Lighting Depths | Overall Design Objectives:

The main purpose of the lighting design in GCC is to accentuate and support the overall architectural concepts found within the forms and features of the building and Perkins + Will's objectives for the new campus location. As stated in the architectural design intent, GCCs foremost purpose is to create a new identity for the education facility housed in the urban center of New Haven, Connecticut. In that respect, the lighting will reflect contemporary ideas and aesthetics as it assimilates into the current architectural design.

Within the proposed spaces, an optimum visual environment will be maintained by avoiding glare, extreme levels of transient adaptation, and unflattering patterns and shadows created by luminaires. By abiding to these cautionary standards, lighting will enhance productivity and not hinder working or social interactions. Furthermore, integration with the exterior environment is a key feature for the prosperity of proposed areas. Daylight shall be used effectively and efficiently in the attempt to supplant the need for electric lighting and therefore lower electrical consumption.

Lighting Depth | Tiered Classroom

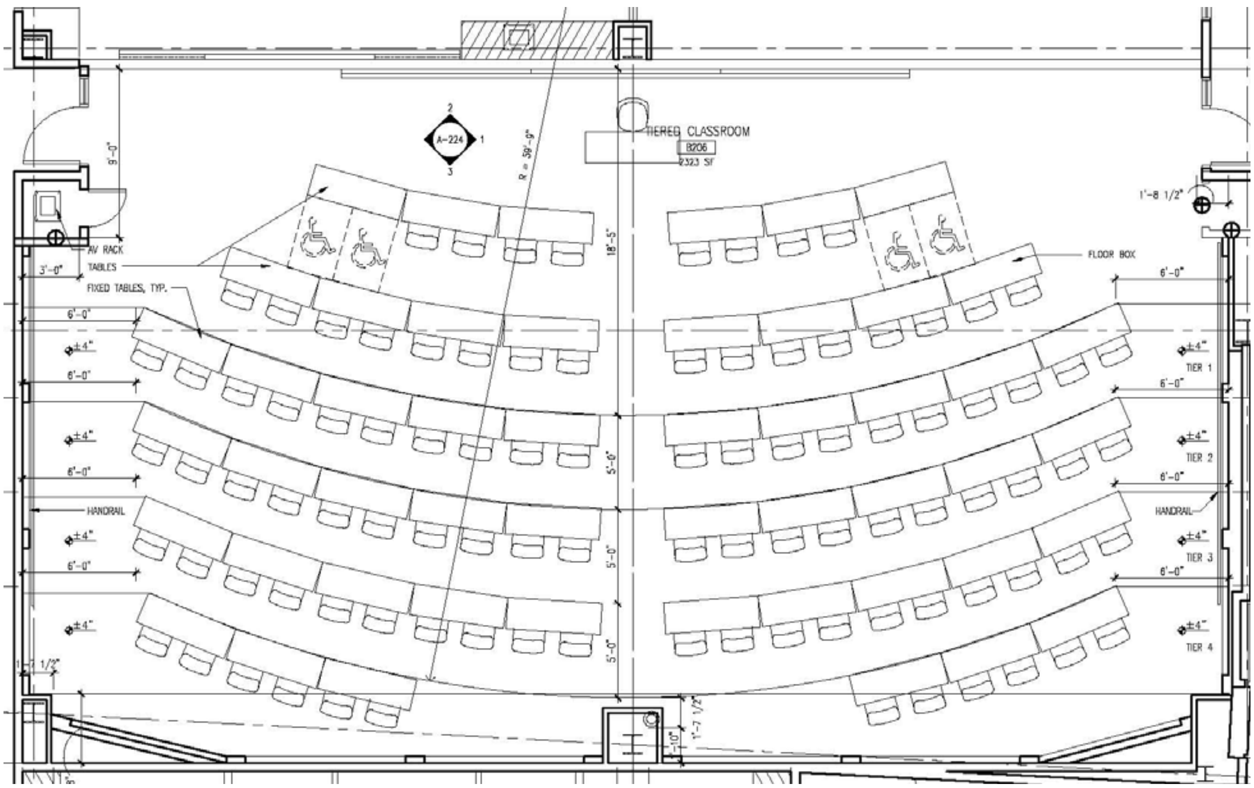


Figure 1 Tiered Class Floor Plan

Spatial Description:

The Tiered Classroom is located in the middle of the South Tower on the second floor and is a simple rectangular plan. Four 4" curved tiers increase the elevation in the back of the room 16". The room is wider (in the direction of the rows) than it is long (the direction the speaker will give lectures). The teacher will be located at the front of the room with two exits on either side. The ceiling mimics the tiered seating and will surely affect acoustic performance in the space. The ceiling has four sections, a front, two middle, and a back; these are symmetrical if looking at the side walls. The front panel slants up away from the speaker, the middle two create a "pyramid" and the back slants down from the ceiling to the back of the room. A drop ceiling surrounds these panels and is a few inches lower than their bottom. Please see DWGs in Appendix A for more information.

List of Activities:

Students will receive lectures which would be presented with the use of white boards and video projectors at the front of the room. The use of laptops to keep notes is possible.

Furnishings: (Material properties and description can be found on the Material Legend Appendix B)

Fifty tables —each seating two— (TB-1 and CH-1) are organized in a continental pattern on the curved tiers. Four spaces are provided in the front for handicapped individuals. Tables and seats are typical to that of classrooms. A podium and stool (PD-1 and ST-1) are also provided for the professor of the class. Please refer to Material Schedule in Appendix C for more information.

Materials:

a. Floor (Main) – Carpet (C-2)
b. Walls –
    i. Ptd. Gyp. Bd. (P-1)
    ii. Fabric wrapped Gyp. Bd. (WC-1)
    iii. Fabric wrapped acoustic panels (WC-1)
    iv. Drywall partition with reveal (P-1)
    v. White Boards (WC-3)
    vi. Presentation Screen (PS-1)
c. Ceiling
    i. Ptd. Gyp. Bd. (P-1)
    ii. Acoustic Ceiling Tile (ACT-6)

Dimensions:

L x W: 64' x 36'-10"
Floor Area: 2256.75 SF
Ceiling Height (front): 9'-2" A.F.F.
Ceiling Height (back): 7'-10" A.F.F.
Approx. Ceiling Height (center): 8'-6" A.F.F.

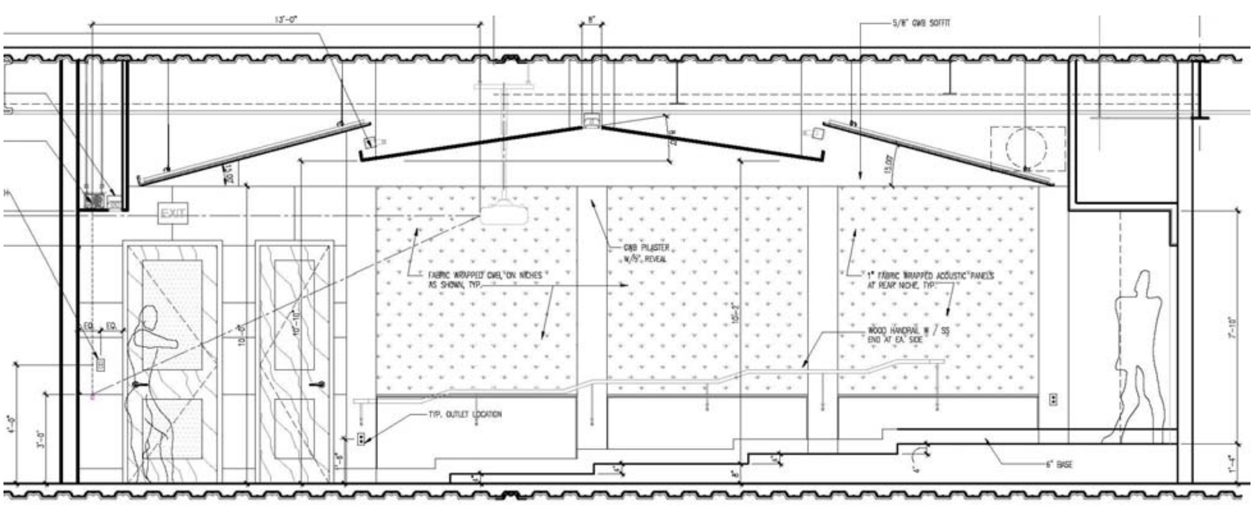


Figure 2 Tiered Class Section

Program Statement:

Classrooms often incorporate a number of activities—which means a number of tasks—into lessons. This classroom is no different. The lighting should reflect the variability within the space and the specific task at hand at any time. Uniform lighting will be needed for typical classroom activities and to add to the impression of clarity. Peripheral modes could be incorporated during multiple tasks for added light (and interest) into the space. A variable control of systems should be available to occupants; who will have the need to change lighting effects and settings per task. Glare and distracting lighting elements should be avoided.

IESNA Design Criteria

- Classrooms should be visually interesting for students; luminaires must be attractive to the eye but not diverting from the task in front of them.
- Low ceiling heights make students susceptible to distracting direct glare. To prevent this, no bare lamps should be in direct view from any point in the classroom.
- Reduction of shadows and striation from lighting systems is very important. This can easily distract students from presentations and lectures. Peripheral lighting may contribute light needed to cancel-out scallops and other shadows around the room.
- During video presentations, it is important to limit the illuminance to less than 5 fc on the presentation screens at the front of the room for optimum viewing. [ii]
- Occupants should have complete control over the lighting in the classroom. Professors may need to change the lighting scheme to better fit the lecture being given. Multiple zones should be configured such that this operation and variation is possible (these could include: downlighting, indirect, and peripheral lighting). Preprogrammed scenes will be available for simple control between desired lighting effects.
- Primary tasks include:
  - Reading and writing; mostly 10 -12 pt types and (#2) pencil and pen. Recommended illuminance on task plane—approximately 2.5 feet A.F.F.—(horizontal) is 30 fc.[iii]
- Secondary tasks include:
  - Passage through space. Recommended illuminance on task plane (horizontal) is 5fc.[iv]

ASHRAE Code Criteria

- Required limitation is 1.4 W/ft^2 for a classroom[v]

LEED Compliance

- EA Credit 1: Optimize Energy Performance: Space LPD (and watts) will be limited to 75% of ASHRAE 90.1 Standard to apply for 5 LEED points.

Design Development

In early schemes, I tried to completely light the space indirectly. By uplighting the suspended ceiling panels from the middle (C1), front, and back (C2) with T5HO fixtures I was able to reach the recommended average illuminance level in the space. I also used a semi-recessed asymmetric luminaire (C3) to light the white board at the front of the room. However, the uniformity suffered due to the lower ceiling heights surrounding the exterior of the space (seen below).

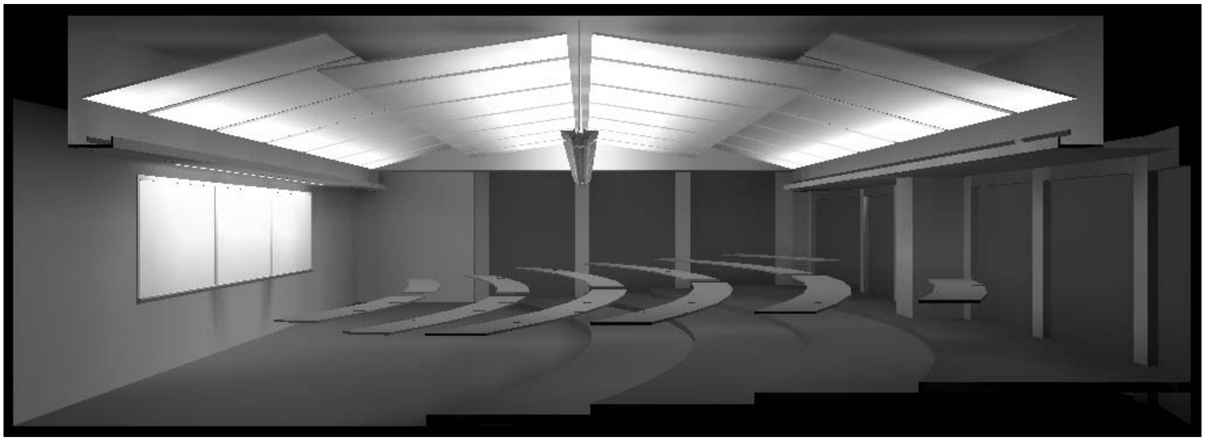


Figure 3 Section North Initial

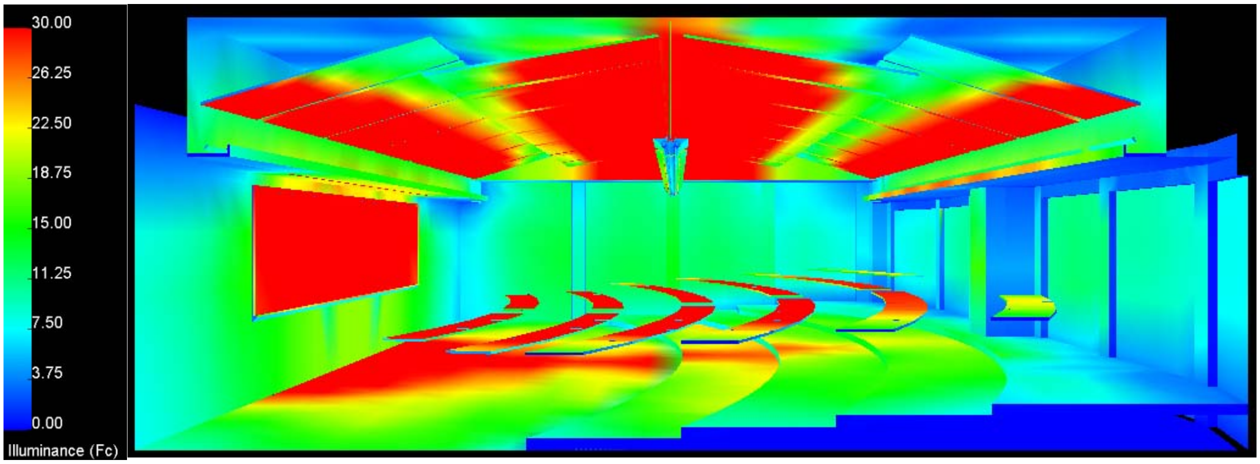


Figure 4 Section North Initial in Pseudo Color

As seen above in Figure 2, maintaining illuminance around the surrounding of the tables was more difficult than expected. Additionally, limiting the illuminance on the front projection screens presented a difficult problem for dimming the indirect system during presentations. It was nearly impossible to reduce the projections screens below 5 fc.

To increase uniformity around the edges and to limit the illuminance on the front screens I employed a downlighting scheme that was limited to the space over the desks. In my most recent design, an array of 32W Triple Tube CFL downlights (C4) helps illuminate the center desks while the indirect system adds light into darker areas and produces vertical illuminance. I also reduced the indirect wattages to 28W T5 lamps. Still, the surrounding edges of the desks were receiving less light than the center.

To fill in the shadows around the perimeter of the room (especially the left and right sides) I added asymmetric F14T5 fixtures (C5) to bounce light from the acoustic panels to the sides of the desks (the results can be seen below in Figure 3).

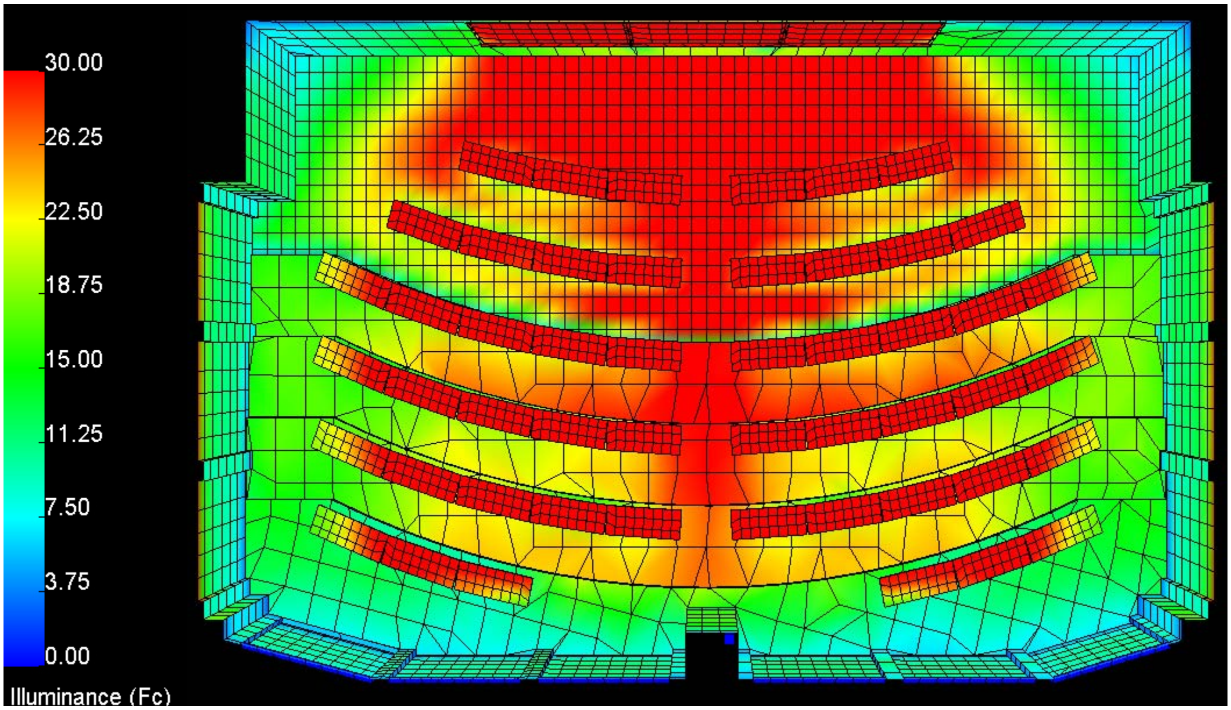


Figure 5 Pseudo Color Plan

Figure 6 Work-plane (2.5' A.F.F.) Isolines

Illuminance Value for work-plane (Fc) →
Criteria: 30 fc average

Maintained Output	
Stat Area for Work-plane 2.5' A.F.F.	
Illuminance Values (Fc)	
Average =	36.1✓
Maximum =	45.2
Minimum =	18.4
Avg/Min =	2
Max/Min =	2.5
Meets Criteria?	**YES**

Table 1 Stat Area Maintained

Under the maintained lumen output and other light loss factors my lighting scheme produces the illuminance seen above in Figure 4. A statistical area, covering the calculation grids on the table, produced the following performance data.

These findings meet my criteria of reaching 30fc average on the work-plane and also have an acceptable max/min ratio. Since differing illuminance values start to be noticed at a max/min ratio of 3:1, having mine at 2.5:1 will not be an extremely noticeable change in the desk illuminance. A rendering of this layout can be seen below in Figure 5.

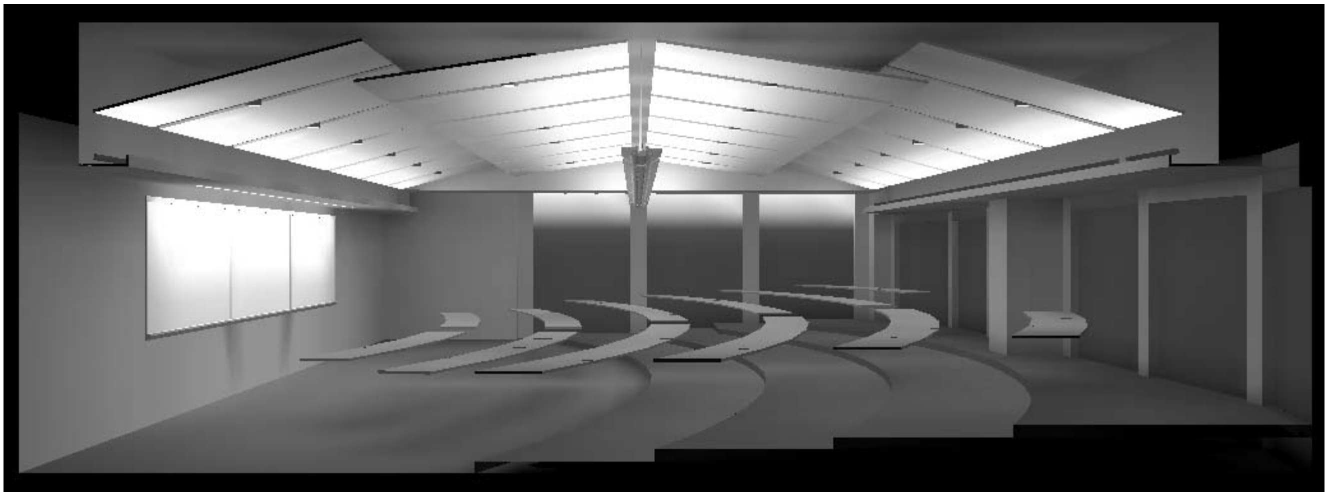


Figure 7 Section North "Final"

After I was able to satisfactorily reach my criteria, I moved on to the second scene I would create during a video presentation. I set a level between 5fc (recommended for passage) and 30fc (recommended for reading pencil type script). I decided on 15fc for the video presentation. To achieve 15 fc on the desks and a limit of less than 5 fc on the front screens, most of the lighting systems had to be sufficiently reduced (seen in Table 2 below). It was important, however, to keep the back three rows of downlights and the recessed luminaires on the side, on a higher level (the bottom rows of Table 2) to maintain the 15 fc average.

Noticeable in Figure 6 are the majority of tables maintained at 20 fc. The front tables are kept around 10 – 12 fc, which is acceptable due to the 3:1 (max : min) rule of thumb and the fact that a small amount of extra light will be added by the light reflecting from the presentation screen. This, according to my measurements, for adequate light during a video presentation, would meet criteria for the given scenario.

Luminaire %Light Output

Luminaire Type	% Full Output
C1	0.183277
C2	0.185216
C3	0
C4 (front row)	0.175
C4 (back three rows)	0.59
C5	0.83

Table 2 Dimmed Levels

Seen in Figure 6 (below) is the corresponding isoline plot for the presentation scene. Below in Table 3 are the statistical summaries for the task plane and two projection screen illuminance values. As you can see both screens are below 5 fc and meet IESNA criteria for video presentations.

		Dimmed Level Illuminance			
Stat Area for 2.5' A.F.F. Work-plane Illuminance Values (Fc)		Projection Screens_1_Proj Screen Illuminance Values (Fc)		Projection Screens_2_Proj Screen Illuminance Values (Fc)	
Average =	17.8	Average	4.04	Average	3.95
Maximum =	23	Maximum	4.9	Maximum	4.8
Minimum =	9.7	Minimum	3	Minimum	3
Avg/Min =	1.8	Avg/Min	1.35	Avg/Min	1.32
Max/Min =	2.4	Max/Min	1.63	Max/Min	1.6

Table 3 Dimmed Output

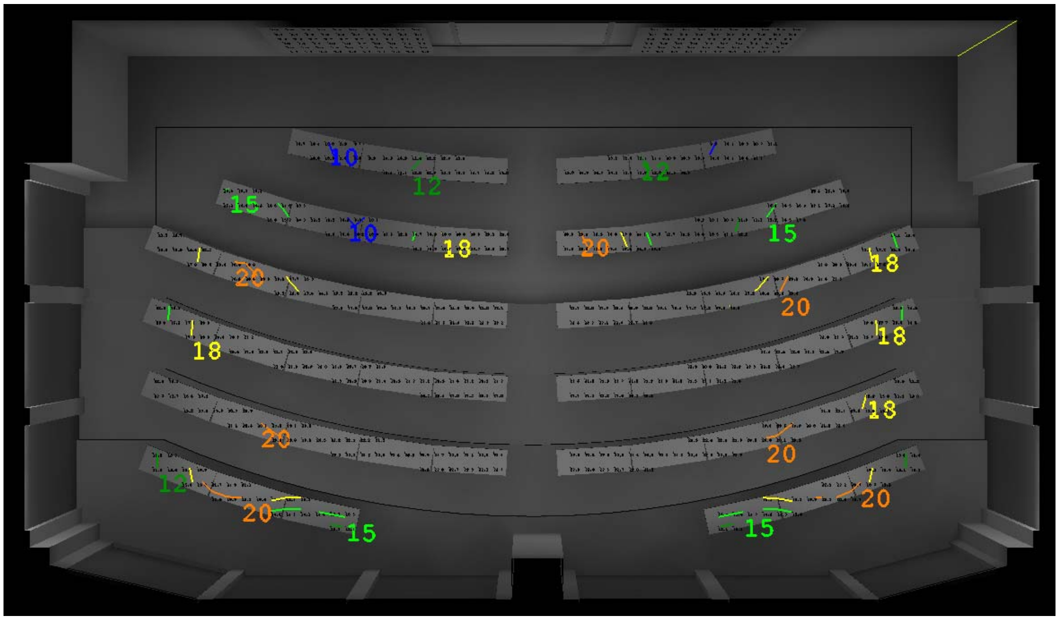


Figure 8 Dimmed Work-plane Illuminance

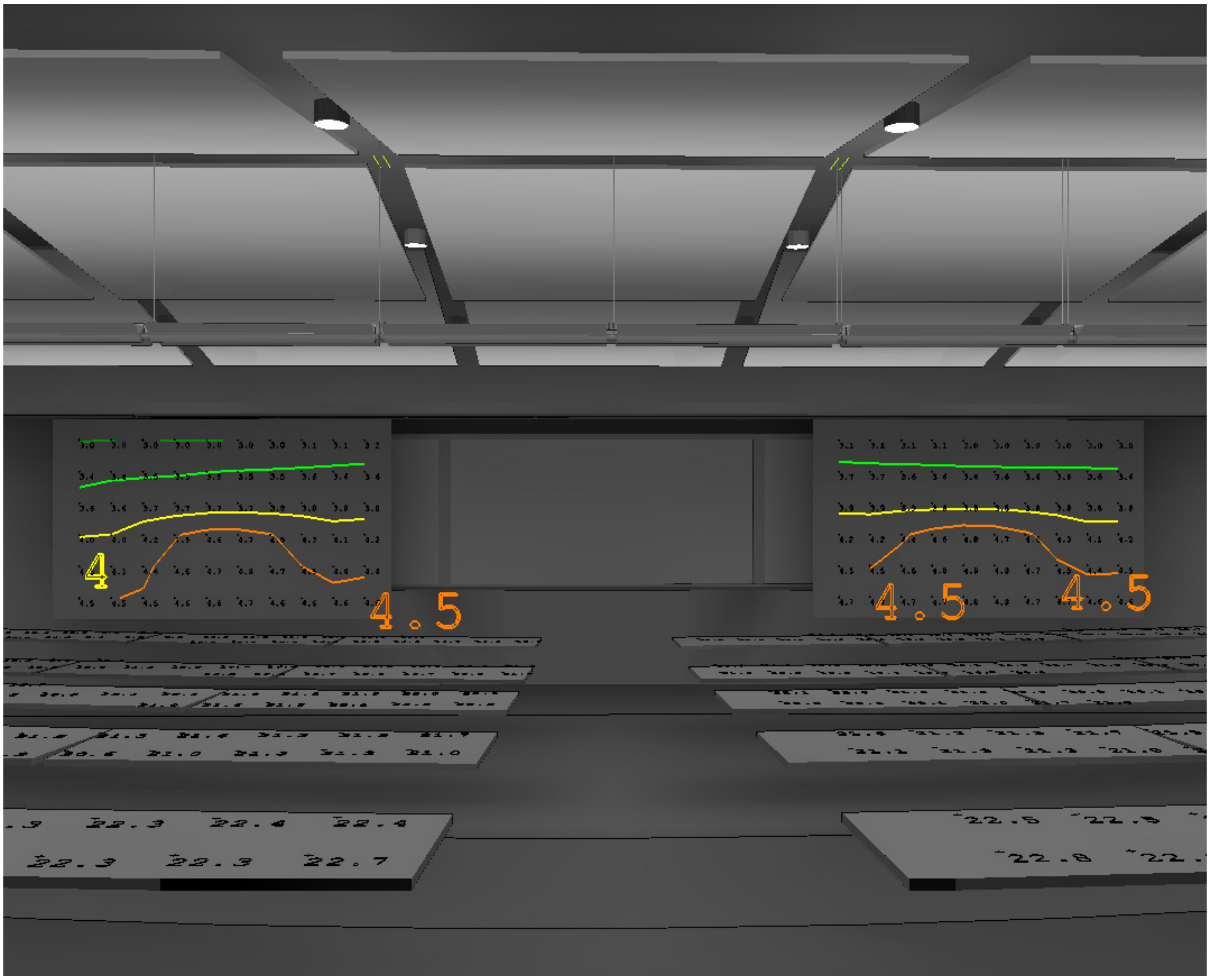


Figure 9 Max Illuminance on Proj. Screens

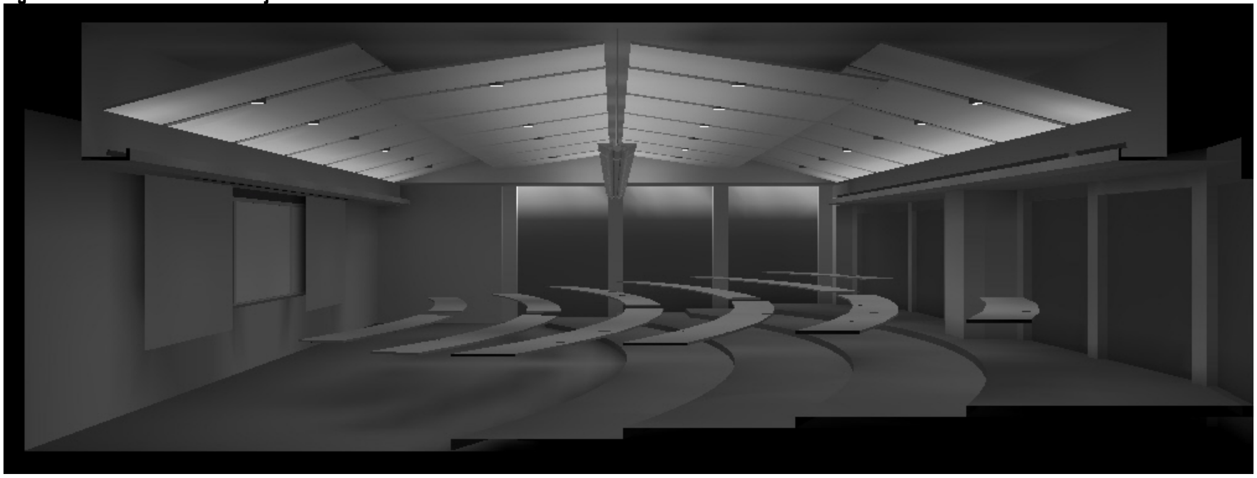


Figure 10 North Section DIM

Controls

To accomplish this means of control, the tiered classroom uses a system that incorporates Digital Addressable Lighting Interface (or a DALI system). Per GCC's specification, a DALI system shall be incorporated for all electric lighting. Ecosystem, a Lutron product, will help my lighting design meet this specification intent as well as provide ease of installation and the potential to modify systems later in the building's life. For the Tiered Classroom, one control stations will be installed at each door (please see Appendix __ for specification and layout). These controls will have two preset scenes and will have capacity for occupants to customize two more scenes based on their needs. Adjustment and control will be possible through infra-red remote control and through faceplate controls buttons.

In addition to manual control, automatic control is also integrated into this space. Dual technology occupancy sensors are used, and utilize both PIR (infrared) and ultrasonic detection. These sensors will cover a range of 1000 ft^2

Code Compliance

Because I will not be analyzing the whole building, I will consider the four spaces as a "whole building." This assumption will be used to comply with ASHRAE criteria (space-by-space method) as well as EA Credit 1: Optimize Energy Performance. Total Lighting Power Density (LPD - W/ft^2) will be limited to 75% of ASHRAE 90.1 Standard to apply for 5 LEED points. Therefore, each space will not need to meet 75% of the given LPD per type. However, the total LPD and watts used must be under the shared LPD and watts for all spaces; much like each space in an actual building would not need to meet it's given LPD. My criteria will be that all interior spaces must be equal to or under 75% of the code set in place by AHRAE. The total allowable wattage for the classroom is = 2257 (ft^2) x (1.4 W/ft^2)x.75 = 2369.85 W. The actual wattage used was 3269, so in this case, I have not met the given power density. Still, by saving wattage in other spaces I am able to share extra watts/ft^2 with the classroom, and supply watts that are under my set goal. (See Appendix B Lighting power Density for calculation of LPD)

Lighting Depth | Library

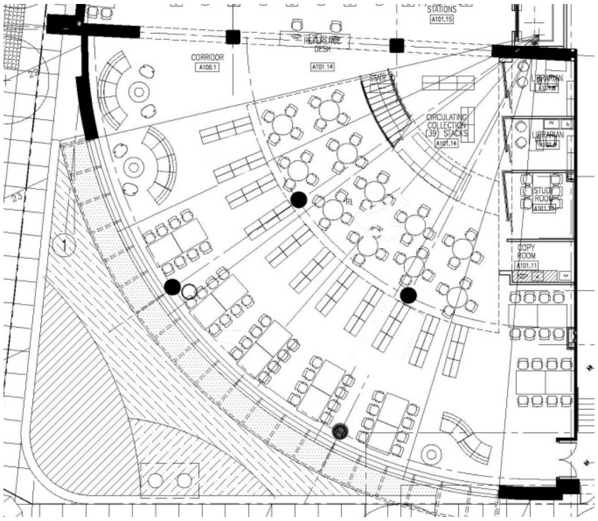


Figure 11 Library First Floor Plan

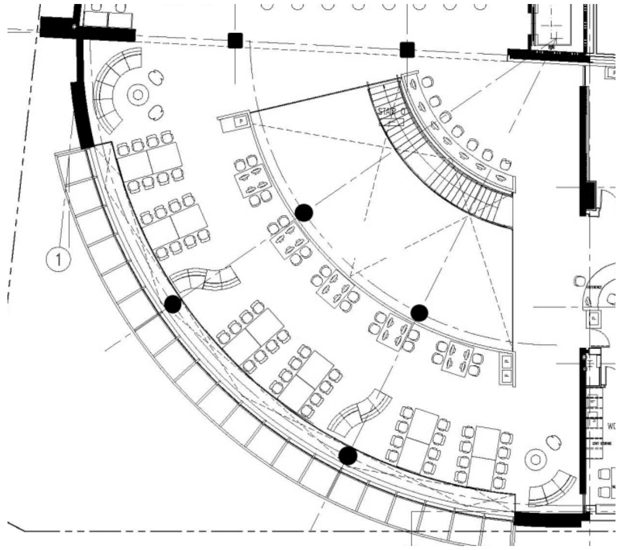
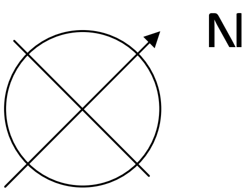


Figure 12 Library Second Floor Plan



Spatial Description:

The Library forms the South East corner of the South Tower and has a "quartered circle" plan that extends up to the fourth floor. It has two floors, the first houses stacks and various reading areas. The second has an opening in the floor where people on the first floor can see through to the two story height space on the floor above. A curving staircase mimics the curve of the exterior curtain wall which extends the whole height of the expansive room. Openness is reinforced through the openings in the North and West walls through which passage is un-hindered. Louvers and fritted glass have been added to reduce direct sun penetration from the glass wall due South.

List of Activities:

Used in addition to other parts of the library, the reading room is home to stacks located on the first floor. The space is primarily used for reading, studying and various homework activities, but also has computer stations positioned around the opening in the second floor.

Furnishings: (Material properties and description can be found on the Material Legend Appendix B)

Book stacks (BK-1) are organized around the same curve as the exterior curtain wall; the ends of the stacks face the curtain wall and if one is looking at the book titles than one is facing perpendicular to the curtain wall. In the same fashion, tables and chairs (TB-1 and CH-1)—typical to libraries—are positioned so the main view of occupant is perpendicular to the exterior wall. Upholstered couches (CH-2) are placed in the same area, some facing towards and some away from the large expanse of glass. Additional stacks are located behind the stairs, on the first floor, one row in the direction of the West wall and one along the North. Similar conditions exist on the second floor; tables, chairs, and couches are arrayed in the same position (in respect to the exterior glass). Computer stations (one table with two computers side-by-side and back-to-back—four per table) create another circular pattern and face perpendicular to the glass. Additional stations behind the stairs curve with the curtain wall but face directly towards it.

Dimensions:

North Boundary Length: 73'-2"
West Boundary Length: 73'-10"
Curtain Wall Radius: 79'-6"
Curtain Wall Length: 99'-6"
Floor Area (first floor): 4319 SF

Ceiling Height (first floor): 10'-6" A.F.F.
Plenum and Floor Thickness: 4'-4"
Ceiling Height (second floor): 24' (ACT) 24'-6" (GYP)
Total Height (interior): 38'-10"
Floor Area (second floor): 3137 SF

Materials: (Material properties and description can be found on the Material Legend)

a. Floor

   i. 1st and 2nd Floor carpet wall to wall (C-1)

   ii. Stairs – wood plank tread and riser (WD-1)

b. Walls

   i. Curtain wall (South East wall)– glass panels with structural silicone glazing (CW-200 refer to drawing A-490 for details)

   ii. 1st floor North AND West Walls Ptd. Gyp. Bd. (P-1)

   iii. Wood acoustic panel (AP-1)

   iv. Drywall partition with reveal (2nd floor) – (P-1)

c. Ceiling

   i. Gyp. Bd. ceiling 1st and 2nd floors (P-1)

   ii. Acoustical ceiling tile -2nd floor (ACT-11)

d. Window Systems (refer to drawing A-490 for glass arrangement)

   i. Mullion – (M-1)

   ii. Clear Curtain Wall - (GL-1)

   iii. Frit Curtain Wall - (GL-2)

e. Miscellaneous

i. Metal enclosures to columns (MP-20/21)

Program Statement:

As a work space, comfort level is extremely important. A uniform lighting scheme with glare elimination will allow the occupants to stay productive and will increase visual clarity. Daylight should be taken advantage of—and controlled—within this space. The enormous span of the South-facing curtain wall allows for a large amount of options for daylight management. It will be a focus of this space to limit the amount of light entering through the glass to an exitance that will eliminate the need for a considerable amount of electric light. This limitation however, should not decrease the amount of exterior views from the Library. During nighttime hours, exterior views should be maintained as much as possible, while still providing adequate light levels for a productive environment. The curved library corner serves as the conceptual "gateway" in Perkins + Will's architectural theme. This will be reinforced by reflections from interior surfaces making the curtain wall glow (from within) at night.

Design Criteria

- The space should represent the quality and innovation of the new institution and be a focal point at the intersection of North Frontage Road and Church Street.
- Luminaire appearance should be medium to high quality to better integrate into the space.
- Primary candela distribution should be in the 0-60 vertical angle range, luminaires with higher intensities nearer to 60-90 degree vertical angles should not be used on the first floor. View into bare-lamps should be avoided on every level. If glare exists, proper shielding should be used to minimize it.
- Luminaire placement should try to avoid arranging in such a fashion that would create reflections of luminous surfaces on computer screens.
- Primary tasks include:
    - Reading and writing; mostly 10 -12 pt type and (#2) pencil and pen. Recommended illuminance on task plane (horizontal) is 30 fc.[vi]
    - Finding and reading titles on book stacks. Recommended illuminance on task plane (vertical) is 30fc 30" above finished floor.[vii]
- Secondary tasks include:
    - Passage through space. Recommended illuminance on task plane (horizontal) is 5fc.[viii]
    - Face to face interaction. Recommended illuminance on task plane (vertical) is 5-10fc.[ix]

Design Development

It was clear in this space that, achieving my illuminance criteria was going to control and lead my design, especially on the second floor. Because of the two story-height ceiling, luminaire direction would need to be primarily downward (or max candela would need to be aimed at zero degree vertical angle). To start, I wanted to obtain 30 fc (maintained) on all of the tables and desks on the second floor. I also desired the layout of luminaires on the ceiling of the second floor to be an abstract representation of the gateway symbol (Figure 1) and to curve (Figure 2). This layout, parallel to the window, would also be cohesive with future daylight integration and harvesting.

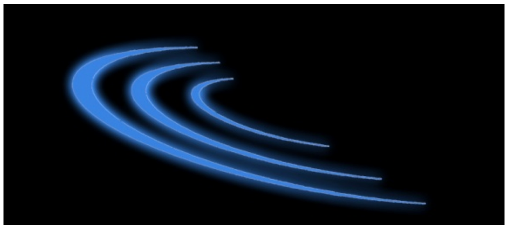


Figure 13 Gateway Symbol

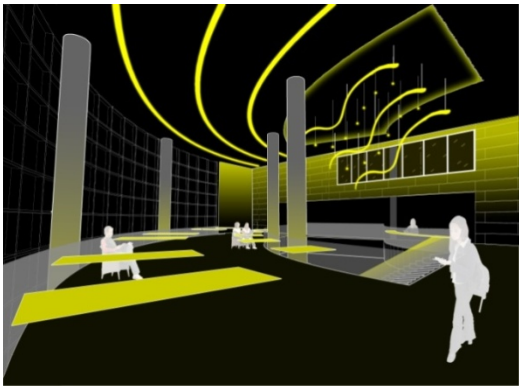


Figure 14 Conceptual Design Intent

However, I knew that finding a luminaire that is recessed and curves in the horizontal direction would be impossible. By using a 70W ceramic metal halide luminaire (L1A), I was able to provide the needed illuminance to the desk tops. To fill in the curve to fit my conceptual design, I designed three custom luminaires that would curve in the horizontal direction. These luminaires (L2A, L2B, and L2C) each use two, one-lamp (28WT5) strip lights recessed into custom-shaped curved housing. . To evaluate this custom luminaire I used Photopia to verify performance characteristics and make IES files which could then be inserted into my AGI verifications for the whole space (for more information please refer to DWG EL-452 in Appendix A). Additional task light on the second floor came from similar downlights (L1A and L1B) which were placed over specific task areas like corridor and computer stations.

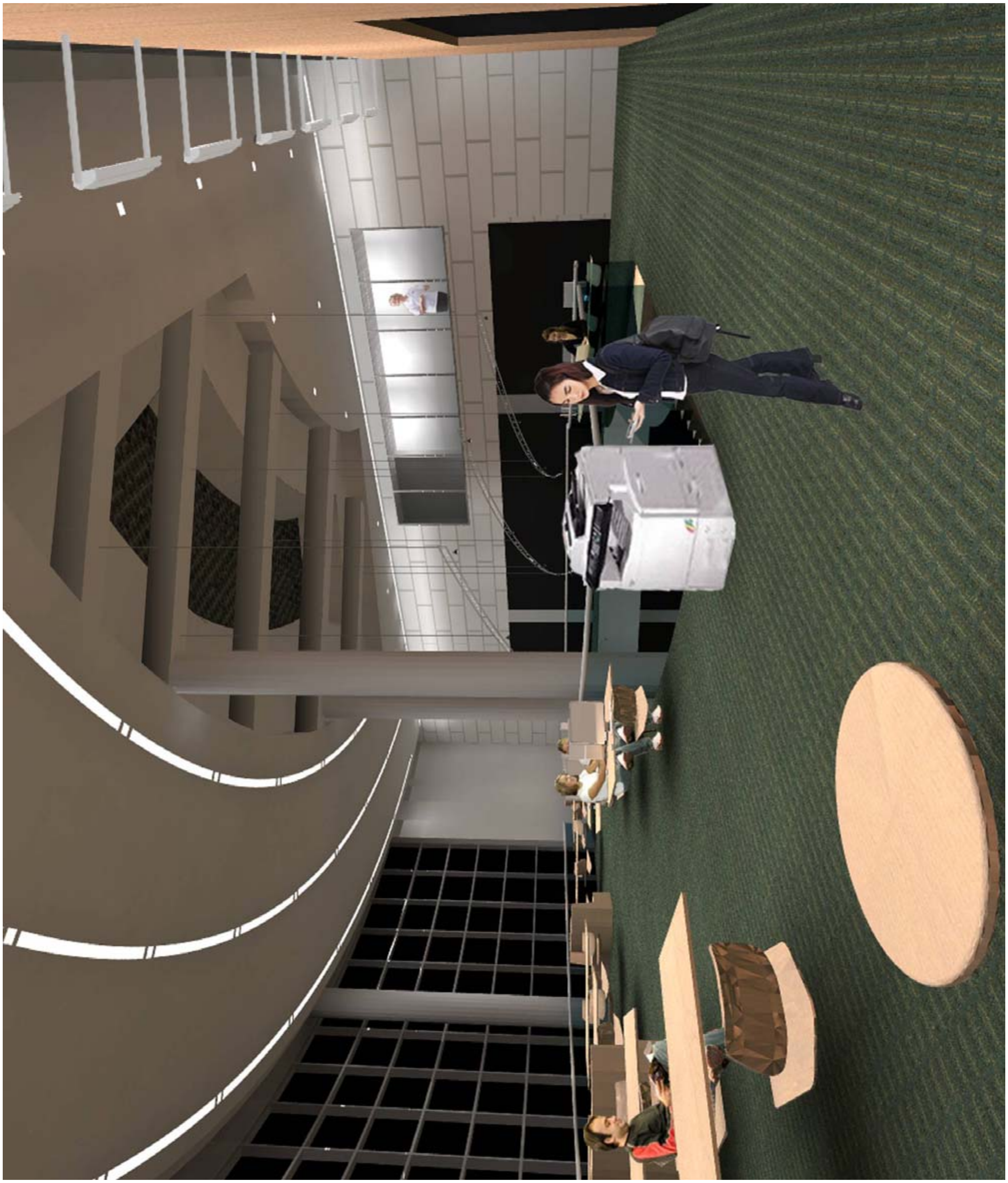


Figure 15 2nd Floor View South West

Figure 16 2nd Floor View North East

After designing the task light for the second floor, I moved to the first. First, I tried to recess luminaires into the ceiling for the book shelve lighting. This method failed to provide 30 fc 30 in A.F.F. under maintained conditions. After exploring different options, I chose the 3032 Stack Light by Elliptipar to illuminate the shelves. The choice was based upon the efficiency of the luminaire producing the needed amount of light while only using one F28T5 fluorescent lamp.

In addition to vertical illuminance criteria, horizontal fc were needed on the tables. I again tried to recess (1) F28T5 luminaires above the tables to achieve the 30fc recommended. This failed to produce 30 fc under maintained conditions. I then switched to a local lighting scheme which involved (2) table mounted direct indirect luminaires (L8) which used (1) F28T5 lamp each, and easily provided 30 fc maintained to the tables. This system also allowed me to increase the quality of the first floor. Because the second floor is so high, the first floor may seem a little cramped due to the lower ceiling. Utilizing a direct-indirect system allowed me to softly illuminate the ceiling, making it appear higher and the first floor roomier. For the curved couches on the first floor, I used decorative globe luminaires (L9A, L9B, and L9C) to make a more decorative touch, and playful area to relax. In this case, it was not my intent to meet 30 fc on the horizontal; I intentionally dropped the illuminance level to create a more relaxing area to sit and read. Fill light (for circulation) is provided by 26W CFL downlights (L10). (Please see Figure 17 for more information)

Figure 17 1st Floor View North West

Figure 18 1st Floor View Up Stairs

The most problems resulted from producing 30 fc on the tables directly under the opening in the second floor. The tables averaged only 15 fc with ambient light from all other systems, so it was clear that more light was needed. On top of lacking in recommended fc, I was missing an integral portion of my lighting design; a decorative suspended luminaire. Seen in Figure 14 (pg 21), I conceptualized a luminaire that would curve both in plan as well as modulate vertically. This luminaire would also serve as connection to the symbol and identity of Gateway Community College through the abstraction of the known symbol (Figure 13). It was desired that that no single view of this luminaire was the same as another, which would create a focal point in the opening of the space. To accomplish this design and shape of luminaire, I began by ruling out what would not help me produce my desired effects. For instance, cold cathode technology was a consideration for the luminaire until under more research I discovered that cold cathode tubes are not meant to bend in more than one axis. Also, the tubes themselves have bulky and unattractive ballasts and/or transformers that would be needed to run the system. These factors helped me eliminate cold cathode from being used. An LED source was also considered for this area, but, due to low lumen per Watt input of most flexible LED strips, and the coordination needed for a custom luminaire, this source was also avoided.

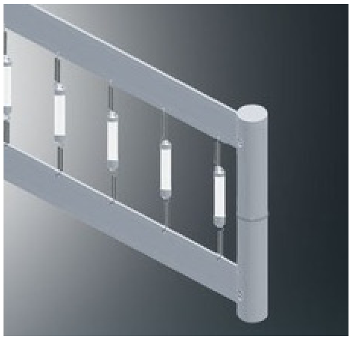


Figure 19 Bruck Flight Track (L9A, B, C)

Figure 20 Bruck Flight Track Head (L9E/D)

My final design incorporates a flexible track by Bruck Lighting Systems. The track itself (L9A,B, and C) features 1.2W festoon lamps mounted vertically between two track channels. These lamps would come to produce the glow that I envisioned early on in my design. Because the lamps are so small and low wattage, their luminance is negligible when considering glare. In addition to these lamps, MR16 lamps can also be attached and suspended from this track. To add light to the tables under the opening, 35 and 45W MR16 track heads (L9D and E) were fixed to the track and aimed at the tables. This solution made it possible to have a glowing luminaire that curved in two directions as well as a luminaire with a directional quality. Because of daylight integration, it is an aim to shut this luminaire off during times with sufficient daylight. Therefore, it was important to consider how this luminaire would look while not producing light. The fact that this track is not only a glowing lens but has a structural and sculptural quality, made it a great choice for this particular application (for more information please refer to DWG EL-453 in Appendix A)

For work plane illuminance verification, please see pseudo color plans below.

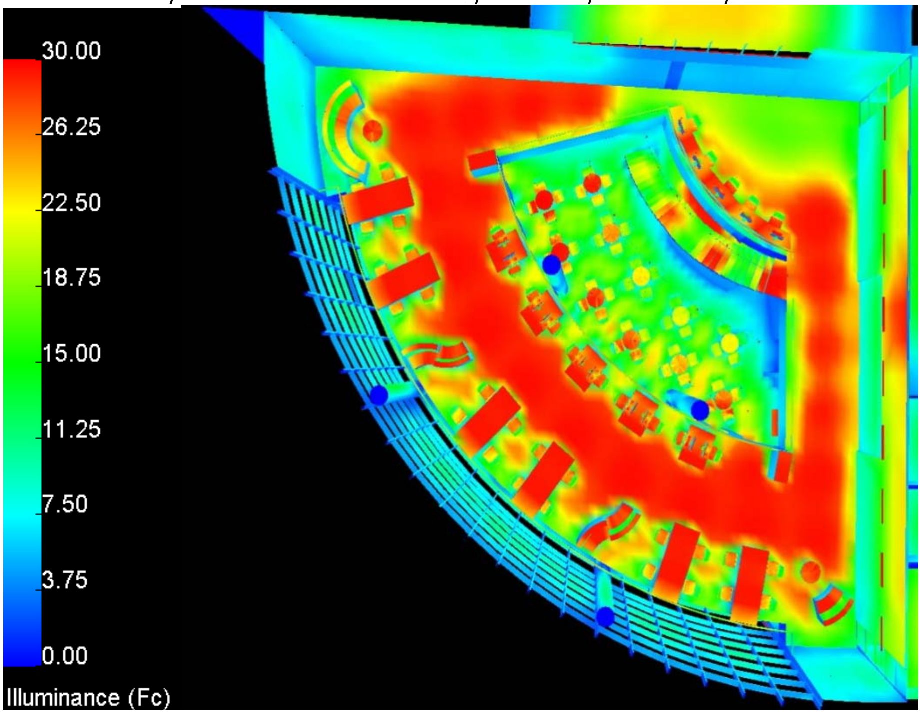


Figure 21 2nd Floor Work Plane Illuminance

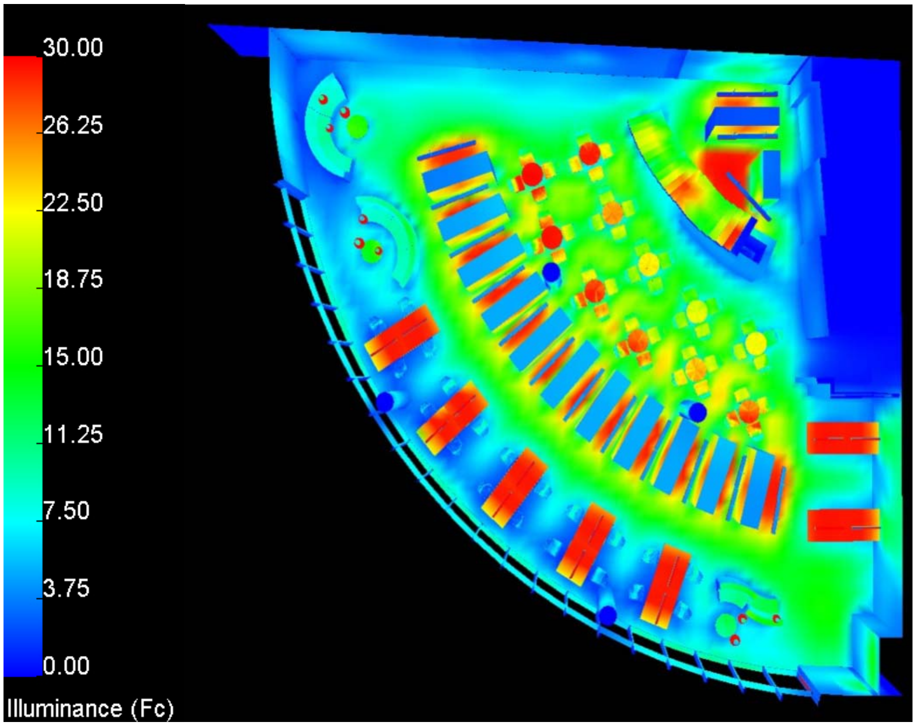


Figure 22 1st Floor Work Plane Illuminance

Highlighting the surrounding walls on the second floor was important to fulfill my design goals of making the Library glow from within at night. A linear fluorescent slot (L4) was used to illuminate the white masonry wall (West wall). Although this lighting scheme does not wash the wall—as originally desired—I am able to maintain the wall as a standout piece of architecture. This also creates the impression that there was an opening between the wall and ceilings in the spaces, which light could come through. The established scheme makes the wall "disconnect" from the bordering ceilings, and due to the high reflectivity of the material it maintains a higher luminance than the rest of the room surfaces. These attributes of the white wall's lighting help support the architectural concept of a "gateway," by creating gateways of light.

Figure 23 Light Through Opening

Figure 24 Wall Slot in Library

Using a cantilevered linear fluorescent luminaire (L5) to create a smooth gradient down the wood wall (North wall) also helps communicate the idea of openings in the space. By lighting these walls a glow emanates from the inside of the library, making it the focal point of the intersection outside. This helps convey the large glass façade as transparent or a "gateway" into the college.

Controls

Because the Library is a large space and many different people will be entering and exiting for use, I do not deem it necessary to incorporate multiple control stations or occupancy sensors for main function hours. For this purpose, automatic control will be integrated. Per HLB's control intent, all electric lighting within 15' of windows will be controlled by daylight sensors; which will reduce interior lighting to a certain level under incident daylight. It will be my intent to increase the radius away from windows (and fenestration) inside which electric lighting will be shut off or dimmed. The Library's South façade is made up almost entirely of glass and will be vital to integrate into the control of the electric lighting and daylight harvesting. Additional daylight will come from the skylight above the second floor opening. This skylight serves as an architectural breadth; for more information please refer to pg 33 Architectural Breadth | Library Skylight / Roof Garden Walkway. Open loop sensors will be used to shut off electric lighting for the given zones when daylight is ample enough to replace. These photosensors will be placed nearer to the window to control the lighting zones that serve seating areas close to the fenestration. Photosensors will also be located in the skylight well to control lighting zones directly under or around the skylight opening. (Please refer to circuiting drawings pg for more information)

During daytime hours, photosensors shall control the electric lighting and turn loads on/off in accordance with daylight penetration; especially those within 15' of windows. Astronomical time-clocks will control non-fluorescent loads. Lighting around the peripheral (wall emphasis) will be shut off during daytime hours and shut on by an astronomical time-clock after the sun has set. Ultra-sonic occupancy sensors will control wall emphasis and other non-HID loads during the night.

Code Compliance

Please see Appendix B for code Compliance

Daylight Analysis

To analyze this control system's potential for energy savings through daylight harvesting; I conducted a study using AGI, Excel, and Daysim. To begin, I conducted a simple daylight model to find what kind of light levels were being provided from the as-designed system and how surrounding buildings impacted the daylighting.

Under the criteria set by the United States Green Building Council (USGBC) and LEED, daylight factor for total glazing must be above 2% and 75% of all spaces must meet 25fc 30" A.F.F. during March 21st (equinox) at noon (standard for achieving EQ Credit 8.1). For this analysis, I have assumed certain window properties of the two types of glazing used; for GL-1 (clear glass around the exterior) I am assuming 70% transmission, for GL-2 (fritted glass on interior) I am assuming 30% transmission.

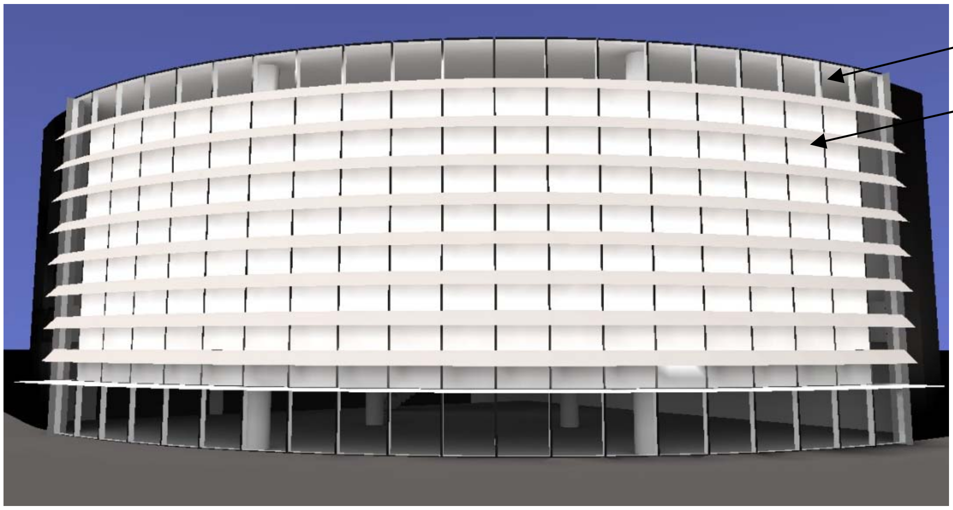


Figure 25 Initial AGI rendering showing glazing types

Assumed Material Properties

a. Floor *(Reflectance)*
   ii. 1st and 2nd Floor – **.2**
   iii. Stairs – **.35**
b. Walls *(Reflectance)* – **.5**
c. Ceiling *(Reflectance)* – **.75**
d. Window Systems *(Reflectance and Transmittance)*
   iv. Mullion – **.65 and 0.0**
   v. Clear Glass – **N/A and .7**
   vi. Fritted Glass – **.5 and .3**
e. Miscellaneous *(Reflectance)*
   vii. Metal enclosures to columns – **.35**
   viii. Ground – **.15**
   ix. Exterior Overhang *(transmittance)* – **.3**
   Exterior Louvers – **.65**

The results were as follows:

Calc Plane 1st Floor Illuminance Values (Fc)	
Average	70.68
Maximum	540
Minimum	10.1
Avg/Min	7.00
Max/Min	53.50

Calc Plane 2nd Floor Illuminance Values (Fc)	
Average	307.86
Maximum	4696
Minimum	39.4
Avg/Min	7.81
Max/Min	119.18

Table 1 Illuminance values of initial daylight model

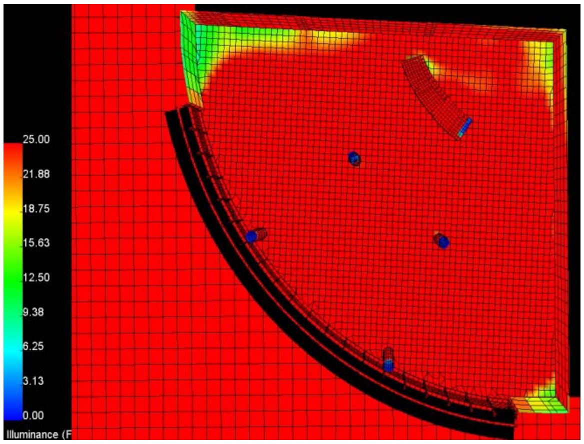


Figure 26 Illuminance 1st floor 25fc Max

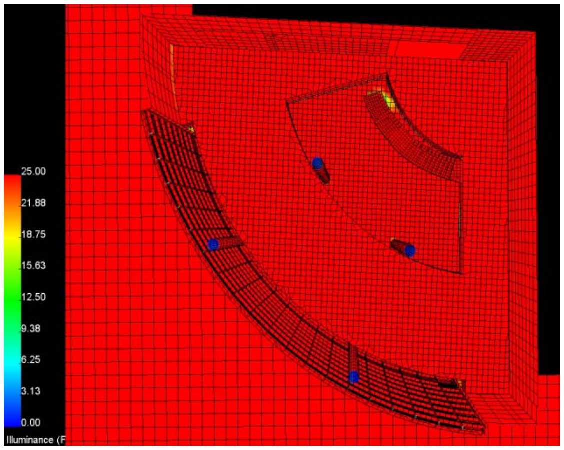


Figure 27 Illuminance 2nd floor 25fc Max

Room	Floor Area	Glazing Area	Window Geometry		Transmittance		Window Height	Daylight Factor (%)		Daylight Area	Glare Control
	[SF]	[SF]	type	factor	actual	minimum	factor	each	room		
Reading Lounge	8773	359.3284	Vision	0.1	0.7	0.4	1	.57	3.17 ✔	8773	1
		107.8596	Vision	0.1	0.3	0.4	1	.07			1 and 6
		659.6	Daylight	0.1	0.7	0.7	1.4	1.05			1 and 6
		2143.78	Daylight	0.1	0.3	0.7	1.4	1.47			1 and 6

Table 2 Daylight Factor Calculation

From the initial analysis, one can see that, per my assumptions, this space would easily meet USGBC and LEED criteria (if considered as a whole building). I came to the conclusion that the light transmission of the daylighting system could be reduced and still provide quality daylighting into the Library, have significant savings (in terms of thermal heat reduction through windows), and still abide by USGBC and LEED criteria.

Daylight Redesign and LEED

In my redesign, my aim was to significantly reduce the amount of incident daylight into the Library while also incorporating changes in the architecture that would allow daylight to penetrate deeper (i.e. getting to the first floor). My first step was to reduce the transmission of the glass on the south façade. I decreased type GL-1A/B from .7 to .45 and reduced GL-2A/B from .3 to .18. These values stem from PPG glass data and combining glazing types Solarban 60 (2) clear, Solarbar 70 Xl (2) Star + CL, and ¼" clear glass; please see Appendix C pg C4-6 for more information. This combination was to mimic the actual size and types of the window types used.

I then proposed the integration of a skylight into the ceiling over the opening in the second floor. This skylight also serves as the roof and deck of the Roof Terrace. With this fenestration I am able to provide daylight onto the table tops on the first floor. More information on the skylight can be found on pg 37.

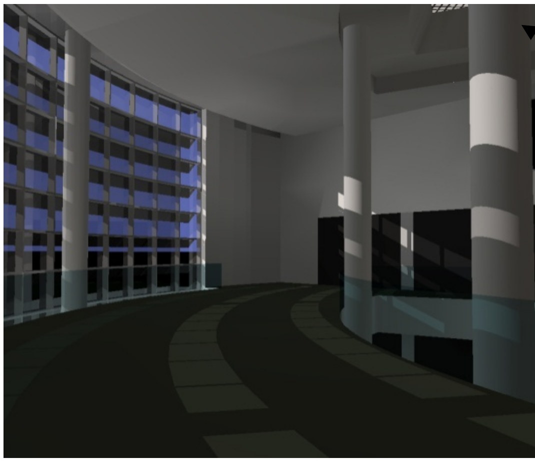


Figure 28 Interior View December 21st Noon

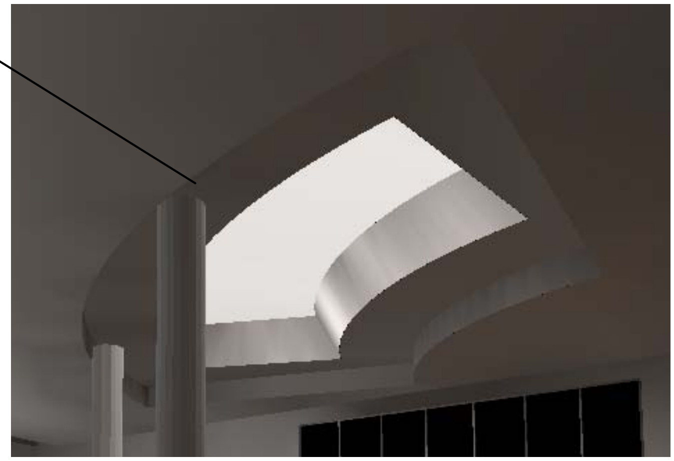


Figure 29 View of Splayed Skylight

It was important to integrate this skylight not just to increase the light levels and daylight factor to pass LEED criteria, but to increase the amount of light entering through the skylight after limiting the original amount of light coming in through windows. Without the skylight, summer months would receive noticeably less amounts of daylight; this is due to louvers outside blocking the direct sunlight from entering the space. The skylight, however, has minimal shade in the summer—save for amount created by the trees located on the roof above (it should be noted that the existence of trees has been omitted for these calculations and an added 30% has been reduced from the skylight).

After changing the daylighting systems, I assured that the new design would pass LEED EQ Credit 8.1. After exporting the points during March 21st (equinox) at noon, I totaled the number of interior points that received light and the number of these points that were above 25fc. The total number of points was 1077, and the number of points above 25fc was 886. To achieve credit 8.1; which states that 75% of all spaces must meet 25fc 30" A.F.F., I am regarding my four spaces as a "whole building" and will consider 75% of total calculation points at or above 25fc to pass the stated criteria. In this space 82.3% of points meet 25fc on the equinox. In the figures below, AGI grid points are highlighted with colors that reflect their illuminance relative to neighboring points. The lowest values are green and the highest are red.

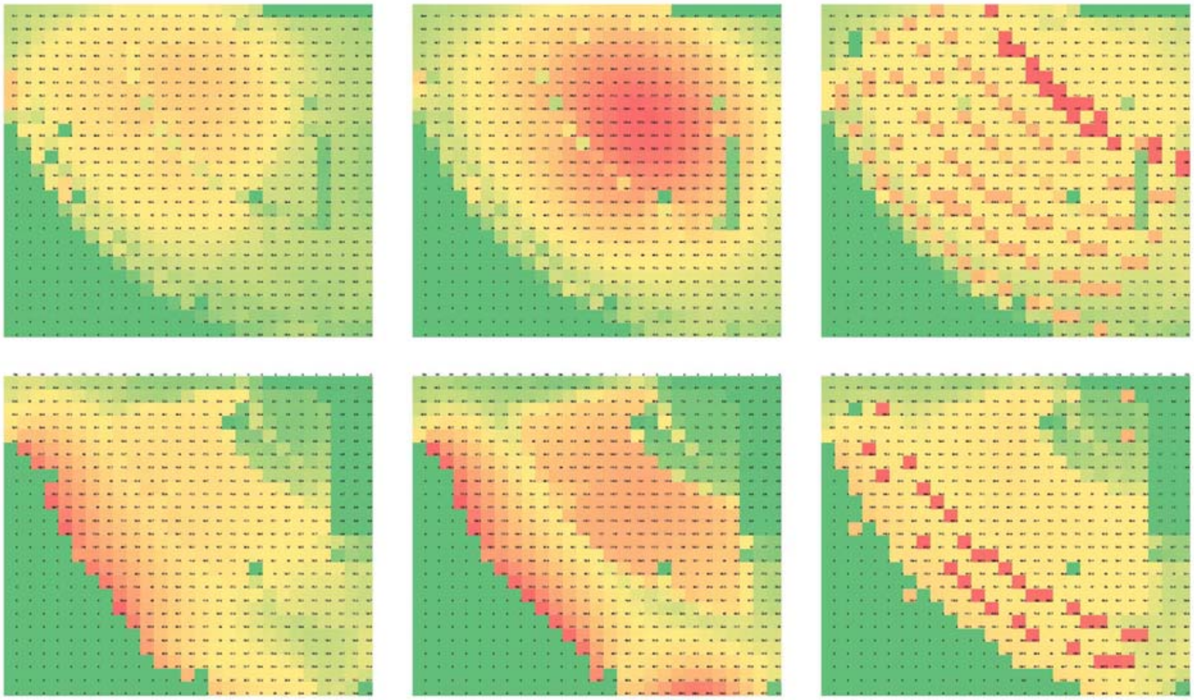


Figure 30 Daylighting Illuminance Contours for clear sky at noon on the 21st; Left to Right – March, June, December; Top to Bottom – Second Floor, First Floor

In addition to the foot-candle criteria being met on March 21st, I also recalculated my Daylight Factor for the Window and the skylight addition. Even with the reduction of window transmittance, I still met the 2% Daylight Factor Criteria for LEED credit 8.1.

Room	Floor Area	Glazing Area	Window Geometry		Transmittance		Window Height	Daylight Factor		Daylight Area	Glare Control
	[SF]	[SF]	type	factor	actual	minimum	factor	each	room		
Library	8773	359.3284	Vision	0.1	0.45	0.4	0.4	0.18	3.09	8773	1
		107.8596	Vision	0.1	0.18	0.4	0.4	0.02			1 and 6
		659.6	Daylight	0.1	0.45	0.7	1.4	0.68			1 and 6
		2143.78	Daylight	0.1	0.18	0.7	1.4	0.88			1 and 6
		310	Skylight	0.5	0.3	0.4	1	1.33			

Table 3 Redesign Daylight Factor

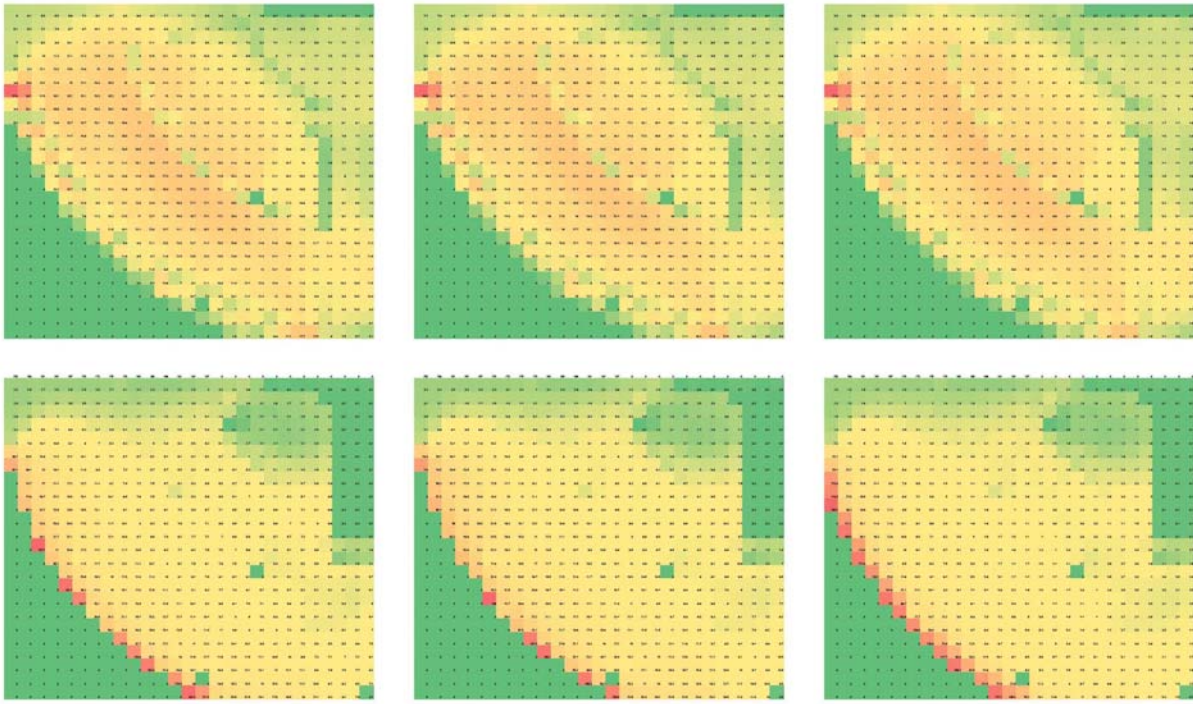


Figure 31 Daylighting Illuminance Contours for overcast sky at noon on the 21st; Left to Right – March, June, December; Top to Bottom – Second Floor, First Floor

Daylight across three months can be seen in Figure 30 on the previous page. It illustrates how light will be distributed by my daylight design. In March (left) direct daylight is minimal but levels on the second floor range from 25 (at walls) to 94 fc (below skylight). In June (middle) there is less direct penetration (from the southern façade), yet daytime illuminance levels increase due to the penetration through the skylight. Because light is coming through the ceiling, it provides more uniform distribution across the work-plane and reduces the likelihood for direct glare. In December, direct penetration is very common—which I attribute to low profile angle in the winter. This can create glare issues and will be countered by automatic blinds around the first and second floor windows. On first, the blinds will lower from the gap between the second floor and south façade. Likewise on the second, blinds will be located in the same gap, but will rise to a height of 7'.

Daylight Harvesting

To quantify how daylight will replace electric light in my design, I have analyzed my design with Daysim, a program that uses Autodesk software that can interface with radiance to produce yearly output for lighting systems. To use this system most efficiently it is beneficial to conduct a critical point analysis of zones under various sky conditions. This study locates a point in a specific lighting zone where light output is reduced to a minimum value. This minimum value is the smallest reduction of light output for that zone such that in combination with other zones and daylight, the work-plane still reaches recommended illuminance levels.

To find this point for various zones, I exported AGI calculation grids to Microsoft Excel, where a computation spreadsheet is easy to work with. Zones were made in AGI and a number of calculations were completed to separate lighting zones for analysis. The calculation points were then imported according to their zone. An example of this sheet is below.

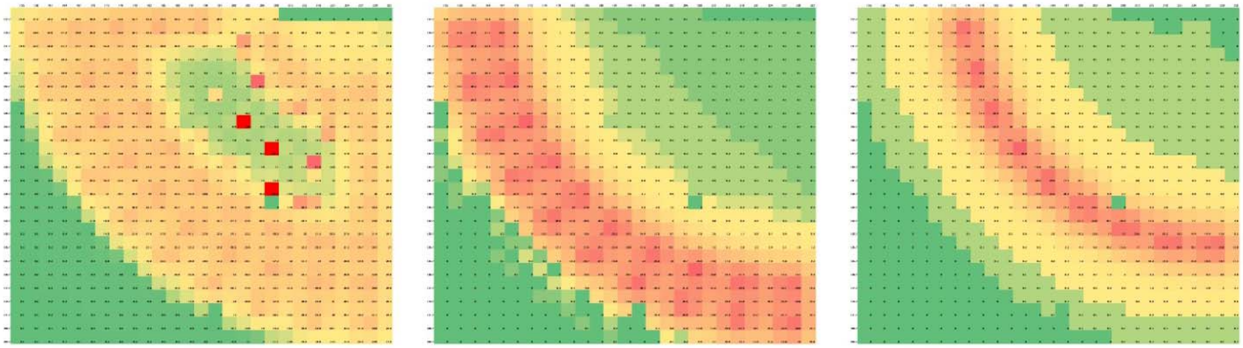


Figure 32 Calculation Points Exported from AGI, Maintained output (left), 2 rows of L1A (middle), and 1 row of L1A (right)

After importing the zone information, I used the following equation to find critical points. The labels represent the fc values for each individual point that are being compared.

$$\text{Dim Level} = \frac{\text{Full Elec.} - \text{Daylight} - \text{Zones not being dimmed}}{\text{Full output of zone being dimmed}}$$

It should be noted that because my lighting system uses HID sources, that dimming is not recommended. An on/off control will be used to control the lighting; however, this critical point analysis is still valid with use of Daysim software. The critical point is the highest value or in other words, the least change in light output. Below, the critical point for Zone 1 (two rows of L1A and L2A) is shown.

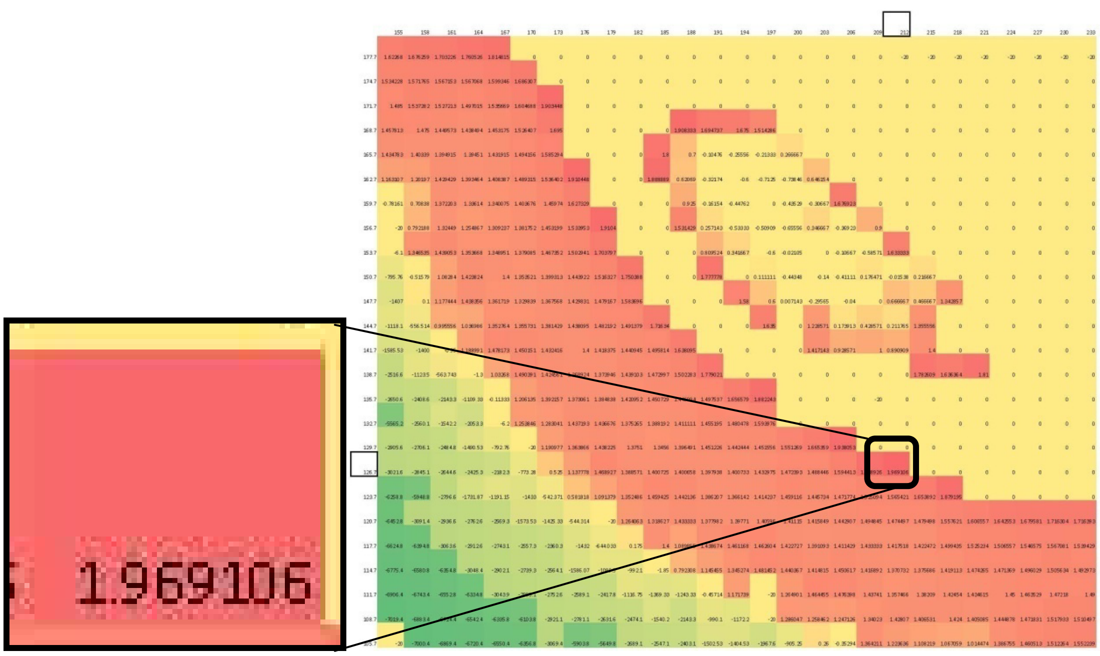


Figure 33 Critical Point for Zone 1 used in Daysim

It should also be noted that overcast sky conditions were used to locate critical points, due to the extreme excess of daylight provided by clear skies. After finding the critical point I started to import and set parameters in Daysim.

A sample output from the program can be seen below

Daysim Simulation Report

In short...

- Daylight Factor (DF) Analysis: 100% of all illuminance sensors have a daylight factor of 2% or higher. If the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone should qualify for the LEED-NC 2.1 daylighting credit 8.1 (see www.usgbc.org/LEED/).
- Daylight Autonomy (DA) Analysis: The daylight autonomies for the core workplane sensor are 87%. for an active user and 87% for a passive user .
- Useful Daylight Index (UDI) Analysis: The Useful Daylight Indices for the Lighting Zone are $UDI_{<100}$=12%, $UDI_{100-2000}$=7%, $UDI_{>2000}$=81% for an active user and $UDI_{<100}$=12%, $UDI_{100-2000}$=7%, $UDI_{>2000}$=81% for a passive user .
- Continuous Daylight Autonomy (DA_{con})and DA_{max} Analysis: 100% of all illuminance sensors have a DA_{con} above 80% for an active user and 100% of all sensors have a DA_{con} above 80% for a passive user . 100% of all illuminance sensors have a DA_{max} above 5% for an active user and 100% of all sensors have a DA_{max} above 5% for a passive user .
- Electric Lighting Use: The predicted annual electric lighting energy use in the investigated lighting zone is: 0.2 kWh/unit area. Assuming a lighting zone size of 8420 [unit area], this corresponds to a total annual lighting energy use of 1333.3 kWh.

Simulation Assumptions

Site Description: The investigated building is located in New (41.27 N/ 72.88 E). Daylight savings time lasts from April 1st to October 31st.

User Description: The zone is continuously occupied Monday through Friday from 8:00 to 20:00. The total annual hours of occupancy at the work place are 3131.3. The electric lighting is activated 3215.3 hours per year. The occupant performs a task that requires a minimum illuminance level of 547 lux. The coordinates of core work place sensors are marked in **blue** in the table below. (Core workplane sensors indicate where occupants are usually located within a lighting zone, e.g. a desk in an office.)

The predicted annual electric lighting energy use of 0.2 kWh/unit area corresponds to the mean energy use in an ensemble of identical offices that are occupied by two user types:

- a user who keeps the electric lighting on throughout the working day, opens the blinds in the morning (upon arrival), and lowers them when direct sunlight above 50 Wm^{-2} hits the seating position (to avoid direct glare), and
- a user who keeps the electric lighting on throughout the working day, and keeps the blinds lowered throughout the year to avoid direct sunlight.

Lighting and Blind Control: The electric lighting system has an installed lighting power density of 0.37 W/unit area and is manually controlled with an on/off switch. The dimming system has an ideally commissioned photosensor-control with a ballast loss factor of 0 percent. The photocell has a standby power of 0.00W per unit area. An advanced dynamic shading device model is used for which the retracted and lowered state of the shading device have been geometrically modelled. The shading device is automatically controlled. The automated control lowers the shading device as soon as direct sunlight above 50Wm^{-2} hits the seating position. The device is automatically retracted otherwise.

Detailed Simulation Results

The table below shows the daylight factor and various dynamic daylight performance metrics for all sensor points individually. Definitions of these quantities are provided in chapter one of the Daysim Tutorial. To guide the reader's eye, the following color code is used:

- Coordinates of core workplane sensors are shown in **blue** .
- Daylight factor levels over 2% are shown in **green**.
- Annual light exposure levels of medium and high sensitivity (CIE Categories III and IV) are shown in **dark green** and **light green** .

x	y	z	DF [%]	DA [%] (active)	DA [%] (passive)	DA_{con} [%] (active)	DA_{con} [%] (passive)	DA_{max} [%] (active)	DA_{max} [%] (passive)	$UDI_{<100}$ [%] (active)	$UDI_{<100}$ [%] (passive)	$UDI_{100-2000}$ [%] (active)	$UDI_{100-2000}$ [%] (passive)	$UDI_{>2000}$ [%] (active)	$UDI_{>2000}$ [%] (passive)	DSP [%] (active)	DSP [%] (passive)	annual light exposure [luxh]
2544.000	**1520.400**	**208.080**	39.3	87	87	88	88	62	62	12	12	7	7	81	81	0	0	36080896
2544.000	1520.400	208.080	39.3	87	87	88	88	62	62	12	12	7	7	81	81	0	0	36080896
2544.000	1520.400	208.080	39.3	87	87	88	88	62	62	12	12	7	7	81	81	0	0	36080896

file:///Y|/BDS/Thesis/DAYSIM/res/Library.el.htm (2 of 3) [4/5/2009 9:26:56 PM]

By using additional zone output from Daysim, I calculated energy savings for zones 1 through 5, and they are as follows:

Area (ft^2)	Maximum c/kWhr (on/off peak)	Minimum c/kWhr (on/off peak)	Average $/kWhr
8420	21.8372	17.4085	0.20083
	23.6778	17.4085	

Zone	kWh/unit area		kWhr (total saved)	$ saved	Hours on (full)
	No Harvesting	Harvested			
1 (2row)	1.2	0.2	8420	1690.9886	3215.3
2 (1row)	0.5	0.1	3368	676.39544	3179.3
3 (dwnlt)	0.4	0.1	2526	507.29658	3179.3
4 (track)	0.7	0.1	5052	1014.59316	3197.3
5 (tamb)	0.1	0.05	421	84.54943	1453.4
			Total saved yearly	$ 3973.82321	

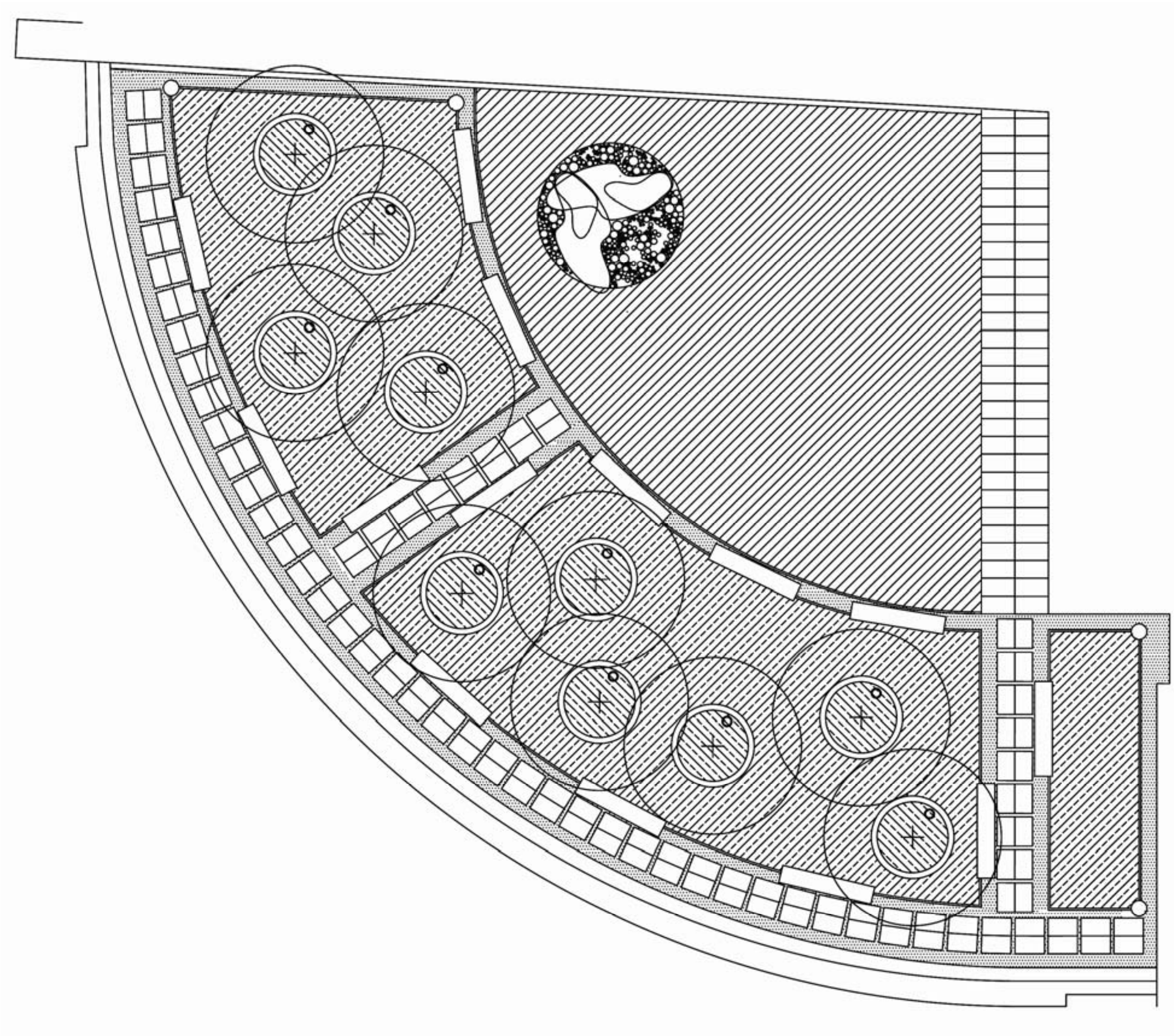
Table 4 Yearly Savings from Daylight Harvesting in Library

In the end my system was extremely successful. However, downsides do exist. Even though I decreased the window transmittances, the daylight getting into the space is ample. One might justify reducing the transmission even further. A stance against this point of view may be that the area of New Haven is going to experience a lot of overcast and cloudy days throughout the year. Because of the number of OC days, it may be beneficial (and get more light inside) if my system was built.

The daysim output also hints at the potential of inaccuracy or that the window transmittances are in fact too high. The normal Daylight Factors for buildings is around 2%. However, in my models it is around 39% for points chosen. However, this output *may* be correct. The DF of this particular space may be high because of the large expanse of glass on the South-facing façade as well as the addition of a skylight. With the orientation of this glazing, the sun is entering the Library the majority of the time while it is up.

All together, considering the potential for error, and the "proven" successes of this system I am confident with the design and output that I have calculated for the Library space.

Lighting Depth | Roof Garden



Spatial Description:

Located on the roof of the Library, the Roof Garden serves as an escape to the outdoors. The Student Gathering space leads directly to the garden which is on the fourth floor. Benches surround round planters that hold trees, which are also surrounded by a pathway that leads around the exterior façade of the lounge below.

List of Activities:

Transition through the space (mostly walking) is obviously the main activity. Others could potentially include reading (books), face-to-face interactions, and computer use.

Furnishings:

Precast benches (B-2) surround the plant bed and planters (PLNT-1) are scattered across the space.

Dimensions:

North Wall Length: 73'-2"
West Wall Length: 73'-10"
Parapet Radius: 79'-6"
Parapet Length: 99'-6"
Area: 4319 SF

Materials:

a. Floor
   i. Wood deck (WD-3)
   ii. Roof deck plant bed (PB-1)
   x. Architectural concrete pavers (PV-1)
   xi. Stepping Stones, Arch. Concr. Pavers, (PV-2)
   xii. Bluestone Curb (CB-1)

b. Walls
   i. Aluminum Composite Metal wall panel system (MP-21)
   ii. Face Brick (BR-1)
   iii. Metal wall panel system (MP-20)

c. Windows Systems
   i. Mullion – (M-1)
   ii. Windows (exterior) – (GL: 1, 1A, 1B, 2A, and 2B)

Program Statement:

As a public space, the roof should be a preferred space to escape to, as well as a relaxing area where one can experience a more natural environment amongst the urban setting. Nature's "modulations" should be accented in an attempt to connect the space more with the natural environment. Lighting surrounding walls on the roof is one way to strengthen impressions of relaxation, pleasantness and preference. A lower light level will be used (as compared to interior spaces) to reflect upon the outside setting. Higher luminances will be located at the trees, Student Gathering, and masonry wall to focus attention. The roof garden will serve as an exterior continuation of the library at night. Light emanating from within the reading lounge will be topped by the soft glow from the garden above. The result will be a less dramatic drop in luminance from space to space and a more cohesive flow created from light.

Design Criteria

- When luminaires are used to highlight natural objects (trees/grass) the effect on these surfaces should reflect the object's geometry and quality (e.g. graze on grass or trees to show texture). Walls should be highlighted for added interest.

- Since the space is used as a relaxing and intimate gathering space, light levels during the night should be low. The ground plane is the most important task plane (for transition through the garden), and the stones and pavers should be illuminated.

- To show modulations of objects and natural forms, the use of shadows will be extremely important. Shadows will display contrast on these features and allude to the form of the particular object. Shadows on tasks (main passageways and benches/planters) should be eliminated.

- Primary tasks include:
    - Passage through space. Recommended illuminance on task plane (horizontal) is .5fc average.[x]

Design Development

Under suggestions from the Lutron presentations earlier this semester, I greatly reduced the number of luminaires and the light levels for this space. My original criteria of 5fc exceeded what both IENA RP-33-99 and me thought was necessary for way-finding in this space. My new criteria is adjacent to the existing recommended maintained average horizontal illuminace for pedestrian ways, which states that .5 foot-candles[xi] as the average. I would like to place 1 fc at major nodes of the Roof Garden; including pathway intersections, the connection between the wood floor and white masonry wall, entrance to the Student Gathering area, and to highlight the trunks and canopies of the trees. An average of .5 fc will be sought for all walking surfaces except the grass. Grass areas and the vertical portion of the white masonry wall will receive less light that originally specified in Tech 1.

To begin, I wanted to make sure the major path and path intersections received light. By arraying a path luminaire (R1 with a 13W CFL) around the curve of the exterior half wall around the roof, I was able to achieve the illuminance levels I desired for the walk itself. A louvered face plate limits the light escaping up, to a minimum. This also allows me to limit the luminance of the fixture, reinforcing the darker environment on the roof. After supplying the main surrounding path with light, I then located light at the intersections of the path with the rest of the roof's floor. To illuminate these nodes, I wanted a smaller bollard—or pillar—that would also have a lower luminance and limited glow. The height of this luminaire (R2) was also important to reduce to keep the luminaire "out of sight" and as non-intrusive as possible. By limiting this height, I was able to reduce the occupant's exposure to higher luminances (because the luminous surfaces were more distant) and bring the light closer to the surface I wanted to be lighted, which allowed me to limit the wattage of the lamps chosen for this application. The styles of the two main luminaires were also matched to maintain cohesiveness. A louvered aperture was used for both luminaires, for aesthetic reasons as well as to focus light in a downwards direction.

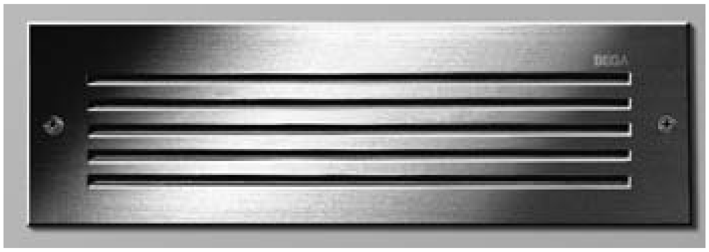


Figure 46 Type R1 Luminaire

Figure 47 Type R2 Luminaire

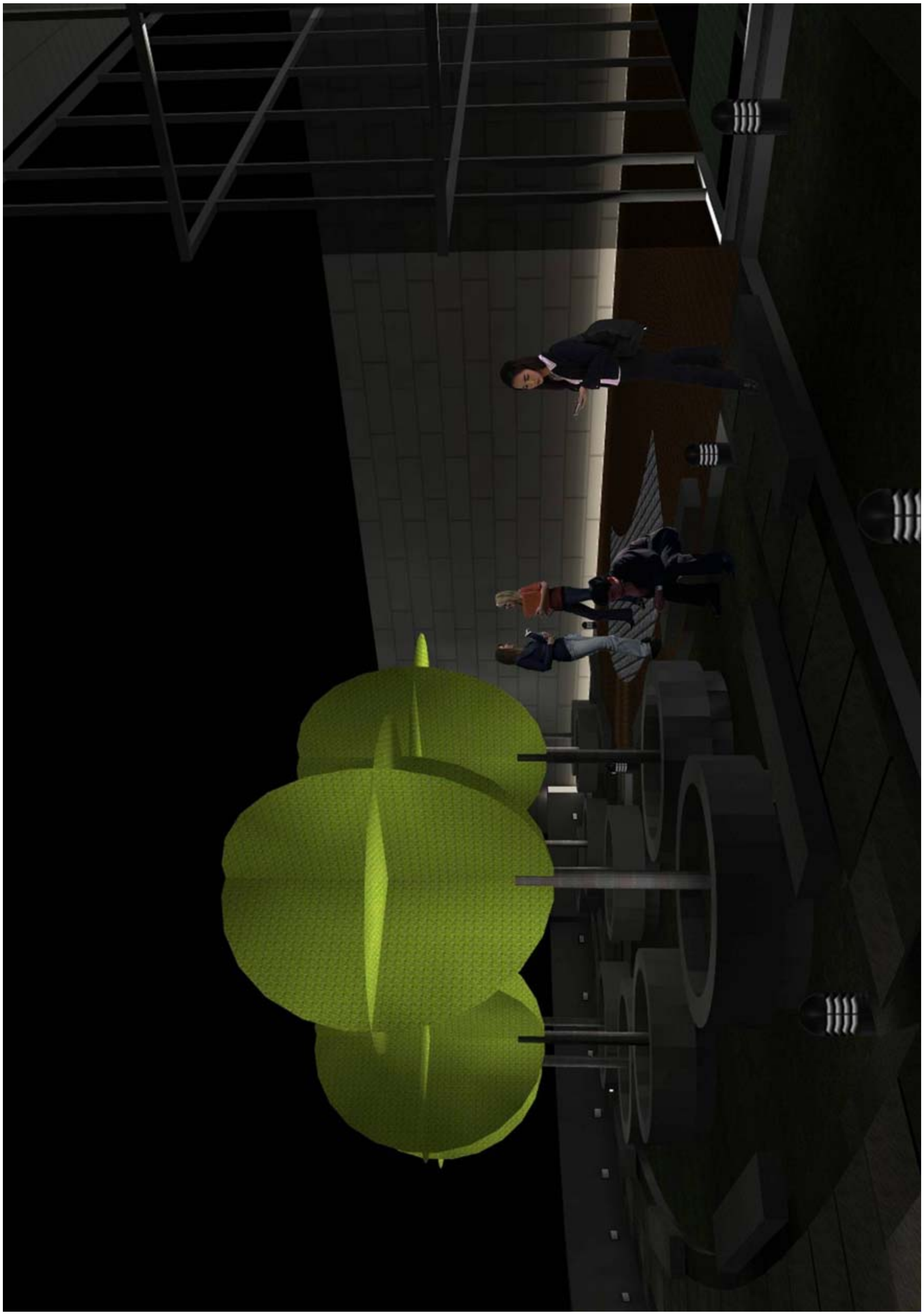


Figure 48 View Toward SG and R2 and R4

Figure 49 Luminaire Type R3

Highlighting the trees was essential for the lighting (and architecture) of the Roof Garden. Without this accent, there would be no depth and no layering of light in the space. To fulfill my design criteria of highlighting and natural patterns, I added 35W par30 Ceramic Metal Halide uplights into the planter beds to light the trunks and canopies of the trees. The aim was to create focus on the trees in comparison to the subdued light levels around the roof. By using a directional source with limited wattage I was able to limit the wattage consumption in this

I used one luminaire per planter in an attempt to limit the uplight and the watts per square foot of roof area. Also, I illuminated the trees on the primary side which it would be viewed. Therefore, trees closer to the Student Gathering would be lighted from the side of the planter closest to the space. This helped limit watts to be shared with other spaces. Additionally, to create a cohesiveness of the white masonry wall I used an luminescent strip 6" wide to make the wall appear to separate from the floor and therefore "float." This also serves as a continuation from the inside the Library where a similar scheme is used to light down the wall. Apart from my original scheme to wash the wall, I used a solution that would limit the roof lighting to a lower level and limit the cost associated with lighting the white wall. Additional light is provided by my proposed skylight, which is actually masonry glass block. This means that it emits reflected light from the Library to the Roof Garden and can also serve as a floor for the garden itself. The light can be seen as the saturate red portion in the middle of the floor in Figure 39.

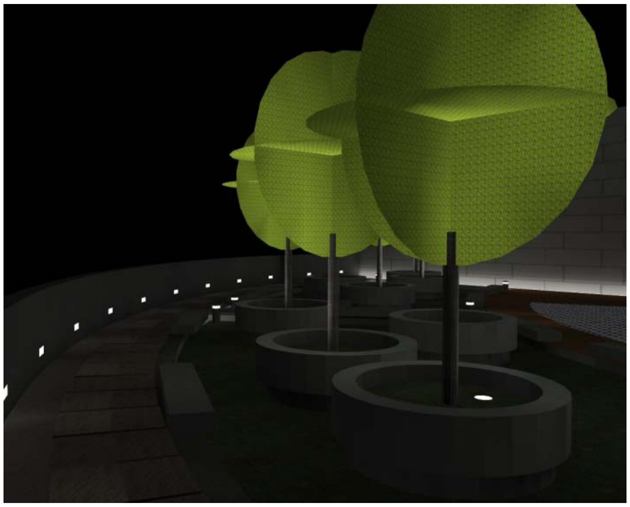


Figure 50 View of Main Exterior Path and R1

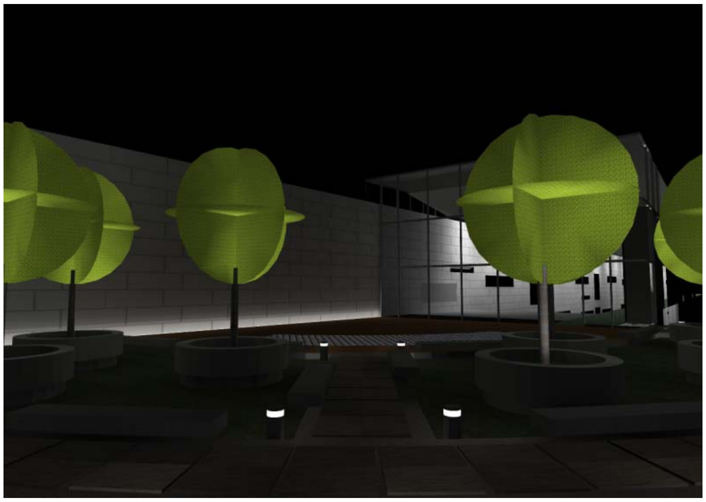


Figure 51 View Toward SG and R2 and R4

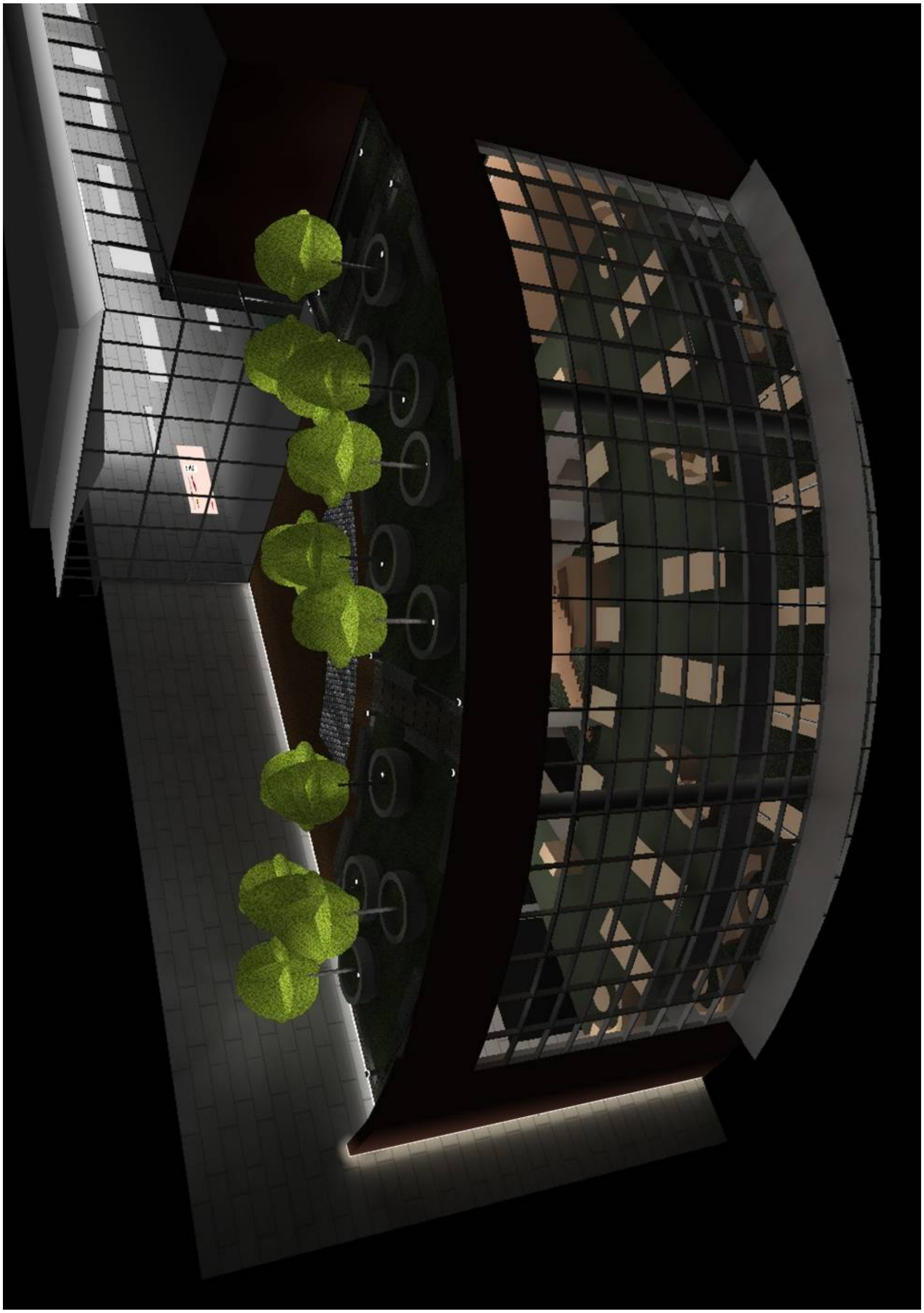


Figure 52 View From building across street

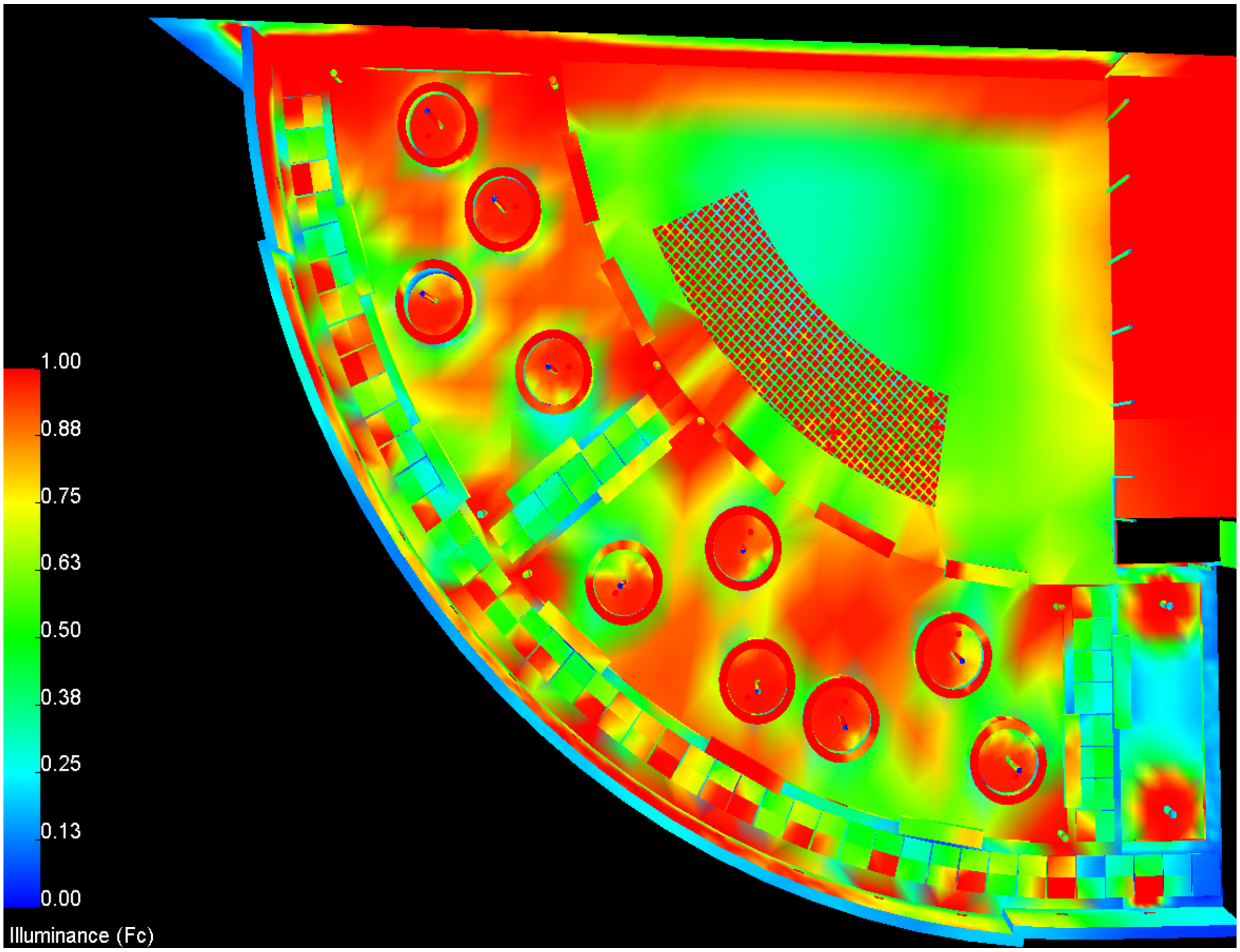


Figure 53 Pseudo Color illuminance Plan

Illuminance Value for Paths(Fc) →
Criteria: .5fc average on ground-plane

Wood Deck	
Average	*0.55* ✓
Maximum	1.9
Minimum	0.3
Avg/Min	1.83
Max/Min	6.33
Meets Criteria?	**YES**

Illuminance Values for Paths (Fc) →
Criteria: .5fc average on ground-plane

Paver Path	
Average	*0.87* ✓
Maximum	5.7
Minimum	0.0
Avg/Min	0.00
Max/Min	0.00
Meets Criteria?	**YES**

Illuminance Value for Paths(Fc) → Criteria: 1fc average for vertical illuminance	
Vertical Grid	
Average	*0.94* ✓
Maximum	2.3
Minimum	0.6
Avg/Min	1.57
Max/Min	3.83
Meets Criteria?	**YES**[i]

i-Assuming that being within +/- 10% of criteria is acceptable (common rule of thumb)

LEED

To abide by LEED criteria I located three points by which I would need to follow; 1) Sustainable Sites, 2) EQ 8.1, 3) EQ8.2. In regards to the Sustainable Sites Credit (SS Credit 8: Light Pollution Reduction) electric lighting must follow this criteria for uplight:

- **LZ4 – High (Major City Centers, Entertainment Districts)**
    - Document that no more than ***10%*** of the total initial designed site lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

By calculating the % of total initial lumens exiting luminaires above 90° vertical angle I was able to eliminate the possibility of meeting this criterion. (See below) It was a sacrifice to not gain this LEED point, but I feel that the choice to highlight the trees on the roof garden was too important to my design criteria to ignore.

% Lumens above 90 V					
	lm/luminaire	**#**	**lm/type**	**% ABOVE 90**	
R1	900	16	14400	3.10%	446.4
R2	1200	10	12000	0.50%	60
R3	420	10	4200	94.00%	3948
R4	2400	3	7200	0.00%	0
R5	6452.527662	1	6452.528	100%	645252.8
				TOTAL	649707.2
				% TOTAL	**14.68181**

Lighting Depth | Student Gathering

Spatial Description:

This space provides the main distribution outlet in Gateway. It runs North to South and extends from the first level up to the fourth with and bridges cutting though the main central space. A walkway borders on the East side of the atrium on every floor. Openings extend from stairs and large landings up to the ceiling above, which seemingly hovers in the air, as light streams in from East and West clerestories which extend the length of the space. Over George St. (which splits the North and South Towers) a walkway joins portions of the Student Gathering space. This space is a continuous climb in through the middle of the building and ends when you reach the top of the Reading Lounge; it's Roof Garden.

List of Activities:

Transition through the space (mostly walking) is the main activity through this space. Others could potentially include reading (books and vertically posted materials), face-to-face interactions, or computer use.

Furnishings: (Material properties and description can be found on the Material Legend)

Benches (B-1) are the only furnishings in the Student Gathering. Spanning bridges have benches near the edge to provide interesting and key views through the breathtaking space.

Dimensions:

Length (North Tower): 92'-8"
Length (walkway): 76'-5"
Length (South Tower): 261'

Width (NT): 19'-6"
Width (walkway): 27'
Width (start/end ST): 24'-10" / 38'-7"
Area (approx. total): 15867 SF

Materials: (Material properties and description can be found on the Material Legend)

a. Floor
    i. Carpet (C-2)
    ii. Resilient Flooring (NF-1)
    iii. Resilient Flooring (RF-8)
    iv. Resilient Flooring (RF-11)
    v. Wood (WD-2)
    vi. Epoxy terrazzo with multiple colors and complex patterns w/ carpet insert (TZ-1)
b. Walls
    i. Painted Masonry Units (P-9)
c. Ceiling
    i. Acoustic Ceiling Tile (ACT-11)
d. Window Systems
    i. Mullion – (M-1)
    ii. Clerestories - Outboard ¼" cl. low E insulating, ½" air space, inboard lam. cl. ¼" (GL-1)
    iii. Walkway Windows (exterior) – (GL: 1, 1A, 1B, 2A, and 2B)
    iv. Interior Windows (F: 40, 43, 44, 45, 46, and 47) - (GL-INT2)
    v. Glass Mosaic – (GL-INT1)
e. Miscellaneous
    i. Metal beam enclosures - (MB-2)
    ii. Pt. GWB. Column cover (P-3)

Program Statement:

Student gathering is the central transition space in GCC, and is meant to be P+Ws version of an interior street. Similar aesthetics to existing exterior lighting conditions should be mimicked to help connect the concept to the occupants. Analogous impressions to the roof garden will be created throughout the exaggerated stair/corridor. The five-story-high white masonry unit wall continues from the gathering space to the roof garden and will be lighted similarly to maintain cohesiveness between spaces. Lighting and emphasis on walls will contribute to the impression of preference while additional general non-uniform lighting will facilitate passage through the space. Daylight is an important factor in this space as well. Like the library, daylight should be used to conserve electric power and efficiently light the space (when possible). Localized lighting will be placed to mark means of access to other areas of the college.

Design Criteria

- Dimmable or switchable systems should automatically lower or increase electric levels in concurrence with the daylight level entering the space. Direct daylight penetrations should be reduced or eliminated from striking the floor of the main passage space.

- The main task plane is the floor; since the space is mainly used for flow and transition through GCC. Because this space is going to be used for gathering, it is important to raise this illuminance level for alternate tasks such as reading or writing, this may also cause the ASHRAE LPD to go up as well.

- The main purpose of this space is for gathering; a place for people to escape from work and socialize. Modeling of faces will be a very important goal for the lighting design.

- Window boxes (to interior spaces), display boxes, directories, and office alcoves surround the main stair of the gathering space. Accenting these features will serve task purposes and create visual interest around the periphery of the space.

- Primary tasks include:
  - Passage through space. Recommended illuminance on task plane (horizontal) is 10fc (subject to increase due to higher illuminance for secondary tasks and their close proximity to the floor).[xii]
  - Face to face interaction. Recommended illuminance on task plane (vertical) is 5-10fc. [xiii]
- Secondary tasks include:
  - Reading and writing; mostly 10 -12 pt type and (#2) pencil and pen. Recommended illuminance on task plane—approximately 1-2 feet off the floor—(horizontal) is 30 fc.[xiv]

<u>Design Development</u>

To adequately provide task plane illuminance (on the ground) in the Student Gathering space, it was necessary to use a large downlight component in the ceiling. Three luminaires (S3, S4, and S5) were used to light the floor of the space; due to the increase in level as you pass through the exaggerated corridor/stairwell three different wattage lamps were used. This variation in lamp wattage allowed me to use the same spacing and produce similar foot-candle levels on the floor. Along with the main passage way—the stairs and landings—the surrounding corridors were equally a challenge to light as well as pass ASHRAE design criteria for corridor lighting power density. Because the LPD for corridors is .5 W/ft^2, and the width of this corridor is 8', this means that I can use only 4 watts per foot of corridor length. So, for every 10 feet of corridor I can only use 40 watts. My original design intent was to orient luminaires in the direction of passage, which means that the length of the luminaire would be parallel to that of the corridor. When I calculated my original conceptual design in AGI the illuminance levels were much higher than my original intent of 5fc Passage through space.[xv] Additionally, this luminaire orientation consumed 2W/ft^2 instead of only .5 (using 2 28WT5 luminaires spaced 4' OC and placed end-to-end). Seen below.

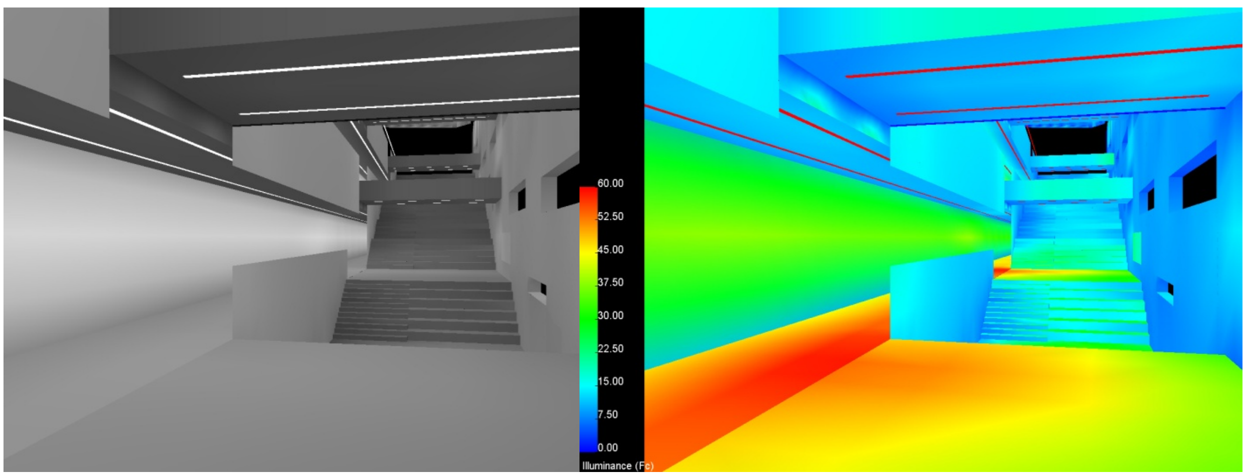


Figure 54 **RGB and Illuminance Pseudo color images of original design**

Because this design would not pass ASHRAE and wasted wattage on unneeded foot-candles, I changed the orientation and spacing; the luminaires (S2) would be spaced 10' OC and orient 90° off of the original design.

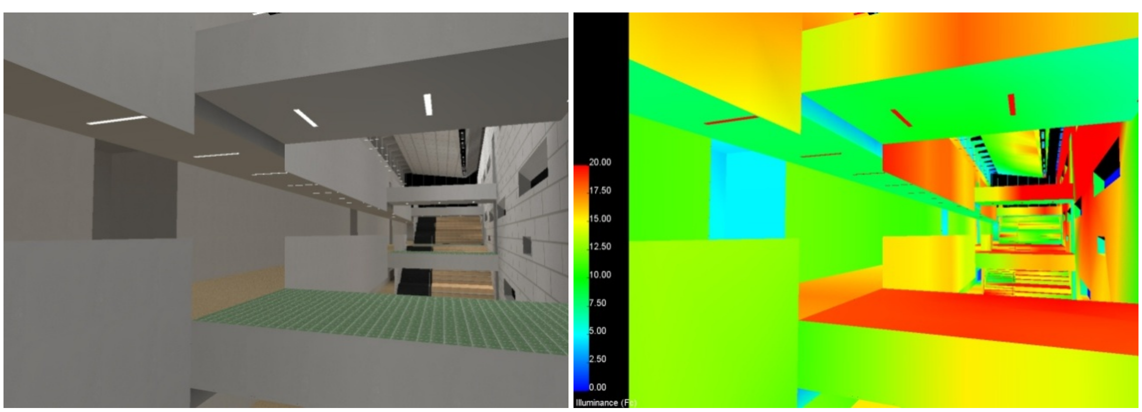


Figure 55 RGB and Illuminance of Re-design

Other changes from my original design criteria involved changing the recommended horizontal illuminance from 10 to 20-25fc. The Student Gathering is a multi-use space and involves many tasks, because not all tasks require the same illuminance, the level was raised to better comply with the task that required the most illuminance. The recommended illuminance on task plane for reading and writing is 30 fc,[xvi] therefore because of this intermittent task amongst the main task of passage through the space, I aimed at providing 20-25fc wherever there was potential for students to stop and read. Because the space incorporates seating into the main stair, I needed to provide 20fc (min) everywhere on this stair. Areas that were not included in raising the horizontal illuminance level were the first floor entrance and the fourth floor exit to the roof garden. Increasing the light levels had implications on my LPD for the space; because I would need more luminaires to provide this added illuminance I would also need more W/ft^2. ASHRAE is commonly known to increase LPD for spaces that need more wattage (than designated by the criteria of Standard 90.1). In this example, I believe that the ASHRAE would consider SG to be a multipurpose space instead of an atrium; which would raise the allowable LPD from .6 (or .2) W/ft^2 to 1.3 W/ft^2.

The Student Gathering has somewhat of an irregular ceiling layout, and the best area to recess downlights is very near to the masonry wall—primarily over the sitting area next to the main stair. This pulls light closer to the masonry wall and further from the stairs themselves.

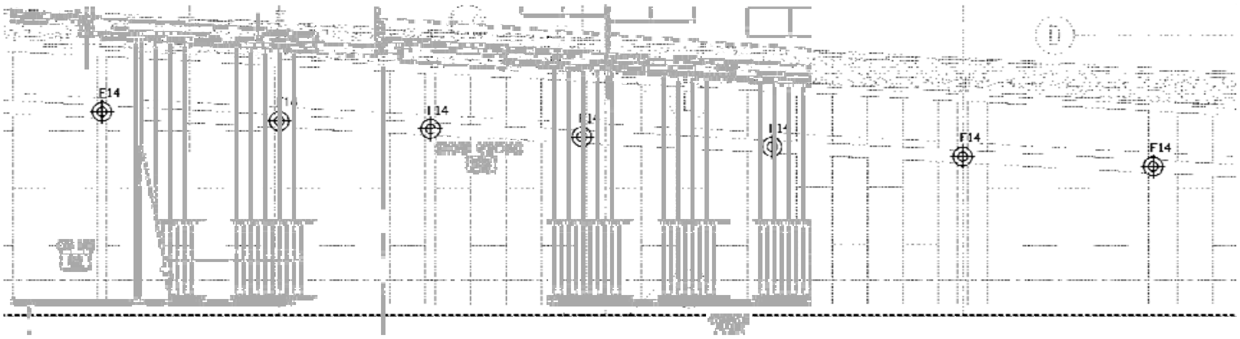


Figure 56 Showing original layout of downlights and relation to main stair

Illuminance Value for Passage (Fc) →
Criteria: 20-25fc average 30" A.F.F.
Criteria: 10fc average on ground-plane

FLOOR	AVG
1	15.82 ✔
2 (bridge)	26.29 ✔
3	25.11 ✔
4	13.26 ✔
Meets Criteria?	**YES**

Illuminance Values for Face-to-face interaction (Fc) →
Criteria: .5-10fc Vertical

FLOOR	AVG
1	8.82 ✔
2	13.05 ✔
3	12.05 ✔
4	5.73 ✔
Meets Criteria?	**YES**

The accuracy of these values can be seen in the iluminance pseudo color below.

To make sure that the stairs receive enough illumination, especially when the downlights were off (either in emergency or daylight harvesting) I chose to integrate LED rail lights (S3) into the handrails of the Student Gathering space. By mounting the luminaires closer to the task at hand (lighting the ground plane) it helped me reduce the wattage needed for this task.

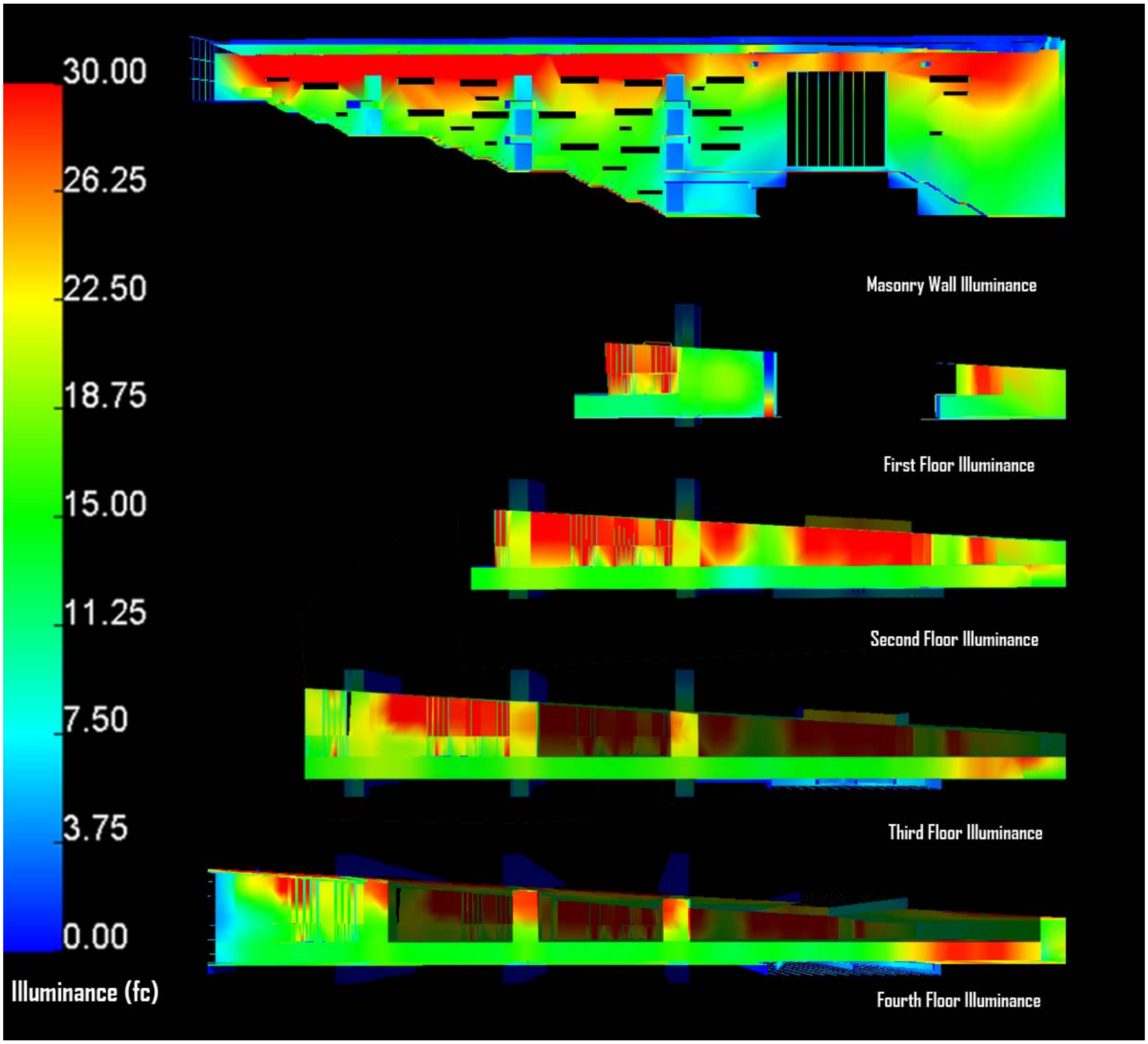


Figure 57 Illuminance Levels for Student Gathering

After I supplied the recommended illuminance to the work-plane of the space, I then focused on complying with my original design criteria and concept. Per Perkins + Will's design concept of an interior street, I wanted the occupants to connect with the idea that they were actually outside. To do this, I would highlight the white masonry wall that extends throughout the space as well as use light to create motion in the window-boxes that are recessed into the same wall. The white wall itself uses a faux-masonry material to relate the common use of masonry on exterior facades of buildings. I used an Elliptipar luminaire using a metal halide lamp to wash and further accent this wall and create a "disconnect" between it and the rest of the building. This would mimic my idea of separating the masonry wall in all instances when it touches other surfaces of the building (a method which is present in the Library and Roof Garden). Motion of light in window boxes would communicate and connect the bustle of light outside into the Student Gathering.

Figure 44 Motion of Light Outside

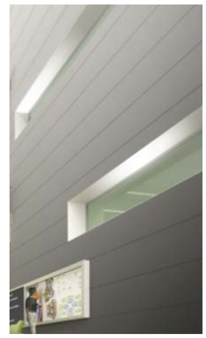


Figure 58 Conceptualized Image of Light Bo

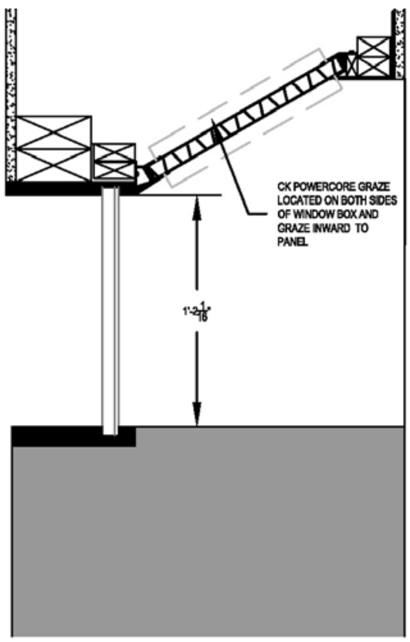


Figure 46 Detail of redesigned window and custom luminaire S7C

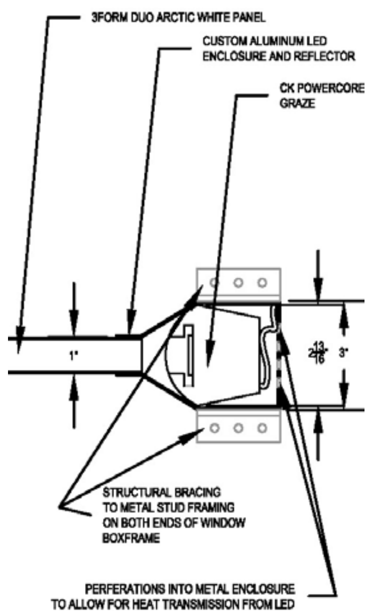


Figure 47 Detail of end LED enclosure

When considering how to produce this light inside the window boxes, a number of lighting-quality issues arose. First, it was a strong concern of how this light would impact the spaces that bordered the opposite side. Avoiding stray light through the windows was a primary concern. Second, I wanted people to see a larger area of these windows from the ground. Using the window boxes original dimensions I customized it into a luminaire. Using a Color Kinetic's LED strip (S7) I illuminated the inside of a 3Form panel made from tubular pieces of acrylic. To resolve these issues, the white panel was then slanted away from the window reducing the amount of light exiting the illuminated panel and going through the window. Also, this allowed the passers-by to see more projected area of the panel itself. (Please see the details below for more information) To connect these custom fixtures with the lines of light outside (as represented by Figure 44), each luminaire will be controlled by a DALI system. This would enable each individual luminaire to be independently controlled and would enable the group as a whole to make sweeping patterns of light throughout the window boxes and across the white wall.

Figure 59 View South in Student Gathering

Controls

The student Gathering space is another with a large amount of exposure to daylight. It is essential to lower the energy consumption of the electric lighting system during the day. The lighting systems in the space will react to this additional light by shutting off when daylight illuminance levels meet the recommended illuminance levels of my design intent. Open loop sensors will be placed near the clerestory and mounted on the Geometrix ceiling above the atrium. Additional closed loop sensors will be placed on the eastern corridor to dim the fluorescent loads when the daylight illuminance levels in the corridor reach an acceptable range.

Some lighting loads will remain on at all times to provide ambient light for means of egress and emergency situations. The space will also be control by an astronomical time clock that will switch on or off electric loads when the sun sets or rises. During daytime hours, the wash on the white wall by S1 will be shut off, while still light out, the lamps will begin to warm up. Type S1 luminaires should be set by astronomical time clock to start warming up before the sun is completely set so that the metal halide color shift will be more difficult to notice. In a case that the metal halide luminaires fail to start up on time, the LED rail-lights (S3) will supplement the absent illuminance on a local level. After daytime hours, the time-clock will be overridden by occupancy sensors. Only non-HID loads—such as the eastern corridor luminaires and LED rail-lights—will be controlled by occupancy sensors during off-peak and nighttime hours.

Daylight

To get an idea of what the daylight effect was in the current design, I conducted a study using AGI throughout various months. The months analyzed include; March, June, and December on the 21st of each. Various material property assumptions are listed below:

a) Floor *(Reflectance)*
   i. 1st and 2nd Floor – .2
   ii. Stairs – .35
b) Walls *(Reflectance)* – .5
c) Ceiling *(Reflectance)* – .75
d) Window Systems *(Reflectance and Transmittance)*
   i. Mullion – .65 and 0.0
   ii. Clear Glass
      1. GL-1 - .7 % Trans
      2. GL-1A/B - .623 % Trans
   iii. Diffuse Glass
      1. GL-2A/B - .23 % Trans
e) Miscellaneous *(Reflectance)*
   i. Ground – .1
   ii. Exterior Buildings .15

From my original study (shown on the next page) I found that during hours of occupation direct sun could present distractions for classes that border the white masonry wall. This, combined with the motivation behind the custom S7 luminaire, influenced me to decrease the aperture of the windows of the neighboring classrooms. By changing this form, I influenced two functions in a mutually beneficial way; the amount of sunlight entering the room was reduced as well as the amount of light entering the room from the S7 type luminaires. From this change I may have reduced the amount of light coming through the window, but there was more that concerned me with the daylight design

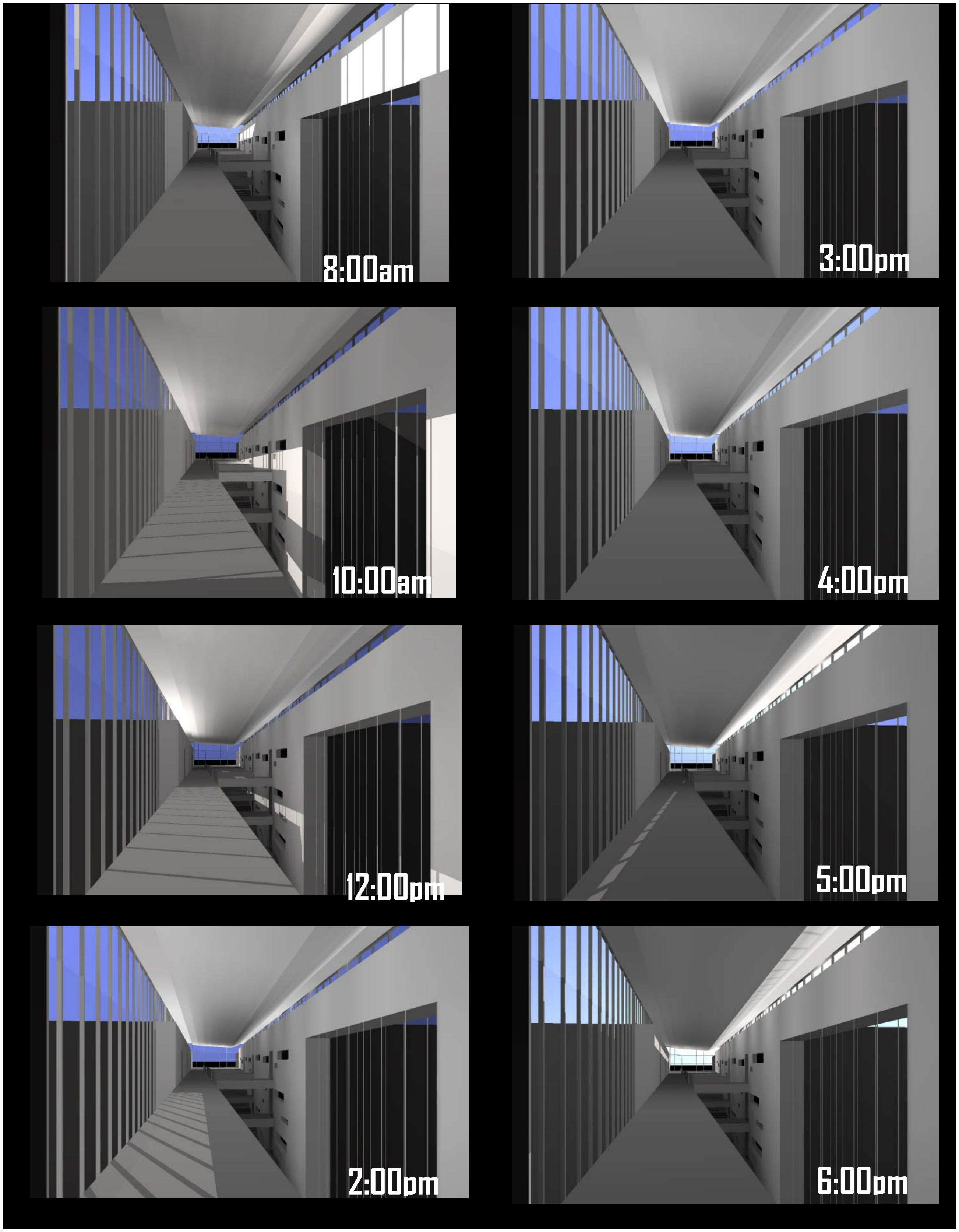
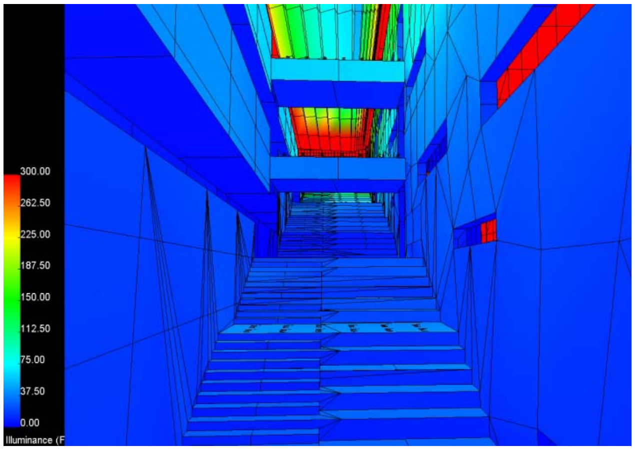
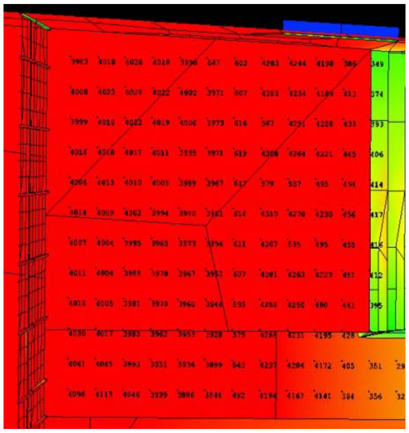


Figure 60 View South West In Student Gathering During 21st of March

In addition to limiting the light coming through the window boxes, I wanted to reduce the illuminance values near the top of the stair passage, while also increasing the amount of light near the bottom. This large corridor runs—for the most part—North East (bottom) to South West (top), and because of the orientation of the site, sun enters through the east façade for most of the day. Until 3:00pm sun is entering through the east clerestory and provides good illuminance deep into the space. However, around this time, the illuminance in the lower Student Gathering becomes very low when compared to the other light levels in higher levels. The view below illustrates the difference in illuminance from the first level up to the exit to the Roof Garden, an approximate ratio of 1:160 from bottom to top (around 25fc on the first floor and 4000fc on the fourth).





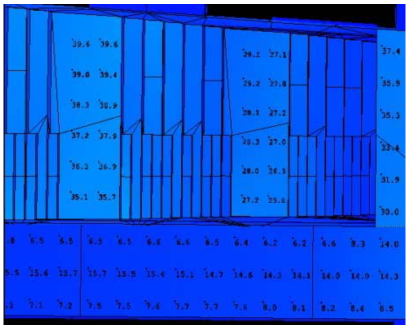


Figure 61

Top: View from downstairs up to Roof Garden

Upper Right: Illuminance levels on the Fourth Floor

Lower Right: Illuminance Levels on the First Floor

To increase the amount of light deeper into the building, as well as reduce the amount of light near the top of the stairwell, one daylight technique stood out to me from the beginning, and that was sky-lighting in this space. As an architecture breadth for the Student Gathering and the Library, I incorporated daylight transition fenestrations on the roofs of both spaces. In the following sections I will describe my findings and final solutions.