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
INTRODUCTION & BACKGROUND

Urban climate and urban living

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

<table>
<thead>
<tr>
<th>Researchers</th>
<th>City</th>
<th>Climate</th>
<th>Spatial scale</th>
<th>Urban morphological parameters</th>
<th>Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fahmy &amp; Sharples (2009)</td>
<td>Cairo, Egypt</td>
<td>sub-tropical dry</td>
<td>Local scale</td>
<td>Compactness factor</td>
<td>Numerical simulation</td>
</tr>
<tr>
<td>Middel et al. (2014)</td>
<td>Phoenix, the United States</td>
<td>sub-tropical dry</td>
<td>Local scale</td>
<td>LCZ classification</td>
<td>Numerical simulation</td>
</tr>
<tr>
<td>Krüger et al (2011)</td>
<td>Curitiba, Brazil</td>
<td>sub-tropical highland</td>
<td>Local scale</td>
<td>SVF</td>
<td>Numerical simulation, Field measurements</td>
</tr>
<tr>
<td>Chen et al.(2012)</td>
<td>Hong Kong</td>
<td>sub-tropical humid</td>
<td>Local scale</td>
<td>SVF</td>
<td>GIS-based simulation</td>
</tr>
<tr>
<td>Ng et al.(2011)</td>
<td>Hong Kong</td>
<td>sub-tropical humid</td>
<td>Local</td>
<td>Frontal area density, Ground coverage ratio</td>
<td>Numerical simulation</td>
</tr>
<tr>
<td>Yuan &amp; Ng (2012a)</td>
<td>Hong Kong</td>
<td>sub-tropical humid</td>
<td>Local</td>
<td>Different building morphologies</td>
<td>Numerical simulation</td>
</tr>
<tr>
<td>Hwang et al (2011); Lin et al. (2012)</td>
<td>Huwei Township, central Taiwan</td>
<td>sub-tropical humid</td>
<td>Local</td>
<td>SVF</td>
<td>Numerical simulation, Field measurements</td>
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</table>
Scientific understanding

Planning and Design

(source: HKPSG)
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.
Qualitative guidelines II

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.
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.
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.
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.
Three key elements:
- Building separation,
- Building set back
- Site coverage of greenery
SBD Guidelines: Building Separation

<table>
<thead>
<tr>
<th>Height(^5) (H) of the tallest building</th>
<th>Permeability (P) of Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site area &lt; 20,000 m(^2) and with building(s) of Lp ≥ 60m long</td>
<td>20%; 20%</td>
</tr>
<tr>
<td>Site area ≥ 20,000 m(^2) (regardless of the length of buildings)</td>
<td>20%; 20%</td>
</tr>
</tbody>
</table>

**Table 1 - Minimum permeability (P) of buildings**

*Continuous Projected Façade Length (Lp)*

The total projected length of façade of a building or a group of buildings if any separation in-between is <15m (as projected to the long side of a notional rectangle for measurement).

- Building portions at low zone of height ≤ 6.67m (1/3H of low zone) may be disregarded in (Lp) measurement (see Fig.11).

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**Permeability (P) of Buildings**

\[ (P) = \frac{\text{Sum of areas of intervening spaces & permeable elements}}{\text{Area of the assessment zone}} \times 100\% \]
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

<table>
<thead>
<tr>
<th>Site Area (A)</th>
<th>Minimum Site Coverage of Greenery (i.e. percentage of greenery area over site area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000 m² ≤ A &lt; 20,000 m²</td>
<td>Pedestrian zone: 10%, Other locations: no limit, Total greenery areas: 20%</td>
</tr>
<tr>
<td>A ≥ 20,000 m²</td>
<td>Pedestrian zone: 15%, Other locations: no limit, Total greenery areas: 30%</td>
</tr>
</tbody>
</table>

Table 2 Site coverage of greenery requirement

Air Ventilation Assessment

Base on the HKPSG and SBD guidelines
### Climate-related considerations in Environmental assessment methods

<table>
<thead>
<tr>
<th>Developer</th>
<th>Assessment Tool</th>
<th>Climate-related considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>CASBEE for Urban Development (CASBEE, 2007)</td>
<td>( Q_{ud1} )- Natural Environment (microclimates and ecosystems) ( LR_{ud1} )- Environmental impact on microclimates, façade and landscape</td>
</tr>
<tr>
<td>Singapore</td>
<td>BCA Green Mark for Districts (BCA, 2013)</td>
<td>Part 4 – Environmental Planning: 4-3 Microclimate Optimisation 4-4 Outdoor Thermal Environment</td>
</tr>
<tr>
<td>HK</td>
<td>BEAM Plus (HKGBC and BEAM Society, 2012)</td>
<td>SA 7 Landscaping and Planters SA 8 Microclimate Around Buildings</td>
</tr>
<tr>
<td>India</td>
<td>IGBC Green New Buildings Rating System (IGBC, 2014)</td>
<td>SA Credit 3 Passive Architecture SSP Credit 6 Heat Island Reduction, Non-roof SSP Credit 7 Heat Island Reduction, Roof</td>
</tr>
</tbody>
</table>
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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