A Study on Thermal Comfortable following the Thermal Environment Migration in Detached Housing Area in Korea

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Improved of the thermal comfortable following the thermal environment migration in detached housing areas

- Focus on the **greening effect** and examine the differences in thermal environment of external spaces of other areas

- Greening methods considering the materials or shape of external space as a **systematic approach** to improving the surface temperature

- **Quantitative prediction and evaluation** for the thermal environment
2. Methodology

Quantitative prediction and evaluation for the thermal environment

1. Analysis of the thermal environment improvement measures used in the design
   - Visible output of surface temperatures to 3D-CAD models in color images

2. Reduction of the thermal load to the surroundings
   - The sensible heat load to the atmosphere
   - Heat Island Potential (HIP) (Sensible heat flux from all surfaces of an analyzed area)
   - The environmental load
   - Air-conditioning load and CO₂ emissions

3. Creation of a comfortable outdoor living space
   - The thermal radiation environment
   - Mean Radiative Temperature (MRT) at a height of 1.5m above the ground
   - The Evaluation of cool spot
   - Calculation of SET* combined with CFD
2. Methodology

**HIP : Heat Island Potential**

The sensible heat load to the atmosphere
(The sensible heat flux from all surfaces in an analyzed area)

\[
HIP_{W/m^2} = \int \alpha_c (T_s - T_a) dS
\]

- Temperature of a small surface (°C)
- Air temperature (°C)
- Convection heat transmission (W/m²°C)
- Horizontal area of an analyzed urban block (m²)

**Heat Island Potential (Heat)**

\[
HIP_{W/m^2} = \frac{\int \alpha_c (T_s - T_a) dS}{A}
\]

**Heat Island Potential (Temperature)**

\[
HIP[^\circ C] = \frac{\int (T_s - T_a) dS}{A}
\]

20 °C (HIP) + 30 °C (Air temp.) = 50 °C (Surface temp.)

HIP=20 °C
(ex. : air temp.=30 °C → surface temp.=50 °C)
Sensible Heat Load to Atmosphere = \( \text{① Sensible Heat from All Surface} + \text{② Sensible Heat from Outdoor Condensing Unit} + \text{③ Sensible Heat Exchange by Ventilation} + \text{④ Waste Heat from Heat Source Equipment} + \text{⑤ Waste Heat from Car and Factory, etc.} \)
2. Methodology

Control effect of thermal environment by greening

- Temperature reduction
- Wind speed reduction
- Humidity increase
- Surface temperature reduction

The surface temperature reduction effect by greening

- By the effect of reduced surface temperature on the green coverage surface
- Shielding effect of solar radiation by trees

Contributing to reduce the heat load of the atmosphere → Highlight to the effect of the surface temperature reduction
2. Methodology

Diagram of the simulation tool

- Creating 3D CAD Models
  - Tree
  - Fence
  - Lawn
- Divided to 3D Mesh Models
  - Direct solar radiation
  - Atmosphere radiation
  - Diffuse Reflective radiation
- Long-wave radiation
- Convection
- Reflected solar radiation

Database
- Hourly weather data (solar radiation, etc.)
- Indoor conditions (room temperature, section internal heat gain, etc.)

Data Input
- Building material data (conductivity, specific heat, albedo, emissivity, etc.)
- Weather data
- Indoor conditions

Thermal Modeling (solving)
- Absorbed solar radiation: $H_s$
- Long-wave radiation: $H_l$
- Convection: $H_c$
- Latent heat: $H_g$

Output
- Air temp = 32.7°C
- Distribution of surface temperature (right) and mean radiant temperature (MRT) (left) at a height of 1.5m (13:00)
- Temperature graph (right): Outdoor air temperature and HIP graph
3. Case study

- **Daegu, Korea (2012)**
  - Area: 884.07km²
  - Population: 2,509,187

![Map showing Daegu, Seoul, and Busan with a study area highlighted.](image-url)
3. Case study

- Study area (external views)
Fence demolition campaign

Yesterday

Today
3. Fence demolition campaign?

- **Goal**: To improve scenery, expand green space and promote the “community” among residents.

- **Projects**:
  - Residents: voluntarily joined
  - Local governments: financial supports

- **Problems**:
  - Lack of voluntary participation of residents
  - Highlighted improve the physical environment

**Urban Regeneration Project**:
- Eco-friendly Urban creating
- Good condition residential environment (Quality of life)
### Housing areas conditions for the analysis of the thermal environment

<table>
<thead>
<tr>
<th>Cases</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yesterday (Case 1)</strong></td>
<td>- Surface: concrete&lt;br&gt;- Road: asphalt&lt;br&gt;- Vacant land and parking lot: vacant&lt;br&gt;- Wall: cement bricks, R.C&lt;br&gt;- Roof: concrete, slates&lt;br&gt;- Green coverage: 5%</td>
</tr>
<tr>
<td><strong>Today (Case 2)</strong></td>
<td>- 8 houses fence demolition&lt;br&gt;- Green coverage: 7%&lt;br&gt;- Surface: grass and water retaining pavement&lt;br&gt;- Tree planting</td>
</tr>
</tbody>
</table>

**Before the fence demolition**

**After the fence demolition**
4. Thermo Environmental Analysis

Surface temperature distribution (15:00)

Yesterday (Case 1)

- Around temperature: 32.4°C
- 35°C
- 34°C

Today (Case 2)

- Around temperature: 32.4°C
- 44°C
- 44°C
4. Thermo Environmental Analysis

- **MRT distribution (15:00)**

<table>
<thead>
<tr>
<th>Yesterday (Case 1)</th>
<th>Today (Case 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td><img src="image3" alt="Image" /></td>
<td><img src="image4" alt="Image" /></td>
</tr>
</tbody>
</table>

- **Around temperature**
  - Yesterday (Case 1): 31.1°C
  - Today (Case 2): 33.6°C
  - Around temperature: 32.4°C

**Legend**
- A
- B
Thermal environmental distribution by greening type

<table>
<thead>
<tr>
<th></th>
<th>Bare ground</th>
<th>Planting</th>
<th>Rooftop planting</th>
<th>Grass</th>
<th>Grass &amp; Rooftop planting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Layer</strong></td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td><strong>Surface Temp.</strong></td>
<td><img src="image6.png" alt="Image" /></td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
<td><img src="image10.png" alt="Image" /></td>
</tr>
<tr>
<td>Air temp: 32.7°C</td>
<td>Ground: 52°C</td>
<td>Tree: 33°C</td>
<td>Rooftop: 34°C</td>
<td>Rooftop: 57°C</td>
<td>Grass: 42°C</td>
</tr>
<tr>
<td>MRT (1.5m)</td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
<td><img src="image13.png" alt="Image" /></td>
<td><img src="image14.png" alt="Image" /></td>
<td><img src="image15.png" alt="Image" /></td>
</tr>
<tr>
<td>Air temp: 32.7°C</td>
<td>Ground: 35.3°C</td>
<td>Tree: 30.5°C</td>
<td>Rooftop: 29.3°C</td>
<td>Rooftop: 34.5°C</td>
<td>Grass: 31.7°C</td>
</tr>
</tbody>
</table>
### Housing areas conditions for the analysis of the thermal environment

**Greening the surface temperature of the reducing effect**

- By the effect of reduced surface temperature on the surface of the green coverage
- Shielding effect of solar radiation by trees

<table>
<thead>
<tr>
<th>Cases</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tomorrow</strong> (Case 3)</td>
<td>- 16 houses fence demolition</td>
</tr>
<tr>
<td></td>
<td>- Green coverage: 25%</td>
</tr>
<tr>
<td></td>
<td>- Surface: grass and water retaining pavement</td>
</tr>
<tr>
<td></td>
<td>- Tree planting and a green roof</td>
</tr>
</tbody>
</table>

**Greening after the fence demolition**
4. Thermo Environmental Analysis

- **Surface temperature distribution (15:00)**

<table>
<thead>
<tr>
<th>Surface temperature</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A point</td>
<td>35°C</td>
<td>44°C</td>
<td>33°C</td>
</tr>
<tr>
<td>B point</td>
<td>34°C</td>
<td>44°C</td>
<td>32°C</td>
</tr>
</tbody>
</table>

Tomorrow (Case 3)

15:00 Around temperature : 32.4°C
4. Thermo Environmental Analysis

MRT distribution (15:00)

Tomorrow (Case 3)

<table>
<thead>
<tr>
<th>MRT</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A point</td>
<td>31.1°C</td>
<td>33.6°C</td>
<td>30.5°C</td>
</tr>
<tr>
<td>B point</td>
<td>31.5°C</td>
<td>32.1°C</td>
<td>30.4°C</td>
</tr>
</tbody>
</table>

15:00 Around temperature: 32.4°C
4. Thermo Environmental Analysis

- **HIP graph (13:00)**

<table>
<thead>
<tr>
<th>Case</th>
<th>Time (h)</th>
<th>Asphalt Temperature</th>
<th>Grass Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case1</td>
<td>Yesterday</td>
<td>difference 0.4°C</td>
<td>difference 10°C</td>
</tr>
<tr>
<td>Case2</td>
<td>Today</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case3</td>
<td>Tomorrow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Conclusion

Create a comfortable urban environment with less impact to the environment!

<table>
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</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Yesterday Image" /></td>
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<td><img src="image3.png" alt="Tomorrow Image" /></td>
</tr>
</tbody>
</table>

- Buildings and grounds are covered with greenery
  - Planting tall trees with large crown along the road
  - Vegetative screens, rooftop, wall and veranda planting
5. Conclusion

➢ Significance of the study

1. Thermal environment can be evaluated in the stage of design

2. Thermal environment can be quantitatively predicted and evaluated

3. Visible output for the thermal environment is easily evaluated by designers and clients
5. Conclusion

Creating comfortable urban households from urban heat environment

| Regionality | Make a good use of natural potential in the building site  
| — Climate, site conditions, microclimate in the surroundings — |
| Spaces      | Space design in which various environmental factors such as heat and wind flow are also considered, not only from the traditional viewpoints of design and spatial structure |
| Materials   | Surface materials should be selected from the viewpoint of the thermal environment  
|             | Various thermal environment improving measures such as rooftop planting are utilized |

Realization of environmentally conscious design, comfortable living spaces, new lifestyle
Thank you for attention
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