The Winsor School

Lubin-O'Donnell Center for Performing Arts, Athletics and Wellness

103 Pilgrim Road, Boston, Massachusetts

Maggie Golden
Lighting / Electrical
Lighting Advisor – Dr. Richard Mistrick
Electrical Advisor – Gary Golaszewski

Final Report

April 8th, 2015

The Winsor School

Location | Boston, Massachusetts
Function | Performance + Wellness Wing
Size | 79,000 gsf
Levels | Five
Construction | May 2013 - Sept 2015
Delivery Method | Design - Bid - Build
+
Architect | William Rawn Associates, Inc.
Lighting Design | Horton Lees Brodgen
MEP | Rist-Frost-Shumway Engineering, PC
Structure | LeMessurier Consultants
Contractor | Lee Kennedy Co Inc.

Rendered Three Story Performance Hall

Architecture

This new wing will add a modern feel to the classic campus, with mostly aluminum cladding and an extensive amount of glazing. On other locations on the façade, limestone and calcium silicate units will be used for a warm and light atmosphere. The linear expansion creates a geometrical aspect that allows the architecture to seemingly float on air.

Lighting + Electrical

The lighting system incorporates fairly high end finishes with sources that range from LEDs and linear fluorescents to compact fluorescents or halogen fixtures. They will be controlled mainly by occupancy sensors and sometimes by daylight sensors as well. The building will run on 480/277 3PH, 4W voltage to fuel the buildings electrical systems. At certain locations the building voltage is transformed to 208/120V by use of step-down transformers for power receptacles and certain mechanical equipment. The electrical system is backed up by a 500 kW/600 VA diesel generator for life safety and fire control.

Mechanical

The building is serviced by 8 air handling units. The AHUs in the mechanical rooms service various corridors and classroom spaces on level 1, each supplying 19500, 15250 or 26000 CFM. Individual air handling units service the locker rooms (4800 CFM), squash courts (6500 CFM) and the stage. Two air handling units are servicing the gym as well, supplying 12000 CFM each. Building heating and cooling is provided through hot water and chilled water coils within the AHUs and powered through natural gas lines. The majority of the general exhaust fans that service the building are on the roof.

Structural

The structure is a composite beam system. Lightweight concrete of 3000 psi is implemented with metal decking that doesn't exceed 3 inches. The steel is high strength, low alloy steel ASTM A992 or ASTM A588. The column sizes range from around W8x31 to W12x152. There is also Carbon Rectangular and Square HSS Tubes Grade B and Round HSS Pipe Grade C. Four 12" CMU shear walls as well as shear and moment connections of the steel are used to combat loading and resist lateral forces.

Rendered Dance Rehearsal Classroom

Rendered Wellness Lobby

Maggie Golden | Lighting + Electrical
Advisor - Dr Richard Mistrick | Renders provided by architect
https://www.engr.psu.edu/ae/thesis/portfolios/2015/mlg292/index.html

Executive Summary

The following report is an account of all work and analyses performed during the AE487G senior thesis. This thesis includes a redesigned lighting solution for four spaces, an electrical depth, a MAE daylighting depth, an acoustical breadth and a landscape architecture breadth. The building chosen for study is The Winsor School Lubin-O'Donnell Center for Performing Arts, Athletics and Wellness. All of the analyses and designs were performed within the four design spaces which are as follows:

+ Wellness Plaza
+ Wellness Lobby & Corridor
+ Dance Rehearsal Room
+ Performing Arts Theatre

As stated in the Building Statistics report, the Winsor School is a day school for young women in grades 5 – 12 located in Boston, Massachusetts. The school's mission is to drive young women towards their aspirations and dreams while also teaching them how to be independent and confident leaders. This building features an abundance of fitness centers, performance spaces, rehearsal rooms, meditations rooms, gymnasiums and squash courts.

The building is a modern design built on a campus filled with classical traditions and the goal of the lighting design was to continue and project that feeling of a modern classic. The new Wellness Plaza landscape architecture design merges the model main lawn with modern techniques in a fresh linear fractal design. The playful and relaxing plaza creates movement through design and even features an artistic musical sculpture that doubles as welcome signage to the new building. The lighting highlights the modern elements in the plaza with low level uplighting while the entrances exhibit higher light levels to create circulation in the space. The Wellness Lobby and Corridor features a complete redesign of the daylighting system, implementing occupant controlled rotating shading devices and a light shelf to bounce light onto the ceiling, indirectly lighting the space. The strategy reduces the potential glare for an individual in the lounge area from an intolerable glare level to an imperceptible glare level. This daylight is then replicated at night with the lighting, playing on the traditions of introducing and filtering light into a space that is easily found in many past classical designs. The Dance Rehearsal Space incorporates a modern grand ceiling supplemented with points of light that create sparkle and visual interest to produce a jeweled focal point for all those who pass by or enter the room. An acoustical redesign was performed in this space to produce clarity in speech and meet classroom standards with a final reverberation time of six-tenths of a second. The last space, the Performing Arts Theatre also incorporates the appeal of a grand ceiling but instead creates this ceiling with color changing points of light along the underside of the catwalk. The theatre lighting also supplements the architecture by grazing and washing the intricate wood slat system that covers the walls of the space.

The electrical design system features a redesign of the branch circuits based on the above changes to the lighting design. A short circuit study was conducted along one of these branches to evaluate safety in overcurrent and power outage situations. The result proved the design was still efficient at preventing a short circuit. Finally, an electrical cost analysis was performed to see whether savings could be produced by switching unnecessary mineral insulated cable to metal clad cable. The results indicated that by switching one branch circuit feeding four panelboards from MI to MC Cable, the cost of the wiring in that branch circuit could be reduced by seventy-eight percent.

The end result of this thesis creates an integrated and modern design that keeps with classic traditions to move The Winsor School into the future and cement its status as prominent women's preparatory school for decades to come.

Contents

Building Statistics

Building Statistics

Building Name
The Winsor School | Lubin-O'Donnell Center for Performing Arts, Athletics and Wellness

Location and Site
103 Pilgrim Road | Boston Massachusetts

Building Occupant Name
The Winsor School

Occupancy or Function Type
Theater (A-1), Exercise Spaces (A-3), Offices (B), Parking Garage (S-2)

Size [total square feet]
79,000 sf

Number of Stories Above Grade | Total Levels
Three Stories above grade | Five Total Levels

Primary Project Team
Owner: The Winsor School | http://www.winsor.edu/
Architect: William Rawn Associates, Architects, Inc. | http://www.rawnarch.com
Construction Manager: Lee Kennedy Co Inc. | http://www.leekennedy.com/
Structural Engineer: LeMessurier Consultants | http://www.lemessurier.com
M / E / P / FP Engineer: Rist-Frost-Shumway Engineering, P.C. | http://www.rfsengineering.com
Civil Engineer: Nitsch Engineer | http://www.nitscheng.com
Geotechnical Engineer: McPhail Associates, Inc. | http://www.mcphailgeo.com
Landscape Architect: Landworks Studio Inc. | http://www.landworks-studio.com
Theatre Consultant: Theatre Projects Consultants | http://www.theatreprojects.com
Acoustic / AV Consultant: Threshold Acoustics | http://www.thresholdacoustics.com
Sports Consultant: Brailsford & Dunlavey | http://www.programmanagers.com
Code Consultant: Sullivan Code Group | http://www.rwsullivan.com/services/code-consulting
Lighting Consultant: Horton Lees Brogden Lighting Design | http://www.hlblighting.com
Sustainability Consultant: The Green Engineer | http://www.greenengineer.com/

Dates of Construction
May 2013 – September 2015

Actual Cost Information
Total Construction - $71,000,000
Electrical - $7,200,000
HVAC - $6,000,000
Plumbing - $2,000,000

Project Delivery Method
Design - Bid - Build

Renderings [courtesy of William Rawn Associates]

Figure 1 - Street View of Winsor School New Wing Addition

Figure 2 - View from the Dining Hall of the Winsor School New Wing Addition

Architecture

The new wing of The Winsor School is a juxtaposition to the 100-year-old classical building that inhabits most of the schools classrooms. This new wing, housing mostly sporting, rehearsal and performance facilities, will add a modern feel to the classic campus. The building's exterior, with no brick except the repairs to the existing structure, will mostly incorporate aluminum cladding and an extensive amount of glazing. On other locations on the façade, limestone and calcium silicate units will be used for a warm and light atmosphere. The warmth will be exemplified with every overhang, which will incorporate wood ceilings. The linear expansion of the building shapes creates a geometrical aspect that allows the architecture to seemingly float on air next to the heavier appearance of the neighboring academic wing.

Major National Model codes

2009 International Building Code / Massachusetts State Building Code, 8th Edition
2011 National Electrical Code
2009 International Mechanical Code
2009 International Energy Conservation Code & Stretch Energy Code
Massachusetts Architectural Access Board Regulations
Massachusetts Fire Prevention Regulations
Massachusetts Plumbing Code

Massachusetts Elevator Code

Zoning

The Campus is located within the H-1 District of the "Brookline" neighborhood or "Boston Proper" section of Boston. This is mostly a residential apartment district stated by Section 3-1 of Boston Zoning Code. It is also located within the Groundwater Conservation Overlay District, per Article 32 of the Zoning Code. Furthermore, according to Article 13, the restrictions for the H-1 district are as follows: a maximum floor area ratio of 1.0, lot size of 5,000 sf, a minimum lot frontage of 25 feet, a minimum side yard between 12.5 ft and 20 ft. Building height is not restricted in the H-1 District.

Building Enclosure

Building Facades

The building façade features many different materials, none of which relate back to the classical academic building of which it is attached. The Southwest façade of the building largely consists of heavily glazed curtain walls and metal panels. The metal panels, which are featured on all sides of the building, are preformed aluminum but vary between a smooth or corrugated kynar finish. Furthermore, the spacing of the corrugation also varies by location. The glazing mentioned above is primarily used on the southwest and northwest facades on multiple expansive curtain walls consisting of steel frames for fire-rated assembly or aluminum framing. The types of glazing incorporates mostly high visible light transmission glass of around 40-65% but on the southwest façade of the building there are portions of highly fritted glass allowing a visible light transmission of around 5-10%. The sparse amount of glazing on the Southeast and Northeast sides of the building follow the same type of glazing as above.

Where there is not glazing or metal panels, a variety of stone is used. The majority of the stone façade is Calcium Silicate Masonry Units of varying sizes. These units are finished with a "sandrift" or tan coloring. Similar to that of the other stone masonry heavily used on the building, limestone of type Jura Buff Dolomite, with varying degrees of light to dark coloring.

Finally, the least used materials on the façade include granite and wood. The granite stone of type Quarra Black is used along the base of the building where the exterior walls meet the ground plane. The wood, used on the underside of all canopies and overhangs is specified to be FSC-Certified local Douglas Fir planks with a smooth face.

Roofing

The roofing, mostly unseen, will hold a large amount of the mechanical equipment which will be mostly disguised as a person may approach the building, though if far enough away not completely, by a half wall. The roof is planned to be in most cases, a low slope roof comprised of a typical insulating system.
The surface roofing material will be mostly a white EPDM (ethylene propylene diene terpolymer or rubber) membrane. The white color of the membrane allows the roof to be US DOE EnergyStar Complaint. In some locations a black EPDM membrane is also used though mostly when it will be covered by another material. The other material is precast concrete pavers located on rubber supports. These will be situated in areas along walking paths or around mechanical equipment.

Sustainability Features

The goal of the building process was to create and obtain a LEED certification through the United States Green Building Council of LEED Silver. This was hoping to be obtained through use of regionally obtain and manufactured materials, low emitting materials, recycled content, high performance building systems and construction waste management.

Primary Engineering Systems

Construction

The construction of The Winsor School is to be completed by Lee Kennedy Co Inc, a preconstruction and a construction management company based in Quincy, Massachusetts. The construction is ongoing, beginning in May 2013 and set for completion in September 2015. The cost of construction is estimated at $71,000,000. The project delivery method is design-bid-build.

Sustainability efforts have been highly focused on the construction of the building in terms of limiting construction waste. To be specific, the end goal will be to salvage or recycle 75% of the non-hazardous construction and demolition debris. This is planned to be a highly coordinated event with plans required to be reviewed by multiple facets at regular meetings along the way. This work may be subcontracted out to sub-contractors specializing in this aspect of construction, it is not known at this time if this was done.

There are also plenty of challenges of this site. Layout wise, the site is extremely tight, surrounded by three main roads and an active campus, leaving minimal room for laydown of materials and limits the site to only one entrance/exit for vehicles and trucks. Furthermore, apart from the site restrictions there are also special focus needed on the squash courts and the acoustical features in many of the performance spaces. The squash courts require complete building enclosure to ensure the materials are not corrupted by incorrect humidity or weather. Also, the specialty glass has to be construction in such a way that allows a maximum deflection if a player were to fall against it. The acoustical requirements are very involved, detailed and strict requiring experts for installation and numerous tests to be investigated concurrent with the construction.

Electrical

The electrical component of the building will enter the site from the eastern most corner of the grounds, and fed into a 2000 kVA pad mounted transformer provided by NSTAR utility company. It will convert the electricity to 480/277 3PH, 4W voltage to fuel the buildings electrical systems. The electricity will then enter a 3000A switchboard located on the plan south basement floor plan in the main electrical room. At certain locations the building voltage is transformed to 208/120V by use of step-down transformers for power receptacles and certain mechanical equipment. The electrical system is backed up by a 500 kW/600 VA diesel generator. The system is designed to respond within 10 seconds of power failure. The generator supplies all life-safety loads like lighting, power and security systems. It also supports one of the two elevators for fire-fighter access.

Lighting

The lighting system incorporates fairly high end finishes with colors that allow them to blend into the locations where the lighting will be seen (i.e. public spaces). In “back of house” spaces, the fixtures are much more industrial. The sources in the fixtures range from light emitting diodes and linear fluorescents to, in a few locations, compact fluorescents or halogen fixtures are used. Most fixtures in the classrooms, offices and fitness centers use linear fixtures while the corridors and transitional spaces use round fixtures. The theatre uses high powered pendant or surface mounted LED sources in an enclosed cylinder and the gymnasium uses high bay linear fluorescent fixtures. The corridors are mostly on the southwest side of the building, up along a fritted glass curtain wall, allowing for direct sunlight exposure. Some of this light could creep into main classroom spaces which typically have glass curtain walls exposing them to the hallway and, thus, the direct light.

The Corridors will be controlled mainly by occupancy sensors and this corridor in particular will be controlled by daylight sensors as well. The high bay occupancy sensor in this hallway uses infrared technology. These sensors will reduce the light output or turn the fixtures off after a certain owner-determined time delay. Also designated by the owner, a time clock shall switch off all luminaires at a designated time and have a manual override. The Daylight sensors in the space are a wireless open-loop system with an integral IR receiver and provides a linear response from 0 to 10,000 footcandles. All other interior spaces will have occupancy sensor control and emergency lighting where indicated. Site Lighting will be controlled by an astronomic time clock with a manual override for daytime re-lamping.

Mechanical

The building is serviced by 8 interior air handling units located in various mechanical rooms on different floors and in the spaces they service. The air handling units in the mechanical rooms service various corridors and classroom spaces on level 1, each supplying 19500, 15250 or 26000 CFM. Individual air handling units service the locker rooms (4800 CFM), squash courts (6500 CFM) and the stage. Two air handling units are servicing the gym as well, supplying 12000 CFM each. Building heating and cooling is provided through hot water and chilled water coils within the air handling units. The hot water is created in 2 different boilers in the basement of the building. They are powered through natural gas lines and pumped through boiler pumps to supply the hot water to the hot water coil. Exhaust fans are located in various designated exhaust spaces like the central plant, IT and electrical rooms. The majority of the general exhaust fans that service the rest of the building are on the roof.

Structural

Except for the slab on grade in the basement, the buildings structure is composed of a composite beam systems, meaning wide flange structural steel beams with composite decking. Lightweight concrete of 3000 psi is implemented with metal decking that doesn't exceed 3 inches or thickness less than 20 gage. The steel is high strength, low alloy steel ASTM A992 or ASTM A588. The column sizes range from around W8x31 to W12x152. There is also Carbon Rectangular and Square HSS Tubes Grade B and Round HSS Pipe Grade C. The design criteria suggests a design that requires no shoring during construction.

The foundation system of The Winsor School consists of concrete with rebar reinforcement. The footings range in size from 4'x4'x1.5' to 14'x14'x3.33' with the footings centered under the columns unless shown otherwise. Four 12" CMU shear walls as well as shear and moment connections of the steel are used to combat loading and resist lateral forces.

Fire Protection

Fire protection is performed by sprinkler and fire pump systems. With five different types of sprinkler heads based on ceiling finish, they are finished with brass, white enamel or chrome and spaced according to IBC requirements. There is both wet-pip and dry-pip sprinkler alarm valves. Some of the walls, between occupancies, are rated for a maximum of 2 hours of fire protection as well as the fireproofing on some of the exposed structural members. The fire alarm is an analogue addressable fire detection and alarm system with both manual and automation initiation. It allows special loading and editing instructions and loss of power will not erase the instructions in the memory. There will be both speakers and strobes, as noted on the plans. In the event of a fire, the system will be able to give full manual or automatic control of elevators, door hold open devices, sprinklers, fire pump and emergency power. There is also an alarm silence button, located in the main office of the building. It receives 120 V power with battery capacity to run for the duration of a power outage and the generator to kick in. Smoke control systems with pressurization located in Stair #2 and Stair #4 with fans are meant to dissipate and damper smoke. There is also a firefighter smoke control panel to indicate to firefighters whether the systems are operating or not.

Transportation

There are two elevators in the building used for transportation. One is used in the main academic wing and not primarily used in this wing of the wellness center. The other elevator is centrally located in the Center for Performing Arts and Wellness Wing designated as Elevator 1 and located right outside Stair 2.The passenger elevator uses a machine-room-less, gearless traction traveling 88 feet in total. It will stop 7 times counting the basement and mezzanine levels. It is rated for 5000 AIA, finished with mostly stainless steel and has a total square footage of 51 ft^2. It is connected to emergency power for use during an event by emergency crews.

There are also 5 staircases throughout the wing, three of which are fold back fire stairs traveling the entire length of the building from basements to the top floor. Stair 1 is also enclosed but is tucked away in the wellness section of the building right by the locker room. It only travels to the third floor. The other stair, Stair 5, is open and transitional stairs and not meant for main egress. It is located right along the glass curtain wall in the performing arts section of the building. This stair case also only leads to the third floor.

Telecommunications

The telecommunications and data portion of this building are very extensive. Not so much from a data sense but rather from a security standpoint. Telecommunication Rooms are located on the basement, first, second and fifth floors of the buildings and designated IT Rooms on the plans. The basement telecom room holds the data center where the main telephone equipment, servers, CCTV, intercom equipment and data racks are located. This is in the north part of the building. The rest of the telecom rooms are more centrally located on the floor plan and house equipment racks, CATV and telephone equipment. The CCTV equipment offers LCD displays for workstations, network video recorders running at 240/100 V, indoor color pan/tilt/zoom dome cameras and door intercom systems.

The access control telecom portion is very extensive as security measures are fairly high in this school. The access control system can be broken down into three different sections: Configuration Reports, History Reports and People Reports. For the configuration reports, the access control handles camera displays, elevators, portals (doors/windows), resources like temperature points and assigned threat level groups. The people reports log current uses, occupancy, photo ID gallery and information, roll call, time specifications and even sound files in emergency situations. The history report logs both of these overtime to develop a report where patterns can be found, if necessary. The groupings allow for a password protected viewing system to allow security officials to assess where people are located throughout the school and what is going on in those locations. Many settings can be activated to trigger possible alarms from video motion detection, camera failure, high or low temperature events, forced or held portals or occupancy limit violations.

Security speakerphones are located in every classroom space. The unit is vandal resistant and ADA compliant. There is a button labeled “PUSH FOR HELP” that will activate a strobe and place a call. Otherwise, the call button can be used to allow calls to be made from the keypad and be projected through the room. It is housed in stainless steel. The Access Control system is listed above alone with its security measures. Cameras are located in every corridor and focused on every entrance and stairwell. They are configured for very little blind spots. There are also wall mounted and ceiling mounted motion detectors.

Lighting Design Depth

Lighting Design Depth

This section is dedicated to the proposed final lighting solution for the Lubin-O'Donnell Center for Performing Arts, Athletics and Wellness. The following sections will break down the locations and details of design, material descriptions, design goals and design criteria. Additionally, the final design will exhibit lighting fixtures, calculation summaries and applicable renderings.

The four spaces are as follows:

- Wellness Plaza
- Wellness Lobby and Corridor
- Dance Rehearsal Room
- Performing Arts Theatre

Concept Overview - A Modern Classic

Figure 3 - Rendering of the Lubin-O'Donnell Center and the Main Academic Building; Courtesy of William Raw Assoc.

The main theme of the building stems from the apparent juxtaposition of the new wing of the school as compared to the original campus building. While seemingly different, the new building implements materials alluding to its predecessor, taking classic prominent features in the original building and modernizing them. For example, instead of using red brick, the new wing uses tan brick. Instead of using cherry wood panels, there is wood slat walls and tan painted metal. In fact, this tactic is comparable to the overall development of this school. From 1886 to 2015 the goal of the school hasn't changed – they take young girls and turn them into successful and independent young women. It's just the girls themselves that have changed, they have become modern women. And so, the main concept for the lighting within the building will do the same, it will embody the classic New England prominent architecture and modernize it.

But the building is not only the sum of its parts, each space has their own identity and personality. It is important to develop a connection between the spaces, while also expressing each individual theme of the room. These themes will be discussed further in each space's section.

Wellness Plaza

Description

The Wellness Plaza is located along the southwest façade of the Lubin-O'Donnell center. The plaza can be considered rectangular in form but because of its ratio between its length and width, the form also resembles a linear path. The actual dimensions of the plaza are 140 feet by 21 feet for a total area of 2,940 square feet. It is fairly open and creates a path from the main lawn and turf sports fields to the secondary entrances into the wellness area and performance areas of the new wing. The plaza was redesigned in a Landscape Architecture Breadth as well. For more information on this new plaza design, please see the Landscape Architecture section located further along in the report.

Square Footage: 2,940 sf
Soffit / Canopy Height: 11 ft

Plans

Below in Figure 4 is a programming plan of the Wellness Plaza, it is marked with green circles to represent points of social interaction and congregation, and the pink area represents areas of large visual interest from both the interior and exterior. In Figure 5, the proposed Landscape Design of the plaza is shown

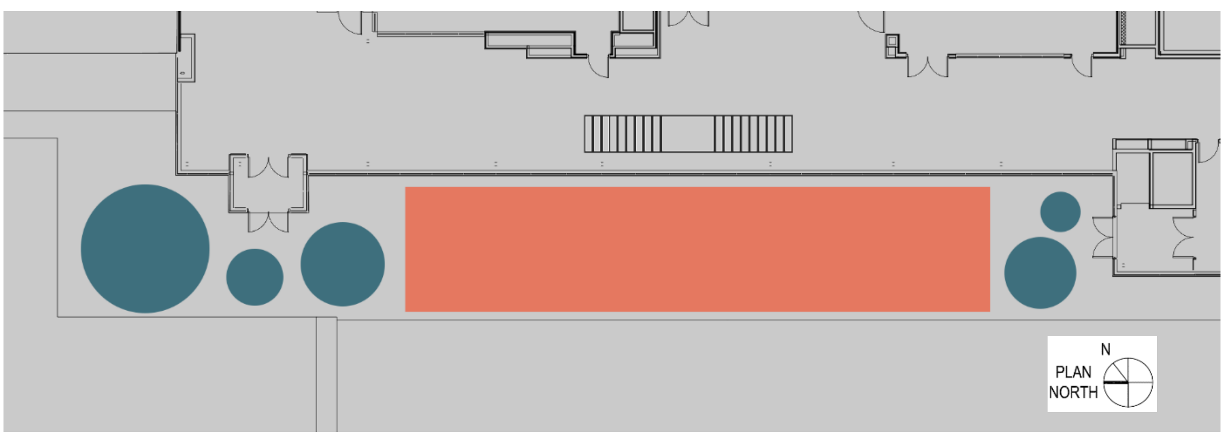


Figure 4 – Programming Plan of the Wellness Plaza

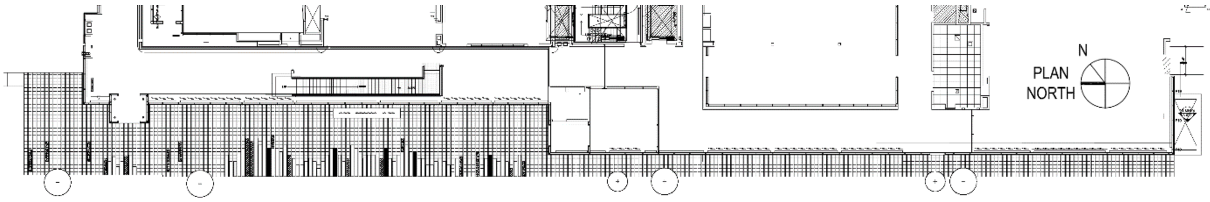


Figure 5 - Final Landscape Design Plan for the Plaza

Finishes & Materials

Around the exits and entrances of the plaza, groupings of benches are placed to encourage social interaction. Along the area where a higher level of visual interest is warranted, a movement of architectural patterns is created with concrete paving, vegetation and carpet-like greenery in neat linear rows. The canopies above the entrances are metal as a juxtaposition to the light colored wood overhang created by the second floor balcony. The plaza is located along a glass curtain wall dividing the plaza from the interior spaces.

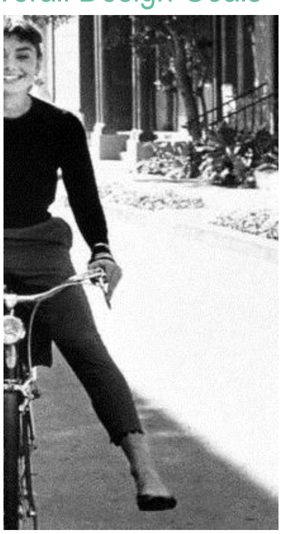
Table 1 - Exterior Materials in the Courtyard Plaza

Type	Description	Color	Reflectance	Manufacturer
Ground	Concrete Pavers	Gray	0.2	Hanover Architectural Products
	Cast Stone Benches	Gray	0.2	Landscape Forms
	Grass / Groundcover/Vegetation	-	0.3	The Earth
Ceiling	Metal Canopy	Aluminum	0.65	-
	Wood Canopy/Balcony	Douglas Fir	0.6	-

Tasks

The main activities on the grounds are socializing and relaxing during the school day or between performance and athletic events. Though, there is some movement and transition of people entering or exiting the building at either of the two vestibules on the plaza.

Overall Design Goals



The Arts and Wellness Vestibules are not the main entrances to the building. Most occupants will be entering the building from the main entrance on the other side of the building, therefore this space is less about way finding and more for relaxation.

It is designed with charm and playful movement in its park-like barrier between the building, the sports fields and the main lawn. Its landscape molds the classic and traditional designs of the main lawn into modern design techniques of linear patterns. The lighting highlights this modern adaptation of the classic by washing light up the low level landscaping intermittent through the plaza. Landscape architecture in the form of the musical sculpture and nearby benches are highlighted with uplighting and under bench lighting, respectfully.

Ambient light for security and safety is provided from downlights in the overhanging canopy, two light columns towards the exterior main lawn and from inside the building, transmitted through the glass curtain wall system.

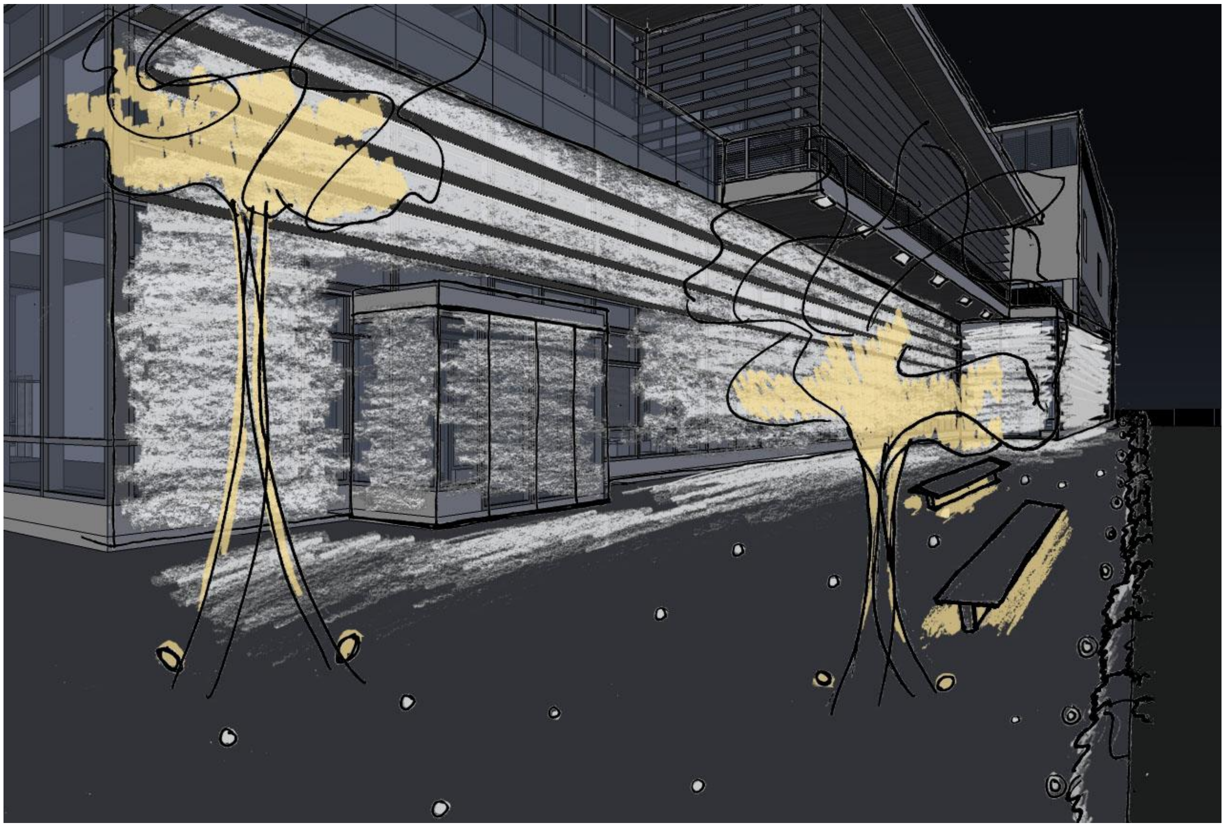


Figure 6 - Original Concept Sketch for the Wellness Plaza

Design Criteria/Considerations

For the following section, the Design Criteria was formed by a combination of resources. ASHRAE 90.1 2010 requires lighting power densities, determined to be watts/square foot, for all spaces in the building. It is very important to meet this criteria as it required by state codes in Massachusetts to allow this building to be opened for use. The values for the Illuminance recommendations, provided in lux, were taken from the IES Light Handbook, 10th Edition. Illuminance levels are important to a design because they aid the functionality of the room. In some cases, they were also provided for safety concerns. Further design criteria was also taken from the IES Handbook or from background information learned throughout school.

Lighting Power Density

Table 2

Space	Space Description	Allowance (W/sf)
Wellness Plaza	Entry Canopies (Zone 3)	0.4
Wellness Plaza	Walkway 10ft or wider (Zone 3)	0.16

Illuminance Requirements

Table 3

Space	Task	E_{hor} (lux)
Wellness Plaza	Canopied Entry LZ3 - Medium Activity	15

Psychological Impression

This outdoor space is designed to feel relaxed and intimate, except at entry spaces which feel public. The entry canopies are lit to a higher light level, while the bench and lounges areas are lit with low level lighting focused away from the occupant. By lighting the nearby ornamental grasses, the occupants have something focus on to feel less in a spotlight and more in a private environment.

Association with the Architecture and Landscape

The plaza is a transitional spot from landscape to architecture, the plaza lighting corresponds to this by implementing low level lighting and transitioning to higher illuminance areas. The lighting also relates the themes developing inside the building since there is a very strong connection between the interior and exterior. For example, the uplighting of the vegetation relates back to the uplighting of the interior ceiling of the corridors.

Glare

Many sections of the landscape are up lit and therefore, special consideration was taken when picking the fixtures and their locations, they are not located in a position to shine into an occupants face. The luminance was also balanced to make sure it was not too bright for viewing.

Fixture Housing

The housing's of all the fixtures must be outdoor rated by IP standards. A rating of IP67 was chosen to be the design standard for all the fixtures in this space.

Color Temperature

The interior of the building utilized 3000K temperature for light. To be consistent throughout all spaces and to reinforce the relaxation and warmth of the plaza, 3000K color temperature was used in this space as well.

Circulation

This area incorporates a secondary entrance to the building and therefore must be able to direct an occupant to the entrance area with relative ease and provide them a clear path to the entrances. By lighting the vestibules to a higher illuminance than the surrounding area, way finding is achieved.

Fixture Selection

Table 4

Type	Fixture Image	Manufacturer	Description	Lamp	Wattage
L1		Moda Light AquaFlex	Wet location LED linear flex light	LED 3000K 127 lm/ft	1.48 W/ft
L2A		Gotham 4" Evo	Wet Location 4" LED Downlight with a Specular finish and clear aperature and trim	LED 3000K 600 lms	16 W
L2B		Gotham 4" Evo	Wet Location 4" LED Downlight with a Specular finish and clear aperature and trim	LED 3000K 1000 lms	21 W
L3		DesignPlan Rio 1.1/2/4	Wet Location low level 1" thick linear in-ground uplight with aluminum casting and diffuse optics, line voltage	LED 2800K 168 lms	8 W
L4		Selux MTR Column	LED Light Column extending 10 ft above grade - 3 ft of Light, 8" diameter and MTR sheilding rings to bend light and a Type 5 Distribution	LED 3000K 6344 lms	90 W

**A light loss factor of 0.7 was used for all of the fixtures per simplified real-world design practices

Controls Strategy

The only controls in this space will be an astronomical time clock which will trigger the lights functionality based on time of day. This is the same as the current existing system.

Lighting Construction Document Drawings

Since producing the lighting plans would be illegible in this report, an appendix has been created for larger and more readable lighting plans. To view these drawings, please see Appendix C – Drawings LP1 and LP2.

Lighting Power Density Calculations

Table 5 – Exterior Plaza LPD

Type	Selux MTR	Moda AquaFlex	Gotham Evo
Total Fixtures	2	100	5
Watts /Fixture	90	1.48	21
Total	180	148	105
Area	3374.806		

Watts/SF	0.1283
Allowed W/SF	0.1600
Does it Pass?	YES :)

Table 6 – Exterior Canopies LPD

Type	Gotham Evo
Total Fixtures	4
Watts /Fixture	16
Total	64
Area	196.280

Watts/SF	0.3261
Allowed W/SF	0.4000
Does it Pass?	YES :)

Table 7 – Decorative Allowance

Type	DesignPlan
Total Fixtures	110
Watts /Fixture	8
Total	880
Area	3374.806

Watts/SF	0.2608
Allowed W/SF	3374.8060
Does it Pass?	YES :)

Illuminance Calculations (measured in lux)

Figure 7 - Performing Arts Entrance Illuminance, measured in lux

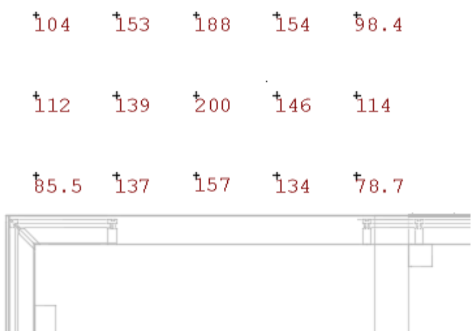


Figure 8 - Wellness Entrance Illuminance, measured in lux

Lighting Calculation Key

Colors	Range (lux)		
	40	to	200
	30	to	40
	20	to	30
	10	to	20
	0	to	10

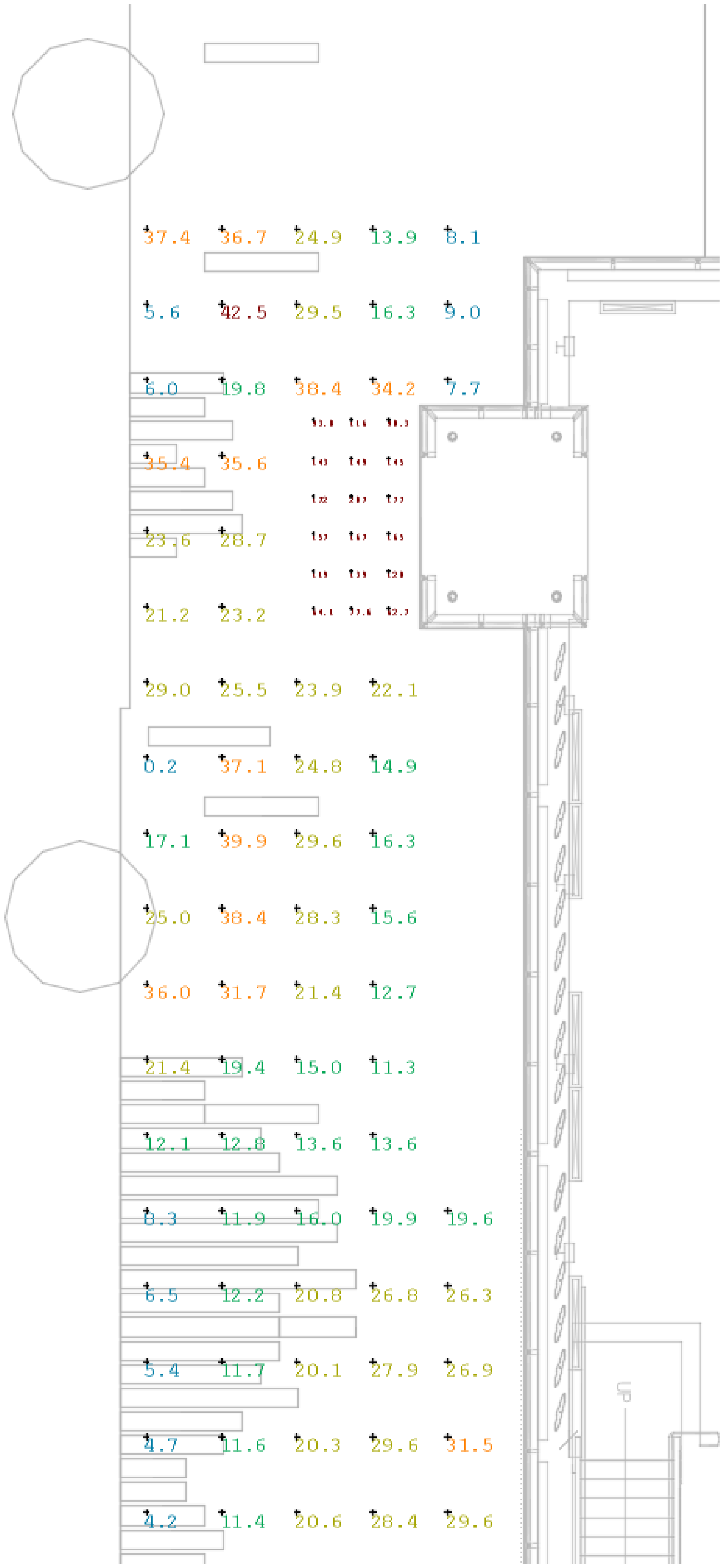


Figure 9 - Illuminance Levels of Part 1 of the Wellness Plaza

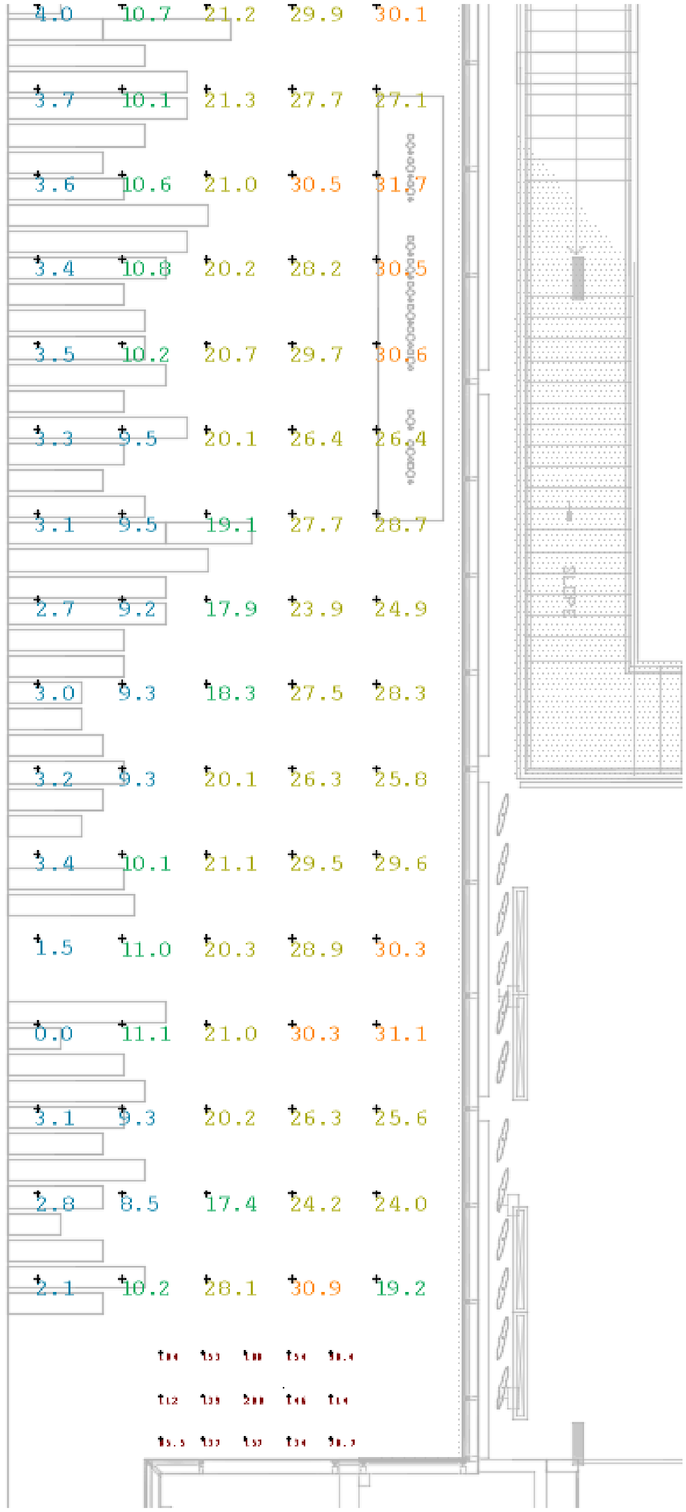
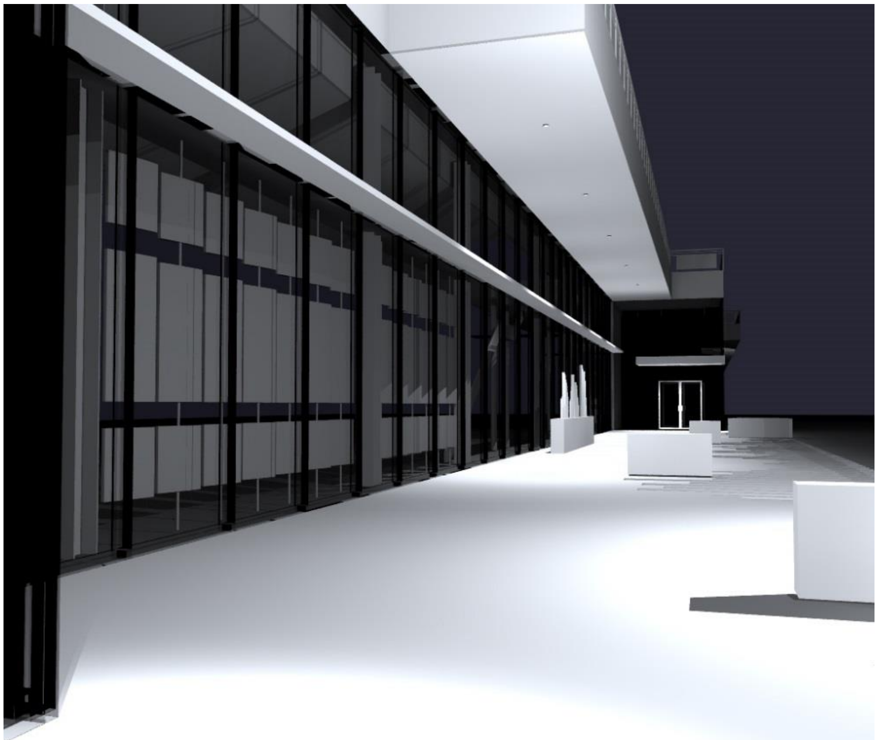


Figure 10 - Illuminance levels for the Wellness Plaza Part 2

AGi32 Renderings



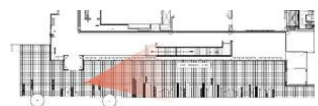
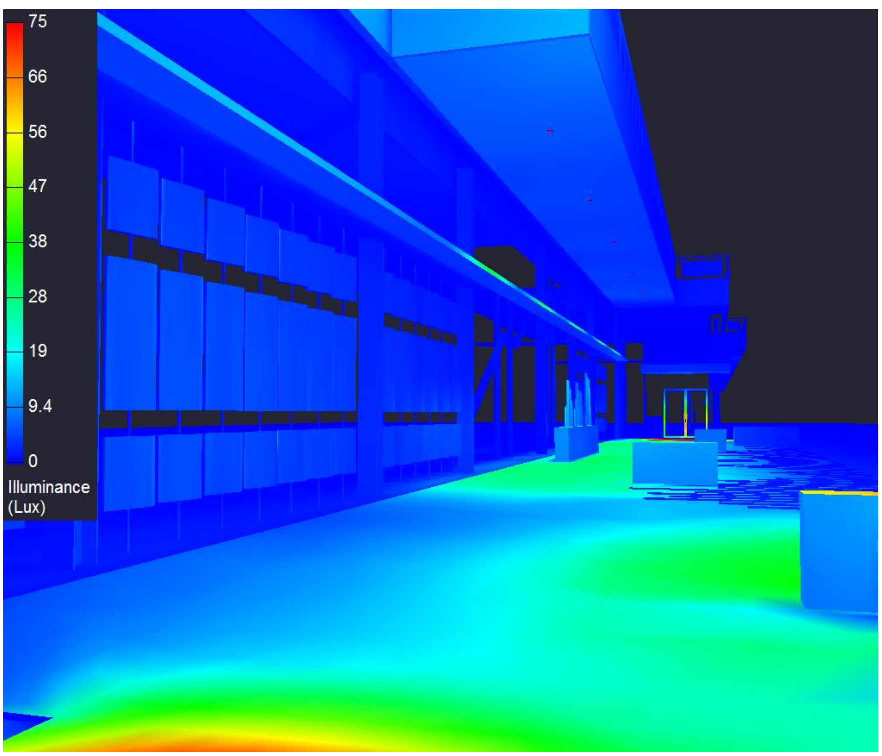


Figure 11 – Raytraced Render Performing Arts Vestibule



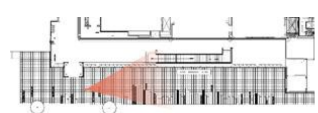
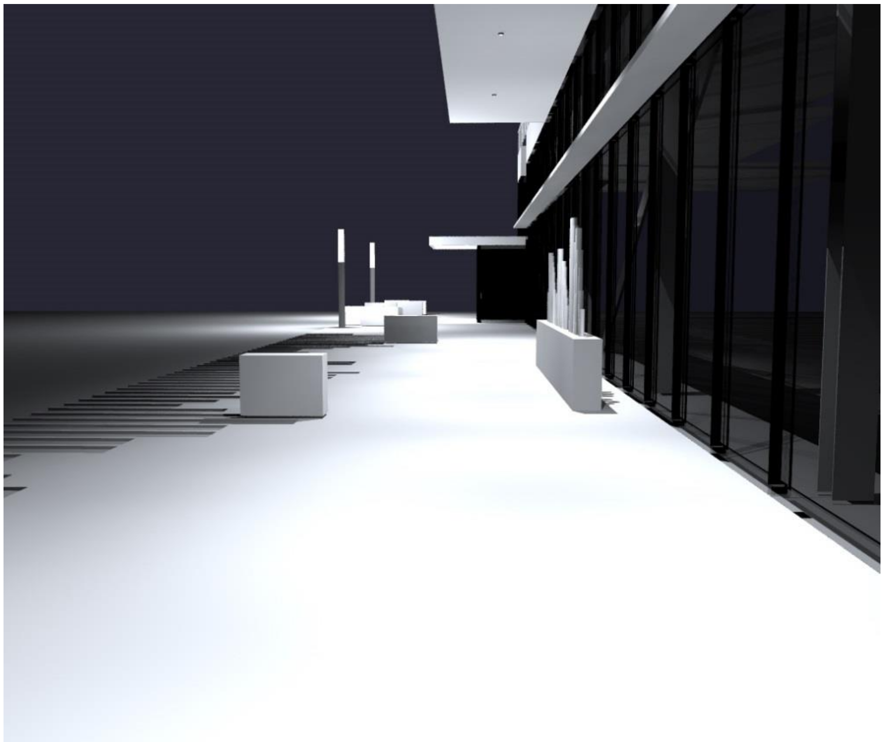


Figure 12 – Psuedo-color Render from Performing Arts Vestibule



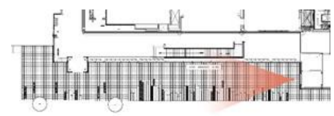
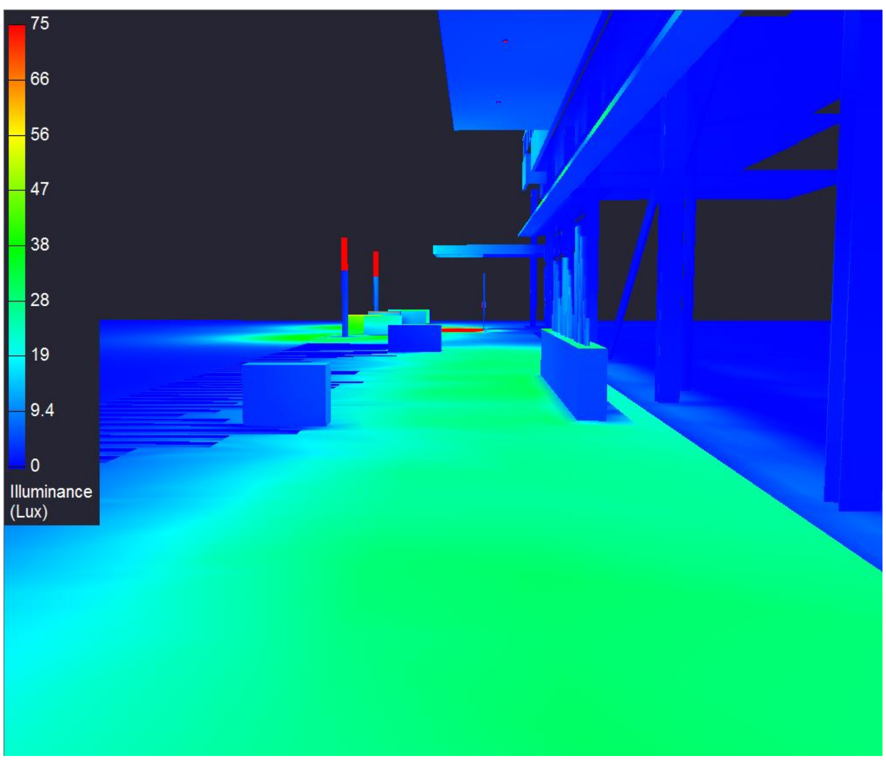


Figure 13 – Raytraced Rendering from Wellness Vestibule



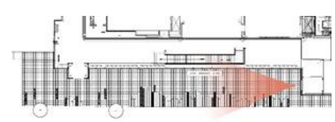


Figure 14 – Psuedo-color Rendering from Wellness Vestibule

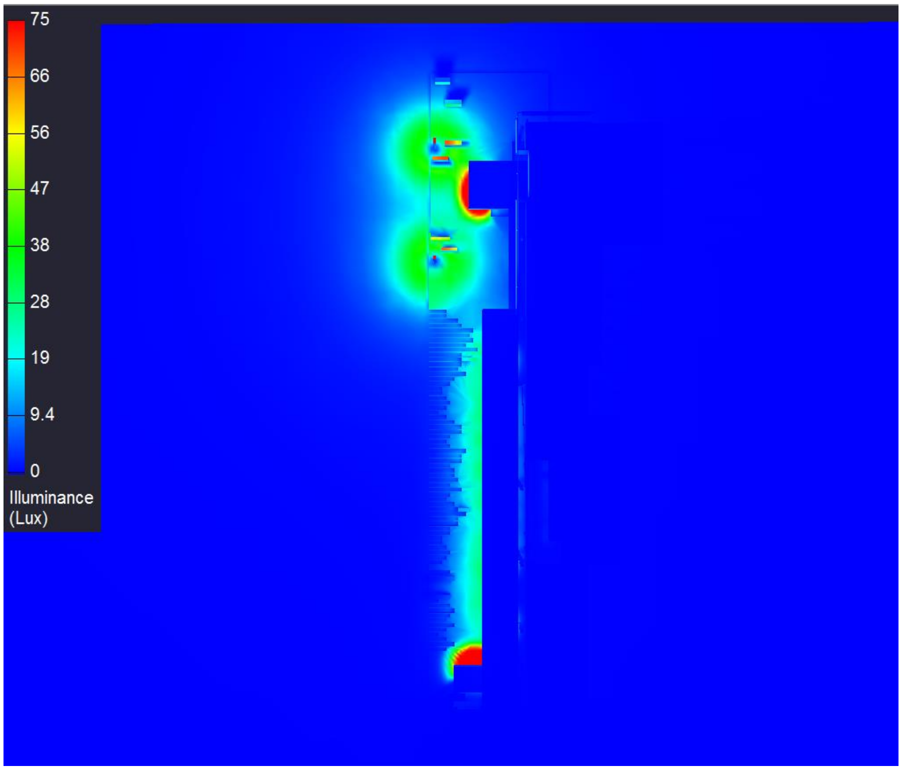


Figure 15 – Overhead Pseudo-color

Illuminance Summary

Table 8 - Exterior Plaza Illuminance Summary

Data	Required	Actual
Illuminance Avg	15	19.3800
Maximum	-	42.5000
Minimum	-	1.5000
Avg/Min	2.0:1	13.0000

Table 9 - Exterior Entrances Illuminance Summary

Data	Required	Actual
Illuminance Avg	100	132.3300
Maximum	-	207.0000
Minimum	-	62.7000
Avg/Min	3.0:1	1.8900

Nighttime Photoshop Rendering

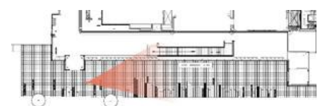


Figure 16 – Nighttime Photoshop Rendering

Evaluation

The Wellness Plaza is meant to be a relaxing and pleasing environment while still playful in movement. This is achieved through limiting downlight and subtly lighting the spirited landscape design. By highlighting the vegetation, the lighting also relates back to the overall concept by taking the classic forms of landscape design like the main lawn and converting them into a modern design. Almost all design standards set were achieved with the exception of uniformity as shown in the Illuminance summary. The illuminance calculation was performed without taking into account the interior building light that would be spilling out. If this was included, it can be assumed that there would be a much more uniform light level across the plaza. Overall, the lighting design delicately highlights the landscape and architecture to create a modern exterior plaza to congregate and unwind.

Wellness Lobby & Corridor

Description

The Wellness Lobby and Corridor is located on the first floor in the southwestern part of the building. It is a double high space with a floor to ceiling glass curtain wall facing the exterior. The curtain wall gives way to a large amount of daylighting and glare penetrating the space. As this is a public transitional space, daylighting may not be a problem to someone walking down the hall but there are table and lounge spaces along the glass curtain wall students can sit, study and socialize. Because of these lounge areas, a daylighting redesign was performed on this space resulting in vertical operable fins 11 feet tall that can be rotated 360° and a light shelf to bounce light onto the ceiling. For more information on this daylighting redesign, please see the Daylighting Depth section of this report. The lobby has their own separate entrance from the performance portion of the building but can be entered from a hallway adjoining the two areas. On the other side of the corridor are cubbies for personal belongs and a glass wall looking into a fitness center. This glass wall has wooden louvers over top of its upper portion. These wood louvers are frequently used throughout the entire building.

Square Footage: 1624 sf
Length: 86 ft
Width: 13ft – 6 in
Height: 17 ft – 0 in

Plans

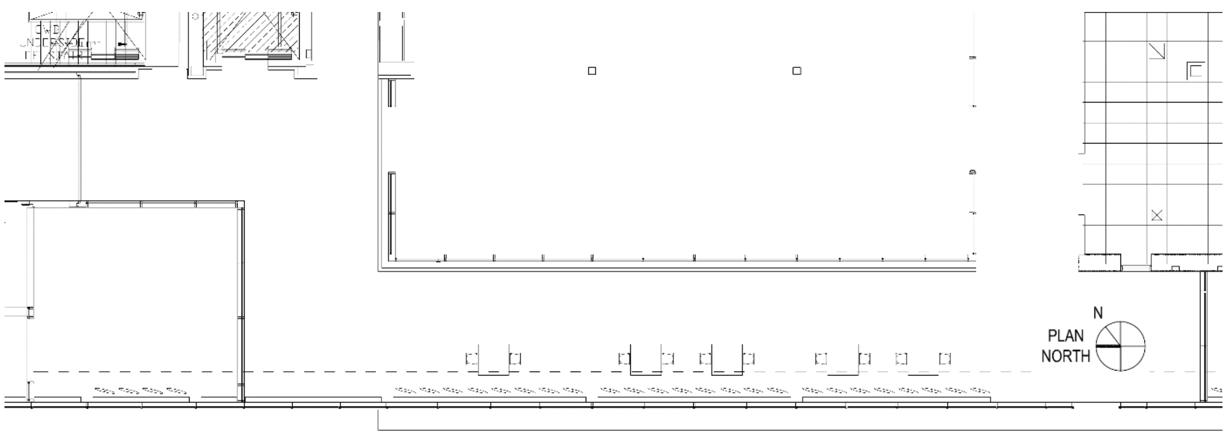


Figure 17 - First Floor South Plan - Wellness Lobby and Corridor

Finishes & Materials

The flooring is a light terrazzo that blends into a slightly less specular recycled rubber athletic material. The interior glass removes the visual barrier between the fitness area and the corridor and allows a site line for an occupant, above this line there are wooden louvers to limit the sunlight coming from the exterior into the fitness center. The exterior wall features clear glass with daylighting techniques to combat the southwest sun. The light shelf that bounces light onto the matte metal panel ceiling is aluminum covered in highly reflective gypsum board. The vertical fins are made of cherry wood and aluminum trim, though one side of the fins features an acrylic panel that emits a faint glow of light.

Table 10 - Interior Finishes of the Wellness Corridor and Lobby

Type	Description	Color	Reflectance	Manufacturer
Floor	Terazzo Floor	Tan	0.6	Key Resin Company
	Recycled Rubber	Matches Terazzo	0.45	Mats Inc.
Walls	GWB	off white	0.7	USG Corporation
	Wood Louvers	Anigre	0.25	-
	Glass	-	.78 transmittance	-
Ceiling	Metal Panels	Matte Gray	0.77	Ceilings Plus

Table 11 - Exterior glazing types along the Wellness Corridor

Glazing	Description	Color	Transmittance	Manufacturer	U-Value	
					Summer	Winter
XG6	**1-1/8" Clear Insulating** 3/8" clear PPG Solarban 70xl 1/2" air space 1/4" clear glass	Clear	64%	PPG ; Solarban 70xl	0.26	0.28

Tasks

This space is first and foremost a transitional area for moving people along within the building. There are though spaces to sit and socialize. If an occupant is using this area for studying it will not be for long periods of time as there is not much downtime during or after the school day for students.

Overall Design Goals

The Wellness Lobby and Corridor are not only meant for circulation but also for study and collaboration. The lobby is a space for conversation before sporting events and during the school day. The corridor has localized areas of privacy with tables and chairs for the students to relax or study during free periods. To emphasize these breakout points, and provide illumination should the occupant want it, the middle panel of the vertical, operable fins are illuminated. This allows the occupant to choose whether or not they wish to have the light upon their desk. Furthermore, this space will be very public and will have lighting to reiterate that. Uplighting onto the ceiling from the light shelf, a fixture directs the light and imitates the path of the daylight during the evening hours. Classic architecture took full emphasis on attempting to make the most of the daylighting they could get into their space, this corridor will do the same. Making the most of the daylighting and mimicking it, while blocking glare. Modern gimbal adjustable downlights are added in areas of possible higher concentration, like the lobby, for additionally ambient light and for life safety.

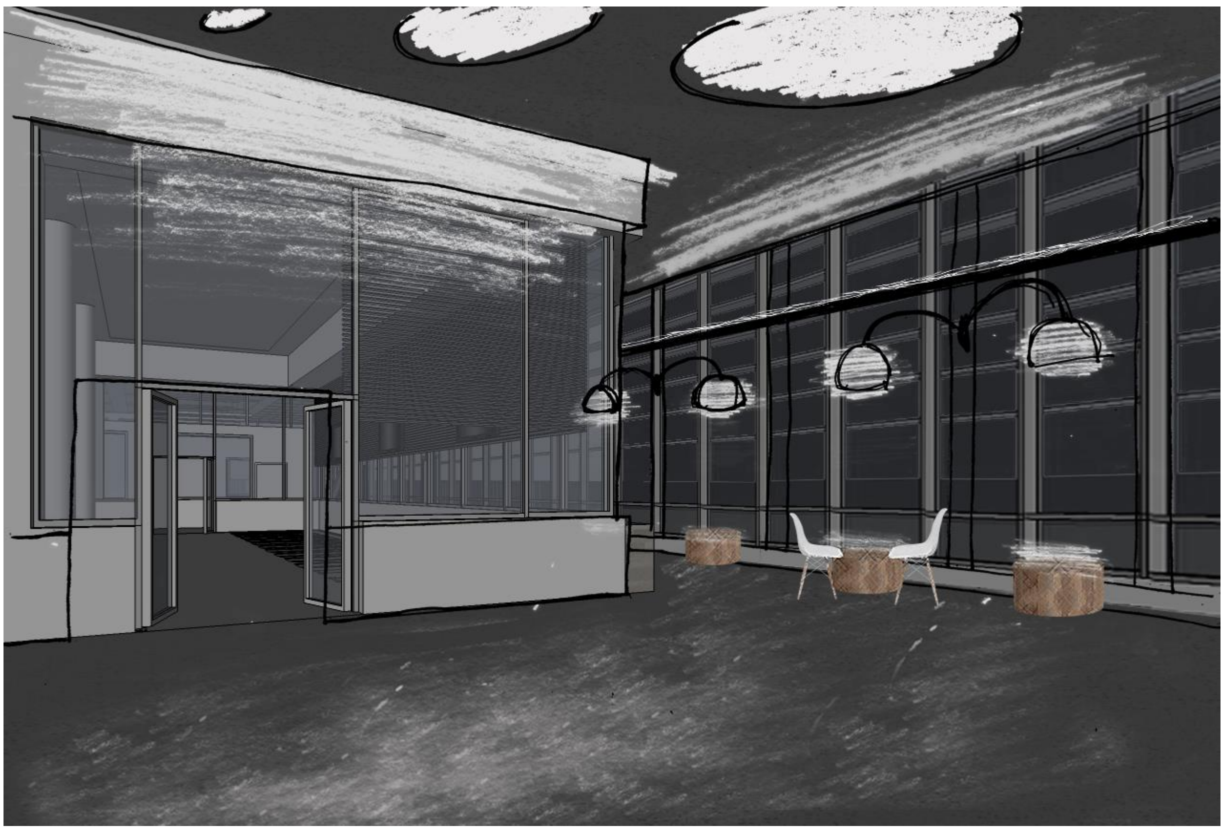


Figure 18 - Original Concept Sketch for the Wellness Lobby and Corridor

Design Criteria/Considerations

For the following section, the Design Criteria was formed by a combination of resources. ASHRAE 90.1 2010 requires lighting power densities, determined to be watts/square foot, for all spaces in the building. It is very important to meet this criteria as it required by state codes in Massachusetts to allow this building to be opened for use. The values for the Illuminance recommendations, provided in lux, were taken from the IES Light Handbook, 10th Edition. Illuminance levels are important to a design because they aid the functionality of the room. In some cases, they were also provided for safety concerns. Further design criteria was also taken from the IES Handbook or from background information learned throughout school.

Lighting Power Density

Table 12

Space	Space Description	Allowance (W/sf)
Lobby	Lobby	0.9
Corridor	Corridor/T rasistion	0.66
Vestibule	Corridor/T rasistion	0.66

Illuminance Requirements

Table 13

Space	Task	E_{hor} (lux)
Lobby	Lobby	50
Corridor	Corridor/T rasistion	50
Vestibule	Corridor/T rasistion	50

Glare

One of the main concerns in this space during design was the solar glare. This was discussed earlier in this report and it was established that a daylighting design was done to prevent glare by use of vertical fins and a continuous light shelf. For more information, please see the Daylighting Depth, particularly the glare calculations, further along in this report. Another source of glare could be from the panel on the vertical fin. It will be close to the occupants and at eye level so there would be a large possibility of glare. When the lighting element was designed, it was designed with glare in mind. The fixture uses a very low illuminance tape light that grazes from the side of fixture instead of emitting directly out of the panel. It also possible for the occupant to rotate the fixture away from where they are seated if they personally do not like the light at their eye level.

Visual Interest

Visual interest is desired in the space as well for those seated in the lounge areas or who can see the corridor from the fitness center. The operable vertical fins accomplish this in two ways. During the day, the panels create shadows and patterns of light along the walkable portion of the corridor. During the night, the illuminated panels turned at various angles creates a line of visual interest along the perimeter.

Controls

The lighting in this space will be controlled by occupancy sensors along the corridor. There is a large amount of light in this space throughout the entire day and even on overcast days. The amount of light means the most economical way occupancy sensors can control the lights is by on and off switching, instead of dimming.

Psychological Impression

The space should still feel spacious and public, even if temporary. According to John Flynn, this means the space should emphasis the peripheral surfaces with relatively higher uniformity and brighter light levels. This is achieved by the illuminated panels along the glass curtain wall and the light shelf directly light onto the ceiling during both the daytime and nighttime.

Circulation

Within the lobby, there is an elevator lobby that leads an occupant to the higher floors so they can get to both the Performing Arts Theatre and the Gymnasium. To attract attention and create way finding to this point of interest, LED slot lights were added to graze the wall above the lobby.

Fixture Selection

Table 14

Type	Fixture Image	Manufacturer	Description	Lamp	Wattage
L5		3G Lighting Madison RC1	Recessed small aperature downlight, gimble adjustment trim and 40° distribution	LED 3000K 1000 lms	8W
L6		Focal Point Trace	Low wattage LED Slot light creates a 3" architectural slot using the fixture (For a detail, please see the specification sheet)	LED 3000K 1207 lms	23W
L7		LiteControl Cove-15	Asymmetric indirect small scale fixture concealed in a cove detail and a high performance specular reflector	LED 3000K 1800 lms	32W
L8		Moda Light Flex 3000K	Dimmable LED linear flexible system, cuttable every 2"	LED 3000K 132 lms/ft	1.40W/ft

**A light loss factor of 0.7 was used for all of the fixtures per simplified real-world design practices

Lighting Construction Document Drawings

Since producing the lighting plans would be illegible in this report, an appendix has been created for larger and more readable lighting plans. To view these drawings, please see Appendix C – Drawing LP3.

Detail(s)

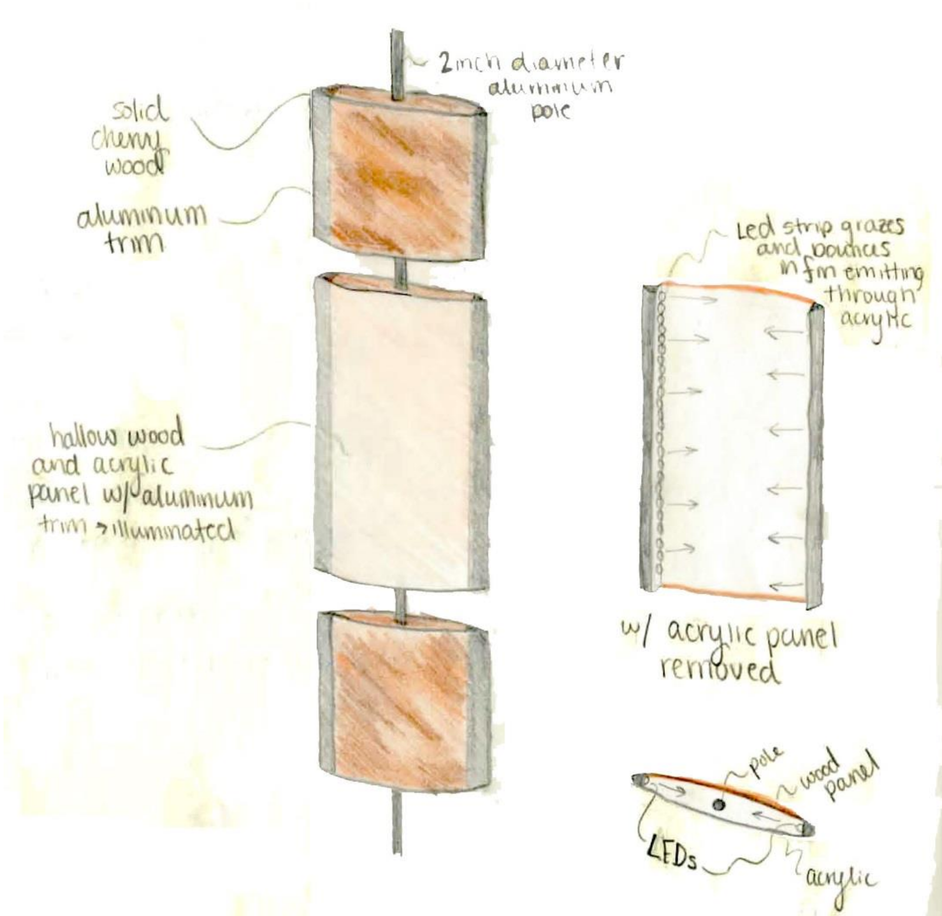


Figure 19 - Perspective Sketch of the Operable Vertical Fins

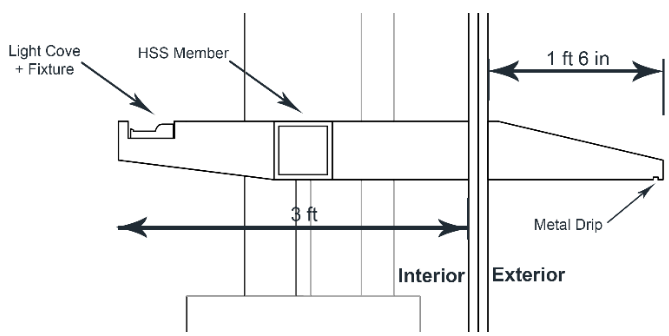


Figure 20 - Section Detail of the Light Shelf and Cove Fixture

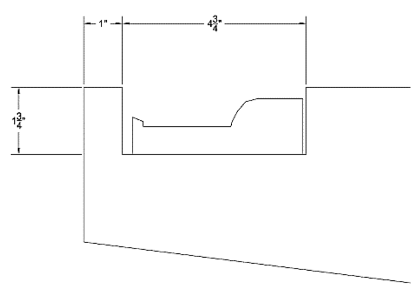


Figure 21 - Detail of Light Cove

Lighting Power Density Calculations

Table 15 – Wellness Vestibule LPD

Type	3G -RC1LED	LiteControl C15	Moda Flex 3000
Total Fixtures	2	5	32
Watts /Fixture	8	32	1.4
Total	16	160	44.8
Area	404.189		

Watts/SF	0.5463
Allowed W/Sf	0.6600
Does it Pass?	YES :)

Table 16 - Wellness Lobby LPD

Type	3G -RC1LED	LiteControl C15	FP Trace	Moda Flex 3000
Total Fixtures	7	3.5	4	0
Watts /Fixture	8	32	23	1.4
Total	56	112	92	0
Area	733.306			

Watts/SF	0.3546
Allowed W/SF	0.9000
Does it Pass?	YES :)

Table 17 - Wellness Corridor LPD

Type	3G -RC1LED	LiteControl C15	Moda Flex 3000
Total Fixtures	8	20.5	184
Watts /Fixture	8	32	1.4
Total	64	656	257.6
Area	1530.435		

Watts/SF	0.6388
Allowed W/Sf	0.6600
Does it Pass?	YES :)

Illuminance Calculations

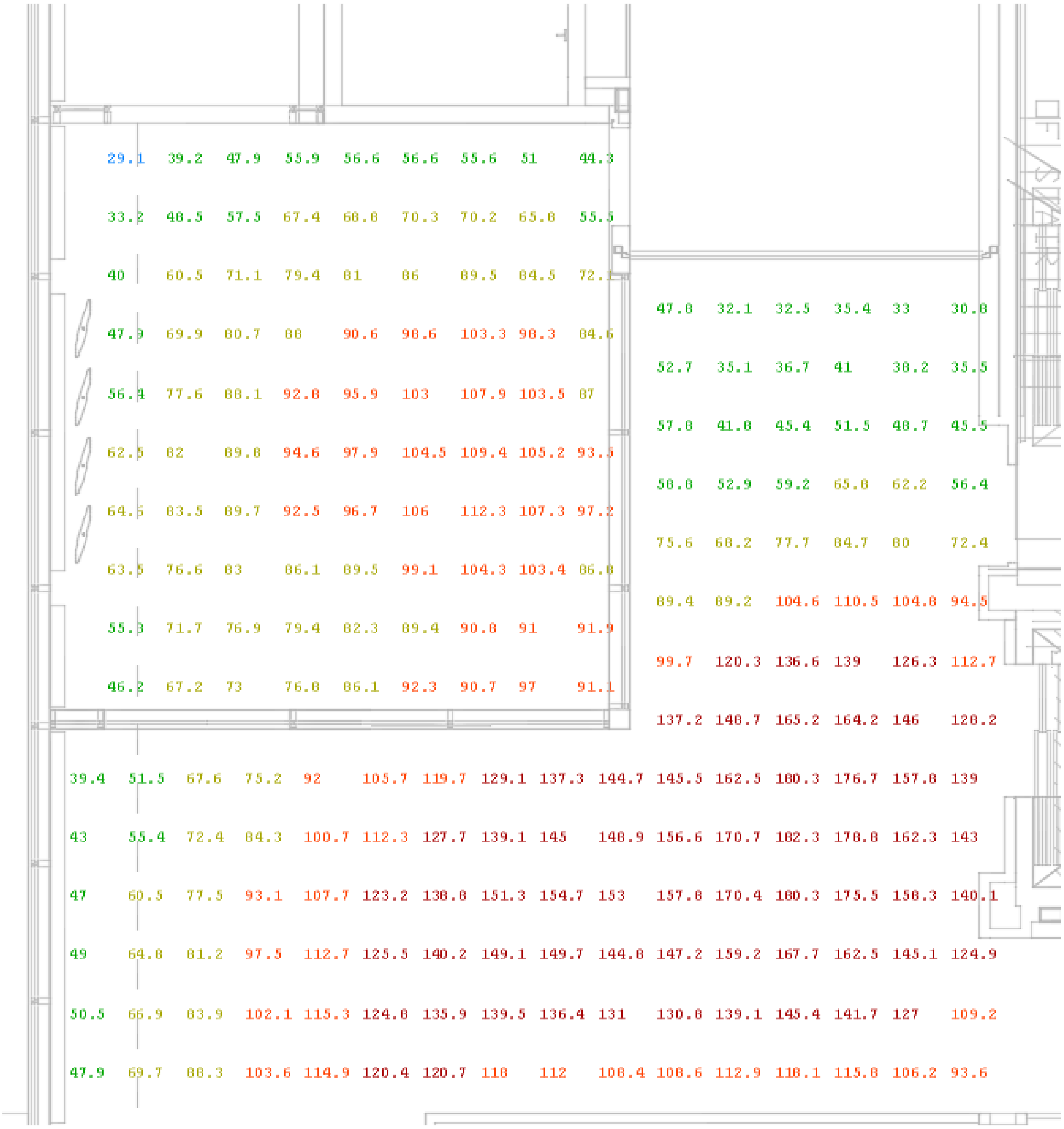


Figure 22 - Illuminance Calculations (Lux) for the Wellness Vestibule and Wellness Lobby

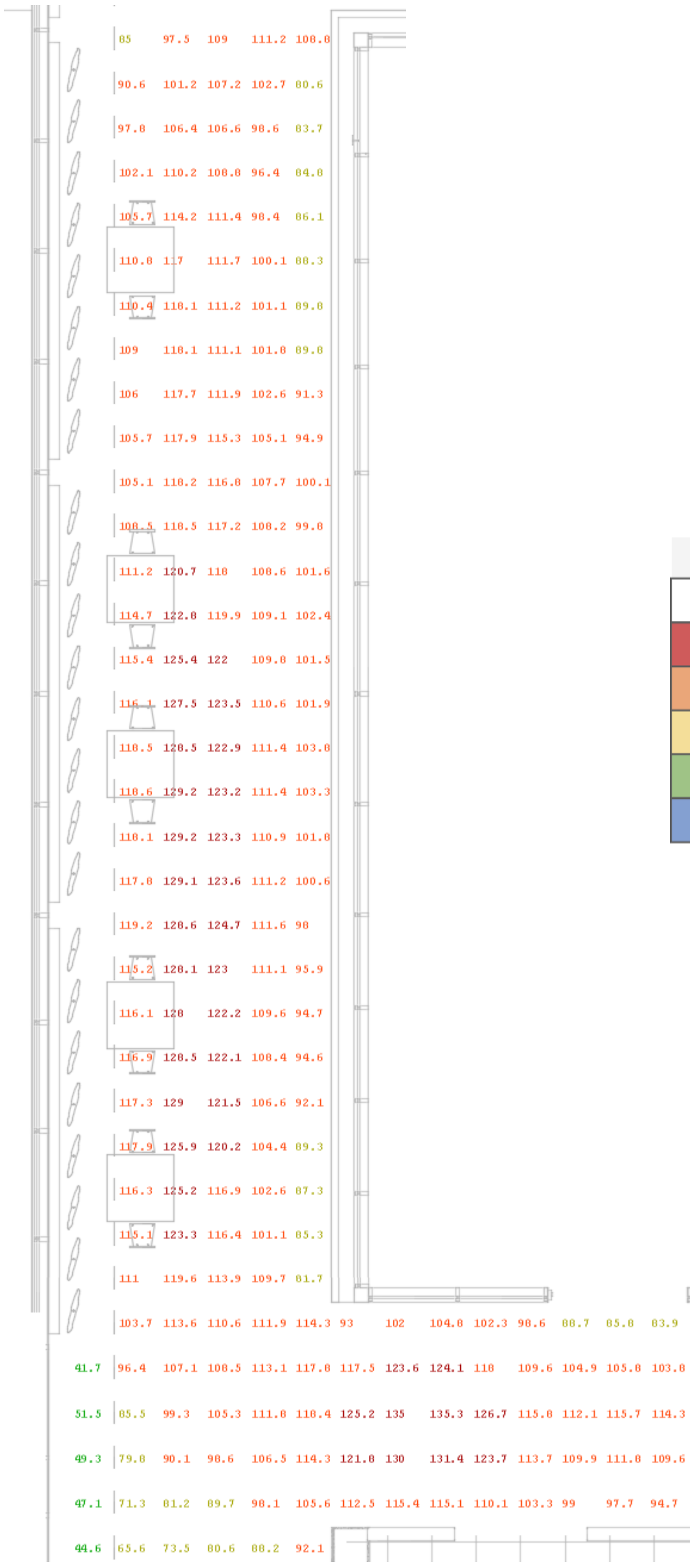


Figure 23 - Illuminance Calculation (lux) for the Wellness Corridor

Lighting Calculation Key

Colors	Range (lux)		
	120	to	150
	90	to	120
	60	to	90
	30	to	60
	0	to	30

AGi32 Renderings

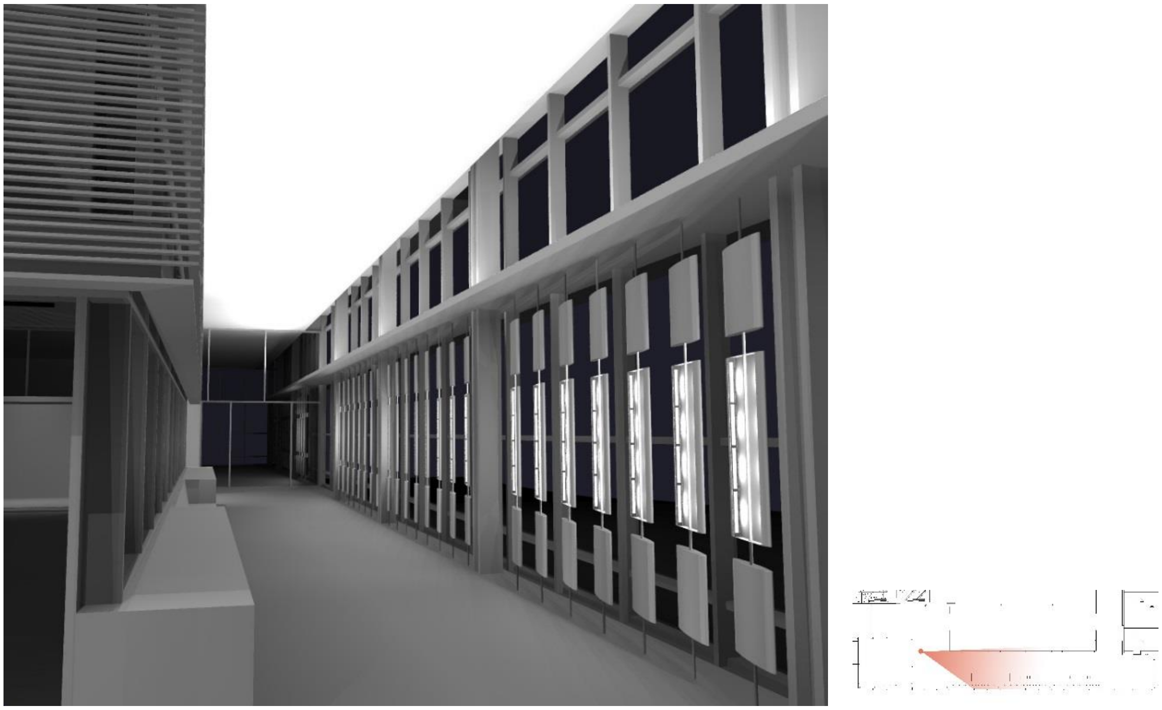


Figure 24 - Raytrace Render from Lobby

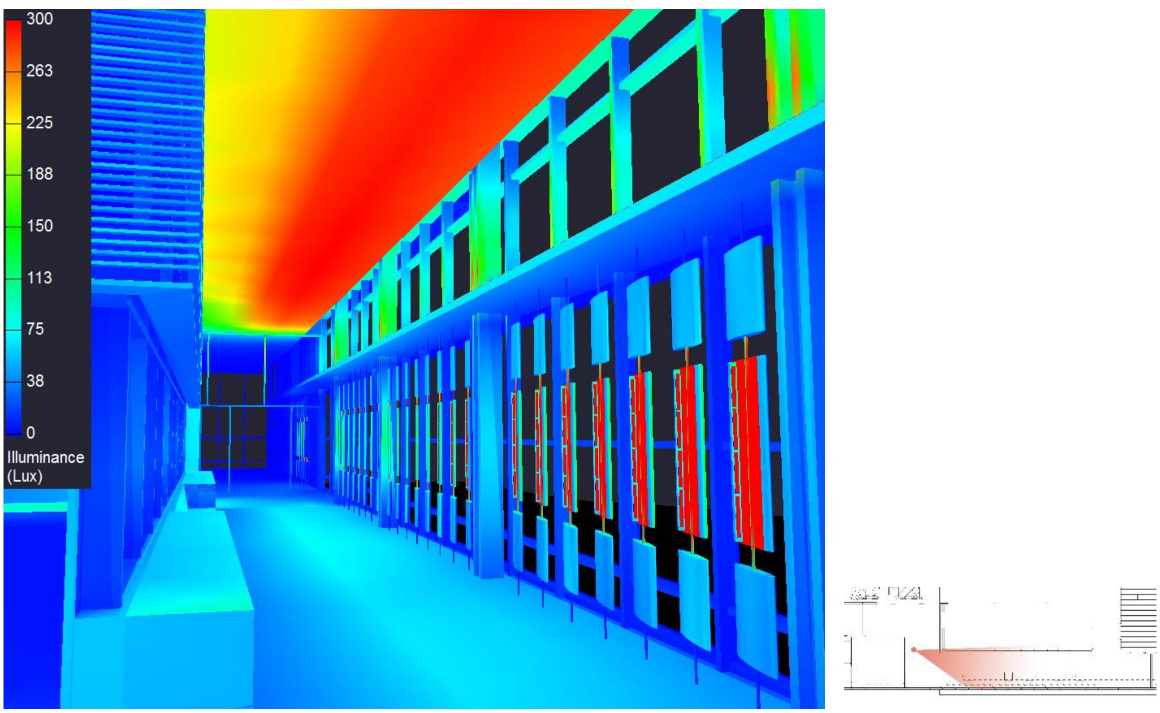


Figure 25 - Pseudo-color from Lobby

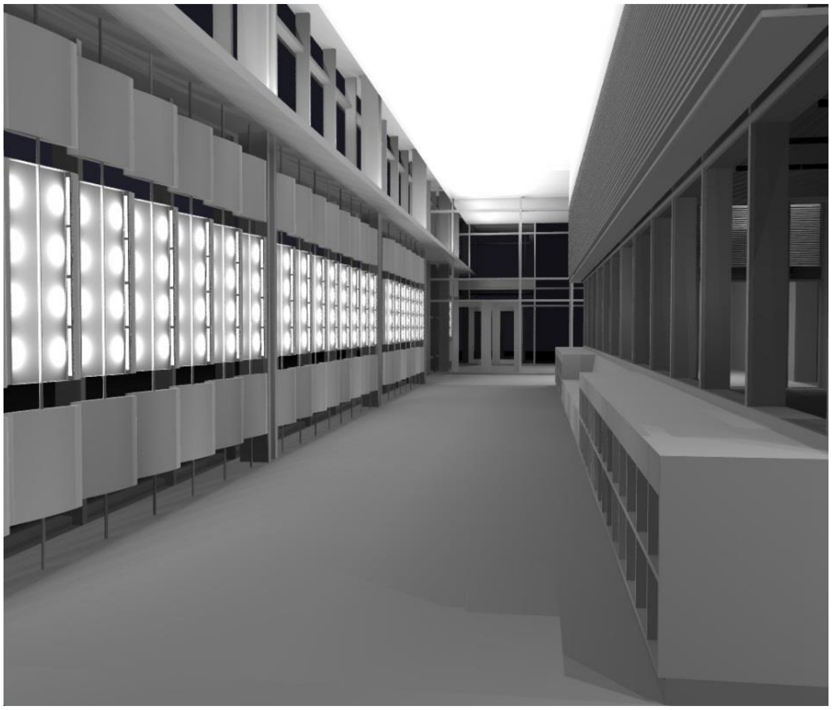
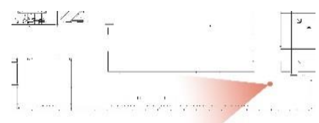
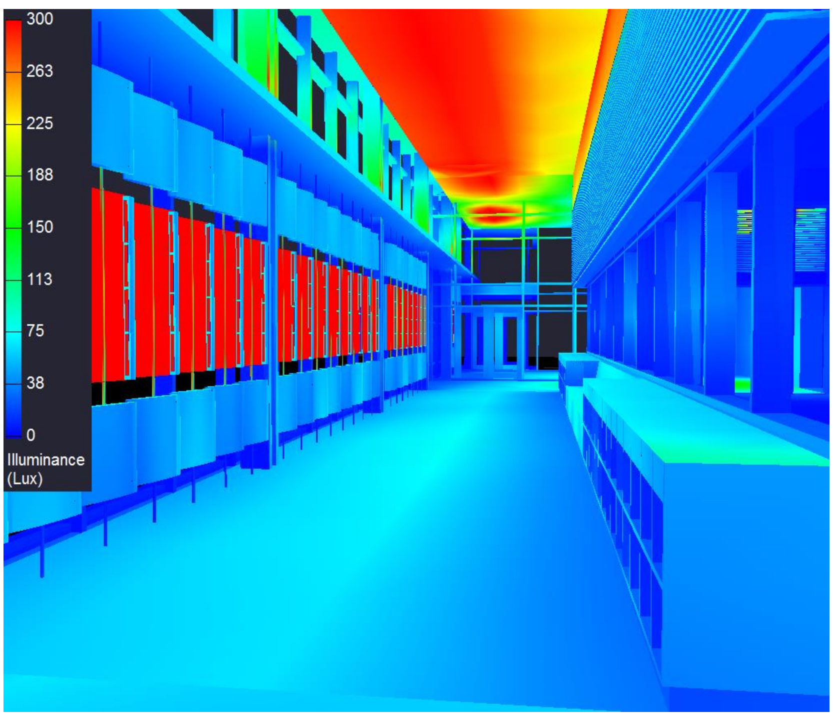



Figure 26 - Raytrace Render from Corridor



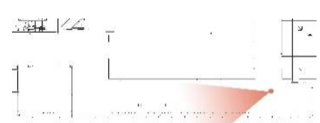


Figure 27 - Pseudo-color from Corridor

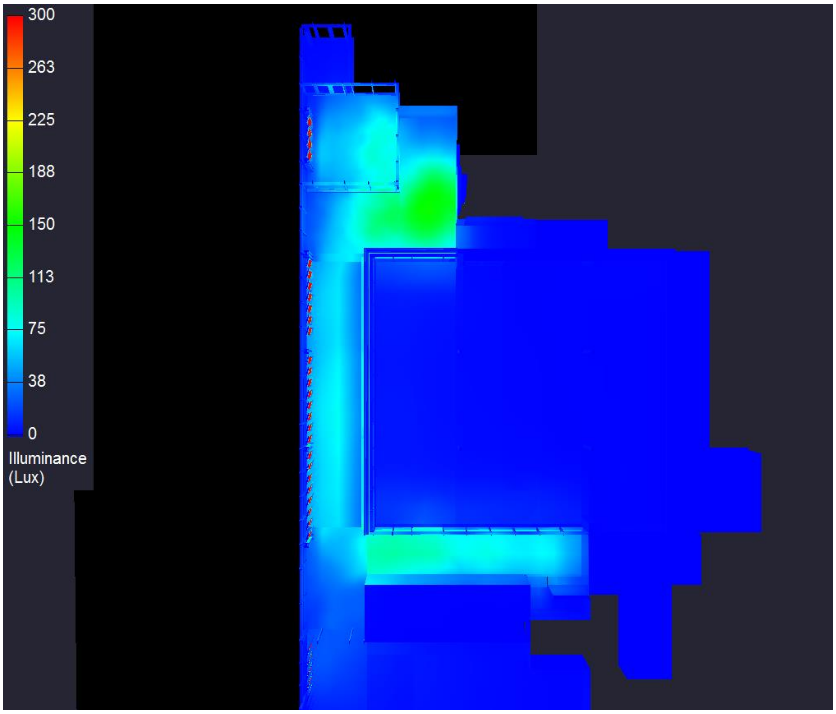


Figure 28 - Overhead Pseudo-color

Illuminance Summary

Table 18 - Wellness Corridor Illuminance

Data	Required	Actual
Illuminance Avg	100	95.1800
Maximum	-	135.0000
Minimum	-	28.4000
Avg/Min	3.0:1	3.3500

Table 19 - Wellness Lobby Illuminance

Data	Required	Actual
Illuminance Avg	100	106.7200
Maximum	-	182.0000
Minimum	-	30.8000
Avg/Min	3.0:1	3.4600

Table 20 - Wellness Vestibule Illuminance

Data	Required	Actual
Illuminance Avg	100	79.3600
Maximum	-	112.0000
Minimum	-	29.1000
Avg/Min	3.0:1	2.7300

Nighttime Radiance Rendering

Figure 29 - Wellness Corridor Radiance Render, People added via Photoshop CS6

Evaluation

The Wellness Lobby and Corridor effectively uses lighting that mimics how the daylight reacts with a light shelf cove. The daylighting in the space implements classic techniques of allowing daylight in controlled amounts without blocking the view, should the occupant want it, of the grand main lawn to the exterior. The operable fins give the occupant the choice of whether they wish to have more or less light on their workplane while also producing visually interesting perimeter light. The lighting accomplishes not only the psychological impressions in the space but the numerical standards as well. Together, the corridor and lobby lighting works with the architecture to create a pleasant environment for both lounging and passing by.

Dance Rehearsal Room

Description

The dance rehearsal space is located on the first floor of the building and adjacent to the northeast façade. Its location makes it one of the first things visitors will see when arriving through performing arts entrance and when traveling to the theatre spaces by route of the main stairs. One wall of the space, the wall that faces the corridor is comprised of mostly glass and a bit of gypsum board. The space also has an intricate drop ceiling that allows for a large view into the dark abyss of the plenum. The ceiling is a prefabricated manufactured design to integrate the mechanical diffusers, the theatre performance fixtures and the architectural lighting as well.

Square Footage: 1648 sf
Approximate width: 33 ft 5 in
Approximate length: 50 ft
Height: 15 ft to 12 ft 6 inches sloped

Plans

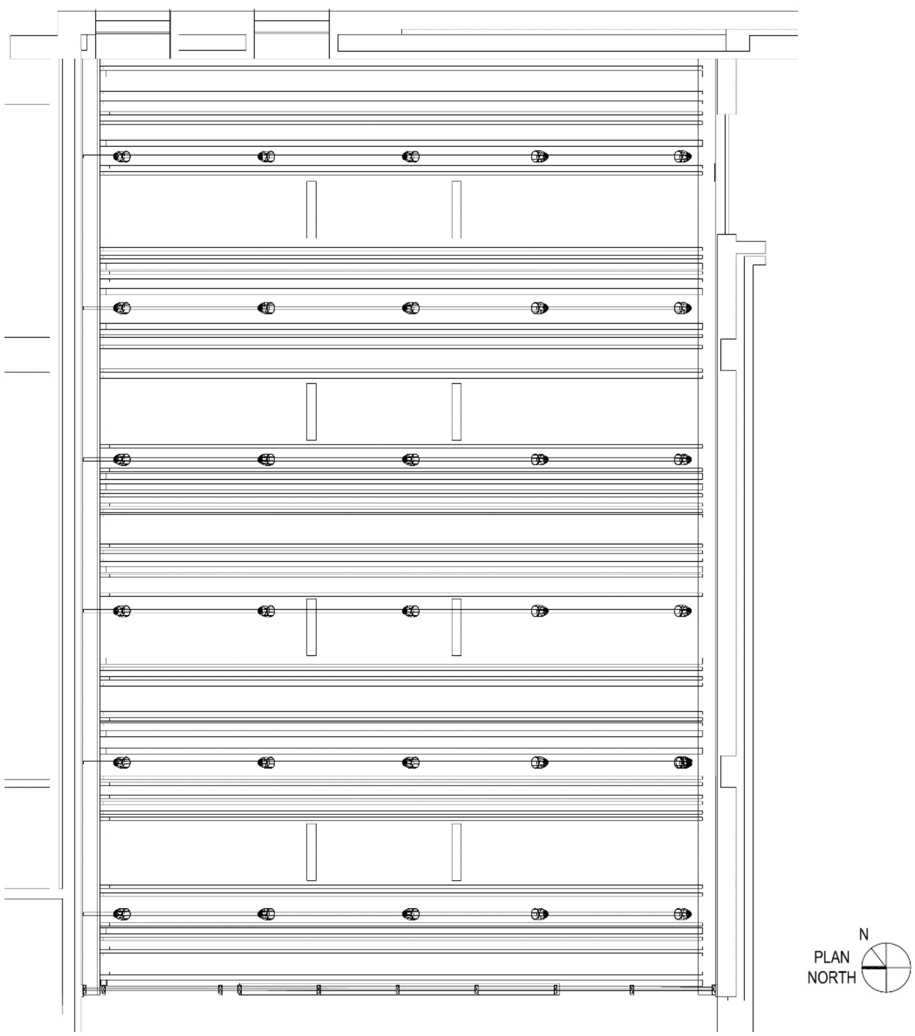


Figure 30 - Dance Rehearsal Room RCP

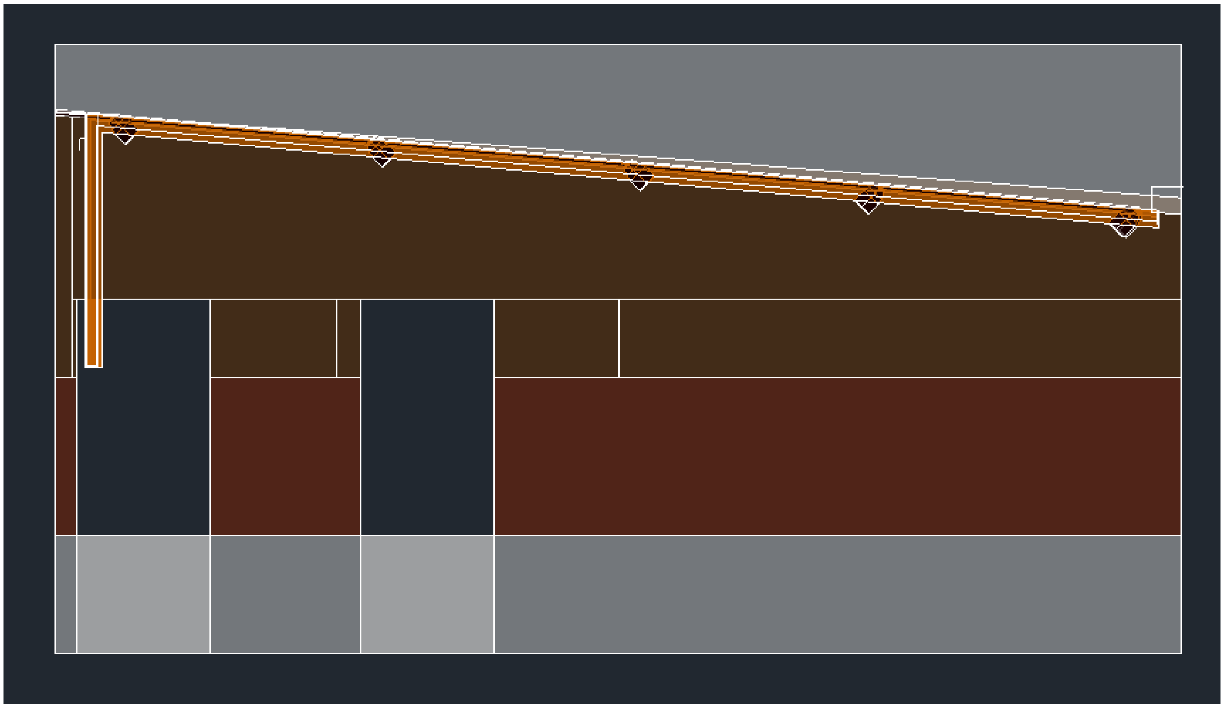


Figure 31 - AutoCAD Elevation looking Northeast into the Dance Rehearsal Room

Finishes & Materials

The materials in the Dance Rehearsal room are designed to look like one entity folding over to create the rectangular room. Though there are many different types of materials, most are created to look like a light tan color of anigre or maple wood. The new ceiling design incorporates this wood as it slopes up through the space before folding down over the back wall. The ceiling planks varying in thickness of an inch to three inches in thickness. The closer they are to the theatre lights, the thinner they are so they do not obstruct the views of the theatre lights. The front wall is mainly made up of wood and mirrors while the rest of the room incorporates wood, gypsum board and acoustical panels.

Table 21

Type	Description	Color	Reflectance	Manufacturer
Floor	Wood	Maple	0.5	T&G Wood Strip
	Dance Floor	Maple	0.5	Marley
Walls	Wood Louvre	Anigre	0.25	Bacon Veneer Company
	Wood Wall Panel	Anigre	0.4	-
	Acoustic Fabric Panel	-	0.3	-
	GWB	Off-white	0.7	USG Corporation
	Mirrors	-	1	-
	Glass	-	.78 transmittance	-
Ceiling	Wood Plank Ceiling	Anigre	0.25	Ceilings Plus; Barz

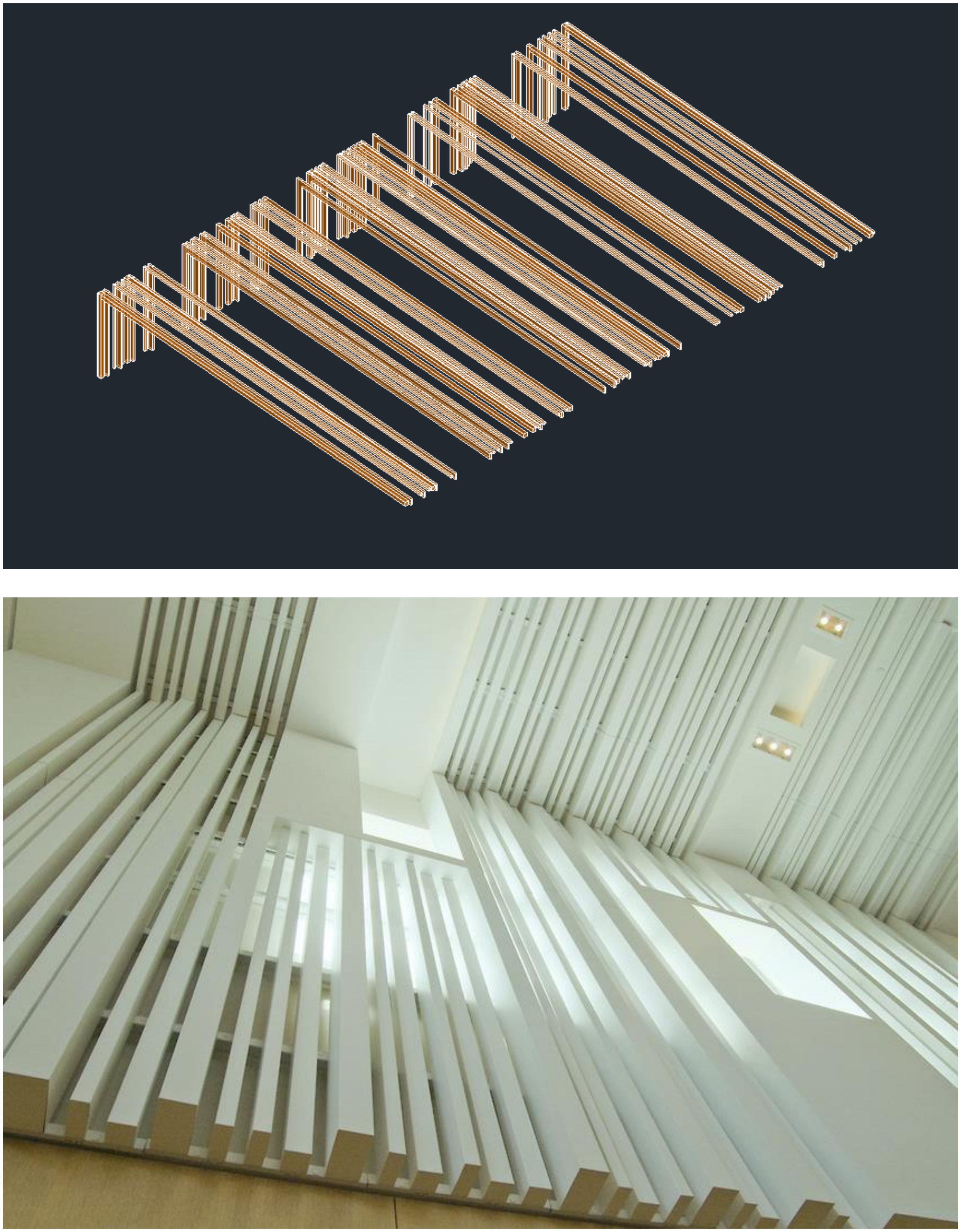


Figure 32 - Perspective of the manufacturer wood slat ceiling in AutoCAD (top) and provided by the manufacturer (bottom) by Ceilings Plus "Barz" – please see the ceiling specifications for more information on the manufacturing and details of this prefabricated ceiling (Appendix B)

Tasks

Within the space, its primary function will be instruction for dance recitals and practice. There is also a possibility of lectures or other small performances occurring within the space.

Overall Design Goals

The Dance Rehearsal Room will be a room of dedication and growth. The students will work for hours on their performances and development of the art of dance. The light, like in the great ballrooms of the past, will have some visual interest and glamour, along with a modern grand ceiling. An irregular pattern of pendant downlights with a frosted glass trim will produce ambient lighting within the space as well as some sparkle with their small aperture. Their random pattern between the wood slats and against the dark ceiling will give a star-like illusion for the grand ceiling. For orientation within the space and to supplement the light coming in from the southwestern glass wall, lighting will graze the front and the back walls of the space. This lighting and ceiling design was coordinated with the mechanical systems and theater lighting that was required by the theatrical consultants.

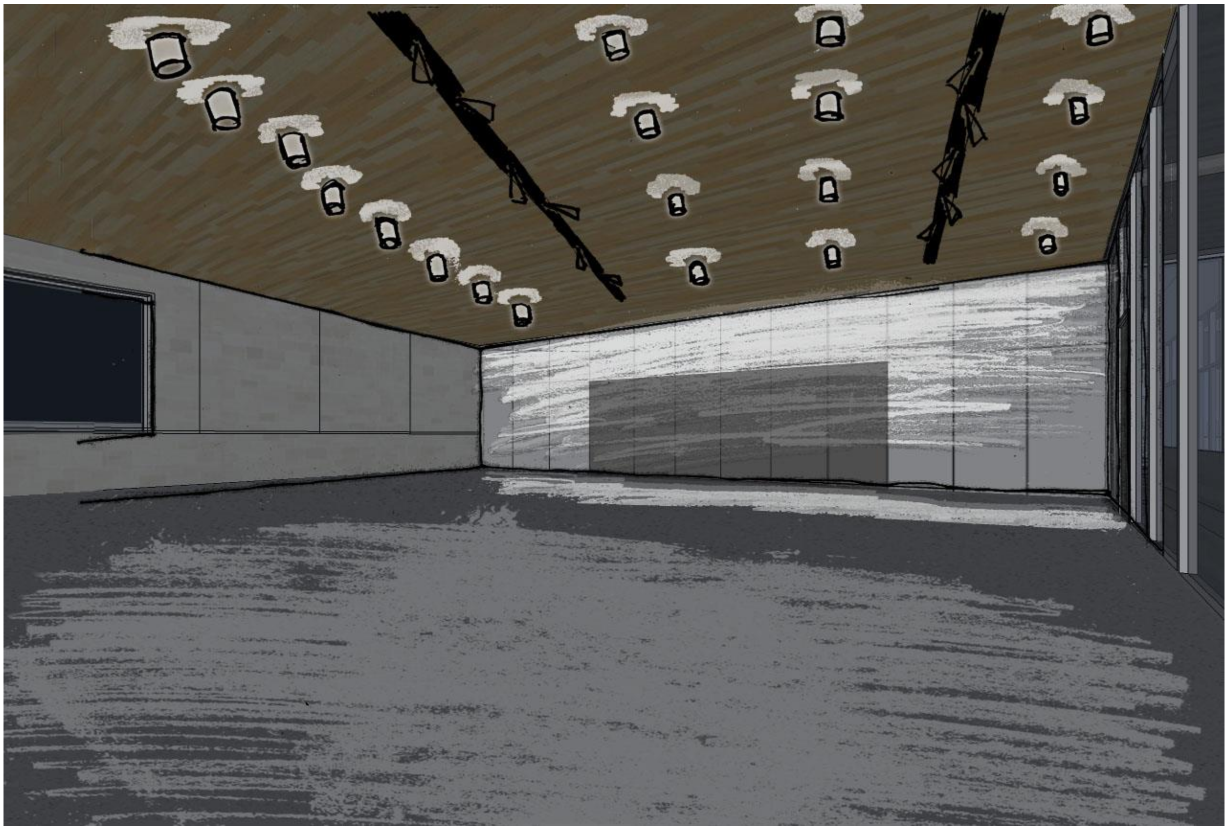


Figure 33 - Original Concept Sketch of the Dance Rehearsal Space

Design Criteria/Considerations

For the following section, the Design Criteria was formed by a combination of resources. ASHRAE 90.1 2010 requires lighting power densities, determined to be watts/square foot, for all spaces in the building. It is very important to meet this criteria as it required by state codes in Massachusetts to allow this building to be opened for use. The values for the Illuminance recommendations, provided in lux, were taken from the IES Light Handbook, 10th Edition. Illuminance levels are important to a design because they aid the functionality of the room. In some cases, they were also provided for safety concerns. Further design criteria was also taken from the IES Handbook or from background information learned throughout school.

Lighting Power Density

Table 22

Space	Space Description	Allowance (W/sf)
Dance Rehearsal	Classroom/Lecture/Training	1.24

Illuminance Requirements

Table 23

Space	Task	E_{hor} (lux)
Dance Rehearsal	Educational Stage - Dance	300

Visual Interest

The Dance Rehearsal Room will be frequently viewed to those passing by and stopping to watch a performance. It is adjacent to the main stairway for this building and therefore should have some visual interest to capture the attention of those passing by. The visual interest of this space was created with the pendant downlights and their frosted glass trim.

Reinforcement of the Architecture

Above this space is the sloping steps of the theatre, to allude to this, the ceiling in the Dance Rehearsal space slopes accordingly. This also helps with the integration of the systems above the dropped architectural ceiling.

Controls

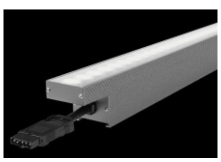
Like the theatre, the complexity of controls in this space is very high in terms performance lighting. While the architectural is much simpler, the theatre consultants wished to completely design the controls in the space with suggestions from the lighting consultant. The architectural lighting will not be used for performances so the only requirement is that the fixtures were able to be dimmed down to 1% then switch off. Therefore, special consideration was taken when examining the dimming capabilities of the selected fixtures so that these standard could be met.

Psychological Impression

As this space is very concentrated and function based, the lighting should respond to this. Therefore the light is concentrated at the center, providing points of interest in the front and back of the room to drive the dance and learning within the space.

Fixture Selection

Table 24

Type	Fixture Image	Manufacturer	Description	Lamp	Wattage
L9		Lumenpulse Interior Façade	Linear LED interior wall grazing fixture with a 30° x 60° Regular Output beam distribution and essitential white technology	LED 2700K 2450 lms	8.5 W/ft
L10		Erco Starpoint	Cylinder small aperature pendant downlight with glowing translucent ring around the bottom of the fixture, extra wide flood distribution	LED 3000K 550 lms	8 W

**A light loss factor of 0.7 was used for all of the fixtures per simplified real-world design practices

Lighting Construction Document Drawings

Since producing the lighting plans would be illegible in this report, an appendix has been created for larger and more readable lighting plans. To view these drawings, please see Appendix C – Drawings LP4.

Detail(s)

The detail for the fixture grazing the front and back walls is shown in Figure 34.

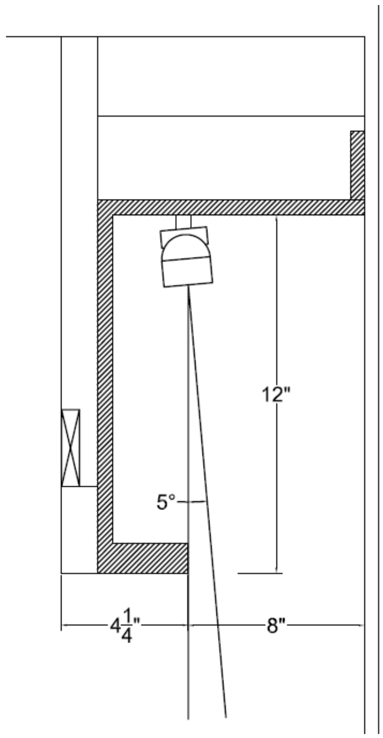


Figure 34 – Slot detail for wall grazing fixture

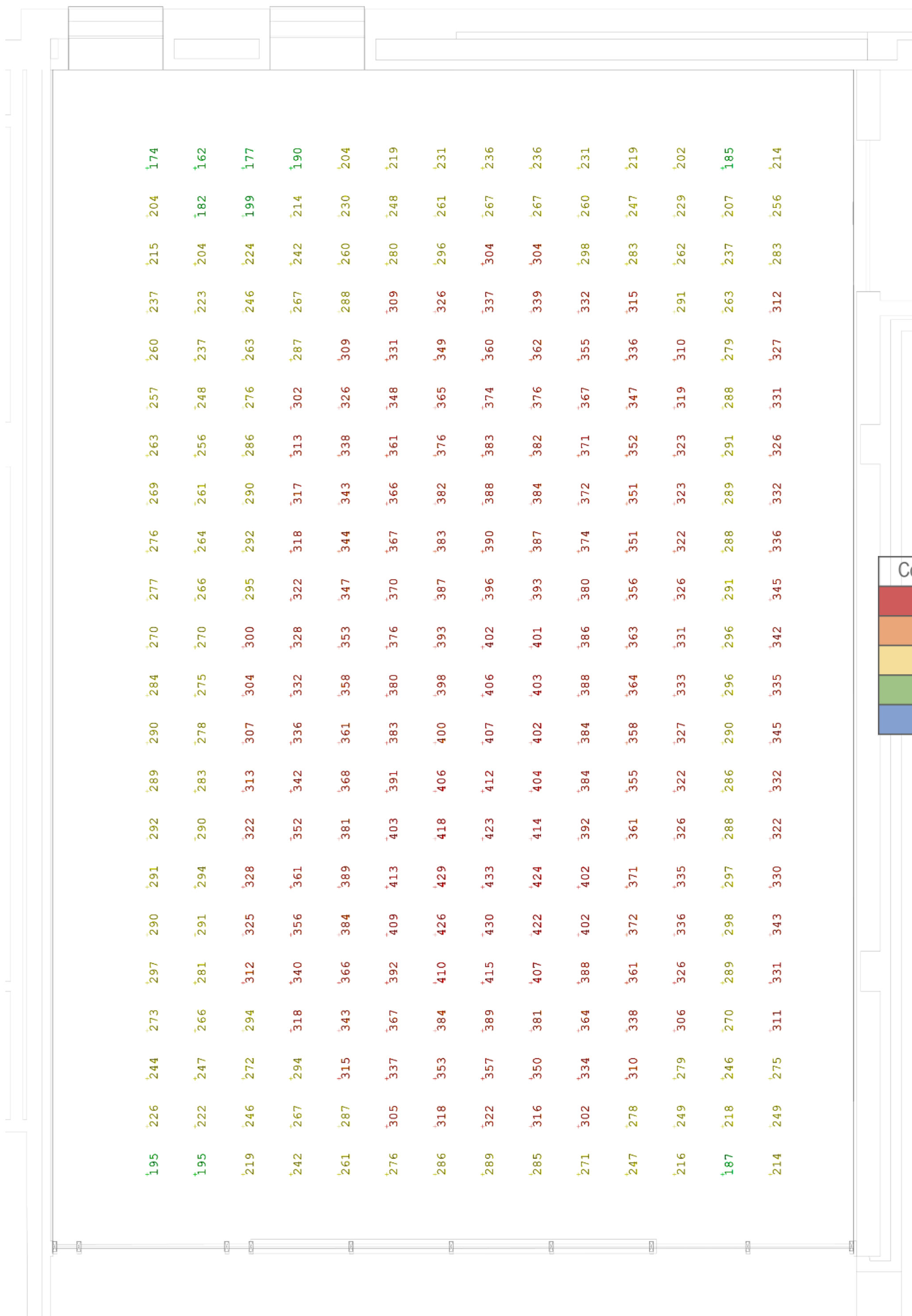
Lighting Power Density Calculations

Table 25 - Dance Rehearsal Room LPD

Type	**Lumenpulse**	**Erco Star**
Total Fixtures	22	155
Watts /Fixture	8.5	8
Total	187	1240
Area	1777.155	

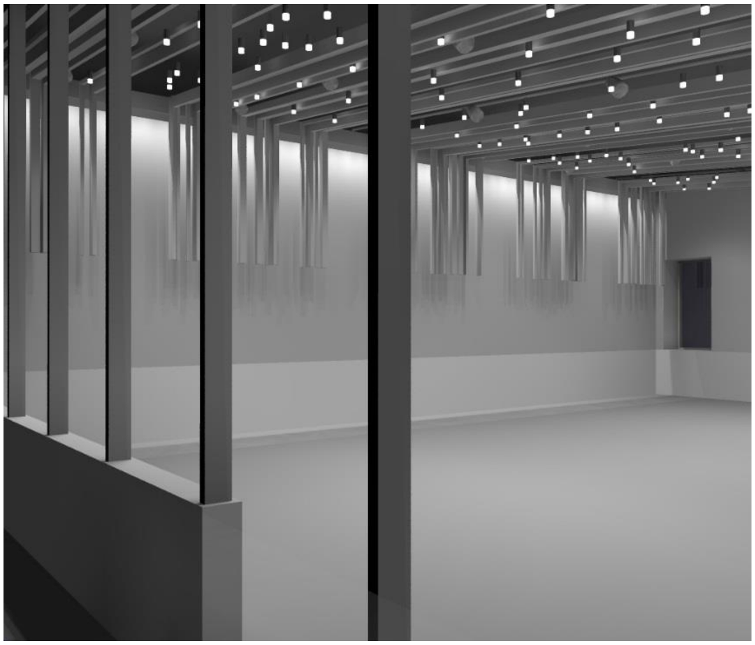
Watts/SF	0.8030
Allowed W/SF	1.2400
Does it Pass?	YES :)

Illuminance Calculations



Colors	Range (lux)		
(red)	120	to	150
(orange)	90	to	120
(yellow)	60	to	90
(green)	30	to	60
(blue)	0	to	30

AGi32 Renderings



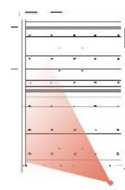
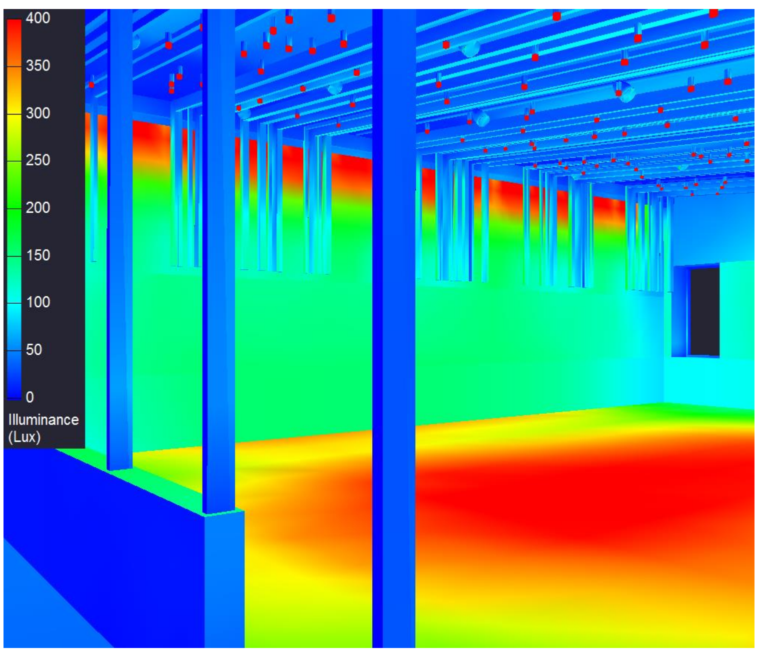


Figure 35 - Raytrace Render from outside the space



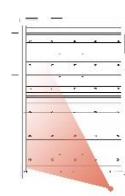
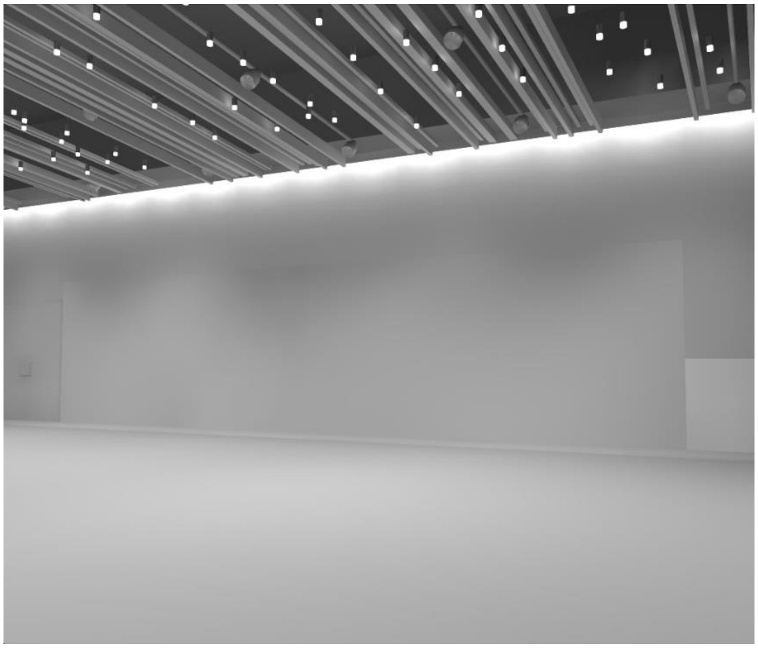


Figure 36 - Pseudo-color Render from outside the space



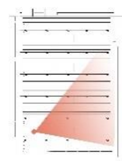
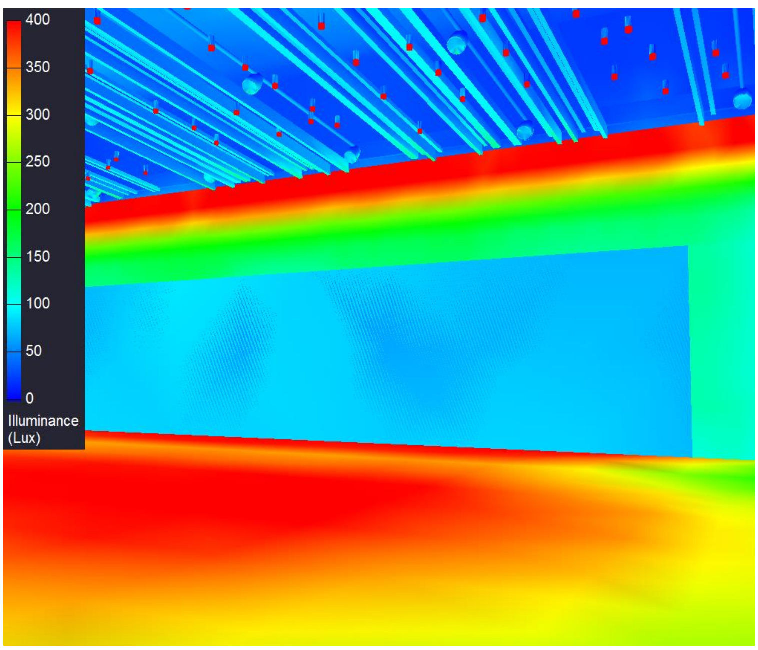


Figure 37 - Raytrace Render looking towards the front of the space



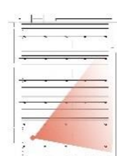


Figure 38 - Pseudo-color Render looking towards the front of the space

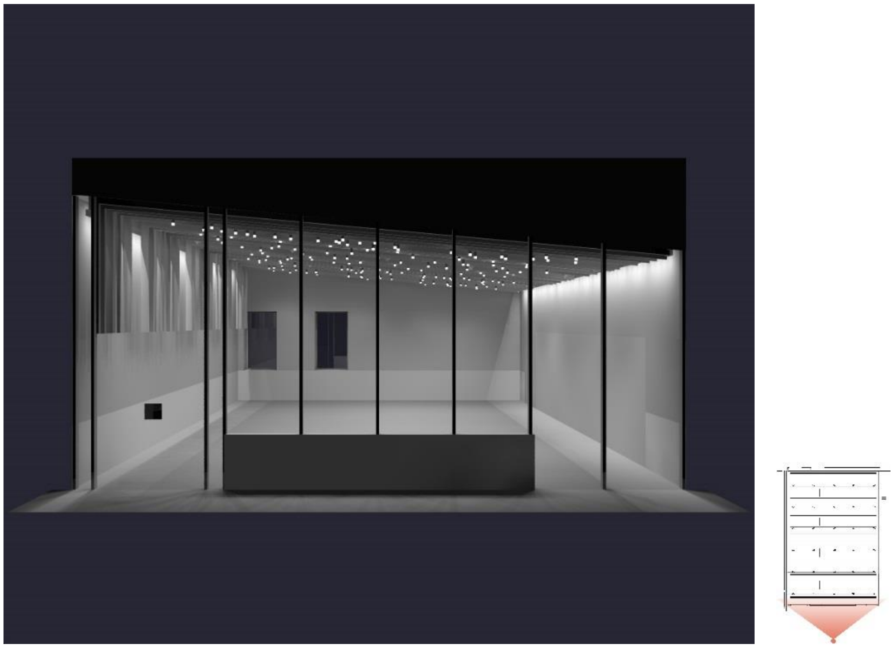


Figure 39 - Raytrace Render looking into the space

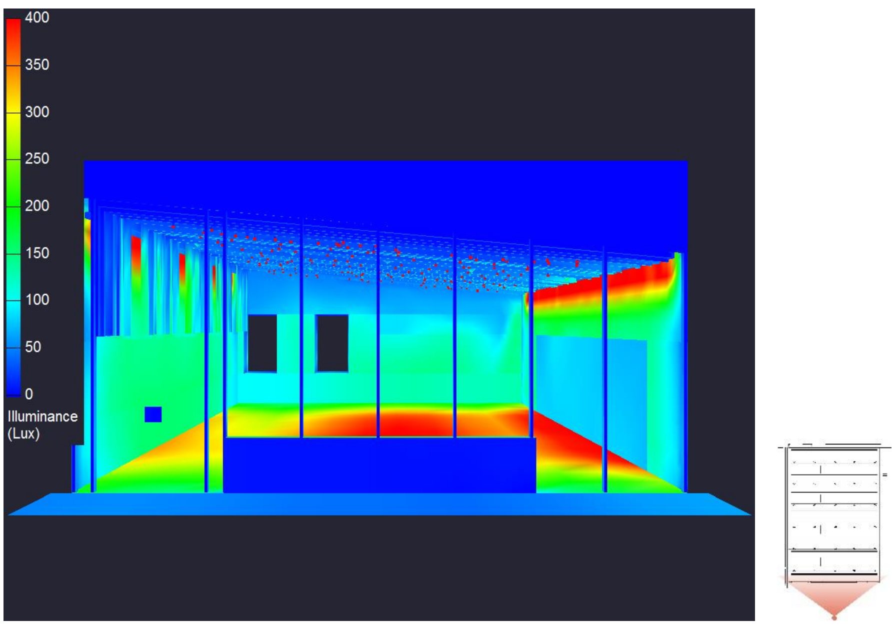


Figure 40 - Pseudo-color Rendering looking into the space

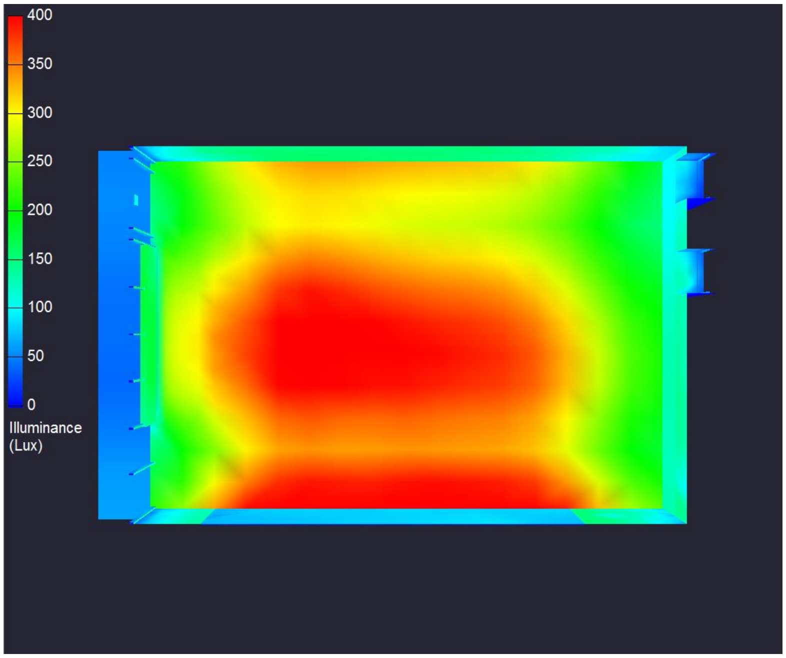


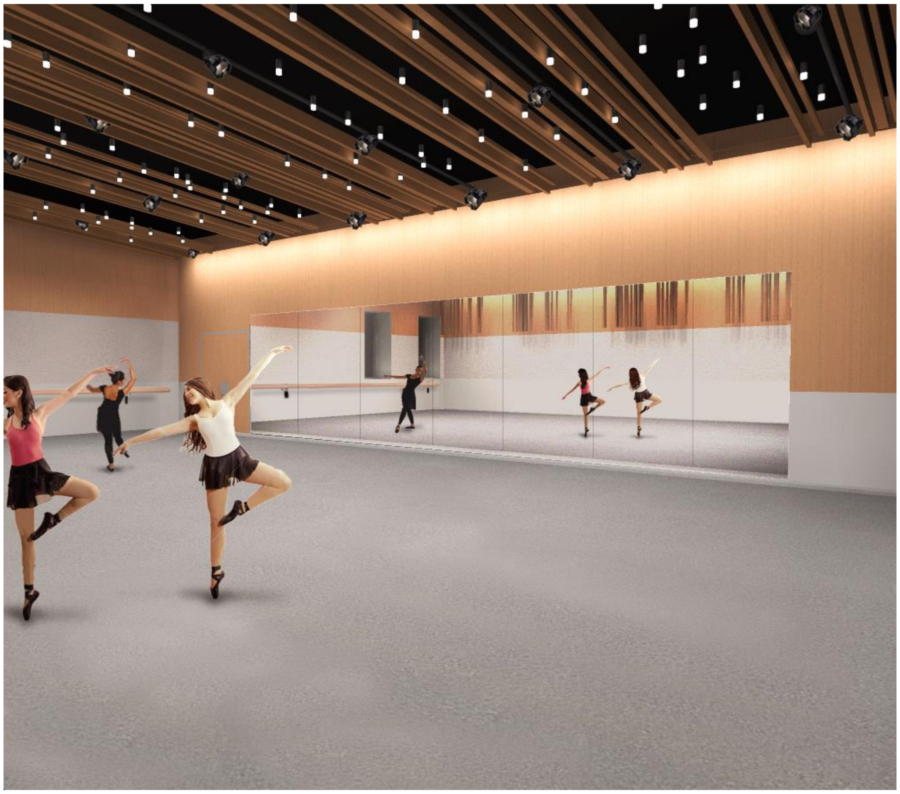
Figure 41 - Pseudo-color Render from overtop of the space

Illuminance Summary

Table 26

Data	Required	Actual
Illuminance Avg	300	315.0400
Maximum	-	433.0000
Minimum	-	162.0000
Avg/Min	1.5:1	1.9500

Final AGi32 Renderings



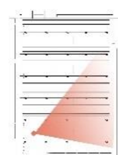
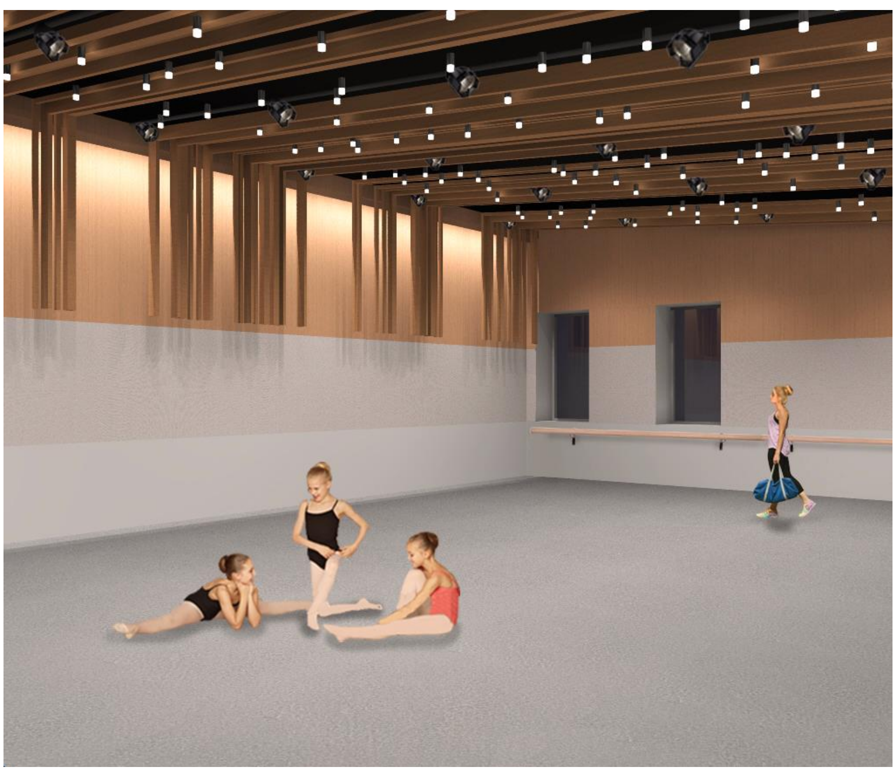


Figure 42 - Final Rendering from AGi32 and People added via Photoshop CS6



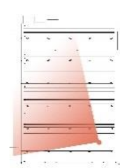


Figure 43 - Final Rendering from AGi32 and People added via Photoshop CS6

Evaluation

The Dance Rehearsal space is where young ladies will practice and grow their skills in art and movement. The space is prominent within the building and will be viewed by many. It will be a jewel within the new building. It creates a grand ceiling and visually interesting starry night architectural lighting. The design is driving by function, concentrating the light towards the center while providing focal points on the front and back walls of the space. The sloping ceiling follows the path of the architecture above it before folding down over the back wall of the space. All design and numerical standards in this space were met to create a thought-provoking and artistic space for dance and creativity.

Performing Arts Theatre

Description

The theatre is located on the third floor of the building and it is contained in the northeast part of the building. It is a triple height 510-seat space that includes a mezzanine and a stepped floor towards the stage. To arrive at this location, occupants must travel through the building from the main entrance and travel up an open staircase, or travel from the existing academic building by way of the “link” bridge. The theatre is extremely well coordinated between mechanical systems, lighting, theatrical lighting and catwalks thus a large change to the theatre lighting was extremely hard to plan. The theatre also features a curtain wall, highlighted in blue on Figure 44 and 45. Manual shades, both sheer and blackout, can be operated by occupants. Furthermore, the entire theatre is surrounded in wooden louvers from floor to ceiling, all railings are also comprised of wooden louvers.

Square Footage: Orchestra - 2982 sf; Mezzanine – 2028 sf; Stage -2058 sf
Orchestra Approximate Length: 48 ft
Orchestra Approximate Width: 66 ft
Height: Entrance to Ceiling – 36ft; Mezzanine at 14ft AFF; Catwalk at 26ft AFF

Plans

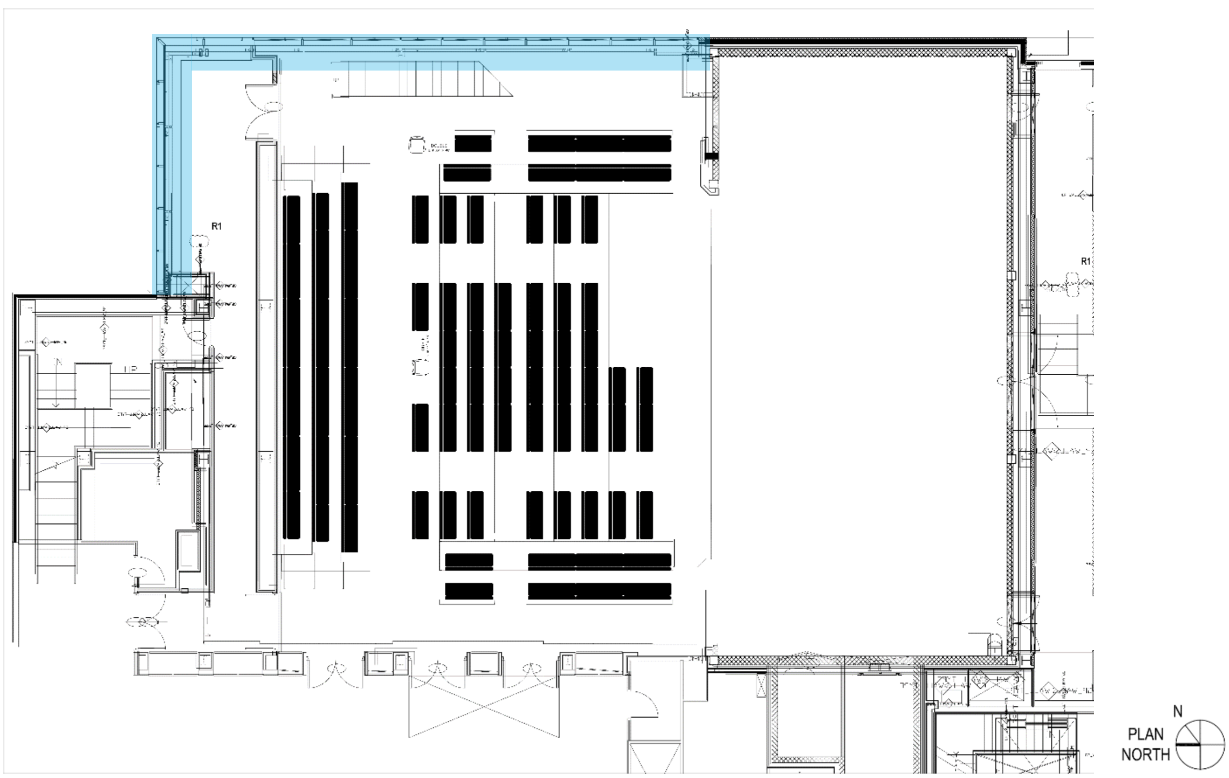


Figure 44 – Theatre Orchestra Floor Plan

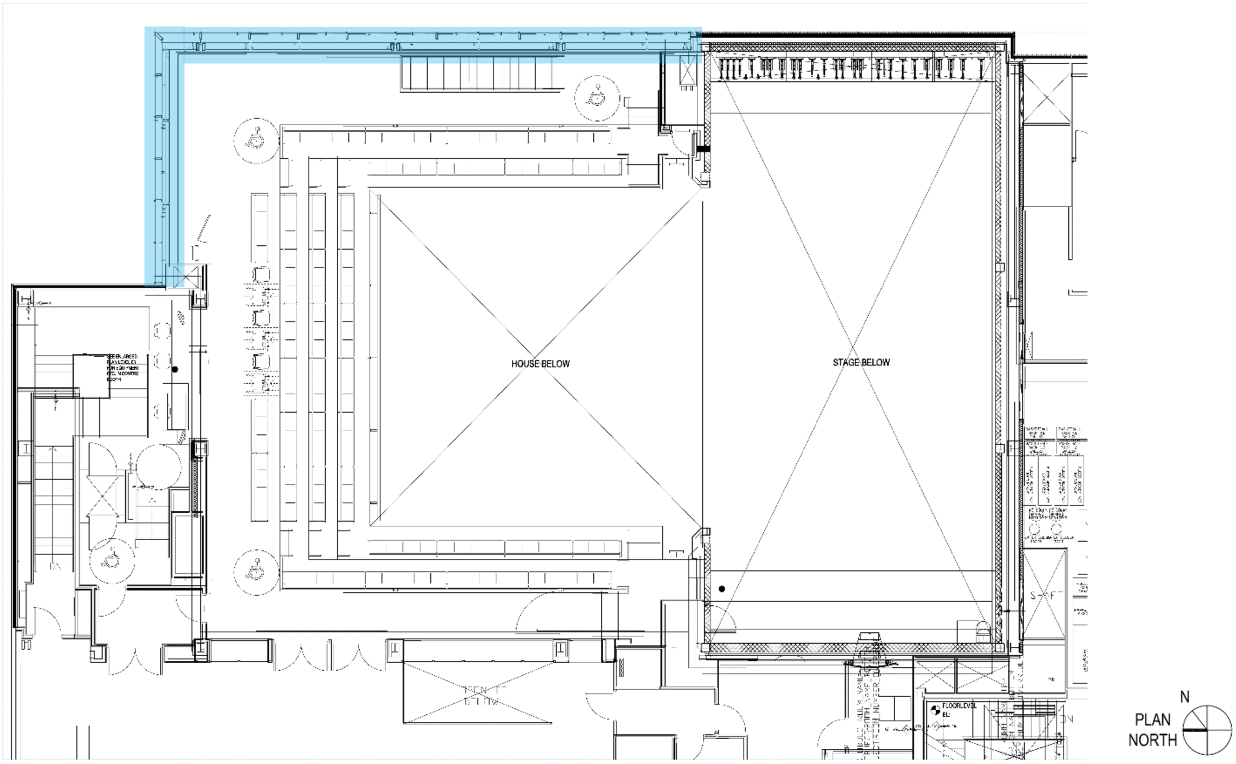


Figure 45 – Theatre Mezzanine Floor Plan

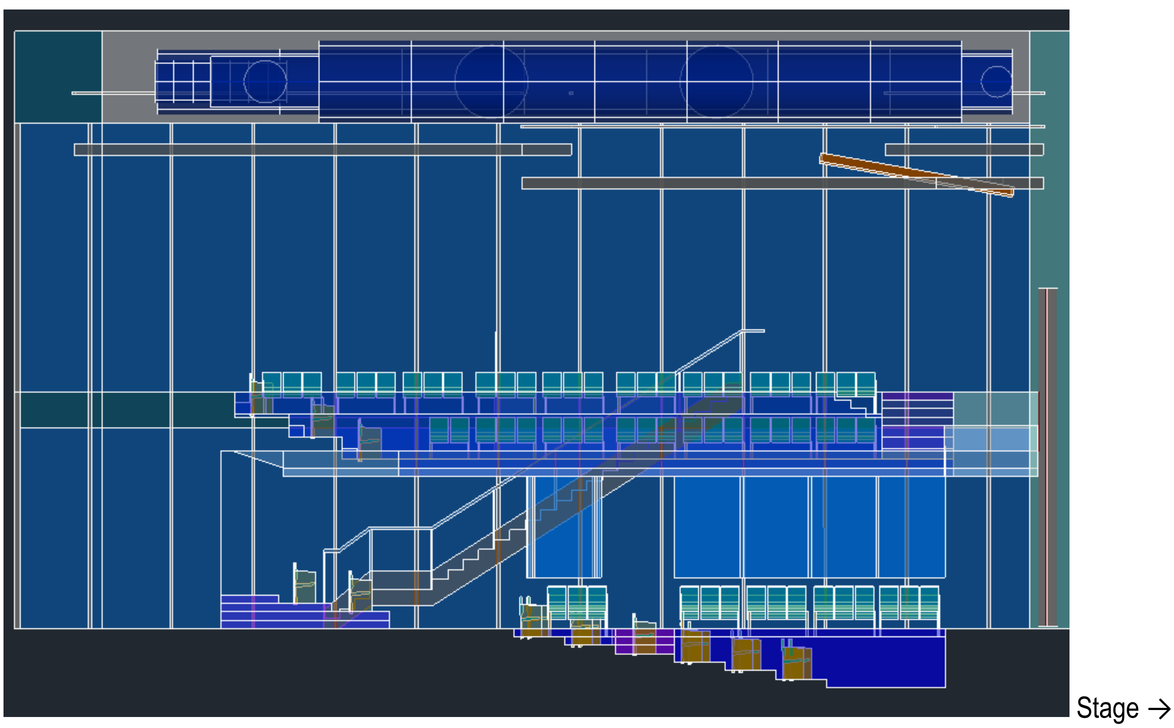


Figure 46 - AutoCAD Theatre Elevation

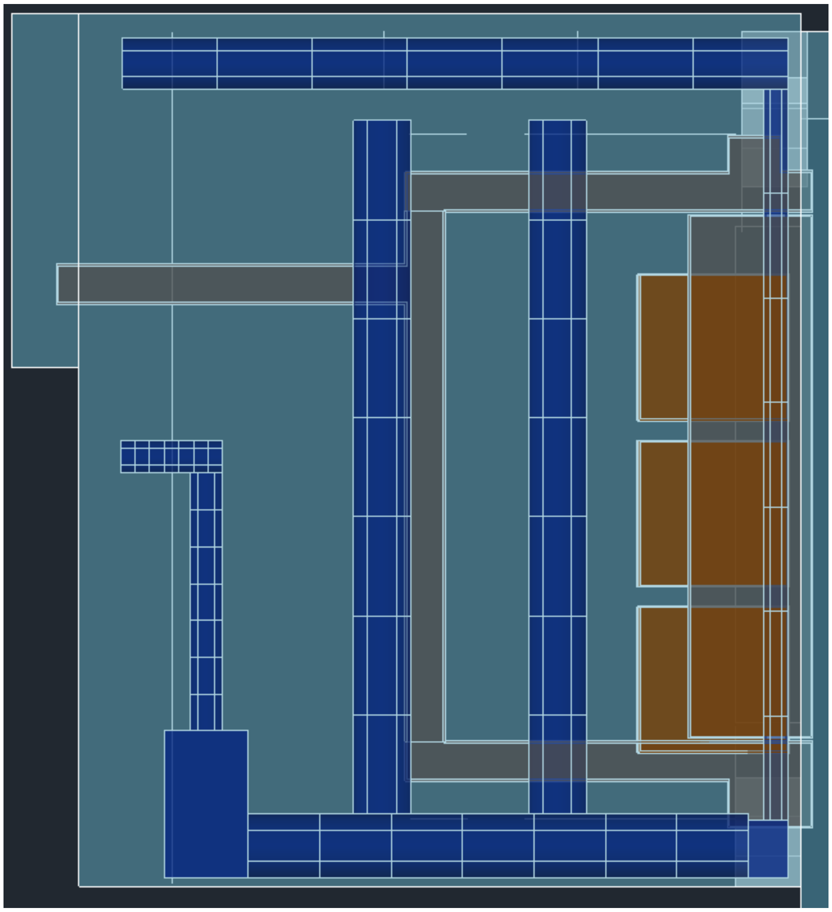


Figure 47 - AutoCAD Plan of the Ceiling systems - Mechanical (Blue), Catwalk (Grey) and Reflectors (Brown)

Finishes & Materials

The materials in this space utilizes a lot of wood variations. The wood walls are designed to the color of a light tan wood, as is the wood louvers located on the walls and railings. The floor and ceiling are designed to be very dark. Where there isn't dark stained concrete, the carpet is a very dark grey. While the mezzanine ceiling is uses off-white drywall, the theatre ceiling is painted black, as is the ductwork. The bottom of the catwalk is a dark bronze. The only exception to the dark ceiling is the plywood acoustical slanted panels that help radiate sound into the orchestra.

Table 27 – Interior materials of the Theatre and Stage

Type	Description	Color	Reflectance	Manufacturer
Floor	Stained Concrete	-	0.5	Vexcon Star Seal
	Carpet	Havana	0.1	Bentley Prince Street
	Plywood (Stage)	Painted Gloss	0.55	-
	Painted Steel (Catwalk)	Black	0.1	-
Walls	Wood Louvre	Anigre	0.25	-
	Wood Wall Panel	Anigre	0.4	Bacon Veneer Company
	CMU Blocks (Stage)	-	0.5	-
Ceiling	Metal Mesh (Catwalk)	Dark Bronze	0.2	Armstrong MetalWorks
	Acoustical Reflectors	-	0.3	-

Tasks

This space will mainly be used for performances and assemblies, though the owner has expressed an interesting in possible conducting standardized tests in the space if necessary. This is not likely going to be case much of the time as there are no desks in the space, yet the lighting levels have been designed to achieve testing recommendations.

Overall Design Goals

The Performing Arts Theatre is a place of expression and drama and the lighting appeals to those ideas. It will have some visual interest in the simulated modern take of the classic “grand” ceiling comprised of small blue color changing fixtures. The occupants (students, parents, donors, etc.) waiting for the show to begin can take in the media driven drama of the space. Highlighting also the bronze metal mesh on the bottom of the catwalk. The lighting is integrated and simple. It does not compete with the expression of the architecture of the space such as the wood slat screen walls. By downlighting the main spaces, the fixtures blend as much as possible into the dark ceiling. Yet the wood slats are highlighted by grazing the back wall and wall washing the side wall. This will provides a depth to space subtly enough not to detract from the focus on the stage. As soon as a performance starts, the flexible lighting system will dim down to off and be presented in a way that will not distract occupants from the stage. For safety purposes, the step lights remain from the original design, though they are upgraded from fluorescent to LED.

Figure 48 - Original Concept Sketch for the Theatre

Design Criteria/Considerations

For the following section, the Design Criteria was formed by a combination of resources. ASHRAE 90.1 2010 requires lighting power densities, determined to be watts/square foot, for all spaces in the building. It is very important to meet this criteria as it required by state codes in Massachusetts to allow this building to be opened for use. The values for the Illuminance recommendations, provided in lux, were taken from the IES Light Handbook, 10th Edition. Illuminance levels are important to a design because they aid the functionality of the room. In some cases, they were also provided for safety concerns. Further design criteria was also taken from the IES Handbook or from background information learned throughout school.

Lighting Power Density

Table 28

Space	Space Description	Allowance (W/sf)
Theatre Seating	Audience/Seating Area Performing Arts Theatre	2.43

Illuminance Requirements

Table 29

Space	Task	E_{hor} (lux)
Theatre Seating	Perfomance House Pre/Post Show	75
Theatre Seating	Testing - Paper Only	400

Psychological Impression

In the theatre, an occupant may sit in the orchestra for longer periods of time for a lecture or waiting for the show to begin. It is important to allow a comforting atmosphere while keeping visual interest and not limiting functionality and safety. The media lights on the underside of the catwalk peak visual interest and the grazing the back walls provides another point focus for the occupant. The large three story space is not lit to feel more spacious but rather enclosed to allow the stage to be the centerfold. This is done by centering the downlights in the space, as described by John Flynn.

Maintenance

Since this space is three stories in height, accessibility to repair, re-lamp and adjust fixtures is critical to allow this space to be highly functioning long after design. All fixtures in this space are LED to ensure long lifetimes before repair or maintenance must be performed.

Flexibility + Controls

The complexity of controls in this space is very high in terms performance lighting. While the architectural is much simpler, the theatre consultants wished to completely design the controls in the space with suggestions from the lighting consultant. The only architectural fixture in the space that requires controls focus is the media dome lights on the underside of the catwalk. They are suggested to be programmed into the existing theatre DMX control system to allow the stage theatre lighting director to control the lights based on the show or use of the space. Otherwise, this space requires every fixture to be turned off in back of house, or in view of people, must be able to be dimmed down to 0.1%. Therefore, special consideration was taken when examining the dimming capabilities of the selected fixtures so that these standard could be met.

Sustainability

In this space, all fixtures were upgraded from halogen and fluorescent to LED to promote a “greener” image for the school to promote.

Glare

The exterior lighting in this space will be of some concern, the previous shading system (Table 30) utilized a 1% openness factor with a visual transmittance of 24% which is fairly high, the color was changed slightly within the GreenScreen Lutron Product base to lower the transmittance to 5% to reduce possible glare and add more daylighting control in the theatre. The new system is shown in Table 31.

Table 30 - Existing Shade Materials

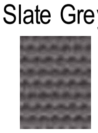
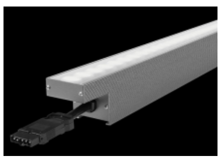
Material	Description	Color	Transmittance	Manufacturer
Normal Shades	**Lutron GreenScreen Revive** 1% openness factor ultra lightweight fabric w/ 80% recycled content	Stone 	24%	Lutron
Blackout Shades	**Lutron Avila** **0**% openness factor 37.5% Polyester, 62.5% Acrylic	Slate Grey 	0%	Lutron

Table 31 - Proposed Shade Materials

Material	Description	Color	Transmittance	Manufacturer
Normal Shades	**Lutron GreenScreen Revive** 1% openness factor ultra lightweight fabric w/ 80% recycled content	Suede 	5%	Lutron
Blackout Shades	**Lutron Avila** **0**% openness factor 37.5% Polyester, 62.5% Acrylic	Slate Grey 	0%	Lutron

Fixture Selection

Table 32

Type	Fixture Image	Manufacturer	Description	Lamp	Wattage
L11		Lumenpulse Interior Façade	Linear LED interior wall grazing fixture with a 30° x 60° High Output beam distribution and essitential white technology	LED 2700K 2883 lms	10 W/ft
L12		Winona Step13	Rectangular LED 6" step light, surface mount with concealed optics, solid aluminum brass plate	LED 3000K 202 lms	5.53 W
L13		Lumenpulse LumenDome Small	2" small color changing pixel luminaire with a 240° domed optic	LED 42 lms	6 W
L14		Gotham 4" Incito	4" LED Downlight with self-flanged, semi-specular reflector with a 40° distribution	LED 3000K 500 lms	8 W
L15		Gotham 4" Evo WW	4" LED Wallwash with self-flanged, semi-specular reflector with a 45° cutoff to source	LED 3000K 600 lms	18 W
L16		Juno Indy LC8	8" LED cable mounted cylinder downlight with a medium hyperbolic distribution	LED 3000K 4000 lms	43.6 W

**A light loss factor of 0.7 was used for all of the fixtures per simplified real-world design practices

Lighting Construction Document Drawings

Since producing the lighting plans would be illegible in this report, an appendix has been created for larger and more readable lighting plans. To view these drawings, please see Appendix C – Drawings LP5 through LP8.

Detail(s)

The detail for the fixture grazing the slat wall is shown in Figure 49.

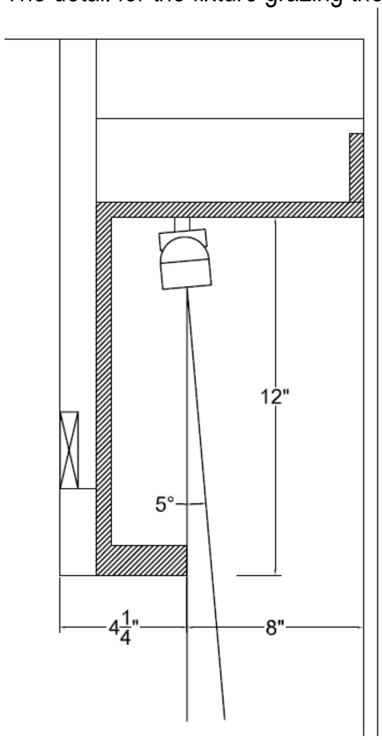


Figure 49 –Slot detail for Wall Grazing Fixture

Lighting Power Density Calculation

Table 33 - Theatre LPD

Type	Lumenpulse	Gotham Incito	Gotham Evo	Juno Indy 8"	Winona Step
Total Fixtures	124	72	16	64	32
Watts /Fixture	10	8	18	43.6	5.53
Total	1240	576	288	2790.4	176.96
Area	5010.000				

Watts/SF	1.0122
Allowed W/SF	2.4300
Does it Pass?	YES :)

Table 34 - Theatre Decorative Allowance (1 W/sf)

Type	LumenDome
Total Fixtures	60
Watts /Fixture	6
Total	360
Area	5010.000

Watts/SF	360.0
Allowed W/SF	5010.0
Does it Pass?	YES :)

AGi32 Renders

No plan calculation points are shown for this space as it was too complex to read because there were many sub areas at many different elevations and often overlapped. The renders have been provided but if a more detailed list of calculation points are please contact the author of this paper.

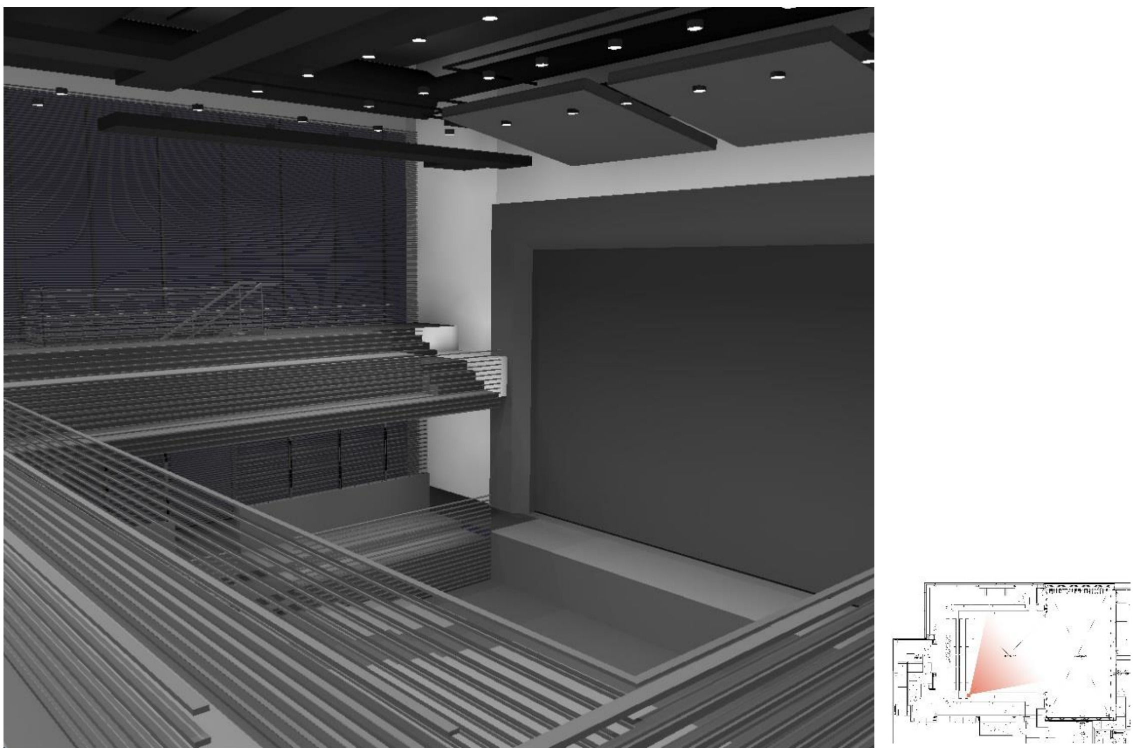


Figure 50 – Raytrace Render from Mezzanine

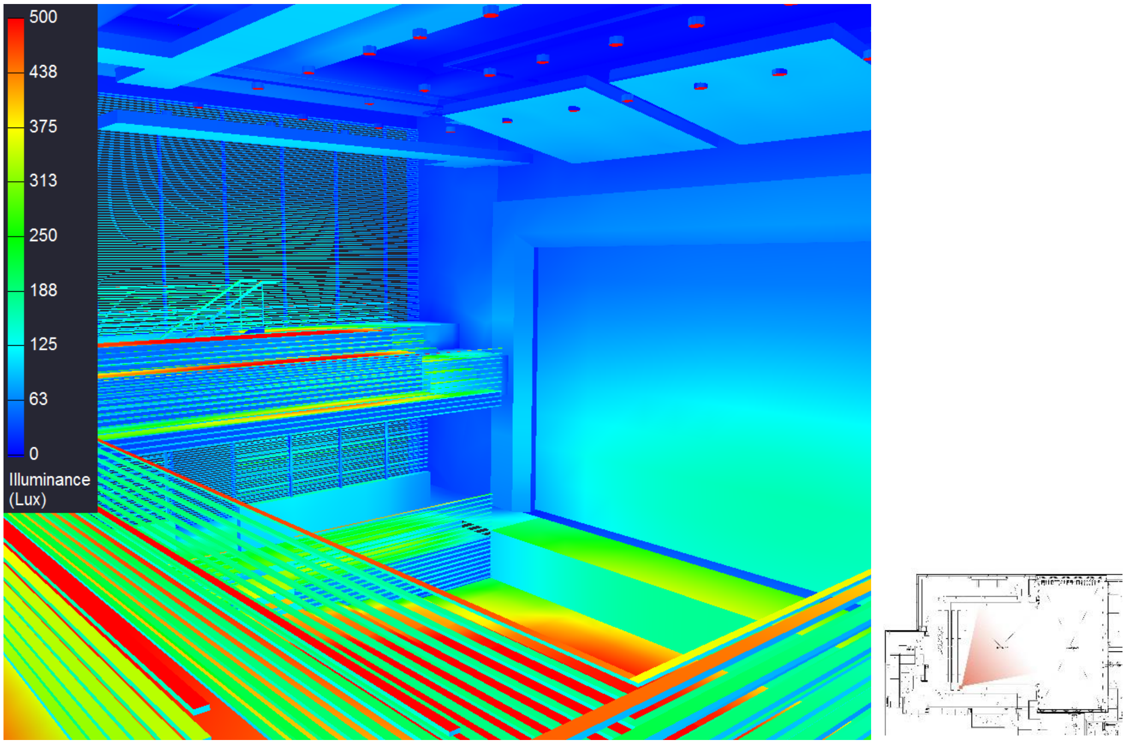


Figure 51 – Pseudo-color Render from Mezzanine

Figure 52 – Raytrace Render View from Stage

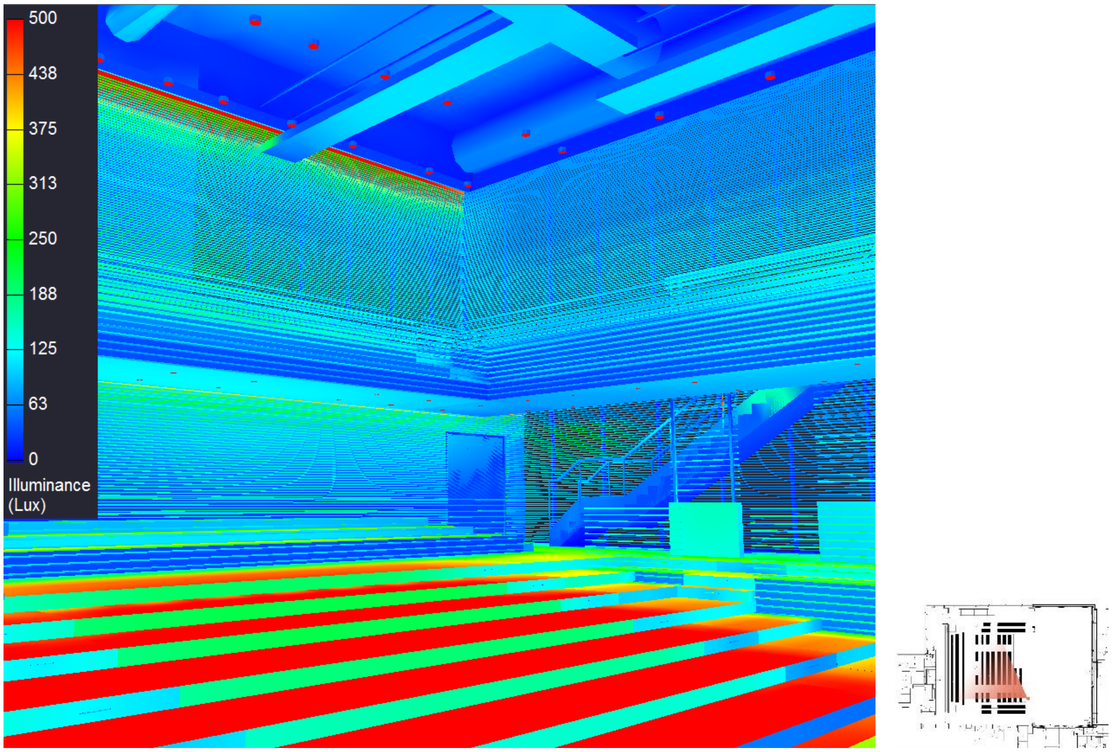


Figure 53 – Pseudo-color View from Stage

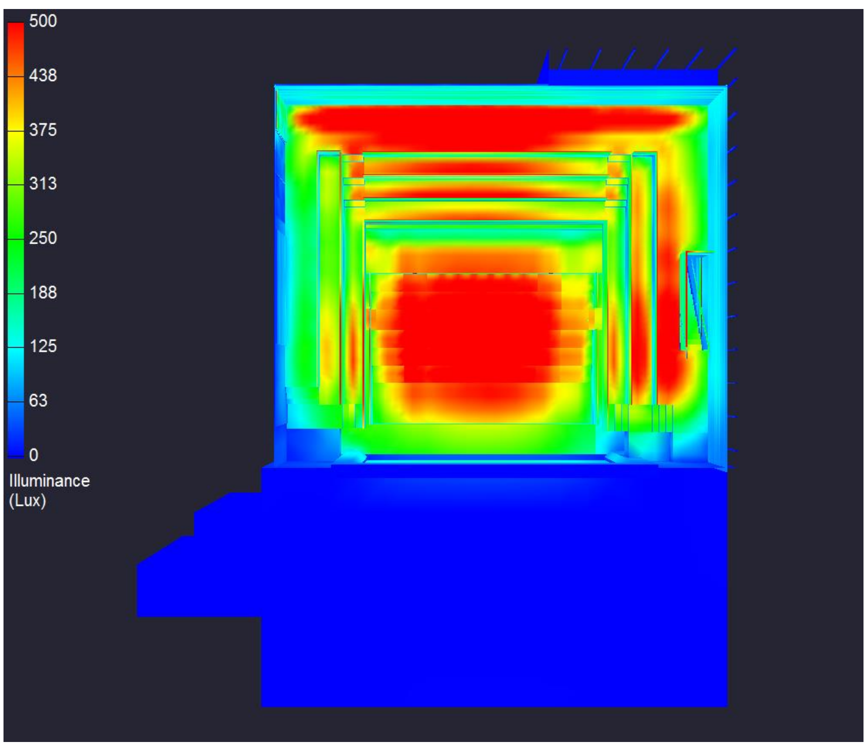


Figure 54 - Overhead Pseudo-color Mezzanine

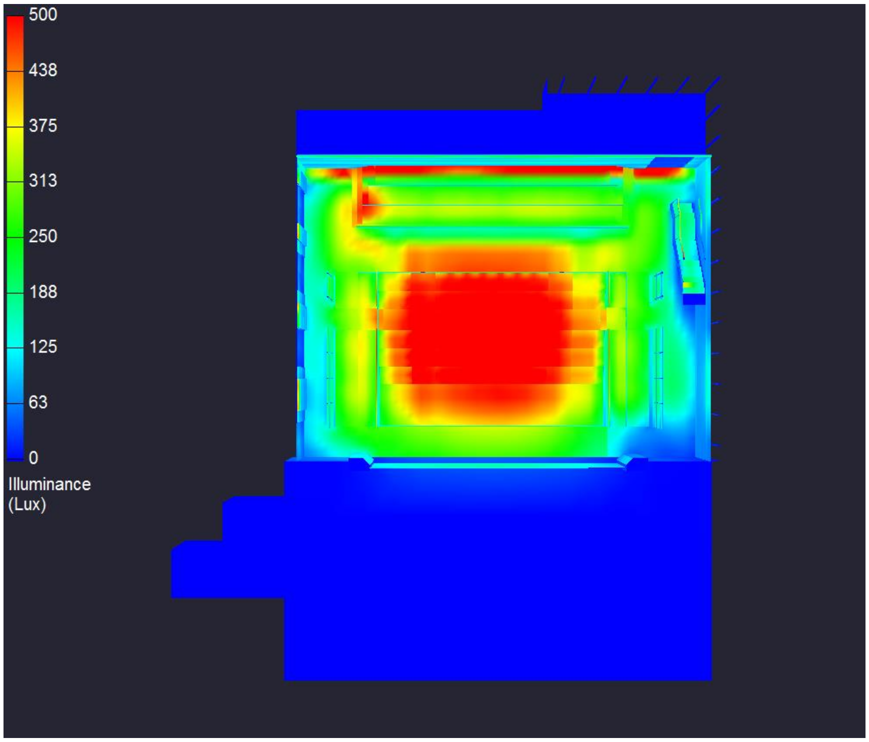


Figure 55 - Overhead Pseudo-color Orchestra

Illuminance Summary

Table 35

Data	Required	Actual
Illuminance Avg	400	407.5100
Maximum	-	692.0000
Minimum	-	172.0000
Avg/Min	3.0:1	2.3547

Evaluation

The Performing Arts Theatre emits drama and expression with a modern grand ceiling and subtle architectural lighting. It achieves lighting levels required for testing scenarios and the uniformity ratios as well. Originally, the design concept was to employ a dramatic and modern large scale pendant, however because of constraints due to theatrical fixture views and the views of the occupant, a pendant could not be hung without obstructing a view. It was unfortunate but overall it was decided the chandelier was not as important as giving the occupants and theatre fixtures an unobstructed view. This was the only design change from concept to final design. The final design in the theatre achieves the goals of enclosure, focus onto the stage and flexibility and low levels of lighting for visual interest.

Electrical Depth

Electrical Depth

The electrical depth of this design will entail a branch circuit redesign for the lighting schemes discussed above, a short circuit analysis for the redesigned spaces and a redesign of the emergency systems for a potential cost reduction.

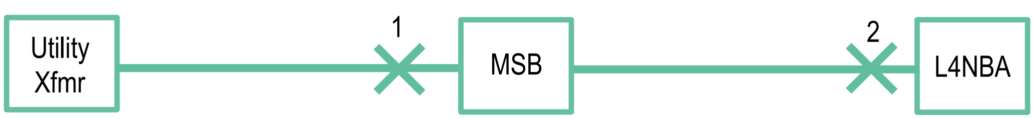
Overview

The Center for Performing Arts and Wellness utilizes a 480/277V exterior utility transformer that feeds the 3000A switchboard, provided distribution to panelboards throughout the building. There are also step-down transformers located at panelboards that require 208/120V for receptacles and mechanical equipment. The telecom and security systems are backed up to allow for a secure and reliable system to support the multitude of cameras, help buttons, intercom, door locks and motion detectors. As for materials, the wiring is mostly aluminum and it is important to note that all emergency branches are fed through mineral insulated cable.

The service entrance is fed by 8 sets of 4#500 kcmil type XHHW wire when used outside or THWN on the interior. To service panelboards, the same wiring shall be used (THHN, THWN or XHHW). The feeder cables are designated to be aluminum alloy of type XHHW-2. There are also two types of cables used. The first is MC Cable with copper conductors of type THHN insulation. Furthermore, both aluminum and copper conductors are used. The other cable is a First Rated mineral insulated cable to NFPA 70 standards with a two hour fire rating. The emergency system has three branches, two of which feed “standby” and “emergency” branches that supply power to life safety loads and mechanical equipment.

Short Circuit

A protective device coordination study was used to determine a short circuit analysis for one path through the distribution system. Using the one-line diagram, the path chosen for examination is that of panelboard L4NBA. This includes the cable from the Utility Transformer to the Main Switchboard (MSB) and then the cable from the Main Switchboard to panelboard L4NBA. Below is a diagram of the path and an “X” denoting where each fault current was found. For the tables needed to solve these equations, please see the references section of this thesis for the Cooper Bussman Short Circuit Calculation paper.



Below is a summary of the equations used and steps taken for the faults and a calculation table:

Step 1 – Determine the 3ø transformer’s full load amps………………………………………$I_{FLA} = \frac{kVA\ x\ 1000}{E_{L-L}\ x\ \sqrt{3}}$

Step 2 – Find the transformer multiplier (Table 1 ref)…………………………………………………$M = \frac{100}{*\%Z_{xfmr}}$

Step 3 – Determine the transformer let-through short-circuit current……………………………………..$Table\ 1$

Step 4 – Calculating the “f” factor………………………………………………………………………$f = \frac{\sqrt{3}\ x\ L\ x\ I_{3\emptyset}}{C\ x\ n\ x\ E_{L-L}}$

Step 5 – Calculating the “M” multiplier………………………………………………………………………$M = \frac{1}{1+f}$

Step 6 – Calculate the available short circuit……………………………………………………$I_{sc-RMS} = I_{sc} x\ M$

Table 36

Fault Point	Panel	kVA	E (Volts)	L (ft)	Wire/Conduit		'C' Value	Step 1	Step 2		Step 3	Step 4	Step 5	Step 6
					Sets	Size		I_{FLA}	%Z	Multiplier	ISC	f	M	ISC
1	MSB	2000	480	50	8	4 #500 KCMIL	22185	2405.63	4.00	25.00	60140.65	0.06114	0.94238	**56675.64**
2	L4NBA	2000	480	20	1	4 #1 AWG	7293	-	-	-	56675.64	0.56084	0.64068	**36310.97**

Both the Main Switchboard (MSB) and the Panelboard L4NBA have AIC ratings of 65K, these values exceed the above short circuit calculations and therefore, the design is sufficient.

Branch Circuit Redesign

Within the four spaces of scope for this design, branch circuits have been redesigned to ensure the accuracy and efficiency of the feeders and panelboards. The resulting lighting loads were divided between existing circuits on existing local panelboards. These branch circuits were then resized.

Affected Panel Boards

The new lighting affects three panelboards and one dimming panelboard within the building. The affected panels are listed below in Table 37. Also below in Figure 56, the panelboards are highlighted in red and the corresponding upstream panel and distribution boards they will affect are highlighted in green. The upstream panelboard (theatre lighting) has been adjusted below but, to conserve space, none of the upstream distribution board changes are shown. There is ample space on each distribution board and feeder to account for the adjusted loads of the new design. In a real world example for this scenario with no large changes, the panelboard loading would be updated on the distribution board based on the wattage found.

If you are not viewing this document in an electronic medium and wish to see a larger version of the one-line diagram for reference, please see Appendix D. If you wish to see the wiring diagram, please see Appendix C.

Table 37 - Affected Panelboards broken down by Redesigned Spaces

Space	Panel Type	Voltage	Panelboard	Up-Stream PB
Wellness Plaza	Normal	480Y/277V	L4NBA	-
	Emergency		L4EBA	D4EBA
Wellness Lobby	Normal	208Y/120V	L4NBA	-
	Emergency		L4EBA	D4EBA
Dance Rehearsal	Normal	480Y/277V	L4NBA	-
	Emergency		L4EBA	D4EBA
Theatre	Normal	208Y/120V	DIM3	-
	Emergency		ELCP1	P2E3A, L4E3A, D4EPA

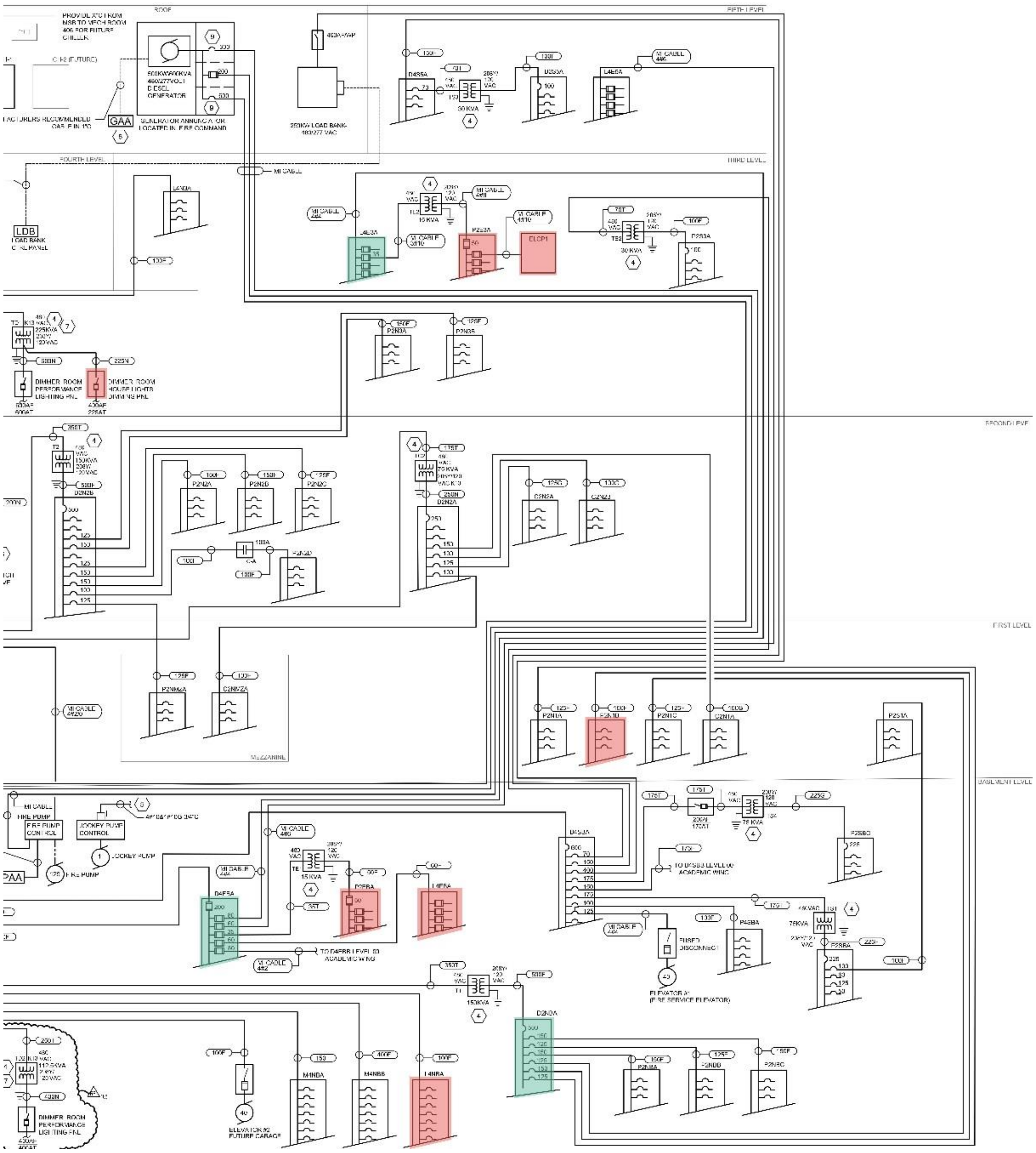


Figure 56 - Affected Panelboards (red) and upstream Panel and Distribution Boards (green)

Non-Theatrical Spaces

Existing Panelboards

The following panelboard schedules (L4NBA, L4EBA) show the existing lighting design and electrical systems thereof. L4NBA is a normal power panelboard while L4EBA is an emergency power panelboard. The circuits that are highlighted in green represent the spaces which will be altered based on the new lighting designs.

It is important to note that the panelboard circuits are not labeled room by room. The circuits within a space are fed into a control panel in surrounding storage closets and then fed back into the panelboards for power. For example the circuits labeled Dance/Drama Storage 133 represents circuits from the Dance Rehearsal Room, the Drama Rehearsal Room and the surrounding areas of the spaces. Because of this, the load was calculated using information gathered on the existing lighting system in past technical reports, subtracted from the circuit's total and then the new load was added back into the circuit.

The existing circuiting is not equally distributed across the three phases on some of the panelboards. This could not be addressed by redistributing the circuits within the panelboard schedule, but this change was not completed at this time as this would change the remainder of the buildings circuiting which is beyond the scope of this project. In reality, a balanced total wattage (about 10% variation) across phases would be desired.

PANELBOARD: L4NBA

BUS SIZE: 125 AMPS — MAIN: ( ) MCB (X) MLO — SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 480 Y/277V 3PH, 4W — MCB AMPS:
NEUTRAL: (X) 100% ( ) 200% ( ) NONE — LOCATION: MAIN ELEC RM 082
ISOLATED GND BUS: ( ) YES (X) NO — MOUNTING: SURFACE
SHORT CIR CURRENT RATING: 65 K — TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
PARKING RMP - RM 144A STORAGE	3320			20	1	2	20	1408			LTG FAN ROOM 086
LTG STORAGE RM (FUTURE)		612		20	3	4	20		998		LTG STAIR 4 ST-4
LTG PARKING ZONE #1 #2 (FUTURE)			1120	20	5	6	20			896	LTG ELEV LOBBY 002
LTG PARKING ZONE #3 (FUTURE)	2100			20	7	8	20	128			LTG ELEV LOBBY 002
LTG VESTIBULE PARKING (FUTURE)		140		20	9	10	20		992		LTG STORAGE 074
LTG MAIN EMER POWER ROOM 080			815	20	11	12	20			1664	LTG MECH 092
LTG FUTURE PARKING LOBBY 069	324			20	13	14	20	1830			LTG COSTUME STORAGE 008
LTG HS OFFICE 124		1054		20	15	16	20		1608		LTG LOWER SCHOOL LOCKER 128
LTG W&F STORAGE 122A			2367	20	17	18	20			500	LTG VESTIBULE 146
LTG P.E. STORE 133	1753			20	19	20	20	2468			LTG P.E. OFFICE 124
LTG EXTERIOR PLAN SOUTH		104		20	21	22	20		384		LTG STAIR 1 ST-1
LTG EXTERIOR PLAN EAST			198	20	23	24	20			2380	LTG DANCE/DRAMA STOR 114A
LTG VESTIBULE 118A EXTERIOR	140			20	25	26	20	2358			LTG ENTRY LOBBY 104
LTG VESTIBULE 102 EXTERIOR		40		20	27	28	20		2838		LTG DANCE/DRAMA STOR 114A
LTG MUSIC STORAGE 110B			1704	20	29	30	20			1139	LTG MUSIC AV ROOM 110D
LTG EXTERIOR PLAN WEST	60			20	31	32	20	80			LTG EXTERIOR PLAN WEST
LTG EXTERIOR PLAN WEST		200		20	33	34	20		516		LTG CORRIDOR 022
SPARE				20	35	36	20				SPARE
SPARE				20	37	38	20				SPARE
SPARE				20	39	40	20				SPARE
SPARE				20	41	42	20				SPARE
SUBTOTAL	**7697**	**2150**	**6204**					**8272**	**7336**	**6579**	**SUBTOTAL**

NOTES:

TOTAL WATTS L1:	15969
TOTAL WATTS L2:	9486
TOTAL WATTS L3:	12783
TOTAL WATTS:	**38238**
TOTAL AMPS @ 100%:	46
TOTAL AMPS @ 125%:	57

TOTAL PANEL RECPT LOAD = 0 WATTS

PANELBOARD: L4EBA

BUS SIZE: 125 AMPS | MAIN: ( ) MCB (X) MLO | SERVICE RATED: ( ) YES (X) NO

VOLTAGE: 480 Y/277V 3PH, 4W | MCB AMPS:

NEUTRAL: (X) 100% ( ) 200% ( ) NONE | LOCATION: MAIN EMER RM 080

ISOLATED GND BUS: ( ) YES (X) NO | MOUNTING: SURFACE

SHORT CIR CURRENT RATING: 25 K | TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
PARKING RMP - RM 144A STORAGE	1260			20	1	2	20	1687			LTG CENTRAL PLANT 016
LTG PARKING ZONE #1 #2 (FUTURE)		1140		20	3	4	20		916		LTG ELEV LOBBY 002
LTG PARKING ZONE #3 (FUTURE)			700	20	5	6	20			998	LTG STAIR 4 ST-4
LTG CENTRAL PLANT 016	448			20	7	8	20	516			LTG STAIR 3 ST-3
LTG LOWER SCHOOL LOCKER 128		932		20	9	10	20		228		LTG CARDIO/FITNESS 122
LTG EGRESS CORRIDOR 137			568	20	11	12	20			328	LTG STAIR 1 ST-1
LTG EXTERIOR PLAN SOUTH	128			20	13	14	20	1152			LTG P.E. OFFICE 124
LTG P.E. STOR 133		1145		20	15	16	20		168		LTG EXTERIOR PLAN EAST
LTG DANCE/DRAMA STOR 114A			2756	20	17	18	20			120	LTG VESTIBULE 118A EXTERIOR
LTG ENTRY LOBBY 104	1161			20	19	20	20	504			LTG ARTS LOBBY 112
LTG MUSIC STORAGE 110B		452		20	21	22	20		40		LTG VESTIBULE 102 EXTERIOR
LTG EXTERIOR PLAN WEST			40	20	23	24	20			3338	LTG WELL STOR 170A
LTG WORKROOM/KITCHEN 236	1152			20	25	26	20	180			LTG OPEN (FUTURE PUMP RM) 015
SPARE				20	27	28	20				SPARE
SPARE				20	29	30	20				SPARE
SPARE				20	31	32	20				SPARE
SPARE				20	33	34	20				SPARE
SPARE				20	35	36	20				SPARE
SPARE				20	37	38	20				SPARE
SPARE				20	39	40	20				SPARE
SPARE				20	41	42	20				SPARE
SUBTOTAL	**4149**	**3669**	**4064**					**4039**	**1352**	**4784**	**SUBTOTAL**

NOTES:

TOTAL WATTS L1:	8188
TOTAL WATTS L2:	5021
TOTAL WATTS L3:	8848
TOTAL WATTS:	**22057**
TOTAL AMPS @ 100%:	27
TOTAL AMPS @ 125%:	33

TOTAL PANEL RECPT LOAD = 0 WATTS

Updated Panelboards

The following updated versions of the panelboards L4NBA and L4EBA are based on the new lighting design electrical systems and past circuiting preferences. Also shown is calculation table (Table 38) of the new designs for the Entrance Plaza, Wellness Lobby and Corridor and Dance Rehearsal Space. Emergency Fixtures are highlighted in gray while normal power has no highlighted color. The spaces are lit entirely of LED's and therefore a power factor of 1.0 was assumed for all wattages so the total real power (watts) is equal to the total apparent power (volt-amps). All lighting circuits utilize a 20 amp circuit breaker, so each lighting circuit can have a maximum of 16 amps to account for continuous load. A calculation of allowable volt-amps per circuit is as follows:

$$VA_{max} = 277V * 16A = 4432\ VA$$

Table 38 - Fixture Calculations for Revised Panelboards

Space	Panel Type	Type	Quantity	W/Fixture	Total Wattage (W)	Total VA	Circuit
Wellness Plaza	Emergency	L2A	2	16	32	32	L4EBA-18
		L2A	2	16	32	32	L4EBA-22
		L2B	5	21	105	105	L4EBA-23
		L4	2	90	180	180	
	Normal	L1	100	1.48	148	148	L4NBA-33
		L3	5	8	40	40	L4NBA-31
Wellness Lobby	Emergency	L5	2	8	16	16	L4EBA-15
	Normal	L7	4	32	128	128	L4NBA-19
		L8	8	1.4	11.2	11.2	
Wellness Corridor	Emergency	L5	15	8	120	120	L4EBA-15
	Normal	L6	4	23	92	92	L4NBA-19
		L7	25	32	800	800	
		L8	176	1.4	246	246	
Dance Rehearsal	Emergency	L10	55	8	440	440	L4EBA-17
	Normal	L9	22	8.5	187	187	L4NBA-28
		L10	100	8	800	800	L4NBA-24

PANELBOARD: L4NBA (REVISED)

BUS SIZE: 125 AMPS | MAIN: ( ) MCB (X) MLO | SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 480 Y/277V 3PH, 4W | MCB AMPS:
NEUTRAL: (X) 100% ( ) 200% ( ) NONE | LOCATION: MAIN ELEC RM 082
ISOLATED GND BUS: ( ) YES (X) NO | MOUNTING: SURFACE
SHORT CIR CURRENT RATING: 65 K | TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
PARKING RMP - RM 144A STORAGE	3320			20	1	2	20	1408			LTG FAN ROOM 086
LTG STORAGE RM (FUTURE)		612		20	3	4	20		998		LTG STAIR 4 ST-4
LTG PARKING ZONE #1 #2 (FUTURE)			1120	20	5	6	20			896	LTG ELEV LOBBY 002
LTG PARKING ZONE #3 (FUTURE)	2100			20	7	8	20	128			LTG ELEV LOBBY 002
LTG VESTIBULE PARKING (FUTURE)		140		20	9	10	20		992		LTG STORAGE 074
LTG MAIN EMER POWER ROOM 080			815	20	11	12	20			1664	LTG MECH 092
LTG FUTURE PARKING LOBBY 069	324			20	13	14	20	1830			LTG COSTUME STORAGE 008
LTG HS OFFICE 124		1054		20	15	16	20		1608		LTG LOWER SCHOOL LOCKER 128
LTG W&F STORAGE 122A			2367	20	17	18	20			500	LTG VESTIBULE 146
LTG P.E. STORE 133	1393			20	19	20	20	2468			LTG P.E. OFFICE 124
LTG EXTERIOR PLAN SOUTH		104		20	21	22	20		384		LTG STAIR 1 ST-1
LTG EXTERIOR PLAN EAST			198	20	23	24	20			1674	LTG DANCE/DRAMA STOR 114A
LTG VESTIBULE 118A EXTERIOR	140			20	25	26	20	2358			LTG ENTRY LOBBY 104
LTG VESTIBULE 102 EXTERIOR		40		20	27	28	20		1905		LTG DANCE/DRAMA STOR 114A
LTG MUSIC STORAGE 110B			1704	20	29	30	20			1139	LTG MUSIC AV ROOM 110D
LTG EXTERIOR PLAN WEST	40			20	31	32	20	0			SPARE
LTG EXTERIOR PLAN WEST		148		20	33	34	20		516		LTG CORRIDOR 022
SPARE				20	35	36	20				SPARE
SPARE				20	37	38	20				SPARE
SPARE				20	39	40	20				SPARE
SPARE				20	41	42	20				SPARE
SUBTOTAL	**7317**	**2098**	**6204**					**8192**	**6403**	**5873**	**SUBTOTAL**

NOTES:	TOTAL WATTS L1:	15509
	TOTAL WATTS L2:	8501
	TOTAL WATTS L3:	12077
	TOTAL WATTS:	**36087**
	TOTAL AMPS @ 100%:	43
TOTAL PANEL RECPT LOAD = 0 WATTS	**TOTAL AMPS @ 125%:**	54

PANELBOARD: L4EBA (REVISED)

BUS SIZE: 125 AMPS | MAIN: ( ) MCB (X) MLO | SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 480 Y/277V 3PH, 4W | MCB AMPS:
NEUTRAL: (X) 100% ( ) 200% ( ) NONE | LOCATION: MAIN EMER RM 080
ISOLATED GND BUS: ( ) YES (X) NO | MOUNTING: SURFACE
SHORT CIR CURRENT RATING: 25 K | TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
PARKING RMP - RM 144A STORAGE	1260			20	1	2	20	1687			LTG CENTRAL PLANT 016
LTG PARKING ZONE #1 #2 (FUTURE)		1140		20	3	4	20		916		LTG ELEV LOBBY 002
LTG PARKING ZONE #3 (FUTURE)			700	20	5	6	20			998	LTG STAIR 4 ST-4
LTG CENTRAL PLANT 016	448			20	7	8	20	516			LTG STAIR 3 ST-3
LTG LOWER SCHOOL LOCKER 128		932		20	9	10	20		228		LTG CARDIO/FITNESS 122
LTG EGRESS CORRIDOR 137			568	20	11	12	20			328	LTG STAIR 1 ST-1
LTG EXTERIOR PLAN SOUTH	128			20	13	14	20	1152			LTG P.E. OFFICE 124
LTG P.E. STOR 133		853		20	15	16	20		168		LTG EXTERIOR PLAN EAST
LTG DANCE/DRAMA STOR 114A			2509	20	17	18	20			32	LTG VESTIBULE 118A EXTERIOR
LTG ENTRY LOBBY 104	1161			20	19	20	20	504			LTG ARTS LOBBY 112
LTG MUSIC STORAGE 110B		452		20	21	22	20		32		LTG VESTIBULE 102 EXTERIOR
LTG EXTERIOR PLAN WEST			285	20	23	24	20			3338	LTG WELL STOR 170A
LTG WORKROOM/KITCHEN 236	1152			20	25	26	20	180			LTG OPEN (FUTURE PUMP RM) 015
SPARE				20	27	28	20				SPARE
SPARE				20	29	30	20				SPARE
SPARE				20	31	32	20				SPARE
SPARE				20	33	34	20				SPARE
SPARE				20	35	36	20				SPARE
SPARE				20	37	38	20				SPARE
SPARE				20	39	40	20				SPARE
SPARE				20	41	42	20				SPARE
SUBTOTAL	**4149**	**3377**	**4062**					**4039**	**1344**	**4696**	**SUBTOTAL**

NOTES:		
	TOTAL WATTS L1:	8188
	TOTAL WATTS L2:	4721
	TOTAL WATTS L3:	8757.5
	TOTAL WATTS:	**21666.5**
	TOTAL AMPS @ 100%:	26
TOTAL PANEL RECPT LOAD = 0 WATTS	**TOTAL AMPS @ 125%:**	33

Theatrical Space

Existing Panelboards and Dimming Panels

The following dimming panel schedules (DIM3, ELCP1) and panelboard (P2E3A) show the existing lighting design and electrical systems thereof. DIM3 is a normal power dimming panel that acts a panelboard for distribution to the load sometimes via transformers. It is located within the theatre space and feeds back to the main switchboard. On the other hand, ELCP1 is an emergency power dimming panel that feeds back through the emergency system via panelboard P2E3A. The circuits that are highlighted in green represent the spaces which will be altered based on the new lighting designs. Circuits highlighted in gray are no longer in the system and have been removed in the updated boards.

LIGHTING CONTROL PANEL : ELCP1 (MAIN C.B PANEL)

CIRCUIT #	DESCRIPTION / FIXTURE TYPE(S)	PANEL	LOAD TYPE	ON/OFF OR DIMMING	SWITCHING ZONE	DAY LIGHTING CONTROL	VOLTAGE/AMPS	LOAD (WATTS)
1	T13/T14 HOUSE CIRCULATION - F14A		L	DIMMING	1	NO	120/20	350
2	T8 MAIN FLOOR WEST - F14A		INC	DIMMING	2	NO	120/20	350
3	T89/T10 MAIN FLOOR NORTH F14A		INC	DIMMING	3	NO	120/20	550
4	T4 MAIN FLOOR EAST - F14A		INC	DIMMING	4	NO	120/20	350
5	STAIR 7 - F23		L	DIMMING	5	NO	120/20	36
6	PROSCENIUM PANELS - F34		INC	DIMMING	6	NO	120/20	747
7	HOUSE AMBIENT - F25C		INC	DIMMING	7	NO	120/20	747
8	BALCONY - F25B		INC	DIMMING	8	NO	120/20	600
9	BALCONY AISLE - F25A		INC	DIMMING	9	NO	120/20	400
10	BALCONY SLL - T10		L	DIMMING	10	NO	120/20	27
11	FLOOR LEVEL HANDRAIL LIGHTS - F45		LED DC	DIMMING	11	NO	120/20	180
12	BALCONY HANDRAIL LIGHTS - F45		LED DC	DIMMING	12	NO	120/20	240
13	(SPARE)							
14	(SPARE)							
15	(SPARE)							
16	(SPARE)							

PANELBOARD: P2E3A

BUS SIZE: 100 AMPS	MAIN: (X) MF ( ) MLO	SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 208 Y/120V 3PH, 4W	MCB AMPS: 50A FUSE	
NEUTRAL: (X) 100% ( ) 200% ( ) NONE	LOCATION: ELEC ROOM 304A	
ISOLATED GND BUS: ( ) YES (X) NO	MOUNTING: SURFACE	
SHORT CIR CURRENT RATING: 10 K	TVSS: ( ) YES (X) NO	

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
FAS EMERGENCY ELECT RM 304A	500							384			LTG STAGE SLL 278
LTG CATWALK		512							576		LTG FLY TOWER
LTG CATWALK			504							256	LTG FLY TOWER
SPARE											SPARE
SPARE											SPARE
SPARE											SPARE
ELCP1 DIMMER ROOM	1386										SPARE
		1386									SPARE
			1386								SPARE
SUBTOTAL	**1886**	**1898**	**1890**					**384**	**576**	**256**	**SUBTOTAL**

NOTES:

TOTAL WATTS L1:	2270
TOTAL WATTS L2:	2474
TOTAL WATTS L3:	2146
TOTAL WATTS:	**6890**
TOTAL AMPS @ 100%:	19
TOTAL AMPS @ 125%:	24

TOTAL PANEL RECPT LOAD = 0 WATTS

LIGHTING CONTROL PANEL : DIM 3 (MAIN C.B PANEL)								
CIRCUIT #	DESCRIPTION / FIXTURE TYPE(S)	PANEL	LOAD TYPE	ON/OFF OR DIMMING	SWITCHING ZONE	DAY LIGHTING CONTROL	VOLTAGE/AMPS	LOAD (WATTS)
1	T15/T16 CIRCULATION - F14A	-	INC	DIMMING	1	NO	120/20	400
2	MAIN FLOOR PERIMETER - F21	-	LED DMX	DIMMING	2	NO	120/20	2176
3	ASSEMBLY/ORCHESTRA STEP LIGHTS - F23	-	LED DC	DIMMING	3	NO	120/20	60
4	ASSEMBLY/ORCHESTRA STEP LIGHTS - F24	-	LED DC	DIMMING	4	NO	120/20	54
5	(OPEN)	-		DIMMING	5	NO	120/20	0
6	T1/T2 MAIN FLOOR WEST -F14A	-	INC	DIMMING	6	NO	120/20	750
7	T5/T6 MAIN FLOOR WEST - F14A	-	INC	DIMMING	7	NO	120/20	750
8	T11/T12 MAIN FLOOR NORTH - F14A	-	INC	DIMMING	8	NO	120/20	550
9	PROSCENIUM ACCENT - F21	-	LED DMX	DIMMING	9	NO	120/20	608
10	MAIN ACCENT - F24	-	INC	DIMMING	10	NO	120/20	747
11	BALCONY - F25B	-	INC	DIMMING	11	NO	120/20	550
12	BALCONY AISLE - F25A	-	INC	DIMMING	12	NO	120/20	500
13	BALCONY SLL - F10	-	LED 0-10V	DIMMING	13	NO	120/20	27
14	(OPEN)	-		DIMMING	14	NO	120/20	0
15	BALCONY STEP LIGHTS - F23	-	LED DC	DIMMING	15	NO	120/20	80
16	BALCONY PERIMETER EAST - F21	-	LED DMX	DIMMING	16	NO	120/20	652
17	BALCONY PERIMETER WEST - F21	-	LED DMX	DIMMING	17	NO	120/20	652
18	BALCONY PERIMETER EAST - F21A	-	LED DMX	DIMMING	18	NO	120/20	652
19	BALCONY PERIMETER WEST - F21A		LED DMX	DIMMING	19	NO	120/20	652
20	(SPARE)							
21	(SPARE)							
22	(SPARE)							
23	(SPARE)							
24	(SPARE)							
25	(SPARE)							
26	(SPARE)							
27	(SPARE)							
28	(SPARE)							
29	(SPARE)							
30	(SPARE)							
31	(SPARE)							
32	(SPARE)							
33	(SPARE)							
34	(SPARE)							
35	(SPARE)							
36	(SPARE)							
37	(SPARE)							
38	(SPARE)							
39	(SPARE)							
40	(SPARE)							
41	(SPARE)							
42	(SPARE)							
43	(SPARE)							
44	(SPARE)							
45	(SPARE)							
46	(SPARE)							
47	(SPARE)							
48	(SPARE)							

Updated Panelboards and Dimming Panels

The following updated versions of the dimming panel schedules (DIM3, ELCP1) and panelboard (P2E3A) are based on the new lighting design electrical systems and past circuiting preferences. The spaces are lit entirely of LED's and therefore a power factor of 1.0 was assumed for all wattages so the total real power (watts) is equal to the total apparent power (volt-amps). Adjustments were also made based on the emergency lighting. For example, the step lights in the existing design were not located in emergency as there were other forms of emergency lighting in the space to cover the stairways, in the new design the step lights are located on emergency power and therefore have been moved to ELCP1. All lighting circuits utilize a 20 amp circuit breaker, so each lighting circuit can have a maximum of 16 amps to account for continuous load. A calculation of allowable volt-amps per circuit is as follows:

$$VA_{max} = 120V * 16A = 1920\ VA$$

LIGHTING CONTROL PANEL : ELCP1 (MAIN C.B PANEL) - REVISED								
CIRCUIT #	DESCRIPTION / FIXTURE TYPE(S)	PANEL	LOAD TYPE	ON/OFF OR DIMMING	SWITCHING ZONE	DAY LIGHTING CONTROL	VOLTAGE/AMPS	LOAD (WATTS)
1	T13/T14 HOUSE CIRCULATION - F14A	P2E3A	INC	DIMMING	1	NO	120/20	350
2	T8 MAIN FLOOR WEST - L14	P2E3A	LED	DIMMING	2	NO	120/20	40
3	T9 MAIN FLOOR NORTH L14	P2E3A	LED	DIMMING	3	NO	120/20	80
4	T4 MAIN FLOOR EAST - L14	P2E3A	LED	DIMMING	4	NO	120/20	104
5	STAIR 7 - L12	P2E3A	LED	DIMMING	5	NO	120/20	108
6	BALCONY STEP LIGHTS - L12	-	LED	DIMMING	6	NO	120/20	156
7	HOUSE AMBIENT - L16	P2E3A	LED	DIMMING	7	NO	120/20	396
8	BALCONY - L16	P2E3A	LED	DIMMING	8	NO	120/20	396
9	BALCONY AISLE - L16	P2E3A	LED	DIMMING	9	NO	120/20	
10	ASSEMBLY/ORCHESTRA STEP LIGHTS - L12	-	LED	DIMMING	10	NO	120/20	120
11	RISER ORCHESTRA STEP LIGHTS - L12	-	LED	DIMMING	11	NO	120/20	120
12	(SPARE)							
13	(SPARE)							
14	(SPARE)							
15	(SPARE)							
16	(SPARE)							

PANELBOARD: P2E3A (REVISED)

BUS SIZE: 100 AMPS — MAIN: (X) MF ( ) MLO — SERVICE RATED: ( ) YES (X) NO

VOLTAGE: 208 Y/120V 3PH, 4W — MCB AMPS: 50A FUSE

NEUTRAL: (X) 100% ( ) 200% ( ) NONE — LOCATION: ELEC ROOM 304A

ISOLATED GND BUS: ( ) YES (X) NO — MOUNTING: SURFACE

SHORT CIR CURRENT RATING: 10 K — TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
FAS EMERGENCY ELECT RM 304A	500							384			LTG STAGE SLL 278
LTG CATWALK		512							576		LTG FLY TOWER
LTG CATWALK			504							256	LTG FLY TOWER
SPARE											SPARE
SPARE											SPARE
SPARE											SPARE
ELCP1 DIMMER ROOM	624										SPARE
		624									SPARE
			624								SPARE
SUBTOTAL	**1124**	**1136**	**1128**					**384**	**576**	**256**	**SUBTOTAL**
NOTES:				TOTAL WATTS L1:				1508			
				TOTAL WATTS L2:				1712			
				TOTAL WATTS L3:				1384			
				TOTAL WATTS:				**4604**			
				TOTAL AMPS @ 100%:				13			
TOTAL PANEL RECPT LOAD =			0 WATTS	**TOTAL AMPS @ 125%:**				16			

LIGHTING CONTROL PANEL : DIM 3 (MAIN C.B PANEL) - REVISED								
CIRCUIT #	DESCRIPTION / FIXTURE TYPE(S)	PANEL	LOAD TYPE	ON/OFF OR DIMMING	SWITCHING ZONE	DAY LIGHTING CONTROL	VOLTAGE/AMPS	LOAD (WATTS)
1	T15/T16 CIRCULATION - F14A	-	INC	DIMMING	1	NO	120/20	400
2	MAIN FLOOR PERIMETER - L11	-	LED	DIMMING	2	NO	120/20	89
3	UNDERSIDE OF CATWALK - L12	-	LED	DIMMING	3	NO	120/20	450
4	(OPEN)							
5	(OPEN)							
6	T1/T2 MAIN FLOOR EAST - L14, L15	-	LED	DIMMING	6	NO	120/20	210
7	T5/T6 MAIN FLOOR WEST - L14, L15	-	LED	DIMMING	7	NO	120/20	334
8	T11/T12 MAIN FLOOR NORTH - L14	-	LED	DIMMING	8	NO	120/20	80
9	PROSCENIUM ACCENT - L11	-	LED	DIMMING	9	NO	120/20	89
10	HOUSE AMBIENT -L16	-	LED	DIMMING	10	NO	120/20	792
11	BALCONY - L16	-	LED	DIMMING	11	NO	120/20	704
12	BALCONY AISLE - L16	-	LED	DIMMING	12	NO	120/20	528
13	(SPARE)							
14	(SPARE)							
15	(SPARE)							
16	(SPARE)							
17	(SPARE)							
18	(SPARE)							
19	(SPARE)							
20	(SPARE)							
21	(SPARE)							
22	(SPARE)							
23	(SPARE)							
24	(SPARE)							
25	(SPARE)							
26	(SPARE)							
27	(SPARE)							
28	(SPARE)							
29	(SPARE)							
30	(SPARE)							
31	(SPARE)							
32	(SPARE)							
33	(SPARE)							
34	(SPARE)							
35	(SPARE)							
36	(SPARE)							
37	(SPARE)							
38	(SPARE)							
39	(SPARE)							
40	(SPARE)							
41	(SPARE)							
42	(SPARE)							
43	(SPARE)							
44	(SPARE)							
45	(SPARE)							
46	(SPARE)							
47	(SPARE)							
48	(SPARE)							

Resized Feeder Calculations

Since all lighting loads are kept well under a 16A per circuit maximum, all branch circuits have 2 #12+#12G in 3/4" conduit. The new lighting design does not change the loads on any of the panelboards greatly enough to impact this sizing. In practice, the sizing of a wire does not typically go below a #12 and therefore the feeders are sized properly as is with no changes to be made. This decision is also based on NEC Table 220.12 General Lighting Loads by Occupancy. The new solution does not exceed the unit loads of the feeders, therefore the feeders are sized properly and can be seen below in Table 39.

Panelboard	Schedule Name	Wire Size	Description
L4EBA	60F	4 #4 & 1 #10G	Four (4) Wire Feeders with Equipment Ground - Copper
L4NBA	100F	4 #1 & 1 #8G	Four (4) Wire Feeders with Equipment Ground - Copper
ELCP1	-	MI 4 #10 Cable	-
DIM3	225N	3 #300, (2) #250N & 2 #4G	Four (4) Wire Feeders with Double Neutral, Isolated Ground and Equipment Ground - Copper
P2E3A	-	MI 4 #8 Cable	-

Table 39 - Feeder Sizes

Emergency Feeder Analysis: MI vs MC cable

Introduction

The emergency power system is an alternating current standby #2 diesel generator that operates on 480/277V 3PH, 4W. It is required that if the power fails, the generator must respond and supply power within 10 seconds of failure. The generator distributes power through three breakers down to a large amount of distribution and power boards and a fire pump. All emergency cables are either mineral insulated (MI) cables or MC cables. Two paths are created within the generator system to distribute output power: a “standby” line and an “emergency” line. Both lines hold loads for lighting and power, though the standby loads do not supply life safety loads due to code. The “standby” line holds much more loading, a total of 136 kVA, and is protected by circuit breakers. It also holds much of the technical equipment such as the elevator, load bank, exhaust fans, telecom lighting and receptacles, UPS unit, smoke dampers and access panel controls. The majority of cable is the MC Cable except in situations where the units are required to have a fire-rated protection such as the fire pump, UPS unit, etc. The “emergency” line holds much less loading, about 45 kVA, and is protected by fuses. This line holds mostly lighting and controls for life safety in the mechanical, IT, theater and electrical spaces.

During this electrical analysis, it was determined that a large amount of emergency electrical panels uses mineral insulated cable where it is not required by law or standards. At first, it was thought that a possible redesign of the “standby” and “emergency” systems could be done to limit this notion but upon further review it was determined that the emergency system also powers the older wings of the buildings which is out of the scope of this project and therefore the two paths were left as is.

Instead, another means to produce savings was chosen to be studied. A cost and electrical analysis was performed to compare the possible savings by eliminating unnecessary mineral insulated cable. The focus of this analysis was the “Emergency” system because it was determined earlier that the only mineral insulated cable used in the “Standby” system was required by fire protection standards. The one-line diagram was addressed to find what panelboards were fed by MI cable as well as its feeder path and size. The one-line diagram can be seen in further detail in Appendix D. The panels found to be fed by mineral insulated cable are panelboards L4E5A, P2E3A, L4E3A and dimming panel ELCP1. These panelboards and dimming panels are loaded as follows:

PANELBOARD: P2E3A (REVISED)

BUS SIZE: 100 AMPS — MAIN: (X) MF ( ) MLO — SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 208 Y/120V 3PH, 4W — MCB AMPS: 50A FUSE
NEUTRAL: (X) 100% ( ) 200% ( ) NONE — LOCATION: ELEC ROOM 304A
ISOLATED GND BUS: ( ) YES (X) NO — MOUNTING: SURFACE
SHORT CIR CURRENT RATING: 10 K — TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			CKT BKR AMPS	POLES		CKT BKR AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
FAS EMERGENCY ELECT RM 304A	500							384			LTG STAGE SLL 278
LTG CATWALK		512							576		LTG FLY TOWER
LTG CATWALK			504							256	LTG FLY TOWER
SPARE											SPARE
SPARE											SPARE
SPARE											SPARE
	624										SPARE
ELCP1 DIMMER ROOM		624									SPARE
			624								SPARE
SUBTOTAL	**1124**	**1136**	**1128**					**384**	**576**	**256**	**SUBTOTAL**

NOTES:

TOTAL WATTS L1:	1508
TOTAL WATTS L2:	1712
TOTAL WATTS L3:	1384
TOTAL WATTS:	**4604**
TOTAL AMPS @ 100%:	13
TOTAL AMPS @ 125%:	16

TOTAL PANEL RECPT LOAD = 0 WATTS

PANELBOARD: L4E3A

BUS SIZE: 125 AMPS — MAIN: ( ) MF (X) MLO — SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 480Y/277V 3PH, 4W — MCB AMPS:
NEUTRAL: (X) 100% ( ) 200% ( ) NONE — LOCATION: ELEC ROOM 304A
ISOLATED GND BUS: ( ) YES (X) NO — MOUNTING: SURFACE
SHORT CIR CURRENT RATING: 25 K — TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			FUSE AMPS	POLES		FUSE AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
	2270			35	1	2	20	1733			LTG 2 COURT GYM
PANEL P2E3A		2474		20	3	4	20		1733		LTG 2 COURT GYM
VIA TE2 15 kVA			2146	20	5	6	20			1733	LTG 2 COURT GYM
LTG MECHANICAL 406	456			20	7	8	20	1733			LTG 2 COURT GYM
SPARE				20	9	10	20				SPARE
SPARE				20	11	12	20				SPARE
SPARE				20	13	14	20				SPARE
SPARE				20	15	16	20				SPARE
SPARE				20	17	18	20				SPARE
SUBTOTAL	**2726**	**2474**	**2146**					**3466**	**1733**	**1733**	**SUBTOTAL**

NOTES:

TOTAL WATTS L1:	6192
TOTAL WATTS L2:	4207
TOTAL WATTS L3:	3879
TOTAL WATTS:	**14278**
TOTAL AMPS @ 100%:	40
TOTAL AMPS @ 125%:	50

TOTAL PANEL RECPT LOAD = 0 WATTS

PANELBOARD: L4E5A

BUS SIZE: 100 AMPS — MAIN: ( ) MF (X) MLO — SERVICE RATED: ( ) YES (X) NO
VOLTAGE: 208 Y/120V 3PH, 4W — MCB AMPS:
NEUTRAL: (X) 100% ( ) 200% ( ) NONE — LOCATION: EMERGENCY ELEC RM 53(
ISOLATED GND BUS: ( ) YES (X) NO — MOUNTING: SURFACE
SHORT CIR CURRENT RATING: 25 K — TVSS: ( ) YES (X) NO

DIRECTORY	WATTS OF LOAD			FUSE AMPS	POLES		FUSE AMPS	WATTS OF LOAD			DIRECTORY
	L1	L2	L3					L1	L2	L3	
LTG ELECTRICAL 304	310			20	1	2	20	360			LTG ELECTRICAL 239
LTG EXTERIOR PLAN WEST		180		20	3	4	20		860		LTG ELECTRICAL 286A
SPARE				20	5	6	20			1275	LTG FOH STORAGE 206B
SPARE				20	7	8	20	1194			LTG ALCOVE
SPARE				20	9	10	20		728		LTG IT 528
SPARE				20	11	12	20				SPARE
SPARE				20	13	14	20				SPARE
SPARE				20	15	16	20				SPARE
SPARE				20	17	18	20				SPARE
SUBTOTAL	**310**	**180**	**0**					**1554**	**1588**	**1275**	**SUBTOTAL**

NOTES:

TOTAL WATTS L1:	1864
TOTAL WATTS L2:	1768
TOTAL WATTS L3:	1275
TOTAL WATTS:	**4907**
TOTAL AMPS @ 100%:	14
TOTAL AMPS @ 125%:	17

TOTAL PANEL RECPT LOAD = 0 WATTS

LIGHTING CONTROL PANEL : ELCP1 (MAIN C.B PANEL) - REVISED								
CIRCUIT #	DESCRIPTION / FIXTURE TYPE(S)	PANEL	LOAD TYPE	ON/OFF OR DIMMING	SWITCHING ZONE	DAY LIGHTING CONTROL	VOLTAGE/AMPS	LOAD (WATTS)
1	T13/T14 HOUSE CIRCULATION - F14A	P2E3A	INC	DIMMING	1	NO	120/20	350
2	T8 MAIN FLOOR WEST - L14	P2E3A	LED	DIMMING	2	NO	120/20	40
3	T9 MAIN FLOOR NORTH L14	P2E3A	LED	DIMMING	3	NO	120/20	80
4	T4 MAIN FLOOR EAST - L14	P2E3A	LED	DIMMING	4	NO	120/20	104
5	STAIR 7 - L12	P2E3A	LED	DIMMING	5	NO	120/20	108
6	BALCONY STEP LIGHTS - L12	-	LED	DIMMING	6	NO	120/20	156
7	HOUSE AMBIENT - L16	P2E3A	LED	DIMMING	7	NO	120/20	396
8	BALCONY - L16	P2E3A	LED	DIMMING	8	NO	120/20	396
9	BALCONY AISLE - L16	P2E3A	LED	DIMMING	9	NO	120/20	
10	ASSEMBLY/ORCHESTRA STEP LIGHTS - L12	-	LED	DIMMING	10	NO	120/20	120
11	RISER ORCHESTRA STEP LIGHTS - L12	-	LED	DIMMING	11	NO	120/20	120
12	(SPARE)							
13	(SPARE)							
14	(SPARE)							
15	(SPARE)							
16	(SPARE)							

Calculations

As the panelboard schedules above show, these panels only feed power to lighting. In a fire emergency, the bulbs or fixtures would most likely be damaged beyond repair before the fire rating ran out on the MI cable. This means that the MI cable is unnecessary when being fed to these panelboards. Therefore, using the one-line diagram to find the feeder cable size and RS Means Electrical Cost 2015, an estimated cost per linear foot was found based on the existing system. This was then compared to a similar cost analysis if the MI cable was replaced by MC Cable of the same size. A table of this information can be seen below.

It is important to note, the actual total cost numerical data may not fully represent how much the system will actually cost at the end, the lengths show in the table were derived based measured distances within the plans from one panelboard to the other. This method is not exact. It was designed not to get a true total cost but rather an estimate for comparison of one cable to the other. This method is especially warranted in the case of panelboards L4E3A and P2E3A which spans several floors from its distribution panel D4EBA while ELCP1 spans only a few feet from its distribution panel.

MI Cable:

Table 40

Tag	From	To	Material	MI Cable		Cost($)/LF			Length** (LF)	Total Cost
				NO.	Size	Material	Labor	Total		
1	D4EBA	L4E5A	Copper	4	#6	2050	485	2535	94	$238,290.00
2	D4EBA	L4E3A	Copper	4	#6	2050	485	2535	104	$263,640.00
3	D4EBA	P2E3A	Copper	4	#8	1575	440	2015	12	$24,180.00
4	P2E3A	ELCP1	Copper	4	#10	1200	400	1600	3	$4,800.00
									Total	**$530,910.00**

**This approxmation was made from measuring distances within the electrical floor plans

MC Cable:

Table 41

Tag	From	To	Material	MC Cable		Cost($)/LF			Length** (LF)	Total Cost
				NO.	Size	Material	Labor	Total		
1	D4EBA	L4E5A	Alum/Alum Clad	4	#6	290	267	557	94	$52,358.00
2	D4EBA	L4E3A	Alum/Alum Clad	4	#6	290	267	557	104	$57,928.00
3	D4EBA	P2E3A	Copper/Alum Clad	4	#8	253	275	527	12	$6,324.00
4	P2E3A	ELCP1	Copper/Alum Clad	4	#10	215	282	497	3	$1,491.00
									Total	**$118,101.00**

**This approximation was made from measuring distances within the electrical floor plans

Conclusion

By replacing the mineral insulated cable with metal clad cable, the total cost in these branch circuits will be reduced by 78%. This is an enormous savings that can allow for a value engineered approach in the design and overall savings for the owner. As the feeders in question do not need to be fire-rated, per NFPA and NEC standards, this alternative is a more economical and effective solution.

Daylighting Depth

Daylighting Depth

Introduction

The Wellness Lobby and Corridor has a large amount of glare potential within the space. The entire length of the corridor is a glass curtain wall that allows sunlight penetration from the southwest. Along this curtain wall glass, there is a plan for movable furniture (tables and chairs) where students can congregate throughout the day to socialize or study. Since the desks are positioned along the glass façade, this could cause large problems especially in the late fall and throughout the winter when low angle sun can throw direct light into this space.

A daylighting study and consequent redesign was performed in the Wellness Lobby and Corridor to eliminate direct glare and promote a user-friendly variable daylighting design that adjusts to the individual occupant's needs and wants.

Overview

The building is located on the outskirts of Boston, specifically in the Brookline or "Boston Proper" neighborhood. The building or plan north is located thirty-eight degrees west of north. This means the façade along the plan west side of the building is fifty-two degrees west of south. Because of this, the sun will be on the glass façade of the Wellness Corridor for the entirety of the afternoon until sunset. The solar paths of both the summer and winter solstice are shown in Figure 57 overlaid onto a satellite image of the site from Google Maps. Boston on average has 210-220 days of sunshine throughout the year, the majority of those days occur during the warmer months of May to September.

Figure 57 - Solar paths during the course of a year for The Winsor School

The Wellness Corridor and Lobby is roughly 1,624 square feet in size, with the corridor itself being 13 feet 6 inches in width. The ceilings in both the lobby and the corridor are double height, occurring at a height of 17 feet above the finished floor. There is also a drywall alcove next to the glazing façade that reaches a height of 18 feet 3 inches. Opposite of the glazed curtain wall, there are cubbies for short term storage, combined with an interior glass curtain wall that allows for views into the Cardio and Fitness Room. This room is filled with cardio machinery and equipment.

The flooring in the lobby and corridor is a light terrazzo that blends into a slightly less specular recycled rubber athletic material. The interior glass removes the visual barrier between the fitness area and the corridor and allows a site line for an occupant. To help shade the fitness center from the sun there are thin wooden louvers to limit the sunlight coming from the exterior. The exterior glass façade incorporates three different types of glazing to limit sun exposure. Along the column are relatively evenly spaced columns and a horizontal HSS structural member extends the length of the hallway from column to column. A plan of the corridor/ lobby and a cross section of the corridor is shown in Figure 58 and Figure 59 respectively.

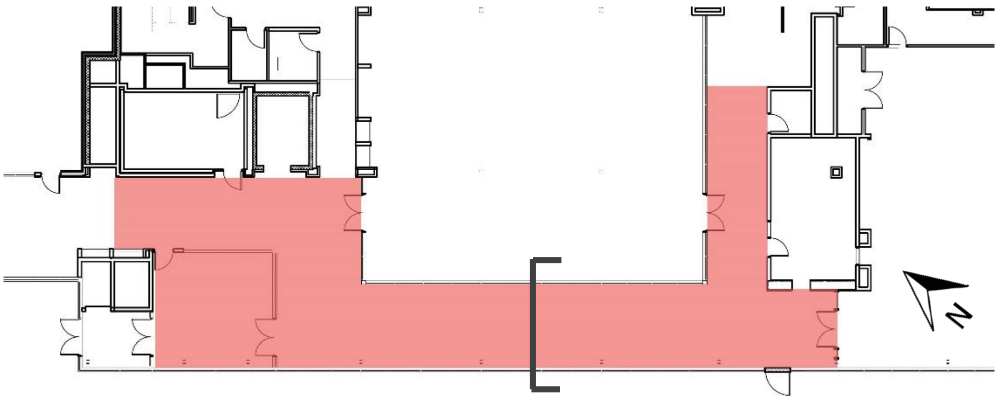


Figure 58 - Plan of the Wellness Lobby and Corridor

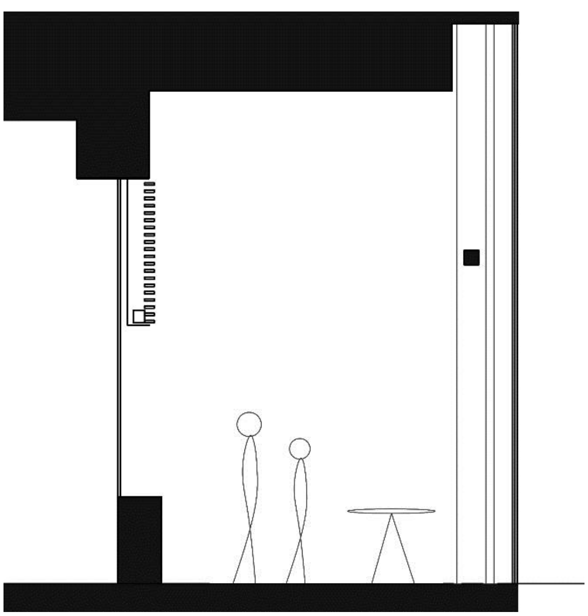


Figure 59 - Section of the Wellness Corridor

The existing exterior daylighting control is a combination of shades, louvers and fritted glass. There are two types of exterior glass on the southwestern façade. They are labeled XG6 and XG7. Type XG6 is located from the ground plane to a height of 11 feet, whereas type XG7 is located from 11 feet to the top of the interior ceiling at which point a metal panel begins and extends up the façade. There are also two shade systems with the same material for the two types of glass. One shade extends from the ceiling to 11 feet and then another shade from 11 feet to the ground, just like the glazing. The materials of the fritted glass and the shades are shown in Table 42.

Table 42 - Glazing and Shade Materials in the Wellness Lobby + Corridor

Material	Description	Color	Transmittance	Manufacturer	U-Value	
					Summer	Winter
XG6	**1-1/8" Clear Insulating** 3/8" clear PPG Solarban 70xl 1/2" air space 1/4" clear glass	Clear	64%	PPG ; Solarban 70xl	0.26	0.28
XG7	**1-1/8" Clear Insulating** 3/8" PPG Solarban 70xl with 40% ceramic dot frit pattern 1/2" air space 1/4" clear glass	Warm Grey Frit Glass + Clear	40%	PPG ; Solarban 70xl	0.26	0.28
Shades	**Lutron GreenScreen Revive** 1% openness factor ultra lightweight fabric w/ 80% recycled content	Stone	24%	Lutron	-	-

The louvers extend 2 feet 6 inches from the glass curtain wall and are sloped slightly to allow for drainage of rain and snow. They begin about 7 feet off the ground plane and continue up the façade every two feet, center to center. They are also continuous down the entire length of the hallway and are comprised of entirely matte aluminum surface.

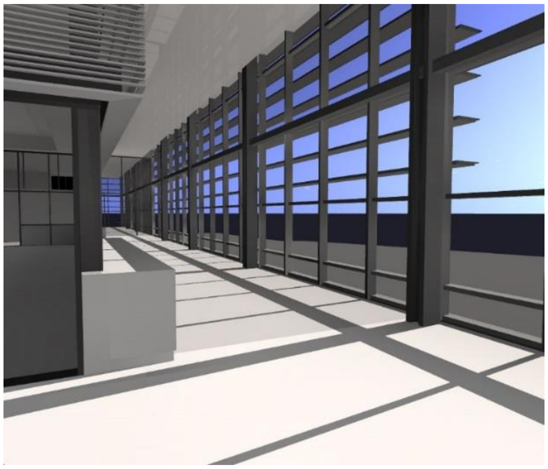
As stated above, the corridor and lobby are mostly public transitional spaces. The most critical aspect of this corridor and lobby from a daylighting perspective is the interior space next to the façade. At this location, there will be movable tables and chairs for socializing and light studying before and after the school day and between classes. It can be assumed that anyone who may sit there may only be there for a short period of time, around an hour or less and may create a situation in which momentary concentration and a more private atmosphere is desired.

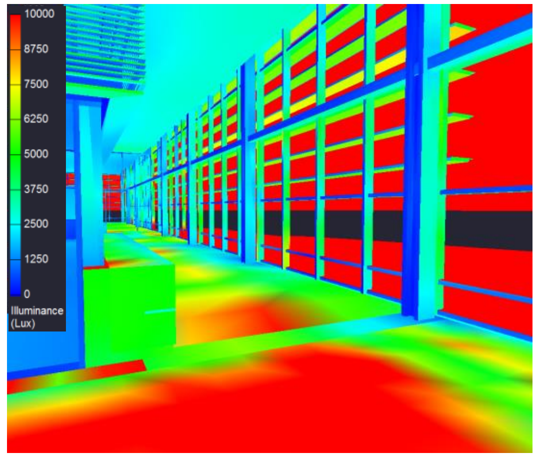
Preliminary AGi32 Daylighting Study

To begin the Daylighting study, an AutoCAD 3D model was created of the existing daylighting system. It was made of entirely 3D faces and to the exact measurements of the building to allow for analysis in both AGi32 and Radiance. The ground plane and the façade were extended to allow for correct reflections off of the exterior surfaces. When imported into AGi32, the reflectances of materials where changed to match the exact data previously show in the Lighting Depth within the Wellness Lobby and Corridor. The reflectance of the louvers, which were not discuss previously, is 0.30.

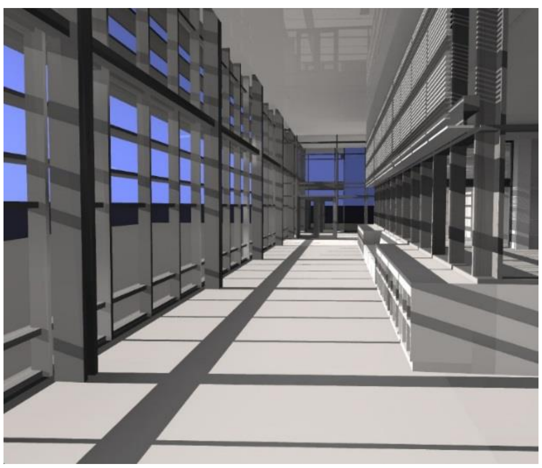
Winter // December 21st - 2 PM

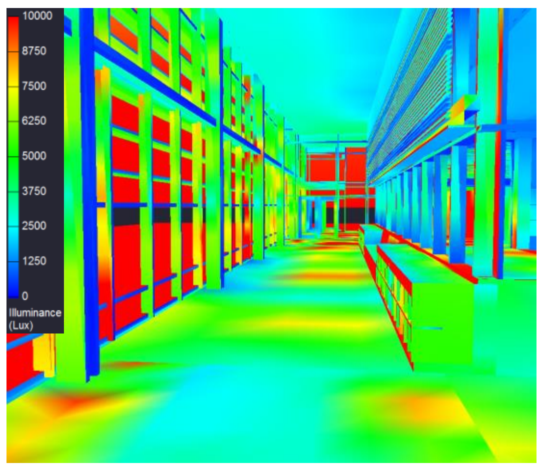
View from Lobby



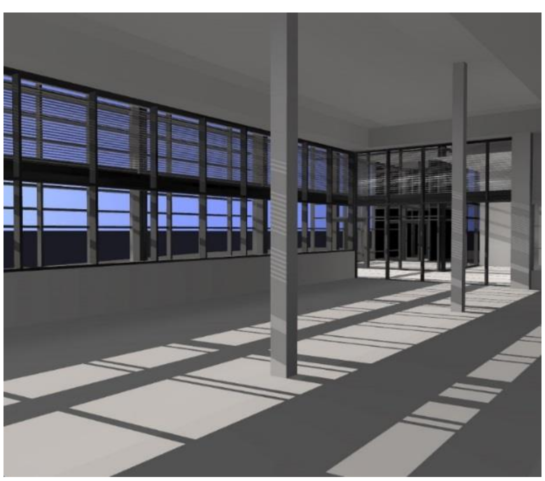


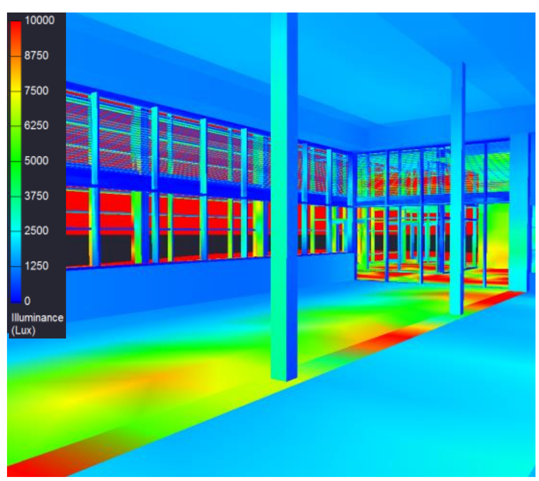
View from Corridor





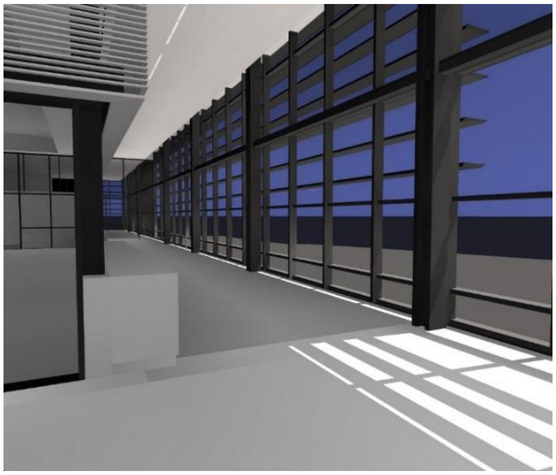
View from Fitness Room

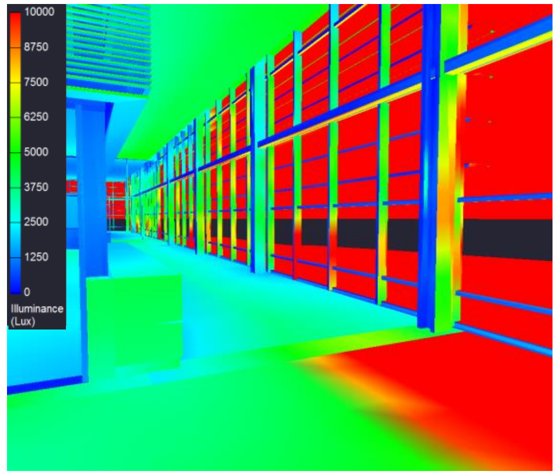




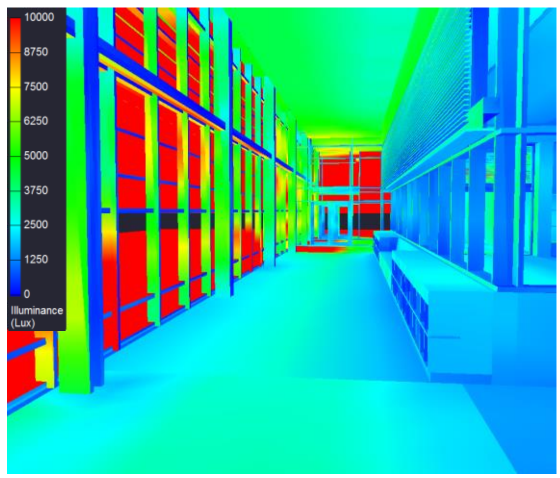
Summer // June 21st - 2 PM

View from Lobby

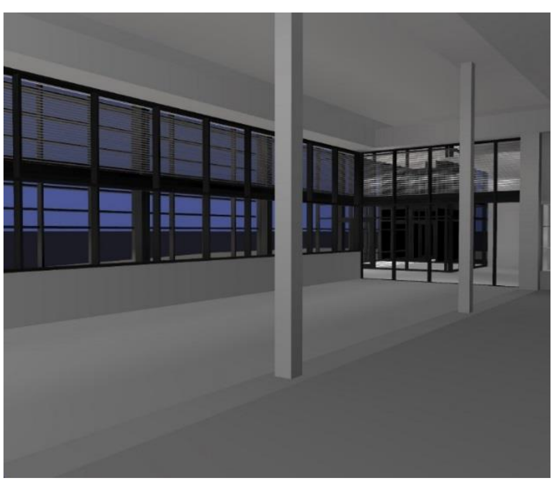


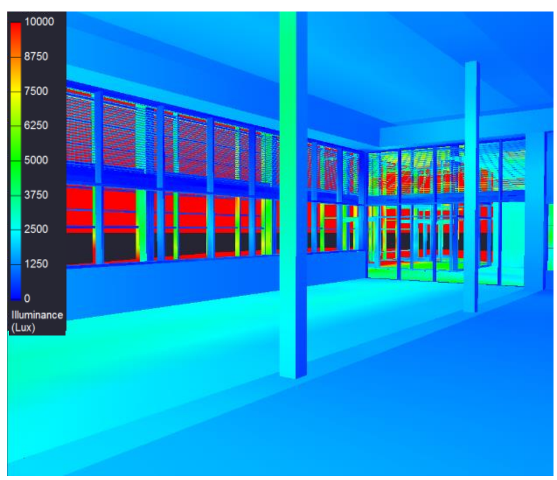


View from Corridor



View from Fitness Room





Evaluation

From the images above, the sunshade louvers appear to function best during the summer when the sun angles are very steep. Unfortunately, this is also when the school is not in session. During the months of September to early June, when the school year is ongoing, there will be a large amount of direct light penetration into the Wellness Corridor. The worst case scenario will occur in December. Direct light floods the space with very high levels of illuminance. The table to the left shows the illuminance values in lux during that time frame. The average illuminance in the space is 11972 lux which is incredibly high and glare intensive light. It is assumed at this point the shades would be pulled down in the space. The low angles of sunlight in the winter, specifically, an elevation of 21.85° at the time shown in the rendering, would mean both upper and lower shading devices would need to be utilized. With the shades employing a 1% openness factor, much of the views will be lost in the process of pulling down the shades, leaving students without a view of their prestigious courtyard, should they want it.

Data	Required	Actual
Illuminance Avg	100 lux	11972 lux
Maximum	-	17712 lux
Minimum	-	3110 lux
Avg/Min	3.0:1 lux	3.8500

Overall, while this system does seem to have an effect of the daylighting in the space, much more could be done to prevent glare in the space, especially in the section where students will have the option to sit down to study and socialize.

Daylighting Redesign

Pre-Design Goals and Research

After looking at the original system, several goals were established at the beginning of the redesign:

- Reduce glare in the hallway, especially in the potential break-out study areas
- Give the occupant control of the amount of direct sunlight/views they have
- Create a system that utilizes a “borrowed light” concept and create a more pleasing environment

Giving the occupant control of the views and direct sunlight was very important in the development of the design. If an occupant chooses to sit in the hallway break-out areas, they may not necessarily be doing work, though they could be. They could also socialize and catch up with friends, eating a snack or just passing time by sitting and looking out the window. Whatever the occupant is doing, they most likely won’t be there for a long period of time since this is day school with little free time in between periods of the day. Therefore, avoiding patterns of direct light is not as critical as if occupants would be spending long periods of time in the space. That said, there is a need to give the occupant an option of whether they wish to be sitting in direct light and have the views to the exterior, or not.

To begin, the decision was made to leave the interior louver system that supports the cardio and fitness room. The louvers are architecturally significant throughout the building and used in many different locations in the building as well as functional to block light from entering the space.

The next step was to research possible solutions to the exterior curtain wall of the Wellness Corridor. Horizontal louvers were already ruled out since they were used on the original design and did not block the low angle sunlight well. Likewise, a large overhang was not desired and would not be very effective for the same reasons as the louvers.

Figure 57 shows that the azimuth of the sun during the course of day will rotate around almost the entire façade. Since this is the case, static vertical fins would be effective in the early and late afternoons but ineffective in the mid-afternoon. Since static vertical fins would potentially work throughout the afternoon, it was thought that maybe a dynamic system would be the best option. This would allow for localized sun shading, should the occupant choose it, as well as a variable direct sun shading device. Upon further research of variable and user friendly system, several images and architectural articles were found on the occupant operable louvers at the Arizona State University Biodesign Institute. The system is comprised of interior wooden louvers that users can rotate around an axis to block the sun as desired. Exterior and Interior images of the louvers are shown in Figures 60.

Figure 60 - Exterior and Interior views of the operable louvers at Arizona State University

Conclusion

At this time, the decision was made to approach the daylighting redesign by using a combination of a light-shelf to borrow daylight and bounce it onto the ceiling for an indirectly lit space and an operable user-controlled louver like those in the Arizona State Biodesign Institute.

Engineering the Design

To begin the design of the light-shelf and operable louver system, the original structure of the curtain wall was examined. Due to the hollow structural section steel member located at 11 feet above the finished floor, the light shelf was also mounted at this height for possible structural support, if necessary. The light shelf was designed to extend 3 feet into the hallway from the glass façade. Architecturally, this distance means the light shelf will protrude 1 foot further into the hallway than the soffit above and will roughly correspond to each other. The light shelf was also extended to the exterior by a length of 1 foot 6 inches. By extending the shelf to the exterior, an overhang is created to shade the seating area should the elevation of the sun be above 63°. This is the case the majority of the early to mid-afternoon from April until August. Furthermore, at this length the light shelf will bounce light onto the entire ceiling for almost the entire duration of the year. The light shelf is aluminum with gypsum board exterior and the exterior overhang is aluminum. The top of the light shelf should be painted with a highly reflective paint. There is also a small 4" cove in the top of the light shelf to incorporate a light fixture to wash the ceiling at night as is discuss in the Lighting Design Depth: Wellness Corridor section. The smallest fixture possible was chosen and the cove was located close to the edge of the shelf so it would not inhibit the functionality of the shelf. A detail of the light shelf is shown in Figure 61 and a section of the entire system is shown in Figure 62.

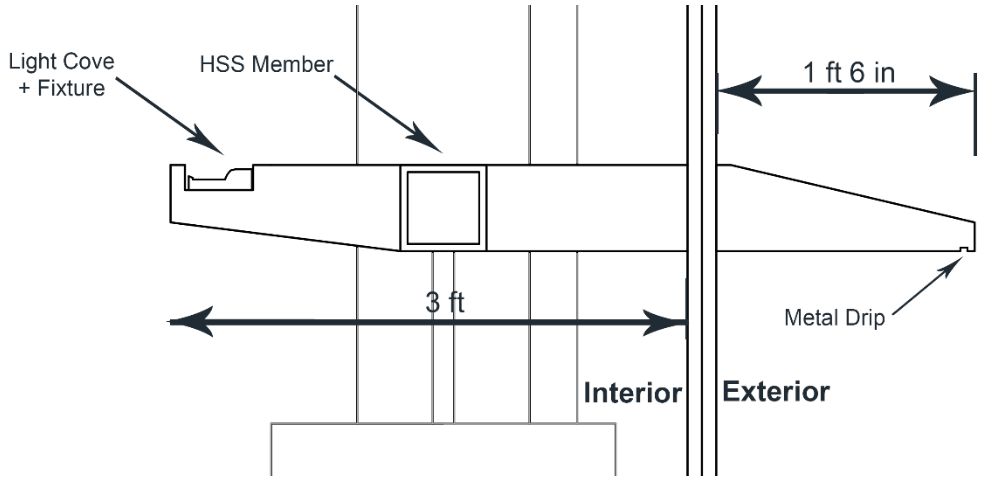


Figure 61 - Light Shelf Section

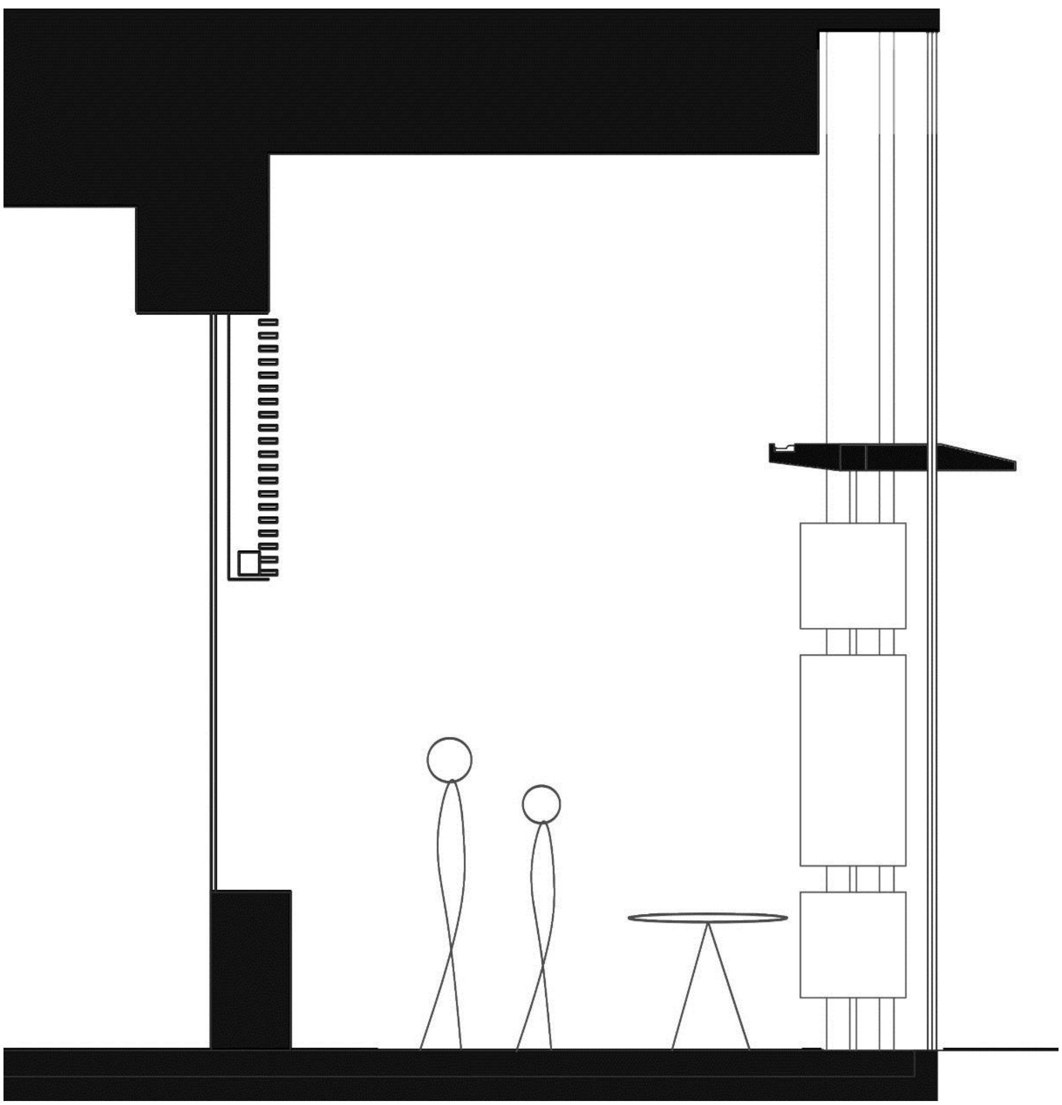


Figure 62 - New Design Corridor Section

When the sun is below 63°, the operable louvers can be used to individually shade the seating area. In the design, the axis pole is 11 feet in height and connected to the light shelf. There are three wooden panels with aluminum trim that rotate about the axis. The dimensions of the louver can be seen in the plan and elevation in Figure 63. The louvers will be centered between columns and architecturally lined up with interior partitions. They are designed to be able to rotate 360°. In the middle section of the louvers, the panel will be hollow. One side will display a wood panel, the other side will be an acrylic panel that is backlit from an LED tape light as described in the Lighting Design Depth: Wellness Corridor section of this report. A sketch of this detail is shown in Figure 64.

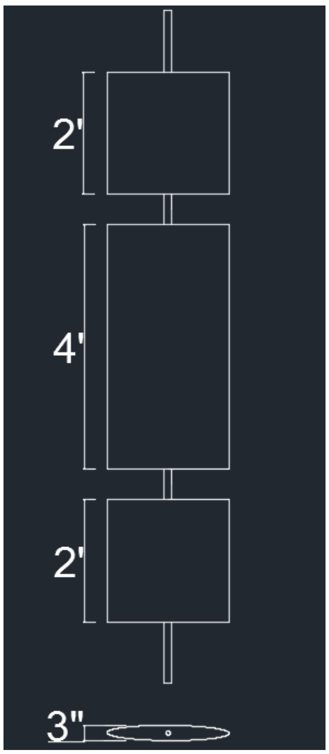


Figure 63 - Dimensioned Louver

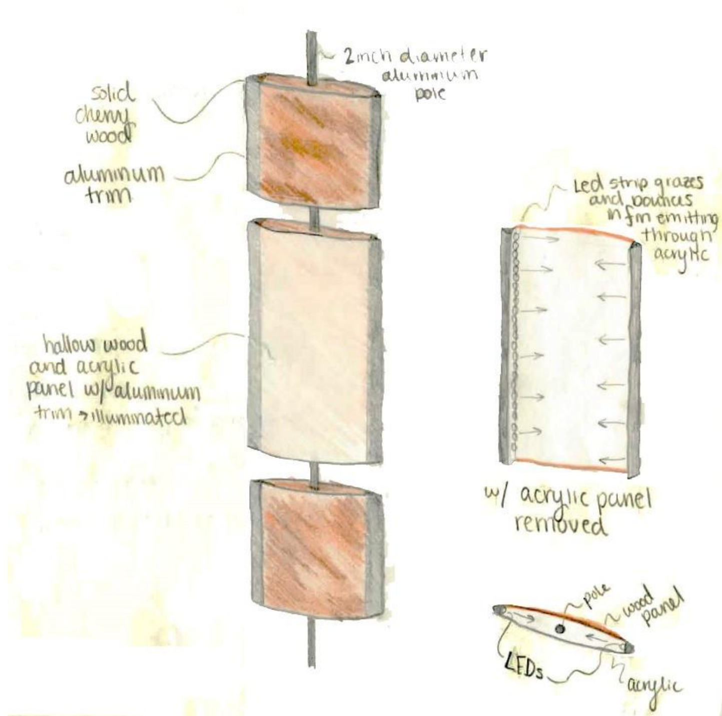


Figure 64 - Sketch Detail of Louver

The operable louvers are designed to completely shade the desks if the occupant desires. The occupant can physically turn the louvers around them based on where the sun is throughout the day to allow for more or less direct light onto their work plane. A detail of possible scenarios are shown in Figure 65. The best case scenario will occur early and late in the afternoon, conversely, the worst case scenario will occur mid-afternoon. At the worst case, the direct light will appear as a strip of light from a 2" gap between louvers. For the most part, the majority of the afternoon will prohibit direct light onto the workplane, the exception being when the sun is near or exactly perpendicular to the façade.

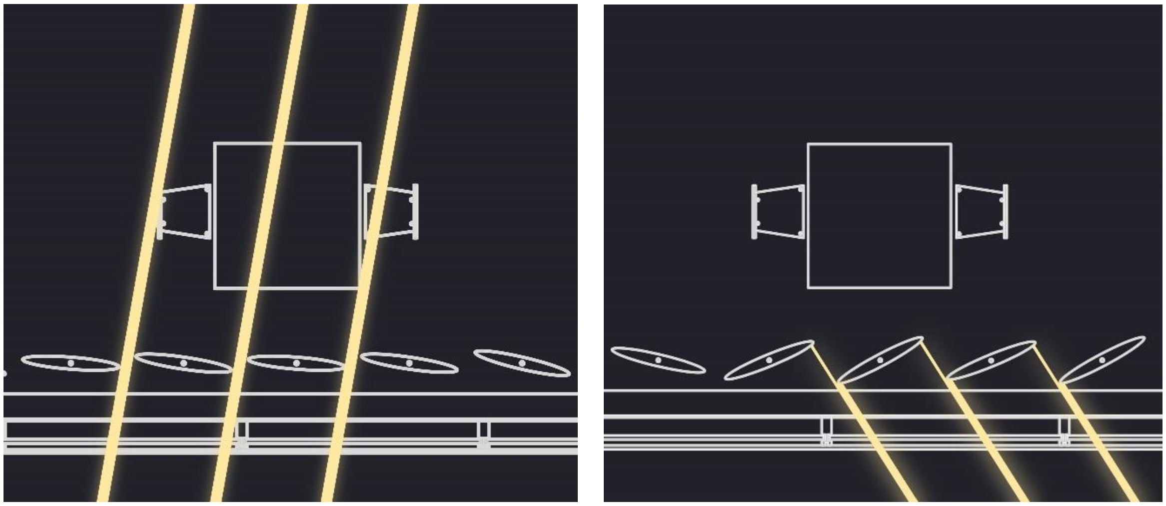


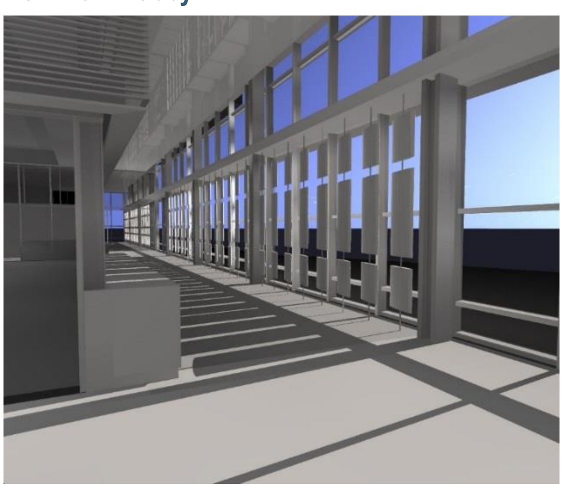
Figure 65 – Examples of the Worst (left) and Best (right) Case Scenarios for the Rotating Louvers

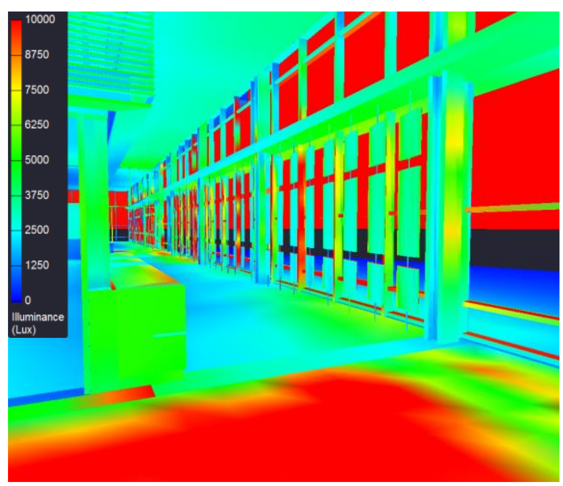
All of the glass was changed so that the entire curtain wall uses type XG6. This glass is completely clear, with no fritting. This will allow more views to the exterior and limit the “frosted” look the glass may have a night with frit. There are sections of the hallway that do not feature the rotating louvers. In those cases, there are corresponding trees on the exterior of the façade to block the light. This was done in coordination of the Landscape Design Breadth. The trees are American Hornbeam. From a daylighting perspective, they were chosen because they are known for holding onto their leaves much longer than most trees and also having an extremely high density of branches. This density of branches mean that the lobby will have some break up of direct light, even in the winter season. For more information on the American Hornbeam or the location of these trees, please see the Landscape Design Breadth.

Final AGi32 Results

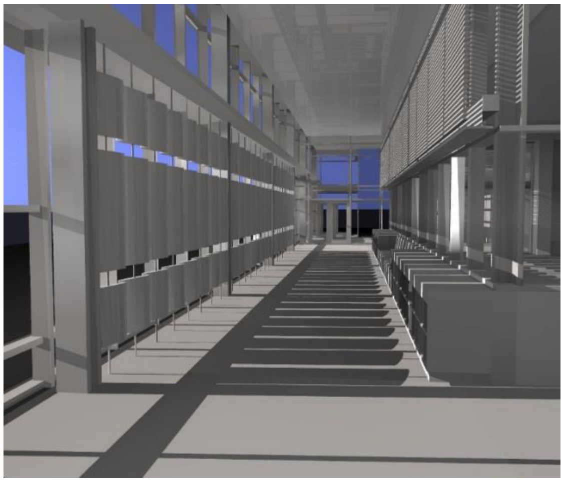
Winter // December 21st - 2 PM

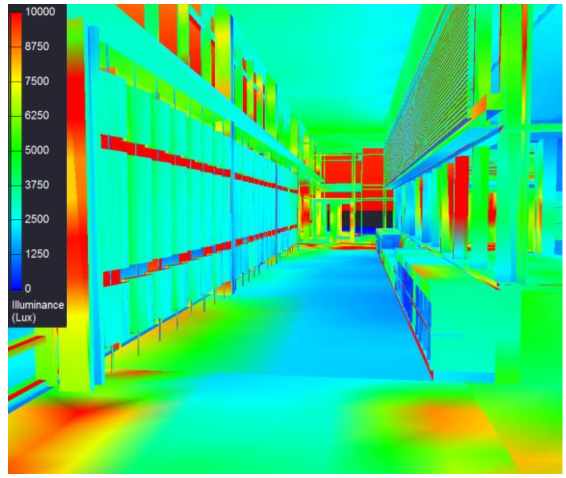
View from Lobby



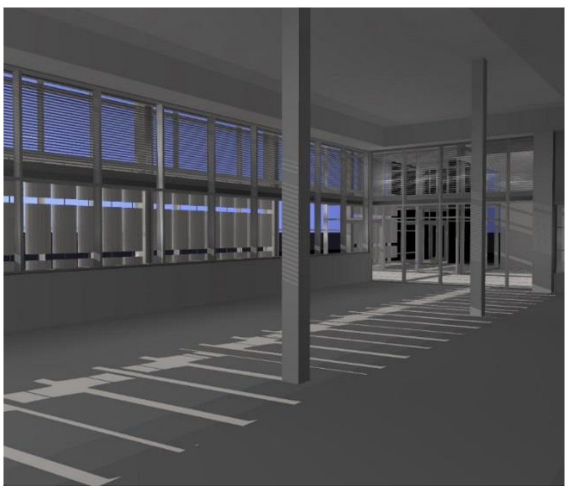


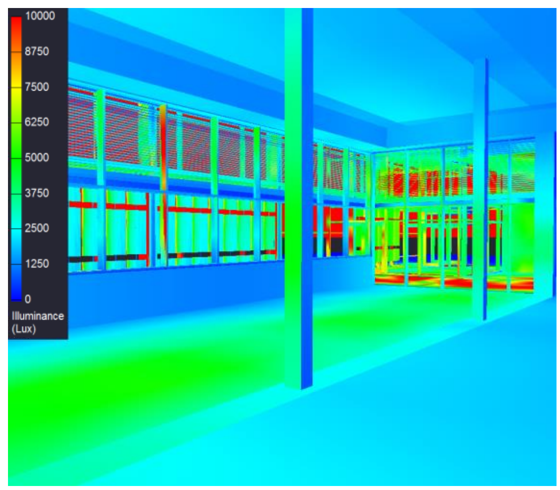
View from Corridor





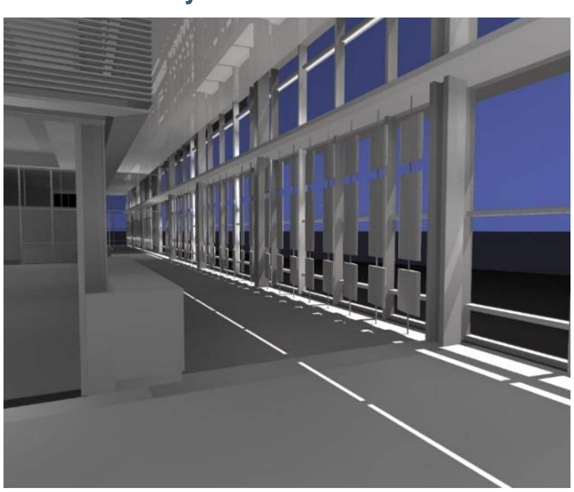
View from Fitness Room

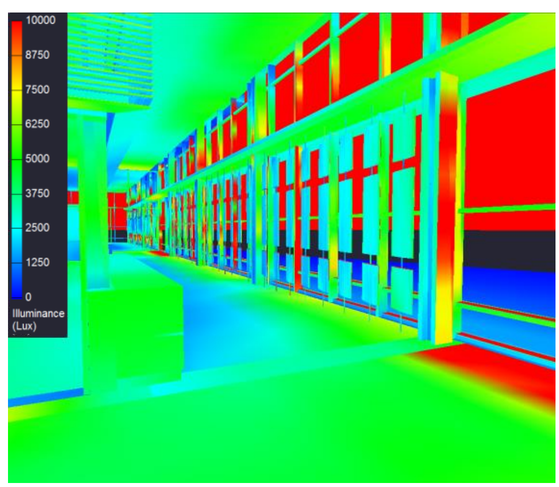




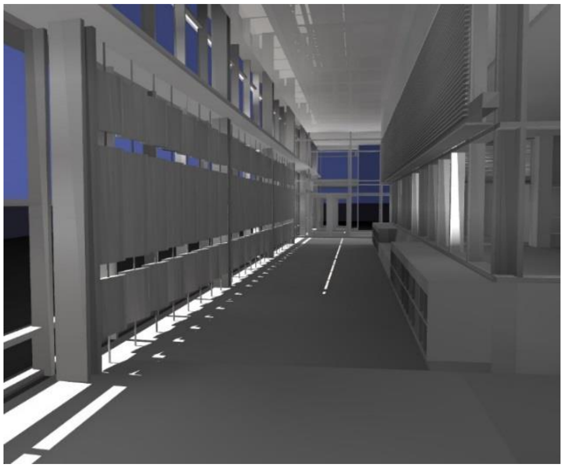
Summer // June 21st - 2 PM

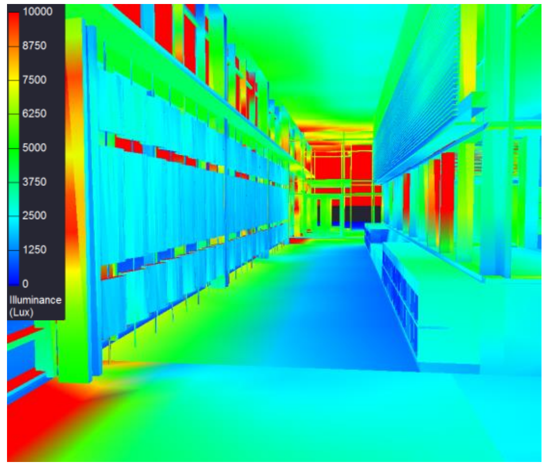
View from Lobby



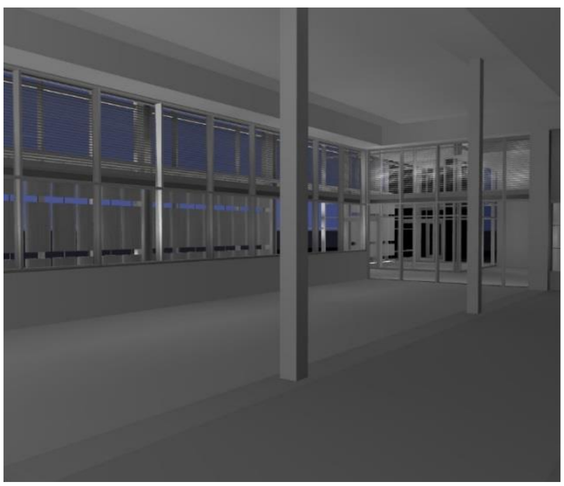


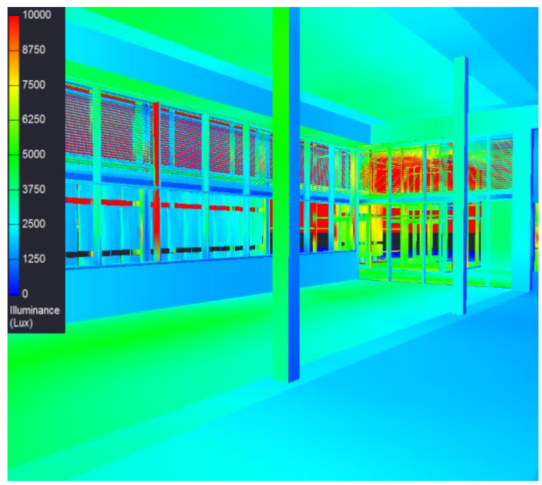
View from Corridor





View from Fitness Room





Original Design vs Proposed Design

The following section compares various aspects of the original and purposed design that have not been shown previously in the AGi32 renders.

Glare Calculation

Overview

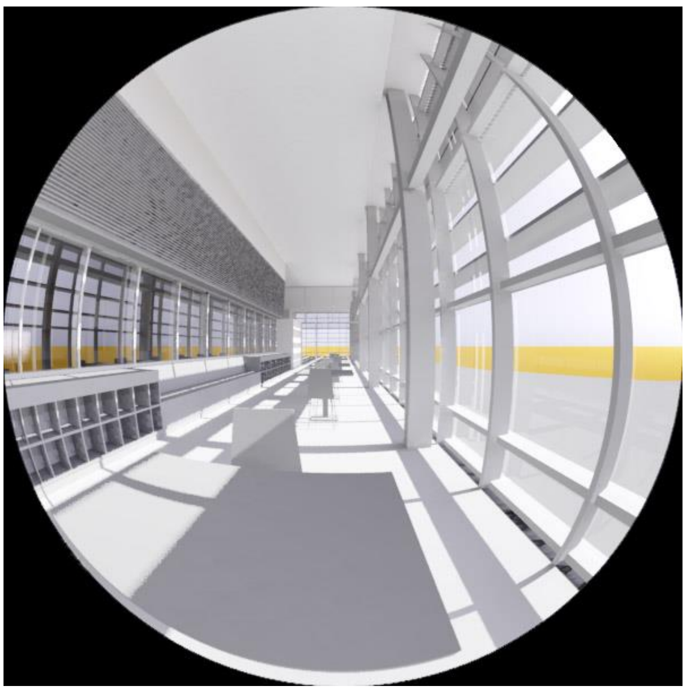
The following images are from Radiance. The model was converted into radiance format, and the reflectances adjusted to match those discussed earlier. At this point, before textures were added for the final rendering, a glare calculation was performed to compare and contrast the perceived glare in the space that could cause the occupant physical discomfort. To determine this, a metric was calculated from within the Radiance systems "evalglare" command. This command requires the images are rendered in a fish-eye perspective.

The metric itself is called Daylight Glare Probability (DGP). This metric measures the contrast ratios in the space, which allows for the direct light to be considered, but not necessarily the distant sky. The following scale shown shows the labels for each level of glare.

Scale	DGP
Intolerable Glare	> 45%
Disturbing Glare	40 - 45 %
Perceptible Glare	35 - 40 %
Imperceptible Glare	< 35 %

For both the original and proposed designs, a glare calculation was performed as if an occupant were sitting at the table, and if the occupant were walking through the hallway. In the proposed design, the surrounding louvers were turned as if the occupant had adjusted them to limit glare.

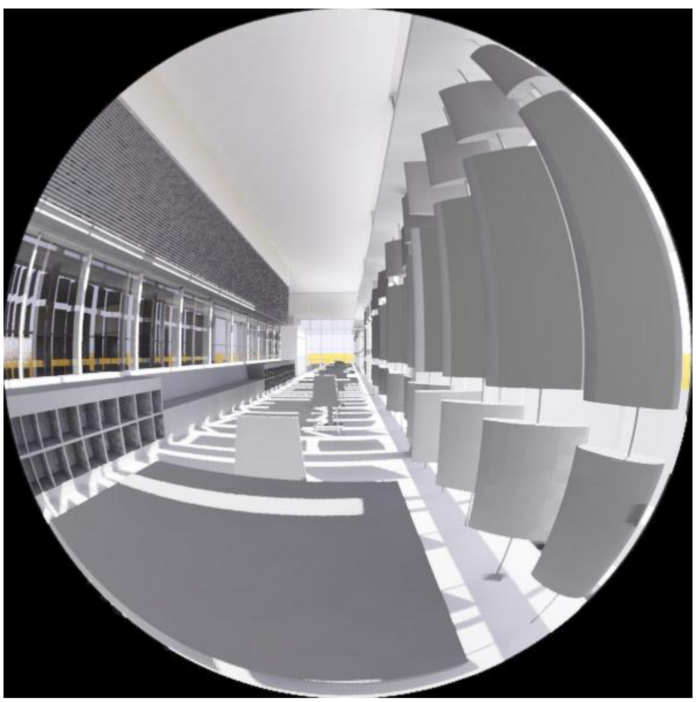
Original Design



DGP	65.25%

DGP	39.31%

Proposed Design

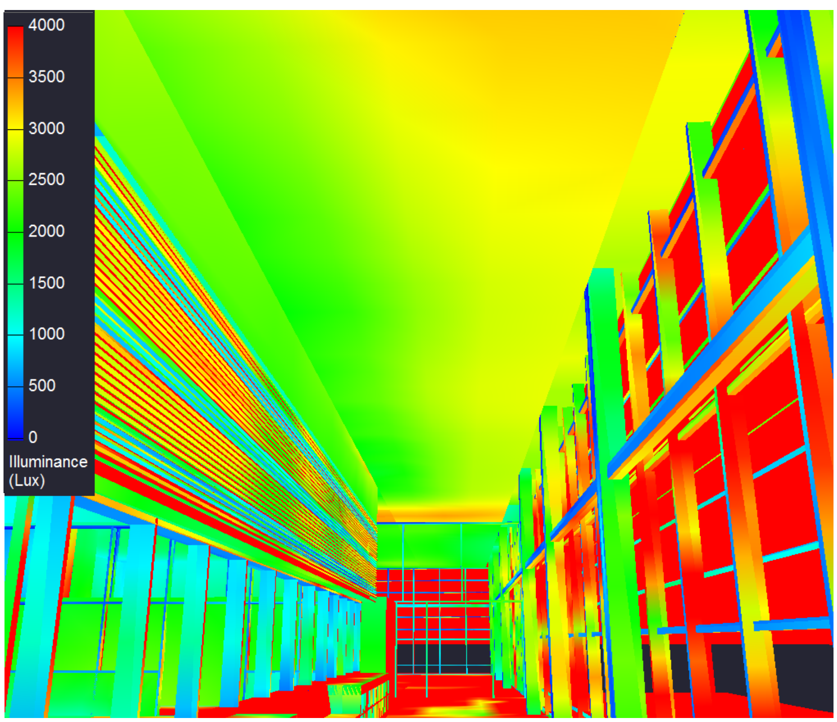


DGP	29.59%

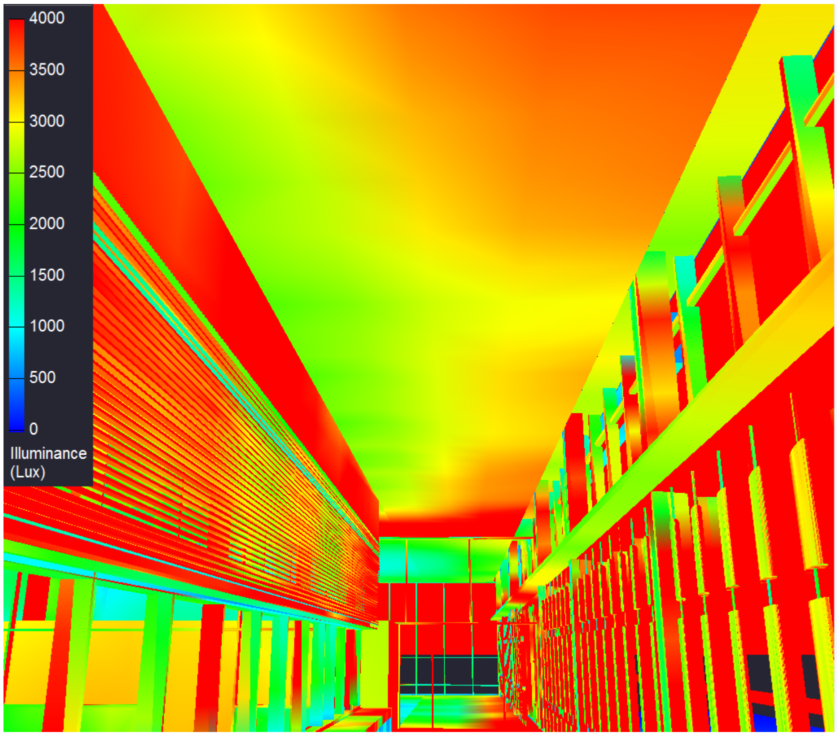
DGP	30.72%

Ceiling Comparison

Original Design



Proposed Design

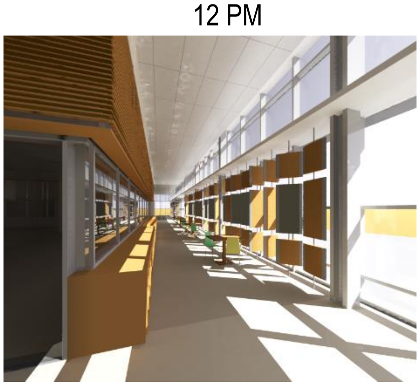


Afternoon Storyboard Radiance Renders

12 PM

1 PM

2 PM



3 PM

4 PM

5 PM

Final Radiance Render

For the radiance textures and materials, the colors were matched to the previous reflectances shown and used above. In radiance, color is chosen by listing three RGB values that range from zero to one. The following formula was used for each material texture to ensure that the end reflectance matched the earlier values.

$$\rho = \left((0.265R + 0.67G + 0.65B)\ x\ Specularity\right) + Specularity$$

Figure 66 - Final Radiance Render with Textures, people and the exterior background were added via Photoshop CS6

Evaluation

With this new daylighting system, all pre-design goals have been met. Based on all the information provided, the overall direct light in the space has been decreased by the proposed daylighting design. Within the seating area, the new design decreases the glare from intolerable to imperceptible and within the corridor from disturbing to imperceptible. While the new system does create a distinct pattern within the hallway, for the majority of the day, occupants are able to control the direct light occurring on their workplane. Finally, the light shelf has created a natural indirect light that bounces onto the ceiling to indirectly light the corridor for a more pleasing environment for a long term occupant.

Data	Required	Actual
Illuminance Avg	100 lux	8394 lux
Maximum	-	15132 lux
Minimum	-	2517 lux
Avg/Min	3.0:1 lux	3.3300

Acoustical + Landscape Architectural Breadths

Acoustical Breadth

Introduction

This breadth is dedicated to the acoustical discipline of the architectural engineering program. The concept of a grand ceiling within the Dance Rehearsal space led to a change in the ceiling from perforated metal to a variable wood slat system. By changing the systems and layout in the space, the acoustics of the space differed from their original performance. Since this space will be used for both dance practices and performances, acoustical performance is very important. The room is considered by the designers to be acoustically critical and special care has been taken with the design of mechanical systems. An acoustical study was performed on how this redesign will affect the reverberation time and other acoustical options have been implemented and studied as well.

Figure 67 - Existing Ceiling Render

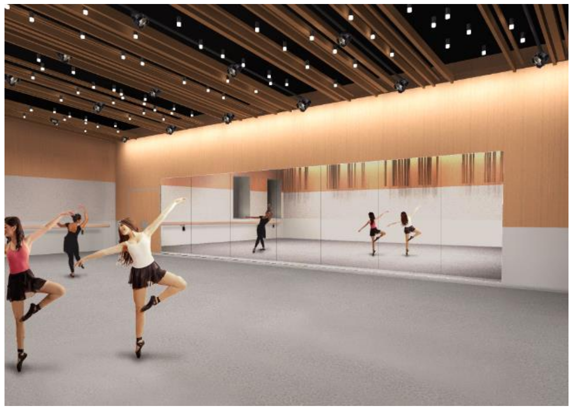


Figure 68 - Proposed Ceiling Render

Figures 67 shows a rendering of the existing ceiling while Figure 68 shows a rendering of the proposed new ceiling design. Also the new ceiling can be seen in plan view in Figure 30. The existing ceiling is a perforated “bacon-colored” metal ceiling that both steps and slopes. The ceiling is divided longitudinally into five sections, each section slopes about 2.5 inches and then steps down 6 inches to meet the next panel. Fixtures are fit into the vertical steps in the ceiling. Acoustical panels are located above the perforated ceilings and on two of the four walls in the space.

The new ceiling is comprised of a variable wood slat system designed by *CeilingsPlus Barz*, an example image of their system is to the left. The ceiling is designed to incorporate fixtures, diffusers, theatrical fixtures and a “grand” ceiling all in a coordinated system. The entire system slopes from 15 feet in the back of the room to 12 feet 6 in in the front. The panels curve down the back of the wall when the ceiling system meets the back wall, as also shown in the image on the left. The overall new ceiling design keeps the same volume of the space yet decreases the acoustical performance of the ceiling by creating more openings.

Performance Criteria

The criteria for the acoustical performance study was based on the appropriate reverberation time (RT) for a concert hall with light music where the main function is dance rehearsals and performances set to music. The music will be recorded for the most part, but a small band may also play in space. The Dance Rehearsal Room is 30,105 ft^3 in volume. The figure below outlines suggested reverberation times for various spaces, including a concert hall with light music and speech auditorium. The reverberation time for the space falls at approximately 1.5 seconds at 500 Hz for a concert hall and 0.75 for a speech auditorium. Since, within this room, speech is also important for teaching as well as the music for practice, the target criteria was combined to 1.0 seconds at 500 Hz to split the difference between both speech and music moving into the acoustical study. This can be backed up by multiple manufacturer guidelines which recommend 1.0 - 1.2 seconds for a dance studio.

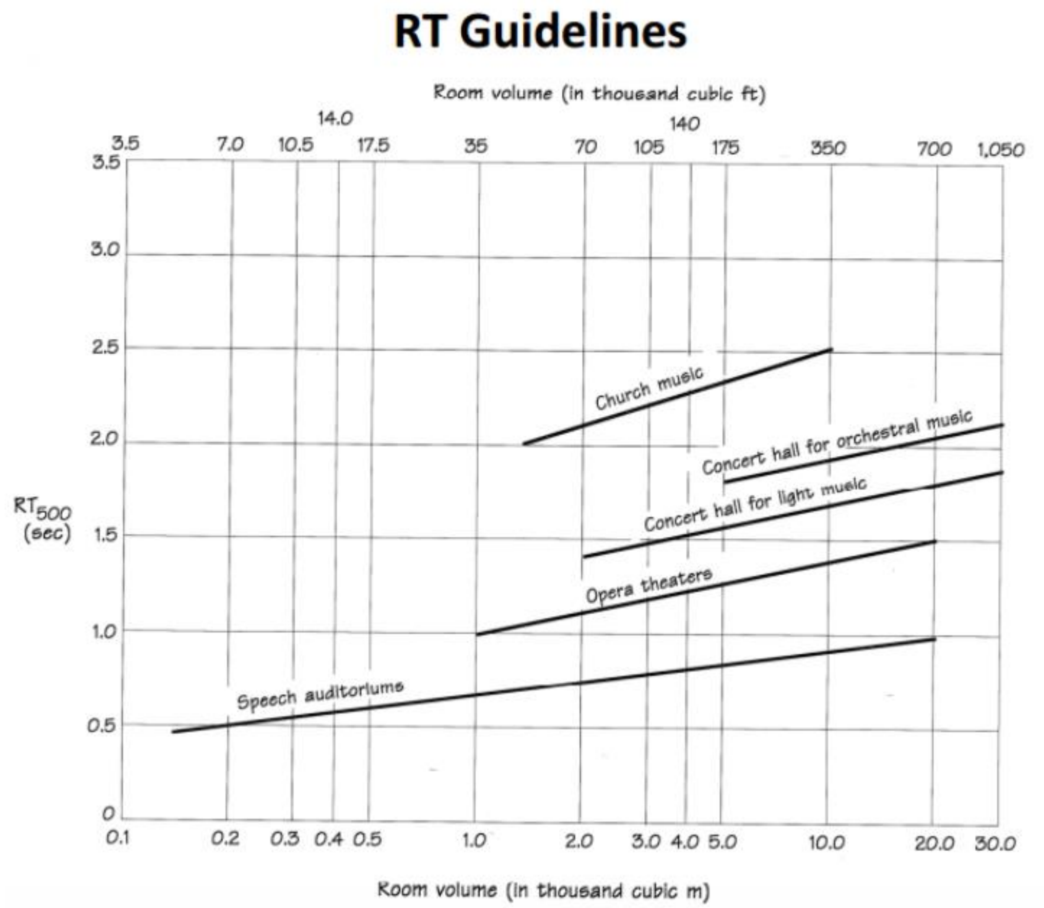


Figure 69 - Suggested optimum RT for various space purposes

Performance Analysis

Sound absorption coefficients (α) were found for each material used in the space. The following formula was then applied to covert the coefficients into Sabines based on the area of the surface.

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

The Sabines for each material were summed together in corresponding frequencies and averaged over the total surface area of the room. At this point, based on the sound absorption coefficient, one of the two equations were used to calculate the reverberation time.

Sabine Equation (α < 0.2): $RT = \frac{0.49V}{S_T \propto + 4mV}$

Norris-Eyring Equation (α > 0.2): $RT = \frac{0.49V}{S_T \ln(1-\propto) + 4mV}$

Results

Original Ceiling Design RT Calculation

AE Thesis 2015 - Reverberation Time Calculations for the Dance Rehearsal Space in The Winsor School

(English Units)

Volume [ft^3] = 30150.00

Total Surface Area [ft^2] = 7451.49

Surface Description	Surface Area, S (ft^2)	Material Description	Sound Absorption Coefficient, α						S*α (sabins)					
			Frequency (Hz)						Frequency (Hz)					
			125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
South Wall - Mirrors	278.14	Mirror	0.01	0.01	0.01	0.01	0.01	0.01	2.78	2.78	2.78	2.78	2.78	2.78
South Wall - Wood Wall	356.31	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	99.77	78.39	60.57	32.07	35.63	39.19
South Wall - Drywall	135.80	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	13.58	9.51	6.79	6.79	5.43	5.43
East Wall - Windows	55.20	Glass Window	0.15	0.05	0.04	0.03	0.12	0.07	8.28	2.76	2.21	1.66	6.62	3.86
East Wall - Acous Panels	116.03	FabriTrak Stretch Fabric Panel NRC .80	0.16	0.40	0.82	0.96	0.92	0.92	18.56	46.41	95.14	111.39	106.75	106.75
East Wall - Wood Panels	202.40	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	56.67	44.53	34.41	18.22	20.24	22.26
East Wall - Drywall	233.41	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	23.34	16.34	11.67	11.67	9.34	9.34
North Wall - Acous Panels	230.64	FabriTrak Stretch Fabric Panel NRC .80	0.16	0.40	0.82	0.96	0.92	0.92	18.56	46.41	95.14	111.39	106.75	106.75
North Wall - Wood Panels	362.44	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	101.48	79.74	61.61	32.62	36.24	39.87
North Wall - Drywall	272.20	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	27.22	19.05	13.61	13.61	10.89	10.89
West Wall - Dry Wall	167.70	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	16.77	11.74	8.39	8.39	6.71	6.71
West Wall - Glass	433.54	Glass Curtain Wall	0.15	0.05	0.04	0.03	0.12	0.07	65.03	21.68	17.34	13.01	52.02	30.35
Plenum - Acoustical Panels	822.80	FabriTrak Stretch Fabric Panel NRC .80	0.16	0.40	0.82	0.96	0.92	0.92	131.65	329.12	674.70	789.89	756.98	756.98
Plenum - Drywall	822.80	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	82.28	57.60	41.14	41.14	32.91	32.91
Floor - Dance Floor	1645.60	Marley Vinyl Dance Floor	0.01	0.03	0.03	0.03	0.03	0.02	16.46	49.37	49.37	49.37	49.37	32.91
Ceiling - Metal Perforated	1316.48	CeilingsPlus Illusions	0.81	0.90	0.75	0.90	0.95	0.81	1066.35	1184.83	987.36	1184.83	1250.66	1066.35
								∑Sα =	1748.79	2000.25	2162.24	2428.81	2489.32	2273.33
								Avg. α =	0.23	0.27	0.29	0.33	0.33	0.31
			Air absorption constant for 20°C and 40% RH, *m*						0	0	1.83E-04	3.26E-04	7.86E-04	2.56E-03
							Sabine Reverb Time: (s)	RT =	0.84	0.74	0.68	0.60	0.57	0.57
							Norris-Eyring Reverb Time: (s)	RT =	0.74	0.63	0.57	0.50	0.47	0.49
							Calculated RT (s)		**0.74**	**0.63**	**0.57**	**0.50**	**0.47**	**0.49**

New Ceiling Design RT Calculation

AE Thesis 2015 - Reverberation Time Calculations for the Dance Rehearsal Space in The Winsor School

(English Units)

Volume [ft^3] = 30150.00
Total Surface Area [ft^2] = 6372.68

Surface Description	Surface Area, S (ft^2)	Material Description	Sound Absorption Coefficient, α						S*α (sabins)					
			Frequency (Hz)						Frequency (Hz)					
			125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
South Wall - Mirrors	278.14	Mirror	0.01	0.01	0.01	0.01	0.01	0.01	2.78	2.78	2.78	2.78	2.78	2.78
South Wall - Wood Wall	356.31	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	99.77	78.39	60.57	32.07	35.63	39.19
South Wall - Drywall	135.80	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	13.58	9.51	6.79	6.79	5.43	5.43
East Wall - Windows	55.20	Glass Window	0.15	0.05	0.04	0.03	0.12	0.07	8.28	2.76	2.21	1.66	6.62	3.86
East Wall - Acous Panels	116.03	FabriTrak Stretch Fabric Panel NRC .80	0.16	0.40	0.82	0.96	0.92	0.92	18.56	46.41	95.14	111.39	106.75	106.75
East Wall - Wood Panels	202.40	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	56.67	44.53	34.41	18.22	20.24	22.26
East Wall - Drywall	233.41	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	23.34	16.34	11.67	11.67	9.34	9.34
North Wall - Acous Panels	230.64	FabriTrak Stretch Fabric Panel NRC .80	0.16	0.40	0.82	0.96	0.92	0.92	18.56	46.41	95.14	111.39	106.75	106.75
North Wall - Wood Panels	362.44	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	101.48	79.74	61.61	32.62	36.24	39.87
North Wall - Drywall	272.20	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	27.22	19.05	13.61	13.61	10.89	10.89
North Wall - Wood Slats	237.67	CeilingsPlus Barz	0.12	0.38	0.95	1.08	1.10	0.99	28.52	90.31	225.79	256.68	261.44	235.29
West Wall - Dry Wall	167.70	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	16.77	11.74	8.39	8.39	6.71	6.71
West Wall - Glass	433.54	Glass Curtain Wall	0.15	0.05	0.04	0.03	0.12	0.07	65.03	21.68	17.34	13.01	52.02	30.35
Plenum - Acoustical Panels	822.80	FabriTrak Stretch Fabric Panel NRC .80	0.16	0.40	0.82	0.96	0.92	0.92	131.65	329.12	674.70	789.89	756.98	756.98
Plenum - Drywall	822.80	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	82.28	57.60	41.14	41.14	32.91	32.91
Floor - Dance Floor	1645.60	Marley Vinyl Dance Floor	0.01	0.03	0.03	0.03	0.03	0.02	16.46	49.37	49.37	49.37	49.37	32.91
Ceiling - Wood Slats	665.78	CeilingsPlus Barz	0.12	0.38	0.95	1.08	1.10	0.99	79.89	253.00	632.49	719.04	732.36	659.12
								∑Sα =	790.85	1158.73	2033.15	2219.70	2232.46	2101.39
								Avg. α =	0.12	0.18	0.32	0.35	0.35	0.33
			Air absorption constant for 20°C and 40% RH, *m*						0	0	1.83E-04	3.26E-04	7.86E-04	2.56E-03
			Sabine Reverb Time: (s)					RT =	1.87	1.27	0.72	0.65	0.63	0.61
			Norris-Eyring Reverb Time: (s)					RT =	1.75	1.16	0.60	0.53	0.52	0.52
								Calculated RT (s)	**1.75**	**1.16**	**0.60**	**0.53**	**0.52**	**0.52**

New Ceiling + Adjusted Design RT Calculation

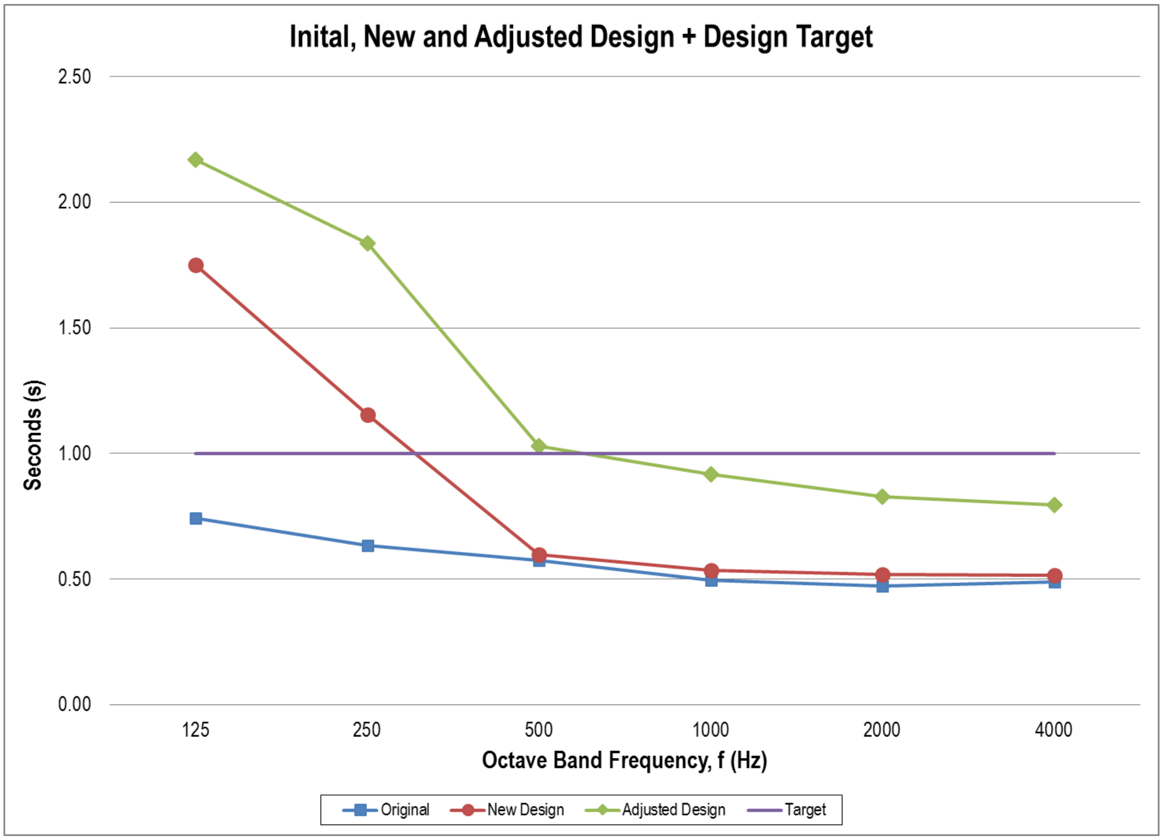
AE Thesis 2015 - Reverberation Time Calculations for the Dance Rehearsal Space in The Winsor School

(English Units)

Volume [ft^3] = 30150.00
Total Surface Area [ft^2] = 5549.88

Surface Description	Surface Area, S (ft^2)	Material Description	Sound Absorption Coefficient, α						S*α (sabins)					
			Frequency (Hz)						Frequency (Hz)					
			125	250	500	1000	2000	4000	125	250	500	1000	2000	4000
South Wall - Mirrors	278.14	Mirror	0.01	0.01	0.01	0.01	0.01	0.01	2.78	2.78	2.78	2.78	2.78	2.78
South Wall - Wood Wall	356.31	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	99.77	78.39	60.57	32.07	35.63	39.19
South Wall - Drywall	135.80	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	13.58	9.51	6.79	6.79	5.43	5.43
East Wall - Windows	55.20	Glass Window	0.15	0.05	0.04	0.03	0.12	0.07	8.28	2.76	2.21	1.66	6.62	3.86
East Wall - Acous Panels	116.03	FabriTrak 1/2" FabriBoard NRC .50	0.08	0.05	0.35	0.70	0.84	0.94	9.28	5.80	40.61	81.22	97.47	109.07
East Wall - Wood Panels	202.40	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	56.67	44.53	34.41	18.22	20.24	22.26
East Wall - Drywall	233.41	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	23.34	16.34	11.67	11.67	9.34	9.34
North Wall - Acous Panels	230.64	FabriTrak 1/2" FabriBoard NRC .50	0.08	0.05	0.35	0.70	0.84	0.94	9.28	5.80	40.61	81.22	97.47	109.07
North Wall - Wood Panels	362.44	Wood Veneer - 1/2" Air Space	0.28	0.22	0.17	0.09	0.10	0.11	101.48	79.74	61.61	32.62	36.24	39.87
North Wall - Drywall	272.20	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	27.22	19.05	13.61	13.61	10.89	10.89
North Wall - Wood Slats	237.67	CeilingsPlus Barz	0.12	0.38	0.95	1.08	1.10	0.99	28.52	90.31	225.79	256.68	261.44	235.29
West Wall - Dry Wall	167.70	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	16.77	11.74	8.39	8.39	6.71	6.71
West Wall - Glass	433.54	Glass Curtain Wall	0.15	0.05	0.04	0.03	0.12	0.07	65.03	21.68	17.34	13.01	52.02	30.35
Plenum - Acous Panels	0.00								0.00	0.00	0.00	0.00	0.00	0.00
Plenum - Drywall	822.80	Two 5/8" Gyp with 3-5/8" studs + fiberglass	0.10	0.07	0.05	0.05	0.04	0.04	82.28	57.60	41.14	41.14	32.91	32.91
Floor - Dance Floor	1645.60	Marley Vinyl Dance Floor	0.01	0.03	0.03	0.03	0.03	0.02	16.46	49.37	49.37	49.37	49.37	32.91
Ceiling - Wood Slats	665.78	CeilingsPlus Barz	0.12	0.38	0.95	1.08	1.10	0.99	79.89	253.00	632.49	719.04	732.36	659.12
								∑Sα =	640.64	748.39	1249.39	1369.48	1456.92	1349.06
								Avg. α =	0.12	0.13	0.23	0.25	0.26	0.24
			Air absorption constant for 20°C and 40% RH, *m*						0	0	1.83E-04	3.26E-04	7.86E-04	2.56E-03
			Sabine Reverb Time: (s)					RT =	2.31	1.97	1.16	1.05	0.95	0.89
			Norris-Eyring Reverb Time: (s)					RT =	2.17	1.84	1.03	0.92	0.83	0.80
								Calculated RT (s)	**2.17**	**1.84**	**1.03**	**0.92**	**0.83**	**0.80**

Plot // Initial, New and Adjusted Design RT



Evaluation

From the graph above, the RT for both the original design and the new design are lower than the selected design target. The original reverberation time of 0.57 could be due to the acoustical consultants on the original project choosing a lower RT target. According to ANSI 16.20 (acoustical standards), an educational classroom should not have a higher RT than 0.70, if the acoustical consultants took this into effect, it could result in a lower reverberation time than the chosen target of 1 second. Furthermore, the new design is also far below the target set. After speaking with Dr. Michelle Vigeant, the acoustical professor here at Penn State, it was agreed that the previous acoustical consultants were aiming for a classroom standard and therefore so should this project.

As addressed above, the only change made from the original design to the new design was the wood slat system replacing the metal perforated ceiling, these changes are highlighted in green on the chart. These changes resulted in RT of 0.60 seconds which is very good for speech conditions in a space of this size.

If the acoustical consultants desired a target RT of around 1.0 seconds which is recommended for Dance Studios, a few items can be adjusted within the room. For instance, the acoustical panels that cover about 50% of the plenum ceiling area can be removed completely. Furthermore, the acoustical panels on the north and east walls can be switched out for a similar yet less absorbing material. The original panels were *FabriTrak* 1" Fabri-Tack panels with a NRC of 0.80, the new panels are *FabriTrak* ½" Fiberglass panels with an NRC of 0.50. The breakdown of the sound absorption coefficients can be seen in Table 43. This adjustment results in an adjusted reverberation time at 500 Hz for 1.03 seconds which is very close to the design target of 1.0 seconds.

Table 43 - Original and Adjusted Acoustical Panels

Item	Description	Frequency (Hz)						NRC	SAA
		125	250	500	1000	2000	4000		
FabriTrak 1" Fabri-Tack	1/6" Fabri-tack glass strate + 5/6" Fiberglass acoustic core material	0.16	0.4	0.82	0.96	0.92	0.9	0.8	0.77
FabriTrak 1/2" Fabri-Board	Fiberglass 1/2" acoustic core material	0.08	0.05	0.35	0.7	0.84	0.94	0.50	0.49

In the new design, with the new ceiling (CeilingsPlus Barz) system, the acoustical material remains just as spread out throughout the room, yet can be adjusted to a higher recommended reverberation time of 1.0 seconds. Though, since the ANSI 16.20 standard is more than likely required in this space by the owner or by code, the changes to the acoustical panels is not recommended to achieve the target reverberation time in the Dance Rehearsal Space of 0.60 seconds and an overall acoustically sound system for speech.

Landscape Architecture Breadth

Introduction

The Winsor School has a large amount of greenery around their campus, more than is usual for an area as urban as Brookline. The campus is located on seven acres of land with about one third of that dedicated to sports fields and a central main lawn. The classic lawn is expansive and flat with a scattering of historic maple trees. The newest addition to the campus, the Lubin-O'Donnell Center, brings many new and modern designs to the campus and the lawn. The existing plaza on the exterior of the Lubin-O'Donnell Center is simple and understated falling away into the rest of the campus. The space is meant as a respite for relaxation during performances and sporting events and therefore should have an impact on the occupants just like the building does to this campus. Like the building it serves, it should employ new and modern designs while taking into account the classic setting.

Overview

Form

The plaza can be considered rectangular in form but because of its ratio between its length and width, the form also resembles a linear path. The actual dimensions of the plaza are 140 feet by 21 feet for a total area of 2,940 square feet. There are infinite ways to approach a space of rectangular or linear form, *Foundations of Landscape Architecture by Norman Booth*, features several recommendations for rectangular and linear paths. For rectangular spaces, spatial depth is important. The space will be perceived as long and narrow due to its proportions and therefore it is important to accentuate the width of the plaza by interjecting forms that are perpendicular to the path of the plaza. Also important is to take into account laying a foundation for multiple spaces within the larger plaza and coordination of materials between spaces. Rectangular plazas are best perceived under a relatively flat plane and the plaza design should follow suit.

Campus Programming

The plaza, located on the southwest façade of the building, connects three pathways (one path towards the main academic building, one path from the exterior sport fields and one path that wraps around the side of new Lubin-O'Donnell Center) and the Lubin-O'Donnell Center. There is a roadway southeast of the building with a fence dividing the path and the road, blocking access to it. Furthermore, west of the building is the main lawn and to the southwest is the turf sports field. Parking is located to the north of the building. The programming of the area around the building and the plaza are shown in Figure 70.

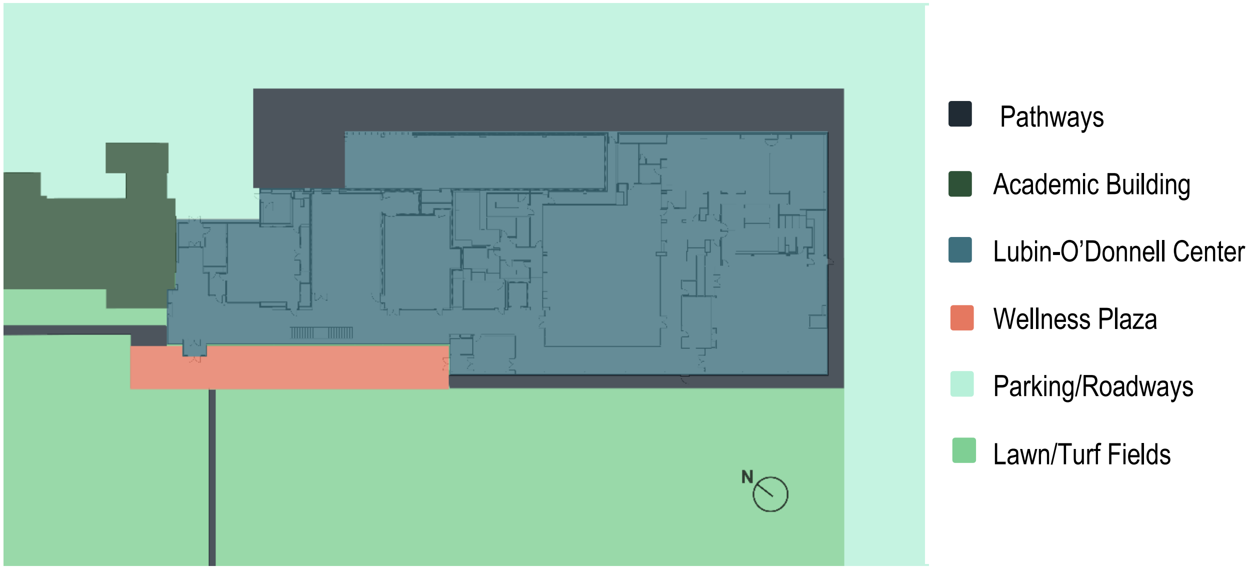


Figure 70 - Programming of Spaces

After laying out the programming of spaces within the area of the plaza, pedestrian traffic at buildings entrances (Figure 71) and probably routes of individuals to points of interest in the building (Figure 72 and 73) were also studied.

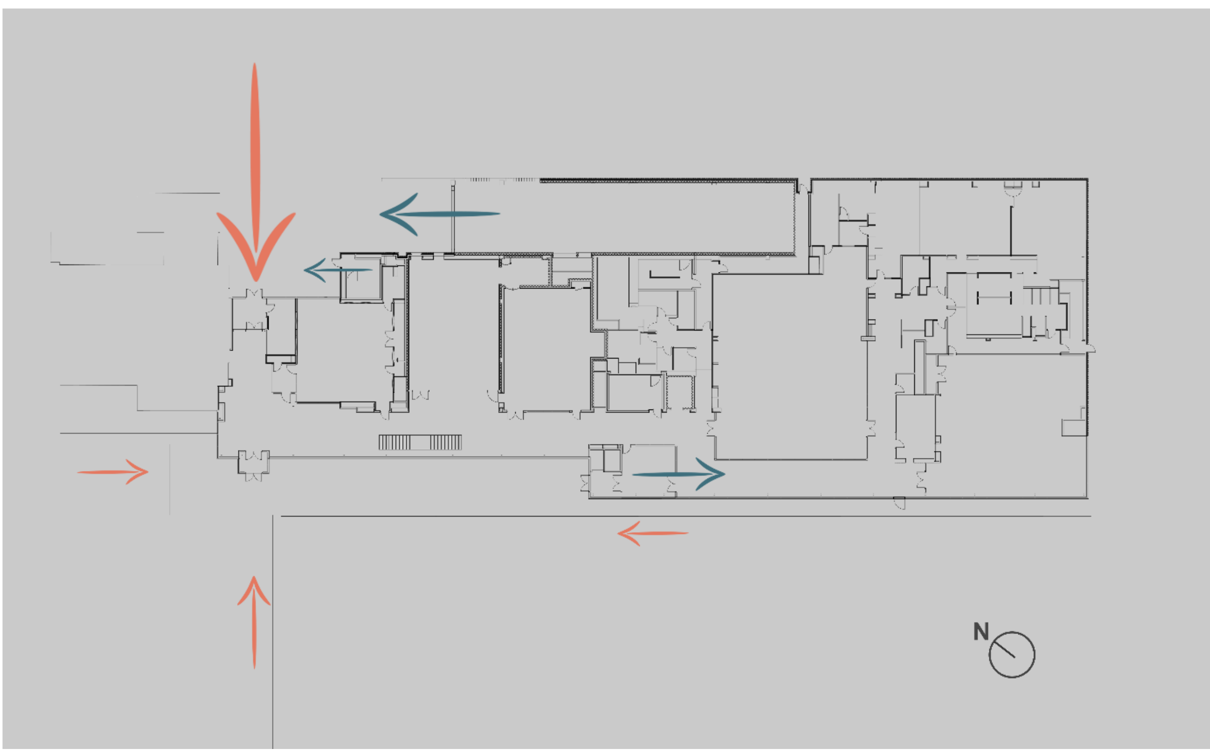


Figure 71 - Pedestrian Traffic at Building Entrances

As, Figure 71 shows, most of the traffic will be coming through the main entrance located on the northeast façade of the building, denoted by the largest arrow. The on-site parking facilities, major transportation points such as the local bus and the MBTA "Longwood" Green Line Stop would all direct pedestrian traffic toward this main entrance to the Lubin-O'Donnell center. If someone is already on campus or finding parking elsewhere, they could possibly use the secondary entrances on the southwest façade of the building, denoted by the smaller pink arrows. Finally, the green arrows denote future paths of pedestrian traffic. The next phase of construction for this site is an underground parking garage beneath the building with pedestrian exits throughout the building as shown.

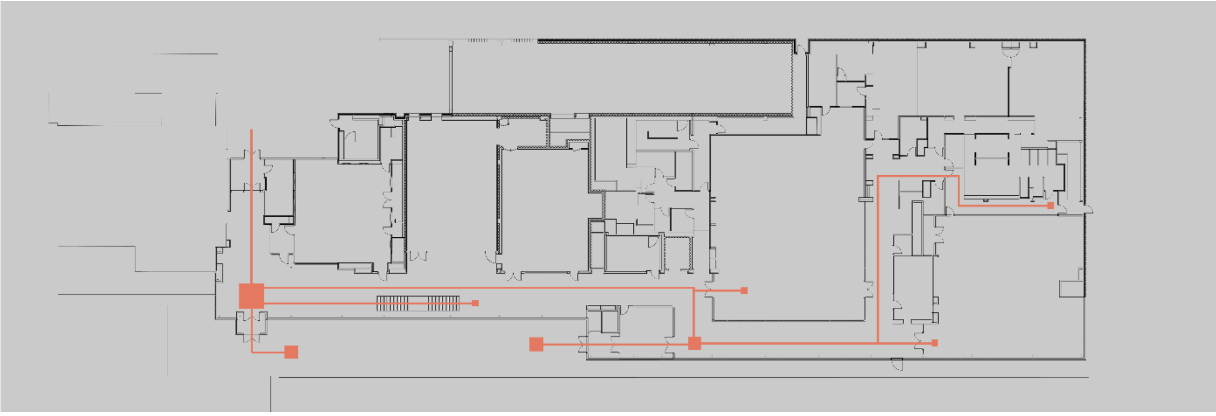


Figure 72 - Possible pedestrian traffic routes to Athletic facilities

Figure 73 - Possible pedestrian traffic routes to Performing Arts facilities

Above, Figure 72 depicts possible routes of individuals traveling from the main entrance to the Athletic facilities inside the building. The routes lead to spaces such as the fitness center, student locker rooms, second floor gymnasium and fifth floor squash courts. The squares show the points of congregation or the end of movement. There is a large amount of possible congregation in the main lobby, just off the exit to the plaza and a smaller point of congregation near the wellness entrance and exit. Likewise, Figure 73 depicts possible routes of individual traveling from the main entrance to the Performing Arts facilities. The routes lead to spaces such as the dance rehearsal room, the drama rehearsal room and the second floor theatre. The larger circles depict the points of congregation or the end of movement. The points of overlap could lead to overflow of socialization into the plaza area during, after or before Athletic or Performing Art events. Furthermore, these routes occur along a glass curtain wall so the visual interest of the plaza is also critical.

Plaza Programming

After the interaction between the site, the building and the plaza was examined, it was concluded that the plaza's function is more social and tranquil than transitional. While there should be a means to get from point A to point B, it doesn't have to be a straight line. Therefore, the plaza programming was laid out in Figure 74. The green circles denote points of possible social interaction, while the pink rectangle denotes points of high visual interest. Where there is a possibility of higher social interaction, the plaza design should respond by allowing more areas for people to group together and the opposite is true for the locations of visual interest. The area of visual interest should be a focal point for individuals both inside and outside.

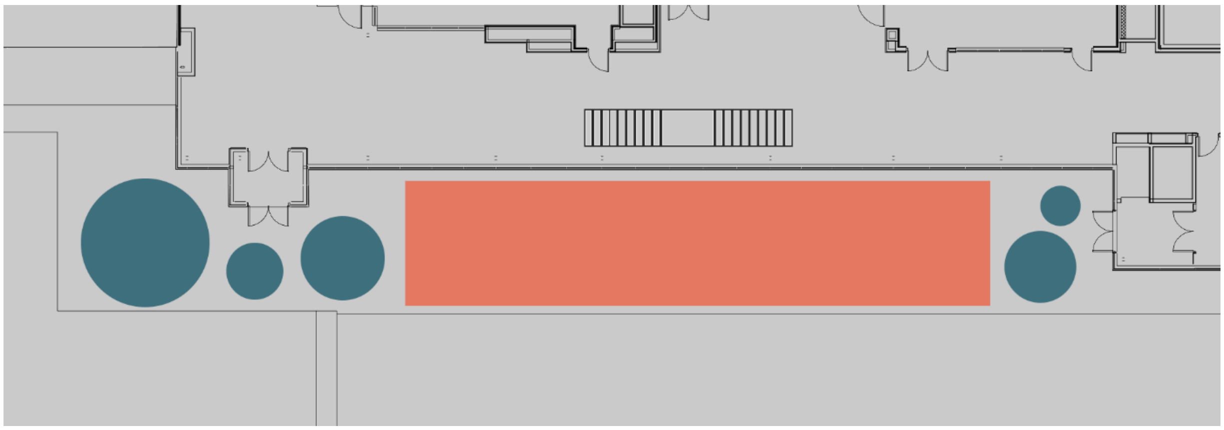


Figure 74 - Plaza programming

Climate

The plaza is located along the southwest façade of the building. The sun will be on the plaza and any of its plantings for the entire afternoon, which is also the warmest part of the day. Therefore, any plants chosen must be able to survive in full sun, with little to no shade. Another important aspect for choosing vegetation for its climate is to pick plants suited for their correct USDA zone. The map in Figure 75 shows the US Department of Agriculture's Plant Hardiness Map. The map is based on an average minimum winter temperature for which plants can still survive. The map is divided into 10 °F zones. Boston, and this site in particular is located in Zone 6b.

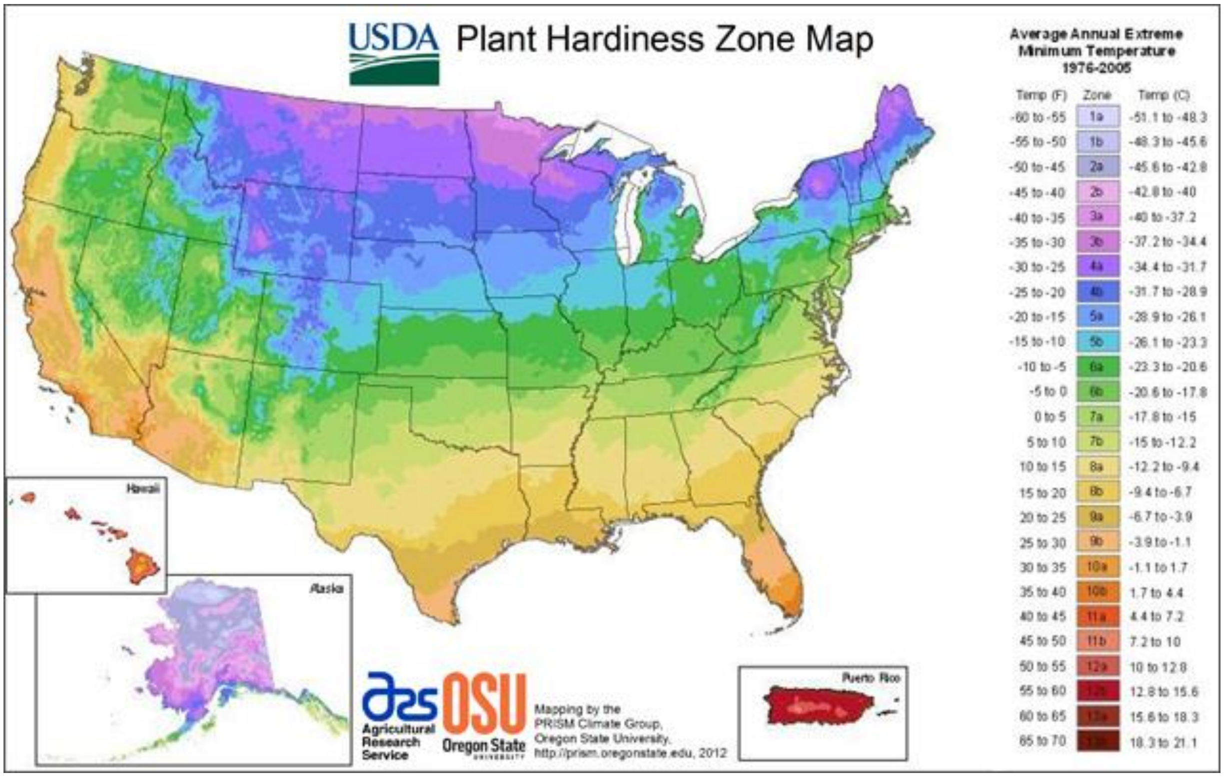
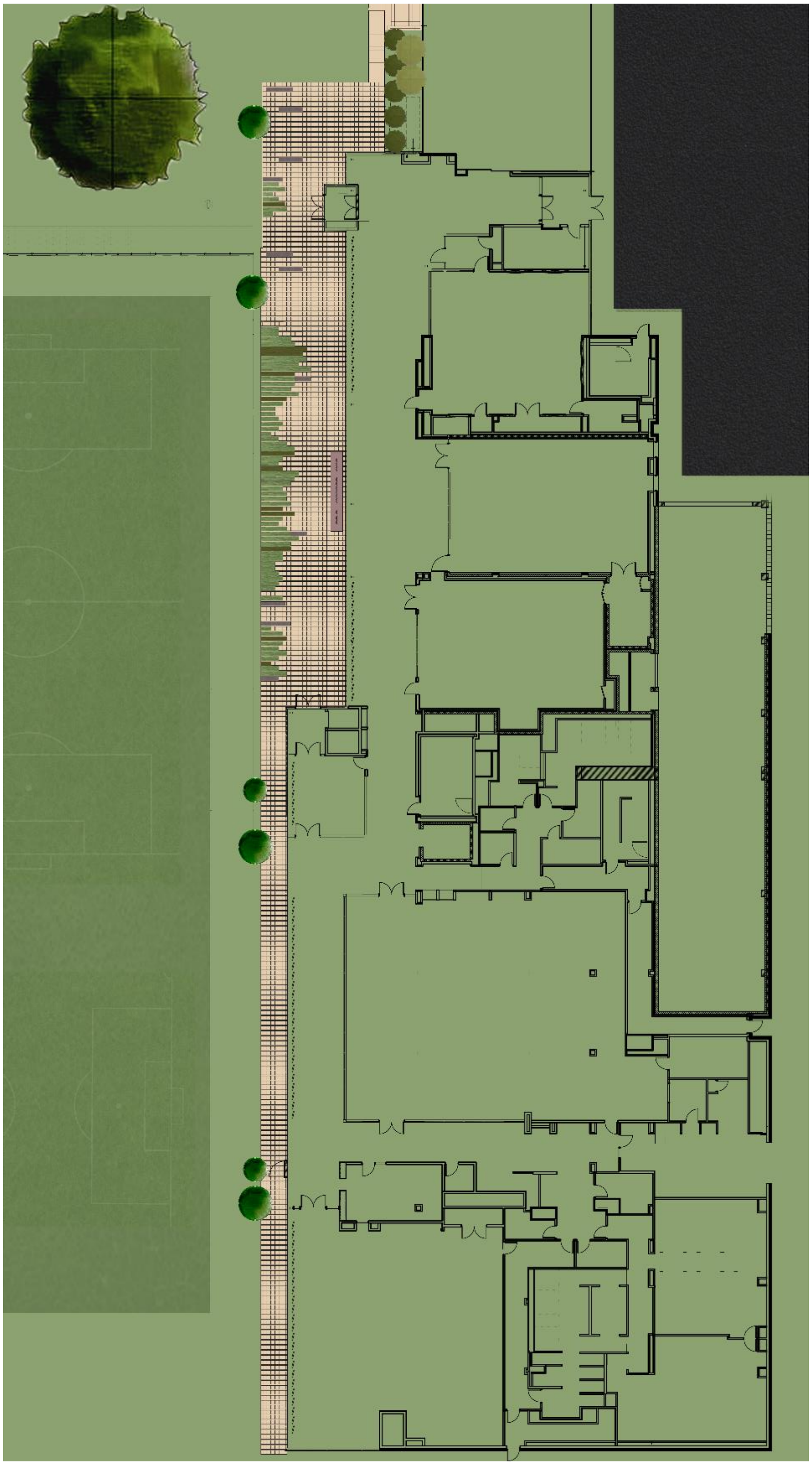


Figure 75 - USDA Plant Hardiness Zones - Boston is located in Zone 6b

Proposed Design

The landscape design makes use of the programming and form techniques listed above. The design was broken down into public and private areas. Around the exits and entrances of the plaza, groupings of benches were placed to encourage social interaction. Along the area where a higher level of visual interest is warranted, a movement of architectural patterns is created with concrete paving, vegetation and carpet-like greenery in neat linear rows. Benches are scattered randomly for those who seek solitude and grouped together for those who do not. Trees, seemingly placed at random, actually are not. Their locations provide a secondary layer of shade and daylighting for the interior spaces where it was lacking before. The linear interjections lead the eye from the horizontal campus, across the plaza and into The Winsor Schools newest building. The plaza is geared towards a relaxing and meandering atmosphere reminiscent of a park of the past while implementing modern landscape design. Interjecting the green of the classical main lawn into the threads of the modern design world. A plaza to mold the classic into the modern as well as pay tribute to the buildings functions. Like the performing arts and athletics within the building, the plaza's design resembles a playful movement and promotes it with the accented musical statue. This exterior statue follows the linear staccato design of the plaza while creating a musical element that students, children and parents alike can use to create their own music. It is also an artistic signage for the school, the patterns of the musical tubes resembles a speech sound wave of The Winsor School. For a larger drafted and scaled plan, please see Appendix F – Drawing LP9.

Photoshop Rendered Plan



Vegetation

All low-level vegetation was chosen based on the following qualifications:

- Low maintenance for future upkeep
- Evergreen or mostly evergreen in Boston's climate zones
- Hardy in harsh environments like the linear pavings
- Low height and barrier conscious, will not overstep it's given boundaries
- Needs full sun to partial shade

Planting A // Sagina Subulata "Irish Moss"

This moss is a soft and sponge like groundcover with a carpet-eques look. The groundcover is not particular about the soil it grows in and is considered evergreens in USDA climate zones four through six but can survive in zones four through nine. It is hardy enough it can be walked on and it is one of the few mosses that is for full-sun to partial shade. The moss is very low maintenance and after it is developed, no maintenance is necessary. It is recommended for rock gardens or high paved areas especially if the paving is of a gray color. The moss is native to Europe though grown heavily now throughout the United States.

Planting B // Heuchera Coral Bells "Plum Pudding"

The Coral Bells "Plum Pudding" is a groundcover perennial. It is known for its purple burgundy color and ruffled leaves. It will grow to its full height of one foot unless maintained, though it is slow growing and requires little maintenance otherwise. It is recommended for contained spaces such as planters or within pavers. It is considered an evergreen that can be located in full sun and is hardy in USDA climate zones four through nine. It is native to the United States and also is known for attracting butterflies.

Planting C // Schuzachyrium Scoparium "Little Bluestem"

Little Bluestem is an ornamental grass that grows in a slender and columnar fashion. It maintains a relatively low full height for grasses, growing to about one to two feet high. This evergreen, though referred to as Bluestem, the Blue/Green color occurs in the winter to early summer, it then transitions to a mahogany red from the late summer to winter. The grass needs full sun to partial shade and it can survive in most soils. It is hardy in USDA climate zones four through nine and native to the United States.

Planting D // Caprinus Caroliniana “American Hornbeam”

The American Hornbeam is often recommended for locations with limited space for growth. It qualifies as a small to medium range tree or large shrub and will grow slowly to a full height around thirty to thirty three feet. Though it grows best in partial shade, it will grow in full sun and many different soils. It has an insignificant amount of flower growth in the spring and the leaves are deciduous, small and elliptical. They will grow into a dark green during the summer and change from yellow to orange to red before they fall off in the early winter. Their branches are extremely dense and can still provide a large amount of shade, even during the winter season. They are a very low maintenance tree with no history of problems with insects or disease and are native to eastern North America.

Materials + Furniture

Material 1 // Socrates Bench

The bench is made of reinforced cast stone with precise geometric form and a polished finish. The bench was envisioned as more of an occasional piece than a normal bench. The bench sits on a low plinth to appear as if the bench is floating. The piece requires low maintenance and durability to increase its life and enhance its product.

Music Sculpture

The Music Sculpture is one of the main points of interest in the plaza. It is modeled after the ‘The Musical Fence” sculpture by Paul Matisse completed for the City of Cambridge. It is a sculpture of hollow aluminum pipes incased in concrete. Its musical features appear when someone hits one of the tubes and the sound reverberates. Each pipe is a different height to allow for many different sound combinations, but the pipes heights were not selected at random. A speech sound wave was created of the words “The Winsor School”, this can be seen in Figure 76. The heights of the poles were modeled to resemble this sound wave and provide and artistic representation of the schools image.

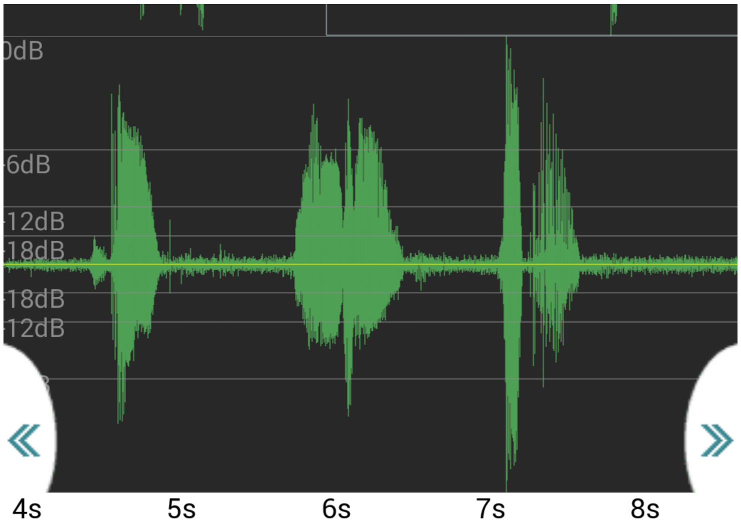


Figure 76 - A sound wave graph of "The Winsor School"

The tubes begin at two and half feet off the ground to allow even small children reach it, the tubes then extend up to six feet into the air to give a commanding presence within the space. It is also located underneath an overhang, this will provide the sculpture an extra layer of shelter during various weather conditions. Overall, the sculpture blends the movement, the music and the art that The Winsor School thrives on.

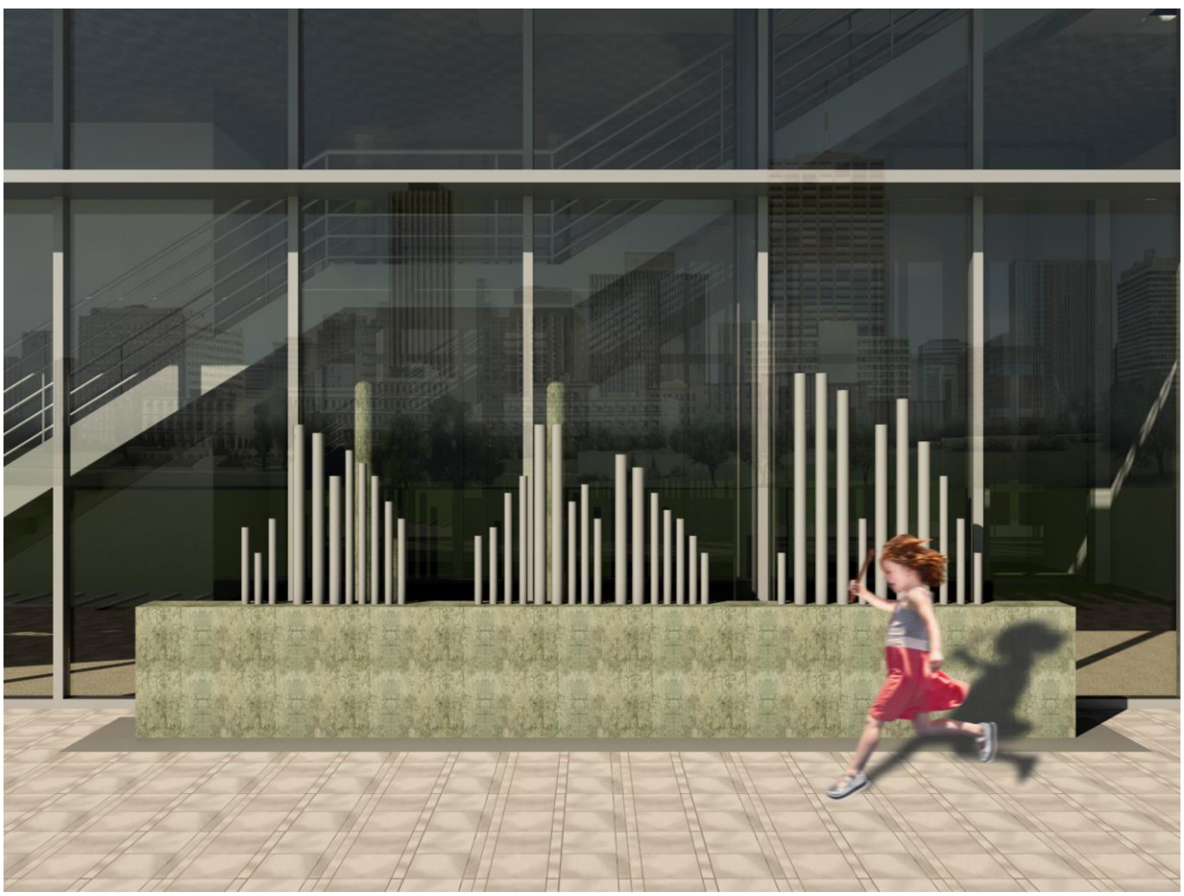


Figure 77 - Revit Render of the Musical Sculpture, Little girl added via Photoshop CS6

Final Perspective Renderings

Figure 78 - Perspective Landscape Rendering - Building rendered in Revit 2015; Landscape, People, Shadows and Background were added via Photoshop CS6

Figure 79 -Perspective Landscape Rendering - Building rendered in Revit 2015; Landscape, People, Shadows and Background were added via Photoshop CS6

Conclusion

The Wellness Plaza is an area of social interaction and congregation. It is a secondary entrance and exit, but mostly will be used for rest and relaxation during performance and athletics events at the school or by students during the school day. It utilizes both public and private based on pedestrian traffic and potential routes and creates visual interest for those in the plaza and walking within the school. The plazas low maintenance design blends the classic grass lawn with modern design elements in a playful manner suited towards the Winsor School. The plaza makes a statement for the future of the Lubin-O'Donnell center and the movement within it.

Conclusion

Conclusion

Summary

This concludes the thesis report for The Winsor School, Lubin-O'Donnell Center. The end goal of the Architectural Engineering Senior Thesis is to use knowledge accrued over our five years in school to integrate specialties with overall background knowledge across options. For this report, that meant designing lighting and electrical systems then recognizing and learning how these changes can affect all other aspects across disciplines. Redesigning or adjusting the designs was the final step so all systems could work and flow together as one.

The design, and in particular the lighting design, improved the design goals of the school by implemented modern design built on classic traditions that embodies the women at this school. The electrical branch circuit redesign was studied based on the architectural lighting changes, as well a short circuit current protection calculation to make sure the lighting system remained a safe design. An electrical cost analysis of emergency mineral insulated cable was performed and the result found a substantial potential savings for the owner upon switching some distribution feeds to metal clad cable. The daylighting depth, with its operable rotating vertical fins and light shelf, created an innovative occupant friendly design and a pleasing indirectly lit space. The acoustical breadth reacted to the grand ceiling of the Dance Rehearsal space to adjust the reverberation time for speech and classroom standards. Finally, the landscape architecture breadth redesigned the meandering Wellness Plaza combining the modern building to the traditional main lawn, creating a space for students, faculty and parents to relax and socialize.

After much design, redesign, research and performance analyses, this final report was written with all technical challenges and decisions for The Lubin-O'Donnell Center for Performing Arts, Athletics and Wellness. The end result is an integrated and modern building to move The Winsor School into the future and cement its status as prominent women's preparatory school for decades to come.

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