Research on Shape Optimization of Houses Considering Thermal Performance Using Metaheuristics

Background / Purpose / Methodology

【Background】
• The zero energy building (ZEB) concept has become increasingly popular.
• The goal of ZEBs is to reduce energy consumption and increase power generation through the use of photovoltaic devices.
• In order to reduce energy consumption, it is critical that optimal building shapes and materials are considered.
• The optimal building shape is one of key factors for the ZEB, an actual house is often designed empirically.

【Purpose】
• The objective of this study was to develop an optimization methodology that could be used to find an optimal shape which minimized the annual thermal load of a detached house.
• We propose a new method in which a building is divided into elements, which cannot be decomposed more, and they are combined again using optimization methodology to minimize energy consumption.

【Methodology】
• The epsilon constrained Differential Evolution with Random Jumping (ε DE-RJ) was used to optimize the room arrangement of the detached house.
• Energy Plus was used to simulate thermal energy, and Radiance was used to simulate daylighting.
Research on Shape Optimization of Houses Considering Thermal Performance Using Metaheuristics

Case study/Result

【Case study】
- The building for simulation is settle upon Ōtemachi, Chiyoda-ku, Tokyo. Occupancy family is constrained by 4 people.
- Formulation of decision variables to the shape of house is enable by arrangement of elemental room boxes.

【Result】
- As the result, almost all air-conditioned rooms were located on the north-western side of the first floor to reduce the solar radiations.

<table>
<thead>
<tr>
<th>Room</th>
<th>Size [m]</th>
<th>Set point Cooling / Heating</th>
<th>Dehumify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>3.6 × 4.5</td>
<td>27 °C / 22 °C</td>
<td>50%</td>
</tr>
<tr>
<td>Dining</td>
<td>2.7 × 3.6</td>
<td>27 °C / 22 °C</td>
<td>50%</td>
</tr>
<tr>
<td>Kitchen</td>
<td>2.7 × 3.6</td>
<td>27 °C / 22 °C</td>
<td>50%</td>
</tr>
<tr>
<td>Bedroom</td>
<td>3.6 × 3.6</td>
<td>27 °C / 22 °C</td>
<td>50%</td>
</tr>
<tr>
<td>Sub A</td>
<td>2.7 × 3.6</td>
<td>27 °C / 22 °C</td>
<td>50%</td>
</tr>
<tr>
<td>Sub B</td>
<td>2.7 × 3.6</td>
<td>27 °C / 22 °C</td>
<td>50%</td>
</tr>
<tr>
<td>Japanese</td>
<td>2.7 × 3.6</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Entrance</td>
<td>2.7 × 2.7</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Step room</td>
<td>2.7 × 2.7</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Bath room</td>
<td>1.8 × 3.6</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Closet</td>
<td>2.7 × 2.7</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>W.C. A</td>
<td>0.9 × 1.8</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>W.C. B</td>
<td>0.9 × 1.8</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Detail of rooms

Formulation of variables to house