Urban Ventilation for Counter Measures for Heat islands towards Quality and Sustainable City Planning in Hong Kong

Towards mitigating urban heat islands in sub-tropical cities

Edward Ng* and K S Wong,
School of Architecture, Chinese University of Hong Kong

Raymond Yau,
Ove Arup & Partners (HK) Ltd.

2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
Hong Kong – The land & its people

Land area: 1000 sq.km
Urban area: 220 sq.km
Population: 7 million
Urban density: approximately 100,000 / sq.km in metro areas

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The city is warming up faster
The urban environment

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Cities of extreme density and intensity

2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
UHI, is there is real solution?

BY BRYAN WALSH

2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
The quest for greenery

Greenery encouraged with plot ratio exemption!

2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
The quest for ventilation

Wall and screen like buildings affecting 1.5 million in the city!

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Urban ventilation and urban permeability

Green government HQ costs more but with holes for better ventilation!

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Urban ventilation and urban permeability

Guidelines on Air Ventilation Assessment

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.

Qualitative guidelines VI
Scale of Podium
For large development sites particularly in the existing urban areas, increase permeability of the podium structure at the 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.

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.

Department of Architecture, The Chinese University of Hong Kong on behalf of Planning Department Hong Kong SAR
Feasibility Study for Establishment of Air Ventilation Assessment System

2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
Consultancy Study on Building Design that Supports Urban Living Space in HK

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Strategies</th>
<th>Planning Actions</th>
<th>Planning Time Scale</th>
<th>Spatial Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHI Thermal Comfort</td>
<td>Albedo</td>
<td>• Cool material-building &amp; pavement; • Cool roof &amp; facade; • Water retention paving;</td>
<td>Short time Material &amp; Surface Level Intervention</td>
<td>Macro Effect</td>
</tr>
<tr>
<td>Urban Ventilation Dynamics</td>
<td>Vegetation</td>
<td>• Planting &amp; greeneries; • Parks &amp; open spaces;</td>
<td>Building Level Intervention</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shading</td>
<td>• Building geometric design; • Shelter design; • Street orientation; • H/W ratio; • Trees;</td>
<td>Urban &amp; Planning Level Intervention</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
<td>• Air paths; • Building ground cover &amp; building bulks; • H/W ratio; • Street orientation; • Open spaces; • Building disposition;</td>
<td>Long time</td>
<td>Micro Effect</td>
</tr>
</tbody>
</table>

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The Study is to review building regulations and practices and recommend any areas for improvement with a view to promoting new building design of individual development sites that can improve our urban living space.

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### Consultancy Study on Building Design that Supports Urban Living Space in HK

#### Review of Existing Measures

<table>
<thead>
<tr>
<th>Planning Level</th>
<th>Urban Living Quality</th>
<th>Building Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Examples of Relevant Guidelines &amp; Measures</td>
<td>Key Design Problems</td>
<td>Examples of Relevant Regulations &amp; Practice Notes</td>
</tr>
</tbody>
</table>

**Urban Design Guidelines**

- **Public Realm**
  - e.g., maximize planting in open space; reserve more ground level spaces and setbacks for tree planting and street activities; provide more green areas and amenity strips along circulation routes

- **Outline Development Plan & Layout Plan**
  - **Streetscape**
    - Stipulation of setback along site boundary for non-building area

- **AVA Guidelines:**
  - Shading and greenery, etc.

**Building (Planning) Regulation**

- 20 & PNAPs 233 & 280: Site Coverage, Open Space Provision, and Dedication of Land/Area for Use as Public Passage.

- PNAPs 116 & 258 & JPNs 1 & 2: Amenity Features (podium roof gardens, etc.), Provision of Sky Garden in Refuge Floor, Communal Sky Gardens, and Balconies.

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*Extracted from Kowloon Planning Area No. 14 (Part) Kwun Tong (Western Part) Outline Development Plan D/K14A/1E*

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## Consultancy Study on Building Design that Supports Urban Living Space in HK

### Review of Existing Measures

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</tr>
<tr>
<td><strong>Urban Design Guidelines</strong></td>
<td></td>
<td><strong>Building (Planning) Regulation 20 &amp; PNAPs 233 &amp; 280:</strong> Site Coverage, Open Space Provision, &amp; Dedication of Land/Area for Use as Public Passage.</td>
</tr>
<tr>
<td>Development Height Profile</td>
<td></td>
<td><strong>Building (Planning) Regulation 20(3) &amp; PNAP 223:</strong> Podium Height Restriction under B(P)R 20(3).</td>
</tr>
<tr>
<td>e.g., lowering of building height where appropriate to provide breezeways, etc.</td>
<td></td>
<td><strong>Building (Planning) Regulation 22 &amp; PNAPs 49 &amp; 70:</strong> Building Proposal affected by Street Widening, &amp; Street Improvement Schemes.</td>
</tr>
<tr>
<td><strong>Waterfront Sites</strong></td>
<td></td>
<td><strong>PNAPs 116 &amp; 258 and JPNs 1 &amp; 2:</strong> Amenity Features (podium roof gardens, etc.), and Communal Sky Gardens.</td>
</tr>
<tr>
<td>e.g., providing breezeways to the waterfront</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breezeways</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g., position open areas, podium, low-rise development and non-building areas to funnel natural air flow, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Streetscape</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.g., provide solar shade for pedestrian, etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Statutory Plan (Outline Zoning Plan &amp; Development Permission Area Plan)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land use zonings and stipulation of building height control</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AVA Guidelines</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breezeway and air path, linkage of open spaces, non-building area, waterfront sites, scale of podium, building heights, building disposition, horizontal projections, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
### Review of Existing Measures

#### Planning Level

**Examples of Relevant Guidelines & Measures**

<table>
<thead>
<tr>
<th>Urban Design Guidelines</th>
<th>Building Level</th>
<th>Building (Planning) Regulation 20 &amp; PNAPs 233 &amp; 280: Site Coverage, Open Space Provision, &amp; Dedication of Land/Area for Use as Public Passage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Realm</td>
<td></td>
<td>Building (Planning) Regulation 20(3) &amp; PNAP 223: Podium Height Restriction under B(P)R 20(3).</td>
</tr>
<tr>
<td>e.g., introduce setback at appropriate corner site, adopt high quality architectural design building facade and podium edge at ground and first floor levels, encourage provision of open space at ground, podium and roof levels, etc.</td>
<td></td>
<td>Building (Planning) Regulation 22 &amp; PNAPs 49 &amp; 70: Building Proposal affected by Street Widening, &amp; Street Improvement Schemes.</td>
</tr>
</tbody>
</table>

#### Streetscape

<table>
<thead>
<tr>
<th>e.g., provide shade for pedestrian, reduce podium coverage to allow more open spaces at grade, etc.</th>
</tr>
</thead>
</table>

#### AVA Guidelines

<table>
<thead>
<tr>
<th>Shading &amp; greenery, cool materials, etc.</th>
</tr>
</thead>
</table>

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Consultancy Study on Building Design that Supports Urban Living Space in HK

Identification of Priority Areas

Promoting building design that facilitates better air ventilation

Promoting building design that mitigates the heat island effect

Promoting building design that enhances the pedestrian environment / public space

Promoting building design that provides more greenery

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Identification of Deficiencies & Constraints

- Need for an Overall Framework

<table>
<thead>
<tr>
<th>Sustainable City Programme Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Sector Objectives</td>
</tr>
<tr>
<td>Indicators</td>
</tr>
<tr>
<td>Building Design Guidelines</td>
</tr>
<tr>
<td>Recommended Practice</td>
</tr>
</tbody>
</table>

- Need for Effective Measures
- Need for Performance-based Approach
1. Building Separation / Permeability

2. Site Coverage of Greenery

3. Setback for Minimum Air Volume at Pedestrian Zone in Deep & Narrow Street Canyon
1. Building Separation / Permeability

Existing Urban Fabric: Mongkok

\[ P \sim 30\% \]
\[ (L_p = 30\sim 45m, \quad S = 15\sim 30m) \]
## 1. Building Separation / Permeability

**Reference Standard: Mainland China**

<table>
<thead>
<tr>
<th>Building Height (H)</th>
<th>Continuous Length of Building Facade (L) <em>(As projected to the adjoining street alignment)</em></th>
<th>Building Separation (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H \leq 24m$</td>
<td>Max. 80m</td>
<td>Min. 6m <em>(or usually 9m for fire separation)</em></td>
</tr>
<tr>
<td>$24m &lt; H \leq 60m$</td>
<td>Max. 70m</td>
<td>Min. 6m; 13m for $H &gt; 30m$</td>
</tr>
<tr>
<td>$H &gt; 60m$</td>
<td>Max. 60m</td>
<td>Min. 13 / 18m <em>(Min. 22 / 26m in less dense zoning areas)</em></td>
</tr>
</tbody>
</table>

Building separation required by different building heights in Mainland China

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1. Building Separation / Permeability

Reference Standard: Mainland China

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### 1. Building Separation / Permeability

**Recommendation:**

**Min. permeability for massive buildings**

(dependent on its building height and site area)

<table>
<thead>
<tr>
<th>Building Height (H)</th>
<th>Building Permeability (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For site &lt; 2 ha and with any continuous projected facade length (Lp) ≥ 60m</td>
<td>For site ≥ 2 ha</td>
</tr>
<tr>
<td>&lt; 60m</td>
<td>1/5 (20%)</td>
</tr>
<tr>
<td>&gt; 60m</td>
<td>1/5 (20%)</td>
</tr>
</tbody>
</table>

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Design Principle 1: Building Separation (S)

Provision of S

- directly proportional to \( L_p \)
- \( \geq 15 \text{m} \)

For the immediate context taken into account, the \( 1/2S \) criteria can be applied to the facade ends with separation distance measured from the adjoining boundary line or the centerline of adjoining street.
1. Building Separation / Permeability

"Continuous projected facade length (Lp)": The total projected length of facade of a building or buildings if any separation in-between < 15m.

Examples:

- Lp=75m
- Lp=75m
- 30m 10m 35m
- 50m 25m
- Lp=75m
- Lp=30m 15m Lp=35m

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Design Principle 2: Maximum Permissible Length of $L_p$

- $L_p$ shall not be larger than 5 times of the mean width of the adjoining urban canyons.
Design Principle 3: Building Design Alternative

For design flexibility, the building separation area can be varied up to 1/3.
Design Principle 4: Performance-based Design Alternative

- Performance-based method for AVA system of PlanD.
Example of Built Project with $P \sim 20\%$ at tower portion:
Residential Development in Tai Koo Shing
Example of Built Project with P ~ 25% at tower portion: Residential Development in West Kowloon
1. Building Separation / Permeability

Example of Built Project with P ~ 33.3% at tower portion:
Residential Development in Shatin

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1. Building Separation / Permeability

South China Morning Post

Monday, November 17, 2008

Set limits would give buildings breathing room

Plan for more space to curb ‘wall effect’

Olga Wong

New rules requiring wider gaps between buildings will be proposed to reduce the so-called wall effect caused by high-rise blocking air flow, a source close to the government said.

The rules, to be proposed in a forthcoming public consultation, would require 30 per cent of a site’s length to be set aside for space between buildings, and 30 per cent of the land area being allocated to landscaping and “green” features.

There is currently no standard requirement on gaps between buildings, which is usually determined on a case by case basis using air ventilation studies and considering the size of the developments. There is also no standard requirement for green features.

The source said care would be taken to prevent developers from profiting from the proposed green space by increasing the overall development density.

The move follows controversy over present arrangements that award bonus floor areas in return for incorporating features such as sky gardens, utility platforms and bigger lobbies and corridors that are assumed to improve the quality of life in the developments.

Secretary for Development Carrie Lam Cheng Yuet-ngor said last month the government would consult the public this year on how green features should be incorporated into new developments without increasing the density of the project.

The consultation is expected to start as early as next month.

The source said building permeability and the green ratio – which refer to the minimum space between blocks and the amount of green space respectively – were major issues under consideration.

Based on air ventilation studies and overseas examples, a government consultant had advised that leaving 30 per cent of a site’s length as gaps would ensure air flow and prevent “walled buildings.”

When developers put buildings along the same line to maximise sea views,” the source said. “To prevent walled buildings, developers would be required to leave at least 30 metres as non-building area if a site is 100 metres wide.

A standard requirement would be easier to implement than working out a figure for each site, the source said. “As a start, developers could be asked to meet a minimum requirement since studying the wind environment of every single site would require much more work.”

The source said a minimum of 30 per cent green area had been a requirement for developments on the mainland for many years.

“Any site should have 30 per cent green area when we look at its aerial photo,” the source said. He acknowledged that the requirement could add management and development costs to government departments and developers, but there was no time to address the situation.

Patrick Lau Sau-shing, the legislator representing the architectural, surveying and planning sector, said increasing the permeability of developments would eliminate podium structures but encourage taller buildings, which might violate the government’s new height restrictions.

He said imposing a site-specific amount of non-building area was preferable and reducing the allowed development density would be the most effective way to minimise the wall effect.

Andrew Thompson, chief executive of the Business Environment Council, an independent non-profit group that promotes corporate social and environmental responsibility, welcomed the initiative but stressed that the business sector would prefer a more flexible approach as the wind factor varied at different locations.

“We would welcome a guiding principle. Prescriptive requirements could result in being designs,”

A Development Bureau spokesperson said the consultation would be held as soon as possible.
Recommendations of Study

1. Building Separation / Permeability

2. Site Coverage of Greenery

3. Setback for Minimum Air Volume at Pedestrian Zone in Deep & Narrow Street Canyon

2nd International Conference on Countermeasures to Urban Heat Islands, 21-23 Sept 2009 – Berkeley, California, USA
2. Site Coverage of Greenery

Reference Standards

1. **BEAM, HK**
   
   **Site Coverage of Greenery > 30%**

<table>
<thead>
<tr>
<th>2.2.4 Landscaping and Planters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 credit for using pervious materials for a minimum of 50% of hard landscaped areas.</td>
</tr>
<tr>
<td>1 credit for providing appropriate planting on site equivalent to at least 30% of the site area.</td>
</tr>
</tbody>
</table>

2. **China**
   
   **Site Coverage of Greenery > 30%**
   
   (Chinese cities such as Beijing, Shanghai and Guangzhou where their respective urban area has achieved a coverage of about 40% green coverage on average, while their individual development sites are required to provide at least 30% coverage of greenery on a mandatory basis)

3. **Tokyo**
   
   **Green Roof > 20%**
   
   (Since April 2001, the TMG required new buildings on site larger than 1,000m² [or 250m² for public buildings], have at least 20% of the rooftop as greenery.)

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2. Site Coverage of Greenery

Recommendation in the Final Report:

Site coverage of greenery for new development to enhance urban greenery: \( \geq 30\% \)

Notes:
1. For development with site area < 1,000m\(^2\), recommended SC of Greenery can be waived.
2. For development with site area between 1,000m\(^2\) and 2ha, recommended SC of Greenery can be reduced to 20%.
3. Grass paver: accountable subject to the actual surface area of greenery of individual paving system.
4. Vertical greenery: accountable with a reduction factor of 0.5.
5. Other features (e.g. water body) that may improve the micro-climate in a similar way can be suggested for consideration as equivalence with or without a reduction factor.
   (Item no. 4 & 5 may be capped by a max. allowable %)
6. Exemption can be considered on individual merits of special case, e.g. prison.
2. Site Coverage of Greenery

Overseas Examples:

High-density residential development in Osaka, Japan, with S-rating in CASBEE-HI assessment:

Site area – 0.15 ha

Plot ratio – 3

Site coverage of greenery – 20%

(Source: CASBEE-HI Tool-4 2006 by Institute of Building Environment and Energy Conservation, Japan)
2. Site Coverage of Greenery

Overseas Examples:

High-density mixed-use development in Tokyo, Japan, with A-rating in CASBEE-HI assessment:

Site area – 1.36 ha
Plot ratio – 6
Site coverage of greenery – 24.3%

(Source: CASBEE-HI Tool-4 2006 by Institute of Building Environment and Energy Conservation, Japan)
2. Site Coverage of Greenery

Overseas Examples:
High-density commercial development in Fukuoka, Japan, with A-rating in CASBEE-HI assessment:

Site area – 1.16 ha
Plot ratio – 6
Site coverage of greenery – 42.7%

(Source: CASBEE-HI Tool-4 2006 by Institute of Building Environment and Energy Conservation, Japan)
2. Site Coverage of Greenery

Overseas Examples:

Library in Kyoto, Japan, with A-rating in CASBEE-HI assessment:

Site area – 5.9 ha

Plot ratio – 1

Site coverage of greenery – 49.2%

(Source: CASBEE-HI Tool-4 2006 by Institute of Building Environment and Energy Conservation, Japan)
2. Site Coverage of Greenery

Local Case Study: Commercial / Mixed-use

Site: Festival Walk, Kowloon
Year of Completion: 1990s
Site Area (ha): 1.9

Site Coverage of Greenery (recommended SC of Greenery ≥ 20%)

<table>
<thead>
<tr>
<th>Current Design</th>
<th>Possible Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost 0%</td>
<td>20%</td>
</tr>
</tbody>
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2. Site Coverage of Greenery

Local Case Study: Residential

Site: Manhattan Hill, Mei Foo
Year of Completion: 2000s
Site Area (ha): 1.3

<table>
<thead>
<tr>
<th>Site Coverage of Greenery (recommended SC of Greenery ≥ 20%)</th>
<th>Possible Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Design</td>
<td>15%</td>
</tr>
<tr>
<td>Possible Improvement</td>
<td>20%</td>
</tr>
</tbody>
</table>

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## 2. Site Coverage of Greenery

### Local Case Study: Residential

- **Site:** Residential Development, Tung Chung
- **Year of Completion:** 2000s
- **Site Area (ha):** 7.5

<table>
<thead>
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<th>Site Coverage of Greenery (recommended SC of Greenery ≥ 30%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Design</strong></td>
</tr>
<tr>
<td><img src="current_design.png" alt="" /></td>
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</tbody>
</table>

<p>| | |</p>
<table>
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<tr>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Current Design</td>
<td>Possible Improvement</td>
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<tr>
<td>26%</td>
<td>30%</td>
</tr>
</tbody>
</table>

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2. Site Coverage of Greenery

Local Case Study: Public Housing

<table>
<thead>
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<th>Site:</th>
<th>Choi Wan Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Completion:</td>
<td>Tentative by 2010s</td>
</tr>
<tr>
<td>Site Area (ha):</td>
<td>3.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Coverage of Greenery (recommended SC of Greenery ( \geq 30% ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Design</td>
</tr>
<tr>
<td>19%</td>
</tr>
</tbody>
</table>

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2. Site Coverage of Greenery

Local Case Study: Institutional

Site: CityU AAB, Kowloon Tong
Year of Completion: Tentative by 2010s
Site Area (ha): 0.5

Site Coverage of Greenery (recommended SC of Greenery ≥ 20%) 

Current Design

45%

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## 2. Site Coverage of Greenery

### Local Case Study: Institutional

<table>
<thead>
<tr>
<th>Site:</th>
<th>Canossa Primary School, San Po Kong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Completion:</td>
<td>2000s</td>
</tr>
<tr>
<td>Site Area (ha):</td>
<td>0.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Coverage of Greenery (recommended SC of Greenery ≥ 20%)</th>
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<tbody>
<tr>
<td>Current Design</td>
</tr>
<tr>
<td>18%</td>
</tr>
</tbody>
</table>

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# 2. Site Coverage of Greenery

## Local Case Study: Institutional

**Site:** Jordan Valley Primary School, Kwun Tong  
**Year of Completion:** Tentative by 2010  
**Site Area (ha):** 0.7

<table>
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<tr>
<th>Site Coverage of Greenery (recommended SC of Greenery ≥ 20%)</th>
<th>Current Design</th>
<th>Possible Improvement</th>
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</thead>
<tbody>
<tr>
<td>15%</td>
<td></td>
<td>20%</td>
</tr>
</tbody>
</table>

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# 2. Site Coverage of Greenery

## Local Case Study: Institutional

<table>
<thead>
<tr>
<th>Site:</th>
<th>Kwun Tong Swimming Pool, Kwun Tong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Completion:</td>
<td>Tentative by 2010s</td>
</tr>
<tr>
<td>Site Area (ha):</td>
<td><strong>3.9</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
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<tr>
<td><strong>15%</strong></td>
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</tbody>
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Recommendations of Study

1. Building Separation / Permeability
2. Site Coverage of Greenery
3. Setback for Minimum Air Volume at Pedestrian Zone in Deep & Narrow Street Canyon

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Recommendations of Study

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Recommendation:
For site with depth $\geq 17.5$m
min. setback of 7.5m
at Pedestrian Zone (0-15m)
for better air volume
[dimensions measured from
centreline of street]
Min. sectional area of urban canyon for better air volume at the Pedestrian Zone = 7.5m x 15m or the equivalence
Public Engagement on Building Design to Foster a Quality and Sustainable Built Environment

20th June – 31st October 2009

Scope of this Public Engagement Exercise

This exercise focuses on the design and layout of buildings within their sites, and the impact they have on the quality and sustainability of the neighbourhood.

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Thanks...