Final Thesis Report

Princeton Theological Seminary Library

Princeton, NJ

Stephanie Deckard

Lighting | Electrical

Faculty Advisor | Dr. Kevin Houser

4/3/2013

Princeton Theological Seminary Library

Jesus spoke to them saying, "I am the light of the world." John 8:12 Princeton, NJ

General Building Data

Size | 99,585 SF
Number of stories | 4 + 1 basement
Total Construction Cost | $55 million
Construction | Mar 2010 – Dec 2012
Occupancy | Assembly
Delivery | design-bid-build

Project Team

Owner | Princeton Theological Seminary
Construction Manager | Barr & Barr
Design Architects | EinhornYaffee Prescott
Architect of Record | EwingCole
Engineers | EwingCole
Landscape Architect | Andropogon Associates
Civil Engineer | Van Note Harvey Associates

South Facade

Center Atrium

Structural

The foundation for the addition consists of conventional reinforced concrete spread footings bearing on residual soils, which supports the slab-on-grade, reinforced with welded wire fabric. Above the ground floor, the floor construction is comprised of steel wide flange beams supporting concrete slab on metal deck. Reinforced concrete walls are seen below grade, with steel frame construction for all floors above grade. Typical roofing is metal roof deck spanning wide flange steel members. Flat roof is used in the center of the roof with areas of sloping roof in a v-type configuration around the perimeter.

Mechanical

The air handling units serving the addition and the existing Luce Library include five variable air volume units and one constant volume unit. Located on the fourth floor, the six AHU's provide a total of 130,000 CFM to the combined buildings. Economizer controls were included for free cooling when outdoor temperature and humidity permits. A new steam plant, located on the lower level of the addition, will be used to create heated water to be supplied to the air handing units preheat and heating coils. The floor of the center atrium provides 30 BTU/SF of radiant heating through tubing located in the concrete slab.

Lighting | Electrical

The lighting in the library is designed based on the individual tasks of each room. Direct/indirect luminaires are used to create uniformity that is supplemented by tasklights. Occupancy sensors and photocells are implemented in the appropriate areas of the building for energy savings purposes.

PSE&G provides 13.2kV 3P 4W of primary electric service, terminating in a new 15kV service switchgear. The interior electrical distribution is provided by a 2000A, 480/277V switchboard. Primary and secondary distribution is located on the lower level in the main electrical room. 480-208/120Vstep down transformers are located on each floor to serve 208/120V appliance loads. Emergency power is provided through a new generator rated 480/277V, 400 kW.

Reference Reading Room

Stephanie Deckard Lighting | Electrical
http://www.engr.psu.edu/ae/thesis/portfolios/2013/sld5202/index.html

Executive Summary

The Princeton Theological Seminary Library is characterized by wide open, tall spaces and stone materials that match those used in the attached Luce Library. Located on the campus of the Princeton Theological Seminary, the new addition to the library proudly represents the historic and prestigious nature of the school. The following proposal aims to enhance these natural characteristics and create an iconic image of the library and the school.

The content of this proposal includes lighting designs for four public spaces, electrical power distribution designs, an architectural study and a structural study. The lighting designs include a description of each space, important design criteria, performance information, lighting controls and renderings. The electrical power changes are broken up into two depth topics. This includes altering the lighting panels based off the new lighting designs and designing a dual bus system within the building to run designated equipment on DC power. DC power with AC backup is supplied to the new LED luminaires around the atrium and the existing IT equipment in the seminar rooms. These devices that are naturally run on DC power are linked to a ceiling grid system that is actively powered by DC current supplied by the existing photovoltaic array. To further enhance the performance of the atrium and surrounding spaces, the architectural and structural studies are focused on this area of the building as well. The architectural changes aim to increase daylight availability and create a centralized circulation path from the addition to the Luce Building. The removing and relocating of the bridges within the atrium, for these purposes, provides opportunity to perform a structural study to resize the members and columns added or changed by these architectural alterations. Both topics first study the existing systems and performance in order to make logical improvements to the space.

This work, combined into one proposal, aims to enhance the character of the library and take advantage of opportunities for energy savings, new technology use and most importantly, in creating an iconic and respectable image for the Princeton Theological Seminary.

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Introduction

The Princeton Theological Seminary Library is located on the campus of the Princeton Theological Seminary in Princeton, NJ. As a celebration for the bi-centennial anniversary of the school, a 99,585 sqft new addition to the library complex was decided upon by the school, along with the renovation of the exiting Luce Library. Completed in December of 2012, the addition rises 4 stores above grade and one story below. Characterized by wide open, tall spaces and stone materials that match those used in the Luce Library, the new addition proudly shows the historic and prestigious nature of the school. With the potential to be cold and powerful, the experience within the library is just the opposite. Large windows throughout the building provide comforting daylight for the occupants while taking advantage of the light and heat as energy savings. The concepts behind the redesign draw upon these characteristics while also focusing on the functionality of the building for the hard working students studying to become closer to God.

Thesis Proposal

The four spaces to be redesigned are the south façade and grounds, café, atrium and reference reading room. These areas designate the most highly populated path of pedestrians through the library and encompass the personality and diversity throughout the Princeton Theological Seminary Library. The scope of my final thesis report covers my lighting and electrical depths as well as my architectural and structural breadth work. Presenting the architectural breadth first will provide information necessary to understand the changes that are applied in my structural breadth and my depth work in the atrium.

Schematic lighting design concepts developed during the fall semester were refined and finalized in this report. Each space is documented in a full set of plans including fixture schedules and lighting plans. Panelboard resizing based on the new lighting equipment is included within the scope of the electrical depth. The other half of the electrical depth is to redesign the electrical distribution system to run on both AC and DC power. The new DC system will supply power to LED luminaires around the atrium and AV/IT devices located in the seminar rooms on each floor. The existing photovoltaic system will be the main power source to the DC powered equipment with AC electrical power as a backup. A cost analysis will be performed based on the new equipment and the equipment that will no longer be needed.

The architectural depth focuses on improving the daylight availability and circulation within the atrium. A daylighting study will be performed using Daysim to analyze the performance of the existing sidelighting, clerestories and skylights. The bridges located along the wall of windows on the western façade of the atrium that connect the addition to the existing Luce Building will be removed in order to receive additional daylight in the space that will allow for dimming in the atrium and surrounding areas. This hallway will be relocated to the center of the building, allowing for centralized circulation that will be more convenient for the users of the building. The structural breadth work is in response to the changes made by the architectural breadth. The relocation of the bridges will make an impact on the existing structure and require additional members to be added to each floor. The area of relocation for the hallway will be analyzed to resize existing members based on new loading conditions and determine sizes for new members. Before these changes are made, a study of the existing structure of the building will be performed in order to understand how to approach the redesign.

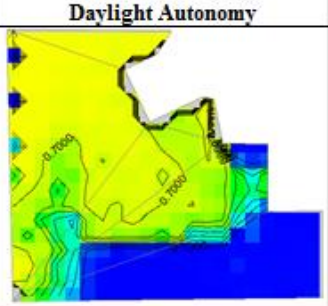
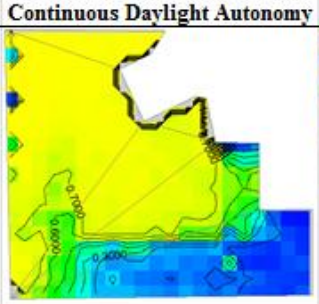
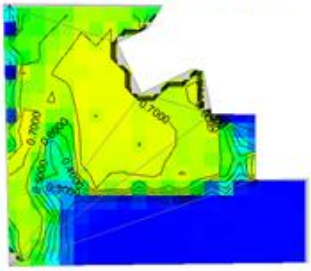
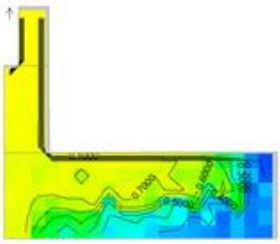
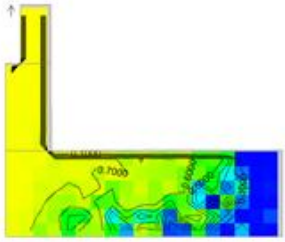
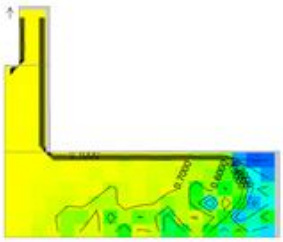
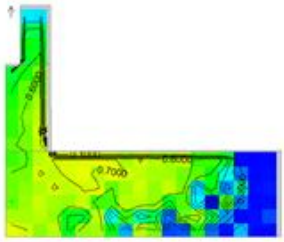
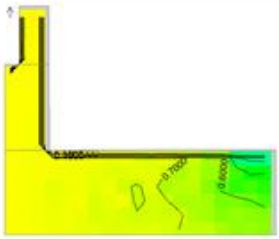
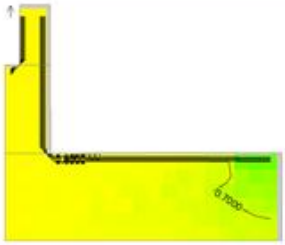
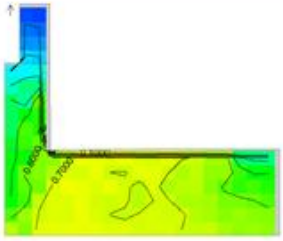
Architectural Breadth: Atrium

The architectural breadth for the redesign of the Princeton Theological Seminary Library will be focused on the atrium. The goal of these changes is to bring more useful daylight into the space and create a more centralized circulation area for building occupants. This section highlights the daylight performance based on the existing conditions in the atrium, the architectural changes that were performed to improve the daylight within the space as well as statistical data that verifies that making these changes increase the amount of useful daylight available.

Existing Daylight Conditions

A daylighting study was performed in Daysim to analyze the performance of the existing sidelighting, clerestories and skylights in the atrium. The results of this study can be seen below. The target illuminance is based off of the illuminance recommendation in a public circulation corridor at a light level of 20% of the surrounding area. With the surrounding stack illuminance value at 200 lux, the target illumination in circulation around the atrium is 40 lux. The pseudo color renderings below represent daylight autonomy (fraction of points that reach 40 lux), continuous daylight autonomy (fraction of points that receive daylight to allow for dimming) and useful daylight illuminance (fraction of points that reach 40 lux but are below 1,000 lux).

Daysim Results - Existing Conditions in Atrium

Floor	Daylight Autonomy	Percentage of Points above 50%	Continuous Daylight Autonomy	Useful Daylight Illuminance
Lower Level		61.46		
First Floor		57.14		
Second Floor		70		
Third Floor		96.43		

The numerical results shown in the third column, titled Percentage of Points above 50%, conclude that the contribution of daylight to the lighting in the atrium is satisfactory but there is room for improvement. The goal of my architectural changes is to maximize the useful daylight to allow for dimming in the atrium and surrounding areas. The proposed changes include removing the bridges and relocated the circulation space to the east side of the atrium. The specific information regarding these changes will be explained later in this section.

Architectural Design Changes

The existing floor plan of the addition has bridges along the western side of the atrium that connect the new addition with the existing Luce Building. These bridges, located on the first, second and third floor, run adjacent to the wall of windows which causes a reduction in the amount of daylight that enters the space. By removing these bridges and relocating the circulation space elsewhere, more daylight will enter the space and reach deeper into the space.

The relocation of the hallway will be between the seminar room, the atrium stairs and the restroom. The existing plan showing the location of the new hallway is shown below.

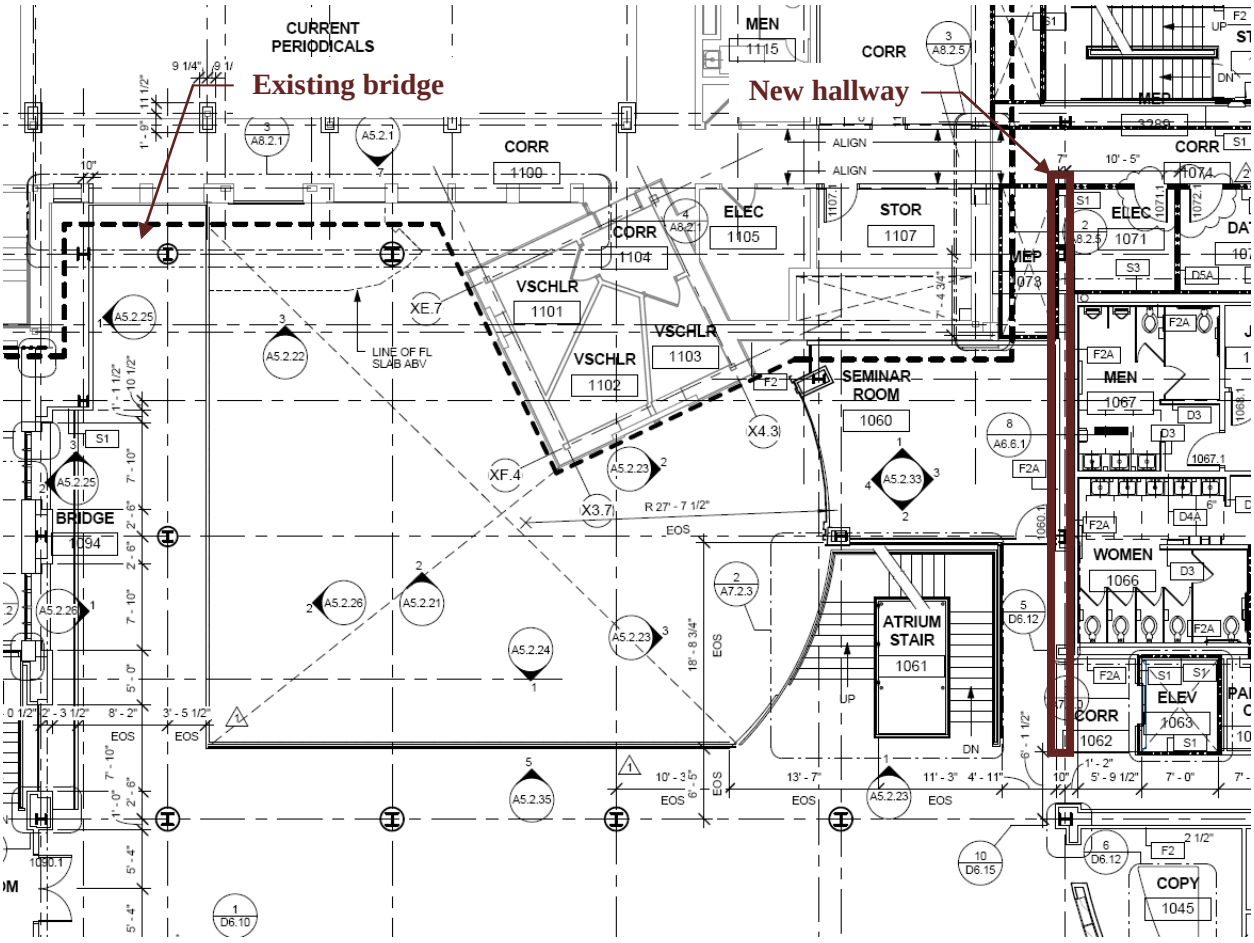


Figure 1 | New Hallway Location

The width of the new hallway will be 8 ft, matching the width of the removed bridges. In order to fit the hallway in the area indicated above, the atrium stairs and seminar room will be moved 8 ft into the atrium. The only other spaces that are affected by this change are the storage areas located on each

floor. Adding the new hallway into this area shrinks the size of the storage areas on each floor by 100 sf for a total of 300 sf. The plan view of the changes applied to the first floor can be seen below.

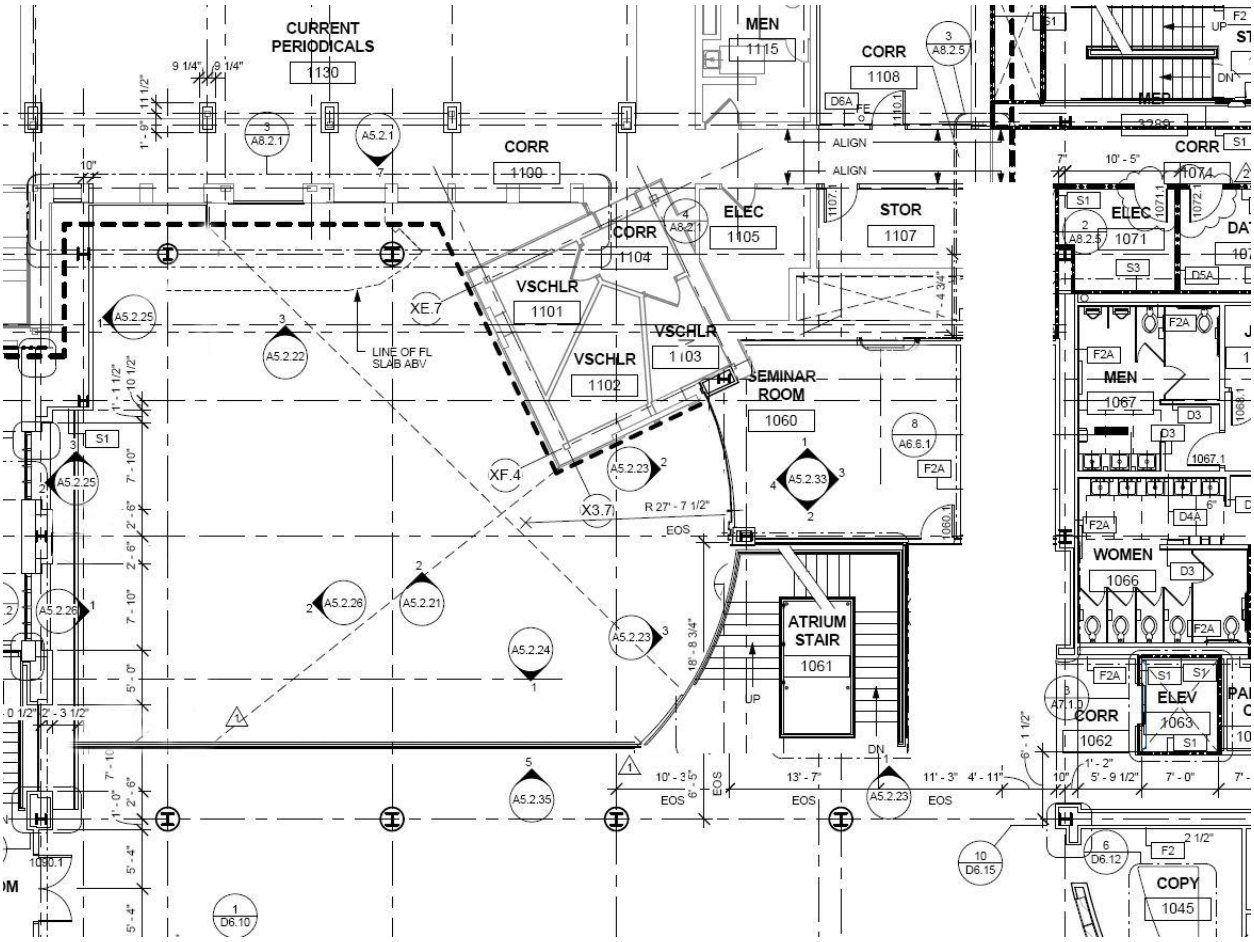


Figure 2 | Atrium Architectural Changes

By moving the hallway to the right of the atrium toward the center of the building, there is more direct circulation from the main entrance of the addition to the Luce Building. Diagrams of the existing and new circulation are shown below.

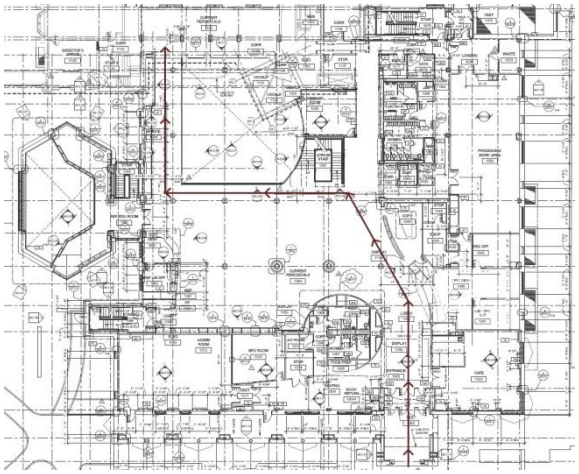


Figure 3 | Existing Circulation

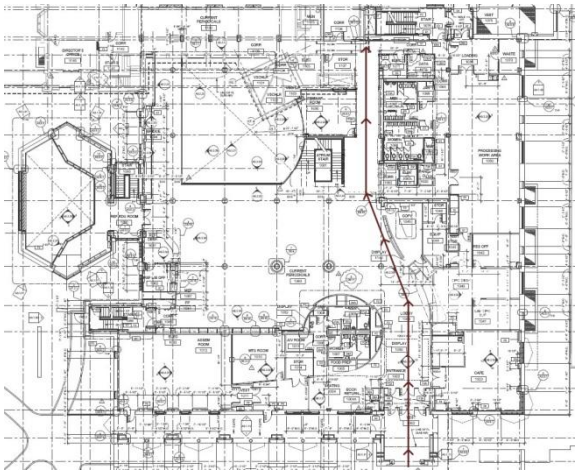
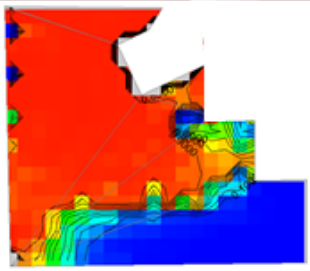
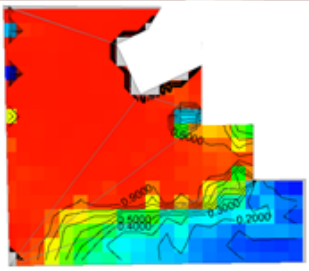
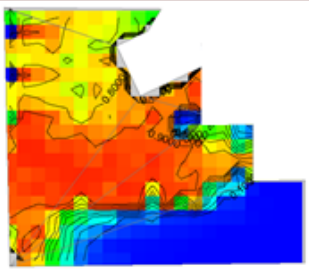
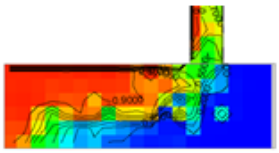
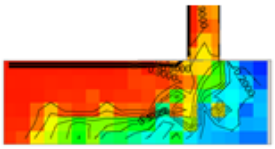
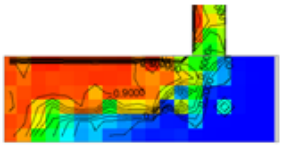
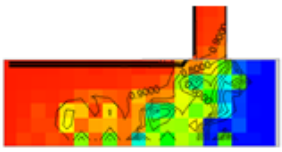
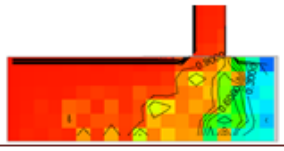
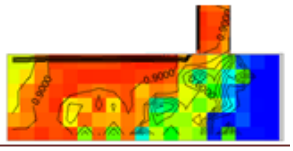
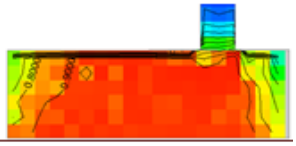


Figure 4 | New Circulation

This new scenario was analyzed in Daysim to verify the benefits of this change. The graphics in the table on the next page show an obvious increase in the amount of daylight entering the space. This additional daylight will allow for dimming in the atrium and surrounding areas which will produce energy savings.

If this daylighting study in the atrium were to continue, the next step of analysis would be to evaluate the window transmittance values on each floor. All floors would be tested with higher transmittance values and analyzed based on maximum daylight availability within the limits of useful daylight illuminance (between 40 and 1000 lux) to avoid glare.

Daysim Results - Architectural Changes Applied in Atrium

Floor	Daylight Autonomy	Percentage of Points above 50%	Continuous Daylight Autonomy	Useful Daylight Illuminance
Lower Level		65.14		
First Floor		58.36		
Second Floor		76		
Third Floor		98.27		

Lighting Depth

The lighting depth covers the design development based on the initial lighting concept for the four spaces redesigned. These spaces include the south façade and grounds, café, atrium and reference reading room. All information regarding the new lighting design including existing conditions, fixture schedule, lighting plans, light loss factor calculation and design, illuminance and energy criteria is explained and documented in this section. All cut sheets for fixtures and control devices used in these designs can be found in Appendix I.

Concept

The recent construction of the addition onto the existing library complex was in celebration of the bicentennial of the Princeton Theological Seminary. The school has been historically influential in American theological education since its establishment and should be recognized as such. Capturing this prestigious history and focusing on the hard work being performed by the masters and PhD students that use this library, the lighting design will represent the connection between God and his pupils. 'God is light'. Through the emphasis on verticality and sparkle, translated as reaching for the heavens, the students learning about God will feel closer to him in this space.

The lighting design in the library will grasp the visitors' attention with eye catching elements then create a comfortable and productive environment in which they can study. Brightly lit work areas will keep occupants awake with a feeling of openness by taking advantage of the height of the spaces. Supplemental task lighting will allow for flexibility in light levels based on occupancy and daylight availability. Daylight has a significant contribution to the light levels in all of the spaces to be redesigned and will have an effect on the fixture and control devices chosen. Daylighting controls will be used to reduce glare in the reading areas and to control dimming when applicable.

South Façade and Grounds

The south façade is the face of the building to all pedestrians who enter. The different elements of the façade serve different purposes and should be treated as such. The goal should be to guide pedestrians toward the entrance while creating an aesthetically pleasing view of the building.

Description of Space

The walkways around the south facade include straight and curving pathways from several directions that guide visitors toward the main entrance at the base of the tower. From the parking lot and streets, the width of the path varies based on estimated pedestrian traffic and should be lit to ensure safety. Providing poles along the paths will serve the purpose of illuminating the path and the faces of the pedestrians. The other path leading to the entrance is through the arcade. The arcade extends the length

of the building, tucked underneath it and exposed to the grounds between its columns. Using in-grade uplights to graze the stone columns and wall-mounted linear fixtures to brighten the ceiling inside the arcade, the space will feel open and safe while calling attention to the interesting texture of the building. By providing higher light levels where the entrance is located in the arcade, pedestrians will be guided to that area.

Seen from the grounds leading up to the building, the large bay windows create a pattern on the façade and provide insight into the activities on the interior. These will be illuminated from inside, exposing the special collection workroom on the second floor and the open offices of the PhD students on the third.

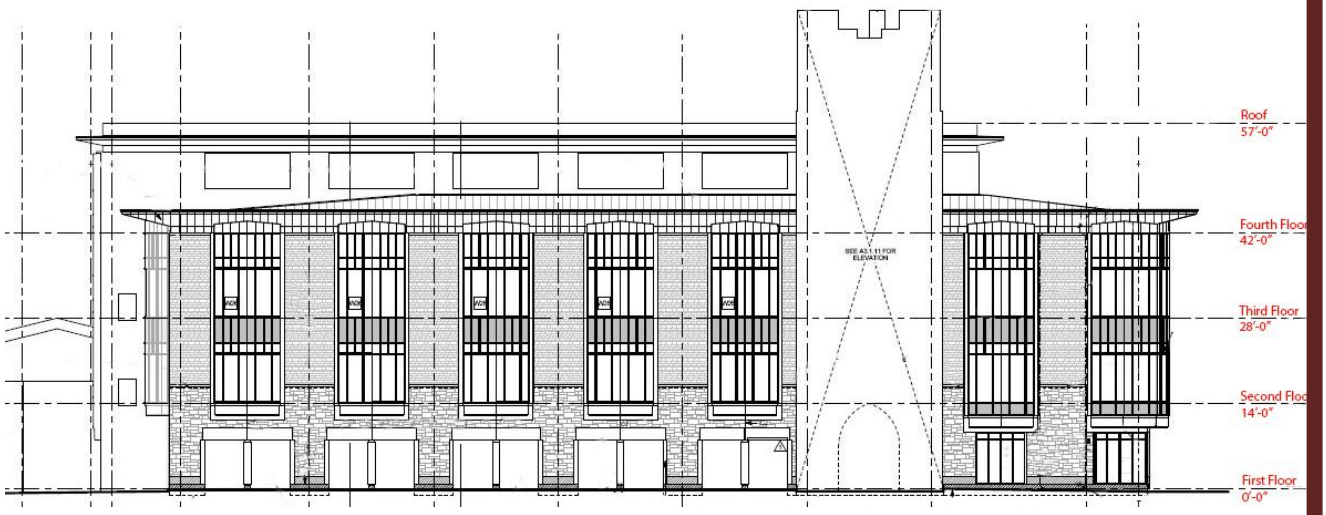


Figure 5 | South Facade

Dimensions

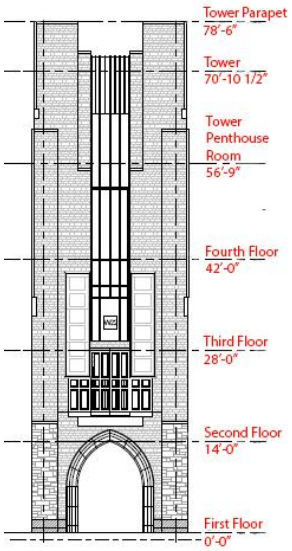


Figure 6 | South Facade Tower

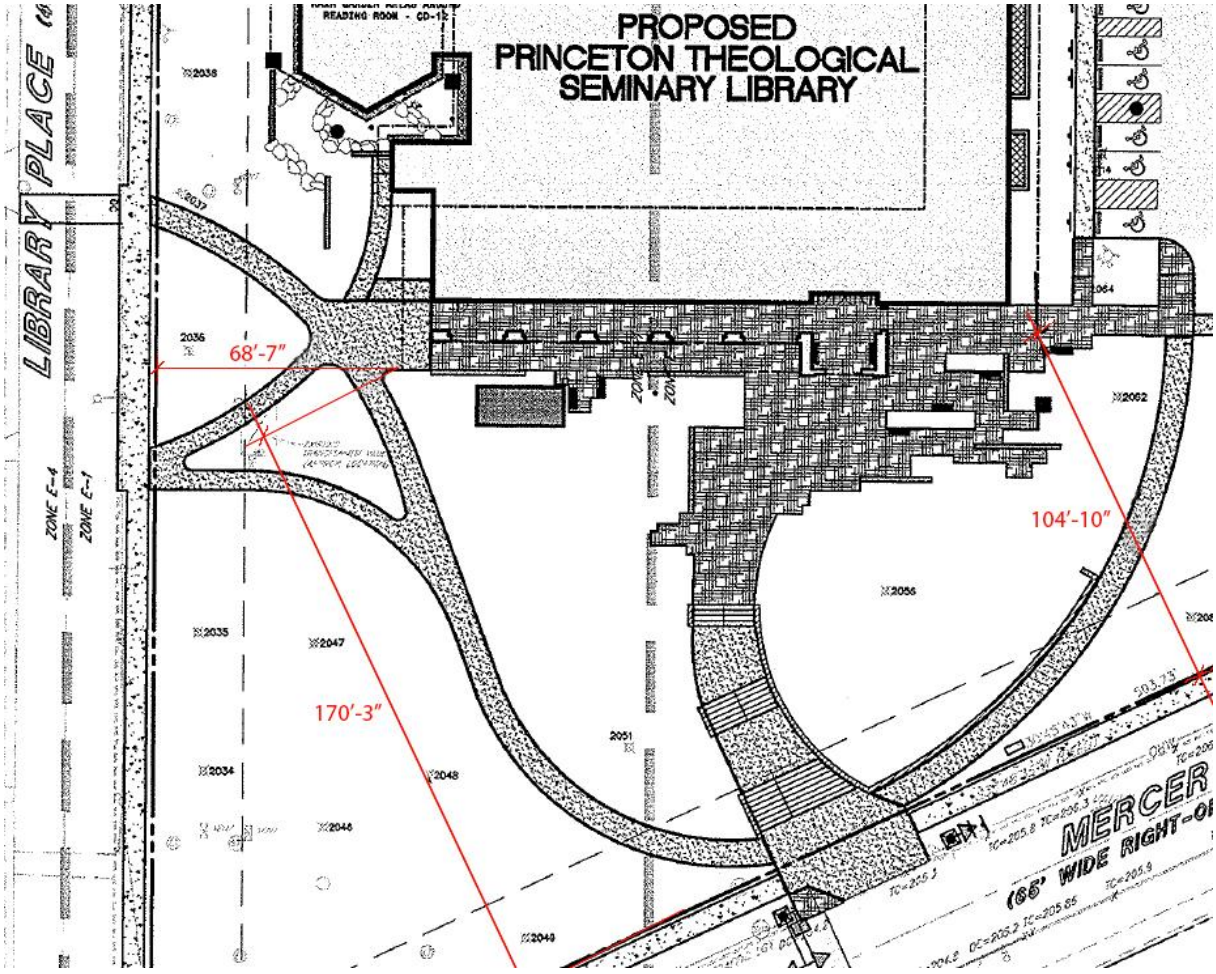


Figure 7 | South Facade Grounds

Finishes

The charts below describe the finishes and window types on the south façade. The stone type Corinthian is used on the bottom 16'-0" of the façade and the 26'-0" above that is South Bay Quartzite. All of the two story bay windows contain three different glass types in the pattern shown below.

Wall		
Finish		**Reflectance**
Champlain Stone – South Bay Quartzite		assume 20%
Champlain Stone – Corinthian		assume 15%

Windows			
Type	**Glass Type**	**Transmittance**	**Manufacurer**
W26/W27	IG-1, Insulating glass	58%	Cardinal Glass Industries, LOE3- 366
	IG-1, Insulating, tempered glass	assume 50%	Cardinal Glass Industries, LOE3- 366
	IG-1, Shadow box behind glass	assume 29%	Cardinal Glass Industries, LOE3- 366

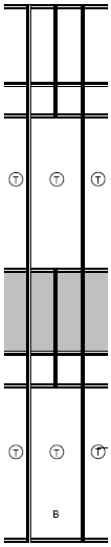


Figure 8 | South Facade Window

Important Design Criteria

- Be an icon for the school
- Lead visitors toward the entrance
- Provide safe light levels for walking at night

Fixture Schedule

Lighting									
Type	Description	Manufacturer	Lamp			Ballast		Voltage	Mounting
			No.	Type	Watts	No.	Type		
I1	In-grade uplight 40 deg	Winona	1	LED	12			277	In-grade
L1	Surface linear wall graze	Color Kinetics	1	LED	13.8			277	Surface
SD1	Surface mounted downlight	Gotham	1	LED	38			277	Surface
S1	Steplight	FC Lighting	1	LED	9			277	Steplight
I2	In-grade uplight 10 deg	Winona	1	LED	12			277	In-grade
WU1	Wall mount uplight	Lumenpulse	1	LED	16			277	Wall Mount
WS1	Wall Sconce	Louis Poulsen	1	CF G24q-3	26	1	Electronic	277	Wall Mount
P2	Pole	Selux	1	H070T6	70	1	Electronic	277	Pole Mount

Lighting Plans

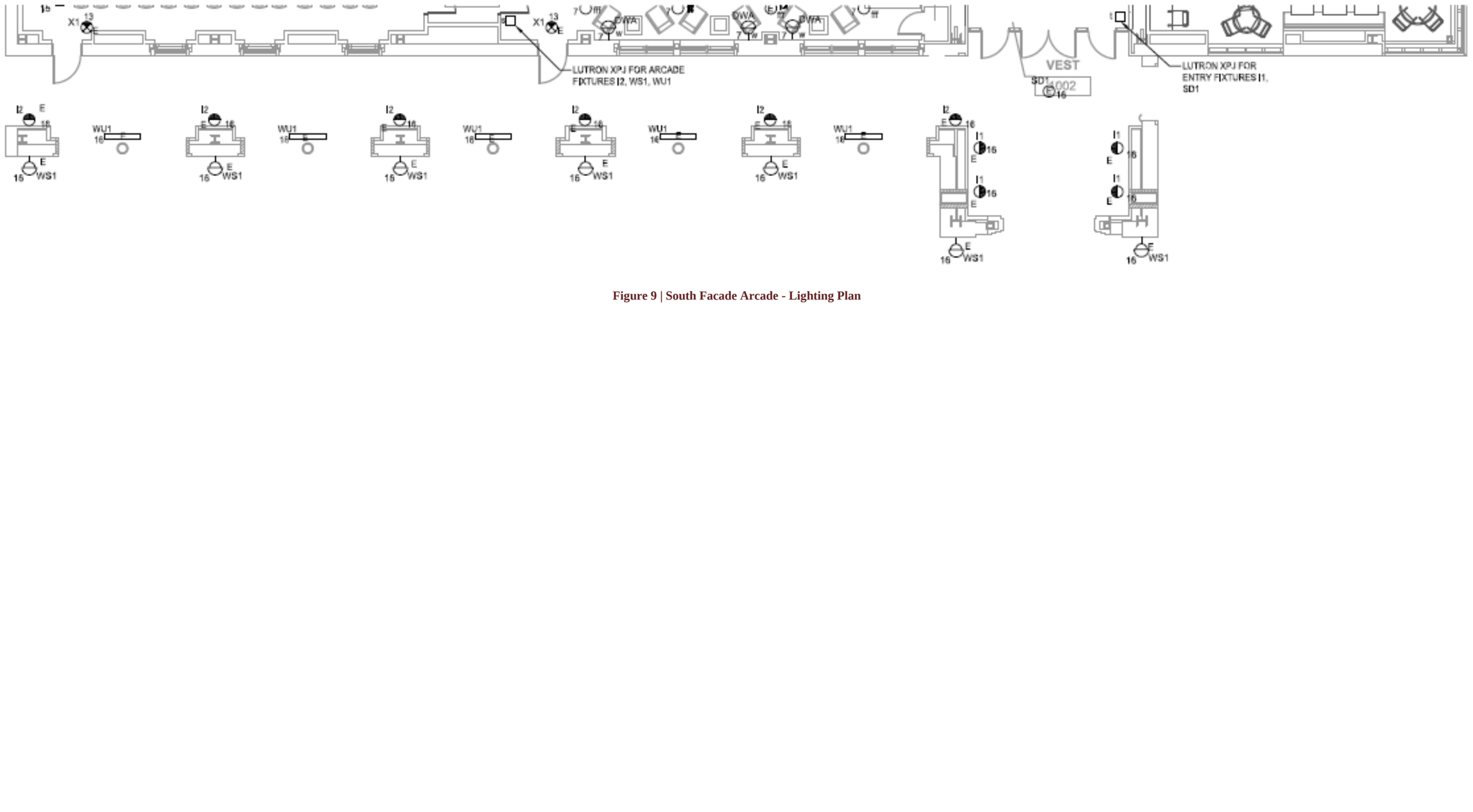


Figure 9 | South Facade Arcade - Lighting Plan

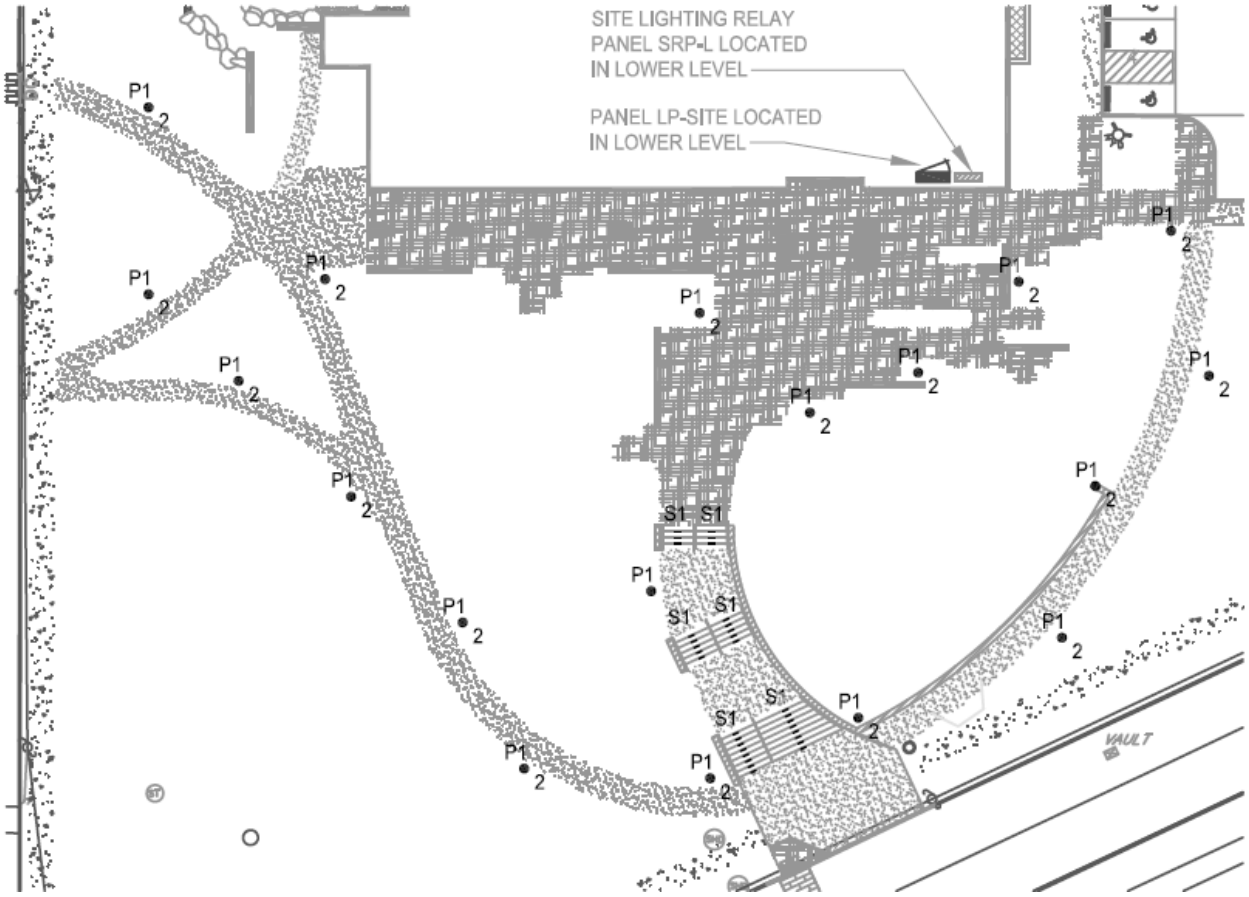


Figure 10 | South Facade Grounds - Lighting Plan

Light Loss Factors

The light sources used on the south façade and grounds include LEDs, metal halide and compact fluorescent. All LEDs will have a LLF of 0.7. For the other light sources, the LLF used is calculated below.

Light Loss Factors (P2)	
LDD	0.85
-Dirty Environment	
-Open/Unventilated	
-Direct	
-12 month cleaning cycle	
LLD	0.80
-Initial Lumens	6300
-Mean Lumens	5040
BF	1
Total LLF:	0.68

Light Loss Factors (WS1)	
LDD	0.85
-Dirty Environment	
-Open/Unventilated	
-Direct/Indirect	
-12 month cleaning cycle	
LLD	0.86
-Initial Lumens	1710
-Mean Lumens	1470
BF	1
Total LLF:	0.73

Illuminance Criteria

Illuminance levels should be sufficient for circulation under the arcade and tower as well as on the pathways around the façade. Illuminance recommendations taken from the Lighting Handbook, Volume 10 and the actual illuminance values are shown in the two tables below followed by calculations and renderings from AGI 32.

Illuminance Recommendations

Task	Illuminance (lux)	
	Horizontal	Vertical
Façade		
-Medium Activity LZ2 Apply to <=15% of building façade		100 (max)
Canopied Entry		
-Medium Activity LZ2 Eh@grade; Ev @5' AFG	10	6
Paths to Curb		
-Medium Activity LZ Eh@grade; Ev@5' AFG	4	1

Actual Illuminance Values

Task	Illuminance (lux)	
	Horizontal	Vertical
Façade		
-Medium Activity LZ2 Apply to <=15% of building façade		60
Canopied Entry		
-Medium Activity LZ2 Eh@grade; Ev @5' AFG	12.6	7.7
Paths to Curb		
-Medium Activity LZ Eh@grade; Ev@5' AFG	7	1.1

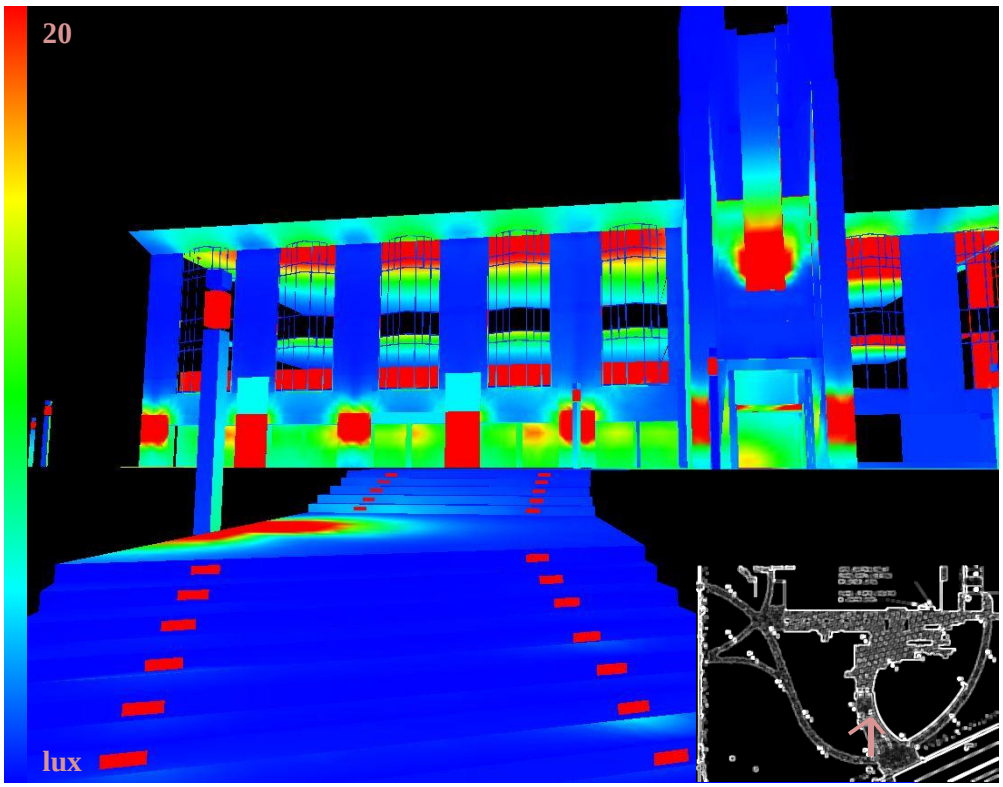


Figure 11 | South Facade - Pseudo color

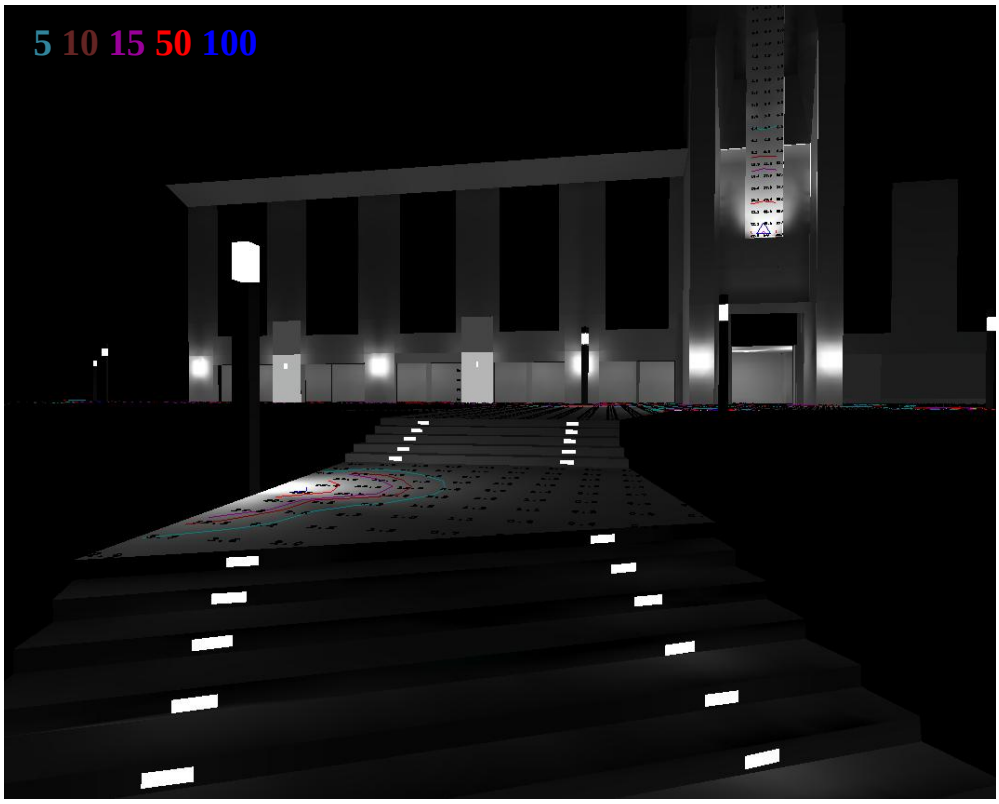


Figure 12 | South Facade – Isolines at ground level

Figure 13 | Atrium - Rendering

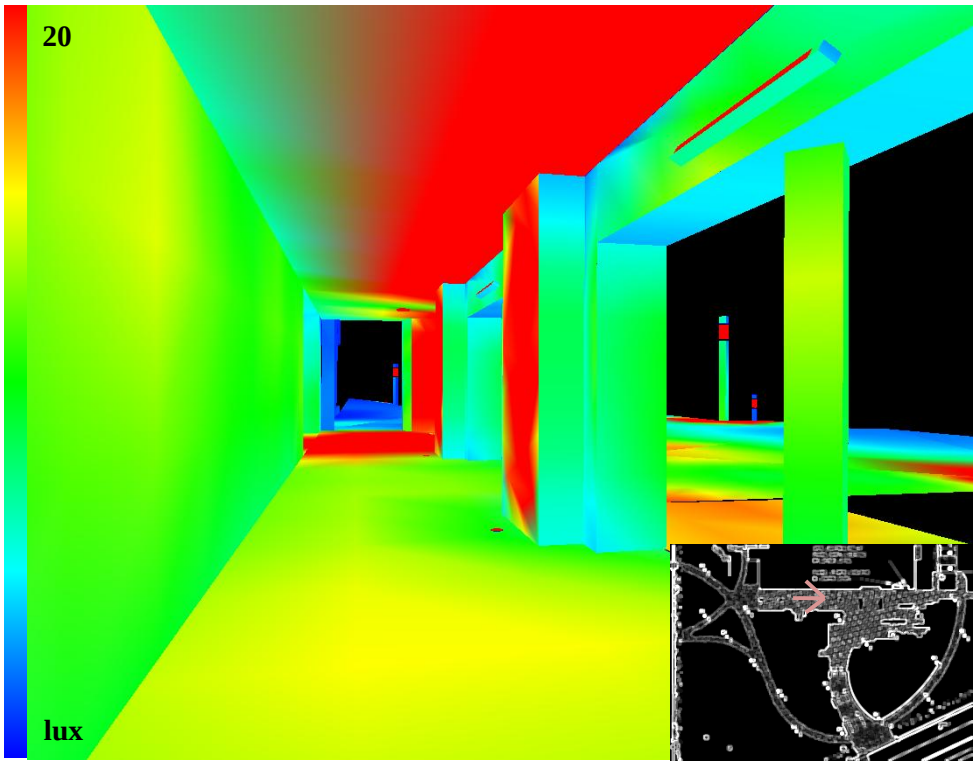


Figure 14 | Atrium - Pseudo color

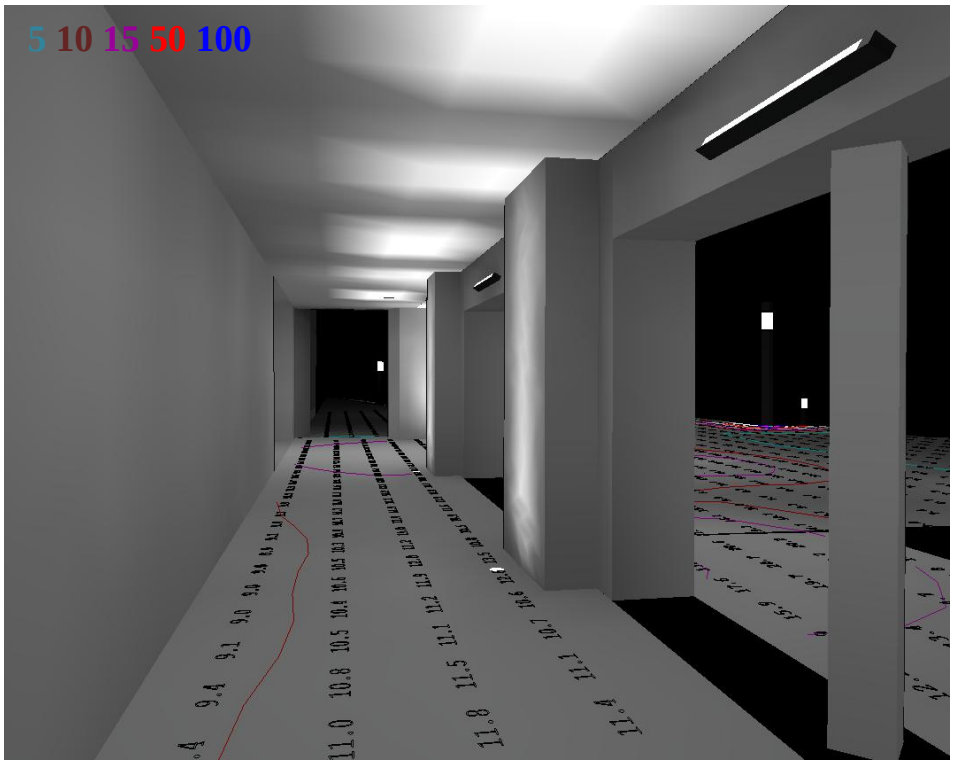


Figure 15 | South Facade Arcade – Isolines at ground level

Figure 16 | Atrium - Rendering

Controls

- *Lutron XPJ* switching control for arcade and entrance fixtures
- *Lutron Energi Savr Node* as a time clock device for I1and I2 fixtures

Energy Criteria

The code requirements for power density are referenced from ASHRAE 90.1 2010.

Power Allowances for Building Exteriors	
Task	**Allowance**
Building Grounds	
-Walkways less than 10 ft wide	0.7 W/linear foot
-Walkways 10 ft wide or greater	0.14 W/ft2
-Pedestrian tunnels	0.15 W/ft2
Building Entrance	
-Main entries	20 W/linear foot of door width
Building Façade	0.1 W/ft2 for each illuminated wall or surface of 2/5 W/linear foot for each illuminanted wall or surface length

Actual Power Usage	
Task	**Allowance**
Building Grounds	
-Walkways less than 10 ft wide	0.7 W/linear foot
-Walkways 10 ft wide or greater	0.124 W/ft2
-Pedestrian tunnels	0.14 W/ft2
Building Entrance	
-Main entries	10.8 W/linear foot
Building Façade	0.097 W/ft2

Café

Located immediately to the right of the main entrance, the café is a place to relax and take a break from the hard work being done in the rest of the building. It should catch people's attention as soon as they enter the building and encourage them to enter. Movable tables and chairs in the room allow for flexibility in furniture layout to adapt to varying needs.

Description of Space

Implementing the psychological impression of relaxation is crucial to defining the function of this room as being different from the rest of the building. Lighting methods to accomplish this feeling will be responsive to the varying contribution from daylight throughout the day and year. There are three ceiling height windows in the room that face east and south. These will bring daylight into the space in the morning and early afternoon hours. As daylight makes people feel connected with the exterior and allows them to see outside, it can also provide dark areas that would appear to be unwelcoming. By providing high light levels on the walls, it will fill in those dark areas when daylight is present. This will also accomplish relaxation as recommended by John Flynn by creating peripheral emphasis away from the people. People are relaxed when they feel as if the attention is not on them. Dim overhead lighting will also be introduced throughout the rest of the room to provide general illumination. It will be organized in an irregular pattern to provide non-uniform light levels across the space. A drop ceiling effect, through the use of light, will be introduced to reinforce the concept of light from the heavens entering the space while also providing illumination to the perimeter areas of the ceiling.

Dimensions

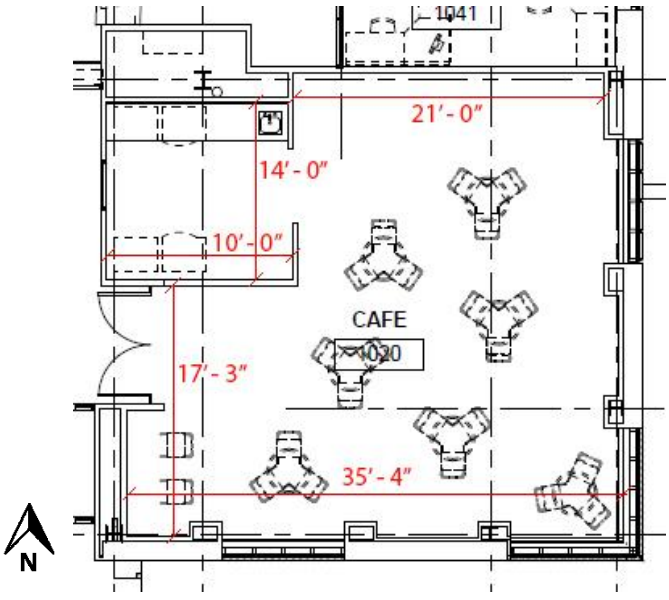


Figure 17 | Café – Floor Plan

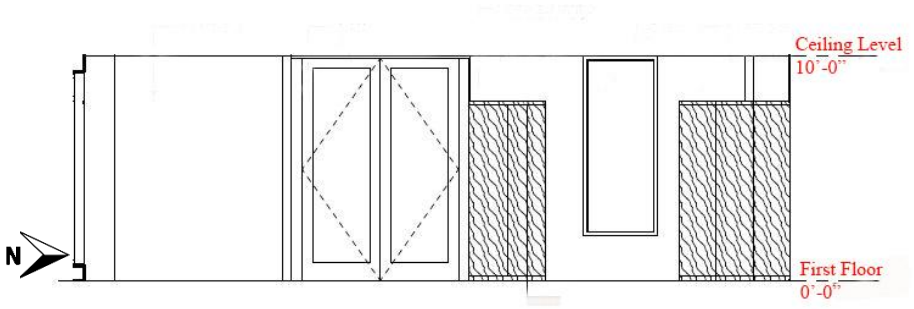
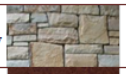
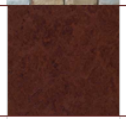


Figure 18 | Cafe – West Elevation

Finishes

The charts below describe the finishes and window types included in the Café. The two flooring materials define the room by creating an area for the entrance, with the stone flooring, and an area for the tables, with carpet. In contrast to the dark colors of the floor, the walls and ceiling are the typical white color that is used throughout the building. The window types chosen for the room also have very distinct purposes. The exterior windows are insulated glass for maximum daylight and the interior window in the kitchen is insulated glass with frit to create a connection to the lobby but maintain privacy.

Floor			Wall		Ceiling	
Finish		Reflectance	Finish	Reflectance	Finish	Reflectance
Champlain Stone – South Bay Quartzite		assume 20%	Benjamin Moore – Color Preview #OC-122 Cotton Balls	assume 80%	Benjamin Moore – Color Preview #OC-122 Cotton Balls	assume 80%
Forbo Lineoleum Flooring – Real #2784 Coffee		assume 20%	Benjamin Moore – Color Preview #OC-122 Cotton Balls	assume 80%	Benjamin Moore – Color Preview #OC-122 Cotton Balls	assume 80%

Windows			
Type	Glass Type	Transmittance	Manufacurer
W26	IG-1, insulating glass	58%	Cardinal Glass Industries, LOE3- 366
W2	IG-2, insulating glass with frit	assume 29%	Cardinal Glass Industries, LOE3- 366

Important Design Criteria

- Draw attention to the space
- Adapt scenes to varying daylight
- Create a relaxing atmosphere

Psychological Impression

To set the café apart from the rest of the building, light can be used to draw the guests in to relax during their study break. Although a difficult task during the day due to the changing sun patterns, the hours of the library make it possible that this task can be accomplished at night. The following references established the guidelines to the design of the café.

The Psychology of Lighting – Article 5: Attitude Reinforcement through Lighting Design

A feeling of relaxation can be created by combining low-intensity downlights with wall washers on two opposite walls.

Subjective Lighting: Power for Perception

By encouraging peripheral emphasis, keeping the luminance levels low and avoiding uniformity, the impression of relaxation can be created.

Fixture Schedule

Lighting									
Type	Description	Manufacturer	Lamp			Ballast		Voltage	Mounting
			No.	Type	Watts	No.	Type		
D2	Recessed downlight	Kurt Versen	1	LED	36			277	Recessed
L1	Linear cove	Color Kinetics	1	LED	13.8			277	Surface

Lighting Plan

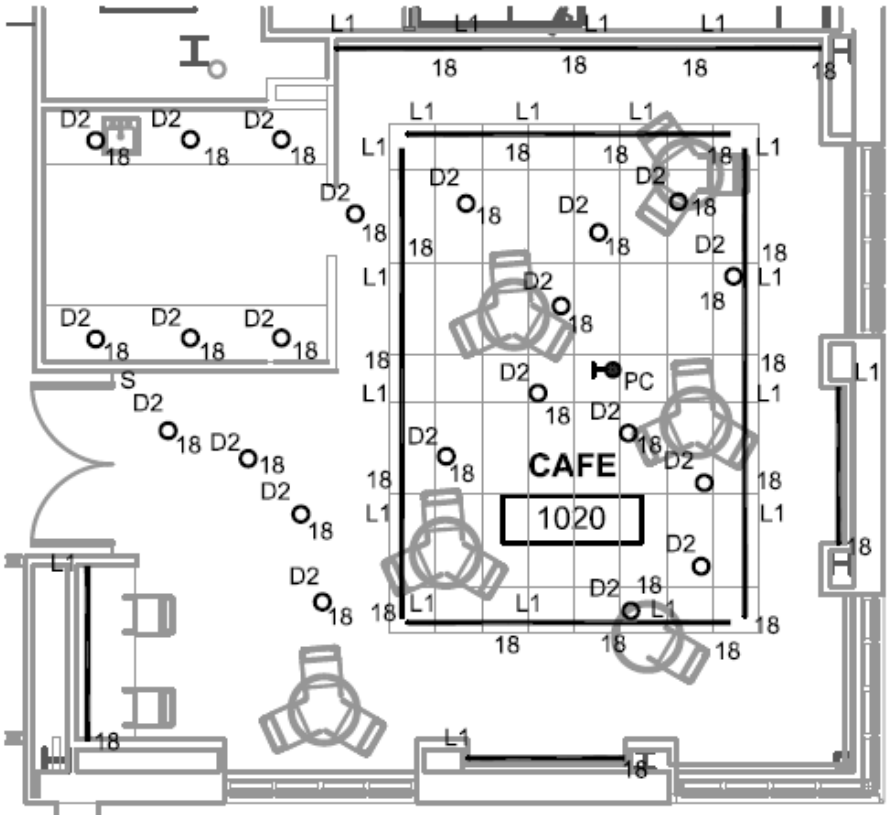


Figure 19 | Cafe - Lighting Plan

Light Loss Factors

The light source used in the atrium is LED with an LLF of 0.7.

Illuminance Criteria

Illuminance levels should be sufficient for general tasks and computer use within the café as well as food preparation within the attached kitchen. Illuminance recommendations taken from the Lighting Handbook, Volume 10 and the actual illuminance values are shown in the two tables below followed by calculations and renderings from AGI 32.

Illuminance Recommendations

Task	Illuminance (lux)	
	Horizontal	Vertical
Café		
-General Eh@floor; Ev@5' AFF	100	50
-Personal Internet Browsing Eh @2'6" AFF; Ev @4'0" AFF	150	50
Kitchen		
-Food Preparation Eh and Ev at counter surface	500	200

Actual Illuminance Values

Task	Illuminance (lux)	
	Horizontal	Vertical
Café		
-General Eh@floor; Ev@5' AFF	250 @40% dim	128
-Personal Internet Browsing Eh @2'6" AFF; Ev @4'0" AFF	260 @40% dim	124
Kitchen		
-Food Preparation Eh and Ev at counter surface	515 @10% dim	154

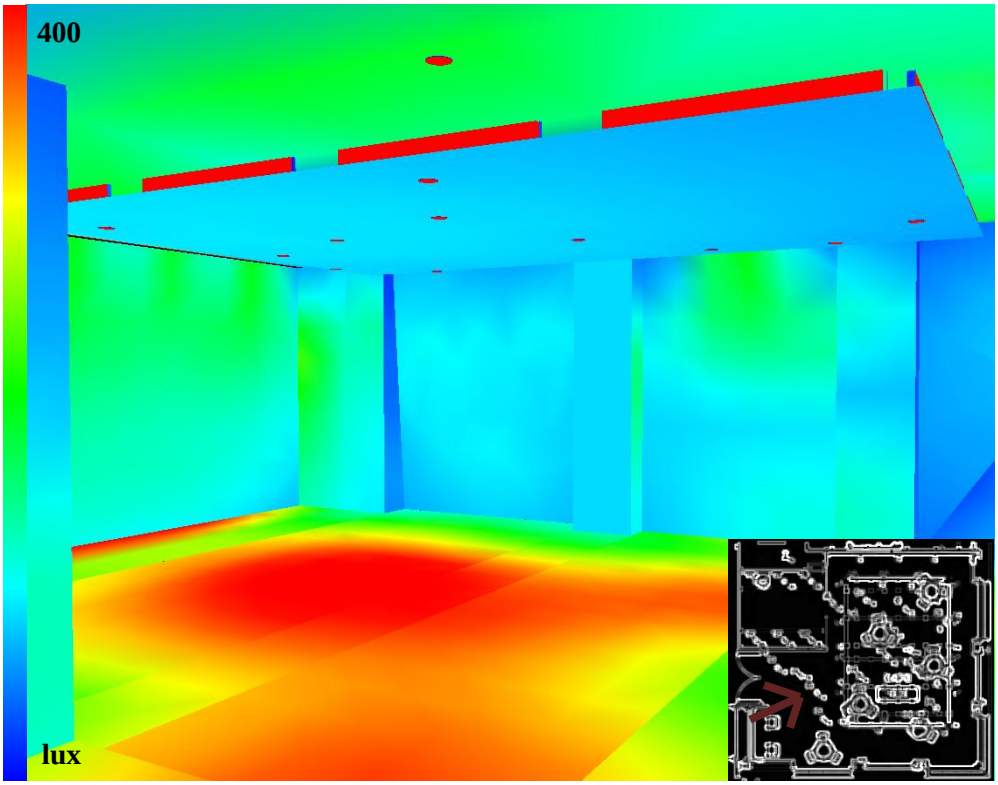


Figure 20 | Cafe - Pseudo color

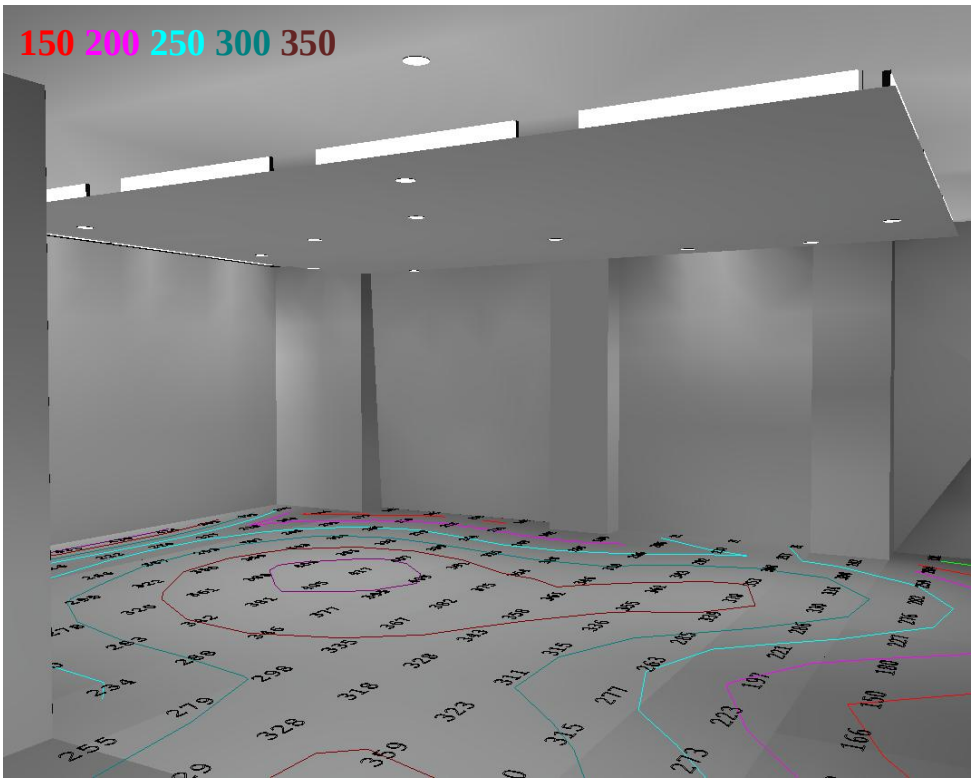


Figure 21 | Cafe – Isolines at floor

Figure 22 | Cafe - Rendering

Controls

- *Radio Powr Savr Wireless Daylight Sensor* to dim D2 fixtures

Energy Criteria

The code requirements for power density are referenced from ASHRAE 90.1 2010.

Power Allowance	
Space Type	**LPD, W/ft2**
Dining Area	
-For Bar Lounge/Leisure Dining	1.31

Actual Power Usage	
Space Type	**LPD, W/ft2**
Dining Area	
-For Bar Lounge/Leisure Dining	1.14

Atrium

The atrium is the largest and most memorable area of the building. It extends up five stories from the lower level and connects the addition to the existing Luce Building. Designed to be a very bright space, the atrium has scattered skylights above it, clerestories along its north side and four levels of side lighting on the west.

Description of Space

By providing a focus in the center of the atrium with the use of sparkle and vertical emphasis, the height of the space will appear to be extended all the way up to the heavens. To reinforce this focus, the surrounding areas will be simple and discrete. General illumination will need to be provided to the circulation space connecting the addition to the existing building and on each level of the stairs. For the surrounding reading areas, task lighting will provide additional light when it is needed. Because the use of a pendant hung from the roof will not provide light to the lower levels nor will daylight reach those areas very often, additional lighting will need to be added. The lower level is the only floor where people will walk through the atrium so the focal point on this floor should be away from this area. Multi-purpose rooms on each floor extend into the atrium stacked on top of each other that provide the perfect opportunity for peripheral emphasis. To avoid wall-mounted fixtures that will break up the height of these walls, in-ground linear uplights will be used to graze the walls that extend into the atrium.

Daylight will be an integral part to the fixture selection and controls chosen for the atrium. Multiple photosensors will be needed to control different zones for dimming.

Dimensions

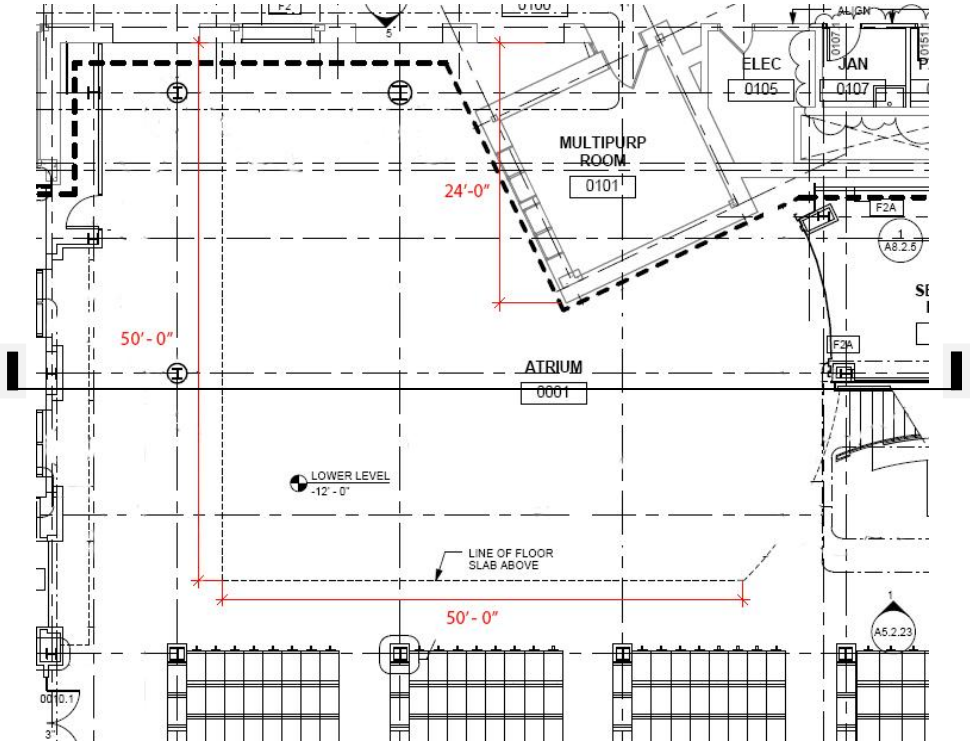


Figure 16 | Atrium - North Elevation

Figure 23 | Atrium - Lower Level

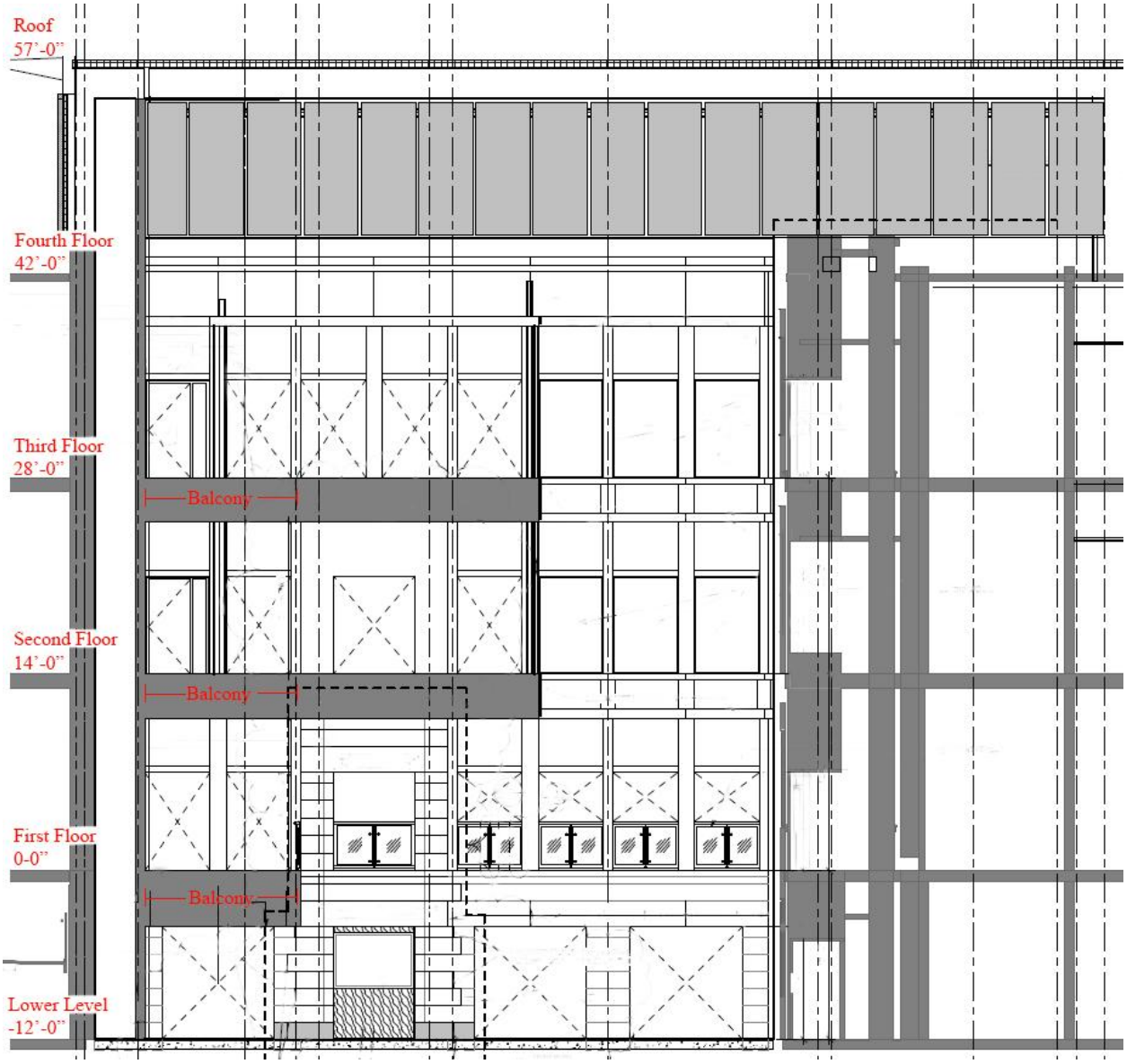
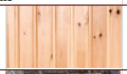


Figure 24 | Atrium – North Elevation

Finishes

The charts below describe the finishes and window types present in the Atrium. A balance of texture and color is used in the atrium, making this space unique in comparison to the finishes in the rest of the building. The combination of skylights and clerestory windows help to bring daylight into the atrium and the surrounding areas.

Floor			Wall			Ceiling		
Finish		Reflectance	Finish		Reflectance	Finish		Reflectance
Champlain Stone – South Bay Quartzite		assume 20%	Benjamin Moore – Color Preview #OC-122 Cotton Balls		assume 80%	Sherwin Williams - Essentials - SW 6217 Topsail		assume 70%
			Wood Paneling		assume 60%			
			Champlain Stone – Corinthian		assume 15%			

Windows			
Type	Glass Type	Transmittance	Manufacurer
Skylight Type 2	750 DS-C, Ray Bender 3000 optic prism	assume 25%	Solatube
W24	IG-2, insulating glass with frit	assume 29%	Cardinal Glass Industries, LOE3- 366

Important Design Criteria

- Create a memorable space
- Avoid glare and distractions for readers
- Take advantage of daylight

Fixture Schedule

Lighting									
Type	Description	Manufacturer	Lamp			Ballast		Voltage	Mounting
			No.	Type	Watts	No.	Type		
L1	Linear uplight	Color Kinetics	1	LED	13.8			277	Surface
D3	Recessed downlight	Kurt Versen	1	LED	18				Recessed
D1	Recessed downlight	Gotham	1	LED	40			277	Recessed
T1	Table mount task lamp	Finelite	1	LED	7.4			277	Table Mount

Lighting Plans

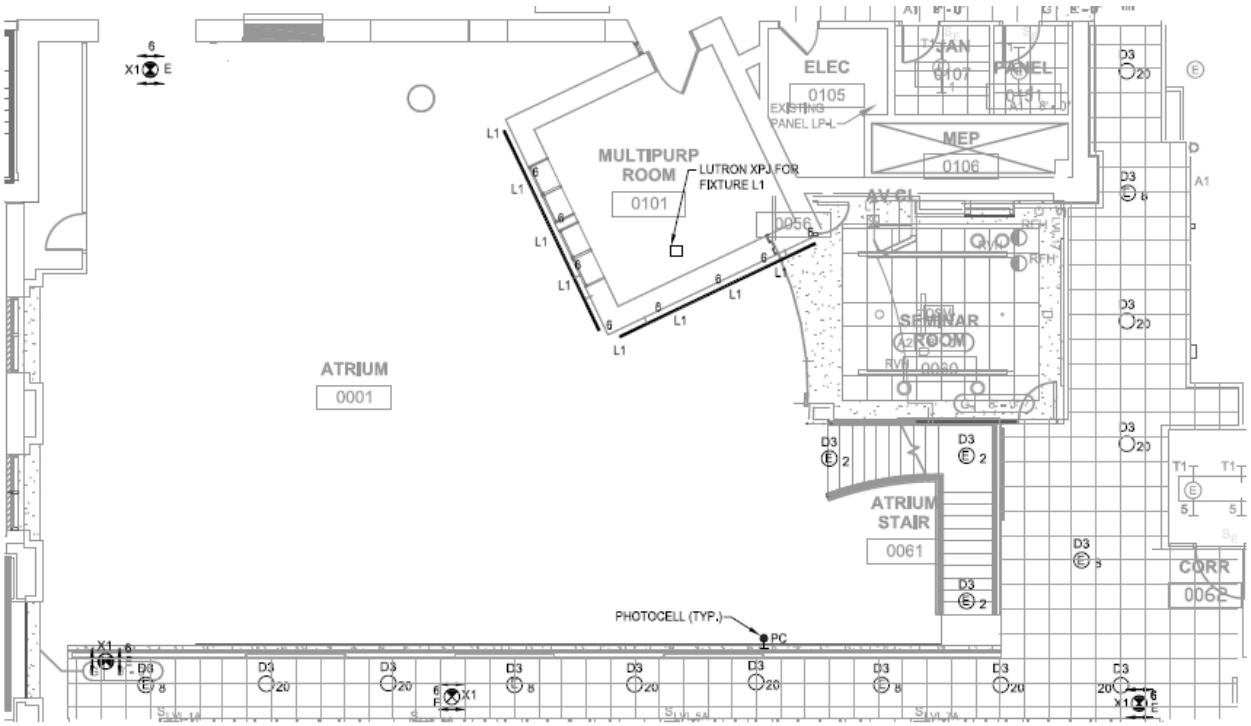


Figure 25 | Atrium - Lower Level

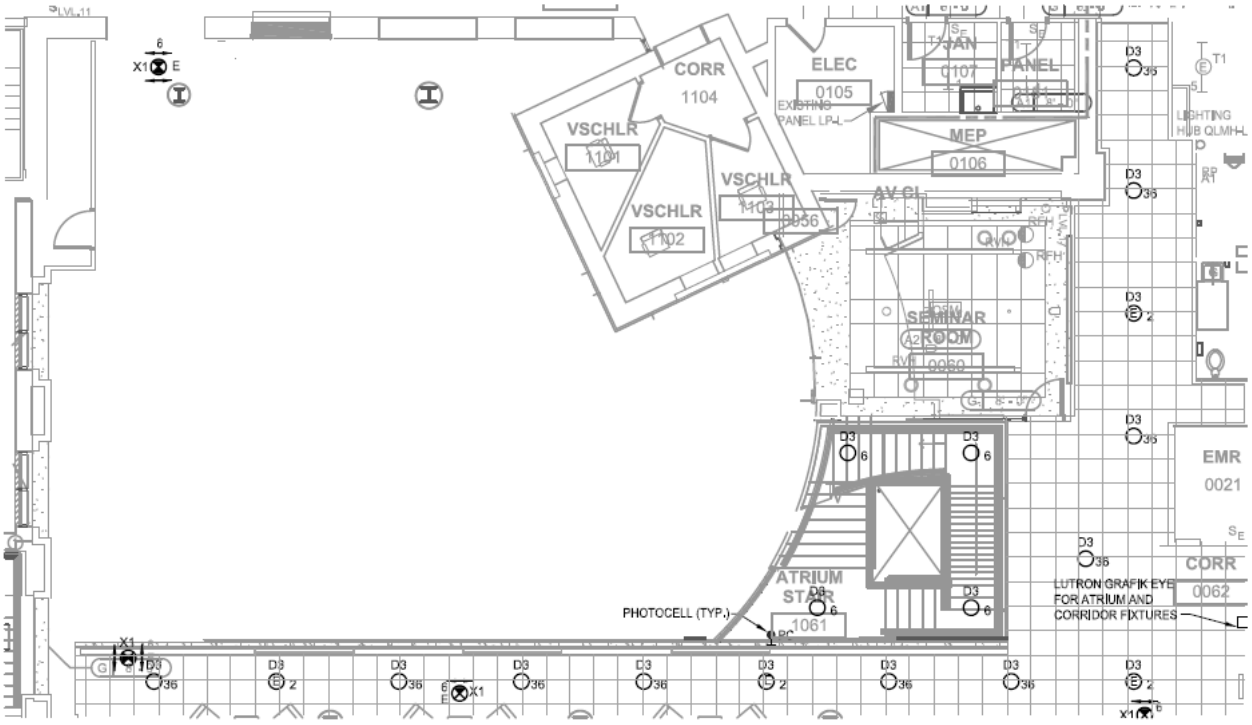


Figure 26 | Atrium - First Floor

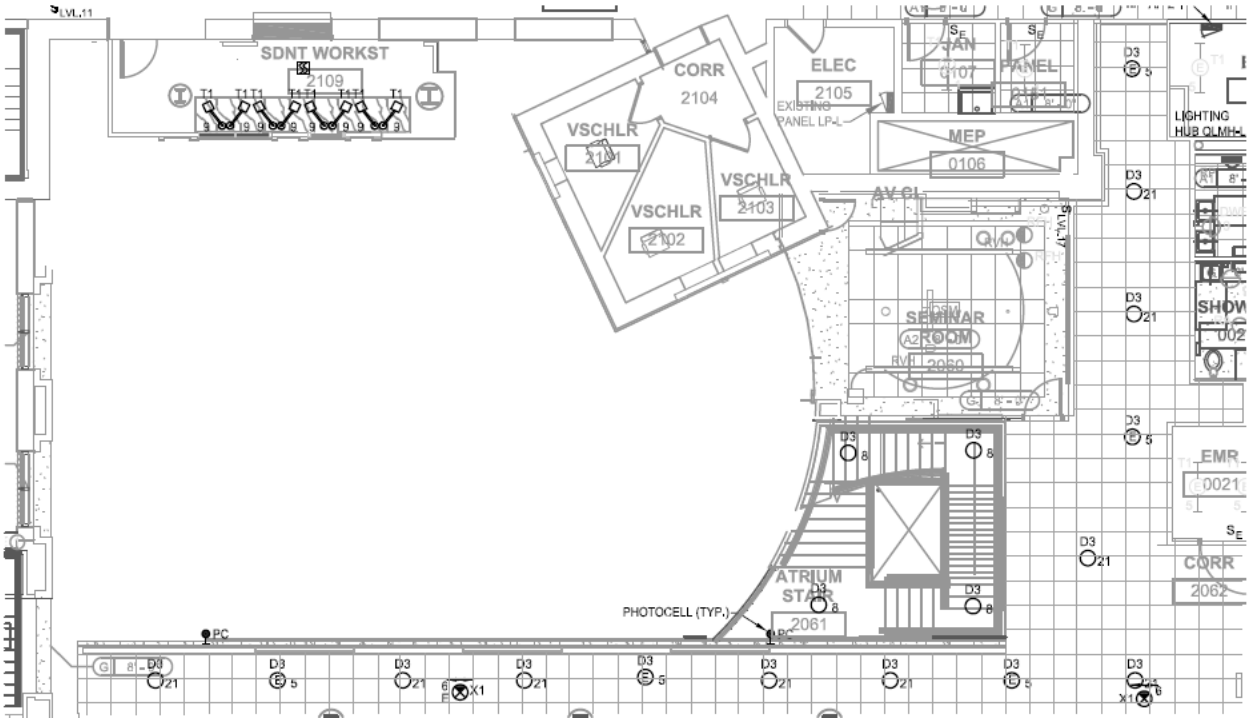


Figure 27 | Atrium - Second Floor

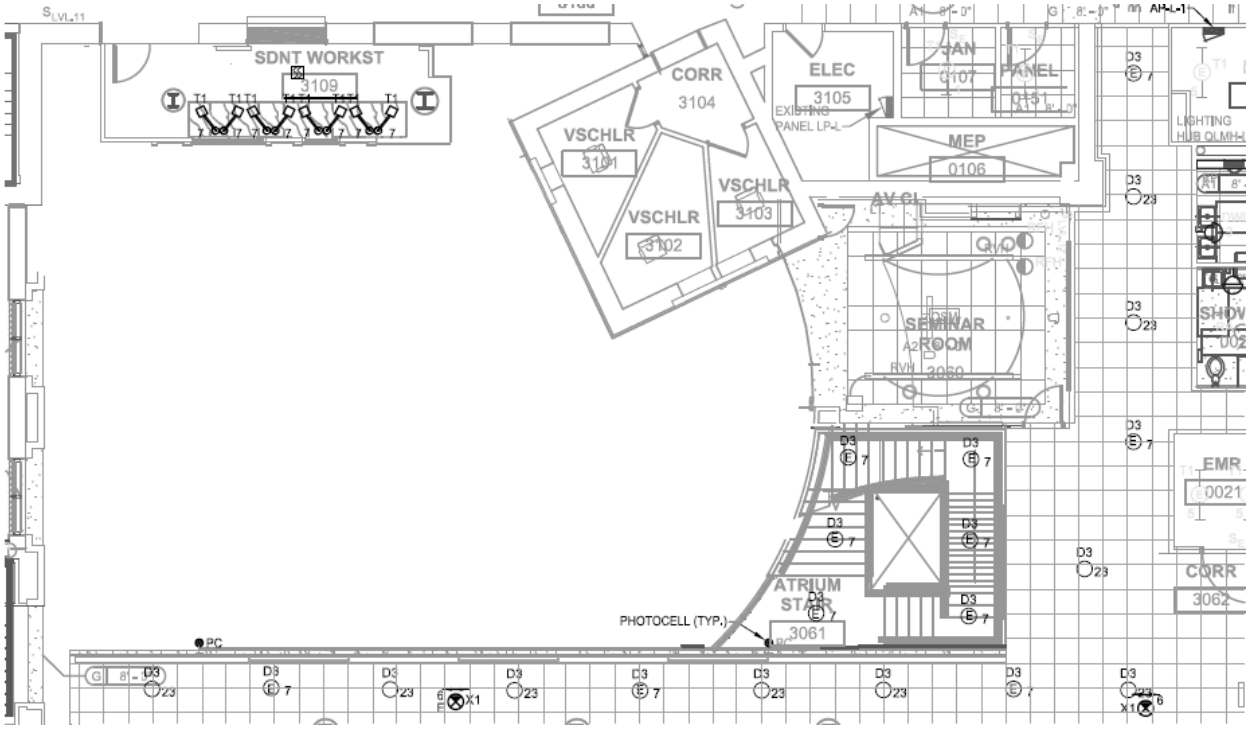


Figure 28 | Atrium - Third Floor

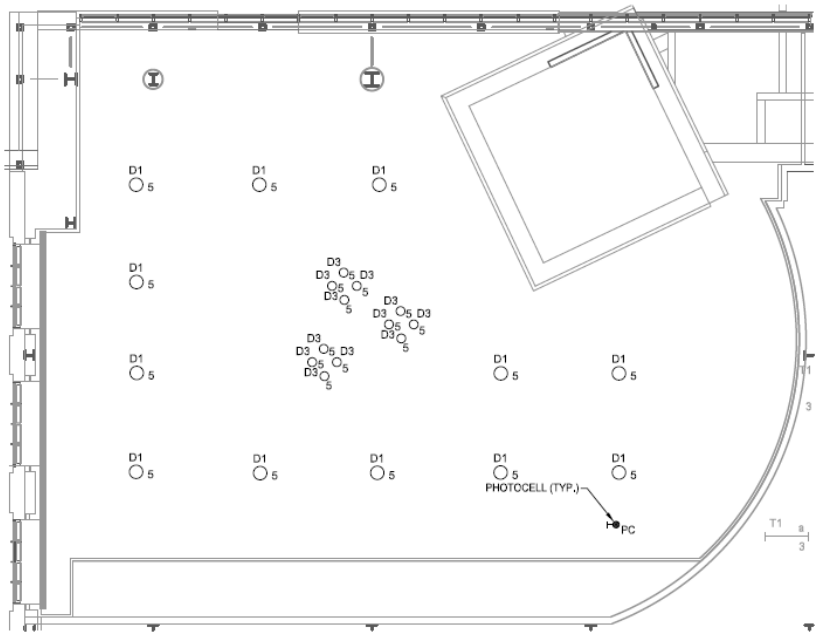


Figure 29 | Atrium - Fourth Floor

Light Loss Factors

The light source used in the atrium is LED with an LLF of 0.7.

Illuminance Criteria

Illuminance levels within the atrium should be sufficient for general circulation through hallways and stairs and provide enough task lighting for the reading areas on the second and third floors. Illuminance recommendations taken from the Lighting Handbook, Volume 10 and the actual illuminance values are shown in the two tables below followed by calculations and renderings from AGI 32.

Illuminance Recommendations		
Task	Illuminance (lux)	
	Horizontal	Vertical
Reading Areas		
-Tables and Chairs Eh @2'" AFF; Ev @4'0" AFF	500	200
Circulation Cooridor		
-Public Adjacency Passageways Eh @floor; Ev @5'0" AFF	Avg >= 0.2x task Eh of adjacent space, min >= 10lux	Avg >= 0.2x task Ev of adjacent space
Stairs		
-Typical Eh @floor; Ev @5'0" AFF	50	30

Actual Illuminance Values		
Task	Illuminance (lux)	
	Horizontal	Vertical
Reading Areas		
-Tables and Chairs Eh @2'" AFF; Ev @4'0" AFF	474	276
Circulation Cooridor		
-Public Adjacency Passageways Eh @floor; Ev @5'0" AFF	40	31
Stairs		
-Typical Eh @floor; Ev @5'0" AFF	85	26

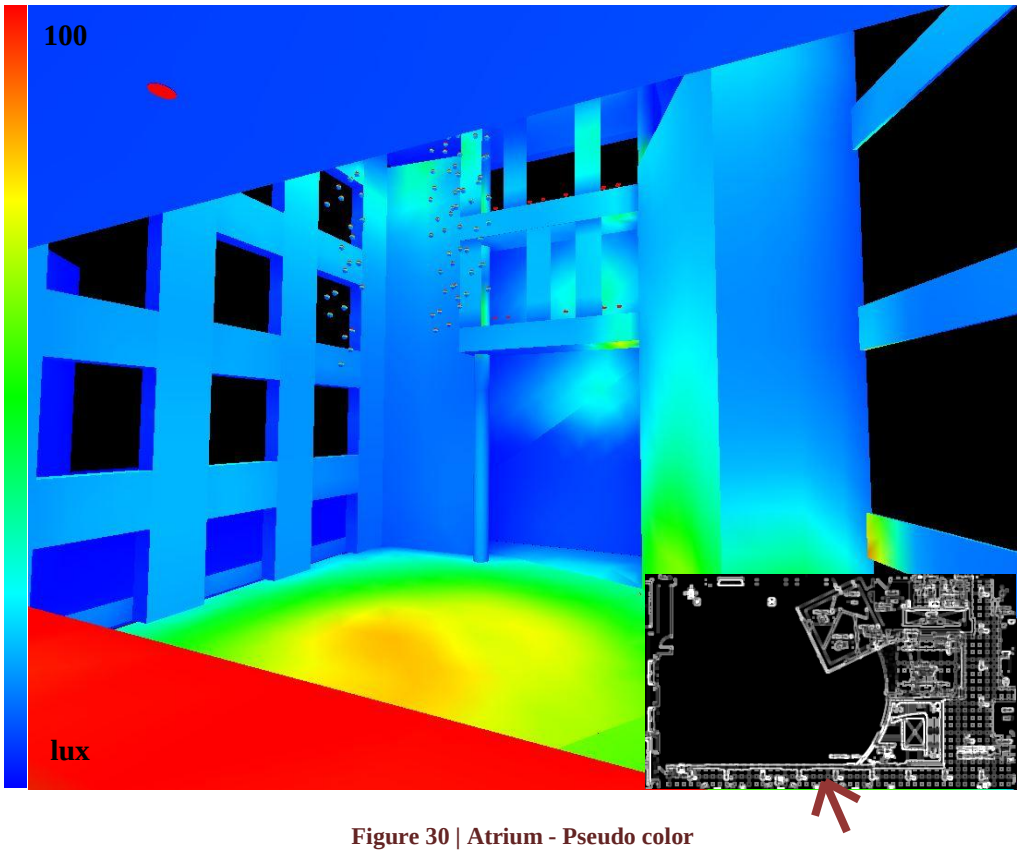


Figure 30 | Atrium - Pseudo color

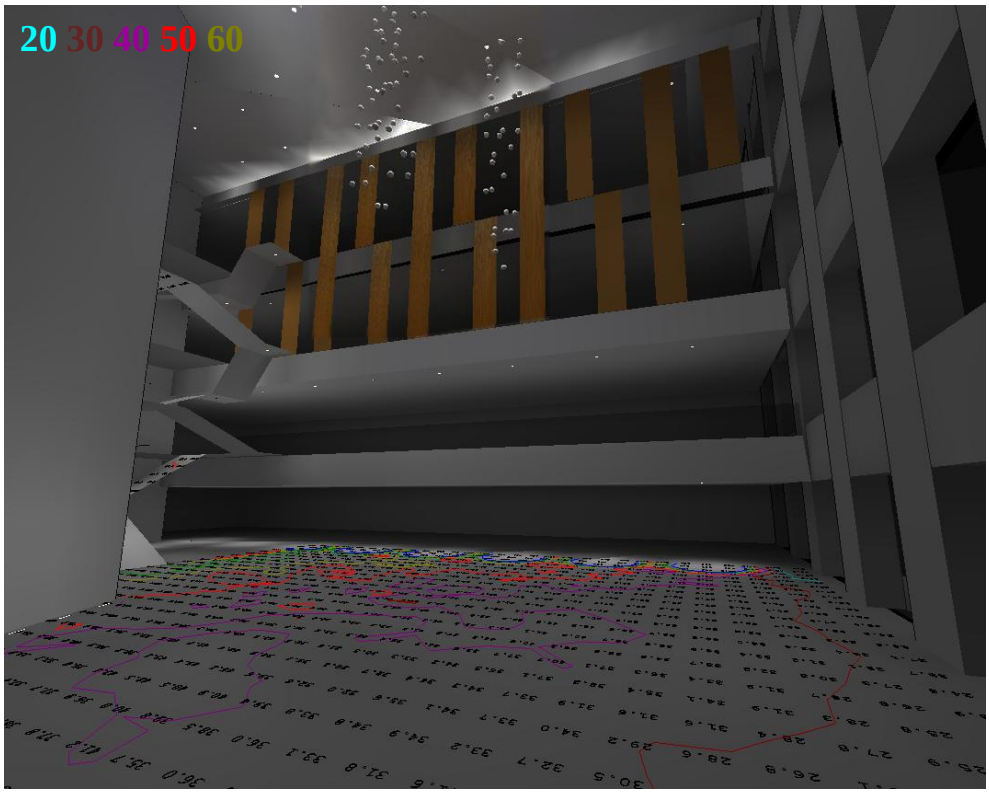


Figure 31 | Atrium - Isolines

Figure 32 | Atrium - Rendering

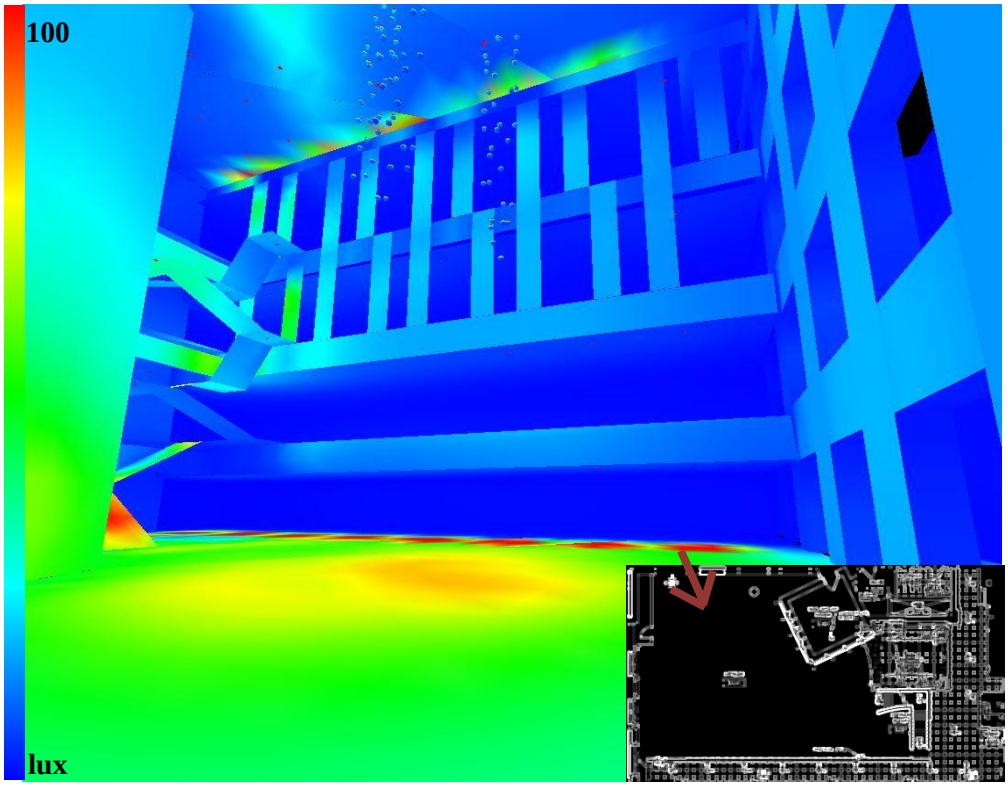


Figure 33 | Atrium - Pseudo color

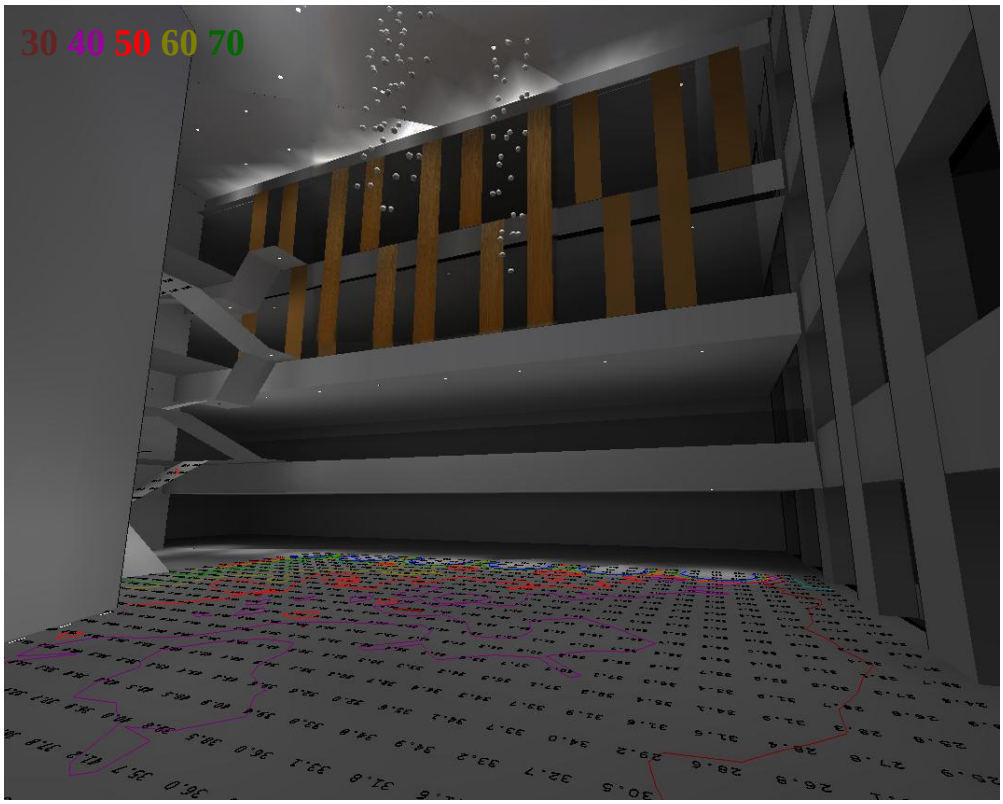


Figure 34 | Atrium - Isolines

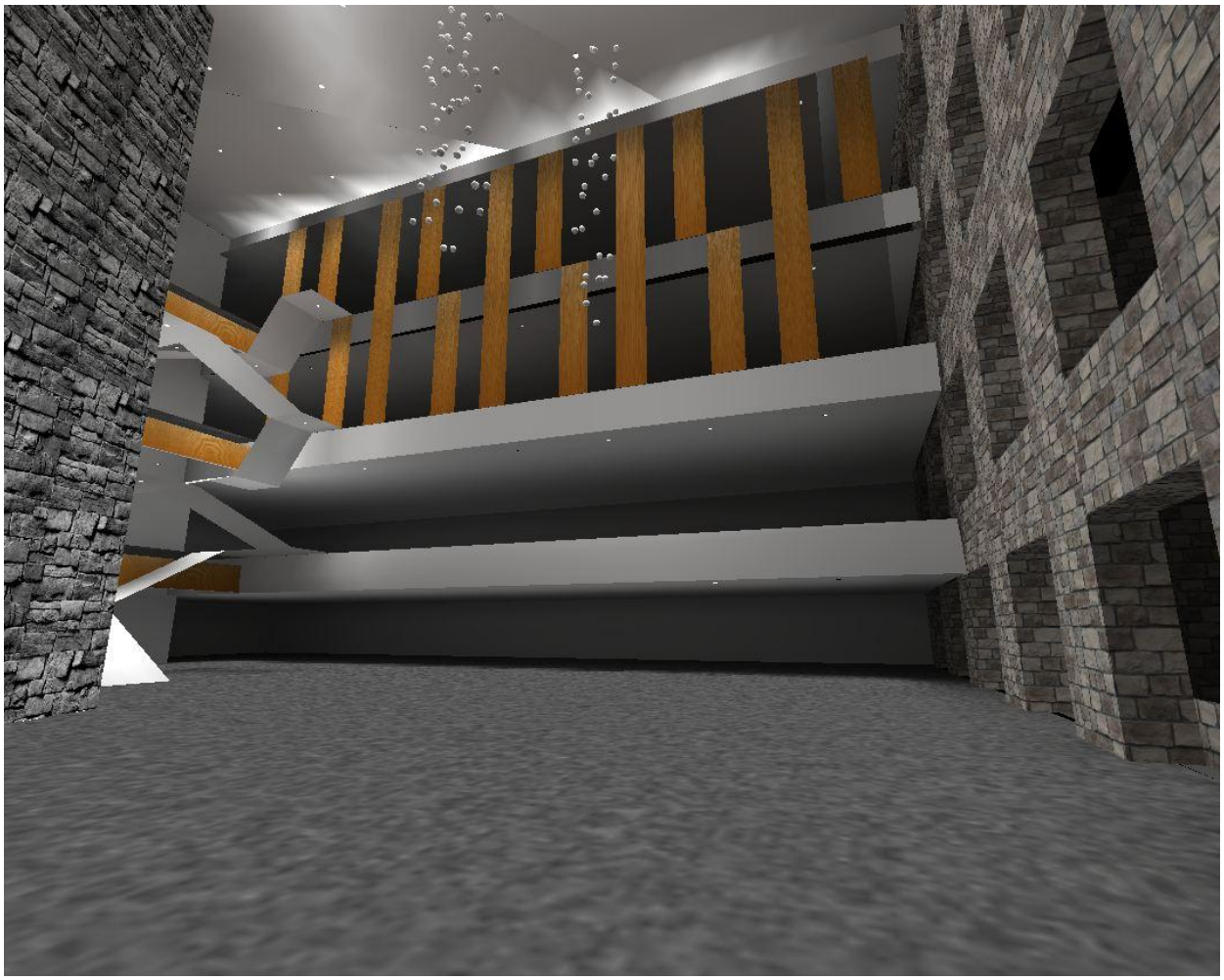


Figure 35 | Atrium - Rendering

Controls

- *Radio Powr Savr Wireless Daylight Sensor* to dim 4th floor D1 ceiling fixtures
- *Radio Powr Savr Wireless Daylight Sensors* on each floor to dim hallway and stairs fixtures south of atrium
- *Lutron LOS C Series Occupancy Sensor* in student workstations on second and third floors
- *Lutron XPJ* controller for uplight fixtures L1

Energy Criteria

The code requirements for power density are referenced from ASHRAE 90.1 2010.

Power Allowance	
Space Type	**LPD, W/ft2**
Atrium	
-First 40 ft in height	0.03 per ft (height)
-height above 40 ft	0.02 per ft (height)
Corridor/Transition	0.66
Library Stacks	1.71

Actual Power Usage	
Space Type	**LPD, W/ft2**
Atrium	
-First 40 ft in height	0.23
-height above 40 ft	
Corridor/Transition	0.66
Library Stacks	1.26

Reference Reading Room

Located on the western facade of the building, the Reference Reading Room is special because of its hexagonal shape and large window area. The small overhang into the space on the first floor allows for additional reading areas without blocking light from reaching the majority of the lower level. Important areas for illumination are located all around the room, including stacks in the center and recessed into the walls as well as reading tables elsewhere on the first floor and lower level.

Description of Space

The design for this room focuses on providing light to the specific tasks while emphasizing the verticality of the space by using illuminating the ceiling to portray the concept that 'God is light'. The intent is to create a spacious room that has a central focus similar to that in the atrium. Direct/indirect pendant fixtures can do this by providing downlight to the table and bookshelf surfaces and uplight to illuminate the pitched ceiling. This will serve both the purpose of creating a vertically elongated space and providing useful light for the tasks. Locally, where the tasks of reading and searching for books will be occurring, additional lighting will be provided on each table and above the bookshelves where needed. Downlights will also be included below the overhang and in the open stairwell for additional illumination.

Dimensions

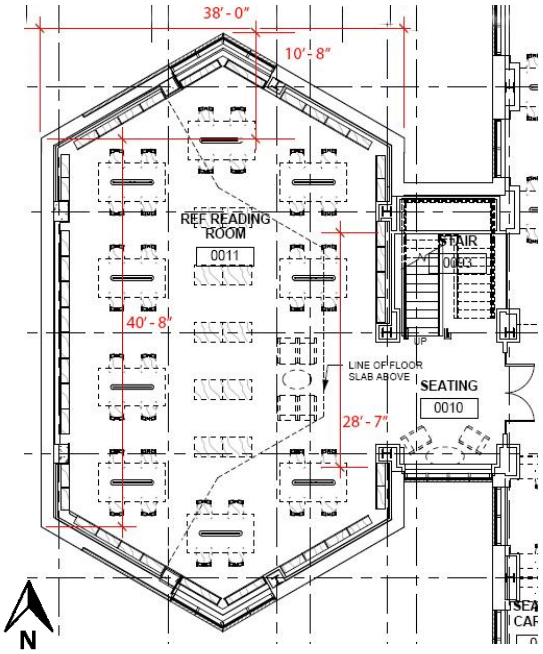


Figure 35 | Reference Reading Room - Lower Level Plan

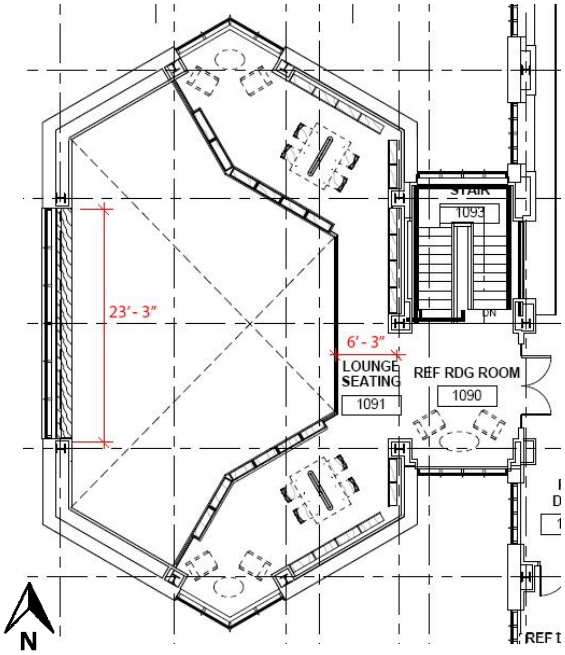


Figure 37 | Reference Reading Room - First Floor Plan

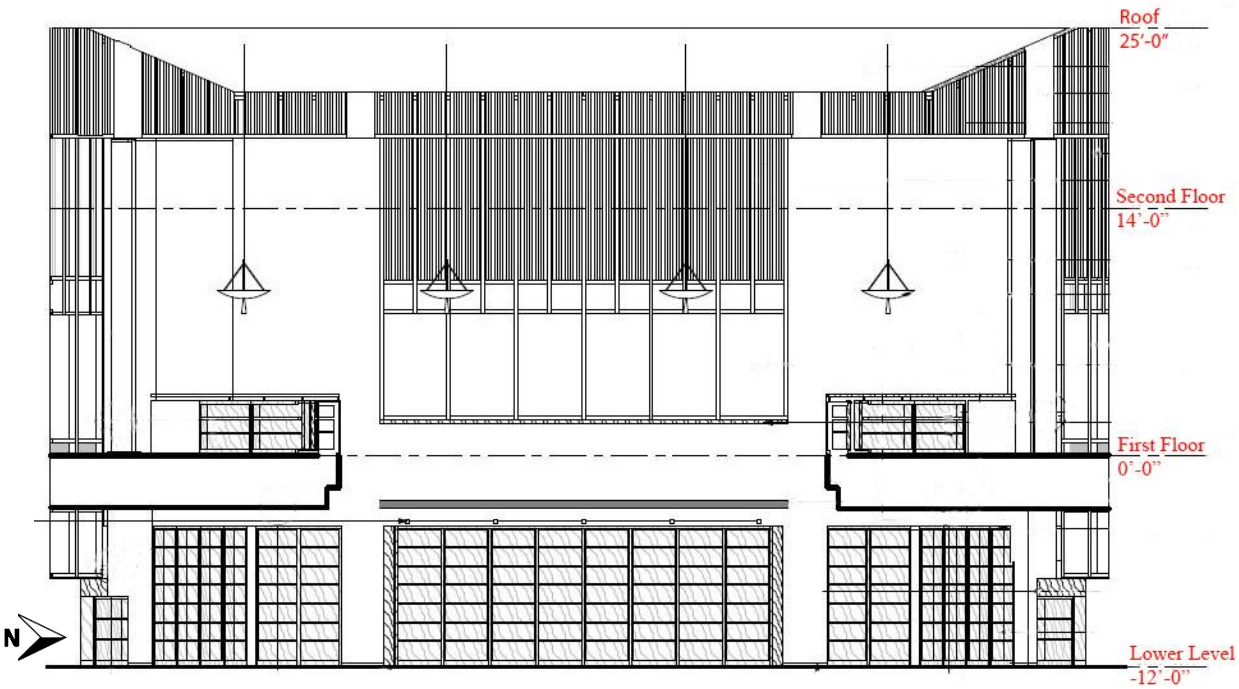


Figure 38 | Reference Reading Room - West Elevation

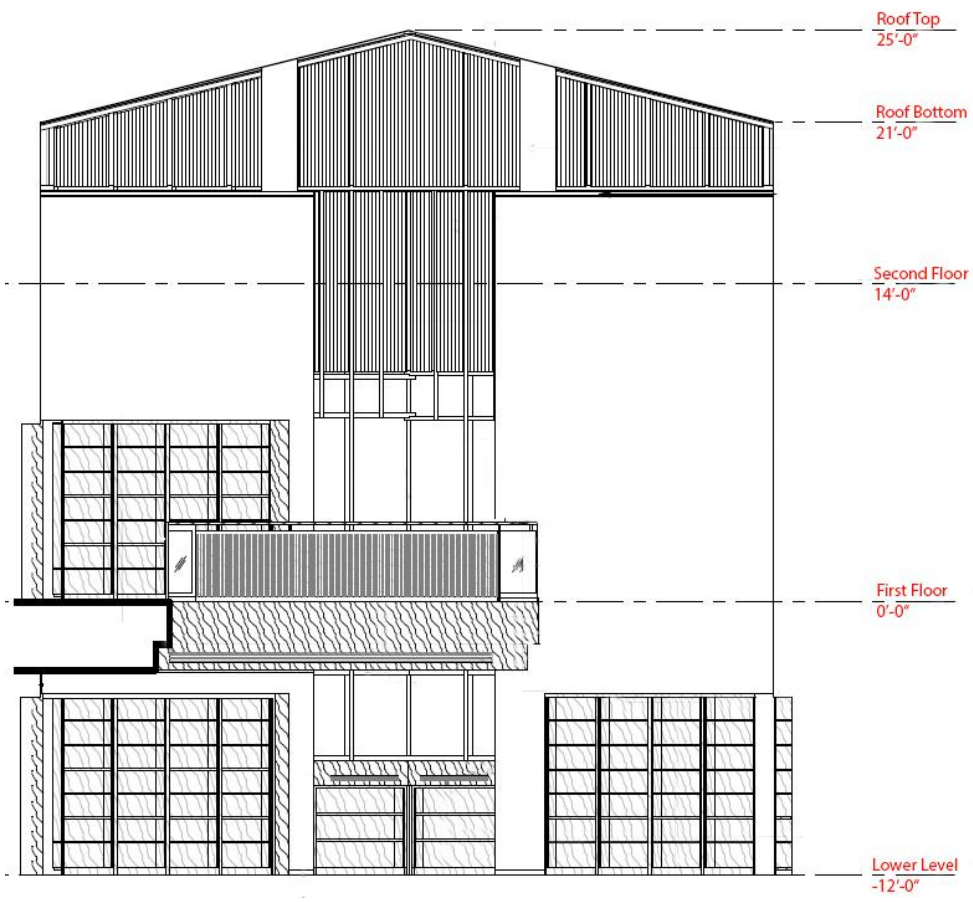


Figure 39 | Reference Reading Room - South Elevation

Finishes

The charts below describe the finishes and window types included in the Reference Reading Room. The white walls and ceiling will make the space feel bright and spacious while the glass types chosen will regulate the amount of sun in the room by varying transmittances based on the height location of the window. The lower transmittance windows are located higher in the space as shown in the elevation.

Floor			Wall		Ceiling	
Finish		Reflectance	Finish	Reflectance	Finish	Reflectance
Bentley Prince Street – Really late Night TV #400290 Under the Covers		assume 20%	Benjamin Moore – Color Preview #OC-122 Cotton Balls	assume 80%	Benjamin Moore – Color Preview #OC-122 Cotton Balls	assume 80%

Windows			
Type	**Glass Type**	**Transmittance**	**Manufacurer**
W33	IG-1, Insulating glass	58%	Cardinal Glass Industries, LOE3- 366
	IG-2, insulating glass with frit	assume 29%	Cardinal Glass Industries, LOE3- 366

Important Design Criteria

- Prove ample light for all tasks
- Control and utilize daylight
- Create an engaging space

Fixture Schedule

Lighting									
Type	**Description**	**Manufacturer**	**Lamp**			**Ballast**		**Voltage**	**Mounting**
			No.	**Type**	**Watts**	**No.**	**Type**		
D3	Recessed downlight	Kurt Versen	1	LED	27			277	Recessed
P1	Down-up pendant	Delta Light	2	F24T5	24	1	Electronic Dimming	277	Pendant
			4	F39T5	39	2	Electronic Dimming	277	
T1	Table mounted task lamp	Finelite	1	LED	7.4			277	Table Mount
L1	Linear wall slot	Color Kinetics	1	LED	13.8			277	Wall Slot

Lighting Plans

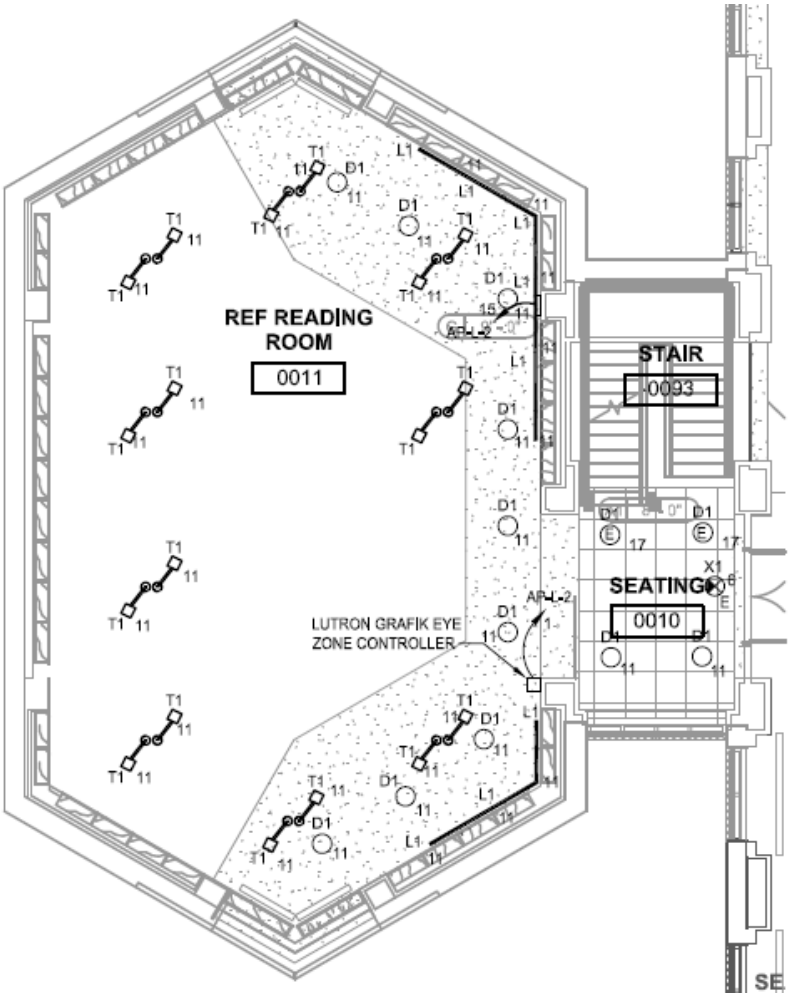


Figure 40 | Reference Reading Room - Lower Level Lighting Plan

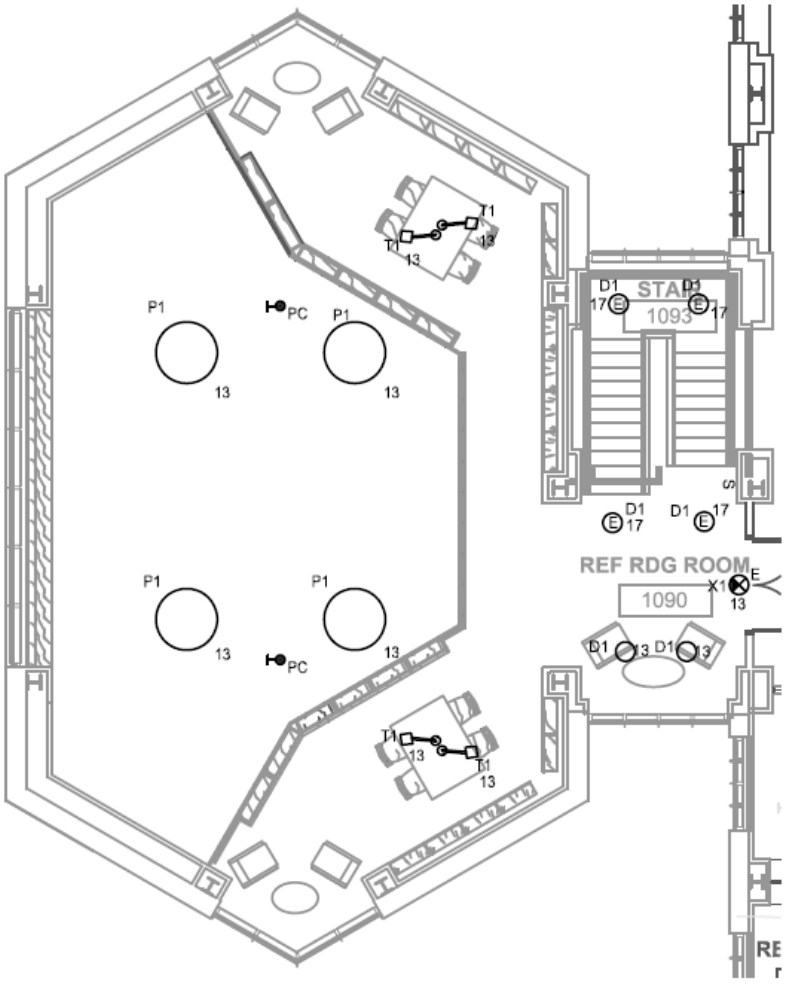


Figure 41 | Reference Reading Room - First Floor Lighting Plan

Light Loss Factors

The light sources used in the reference reading room include LEDs and fluorescent. All LEDs will have an LLF of 0.7. For the fluorescent sources, the LLF used is calculated below.

Light Loss Factors (P1 - 24W)	
LDD	0.95
-Clean Environment	
-Closed/Unventilated	
-Direct/Indirect	
-12 month cleaning cycle	
LLD	0.81
-Initial Lumens	2000
-Mean Lumens	1627
BF	1
Total LLF:	0.77

Light Loss Factors (P1 - 39W)	
LDD	0.95
-Clean Environment	
-Closed/Unventilated	
-Direct/Indirect	
-12 month cleaning cycle	
LLD	0.82
-Initial Lumens	3500
-Mean Lumens	2883
BF	1
Total LLF:	0.78

Illuminance Criteria

Illuminance levels should be sufficient for browsing through the stacks and provide enough task lighting for the reading areas. Illuminance recommendations taken from the Lighting Handbook, Volume 10 and the actual illuminance values are shown in the two tables below followed by calculations and renderings from AGI 32.

Illuminance Recommendations

Task	Illuminance (lux)	
	Horizontal	Vertical
Book Stacks		
-at Floor	200	
-1' 0" AFF		100
-2' 6" AFF	300	200
Reading Areas		
-Tables and Chairs Eh @2'" AFF; Ev @4'0" AFF	500	200

Actual Illuminance Values

Task	Illuminance (lux)	
	Horizontal	Vertical
Book Stacks		
-at Floor	259	
-1'-0" AFF		100
-2'-6" AFF	301	100
Reading Areas		
-Tables and Chairs Eh @2'-0" AFF; Ev @4-0" AFF	475	150

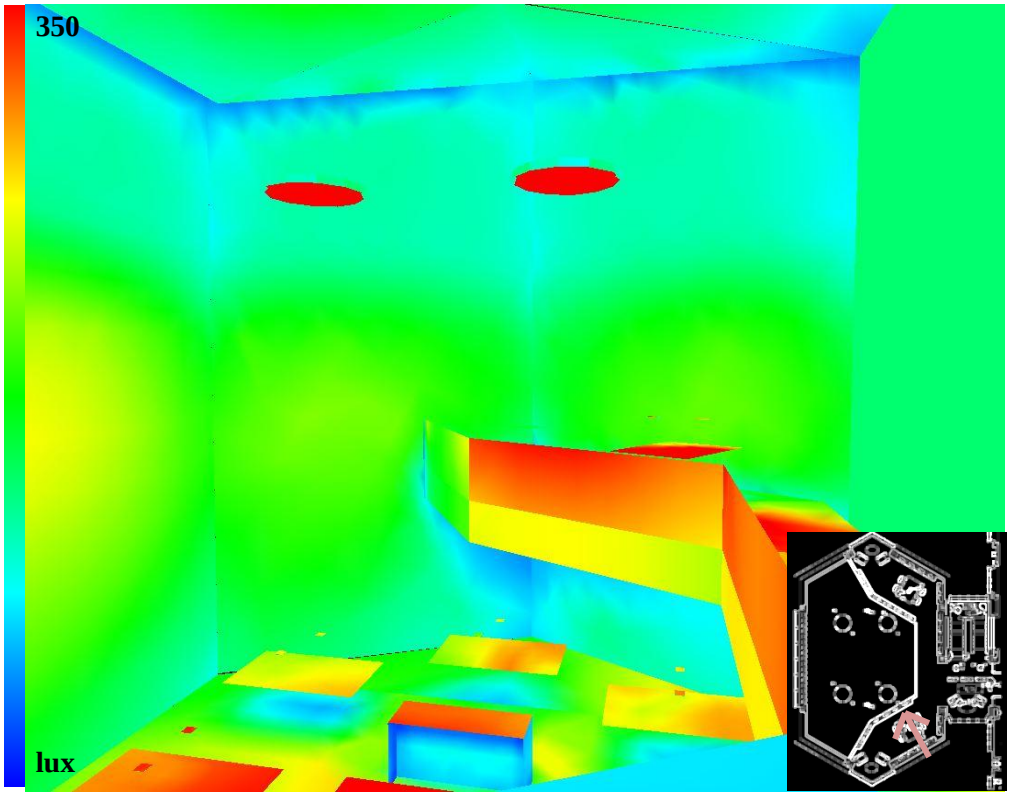


Figure 42 | Reference Reading Room - Pseudo color

Figure 43 | Reference Reading Room - Rendering

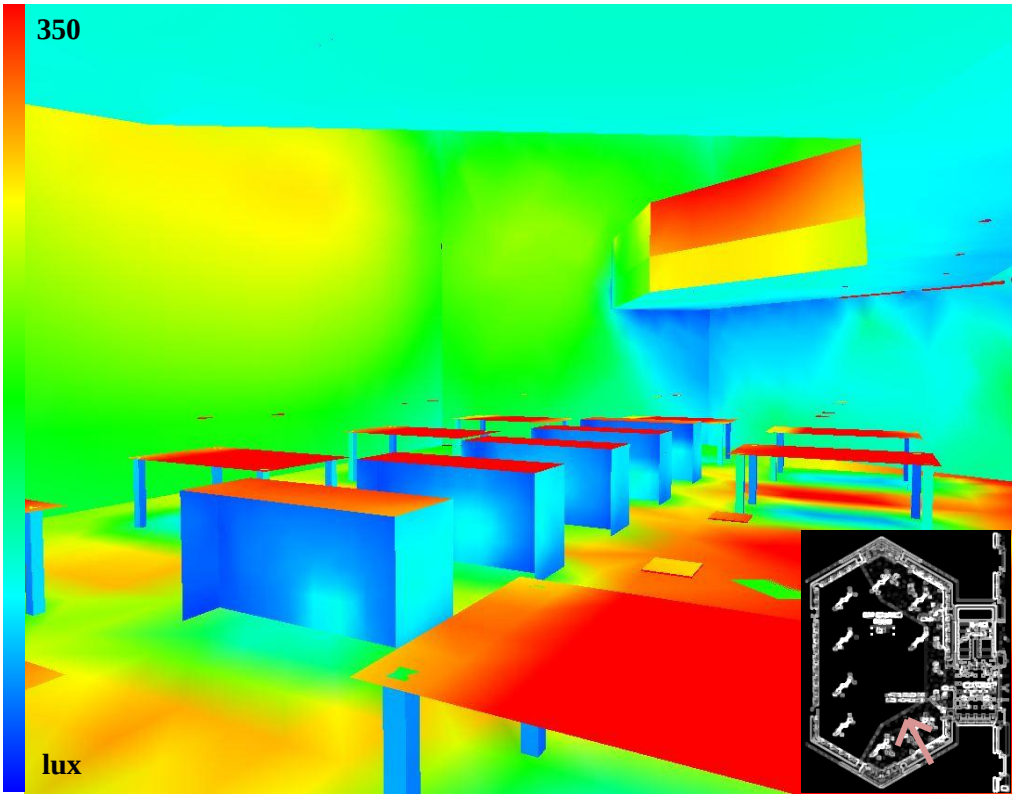


Figure 44 | Reference Reading Room - Pseudo color

Figure 45 | Reference Reading Room - Rendering

Controls

- *Radio Powr Savr Wireless Daylight Sensor* to switch off 2 24W lamps in P1 fixtures
- *Grafik Eye* for flexible control of lower level

Energy Criteria

The code requirements for power density are referenced from ASHRAE 90.1 2010.

Power Allowance	
Space Type	**LPD, W/ft2**
Library	
-Stacks	1.71

Actual Power Usage	
Space Type	**LPD, W/ft2**
Library	
-Stacks	1.58

Electrical Depth

The scope of the first electrical depth includes altering the lighting panels in response to the four spaces that were redesigned. The four spaces include the south façade and grounds, café, atrium and reference reading room. Adapting the existing electrical system to these changes includes recalculating loads and resizing panels.

The second electrical depth topic covers the background and design implementation of a dual bus system within a section of the building. The dual bus system provides power to the AV equipment within the seminar rooms on each floor and the LED lighting in the surrounding corridor. The DC power will be supplied by the existing photovoltaic panels on the roof of the addition.

Lighting Panel Alterations

All existing lighting panels that were affected by the new lighting have no significant change in load. Therefore, the lighting panels and their corresponding feeders do not need resized. All lighting panels and their corresponding voltage and main amp rating can be seen on the next page.

Lighting Panels		
Panel	**Voltage**	**Size (amps)**
LP-SITE	480/277V	70A
LP-L	480/277V	60A
LP-1	480/277V	60A
ELP-ES-1	480/277V	100A
LP-2	480/277V	60A
ELP-ES-3	480/277V	100A
LP-3	480/277V	60A
LP-4	480/277V	60A

The new panel schedules based on changes made by the new lighting can be seen below. Some new lighting fixtures from the corridor surrounding the atrium are not including in these schedules because of the new dual bus system design.

The new lighting fixtures on the emergency panels are areas that require lighting during a power failure for safety and egress purposes. The light levels at these locations are at least 10 lux as required in the International Building Code.

PANEL: LP-SITE
SECTION: 1 OF 1
LOCATION: ELEC RM 0047
LOWER LEVEL

VOLTAGE: 480/277V
PHASE & WIRE: 3PH 4W
MAIN (AMPS): 70A M.C.B.

[X] NORMAL [ ] EMERGENCY
[X] NEW [ ] EXISTING
KAIC RATING: 10
POLES: 12

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	STEP LIGHTING	0.36	0.40			0.041	SITE LIGHTING- MAIN ENTRANCE/DRIVE	20	1	2	
	3	20	1	SITE LIGHTING- EAST PARKING	1.8		3.30		1.5	SITE LIGHTING- EAST PARKING	20	1	4	
	5	20	1	SITE LIGHTING- NORTH PARKING	1.2			2.40	1.2	SITE LIGHTING- NORTH PARKING	20	1	6	
	7	20	1	SPARE		1.37			1.368	SITE LIGHT - SOUTH GROUNDS	20	1	8	
	9	20	1	SPARE			0.00			SPARE	20	1	10	
	11	20	1	SPARE				0.00		SPARE	20	1	12	
				LOAD SUMMARY PER PHASE (KVA)		1.77	3.30	2.40						
				TOTAL CONNECTED LOAD (KVA)			7.47							

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]
[ ]	RECESSED	FEED THRU LUGS	[ ]
[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]
[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]
[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]

ISSUE DATE: 9/21/2010
REVISION DATE:

PANEL: LP-L
SECTION: 1 OF 1
LOCATION: ELEC RM 0071
LOWER LEVEL

VOLTAGE: 480/277V
PHASE & WIRE: 3PH 4W
MAIN (AMPS): 60A M.C.B.

[X] NORMAL [ ] EMERGENCY
[X] NEW [ ] EXISTING
KAIC RATING: 22
POLES: 30

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
1	1	20	1	VAV BOX AVB-L-1 & AVB-L-3	2.50	4.27			1.77	LIGHTING - MEP 0043	20	1	2	
1	3	20	1	VAV BOX AVB-L-5 & AVB-L-6	3.65		6.39		2.74	LIGHTING - RM. 0002	20	1	4	*1*
1	5	20	1	LIGHTING - GEN. COLLECTION 0002	2.74			4.00	1.256	LIGHTING - CORRIDORS	20	1	6	
1	7	20	1	LIGHTING - GEN COLLECTION 0003	1.22	2.63			1.41	LIGHTING - GEN COLLECTION 0003	20	1	8	*1*
	9	20	1	LIGHTING - RMS. 0066, 0067, 001, 0060	0.91		1.22		0.31	LIGHTING - GEN COLLECTION CORRIDOR	20	1	10	
1	11	20	1	LIGHTING - READING RM. 0011	0.54			2.08	1.54	LIGHTING - GEN COLLECTION 0003	20	1	12	*1*
	13	20	1	SPARE		1.54			1.54	LIGHTING - GEN COLLECTION 0003	20	1	14	*1*
	15	20	1	SPARE			0.00			SPARE	20	1	16	
	17	20	1	SPARE				0.00		SPARE	20	1	18	
	19	20	1	SPARE		0.00				SPARE	20	1	20	
	21	20	1	SPARE			0.00			SPARE	20	1	22	
	23	20	1	SPARE				0.00		SPARE	20	1	24	
	25	20	1	SPARE		0.00				SPARE	20	1	26	
	27	20	1	SPARE			0.00			SPARE	20	1	28	
	29	20	1	SPARE				0.00		SPARE	20	1	30	
				LOAD SUMMARY PER PHASE (KVA)		8.44	7.61	6.07						
				TOTAL CONNECTED LOAD (KVA)			22.12							

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]
[ ]	RECESSED	FEED THRU LUGS	[ ]
[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]
[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]
[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]

ISSUE DATE: 9/21/2010
REVISION DATE: *RFP NO. 027, 10/11/2011*

NOTES:
1. PROVIDE 2#10 & #10G. SPLICE ONTO #10 CABLING FOR CONNECTIONS TO CIRCUIT BREAKERS AND WIRING DEVICES.

PANEL: LP-1
SECTION: 1 OF 1
LOCATION: ELEC RM 1071
1ST FLOOR

VOLTAGE: 480/277V
PHASE & WIRE: 3PH 4W
MAIN (AMPS): 60A M.C.B.

[X] NORMAL
[ ] EMERGENCY

[X] NEW
[ ] EXISTING
KAIC RATING: 18
POLES: 30

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	VAV BOXES AVB-1-3 & AVB-1-14	2.29	4.12			1.83	VAV BOX AVB-1-26	20	1	2	
	3	20	1	VAV BOXES AVB-1-15 & AVB-1-16	3.66		7.32		3.66	VAV BOXES AVB-1-9 & AVB-1-10	20	1	4	
	5	20	1	VAV BOXES AVB-1-24 & AVB-1-25	2.29			3.97	1.68	LIGHTING - RM. 1080	20	1	6	
	7	20	1	LIGHTING - RMS. 1013, 1014, 1004	0.52	1.65			1.13	LIGHTING - RMS. 1040-1043	20	1	8	
	9	20	1	LIGHTING - RMS. 1080, 1090	1.43		2.69		1.26	LIGHTING - RMS. 1046, 1050, 1069	20	1	10	
	11	20	1	LIGHTING - RM. 1064	0.55			1.70	1.15	LIGHTING - RMS. 1066, 1067, ATRIUM	20	1	12	
	13	20	1	LIGHTING - RM. 1090	0.90	1.40			0.50	JB - DONOR WALL - ENTRANCE 1003	20	1	14	
	15	20	1	LIGHTING - RMS. 1010, 1012, 1082	1.76		2.86		1.10	LIGHTING - RM. 1090	20	1	16	
	17	20	1	SPARE				0.00		SPARE	20	1	18	
	19	20	1	SPARE		0.00				SPARE	20	1	20	
	21	20	1	SPARE			0.00			SPARE	20	1	22	
	23	20	1	SPARE				0.00		SPARE	20	1	24	
	25	20	1	SPARE		0.00				SPARE	20	1	26	
	27	20	1	SPARE			0.00			SPARE	20	1	28	
	29	20	1	SPARE				0.00		SPARE	20	1	30	
				LOAD SUMMARY PER PHASE (KVA)		7.17	12.87	5.68						
				TOTAL CONNECTED LOAD (KVA)		25.71								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED [ ]	
	[ ]	RECESSED	FEED THRU LUGS [ ]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS) [ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL [ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE [ ]	

ISSUE DATE: 9/21/2010
REVISION DATE:

PANEL: ELP-ES-1
SECTION: 1 OF 1
LOCATION: ELEC RM 1071
1ST FLOOR

VOLTAGE: 480/277V
PHASE & WIRE: 3PH 4W
MAIN (AMPS): 100A, M.L.O.

[ ] NORMAL
[X] EMERGENCY

[X] NEW
[ ] EXISTING
KAIC RATING: 10
POLES: 24

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	LTG - RMS. 0002, 0003, 0047-0048	1.14	1.78			0.64	LTG - CORRIDORS	20	1	2	
	3	20	1	LTG - RM. 0003	0.70		1.94		1.24	LTG - MEP 0043	20	1	4	
	5	20	1	LTG. - RMS. 0021, 0066-67, 0071-72	0.68			0.75	0.07	EXIT SIGNS - LOWER LEVEL	20	1	6	
	7	20	1	LTG - COOLING TOWER 1078	0.49	0.62			0.13	LTG - CORR. 1064	20	1	8	
	9	20	1	LTG - 1004, 1080	0.44		0.74		0.30	LTG. - RMS. 1040, 1045, 1050	20	1	10	
	11	20	1	LTG. - RM. 1002 AND EXTERIOR	0.84			2.48	1.64	LTG - 1066-67, 1071-72, 1076	20	1	12	
	13	20	1	EXIT SIGNS - FIRST FLOOR	0.10	0.60			0.50	LTG - LOADING DOCK	20	1	14	
	15	20	1	LTG - STAIR #2, ACCESS SPACE	0.66		1.16		0.50	LTG - EXTERIOR ARCADE	20	1	16	
	17	20	1	LTG - STAIR #1, RM 0093	0.6			0.60		SPARE	20	1	18	
	19	20	1	SPARE		0.00				SPARE	20	1	20	
	21	20	1	SPARE			0.00			SPARE	20	1	22	
	23	20	1	SPARE				0.00		SPARE	20	1	24	
				LOAD SUMMARY PER PHASE (KVA)		3.01	3.84	3.83						
				TOTAL CONNECTED LOAD (KVA)		10.68								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED [ ]	
	[ ]	RECESSED	FEED THRU LUGS [ ]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS) [ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL [ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE [ ]	

ISSUE DATE: 9/21/2010
REVISION DATE: *RFP NO. 027, 10/11/2011*

PANEL: LP-2
SECTION: 1 OF 1
LOCATION: ELEC RM 2071
2ND FLOOR

VOLTAGE: 480/277V
PHASE & WIRE: 3PH 4W
MAIN (AMPS): 60A M.C.B.

[X] NORMAL
[ ] EMERGENCY

[X] NEW
[ ] EXISTING
KAIC RATING: 18
POLES: 24

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	VAV BOX AVB-2-8	0.46	1.19			0.728	LIGHTING - RMS. 2022, 2030, 2061	20	1	2	
	3	20	1	LIGHTING - GENERAL COLLECT. 2002	2.74		5.50		2.76	LIGHTING - RMS. 2050, 2058-2059	20	1	4	
	5	20	1	LIGHTING - CORRIDORS	0.754			2.89	2.14	LIGHTING - 2023-2026	20	1	6	
	7	20	1	LIGHTING - RMS. 2030, 2033-2035	2.22	2.22				SPARE	20	1	8	
	9	20	1	LIGHTING - RMS. 2060, 2066-2068	1.1		1.10			SPARE	20	1	10	
	11	20	1	SPARE				0.00		SPARE	20	1	12	
	13	20	1	SPARE		0.00				SPARE	20	1	14	
	15	20	1	SPARE			0.00			SPARE	20	1	16	
	17	20	1	SPARE				0.00		SPARE	20	1	18	
	19	20	1	SPARE		0.00				SPARE	20	1	20	
	21	20	1	SPARE			0.00			SPARE	20	1	22	
	23	20	1	SPARE				0.00		SPARE	20	1	24	
				LOAD SUMMARY PER PHASE (KVA)		3.41	6.60	2.89						
				TOTAL CONNECTED LOAD (KVA)		12.90								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED [ ]	
	[ ]	RECESSED	FEED THRU LUGS [ ]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS) [ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL [ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE [ ]	

ISSUE DATE: 9/21/2010 REVISION DATE:

PANEL: ELP-ES-3
SECTION: 1 OF 1
LOCATION: ELEC RM 3071
3RD FLOOR

VOLTAGE: 480/277V
PHASE & WIRE: 3PH 4W
MAIN (AMPS): 100A, M.L.O.

[ ] NORMAL
[X] EMERGENCY

[X] NEW
[ ] EXISTING
KAIC RATING: 10
POLES: 18

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	EMERG. LTG. - RMS. 2002, 2024, 2026	1.28	1.73			0.45	EMERG. LTG. - RMS. 2066-67, 2071-72	20	1	2	
	3	20	1	EMERG. LTG. - RMS. 2005, 2022, 2030	0.29		0.36		0.07	EXIT SIGNS - SECOND FLOOR	20	1	4	
	5	20	1	EMERG. LTG. - 2ND FLOOR CORR.	0.50			1.30	0.80	EMERG. LTG. - RM. 3002	20	1	6	
	7	20	1	EMERG. LTG. - RMS. 3030, 3095	0.91	1.97			1.06	EMERG. LTG. - MECH. 4060, BRIDGE 3006	20	1	8	
	9	20	1	EMERG. LTG. - RMS. 3028, 3066, 3067	0.62		0.64		0.02	EXIT SIGNS - FOURTH FLOOR	20	1	10	
	11	20	1	EXIT SIGNS - THIRD FLOOR	0.07			0.67	0.60	LTG - EXT., TOWER PENTHOUSE, ATTIC	20	1	12	
	13	20	1	SPARE		0.00				SPARE	20	1	14	
	15	20	1	SPARE			0.00			SPARE	20	1	16	
	17	20	1	SPARE				0.00		SPARE	20	1	18	
				LOAD SUMMARY PER PHASE (KVA)		3.70	1.00	1.97						
				TOTAL CONNECTED LOAD (KVA)		6.67								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED [ ]	
	[ ]	RECESSED	FEED THRU LUGS [ ]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS) [ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL [ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE [ ]	

ISSUE DATE: 9/21/2010 REVISION DATE:

PANEL: LP-3 | VOLTAGE: 480/277V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W
LOCATION: ELEC RM 3071 3RD FLOOR | MAIN (AMPS): 60A M.C.B. | KAIC RATING: 18 | POLES: 24

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	VAV BOX AVB-3-7	0.46	3.20			2.74	LIGHTING - GENERAL COLLECT. 3002	20	1	2	
	3	20	1	LIGHTING - GENERAL COLLECT. 3002	2.56		2.90		0.34	LIGHTING - RMS. 3021-3024, 3026	20	1	4	
	5	20	1	SPARE				0.70	0.7	LIGHTING - RMS. 3030, 3039, 3050	20	1	6	
	7	20	1	LIGHTING - CORRIDORS	0.94	4.56			3.62	LIGHTING - RMS. 3007-3015	20	1	8	
	9	20	1	LIGHTING - RMS. 3032-3038	1.96		3.23		1.27	LIGHTING - RMS. 3060, 3066-3068	20	1	10	
	11	20	1	LIGHTING - RMS. 3026-3028, 3095	1.27			1.27		SPARE	20	1	12	
	13	20	1	SPARE		0.00				SPARE	20	1	14	
	15	20	1	SPARE			0.00			SPARE	20	1	16	
	17	20	1	SPARE				0.00		SPARE	20	1	18	
	19	20	1	SPARE		0.00				SPARE	20	1	20	
	21	20	1	SPARE			0.00			SPARE	20	1	22	
	23	20	1	SPARE				0.00		SPARE	20	1	24	
				LOAD SUMMARY PER PHASE (KVA)		7.76	6.13	1.97						
				TOTAL CONNECTED LOAD (KVA)		15.86								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	
	RECESSED	FEED THRU LUGS	
X	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	
	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	
	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	

ISSUE DATE: 9/21/2010 REVISION DATE:

PANEL: LP-4 | VOLTAGE: 480/277V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W
LOCATION: 4TH FLOOR PENTHOUSE | MAIN (AMPS): 60A, M.C.B. | KAIC RATING: 14 | POLES: 12

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	VAV BOX AVB-4-1	1.83	1.83				SPARE	20	1	2	
	3	20	1	LIGHTING - MECH. 4060	2.24		2.24			SPARE	20	1	4	
	5	20	1	ATRIUM	0.696			0.70		SPARE	20	1	6	
	7	20	1	SPARE		0.00				SPARE	20	1	8	
	9	20	1	SPARE			0.00			SPARE	20	1	10	
	11	20	1	SPARE				0.00		SPARE	20	1	12	
				LOAD SUMMARY PER PHASE (KVA)		1.83	2.24	0.70						
				TOTAL CONNECTED LOAD (KVA)		4.77								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	
	RECESSED	FEED THRU LUGS	
X	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	
	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	
	ISOLATED GROUND BUS	INTEGRAL TVSS DEVICE	

ISSUE DATE: 9/21/2010 REVISION DATE:

AC/DC Dual Electrical Power

A dual bus AC/DC power system will be implemented to supply DC power to equipment that is naturally run on DC but converted to AC due to normal utility service power supply. When available, the existing photovoltaic system on the roof will supply DC power through the bus to the devices chosen. As a backup, AC power will be supplied to the bus which will be converted to DC to run the devices. This section highlights how this type of system works electrically, the equipment that will be run on this system, and the benefits of this system. Some aspects of this design are theoretical due to the current design of some electrical products.

Dual Bus System Concept

A dual bus system is used to supply DC power to devices that naturally run on DC current. These types of devices include electronic lighting, AV/IT devices, data and telecom centers, HVAC actuators, sensors and controls and security and safety devices. DC power can come from various sources including photovoltaic arrays, wind power, fuel cells or site generation. In the design of this dual bus system, the existing photovoltaic array will be used to supply power to the bus. In the event that there is not enough DC current coming from the PV array, normal AC power from the utility company will be used. The exact location of the panels that will supply backup AC power can be seen later in this report in the updated one line diagram.

DC power is distributed to the devices from the PV array, to the inverter then through the ceiling grid with tap off points to connect the devices to the grid. The backup AC power is connected to the DC bus then the inverter in order to step down the voltage from 208/120V AC to 24V DC. A simplified diagram of the distribution of this power can be seen in the image on the next page.

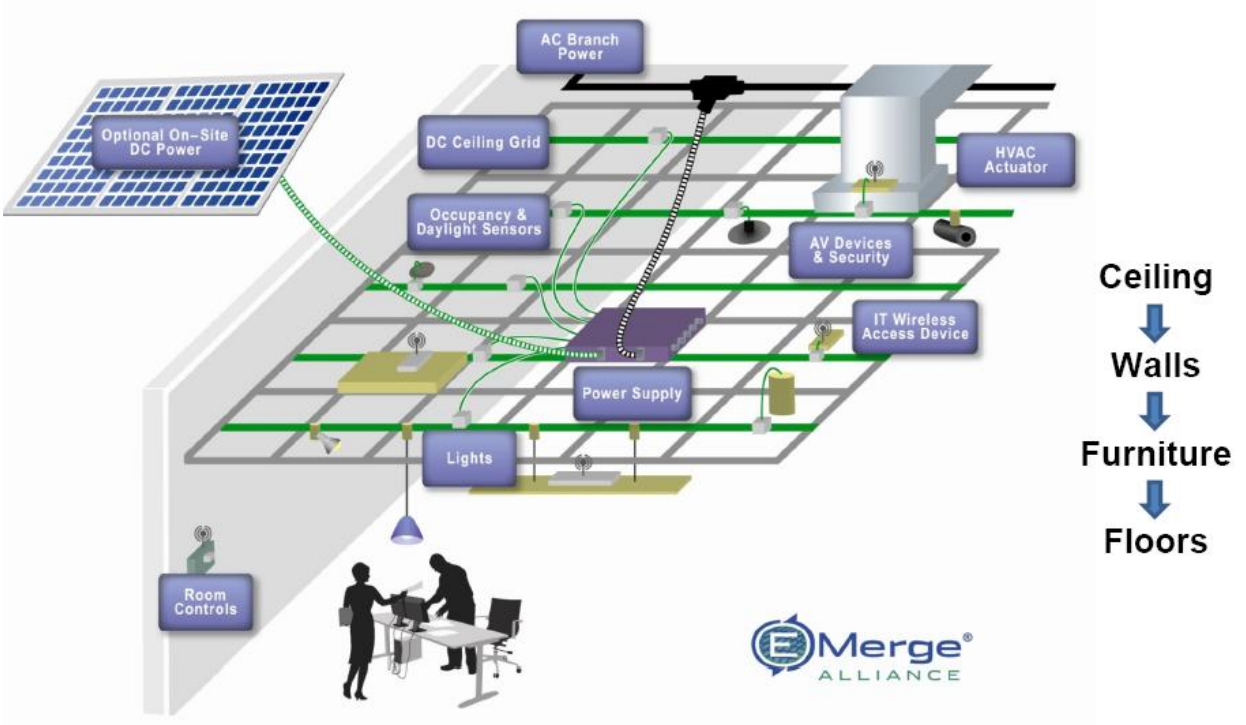


Figure 46 | DC Bus Example

DC Bus Application

Power generated from a PV array is typically sold to the utility company for credit, which is the case for the Princeton Theological Seminary Library. To make use of this power for the new DC bus system, the PV array distribution panel will be directly attached to the inverters within the rooms. The areas within the building that are going to be run on DC power include the seminar rooms and surrounding corridor area stacked on top of each other on the lower, first, second and third floors.

The AV devices to be run on DC within the seminar rooms differ slightly on each floor so each room is shown below. The new circuit information is included in these floor plans as well.

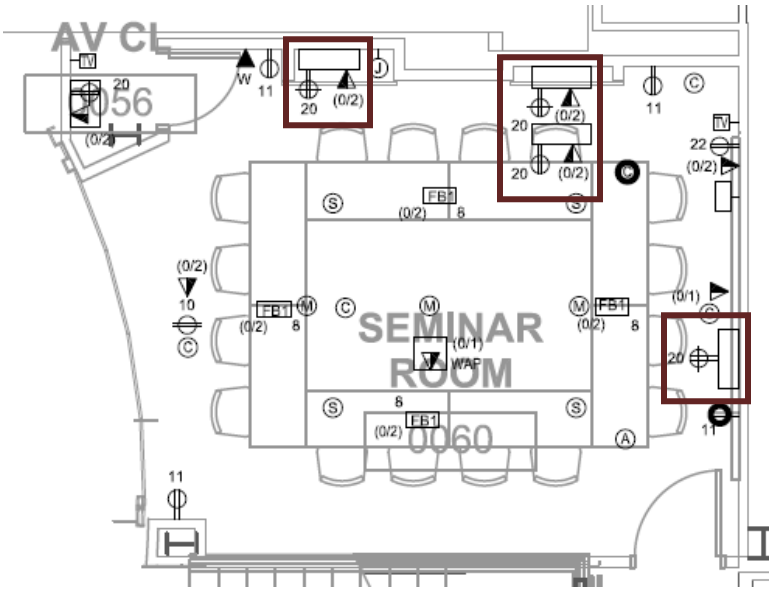


Figure 47 | Seminar Room - 0060

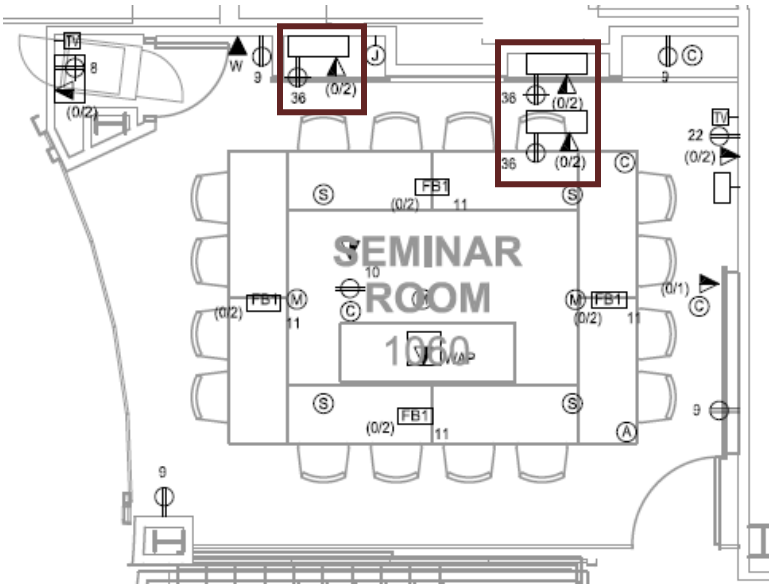


Figure 48 | Seminar Room 1060

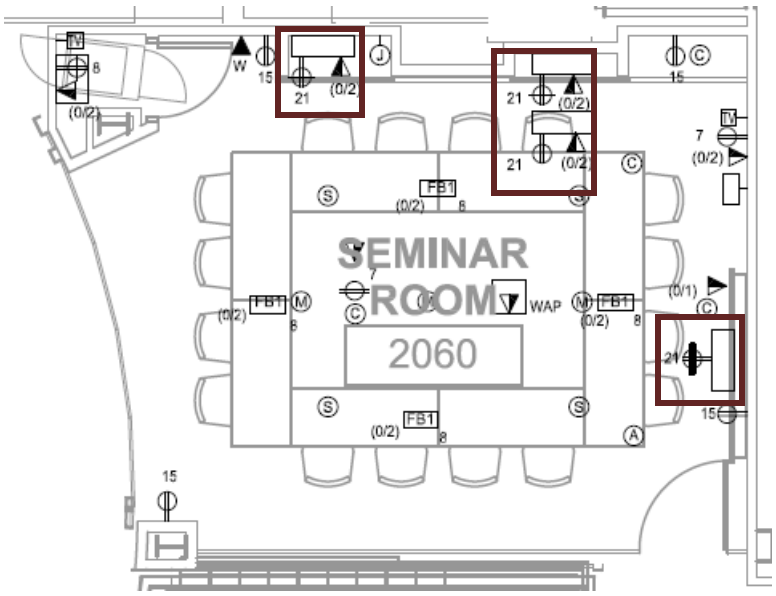


Figure 49 | Seminar Room 2060

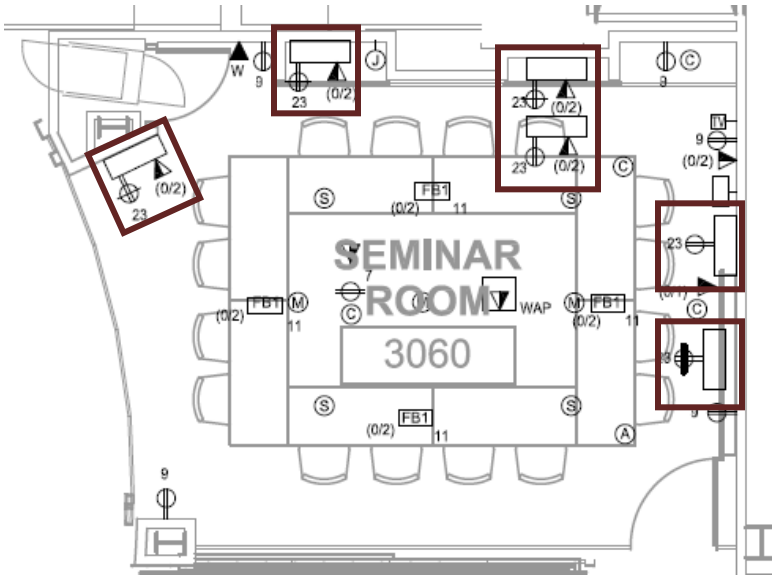


Figure 50 | Seminar Room - 3060

In the surrounding hallways, DC power will run the LED lighting as can be seen below. All emergency egress lighting in these areas will be run on normal AC power from the lighting panels.

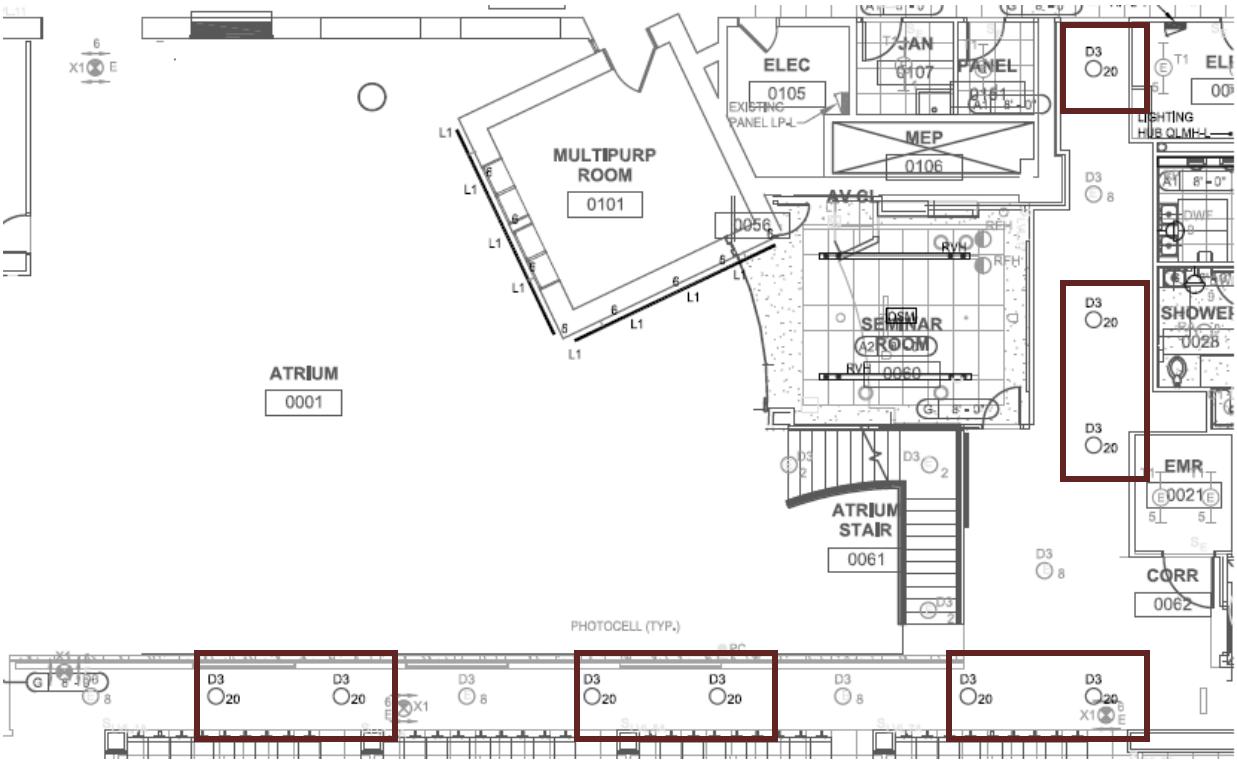


Figure 51 | Corridor - Lower Level

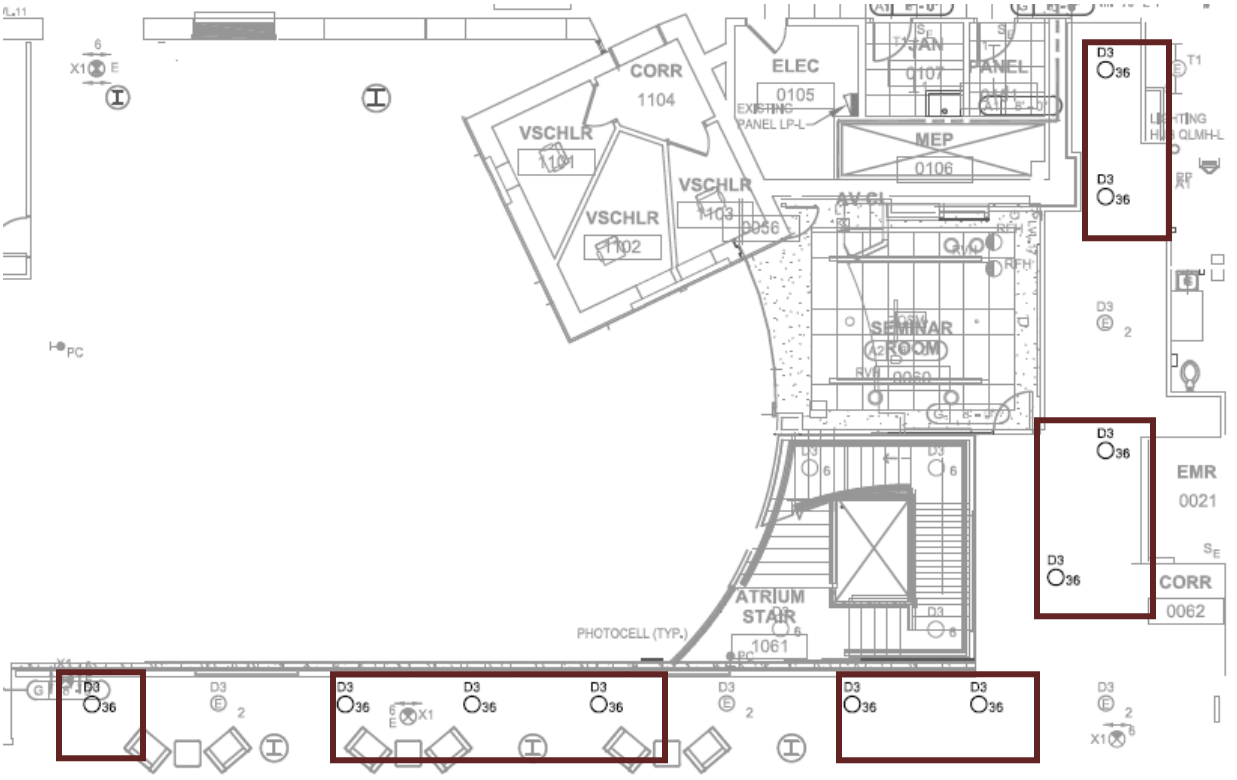


Figure 52 | Corridor - First Floor

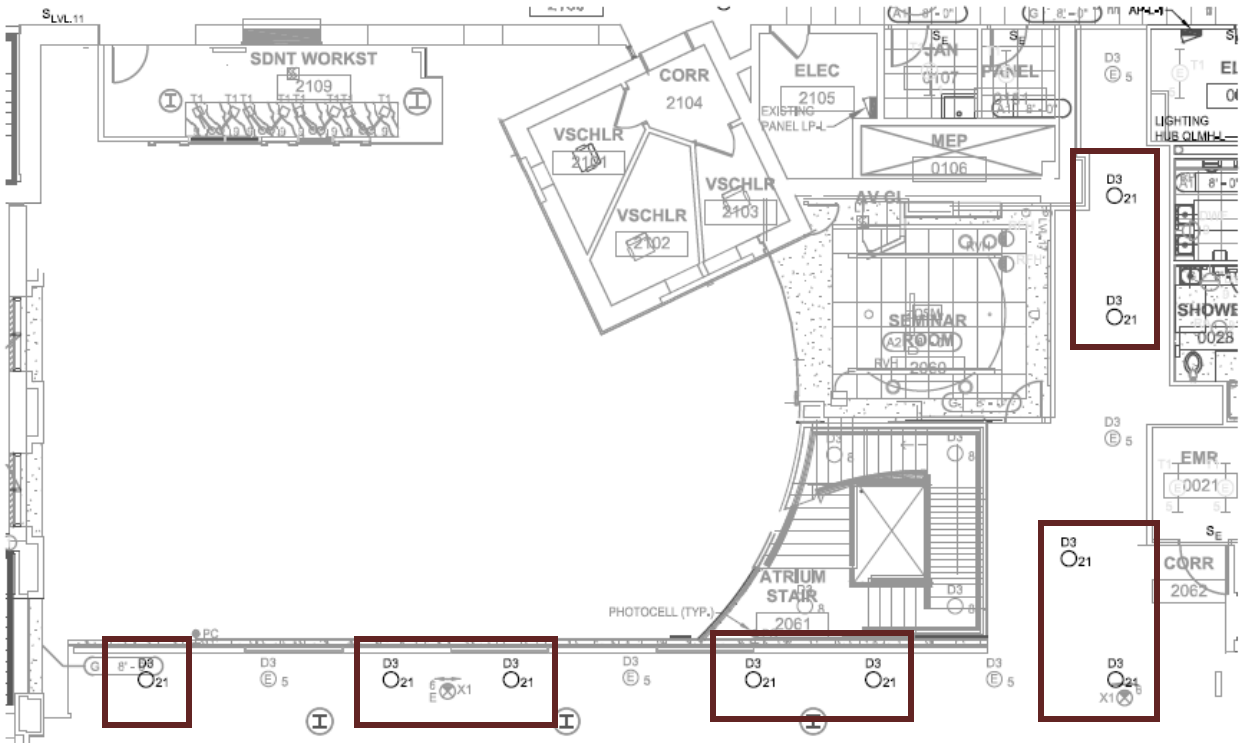


Figure 53 | Corridor - Second Floor

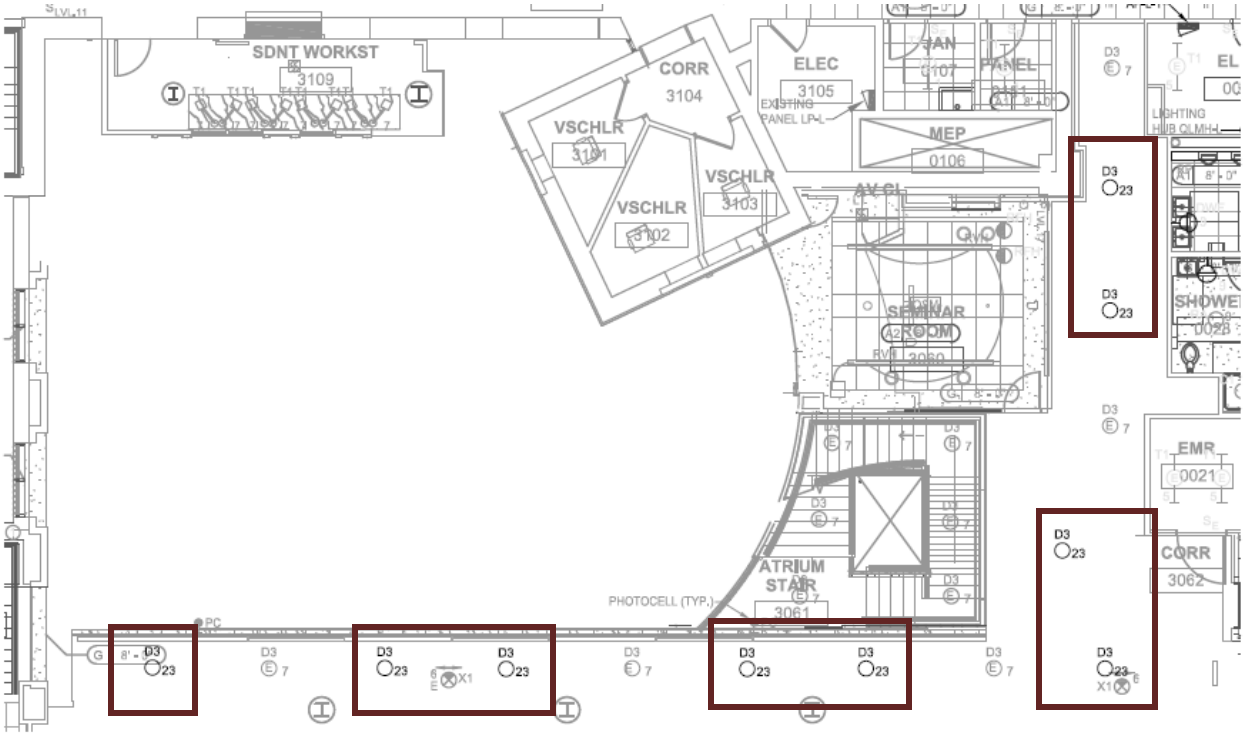


Figure 54 | Corridor - Third Floor

The power panels containing the existing circuitry for the AV equipment within the seminar rooms is shown below highlighted in red.

PANEL: AP-L-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W | AIC RATING: 10
LOCATION: ELEC RM 0071 LOWER LEVEL | MAIN (AMPS): 150A, M.C.B. | POLES: 42

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	REC. - ATRIUM 0001	0.36	1.98			1.62	FLOOR BOXES - ATRIUM 0001	20	1	2	
	3	20	1	REC. - ATRIUM 0001	0.72		1.92		1.20	A/V EQUIPMENT - SEMINAR 0060	20	1	4	
	5	20	1	REC. - MEP 0043	0.54			1.98	1.44	FLOOR BOXES - ATRIUM 0001	20	1	6	
	7	20	1	FLOOR BOXES - ATRIUM 0001	1.26	2.70			1.44	FLOOR BOXES - SEMINAR ROOM 0060	20	1	8	
	9	20	1	FLOOR BOXES - ATRIUM 0001	1.08		1.44		0.36	REC - TV AND CAMERA - SEMINAR 0060	20	1	10	
	11	20	1	REC. - SEMINAR ROOM 0060	0.72			2.16	1.44	FLOOR BOXES - ATRIUM 0001	20	1	12	
	13	20	1	REC. - MEN 0067, WOMEN 0066	1.26	1.76			0.50	PLUMBING ACTUATORS	20	1	14	
	15	20	1	REC. - CORRIDOR 0064, 0074	0.72		1.32		0.60	A/V EQUIPMENT - SEMINAR 0060	20	1	16	
	17	20	1	UNIT HEATER CUH-L4 - STAIR #1	0.26			1.44	1.18	FAN COIL UNIT FCU-L-1	20	1	18	
	19	20	1	JB - MOTOR OPERATED DAMPERS		0.72			0.72	EQUIPMENT ACCESS RACK - SEMINAR 0060	20	1	20	
	21	20	1	HOT WATER RECIRC. - HWRP-1	0.35		1.07		0.72	A/V EQUIPMENT - SEMINAR 0060	20	1	22	
	23	20	1	LIGHTING - SEMINAR RM. 0060	0.19			0.29	0.10	FIXTURE DPEH WINCH CONTROLLERS	20	1	24	
	25	20	1	TRANSFER FAN TF-L-1	0.90	0.90				SPARE	20	1	26	
	27	20	1	SPARE			0.00			SPARE	20	1	28	
	29	20	1	SPARE				0.00		SPARE	20	1	30	
	31	20	1	SPARE		0.00				SPARE	20	1	32	
	33	20	1	SPARE			0.00			SPARE	20	1	34	
	35	20	1	SPARE				0.00		SPARE	20	1	36	
	37	20	1	SPARE		10.06			10.06				38	SEE
	39	20	1	SPARE			9.32		9.32	PANEL AP-L-2	90	3	40	SLD
	41	20	1	SPARE				8.02	8.02				42	E0.1.2
				LOAD SUMMARY PER PHASE (KVA)		18.12	15.07	13.89						
				TOTAL CONNECTED LOAD (KVA)			47.08							

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

[X]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]
[ ]	RECESSED	FEED THRU LUGS	[X]
[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]
[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]
[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]

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PANEL: AP-1-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 2 | PHASE & WIRE: 3PH 4W | MAIN (AMPS): 250A, M.C.B. | KAIC RATING: 10
LOCATION: ELEC RM 1071 1ST FLOOR | POLES: 42

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	REC. - EXTERIOR	0.54	1.44			0.90	REC. - ROOMS 1066, 1067, 1068	20	1	2	
	3	20	1	REC. - COOLING TOWER 1078	0.90		1.40		0.50	PLUMBING ACTUATORS	20	1	4	
	5	20	1	REC. - LOADING 1069, RECYCLE 1070	0.54			1.26	0.72	REC. - CORRIDOR 1064, 1074	20	1	6	
	7	20	1	REC. - PROCESSING WORK AREA 1050	1.08	1.44			0.36	REC - TV AND CAMERA - SEMINAR 1060	20	1	8	
	9	20	1	REC. - SEMINAR ROOM 1060	0.72		2.16		1.44	REC. - PROCESSING WORK AREA 1050	20	1	10	
	11	20	1	FLOOR BOXES - SEMINAR ROOM 1060	1.44			2.88	1.44	REC. - PROCESSING WORK AREA 1050	20	1	12	
	13	20	1	A/V EQUIPMENT - SEMINAR ROOM 1060	1.26	2.46			1.20	PROJECTOR - SEMINAR 1060	20	1	14	
	15	20	1	REC . - PROCESSING WORK AREA 1050	1.44		1.74		0.30	INTERCOM SYSTEM - RM 1050	20	1	16	
	17	20	1	REC AND FLOOR BOXES - RM 1050	0.90			1.20	0.30	UNIT HEATER CUH-1-1 - RM. 1075	20	1	18	
	19	20	1	FAN COIL UNIT FCU-1-1	0.58	1.78			1.20	REC. - COPY 1045	20	1	20	
	21	20	1	REC. - RMS. 1044, 1045, 1046	1.08		2.28		1.20	REC. - COPY 1045	20	1	22	
	23	20	1	REC. - RMS. 1042, 1043, 1044	1.44			2.64	1.20	REC. - COPY 1045	20	1	24	
	25	20	1	REC. - CIRC. DESK 1040	1.44	2.52			1.08	REC. - LIBRARY CIRC. SUP. 1041	20	1	26	
	27	20	1	REC. - CIRC. DESK 1040	0.54		1.26		0.72	REC. - COPY 1045, DISPLAY 1149	20	1	28	
	29	20	1	REC. - RMS. 1040, 1041	0.72			1.92	1.20	REC. - COPY 1045	20	1	30	
	31	20	1	LIGHTING - SEMINAR RM 1060	0.19	0.99			0.80	REC - OFFICE 1042	20	1	32	
	33	20	1	LIGHTING - ATRIUM	0.28		1.00		0.72	EQUIP ACCESS RACK - SEMINAR 1060	20	1	34	
	35	20	1	REC AND FLOOR BOXES - RM 1050	0.90			1.26	0.36	A/V EQUIPMENT - SEMINAR 1060	20	1	36	
	37	20	1	TRANSFER FAN TF-1-1	0.90	0.90				SPARE	20	1	38	
	39	20	1	SPARE			0.00			SPARE	20	1	40	
	41	20	1	SPARE				0.00		SPARE	20	1	42	
				LOAD SUMMARY PER PHASE (KVA)		11.53	9.84	11.16						
				TOTAL CONNECTED LOAD (KVA)		32.53								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

[X]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]
[ ]	RECESSED	FEED THRU LUGS	[X]
[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]
[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]
[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]

ISSUE DATE: 9/21/2010 REVISION DATE: *RFP NO. 33 - A/V PROGRAM - 02/28/2012*

PANEL: AP-2-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W | AIC RATING: 10
LOCATION: ELEC RM 2071 2ND FLOOR | MAIN (AMPS): 150A, M.C.B. | POLES: 42

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	A/V EQUIPMENT - SEMINAR 2060	1.26	1.62			0.36	REC - CAMERA AND TV - RM 2060	20	1	2	
	3	20	1	REC. - BRIDGE 2006	1.44		2.34		0.90	REC. - RMS. 2066, 2067, 2068	20	1	4	
	5	20	1	FLOOR BOXES - WORKSTATION 2109	1.62			2.12	0.50	PLUMBING ACTUATORS	20	1	6	
	7	20	1	A/V EQUIPMENT - SEMINAR 2060	1.08	2.52			1.44	FLOOR BOXES - SEMINAR RM 2060	20	1	8	
	9	20	1	REC. - CORR. 2064, 2074	0.72		1.92		1.20	REC. - TECH WORK RM 2050	20	1	10	
	11	20	1	REC. - RMS. 2058, 2059	0.90			2.10	1.20	REC. - TECH WORK RM 2050	20	1	12	
	13	20	1	FLOOR BOXES - TECH WORK RM 2050	1.08	2.16			1.08	REC. - TECH WORK RM 2050	20	1	14	
	15	20	1	REC. - SEMINAR RM 2060	0.72		1.80		1.08	REC. - TECH WORK RM 2050	20	1	16	
	17	20	1	REC. - TECH WORK RM 2050	1.08			1.36	0.28	LIGHTING - ATRIUM	20	1	18	
	19	20	1	FAN COIL UNIT FCU-2-1	0.53	1.61			1.08	EQUIP ACCESS RACK - SEMINAR 2060	20	1	20	
	21	20	1	LIGHTING - SEMINAR 2060	0.19		0.91		0.72	A/V EQUIPMENT - SEMINAR 2060	20	1	22	
	23	20	1	TRANSFER FAN TF-2-1	0.90			0.90		SPARE	20	1	24	
	25	20	1	SPARE		0.00				SPARE	20	1	26	
	27	20	1	SPARE			0.00			SPARE	20	1	28	
	29	20	1	SPARE				0.00		SPARE	20	1	30	
	31	20	1	SPARE		0.00				SPARE	20	1	32	
	33	20	1	SPARE			0.00			SPARE	20	1	34	
	35	20	1	SPARE				0.00		SPARE	20	1	36	
	37	20	1	SPARE		14.34			14.34				38	SEE
	39	20	1	SPARE			10.81		10.81	PANEL AP-2-2	100	3	40	SLD
	41	20	1	SPARE				9.68	9.68				42	E0.1.2
				LOAD SUMMARY PER PHASE (KVA)		22.25	17.78	16.16						
				TOTAL CONNECTED LOAD (KVA)		56.19								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[X]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]	
	[ ]	RECESSED	FEED THRU LUGS	[X]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]	

ISSUE DATE: 9/21/2010 | REVISION DATE: *RFP NO. 33 - A/V PROGRAM - 02/28/2012*

PANEL: AP-3-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W | AIC RATING: 10
LOCATION: ELEC RM 3071 3RD FLOOR | MAIN (AMPS): 250A, M.C.B. | POLES: 30

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	FLOOR BOXES - WORKSTATION 3109	1.08	1.58			0.50	PLUMBING ACTUATORS	20	1	2	
	3	20	1	REC. - CORR 3064, 3074	0.90		1.43		0.53	FAN COIL UNIT FCU-3-1	20	1	4	
	5	20	1	REC. - RMS. 3066, 3067, 3068	0.90			1.99	1.09	LIGHTING - SEMINAR 3060	20	1	6	
	7	20	1	LIGHTING - ATRIUM	0.40	1.84			1.44	REC. - DIR. INTEL. PROP. 3046	20	1	8	
	9	20	1	REC. - LIBRARIAN 3057	1.08		2.28		1.20	PRINTER - ADMIN. AIDE 3053	20	1	10	
	11	20	1	PRINTER - RM. 3046	1.20			2.10	0.90	REC. - ADMIN AIDE 3053, STOR. 3049	20	1	12	
	13	20	1	REC. - DIR. EXT. REL - 3044	0.72	2.16			1.44	REC. - RMS. 3039, 3045	20	1	14	
	15	20	1	PRINTER - ASSOC. SYS. LIB. 3040	1.20		1.92		0.72	FLOOR BOX - SEMINAR 3060	20	1	16	
	17	20	1	REC. - ASSOC. SYS. LIB. 3040	1.44			2.16	0.72	FLOOR BOX - SEMINAR 3060	20	1	18	
	19	20	1	A/V EQUIPMENT - SEMINAR 3060	1.20	2.20			1.00	A/V EQUIPMENT - SEMINAR 3060	20	1	20	
	21	20	1	A/V EQUIPMENT - SEMINAR 3060	0.90		1.62		0.72	A/V EQUIPMENT - SEMINAR 3060	20	1	22	
	23	20	1	A/V EQUIPMENT - SEMINAR 3060	0.90			1.26	0.36	REC - TV AND CAMERA - SEMINAR 3060	20	1	24	
	25	20	1	TRANSFER FAN TF-3-1	0.90	22.35			21.45				26	SEE
	27	20	1	FIXTURE DPG3 WINCH MOTOR & CTRL	0.31		21.36		21.05	PANEL AP-3-2	150	3	28	SLD
	29	20	1	SPARE				16.88	16.88				30	E0.1.2
				LOAD SUMMARY PER PHASE (KVA)		30.13	28.61	24.39						
				TOTAL CONNECTED LOAD (KVA)		83.13								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]	
	[ ]	RECESSED	FEED THRU LUGS	[X]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]	

ISSUE DATE: 9/21/2010 | REVISION DATE: *RFP NO. 036 - 03/28/2012*

To run both the AV and lighting equipment on DC power from energy collected from the PV panels, the loads were combined onto one circuit per floor on the existing 208/120 V power panels. The circuits for the lighting and AV are shown in bold red in the panel schedules. A summary of the loading calculations from AV and lighting equipment can be seen below.

Lighting (D3) = 9 x (18 W)

Total load: LOWER (AP-L-1): RM. 0060 = 2.52 (A/V)

Hallway = 0.16 (LTG)

FIRST (AP-1-1): RM. 1060 = 1.62 (A/V)

Hallway = 0.16 (LTG)

SECOND (AP-2-1): RM. 2060 = 3.06 (A/V)

Hallway = 0.16 (LTG)

THIRD (AP-3-1): RM. 3060 = 4.72 (A/V)

Hallway = 0.16 (LTG)

TOTAL = 12.56 KVA

PANEL: AP-L-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W | AIC RATING: 10
LOCATION: ELEC RM 0071 LOWER LEVEL | MAIN (AMPS): 150A, M.C.B. | POLES: 42

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	REC. - ATRIUM 0001	0.36	1.98			1.62	FLOOR BOXES - ATRIUM 0001	20	1	2	
	3	20	1	REC. - ATRIUM 0001	0.72		2.16		1.44	FLOOR BOXES - ATRIUM 0001	20	1	4	
	5	20	1	REC. - MEP 0043	0.54			1.98	1.44	FLOOR BOXES - SEMINAR ROOM 0060	20	1	6	
	7	20	1	FLOOR BOXES - ATRIUM 0001	1.26	1.62			0.36	REC - TV AND CAMERA - SEMINAR 0060	20	1	8	
	9	20	1	FLOOR BOXES - ATRIUM 0001	1.08		2.52		1.44	FLOOR BOXES - ATRIUM 0001	20	1	10	
	11	20	1	REC. - SEMINAR ROOM 0060	0.72			1.22	0.50	PLUMBING ACTUATORS	20	1	12	
	13	20	1	REC. - MEN 0067, WOMEN 0066	1.26	2.44			1.18	FAN COIL UNIT FCU-L-1	20	1	14	
	15	20	1	REC. - CORRIDOR 0064, 0074	0.72		1.44		0.72	EQUIPMENT ACCESS RACK - SEMINAR 0060	20	1	16	
	17	20	1	UNIT HEATER CUH-L4 - STAIR #1	0.26			0.36	0.1	FIXTURE DPEH WINCH CONTROLLERS	20	1	18	
	19	20	1	JB - MOTOR OPERATED DAMPERS		2.68			2.682	LTG AND A/V - CORR, 0060	30	1	20	
	21	20	1	HOT WATER RECIRC. - HWRP-1	0.35		0.35			SPARE	20	1	22	
	23	20	1	LIGHTING - SEMINAR RM. 0060	0.19			0.19		SPARE	20	1	24	
	25	20	1	TRANSFER FAN TF-L-1	0.90	0.90				SPARE	20	1	26	
	27	20	1	SPARE			0.00			SPARE	20	1	28	
	29	20	1	SPARE				0.00		SPARE	20	1	30	
	31	20	1	SPARE		0.00				SPARE	20	1	32	
	33	20	1	SPARE			0.00			SPARE	20	1	34	
	35	20	1	SPARE				0.00		SPARE	20	1	36	
	37	20	1	SPARE		10.06			10.06				38	SEE
	39	20	1	SPARE			9.32		9.32	PANEL AP-L-2	90	3	40	SLD
	41	20	1	SPARE				8.02	8.02				42	E0.1.2
				LOAD SUMMARY PER PHASE (KVA)		19.68	15.79	11.77						
				TOTAL CONNECTED LOAD (KVA)		47.24								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

[X]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]
[ ]	RECESSED	FEED THRU LUGS	[X]
[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]
[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]
[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]

ISSUE DATE: 9/21/2010 REVISION DATE: *RFP NO. 036, 03/28/2012*

PANEL: AP-1-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 2 | PHASE & WIRE: 3PH 4W | KAIC RATING: 10
LOCATION: ELEC RM 1071 1ST FLOOR | MAIN (AMPS): 250A, M.C.B. | POLES: 42

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	REC. - EXTERIOR	0.54	1.44			0.90	REC. - ROOMS 1066, 1067, 1068	20	1	2	
	3	20	1	REC. - COOLING TOWER 1078	0.90		1.40		0.50	PLUMBING ACTUATORS	20	1	4	
	5	20	1	REC. - LOADING 1069, RECYCLE 1070	0.54			1.26	0.72	REC. - CORRIDOR 1064, 1074	20	1	6	
	7	20	1	REC. - PROCESSING WORK AREA 1050	1.08	1.44			0.36	REC - TV AND CAMERA - SEMINAR 1060	20	1	8	
	9	20	1	REC. - SEMINAR ROOM 1060	0.72		2.16		1.44	REC. - PROCESSING WORK AREA 1050	20	1	10	
	11	20	1	FLOOR BOXES - SEMINAR ROOM 1060	1.44			2.88	1.44	REC. - PROCESSING WORK AREA 1050	20	1	12	
	13	20	1	TRANSFER FAN TF-1-1	0.90	2.10			1.20	PROJECTOR - SEMINAR 1060	20	1	14	
	15	20	1	REC . - PROCESSING WORK AREA 1050	1.44		1.74		0.30	INTERCOM SYSTEM - RM 1050	20	1	16	
	17	20	1	REC AND FLOOR BOXES - RM 1050	0.90			1.20	0.30	UNIT HEATER CUH-1-1 - RM. 1075	20	1	18	
	19	20	1	FAN COIL UNIT FCU-1-1	0.58	1.78			1.20	REC. - COPY 1045	20	1	20	
	21	20	1	REC. - RMS. 1044, 1045, 1046	1.08		2.28		1.20	REC. - COPY 1045	20	1	22	
	23	20	1	REC. - RMS. 1042, 1043, 1044	1.44			2.64	1.20	REC. - COPY 1045	20	1	24	
	25	20	1	REC. - CIRC. DESK 1040	1.44	2.52			1.08	REC. - LIBRARY CIRC. SUP. 1041	20	1	26	
	27	20	1	REC. - CIRC. DESK 1040	0.54		1.26		0.72	REC. - COPY 1045, DISPLAY 1149	20	1	28	
	29	20	1	REC. - RMS. 1040, 1041	0.72			1.92	1.20	REC. - COPY 1045	20	1	30	
	31	20	1	LIGHTING - SEMINAR RM 1060	0.19	0.99			0.80	REC - OFFICE 1042	20	1	32	
	33	20	1	LIGHTING - ATRIUM	0.28		1.00		0.72	EQUIP ACCESS RACK - SEMINAR 1060	20	1	34	
	35	20	1	REC AND FLOOR BOXES - RM 1050	0.90			2.68	1.78	LTG AND A/V - RM. 1062, 1060	20	1	36	
	37	20	1	SPARE		0.00				SPARE	20	1	38	
	39	20	1	SPARE			0.00			SPARE	20	1	40	
	41	20	1	SPARE				0.00		SPARE	20	1	42	
				LOAD SUMMARY PER PHASE (KVA)		10.27	9.84	12.58						
				TOTAL CONNECTED LOAD (KVA)		32.69								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

[X]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED	[ ]
[ ]	RECESSED	FEED THRU LUGS	[X]
[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS)	[ ]
[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL	[ ]
[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE	[ ]

ISSUE DATE: 9/21/2010 | REVISION DATE: *RFP NO. 33 - A/V PROGRAM - 02/28/2012*

PANEL: AP-2-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W | AIC RATING: 10
LOCATION: ELEC RM 2071 2ND FLOOR | MAIN (AMPS): 150A, M.C.B. | POLES: 42

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	REC. - BRIDGE 2006	1.44	1.80			0.36	REC - CAMERA AND TV - RM 2060	20	1	2	
	3	20	1	FLOOR BOXES - WORKSTATION 2109	1.62		2.52		0.90	REC. - RMS. 2066, 2067, 2068	20	1	4	
	5	20	1	REC. - CORR. 2064, 2074	0.72			1.22	0.50	PLUMBING ACTUATORS	20	1	6	
	7	20	1	REC. - RMS. 2058, 2059	0.90	2.34			1.44	FLOOR BOXES - SEMINAR RM 2060	20	1	8	
	9	20	1	FLOOR BOXES - TECH WORK RM 2050	1.08		2.28		1.20	REC. - TECH WORK RM 2050	20	1	10	
	11	20	1	REC. - SEMINAR RM 2060	0.72			1.92	1.20	REC. - TECH WORK RM 2050	20	1	12	
	13	20	1	REC. - TECH WORK RM 2050	1.08	2.16			1.08	REC. - TECH WORK RM 2050	20	1	14	
	15	20	1	FAN COIL UNIT FCU-2-1	0.53		1.61		1.08	REC. - TECH WORK RM 2050	20	1	16	
	17	20	1	LIGHTING - SEMINAR 2060	0.19			0.47	0.28	LIGHTING - ATRIUM	20	1	18	
	19	20	1	TRANSFER FAN TF-2-1	0.90	1.98			1.08	EQUIP ACCESS RACK - SEMINAR 2060	20	1	20	
	21	30	1	LTG AND A/V - CORR 2005, 2060	3.22		3.22			SPARE	20	1	22	
	23	20	1	SPARE				0.00		SPARE	20	1	24	
	25	20	1	SPARE		0.00				SPARE	20	1	26	
	27	20	1	SPARE			0.00			SPARE	20	1	28	
	29	20	1	SPARE				0.00		SPARE	20	1	30	
	31	20	1	SPARE		0.00				SPARE	20	1	32	
	33	20	1	SPARE			0.00			SPARE	20	1	34	
	35	20	1	SPARE				0.00		SPARE	20	1	36	
	37	20	1	SPARE		14.34			14.34				38	SEE
	39	20	1	SPARE			10.81		10.81	PANEL AP-2-2	100	3	40	SLD
	41	20	1	SPARE				9.68	9.68				42	E0.1.2
				LOAD SUMMARY PER PHASE (KVA)		22.62	20.44	13.29						
				TOTAL CONNECTED LOAD (KVA)		56.35								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[X]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED [ ]	
	[ ]	RECESSED	FEED THRU LUGS [X]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS) [ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL [ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE [ ]	

ISSUE DATE: 9/21/2010 | REVISION DATE: *RFP NO. 33 - A/V PROGRAM - 02/28/2012*

PANEL: AP-3-1 | VOLTAGE: 208/120V | [X] NORMAL [ ] EMERGENCY | [X] NEW [ ] EXISTING
SECTION: 1 OF 1 | PHASE & WIRE: 3PH 4W | AIC RATING: 10
LOCATION: ELEC RM 3071 3RD FLOOR | MAIN (AMPS): 350A, M.C.B. | POLES: 30

NOTES	CKT NO.	C.B. A	C.B. P	DESCRIPTION	LOAD (KVA)	A	B	C	LOAD (KVA)	DESCRIPTION	C.B. A	C.B. P	CKT NO.	NOTES
	1	20	1	FLOOR BOXES - WORKSTATION 3109	1.08	1.58			0.50	PLUMBING ACTUATORS	20	1	2	
	3	20	1	REC. - CORR 3064, 3074	0.90		1.43		0.53	FAN COIL UNIT FCU-3-1	20	1	4	
	5	20	1	REC. - RMS. 3066, 3067, 3068	0.90			1.99	1.09	LIGHTING - SEMINAR 3060	20	1	6	
	7	20	1	LIGHTING - ATRIUM	0.40	1.84			1.44	REC. - DIR. INTEL. PROP. 3046	20	1	8	
	9	20	1	REC. - LIBRARIAN 3057	1.08		2.28		1.20	PRINTER - ADMIN. AIDE 3053	20	1	10	
	11	20	1	PRINTER - RM. 3046	1.20			2.10	0.90	REC. - ADMIN AIDE 3053, STOR. 3049	20	1	12	
	13	20	1	REC. - DIR. EXT. REL - 3044	0.72	2.16			1.44	REC. - RMS. 3039, 3045	20	1	14	
	15	20	1	PRINTER - ASSOC. SYS. LIB. 3040	1.20		1.92		0.72	FLOOR BOX - SEMINAR 3060	20	1	16	
	17	20	1	REC. - ASSOC. SYS. LIB. 3040	1.44			2.16	0.72	FLOOR BOX - SEMINAR 3060	20	1	18	
	19	20	1	TRANSFER FAN TF-3-1	0.90	1.26			0.36	REC - TV AND CAMERA - SEMINAR 3060	20	1	20	
	21	20	1	FIXTURE DPG3 WINCH MOTOR & CTRL	0.31		21.76		21.45			1	22	
	23	50	1	LTG AND A/V - CORR 3005, 3060	4.88			25.92	21.04	PANEL AP-3-2	150	1	24	
	25	20	1	SPARE		16.88			16.88				26	SEE
	27	20	1	SPARE			21.05		21.05	SPARE	20	3	28	SLD
	29	20	1	SPARE				16.88	16.88	SPARE	20		30	E0.1.2
				LOAD SUMMARY PER PHASE (KVA)		23.72	48.44	49.05						
				TOTAL CONNECTED LOAD (KVA)		121.21								

OPTIONS AND ACCESSORIES - (X) INDICATES SELECTION

	[ ]	MULTIPLE SECTION PANEL	CONTACTOR CONTROLLED [ ]	
	[ ]	RECESSED	FEED THRU LUGS [X]	
	[X]	SURFACE	SUB FEED MAIN LUGS (DOUBLE LUGS) [ ]	
	[ ]	200% RATED NEUTRAL	CONTROLLABLE CIRCUIT BREAKER PANEL [ ]	
	[ ]	ISOLATED GROUND BUS	INTEGRAL TUSS DEVICE [ ]	

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Each circuit called out in red above is run to the corresponding DC bus on each floor. An excerpt from the one line diagram Drawing E0.1.2 containing these appliance panels is shown below followed by the one line diagram from Drawing EPV.3 containing the PV panel wiring diagram. The completed one line diagram containing information regarding the DC Bus System can be found in Appendix II.

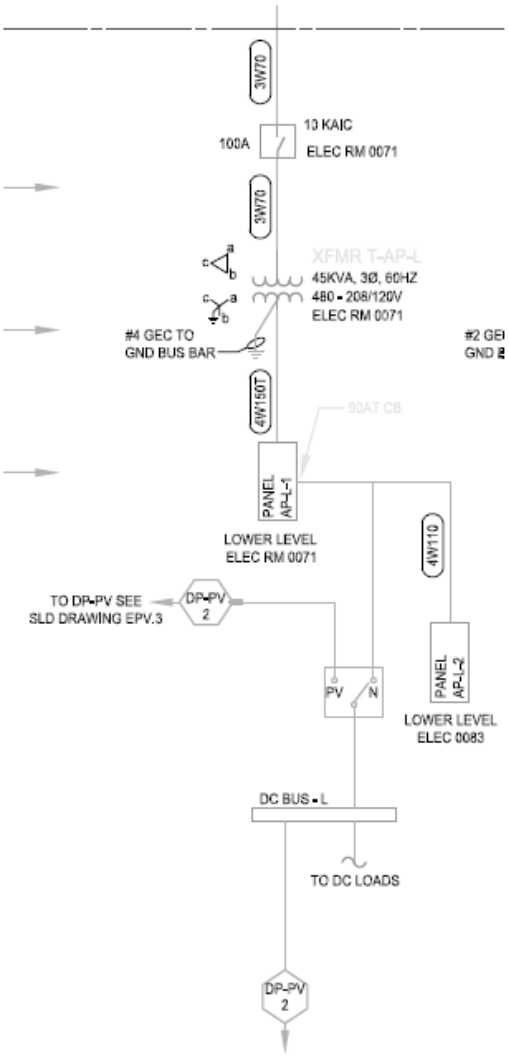

Figure 55 | One Line Diagram Excerpt - Drawing E0.1.2

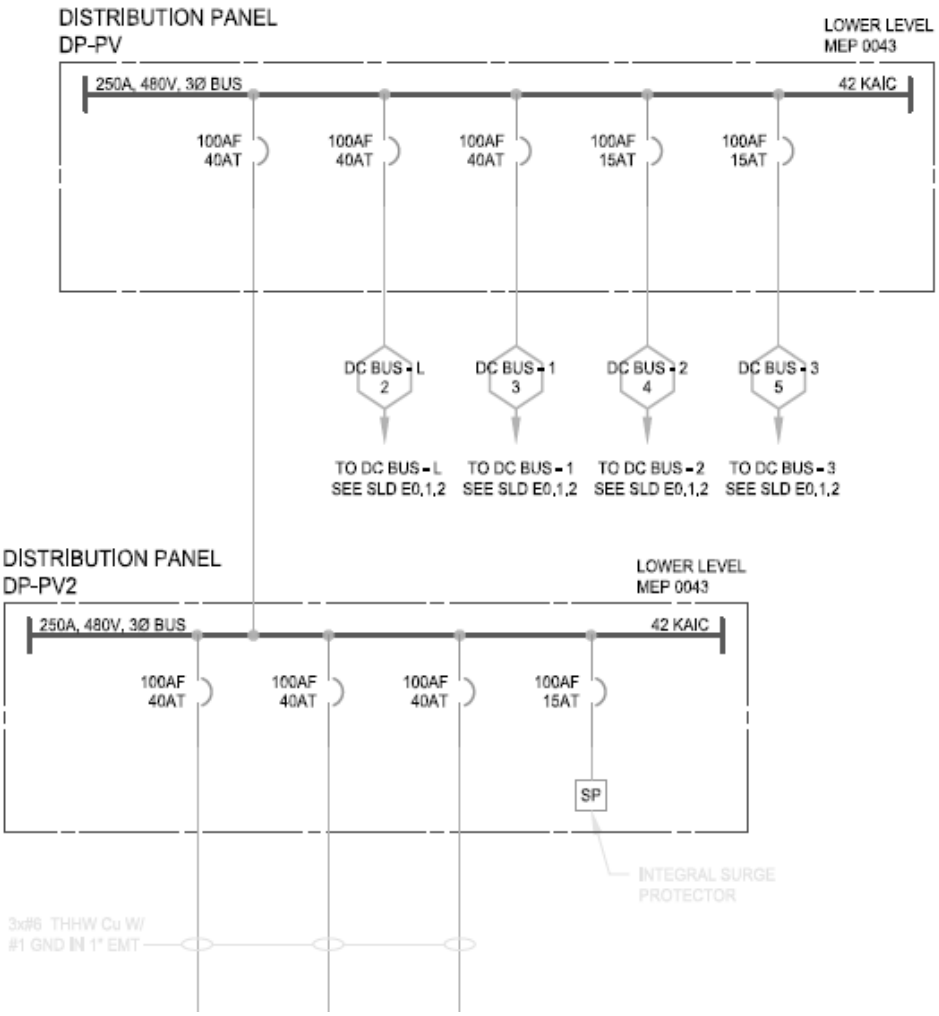

Figure 56 | One Line Diagram Excerpt – Drawing EPV.3

The location of the electrical rooms where the appliance panels are located is the same distance from the corresponding DC bus on each floor. The DC bus will run parallel to the eastern wall of the seminar room between the seminar room and corridor in order to run power to both ceiling grids. The location of the electrical room and the DC bus can be seen below.

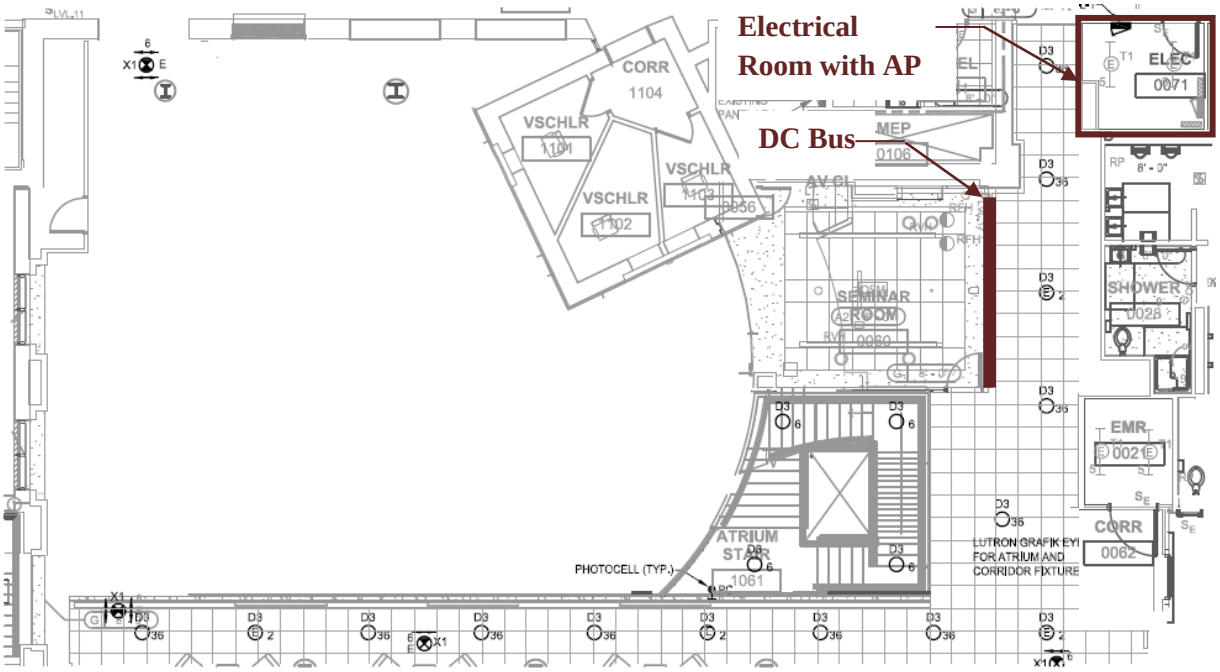

Figure 57 | Atrium – First Floor DC Bus location

Benefits of Using this System

Including this type of system within the building supplies many benefits to the electrical distribution system. By using the output from the PV panels in the building instead of selling the power generated back the utility company, there is opportunity to save time, energy and money.

Benefits:

- Minimize energy losses from individual inverters
- Less wire and conduit
- Less installation time than standard electrical wiring
- Changes to system within room will not require an electrician
- Safer installation and use due to lower voltage
- Less conduit and converters
- Cheaper fixtures
- Flexible layout

Drawbacks:

- Voltage drop issues
- Additional transfer switches needed

Structural Breadth: Atrium

The structural breadth is based on the changes made from the architectural breadth. By creating additional floor space in the center of the building around the atrium, existing members need to be resized and new members added in order to adapt the structure on each floor to the additional load.

Existing Structure

The existing structural system for the Princeton Theological Seminary Library uses concrete support below grade and steel frame construction for all floors above grade. The floor construction is comprised of steel wide flange beams supporting concrete slab on metal deck. Typical member spacing in the bridges to be removed in the atrium are 6.5 ft with typical members 7.75 ft in length. A similar pattern of design is used in the structural design of the new hallways.

The existing structural floor plan for the first floor can be seen below. In this area of the building, the area affected by the architectural changes have the same structural layout on each floor; the first, second and third floors.

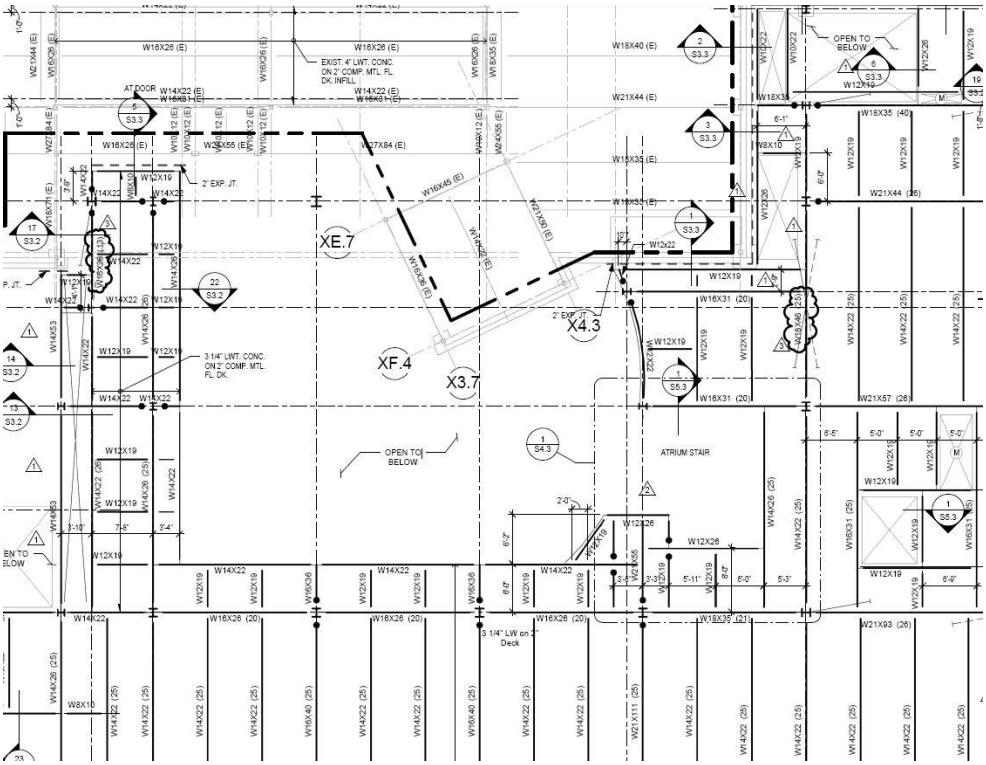

Figure 58 | First Floor Structural Plan – Existing

Structural Changes

The process of resizing the beams, girders and columns was broken down into several steps that will be distinguished within this section: *Determine Existing Decking*, *Loading Characteristics*, and *Beam, Girder, and Column Resizing*.

The structural redesign can be seen in the plan below. The color coded members in the new plan represent either resized existing members or new members. Red highlights the resized members and blue highlights the resized columns.

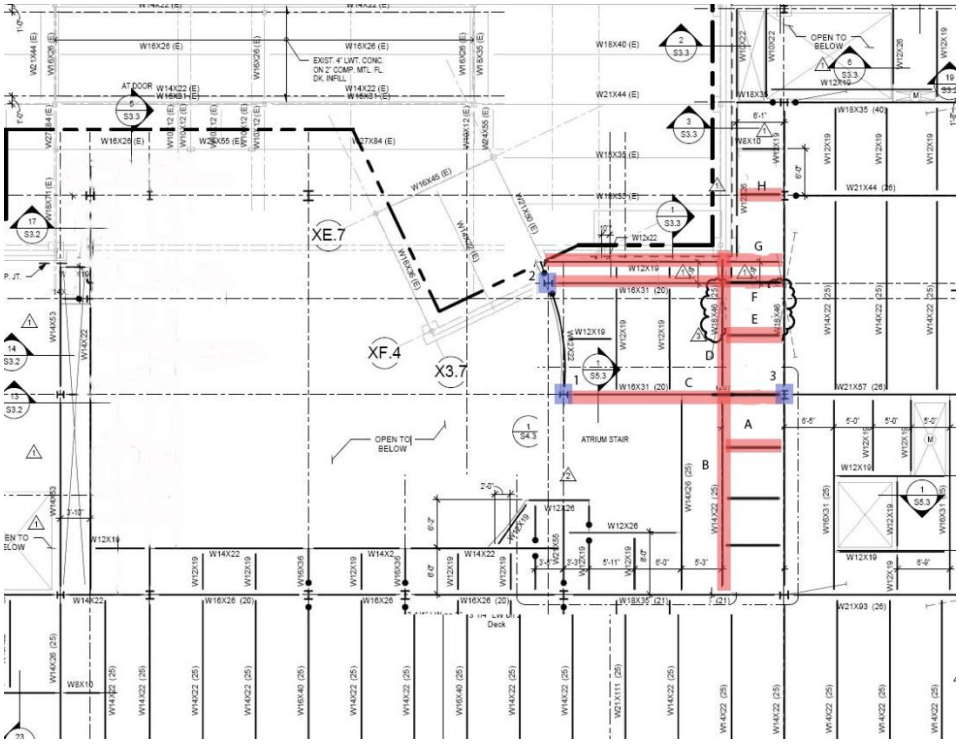

Figure 59 | First Floor Structural Floor Plan - New

Determine Existing Decking

Decking information was extracted from the Princeton Theological Seminary Library drawing set. The decking indicated is 3-1/4" lightweight concrete slab on 2", 20 gauge galvanized composite metal floor deck with a maximum span of 9'-0". The decking load of 42psf was found in the Vulcraft Decking Catalogue Section 2VLI lightweight concrete.

Loading Characteristics

Multiple room types contribute to the loads on the members to be resized. The occupancy type changes the loading conditions and needs to be taken into account for accurate calculations. These can be found in Table 4-1 Minimum Uniformly Distributed Live Loads and Minimum Concentrated Live. The following room types contribute to the loading on the resized members and columns:

Live Loads	
Occupancy or Type	**Uniform psf**
Restrooms	50
Library	
-First Floor Corridor	100
-Corridors above First Floor	80
-Reading Rooms	60

Beam, Girder and Column Resizing

The layout for the new structure of the corridor was chosen with the intention to mimic the structural layout of the bridges that were removed. The existing structure for the multi-purpose room and the stairs were shifted and remained the same while other members were added or resized. Seven members were added, three members were resized and three columns were resized. The following equations were used to determine the moments for each member:

$$LL_{reduction} = = 0.25 + \frac{15}{\sqrt{K_{LL} * A_T}}$$

$w_u = 1.2D + 1.6L + 0.5S$

Column point loads = $(1.2D + 1.6L + 0.5S) * K_{LL}A_T/1000$

Once the moment on the member was determined, the member sizes were chosen from Table 3-2 W-Shapes Selection by Z_x. Due to the loading change from the first floor to all other floors in library corridors, each member was sized twice with the 100 psf and 80 psf loading conditions. But only two members changed sizes. The calculations for all ten members can be found in Appendix III.

For the columns, tributary areas were calculated and floor heights determined in order to calculate the column sizes. The columns supporting the first through fourth floors and the roof were sized first. Because the sizes of these columns were so small, all columns above were assumed to be the same. The column sizes were determined from Table 4-1 Available Strength in Axial compression, kips W-Shapes. The calculations for all three columns can be found in Appendix III.

Conclusion

The work presented in this thesis strives to create a connection between God and his pupils as a reminder that 'God is light.' Capturing the prestigious history of the school and focusing on the hard work being performed by the students that use this library, the lighting design emphasizes verticality and sparkle as a translation for reaching for the heavens. Drawing attention to the historical stone elements used within the library's addition provides a background of texture and tradition for each space. The cold stone elements are balanced by the warm, kinetic daylight in each space to produce an interesting and comfortable environment. Each study within this proposal supports the overall goal to create an iconic and memorable place for the students to live and learn.

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