Zero Energy Design Lab

**Design**

**Location**
- University of Minnesota - East Bank
- Rapson Hall

**Site Integration**
- Climate Considerations
- Material Palette
- Green Space

**Beacon**
- Light
- Directional
- South Entrance

**Thermal Comfort**
- Appropriate Working Levels
- Trombe Wall
- Thermal Flux Zone Hallway
- Systems Integration

**Orientation**
- Views
- Wayfinding
- Lighting

**Material Integration**
- Original Rapson Hall
- Steven Holl Addition

**Lighting & Thermal Program**

<table>
<thead>
<tr>
<th>Space</th>
<th>Area (sf)</th>
<th>Occupancy</th>
<th>Required lighting level</th>
<th>Light Quality</th>
<th>Thermal Comfort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms</td>
<td>1900</td>
<td>75</td>
<td>10-20 ft</td>
<td>Diffuse/Even</td>
<td>65-75°F</td>
</tr>
<tr>
<td>Labs</td>
<td>4075</td>
<td>20</td>
<td>10-20 ft</td>
<td>Diffuse/Adaptable Diffuse</td>
<td>65-75°F</td>
</tr>
<tr>
<td>Demonstration</td>
<td>1380</td>
<td>20</td>
<td>10-20 ft</td>
<td>Diffuse/Even</td>
<td>65-75°F</td>
</tr>
<tr>
<td>Offices</td>
<td>1843</td>
<td>5</td>
<td>5-10 ft</td>
<td>Diffuse/Even</td>
<td>65-75°F</td>
</tr>
<tr>
<td>Conference</td>
<td>680</td>
<td>10</td>
<td>5-10 ft</td>
<td>Ambient/Adaptable</td>
<td>65-75°F</td>
</tr>
<tr>
<td>Circulation</td>
<td>3176</td>
<td>-</td>
<td>5-10 ft</td>
<td>Dynamic/Direct</td>
<td>65-75°F</td>
</tr>
<tr>
<td>Energy Utility</td>
<td>730</td>
<td>5</td>
<td>5-10 ft</td>
<td>Dynamic/Direct</td>
<td>65-75°F</td>
</tr>
</tbody>
</table>

**Mechanical Services**
- 942 sf
- Ay 2-5 ft
- Flexible
- 62-84°F

**Summary, Site & Location**
- Minnesota
- Minneapolis
- University of Minnesota - East Bank
- Rapson Hall

**Daylight, Wind, and Landscaping Influence**
- Winter Wind
- Summer Wind

**Skin Relationship**
- Structural system aligns with every other window of the existing Rapson building
A. Skin Adjacent to Thermal Envelope

Relevant Strategies:
- Punched opening through cohesive vertical screen
- Filtered light screen at night
- Gradient of screen varies to change quality of light
- Passive ventilation

B. Skin Separate from Thermal Envelope

Relevant Strategies:
- Variable screen to take advantage of desired lighting and solar gains
- Transparent, semi-transparent, and opaque openings in the screen as appropriate to high light views while being conscious of solar gains and ventilation

C. Operable Skin and Trombe Wall

Relevant Strategies:
- Operable overhang provides shading during summer months
- Closed screen provides thermal insulation
- Operable overhang with a second skin allows variability within a consistent facade

D. Storm Water Collection

Relevant Strategies:
- Allows greater utilization of green space directly adjacent to the building
- Brings more light into the basement of the existing Rapson building
- Collects water for hydration of green roof system

Eneveloppe and Skin
Screen 1

Screen 1 is a staggered rectangular pattern based on the spacing of the channel glass. The density of the screen is determined by programmatic lighting requirements of the space. Two versions of the screen were designed: one with an opaque material and a second with a semi-transparent material. Based on the sunpeg photos, the transparent material was chosen because of its poetic qualities as well as its ability to diffuse light and glare.

Summary

Screen 1 used a staggered rectangular pattern based on the spacing of the channel glass. The density of the screen is determined by programmatic lighting requirements of the space. Two versions of the screen were designed: one with an opaque material and a second with a semi-transparent material. Based on the sunpeg photos, the transparent material was chosen because of its poetic qualities as well as its ability to diffuse light and glare.

Screen 2

Screen 2 uses vertical and horizontal pieces to create a more opaque sun screen. The density of the screen is determined by programmatic lighting requirements of the space. Based on the sunpeg photos, there was minimal change to the interior daylighting levels from other models and so it was considered less effective than Screen 1.

Screen 3

Screen 3 used a 40% horizontal and vertical grid system for the outer shell, showing minimal improvement for daylight distribution. After analyzing the light qualities with DAYSIM, the 40% grid system seemed to have a similar effect as the 75% grid system. We found that both externally and internally, the quality of light and reflectance was not adequate for our programming goals.

Screen 4

Screen 4 used a 75% horizontal and vertical grid system for the outer shell, showing minimal improvement for daylight distribution. After analyzing the light qualities with DAYSIM, the 40% grid system seemed to have a similar effect as the 75% grid system. We found that both externally and internally, the quality of light and reflectance was not adequate for our programming goals.

Conclusions

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We have achieved daylight autonomy of greater than 50 fc for all occupied spaces over 60% of the time, which increases to 80% when calculated as continuous daylight autonomy.

Our Use Daylighting Index (UDI) testing stays within the workable zone of 10-200fc for 75% of the time in all occupied spaces. The UDI tests at 10fc and 200fc illustrate in isolation the areas that receive too little and much light respectively.
Comparative Thermal Analysis

Base

<table>
<thead>
<tr>
<th>Category</th>
<th>Losses</th>
<th>Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLAR</td>
<td>5.0%</td>
<td>0.0%</td>
</tr>
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<td>0.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>VENTILATION</td>
<td>1.0%</td>
<td>8.0%</td>
</tr>
<tr>
<td>INTERIOR</td>
<td>80.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>TOTAL LOSSES</td>
<td>81.0%</td>
<td>10.0%</td>
</tr>
</tbody>
</table>

Alternative Thermal Strategies

Heating Load Reduction: 0.9%  
Cooling Load Reduction: 0.8%

Emissions Calculation

CO₂ Emissions from Electric Use:
-52,920 lbs.  
CO₂ Emissions from Heating (BTUs):
-29,400 lbs.  
TOTAL ANNUAL CO₂ Emissions: -82,320 lbs.

Energy Use Intensity

Final Building Loads

Heating Load: 428,146,119 BTU  
Cooling Load: 8,285,321 BTU  
Electric Use: 13,960 kWh  
HVAC Energy Use: 4,973,091 BTU  
or 14,990 kWh

Total Energy Use: 823,779 BTU  
or 241,436 kWh

Total Energy Use Intensity (EUI): 43 kBtu/ft²

EUI after optimizing design and considering

Total Energy Use Intensity (EUI): 43 kBtu/ft²