Final Thesis Report

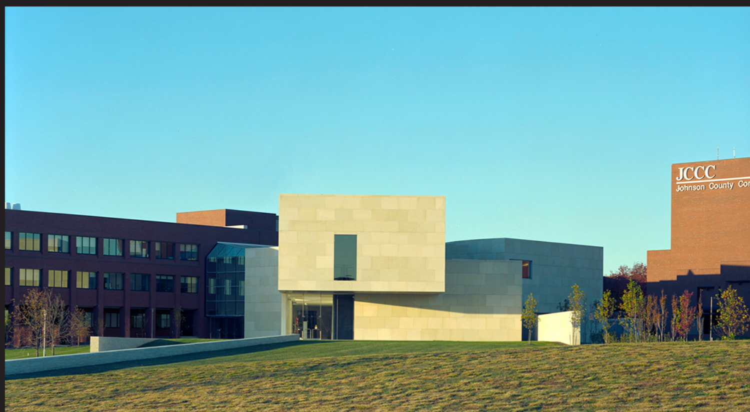
jack risser | lighting/electrical

s. good | the nerman museum

overland park, kansas | feb 16th, 2014

The Nerman Museum of Contemporary Art

Jack Risser | Lighting / Electrical



Project Team

Architect | Kyu Sung Woo Architects

Lighting | Lam Partners

MEP | Smith & Boucher

Structural | Walter P. Moore

Contractor | JE Dunn Construction

Statistics

Location | Overland Park, KS

Occupancy | Museum

Size | 38,190 FT^2 (GSF)

Levels | 2 above grade | 2 total

Construction | April 05 - August 07

Delivery | Design - Bid - Build

Building Systems

Lighting

Using a combination of compact fluorescent and halogen downlights, the general ambient lighting is satisfied for most of the spaces in the building. Halogen PAR lamps on track provide all of the display and art lighting. A light installation by Leo Villareal on the underside of the cantilever block serves as a decorative showcase.

Electrical

Primary service to the building is provided by JCCC. The primary utility transformer steps power down to 480/277V 3P 4W to distribute to mechanical and kitchen equipment. The lighting and receptacle loads are then stepped down by another secondary dry type transformer to a 208/120V Delta-Wye. Emergency power is provided by existing college generator and utilizes an onsite ATS.

Mechanical

Six air handling units – three inside and three outside – provide a total of 66500 CFM to the building. One air cooled chiller and Variable air volume terminal units are used within the branch duct scheme.

Structural

The overall structural system is concrete slab on concrete load bearing walls. The cantilever is supported by upturn beams. Slab on grade with transfer girders transfer the foundation loads to a pier system.

Architecture

Designed by Kyu Sung Woo Architects in Cambridge, MA, The Nerman Museum of Contemporary Art stands out from the other Johnson County Community College buildings it belongs to. Built in a modern, clean approach, the architecture is simple and elegant. Local white limestone covers the façade while expansive glass windows create voids. The dramatic cantilever overhang that is part of the second floor creates a bold entrance for the museum. The Nerman Museum is meant to be a piece of art, just as much as the art it is intended to protect inside.

Executive Summary:

This report will focus on a lighting design depth, an electrical analysis depth, a structural breath, and an acoustical breadth. These studies were also examined for their integration with each other. By looking at these systems and how they are put together, a thorough overall design was completed. The five spaces that will be focused on are: The exterior and grounds, the solarium, the café, the auditorium, and a second floor gallery.

The grounds and exterior of the museum was left largely intact, with just a few adjustments to walkway lighting that further enhanced the minimal architecture. The solarium was transformed into a piece of art. By using the wind and sun to its advantage, the space was converted to a place of visual interest much like the LED light installation found at the buildings entrance. The café, using existing lines of architecture and forms, was made into a glowing leaf that promotes warmth and comfort. By bringing in daylight to the auditorium, the space feels more bright and alert, while adding some visual interest. Being the main attraction, the gallery space needed to focus on the art. By hiding the track fixtures into the grazed fabric panels, the art is allowed to stand out and not compete with lines of track fixtures carving into the ceiling.

The electrical system was also redesigned for those areas touched by the lighting depth. A branch circuit redesign, short circuit study provides the safety needed for overcurrent and power outages. These analyses were imperative to make sure the new lighting was up to date and reasonable at an engineering perspective. Integration between the solar protection system in the solarium and a wind power harvesting system was also studied as part of an art installation. While this power system may not generate a lot of useable electricity for the building, its connection to the power of the wind and time of day, will prove to be an informative form of art.

A structural redesign was also needed to fully realize the lighting concept in the auditorium. By introducing skylights into the space, the joists needed to span more, creating the need to resize the metal roof deck, and joists above the ceiling in the auditorium.

Due to the redesigned ceiling in the auditorium and the added PVC material, a study into how these ceiling panels would affect the acoustics of the space was needed. It was found that the absorptive quality of these panels lowered the RT too far. The back wall also needed to be redesign to another material in order for the whole room to function acoustically.

Table of Contents:

Background:

Location Building name

The Nerman Museum of Contemporary Art

Location and site

Johnson County Community College

Overland Park, KS

Building Occupant Name

The Nerman Museum

Occupancy or function types

Education | Art Gallery | Café

Size

38,190 SF

Number of stories above grade / total levels

2 stories above grade | 2 total

Dates of construction

Start: April 2005

Completion: August 2007

Actual cost information

Approx. $15 million

Details not released

Project delivery method

Design Bid Build

Building Statistics:

General Building Data

Building name

The Nerman Museum of Contemporary Art

Location and site

Johnson County Community College

Overland Park, KS

Building Occupant Name

The Nerman Museum

Occupancy or function types

The building occupants primarily consist of the patrons of the museum and the staff that maintain it. Being attached to an existing college building allows the students and staff to easily flow through each space, creating a connection between the arts and academia.

Education | Art Gallery | Café

Size

38,190 SF

Number of stories above grade / total levels

2 stories above grade | 2 total

Primary Project Team

Owner: The Nerman Museum of Contemporary Art | Johnson County Community College | http://www.nermanmuseum.org/welcome

Construction Manager: JE Dunn Construction | http://www.jedunn.com/

Architect: Kyu Sung Woo Architects, Inc | http://www.kswa.com/

Architect of Record: Gould Evans Goodman | http://www.gouldevans.com/

Landscape Architect: Reed Hilderbrand | http://www.reedhilderbrand.com/

Structural Engineer: Walter P. Moore| http://www.walterpmoore.com/

MEP Engineer: Smith & Boucher| http://www.smithboucher.com/

Civil Engineer: Kaw Valley Engineering | http://www.kveng.com/

Tech Consultant: KJWW Engineering Consultants | http://www.kjww.com/

Acoustical Consultant: Acoustical Design Group| http://www.heieng.com/Pages/ADGAcquisition/

Food Service: Santee Becker | no link available

Dates of construction

Start: April 2005

Completion: August 2007

Actual cost information

Aprox. $15 million

Details not released

Project delivery method

Design Bid Build

Architecture

Architecture

Using bold and regular geometrical shapes, Kyu Sung Woo created an elegant, minimalist building that houses a wide range of activities. Its main function is to house the modern art that the museum displays. By using a plain, minimal approach, the interior architecture fades into the background, allowing the art to stand alone. The façade is made of local white limestone, and strategically placed windows. This style stands out from a more classical style building and reflects the modern art inside. The museum is experiential. Not only in the art that one comes to see, but in the building itself. Art can be found in the dramatic, central staircase, the gallery clerestories and giant windows, and the glass encased solarium. The Nerman Museum is meant to be a piece of art, as much as the art it protects inside.

Major national model codes

IBC 2003

NEC 2005

International Existing Building Code

International Fire Code

International Plumbing Code

International Energy Code

International Mechanical Code

International Fuel Gas Code

International Property Maintenance Code

International Private Sewage Disposal Code

Zoning

Chapter 18.27

Commercial – 2 Zoning: Planned General Business District

Pertinent excerpts:

No building height limit

Minimum front yard – 10 feet

"Any lighting used to illuminate an off-street parking area, sign or other structure shall be arranged as to deflect light away from any adjoining residentially zoned property or from public streets. Direct or sky-reflected glare, from flood-lights or commercial operations, shall not be directed into any adjoining property. The source of lights shall be hooded or controlled. Bare incandescent light bulbs shall not be permitted in view of adjacent property or public right-of-way. Any light or combination of lights that cast light on a public street shall not exceed one foot-candle (meter reading) as measured from the centerline of the street. Any light or combination of lights that cast light on adjacent residentially zoned property shall not exceed 0.5 foot-candles (meter reading) as measured from said property line."

Link: http://www.opkansas.org/wp-content/uploads/downloads/18270-c-2-general-business-district-and-cp-2-planned-general-business-district.pdf

IBC Section 304.1 Business Group B: Educational occupancies for students above the 12th grade

Assembly Group A-3

Historical requirements

None

Building Enclosure

Building facades

Clad in local Kansas limestone. Expansive glazing on first floor with strategic window placement on second floor. Solarium, joining the two buildings, is covered in glass on 2 sides and the roof as well as perforated metal for daylight control. The overall shape of the building is very regular with clean edges which results in the absence of any cornicing or footings. At the top of the façade walls, limestone coping is applied.

Roofing

The main roofing for the building is in-set behind the cover of walls that come up to give the building the look of a flat roof from below. Some of the mechanical equipment is in fact located on the roof, but from the ground floor, one would never see it. The roofing system is a lightweight insulating concrete slab on top of a concrete roof deck system that is supported by load bearing walls. An APP (Atactic Polypropylene) roofing membrane is then used on top of the lightweight concrete for waterproofing, increased UV protection, and improved energy performance.

Sustainability features

Daylight features with ceiling slots over gallery areas to allow light in to supplement the ambient light in the space.

Primary Engineering Systems

Construction

The construction of the Nerman Museum was completed by JE Dunn Construction. The design-bid-build contract is estimated at $15 million. The attached building was also constructed during the construction of the Nerman Museum which is called the Regnier Technology Center. Construction started in 2005 and ended in 2007.

Electrical

The primary service comes into the building on the north end through an outside transformer. JCCC owns the primary campus electrical loop. The primary utility transformer steps down the power to 480/277V 3P 4W and is carried inside the building to the main 1600A panel board. From there it is distributed to the mechanical and kitchen equipment service panels as well as the receptacle and lighting panels found on the first and second floors. A secondary step-down transformer provides 208/120V power to the lighting and receptacle equipment as necessary. Emergency power is provided by existing college generator and utilizes an onsite ATS for quick transfer during a power outage.

Lighting

The lighting for the Nerman Museum integrates electrical light with natural sunlight. The gallery spaces, solarium, and most of the offices utilize daylighting as a main aspect in their design. Most rooms have windows that can let in natural light. Compact fluorescents and halogen fixtures are used for most of the ambient lighting. PAR lamps in track fixtures provide the lighting for display art. A lighting installation by Leo Villareal on the underside of the main cantilever block serves as a decorative showcase of art.

Mechanical

Seven outdoor air handling units that range from VAV, multi-zone, and single-zone applications provide the chilled water cooling and electric heat for the building spaces. A series of variable air volume terminals are used throughout the building to supplement the electric heating. Convector baseboard heater units use a finned tube configuration and are found near the floor to provide general heating. Exhaust fans are found in the kitchen and toilet areas of the building.

Structural

The overall structural system of the Nerman Museum is a concrete slab on concrete load bearing walls. A beam and column system transfers the loads down to the foundation. The cantilever part of the building is supported by upturn beams. Slab on grade with transfer girders transfer the foundation loads to a pier system underneath the building.

Primary Engineering Systems

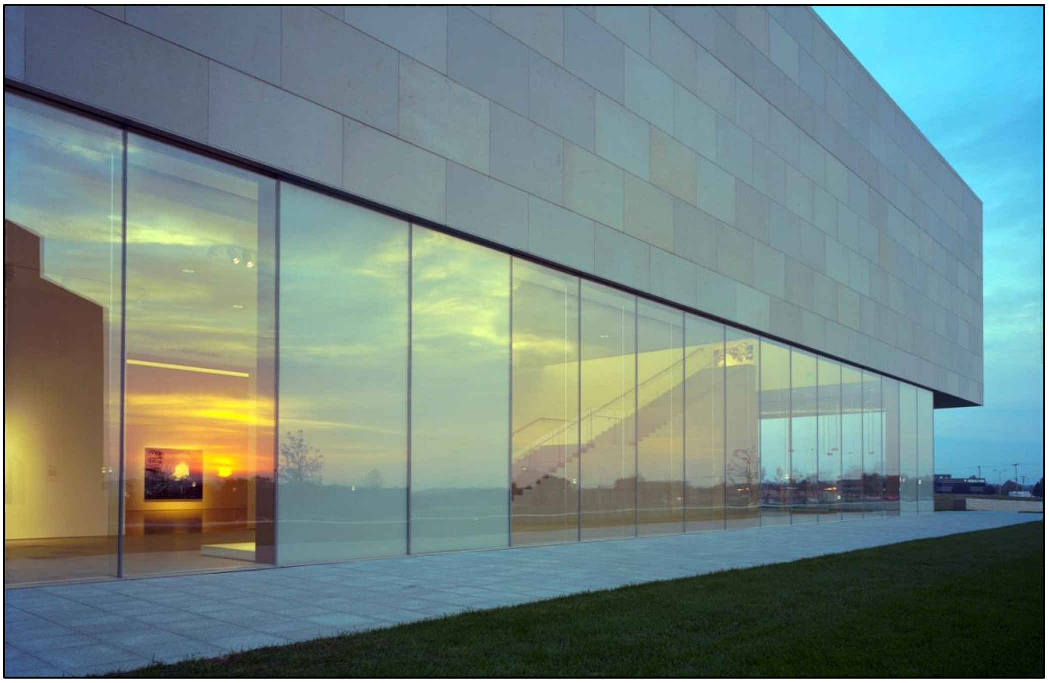
Fire Protection

Fire protection is applied in the building through sprayed fireproofing on the structural concrete. These members on the first and second floor are rated for two hour protection. The firewall construction allows 1-2 hour protection for the partition drywall. Room protection to prevent the spread of a fire consists of sprinklers on each floor.

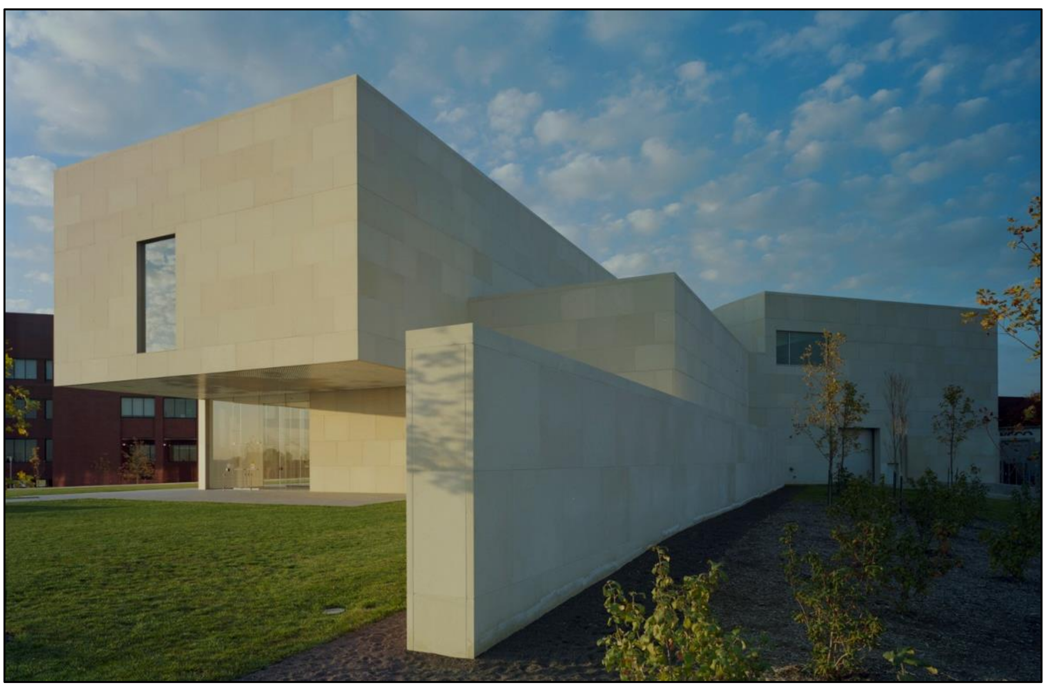
Transportation

Two elevators are used as transportation from the first floor to the second. One of these elevators is the freight elevator to move art pieces to the second floor galleries. Two staircases also connect the visitors to the first and second floor galleries as well as the auditorium and office spaces.

Pictures



Façade: Local limestone with glazing | photo courtesy of KSWA



Architecture: Dramatic cantilever with regular geometric shapes | photo courtesy of KSWA

Lighting Depth:

The lighting depth will focus on five spaces of the Nerman Museum of Contemporary Art: The grounds/exterior, the solarium, the café, the auditorium, and a 2nd floor gallery space.

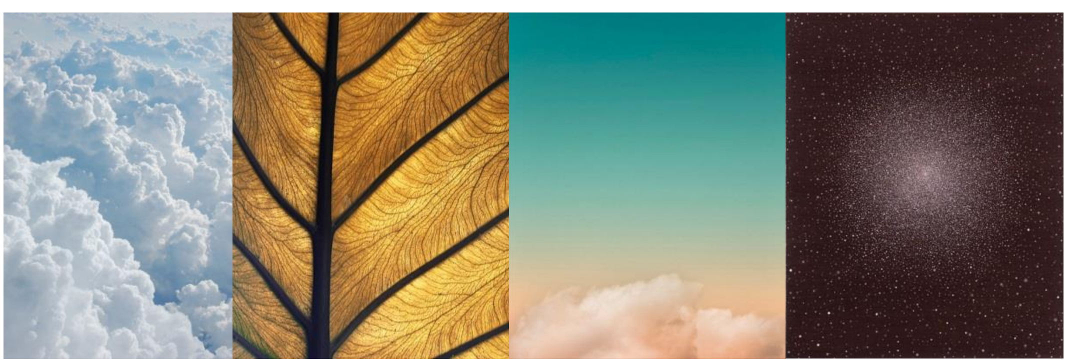
Concept

The lighting design concept comes directly from the design of the architecture. The Nerman Museum's architectural is one of minimalism. It provides subdued palette of colors and highly sophisticated levels of finish within a vastly controlled structure. It comprises leanness, space, linearity, simplicity, and contemplation.

When first looking at this building, the first thing that jumped out was how different the Nerman Museum was. As much as it is meant to house art, the building itself can be viewed as a piece of art. You were first meant to experience the art, then the design of building.

The building's design, like most minimalist structures, focuses the occupant's perspective not into the home, but out. The landscape and the environment are really at the forefront. Focusing our attention outward then enhances the feeling of space and form. This creates feelings of ease, calm, and evokes the power of soothing nature.

The lighting design takes it cues from this minimal architecture. It enhances the experience of regular geometry, orderly forms, efficient use of space, well-ordered systems, and well-organized lighting schemes. It also reflects the building's outwardly turn to its environment, drawing from the natural world imagery for each space.



Exterior and Grounds

description

The Site of the Nerman Museum is located on a fairly flat campus. It sits on the edge of the campus at the NE end. Another building is attached via the solarium on the south side of the building. The main entrance and lawn are located to the east of the museum. A walkway leading up from a parking lot leads you up to the main entrance at the large cantilever part of the building. The walkway continues on the edge of the building arriving at the solarium entrance.

The entrance also has an LED light installation located on the underside of the cantilevered area. This feature is a huge attraction and should be one of the main focal points of the exterior.

Figure 1.1
LED Light Installation

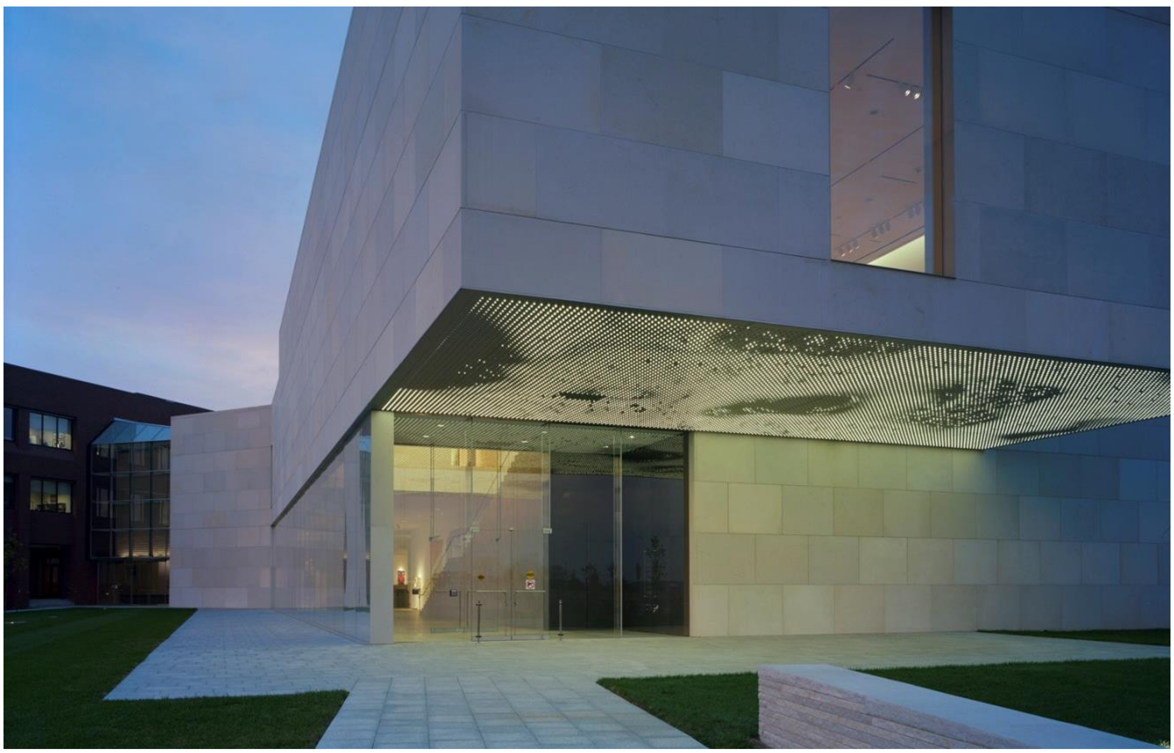


Figure 1.1
Site Plan

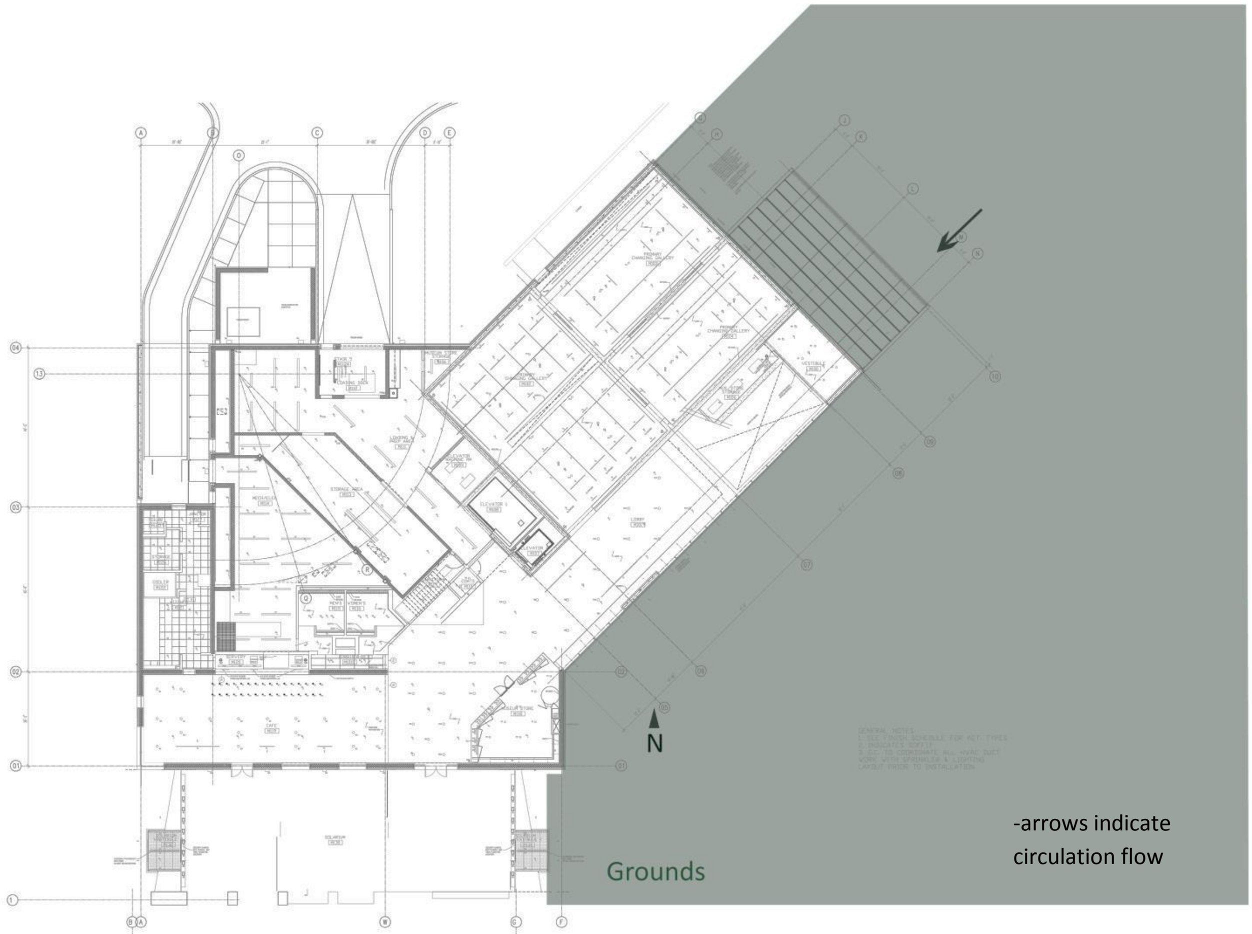


Figure 1.1
Exterior and Grounds Site Plan

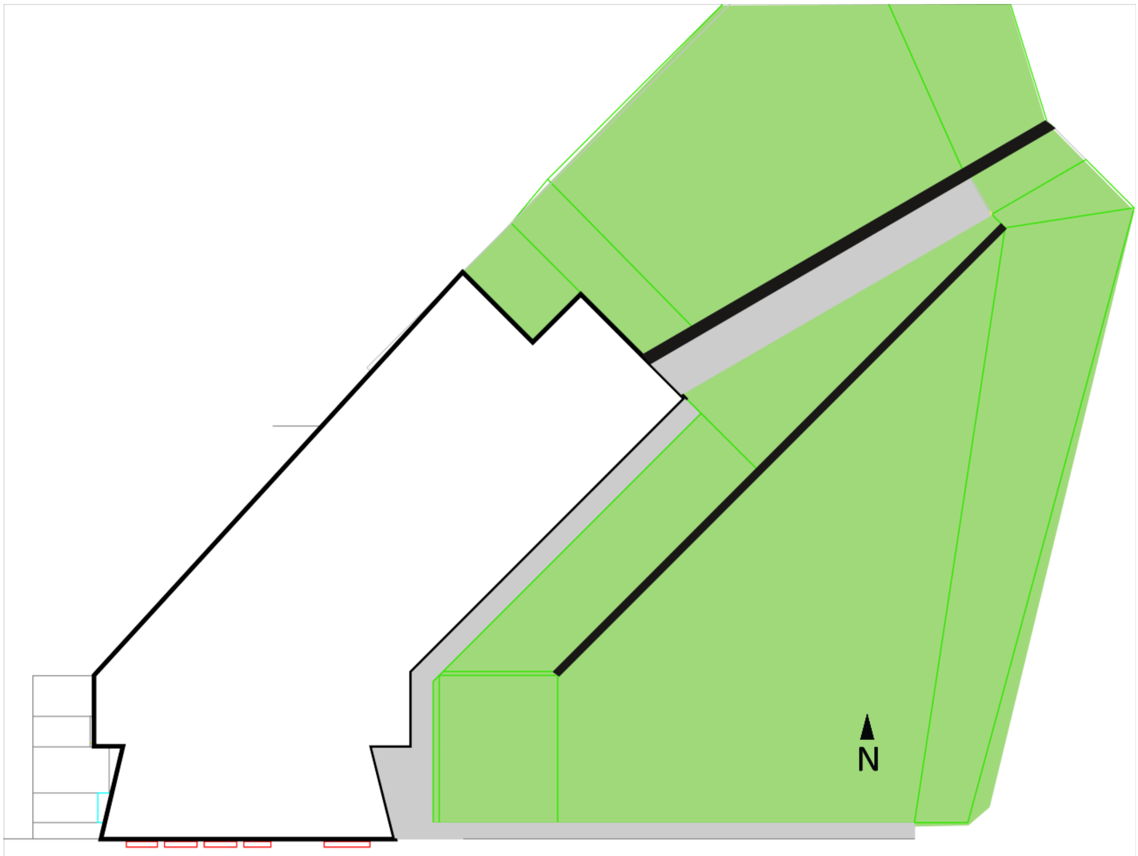


Table 1.1
Exterior and Grounds Finishes

Type	Description	Color	Reflectance	Manufacturer
grounds	grass	green	0.3	-
walkways	pavers - stone	grey	0.6	-
building exterior	white limestone	off white / silver	0.7	-
adjacent building exterior	brick	dark red	0.25	-
windows	glazing	glass	t=0.7	-
led light installation	led dynamic light art installation located on the underside of the cantilever	white led	-	artist - Leo Villareal

overall design goals

The main design objective for the exterior and grounds is to create an orientation to the museum as you walk around it, establishing a connection with the architecture, and, to help create that sense of connection, form a response to the lighted environment. The form of the architecture is really what needs to be celebrated here. By washing the white limestone façade softly and letting the window voids pop against the dim structure, the architecture's geometry is reinforced. This lighting will allow the Nerman Museum to become just another dune in the landscape, while allowing the minimal lines of the building to show forth. The marker lights added to the walk way will add an additional focus to the architectural forms. It takes the shape of the dramatic sole window in the cantilever form.

The window profile is replicated in the in the profile of the maker lights marching down the pathway. These will grow brighter as patrons move through this space to create orientation as well as the lighting responding to its dynamic environment.

tasks + activities

The main activities on the grounds will be to view the architecture of the museum and moving from one destination to another. The first impression of the building will be made from here to entice the patrons into the museum.

design criteria

The illuminance values as well as certain design criteria were taken from IESNA Lighting Handbook. The lighting power density values were taken from ASHRAE/IESNA 90.1.

quantity of light

Table 1.1
Exterior and Grounds Illuminace (IES recommendations)

Space	E_h (lux)	E_v (lux)
exterior - pathway	3	-

Table 1.1
Exterior and Grounds LPD

Space	Allowance (W/SF)
exterior – pathway (width>10ft)(zone 2)	0.14
exterior – façade (zone 2)	0.1

quality of light

orientation

The main entrance, when entering from the west parking lot, has to be a visually strong one. This is also where the cantilever part of the building is with its LED light art underneath it. Creating orientation and direction is the landscape. A straight path leads up to the front glass doors. Adding marker lights down the path at 15' increments provides additional directionality.

association with the architecture

The added marker lights will take the form factor of the one window in the second story of the building. This window has a profile of a 2 to 1 rectangle. The marker lights will have a dimension of 1'x1'x2'. These lights will be a small indication of the minimalist architecture and reinforce the regular lines found in the building.

response to the environment

In addition to marking the pathway towards the museum, the rectangular marker lights will glow brighter when a person walks past them. Occupancy sensors will allow the fixture to "know" when something is moving past. This active response to the people moving through will strengthen the lighting's connection to the environment.

first impression

Being most outsiders first look at the Nerman Museum, it has to impress visually. By balancing the lighting and allowing the architecture to stand front and center, the museum can be true to its original form. While the museum will look undoubtedly different from the daylight, it will still be able to uniquely its own building by letting the voids shine.

glare

Because the building's façade is being washed from the ground plane, glare will be in issue. Making sure the fixture's main photometry is focused on the upper building will be crucial. The luminance of the glowing marker lights will also need to be balanced as to not be too bright, but still put the required amount of light on the pathway.

fixture housing requirements

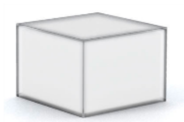
The housing's for all the fixtures will need to be rated for outdoor conditions. An IP67 rating will be a goal.

color temperature

The interior of the building will be using a color temperature of 3500K. To be consistent from inside to outside, the exterior and the grounds will use 3500K CCT as well.

fixtures and equipment

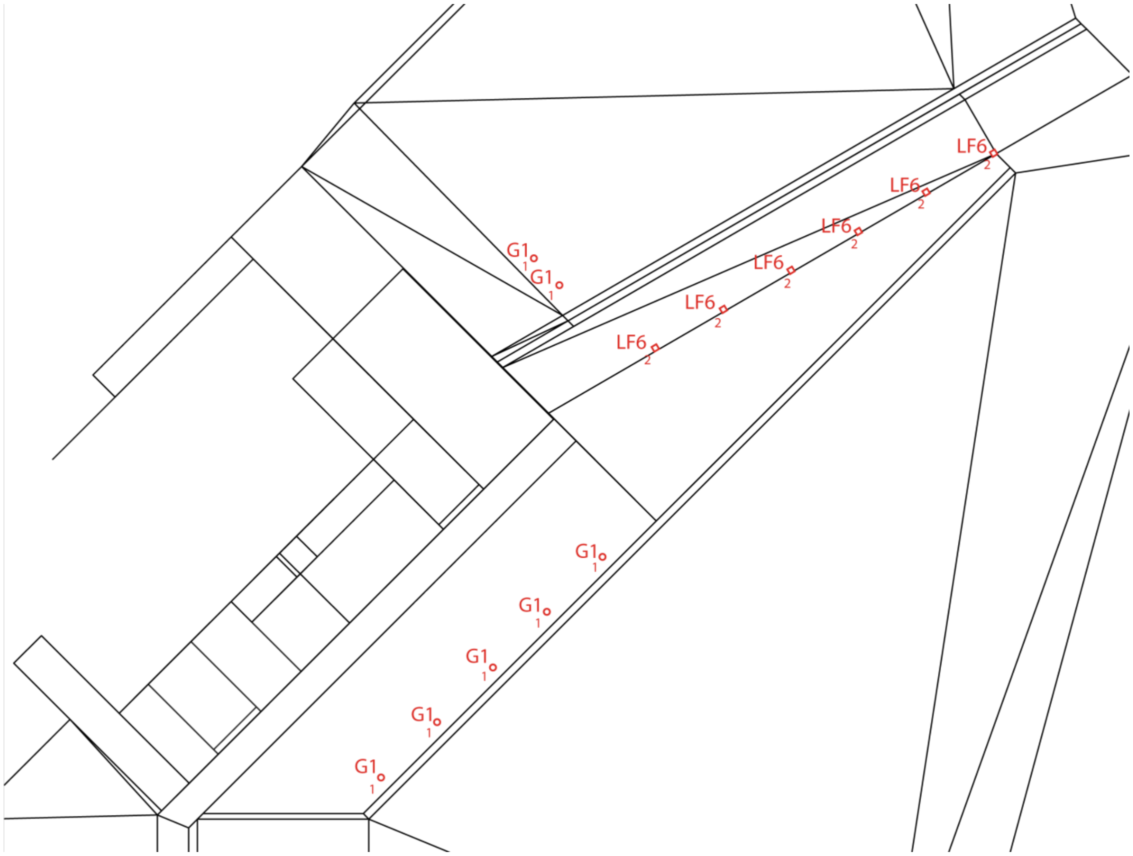
Table 1.1
Exterior and Grounds Equipment Schedule

Type		Manufacturer	Description
	G1	We-ef	24W LED in grade outdoor fixture with asymmetrical throw. 2000 lms. Medium beam distribution. IP67.
	LF6	3Form	One layer 1" Chroma material with C3 Ghost layer for light diffusion. Integral slot into paver walkway. LED light board uplighting in grade for even distribution. Light to be on all 5 sides of the form.
	L8	3Form	LT series LED tape 3500K. No Channel. 1.8 watts per foot. Warm White. 30 lumens/foot.

controls

Controls are needed for the marker light's function in responding to its environment. An occupancy sensor coupled with a timed dimmer is needed realize the lighting design. As patrons move though the walkway, the marker lights glow slightly brighter. This will promote direction to the Nerman Museum and help visitors along their way. It's also an entertaining and dynamic control in the spirit with the Nerman's art and overall themes.

grounds: lighting plan



Renderings

Figure 1.1

Exterior and Grounds: Pseudo Color Rendering (Nighttime)(Perspective View)

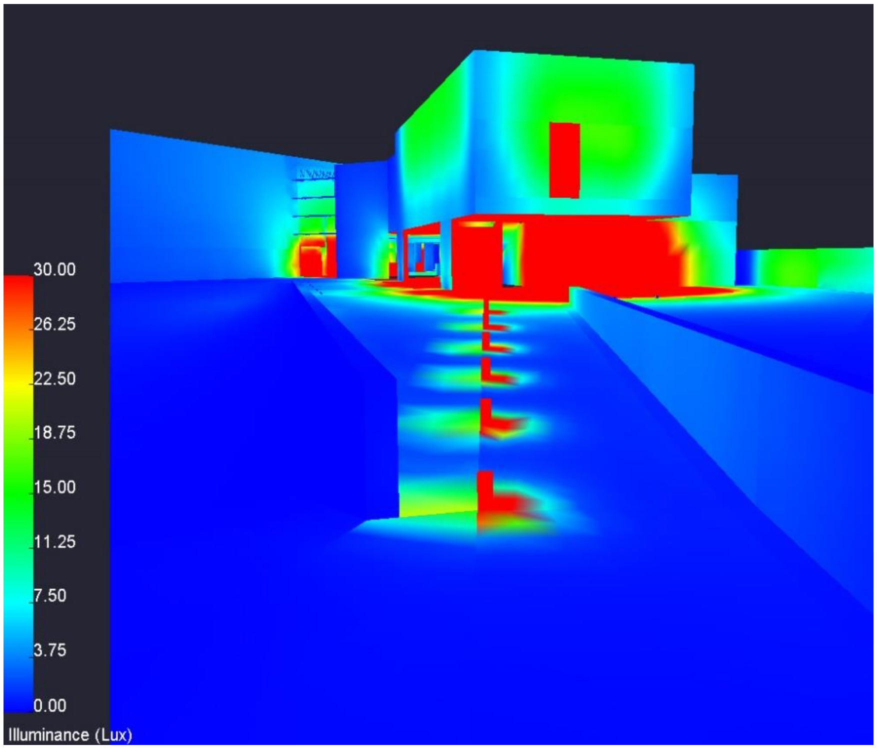


Figure 1.1

Exterior and Grounds: Nighttime Perspective Rendering

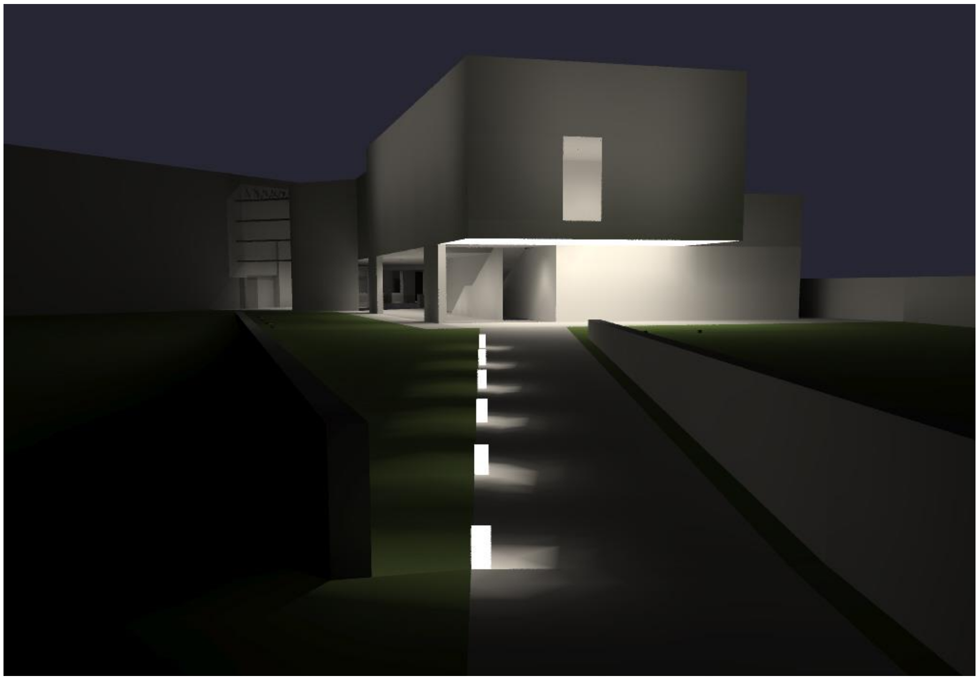
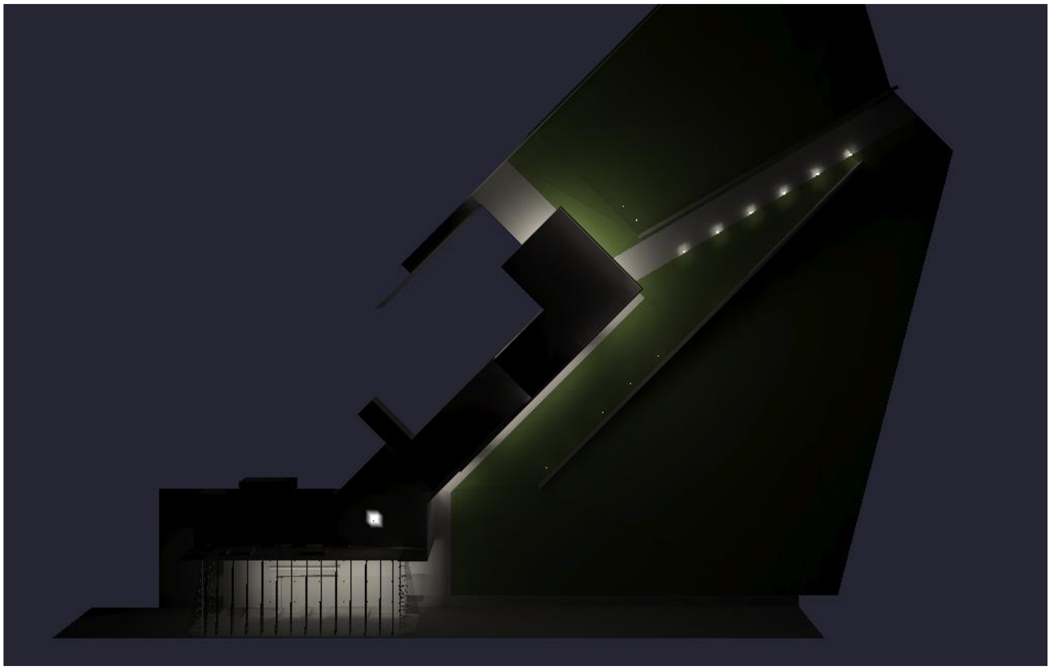


Figure 1.1
Exterior and Grounds: Nighttime Overhead Rendering



calculations

Illuminance

Figure 1.1
Exterior and Grounds: Pseudo Color Rendering (Nighttime)(Overhead View)

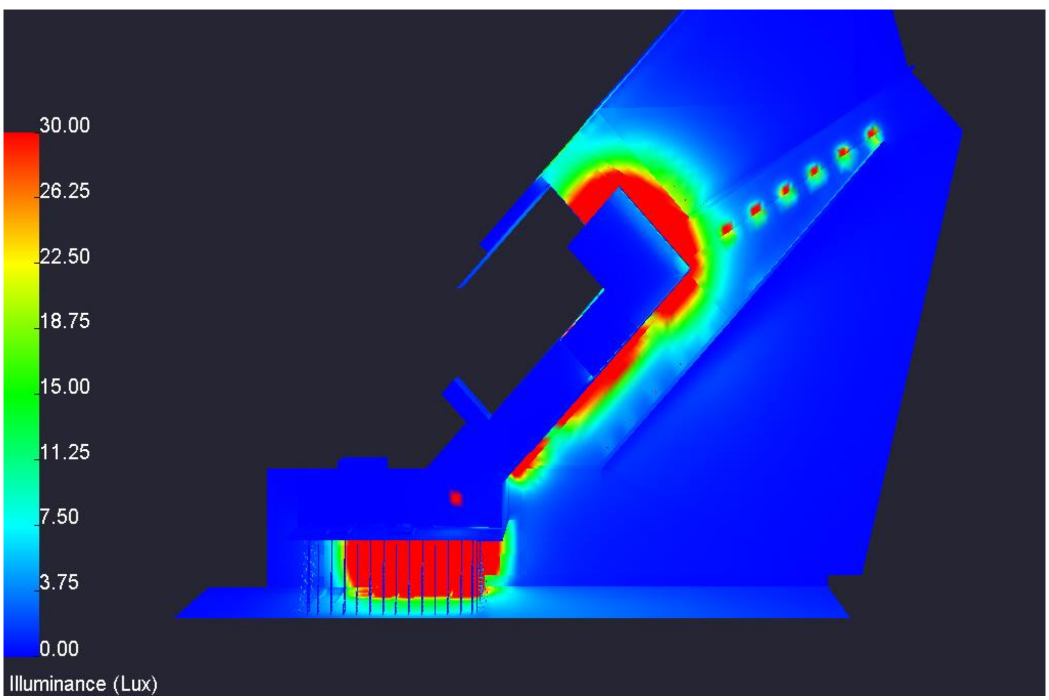
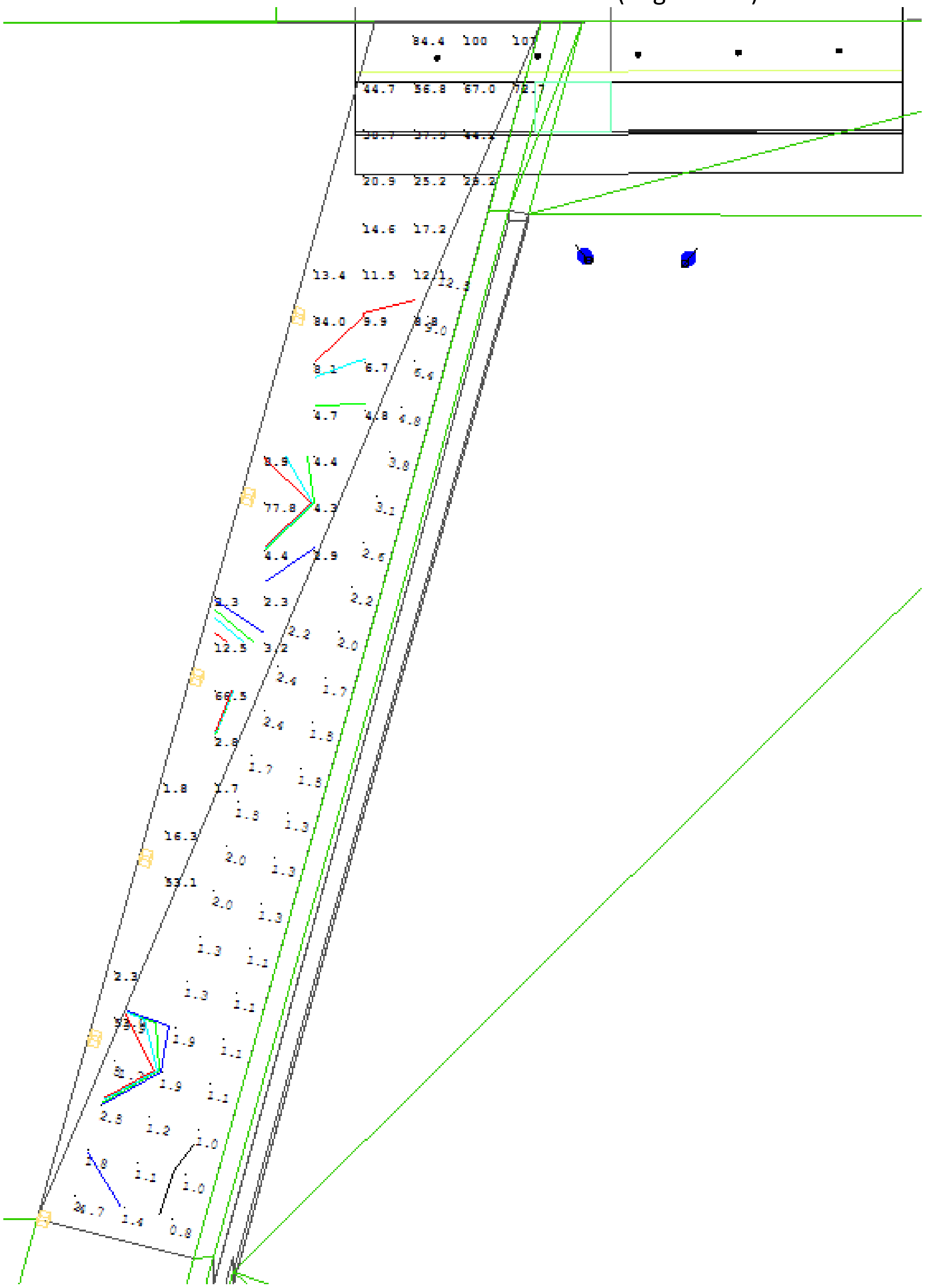


Figure 1.1
Exterior and Grounds: Illuminance Grid Points with Isolines (Nighttime)



An average of at least 3lux can be found on the walkway – with an increase found near the building entrance.

Table 1.1
Exterior and Grounds Illuminance Calculation Summary (workplane 1.5')

Space	E_h Recommendation (lux)	E_h Calculated (lux)
exterior - pathway	3	6

Lighting Power Density

Table 1.1
Exterior and Grounds Lighting Power Density: Walkway 10ft or wider (Zone 2)

Fixture Type	System Wattage	Quantity	Total Watts
G1	24	7	168
Total Watts			168
Area (SF)			2194.5
Watts/SF			0.08
ASHRAE 90.1 compliant?			0.1 - Yes

Table 1.1
Exterior and Grounds Lighting Power Density: Façade (Zone 2)

Fixture Type	System Wattage	Quantity	Total Watts
LF6	5.4	6	32.4
Total Watts			32.4
Area (SF)			5425
Watts/SF			0.01
ASHRAE 90.1 compliant?			0.14 - Yes

evaluation

The Grounds already has a main focal point in the LED light installation on the underside of the cantilever. The proposed lighting is just meant to highlight the form of the architecture, and blend into the landscape. By softly washing the sides of the limestone, the stark rectangular box that is the Nerman Museum glows in the darkness. This is a subtle approach and one that adds value to the understated building.

Solarium

description

The Solarium is located in-between an existing community college building and the Nerman Museum. It is the main connection point for the campus side of the building. The space is almost as tall as it is long. The multi-story space is very large and open to facilitate movement by simulating the outdoors. It is surrounded by three sides of glazing, which is unlike the other part of the building, but relates well to the overall architecture. The two solid sides of the existing building and the museum create a cavern, making the glass appear suspended in the void.

Figure 1.1
1st Floor Plan

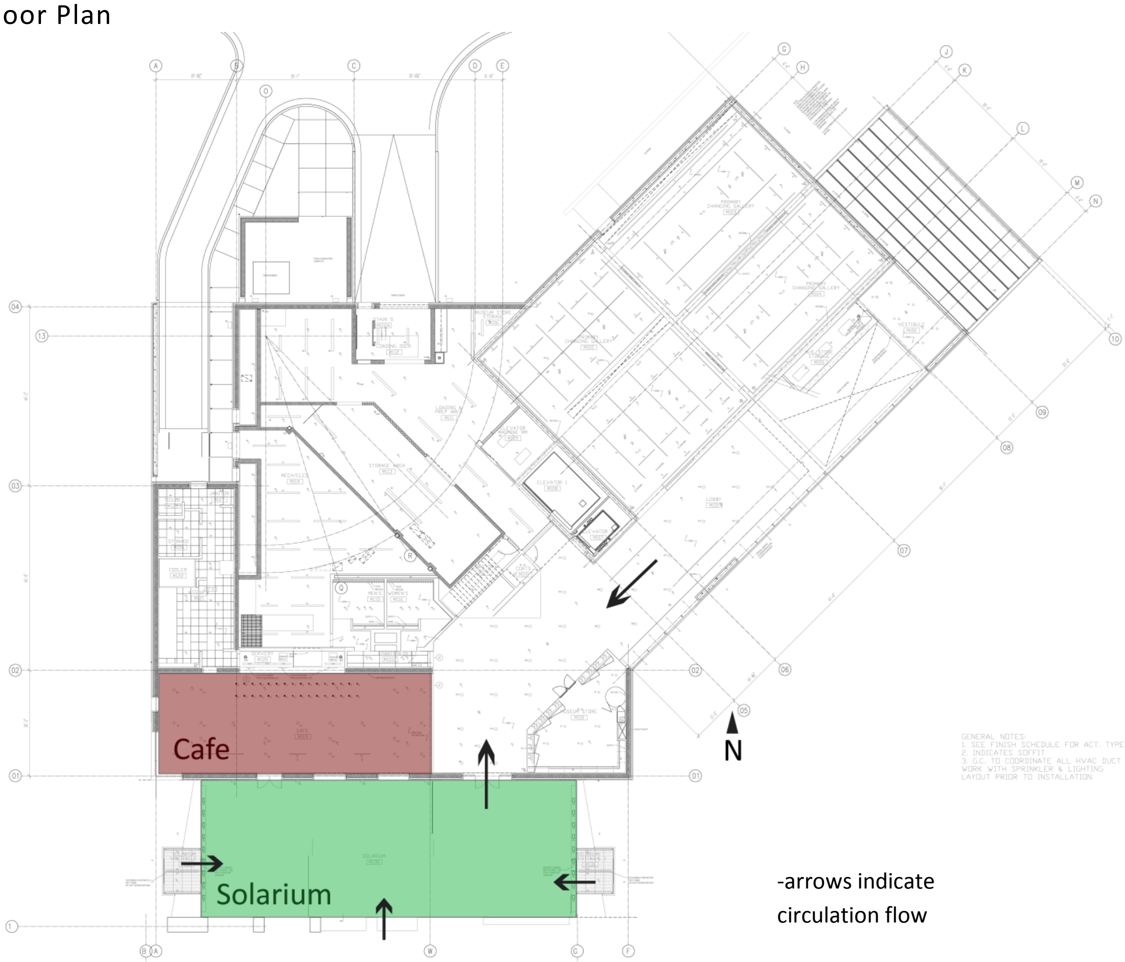


Figure 1.1
Solarium Floor Plan

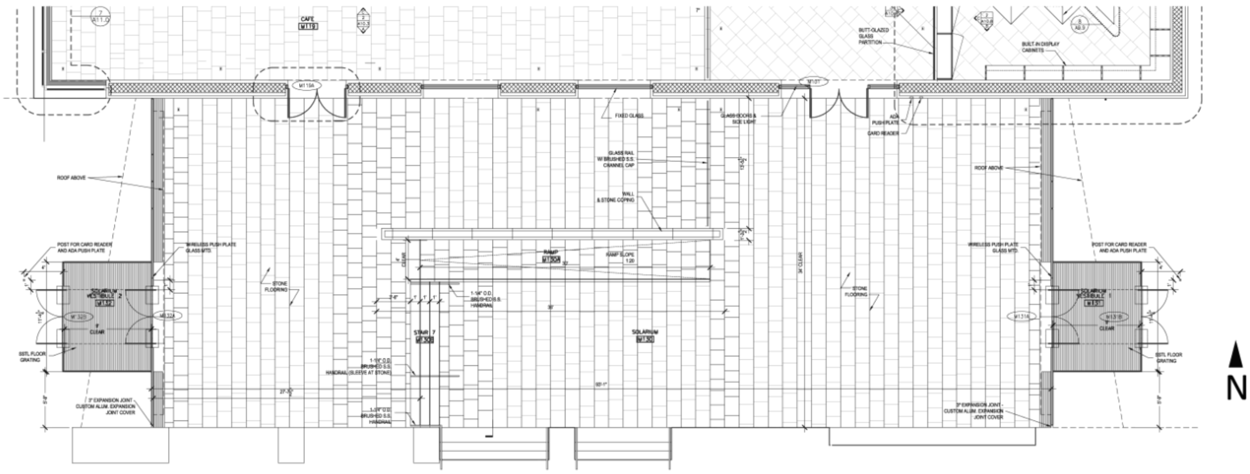


Table 1.1
Solarium Finishes

Type	Description	Color	Reflectance	Manufacturer
floor	stone	off white	0.6	-
base	aluminum	silver / painted	0.7	-
wall (Nerman Museum)	white limestone	off white / stone	0.7	-
wall (adjacent building)	brick	red	0.25	-
window	glazing	glass	t=0.7	-
truss	steel	grey metal	0.5	-

overall design goals

The main lighting design goals for the solarium are to create a visually comfort environment while still adding visual interest. Glare was a huge concern because of the amount of glazing used in this space. A new solar protection panel system was designed to create continuity to the themes of the building, as well as providiving glare protection.

Just as a stary night sky inspires and intreages us, so does the effect from the newly designed solar panel system.

tasks + activities

The main task for the solarium is a meeting spot. Being a junction for two buildings and the campus side of the Nerman Museum, it is a major connection point. There is also seating for the café that is located adjacent to the solarium space. People will mainly be passing through the space to get to the museum or the rest of campus. The sheer amount of volume this space offers is a major point of interest to the visitors.

design criteria

The illuminance values as well as certain design criteria were taken from IESNA Lighting Handbook. The lighting power density values were taken from ASHRAE/IESNA 90.1.

quantity of light

Table 1.1
Solarium Illuminace (IES recommendations)

Space	E_h (lux)	E_v (lux)
work area	150	50
social/waiting area	40	15

Table 1.1
Solarium LPD

Space	Allowance (W/SF)
solarium - circulation	0.02 per foot (height)
	0.02 x 44' = 0.88 W/SF

quality of light

spaciousness

Closing off the solarium in the fear of glare could be the worst thing you could do for this space. Knowing this space is meant to feel like an outdoor space is a main draw for visitor's interest. Keeping the glazing on all three sides and not over using solar protection are keys to making this space feel spacious during the day. During the night, the space also should feel open to the night. By lighting the vertical surfaces and ceiling, the space can create that spaciousness during night time conditions.

glare

Glare is a major concern anytime a lot of glazing is used in a space. For most of the solarium, glare doesn't matter too much because it's just a circulation point and is directly connected to the outside. The idea of a solarium is a sun filled room. The area of concern is the café seating area that is located on the museum's side of the space. This will receive direct light during the summer months of the year. Providing a solar protection system that limits full direct sun will be used.

visual interest

Creating visual interest for this space can really add value to the Nerman Museum overall. By taking cues from the lighting installation in the front of the building, the visual interest comes from the daylighting directly. The solar protection system uses a peppered-hole design, with disks that spin to cut off the direct light with the power of the wind. This dynamic system will create a shimmering wall of daylight. By creating this ever-changing solar condition, the lighting will create visual interest and draw visitors inside.

circulation

Having the lighting promote a clear line of circulation and task importance hierarchy will support the flow of people in and out of the museum. Using higher light levels at the café seating area will produce a pivot point for the rest of the circulation area. The rest of the open area will be lighted dimmer.

luminance contrast

Luminance contrast between the solar protection system, the sky, the sun and the vertical surfaces will need to be studied. Creating too high of a contrast will make the space feel dark and unfriendly. High brightness overall is needed to create a spacious area.

color temperature + rendering

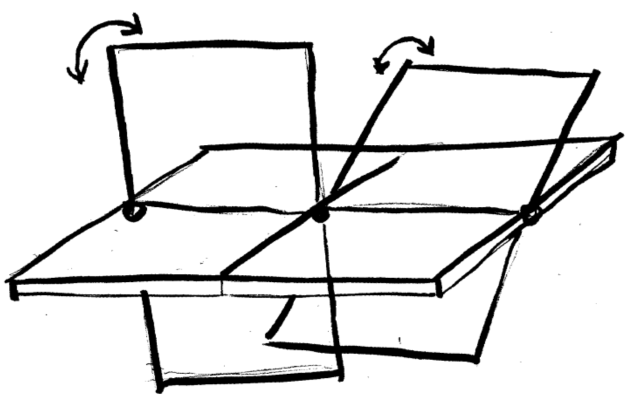
Since this space receives a lot of daylight, and also needs to be sensitive to artwork and the color rendering of traditional light sources, a middle of the road color temperature was selected throughout the building (3500K). Track lighting, whenever lighting a piece of art, requires a CRI in the 90s, but the general ambient light in the space can be a lower CRI in the 80s.

fixtures and equipment

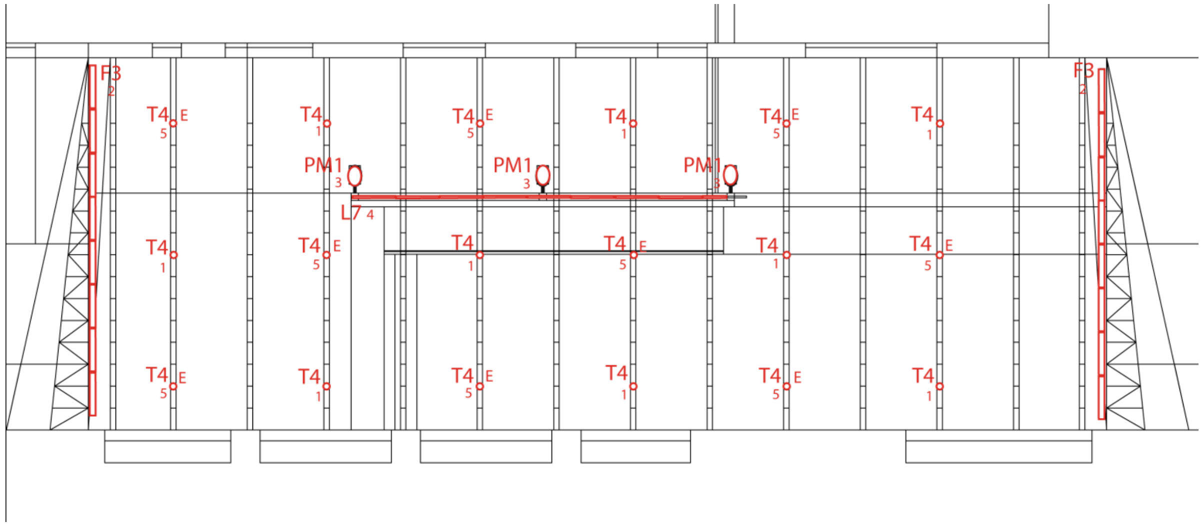
Table 1.1
Solarium Equipment Schedule

Type		Manufacturer	Description
	L7	Lumenpulse	4 foot LED strip. 8.5 watts/foot, Regular Output. 60x60 degree beam spread. Remote driver with standard dimming.
	F3	Litecontrol	(2) T8 fluorescent 4’ length. Concealed cove fixture. 3500K 81CRI. 64W
	T4	Edison Price	Hanging LED tack system, integrated with fabric panel system, 1500 lumen package, 80+ CRI. 20 degree beam spread. Dimmable standard driver. 3500K
	PM1	Bega	52W LED pole mounted fixture. Clear acrylic diffused light distribution optic with 3500K. 4,900 lumen package. Type IV (IES classification).

Detail Solar Control Panel



solarium: lighting plan



Renderings

Figure 1.1
Solarium: Pseudo Color Rendering (Plan View)

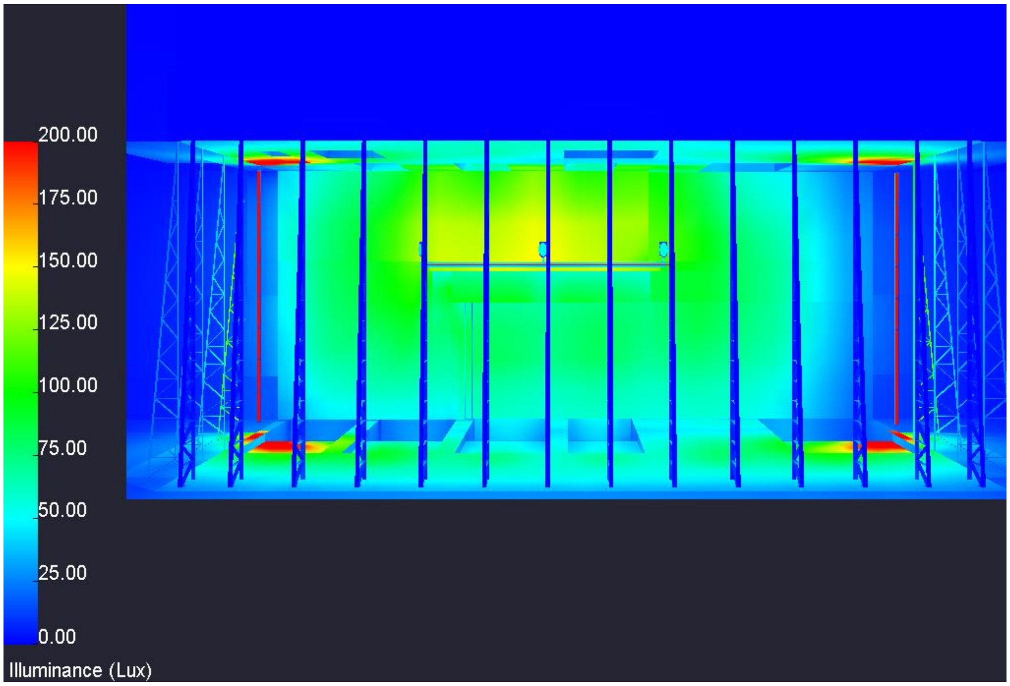


Figure 1.1
Solarium: Pseudo Color Rendering (Perspective View)

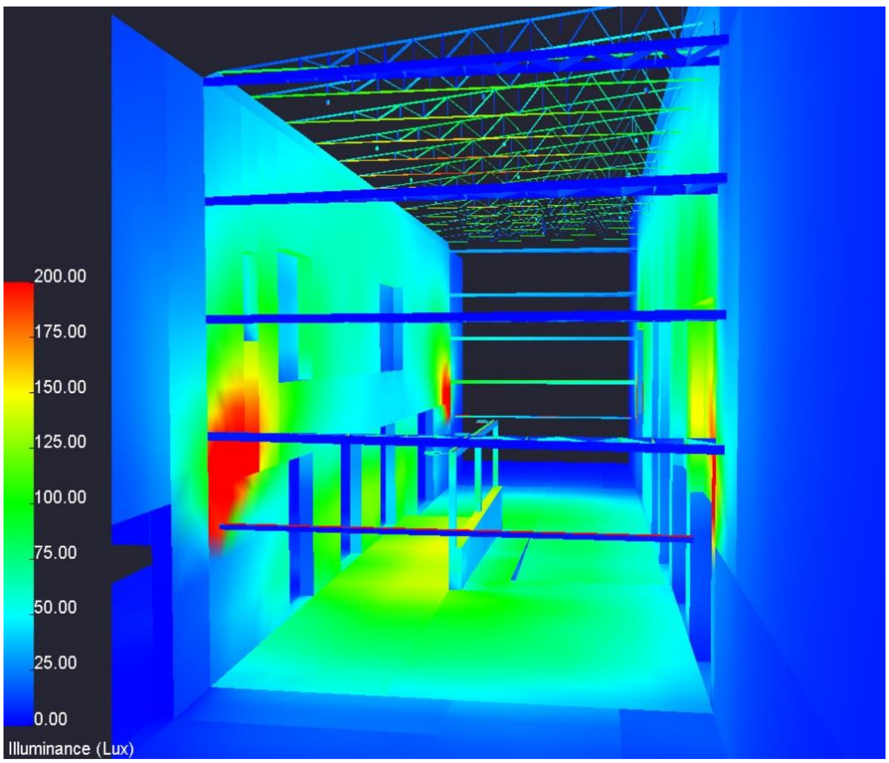


Figure 1.1
Solarium: Perspective Rendering (March 15th 11:00 a.m. – Sunny day)

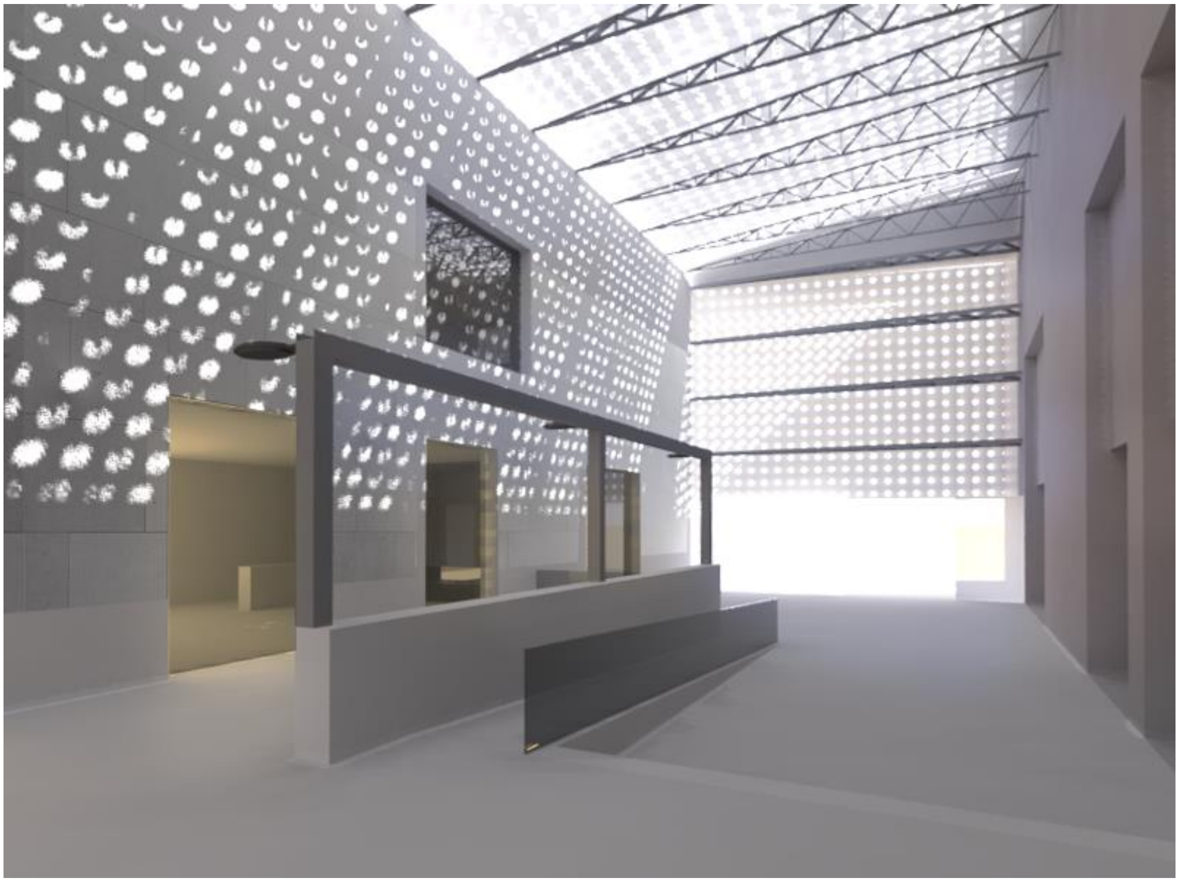


Figure 1.1
Solarium: Perspective Rendering (March 15th 11:00 a.m. – Sunny day)\

calculations

Illuminance

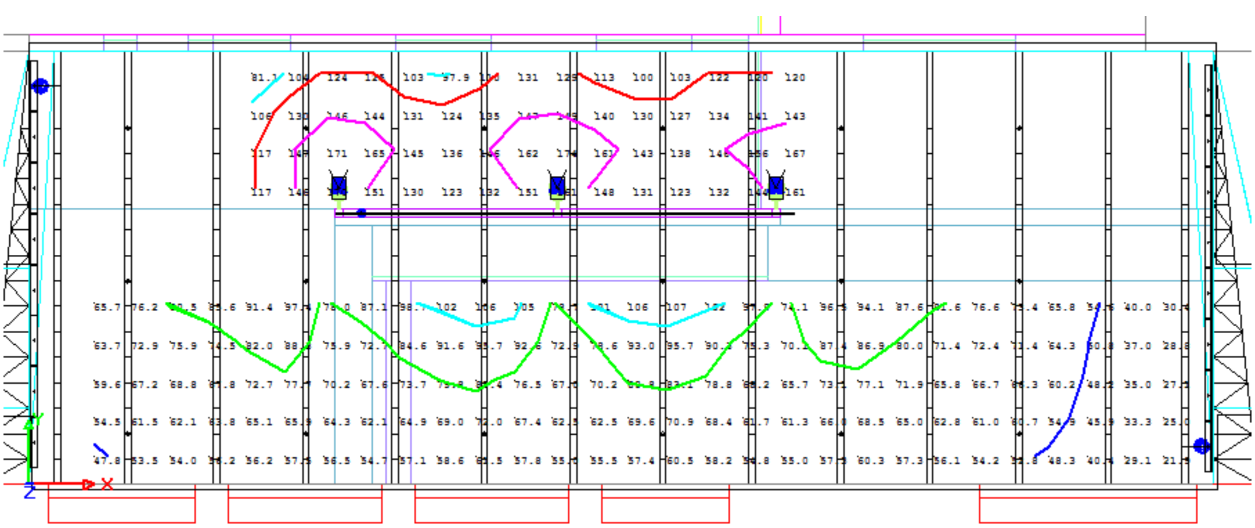


Table 1.1
Solarium Illuminance Calculation Summary (workplane 1.5')

Space	E_h Recommendation (lux)	E_h Calculated (lux)
work area (seating area)	150	135
social/waiting area (circulation space)	40	68.5

Lighting Power Density

Table 1.1
Solarium Lighting Power Density

Fixture Type	System Wattage	Quantity	Total Watts
L6	29	9	261
F3	56	16	896
TC	60	18	1080
PM1	57	3	171
Total Watts			2,408
Area (SF)			3,500
Watts/SF			0.69
ASHRAE 90.1 compliant?			0.88 - Yes

evaluation

The solarium, from this lighting design, is now much more than just a circulation space. During the day, its wall is turned into art itself. The solar protection system creates a shimming wall of lighting that inspires and adds to the overall plan of the Nerman Museum. At night, it is a very functional space that generates spaciousness and movement to and from the museum and the campus itself.

Cafe

description

The café is located on the first floor, adjacent to the main entrance and the solarium. This makes the space a pivot point as it joins two high traffic areas. Steps are positioned at the entrance, raising the café area and setting it apart from the bordering hallway. Measuring 65' x 25' x 12'(h), the space feels long while it covers around 1,625 SF. Seating for the café is also available in the solarium. The café and solarium are connected by doorway that allows for easy access between the two spaces.

Figure 1.1
1st Floor Plan

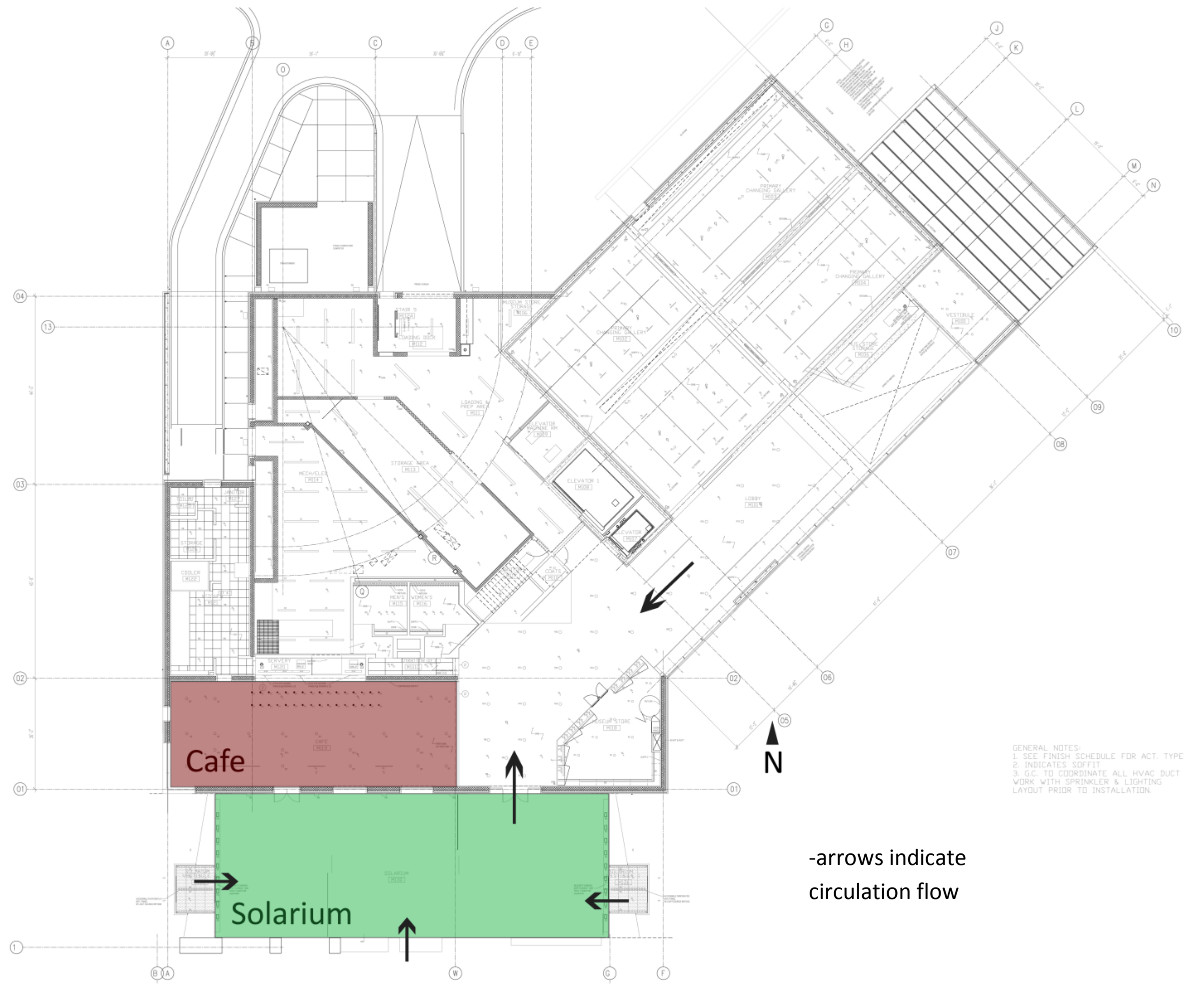


Figure 1.1
Café Floor Plan

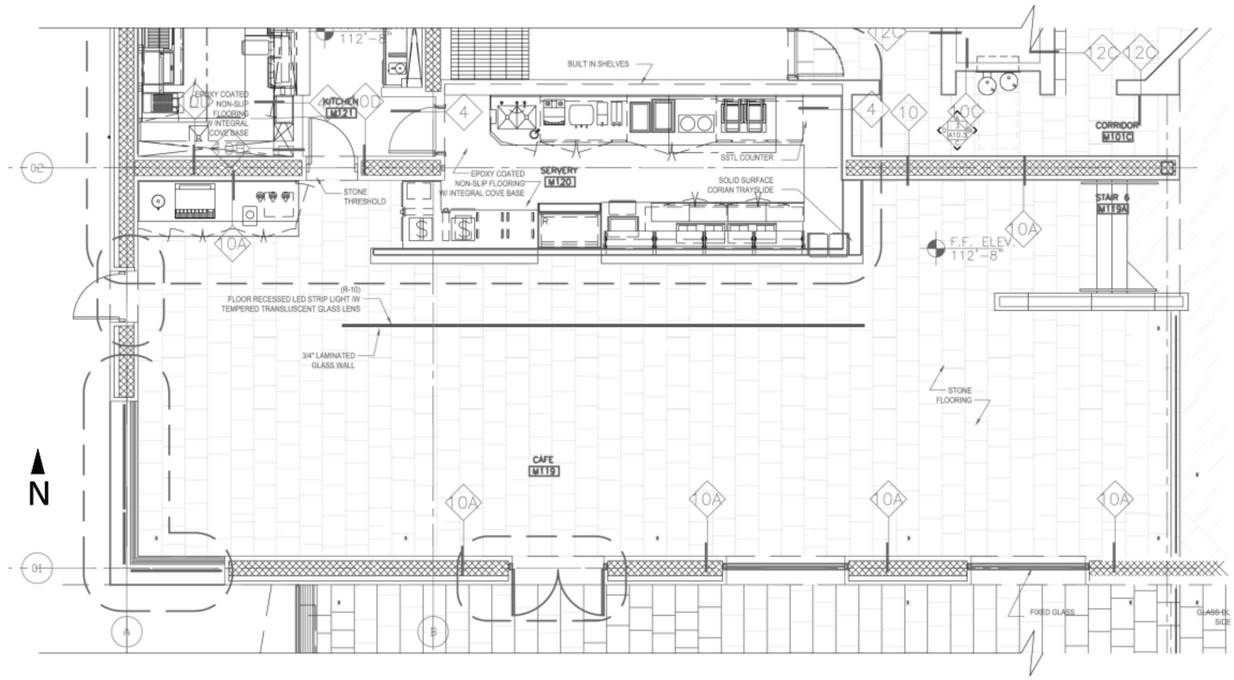


Table 1.1
Café Finishes

Type	Description	Color	Reflectance	Manufacturer
floor	stone	off white	0.6	-
base	aluminum	silver / painted	0.7	-
walls	GWB	off white / painted	0.7	-
ceiling	perf. GWB	off white / painted	0.7	-
window	glazing	glass	t=0.7	-
luminous panel	backlighted ceiling panel	white	t=0.71	Newmat stretch ceiling systems

overall design goals

The main lighting design goals for the café are to create a visually comfort environment while still adding intimacy into the space. Sight lines from the solarium, main hallway, and the outside were considered for reduced glare. Lighted forms dominate the space. Large light sources create intimacy and drama. The luminances of these light forms were not to create a glaring object, but one of visual comfort.

Just as a leaf's biological structure glows by daylight, so do the architectural lighted panels and forms.

tasks + activities

Café Tempo (as it's called), starting at 7am, is open into the evening to all who come to the museum. Patrons as well as passing students can sit down and have a range of different foods. The café also allows for party reservations. It has received a silver medal in the "retail sales-stand-alone" category of the National Association of College and University Food Services Dining Awards. The main activities in this space are dinning and serving food.

design criteria

The illuminance values as well as certain design criteria were taken from IESNA Lighting Handbook. The lighting power density values were taken from ASHRAE/IESNA 90.1.

quantity of light

Table 1.1
Café Illuminace (IES recommendations)

Space	E_h (lux)	E_v (lux)
coffee shop	100	30
servery-employee served	500	200

Table 1.1
Café LPD

Space	Allowance (W/SF)
bar lounge/leisure dining	1.31

table 1

quality of light

visual comfort

Since this is a space where patrons and students come to eat and relax, the visual experience has to be pleasing. Lighted vertical surfaces and ceilings provide comfort to the space which creates an inviting place to unwind.

reinforcement of architecture

The geometry of the large window forms in-between the café and solarium serve as inspiration for the back lighted ceiling surfaces illuminating the main seating area. These lighted panels follow the vertical lines of the window up onto and across the ceiling to envelope the space. The lighted cantilevered form projecting out over the servery imitates the large architectural cantilever at the entrance to the museum. These lighted forms strengthen the minimalist architecture and creates a space full of interest.

creating intimacy

The minimal back lighted forms instill drama into the space. By having such large bright areas and, in contrast, such large dark areas, the café feels intimate and cozy; a place to feel inspired and connected to the people across from you. Creating light as well as shadows provide some visual interest into the space this is fairly plain.

luminances of light sources

Since these back lighted panels provide all of the illumination for the space they need to be bright enough for the café tasks. But these sources should not be overly bright, whereas the luminance should not exceed 150 cd/SF.

modeling of faces

Eating and socializing at the café tables is a personal experience. Therefore the lighting should have quality modeling of faces. Provided area light sources with highlights from track lighting and half height partition walls should give adequate definition on faces.

directionality / circulation

Creating a hierarchy of space relationship within the café is essential for circulation and way finding. The servery, which requires more detailed attention than eating at the seating area, also requires a higher magnitude visual cue. The cantilevered lighted form acts as a beacon to the servery by enclosing the vertical space it surrounds. This leads your eye toward this space while entering.

visual interest

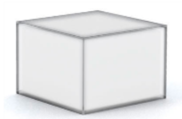
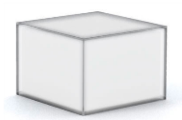
The visual interest for this space comes from the lighted forms and panels. Creating interest also inspires, which is important in any school/museum building.

color temperature + rendering

Since this space receives a lot of daylight, and also needs to be sensitive to artwork and the color rendering of traditional light sources, a middle of the road color temperature was selected throughout the building (3500K). Track lighting, whenever lighting a piece of art, requires a CRI in the 90s, but the general ambient light in the space can be a lower CRI in the 80s.

fixtures and equipment

Table 1.1
Café Equipment Schedule

Type		Manufacturer	Description
	LF1	Newmat	NewLight double-layer ceiling system using T0B/white translucent with T8/clear membranes backlighted with florescent strips
	LF2	Newmat	NewLight double-layer ceiling system using T0B/white translucent with T8/clear membranes backlighted with florescent strips
	LF3	Newmat	NewLight double-layer ceiling system using T0B/white translucent with T8/clear membranes backlighted with florescent strips
	LF4	3 Form	Acrylic cantilever form. One layer 1" Chroma material with 2 layers of vapor material for light diffusion. Integral slot into paver walkway. LED light board side-lighting wall side for gradient distribution. Light to be on all 5 sides of the form.
	LF5	3 Form	Acrylic partition wall. One layer 1" Chroma material with 3 layers of vapor material for light diffusion. Integral slot into paver walkway. LED light board uplighting in grade for gradient distribution. Light to be on all 5 sides of the form.
	L2	Acolyte	LED RibbonLyte static white 3500K. No Channel. 1.5 watts per foot. ~90 lumens/foot package.
	L3	Acolyte	LED RibbonLyte static white 3500K. No Channel. 5 watts per foot. ~440 lumens/foot package.
	L4	Acolyte	LED RibbonLyte static white 3500K. No Channel. 8.8 watts per foot. ~650 lumens/foot package.

	T2	Edison Price	Hanging LED tack system, 1000 lumen package, artist series 97 CRI. 40 degree beam spread. Dimmable standard driver. 3500K

Back-Lighted Panels

The luminous panels overhead of the eating area will be backlighted with LED strips. A ceiling cavity will be made in the profile of the specified panels with 18" depth. L2 luminaires will be use directed straight down, backlighting the PVC Newmat material. To achieve an even distribution of light a mock up would be done. But a spacing of 2' O.C. is a general good rule of thumb. So four strips will be used for the bigger, front panels, while three strips will be used for the smaller, back panels.

Edge-Lighted Partition Wall

The luminous glass partition wall will be lighted from the ground level with an in-grade LED strip. 3From Chroma material will be used as the tranlusent form. A system of three sheets will be installed: One that slides into the raise stone floor and around the LED fixture to ensure stability for the form. One that is used as a thin film, nearly transparent sheet, and finally one that rests on the stone floor to create a perfect seam.

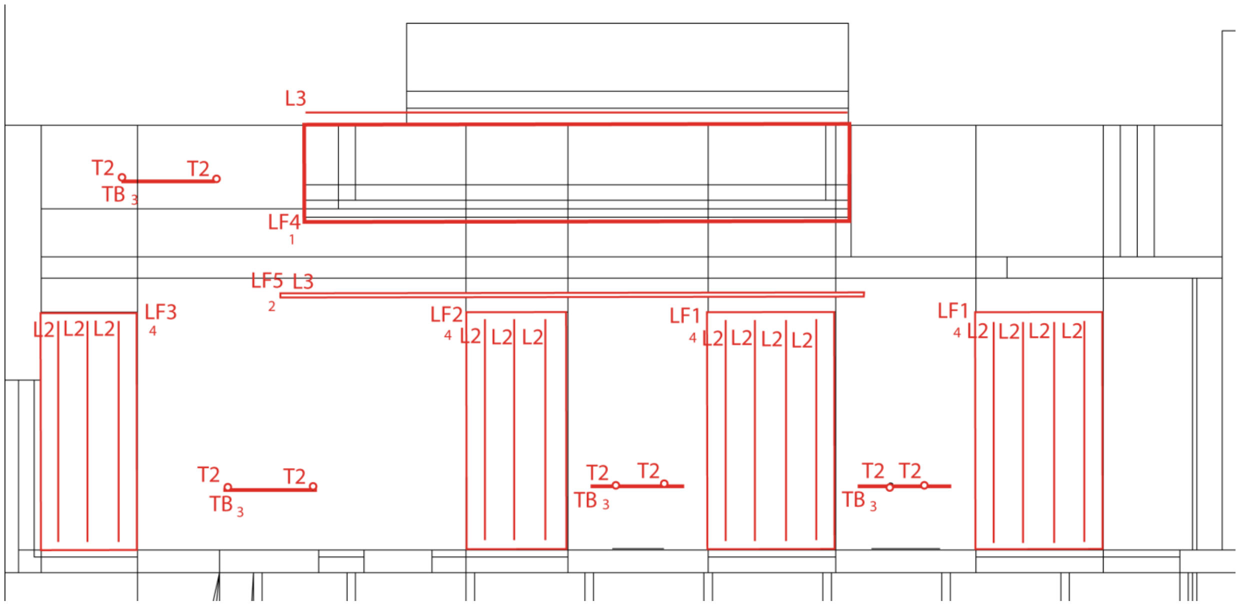
Edge-Lighted Cantilevered Form

The luminous cantilevered form will take special attention to realize. Using tube-steel as the structural support and a multi-layered system of 3Form Chroma material, a completely lighted form could be possible. This form would rest on top of the steel support system and be edge lit from behind the servery. Three LED strips will be needed to have enough light to have an adequately amount of lumens. A removable panel in the ceiling of the servery is used to access the LED luminaires when they need maintenance.

controls

The café will be open for breakfast, lunch, and dinner, as well as for special dinning events for parties. The lighting, therefore, needs to be highly flexible in scene control. Because of the amount of daylight coming into the space, the control schemes also need to be highly reactive. Due to the solarium receiving an abundance of light during all hours of the day, the café will experience, through the connected windows, an adequate amount of light sufficient enough to allow for dimming and off conditions.

café: lighting plan



Renderings

Figure 1.1
Café: Pseudo Color Rendering (Plan View)

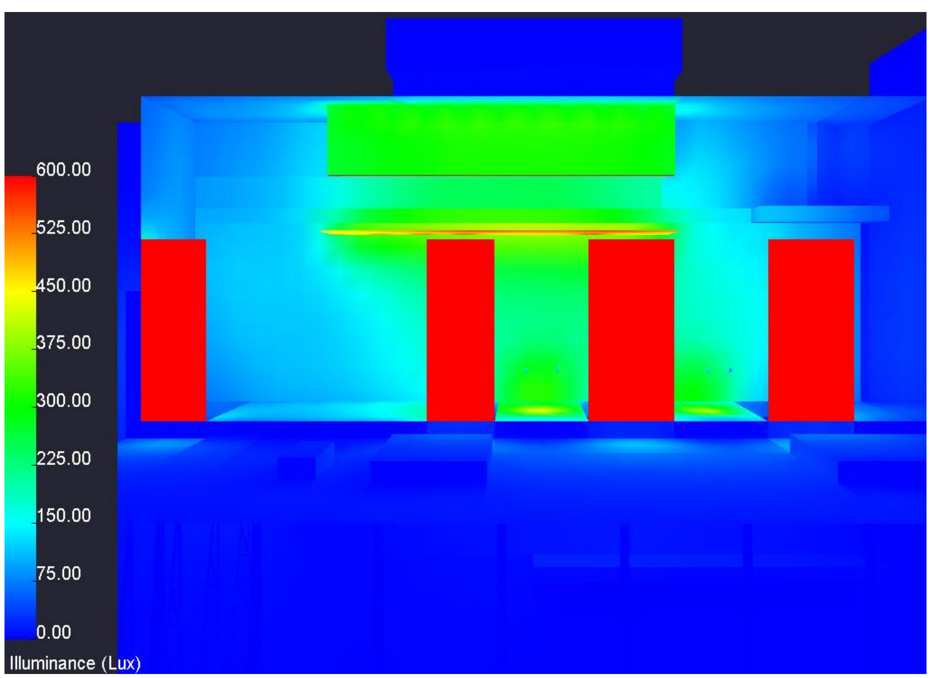


Figure 1.1

Café: Perspective Rendering

calculations

Illuminance

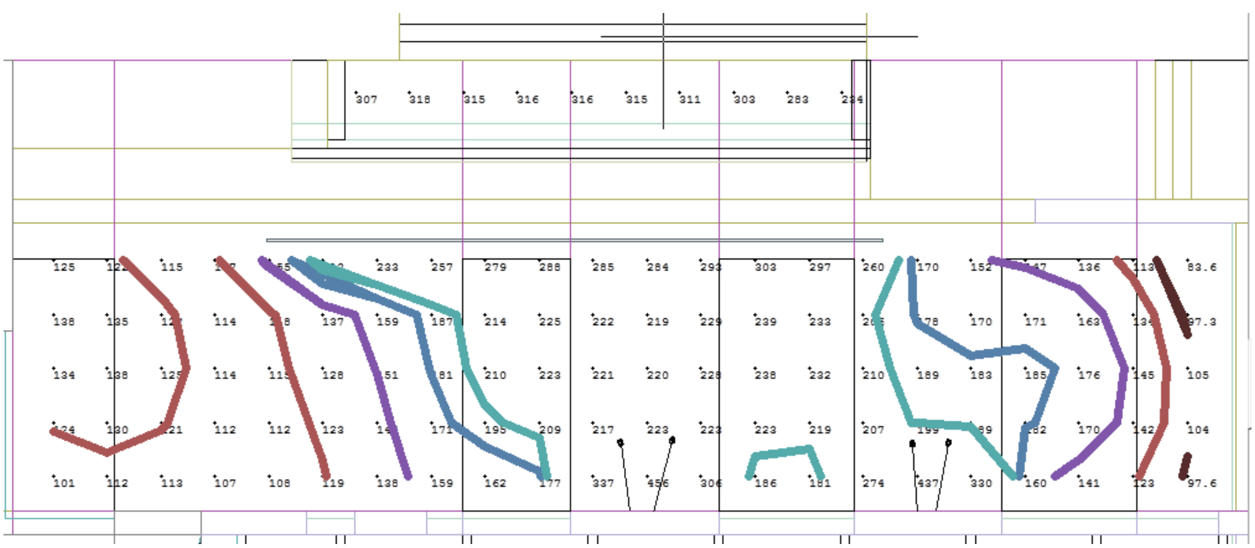


Table 1.1
Café Illuminance Calculation Summary (workplane 1.5')

Space	E_h Recommendation (lux)	E_h Calculated (lux)
coffee shop - eating area	100	183
servery	500	302

Lighting Power Density

Table 1.1
Café Lighting Power Density

Fixture Type	System Wattage	Quantity	Total Watts
LF1	78	2	156
LF2	59	1	59
LF3	59	1	59
LF4	450	1	450
LF5	290.4	1	290.4
TB	120	4	480
Total Watts			1,494.4
Area (SF)			1,625
Watts/SF			0.92
ASHRAE 90.1 compliant?			1.31 - Yes

evaluation

The café, being a place that people come together to relax and enjoy a tasty lunch from the chefs, needed a lighting design that promoted intimacy and visual comfort. By using luminance back-lighted panels in accordance with the architecture, it created a soft, warm atmosphere by which to eat by. The lit forms of the space (partition wall, cantilevered form) bring a little drama and visual interest while still holding true the overall design goals of the museum's minimalism.

Auditorium

description

The Auditorium is located on the second floor, and is connected to the main staircase and elevators. This space is used for presentations and as a classroom. The different programs in the space are very flexible. The space is geometrically a quarter-circle, making the curved wall the back of the room and focusing the front of the room on the center of the circle. The side walls measure 42' while the radius of the circle is 60'. The ceiling is set up in a radial fan pattern, sloping up in the front of the room and down toward the back. The total square footage is about 3,180 SF. Nine rows of desks are located around the quarter circle and slopes down toward the front of the room.

Figure 1.1
2nd Floor Plan

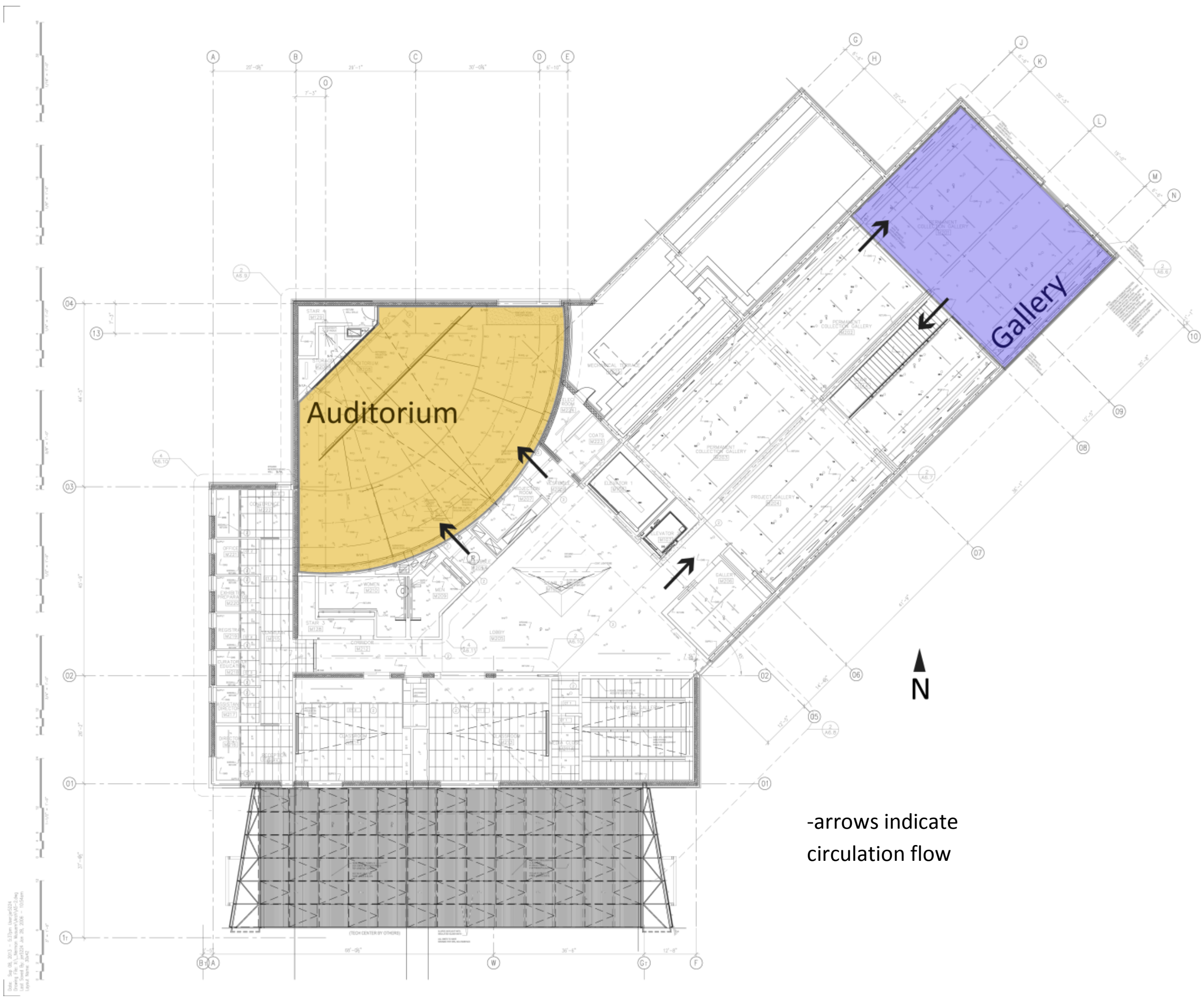


Figure 1.1
Auditorium Floor Plan

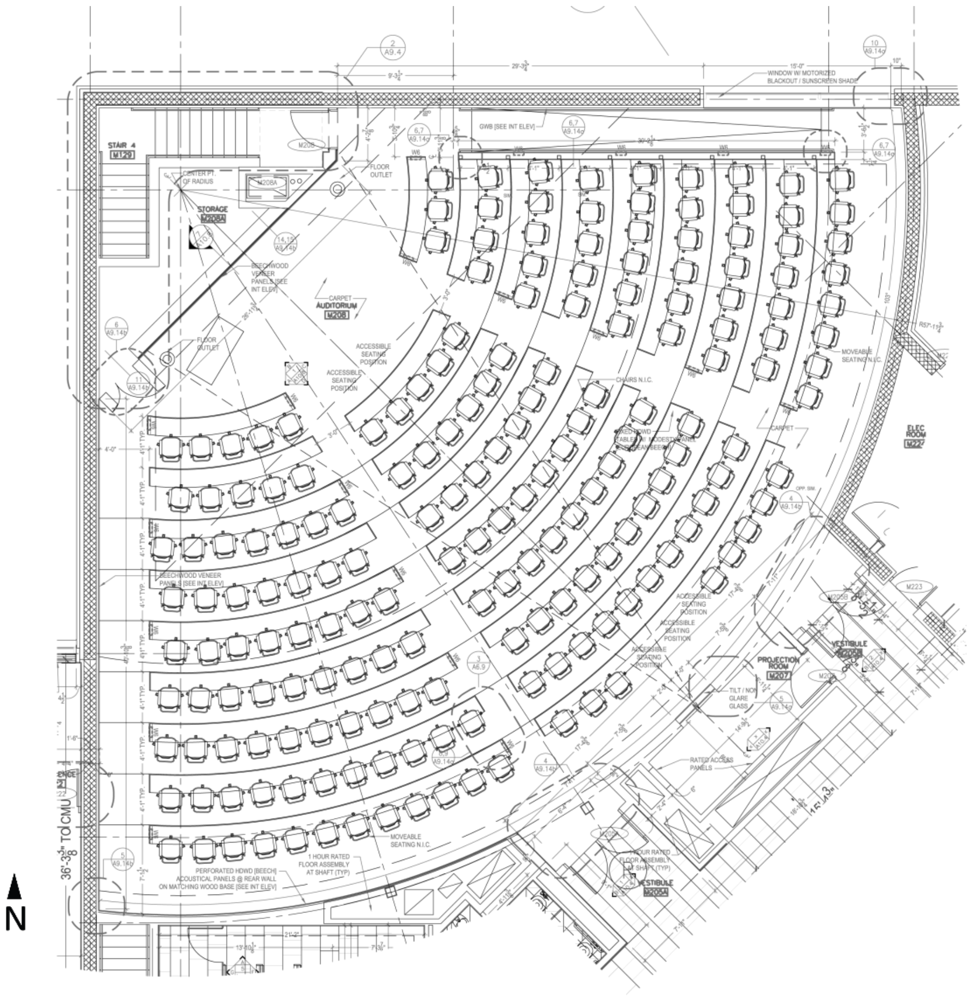


Table 1.1
Auditorium Finishes

Type	Description	Color	Reflectance	Manufacturer
floor	carpet	tan	0.35	-
base	aluminum	silver / painted	0.7	-
walls(side)	GWB / acoustic	off white / painted	0.7	-
walls(front / back)	wood / acoustic	light stain brown	0.5	-
ceiling(behind ceiling panels)	open to metal deck and truss system	grey	0.25	-
window(side)	glazing	glass	t=0.7	-
window(skylight)	diffuse skylight	acrylic	t=0.3	TBD
luminous ceiling panel	backlighted ceiling panel	white	t=0.71	Newmat stretch ceiling systems

overall design goals

The main lighting design goals for the auditorium are to create a relationship with the outside, creating center room focus, providing flexibility to the lighting scheme, creating a general brightness for alertness, and the right amount of illuminance for reading and writing on the desks. By simulating a cheery, overhead sky for the back-lighted ceiling panels, the room be provided with a relationship to the environment. The amount of light will fluctuate a little bit during the day while clouds move overhead. Skylights will provide daylight above the ceiling panels.

Just as a cloudy sky is contrasted by sunlight filtering through, so do the back-lighted ceiling panels.

tasks + activities

The auditorium is mainly used as a classroom throughout the day (8 am – evening classes). Being a part of the Johnson County Community College, the space will need to provide for a variety of different activities. Presentation on art and the work of the Nerman Museum will also take place in the auditorium.

design criteria

The illuminance values as well as certain design criteria were taken from IESNA Lighting Handbook. The lighting power density values were taken from ASHRAE/IESNA 90.1.

quantity of light

Table 1.1
Auditorium Illuminace (IES recommendations)

Space	E_h (lux)	E_v (lux)
av and notes	50	15
av no notes	10	6
feature presentations	10	6
no av	100	40
screen	-	10
speaker face	-	3x audience task
demonstration	1000	500
reading/writing	300	100

Table 1.1
Auditorium LPD

Space	Allowance (W/SF)
classroom/lecture/training	1.24

quality of light

relationship to the outside

By reshaping the ceiling and installing skylights above the auditorium, a connection to the outside will be created. As the clouds over head move, and as the sun moves around the building, the ceiling will change slightly in luminance. It is important to feel that connection to the environment because it will reinforce the heart of the Kyu Sung Woo's architecture.

center room focus

Establishing center room focus at the front of the room and the speaker or lecture is very important to any classroom and auditorium. A higher illuminance and luminance will be needed to achieve this hierarchy of space relationship.

flexibility

Since this space will need to house many different functions, the lighting will need to change accordingly. When the function calls for all the lights to be out, and just the AV running, motorized black-out shades will be deployed over the skylights for total darkness (under daylight condition). All fixtures will have dimming capabilities for the teacher to change as they please, with preset scenes also implemented for easy control. It is very import to have a lighting system that changes as much as the different programs occurring in the auditorium space.

brightness for alertness

A general brightness, that will keep the students awake and at attention, is needed for the overall classroom function of this space. During the daytime hours, when the skylights are being used, the illuminance will be brighter than most times. Lighting the ceiling, walls, and highlighting the front of the room will create a brighter room psychologically, even if the illuminance is at a normal level.

task illuminance

Because students will be using this space as a classroom, it is important that they have enough light to see general reading and writing tasks. Therefore the task illuminance at the work plane (2.5' height) will reach the target IES recommendation.

rendering of faces

Since the auditorium will have different lecturers, moving around the front of the room, it is important to light their faces well. Track lighting will highlight their faces from multiple locations in the ceiling, while a soft wash on the front wall will give depth to the scene.

visual interest

Creating some visual interest is fairly important because this is a school building and museum. The visual scale and brightness of the ceiling will provide the some additional visual interest to the space that is already rich with interesting architecture.

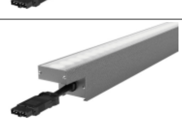
color temperature

Staying consistent with 3500K color temperature for the light sources is very important. When moving from space to space, a constant feel or tone is needed to create a total visual experience.

fixtures and equipment

Table 1.1

Auditorium Equipment Schedule

Type		Manufacturer	Description
	F1	Bartco	4 foot linear fluorescent strip. Integral ballast. (1) T8 lamp.
	F2	Bartco	4 foot linear fluorescent strip. Integral ballast. (2) T8 lamp.
	P1	Indy (Juno)	Pendant mount LED 9 inch cylinder downlight. 2000 lumen package. 31 watts. Open aperture with integral driver.
	P2	Indy (Juno)	Pendant mount LED 9 inch cylinder downlight. 2800 lumen package. 46 watts. Open aperture with integral driver.
	L5	Lumenpulse	1 foot LED strip. 8.5 watts/foot, Regular Output. 10x60 degree beam spread. Integral driver with standard dimming.
	L6	Lumenpulse	4 foot LED strip. 8.5 watts/foot, Regular Output. 10x60 degree beam spread. Integral driver with standard dimming.

	T4	Edison Price	Hanging LED tack system, integrated with fabric panel system, 1500 lumen package, 80+ CRI. 20 degree beam spread. Dimmable standard driver. 3500K
	T5	Edison Price	Hanging LED tack system, integrated with fabric panel system, 1500 lumen package, 80+ CRI. 40 degree beam spread. Dimmable standard driver. 3500K

Ceiling Redesign

To fully realize the lighting design concept for the auditorium, a new ceiling design was needed to let more daylight into the room. Respect to the architecture and its overall concept was kept in mind when coming up with the new ceiling. Taking cues from the architecture's clean lines, regular geometry, and use of voided space, a series of radial panels in the shape of a fan were designed. By sloping up in the front of the room, and coming back down toward the back of the room, the auditorium is transformed into a vaulted space. The overlap of the panels adds depth and a focal point to the front of the room, marking the pinnacle of the space. The vaulted ceiling also adds acoustical performance by relaying speech to the back of the room more effectively.

Figure 1.1
Initial Ceiling Design

Figure 1.1
New Ceiling Design – Concept

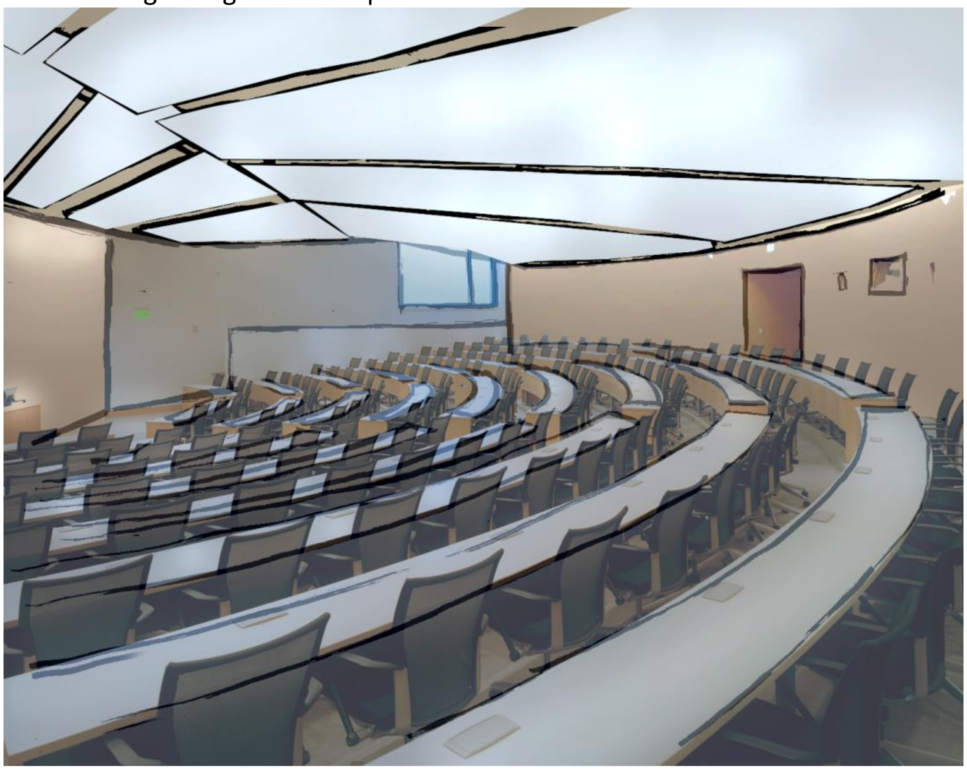
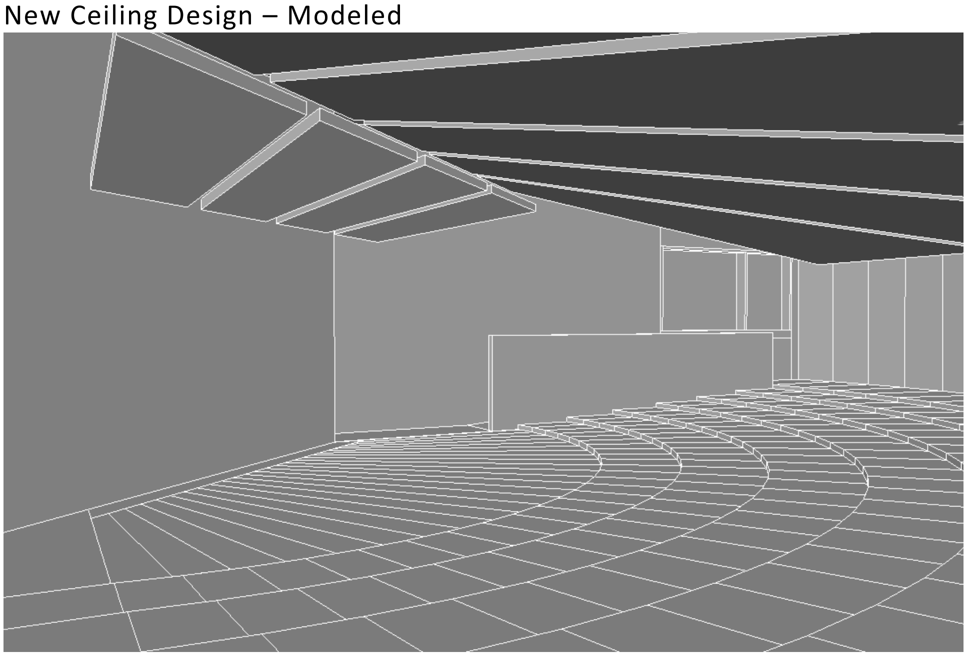


Figure 1.1
New Ceiling Design – Modeled



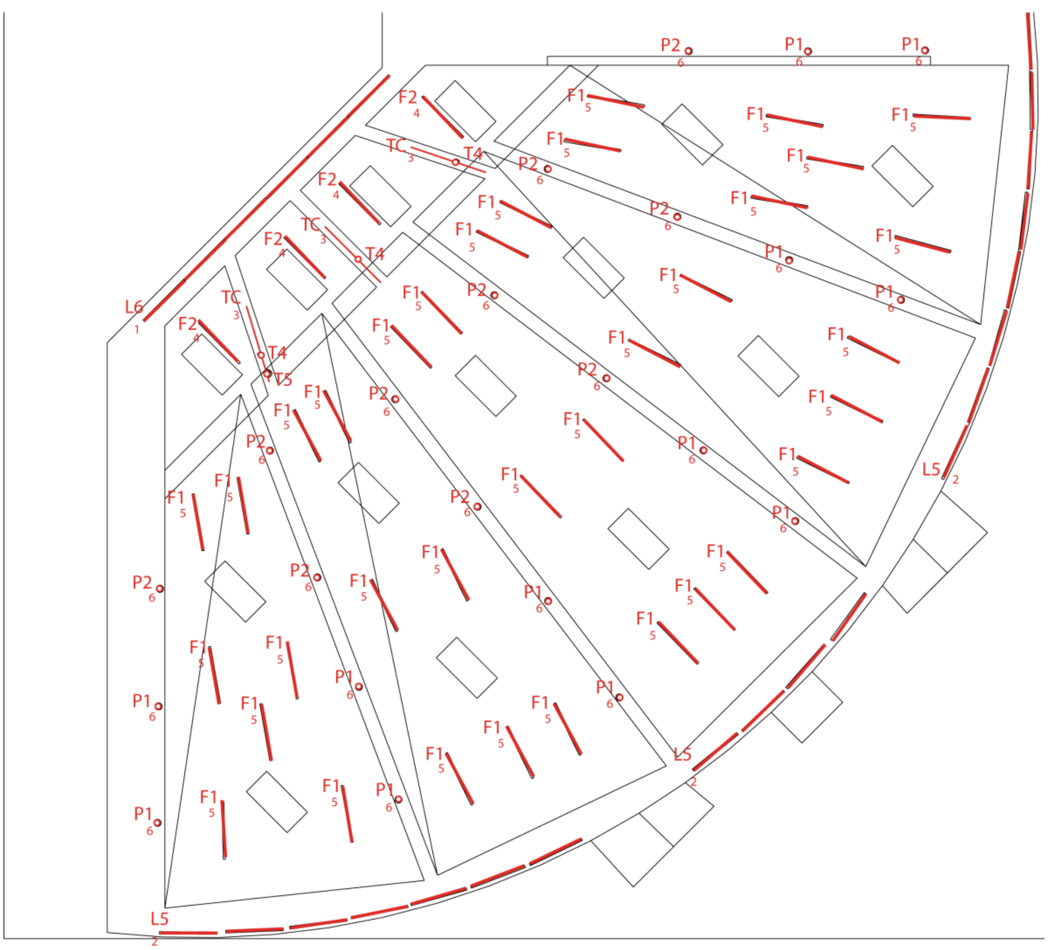
controls

A workable control scheme for the auditorium is imperative to make this space function. Being a space that's also a classroom, total darkness is needed from time to time to view AV presentations. Controls for manual black-out shades for the skylights, and the window will be used, so that any time the presenter needs a dark room, a button can be pressed to achieve it.

Balancing light levels across the space is also very important to a space that can't have too many distractions. The overall light contribution from the skylights is minimal, but during the day, all the supplementary fluorescent fixtures can be turned off. Dimming of the LED cylinders will be utilized on a photo-sensor. A closed loop photo-sensor placed at 3 points throughout the room will work together to dim these LED cylinder luminaires to the desired light levels. This will save energy and maintain appropriate light levels.

Each the back and front wall grazing luminaires can be turned on and off separately to added control. All fixtures are dimmable. But there will be a control panel that has a few pre-set scenes for AV, AV with notes, full on, and daylight scene. These are simple, and make up for most of the scene needed throughout the year. Some settings can be found at the calculations part of this section.

auditorium: lighting plan



Renderings

Figure 1.1
Auditorium: Pseudo Color Rendering (Nighttime)(Perspective View) Calculation is in Fc

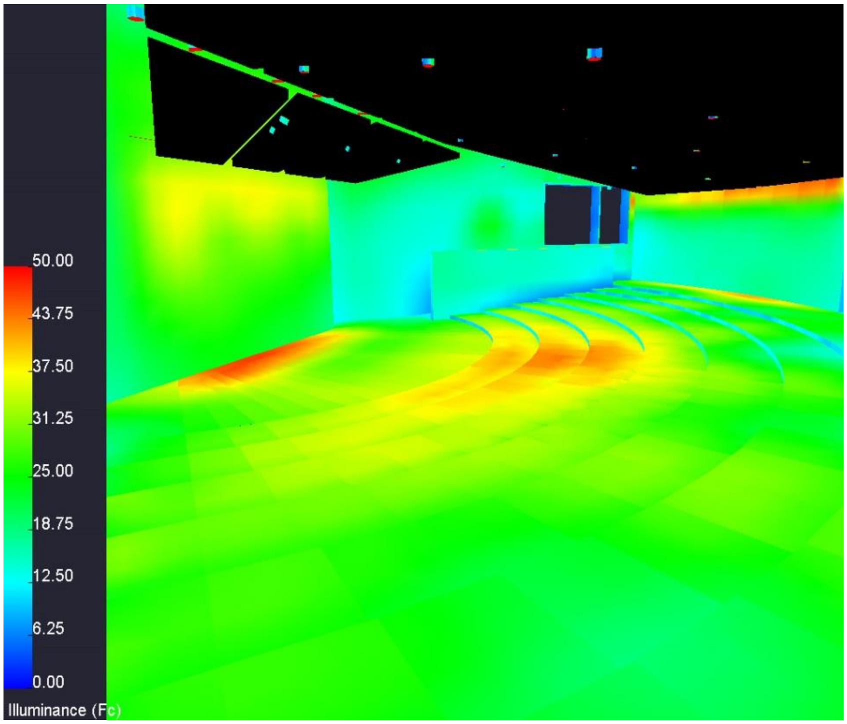


Figure 1.1
Auditorium: AV Scene (Perspective View) Calculation is in lux

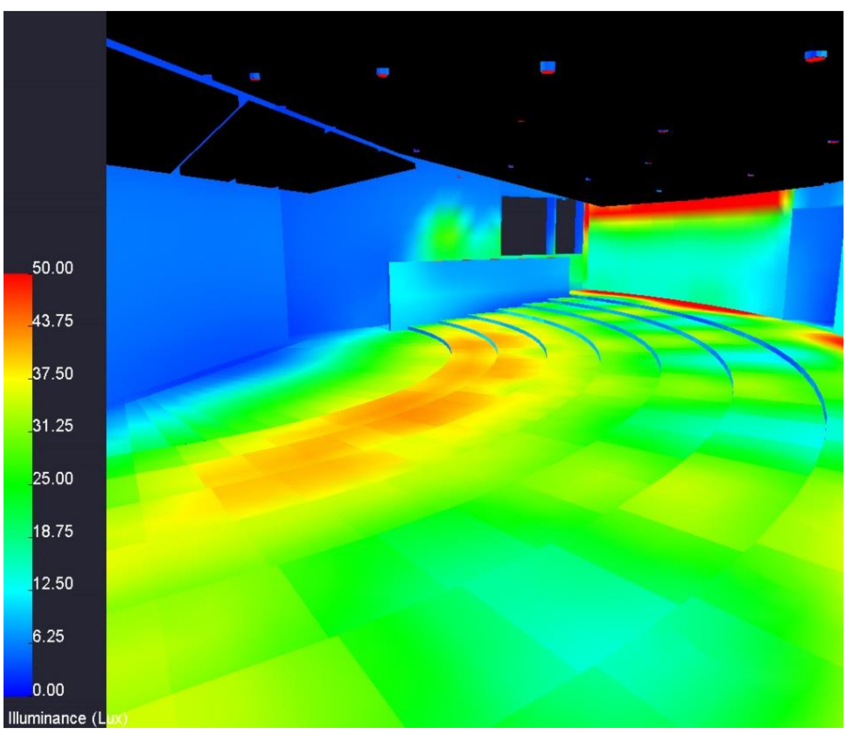


Figure 1.1
Auditorium: Daytime June 21st 1:00 pm – clear sky (Perspective View) Calculation is in lux

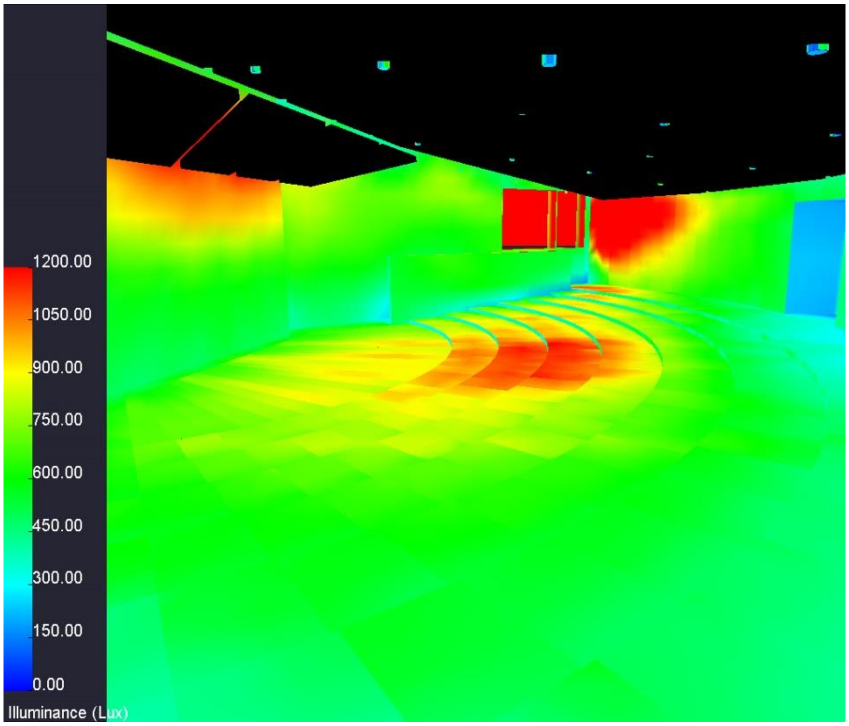


Figure 1.1
Auditorium: Daytime June 21st 1:00 pm – clear sky (Perspective View) Calculation is in lux

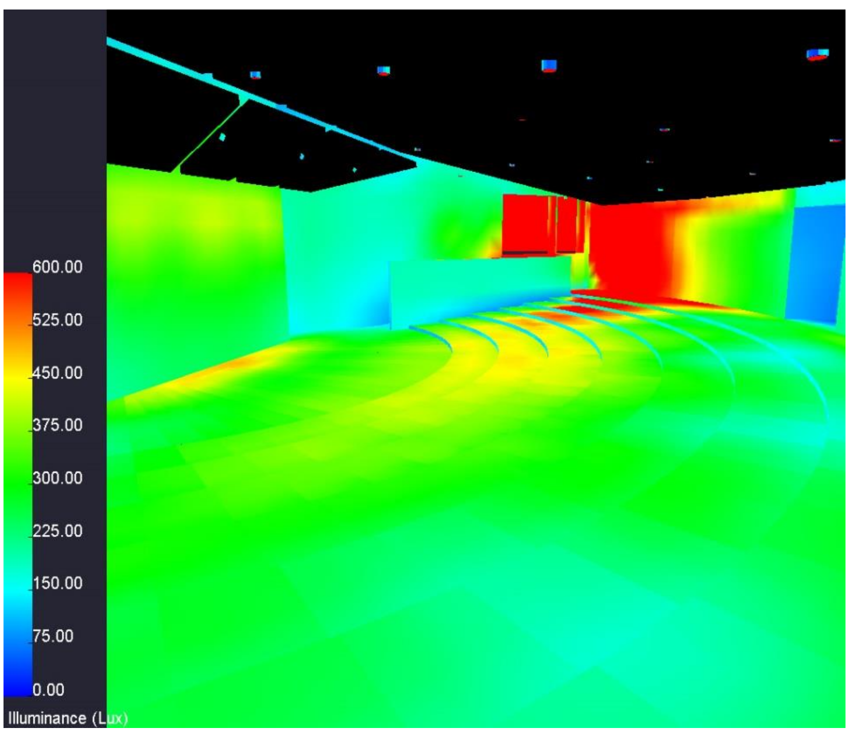


Figure 1.1

Auditorium: Nighttime Perspective Rendering #1 (All lighting on)

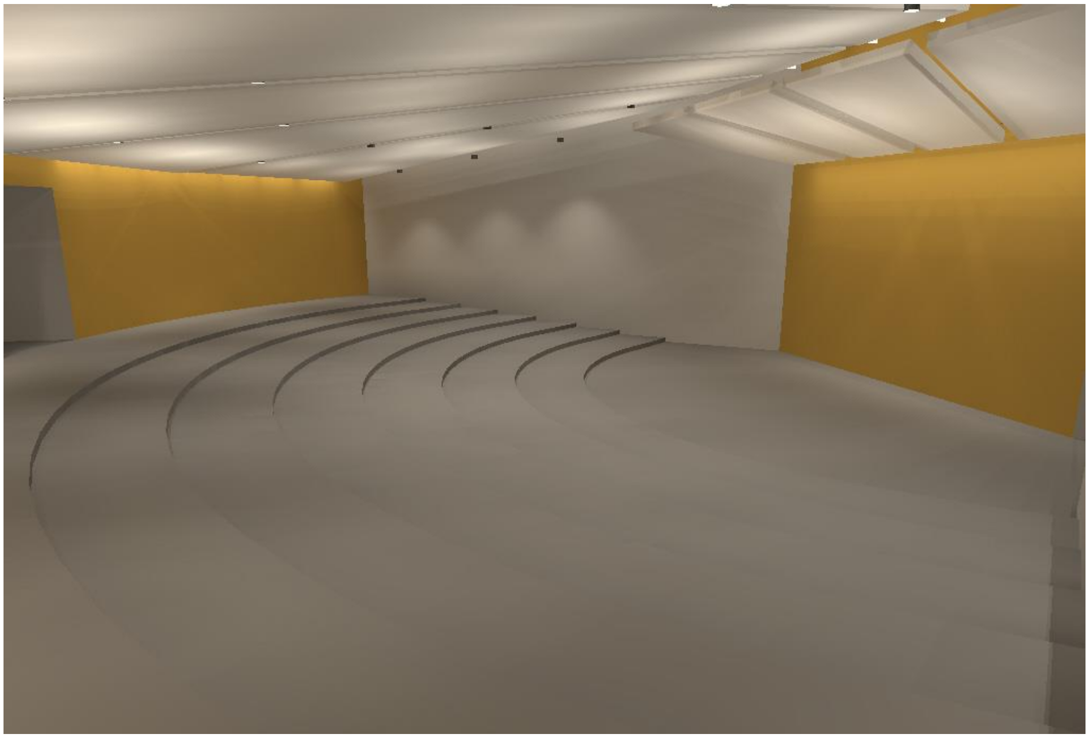


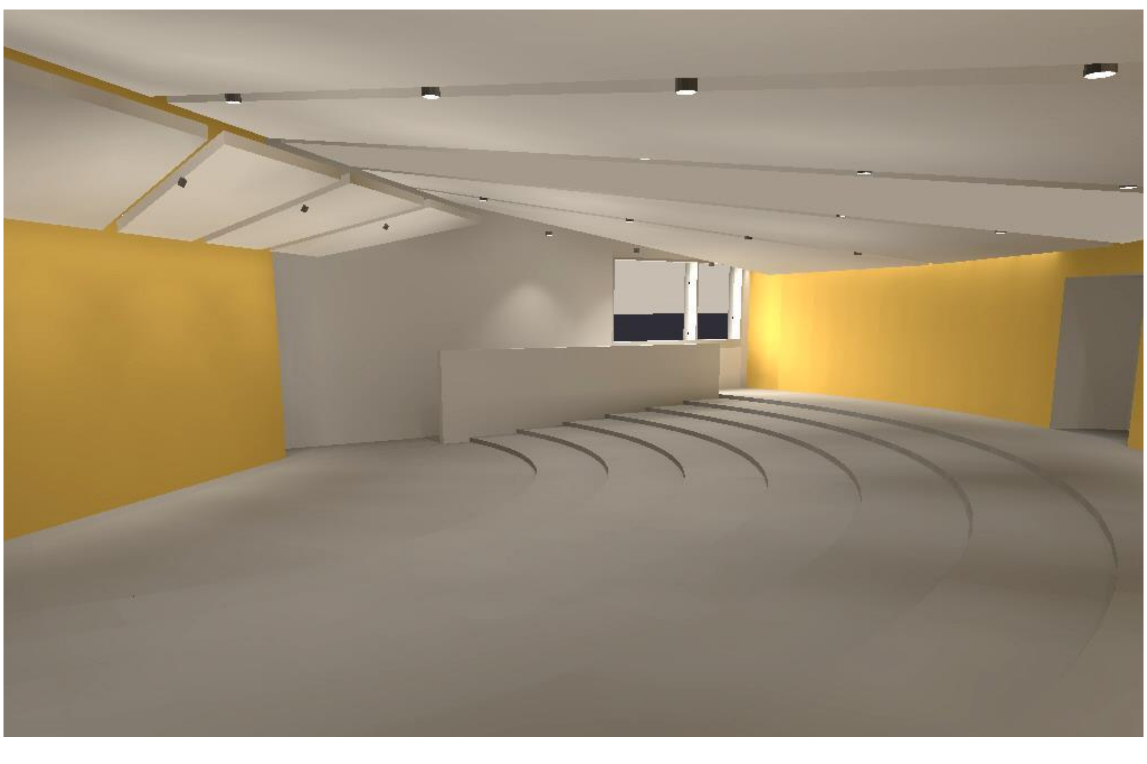
Figure 1.1

Auditorium: Nighttime Perspective Rendering #2(All lighting on)

Figure 1.1
Auditorium: AV Scene Perspective Rendering

Figure 1.1
Auditorium: Perspective Rendering (Daytime June 21st 1:00 pm – clear sky)

Figure 1.1
Auditorium: Perspective Rendering (Daytime June 21st 1:00 pm – overcast sky)



calculations

Illuminance

Figure 1.1

Auditorium: Illuminance Grid Points with Isolines (Nighttime) All lighting on

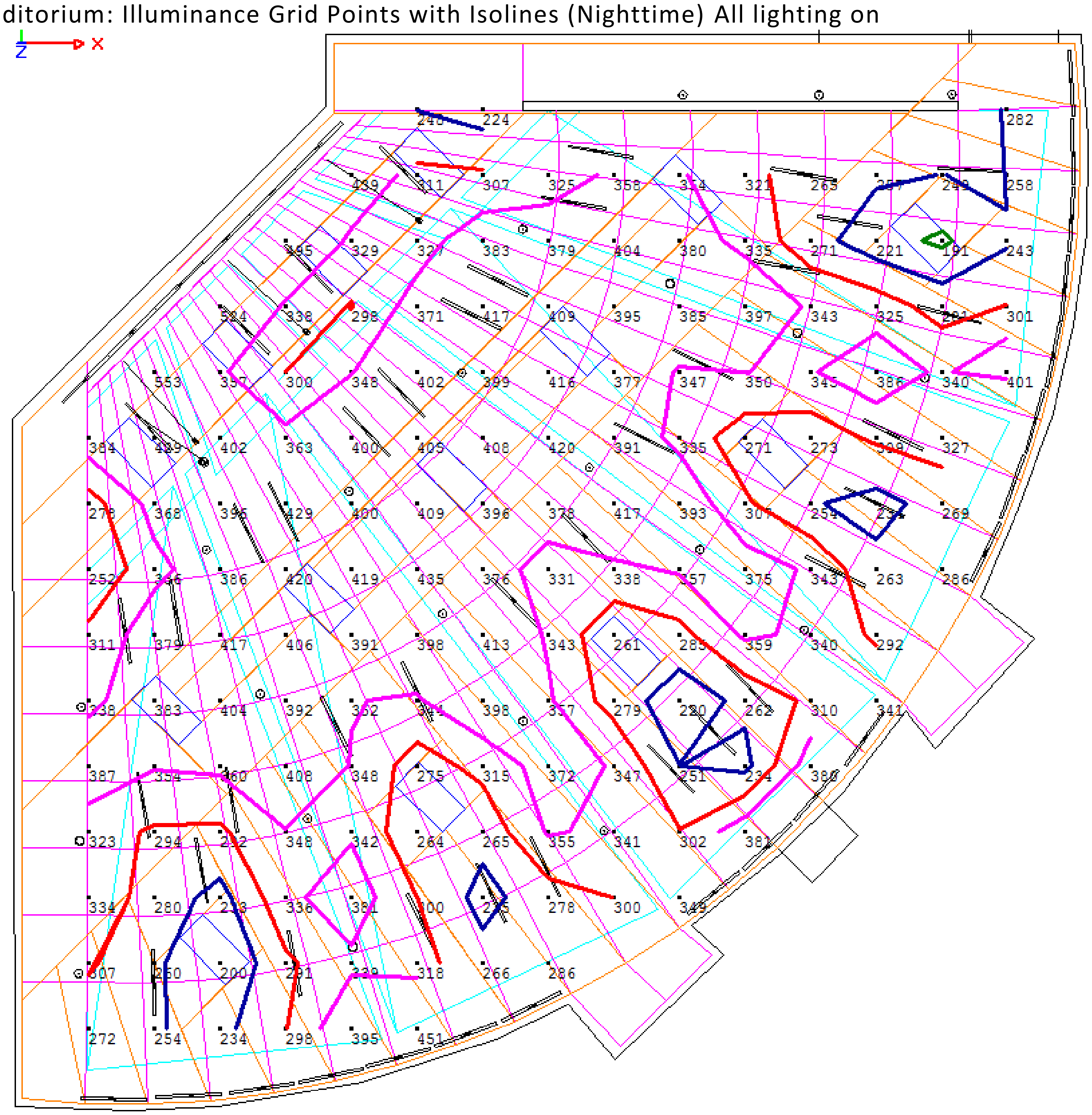


Figure 1.1

Auditorium: Illuminance Grid Points with Isolines (Nighttime) All lighting on

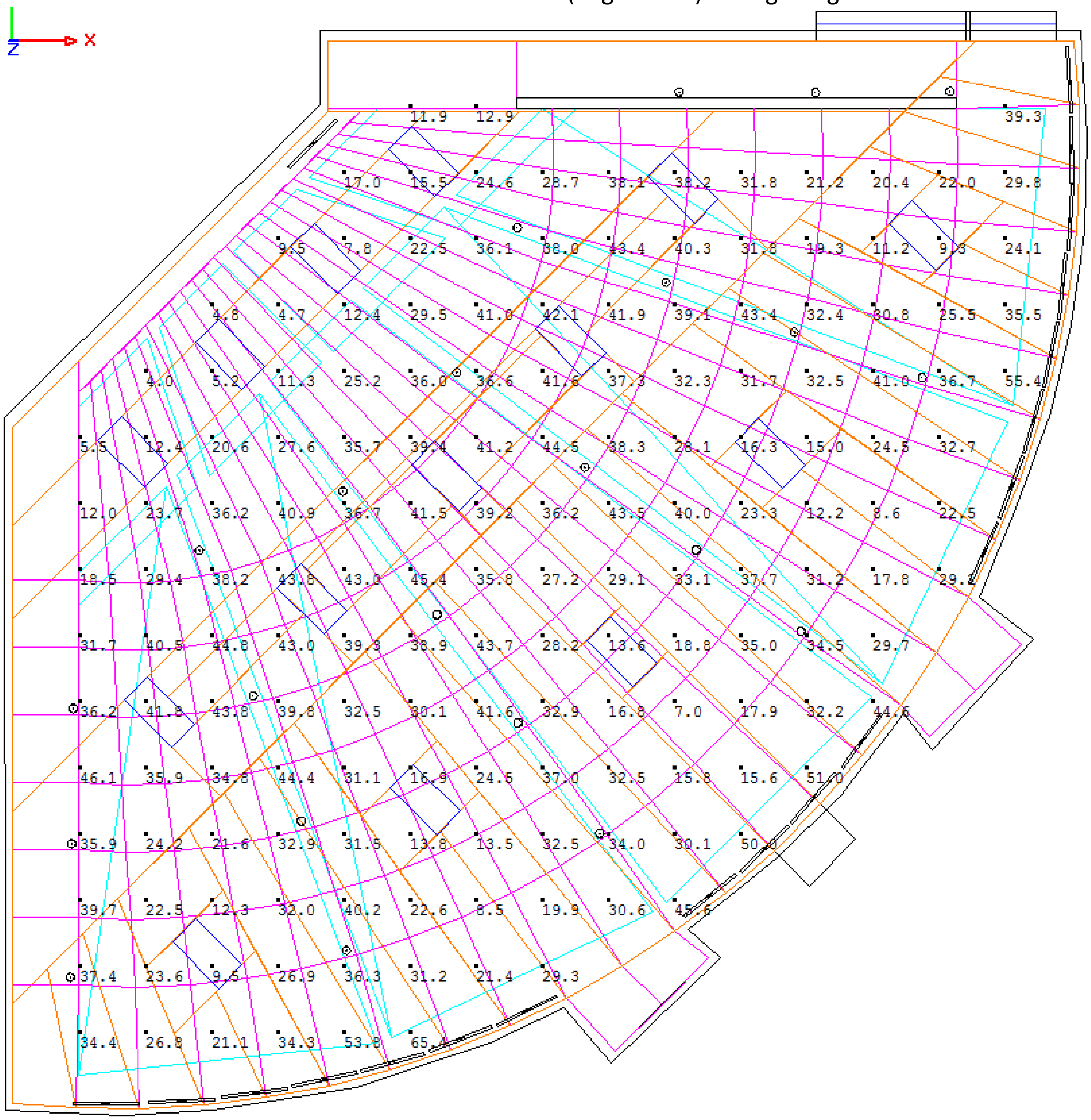


Figure 1.1

Auditorium: Illuminance Grid Points with Isolines (Daytime June 21st 1:00 pm – clear sky)

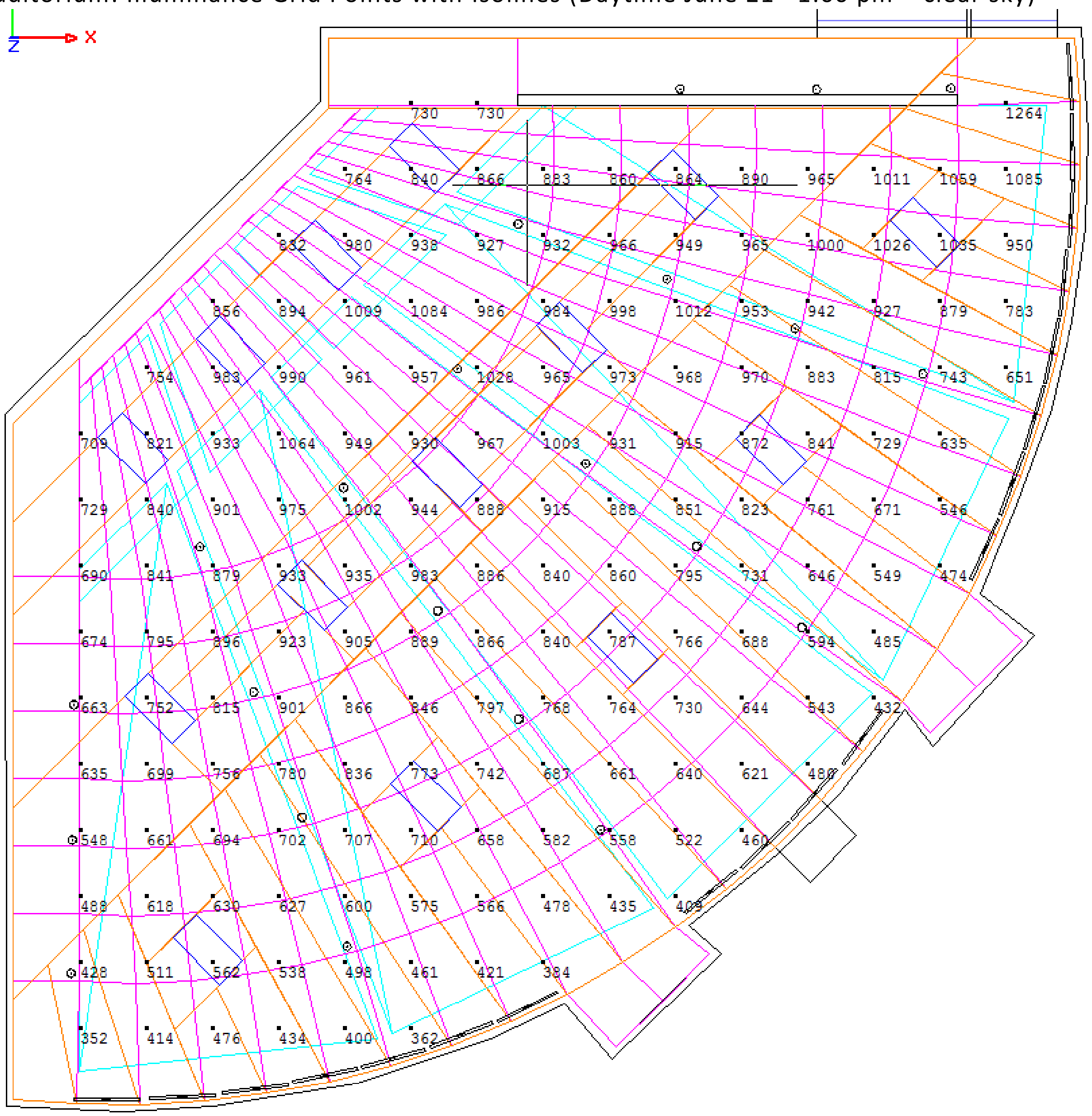


Figure 1.1

Auditorium: Illuminance Grid Points with Isolines (Daytime June 21st 1:00 pm – overcast sky)

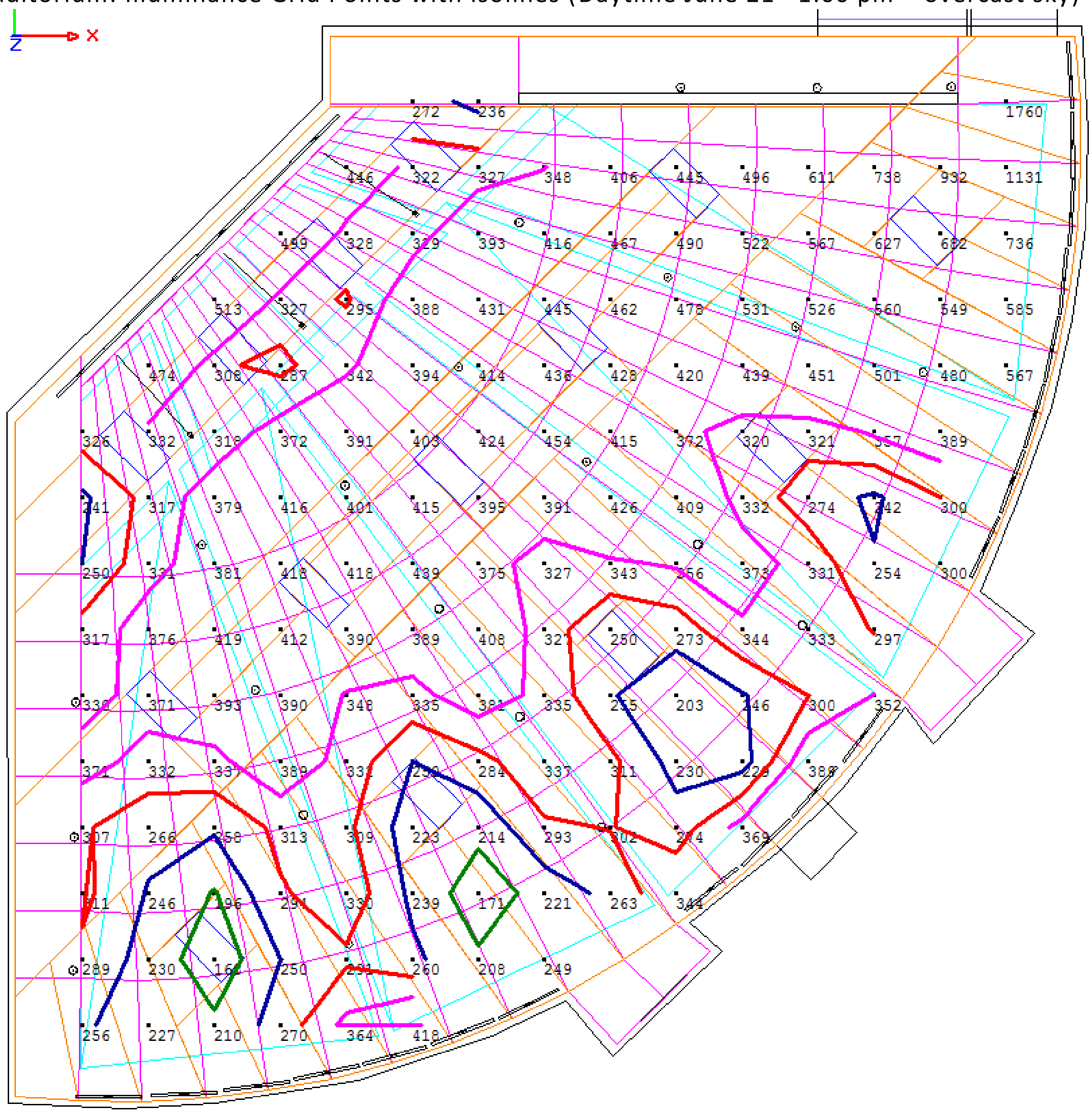


Table 1.1

Auditorium Illuminance Calculation Summary (workplane 1.5')

Space	E_h Recommendation (lux)	E_h Calculated (lux)
classroom reading and writing	300	336
AV & Notes	50	30
Daylight on clear day	-	940
Daylight on overcast day	-	378

Lighting Power Density

Table 1.1
Auditorium Lighting Power Density

Fixture Type	System Wattage	Quantity	Total Watts
F1	33	32	1,056
F2	66	7	462
P1	31	13	403
P2	46	10	460
L5	8.5	76	646
L6	34	6	204
TB	120	3	360
Total Watts			3,591
Area (SF)			3,350
Watts/SF			1.07
ASHRAE 90.1 compliant?			1.24 - Yes

evaluation

The Auditorium, originally having little connection to the outside environment, now has a fully dynamic day-lit space. This adds some visual interest and overall brightness to the room for alertness. Controls are used to achieve highly flexible lighting scenes that are necessary for classroom functions. Overall, the space feels more lively, interesting, and visually comforting.

Gallery

description

The Gallery of study is located on the second floor, in the cantilever part of the building. This gallery is also the only gallery with a side window making it problematic with glare issues. There are two entrances and/or exits for this gallery. One is through another adjacent gallery, and the other is through a doorway and down a set of stairs that lead to the main first floor hallway. It measures 51' x 36' x 16'(h). This makes the space one large box that amounts to 1,836 SF. Art work can be found on all four sides as well as the potential for sculpture in the middle of the space.

Figure 1.1
2nd Floor Plan

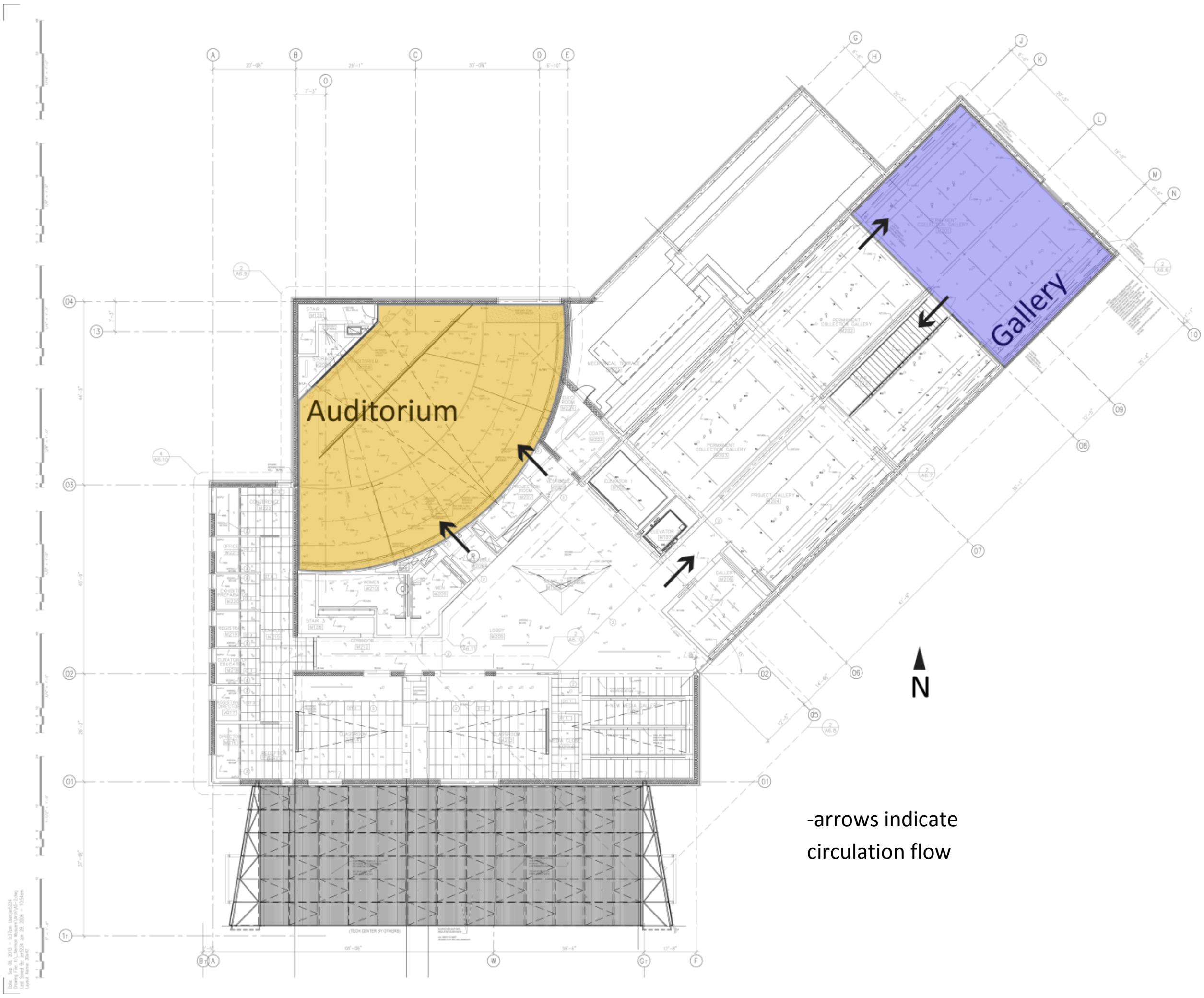


Figure 1.1
Gallery Floor Plan

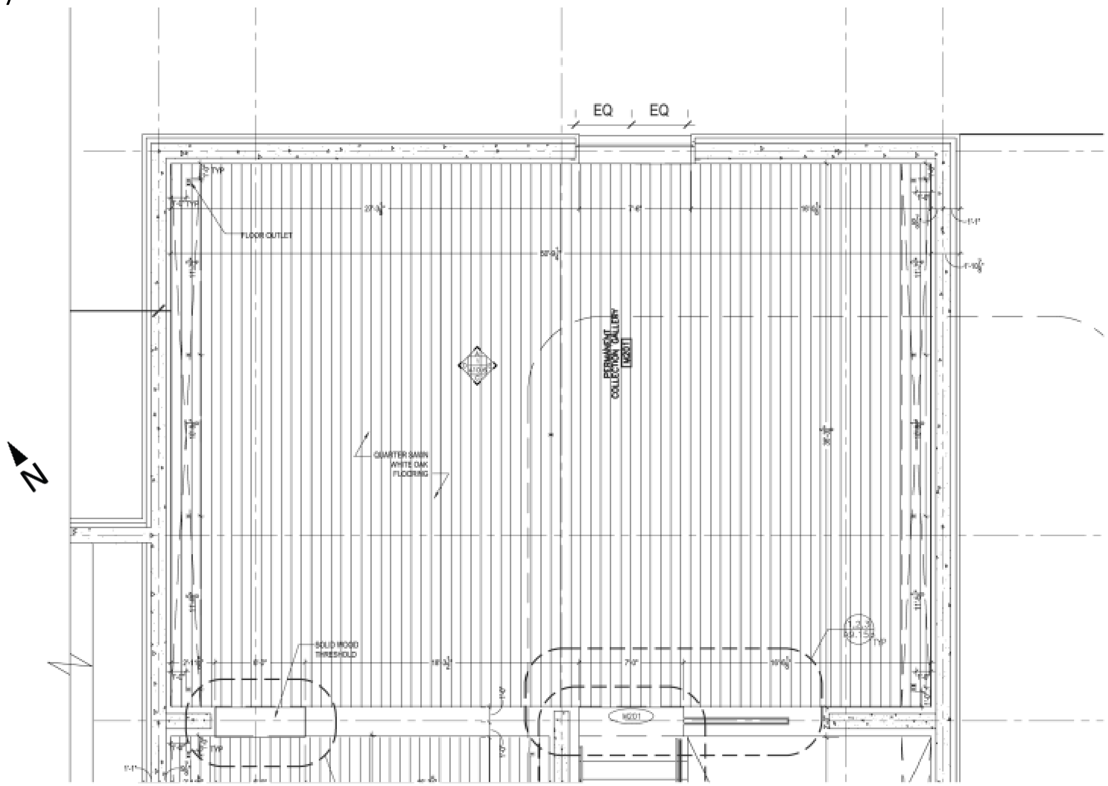
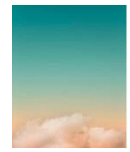


Table 1.1
Gallery Finishes

Type	Description	Color	Reflectance	Manufacturer
floor	stone	brown	0.6	-
base	aluminum	silver / painted	0.7	-
walls	GWB	off white / painted	0.7	-
ceiling	perf. GWB	off white / painted	0.7	-
window	glazing	glass	t=0.7	-
fabric panel	stretched fabric over track system	fairly translucent	openness= TBD	TBD

overall design goals

The main design objective for the gallery, first and foremost, is to compel the artwork to standout. The lighting will also take into account the contrast, particularly during daytime hours, reinforcing architectural form, protecting the artwork from harmful electromagnetic light, and creating an overall pleasant space to look at art in. The ceiling will be reconfigured to have three drop down fabric panels. The track lighting will be integrated into the framing system. These fabric panels will be grazed at the edge of the frame to create a gradient sky. This strengthens the connection to the buildings environment.



Just as a sky's horizon is painted with a gradient, so are the grazed fabric ceiling panels.

tasks + activities

The main activities in this space will be to view the artwork. During off hours, the lighting will have to accommodate work conditions to change or alter art in the space.

design criteria

The illuminance values as well as certain design criteria were taken from IESNA Lighting Handbook. The lighting power density values were taken from ASHRAE/IESNA 90.1.

quantity of light

Table 1.1
Gallery Illuminace (IES recommendations)

Space	E_h (lux)	E_v (lux)
art(high sensitivity)- moderate focals	-	50
art(low sensitivity)- moderate focals	-	200
art(no sensitivity)- moderate focals	-	1000
gallery general- moderate focals	0.1x E_v of art w/ ≥ 10	-
security	30	30
work light	150	30

Table 1.1
Gallery LPD

Space	Allowance (W/SF)
gallery - artwork	1.05
ASHRAE 90.1 section 9.6.2: additional interior lighting power for highlighting art (+1.0 W/SF)	1.00 + 1.05 = 2.05

quality of light

contrast

Balancing the luminances between the window, walls, and art work is imperative to allowing the art work to stand out. Using IES recommended values for moderate artwork focus will be used to create a pleasing viewing experience. Too much contrast and the viewers will become fatigued, while not enough contrast won't allow the art to stand out.

flexibility

Flexibility for the different artwork moving around the space is crucial. Wherever the art director of the museum needs to put the art, he or she needs the appropriate aiming angles. A track system will be used in the space to allow for maximum flexibility, but also the track placement also has to well thought-out and adaptable.

architectural form

The minimalist box that is the space also needs to be preserved by the lighting design. Consideration to fixture locations will be looked at.

luminances visual surfaces

The luminances of the artworks and room area will be balanced under a moderate focus according to IES recommendations.

protecting the artwork

Pieces of art often are very sensitive to UV and IR light. They can deteriorate the art over long exposures. Although most contemporary artwork is not as susceptible to UV light as ancient artworks, consideration still needs to be made. Paint finishes as well as fixture filters will be studied to protect the artworks from harmful electromagnetic radiation.

color rendering

Color rendering is very important to lighting pieces of art. A high CRI (+90s) is required to fully see the accurate colors of the artwork. By considering LEDs, the light engine must be looked at to make sure the CRI will render all colors accurately. Halogen sources are traditionally used because of their high color rendering properties.

visual interest

Creating some visual interest that reinforces the architecture and overall design is important to strengthen the total visual experience of the Nerman Museum.

color temperature

Since this space receives a lot of daylight, and also needs to be sensitive to artwork and the color rendering of traditional light sources, a middle of the road color temperature was selected throughout the building (3500K). Track lighting, whenever lighting a piece of art, requires a CRI in the 90s, but the general ambient light in the space can be a lower CRI in the 80s.

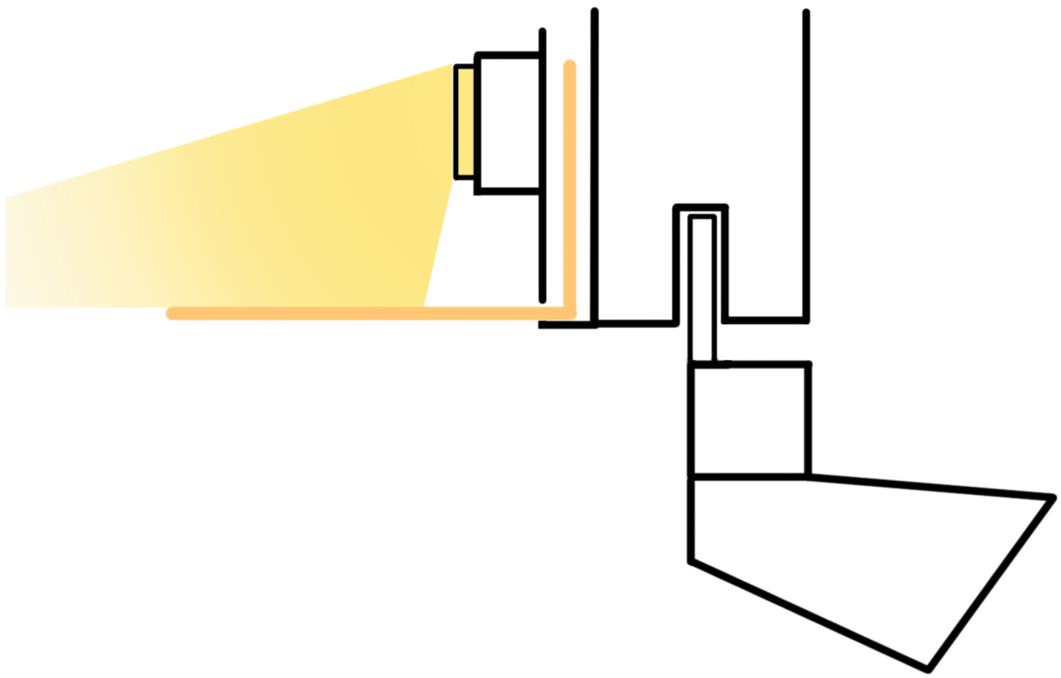
fixtures and equipment

Table 1.1
Gallery Equipment Schedule

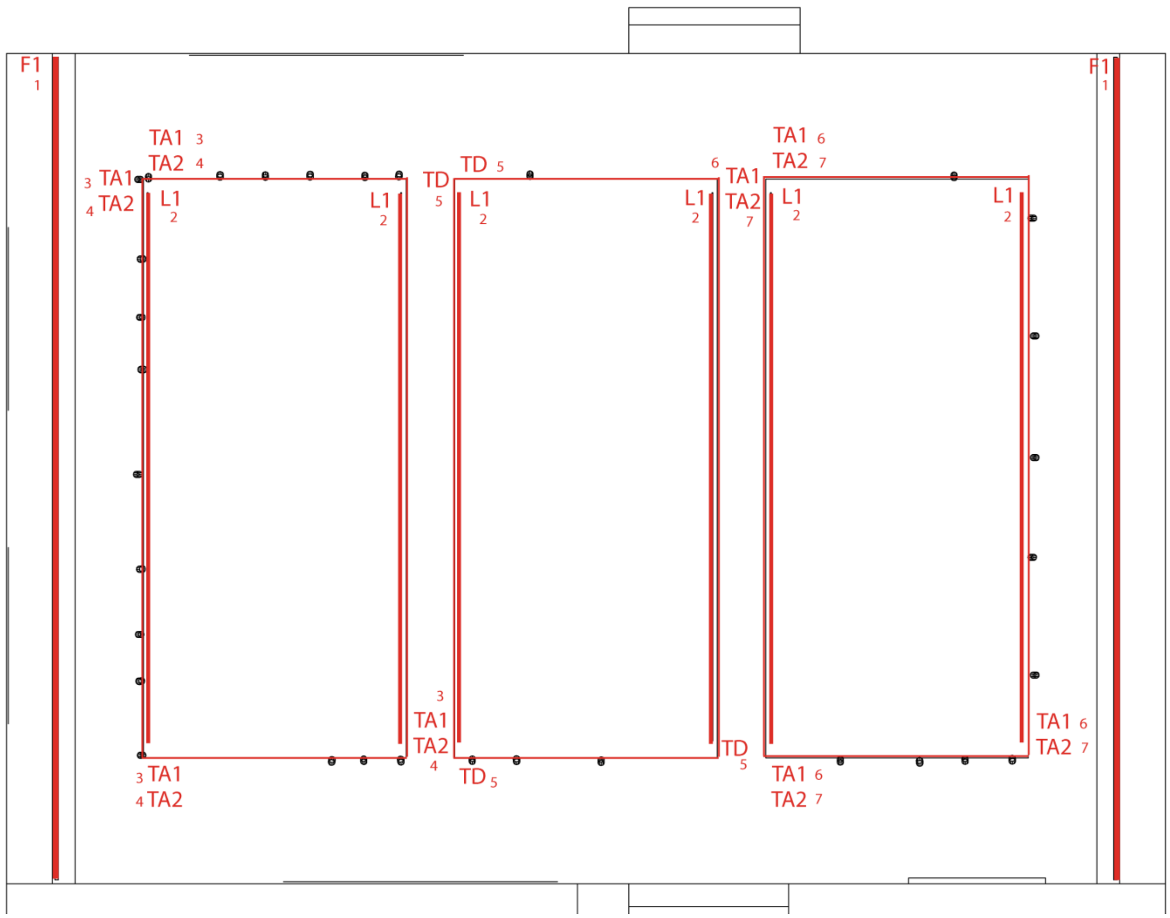
Type		Manufacturer	Description
	F1	Bartco	4 foot linear fluorescent strip. Integral ballast. (1) T8 lamp.
	L1	Acolyte	LED RibbonLyte static white 3500K. AT3 Channel with 30 degree beam spread. 1.5 watts per foot.
	T1	Edison Price	Hanging LED tack system, integrated with fabric panel system, 1000 lumen package, artist series 97 CRI. 20 degree beam spread. Dimmable standard driver. 3500K
	T2	Edison Price	Hanging LED tack system, integrated with fabric panel system, 1000 lumen package, artist series 97 CRI. 40 degree beam spread. Dimmable standard driver. 3500K
	T3	Edison Price	Hanging LED tack system, integrated with fabric panel system, 1000 lumen package, artist series 97 CRI. 60 degree beam spread wall washer. Dimmable standard driver. 3500K

Detail of Track Integration into Fabric Panel System

The stretched fabric is fully integrated with the track system. This system is hanging a full 1' off the ceilng. This lets the form of the space remain intact and not full of track fixtures. The LED strip is mounted directly behind the fabric to gently graze it. A grating pattern for the fabric will be used. This system allows for flexibility with different aiming points while still adding ambient light to the middle of the gallery.



gallery: lighting plan



Renderings

Figure 1.1
Gallery: Pseudo Color Rendering (Nighttime)(Perspective View)

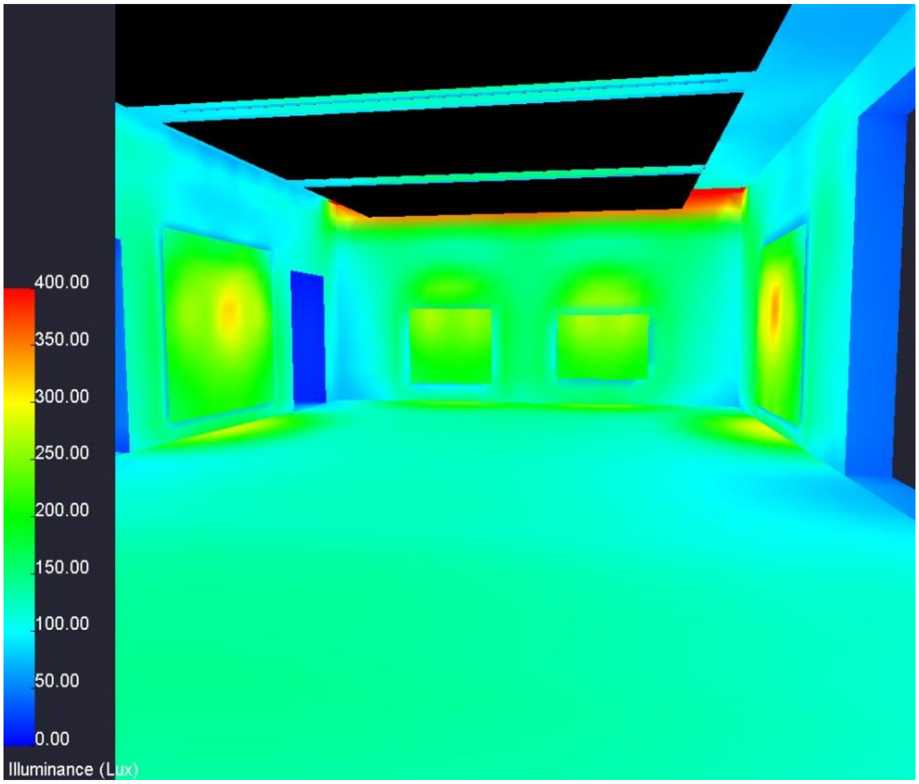


Figure 1.1
Gallery: Daytime Perspective Rendering (June 20th 1:00 p.m. – Overcast sky)

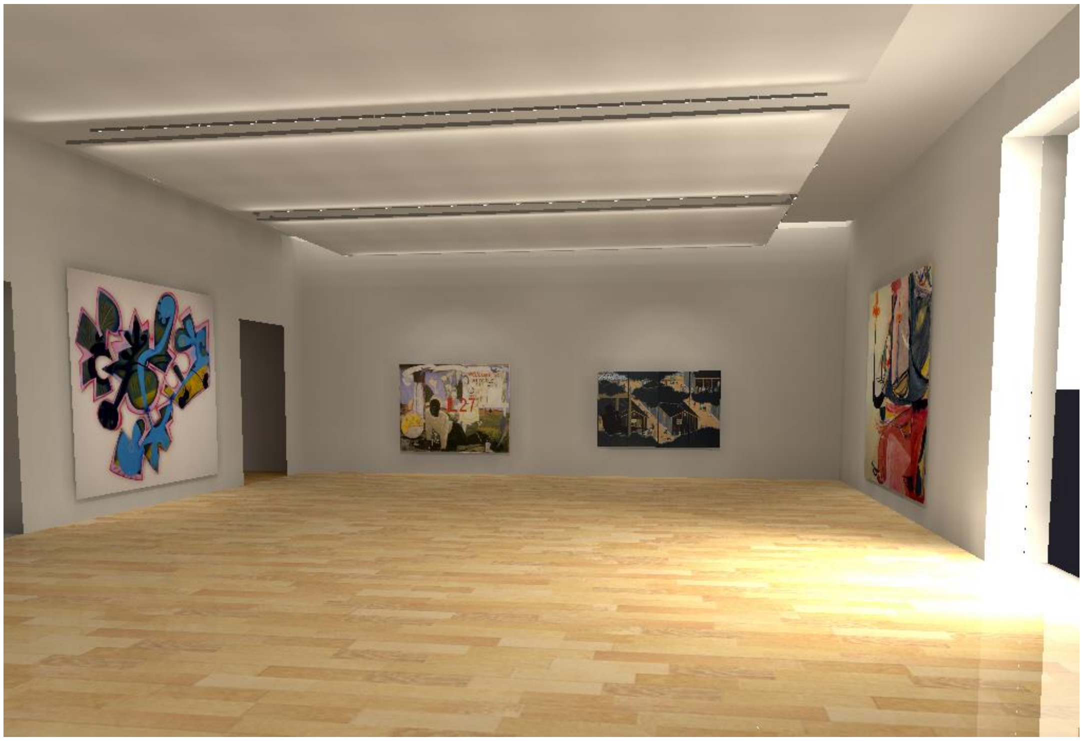
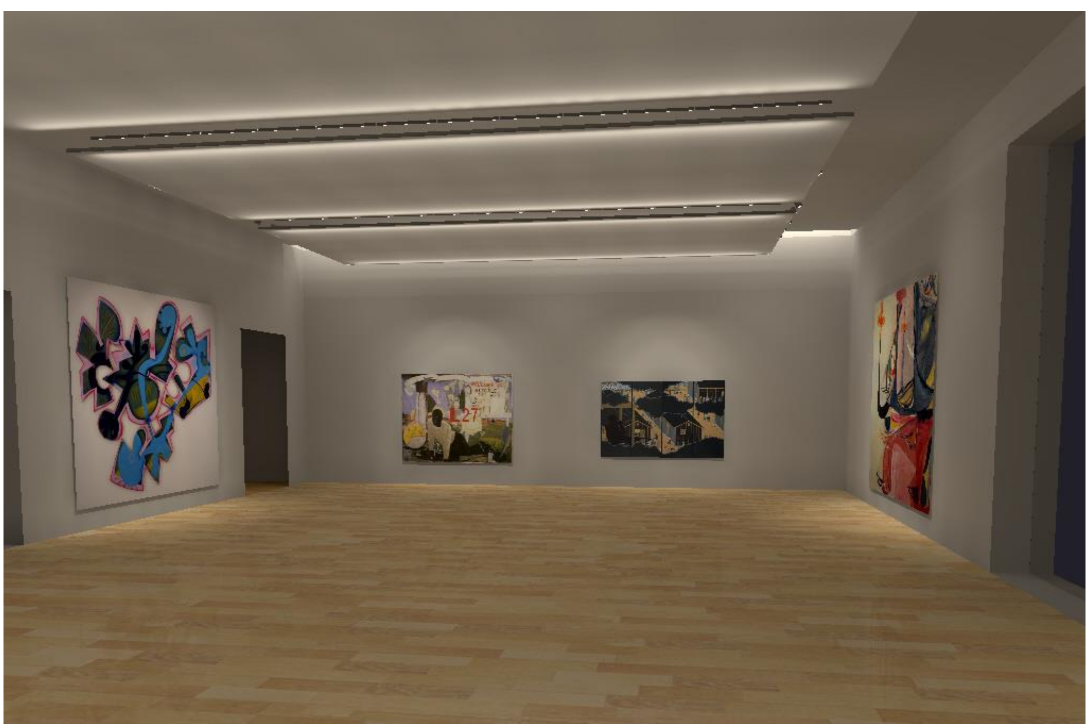


Figure 1.1
Gallery: Nighttime Perspective Rendering



calculations

Illuminance

Figure 1.1

Gallery: Illuminance Grid Points with Isolines (Nighttime)

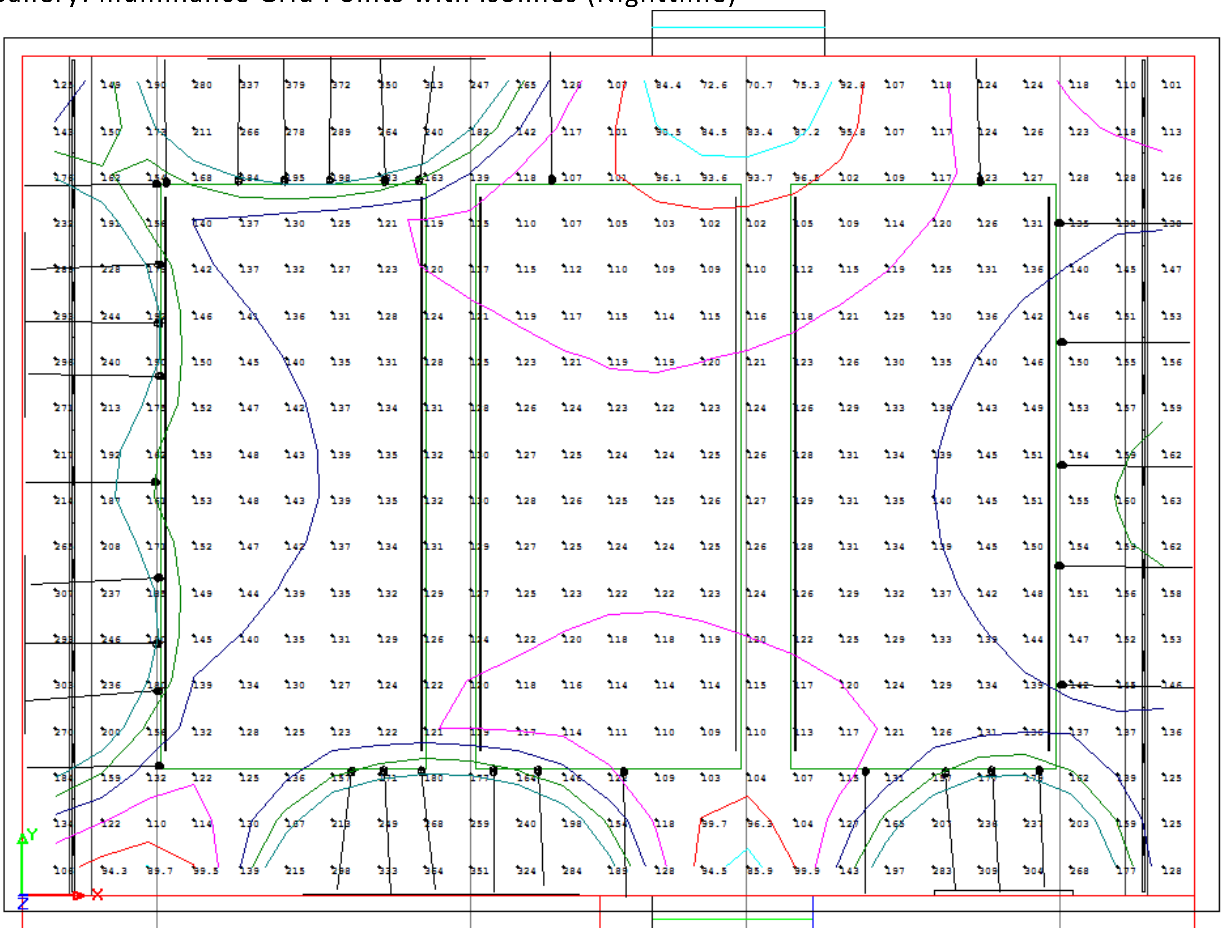


Table 1.1

Gallery Illuminance Calculation Summary (workplane 1.5’)

Space	E_h Recommendation (lux)	E_h Calculated (lux)
gallery floor space	20	115
artwork (typical)	200 (E_v)	305(E_v)

Lighting Power Density

Table 1.1
Gallery Lighting Power Density

Fixture Type	System Wattage	Quantity	Total Watts
F1	33.5	18	603
L1	4.4	72	316.8
TA1	600	2	1200
TA2	600	2	1200
TD	600	1	600
Total Watts			3,919.8
Area (SF)			1,990
Watts/SF			1.97
ASHRAE 90.1 compliant?			2.05 - Yes

The LPD currently used in the gallery falls under the ASHRAE requirement of 1.05 W/SF with an additional 1.0 W/SF for spaces which the lighting is specific to highlighting art or exhibits by section 9.6.2. ASHRAE also states that track fixtures are to be counted as 30 W/LF, but with the alternative of using a permanent current-limiting device on the system by section 9.1.4. By using current limiters of 5A per circuit, the track lighting can stay under ASHRAE requirements. The table below highlights the calculations used to split up each circuit under each panel's track system.

Table 1.1
Gallery Track Lighting Current Limiter Design

track: TA	LF	W	W/LF	# of Fixtures	# of Fixtures
end panel1	72	600	8.3	28.6	28
end panel2	72	600	8.3	28.6	28
middle panel	72	600	8.3	28.6	28
end panel1	72	600	8.3	28.6	28
end panel2	72	600	8.3	28.6	28
total	360	3000		total	140
		603			
		316.8			
	total W	3919.8			

*The end panels have (2) 5A current limiters: two-way track system
*The middle panel has (1) 5A current limiter: one-way track system

evaluation

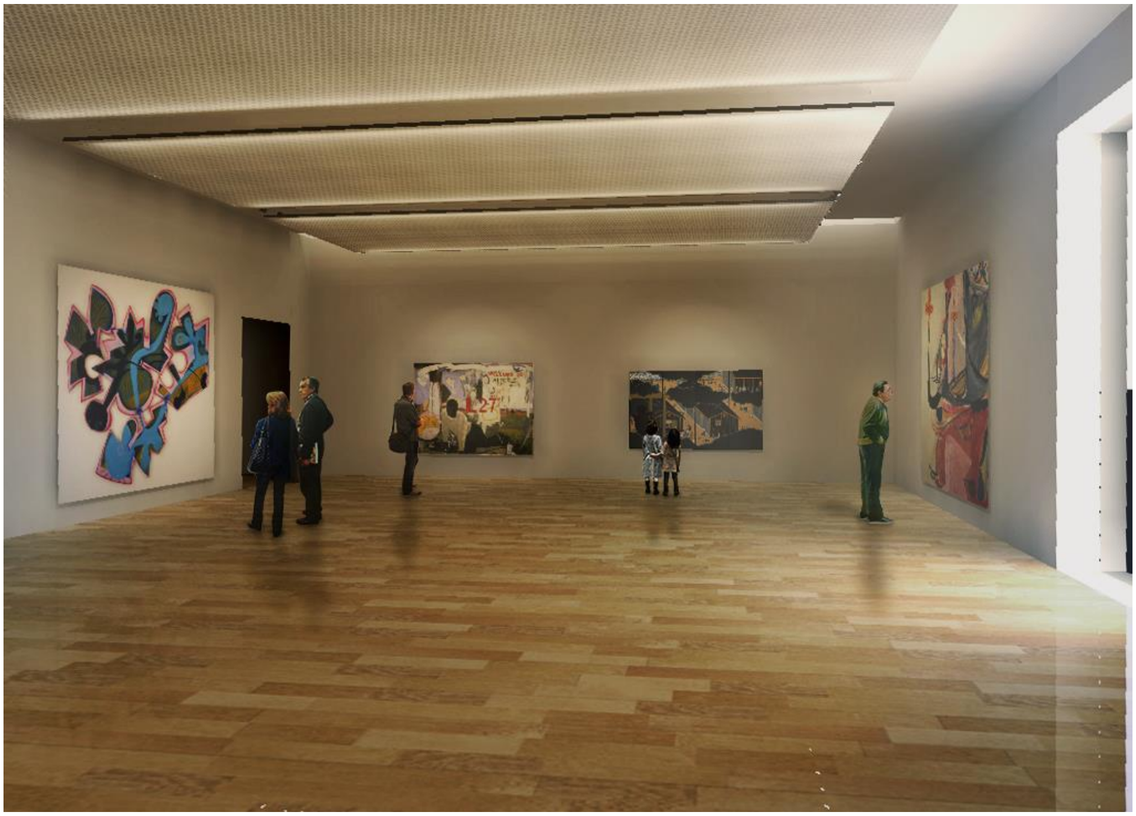
The Gallery benefits from the new lighting design by adding to architectural forms. Using three drop down panels of stretched fabric which is grazed from behind adds depth to the room while still having a flexible track system to light art wherever it may be located.

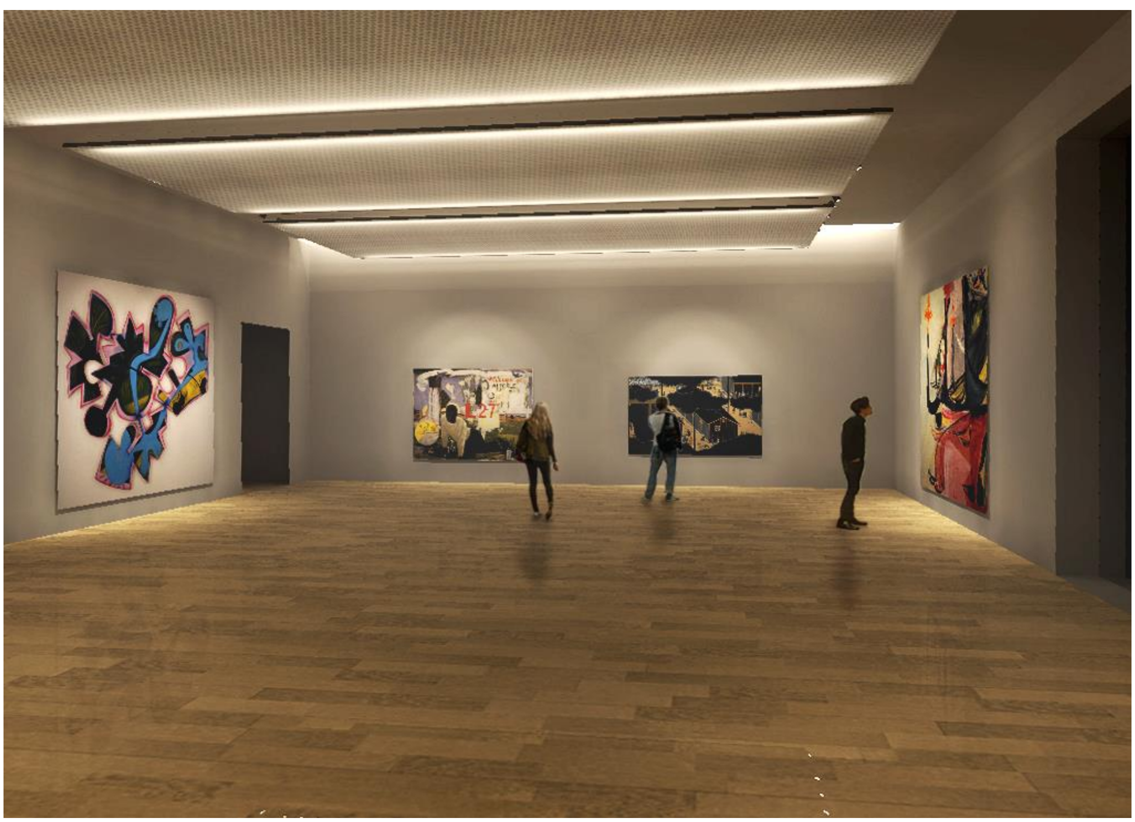
Final Visualizations

These renderings were done for the final presentation as a visualization technique to further the skills needed to display one's lighting designs. The following renders are the night and day conditions for the gallery and solarium spaces.

solarium:

gallery:





Electrical Depth:

The electrical depth will focus on a branch circuit redesign for the five spaces redesigned in the lighting depth, a short circuit protection study, and a wind powered electricity generation system integrated into the solarium's solar protection panel.

overview

Since the Nerman Museum is located on a college campus, the main service power is coming off the primary Johnson County Community College's loop. The power comes into the building on the north side where the utility transformer is located. It is then transferred down to 480/277V that feeds into the main switchboard. A TVSS is located here to clean up the power that results from harmonic loading downstream. The main switchboard is (MS-E1) is located in the mechanical / electrical room "M114," on the first floor. This room has access to the loading dock on the north part of the building. Five sets of 4-#400 MCM, 3" Conduit comes into the switchboard from the transformer.

This room also houses most of the secondary panelboards that distribute power to the kitchen and first floor lighting and receptacle loads. Metering is applied at the service entrance before the main 1600A breaker on the switchboard, but after the primary transformer. Grounding is also utilized through a concrete encased electrode as well as the water pipe and building steel to ground the switchboard and whole electrical system.

Branch Circuit Redesign

The electrical loads for the five redesigned spaces under the lighting depth will be calculated in this section. The resulting lighting loads will be divided between existing circuits on existing local panelboards. These branch circuits will then be resized. The redesigned lighting loads will affect each of the following panelboards:

Table 1.1
Panelboards to be Modified

Space	Panel Type	Voltage	Panelboard
Grounds	Normal	208Y/120	1L1
	Emergency	208Y/120	E1L1
Solarium	Normal	208Y/120	1L1
	Emergency	208Y/120	E1L1
Café	Normal	208Y/120	1L1
	Emergency	208Y/120	E1L1
Auditorium	Normal	208Y/120	2L1
	Emergency	208Y/120	E1L1
Gallery	Normal	208Y/120	2L1
	Emergency	208Y/120	E1L1

Grounds Electrical Redesign

normal power

Table 1.1
Grounds: Total VA

Fixture Type	System VA	Quantity	Total VA
G1	24	7	168
LF6	5.4	6	32.4
Total VA			200.4

Table 1.1
Grounds: Volt-Amps to go on Panelboard 1L1

Fixture Type	VA
G1	168
LF6	32.4
Total VA	200.4

The following panelboards show first, the existing panelboard with the locations affected by the redesigned lighting highlighted in orange. The second panelboard has the new lighting loads applied to the panelboard and the initial loads taken off. These loads are highlighted in red. In the case of the grounds, there was no pervious load associated.

Table 1.1

Lighting Panelboard 1L1 – Grounds Existing Panelboard

120/208 Volt 3-PH / 4-W (2) 42 Space 1 -Nema Rating	400 Main Bus Amps 400 Main Breaker - ISO. GRND. BUS	10,000 AIC Rating	Mountin Surface

Notes	Load (VA)	Description	Type	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20/	1	A	2	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 102	R	12	20/	3	B	4	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 1119-	R	12	20/	5	C	6	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 100	R	12	20/	7	A	8	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 110	R	12	20/	9	B	10	20/	12	R	Recept Rm 118	720	
	720	Recept Rm 110	R	12	20/	11	C	12	20/	12	R	Recept Rm 100-	720	
	720	Recept Rm 110	R	12	20/	13	A	14	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M119,	L	12	20/	15	B	16	20/	12	L	Ltg Rm M101	1920	
	900	Ltg Rm M119,	L	12	20/	17	C	18	20/	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M119,	L	12	20/	19	A	20	20/	12	L	Ltg Rm M118	1920	
	700	Ltg Rm M119,	L	12	20/	21	B	22	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	23	C	24	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	25	A	26	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	27	B	28	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	29	C	30	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	31	A	32	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	33	B	34	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	35	C	36	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	37	A	38	20/	12	L	Ltg Rm M118	**384**	
	1296	Ltg Rm M119,	L	12	20/	39	B	40	20/	12	L	Ltg Rm M102	**324**	
	320	Ltg Rm M119,	L	12	20/	41	C	42	20/	12	L	Ltg Rm M103	**324**	
	800	Ltg Rm M101	L	12	20/	43	A	44	20/	12	L	Ltg Rm M101	**286**	
	130	Ltg Rm M101	L	12	20/	45	B	46	20/	12	L	Ltg Rm M100	**168**	
	1920	Ltg Rm M230	L	12	20/	47	C	48	20/	12	L	Ltg Rm M230	**1920**	
	1920	Ltg Rm M230	L	12	20/	49	A	50	20/	12	L	Ltg Rm M230	**1920**	
	1920	Ltg Rm M230	L	12	20/	51	B	52	20/	12	L	Ltg Rm M230	4125	
	1920	Ltg Rm M230	L	12	20/	53	C	54	20/	12	L	Ltg Rm M230	750	
		Spare		0	-	55	A	56	-	0				
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	36,066	Subtotal										Subtotal	37,561	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversity
220.44	(R) Recept.	9,360		9,360	210.20(a)	(L)	64,267	125	80,334
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water Ht.	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	73,627	VA	204.5	AM	Location of MECH/ELEC M114
Total Load (Diversified)=	89,694	VA	249.1	AM	

Table 1.1

Lighting Panelboard 1L1– Grounds Modified Panelboard

120/208 Volt 3-PH / 4-W	400 Main Bus Amps	10,000 AIC Rating	Mounting: Surface
(2) 42 Space	400 Main Breaker		
1 -Nema Rating	ISO. GRND. BUS		

Notes	Load (VA)	Description	Type	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20/	1	A	2	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 102	R	12	20/	3	B	4	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 1119-	R	12	20/	5	C	6	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 100	R	12	20/	7	A	8	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 110	R	12	20/	9	B	10	20/	12	R	Recept Rm 118	720	
	720	Recept Rm 110	R	12	20/	11	C	12	20/	12	R	Recept Rm 100-	720	
	720	Recept Rm 110	R	12	20/	13	A	14	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M119,	L	12	20/	15	B	16	20/	12	L	Ltg Rm M101	1920	
	900	Ltg Rm M119,	L	12	20/	17	C	18	20/	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M119,	L	12	20/	19	A	20	20/	12	L	Ltg Rm M118	1920	
	700	Ltg Rm M119,	L	12	20/	21	B	22	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	23	C	24	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	25	A	26	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	27	B	28	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	29	C	30	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	31	A	32	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	33	B	34	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	35	C	36	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	37	A	38	20/	12	L	Ltg Rm M118	**384**	
	1296	Ltg Rm M119,	L	12	20/	39	B	40	20/	12	L	Ltg Rm M102	**324**	
	320	Ltg Rm M119,	L	12	20/	41	C	42	20/	12	L	Ltg Rm M103	**324**	
	800	Ltg Rm M101	L	12	20/	43	A	44	20/	12	L	Ltg Rm M101	**286**	
	130	Ltg Rm M101	L	12	20/	45	B	46	20/	12	L	Ltg Rm M100	**168**	
	1920	Ltg Rm M230	L	12	20/	47	C	48	20/	12	L	Ltg Rm M230	**1920**	
	1920	Ltg Rm M230	L	12	20/	49	A	50	20/	12	L	Ltg Rm M230	**1920**	
	1920	Ltg Rm M230	L	12	20/	51	B	52	20/	12	L	Ltg Rm M230	4125	
	1920	Ltg Rm M230	L	12	20/	53	C	54	20/	12	L	Ltg Rm M230	750	
	200.4	Grounds	L	12	20/	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	36,266	Subtotal										Subtotal	37,561	

N.E.C.	Load Type	Conn.	Fct.	Diversity
220.44	(R) Recept.	9,360		9,360
220.56	(K) Kitchen	0	100	0
220.60	(C) Cooling	0	0%	0
220.60	(H) Heating	0	0%	0
220.60	(F) Fans	0	100	0
	(M) Misc.	0	100	0

N.E.C.	Load Type	Conn.	Fct.	Diversit
210.20(a)	(L)	64,467	125	80,584
	(EL) Ext. Ltg.	0	125	0
620.14	(E) Elevators	0	0%	0
	(WH) Water Ht.	0	100	0
220.5	(MT) Lrg. Mot.	0	125	0
	(SP) Sub Panel	0	100	0

Total Connected	73,827	VA	205.1	AM
Total Load (Diversified)=	89,944	VA	249.8	AM

Location of MECH/ELEC M114

Solarium Electrical Redesign

normal power

Table 1.1
Solarium: Total VA

Fixture Type	System VA	Quantity	Total VA
L6	29	9	261
F4	56	16	896
TC	150 (2’ of track)	18	2,700
PM1	57	3	171
Total VA			4,028

Table 1.1
Solarium: Volt-Amps to go on Panelboard 1L1 (circuit 1)

Fixture Type	VA
L6	261
F4	896
PM1	171
Total VA	1,328

Table 1.1
Solarium: Volt-Amps to go on Panelboard 1L1 (circuit 2)

Fixture Type	VA
TC	1,350
Total VA	1,350

Table 1.1
Solarium: Volt-Amps to go on Panelboard 1L1 (circuit 3)

Fixture Type	VA
TC	1,350
Total VA	1,350

The following panelboards show first, the existing panelboard with the locations affected by the redesigned lighting highlighted in orange. The second panelboard has the new lighting loads applied to the panelboard and the initial loads taken off. These loads are highlighted in red.

Table 1.1

Lighting Panelboard 1L1– Solarium Existing Panelboard

120/208 Volt 3-PH / 4-W (2) 42 Space 1 -Nema	400 Main Bus Amps 400 Main Breaker - ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CKT #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20	1	A	2	20	12	R	Recept Rm	720	
	720	Recept Rm 102	R	12	20	3	B	4	20	12	R	Recept Rm	720	
	720	Recept Rm	R	12	20	5	C	6	20	12	R	Recept Rm	720	
	720	Recept Rm 100	R	12	20	7	A	8	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	9	B	10	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	11	C	12	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	13	A	14	20	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M119,	L	12	20	15	B	16	20	12	L	Ltg Rm M101	1920	
	900	Ltg Rm M119,	L	12	20	17	C	18	20	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M119,	L	12	20	19	A	20	20	12	L	Ltg Rm M118	1920	
	700	Ltg Rm M119,	L	12	20	21	B	22	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20	23	C	24	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20	25	A	26	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20	27	B	28	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20	29	C	30	20	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20	31	A	32	20	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20	33	B	34	20	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20	35	C	36	20	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20	37	A	38	20	12	L	Ltg Rm M118	384	
	1296	Ltg Rm M119,	L	12	20	39	B	40	20	12	L	Ltg Rm M102	324	
	320	Ltg Rm M119,	L	12	20	41	C	42	20	12	L	Ltg Rm M103	324	
	800	Ltg Rm M101	L	12	20	43	A	44	20	12	L	Ltg Rm M101	286	
	130	Ltg Rm M101	L	12	20	45	B	46	20	12	L	Ltg Rm M100	168	
	1920	Ltg Rm M130	L	12	20	47	C	48	20	12	L	Ltg Rm M130	**1920**	
	1920	Ltg Rm M130	L	12	20	49	A	50	20	12	L	Ltg Rm M130	**1920**	
	1920	Ltg Rm M130	L	12	20	51	B	52	20	12	L	Ltg Rm M130	4125	
	1920	Ltg Rm M130	L	12	20	53	C	54	20	12	L	Ltg Rm M130	750	
		Spare		0	-	55	A	56	-	0				
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	36,066	Subtotal										Subtotal	37,561	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	9,360		9,360	210.20(a)	(L)	64,267	125	80,334
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected Load =	73,627	VA	204.5	AM	Location of	MECH/ELEC M114
Total Load (Diversified)=	89,694	VA	249.1	AM		

Table 1.1

Lighting Panelboard 1L1– Solarium Modified Panelboard

120/208 Volt 3-PH / 4-W (2) 42 Space 1 -Nema Rating	400 Main Bus Amps 400 Main Breaker ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CKT #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20/	1	A	2	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 102	R	12	20/	3	B	4	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 1119-	R	12	20/	5	C	6	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 100	R	12	20/	7	A	8	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 110	R	12	20/	9	B	10	20/	12	R	Recept Rm 118	720	
	720	Recept Rm 110	R	12	20/	11	C	12	20/	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20/	13	A	14	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M119,	L	12	20/	15	B	16	20/	12	L	Ltg Rm M101	1920	
	900	Ltg Rm M119,	L	12	20/	17	C	18	20/	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M119,	L	12	20/	19	A	20	20/	12	L	Ltg Rm M118	1920	
	700	Ltg Rm M119,	L	12	20/	21	B	22	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	23	C	24	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	25	A	26	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	27	B	28	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	29	C	30	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	31	A	32	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	33	B	34	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	35	C	36	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	37	A	38	20/	12	L	Ltg Rm M118	384	
	1296	Ltg Rm M119,	L	12	20/	39	B	40	20/	12	L	Ltg Rm M102	324	
	320	Ltg Rm M119,	L	12	20/	41	C	42	20/	12	L	Ltg Rm M103	324	
	800	Ltg Rm M101	L	12	20/	43	A	44	20/	12	L	Ltg Rm M101	286	
	130	Ltg Rm M101	L	12	20/	45	B	46	20/	12	L	Ltg Rm M100	168	
	1350	Ltg Rm M130	L	12	20/	47	C	48	20/	12	L	Ltg Rm M130	1328	
	1350	Ltg Rm M130	L	12	20/	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	31,086	Subtotal										Subtotal	30,174	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	9,360		9,360	210.20(a)	(L)	50,280	125	62,850
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	59,640	VA	165.7	AM	Location of	MECH/ELEC M114
Total Load (Diversified)=	72,210	VA	200.6	AM		

emergency power

The emergency power for this egress section of the building specified to an emergency panelboard (E1L1) supplied by an offsite generator. Every other row of the track lighting will be wired for emergency power so when there is a power outage, these few fixtures will come on to illuminate to 50 lux. This will allow occupants to remain safe through this part of the egress path. A total of 250VA will be needed for this circuit due to 9 locations of 9 individual track fixtures as specified as "T4" under the fixture schedule. These track luminaires will have fixed aiming angles and locations.

Café Electrical Redesign

normal power

Table 1.1
Café: Total VA

Fixture Type	System VA	Quantity	Total VA
LF1	78	2	156
LF2	59	1	59
LF3	59	1	59
LF4	450	1	450
LF5	290.4	1	290.4
TB	300 (4' of track)	4	1,200
Total VA			2,214.4

Table 1.1
Café: Volt-Amps to go on Panelboard 1L1 (circuit 1)

Fixture Type	VA
LF1	156
LF2	59
LF3	59
LF4	450
LF5	290.4
Total VA	1,014.4

Table 1.1
Café: Volt-Amps to go on Panelboard 1L1 (circuit 2)

Fixture Type	VA
TB	1,200
Total VA	1,200

The following panelboards show first, the existing panelboard with the locations affected by the redesigned lighting highlighted in orange. The second panelboard has the new lighting loads applied to the panelboard and the initial loads taken off. These loads are highlighted in red.

Table 1.1

Lighting Panelboard 1L1– Café Existing Panelboard

120/208	Volt 3-PH / 4-W	400	Main Bus Amps	10,000 AIC Rating	Mounting: Surface
(2)	42 Space	400	Main Breaker		
1	-Nema Rating		ISO. GRND. BUS		

Notes	Load (VA)	Description	Type	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20/	1	A	2	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 102	R	12	20/	3	B	4	20/	12	R	Recept Rm 103	720	
	720	Recept Rm 1119-	R	12	20/	5	C	6	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 100	R	12	20/	7	A	8	20/	12	R	Recept Rm 104	720	
	720	Recept Rm 110	R	12	20/	9	B	10	20/	12	R	Recept Rm 118	720	
	720	Recept Rm 110	R	12	20/	11	C	12	20/	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20/	13	A	14	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M119,	L	12	20/	15	B	16	20/	12	L	Ltg Rm M101	1920	
	900	Ltg Rm M119,	L	12	20/	17	C	18	20/	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M119,	L	12	20/	19	A	20	20/	12	L	Ltg Rm M118	1920	
	700	Ltg Rm M119,	L	12	20/	21	B	22	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	23	C	24	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	25	A	26	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	27	B	28	20/	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20/	29	C	30	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	31	A	32	20/	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M103	L	12	20/	33	B	34	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	35	C	36	20/	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M104	L	12	20/	37	A	38	20/	12	L	Ltg Rm M118	384	
	1296	Ltg Rm M119,	L	12	20/	39	B	40	20/	12	L	Ltg Rm M102	324	
	320	Ltg Rm M119,	L	12	20/	41	C	42	20/	12	L	Ltg Rm M103	324	
	800	Ltg Rm M101	L	12	20/	43	A	44	20/	12	L	Ltg Rm M101	286	
	130	Ltg Rm M101	L	12	20/	45	B	46	20/	12	L	Ltg Rm M100	168	
	1920	Ltg Rm M230	L	12	20/	47	C	48	20/	12	L	Ltg Rm M230	1920	
	1920	Ltg Rm M230	L	12	20/	49	A	50	20/	12	L	Ltg Rm M230	1920	
	1920	Ltg Rm M230	L	12	20/	51	B	52	-	12	L	Ltg Rm M230	4125	
	1920	Ltg Rm M230	L	12	20/	53	C	54	-	12	L	Ltg Rm M230	750	
		Spare		0	-	55	A	56	-	0				
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	36,066	Subtotal										Subtotal	37,561	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	9,360		9,360	210.20(a)	(L)	64,267	125	80,334
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	73,627	VA	204.5	AM	Location of	MECH/ELEC M114
Total Load (Diversified)=	89,694	VA	249.1	AM		

Table 1.1

Lighting Panelboard 1L1– Café Modified Panelboard

120/208 Volt 3-PH / 4-W - (2 42 Space 1 -Nema	400 Main Bus Amps 400 Main Breaker - ISO. GRND. BUS		10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CKT #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20	1	A	2	20	12	R	Recept Rm	720	
	720	Recept Rm 102	R	12	20	3	B	4	20	12	R	Recept Rm	720	
	720	Recept Rm	R	12	20	5	C	6	20	12	R	Recept Rm	720	
	720	Recept Rm 100	R	12	20	7	A	8	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	9	B	10	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	11	C	12	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	13	A	14	20	12	L	Ltg Rm M101	1920	
	1014	Ltg Rm M119,	L	12	20	15	B	16	20	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M102	L	12	20	17	C	18	20	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M102	L	12	20	19	A	20	20	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M102	L	12	20	21	B	22	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20	23	C	24	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M103	L	12	20	25	A	26	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M103	L	12	20	27	B	28	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M104	L	12	20	29	C	30	20	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M104	L	12	20	31	A	32	20	12	L	Ltg Rm M103	1920	
	800	Ltg Rm M101	L	12	20	33	B	34	20	12	L	Ltg Rm M104	1920	
	130	Ltg Rm M101	L	12	20	35	C	36	20	12	L	Ltg Rm M104	1920	
	1920	Ltg Rm M230	L	12	20	37	A	38	20	12	L	Ltg Rm M118	**384**	
	1920	Ltg Rm M230	L	12	20	39	B	40	20	12	L	Ltg Rm M102	**324**	
	1920	Ltg Rm M230	L	12	20	41	C	42	20	12	L	Ltg Rm M103	**324**	
	1920	Ltg Rm M230	L	12	20	43	A	44	20	12	L	Ltg Rm M101	**286**	
	1200	Ltg Rm M119,	L	12	20	45	B	46	20	12	L	Ltg Rm M100	**168**	
		Spare		0	-	47	C	48	20	12	L	Ltg Rm M230	**1920**	
		Spare		0	-	49	A	50	20	12	L	Ltg Rm M230	**1920**	
		Spare		0	-	51	B	52	20	12	L	Ltg Rm M230	4125	
		Spare		0	-	53	C	54	20	12	L	Ltg Rm M230	750	
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	30,504	Subtotal										Subtotal	37,561	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	9,360		9,360	210.20(a)	(L)	58,705	125	73,381
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected Load =	68,065	VA	189.1	AM	Location of	MECH/ELEC M114
Total Load (Diversified)=	82,741	VA	229.8	AM		

Auditorium Electrical Redesign

normal power

Table 1.1
Auditorium: Total VA

Fixture Type	System VA	Quantity	Total VA
F2	33	32	1,056
F3	66	7	462
P1	31	13	403
P2	46	10	460
L5	8.5	76	646
L6	34	6	204
TB	300	3	900
Total VA			4,131

Table 1.1
Auditorium: Volt-Amps to go on Panelboard 2L1 (circuit 1)

Fixture Type	VA
F2	1,056
Total VA	1,056

Table 1.1
Auditorium: Volt-Amps to go on Panelboard 2L1 (circuit 2)

Fixture Type	VA
L5	646
L6	204
TB	900
Total VA	1,750

Table 1.1
Auditorium: Volt-Amps to go on Panelboard 2L1 (circuit 3)

Fixture Type	VA
F3	462
P1	403
P2	460
Total VA	1,325

The following panelboards show first, the existing panelboard with the locations affected by the redesigned lighting highlighted in orange. The second panelboard has the new lighting loads applied to the panelboard and the initial loads taken off. These loads are highlighted in red.

Table 1.1

Lighting Panelboard 2L1– Auditorium Existing Panelboard

120/208 Volt 3-PH / 4-W (2) 42 Space 1 -Nema	400 Main Bus Amps 400 Main Breaker ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	1500	Ltg Rm	L	12	20/	1	A	2	20/	12	L	Ltg Rm M208	1500	
	1600	Ltg Rm	L	12	20/	3	B	4	20/	12	L	Ltg Rm M208	1600	
	40	Ltg Rm	L	12	20/	5	C	6	20/	12	L	Ltg Rm M205	1920	
	1920	Ltg Rm	L	12	20/	7	A	8	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm	L	12	20/	9	B	10	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm	L	12	20/	11	C	12	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm	L	12	20/	13	A	14	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm	L	12	20/	15	B	16	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm	L	12	20/	17	C	18	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm	L	12	20/	19	A	20	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm	L	12	20/	21	B	22	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm	L	12	20/	23	C	24	20/	12	L	Ltg Rm M203	1920	
	1920	Ltg Rm	L	12	20/	25	A	26	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm	L	12	20/	27	B	28	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm	L	12	20/	29	C	30	20/	12	L	Ltg Rm M206	1920	
	1920	Ltg Rm	L	12	20/	31	A	32	20/	12	L	Ltg Rm M222	162	
	1920	Ltg Rm	L	12	20/	33	B	34	20/	12	L	Ltg Rm M228,	1875	
	3186	Ltg Rm	L	12	20/	35	C	36	20/	12	L	Ltg Rm M201	192	
	1920	Ltg Rm	L	12	20/	37	A	38	20/	12	L	Ltg Rm M203	192	
	17	Ltg Rm	L	12	20/	39	B	40	20/	12	L	Ltg Rm M101	192	
	192	Ltg Rm	L	12	20/	41	C	42	20/	12	L	Ltg Rm M222	192	
	192	Ltg Rm	L	12	20/	43	A	44	20/	12	L	Ltg Rm M215	**1920**	
	192	Ltg Rm	L	12	20/	45	B	46	20/	12	L	Ltg Rm M222	1920	
	1920	Ltg Rm	L	12	20/	47	C	48	-	0		Spare		
		Spare		0	-	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	37,639	Subtot										Subtotal	34,705	

N.E.C.	Load Type	Conn.	Fct.	Diversity		N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	0		0		210.20(a)	(L)	72,344	125	90,430
220.56	(K) Kitchen	0	100	0			(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0		620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0			(WH) Water	0	100	0
220.60	(F) Fans	0	100	0		220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0			(SP) Sub Panel	0	100	0

Total Connected	72,344	VA	201.0	AM	Location of	MECH/ELEC C215
Total Load (Diversified)=	90,430	VA	251.2	AM		

Table 1.1

Lighting Panelboard 2L1– Auditorium Modified Panelboard

120/208 Volt 3-PH / 4-W (2 42 1 -Nema	400 Main Bus Amps 400 Main Breaker ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Typ	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	1056	Ltg Rm M208	L	12	20/	1	A	2	20/	12	L	Ltg Rm M205	1920	
	1750	Ltg Rm M208	L	12	20/	3	B	4	20/	12	L	Ltg Rm M201	1920	
	40	Ltg Rm M205	L	12	20/	5	C	6	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M205	L	12	20/	7	A	8	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M201	L	12	20/	9	B	10	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M201	L	12	20/	11	C	12	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M201	L	12	20/	13	A	14	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M201	L	12	20/	15	B	16	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M202	L	12	20/	17	C	18	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M101	L	12	20/	19	A	20	20/	12	L	Ltg Rm M203	1920	
	1920	Ltg Rm M203	L	12	20/	21	B	22	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M203	L	12	20/	23	C	24	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M203	L	12	20/	25	A	26	20/	12	L	Ltg Rm M206	1920	
	1920	Ltg Rm M204	L	12	20/	27	B	28	20/	12	L	Ltg Rm M222	162	
	1920	Ltg Rm M204	L	12	20/	29	C	30	20/	12	L	Ltg Rm M228,	1875	
	1920	Ltg Rm M206	L	12	20/	31	A	32	20/	12	L	Ltg Rm M201	192	
	1920	Ltg Rm M222	L	12	20/	33	B	34	20/	12	L	Ltg Rm M203	192	
	1920	Ltg Rm M222	L	12	20/	35	C	36	20/	12	L	Ltg Rm M101	192	
	192	Ltg Rm M201	L	12	20/	37	A	38	20/	12	L	Ltg Rm M222	192	
	192	Ltg Rm M202	L	12	20/	39	B	40	20/	12	L	Ltg Rm M215	**1920**	
	192	Ltg Rm M204	L	12	20/	41	C	42	20/	12	L	Ltg Rm M222	1920	
	1920	Ltg Rm M215	L	12	20/	43	A	44	20/	12	L	Ltg Rm M208	1325	
		Spare		0	-	45	B	46	-	0		Spare		
		Spare		0	-	47	C	48	-	0		Spare		
		Spare		0	-	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	33,602	Subtota										Subtotal	32,930	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	0		0	210.20(a)	(L)	66,532	125	83,165
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	66,532	VA	184.8	AM	Location of	MECH/ELEC C215
Total Load (Diversified)=	83,165	VA	231.0	AM		

Gallery Electrical Redesign

normal power

Table 1.1
Gallery: Total VA

Fixture Type	System VA	Quantity	Total VA
F1	33.5	18	603
L1	4.4	72	316.8
TA1	600	2	1200
TA2	600	2	1200
TD	600	1	600
Total VA			3,919.8

Table 1.1
Gallery: Volt-Amps to go on Panelboard 1L1(circuit 1)

Fixture Type	VA
F1	1,056
L1	462
Total VA	1,518

Table 1.1
Gallery: Volt-Amps to go on Panelboard 1L1(circuit 2)

Fixture Type	VA
TA1	1200
Total VA	1200

Table 1.1
Gallery: Volt-Amps to go on Panelboard 1L1(circuit 3)

Fixture Type	VA
TA2	1200
Total VA	1200

Table 1.1
Gallery: Volt-Amps to go on Panelboard 1L1(circuit 4)

Fixture Type	VA
TD	600
Total VA	600

The following panelboards show first, the existing panelboard with the locations affected by the redesigned lighting highlighted in orange. The second panelboard has the new lighting loads applied to the panelboard and the initial loads taken off. These loads are highlighted in red.

Table 1.1

Lighting Panelboard 2L1– Gallery Existing Panelboard

120/208 Volt 3-PH / 4-W (2) 42 Space 1 -Nema Rating	400 Main Bus Amps 400 Main Breaker ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	1500	Ltg Rm M208	L	12	20/	1	A	2	20/	12	L	Ltg Rm M208	1500	
	1600	Ltg Rm M208	L	12	20/	3	B	4	20/	12	L	Ltg Rm M208	1600	
	40	Ltg Rm M205	L	12	20/	5	C	6	20/	12	L	Ltg Rm M205	1920	
	1920	Ltg Rm M205	L	12	20/	7	A	8	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M201	L	12	20/	9	B	10	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M201	L	12	20/	11	C	12	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M201	L	12	20/	13	A	14	20/	12	L	Ltg Rm M201	1920	
	1920	Ltg Rm M201	L	12	20/	15	B	16	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M202	L	12	20/	17	C	18	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M101	L	12	20/	19	A	20	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M203	L	12	20/	21	B	22	20/	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M203	L	12	20/	23	C	24	20/	12	L	Ltg Rm M203	1920	
	1920	Ltg Rm M203	L	12	20/	25	A	26	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M204	L	12	20/	27	B	28	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M204	L	12	20/	29	C	30	20/	12	L	Ltg Rm M206	1920	
	1920	Ltg Rm M206	L	12	20/	31	A	32	20/	12	L	Ltg Rm M222	162	
	1920	Ltg Rm M222	L	12	20/	33	B	34	20/	12	L	Ltg Rm M228,	1875	
	3186	Ltg Rm M208	L	12	20/	35	C	36	20/	12	L	Ltg Rm M201	192	
	1920	Ltg Rm M222	L	12	20/	37	A	38	20/	12	L	Ltg Rm M203	192	
	17	Ltg Rm M208	L	12	20/	39	B	40	20/	12	L	Ltg Rm M101	192	
	192	Ltg Rm M201	L	12	20/	41	C	42	20/	12	L	Ltg Rm M222	192	
	192	Ltg Rm M202	L	12	20/	43	A	44	20/	12	L	Ltg Rm M215	**1920**	
	192	Ltg Rm M204	L	12	20/	45	B	46	20/	12	L	Ltg Rm M222	1920	
	1920	Ltg Rm M215	L	12	20/	47	C	48	-	0		Spare		
		Spare		0	-	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	37,639	Subtotal										Subtotal	34,705	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	0		0	210.20(a)	(L)	72,344	125	90,430
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water Ht.	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	72,344	VA	201.0	AM	Location of	MECH/ELEC C215
Total Load	90,430	VA	251.2	AM		

Table 1.1

Lighting Panelboard 2L1– Gallery Modified Panelboard			
120/208 Volt 3-PH / 4-W (2) 42 Space 1 -Nema Rating	400 Main Bus Amps 400 Main Breaker ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CK #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	1500	Ltg Rm M208	L	12	20/	1	A	2	20/	12	L	Ltg Rm M208	1500	
	1600	Ltg Rm M208	L	12	20/	3	B	4	20/	12	L	Ltg Rm M208	1600	
	40	Ltg Rm M205	L	12	20/	5	C	6	20/	12	L	Ltg Rm M205	1920	
	1920	Ltg Rm M205	L	12	20/	7	A	8	20/	12	L	Ltg Rm M202	1920	
	1200	Ltg Rm M201	L	12	20/	9	B	10	20/	12	L	Ltg Rm M202	1920	
	1200	Ltg Rm M201	L	12	20/	11	C	12	20/	12	L	Ltg Rm M202	1920	
	600	Ltg Rm M201	L	12	20/	13	A	14	20/	12	L	Ltg Rm M101	1920	
	1518	Ltg Rm M201	L	12	20/	15	B	16	20/	12	L	Ltg Rm M203	1920	
	1920	Ltg Rm M202	L	12	20/	17	C	18	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M101	L	12	20/	19	A	20	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M203	L	12	20/	21	B	22	20/	12	L	Ltg Rm M206	1920	
	1920	Ltg Rm M203	L	12	20/	23	C	24	20/	12	L	Ltg Rm M222	162	
	1920	Ltg Rm M203	L	12	20/	25	A	26	20/	12	L	Ltg Rm M228,	1875	
	1920	Ltg Rm M204	L	12	20/	27	B	28	20/	12	L	Ltg Rm M203	192	
	1920	Ltg Rm M204	L	12	20/	29	C	30	20/	12	L	Ltg Rm M101	192	
	1920	Ltg Rm M206	L	12	20/	31	A	32	20/	12	L	Ltg Rm M222	192	
	1920	Ltg Rm M222	L	12	20/	33	B	34	20/	12	L	Ltg Rm M215	1920	
	3186	Ltg Rm M208	L	12	20/	35	C	36	20/	12	L	Ltg Rm M222	1920	
	1920	Ltg Rm M222	L	12	20/	37	A	38	-	0		Spare		
	17	Ltg Rm M208	L	12	20/	39	B	40	-	0		Spare		
	192	Ltg Rm M202	L	12	20/	41	C	42	-	0		Spare		
	192	Ltg Rm M204	L	12	20/	43	A	44	-	0		Spare		
	1920	Ltg Rm M215	L	12	20/	45	B	46	-	0		Spare		
		Spare		0	-	47	C	48	-	0		Spare		
		Spare		0	-	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	34,285	Subtotal										Subtotal	26,833	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	0		0	210.20(a)	(L)	61,118	125	76,398
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water Ht.	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	61,118	VA	169.8	AM	Location of	MECH/ELEC C215
Total Load	76,398	VA	212.2	AM		

Lighting Redesign: Total Modified Panelboards

The following panelboards are the result of all the new lighting loads applied to the 1L1 and 2L1 panelboards. These panels have the new loads added while the initial loads for each space taken off. All other spaces on the panelboard have their initial design loads. New electrical loads are highlighted in red.

Lighting Panelboard 1L1 Redesign

Lighting Panelboard 1L1 – Modified (All Spaces)

120/208 Volt 3-PH / 4-W - (2 42 Space 1 -Nema	400 Main Bus Amps 400 Main Breaker - ISO. GRND. BUS	10,000 AIC Rating	Mounting: Surface

Notes	Load (VA)	Description	Type	Wire	CB	CKT #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	720	Recept Rm 102	R	12	20	1	A	2	20	12	R	Recept Rm	720	
	720	Recept Rm 102	R	12	20	3	B	4	20	12	R	Recept Rm	720	
	720	Recept Rm	R	12	20	5	C	6	20	12	R	Recept Rm	720	
	720	Recept Rm 100	R	12	20	7	A	8	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	9	B	10	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	11	C	12	20	12	R	Recept Rm	720	
	720	Recept Rm 110	R	12	20	13	A	14	20	12	L	Ltg Rm M101	1920	
	1920	Ltg Rm M102	L	12	20	15	B	16	20	12	L	Ltg Rm M101	1920	
	1014	Ltg Rm M119,	L	12	20	17	C	18	20	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M102	L	12	20	19	A	20	20	12	L	Ltg Rm M118	1920	
	1920	Ltg Rm M102	L	12	20	21	B	22	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M102	L	12	20	23	C	24	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M103	L	12	20	25	A	26	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M103	L	12	20	27	B	28	20	12	L	Ltg Rm M102	1920	
	1920	Ltg Rm M104	L	12	20	29	C	30	20	12	L	Ltg Rm M103	1920	
	800	Ltg Rm M101	L	12	20	31	A	32	20	12	L	Ltg Rm M103	1920	
	1920	Ltg Rm M104	L	12	20	33	B	34	20	12	L	Ltg Rm M104	1920	
	1350	Ltg Rm M130	L	12	20	35	C	36	20	12	L	Ltg Rm M104	1920	
	130	Ltg Rm M101	L	12	20	37	A	38	20	12	L	Ltg Rm M118	384	
	200	Grounds	L	12	20	39	B	40	20	12	L	Ltg Rm M102	324	
	1350	Ltg Rm M100	L	12	20	41	C	42	20	12	L	Ltg Rm M119,	1200	
	1328	Ltg Rm M130	L	12	20	43	A	44	20	12	L	Ltg Rm M101	286	
	168	Spare		0	-	45	B	46	20	12	L	Ltg Rm M103	324	
		Spare		0	-	47	C	48	-	0		Spare		
		Spare		0	-	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	26,740	Subtotal										Subtotal	29,878	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	9,360		9,360	210.20(a)	(L)	44,918	125	56,148
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected Load =	56,618	VA	157.3	AM	Location of	MECH/ELEC M114
Total Load (Diversified)=	68,433	VA	190.1	AM		

Panelboard 1L1 Phase Loading

PHASE LOADING					
RIGHT SIDE OF PANEL			LEFT SIDE OF PANEL		
PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C
720	-	-	720	-	-
-	720	-	-	720	-
-	-	720	-	-	720
720	-	-	720	-	-
-	720	-	-	720	-
-	-	720	-	-	720
1,920	-	-	720	-	-
-	1,920	-	-	1,920	-
-	-	1,920	-	-	1,014
1,920	-	-	1,920	-	-
-	1,920	-	-	1,920	
-	-	1,920	-	-	1,920
1,920	-	-	1,920	-	-
-	1,920	-	-	1,920	
-	-	1,920	-	-	1,920
1,920	-	-	800	-	-
-	1,920	-	-	1,920	
-	-	1,920	-	-	1,350
384	-	-	130	-	-
-	324	-	-	200	
-	-	1,200	-	-	1,350
286	-	-	1,328	-	-
	324			168	
9,790	9,768	10,320	8,258	9,488	8,994

PHASE LEG	(VA/PHASE)
PHASE A =	18,048
PHASE B =	19,256
PHASE C =	19,314

Lighting Panelboard 2L1 Redesign

Lighting Panelboard 2L1 – Modified (All Spaces)

120/208 Volt 3-PH / 4-W	400 Main Bus Amps	10,000 AIC Rating	Mounting:
(2) 42 Space	400 Main Breaker		Surface
1 -Nema Rating	ISO. GRND. BUS		

Notes	Load (VA)	Description	Type	Wire	CB	CKT #	PH	CKT #	CB	Wire	Type	Description	Load (VA)	Notes
	1056	Ltg Rm M208	L	12	20/	1	A	2	20/	12	L	Ltg Rm M205	1920	
	1750	Ltg Rm M208	L	12	20/	3	B	4	20/	12	L	Ltg Rm M202	1920	
	40	Ltg Rm M205	L	12	20/	5	C	6	20/	12	L	Ltg Rm M202	1920	
	1920	Ltg Rm M205	L	12	20/	7	A	8	20/	12	L	Ltg Rm M202	1920	
	1200	Ltg Rm M201	L	12	20/	9	B	10	20/	12	L	Ltg Rm M101	1920	
	1200	Ltg Rm M201	L	12	20/	11	C	12	20/	12	L	Ltg Rm M203	1920	
	600	Ltg Rm M201	L	12	20/	13	A	14	20/	12	L	Ltg Rm M204	1920	
	1518	Ltg Rm M201	L	12	20/	15	B	16	20/	12	L	Ltg Rm M204	1920	
	1920	Ltg Rm M202	L	12	20/	17	C	18	20/	12	L	Ltg Rm M206	1920	
	1920	Ltg Rm M101	L	12	20/	19	A	20	20/	12	L	Ltg Rm M222	162	
	1920	Ltg Rm M203	L	12	20/	21	B	22	20/	12	L	Ltg Rm M228,	1875	
	1920	Ltg Rm M203	L	12	20/	23	C	24	20/	12	L	Ltg Rm M203	192	
	1920	Ltg Rm M203	L	12	20/	25	A	26	20/	12	L	Ltg Rm M101	192	
	1920	Ltg Rm M204	L	12	20/	27	B	28	20/	12	L	Ltg Rm M222	192	
	1920	Ltg Rm M204	L	12	20/	29	C	30	20/	12	L	Ltg Rm M215	1920	
	1920	Ltg Rm M206	L	12	20/	31	A	32	20/	12	L	Ltg Rm M222	1920	
	1920	Ltg Rm M222	L	12	20/	33	B	34	20/	12	L	Ltg Rm M202	192	
	1920	Ltg Rm M222	L	12	20/	35	C	36	20/	12	L	Ltg Rm M204	192	
	1325	Ltg Rm M208	L	12	20/	37	A	38	20/	12	L	Ltg Rm M215	1920	
		Spare		0	-	39	B	40	-	0		Spare		
		Spare		0	-	41	C	42	-	0		Spare		
		Spare		0	-	43	A	44	-	0		Spare		
		Spare		0	-	45	B	46	-	0		Spare		
		Spare		0	-	47	C	48	-	0		Spare		
		Spare		0	-	49	A	50	-	0		Spare		
		Spare		0	-	51	B	52	-	0		Spare		
		Spare		0	-	53	C	54	-	0		Spare		
		Spare		0	-	55	A	56	-	0		Spare		
		Spare		0	-	57	B	58	-	0		Spare		
		Spare		0	-	59	C	60	-	0		Spare		
		Spare		0	-	61	A	62	-	0		Spare		
		Spare		0	-	63	B	64	-	0		Spare		
		Spare		0	-	65	C	66	-	0		Spare		
		Spare		0	-	67	A	68	-	0		Spare		
		Spare		0	-	69	B	70	-	0		Spare		
		Spare		0	-	71	C	72	-	0		Spare		
		Spare		0	-	73	A	74	-	0		Spare		
		Spare		0	-	75	B	76	-	0		Spare		
		Spare		0	-	77	C	78	-	0		Spare		
		Spare		0	-	79	A	80	-	0		Spare		
		Spare		0	-	81	B	82	-	0		Spare		
		Spare		0	-	83	C	84	-	0		Spare		
	29,809	Subtotal										Subtotal	26,037	

N.E.C.	Load Type	Conn.	Fct.	Diversity	N.E.C.	Load Type	Conn.	Fct.	Diversit
220.44	(R) Recept.	0		0	210.20(a)	(L)	56,572	125	70,715
220.56	(K) Kitchen	0	100	0		(EL) Ext. Ltg.	0	125	0
220.60	(C) Cooling	0	0%	0	620.14	(E) Elevators	0	0%	0
220.60	(H) Heating	0	0%	0		(WH) Water Ht.	0	100	0
220.60	(F) Fans	0	100	0	220.5	(MT) Lrg. Mot.	0	125	0
	(M) Misc.	0	100	0		(SP) Sub Panel	0	100	0

Total Connected	57,112	VA	158.6	AM	Location of	MECH/ELEC C215
Total Load	71,390	VA	198.3	AM		

Panelboard 2L1 Phase Loading

PHASE LOADING					
RIGHT SIDE OF PANEL			LEFT SIDE OF PANEL		
PHASE A	PHASE B	PHASE C	PHASE A	PHASE B	PHASE C
1,920	-	-	1,056	-	-
-	1,920	-	-	1,750	-
-	-	1,920	-	-	40
1,920	-	-	1,920	-	-
-	1,920	-	-	1,200	-
-	-	1,920	-	-	1,200
1,920	-	-	600	-	-
-	1,920	-	-	1,518	-
-	-	1,920	-	-	1,920
162	-	-	1,920	-	-
-	1,875	-	-	1,920	-
-	-	192	-	-	1,920
192	-	-	1,920	-	-
-	192	-	-	1,920	-
-	-	1,920	-	-	1,920
192	-	-	1,920	-	-
-	1,920	-	-	1,920	-
-	-	192	-	-	3,186
1,920	-	-	1,325	-	-
8,226	9,747	8,064	10,661	10,228	10,186

PHASE LEG	(VA/PHASE)
PHASE A =	18,887
PHASE B =	19,975
PHASE C =	18,250

Short Circuit Analysis

Analysis for the short circuit study started at the existing one line diagram. I will be focusing on the path of the 1L1 panelboard. This includes the cable to the main switchboard (MS-E1), the cable to a high density panelboard (1H1), the cable to the transformer (T1L1), the transformer itself (T1L1), and finally the cable to the lighting panelboard (1L1).

This short circuit study was analyzed by X & R ratio methods. A list of equations for this study are as follows:

Transformers:

$$XFMR_{Xu} = \frac{(X)(Base\ kVA)}{XFMR\ kVA}\ ;\ XFMR_{Ru} = \frac{(R)(Base\ kVA)}{XFMR\ kVA}$$

Components (cables):

$$X_u = \frac{(X)(Base\ kVA)}{(1000)(kV)^2}\ ;\ R_u = \frac{(R)(Base\ kVA)}{(1000)(kV)^2}$$

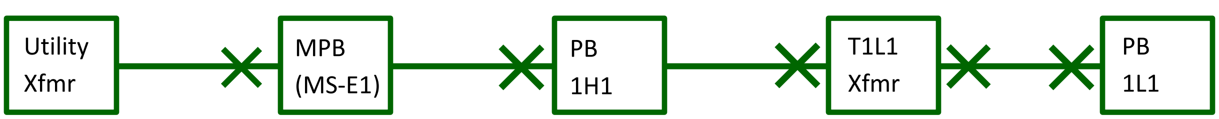
$I_{short\ circuit}$:

$$I_{sc} = \frac{(Base\ kVA)}{(\sqrt{3})(kV)(Z_u)}$$

Resultant Z_u:

$$(Z_u)^2 = (R_u)^2 + (X_u)^2$$

Short Circuit Study Path:
The five “X’s” note the locations where each fault-current was found.



The following tables were made in excel to study each location. The X and R components build further and further down the circuit path until it stops at panelboard 1L1. These excel tables use the above equations and use a base kVA of 25,000. Table 14 is used for transformers and table 17 is used for cables. These charts can be found at the end of this short circuit study.

To Main Switchboard (MS-E1) (1^{st} "X")

xfmr	
Base kVA	25000
Xfmr kVA	0
	From Table 14
%X	0.00%
%R	0.00%
Ru	#DIV/0!
Xu	#DIV/0!

cable1 - to MPB		
Base kVA	25000	
Length	55	
Cable	400MCM	
sets	5	
	Fromt Table 17	Adjusted
%X	0.0409	0.00045
%R	0.0348	0.000383
Ru	0.041536458	
Xu	0.048817274	

Type	X	R
Base	0.691038289	0.691038
Cable1	0.048817274	0.041536
total	0.739855563	0.732575

Final		
kV	0.48	
	Z2=X2+R2	
Z2	1.041178186	
Isc	28881.06	A
	28.88	kA

To Panelboard (1H1) (2nd "X")

xfmr	
Base kVA	25000
Xfmr kVA	0
	From Table 14
%X	0.00%
%R	0.00%
Ru	#DIV/0!
Xu	#DIV/0!

cable1 - to MPB		
Base kVA	25000	
Length	55	
Cable	400MCM	
sets	5	
	Fromt Table 17	Adjusted
%X	0.0409	0.00045
%R	0.0348	0.000383
Ru	0.041536458	
Xu	0.048817274	

cable2 - to 1H1		
Base kVA	25000	
Length	15	
Cable	250MCM	
sets	1	
	Fromt Tab	Adjusted
%X	0.0428	0.000642
%R	0.0534	0.000801
Ru	0.086914	
Xu	0.069661	

Type	X	R
Base	0.691038289	0.691038
Cable1	0.048817274	0.041536
Cable2	0.069661458	0.086914
total	0.809517021	0.819489

Final	
kV	0.48
	Z2=X2+R2
Z2	1.151902651
Isc	26104.92 A
	26.10 kA

To Transformer (T1L1) (3rd "X")

xfmr	
Base kVA	25000
Xfmr kVA	0
	From Table 14
%X	0.00%
%R	0.00%
Ru	#DIV/0!
Xu	#DIV/0!

cable1 - to MPB		
Base kVA	25000	
Length	55	
Cable	400MCM	
sets	5	
	Fromt Table 17	Adjusted
%X	0.0409	0.00045
%R	0.0348	0.000383
Ru	0.041536458	
Xu	0.048817274	

cable2 - to 1H1		
Base kVA	25000	
Length	15	
Cable	250MCM	
sets	1	
	Fromt Tab	Adjusted
%X	0.0428	0.000642
%R	0.0534	0.000801
Ru	0.086914	
Xu	0.069661	

cable3 - to T1L1 xfmr		
Base kVA	25000	
Length	15	
Cable	#4	
sets	1	
	Fromt Tab	Adjusted
%X	0.0492	0.000738
%R	0.3114	0.004671
Ru	0.506836	
Xu	0.080078	

Type	X	R
Base	0.691038289	0.691038
Cable1	0.048817274	0.041536
Cable2	0.069661458	0.086914
Cable3	0.080078125	0.506836
total	0.889595146	1.326325

Final	
kV	0.48
	Z2=X2+R2
Z2	1.597033769
Isc	18828.86 A
	18.83 kA

Transformer (T1L1) (4th "X")

xfmr - T1L1	
Base kVA	25000
Xfmr kVA	45
	From Table 14
%X	1.73%
%R	2.52%
Ru	14
Xu	9.611111111

cable1 - to MPB		
Base kVA	25000	
Length	55	
Cable	400MCM	
sets	5	
	Fromt Table 17	Adjusted
%X	0.0409	0.00045
%R	0.0348	0.000383
Ru	0.041536458	
Xu	0.048817274	

cable2 - to 1H1		
Base kVA	25000	
Length	15	
Cable	250MCM	
sets	1	
	Fromt Tab	Adjusted
%X	0.0428	0.000642
%R	0.0534	0.000801
Ru	0.086914	
Xu	0.069661	

cable3 - to T1L1 xfmr		
Base kVA	25000	
Length	15	
Cable	#4	
sets	1	
	Fromt Tab	Adjusted
%X	0.0492	0.000738
%R	0.3114	0.004671
Ru	0.506836	
Xu	0.080078	

Type	X	R
Base	0.691038289	0.691038
Cable1	0.048817274	0.041536
Cable2	0.069661458	0.086914
Cable3	0.080078125	0.506836
Xfmr	9.611111111	14
total	10.50070626	15.32632

Final	
kV	0.48
	Z2=X2+R2
Z2	18.57851076
Isc	1618.55 A
	1.62 kA

To Panelboard (1L1) (5th "X")

xfmr - T1L1	
Base kVA	25000
Xfmr kVA	45
	From Table 14
%X	1.73%
%R	2.52%
Ru	14
Xu	9.611111111

cable1 - to MPB		
Base kVA	25000	
Length	55	
Cable	400MCM	
sets	5	
	Fromt Table 17	Adjusted
%X	0.0409	0.00045
%R	0.0348	0.000383
Ru	0.041536458	
Xu	0.048817274	

cable2 - to 1H1		
Base kVA	25000	
Length	15	
Cable	250MCM	
sets	1	
	Fromt Tab	Adjusted
%X	0.0428	0.000642
%R	0.0534	0.000801
Ru	0.086914	
Xu	0.069661	

cable3 - to T1L1 xfmr		
Base kVA	25000	
Length	15	
Cable	#4	
sets	1	
	Fromt Tab	Adjusted
%X	0.0492	0.000738
%R	0.3114	0.004671
Ru	0.506836	
Xu	0.080078	

cable4 - to 1L1		
Base kVA	25000	
Length	15	
Cable	#1	
sets	1	
	Fromt Tab	Adjusted
%X	0.0371	0.000557
%R	0.1553	0.00233
Ru	0.252767	
Xu	0.060384	

Type	X	R
Base	0.691038289	0.691038
Cable1	0.048817274	0.041536
Cable2	0.069661458	0.086914
Cable3	0.080078125	0.506836
Xfmr	9.611111111	14
Cable4	0.060384115	0.252767
total	10.56109037	15.57909

Final	
kV	0.48
	$Z^2=X^2+R^2$
Z2	18.82139015
Isc	1597.67 A
	1.60 kA

So the final I_{sc} for this circuit that ends with panelboard 1L1 comes to 1,598 Amps of fault-current.

Table 1.1
Fault Current Analysis Summary

Switchgear	Available Fault (kA)	Standard Breaker Rating (kA)
Main Switchboard (MS-E1)	28.88	65
Panelboard (1H1)	26.1	30
To Transformer (T1L1)	18.86	22
Transformer (T1L1)	1.62	10
Panelboard (1L1)	1.6	10

Table 1.1

TABLE 14—Dry-type transformers—Type QHT, % Impedance, Reactance and Resistance ‡

kVA	Single-phase			Three-phase			
	%IX	%IR	%IZ	kVA	%IX	%IR	%IZ
5	1.68	2.94	3.4	6	1.72	2.72	3.2
7.5	1.84	2.42	3.0	9	1.16	2.31	2.6
10	1.92	2.04	2.75	15	1.82	2.1	2.8
15	2.02	1.60	2.6	30	1.37	3.8	4.0
25	2.3	1.4	2.7	45	1.73	2.52	3.1
37.5	2.7	3.6	4.5	75	1.91	2.27	3.0
50	2.8	3.1	4.2	112½	3.87	2.43	4.6
75	3.7	2.48	4.45	150	5.0	2.35	5.5
100	3.55	2.12	4.14	225	5.5	1.15	5.9
167	3.25	1.60	3.63	300	4.5	1.8	4.9
				500	5.9	1.6	6.1

‡Typical values based on data from several manufacturers.

Table 1.1

TABLE 17—Cables

Approximate 60-cycle resistance and reactance of copper and aluminum cable, 75 C conductor temperature. 600 volts, 5 kV and 15 kV. Magnetic and nonmagnetic conduit ohms/1000 ft l-n*.

Cable Size	Copper Conductor							
	Cable in Magnetic Conduit				Cable in Nonmagnetic Conduit			
	l/C Conductor		3/C Conductor		1/C Conductor		3/C Conductor	
	R	X	R	X	R	X	R	X
600 Volts								
8 AWG	0.7873	0.0514	0.7873	0.0394	0.7873	0.0411	0.7873	0.0343
6 AWG	.4954	.0521	.4954	.0399	.4954	.0417	.4954	.0347
4 AWG	.3114	.0492	.3114	.0377	.3114	.0393	.3114	.0328
3 AWG	.247	.0479	.247	.0367	.247	.0383	.247	.0319
2 AWG	.1959	.0466	.1959	.0357	.1959	.0373	.1959	.0311
1 AWG	.1553	.0485	.1553	.0371	.1553	.0388	.1553	.0323
1/0 AWG	.1231	.0457	1231	.035	.1231	.0366	.1231	.0305
2/0 AWG	.0977	.0446	.0977	.0341	.0977	.0356	.0977	.0297
3/0 AWG	.0775	.0435	.0775	.0333	.0775	.0348	.0775	.029
4/0 AWG	.0614	.0425	.0614	.0326	.0614	.034	.0614	.0283
250 MCM	.0534	.0428	.0534	.0328	.0529	.0342	.0529	.0285
300 MCM	.0452	.042	.452	.032	.0443	.0336	.0443	.028
350 MCM	.0392	.0414	.0392	.0315	.0383	.0331	.0383	.0276
400 MCM	.0348	.0409	.0348	.0311	.0337	.0327	.0337	.0273
500 MCM	.0287	.0402	.0287	.0301	.0275	.0321	.0275	.0268
600 MCM	.0249	.0404	.0249	.0299	.0234	.0323	.0234	.0269
750 MCM	.0213	.0396	.0213	.0288	.0194	.0317	.0194	.0264
1000 MCM	.0179	.0388	.0179	.0276	.0155	.031	.0155	.0259
1250 MCM	.0161	.0388	.0161	.0271	.0131	.031	.0131	.0258
1500 MCM	.0149	.0383	.0149	.0265	.0115	.0306	.0115	.0255
1750 MCM	.0141	.0378	.0141	.026	.0104	.0302	.0104	.0252
2000 MCM	.0135	.0375	.0135	.0257	.0096	.03	.0096	.025

Wind Power Generation

This section will be discussing a wind powered electricity generation system. This system is integrated into the solar shading system that protects the solarium. This shading system is part of my proposed lighting depth. An in-depth description can be found in that section of this report.

design + components

Using the power of the wind, the disks found in the solar shading system will rotate when propelled. This rotation is what will be harnessed into electric energy. The system essentially turns kinetic energy in the form of wind and turns it into electricity. The rotating part of the disk will turn a small individual induction motor. This motor will have a small output of 6 watts, but with each disk having its own motor, there will be a total of 1,298 small induction motors. Therefore, this system can then power about 7,788 watts. The output is 120/208V A/C power. This is then daisy-chained together to a separate panelboard. The power will be split onto six circuits with 1,298 watts per circuit.

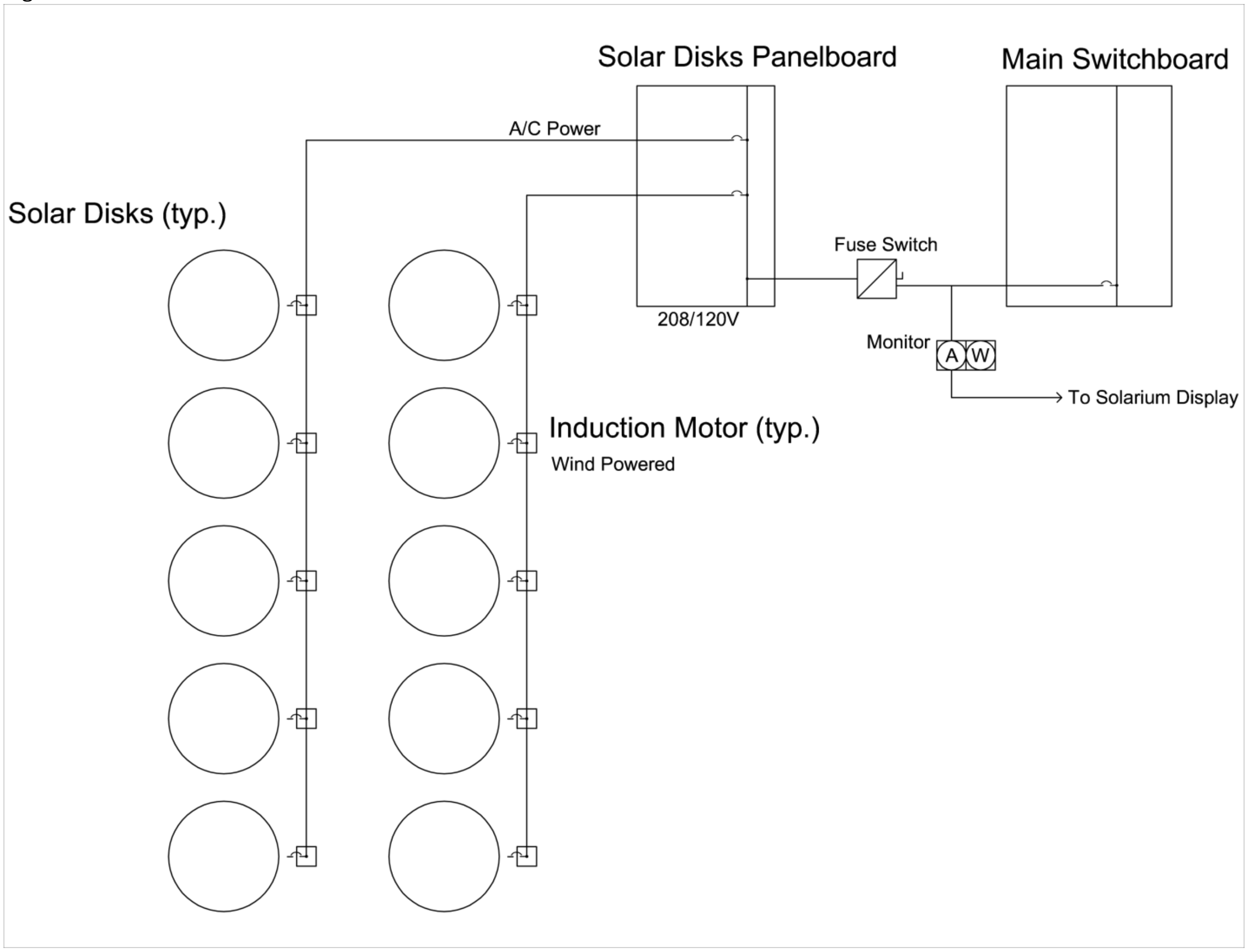
In order to protect the main switchboard, and when shut-off is needed, a fused switch will be needed in-between the main switchboard and the solar disk panelboard. A monitor will also be used here to observe the amount of energy the system is generating at each point of the day. The power can then be brought back to the main switchboard, which is then apart of the museum's power it can use. This system could reduce the total power consumption of the building by 0.59%.

This power generation is not meant to fill a large portion of the total power usage of the Nerman Museum. Instead it is used as part of an art installation. Fitting with the theme of the buildings minimal design, and connection to its surroundings, this system is meant to further realize that link to nature. By putting numbers to nature, and literally, putting the forces of nature back into the building, the museum as a whole grows stronger in its overall design.

The power generated by this system will be for the whole museum to see. In the solarium, there will be a LED screen with data on the power generation of these spinning disks. It will have totals for the day, month, and year as well as a timeline of different parts of the day's wind generation. This installation can become a learning experience for the patrons that come to the museum.

single line integration

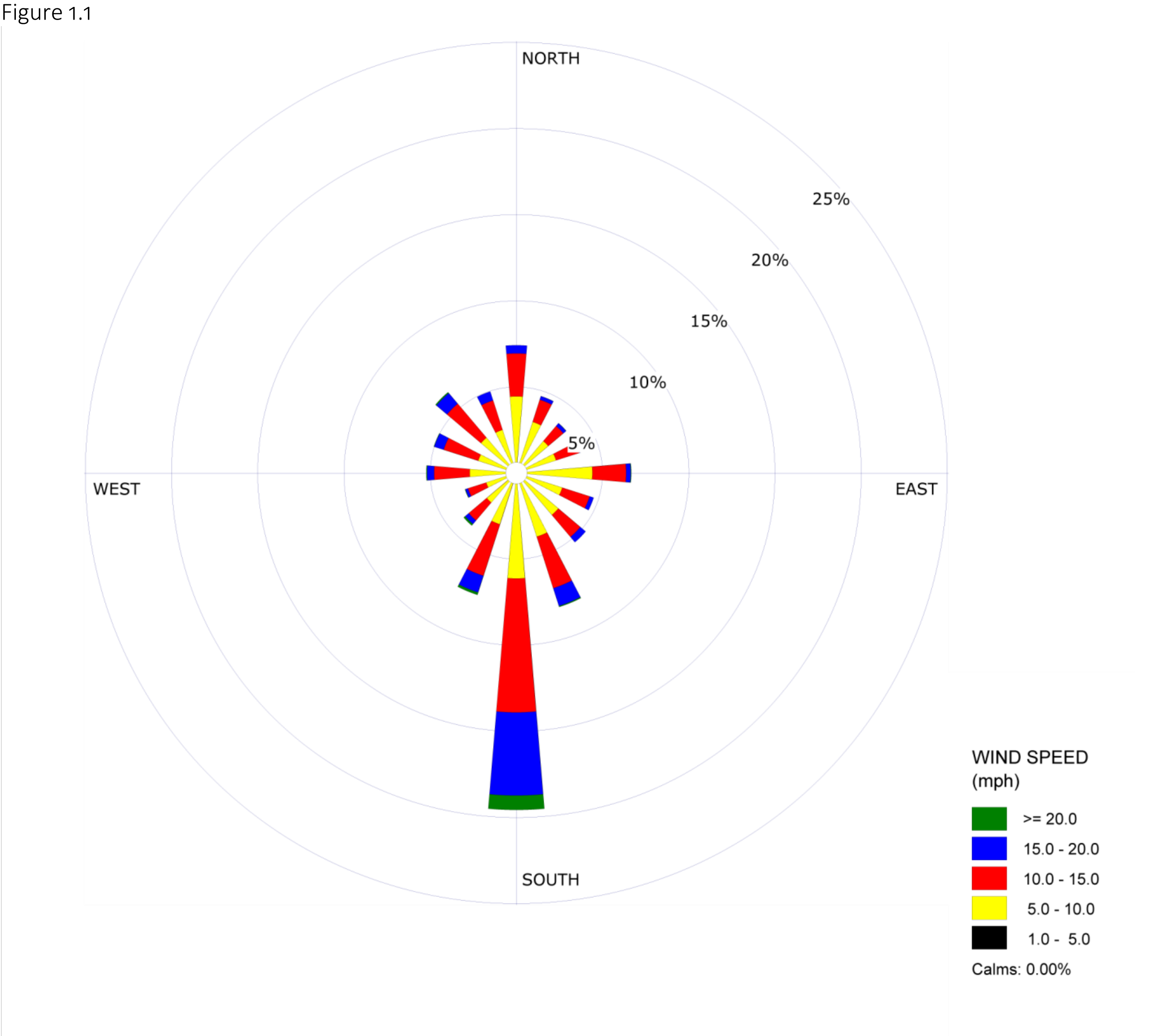
Figure 1.1



proformance

overland park wind rose

Figure 1.1



This wind rose shows that wind is mostly from the south. In order for the disks to spin, there needs to be east or west direction wind. By this wind rose, you can see that wind comes from the East 22% of the time, and from the West, also about 22% of the time. So totally, the solar disks should be able to be spinning about 44% of the day. This means they could spin up to 10.5 hours out of the day. The wind rose also shows that the average wind speed is about 10 mph.

The radius of the solar disks are 8" each. This means if the wind speed is 10 mph constantly, the disks will spin 210 rotations per minute. Now this is not a perfect system and there are certainly losses with the torque needed to turn each disk as well as the small surface area that can be forced to turn by the wind. This system will not perform at this optimum output.

$$RPM = \left(\frac{1}{16\ inches\ (diameter)}\right)\left(\frac{1}{\pi}\right)\left(\frac{10\ miles}{hour}\right)\left(\frac{63360\ inches}{1\ mile}\right)\left(\frac{1\ hour}{60\ mins}\right) = 210\ RPM$$

Below is an induction motor's frequency setting. By choosing a 7.5 ratio, the motor will need to spin at 200 RPM to maintain a 6 watt output. This will allow for minimum torque needed to spin the motor.

Freqency	Ratio		3	3.6	5	6	7.5	9	10	12.5	15	18	20	25
50HZ	Output Speed	r/min	500	417	300	250	200	166	150	120	100	83	75	60
	Allow Toruqe	N.m	0.13	0.15	0.21	0.21	0.32	0.38	0.42	0.53	0.63	0.76	0.76	0.95
		kgf.cm	1.3	1.5	2.1	2.1	3.2	3.9	4.3	5.4	6.4	7.7	7.7	9.7

Frequency	Ratio		30	36	40	50	60	75	90	100	120	150	180	200
50HZ	Output Speed	r/min	50	41	37	30	25	20	16	15	12	10	8	7.5
	Allow Toruqe	N.m	1.14	1.36	1.52	1.72	2.06	2.57	2.94	2.94	2.94	2.94	2.94	2.94

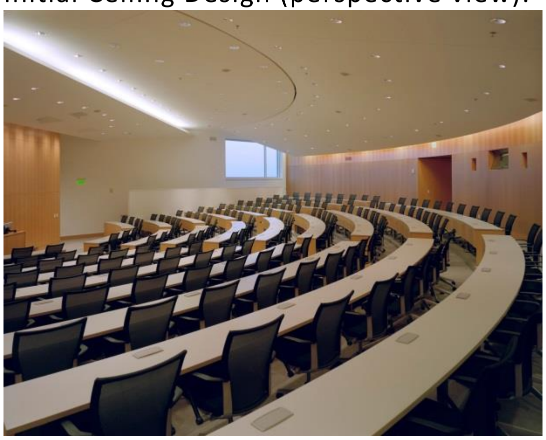
Since the disks will only be spinning, on average, 44% of the time, the power generated will not be the full 6 watts. It will therefore only generate about 3427 watts of power. This will also see significant losses that were discussed above. At losses of about 70%, the system could produce around 1000 watts total. As stated above, this system is not meant to provide a large amount of power to the building, but more to support the museums overall design concept and atmosphere.

Breadth I - Structural:

Breadth I is a structural study into the joist and roof deck of the auditorium. It is necessary to redesign these systems due to the changes made during the lighting depth. During the redesign of the lighting in the auditorium, skylights were added overhead. New ceiling panels were also designed to take reflect the overall lighting design concept. Working with optimal sky-lighting placement and total joist spans, a compromise was found between the lighting and structural requirements for the space. This breadth deals with the structural portion of the design.

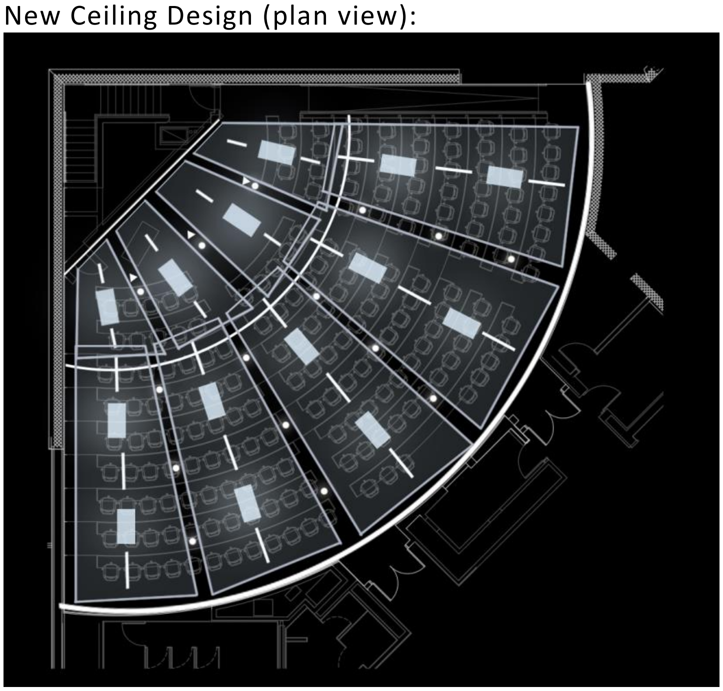
New Ceiling Design

Initial Ceiling Design (perspective view):



New Ceiling Design (perspective view):

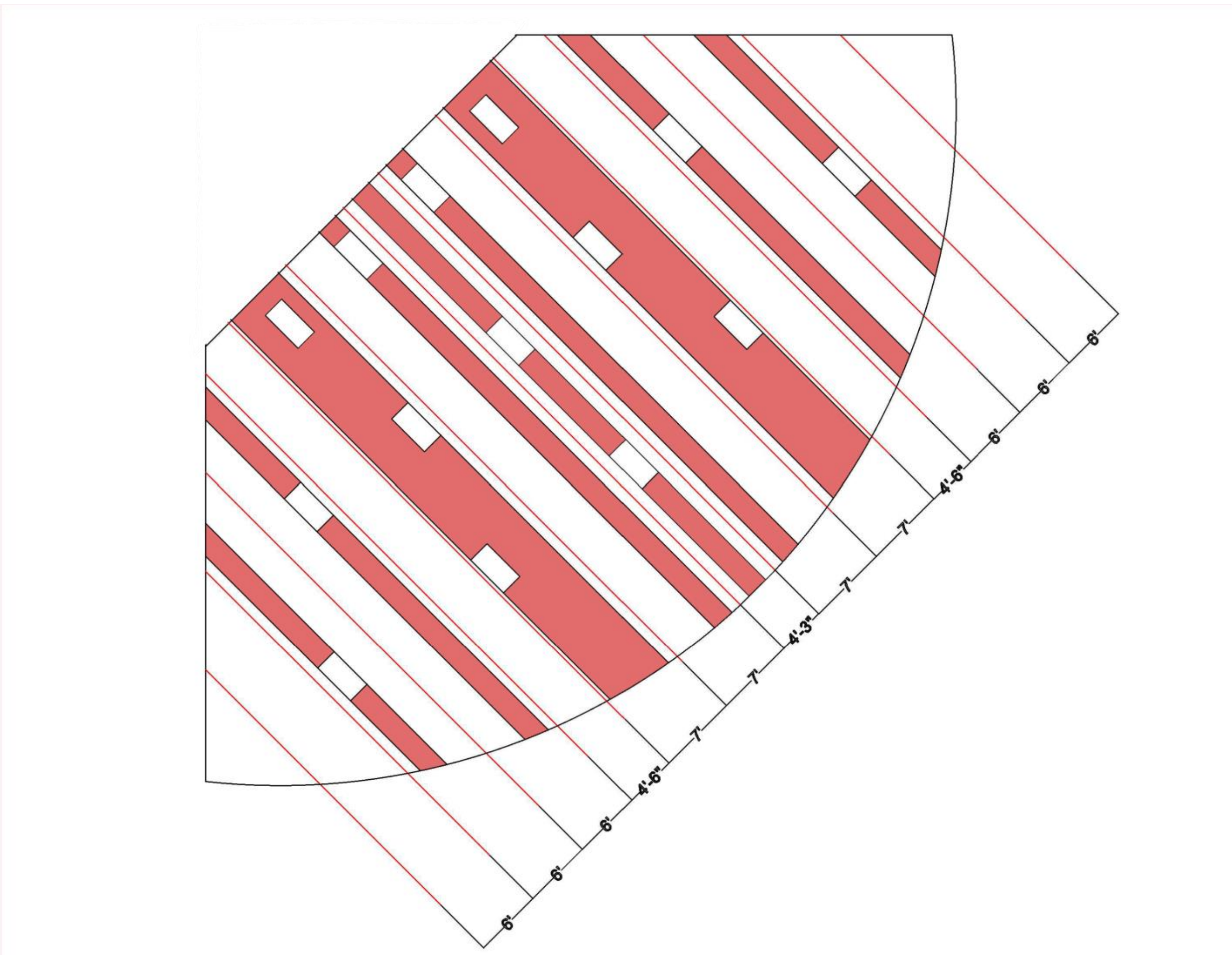
New Ceiling Design (plan view):



Design Process

The first part of the design was placing the skylights in optimal locations over the drop ceiling panels so that they could be evenly distributed over the space, and to the desired effect of the lighting concept. With the skylights placed, the locations where the joists may run at full span could be looked at.

Figure 1.1
Area study for joist placement



In the figure above, the skylight spans are highlighted in red to show where the structural joist cannot be placed. Only in the white parts could the joists span the whole length of the auditorium. Slight adjustments were needed to the placement of the skylights in order to accommodate the spans between joists. A span of 7' was chosen to be the largest span acceptable. This decision was based on the upper limitations of LH joists with they're depth and self-weight restrictions.

Roof Deck Calculation:

The analysis started with the roof deck. The roof deck needed to be redesign due to the increase spans needed (7 feet). The old deck can be found below.

9 TYPICAL ROOF DECK IS 1½" DEEP x 22 GAGE WIDE RIB (TYPE B) GALVANIZED METAL ROOF DECK. WELD TO SUPPORTING STRUCTURE WITH ⅝"ø PUDDLE WELDS @6"OC MAXIMUM AND #10 TEK SCREWS SIDE LAP FASTENERS @6"OC MAXIMUM TYPICAL. (MAXIMUM DECK SPAN ALLOWED = 5'–6").

This deck could only span 5'-6" and the newly design roof deck needed to be able to span 7'. For the roof deck calculation, a list of load assumptions used is as followed:

Metal deck = 2 psf
Rigid Insulation = 2 psf
Built-up roof = 20 psf
Misc. deal load = 10 psf (lighting, ductwork, new ceiling panels) (less due to added skylights)
Self-weights of joist girders = 5 psf
Live load = 20 psf
Snow load = 20 psf (Kansas)

Since the live load and snow load are the same, the dynamic loading is 20 psf by default.

Loading Equation:

$$\boldsymbol{W_u = 1.2(Dead) + 1.6(Live\ or\ Snow)}$$

$$\boldsymbol{W_u = 1.2(2 + 2 + 20 + 10 + 5) + 1.6(20) = 78.8\ psf}$$

This total, 78.8 psf, was then used to find an appropriate roof deck using Vulcraft (manufacture)(Roof Deck catalog excerpt found at end of section). Two evaluations were used to test against the decks max stress and deflection. A Vulcraft 1.5B20 was specified to span 7'-0".

Max Stress:

$$\boldsymbol{78.8\ psf \leq Allowable\ stress\ (black\ \#)}$$

$$\boldsymbol{78.8\ psf \leq 82} \checkmark$$

Max Deflection:

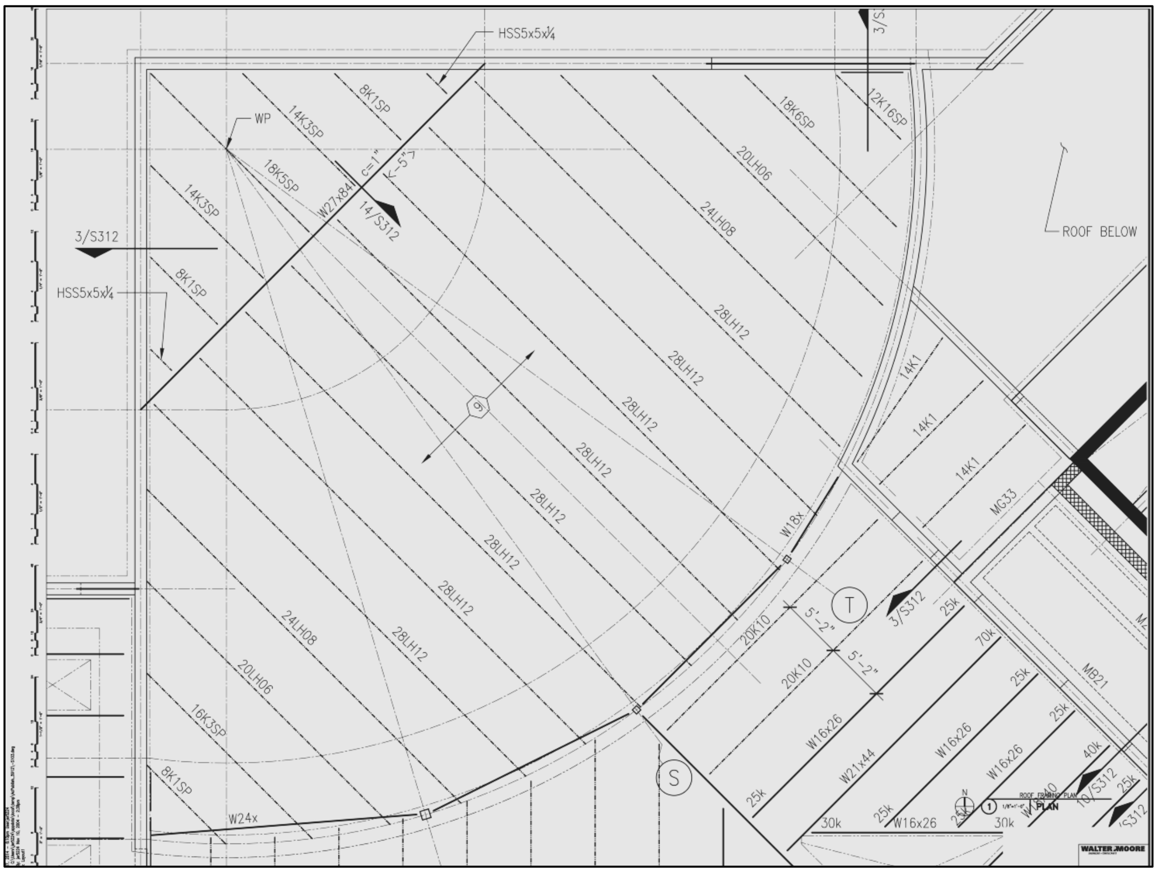
$$\boldsymbol{78.8\ psf \leq Allowable\ stress\ (red\ \#) \times \frac{240}{180}}$$

$$\boldsymbol{78.8\ psf \leq 101.33} \checkmark$$

Joist Calculation:

The joists then needed to be resized according to the new spans. Since 7'-0" was the biggest span needed, a spacing of 7'-0" was used for all joists to be conservative. The initial joist layout can be found below:

Figure 1.1
Initial Joist Design



A factored and unfactored load was then calculated to compare to the max load (factored) and the max deflection (unfactored). An L/240 deflection equation was used to find the joist design. The Vulcraft catalog provides L/360, which is a more stringent design criterion. The max load is taken from the roof decking assumptions.

Dead load = 39 psf
Live load = 20 psf
Snow load = 20 psf

Loading Equation in linear feet (for influence area):

$$W_u(plf) = W_u(psf) \times 7ft\ (span)$$

Factored Load Equation in linear feet:

$$W_u(plf) = 78.8(psf) \times 7ft\ (span) = 551.6\ plf$$

Unfactored Load Equation in linear feet (for L/240):

$$W_u(plf) = (29 + 20)(psf) \times 7ft\ (span) = 413\ plf$$

Max Loading Equation:

$$551.6\ plf + 1.2(self\ wt) \leq max\ loading\ (black\ \#)$$

Max Deflection Equation (for L/240):

$$413\ plf + (self\ wt) \leq 1.5\ \times\ max\ deflection\ (red\ \#)$$

These two loads were then compared to the max load and max deflection stats for joists in the Vulcraft catalog. After multiple comparisons a joist was selected for each joist length.

Joists needing sized:

- (6) 50' length joists
- (2) 42' length joists
- (2) 34' length joists
- (2) 25' length joists
- (2) 14' length joists

(6) 50' length joists – Vulcraft 28LH11

Factored: $551.6\ plf + 1.2(25) \leq 841\ (black\ \#)$ ✓

Unfactored: $413\ plf + 25 \leq 1.5\ \times\ 294\ (red\ \#)$ ✓

(2) 42’ length joists – Vulcraft 28LH07

Factored: $\mathbf{551.6}\,\boldsymbol{plf} + \mathbf{1.2(17)} \leq \mathbf{726}\ (\boldsymbol{black}\ \#)$ ✓

Unfactored: $\mathbf{413}\,\boldsymbol{plf} + \mathbf{17} \leq \mathbf{1.5} \times \mathbf{305}\ (\boldsymbol{red}\ \#)$ ✓

(2) 34’ length joists – Vulcraft 24LH05

Factored: $\mathbf{551.6}\,\boldsymbol{plf} + \mathbf{1.2(13)} \leq \mathbf{669}\ (\boldsymbol{black}\ \#)$ ✓

Unfactored: $\mathbf{413}\,\boldsymbol{plf} + \mathbf{13} \leq \mathbf{1.5} \times \mathbf{297}\ (\boldsymbol{red}\ \#)$ ✓

(2) 25’ length joists – Vulcraft 18K5

Factored: $\mathbf{551.6}\,\boldsymbol{plf} + \mathbf{1.2(7.7)} \leq \mathbf{600}\ (\boldsymbol{black}\ \#)$ ✓

Unfactored: $\mathbf{413}\,\boldsymbol{plf} + \mathbf{7.7} \leq \mathbf{1.5} \times \mathbf{281}\ (\boldsymbol{red}\ \#)$ ✓

(2) 14’ length joists – Vulcraft 10K1

Factored: $\mathbf{551.6}\,\boldsymbol{plf} + \mathbf{1.2(5)} \leq \mathbf{618}\ (\boldsymbol{black}\ \#)$ ✓

Unfactored: $\mathbf{413}\,\boldsymbol{plf} + \mathbf{5} \leq \mathbf{1.5} \times \mathbf{289}\ (\boldsymbol{red}\ \#)$ ✓

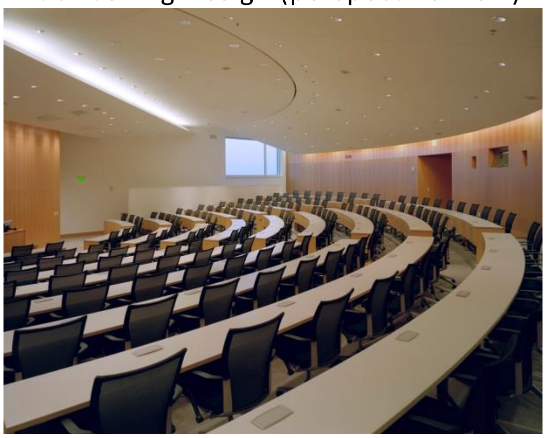
Conclusion:

The integration of the lighting and structural system came together here to create a workable solution. The structural design may be conservative by sizing each joist to 7’ spans, but compromise is needed to achieve a high quality design. The overall joist depth was never design over 28” which allows the ceiling panels to be higher in the room, creating a much needed feeling of space.

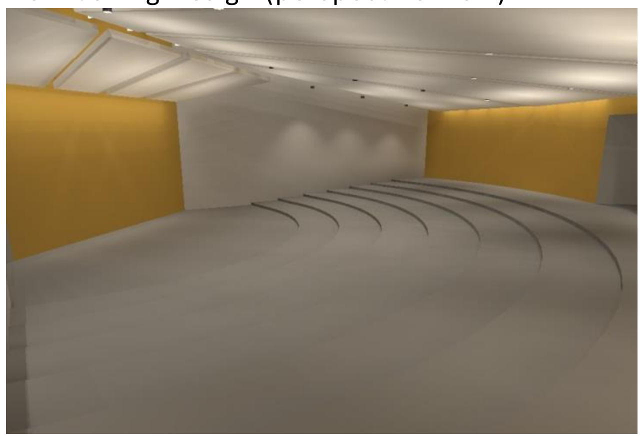
Breadth II - Acoustical:

Breadth II is an acoustical study into the redesign of the auditorium. Due to the lighting concept for this space, the ceiling of the auditorium was designed to let sunlight into the space. The shape and material of the ceiling were changed to achieve the lighting goals.

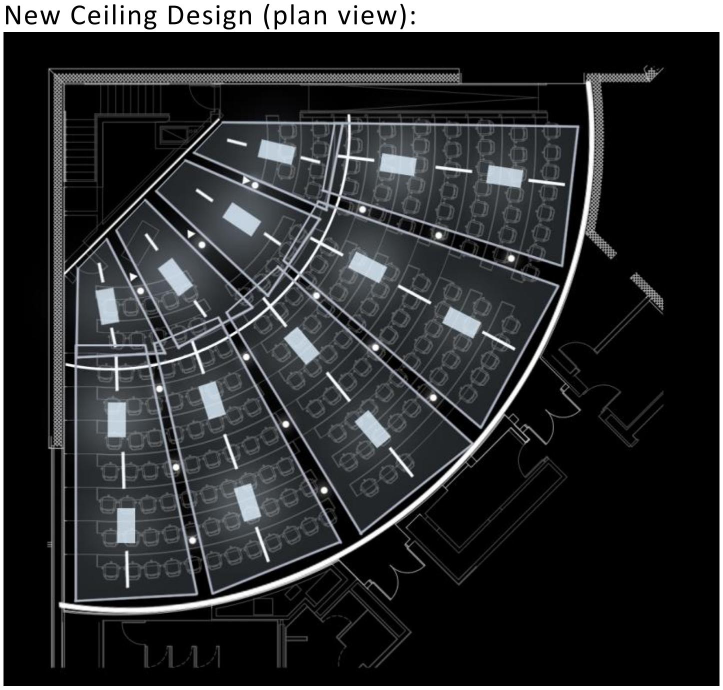
Initial Ceiling Design (perspective view):



New Ceiling Design (perspective view):



New Ceiling Design (plan view):



The pictures above illustrate the new ceiling design for the auditorium. The original ceiling, made of GWB, slopes up in the front of the room, levels off in the middle and then slopes back toward the back of the room. The new ceiling is laid out in a radial fan pattern. It is made up of nine panels of

PVC Newmat stretch material. The panels slope up in the front of the room, and then gradually back down toward the back of the room. This overall new ceiling design lessens the total volume of the room and decreases the total surface area.

Performance Criteria

The acoustical performance study will be based on the appropriate reverberation time (RT) for a lecture room or classroom where the main activity is speaking. The Nerman Musuem's auditorium is 47,142 ft^3 and the main function of the space presenting lectures with some classroom activities. The figure below outlines the appropriate RTs for a speech auditorium at a certain volume. The museum's auditorium falls at approximately 0.7 RT_{500}. The new ceiling design will decrease the overall volume of the space to 43,920 ft^3 which will make the new target 0.65 RT_{500}.

Figure 1.1

RT Guidelines

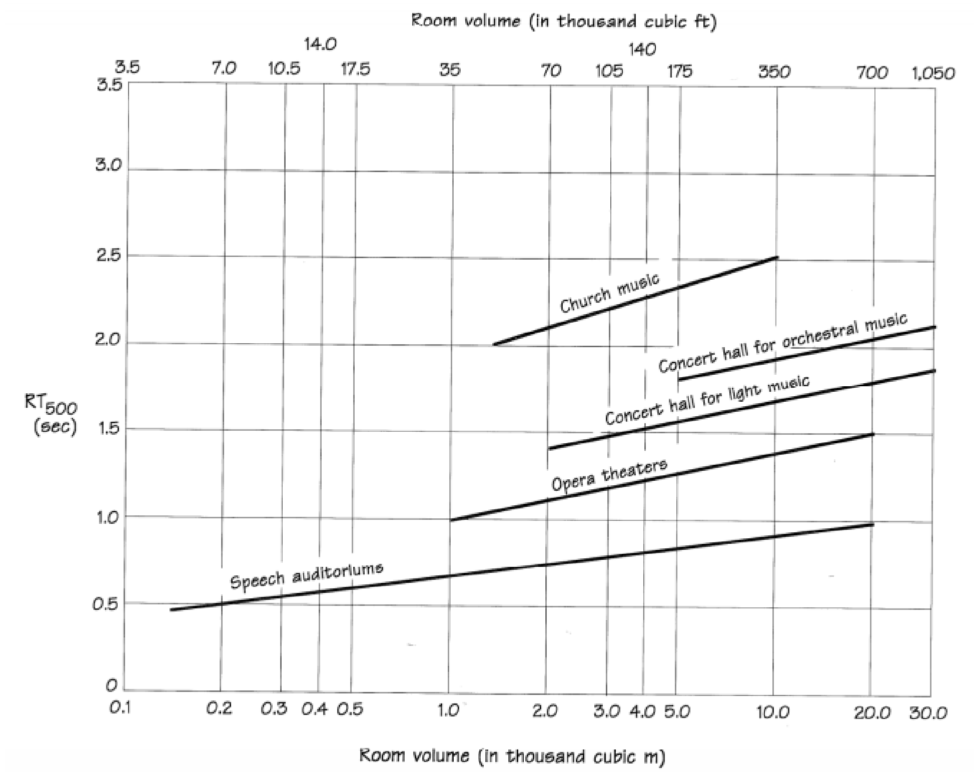


Figure 10.12 Suggested optimum RTs for various space purposes
(Architectural Acoustics by Mehta *et al* 1999)

The American National Standards Institute (ANSI) also has developed performance criteria concerning school and college buildings under ANSI S12.60. Learning spaces in schools should not have background noise levels (BNLs) that exceeds 35 dBA and a reverberation time of 0.6-0.7 seconds which is also based on the volume of the room. The table below outlines these guidelines.

Table 1.1
Limits on Background Noise Levels and RT times

Learning Spaces	SPL – Background Exterior Noise (dBA/C)	SPL – Background Interior Noise (dBA/C)	Maximum Permitted RT
Spaces ≤ 10,000 ft^3	35/55	35/55	0.6s
Spaces > 10,000 ft^3 ≤ 20,000 ft^3	35/55	35/55	0.7s
Spaces ≤ 10,000 ft^3 and all ancillary learning spaces	40/60	40/60	none

Performance Analysis

Sound absorption coefficients (α) were found for each material used in the space. This was then converted into sabines by the formula below:

$$\boldsymbol{Sabine} = (\boldsymbol{A_{surface}})(\propto)$$

The sabines for each material were added together in their respectable frequencies and averaged over the total surface area of the room. This was then used in the Reverberation Time Equations:

Sabine Equation: When $\alpha < 0.2$

$$\boldsymbol{RT} = \frac{\mathbf{0.049}\boldsymbol{V}}{\boldsymbol{S_T} \propto +\mathbf{4}\boldsymbol{mV}}$$

Norris-Eyring Equation: When $\alpha \geq 0.2$

$$\boldsymbol{RT} = \frac{\mathbf{0.049}\boldsymbol{V}}{\boldsymbol{S_T}\, \boldsymbol{ln}(\mathbf{1}-\propto) + \mathbf{4}\boldsymbol{mV}}$$

Where S_T = Total surface area of the room in ft;
m = Air attenuation constant;
V = Volume of room in ft^3

Results

Original Ceiling Design RT Calculation:

Table 1.1

Room Volume and SA

Volume (ft³) [V]	47,142.00
Total Surface Area (sqft) [Stot]	10,052.25

			Sound Absorption Coefficient (α)						S*α (sabines)					
			Frequency [f] (Hz)						Frequency [f] (Hz)					
Surface Description	**Surface Area [S] (ft²)**	**Material Description**	125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
Front Wall	580.50	Veneer Panel System	0.1	0.11	0.1	0.08	0.08	0.11	58.05	63.86	58.05	46.44	46.44	63.86
Side Wall Right	881.50	Veneer Panel System	0.1	0.11	0.1	0.08	0.08	0.11	88.15	96.97	88.15	70.52	70.52	96.97
Side Wall Left	1,307.25	5/8" PTD GWB	0.22	0.08	0.05	0.04	0.03	0.03	287.60	104.58	65.36	52.29	39.22	39.22
Back Wall	2,052.00	Perf HDWD 5/8" Decoustics Solo Board Panels w 1" Accoustical Fiberglass	0.1	0.45	1.03	0.96	0.71	0.69	205.20	923.40	2113.56	1969.92	1456.92	1415.88
Window Left	120.00	Window	0.35	0.25	0.18	0.12	0.07	0.04	42.00	30.00	21.60	14.40	8.40	4.80
Front Ceiling	286.00	5/8" GWB	0.22	0.08	0.05	0.04	0.03	0.03	62.92	22.88	14.30	11.44	8.58	8.58
Middle Ceiling	975.00	5/8" GWB	0.22	0.08	0.05	0.04	0.03	0.03	214.50	78.00	48.75	39.00	29.25	29.25
Back Ceiling	550.00	5/8" GWB	0.22	0.08	0.05	0.04	0.03	0.03	121.00	44.00	27.50	22.00	16.50	16.50
Floor Carpet	1,320.00	Carpet	0.03	0.05	0.09	0.2	0.3	0.4	39.60	66.00	118.80	264.00	396.00	528.00
Floor Desks	990.00	P-Lam Top	0.02	0.03	0.03	0.03	0.03	0.02	19.80	29.70	29.70	29.70	29.70	19.80
Floor Seating	990.00	Light uphostered Seating	0.35	0.45	0.57	0.61	0.59	0.55	346.50	445.50	564.30	603.90	584.10	544.50
	10,052.25													

	125	250	500	1000	2000	4000
Sum S*α=	1485.32	1904.88	3150.07	3123.61	2685.63	2767.35
Avg α=	0.147759	0.189498	0.31337	0.310737	0.267167	0.275296
Air apsorption constant for 20 degC and 40% RH (m)=	0	0.001	0.0003	0.0004	0.009	0.027
Sabine =	1.555197	1.103423	0.720366	0.722079	0.527058	0.293937
Norris-Eyring =	1.437239	1.004086	0.602209	0.605303	0.479073	0.27737
Calculated RT(s) =	1.555197	1.103423	0.602209	0.605303	0.479073	0.27737

New Ceiling Design RT Calculation:

Table 1.1

Room Volume and SA

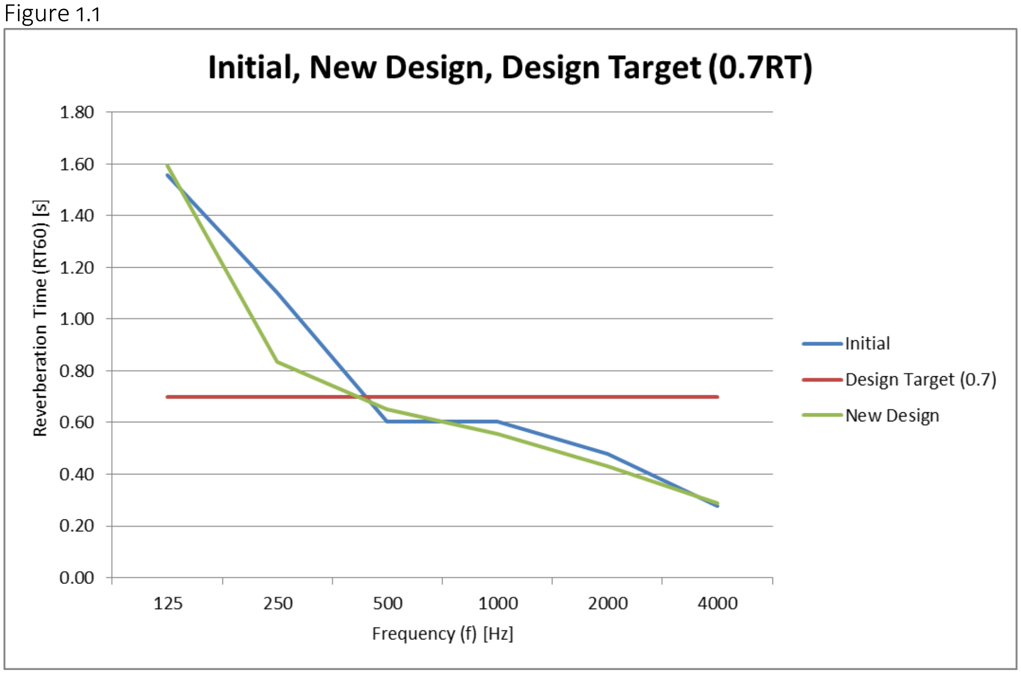
Volume (ft³) [V]	43,920.00
Total Surface Area (sqft) [Stot]	9,907.25

			Sound Absorption Coefficient (α)						S*α (sabines)					
			Frequency [f] (Hz)						Frequency [f] (Hz)					
Surface Description	**Surface Area**	**Material Description**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**125**	**250**	**500**	**1000**	**2000**	**4000**
Front Wall	580.50	Veneer Panel System	0.1	0.11	0.1	0.08	0.08	0.11	58.05	63.86	58.05	46.44	46.44	63.86
Side Wall Right	881.50	Veneer Panel System	0.1	0.11	0.1	0.08	0.08	0.11	88.15	96.97	88.15	70.52	70.52	96.97
Side Wall Left	1,307.25	5/8" PTD GWB	0.22	0.08	0.05	0.04	0.03	0.03	287.60	104.58	65.36	52.29	39.22	39.22
Back Wall	2,052.00	Perf HDWD 5/8" Decoustics Solo Board Panels	0.09	0.12	0.37	0.82	0.68	0.4	184.68	246.24	759.24	1682.64	1395.36	820.80
Window Left	120.00	Window	0.35	0.25	0.18	0.12	0.07	0.04	42.00	30.00	21.60	14.40	8.40	4.80
Front Ceiling	286.00	PVC Newmat stretched film	0.17	0.63	0.64	0.24	0.19	0.14	48.62	180.18	183.04	68.64	54.34	40.04
Middle Ceiling	1,380.00	PVC Newmat stretched film	0.17	0.63	0.64	0.24	0.19	0.14	234.60	869.40	883.20	331.20	262.20	193.20
									0.00	0.00	0.00	0.00	0.00	0.00
Floor Carpet	1,320.00	Carpet	0.03	0.05	0.09	0.2	0.3	0.4	39.60	66.00	118.80	264.00	396.00	528.00
Floor Desks	990.00	P-Lam Top	0.02	0.03	0.03	0.03	0.03	0.02	19.80	29.70	29.70	29.70	29.70	19.80
Floor Seating	990.00	Light uphostered Seating	0.35	0.45	0.57	0.61	0.59	0.55	346.50	445.50	564.30	603.90	584.10	544.50
	9,907.25													

Sum S*α=	1349.60	2132.42	2771.44	3163.73	2886.28	2351.18
Avg α=	0.136223	0.215238	0.279739	0.319335	0.29133	0.237319
Air apsorption constant for 20 degC and 40% RH (m)=	0	0.001	0.0003	0.0004	0.009	0.027
Sabine =	1.594612	0.932403	0.762028	0.665454	0.48173	0.303343
Norris-Eyring =	1.48335	0.835126	0.651418	0.554454	0.431034	0.289749
Calculated RT(s) =	1.594612	0.835126	0.651418	0.554454	0.431034	0.289749

Graph of Initial, New & Target Design:

Figure 1.1



From the graph above, you can see that the RT_{500} of the new ceiling design is right underneath the target RT of 0.7. At 500 Hz the new design results in an RT of 0.65. The initial design does provide an RT of 0.6, which is also very good for this space.

In order for the new design to perform well, the back wall acoustical material had to change. Originally, the back wall was made of Decousitcs Solo 8-25 wood panels with a fiber glass backer. This material made up for a lot of the absorption in the room. The ceiling was GWB. By adding in the new ceiling design, and the PVC stretch material, it added additional absorption. An adjustment was then made to the back wall to lower the total absorption. The back wall was changed to a Decousitcs Solo 8-25 wood panel but without a fiber glass backer. This reduced the absorption significantly. The specs can be found below:

Table 1.1
Decoustics Solo Sound Absorption Coefficients

		Frequency (Hz)							
Description	**Thickness**	125	250	500	1000	2000	4000	NRC	SAA
*Solo 8-25**	*1 5/8 (41mm)*	*0.1*	*0.45*	*1.03*	*0.96*	*0.51*	*0.51*	*0.75*	*0.73*
*Solo 8-50**	*2 5/8 (67mm)*	*0.36*	*0.97*	*1.15*	*0.92*	*0.71*	*0.69*	*0.95*	*0.95*
*Solo 8***	*5/8 (16mm)*	*0.09*	*0.12*	*0.37*	*0.82*	*0.68*	*0.40*	*0.50*	*0.50*

** Type A Mounting (with 1" (Solo 8-25), or 2" (Solo 8-50) fiber glass backer)*
*** Type F25 Mounting (1" (25mm) furring/airspace - no backer)*

Evaluation

In this new design, the main acoustical materials in the space are more spread out over the area of the room. In the initial design, they were confined to the back wall. In the new ceiling design, the Newmat PVC ceiling panels add additional absorption, while the back wall doesn't need as much absorption. This creates an overall better system and the sound quality should reflect that.

Summary + Conclusions + Credits:

The goal of the AE senior thesis is to integrate our own individual specialties, with our overall background in Architectural Engineering. Seeing how my lighting and electrical depths could affect other systems in the building allowed for a better understanding of all aspects on designing a building. The result of this report, after many hours of design development, performance analysis, and research into technical challenges, lead to a new design that tries to enhance the performance, aesthetics, and overall design integrity of the Nerman Museum of Contemporary Art.

The lighting depth improved the total design goals of the museum and added to the original Kyu Sung Woo's architectural vision. The electrical redesign of the branch circuits was studied as well as overcurrent protection to make sure this lighting system was a safe design. A wind powered electricity generation scheme was integrated into the solarium's solar protection panels. The structural breath investigated the effect of the added skylights into the auditorium, and the acoustical breath focused on the effect of the PVC Newmat ceiling panels on the RT of the space.

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References

Texts:

ASHRAE Standard 90.1-2010. Atlanta, GA: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 2010

Houser, Mistrick, and Stefy (2011) The IESNA Lighting Handbook: Reference & Application (10th ed.).Illuminating Engineering Society of North America. New York, NY.

National Electric Code 2008, Quincy, MA: National Fire Protection Association, Inc., 2011

Software:

AutoCAD 2014
AGI32
Radiance
Photoshop CS6