Architectural Breadth | Student Gathering

This breadth began as an effort to integrate a number of disciplines; I attempted to join my lighting perspective to that of an architect, electrical, structural, and mechanical engineer. The Student Gathering was the main point from which my thesis would take form, and where I tried to create a more holistic design.

It started with architecture. I wanted to make the architecture of the space better. I wanted to use the form of the building to help shape the interaction of natural light and produce a livelier environment inside. To accomplish this goal I propose the use of Kalwall, a diffuse skylight product that would spread light around the walls and other surfaces of the space. Also, the window transmittances will be reduced accordingly due to the extra light admitted by the skylight. This architectural change would also help me accomplish some of my own goals in respect to my unfulfilled conceptual design.

Originally, I wanted to provide lines of light in major traffic directions (i.e. lengths of luminaires or light would be parallel to main flows of transition). I was unable to do this with electric light due to the limits on watts per ft^2 within different space types. With the skylights, however, I was able to integrate these long illuminated surfaces along the major length of the building. Below is an image of what these "lines of light" look like from inside as compared to the original design.

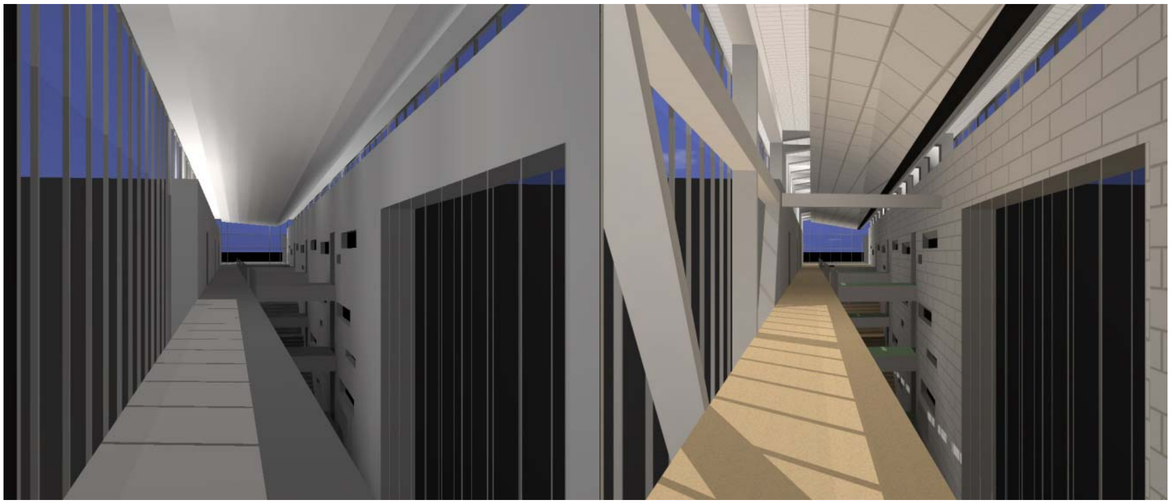


Figure 62 As-designed vs. Re-design Ceiling/Roof

The majority of people will be looking at the original roof from floors below and will not be able to tell where the roof would stop and the wall begins. The roof and ceiling were a very solid entity; what I have proposed minimizes the roof to a skeletal form and opens the ceiling more than the original scheme. Although the ceiling is not transparent, the brightness of the surface makes it appear to float further from the occupant, and also creates a contrast between the ceiling and the backdrop of sky alluding that the ceiling is hovering above the large corridor.

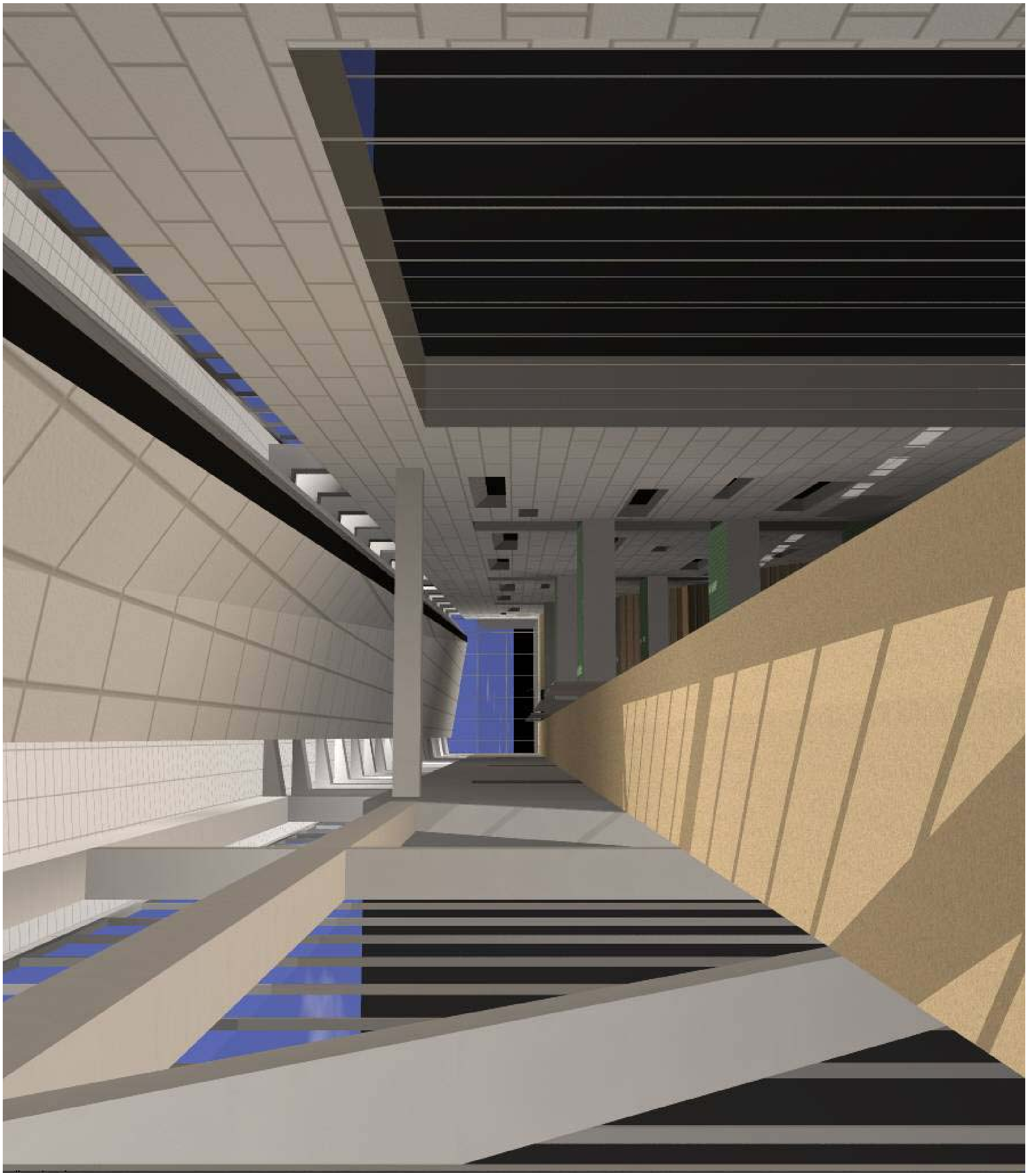
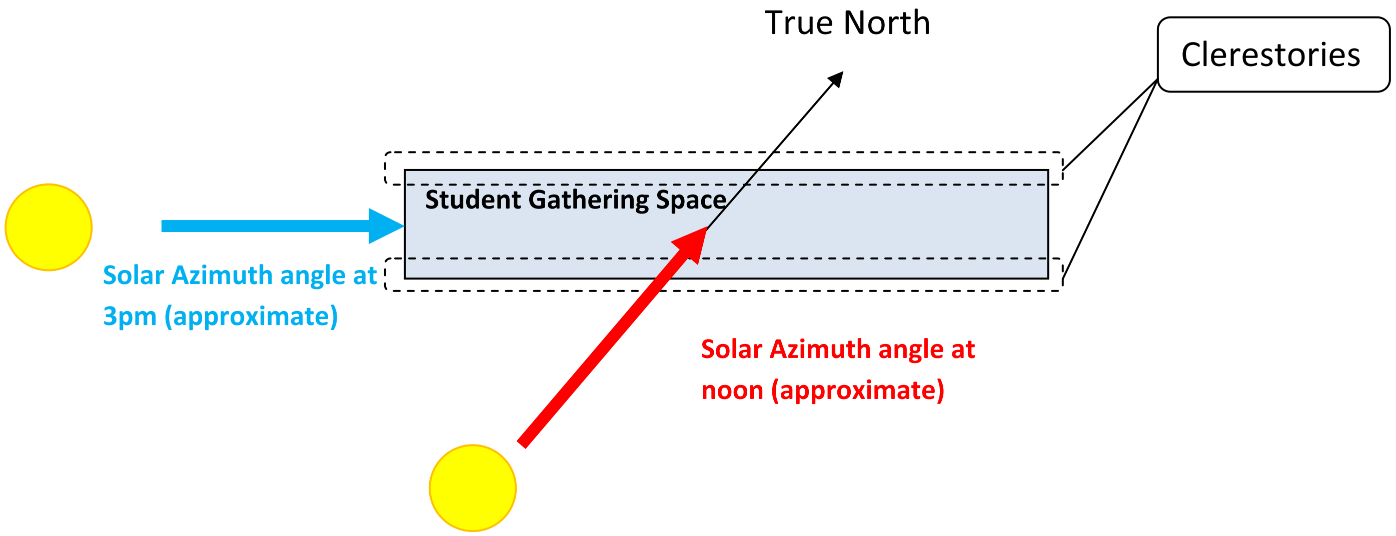


Figure 63 Student Gathering Redesign March 21st Noon

In addition to the conceptual imagery that the new system presents, it also enhances the distribution of light throughout the space making it brighter and animated throughout the day. Because the building runs in the north east (and south west) direction, around 3:00pm, the solar azimuth angle is equal to the building elevation angle (or the sun's rays are parallel with the length of the Student Gathering). (Please see diagram on the next page). This means that a lot less sun enters through the clerestories as compared to the morning or evening (see image for 3:00pm above). By incorporating skylights, it would mean that more light could come into the atrium throughout the day.



I conducted some sample tests to see how effective my design would be for the December, March and June (21st at noon). Throughout these tests, the skylight model preformed the best at providing more illumination to the lower floors, especially the eastern corridor. This area is the most important place to provide daylight; most everywhere else in SG has ample amounts of daylight throughout the day. Being on the eastern side of the building, this corridor gets blocked from daylight throughout most—if not all—of the day. The increase of daylight provided to this area and other all spaces will be directly proportional to productivity, good humor, and overall appreciation of GCC architecture.

I knew in the beginning of this study that December would be the hardest month to increase the amount of daylight. This was due to the lowest profile angle of the sun (or the sun being the lowest in the sky). Because it is so low, a smaller ratio of light would be passing through the skylights in comparison to the existing clerestories. Under investigation of this model, I found that even with the lowest profile angle, illuminance levels were increasing in some places my 10fc.

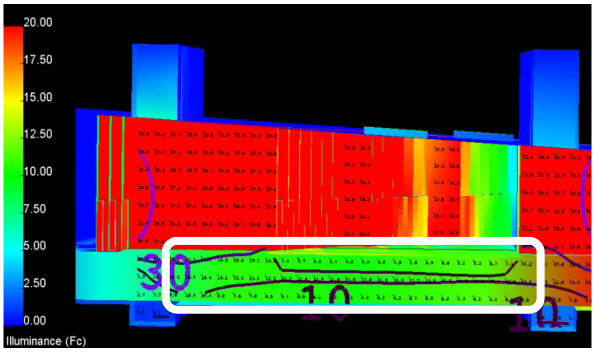


Figure 64 Eastern Corridor Clerestory December

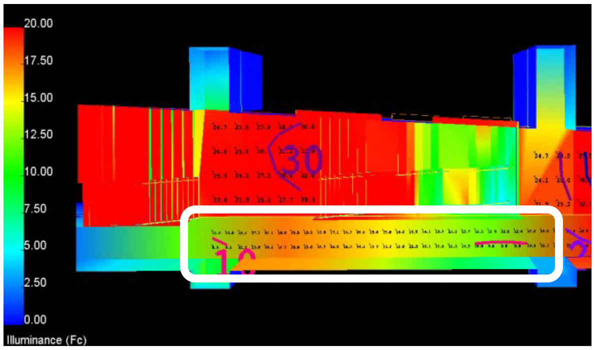


Figure 65 Eastern Corridor Skylight and Clerestory December

Here you can see that on the second floor eastern corridor, the levels increased when window transmittance was reduced and skylights were added.

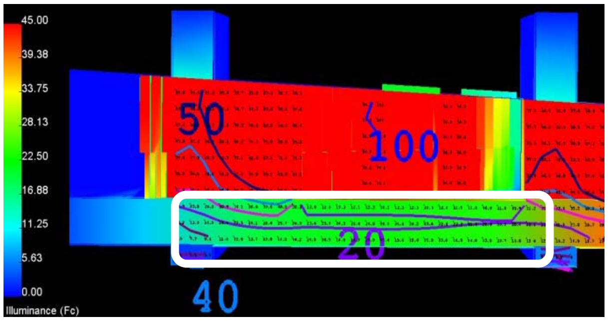


Figure 66 Eastern Corridor Clerestory March

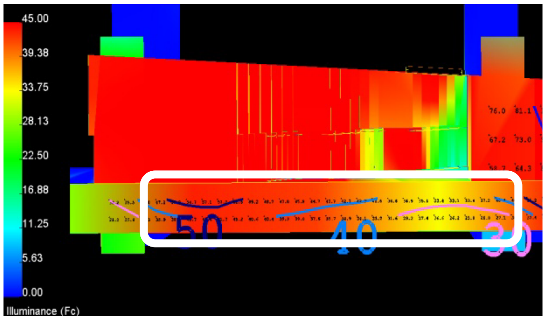


Figure 67 Eastern Corridor Skylight and Clerestory March

During March, the sun gets higher in the sky; similar effects are seen but now since more sun is entering through the skylight, a larger difference exists between illuminance values.

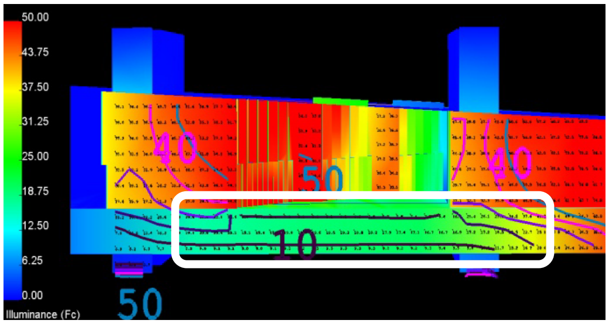


Figure 68 Eastern Corridor Clerestory June

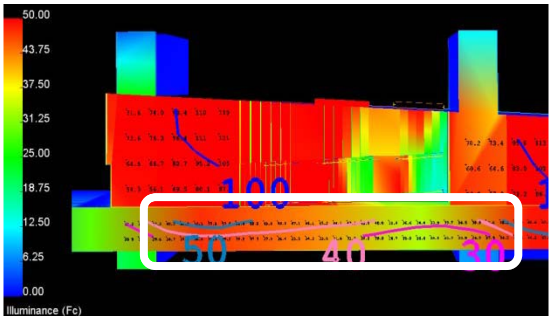


Figure 69 Eastern Corridor Skylight and Clerestory June

During June, similar effects like in March occur. The sun is yet higher in the sky, which means more light through skylights and more difference in fc level. As seen in the pictures above, on the lower levels beneath openings in floors, illuminance levels are not a concern (for being too low). The highlighted walkway is the major concern, minus direct glare from the clerestory windows. Because these windows have been reduced in transmittance, they will let less light into the classrooms compared to before, also the changes in the window boxes will reduce this interference even more.

LEED

When I finished the daylight study for the Student Gathering, verified the eligibility for LEED Credit 8.1

Products and Changes

	Original Glass	Changed	Glazing Type Change
GL-1	Transmittance: .7, SGH Coef:.38	Transmittance: .51, SGH Coef:.25	Change from Solarban 60 (2) Cl + Cl to Solarban z50 (2) Optiblue + Cl
GL-1A+B	Transmittance: .623, SGH Coef: .31	Transmittance: .454, SGH Coef: .25	Change from Solarban 60 (2) Cl + Cl to Solarban z50 (2) Optiblue + Cl
GL-2A+B	Transmittance: .23, SGH Coef: .25	Transmittance: .18, SGH Coef: .25	Change from Solarban 60 (2) Cl + Cl to Solarban z50 (2) Optiblue + Cl

My original scheme involved using translucent photovoltaic modules to transmit light inside as well as collect usable energy. Under closer examination and scrutiny, I discovered that these panels would not work out for energy savings down the road. Once this was clear, I started looking for other solutions for the ceiling and roof. When I came across Kalwall I was impressed by its thermal properties and its structural capabilities. The typical dimension of a Kalwall panel is 12" x 24" and it can be arrayed into larger grids (Please see drawing A-400 in Appendix C for more details).

Figure 70 Kalwall Panels

Also included in my redesign of the roof and daylighting in SG, are other systems affected by any changes that I have made. For instance, the original layout of photovoltaic panels on the roof would no longer be adequate for the re-designed roof. And since these panels and *their* structure will be removed (see Photovoltaic Analysis in Electrical Analyses) the structure supporting the roof and skylights can be resized (and most likely reduced). Other influences and changes came from the addition of skylights and the thermal load that would result from replacing the original roofing.

To best analyze how the addition of skylights affect these systems I will be conducting the following studies:

- Photovoltaic array study with feasible replacement or alternate solution (Electrical Section)
- Hand calculation to size steel members that support roofing system (Structural Breadth Section)
- Thermal load analysis of replacement glazing types (Mechanical Breadth Section)

Structural Breadth | Student Gathering Roof

The structure in the original design consisted of a steel frame system using five types of wide-flange beams spaced at approximately 6' O.C. to span across the large stairwell and support the roof/ceiling above. The types of beams were W18x35, W16x26, W14x22, and W12x19, and W12x14. Multiple depths were used because the space starts and ends at two different widths. This means that the beam supporting the roof can decrease in load carrying capability from the south to the north end. The roof originally supported a separate steel structure made up of channel members that supported the PV array (totaling 448 panels). I will be removing and replacing this array on another part of the building and will not consider this weight in my calculations.

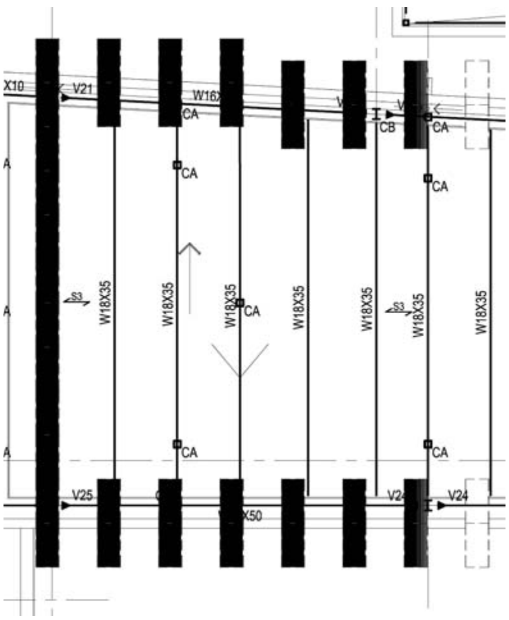


Figure 71 South End SG Structure

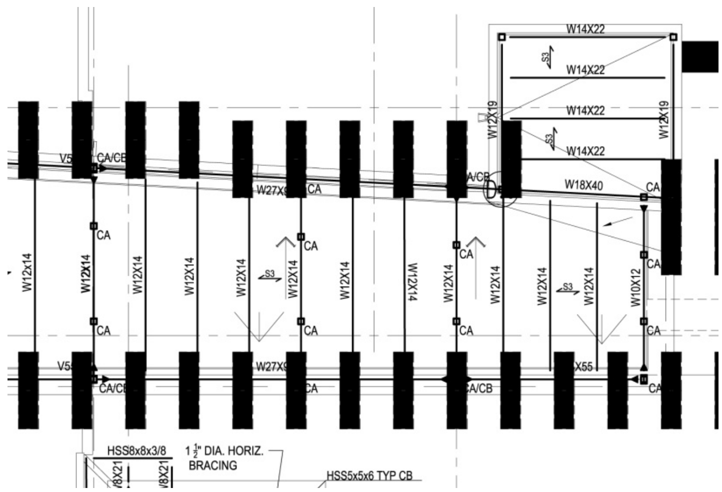


Figure 72 North End SG Structure

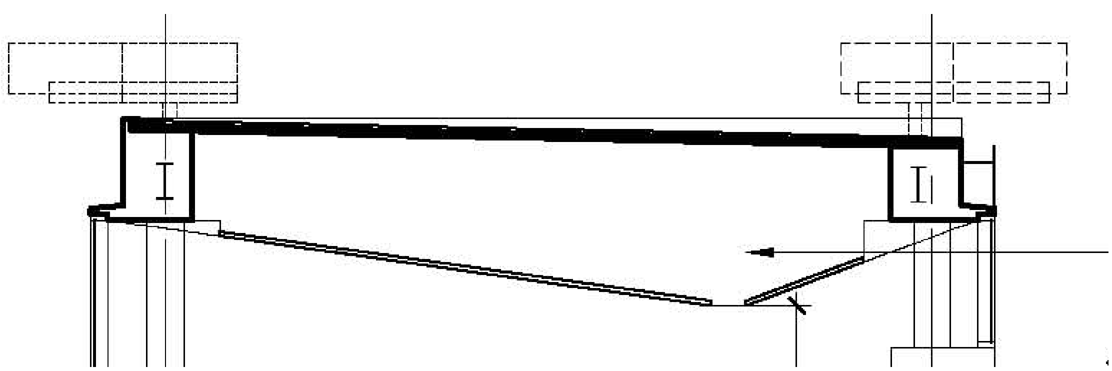


Figure 73 Section through Original SG Structure

In my redesign, I based the structure around the daylighting system I just designed. Therefore, it was important to limit the amount of structure around the Kalwall skylight to a minimum so as to not interfere with the sunlight getting into the Student Gathering. Therefore, I tried not to move the columns running up to the beams, and would increase the O.C. spacing to 18' 4" (the O.C. spacing of the columns). I assumed that the roof live load would be 20 psf, and that the dead load would be the self weight of a type H6 metal roof deck to be 4.5 psf. This deck type was chosen because it can span 19' (required span of beam). Correct dimensions are shown in detail.

Similar to the calculations performed for the Library skylight structure, I made a spreadsheet for the Student Gathering. (Please refer to pg 40 for more information) For the new beam types, I planned on resizing for four different sizes; like the original design. To do so, I started by choosing the sections by which a new type of beam would be used. I split the roof area into four sections and used the original design to place where the new types of beams would begin. A sample of the spreadsheet I made can be seen below.

PSF	(sw of deck)		(roof load)	Total lb/ft		
1.2	4.5	1.6	20	685.6667		
				=[1.2(**DL**)+1.6(**LL)**]***Span**(f		
Span	**ft**	**in**				
	18.33333	220				
Lmax	35.55					
Mu	**moment**	**simple**				
	72.21227	108.318	← Moment Con.= (**lb/ft**)*(**L**^2)/(**12***1000)			
			Simple Con.= (**lb/ft**)*(**L**^2)/(**8**x1000)			
Vu	12.18773		← Vu.= (**lb/ft**)*(**L**)/(**2**x1000)			
Δ	**moment**	**simple**	**Pass?**	**Δ**	**live**	**total**
live	0.016468	0.08233	PASS		l/360	l/240
total	0.020173	0.10086	PASS		1.18	1.777
Δ live	=**LL***(**L**^4)*12^3*/(384*29000***I**)	=5***LL***(**L**^4)*12^3*/(384*29000***I**)		*I is given in table below*		
Δ total	=(**DL**+**LL**)*(**L**^4)*2^3*/(384*29000***I**)	=(**DL**+**LL**)*(**L**^4)*2^3*/(384*29000***I**)		*I is given in table below*		
Beam Size	W16x26					

The new beam sizes were the same size as the old, save for W12x16, which has a heavier self weight than the W12x14 and lighter than the W12x19 that were used. In this example I reduced the number of beams by 2/3, and as in the Library structure, I was able to reduce the weight of the beams which is directly related is their pricing. See Table below.

Original					Redesign				
Beam Type	#	Avg Length (ft)	Beam lbs/ft	Weight	Beam Type	#	Length (ft)	Beam lbs/ft	Weight
W18x35	14	38.315	35	18774.35	**W18x35**	5	38.315	35	6705.125
W16x31	5	35.6	31	5518	**W16x26**	7	26	26	4732
W16x26	14	32.04	26	11662.56	**W14x22**	6	28.61	22	3776.52
W14*22	7	28.61	22	4405.94	**W12x19**	4	27.065	19	2056.94
W12x19	2	27.065	19	1028.47					
W12x16	4	26.805	16	1715.52					
W12x14	19	23.715	14	6308.19					
			Total	**49413.03**				**Total**	**17270.585**

However, higher price and more difficult coordination will be associated with a custom beam shape. Seven beams will need to be bent as seen in the Figure below to assimilate into the roofing structure.

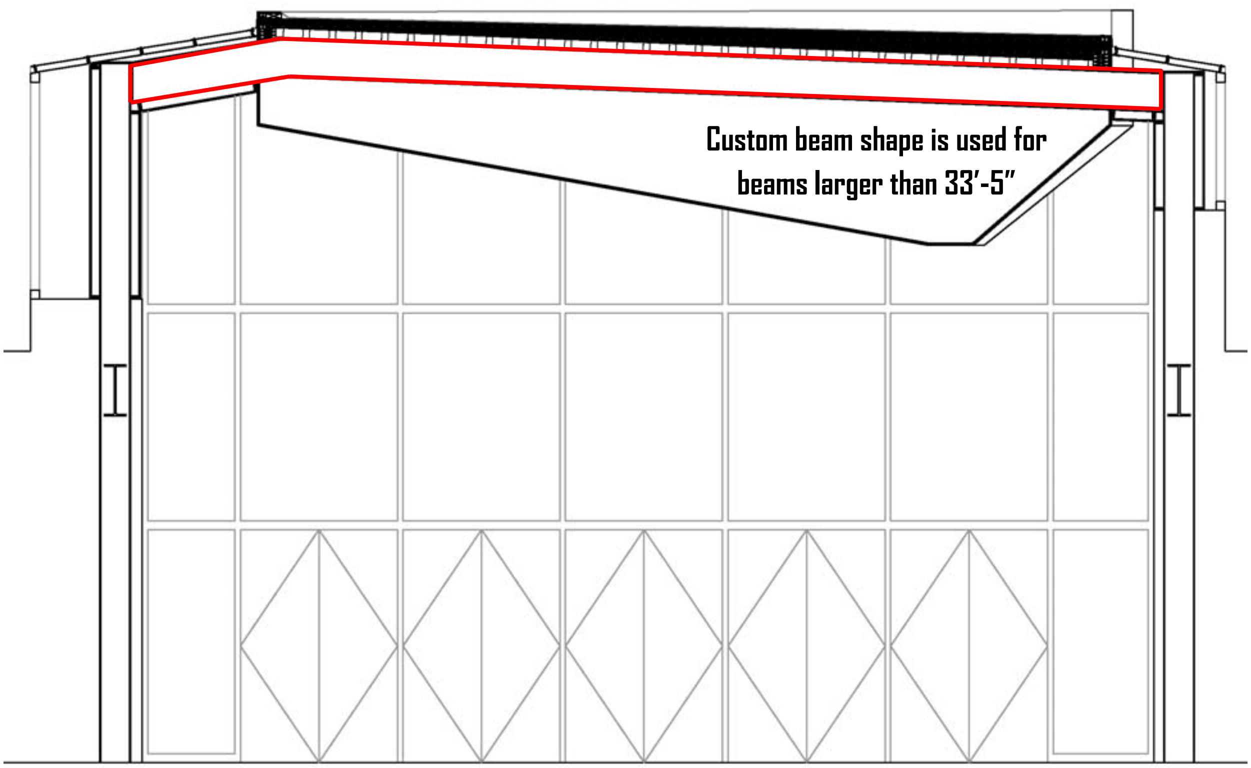


Figure 74 Section South through SG

Mechanical Breadth | Student Gathering Fenestration

Like the Library, once I changed the fenestration in the Student Gathering, I wanted to assure that the mechanical system would be unaffected. To do so I followed the same methods that I used in the Library mechanical breadth (see Mechanical Breadth Library pg 41). Much of the same process was the same for both of these spaces, although different results were found. The properties of the glazing analyzed are below.

Atrium Roof Area (Replaced)

Total Area (ft^2)	U				
5258	0.283723		W/m^2 ºC		
	ASHRAE PG 23 (25)				

Atrium Clerestory Glazing Area As Designed

Glazing Type	Façade Direction	Total Area (ft^2)	SHGC	U	SC
GL-1	1	3433	0.38	1.55	0.44
GL-1	3	1847	0.38	1.55	0.44
GL-1	2	378	0.38	1.55	0.44
GL-1A+B	1	3507	0.31	1.55	0.4532
GL-1A+B	2	729	0.31	1.55	0.4532
GL-2A+B and GL-INT	3	1873	0.051076	1.55	0.4532

Atrium Clerestory Glazing Area Re Designed

Glazing Type	Façade Direction	Total Area (ft^2)	SHGC	U	SC
GL-1	1	3433	0.25	1.220890411	0.2875
GL-1	3	1847	0.25	1.220890411	0.2875
GL-1	2	378	0.25	1.220890411	0.2875
GL-1A+B	1	3507	0.25	1.220890411	0.2875
GL-1A+B	2	729	0.25	1.220890411	0.2875
GL-2A+B and GL-INT	3	1873	0.051076	1.55	0.0587374
Kalwall	5	5258.00	0.09	0.283723	0.1035

Figure 75 As-Designed and Re-Designed Fenestration Properties

Using the ASHRAE analysis, it was clear that the redesigned daylighting fenestration would result in a lower cooling load than the original design. (See figure below)

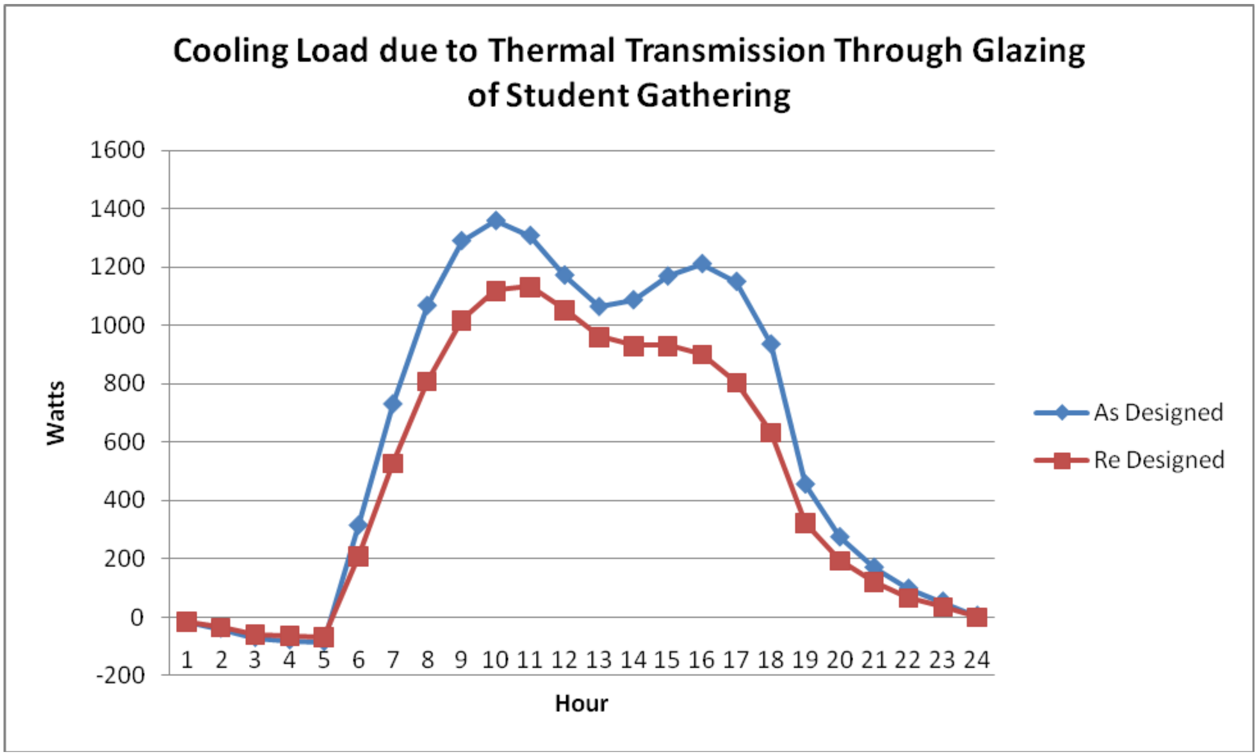


Figure 76 Graph for Cooling Load using ASHRAE Method (Student Gathering)

In this calculation, there was a clear difference between the two fenestration layouts. While in the Library example, the as-designed and redesigned systems were very close; this graph shows a noticeable difference. The separation stems from similar properties between the two systems. For example, the U value of the original roof was .05, the same as the Kalwall substitution. This was not so in the Library, where the U value of the skylight was much higher than the replaced roof. The glazing transmission reduction helped the cooling load decrease in both spaces, however, if a skylight was chosen with high transmission (and high SHGC, SC, or U value) the cooling load had a very high potential to rise above that of the original. In the given information from ASHRAE, the horizontal transmission values were the highest and most influential on cooling loads.

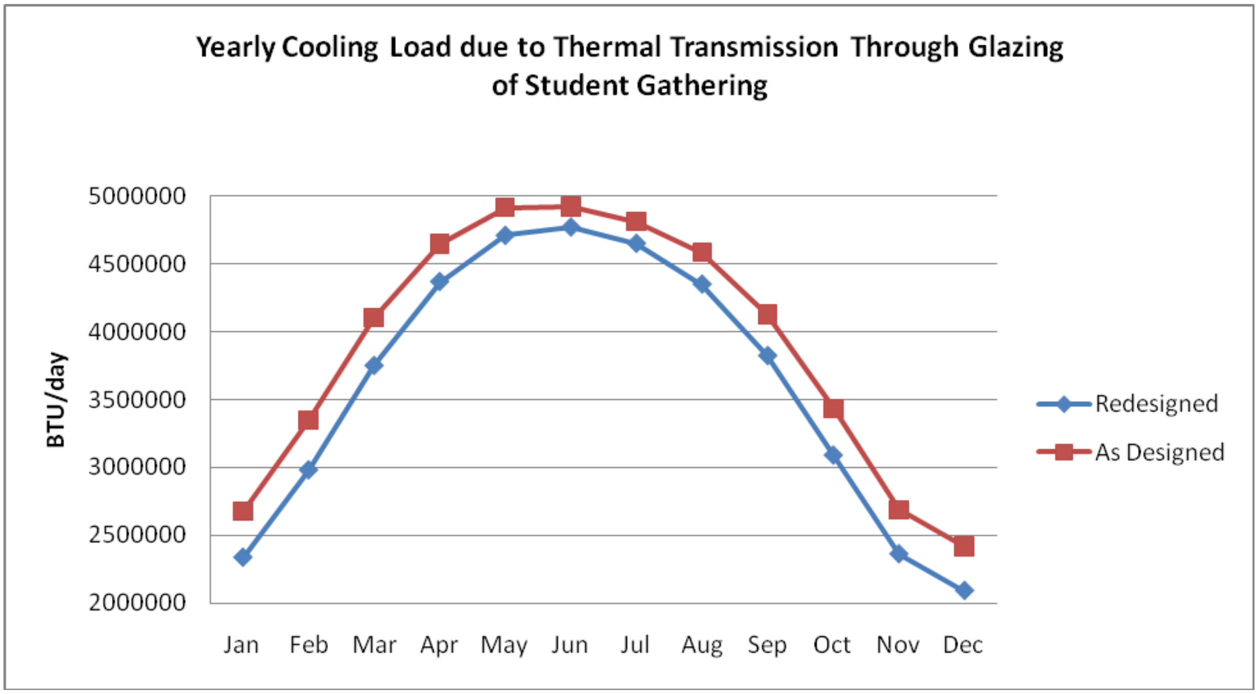


Figure 77 Graph for Cooling Load using NREL Method (Student Gathering)

From the NREL method, this conclusion is also supported. Like the ASHRAE method, the lack of a large load contribution from the roof (or the lack of a highly transmissive skylight) was beneficial in staying under the as-designed cooling load. In this example, I limited the amount of added cooling load by choosing a material with a great balance of light transmission and thermal insulation.