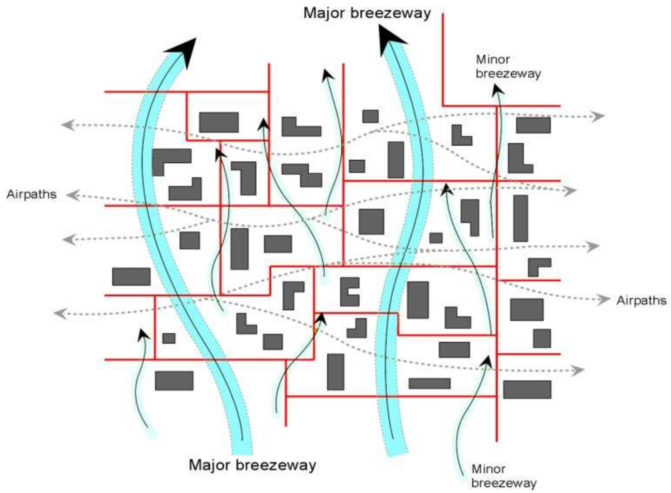


HONG KONG PLANNING STANDARDS AND GUIDELINES

Ch11 Urban Design Guidelines

11. Qualitative Guidelines on Air Ventilation

Qualitative guidelines I



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 forms 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

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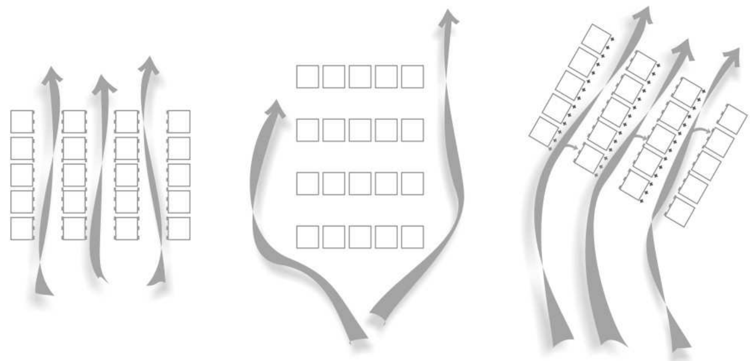
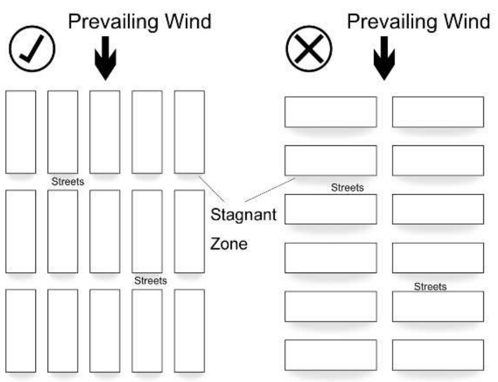
Qualitative guidelines II



Street parallel to the prevailing wind direction. This ensure penetration of wind suction pressure on the facade of the building

Streets which are perpendicular to the wind direction, the principal air current could hardly penetrate and would flows above the buildings' roofs or away from the cluster.

Street oblique to wind direction at small angle promote ventilation across streets.



Orientation of Street Grids

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

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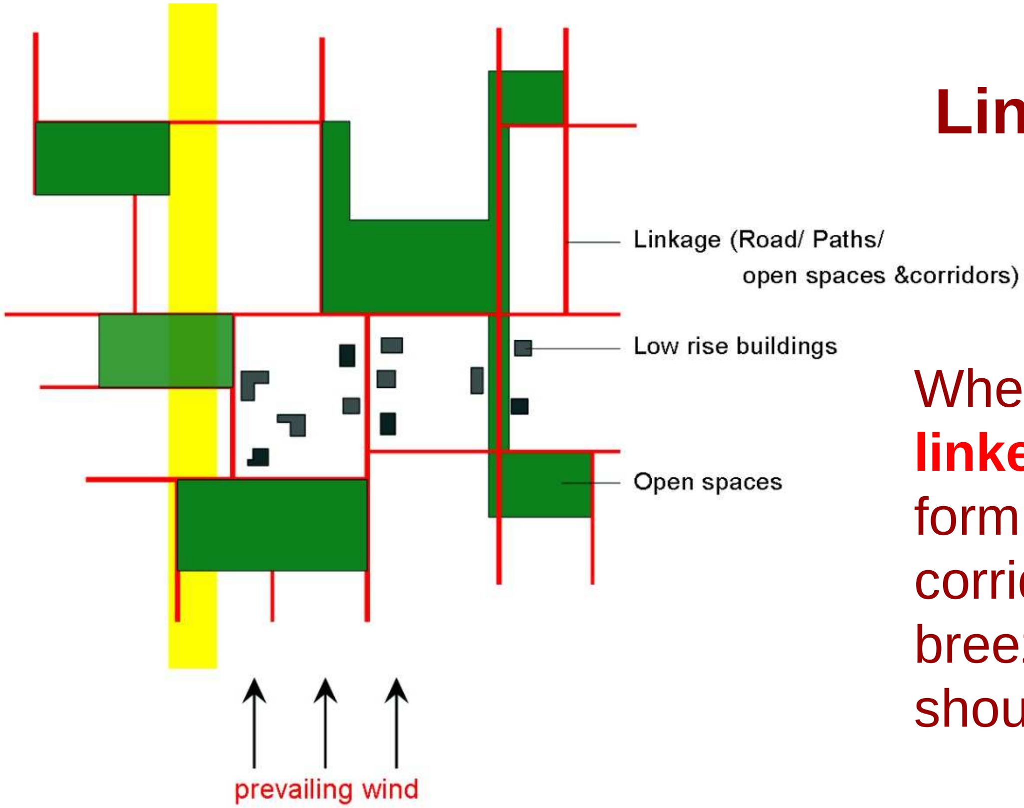
Qualitative guidelines III



Linkage of Open Spaces

Where possible, open spaces may be **linked** and **aligned** in such a way to form breezeways or ventilation corridors. Structures along breezeways/ventilation corridors should be low-rise.

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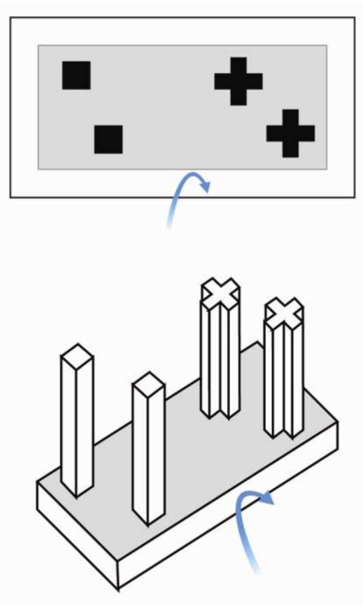
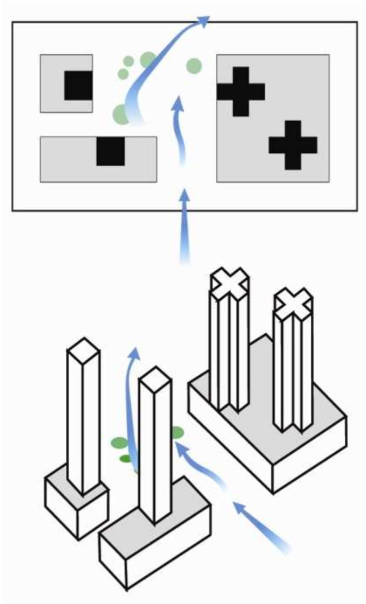
Qualitative guidelines IV





Non-building Area

Compact developments on large sites are particularly impeding air movement. Development plots should be laid out and orientated to maximize air penetration by aligning the longer frontage in parallel to the wind direction and by introducing non-building areas and setbacks where appropriate.

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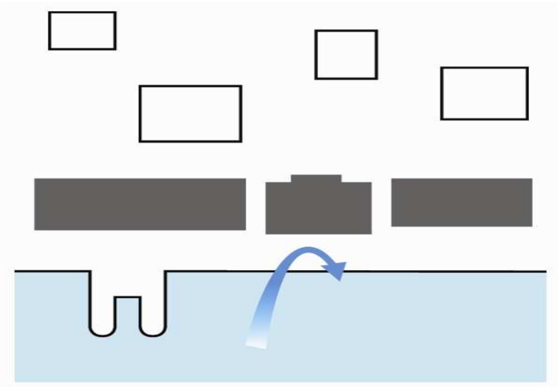
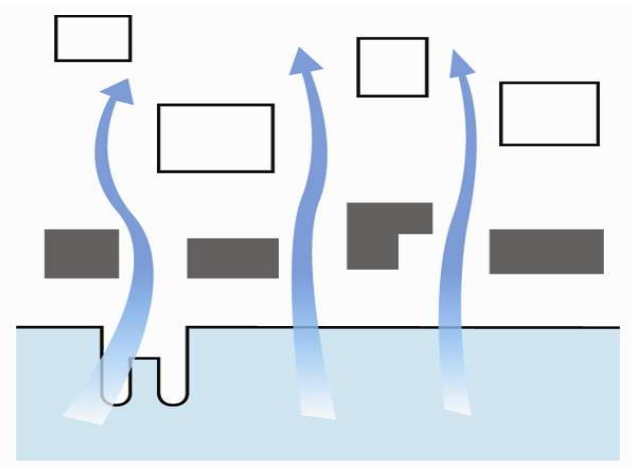
Qualitative guidelines V



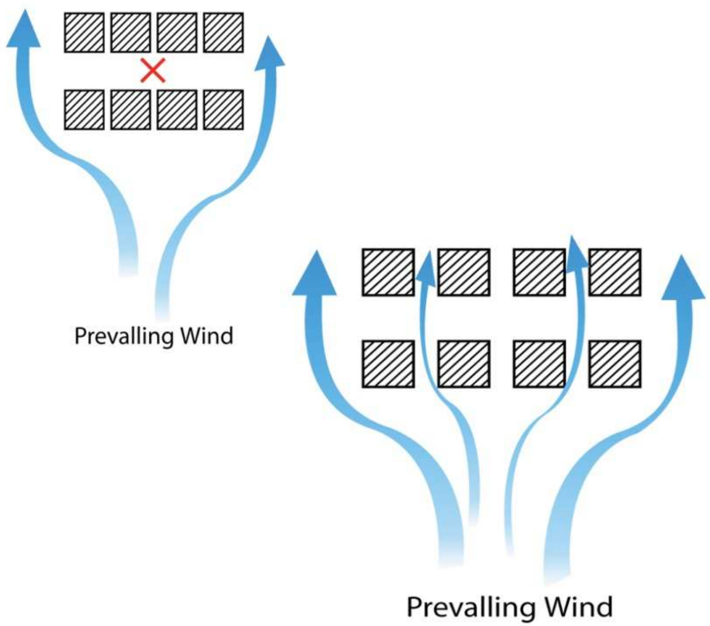


Waterfront Sites

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.

Qualitative guidelines VIII

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 wind capturing potential of adjacent developments. The gaps for enhancing air permeability are preferably at a face perpendicular to the prevailing wind.

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Buildings Department
The Government of the Hong Kong Special Administrative Region

First issue January 2011

Buildings Department	Practice Note for Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers	APP - 152

Sustainable Building Design Guidelines

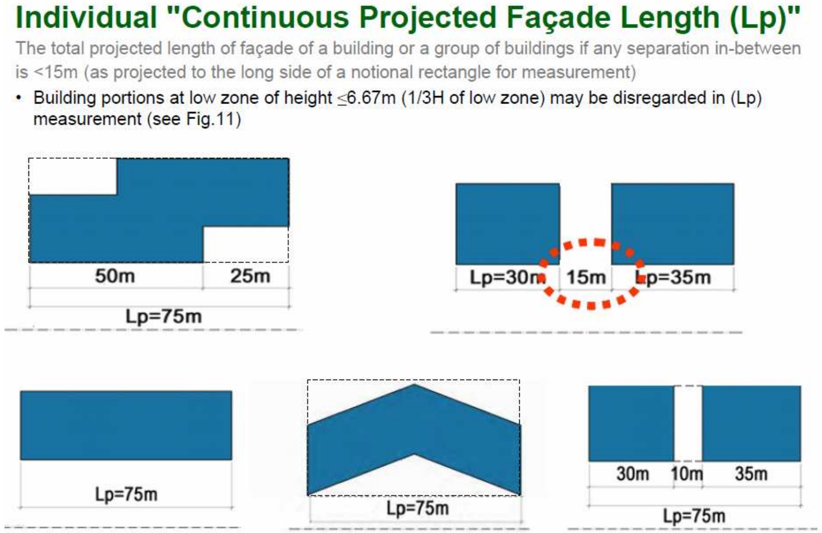
Three key elements:

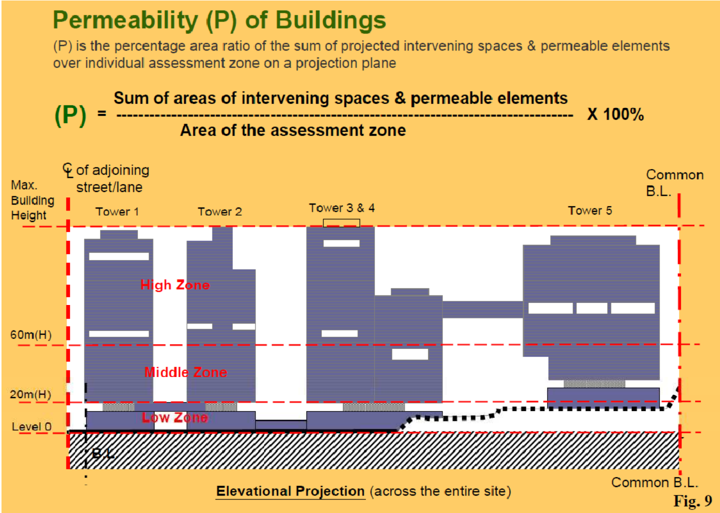
- Building separation,
- Building set back
- Site coverage of greenery

SBD Guidelines: Building Separation

Height[5] (H) of the tallest building	Permeability (P) of Buildings	
	Site area < 20,000 m^2 and with building(s) of Lp ≥ 60m long	Site area ≥ 20,000 m^2 (regardless of the length of buildings)
H ≤ 60m	20%; 20%	20%; 25%
H > 60m	20%; 20%	20%; 33.3%

Table 1 - Minimum permeability (P) of buildings.





SBD Guidelines: Building Set Back

Measures for Compliance with the Building Set Back Requirement

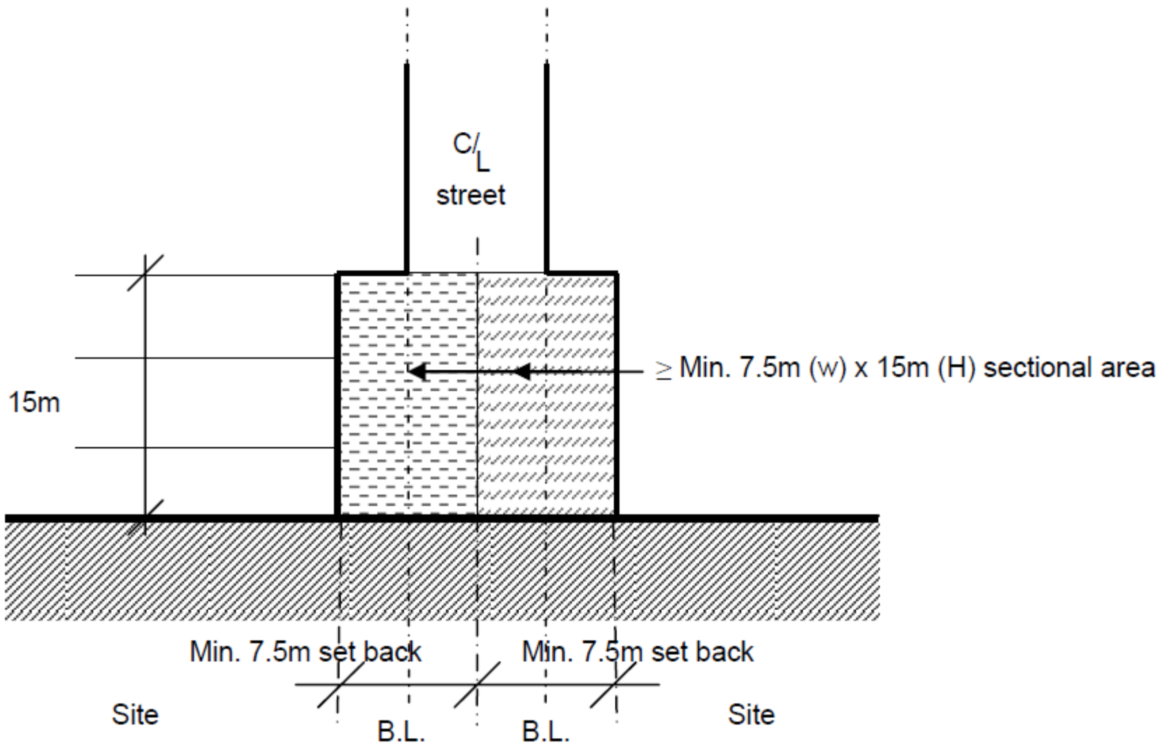
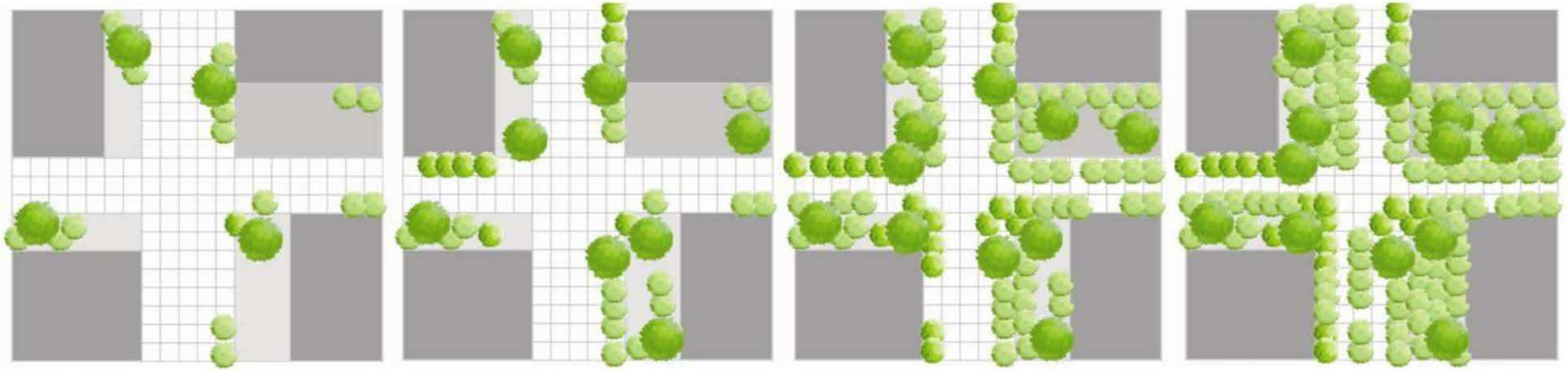


Fig. 1 Building set back as detailed in paragraph 13(a)

SBD Guidelines: Site Coverage of Greenery

Site Area (A)	Minimum Site Coverage of Greenery (i.e. percentage of greenery area over site area)		
	Pedestrian zone	Other locations	Total greenery areas
1,000 m^2 ≤A< 20,000 m^2	10%	no limit	20%
A ≥ 20,000 m^2	15%	no limit	30%

Table 2 Site coverage of greenery requirement



Ng, E., Liang, C., Wang, Y. N. and Yuan, C., (2011) *A study on the Cooling Effects of Greening in High Density City: an experience from Hong Kong*, Building and Environment, online 28 July 2011, ISSN 0360-1323, DOI: 10.1016/j.buildenv.2011.07.014.

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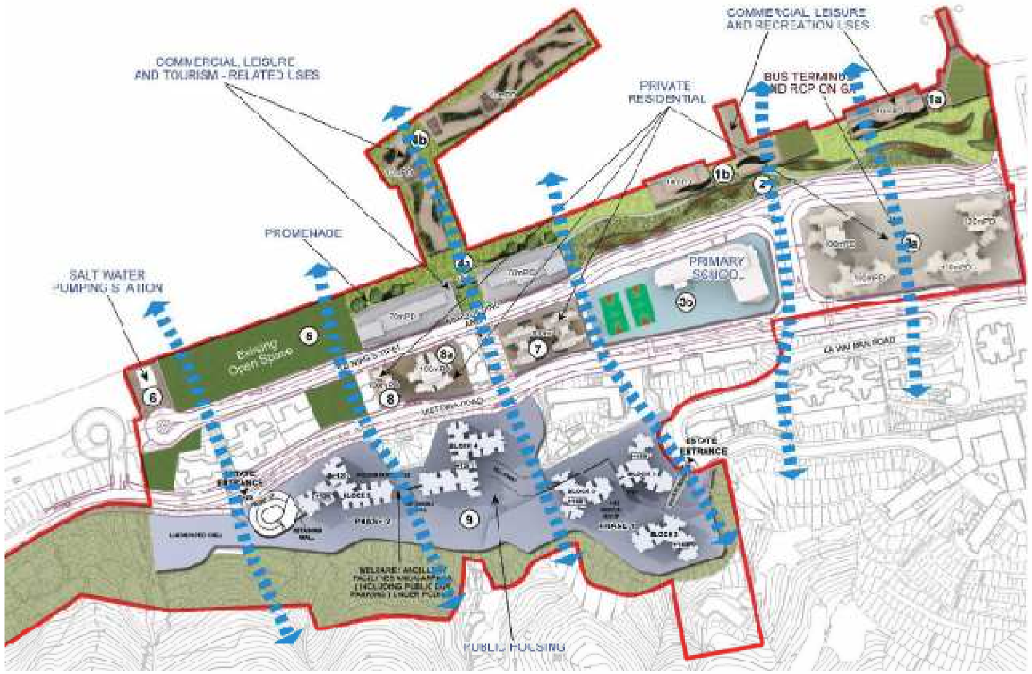
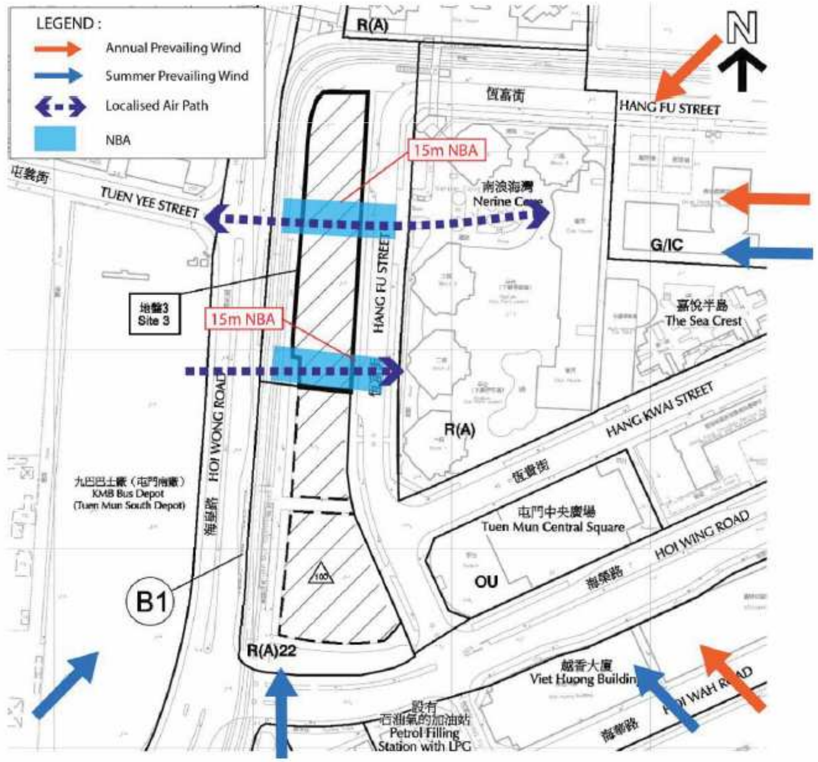
Air Ventilation Assessment

Base on the HKPSG and SBD guidelines





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Climate-related considerations in Environmental assessment methods

Developer	Assessment Tool	Climate-related considerations
Japan	CASBEE for Urban Development(CASBEE, 2007)	Q_{ud}1- Natural Environment (microclimates and ecosystems) LR_{ud}1- Environmental impact on microclimates, façade and landscape
Singapore	BCA Green Mark for Districts(BCA, 2013)	Part 4 – Environmental Planning : 4-3 Microclimate Optimisation 4-4 Outdoor Thermal Environment
HK	BEAM Plus (HKGBC and BEAM Society, 2012)	SA 7 Landscaping and Planters SA 8 Microclimate Around Buildings
India	IGBC Green New Buildings Rating System(IGBC, 2014)	SA Credit 3 Passive Architecture SSP Credit 6 Heat Island Reduction, Non-roof SSP Credit 7 Heat Island Reduction, Roof

DISCUSSION AND CONCLUSIONS

- Correct understanding of local climate and urban morphology is crucial for climate-based urban planning and design. (High H/W not applicable to everywhere)
- The translation of the scientific understanding of mitigation strategies to urban planning and design guidelines is little in tropical and sub-tropical regions.
- The climate change will intensify the impact of urban microclimate on tropical and sub-tropical environments and make city more vulnerable. One of future urban climate studies in these regions needs to incorporate the consideration of climate change and its impact at city level.

Thank you!

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