Precedent Studies

Musee De Quai Branly - Jean Nouvel, Architect - Patrick Blanc, Living Wall - Paris, France

This system consists of a metal support structure to hold the garden and to create an air gap, PVC panels to add stability, a felt irrigation cloth to hold water and provide a base for the plants, and finally the plant life. As a general rule, living walls organize the larger shrub species toward the top and less voluminous species at the bottom. This provides interest and space for passersby if the wall meets the ground. Living walls provide cooling in the summer through evapo-transpiration. They also provide habitat for local species.

Schematic Hillside Homes - Tobias Weiss & Gernot Reisenhofer - Austria

Terracing green roofs are a design feature that will be incorporated in the mnZED design. Thermally, the green roofs will provide added insulation as well as contribute to cooling through evapo-transpiration. Inherent in terracing is the opportunity to create clerestories which have been found to be effective for natural ventilation when made operable. Finally, the opportunity for allowing light deeper into spaces for solar gain is achievable through use of clerestories when properly paired with a heat collector.

School of Slavonic and East European Studies (SSEES) - Short and Associates - University College London

The SSEES in London utilizes a large light well in the center of the building and doubles as a ventilation shaft. It draws fresh air in and heats it using heating elements near the base of the shaft. Displacement ventilation allows the continuous movement of air. Each floor has its own warm air intake vent which draws from the shaft. Floors with air at like temperatures have coupled exhaust vents, and a double façade with vertical circulation is heated by allowing the lighter air to rise and exit through a stack at the top of the double façade.

BioHaus - Stephan Tanner of INTEP, LLC. - Bemidji, Minnesota

BioHaus uses a series of super-insulated cladding systems that establishes both very high R values and an airtight infiltration rate of .18. In particular, we have chosen to use the same StoTHERM cladding system that this project uses. Additionally, an airtight design should also be applied to this thermal proposal to increase efficiency.

Meadow House - Ian MacDonald - Toronto, Canada

Meadow House uses strategically placed thermal mass to passively heat the building. Its deep overhang and setback thermal mass is especially important as a similar concept may be employed in some areas of our project.
Parametric Analysis

Analysis I - Roof R-Values

Hypothesis: As the R-values increase, losses through the roof decrease. Loads for heating and cooling will decrease. This will be tested by changing the R-Values of every roof plane in the design.

Conclusion: As seen in the graph, the benefits of increased R-values begin to diminish around a value of 40 or 50.

Optimal Roof: R-Value of 50

Analysis II - Wall R-Values

Hypothesis: As the R-values increase, losses through the walls decrease. Loads for heating and cooling will decrease. This will be tested by changing the R-Values of every wall in the design.

Conclusion: As seen in the graph, the benefits of increased R-values begin to diminish around a value of 35 or 40.

Optimal Walls: R-Value of 40

Analysis III - Window Size (South)

Hypothesis: As the windows become larger, more heat will be gained. However, because of loss inherent in glazing, loads will probably even out.

Conclusion: The graph shows that as the windows became larger the total annual loads of the building increased.

Optimal Window Size: A definite decision has not been made. Further study of lighting qualities in combination with thermal will be explored.

Analysis IV - Window Type

Hypothesis: Increasing U-Values will decrease losses through conduction. Increasing solar heat gain coefficients will increase solar gain. This will be tested by changing U-Values, SHGC, and Visual Transmittance values of every window in the design according to real products.

Conclusion: The higher quality glazing types performed best overall. Higher R-Values combined with higher SHGC makes for a better passive window in our climate.

Optimal Window Type: Serious Windows 925 Series, Dual Pane, Krypton Filled (Option 2)
Add Optiwin windows where necessary (Option 1)
Parametric Analysis

Analysis VII - Shading Devices (South)

Hypothesis: As shading size increases, solar gains in the summer will decrease, thus decreasing overall loads. This test will be done by varying the shading device depth.

Conclusion: It was determined that shading devices are important in decreasing heat that would otherwise occur in the summer. However, an optimal length was not made apparent from the study.

Optimal Shading Length: Dependent upon placement, preferred design aesthetic, and dual usage (i.e. trellis for vegetation, light shelves, etc.)

Analysis V - East Fenestration Configuration

Hypothesis: This will be done to determine if the use of angled glazing toward the south, on the east side of the design helps as a passive strategy as compared to other possible configurations. Various configurations of fenestration will be tested on the east side of the design.

Conclusion: It was determined that the use of the angled window helped us with solar gain, but the amount of fenestrations was too high on the baseline design.

Optimal East Fenestration Configuration: Option 1 - decreasing number of fenestrations by 50% from the baseline design.

Analysis VI - Laboratory Configuration

Hypothesis: The baseline of tube-like north/south oriented laboratories is thought to be thermally inefficient. This analysis looks at various design configurations for the laboratories to determine one with optimal performance.

Conclusion: It was found that the north/south oriented labs were in fact thermally inefficient in relation to the three other options tested. Options 1 & 2 performed equally well. The decision came down to what was aesthetically preferred as well as what seemed reasonable, structurally, for the addition.

Optimal Laboratory Configuration: Option 1 - Stacked laboratories and circulation
Baseline Design

Performance Statistics

MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones
Comfort: Zonal Bands
Floor Area: 14428.41 FT²
Max Heating: 710333.8 Btu/hr at 04:00 on 30th January
Max Cooling: 336909.3 Btu/hr at 15:00 on 19th July

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Performance

The annual passive gains breakdown is showing that the building is actually losing substantially more Btu/FT² through its skin that it is gaining. As compared with the internal gains, the solar gains of the building do not account for much passive gain.

A closer look at passive gains for the winter months shows that the solar gains become greater as the weather gets warmer. In the middle of the winter the solar gains are comparatively very low.

As expected for Minnesota climate, the baseline model requires a lot of mechanical heating to keep the building in a comfort range of 64 - 78 degrees Fahrenheit. Zones contributing most to the loads are the offices and classrooms both located in the northwest corner.

The annual discomfort graph confirms that the design will have to be heated a lot during the winter months. Better utilization of passive solar strategies should allow the spaces to heat better.

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 Optimized Design

Performance Statistics/Conclusions

MONTHLY HEATING/COOLING LOADS
All Visible Thermal Zones:
Comfort: Zonal Bands

Max Heating: 4690.6 Btu/hr at 22:00 on 21st January
Max Cooling: 2674.8 Btu/hr at 16:00 on 2nd August

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40 Kbtu/FT²

The annually heating and cooling loads of the optimized design have decreased overall. The north west zones of our building are still contributing the most to the need for heating during the winter months. There has been a shift with the cooling in the optimized design as the building requires cooling year round, something that could be improved with natural ventilation.

The annual discomfort graph shows that we have brought levels closer to comfort with the majority of months calculating within 4,000 degree hours on the sides of both heating and cooling. The baseline, comparatively was reaching 6,000 degree hours for heating in most winter months.

Passive gains have improved from the baseline design. The building is losing substantially less through the skin due to the selection of higher R-Valued materials. Also, by tightening the building through super insulation, it has decreased the amount of loss through ventilation.

The winter analysis still shows the gains higher toward warmer times of year despite the use of exterior shading.
Optimized Design

Drawings/Experiential Design Concept

The big idea behind the design is terracing. The design starts at its highest point in the NE corner of Rapson Hall. Through differing ceiling heights that highlight different programmatic areas, the design cascades across the roof of Rapson Hall and back down the SW corner. The terracing is reinforced by the use of greenery in the form of green roofs and living walls, which visually connect this design from the ground plane up to the top of Rapson Hall. By visually cascading over the edges, the design reinforces the groups belief in the symbiosis between architecture and sustainable building research.

Key Thermal Strategies

- Direct gain zones in areas with Southern Glazing
  - South facing horizontal overhangs with plant material
    - Plants block the summer sun
    - Winter sun can pass through for direct gain
  - Compact Massing to optimize efficiency in design
    - Terracing of the program to allow for greater amounts of southern glazing
    - Operable windows
      - User control
      - Passive ventilation
- Light/Wall/WEST Entrance
  - Brings light to labs as well as Rapson Hall studios
  - Facilitates passive ventilation by evacuating warm air through the top
  - E/W Windows are angled 15 degrees from south
    - Catch southern morning and afternoon sun
    - Less glare and heat loss as compared to punched openings
    - Fewer openings on the north façade to reduce heat loss in the winter
  - NW stair well circulation area to work as an isolated sun space

New Entrance with Living Walls

Perspective to Church Street from NE Corner

Aerial Perspective

West - East Section
1/32" = 1'

East Elevation
1/32" = 1'

New Entrance with Living Walls

Perspective to Church Street from NE Corner

Lab Wall/Roof Section Typical & Western Stairwell Sunspace
1/32" = 1'

Floor Plans
1/16" = 1'

South Elevation
1/16" = 1'