Green Roofs As An Environmentally Responsive Element in Buildings

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What is Green Roof?

- Green roofs
  - Living vegetation installed on the roofs
  - Could help mitigate urban heat island and enhance building thermal & environmental performance
  - Also known as eco-, vegetated and nature roofs
- Three major types
  - Extensive green roofs
  - Semi-intensive green roofs
  - Intensive green roofs
Extensive green roof
(Putrajaya International Convention Centre, Malaysia)

Intensive green roof
(Millenium Park, Chicago, USA)
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Extensive</th>
<th>Semi-intensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of material</td>
<td>150 mm or less</td>
<td>Above and below 150 mm</td>
<td>More than 150 mm</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Often inaccessible</td>
<td>May be partially accessible</td>
<td>Usually accessible</td>
</tr>
<tr>
<td>Fully saturated weight</td>
<td>Low (70-170 kg/m²)</td>
<td>Varies (170-290 kg/m²)</td>
<td>High (290-970 kg/m²)</td>
</tr>
<tr>
<td>Plant diversity</td>
<td>Low</td>
<td>Greater</td>
<td>Greatest</td>
</tr>
<tr>
<td>Plant communities</td>
<td>Moss-sedum-herbs and grasses</td>
<td>Grass-herbs and shrubs</td>
<td>Lawn or perennials, shrubs and trees</td>
</tr>
<tr>
<td>Use</td>
<td>Ecological protection layer</td>
<td>Designed green roof</td>
<td>Park like garden</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>Varies</td>
<td>Highest</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Minimal</td>
<td>Varies</td>
<td>Highest</td>
</tr>
</tbody>
</table>

Table 1. Major types of green roofs and their characteristics
Typical structure of extensive green roof
Green roof systems from Germany (left) and Japan (right)
Potential Benefits

• Major aspects
  • Visual and aesthetic
  • Ecological
  • Local microclimate and thermal
  • Amenity

• Benefits for the community (public)
• Benefits for building owners & users (private)
Environmental Benefits

- Oxygen Release
- Water Retention
- Noise Reduction
- Heat Reduction
- Dust Reduction
- Save of Energy
- Wildlife Attraction
- Use of Space

[Source: Zinco (www.zinco.de)]
Our Research Studies

- Multi-disciplinary approach
  - Engineering
  - Architecture
  - Construction
- Current research topics
  - Energy and environmental performance
  - Modular green roof systems
  - Thermal modelling (green roofs & living walls)
  - Life cycle assessment
Green roof research at a construction site office (2002-2006)

Green site office

Modular design

Green site office and typical site office

Water sprinkler
Green roof research at a construction site office (cont’d)

Infrared pictures:

Green roof

Conventional roof
Study of modular green roof systems (on-going)

Aluminum trays

Wooden boxes

Plastic trays

Plastic trays (infrared photo)

Dry plant

Wet plant
Thermal modelling of green roofs

Radiation: \[ R_n = R \exp(-k_s \text{LAI}) \]

Evapo-transpiration: \[ q'' = -2 \text{LAI} \frac{\rho C_p}{\gamma (r_e + r_i)} \left( \frac{w \text{RT}}{h_m} \right) \]

Conduction: \[ q'' = \frac{(T_{s1} - T_{s2})}{R_{total}} \]
Life cycle cost analysis of green roofs
Applications in Hong Kong

• Hong Kong situation
  • Driving forces:
    • Government, building designers & green groups
  • Major barriers:
    • High-density & high-rise buildings (limited roof areas)
    • Limitations in existing buildings (a design challenge)
    • Economic factors (hard to measure the benefits)

• Our R&D strategy
  • Technical knowledge
  • Demonstration & pilot projects
  • Education & training (local people & stakeholders)
Examples of green roofs in Hong Kong

HK Wetland Park

Tai Lung Veterinary Laboratory

A school in San Po Kong

EMSD New Headquarters
Research & development of green roofs for a primary school

Pilot study:
Roof of a function room
Roof area = 58 sq.m
Soil depth = 150 mm

Studies on thermal performance & sedum

Proposed project:
Roof of an assembly hall
Roof area = 530 sq.m
Soil depth = to be determined

Studies on modular system & life cycle performance
Applications in Hong Kong

- Issues to consider when applying green roofs:
  - Position and orientation of the roof
  - Height of the roof above ground
  - Roof pitch (flat or slopped)
  - Weight limitation of the roof
  - Preferred planting
  - Levels of maintenance (usually low is better)
  - Possibility of rainwater recycling
  - Sustainability of components (recycled materials)
Green roofs as an environmentally responsive element in our minds.