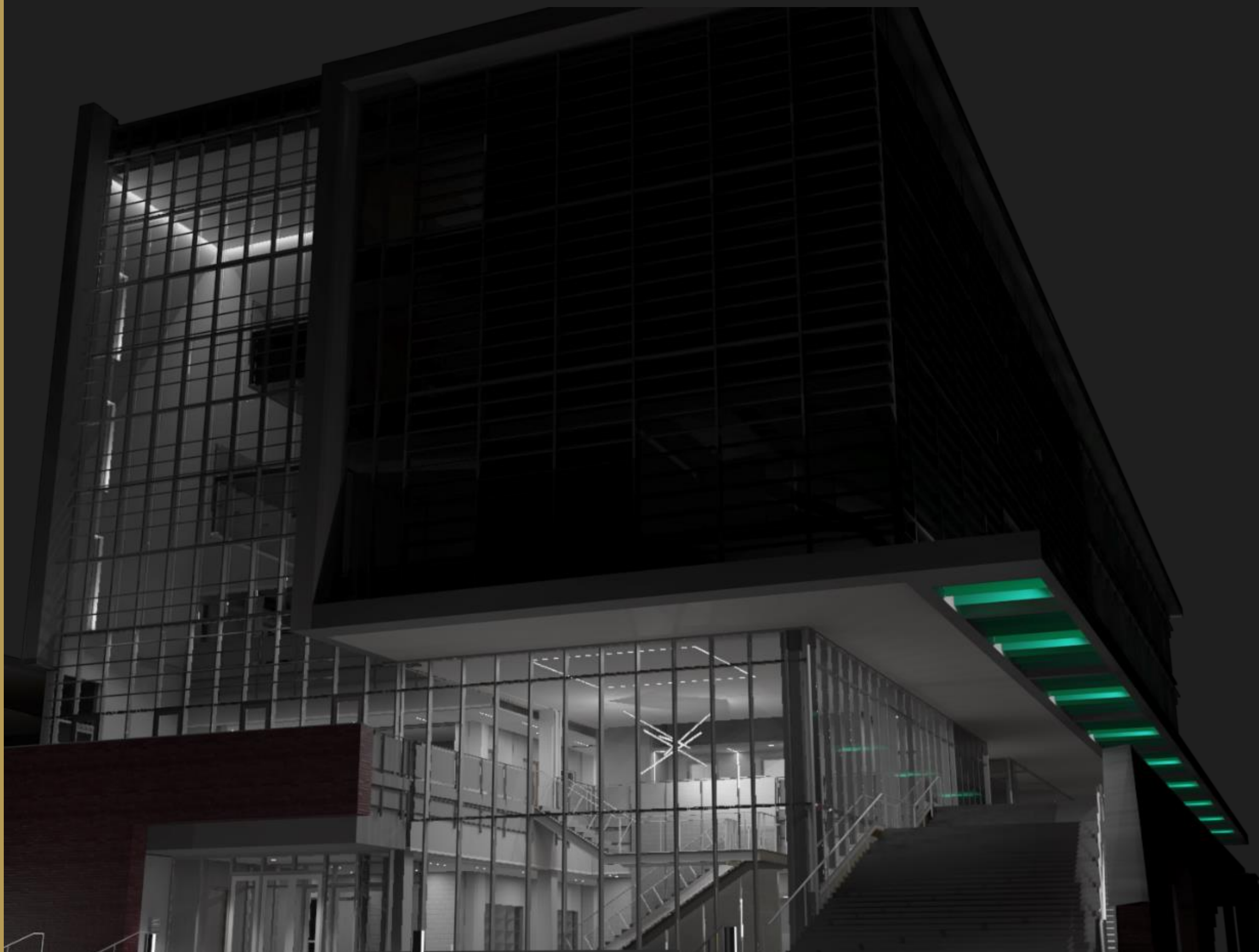

OAKLAND UNIVERSITY ENGINEERING CENTER

ROCHESTER, MI

SENIOR THESIS FINAL REPORT

JOHN CONLEY | LIGHTING + ELECTRICAL
SHAWN GOOD | FACULTY ADVISOR

04.08.2015

OAKLAND UNIVERSITY

engineering center
rochester, michigan

john conley | lighting + electrical

general building statistics |

occupant | Oakland University, School of Engineering and Computer Science

occupancy or function types | 2 Buildings separated by firewall; Building A is MBC TYPE IIB, NFPA TYPE II(000) and Building B is MBC TYPE IB, NFPA TYPE II(222)

size | 136,653 GSF

levels | 5 all above grade

dates of construction | January 2013 – September 2014

estimated cost | $57 Million Construction Cost

project delivery method | Design-bid-build

architects + engineers | SmithGroupJJR

construction manager | Walbridge Aldinger Company

Figure 1 South Lobby perspective | SmithGroupJJR

Figure 2 Lecture Hall perspective | SmithGroupJJR

architecture |

The new Engineering Center is a state-of-the-art facility for research and education within the School of Engineering and Computer Science and consolidates four departments under one roof. This building is designed to foster curiosity, research enthusiasm and student collaboration.

lighting + electrical |

The lighting and electrical systems consist of:

- Low voltage LED and FL fixtures with clean aesthetic
- Primary service 13.2KV down to 480/277V 3PH, 4W from a substation transformer.
- Step-down transformers per floor 480Y/277V down to 208Y/120V 3PH, 4W
- Rooftop natural gas generator which provides 480V power to the emergency panels

mechanical |

The main mechanical systems are located on the penthouse level and include two centrifugal chillers both with a nominal capacity of 290 tons, two turbogenerators, and the main air handling unit supplying 5200 CFM to the building.

structural |

The structural system of the building consists of:

- Concrete footings and slabs
- Steel decking
- A framework of steel beams and columns
- Reinforced CMUs on the lower level perimeter

EXECUTIVE SUMMARY |

The following report is the culmination of a semester of work to research the building, study redesign possibilities, and develop final designs and recommendations. The report focuses on the lighting and electrical aspects of the building as the senior thesis depth topics. Additionally, a daylighting study was performed as an MAE special topic based on work done in graduate courses. And finally, two breadth topics were studied to display the wide base of knowledge that the Penn State Architectural Engineering has provided.

The existing lighting for four select spaces in the new Engineering Center at Oakland University was redesigned. The lighting redesign is focused on a central concept of furthering the engineering industries through the studies undergone at Oakland University which ultimately pave the way for progress. The lighting design also attempts to accent the very geometric forms of the Engineering center and provide spaces that are visually appealing and conducive to collaboration.

From these redesigns, the effects on the electrical system were analyzed and branch circuits were altered to show the differences in connected loads. The electrical system was not drastically altered and no changes would have to be made to the main electrical equipment.

The two breadth topics, as well as the daylighting analysis are centered around the addition of three Kalwall pre-engineered Skyroof products to the project labs space on the first level. The main purpose for these skylights was to increase the daylighting in the project labs space to further the lighting concept and save energy through photosensor dimming of the electric lighting. The addition of these skylights also decreased the structural dead load providing the possibility to downsize the members directly affected by this decrease. Hand calculations were done to show this possible change in structure. Likewise, the mechanical heating and cooling loads were affected by the addition of the skylights and analyzed. A simple payback period was calculated based on an official quote of the Kalwall system and final recommendations are given.

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BUILDING OVERVIEW |

General Building Data

Building name | Engineering Center

Location and Site | Oakland University, Rochester, Michigan

Building Occupant Name | Oakland University, School of Engineering and Computer Science

Occupancy or function types | 2 Buildings separated by firewall; Building A is MBC TYPE IIB, NFPA TYPE II(000) and Building B is MBC TYPE IB, NFPA TYPE II(222)

Size | 136,653 SF (Gross)

Number of stories above grade / total levels | 5 / 5

Primary project team |

Owner	Oakland University (http://www.oakland.edu/)
Architect	SmithGroup JJR (http://www.smithgroupjjr.com/)
Lighting Designer	
MEP Engineer	
Structural Engineer	
Civil Engineer	Johnson & Anderson (http://ja-engr.com/)
Audiovisual, Telecommunications, Security, Acoustics	Convergent Technologies (http://www.cti-usa.net/)
Construction Manager	Walbridge Aldinger Company (http://www.walbridge.com/)

Dates of construction | January 2013 – September 2014

Actual cost information | $57 Million Construction Cost

Project delivery method | Design-bid-build

Architecture

Southeast Perspective | Courtesy of SmithGroupJJR

Southwest Perspective | Courtesy of SmithGroupJJR

Design | This new Engineering Center for Oakland University's campus is a much needed addition to the campus in terms of faculty office, classroom and research lab space for the campus' ever growing school of engineering and computer science. As the new heart of Oakland University's School of Engineering and Computer Science, this building needs to provide the appropriate spaces for the improvement of teaching, learning and research. The building's program of spaces includes, 1000 seats of classroom space, 200 seat lecture hall, SECS (School of Engineering and Computer Sciences) office spaces, departmental office spaces, faculty office spaces, student office spaces, class laboratories, research laboratories, clean rooms and study spaces including a café. This building, for those involved at Oakland University, is a symbol of future growth of the university and the School of Engineering and Computer Science (SECS), interdisciplinary collaboration and an incubator of ideas in research and learning.

The design aesthetics of the building are intended to be very raw and geometric in nature. That being said, there were attempts, architecturally, to tie the building into the campus fabric through the use of the brick on the lower levels to reflect the older buildings on the campus and the modern feeling panels and curtain walls to reflect the more recent projects completed on the campus. The building sits on a hill and creates a nice transition from the upper level near the campus library to the lower parking area as well as helping to create more of a quad feeling in the upper area and a nice stair feature for transition through the campus. The new Engineering Center is to be a tangible symbol of the future for Oakland University and the School of Engineering and Computer Science.

National Model Codes | The main codes used by the architects and engineers while designing include: The Michigan Building Code 2009 (MBC 2009) which is an amended version of IBC 2009; the Michigan Fire Prevention Code MFPC which adopts NFPA 1; Michigan 2008 Electrical Code incorporating National Electrical Code 2008 (NEC); the Michigan Plumbing Code 2009 (MPC) which is an amended version of the International Plumbing Code 2009; the Michigan Mechanical Code 2009 (MMC) which is an amended version of the International Mechanical Code 2009; 2003 ICC/ANSI A117.1 2010 ADA Standards for accessibility and usability.

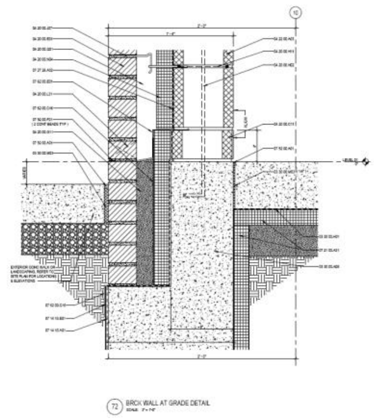
Zoning | For zoning purposes, Oakland University is located in both the Auburn Hills zone and the Rochester Hills zone. The Engineering Center will be situated within the Auburn Hills zoning ordinance under a special purposes designation. According to Article X, Section 1000 Special Land Uses Permitted, colleges, universities or other institutions of higher learning have to comply with three stipulations: First being that to be considered in this special purpose designation the site must be greater than 40 acres. The second, is that the ingress and egress from the site must be onto a major or secondary thoroughfare. And third, no building can be closer than 75 feet from any property line unless it is for one family residential purposes.

Historic Requirements | There are no historic requirements to adhere to in the design of this new engineering building for Oakland University’s campus.

Building Enclosure

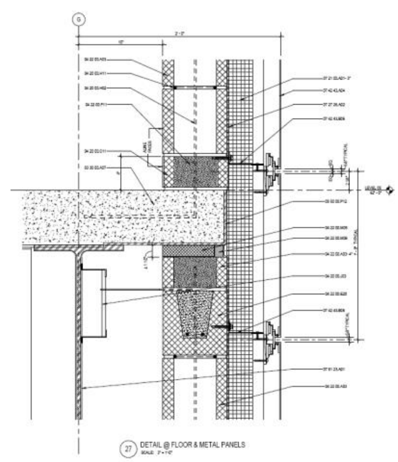
Building Facades |

Brick Walls | The exterior brick facades, found on the lower two floors of the building, are typically made up of a veneer face brick tied back into a CMU wall with dovetail wire anchors, an air space, fluid-applied vapor-retarding membrane, then the concrete wall separating the exterior from the interior wall structures.



Courtesy of SmithGroupJJR

Panel Walls | The metal panel walls, found in the upper floors of the Engineering Center, include a zinc faced composite wall panel connected to the structure with adjustable framing angles which allows for room for an air space and XPS-1 extruded-polyestrene board insulation followed by the concrete masonry unit wall assembly.

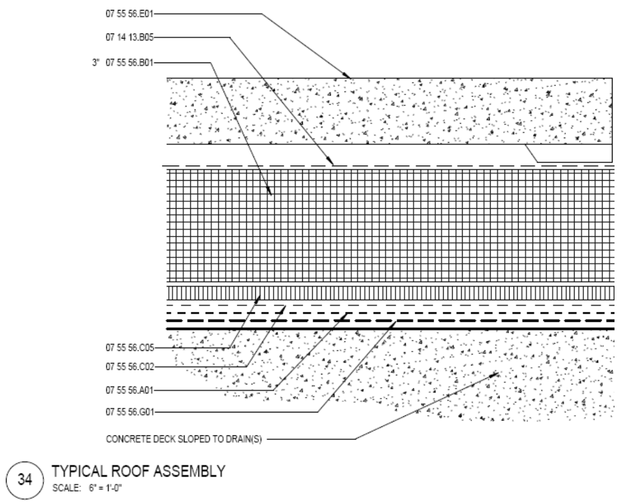


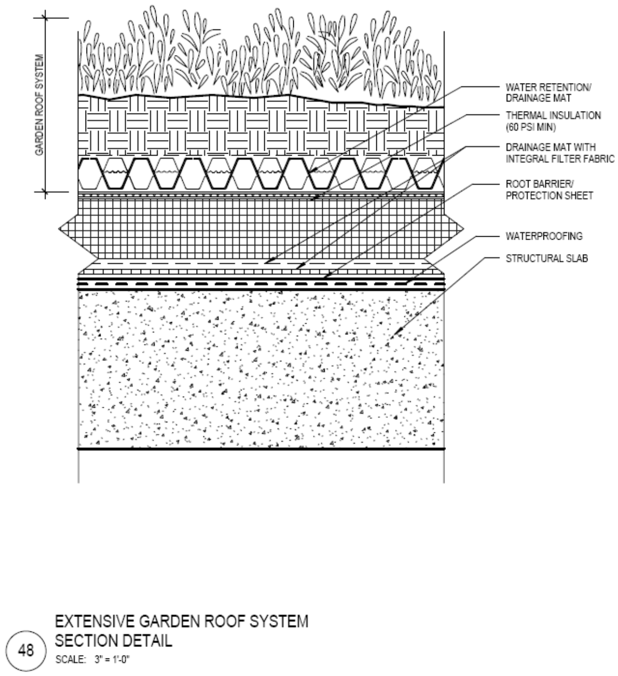
Panel Façade Section | Courtesy of SmithGroupJJR

Curtain Walls | The curtain wall system utilizes two sided structural sealant glazed curtain wall with 1" insulating glass with ½" argon airspace and a visible transmittance of 79% as well as vertical mullion mounted sunshade system which is horizontal louver based and angled down at 20 degrees.

Atrium Section showing exterior glazing and shading louvers | Courtesy of SmithGroupJJR

Roofing |

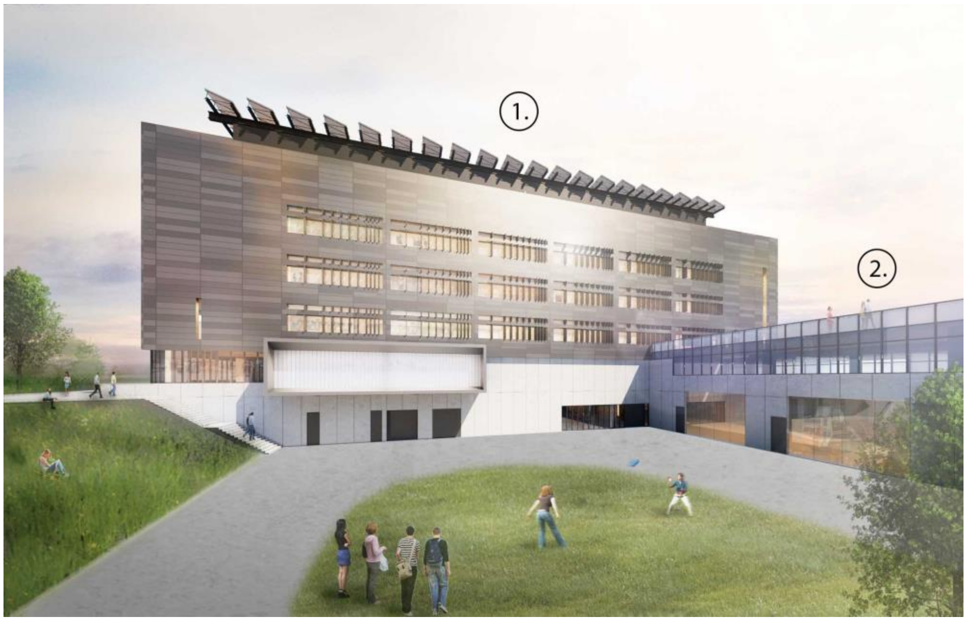




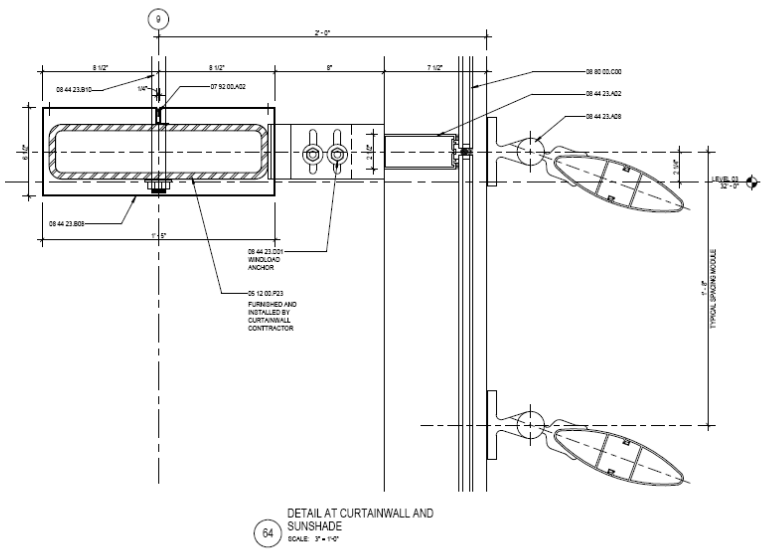
A section of a typical roof (left) as well as the garden roof (right) | Courtesy of SmithGroupJJR

A typical roof section, shown above on the left, contains, from the structure to the exterior, surface conditioner, fluid-applied protected membrane roofing, protection course, drainage panel, three inches of semi-rigid insulation, a filter fabric and another later of concrete which is a precast concrete roof paver. For the garden roof assembly we have, waterproofing, root barrier protection sheet, drainage mat with integral filter fabric, thermal insulation (60 psi minimum) and a water retention drainage mat all below the actual garden roof system.

Sustainability Features



West Perspective with two sustainability features | Courtesy of SmithGroupJJR



Curtain wall and sunshade section detail | Courtesy of SmithGroupJJR

Of the sustainability features included in the design of this building, the ones that are most apparent are the photovoltaic panels on the main roof (1 above), the garden roof on the lower roof (2 above), and the sun shading features on the South curtain wall façade. The photovoltaics, create energy for the building's use, provides a testing ground for the energy research that the school foresees in their future and compliments the overall aesthetic of the building giving it an interesting and raw quality. The lower roof garden will aid with the heating and cooling of the lab spaces below and also provide the students and faculty a nice environment to walk around. The sunshades on the curtain wall façade on the South side of the building will provide shading to the interior and let in a smaller portion of the total daylight into the atrium space and also add another layer to the curtain wall aesthetic. The designers and construction managers along with Oakland University are targeting a LEED Gold Certification upon completion of the project and have outlined a plan so as to obtain this.

Construction

Walbridge Aldinger Company was the construction manager at risk for this project. They started work on the construction in January of 2013 and finished up construction in late August of 2014 opening the Engineering Center for use in the fall 2014 semester. As part of the construction of this new facility for the School of Engineering and Computer Sciences, they also renovated 15,000 square feet of space in other buildings that the SECS previously occupied on campus.

Electrical

Utility power, at 13.2 kV, enters the building on the ground level into a designated substation room. The substation room contains two transformers taking the voltage down to 480Y/277V power, which travels through feeders to the electrical rooms on each level and multiple 480/277V panels in the substation room. There are designated electrical rooms on every floor including the penthouse level. Within each electrical room are step-down transformers from 480Y/277V power to 208Y/120V which supplies the power to branch panelboards powering the receptacles, mechanical equipment, and some lighting.

The emergency power is supplied by a 225A natural gas generator in the penthouse provides the power to the fire pump controller from a 480Y/277V panel. Two turbogenerators are also located in the penthouse and provide the power to the other necessary amenities for life safety including emergency lighting, elevators, stair pressure fans, lab and atrium exhaust fans, sump pumps, atrium coiling doors, and the other loads on the legally required panels.

Lighting

The lighting design for the Engineering Center is energy efficient, functional, fairly minimalistic, and pleasingly accents the architecture of the spaces. Each space was evaluated both quantitatively and qualitatively to provide the building with a solution that works with the architecture and provides quality lighting. The building primarily uses LED and linear fluorescent fixtures. The spaces with one or two main tasks are simpler in design and contain a minimal number of fixture types. Those that are more public and more complex, in terms of task, have more complex and visually appealing lighting schemes with points of interest and layers of lighting.

A very important aspect of the lighting scheme is the use of controls. The larger classrooms are all equipped with Lutron lighting controllers to provide zonal control and scene control of the spaces as well as interface with projector and projector screen control. Daylight dimming photocell sensors are used throughout the building for lighting dimming purposes to save energy by supplementing daylight for electric light. Combination occupancy/daylight/HVAC sensors are also used to turn on lights and HVAC systems when occupied as well as dimming as daylight increases.

Mechanical

The air handling system for the Engineering Center comprises of one 5200 CFM capacity air handling unit in the penthouse of the building, a 30000 CFM make-up air unit on the roof, and a 30000 CFM heat recovery unit also on the roof. These units provide the required air exchanges to all of the interior spaces through volume control boxes.

Cooling for the building uses two cooling towers, CT-1 and CT-2, rated 750 GPM each and an 8" main cooling loop servicing the building fan coil units and chilled beams. If the system is in a heating mode, heat exchangers connected to the system provide cooling as well.

General building heating is provided by a low temp heat recovery boiler that recovers heat from the exhaust of the turbine generators. The high temp heat recovery system also recovers the exhaust from the turbine generators and provides some heat to the building and some to the campus high temperature loop.

A building management system, or BMS, controls the mechanical systems in the building through a central control.

Structural

The structure of the Engineering Center consists of a concrete foundation, steel framing structure, and composite decking for the floors and roof. Foundations include 3000 PSF continuous footings, 35 PCF retaining walls, and 55 PCF basement walls. Structural beams are placed to account for building dead and live loads as per code in a manner that does not detract from the building aesthetic. The column sizes vary in size from W8x28 to W14x176 and are spliced for the longer column lengths. The composite slab typically consists of 2" depth 16 or 18GA steel decking, 4.5" deep normal weight concrete at 4000-PSI strength, and steel reinforcing.

The most interesting structural challenge on this project was the cantilevered stair structure in the southern lobby space. Here the engineers used an exposed beam structure to support the middle of the stair without detracting from the effect.

Fire Protection

Fire protection is important for both the safety of the occupants as well as the building. The building is fully equipped, in accordance with NFPA requirements, with smoke detectors, fire alarms and sirens, strobe lights, a sprinkler system, exit signs, fire-proofing, fire walls, and lab and atrium exhaust fans. On the first level there is a designated fire pump room with a 480V, 3PH, 3W, 100HP fire pump and a 480V, 3PH, 3W, 2HP jockey pump as well as a fire pump controller with wye-delta starter and integral automatic transfer switch. The systems necessary for life safety and code are all included on the emergency power.

Transportation

There are three elevators servicing the building and transporting occupants to all levels of the Engineering Center. Elevator #1 is 30HP and is controlled in room 100A. Elevator #2 is 30HP and is controlled in room 100B and elevator #3 is 45HP and is controlled in room 153A; elevators #2 and #3 are included in the emergency power scheme.

Another transportation related device in the Engineering Center is a wheelchair lift located in the 200-seat lecture hall and provides disabled individuals access to the bottom tier of the lecture hall.

Telecommunications

The Engineering Center uses many different telecommunications systems to be the most state-of-the-art a facility as possible. CATV and CCTV cables service the building's video surveillance and television systems. Each of the classroom spaces house projectors, projector screens, central control systems, video cameras, and audio speaker systems. Certain rooms and the building entrances require card reader access so as to keep the facilities safe. This facility is certainly equipped for the future for the School of Engineering and Computer Sciences.

LIGHTING DEPTH |

Overview

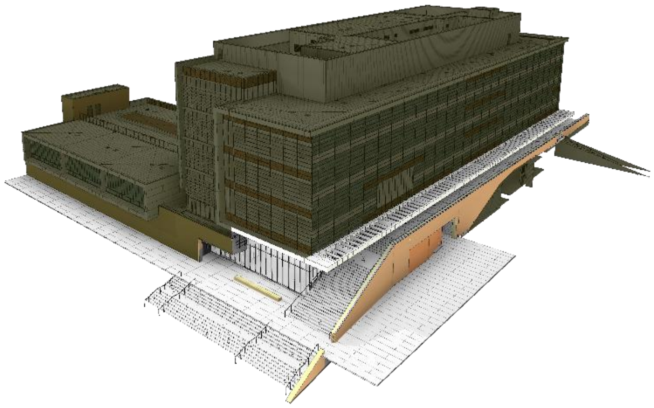
The lighting depth section of this report will explore the design development of four selected spaces in the new Engineering Center at Oakland University. The schematic design for these spaces were completed in the Fall 2014 semester culminating a presentation to the faculty advisor and another presentation at the Lutron facility in Coopersburg, PA to lighting design professionals. The comments that were received during both presentations were considered and further design on each of the spaces was conducted to refine and improve.

The spaces that were studied include: the exterior walkway that travels up the eastern side of the building from the southern entrance to the entrance on the north side of the building, the large transition area of the southern lobby and atrium spaces including the corridors that run into them, the 200-seat lecture hall auditorium, and the project labs large workspace in the western wing of the building.

Concept | Paving the Road to Progress

The design of these spaces is unified by a design concept that embodies the essence of the building and the goals of the occupants. Oakland University's engineering program has a close interaction with the automotive industry in southeastern Michigan. The work that they are doing in the engineering programs there is important as they hold the ability to ensure a more promising future in the automotive industry. They are "paving the road to progress" with the research and studies they undergo at school, building on the successes of the past in southeastern Michigan, and starting a new generation of engineers for the future of the automotive industry. The concept "paving the road to progress" focuses on automobile related ideas and the importance of collaboration, research, and innovation in the work that will be conducted in the new Engineering Center to further enhance the industry. This idea of a path, and a continuation from past to present embodies the idea that everyone has a part in this overall progress and that all of these individual paths intersect in points of studying the past and collaborating towards a common goal.

Outdoor Space | Covered Walkway + Stair



Space Locator

Description of Space

The exterior walkway stretches from the southern side of the building to the north and elevates from the first level of the building to the second. This is a major transition area for the building, with three entrances off of this walkway, and for the campus, with intersections with other paths and the connection to the parking lot in the south. The materiality of the exterior here is consistent with the rest of the building with brick exterior walls, concrete stairs and ground, and a metal panel overhang with green tinted architectural fins.

Concept

Figure 1 Exterior Schematic Design Sketch

With the heavy traffic potential and the importance of this main walkway for the building and the campus, the idea of an intersection of is going to be used to emphasize the lighting design. An intersection is a crossing of paths by definition, and as the students and faculty traverse the campus and share knowledge, these paths are crossed. The pathways will be clearly marked and the entrances to building are the intersections of the pathways and will be given importance through higher illuminances.

Design Criteria

The following is a list of important design criteria, both quantitative and qualitative, to reinforce design concepts and desires for the final lighting design.

Illuminance Criteria | According to the IES Lighting Handbook
LZ2 According to Table 26.4
Table 26.2 Building Entries
Covered Entry High Activity = 20 lux E_h, 10 lux E_v (25-65 age range)
Stairs High Activity = 6 lux E_h, 2 lux E_v

Safety | Since this is an exterior space on campus, it was very important to consider how this space would ultimately feel in terms of safety and to provide a space that welcomes rather intimidates.

Color Rendering | The color temperatures desired were in the 4000 K range with high color rendering indexes to reinforce the safety factor and to ensure that the rendering of faces would be adequate.

Lighting Power Density | According to ASHRAE 90.1 – 9.4.2-1 Zone 3,
Large Walkways = 0.16 W/ft^2
Stairways = 1 W/ft^2
Main Entries = 30 W/(linear ft of doorway)

Lighting Layers

Due to comments from the Lutron presentation, the design was simplified from the initial schematic design which was deemed to be too literal with the concept. The linear in grade fixtures and step lights that created the center of the roadway were taken out of the design. A schematic sketch is shown on the previous page.

The final lighting design contains five main layers of light to achieve the design goals outlined above. The architectural element of the brick handrail on the right hand side of the walkway has a linear LED detail to accent the wall and to provide a clean line of travel from north to south along the building. The recessed downlight fixtures are used at each of the covered entryways to provide a higher illuminance to the entry as the literal intersections of the paths creating a hierarchy of light for the pedestrians. The architectural fins are highlighted with a wall mounted fixture in-between the fins which also provides a repeated pool of light on the walkway to brighten the path and create the sense of safety that is intended. Bollard fixtures at the top of the southernmost stair and along the path in front of the building create another pathway line and levels of lighting that allow for proper vision while traversing the steps. And finally, two linear in grade fixtures are used near the north entry to highlight the architectural feature there which contains the nameplate for the building. These layers of light can be seen in the renders below.

Fixture Schedule

Exterior Fixture Schedule

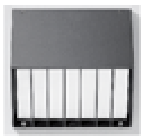
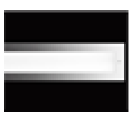
Type	Symbol	Image	Description	Manufacturer
L1			Handrail detail encapsulated LED strip light, IP67 plug in connectors at both ends, 4000K, 85 CRI, 3-Step MacAdam binning	LED Linear
L2			Recessed 6" round LED downlights, tempered clear glass enclosure, anodized aluminum reflector, Outdoor rating IP65, 4000K, 85CRI	Bega
L3			8" square wall mounted assymmetric LED, die-cast aluminum housing, semi-specular anodized aluminum internal reflector, weather tight IP65 rating, 4000K, 85 CRI	Bega
L4			30" tall two sided bollard with 21-5/8" illuminated height per side, 1/4" thick aluminum extruded housing with electrostatically applied powder coat finish, 1/4" polycarbonate lens, UL/CUL Wed Location rated, 4000K	A-Light
L5			20-7/8" x 3-1/2" linear LED ingrade symmetrical floodlight, extruded stainless steel with 1/4" tempered matte safety glass cover, IP67 rating, 4000K, 80 CRI	Bega

Figure 2 Exterior Fixture Schedule with symbol colors matching those in the plans on the following pages

Controls

According with ASHRAE 90.1 9.4.1.4, the exterior lighting must be controlled by a time clock system with photosensors to turn the exterior lights on or off depending on the time of day to provide light when sufficient daylight is not present. The lighting must also be able to retain programming. This will save on energy as well as provide insurance of safety.

Lighting Plans

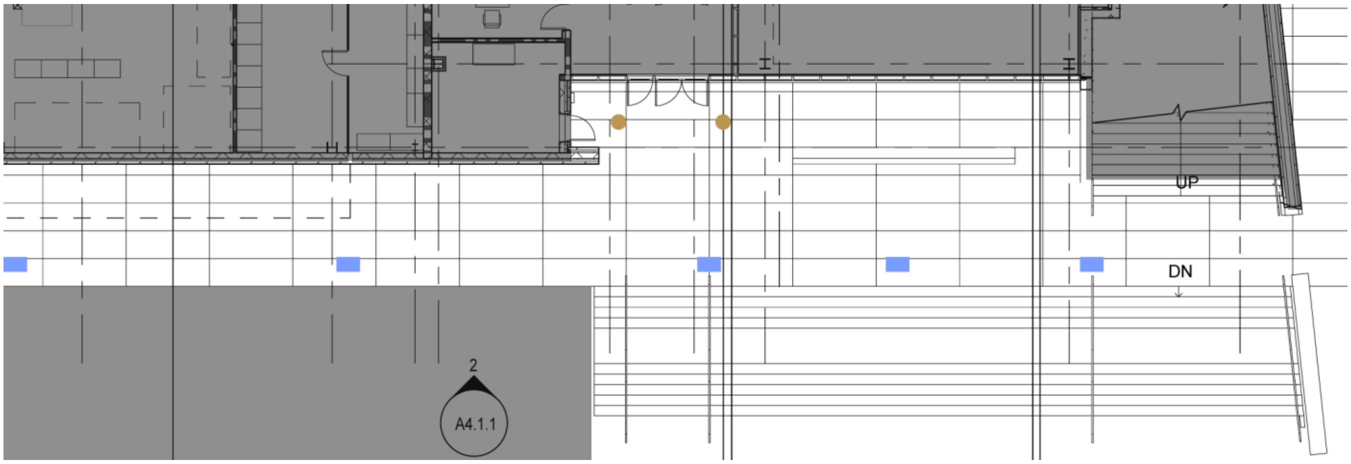


Figure 3 Exterior Level 1 showing South Stair and Entrance

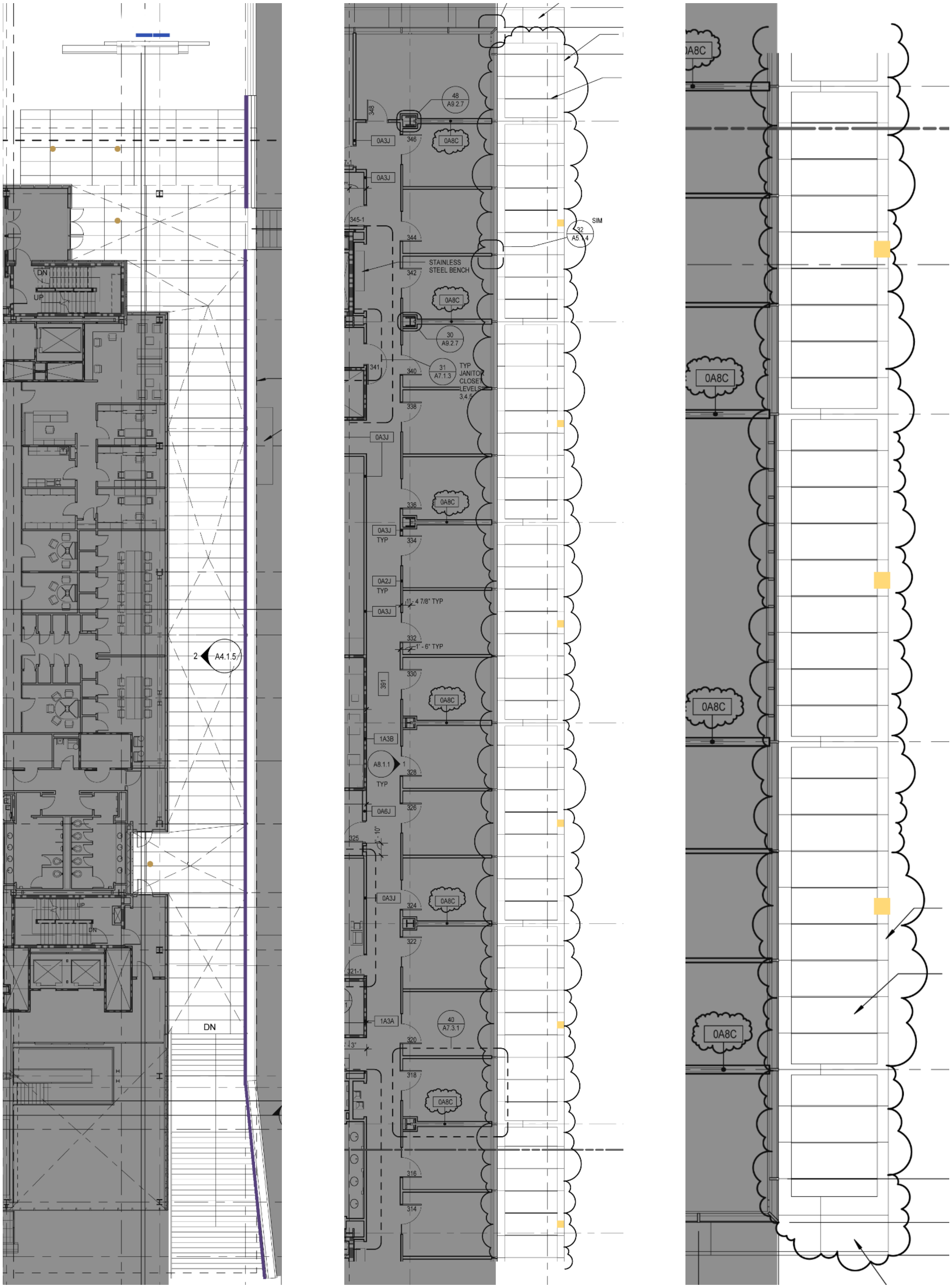


Figure 4 (Left to Right) Level 2 Lighting Plan of walkway, Level 3 Architectural Fins Northern portion, Level 3 Architectural Fins Southern Portion

Renders

The following lighting plans and sections have colored symbols to indicate the fixtures used and their locations in the space. The fixture schedule above indicates what fixture each symbol stand for. The circuiting for these fixtures can be found in the electrical depth.

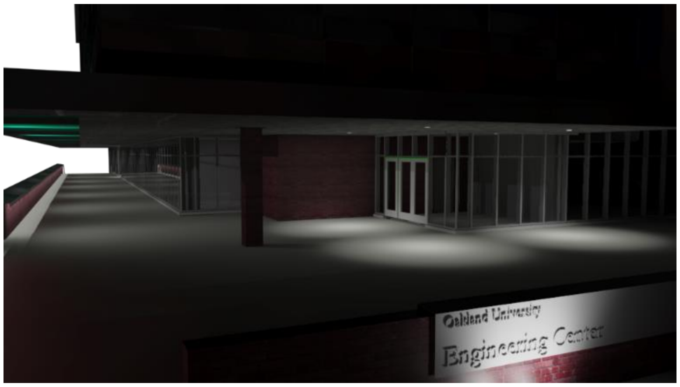


Figure 5 North Entry

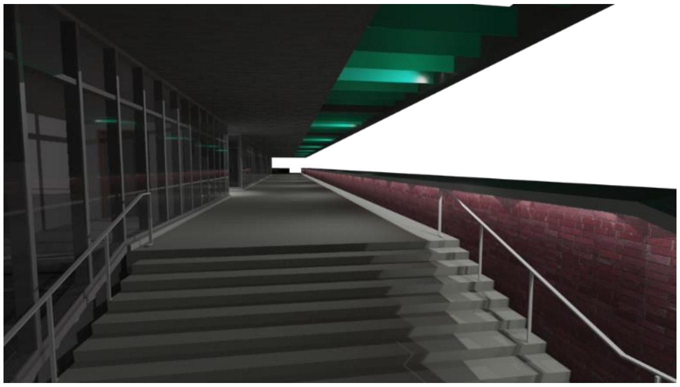


Figure 6 Covered Walkway

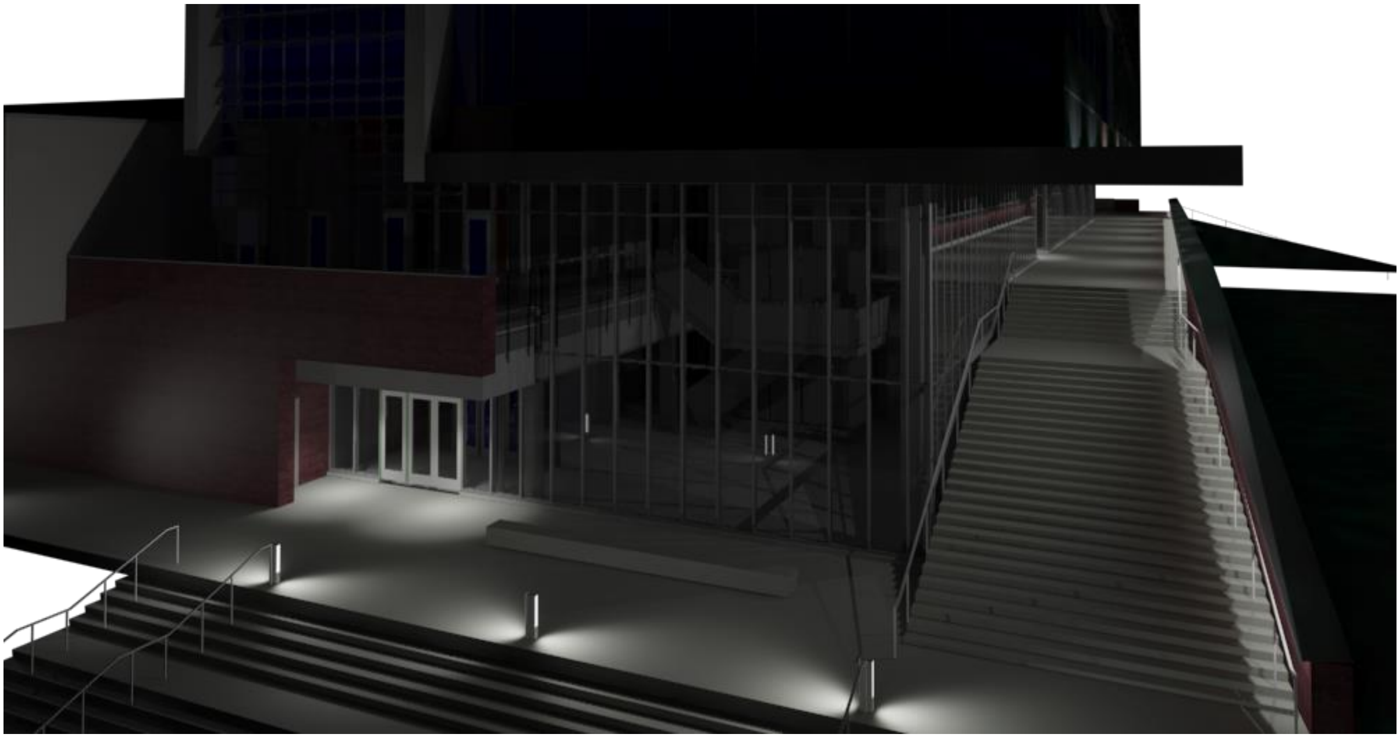


Figure 7 Southern View

Pseudocolors (Light Levels)

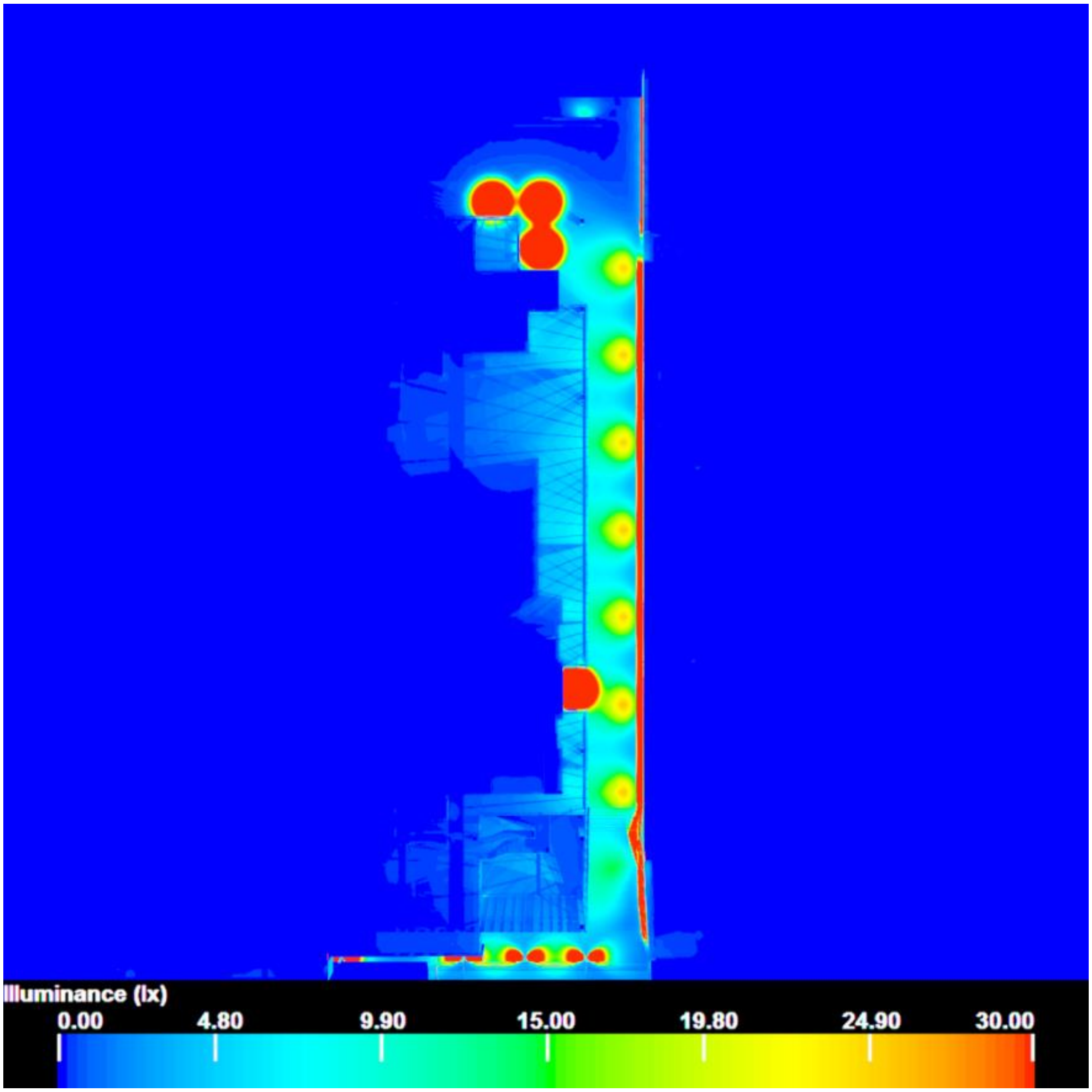


Figure 8 Pseudocolor Render from the top

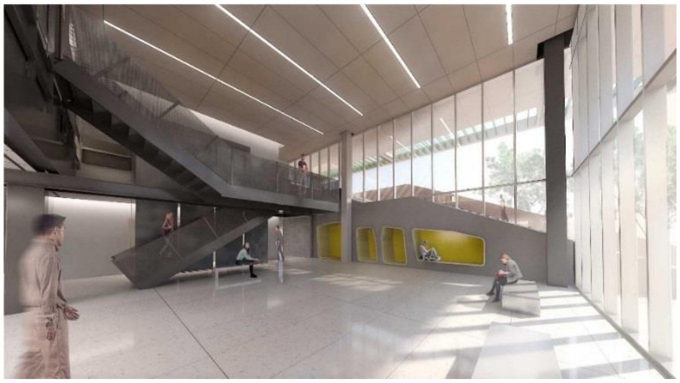
Lighting Power Density

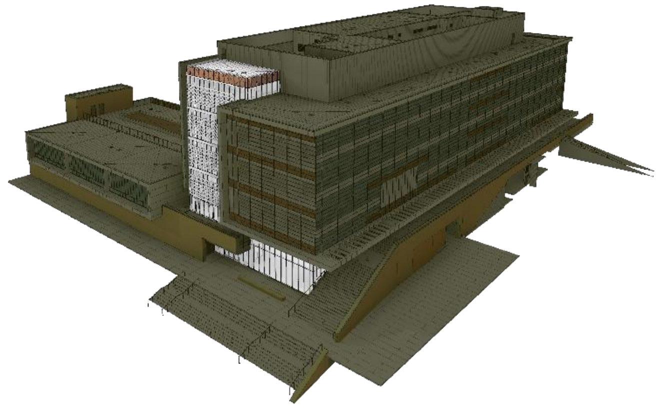
Exterior Lighting Power Density				
Space	**Watts Allowed**	**Area or Length**	**Total Watts Allowed**	**Watts Used**
Large Walkways				
Covered Walkway	0.16 W/ft²	5328 ft²	852.48 W	588.8 W
South Entry Walkway		6978 ft²	1116.48 W	120 W
Stairways				
Lower Stair	1 W/ft²	1307 ft²	1307 W	-
Walkway Stair		1099 ft²	1099 W	145.6 W
Main Entries				
South Entry	30 W/linear ft of doorway	10 ft	300 W	46 W
North Entry		10 ft	300 W	69 W
Walkway Entry		7.33 ft	220 W	23 W

Space Evaluation + Summary

The final lighting design for the exterior space creates literal lines of travel from north to south along the walkway and east to west across the south of the building and dramatically highlights the entryways with a hierarchy of light. The illuminances achieved on the pathways and stairs average around 10 lux with spots of higher illuminance which acceptably exceeds the criteria. The illuminances at the entries also exceed target illuminances but create an easier transition to the higher interior lighting. The lighting power densities from the lighting design are well below what is allowed by ASHRAE 90.1 which also reinforces the validity of the design and the hopes to create a well-lit and safe exterior space. The lighting design criteria here are found to be met and the lighting design follows the overall lighting concept by lighting the roads to progress which lead to the intersections with the building in which the students who enter find the knowledge to improve the industry.

Transition Space | South Lobby + Atrium





Space Locator

Description of Space

The lobby and atrium spaces off of the southern entrance are heavily trafficked areas within the building providing a transition space through which most people will see when traveling to specific parts of the building. Because of the high level of use and visibility in the building, this space needs to provide a visual statement as well as provide ease of way finding and places for occupants to feel comfortable in.

The space has a nice and rustic palate of materiality including terrazzo flooring, exposed CMU and gypsum walls, perforated metal handrails, and acoustic ceiling tile and metal mesh ceilings.

The main tasks of the space are general transition of pedestrians, congregation to study and sit near the café on the second level, and reading/studying in the study niches in the southern lobby.

Concept

Figure 9 Schematic Lighting for Lobby

The combined space of the southern lobby and atrium with the prominent connecting staircase is the largest and most important transition space in the whole of the Engineering Center. With such a high level of activity, and so many different ways to travel through the space, the idea of a highway with off-ramps drove the design concept. There are areas of high traffic, the highways, where the light will be more direct and intense to provide a feeling of tension to direct the traffic in specific ways. Then there are areas of congregation, or off-ramps, with more decorative and perimeter lighting to denote areas of relaxation where the light is less intense.

Design Criteria

The following is a list of important design criteria, both quantitative and qualitative, to reinforce design concepts and desires for the final lighting design.

Illuminance Criteria | According to the IES Lighting Handbook
Lobbies | Circulation | Building Entries
Day = 100 lux E_h, 50 lux E_v, 3:1 Avg:Min
Night = 50 lux E_h, 20 lux E_v, 3:1 Avg:Min
Lounges | Pleasure Reading = 200 lux E_h, 100 lux E_v, 1.5:1 Avg:Min
Stairs | High Activity = 100 lux E_h, 50 lux E_v, 2:1 Avg:Min
Dining Areas | Coffee Shops = 100 lux E_h, 30 lux E_v, 3:1 Avg:Min

Way Finding | Lines of light to denote main traveling routes and aid in finding the desired means to reaching locations within the building

Psychological Impression | In these spaces, the John Flynn psychological impressions of tension and relaxation are employed to denote areas of transition and areas of study and collaboration

Color Rendering | The color temperatures desired were in the 4000 K range with high color rendering indexes to provide a consistent design

Lighting Power Density | According to ASHRAE 90.1
Lobby | All other Lobbies = 0.90 W/ft^2
Lobby | Elevator Lobbies = 0.64 W/ft^2
Corridor | All other Corridors = 0.66 W/ft^2
Atriums = 0.4 + 0.02 * total height = 1.82 W/ft^2

Lighting Layers

A few changes were made to the lighting design since the schematic design presentations due to limitations from the quantitative criteria, limitations with the fixtures to achieve the desired look, and misunderstandings regarding the architecture. The circular recessed lights were taken out of the design near the elevator lobbies due to available ceiling area in which to mount the fixtures and an overhang that would block much of the light from illuminating the ground in front of the elevators. The circular recessed light in the main lobby space was replaced with a square due to the very angular and geometric architecture of the building to better enhance the overall aesthetic. Due to the task of reading in the study niches it was determined that mounting LED tape to the perimeter was not going to be sufficient. And finally, in the lobby, due to LED driver limitations, maintenance issues, and possible safety issues, the tube pendants in the atrium space were taken out and replaced with window details to create the sense of verticality. A schematic design sketch of the lobby space can be seen on the previous page.

The lobby has multiple layers of lighting to create visual interest in the space. To provide ease of way finding and areas of tension for the purpose of movement, scattered lines of recessed linear luminaires provide downlighting to the corridors on the first and second levels adjacent to the lobby and atrium spaces. To bring attention to the staircase, a decorative cluster of linear LED pendant fixtures hovers above the stair as a statement piece which also exemplifies the importance of the stair as an intersection of paths between two levels of transition. To bring attention to the architecture of the study niches on the western side of the lobby, linear LED details in the wooden finishes of the niches provide adequate reading light to the workplanes for relaxing places to study and congregate. The elevator lobbies on both the first and second floors incorporate recessed linear wall to ceiling fixtures to indicate the vertical transition of the elevators and create a waiting space that is not fully tense as the hallways are, and not fully relaxing with perimeter lighting. And finally, to indicate the spaces of respite within all of the busyness of the space, recessed linear lights in a square provide perimeter lighting for main area of the lobby for congregation purposes.
The stairway goes up to the second floor café seating area and four story atrium space. This space lends itself to being a great place for social interaction outside of the classroom. To create an area of relaxation, perimeter lighting will be provided from mullion mounted lighting over the seating area and cove lighting on the third floor. In an attempt to draw the eye upwards, and metaphorically towards a common future for the engineering and computer science goals of the school, linear lights uplight the window recesses along the western wall of the atrium. As your eye travels up the atrium, they reach the top where more cove lights create a floating ceiling effect as this sort of exciting and promising future within site. These layers of light can be seen in the renders below.

Fixture Schedule

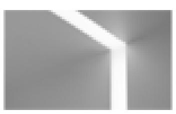
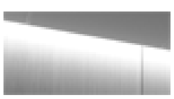
Lobby + Atrium Fixture Schedule				
Type	**Symbol**	**Image**	**Description**	**Manufacturer**
L2			Recessed 6" round LED downlights, tempered clear glass enclosure, anodized aluminum reflector, Outdoor rating IP65, 4000K, 85CRI	Bega
L6			4' x 2.64" Recessed linear LED downlight, flush mount, extruded aluminum housing, white powder coat steel reflector, frosted acrylic lens, replaceable LED modules and drivers from below, 4000 K, 80 CRI	Focal Point
L7			Linear surface mounted LED, 11-5/16" length segments, anodized aluminum extrusion with injection molded end caps, clear high strength acrylic lens, 3500K, 85 CRI	USAI
L8			8' linear LED pendant, aluminum extrusion with a matte anodized finish, frosted white acrylic lens diffuser, suspended with adjustable aircraft cable with push button glider, 4000K, 90 CRI	Delray Lighting Inc.
L9			Same product as L6 with a modified wall to ceiling housing and flex whip connector	Focal Point
L10			7' x 2.25" x 3.375" Mullion mounted assymmetric LED fixture, aluminum extruded housing, precision milled endcaps, 4000K	A-Light
L11			1' x 1.5" x 2.1" linear LED wall grazing fixture, narrow 10 x 60 degree beam angle, 4000K, 84 CRI	Philips Color Kinetics
L12			Cove lighting LED fixture with a 4" opening from ceiling grid and total 7.3" depth above ceiling, extruded aluminum housing with polyester poweder coat, frosted lens, 3500K	Focal Point

Figure 10 Lobby + Atrium Fixture Schedule with symbol colors matching those in the plans on the following pages

Controls

To provide dimmer lighting during the nighttime, all fixtures will be on dimmer circuits to allow for dimming. Manual control of these fixtures will be provided in convenient locations for those allowed to control the lighting without access to the general public. Lighting in the atrium will utilize daylighting controls due to the amount of natural light that enters the space during the day.

Lighting Plans + Sections

The following lighting plans and sections have colored symbols to indicate the fixtures used and their locations in the space. The fixture schedule above indicates what fixture each symbol stand for. The circuiting for these fixtures can be found in the electrical depth.

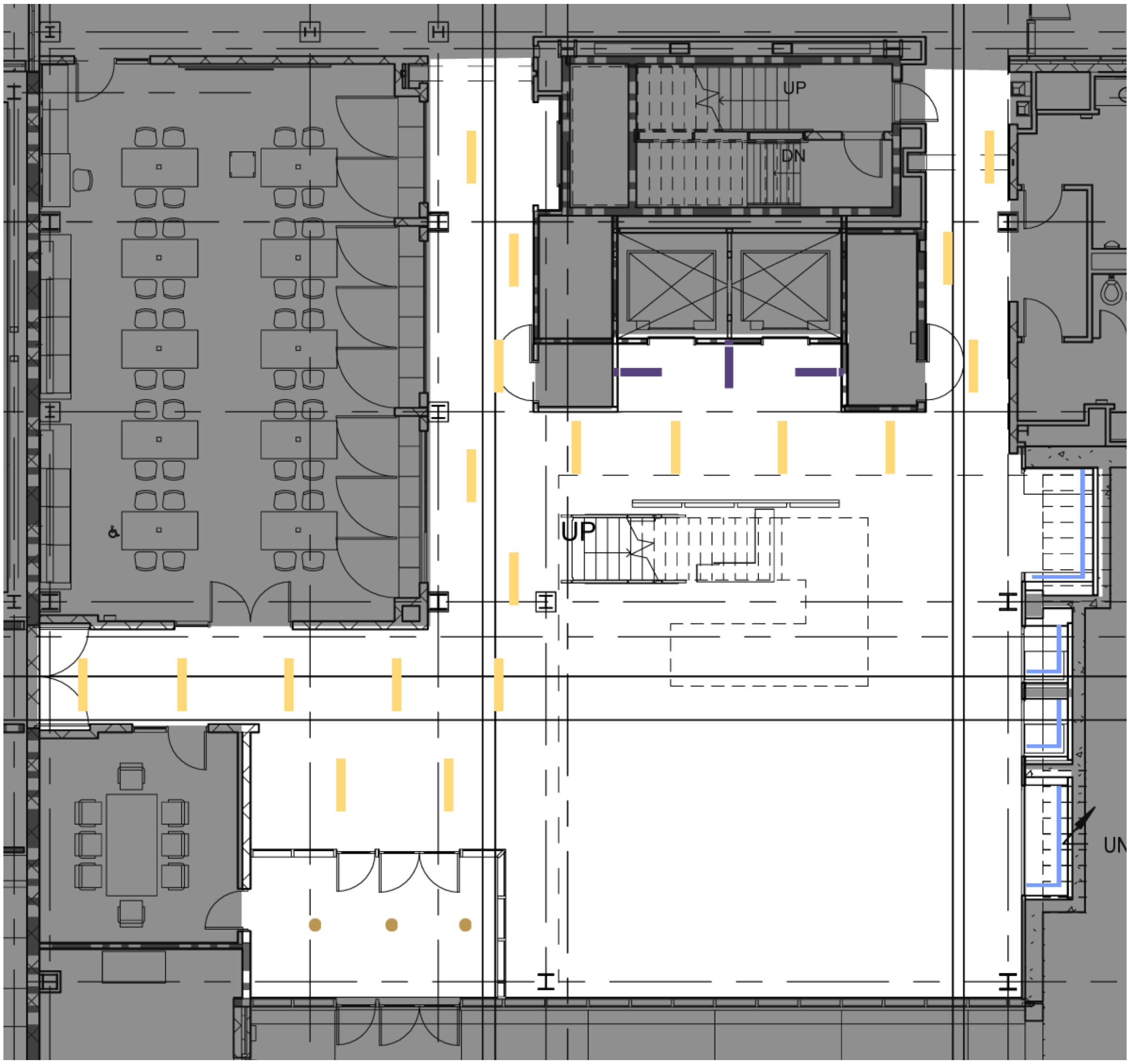


Figure 11 First Floor lobby and Corridor Lighting Plan

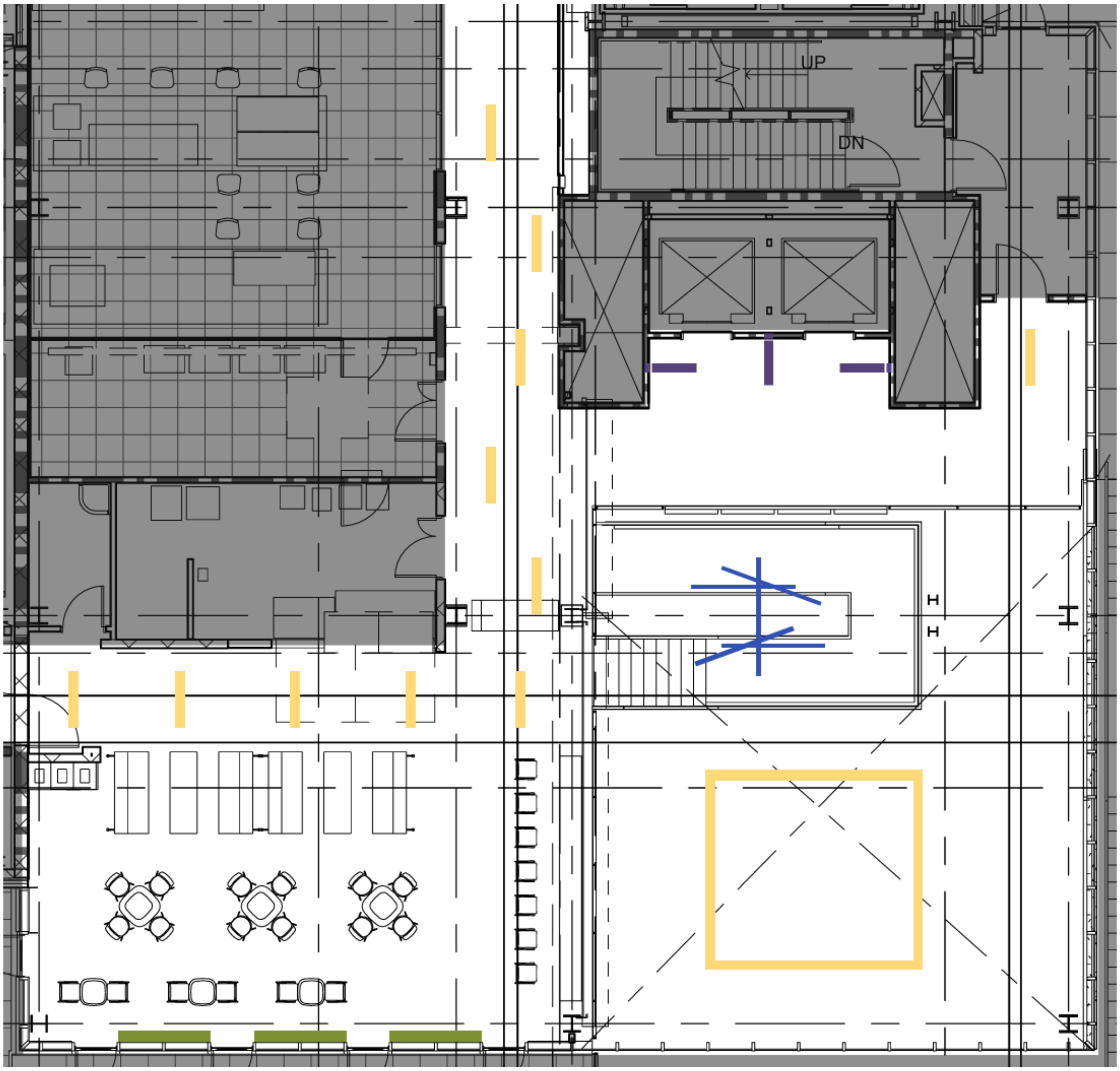


Figure 12 Level Two Lobby and Atrium Lighting Plan

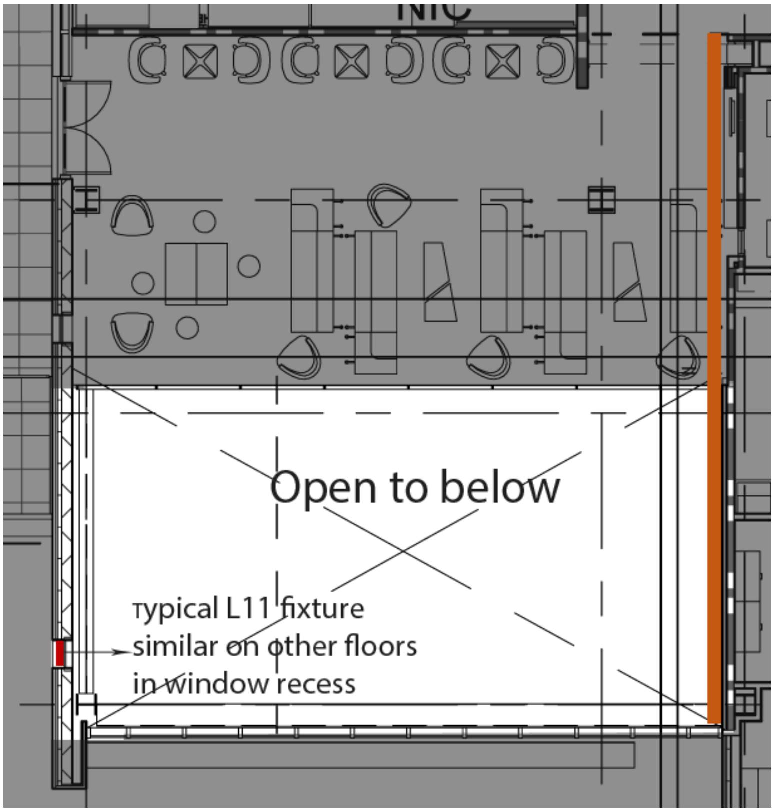


Figure 13 Level Three Atrium Lighting Plan

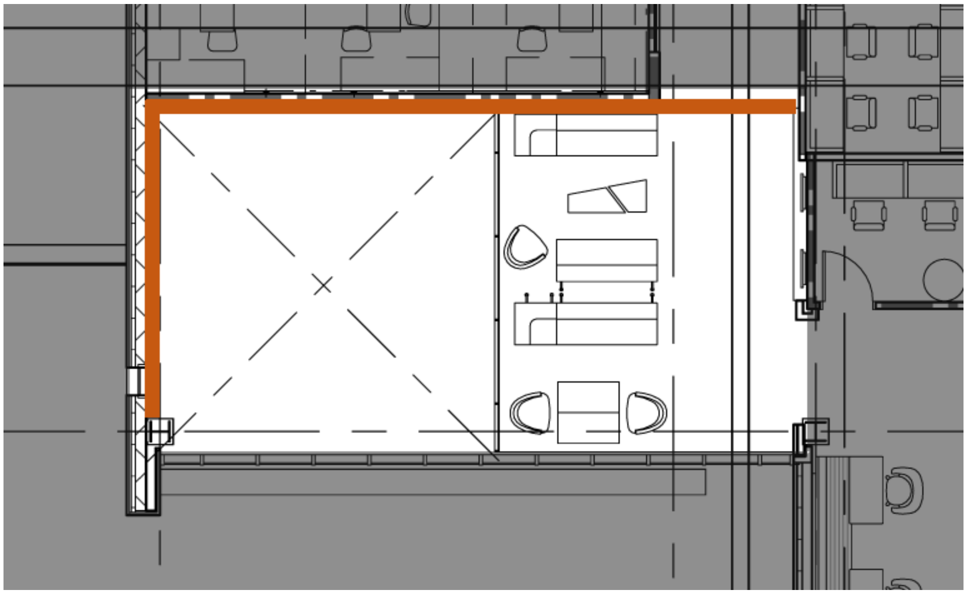


Figure 14 Level Five Atrium Lighting Plan

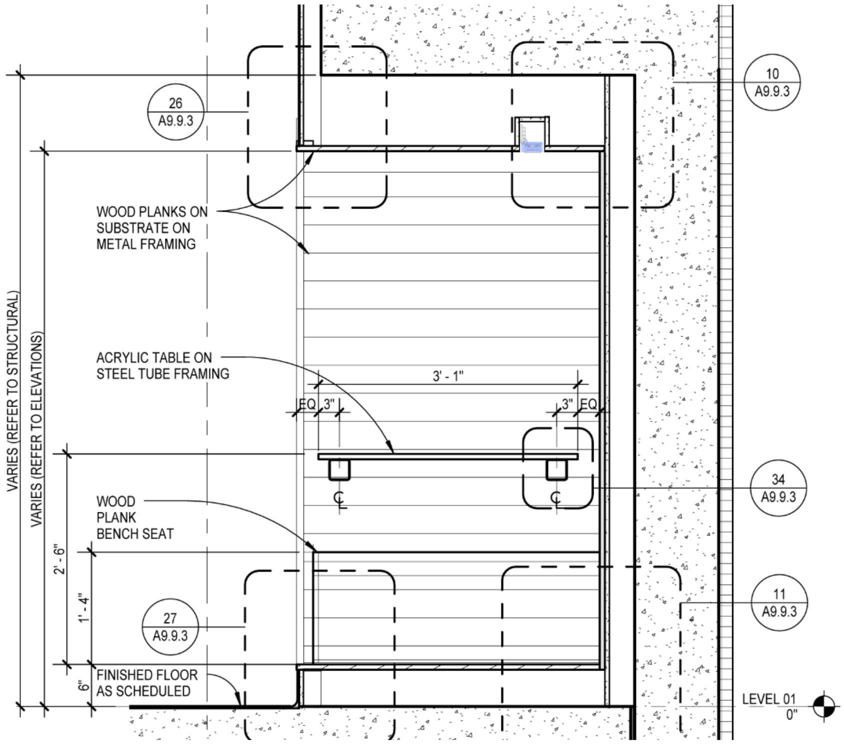


Figure 15 Lobby Study Niche Lighting Detail with L7 Fixture

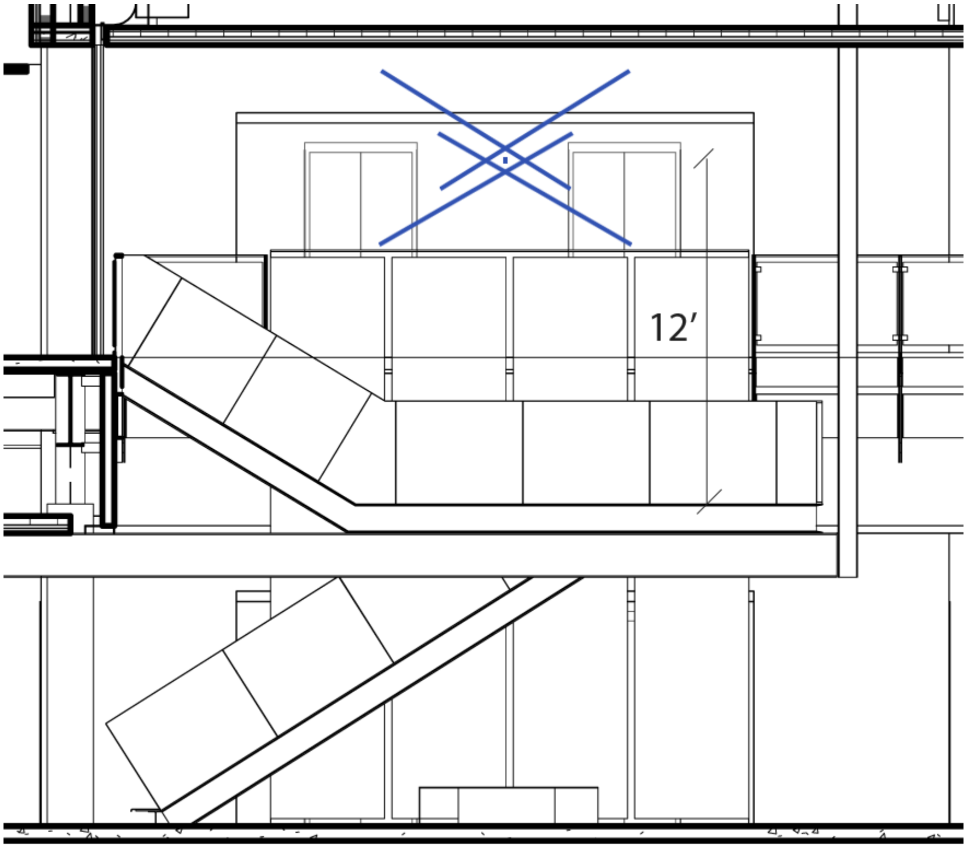


Figure 16 Elevation Showing Stair Pendant Fixtures

Renders

Figure 17 Lobby Section Render

Figure 18 Vestibule and Corridor Render

Figure 19 1st Floor Corridor Render

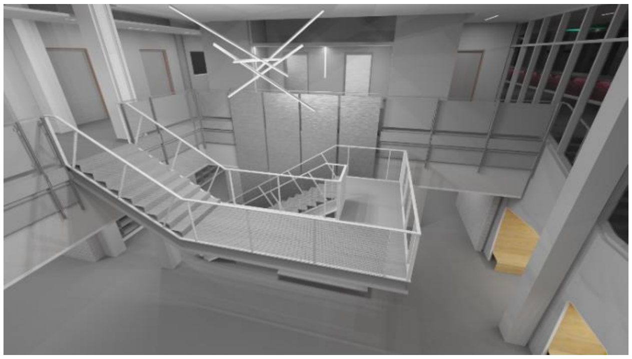


Figure 20 Stair Pendant Render

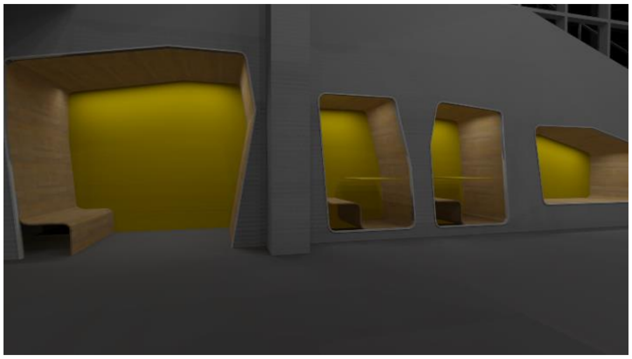


Figure 21 Study Niches Render

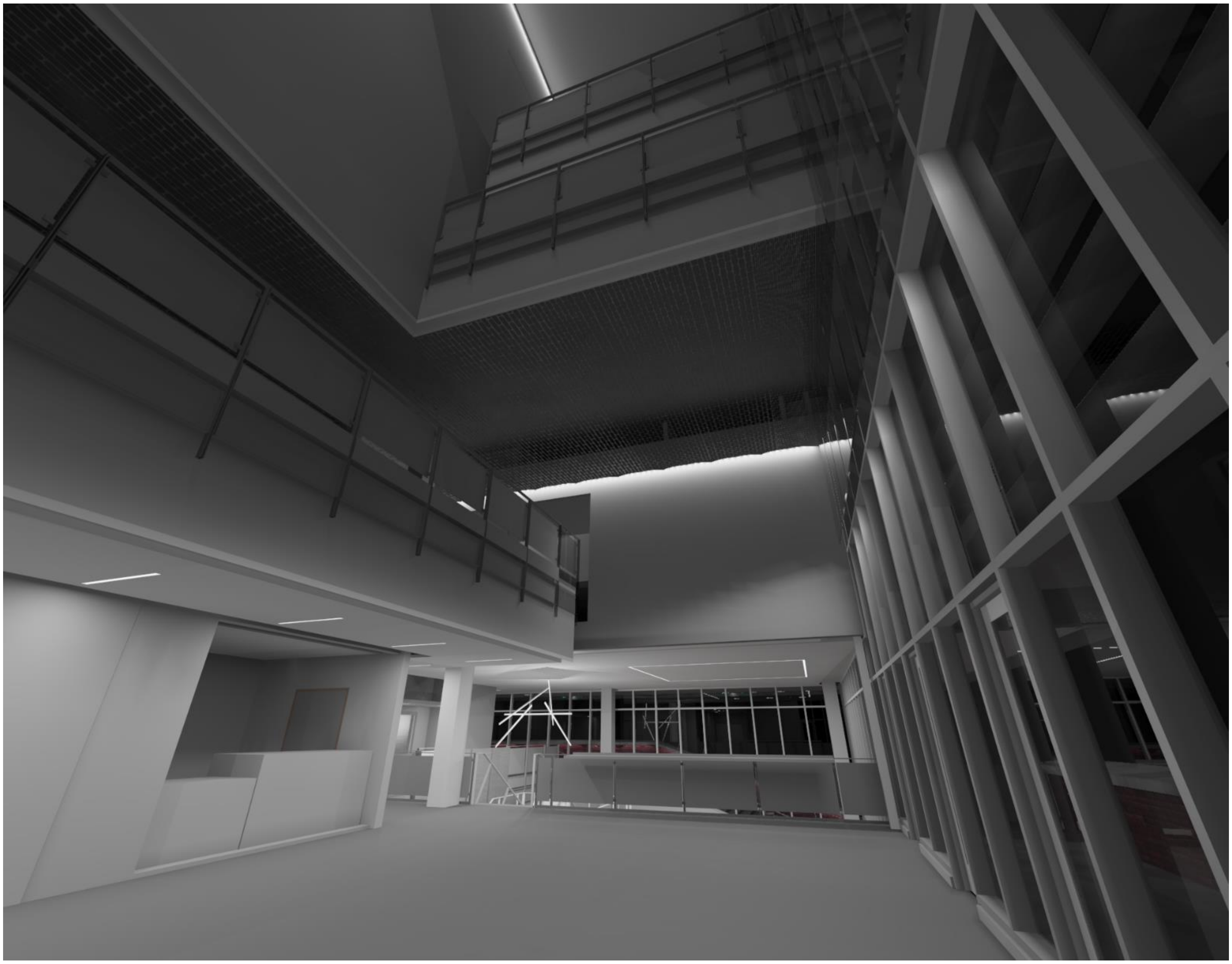


Figure 22 Atrium Perspective Render

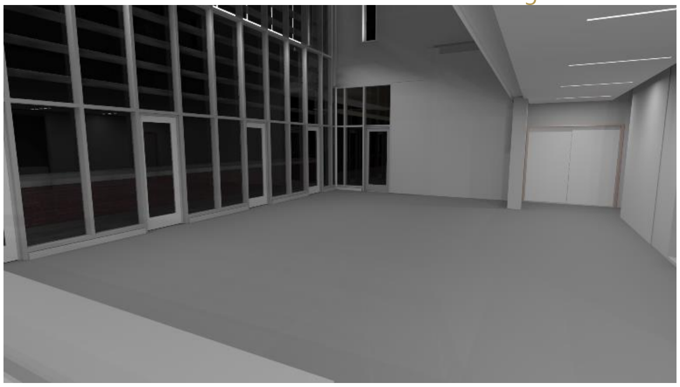


Figure 23 Atrium Level Two Render

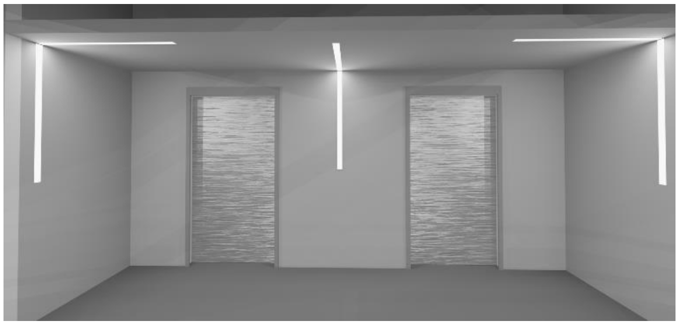


Figure 24 Level Two Elevator Lobby Render

Pseudocolors (Light Levels)

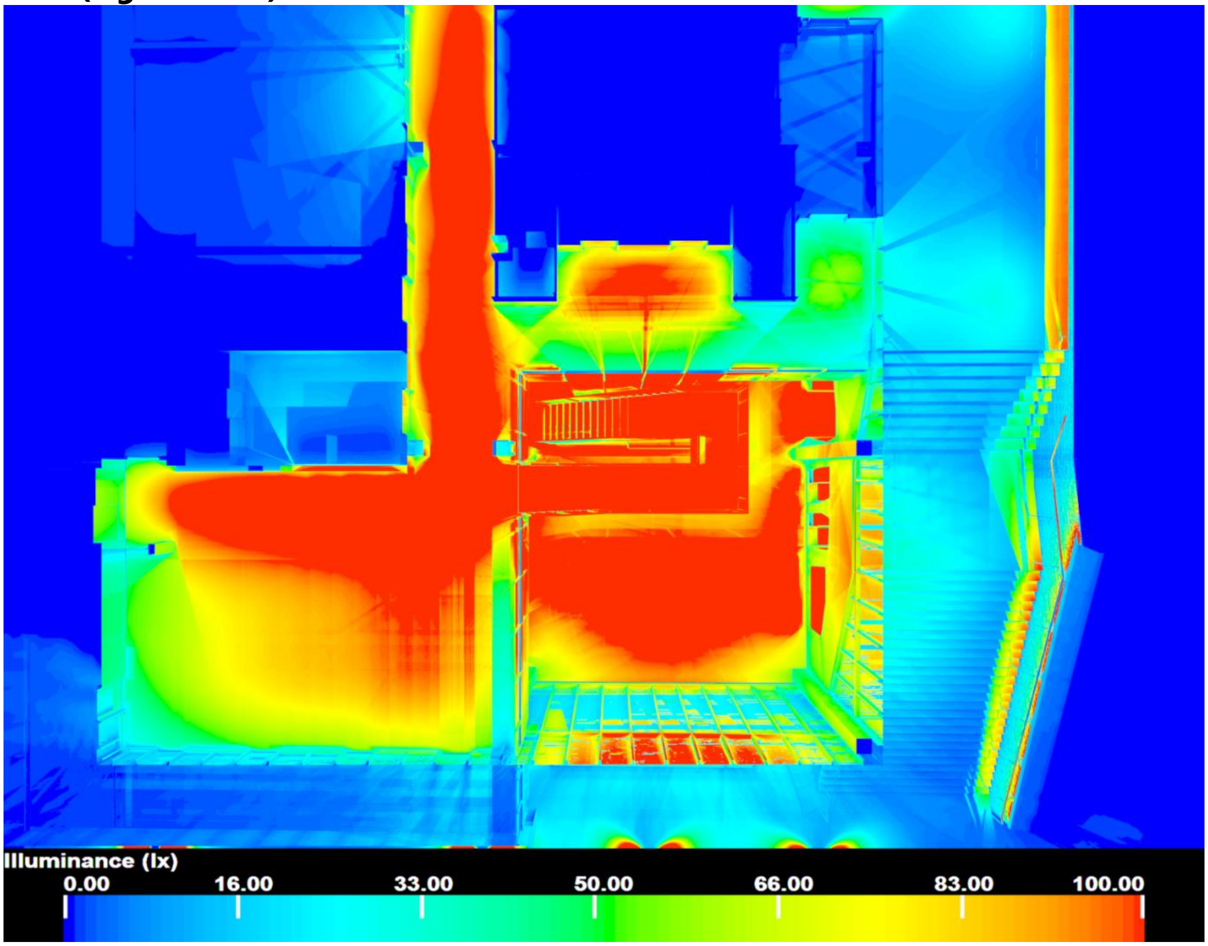


Figure 25 Top Section Pseudocolor showing Atrium Level 2 and Lobby Level 1

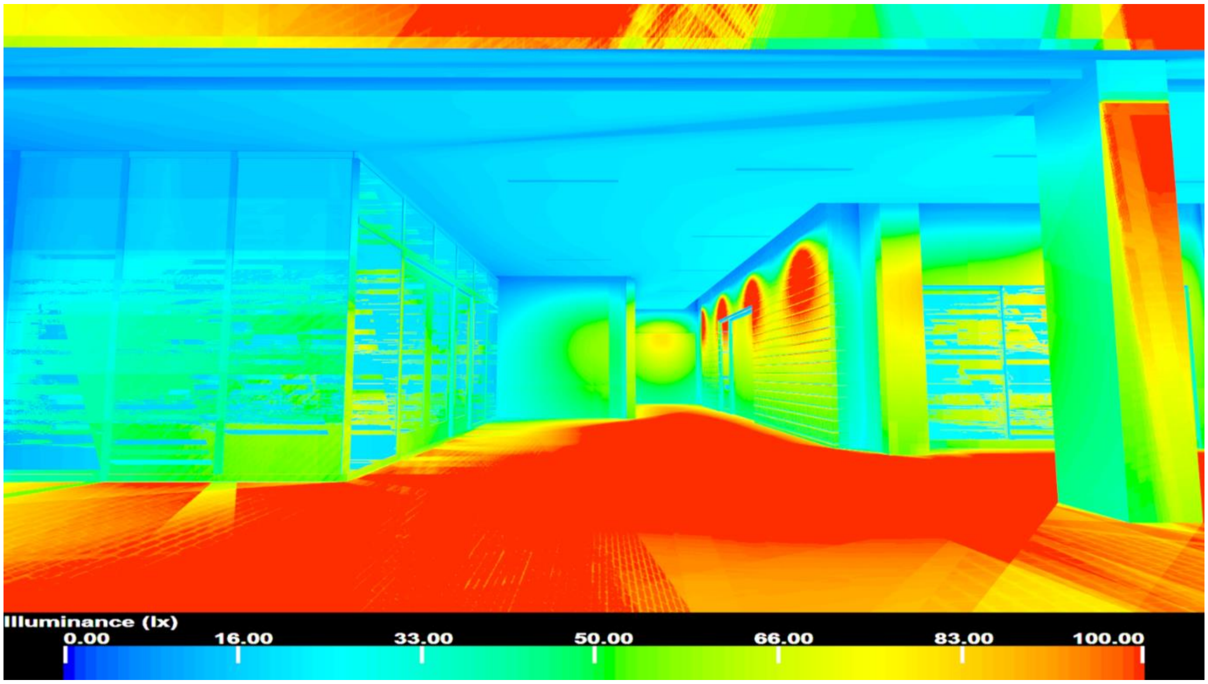


Figure 26 Vestibule to Lobby Pseudocolor

Lighting Power Density

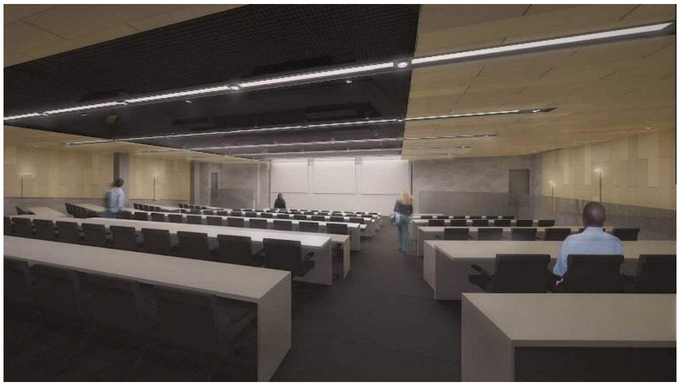
Lobby Lighting Power Density					
Type	**Quantity**	**Input Watts**	**Lobby Watts**	**Corridor Watts**	**Elev. Lobby Watts**
L2	3	19.5	58.5		
L6	35	21	336	399	
L7	38 FT	6.3 W/FT	239.4		
L8	10	24	240		
L9	12	8			96
		Total Watts	874	399	96
		Total Area	1933	1564	176
		Calculated LPD	0.45	0.26	0.55
		ASHRAE 90.1 LPD Allowed	0.90	0.66	0.64
		Difference	0.45	0.40	0.09

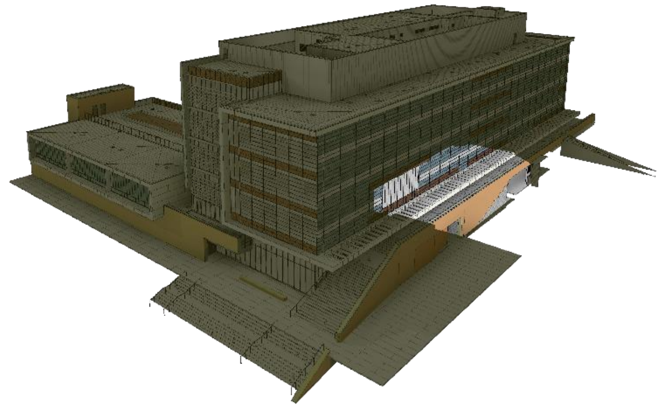
Atrium Lighting Power Density				
Type	**Quantity**	**Input Watts**	**Total Atrium Watts**	**Total Corridor Watts**
L6	11	21		231
L10	3	30	90	
L11	3	12.5	37.5	
L12	24	22.9	549.6	549.6
		Total Watts	677.1	780.6
		Total Area	886	1800
		Calculated LPD	0.76	0.43
		ASHRAE 90.1 LPD Allowed	1.82	0.66
		Difference	1.06	0.23

Space Evaluation + Summary

By dividing the intents of the space into transient areas of movement and areas for congregation, the lighting design has a connectedness but also a clear shift which helps to aid in the design intents for this space. The final lighting design is in accordance with the lighting design criteria, creates an affective transition space through the building, and acts as a nice architecture improving statement from the exterior. The transition space meets the illuminance criteria of 100 lux in the lobby, corridors, and the stairway and fades off in the café seating area to bring more attention to the verticality and because the space will mostly be used during the daytime. The lobby lighting is 50% more efficient than the maximum allowed loads according to ASHRAE 90.1. Likewise, the atrium was 58% more efficient due to minimal design, the elevator lobby 15%, the first floor corridors 61%, and the second floor corridors 34%. The final design seems to be successful even after having gone through a reality check filter to make it more reasonable than the schematic design.

Special Purpose Space | Lecture Hall





Auditorium Space Locator

Description of Space

The 200-seat lecture hall auditorium, located on the first level, is the largest space in the building for the instruction of students and is thus very important to the program of the building. This space will be used for classes, presentations, guest lectures, and any multitude of other uses to the school of engineering and computer science. Because of this multiuse aspect of the space, the lighting design, scene control, and AV schemes are very important and will need to be coordinated. The lighting design needs to have multiple layers of functionality as well as providing appropriate lighting levels for reading, writing, presentations and safe travel through the space.

The space materials are quite interesting comprising of carpet tile flooring, wooden panel side walls and side ceilings, a metal mesh ceiling in the center of the space, and exposed CMU walls in the front and backs of the room.

Some significant features of the space are the three motorized projectors, the slightly tiered aspect to the seating, the wheelchair ramp along the right-hand side of the space, and the personal wheelchair lift in the front left of the space. A plan and section of the space are shown below.

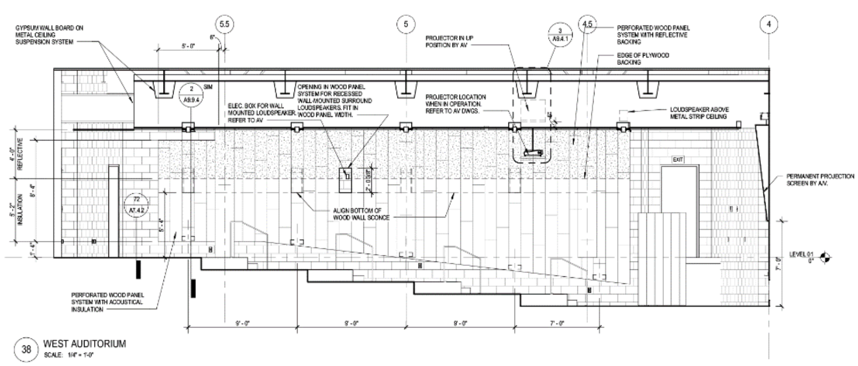


Figure 27 Auditorium Section Looking West

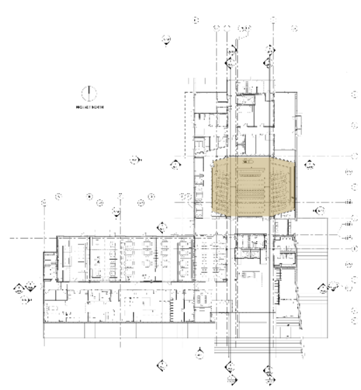


Figure 28 Auditorium 1st Floor

Concept

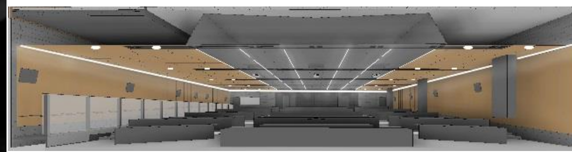
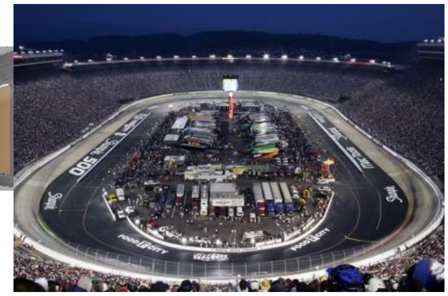


Figure 29 Auditorium Schematic Sketch



When coming up with an appropriate concept for the auditorium space, three schematic concepts were created for the schematic presentations last semester. There was not one concept that stood out from the rest however comments were made to steer the lighting design away from a literal interpretation of the concept. The schematic concepts all centered on the presenter and this idea of displaying and sharing of knowledge to reach a common future for the industry.

By taking these initial concepts and analyzing the feelings of the space that are desired, a new concept was formulated. The space really is a testament to the present and an arena to display and share achievements. For these reasons, the new concept is “embracing the present”. This concept fits with the building overall concept and lives within it as a snapshot in the continuum from past to future. This idea of embracing the future shapes the lighting design for the auditorium space.

Design Criteria

The following is a list of important design criteria, both quantitative and qualitative, to reinforce design concepts and desires for the final lighting design.

Illuminance Criteria | According to the IES Lighting Handbook
Educational Facilities | Auditoria
- Lecture Hall | Audience | AV and Notes = 50 lux E_h, 15 lux E_v, 2:1 Avg:Min
- Lecture Hall | Audience | AV and No Notes = 10 lux E_h, 6 lux E_v 2:1 Avg:Min
- Lecture Hall | Speaker/Panel | AV = 30 lux E_h, 18 lux E_v (<3 times audience)
- Lecture Hall | Speaker/Panel | No AV = 500 lux E_h, 200 lux E_v, 3:1 Avg:Min
- Circulation | AV = 2 lux E_h, 10 lux E_v, 5:1/3:1 Avg:Min
- Circulation | All but AV = 10 lux E_h, 30 lux E_v, 10:1/3:1 Avg:Min
- Reading + Writing = 300 lux E_h

Versatility | Multiple layers of light to allow for zone control and scene selections

Color Rendering | The color temperatures desired were in the 4000 K range with high color rendering indexes to provide a consistent design

Lighting Power Density | According to ASHRAE 90.1
Classroom | Lecture Hall = 1.24 W/ft^2

Design Development

As stated in the concept portion of this section, the original three schematic designs were combined and discarded for a new concept and final design. As per the design criteria, a versatile and multi-function design is desired which meets the necessary quantitative criteria. For the final design, five layers, or zones, of lighting fixtures are used to be as versatile as possible.

The main general illuminance is provided by large surface mounted luminaires which have a rounded square shape and embody the idea of an embrace as per the concept.

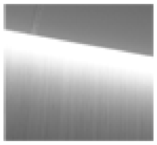
The second layer also embodies the idea of the embrace. It is a series of cove mounted fixtures which line the side walls and a portion of the front wall to bring attention to the presenter and to provide illuminance to the circulation areas on the perimeter.

The third layer provides the illuminance for the presenter area and consists of 5 square downlight fixtures. Using a similar fixture with a wider beam spread and lower lumen output, a filler general illuminance is provided to the audience area for certain lighting applications of the space.

The final layer is a series of linear surface mounted LED strip lights to provide low light levels and a dappled look to the center of the room by shining down through the metal mesh ceiling. These lines of light are also intended to draw the audience's eyes towards the front of the room.

Appropriate control schemes will be in place to allow for infinite possibilities for using these five layers for different situations. Three possible lighting schemes are shown in the renders below.

Fixture Schedule

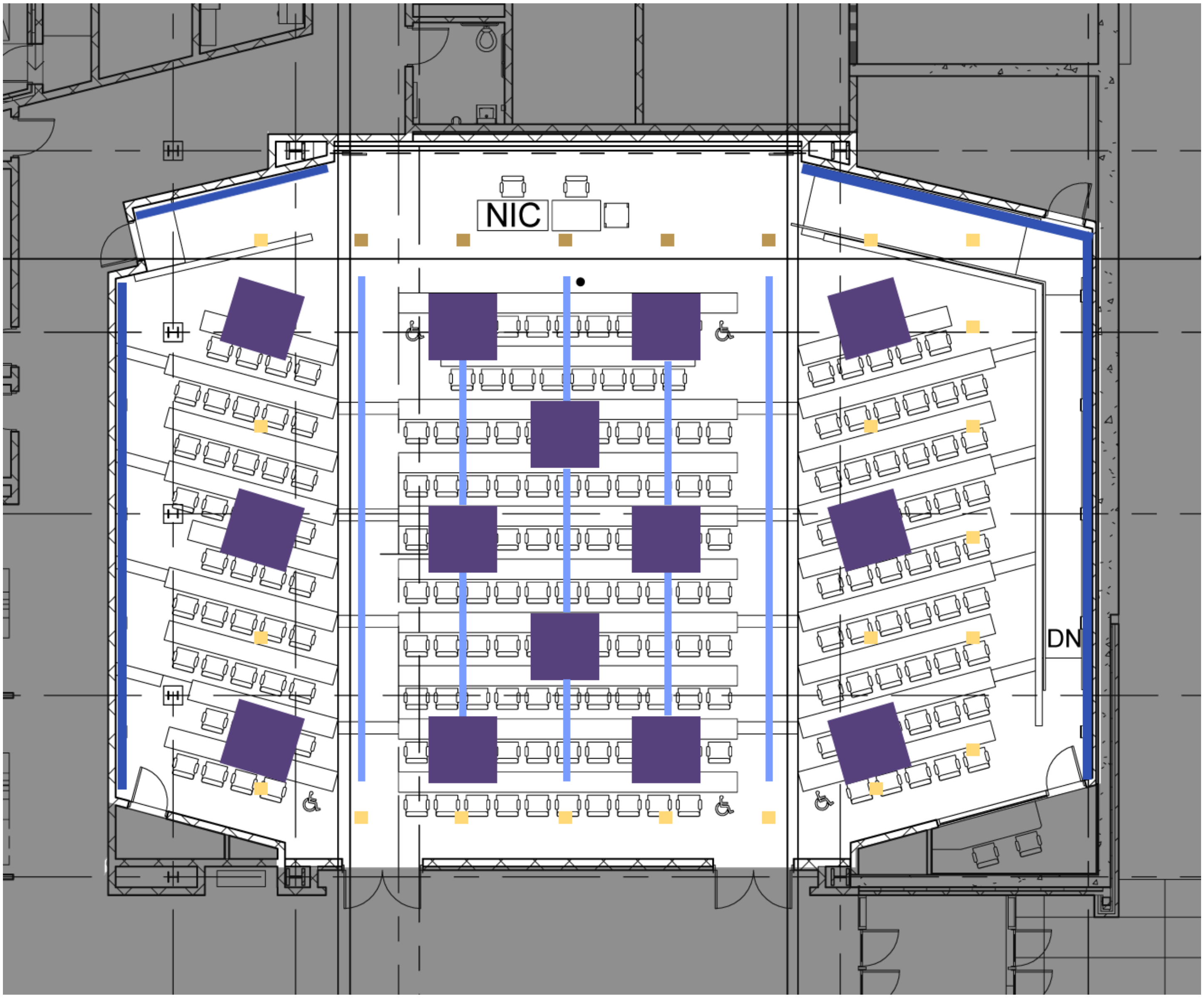
Auditorium Fixture Schedule				
Type	**Symbol**	**Image**	**Description**	**Manufacturer**
L7			Linear surface mounted LED, 11-5/16" length segments, anodized aluminum extrusion with injection molded end caps, clear high strength acrylic lens, 3500K, 85 CRI	USAI
L12			Cove lighting LED fixture with a 4" opening from ceiling grid and total 7.3" depth above ceiling, extruded aluminum housing with polyester poweder coat, frosted lens, 3500K	Focal Point
L13			66.7" x 66.7" x 3.1" Ceiling mounted direct LED fixture, polished aluminum housing finish, integrated acrylic cover, fabric covering as a light and acoustic diffuser, 4000K	Sattler
L14A			4" Square recessed LED downlight, self-flanged semi-specular reflector, highly transmissive lens, 20 degree beam angle, 3500K	Gotham
L14B			4" Square recessed LED downlight, self-flanged semi-specular reflector, highly transmissive lens, 60 degree beam angle, 3500K	Gotham

Controls

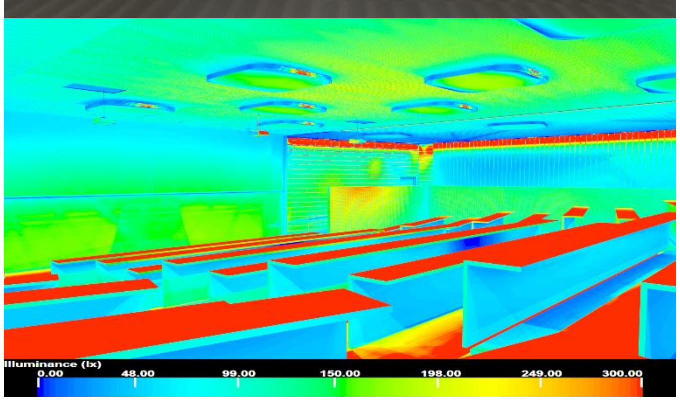
Using Lutron's GRAFIK Eye software, and researching their products, it was determined that a GRAFIK Eye QS system would be used with at least one wall mounted button control in the back and one in the front. The QS system can be used to control the five zones of light by determining their dimming levels and coming up with set lighting schemes for the space and can be wirelessly addressed by the wall mounted button controls. There will be two wall mounted infrared occupancy sensors, one in the front of the room and one in the back. In the back, an all-on and all-off button control will be available in case the occupancy sensors are not working correctly. The front button control will allow the presenter to control the lights to any scene that they desire. Information on these Lutron products are shown in Appendix IV. For the study of this space, 3 lighting schemes were devised.

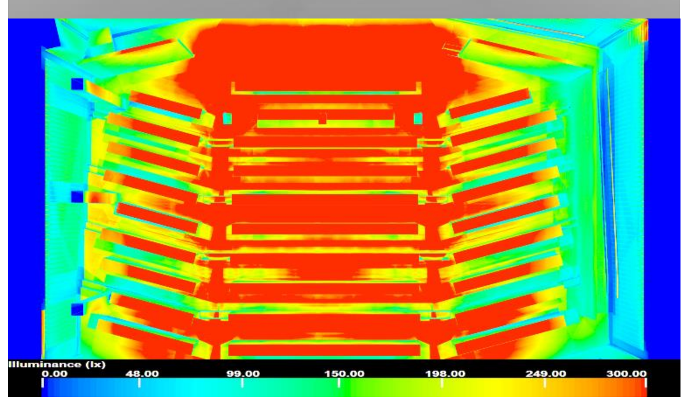
All-On Testing Mode = all lights at 100%
Presenter = L7, L12, L14B at 50%, L13 off, and L14A at 100%
AV mode = L7, L12, L14B at 50%, L13 and L14A off

Lighting Plans

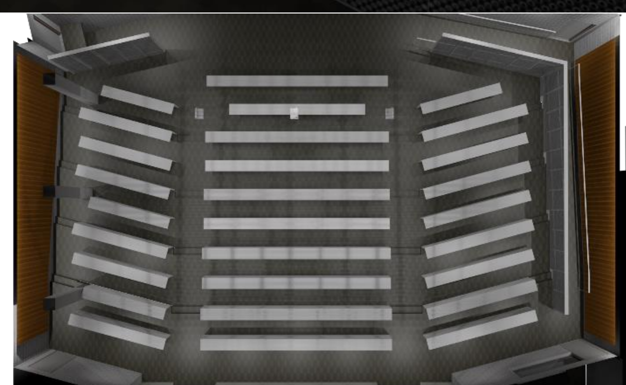


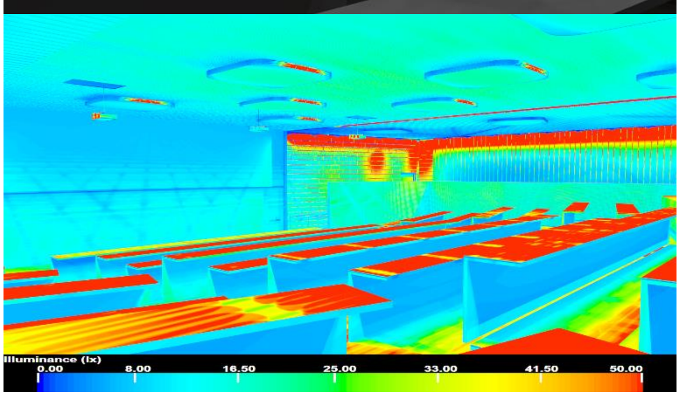
Renders + Pseudocolors | All-On Testing Mode

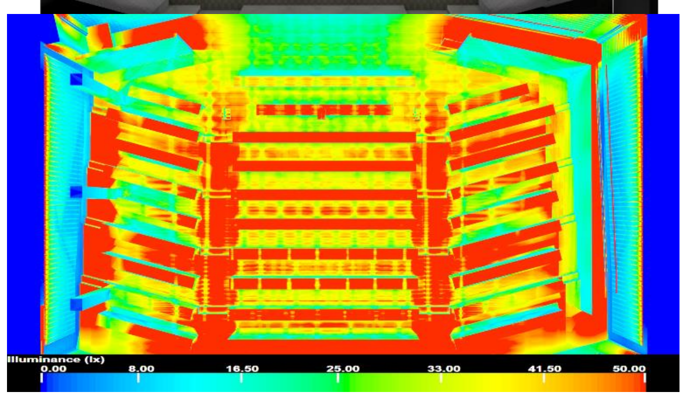




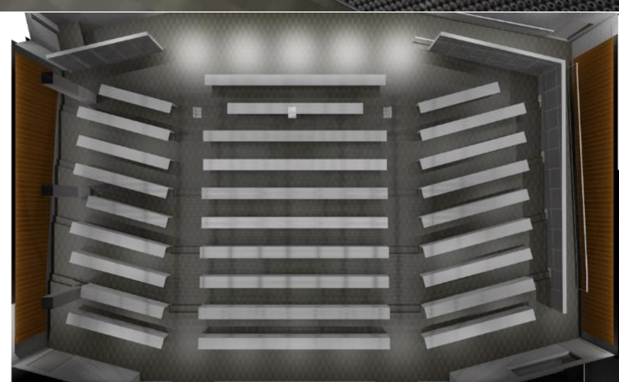
Renders + Pseudocolors | AV Mode

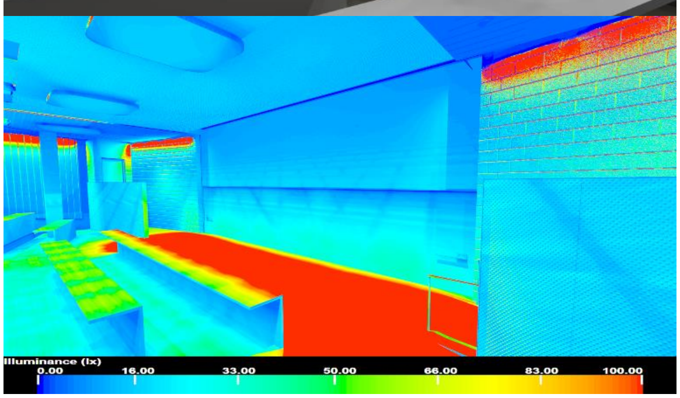


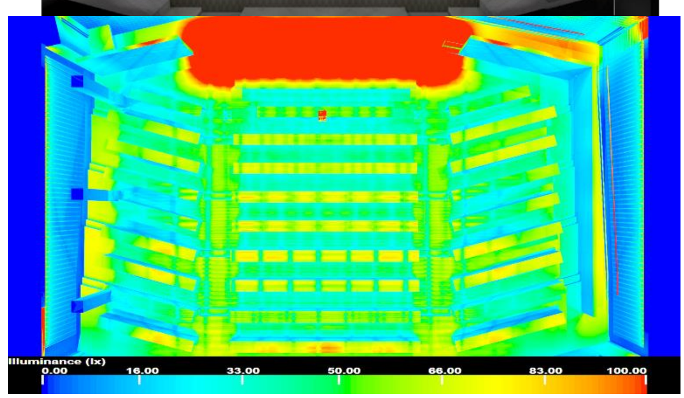




Renders + Pseudocolors | Presenter Mode







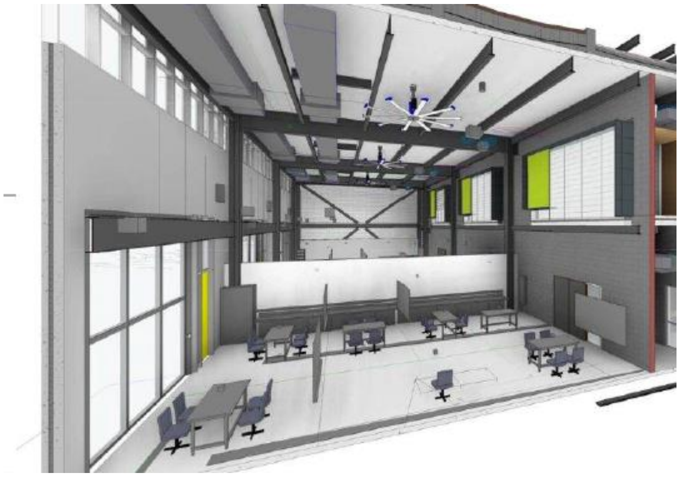
Lighting Power Density

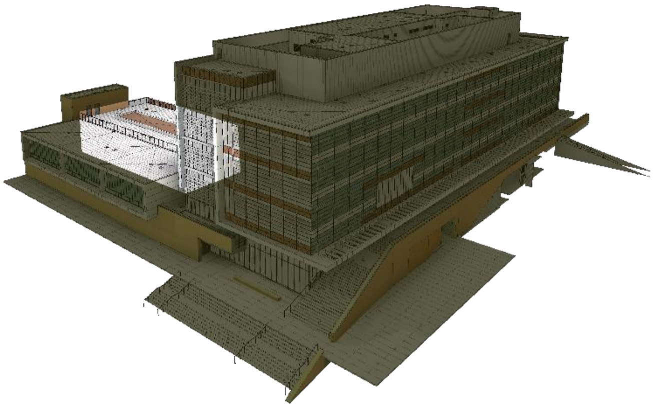
Auditorium Lighting Power Density			
Type	**Quantity**	**Input Watts**	**Total Watts**
L7	159 ft	6.3	55.65
L12	31	22.9	709.9
L13	14	87	1218
L14A	5	42	210
L14B	19	8	152
		Total Watts	2345.55
		Total Area	4408
		Calculated LPD	0.532112069
		ASHRAE 90.1 LPD Allowed	1.24
		Difference	0.71

Space Evaluation + Summary

The design for the auditorium successfully embraces the present and provides a lighting situation that is affective and versatile. The lighting levels for the all on testing mode are around 300 lux on the desk surfaces as well as the presenting area providing a nice bright test taking atmosphere. The other two schemes provide about 50 lux on the desks which is the desired level. The circulation levels are kept slightly higher than those recommended in the IES handbook at between 40 and 50 lux depending on the scheme because it was decided that higher illuminances would be more acceptable than lower illuminances and that way the lighting for the space is more uniform. The presenting area was kept slightly under that recommended for the presenter mode but slightly higher for the AV mode. This compromise was determined to be acceptable and the design allows for a reconfiguration of the scene levels. The lighting power density for the space is 40% more efficient than the ASHRAE allowable wattage.

Large Workspace | Project Labs





Project Labs Locator

Description

The project labs space is the largest workspace in the building and will be used for the production of formula cars as well as a multitude of other products in the school of engineering. This is where the ideas of the students and the knowledge they have obtained are put together to create and to show off and test their ideas which is why this space deserves to be a place that is comfortable to work in as well as functional. The design will have layers of stylized light to make the space visually appealing and layers of high level lighting for the visually intensive tasks of using machinery. The materiality is fairly plain with concrete flooring, exposed ceiling, exposed CMU walls, and exposed steel beams throughout.

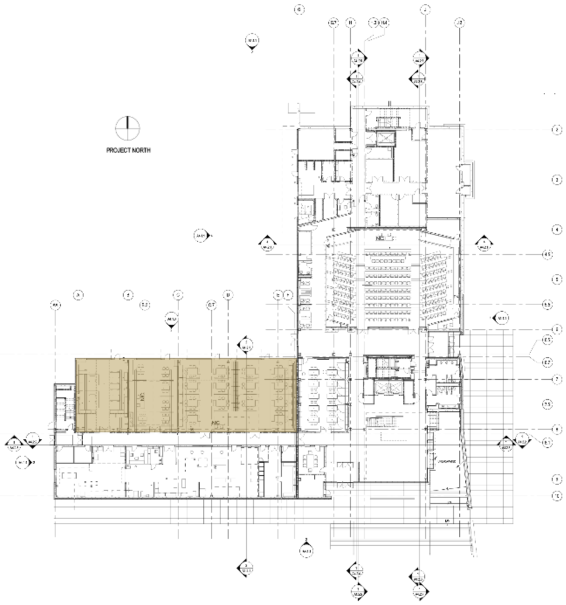


Figure 30 Project Labs 1st Floor

Concept

Figure 31 Schematic Design Sketch

The project labs space, as a hands-on learning experience for the students, was seen as a sort of an outlet to allow the students to break out of their normal schooling and push the boundaries with the application of knowledge. Here, the past is set aside and the projects look only to the future. This space needs to have a stylized and industrial feel to the space to make it both realistic and yet also visually stimulating.

Design Criteria

The following is a list of important design criteria, both quantitative and qualitative, to reinforce design concepts and desires for the final lighting design.

Illuminance Criteria | According to the IES Lighting Handbook
Educational Facilities | Classrooms
Shops | Assembly = 500 lux E_h, 250 lux E_v (<25 years old)

Stylized Industrial Feeling | According with the concept, a higher end feeling to this fairly industrial space is desired

Color Rendering | The color temperatures desired were in the 4000 K range with high color rendering indexes to provide a consistent design as well as a good quality of light for the type of work that is to be done in the project labs

Lighting Power Density | According to ASHRAE 90.1
Many space types seemed to match the project labs space which is in fact three different rooms. Laboratory in or as a classroom = 1.43 W/ft^2, Workshop = 1.59 W/ft^2, Vehicular Maintenance Area = 0.67 W/ft^2, and Manufacturing Facility (25-50 ft floor to ceiling) = 1.23 W/ft^2. The average of these four lighting power densities is 1.23 W/ft^2 and also matches that of the manufacturing facility and thus this one was used

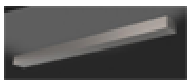
Design Development

During the schematic design phase last semester, many perimeter lighting layers were envisioned which would uplight the ceiling and provide ground plane illuminance at the entrances along with an industrial pendant array for the visual tasks. Due to the open ceiling plan, and large amount of mechanical equipment and structural beams in the space, many of the perimeter lights were abandoned in the design development phase of design. The number of pendant fixtures was minimized from the original design.

The pendant array are grouped into 4 main zones for the 2 smaller spaces and then the larger space on the east side having 2 zones. This was done for dimming capabilities as well as occupancy sensing. There are two layers of stylized light in the final design above and below the second floor overlooks into the space. The luminaires below the overlooks are surface mounted and illuminate the entryways from the first floor corridor. The luminaires above are linear bottom mounted asymmetric LED fixtures that provide some uplighting to the ceiling and mechanical equipment as well as emphasizing the overlook architecture.

A very important aspect to the project labs lighting scheme was added during the design development phase with the addition of the Kalwall Skyroof skylights. These skylights allow the LED pendants to dim much of the day and provide a nice diffuse layer of sunlight to the space and emphasizes the idea of “breaking out of normal schooling” and “pushing the boundaries”. This topic is further discussed in the MAE daylighting section of this report.

Fixture Schedule

Project Labs Fixture Schedule				
Type	**Symbol**	**Image**	**Description**	**Manufacturer**
L15			3.15' x 9.18" x 4.63" Industrial high-bay LED pendant, 6' cable length, heavy duty extruded anodized aluminum construction, protective optical lumen maintenance tray, 4000K, 73 CRI	Big Ass Lights
L16			11' x 3.5" x 2.5" Bottom mounted assymmetric LED fixture, aluminum extruded housing, 4000K	A-Light
L17			11' x 2-3/8" x 3-9/16" Surface mounted Linear LED fixture, extruded aluminum housing with aluminum endcaps, polyester powder coating, extruded impact resistant acrylic lens, 4000K, 80 CRI	Selux

Controls

The main control aspects of the space include, vacancy sensors, multiple zones for switching of each of the three main spaces, and photosensor dimming of the pendant fixtures due to the addition of the skylights. The controls will be easily accessible from either side of the project labs.

Lighting Plans + Sections

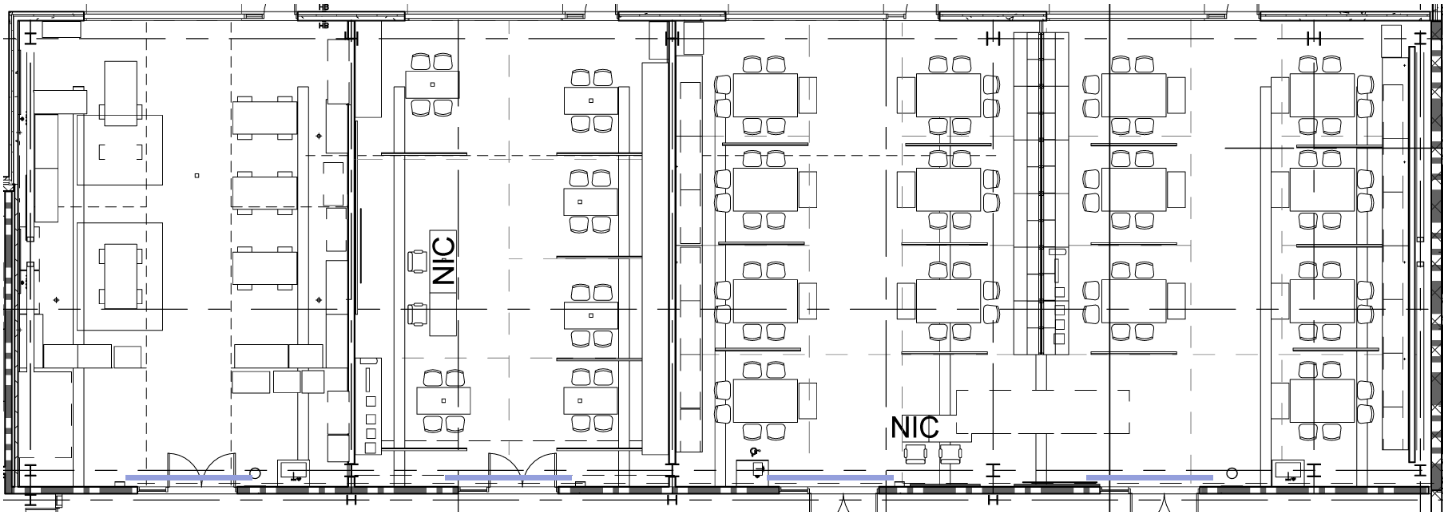


Figure 32 First Floor Lighting Plan

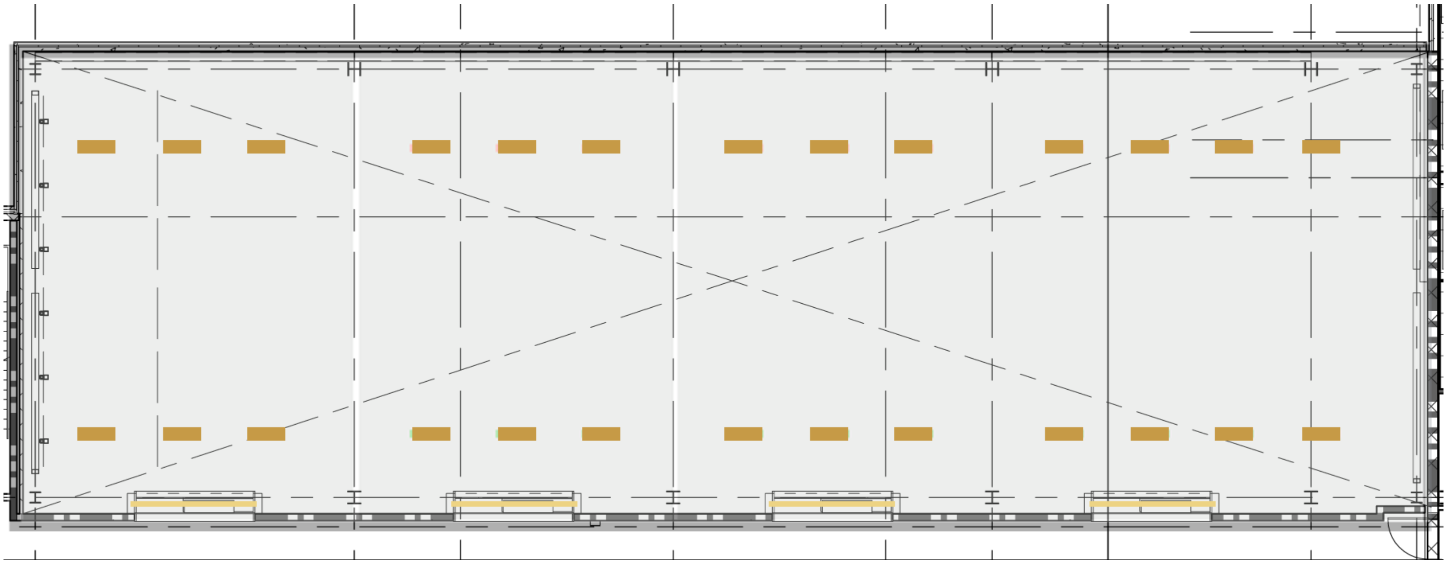


Figure 33 Second Floor Lighting Plan

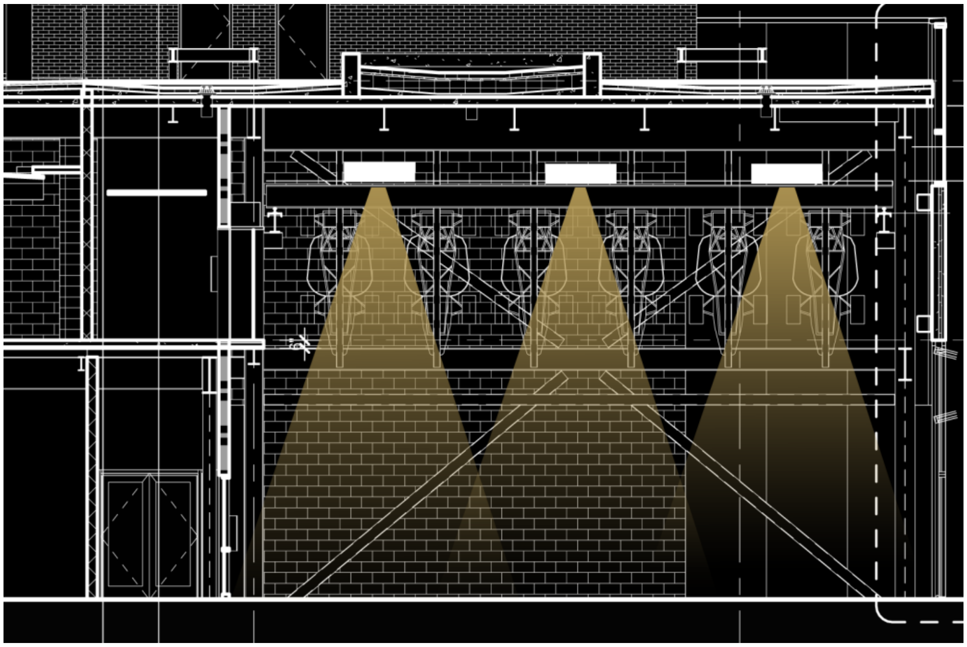


Figure 34 Original Lighting Section

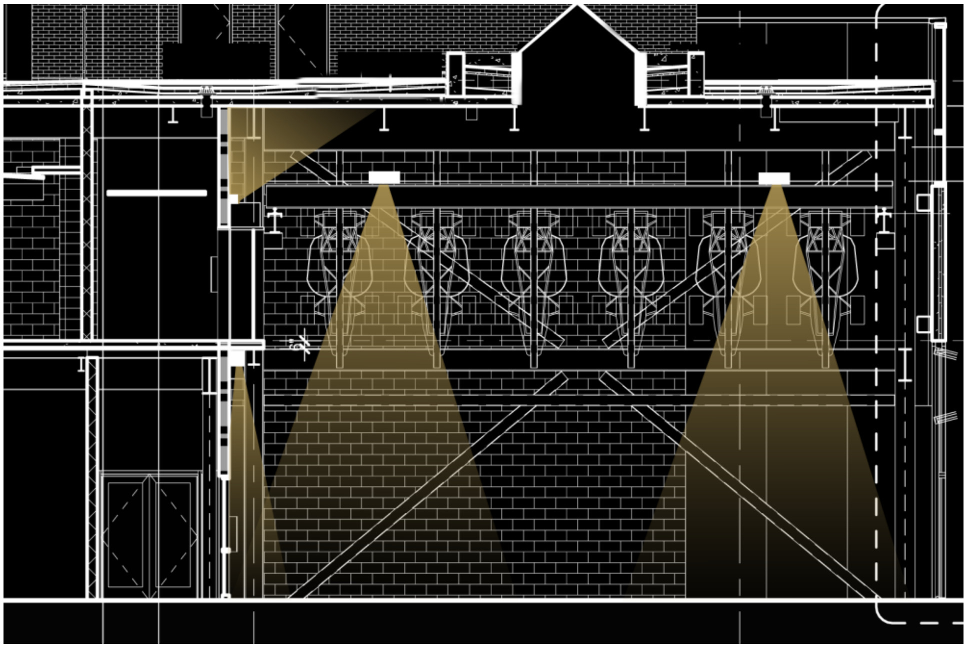


Figure 35 New Lighting Section with Skylight

Renders

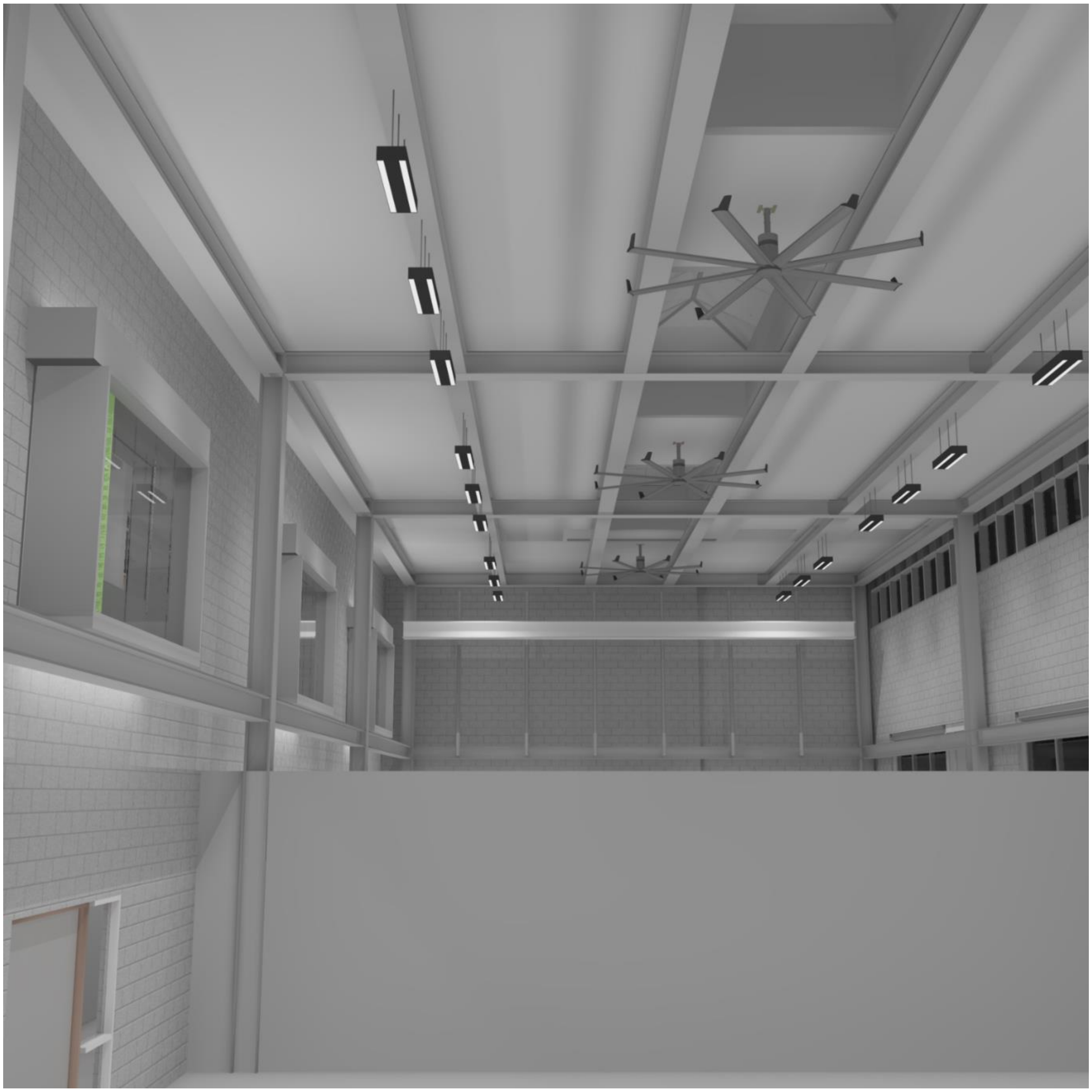


Figure 36 Perspective Rendering

Figure 37 Section Render Looking East

Figure 38 Perspective Render Looking Southwest

Pseudocolors (Light Levels)

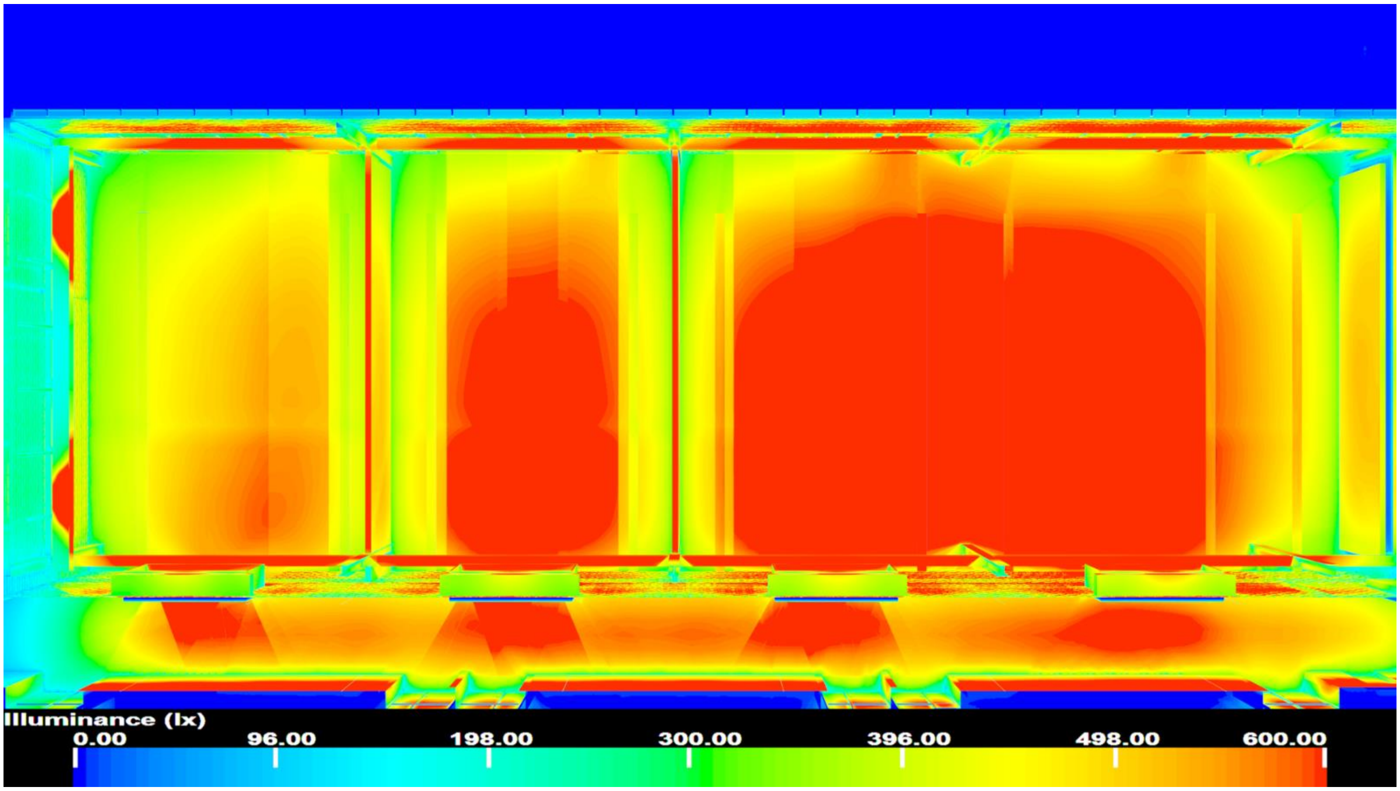


Figure 39 Top Section Pseudocolor

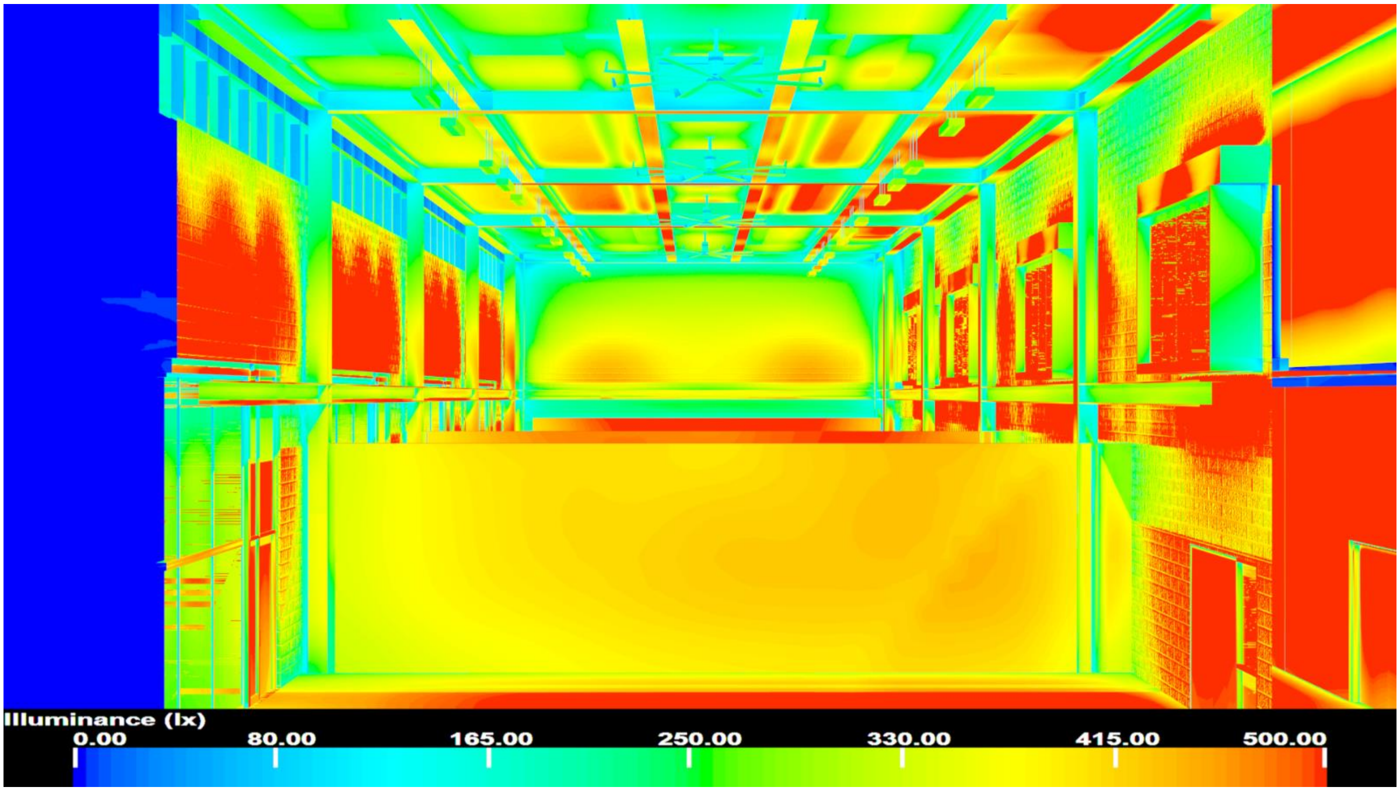


Figure 40 Project Lab Section Looking East

Lighting Power Density

Project Labs Lighting Power Density			
Type	**Quantity**	**Input Watts**	**Total Watts**
L15	26	194	5044
L16	44 FT	10	440
L17	44 FT	8.4	369.6
		Total Watts	5853.6
		Total Area	5704
		Calculated LPD	1.03
		ASHRAE 90.1 LPD Allowed	1.23
		Difference	0.20

Space Evaluation + Summary

Overall, the three layers of light in conjunction with the addition of the skylights seem to emphasize the concepts of breaking from tradition and pushing the boundaries. The lighting emphasizes both the industrial feeling of a workshop and the stylized feel with the perimeter lighting and the stylish LED pendant luminaires used. The quantitative design criteria also seem to be met fairly well. The average ground plane illuminance ranges between 400 and 600 lux which is fine for the space which should be around 500 lux on the workplane. The lighting power density for the space was calculated to be 1.03 and is 17% more efficient than the ASHRAE 90.1 allowed lighting power density. The space seems to meet the criteria set forth and is a successful space.

General Lighting Notes

This short section outlines a few lighting design general notes for the process used in coming up with the final lighting designs. These notes can be applied to each space.

3ds Max Studio

3ds Max was used to perform all interior lighting calculations and renders. Revit models were provided by the architect, SmithGroupJJR. These models were exported as .dwf files from Revit and imported into 3ds Max. The models were cleaned up of extra geometries and then the layers were assigned appropriate general materials and or specific materials if they could be made and were important to the design. From here, there was a long iterative process of determining appropriate lights to place into the model to achieve the desired effects that were thought of during the schematic phase to ultimately achieve the lighting levels desired.

To check the lighting levels, radiosity solutions were calculated with adaptive subdivision. In 3ds Max, this radiosity solution stores the luminance values in each of the surfaces and allows for a convenient way to explore the model to determine any problems. From the radiosity solution, renders could then be made through the Scanline rendering settings of 3ds Max. For the normal renders, a logarithmic lighting solution was used. For the pseudocolors, a linear illuminance solution was used.

3ds Max Studio has been validated by many as a decent lighting tool and the methods used were a variation of what was learned at a previous internship. The materiality and complexity of the models made this process fairly time consuming and the final solutions do not reflect how exactly how the lighting would most likely appear. The renders were done to the best of my knowledge of the program and of the use of materials however and they are good enough for the purposes of getting my points across.

Light Loss Factors

Due in part to using strictly LED fixtures for each space and due to the fact that the technology is getting increasingly better in terms of lamp life, a light loss factor of 0.7 was used for each fixture. Using lamp dirt depreciation as well for some fixtures was considered, but due to the 0.7 being fairly conservative already this was determined to be sufficient enough. During the past internship, 0.7 LLF was almost always utilized.

ELECTRICAL DEPTH |

Overview

The new Engineering Center, being located on the Oakland University campus, receives its utility power from the University at a discounted cost compared to the surrounding area of Rochester, Michigan. This utility power enters the building at the ground level into a secondary unit substation, room 160, which contains two 15 kV fused load interrupter break switches (PS-A2 + PS-B2) for the two primary service transformers. All of the electrical rooms are fed from feeders located in this room. A penthouse generator is used in the event that emergency power is needed. Most of the panels in this building use 480Y/277V 3PH, 4W power from the two main transformers through distribution panels however, some panels using 208Y/120V power require step-down transformers in the designated electrical rooms on each floor. There are 63 wall-mounted branch panel boards located in the eight designated electrical rooms throughout the building. Of these, only nine panels were affected by the lighting redesign.

The electrical depth consists mainly of a branch circuit analysis of the lighting panels that have been impacted by the lighting redesign of the four main spaces that are covered in the lighting depth portion of this report. The lighting panels are all very conservatively designed to meet NEC requirements and to allow for changes during the life of this building. Because of this, none of the panels have been resized as the load added to the panels in most cases does not impact the connected load very much.

The second portion of this depth includes a point-by-point short circuit analysis from the substation main transformer to one of the impacted lighting branch circuit panel boards. This analysis showed what was assumed about the oversizing of the panels with all points along the fault analysis having less load than the equipment's Ampere Interrupting Capacity (AIC) rating.

Branch Circuit Calculation

Firstly, the affected branch circuit panels were determined and the loads were noted and each fixture on these panels were used to calculate the load that would be subtracted from the appropriate circuits.

Modified Panelboards						
Panel	**Voltage**	**Normal/Emergency**	**Exterior**	**Lobby + Atrium**	**Auditorium**	**Project Labs**
L11A	480Y/275	Normal			X	
H11	480Y/277	Normal			X	
H13	480Y/278	Normal	X			
H13LS	480Y/279	N/E	X	X	X	
H21	480Y/280	Normal	X			
H23	480Y/281	Normal		X		X
H23LS	480Y/282	N/E	X			X
H31	480Y/283	Normal		X		
H51	480Y/284	Normal		X		

Table 1 Modified Panel boards to Analyze

Original Design Loads						
Area	**Type**	**Quantity**	**Wattage**	**Voltage**	**VA**	**Circuit**
Project Labs	**F7**	27	364 W	277 V	9828 VA	H23-8
Project Labs	**F7**	8	364 W	277 V	2912 VA	H23LS-5
Lobby 1	**L7**	10	14 W	277 V	140 VA	H13-1
Exterior	**L7**	1	14 W	277 V	14 VA	H13-1
Exterior 1	**L11**	22	6 W	277 V	132 VA	H13-3
Exterior 2	**L11**	12	6 W	277 V	72 VA	H21-5
Auditorium	**L13**	10	4.5 W	277 V	45 VA	H11-1
Lobby 1	**L14**	24 FT	6 W/FT	277 V	144 VA	H13-1
Auditorium	**L15**	27	5 W	120 V	135 VA	L11A-34
Lobby 2	**SF1**	90 FT	7.5 W/FT	277 V	675 VA	H23-1
Hallway 2	**SF5**	7	36 W	277 V	252 VA	H23LS-5
Atrium 5	**SH4**	6	75 W	277 V	450 VA	H51-7
Exterior 2	**SL1**	3	20 W	277 V	60 VA	H23LS-5
Exterior 2	**SL2**	22	10 W	277 V	220 VA	H23LS-1
Lobby 2	**SL4**	41 FT	9 W/FT	277 V	369 VA	H23-5
Atrium 3	**SL4**	46 FT	9 W/FT	277 V	414 VA	H31-8
Exterior 1	**SL5**	34	11 W	277 V	374 VA	H13LS-5
Lobby 1	**SL10**	10	21 W	277 V	210 VA	H13-1,H13LS-3
Auditorium	**SL10A**	5	21 W	277 V	105 VA	H11-1
Exterior 1	**SL10B**	2	20 W	277 V	40 VA	H13-1
Exterior 2	**SL10B**	7	20 W	277 V	140 VA	H21-1,H23LS-1
Auditorium	**SL11**	10	3 W	120 V	30 VA	L11A-34
Auditorium	**SL13**	28	18 W	120 V	504 VA	H11-1
Auditorium	**SL13B**	7	40 W	120 V	280 VA	L11A-34
Atrium 3	**SL13C**	10	28 W	277 V	280 VA	H31-7
Lobby 2	**SL22**	120 FT	9 W/FT	277 V	1080 VA	H23-5
Auditorium	**SL26**	12	2.2 W	120 V	26 VA	L11A-34
Auditorium	**SL27**	8	20 W	120 V	160 VA	L11A-34
Lobby 1	**SL28**	23	36 W	277 V	828 VA	H13-1,H13LS-3
Lobby 2	**SL28**	11	36 W	277 V	396 VA	H23-1,H23LS-5
Auditorium	**SL29**	30	63 W	277 V	1890 VA	H11-1

Table 2 Original Loads and Circuits Affected

For the branch circuits affected by the lighting redesign, the loads from all of the installed fixtures from the four main spaces were added to appropriate circuits according to proximity to the electrical rooms and the lighting fixtures that they are replacing. Installed lighting with the lighting redesign Refer to lighting depth section for luminaire type descriptions or Appendix I for the full lighting fixture schedule.

To find the volt-amp loads for each of the fixtures, a 0.9 power factor was used as a conservative value as per EnergyStar and DoE recommendations. And, for the maximum continuous load, in VA, a continuous load factor of 125% was used to determine the maximum VA to put on each circuit as per the NEC.

Maximum Continuous Load VA per circuit for 480Y/277V Panels = 277V * 20A * 0.8 = 4432 VA

Maximum Continuous Load VA per circuit for 208Y/120V Panels = 120V * 20A * 0.8 = 1920 VA

		US						
		DoE	EnergyStar	California	Europe	China	Korea	Japan
Residential	Efficiency	50lm/W	50lm/W	N/A	N/A	N/A	N/A	N/A
	PF	>0.7	>0.7	N/A	>0.7	N/A	>0.85	N/A
	THD	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Commercial	Efficiency	55lm/W	55lm/W	55lm/W	N/A	N/A	N/A	N/A
	PF	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9
	THD	<20%	<20%	<20%	<20%	<30%	<30%	<30%

Figure 41 Power Factor for LED Lighting

Then, for each luminaire type in the lighting redesign, the VA contribution was calculated and the appropriate circuit was chosen as shown in the figures below.

Exterior Lighting Load Calculation

Type	Quantity	Wattage	Voltage	PF	VA	Circuits
L1	91 m	4.8 W/m	24 V	0.9	485 VA	(19m) H13-3, (72m) H21-5
L2	6	23 W	277 V	0.9	153 VA	(2) H13LS-3, (4) H21-1
L3	9	32 W	277 V	0.9	320 VA	H23LS-1
L4	6	40 W	277 V	0.9	267 VA	H13-3
L5	2	27 W	277 V	0.9	60 VA	H23
				Total:	1285 VA	

Lobby Level One Lighting Load Calculation

Type	Quantity	Wattage	Voltage	PF	VA	Circuits
L2	3	23 W	277 V	0.9	77 VA	H13-1
L6	19	21 W	277 V	0.9	443 VA	H13-12
L7	38 FT	6.3 W/FT	277 V	0.9	266 VA	H13-1
L9	6	8 W	277 V	0.9	53 VA	H13LS-3
				Total:	839 VA	

Lobby + Atrium Level Two Lighting Load Calculation						
Type	**Quantity**	**Wattage**	**Voltage**	**PF**	**VA**	**Circuits**
L6	27	21 W	277 V	0.9	630 VA	H23-5
L8	5	48 W	277 V	0.9	267 VA	H23-1
L9	6	8 W	277 V	0.9	53 VA	H23LS-5
L10	18 FT	5 W/FT	277 V	0.9	100 VA	H23-1
L11	3 FT	12.5 W/FT	277 V	0.9	42 VA	H23-1
				Total:	1092 VA	

Atrium Level Three Lighting Load Calculation						
Type	**Quantity**	**Wattage**	**Voltage**	**PF**	**VA**	**Circuits**
L12	10	22.9 W	277 V	0.9	254 VA	H31-8

Atrium Level Five Lighting Load Calculation						
Type	**Quantity**	**Wattage**	**Voltage**	**PF**	**VA**	**Circuits**
L12	14	22.9 W	277 V	0.9	356 VA	H51-7

Auditorium Lighting Load Calculation						
Type	**Quantity**	**Wattage**	**Voltage**	**PF**	**VA**	**Circuits**
L7	159 FT	6.3 W/FT	24 V	0.9	1113 VA	L11A-34
L12	31	22.9 W	277 V	0.9	789 VA	H11-1
L13	14	87 W	277 V	0.9	1353 VA	H11-1
L14A	5	42 W	277 V	0.9	233 VA	H11-1
L14B	19	8 W	277 V	0.9	169 VA	H11-1
				Total:	3657 VA	

Project Labs Lighting Load Calculation						
Type	**Quantity**	**Wattage**	**Voltage**	**PF**	**VA**	**Circuits**
L15	26	194 W	277 V	0.9	5604 VA	(14) H23-8, (12) H23-10-6
L16	44 FT	10 W/FT	277 V	0.9	489 VA	H23-11
L17	44 FT	8.4 W/FT	277 V	0.9	411 VA	H23-11
				Total:	6504 VA	

These loads were then added to the selected circuits and the original loads were subtracted to determine the final loads on these circuits which then updated the panel boards. All of the updated and original panels are shown on the following pages with the affected circuits highlighted.

VA Normal Load Changes					
Circuit	**Area**	**VA**	**VA Taken Out**	**VA Replaced**	**New Total**
H11-1	Auditorium	2005 VA	2005 VA	2544 VA	2544 VA
H13-1	South Entry + Lobby 1	1732 VA	1022 VA	343 VA	1053 VA
H13-3	Handrail + Exterior 1	322 VA	322 VA	368 VA	368 VA
H13-12	Lobby 1	0 VA	0 VA	443 VA	443 VA
H13LS-3	Lobby 1	757 VA	354 VA	104 VA	507 VA
H21-1	North Entry	1395 VA	140 VA	162 VA	1417 VA
H21-5	Handrail	173 VA	72 VA	384 VA	485 VA
H23-1	Lobby 2	1059 VA	675 VA	408 VA	792 VA
H23-5	Lobby 2	1237 VA	1237 VA	630 VA	630 VA
H23-6	Project Labs	0 VA	0 VA	2587 VA	2587 VA
H23-8	Project Labs	3420 VA	3420 VA	3018 VA	3018 VA
H23-11	Project Labs	0 VA	0 VA	900 VA	900 VA
H23LS-1	Exterior 2	92 VA	92 VA	320 VA	320 VA
H23LS-5	Lobby 2	3455 VA	258 VA	53 VA	3250 VA
H31-7	Atrium 3	2461 VA	280 VA	0 VA	2181 VA
H31-8	Atrium 3	386 VA	386 VA	254 VA	254 VA
H51-7	Atrium 5	3428 VA	450 VA	356 VA	3334 VA
L11A-34	Auditorium	501 VA	501 VA	1113 VA	1113 VA
	Totals:	22.4 KVA	11.2 KVA	14.0 KVA	25.2 KVA

Table 3 Circuit VA Load Changes

Panelboard: H11 Updated

Location:	ELEC 154	**Volts:**	480Y/277	**A.I.C. Rating:**	14000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting 200 Seat Classroom 116	20 A	1	2544	3078					1	20 A	Lighting Fire Pump/Domestic Water 152	2
3	Lighting Corridor 193	20 A	1			408 VA	384 VA			1	20 A	Lighting	4
5	Lighting	20 A	1					428 VA	352 VA	1	20 A	Lighting Room 731	6
7	Lighting	20 A	1	360 VA	0 VA					1	20 A	Spare	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Spare	--	--	0 VA	0 VA					--	--	Spare	20
21	Spare	--	--			0 VA	0 VA			--	--	Spare	22
23	Spare	--	--					0 VA	0 VA	--	--	Spare	24
25	Spare	--	--	0 VA	0 VA					--	--	Spare	26
27	Spare	--	--			0 VA	0 VA			--	--	Spare	28
29	Spare	--	--					0 VA	0 VA	--	--	Spare	30
			Total Load:	5982 VA		792 VA		780 VA					
			Total Amps:	22 A		3 A		3 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	7554 VA	80%	6043 VA		
				Total Conn. Load:	7554 VA
				Total Est. Demand:	6043 VA
				Total Conn.:	9 A
				Total Est. Demand:	7 A

Panelboard: H13 Updated

Location:	ELEC 173	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting PRE-FUNCTION 196	20 A	1	1053	1629					1	20 A	Lighting SOPHOMORE DESIGN LAB 170	2
3	Lighting	20 A	1			368 VA	2724			1	20 A	Lighting PROJECT LAB STORAGE 177	4
5	Lighting	20 A	1					81 VA	270 VA	1	20 A	Lighting CORRIDOR-1 197-1	6
7	Lighting	20 A	1	804 VA	780 VA					1	20 A	Lighting	8
9	Lighting	20 A	2			2138	0 VA			1	20 A		10
11								2138	443 VA	1	20 A	Lighting Lobby Linear Downlights	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	1	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	1			0 VA	0 VA			1	--	Space	22
23	Space	--	1					0 VA	0 VA	1	--	Space	24
25	Space	--	1	0 VA	0 VA					1	--	Space	26
27	Space	--	1			0 VA	0 VA			1	--	Space	28
29	Space	--	1					0 VA	0 VA	1	--	Space	30
			Total Load:	4266 VA		5230 VA		2932 VA					
			Total Amps:	15 A		19 A		11 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	12428 VA	80.00%	9942 VA		
				Total Conn. Load:	12428 VA
				Total Est. Demand:	9942 VA
				Total Conn.:	15 A
				Total Est. Demand:	12 A

Panelboard: H13LS Updated

Location:	ELEC 173	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	DP-LS	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	60 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting ELEVATOR CONTROL ROOM 150	20 A	1	2210	295 VA					1	20 A	Lighting CORRIDOR 193	2
3	Lighting PRE-FUNCTION 196	20 A	1			507 VA	962 VA			1	20 A	Lighting ELEC 173	4
5	Lighting	20 A	1					689 VA	485 VA	1	20 A	Lighting CORRIDOR-1 197-1	6
7	Lighting Room 731	20 A	1	192 VA	64 VA					1	20 A	Lighting ELEV. 153A	8
9	Spare	20 A	1			0 VA	96 VA			1	20 A	Lighting ELEV. 100A	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					--	--	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	2761 VA		1565 VA		1174 VA					
			Total Amps:	10 A		6 A		4 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	5500 VA	80.00%	4400 VA		
				Total Conn. Load:	5500 VA
				Total Est. Demand:	4400 VA
				Total Conn.:	7 A
				Total Est. Demand:	5 A

Panelboard: H21 Updated

Location:	ELEC 265C	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	1417	262 VA					1	20 A	Lighting Room 247	2
3	Lighting Room 203, 293B, _293C, 179F, _293B	20 A	1			1191	3420			1	20 A	Lighting WAITING 255	4
5	Lighting	20 A	1					485 VA	2547	1	20 A	Lighting 100 SEAT CLASSROOM _704	6
7	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	1679 VA		4611 VA		3032 VA					
			Total Amps:	6 A		17 A		11 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	9322 VA	80.00%	7458 VA		
				Total Conn. Load:	9322 VA
				Total Est. Demand:	7458 VA
				Total Conn.:	11 A
				Total Est. Demand:	9 A

Panelboard: H23 Updated

Location:	ELEC 273	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	792	1026					1	20 A	Lighting Room 179F, 297, 202, 212	2
3	Lighting	20 A	1			4509	26 VA			1	20 A	Lighting MENS 265E	4
5	Lighting STAIR _261X	20 A	1					630	2587	1	20 A	Lighting Project Labs	6
7	Lighting	20 A	1	2697	3018					1	20 A	Lighting	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Lighting Project Labs	20 A	1					900 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	7533 VA		4535 VA		4116 VA					
			Total Amps:	27 A		16 A		15 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	16184 VA	80.00%	12947 VA		
				Total Conn. Load:	16184 VA
				Total Est. Demand:	12947 VA
				Total Conn.:	19 A
				Total Est. Demand:	16 A

Panelboard: H23LS Updated

Location:	ELEC 273	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	DP-LS	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	60 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	320 VA	702 VA					1	20 A	Lighting CORRIDOR 193	2
3	Lighting WAITING 255	20 A	1			719 VA	0 VA			1	20 A	Lighting ELEC 173	4
5	Lighting Room 267, 212, _261X, 179F, 102-2, 297	20 A	1					3250	0 VA	1	20 A	Lighting CORRIDOR-1 197-1	6
7	Spare	20 A	1	0 VA	0 VA					1	20 A	Lighting ELEV. 153A	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Lighting ELEV. 100A	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			--	--	Space	16
17	Space	--	--					0 VA	0 VA	--	--	Space	18
19	Space	--	--	0 VA	0 VA					--	--	Space	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	1022 VA		719 VA		3250 VA					
			Total Amps:	4 A		3 A		12 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	4991 VA	80.00%	3993 VA		
				Total Conn. Load:	4991 VA
				Total Est. Demand:	3993 VA
				Total Conn.:	6 A
				Total Est. Demand:	5 A

Panelboard: H31 Updated

Location:	ELEC 365C	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting SEMINAR 347	20 A	1	2474	3609					1	20 A	Lighting GRAD OFFICE 354	2
3	Lighting LAB MANAGER/ ELECTRONICS SHOP	20 A	1			2872	994 VA			1	20 A	Lighting	4
5	Lighting ROOFTOP LAB 390	20 A	1					23 VA	950 VA	1	20 A	Lighting CORRIDOR 391	6
7	Lighting CORRIDOR 390	20 A	1	2181	254 VA					1	20 A	Lighting Room 271	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	8518 VA		3866 VA		973 VA					
			Total Amps:	31 A		14 A		4 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	13357 VA	80.00%	10686 VA		
				Total Conn. Load:	13357 VA
				Total Est. Demand:	10686 VA
				Total Conn.:	16 A
				Total Est. Demand:	13 A

Panelboard: H51 Updated

Location:	ELEC 565C	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting GROUP PROJECT/ STUDY 547	20 A	1	3168	3285					1	20 A	Lighting COMPUTING LAB 550	2
3	Lighting INFORMAL LEARNING 563	20 A	1			2963	2260			1	20 A	Lighting GROUP PROJECT/ STUDY 575	4
5	Lighting CORRIDOR590	20 A	1					1000	1449	1	20 A	Lighting CORRIDOR-2 593-2	6
7	Lighting Room 655,653	20 A	1	3334	0 VA					1	20 A	Spare	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					--	--	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	9787 VA		5223 VA		2449 VA					
			Total Amps:	35 A		19 A		9 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	17459 VA	80.00%	13967 VA		
				Total Conn. Load:	17459 VA
				Total Est. Demand:	13967 VA
				Total Conn.:	21 A
				Total Est. Demand:	17 A

Panelboard: L11A Updated

Location:	ELEC 154	**Volts:**	208Y/120	**A.I.C. Rating:**	10,000
Supply From:		**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	225 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Power FIRE PUMP/DOMESTIC WATER 152	20 A	1	110	75					1	20 A	Power ELEC 154	2
3	Power SUBSTATION _732	20 A	1			145 VA	110 VA			1	20 A	Power	4
5	EF-11	20 A	1					828 VA	110 VA	1	20 A	Power SUBSTATION 160	6
7	Receptacle Space _728	20 A	1	360 VA	1080					1	20 A	Receptacle HAZARD. WASTE 156B	8
9	Receptacle OFFICE 156H	20 A	1			900 VA	180 VA			1	20 A	Receptacle VENDING 164	10
11	Receptacle FAMILY TOILET 166	20 A	1					900 VA	720 VA	1	20 A	Receptacle GROUP PROJECT/STUDY 168C	12
13	Receptacle CORRIDOR 195	20 A	1	900 VA	720 VA					1	20 A	Receptacle	14
15	Receptacle JC 155	20 A	1			540 VA	720 VA			1	20 A	Receptacle SUBSTATION 160	16
17	Receptacle STORAGE CAGES 163	20 A	1					900 VA	180 VA	1	20 A	Receptacle SUBSTATION 160	18
19	Spare	20 A	1	0 VA	200 VA					1	20 A	LCP	20
21	Power FAMILY TOILET 166	20 A	1			1500	1500			1	20 A	Power M TOILET 171	22
23	Power W TOILET 169	20 A	1					1500	1200	1	20 A	Receptacle VENDING 164	24
25	Receptacle VENDING 164	20 A	1	1200	1200					1	20 A	Receptacle VENDING 164	26
27	Receptacle VENDING 164	20 A	1			1200	1200			1	20 A	Receptacle VENDING 164	28
29	EF-10	20 A	1					828 VA	368 VA	1	20 A	Power CORRIDOR 195	30
31	Power SHIPPING/ RECEIVING LOADING 156	20 A	1	828 VA	0 VA					1	20 A	Spare	32
33						0 VA	1113			1	20 A	Lighting 200 SEAT CLASSROOM 116	34
35	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	36
37	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	38
39	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	40
41	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	42
			Total Load:	6673 VA		9108 VA		7534 VA					
			Total Amps:	56 A		76 A		63 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	1113 VA	80.00%	890 VA		
Power	6446 VA	30.00%	1934 VA	**Total Conn. Load:**	23315 VA
Receptacle	14100 VA	85.46%	12050 VA	**Total Est. Demand:**	15867.66 VA
Mechanical Equipment	1656 VA	60.00%	994 VA	**Total Conn.:**	65 A
				Total Est. Demand:	44 A

Panelboard: H11(Unchanged)

Location:	ELEC 154	**Volts:**	480Y/277	**A.I.C. Rating:**	14000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting 200 Seat Classroom 116	20 A	1	2005	3078					1	20 A	Lighting Fire Pump/Domestic Water 152	2
3	Lighting Corridor 193	20 A	1			408 VA	384 VA			1	20 A	Lighting	4
5	Lighting	20 A	1					428 VA	352 VA	1	20 A	Lighting Room 731	6
7	Lighting	20 A	1	360 VA	0 VA					1	20 A	Spare	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Spare	--	--	0 VA	0 VA					--	--	Spare	20
21	Spare	--	--			0 VA	0 VA			--	--	Spare	22
23	Spare	--	--					0 VA	0 VA	--	--	Spare	24
25	Spare	--	--	0 VA	0 VA					--	--	Spare	26
27	Spare	--	--			0 VA	0 VA			--	--	Spare	28
29	Spare	--	--					0 VA	0 VA	--	--	Spare	30
			Total Load:	5443 VA		792 VA		780 VA					
			Total Amps:	20 A		3 A		3 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	7015 VA	80%	5612 VA		
				Total Conn. Load:	7015 VA
				Total Est. Demand:	5612 VA
				Total Conn.:	8 A
				Total Est. Demand:	7 A

Panelboard: H13 (Unchanged)

Location:	ELEC 173	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting PRE-FUNCTION 196	20 A	1	1732	1629					1	20 A	Lighting SOPHOMORE DESIGN LAB 170	2
3	Lighting	20 A	1			322 VA	2724			1	20 A	Lighting PROJECT LAB STORAGE 177	4
5	Lighting	20 A	1					81 VA	270 VA	1	20 A	Lighting CORRIDOR-1 197-1	6
7	Lighting	20 A	1	804 VA	780 VA					1	20 A	Lighting	8
9	Lighting	20 A	2			2138	0 VA			1	20 A		10
11								2138	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	1	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	1			0 VA	0 VA			1	--	Space	22
23	Space	--	1					0 VA	0 VA	1	--	Space	24
25	Space	--	1	0 VA	0 VA					1	--	Space	26
27	Space	--	1			0 VA	0 VA			1	--	Space	28
29	Space	--	1					0 VA	0 VA	1	--	Space	30
			Total Load:	4945 VA		5184 VA		2489 VA					
			Total Amps:	18 A		19 A		9 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	12618 VA	80.00%	10094 VA		
				Total Conn. Load:	12618 VA
				Total Est. Demand:	10094 VA
				Total Conn.:	15 A
				Total Est. Demand:	12 A

Panelboard: H13LS (Unchanged)

Location:	ELEC 173	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	DP-LS	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	60 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting ELEVATOR CONTROL ROOM 150	20 A	1	2210	295 VA					1	20 A	Lighting CORRIDOR 193	2
3	Lighting PRE-FUNCTION 196	20 A	1			757 VA	962 VA			1	20 A	Lighting ELEC 173	4
5	Lighting	20 A	1					689 VA	485 VA	1	20 A	Lighting CORRIDOR-1 197-1	6
7	Lighting Room 731	20 A	1	192 VA	64 VA					1	20 A	Lighting ELEV. 153A	8
9	Spare	20 A	1			0 VA	96 VA			1	20 A	Lighting ELEV. 100A	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					--	--	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	2761 VA		1815 VA		1174 VA					
			Total Amps:	10 A		7 A		4 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	5750 VA	80.00%	4600 VA		
				Total Conn. Load:	5750 VA
				Total Est. Demand:	4600 VA
				Total Conn.:	7 A
				Total Est. Demand:	6 A

Panelboard: H21 (Unchanged)

Location:	ELEC 265C	**Volts:**	480Y/277	**A.I.C. Rating:**	14,000
Supply From:	LDP-H11	**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	100 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	1395	262 VA					1	20 A	Lighting Room 247	2
3	Lighting Room 203, 293B, _293C, 179F, _293B	20 A	1			1191	3420			1	20 A	Lighting WAITING 255	4
5	Lighting	20 A	1					173 VA	2547	1	20 A	Lighting 100 SEAT CLASSROOM _704	6
7	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	1657 VA		4611 VA		2720 VA					
			Total Amps:	6 A		17 A		10 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	8988 VA	80.00%	7190 VA		
				Total Conn. Load:	8988 VA
				Total Est. Demand:	7190 VA
				Total Conn.:	11 A
				Total Est. Demand:	9 A

Panelboard: H23 (Unchanged)

Location: ELEC 273
Supply From: LDP-H11
Mounting: Surface
Enclosure: Type 1

Volts: 480Y/277
Phases: 3
Wires: 4

A.I.C. Rating: 14,000
Mains Type: MCB
Bus Rating: 100 A
MCB Rating: 100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	1059	1026					1	20 A	Lighting Room 179F, 297, 202, 212	2
3	Lighting	20 A	1			4509	26 VA			1	20 A	Lighting MENS 265E	4
5	Lighting STAIR _261X	20 A	1					1237		1	20 A		6
7	Lighting	20 A	1	2697	3420					1	20 A	Lighting	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	8202 VA		4535 VA		1237 VA					
			Total Amps:	30 A		16 A		4 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	13974 VA	80.00%	11179 VA		
				Total Conn. Load:	13974 VA
				Total Est. Demand:	11179 VA
				Total Conn.:	17 A
				Total Est. Demand:	13 A

Panelboard: H23LS (Unchanged)

Location: ELEC 273 **Volts:** 480Y/277 **A.I.C. Rating:** 14,000
Supply From: DP-LS **Phases:** 3 **Mains Type:** MCB
Mounting: Surface **Wires:** 4 **Bus Rating:** 100 A
Enclosure: Type 1 **MCB Rating:** 60 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting	20 A	1	92 VA	702 VA					1	20 A	Lighting CORRIDOR 193	2
3	Lighting WAITING 255	20 A	1			719 VA	0 VA			1	20 A	Lighting ELEC 173	4
5	Lighting Room 267, 212, _261X, 179F, 102-2, 297	20 A	1					3455	0 VA	1	20 A	Lighting CORRIDOR-1 197-1	6
7	Spare	20 A	1	0 VA	0 VA					1	20 A	Lighting ELEV. 153A	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Lighting ELEV. 100A	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			--	--	Space	16
17	Space	--	--					0 VA	0 VA	--	--	Space	18
19	Space	--	--	0 VA	0 VA					--	--	Space	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	794 VA		719 VA		3455 VA					
			Total Amps:	3 A		3 A		12 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	4968 VA	80.00%	3974 VA		
				Total Conn. Load:	4968 VA
				Total Est. Demand:	3974 VA
				Total Conn.:	6 A
				Total Est. Demand:	5 A

Panelboard: H31 (Unchanged)

Location: ELEC 365C **Volts:** 480Y/277 **A.I.C. Rating:** 14,000
Supply From: LDP-H11 **Phases:** 3 **Mains Type:** MCB
Mounting: Surface **Wires:** 4 **Bus Rating:** 100 A
Enclosure: Type 1 **MCB Rating:** 100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting SEMINAR 347	20 A	1	2474	3609					1	20 A	Lighting GRAD OFFICE 354	2
3	Lighting LAB MANAGER/ ELECTRONICS SHOP	20 A	1			2872	994 VA			1	20 A	Lighting	4
5	Lighting ROOFTOP LAB 390	20 A	1					23 VA	950 VA	1	20 A	Lighting CORRIDOR 391	6
7	Lighting CORRIDOR 390	20 A	1	2461	386 VA					1	20 A	Lighting Room 271	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					1	20 A	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	8930 VA		3866 VA		973 VA					
			Total Amps:	32 A		14 A		4 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	13769 VA	80.00%	11015 VA		
				Total Conn. Load:	13769 VA
				Total Est. Demand:	11015 VA
				Total Conn.:	17 A
				Total Est. Demand:	13 A

Panelboard: H51 (Unchanged)

Location: ELEC 565C	**Volts:** 480Y/277	**A.I.C. Rating:** 14,000	
Supply From: LDP-H11	**Phases:** 3	**Mains Type:** MCB	
Mounting: Surface	**Wires:** 4	**Bus Rating:** 100 A	
Enclosure: Type 1		**MCB Rating:** 100 A	

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Lighting GROUP PROJECT/ STUDY 547	20 A	1	3168	3285					1	20 A	Lighting COMPUTING LAB 550	2
3	Lighting INFORMAL LEARNING 563	20 A	1			2963	2260			1	20 A	Lighting GROUP PROJECT/ STUDY 575	4
5	Lighting CORRIDOR590	20 A	1					1000	1449	1	20 A	Lighting CORRIDOR-2 593-2	6
7	Lighting Room 655,653	20 A	1	3428	0 VA					1	20 A	Spare	8
9	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	10
11	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	12
13	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	14
15	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	16
17	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	18
19	Space	--	--	0 VA	0 VA					--	--	Spare	20
21	Space	--	--			0 VA	0 VA			--	--	Space	22
23	Space	--	--					0 VA	0 VA	--	--	Space	24
25	Space	--	--	0 VA	0 VA					--	--	Space	26
27	Space	--	--			0 VA	0 VA			--	--	Space	28
29	Space	--	--					0 VA	0 VA	--	--	Space	30
			Total Load:	9881 VA		5223 VA		2449 VA					
			Total Amps:	36 A		19 A		9 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	17553 VA	80.00%	14042 VA		
				Total Conn. Load:	17553 VA
				Total Est. Demand:	14042 VA
				Total Conn.:	21 A
				Total Est. Demand:	17 A

Panelboard: L11A (Unchanged)

Location:	ELEC 154	**Volts:**	208Y/120	**A.I.C. Rating:**	10,000
Supply From:		**Phases:**	3	**Mains Type:**	MCB
Mounting:	Surface	**Wires:**	4	**Bus Rating:**	225 A
Enclosure:	Type 1			**MCB Rating:**	100 A

CKT	Circuit Description	Trip	Poles	A		B		C		Poles	Trip	Circuit Description	CKT
1	Power FIRE PUMP/DOMESTIC WATER 152	20 A	1	110	75					1	20 A	Power ELEC 154	2
3	Power SUBSTATION _732	20 A	1			145 VA	110 VA			1	20 A	Power	4
5	EF-11	20 A	1					828 VA	110 VA	1	20 A	Power SUBSTATION 160	6
7	Receptacle Space _728	20 A	1	360 VA	1080					1	20 A	Receptacle HAZARD. WASTE 156B	8
9	Receptacle OFFICE 156H	20 A	1			900 VA	180 VA			1	20 A	Receptacle VENDING 164	10
11	Receptacle FAMILY TOILET 166	20 A	1					900 VA	720 VA	1	20 A	Receptacle GROUP PROJECT/STUDY 168C	12
13	Receptacle CORRIDOR 195	20 A	1	900 VA	720 VA					1	20 A	Receptacle	14
15	Receptacle JC 155	20 A	1			540 VA	720 VA			1	20 A	Receptacle SUBSTATION 160	16
17	Receptacle STORAGE CAGES 163	20 A	1					900 VA	180 VA	1	20 A	Receptacle SUBSTATION 160	18
19	Spare	20 A	1	0 VA	200 VA					1	20 A	LCP	20
21	Power FAMILY TOILET 166	20 A	1			1500	1500			1	20 A	Power M TOILET 171	22
23	Power W TOILET 169	20 A	1					1500	1200	1	20 A	Receptacle VENDING 164	24
25	Receptacle VENDING 164	20 A	1	1200	1200					1	20 A	Receptacle VENDING 164	26
27	Receptacle VENDING 164	20 A	1			1200	1200			1	20 A	Receptacle VENDING 164	28
29	EF-10	20 A	1					828 VA	368 VA	1	20 A	Power CORRIDOR 195	30
31	Power SHIPPING/ RECEIVING LOADING 156	20 A	1	828 VA	0 VA					1	20 A	Spare	32
33						0 VA	501 VA			1	20 A	Lighting 200 SEAT CLASSROOM 116	34
35	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	36
37	Spare	20 A	1	0 VA	0 VA					1	20 A	Spare	38
39	Spare	20 A	1			0 VA	0 VA			1	20 A	Spare	40
41	Spare	20 A	1					0 VA	0 VA	1	20 A	Spare	42
			Total Load:	6673 VA		8496 VA		7534 VA					
			Total Amps:	56 A		71 A		63 A					

Load Classification	Connected Load	Demand Factor	Estimated Demand	Panel Totals	
Lighting	501 VA	80.00%	401 VA		
Power	6446 VA	30.00%	1934 VA	**Total Conn. Load:**	22703 VA
Receptacle	14100 VA	85.46%	12050 VA	**Total Est. Demand:**	15378.06 VA
Mechanical Equipment	1656 VA	60.00%	994 VA	**Total Conn.:**	63 A
				Total Est. Demand:	43 A

Short Circuit Analysis

A short circuit analysis was performed in accordance with the National Electrical Code and with guidance from the Cooper Bussmann Short Circuit Current Calculations

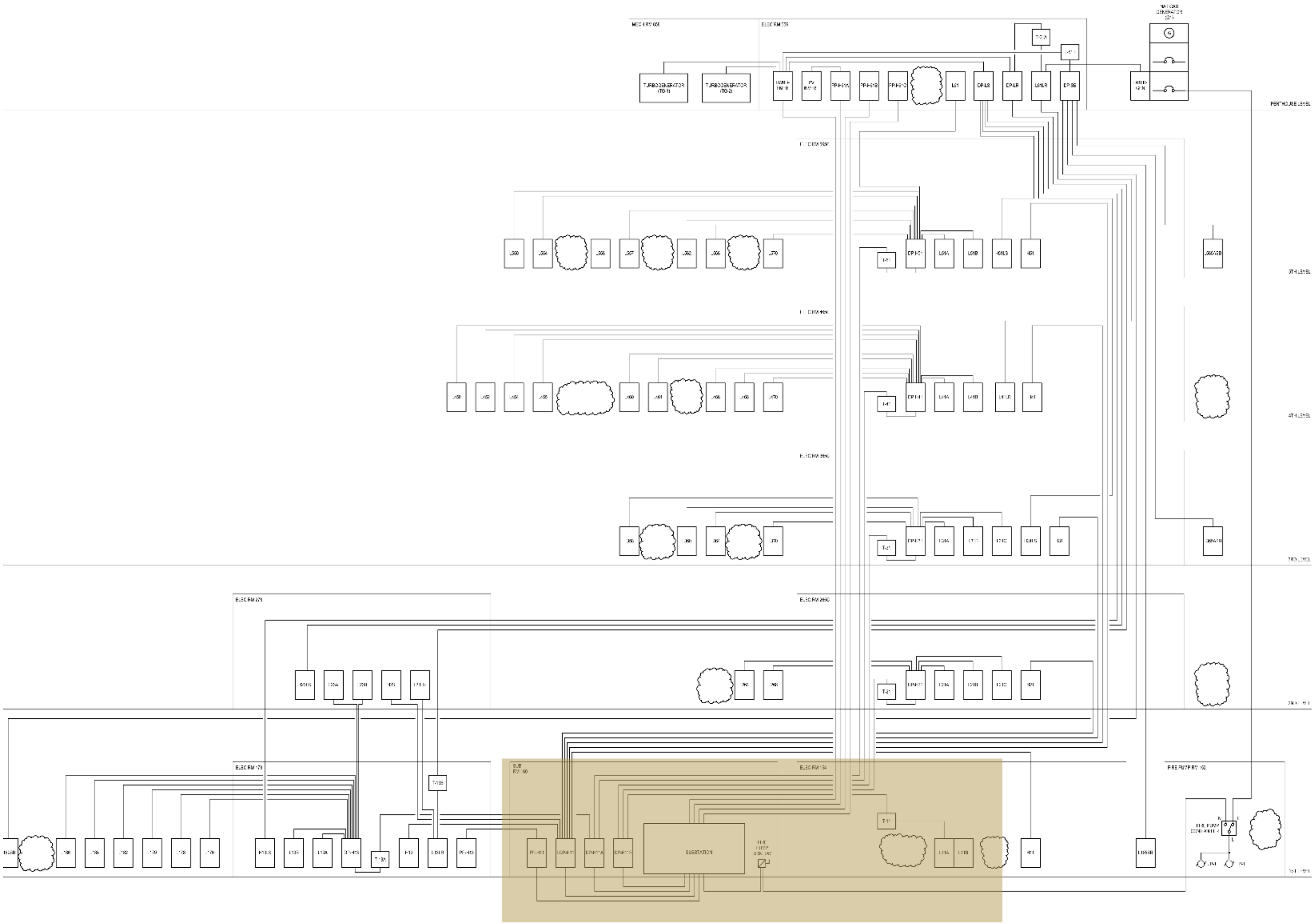


Figure 42 One Line Diagram of the Building

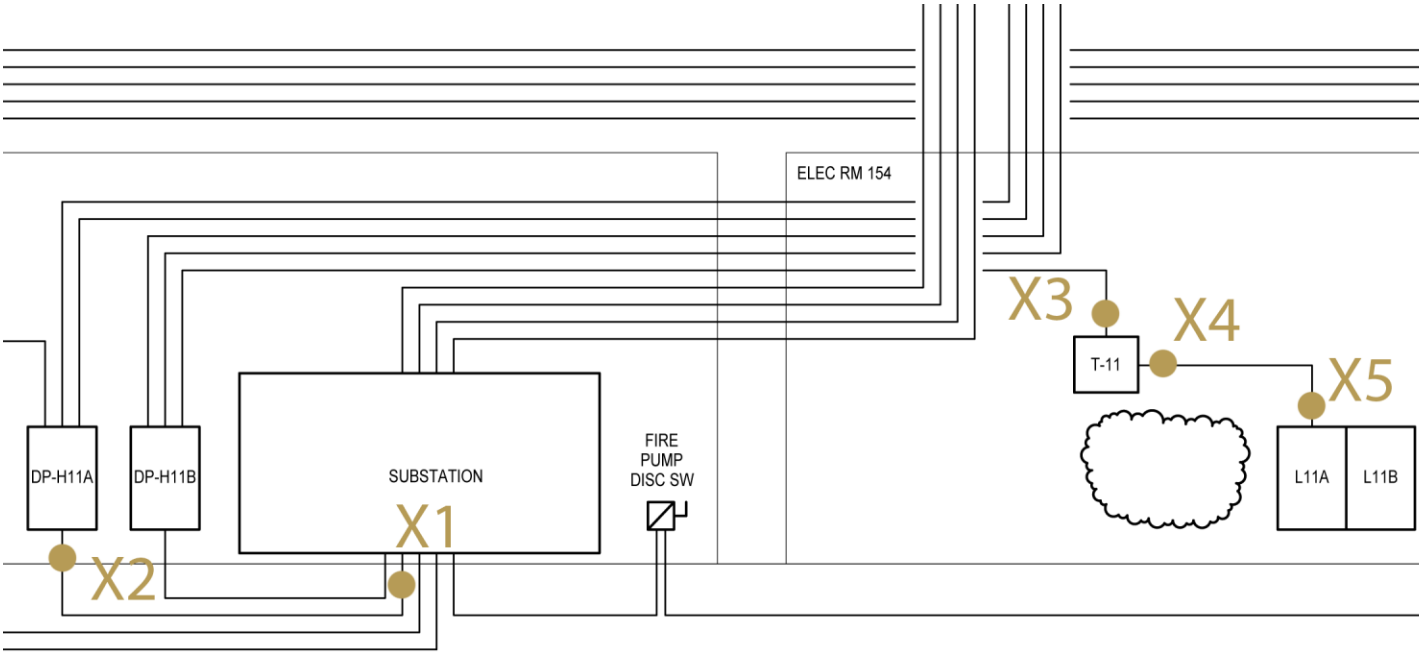


Figure 43 Enlarged One-Line Showing Fault Locations

FAULT X1

Available Utility Infinite Assumption

1500 KVA Transformer, 13.2kV - 480Y/277V, 3Φ, 3.5%Z

Step 1. $3\emptyset\ Transformer\ I_{FLA} = \frac{kVA \times 1000}{E_{LL} \times 1.732} = \frac{1500 \times 1000}{480 \times 1.732} = 1804.27$

Step 2. $Multiplier = \frac{100}{3.5} = 28.57$

Step 3. $I_{S.C.} = 1804.27 \times 28.57 = 51{,}551A$

Step 4. $f\ factor = \frac{1.732 \times L \times I_{3\emptyset}}{C \times n \times E_{LL}} = \frac{1.732 \times 0 \times 1804.27}{28752 \times 2 \times 480} = 0$

Step 5. $M = \frac{1}{1+f} = 1$

Step 6. $I_{s.c.symRMS} = I_{s.c.} \times M = 51{,}551\ A$

Step 6A. No motor short circuit contribution.

FAULT X2

This fault is just before the distribution panel, DP-H11A, located in the substation room 160 with the primary transformers. This fault is approximately 18.25 feet from the first fault.

Step 4. $f\ factor = \frac{1.732 \times L \times I_{3\emptyset}}{C \times n \times E_{LL}} = \frac{1.732 \times 18.25 \times 51551}{28752 \times 2 \times 480} = 0.0590$

Step 5. $M = \frac{1}{1+f} = \frac{1}{1+0.059034} = 0.944$

Step 6. $I_{s.c.symRMS} = I_{s.c.} \times M = 51551 \times 0.944 = 48{,}677\ A$

Step 6A. No motor short circuit contribution.

FAULT X3

Fault 3 is directly before the low voltage transformer T11 in the electrical room 154. Faults 2 and 3 are approximately 53.75 feet apart.

Step 4. $f\ factor = \frac{1.732 \times L \times I_{3\emptyset}}{C \times n \times E_{LL}} = \frac{1.732 \times 53.75 \times 48677}{3830 \times 1 \times 480} = 2.465$

Step 5. $M = \frac{1}{1+f} = 0.289$

Step 6. $I_{s.c.symRMS} = I_{s.c.} \times M = 48677 \times 0.289 = 14{,}048\ A$

Step 6A. No motor short circuit contribution.

FAULT X4

This fault lies directly after the transformer T11 and uses slightly adjusted equations.

Step A. $f\ factor = \frac{I_{S.C.primary} \times V_{primary} \times 1.732 \times (\%Z)}{100{,}000 \times KVA_{transformer}} = \frac{14{,}048 \times 480 \times 1.732 \times 1.0}{100{,}000 \times 45} = 2.595$

Step B. $M = \frac{1}{1+f} = \frac{1}{1+2.595} = 0.278$

Step C. $I_{s.c.secondary} = \left(\frac{V_{primary}}{V_{secondary}}\right) \times I_{s.c.primary} \times M = 9{,}017\ A$

Step 6A. No motor short circuit contribution.

FAULT X5

The final fault is directly before the branch circuit panel L11A, which is also located in electrical room 154 about 3.25 feet from the transformer T11.

Step 4. $$f\ factor = \frac{1.732 \times L \times I_{3\emptyset}}{C \times n \times E_{LL}} = \frac{1.732 \times 3.25 \times 9017}{617 \times 1 \times 208} = 0.395$$

Step 5. $$M = \frac{1}{1+f} = \frac{1}{1+0.395} = 0.717$$

Step 6. $$I_{s.c.symRMS} = I_{s.c.} \times M = 9017 \times 0.717 = 6{,}461\ A$$

Step 6A. No motor short circuit contribution.

Below is a table summarizing the above calculations and also showing the conductors that were chosen when going through the calculations which were used to fine the ‘C’ values. In order to determine whether or not the calculations were done correctly, Cooper Bussmann’s online short circuit calculation software, FC^2, was used. The results from the website with normal impedance came out the same as these results and can be found in Appendix V. When the max impedance of -10% was used, the values were still fine in terms of the equipment AIC ratings which shows that the equipment was conservatively oversized.

Short Circuit Calculation (Cooper Bussmann Method, see References)

Fault Point	Panel/XFMR	E_{LL} (V)	XFMR (%Z)	I_{FLA}	M	$I_{S.C.}$	L (ft)	Conductors + Busways n	Conductors + Busways Size	Conductor Material	'C' Value	f	M	$I_{s.c.symRMS}$	AIC Rating
1	1500 kVA TR-B2	480	3.50	1804.27	28.57	51551	0	2	600 kcmil	Copper	28752	0	1	51551 A	100000
2	DP-H11A	480	-	-	-	51551	18.25	2	600 kcmil	Copper	28752	0.059034	0.944256	48677 A	65000
3	T11 Before	480	-	-	-	48677	53.75	1	#4 AWG	Copper	3830	2.464963	0.288603	14048 A	65000
4	T11 After	208	1.00	0.000125	100.00	14048	-	1	#12 AWG	Copper	617	2.595387	0.278134	9017 A	65000
5	L11A	208	-	-	-	9017	3.25	1	#12 AWG	Copper	617	0.395495	0.716592	6461 A	10000

Figure 44 Short Circuit Calculation Summary

Conclusions

Though the analyses of the electrical systems were merely surface level and reactionary, they showed that the lighting changes were minimal. The electrical system would not need to have any resizing and the branch circuits are all still conservatively designed. If there were more time, a downsizing of the branch panels and distribution panels could have been done, but not advised due to future changes in building use and additions that could be in store as the University grows and the School of Engineering and Computer Science engrains itself into the new building.

MAE DAYLIGHTING |

Overview

The daylighting in the project labs space has been improved to provide the space with an improved appearance during the daytime and a more energy efficient space by photosensor dimming of the electric lighting. Firstly, an analysis of the existing conditions showed that the space was not receiving very much sunlight as the only glazing was on the northern side of the space. As a fairly large space, and one that requires higher illuminances, it seemed a logical space to try to improve the daylighting and harness natural light to provide task plane illuminance. Since the space is only open to the north for side lighting and there is a roof deck directly above the space, top lighting is the most logical means to improvement. For this daylighting analysis, many different skylight systems were researched to try to find the best way to integrate into the existing architecture, structural grid, and mechanical equipment layout in the space. In order to accomplish the best integration and to maximally enhance the design of the building, Kalwall Skyroof systems were chosen as the basis for this study.

Introduction to Kalwall

The technology behind the Kalwall panel system is a great architectural material due to its structural strength, diffuse visual light transmittance capabilities, and incredible insulation properties far exceeding most glazing systems. The Kalwall panel is a structural composite sandwich panel formed of translucent fiberglass sheets bonded to a grid core of interlocking I-beams that are thermally broken. Kalwall products are custom made to fit the design needs and have a multitude of design choices. The custom Skyroof skylights are also lightweight at less than 3 lbs./ft^2 and structurally sound. For these reasons, the Skyroof product line was chosen for this study.

Integration

The layout for the skylights and the specific product were chosen in order to minimally affect the architecture, structure, and mechanical systems and maximize the daylighting capabilities. The structural members are approximately 8 feet on center going east to west across the project labs space and there are four large fans hanging in the center of the room 30 feet apart from each other with a blade diameter of 10 feet. For this reason, it was decided that the most integrative way to implement the skylights was to use three of the self-supporting ridge Skyroof product with plan dimensions of 8 feet by 20 feet as shown in the image below. Kalwall representatives confirmed that these dimensions can be used for this product. The self-supporting ridge product is also visually appealing for the pedestrian-accessible rooftop and structurally sound adding to the benefits of using this system.

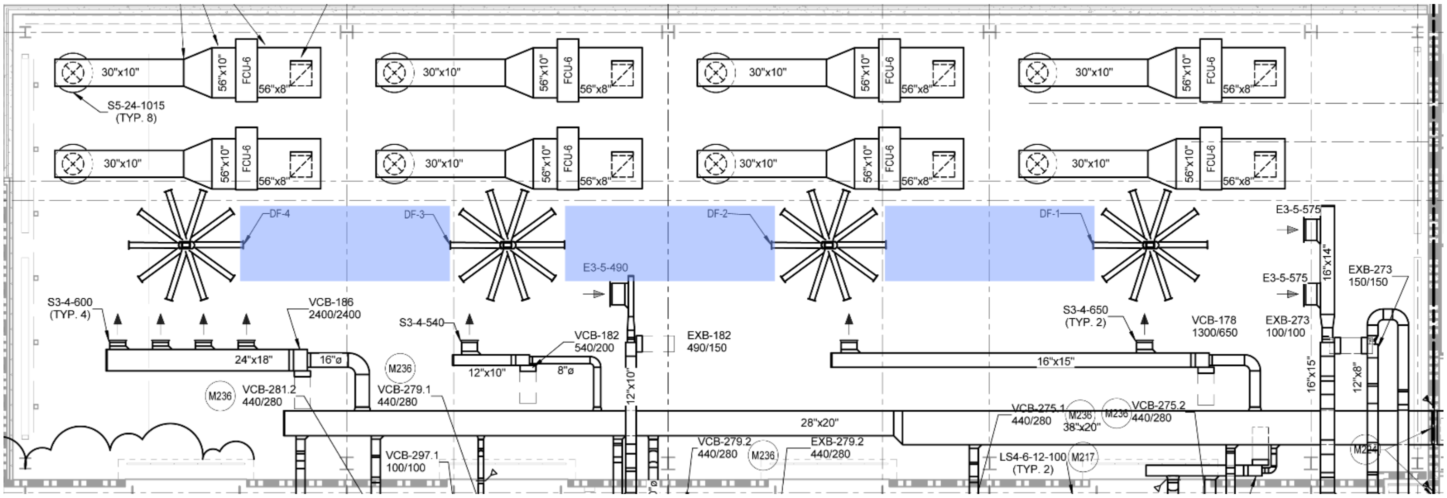


Figure 45 Skylight Integration

Self-Supporting Ridge Roof with Hip Ends

Plan Dimensions – 8′ x 20′

Angle of Inclination - 27°

Panel Type – 2-3/4″ panels, Crystal outside / White inside, with VLT of 20%

KALWALL®

high performance translucent building systems

LIGHT TRANSMISSION & SOLAR HEAT GAIN COEFFICIENT FOR 2 ¾" (70mm) PANELS

(For 4" (100mm) Light Transmission & Solar Heat Gain Coefficent values, see Page 9.10)

FACE SHEET COMBINATION note 1,5		% LIGHT TRANSMISSION note 2					WALL SYSTEM SOLAR HEAT GAIN COEFFICIENT AT 0° note 3				
EXTERIOR COLOR	INTERIOR COLOR	0.53 "U" note 4	0.29/0.23 "U"	0.22/0.14 "U"	0.18/0.10 "U"	0.05 "U"	0.53 "U"	0.29/0.23 "U"	0.22/0.14 "U"	0.18/0.10 "U"	0.05 "U"
Greenish Blue	White	25	14	5	3	14	0.50	0.23	0.14	0.10	0.19
Aqua	White	29	17	6	4	15	0.45	0.24	0.14	0.10	0.21
Rose	White	30	18	6	4	16	0.46	0.24	0.15	0.10	0.21
Ice Blue	White	35	20	8	6	21	0.54	0.28	0.17	0.12	0.26
Greenish Blue	Crystal	37	20	7	4	NA	0.53	0.26	0.16	0.11	NA
Aqua	Crystal	43	23	7	4	NA	0.55	0.27	0.16	0.11	NA
Rose	Crystal	48	24	8	5	NA	0.57	0.28	0.17	0.12	NA
Ice Blue	Crystal	53	27	10	6	NA	0.68	0.32	0.19	0.13	NA
White	Crystal	30	18	12	8	NA	0.46	0.24	0.14	0.10	NA
White	White	20	15	8	5	14	0.38	**0.23**	**0.15**	**0.11**	**0.18**
Crystal	White	35	20	12	8	20	0.52	**0.28**	**0.17**	**0.13**	**0.25**
Crystal	Crystal	50	30	15	10	NA	0.65	**0.33**	**0.18**	**0.13**	NA
Crystal SWC	White	29	16	9	6	16	0.47	0.25	0.15	0.10	0.23
Crystal SWC	Crystal	44	22	11	8	NA	0.58	0.29	0.17	0.12	NA

Figure 46 Kalwall Panel Choices

Daysim

For the analysis, DaysimPS was used to determine the light levels achieved, annual daylighting metrics, dimming capabilities, and cost savings from dimming. A simplified model of the project labs space was created in AutoCAD, with and without the skylight geometries added in, and converted to .rad files with dxf2rad.exe. The material file was created with generalized reflectances given to all of the opaque geometries, a 63% VLT glass as per SmithGroupJJR drawings, and the Kalwall trans-material was specified as per Christoph Reinhart's paper entitled "Development and validation of a Radiance model for a translucent panel" shown in the image below. For the Daysim runs, an assumed occupancy schedule was created, a location specific weather file was used, and the luminaires specified in the lighting depth were added.

```
# RADIANCE "trans" model of a translucent panel assuming
# only direct normal hemispherical transmittance is available
# Rd = Cr = Cg = Cb = 0.21 = diffuse reflectance
# Rs = A4 =0.08 = specular reflectance
# Sr = 0.0 = surface roughness
# Td = 0.24 = direct normal diffuse hemispherical transmittance
# Ts = 0 = transmitted specularity (ideal diffuser)
# A7 = Ts/(Td+Ts) = 0
# A6 = (Td+Ts)/(Rd+Td+Ts) = 0.5333
# A5 = Sr = 0
# A1 = A2 =A3 = Rd/((1-Rs)*(1-A6)) = 0.48913
# St = A6*A7*(1-A1)*A4 = 0
# resulting Radiance material:
void trans PANEL
0
0
7 0.48913 0.48913 0.48913 0.08 0  0.5333 0
# A1      A2      A3      A4   A5 A6     A7
```

Figure 47 Kalwall Radiance Material

```
Mat.rad - Notepad
File  Edit  Format  View  Help
#######################################################
# Daysim Material File
# JOHN CONLEY
# Oakland University - Engineering Center
#######################################################

void plastic l_surrounds 0 0 5 0.3000 0.3000 0.3000 0.0000 0.0000

void plastic l_walls 0 0 5 0.5000 0.5000 0.5000 0.0000 0.0000

void plastic l_ceiling 0 0 5 0.8000 0.8000 0.8000 0.0000 0.0000

void plastic l_floor 0 0 5 0.3 0.3 0.3 0.0000 0.0000

void plastic l_mullions 0 0 5 0.5000 0.5000 0.5000 0.0000 0.0000

void plastic l_metalpnl 0 0 5 0.5000 0.5000 0.5000 0.0000 0.0000

void glass l_glass 0 0 3 0.697575 0.697575 0.697575

void plastic l_roofwall 0 0 5 0.5000 0.5000 0.5000 0.0000 0.0000

#20% transmitance kalwall crystal-white

void trans l_kalwall1 0 0 7 0.445652174 0.445652174 0.445652174 0.08 0 0.487804878 0
```

Figure 48 Material .rad file

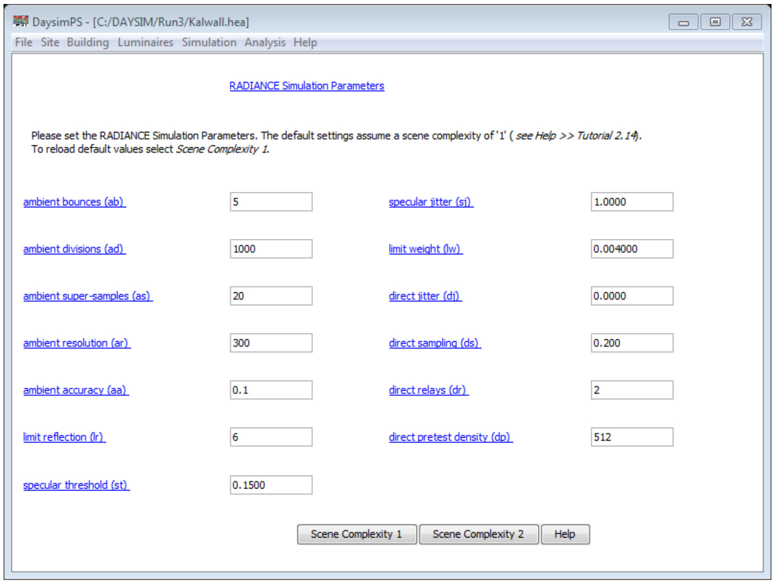


Figure 49 Daysim Simulation Settings

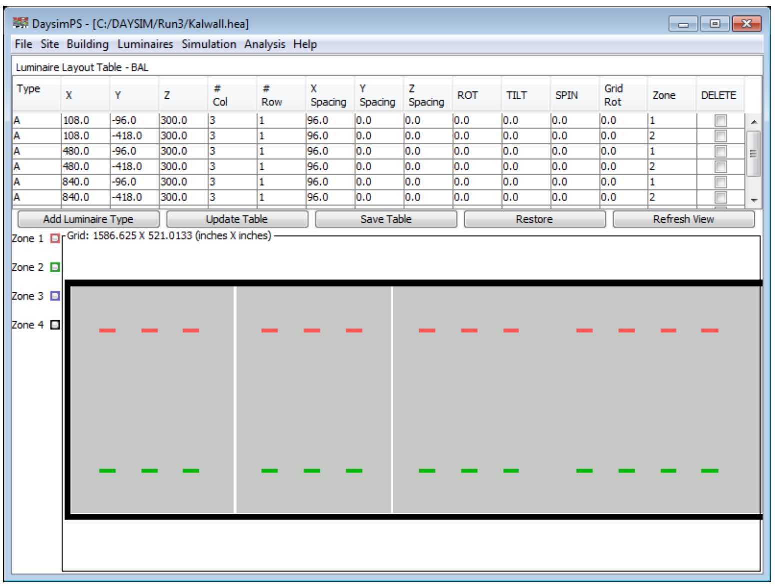


Figure 50 Luminaire Layout and Schedule (2 Zones)

Comparisons

The following section is a series of comparisons between the project labs space with and without the skylights added. In all aspects, it appears that with the added skylights, the daylighting condition in the space will be greatly enhanced by reaching further into the space and providing higher levels of daylight for more of the year. It can also be noted that with the addition of the skylights, the illuminance levels greatly increase on the north side of the space due to skylight and window contributions. Since this is the north side of the building, it is not beneficial to look into shading systems to lessen the lighting level. However, the situation lends itself very nicely to photosensor control of the dimming of zone 1 of the electric lighting.

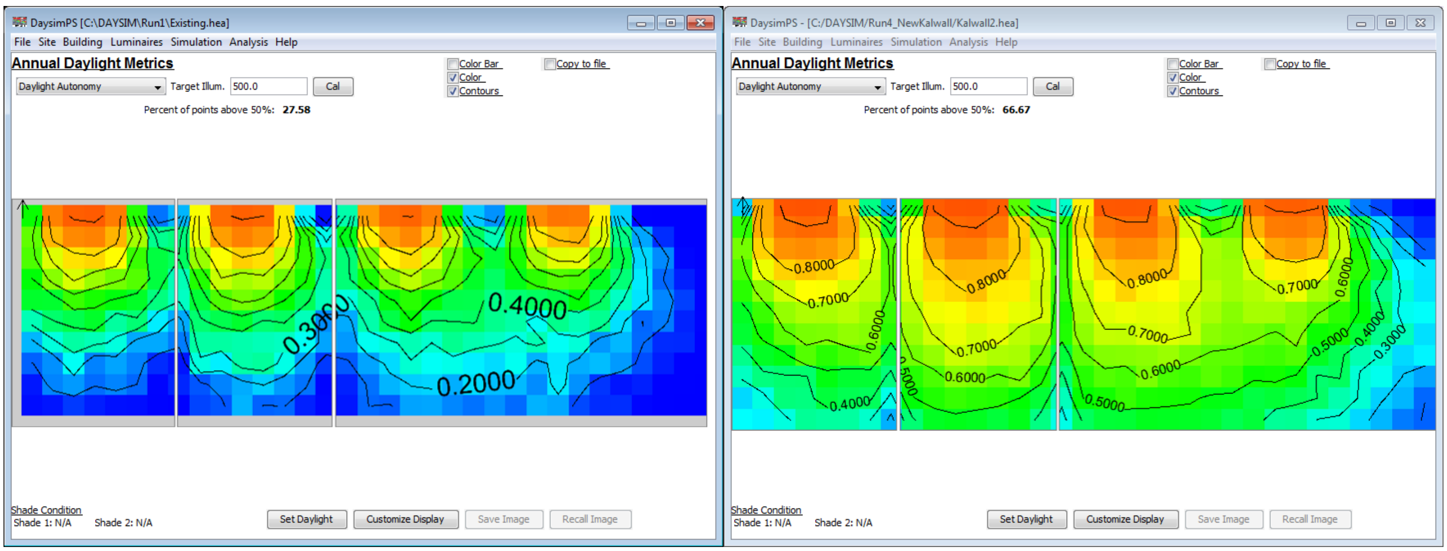


Figure 51 Daylight Autonomy Comparison (27.58 without, 66.67 with skylights)

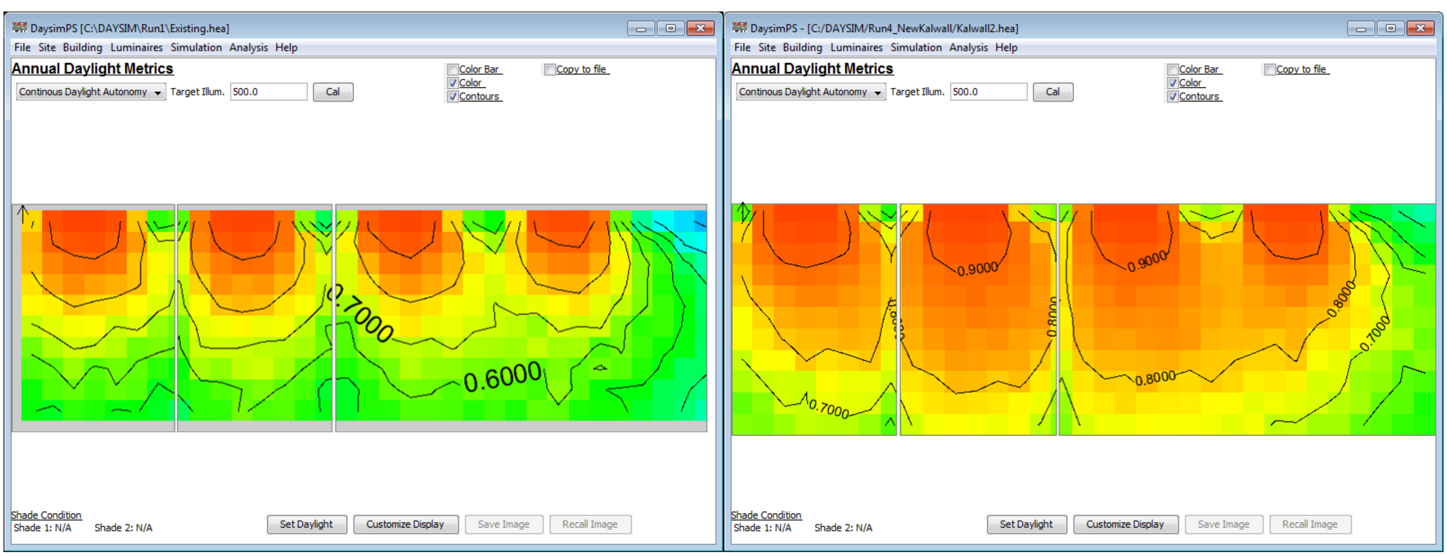


Figure 52 Continuous Daylight Autonomy Comparison

Equinox | June, 21 (Dates are for this year; times are approximately every hour from 8 to 5)

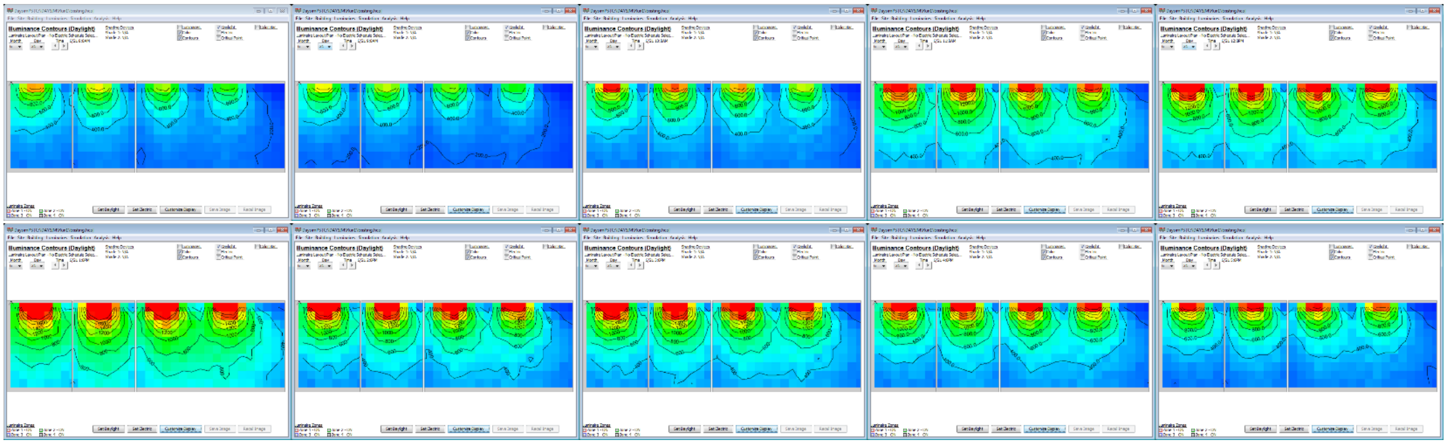


Figure 53 June 21st Without Skylights

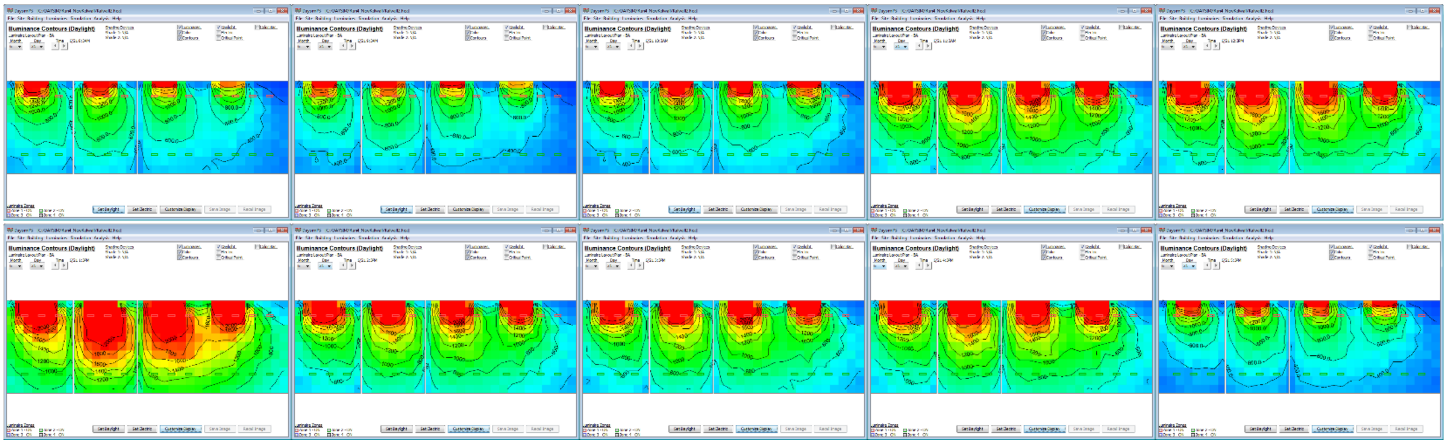


Figure 54 June21st with Skylights

Solstice | September, 23

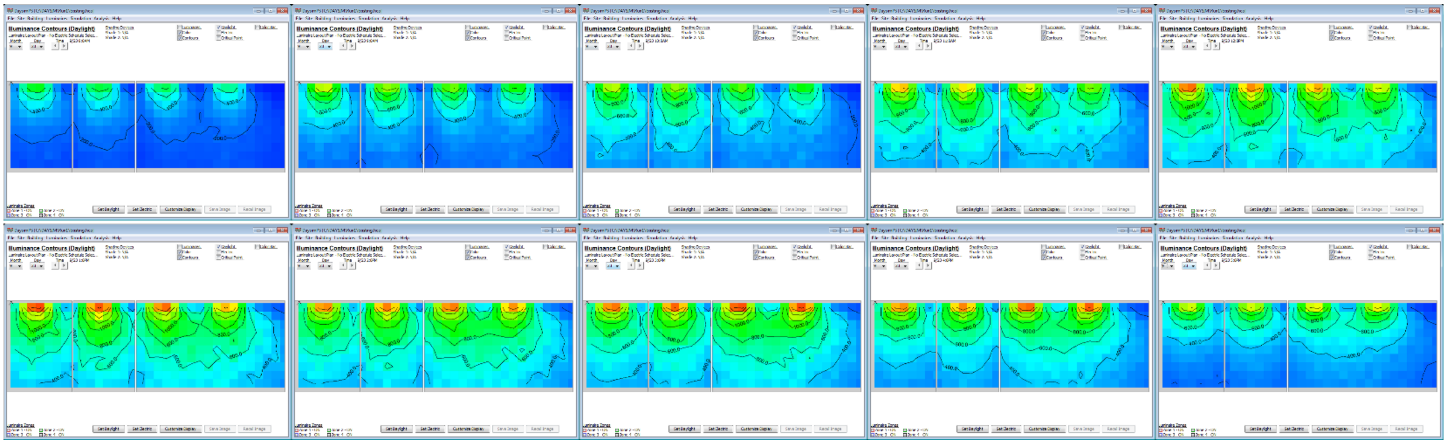


Figure 55 September 23rd Without Skylights

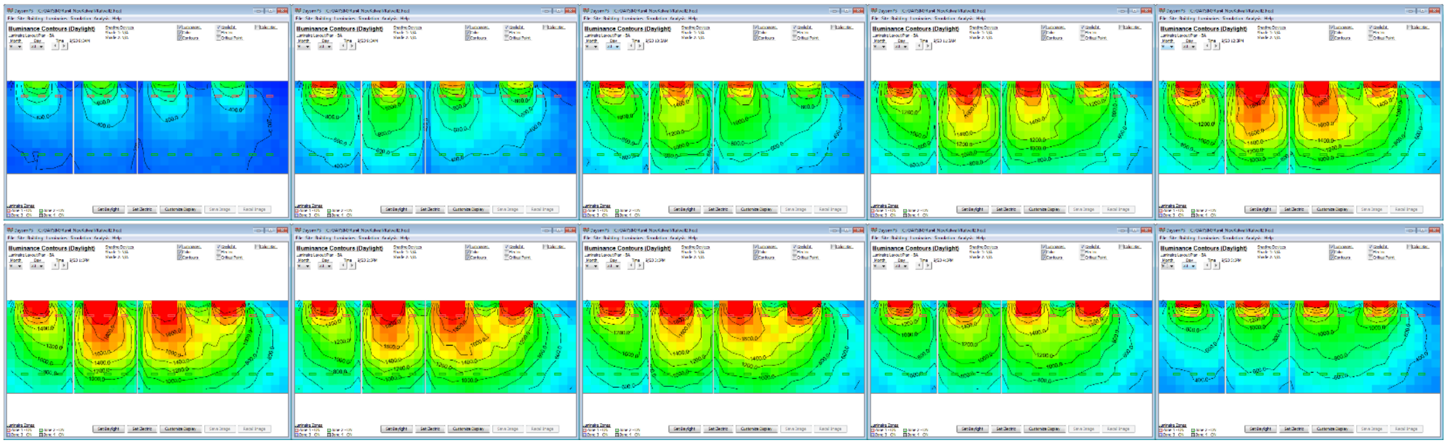


Figure 56 September 23rd with Skylights

Equinox | December, 22

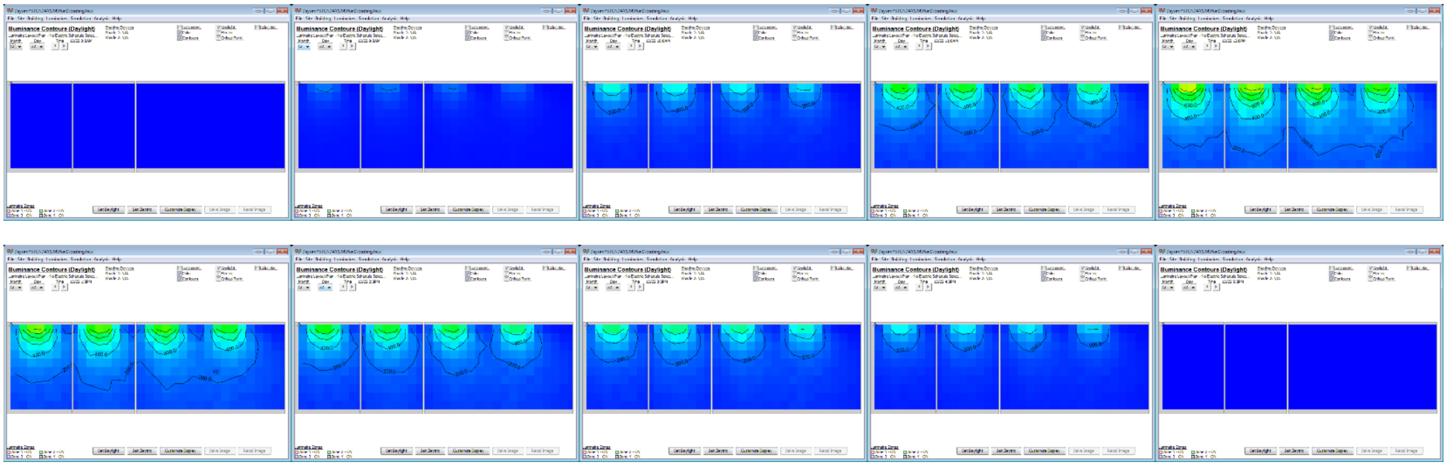


Figure 57 December 22nd Without Skylights

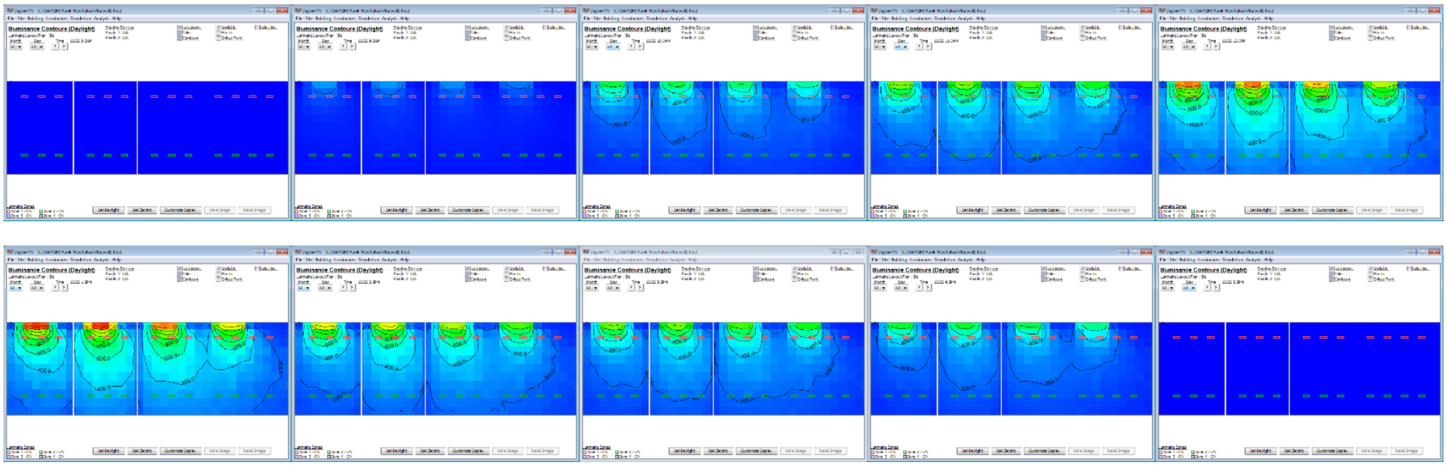


Figure 58 December 22nd with Skylights

Analysis

Dimming of zone 1 is explored by noting the lighting levels of the standalone electric lights and finding a suitable critical point and photosensor algorithm through manipulation of the critical point tool and the photosensor location. Since the Big Ass Lights used in the project labs space have built in photosensors, the photosensor was placed at the level of the luminaires facing downward and used in conjunction with a closed loop proportional algorithm.

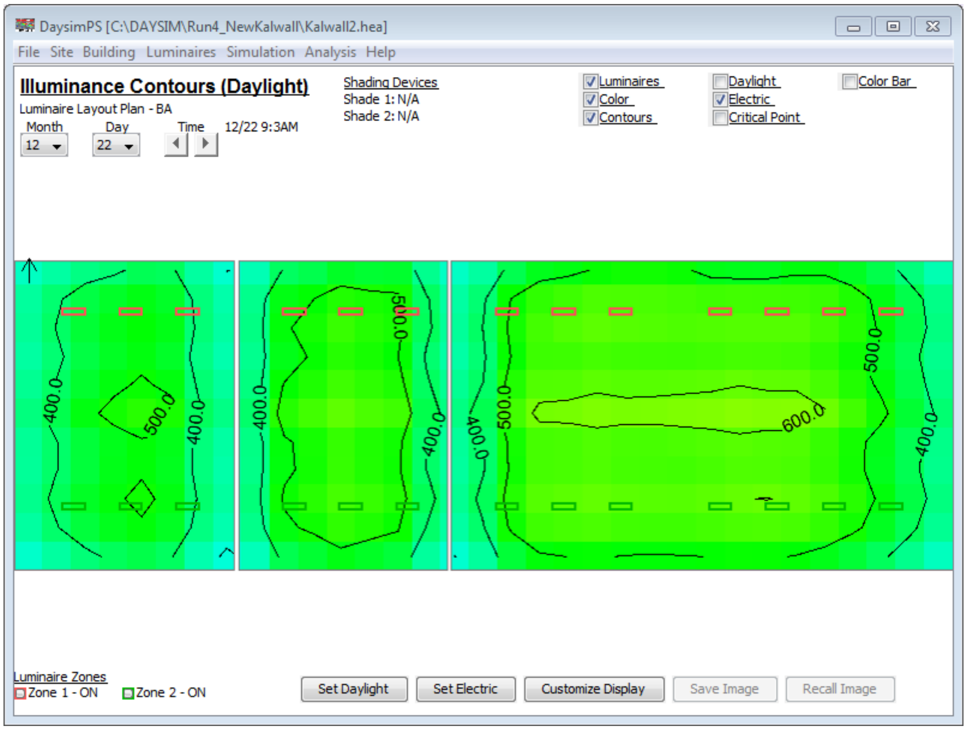


Figure 59 Electric Lighting Levels

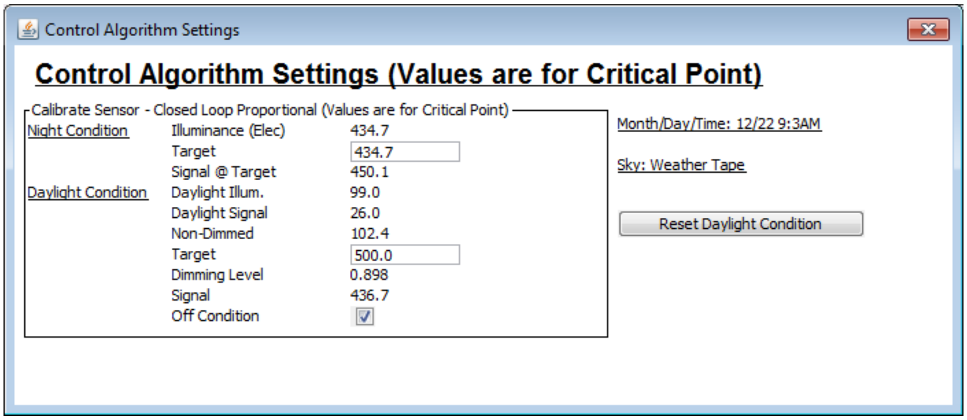


Figure 60 Photosensor Control Algorithm

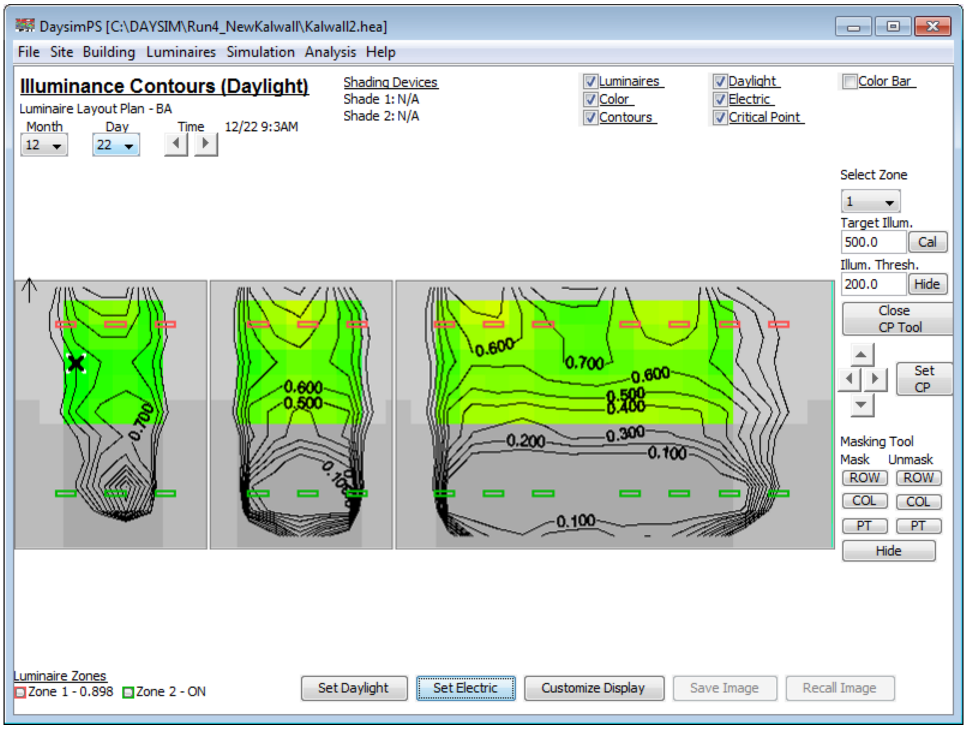


Figure 61 Critical Point Selection

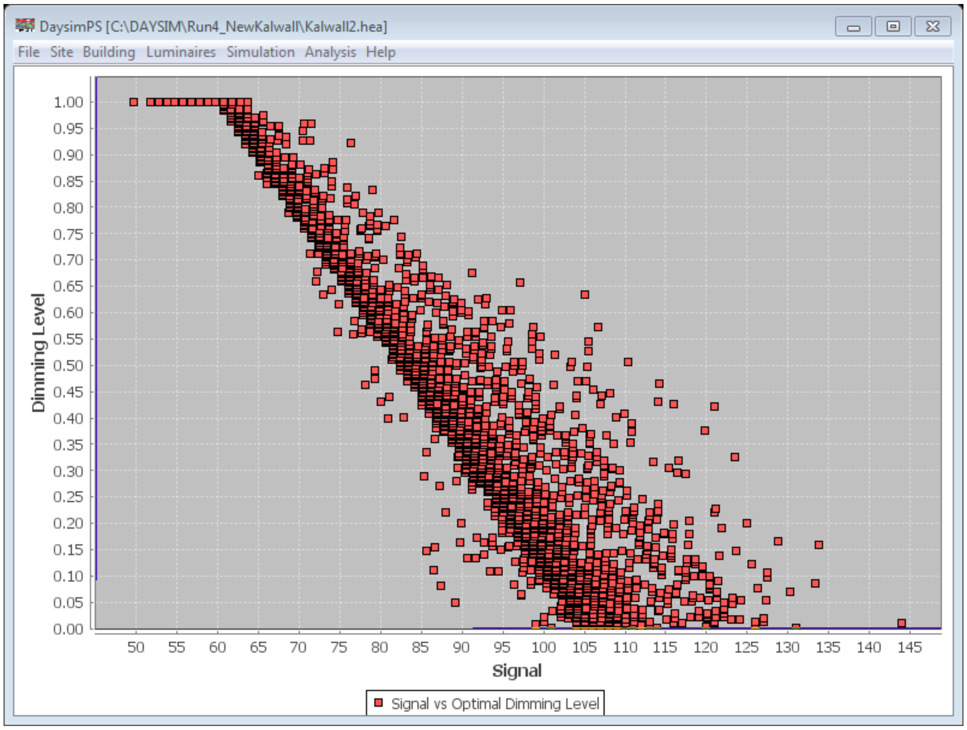


Figure 62 Signal vs. Dimming Level Plot

Savings

Energy Tables (KWh)

Controlled Zone | Grand Total

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Base	327.9	289.52	319.32	306.53	327.9	306.53	319.32	327.9	297.95	327.9	315.11	310.74	3776.65
Optimal	181.33	149.76	161.95	153.86	164.11	153.39	159.72	164.39	150.11	170.5	174.93	186.99	1971.08
Algorithm	179.36	149.45	161.91	153.89	164.11	153.41	159.76	164.38	150.05	169.7	172.63	182.99	1961.7
Savings	148.53	140.06	157.4	152.63	163.78	153.11	159.55	163.52	147.89	158.2	142.48	127.75	1814.95

After a seemingly good critical point was chosen with an acceptable signal vs. dimming plot, the data from the energy table function of Daysim could be looked at. The savings per year amount to around 1814.95 kWh. This number however is less than optimal. At an electricity cost of $0.054/kWh, annual savings due to the dimming of Zone 1 in Daysim would amount to approximately $98. These savings were then compared to SkyCalc savings which are based on a less precise model of the situation. SkyCalc overestimated the savings by 350 kWh/yr, which is pretty impressive due to the simplicity of the information that is used as input for the SkyCalc program. Since Daysim results are probably slightly more correct, these savings will be used to analyze the payback period of the Kalwall skylights which can be found in the Mechanical Breadth section of this report.

Skylighting System Description

Skylight unit size (ft^2)	160.0
Number of Skylights	3
Total Skylight Area (ft^2)	480
Skylight to Floor Ratio (SFR)	8.4%
Effective Aperture	0.9%
Floor Area per Skylight	1,901
Skylight U-value	0.230
Skylight SHGC	25%
Skylight T_{vis}	20%
Well Efficiency (WF)	78%
Dirt and Screen Factor	70%
Overall Skylight System Tvis	11%
Skylight CU	66%

Site Description

Climate Location	Pontiac.wea3
Climate Zone	CZ5 (cool, 5,400 < HDD65°F <= 7,200)
Building Type	University 9 mo
Building Area	5,704 (ft^2)

Elecric Lighting System Description

Lighting Type	Industrial fluorescent	
Lighting Control	Dimming min 5% light	
Light Level Setpoint	50	fc
Lighting Density	1.03	W/ft^2
Connected Load	5.9	kW
Fraction Controlled	50%	

Savings from Design Skylighting System

Savings		**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting		2,165	$116

Figure 63 SkyCalc Output

Conclusions

Daylighting is an important part of any architectural space to render the world in a bright and comfortable light. With the implementation of these Kalwall skylights, the architectural aesthetic of the space is increased as well as providing an informed and integrated solution that will provide savings in the building electricity costs as well. This solution brings together multiple aspects into one integrated product.

Figure 64 Visualization of the Roof Top with Skylights

STRUCTURAL BREADTH |

Overview

Due to the addition of large skylights into the project labs space, which is discussed in more depth in the daylighting section of this report, there is a large decrease in dead weight of the roof. Due to the layout of the structural system as well as the mechanical equipment and fan layouts in the space, the skylights were placed to span between bays in the center of the room. The structural system was analyzed and hand calculations were performed to determine if a resizing of the structural members directly affected by the skylights would be cost beneficial. From these calculations, a small decrease in some of these beams could save the project some money in initial costs but may be disregarded due to an attempt save money with bulk purchase of same-size members.

The figure below shows the main structural members for the 5 bays of the project labs space with the green roof highlighted in green.

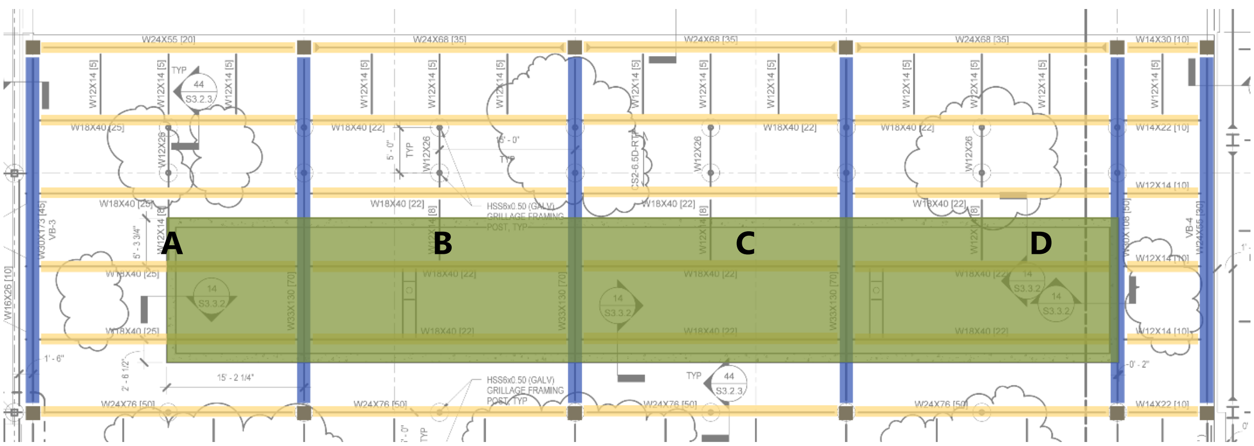


Figure 65 Original Layout with Green Roof Shown

The green roof shift and the addition of the Kalwall SkyRoof is shown in the figure below.

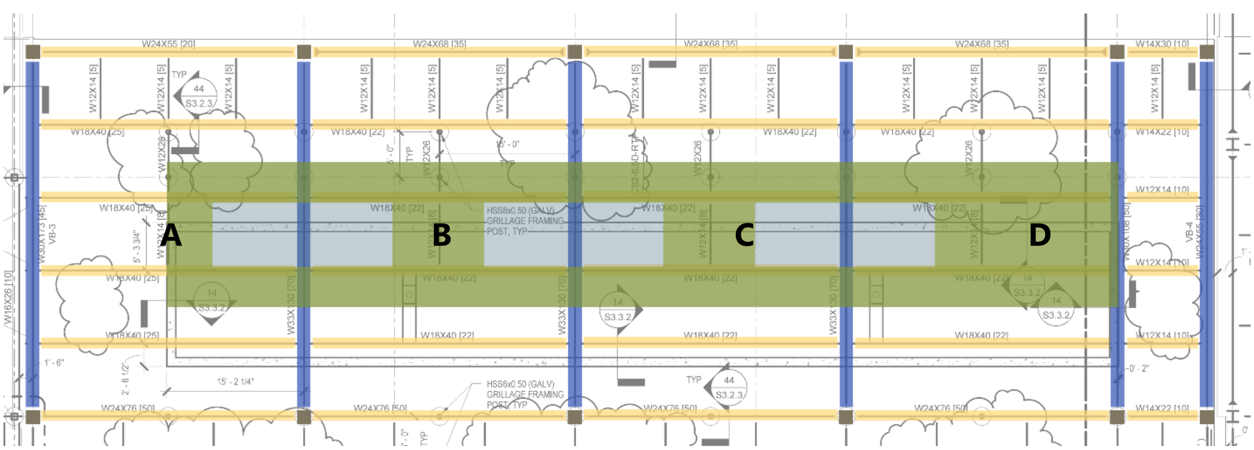


Figure 66 Green Roof Moved and Skylights Added

Loads

To start with, the major loads on the roof were calculated and or researched through ASCE 7-10 and SmithGroupJJR's structural and architectural plans.

Live Load = 100 psf

From the 2010 ASCE 7 Design Loading Code for "Roofs used for roof gardens"

Snow Load = 19.25 psf

Ground Snow Load P_g = 25 psf from Figure 7-1 of ASCE 7-10

Exposure coefficient C_e = 1.1 from Figure 7-2 of ASCE 7-10 and Terrain Category from Section 26.7 for a Sheltered roof of Terrain Category C. *This designation was provided by SmithGroupJJR and checked

Thermal Factor C_t = 1.0 from Figure 7-3 of ASCE 7-10

Importance Factor I_s = 1.0 for normal buildings

$$\boldsymbol{P_f = 0.7C_eC_tI_sP_g = 0.7(1.1)(1.0)(1.0)(25) = 19.25\ psf}$$

The superimposed dead load for a roof, as provided in the SmithGroupJJR plans, is given as 110 psf. This number is providing for some extra safety in the design and thus a calculation was performed, with some approximation, to check the validity of this number.

Greenroof = 35 psf (saturated maximum from SmithGroupJJR specifications)

Roof concrete pavers = 51 psf (calculated based on area and makeup of the roof flooring)

Kalwall SkyRoof System = 3 psf

Misc. Dead Load (Duct, Lights, Plumbing, Sprinklers) = 10 psf

Rigid Insulation = 2 psf

Total SDL = 35+51+3+10+2 = 101 psf

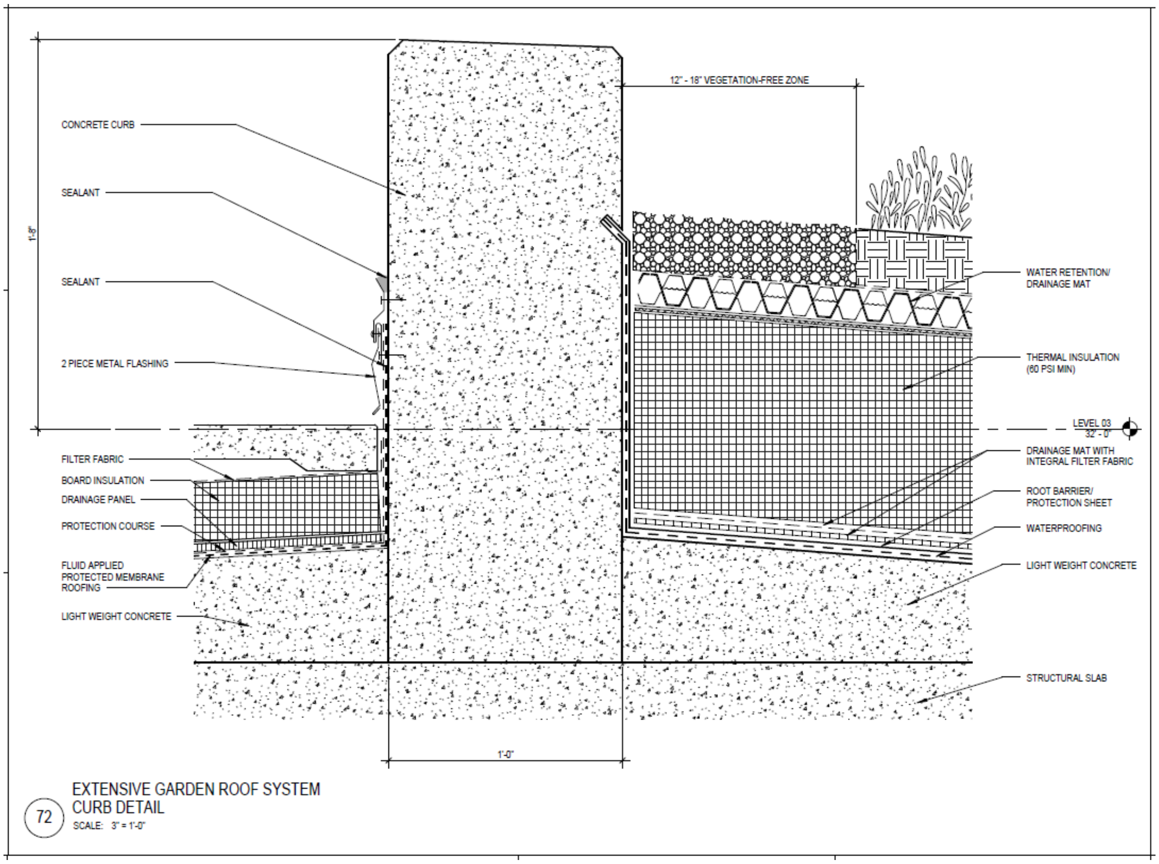


Figure 67 Green Roof Section Detail

Since the calculated value is very close to the 110 psf which is used by SmithGroupJJR, 110 psf will be used. Since the Kalwall skylight system is so light, it will not have much of an impact on the structural member sizes. The following calculations will test the validity of the current beam sizes and determine if there is a possibility of downsizing the beams to save some money structurally with the addition of the skylights. The reason that the current structure is more robust is due to a sliding crane in the SAE lab which has a substructure below the primary beams and girders and has been omitted in this analysis of the structural system as it does not directly affect the sizing of the beams that are being analyzed.

Deck Calculations

The structural plans state that the top of steel is at an elevation of 30'-5 ½" and that the top of concrete elevation is 31'-0". The plans also dictate that a 2" composite floor deck should be used, installed in 3 span lengths only, and with normal weight concrete. Thus, a 2VLI20 Vulcraft deck will be used with a 6 ½" total slab depth. This decking has a SDI maximum unshored clear span of 9'-0" which is greater than the needed 8'-3.8" span necessary in this situation. The superimposed live load for this will then be 264 PSF for an 8'-0" clear span. To check the validity of this deck the following needs to be true, $W_{LL} + W_{misc\ DL} \leq Superimposed\ Live\ Load$. W_{LL} is equal to 100 psf and $W_{misc\ DL}$ is equal to 110 psf, so $210\,psf \leq 264\,psf$ and this composite roof deck will work. This deck will have a dead weight of 69 psf which will be used to specify the beams.

Beam Calculations

The following calculations will look at the beams that are directly affected by the decrease in weight due to the skylight addition and determine if a decrease in beam size is warranted. The dead load for the beam calculations will include a typical beam self-weight allowance of 5 psf, the specified deck weight of 69 psf, and the superimposed dead load used above of 110 psf which includes the roof paver system, greenroof, miscellaneous loads. Live loads for roofs cannot be reduced thus, the live load used will be 100 psf for the roof and 40 psf for the skylight areas. Loading combination 3 will be used in this case because this is a roof calculation with dead loads and a roof live load.

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

The live load is much larger than the snow load, so the live load will be used. For beams along the two lines shown below, the tributary area, shaded in grey, will include partially the typical roof load and partially the new skylight roof load. The only bay that does not have a partial skylight load is bay E, but a calculation for this bay has also been conducted.

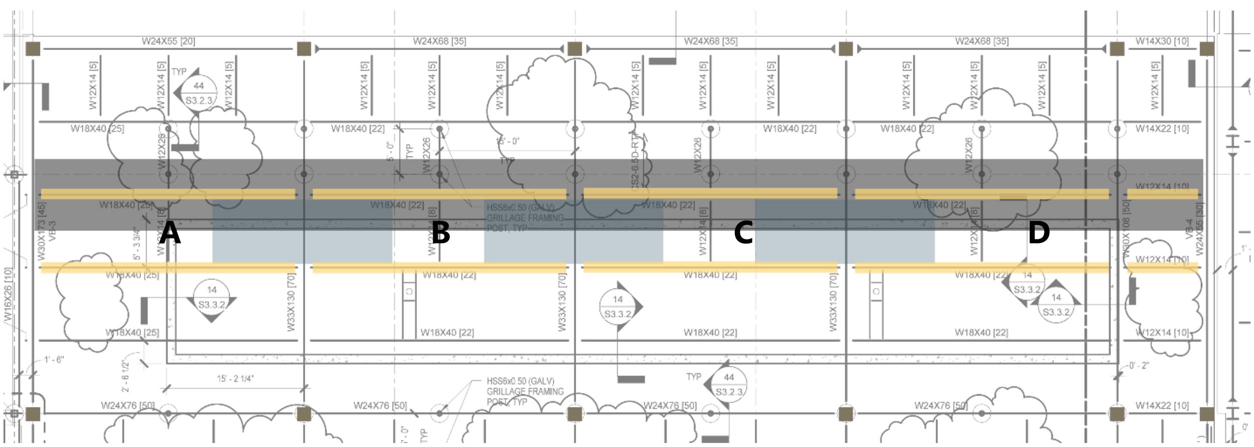


Figure 68 Altered Layout with Beam Tributary Areas Highlighted

For the tributary area with normal roofing conditions the factored load is as follows.

$$\boldsymbol{W_u = 1.2 * (110 + 5 + 69) + 1.6 * (100) = 381\,psf}$$

For the tributary area containing the skylighting system the factored load is as follows.

$$\boldsymbol{W_u = 1.2 * (3) + 1.6 * (40) = 67.6\,psf}$$

For bays A & D the skylight covers approximately ¼ of the tributary area.

$$w_u(bays\ A\ \&D) = W_u * \left(\frac{spacing}{1000}\right) = \left(\left(381 * \frac{3}{4}\right) + \left(67.6 * \frac{1}{4}\right)\right) * (8'3.8")/1000\ =\ 2.52\ klf$$

$$V_u = (w_u * l)/2 = (2.52\ klf * 30')/2 = 37.7\ kips$$

$$M_u = (w_u * l^2)/8 = (2.52\ klf * 30'^2)/2 = 283\ kip - ft$$

The middle bays will assume ½ skylight tributary area.

$$w_u(bays\ B\ \&\ C) = W_u * \left(\frac{spacing}{1000}\right) = 0.5 * (381 + 67.6) * (8'3.8")/1000 =\ 1.86\ klf$$

$$V_u = (w_u * l)/2 = (1.86\ klf * 30')/2 = 27.97\ kips$$

$$M_u = (w_u * l^2)/8 = (1.86\ klf * 30'^2)/2 = 210\ kip - ft$$

For bay E the tributary area is all roof .

$$w_u(bay\ E) = W_u * \left(\frac{spacing}{1000}\right) = 381 * ((8'3.8")/2)/1000 =\ 1.58\ klf$$

$$V_u = (w_u * l)/2 = (1.58\ klf * 30')/2 = 7.87\ kips$$

$$M_u = (w_u * l^2)/8 = (1.58\ klf * 30'^2)/2 = 19.6\ kip - ft$$

Table 3-2 of th AISC Steel Construction Manual, 14th ed. was used to determine the most economical beam size for the strength criteria calculated. For bays A and D, W18x40 was chosen which is the same size that is already installed. For bays B and C, which have more influence by the lighter skylights, W18x35 beams were chosen. For bay E, it was determined that these beams may be oversized at W12x14 when W8x10 beams seem to work with the loading that is present. These sizes were checked against the moment, shear, floor deflection of members due to the accessibility of the roof and the large live load, and against the roof deflection of members. The summary of each of the calculations is shown below and the full calculation process for bays B and C is also outlined.

Bays A and D (0.75 roof, 0.25 skylight)				Bays B and C (0.5 roof, 0.5 skylight)				Bay E (all roof)			
wu	2.52	klf		wu	1.86	klf		wu	1.58	klf	
Vu	37.74	kips		Vu	27.97	kips		Vu	7.87	kips	
Mu	283.03	ft-kip		Mu	209.77	ft-kip		Mu	19.55	ft-kip	
(size) W	18		40	(size) W	18		35	(size) W	8		10
Vn	169	kips		Vn	159	kips		Vn	40.2	kips	
Mn	294	ft-kip		Mn	249	ft-kip		Mn	32.9	ft-kip	
I	612	in^4		I	510	in^4		I	30.8	in^4	
E	29000	ksi		E	29000	ksi		E	29000	ksi	
wLL	10.22	klf		wLL	8.42	klf		wLL	12.02405	klf	
Defl.	0.010495	in		Defl.	0.010372	in		Defl.	0.002954	in	
L/360	1	in		L/360	1	in		L/360	0.33125	in	
wTL	26.90	klf		wTL	19.65932	klf		wTL	34.1483	klf	
Defl.	0.03	in		Defl.	0.024225	in		Defl.	0.008389	in	
L/240	1.50	in		L/240	1.5	in		L/240	0.496875	in	
Self Wt.	41.58	plf		Self Wt.	41.58	plf		Self Wt.	41.58	plf	

Table 4 Summary of Structural Calculations

Bays B and C are loaded with approximately half roof load and half skylight load in the beam tributary areas. With the max moment and shear calculated above, the beam W18x35 was chosen as the most economical size for strength calculated.

$$V_u = 27.97\ kips\ < 159\ kips = \varphi V_n\ From\ AISC\ Table\ 3-2$$

$$M_u = 210\ ft-kips\ < 249\ ft-kips = \varphi M_n\ From\ AISC\ Table\ 3-2$$

Then, the deflections need to be checked; with I = 510 in^4 and E = 29,000 ksi. The distributed live load for the tributary area is calculated then, the deflection is checked against the L/360 value for the floor member deflection calc. The distributed total load for the tributary area is calculated then, the deflection is checked against the L/240 value for the roof member deflection calc.

$$w_{LL} = \frac{\frac{LL}{2}}{(tributary\ length)} = \frac{1}{2} * \frac{(100\ psf + 40\ psf)}{8' - 3.8"} = 8.42\ klf$$

$$\Delta_{LL} = \frac{5 * w_{LL} * L^4}{384 * E * I} = \frac{5 * 8.42klf * 30'^4}{384 * 29,000ksi * 510in^4} * \frac{1728\frac{in^3}{ft^3}}{1000\frac{lb}{kip}} = 0.0104\ in$$

$$\frac{L}{360} = \frac{30'}{360} * 12\frac{in}{ft} = 1\ in$$

$$\Delta_{LL} < \frac{L}{360} so, live\ load\ floor\ deflection\ is\ acceptable$$

$$w_{TL} = \frac{\frac{TL}{2}}{(tributary\ length)} = \frac{1}{2} * \frac{(110 + 69 + 5 + 100\ psf + 3 + 40\ psf)}{8' - 3.8"} = 19.66\ klf$$

$$\Delta_{LL} = \frac{5 * w_{LL} * L^4}{384 * E * I} = \frac{5 * 19.66klf * 30'^4}{384 * 29{,}000ksi * 510in^4} * \frac{1728\frac{in^3}{ft^3}}{1000\frac{lb}{kip}} = 0.0242\ in$$

$$\frac{L}{240} = \frac{30'}{240} * 12\frac{in}{ft} = 1.5\ in$$

$$\Delta_{TL} < \frac{L}{240}\ so, total\ load\ roof\ deflection\ is\ also\ acceptable$$

As a final check, the self-weight assumption needs to be checked against the actual weight of the beam. Self-weight was assumed to be 5 psf as a safe bet. The beam in this case is only 35 plf so the assumption was safe.

$$5psf * (8' - 3.8") = 41.58\ plf > 35\ plf\ for\ this\ beam\ so\ this\ is\ acceptable$$

Conclusions

The calculations that were done proved that the structural members that are already in place are adequately sized if not conservatively designed. It was also determined that some of the members that would be directly affected by the decrease in load due to the skylight installation could be downsized slightly. This would provide a decrease in tonnage of steel members by about 0.34 tons from the resizing of the members that were calculated above. This change in tonnage would amount to some savings, but for the sake of consistency in the project labs structural design and some level of conservancy it is not advised to make these changes.

MECHANICAL BREADTH |

Overview

Modifications to the project labs space have been made with the addition of the three Kalwall Skyroof products as described in the daylighting section of this report. In order to validate the choice to implement these skylights it was crucial to investigate other effects beyond the daylighting, including the change in the mechanical loads on the space due to the difference in the boundary materials. For this breadth, the excel-based energy analysis program, SkyCalc, was used. This program is provided for free use by Heschong Mahone Group.

Through this program it was noted that due to the incredible insulation properties of the Kalwall system, implementing these skylights would actually allow for savings in heating. Kalwall gives a much better U-value than more traditional skylight options, especially when the panels are thermally broken. However, since these panels will let more solar heat gain into the space it also means that there will be some cooling energy losses. It was also discovered that adding even more square footage of skylight would only increase the overall annual savings. Due to the existing mechanical and structural layouts as well as the cost of the Kalwall system, it was determined not to pursue an increase in the area of skylights used.

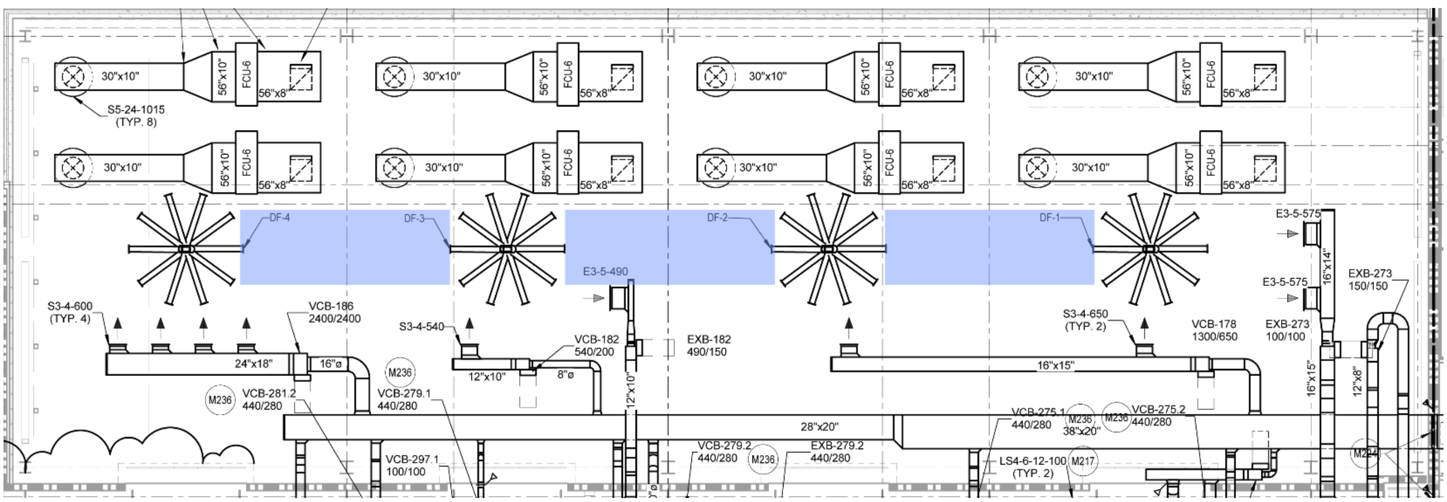
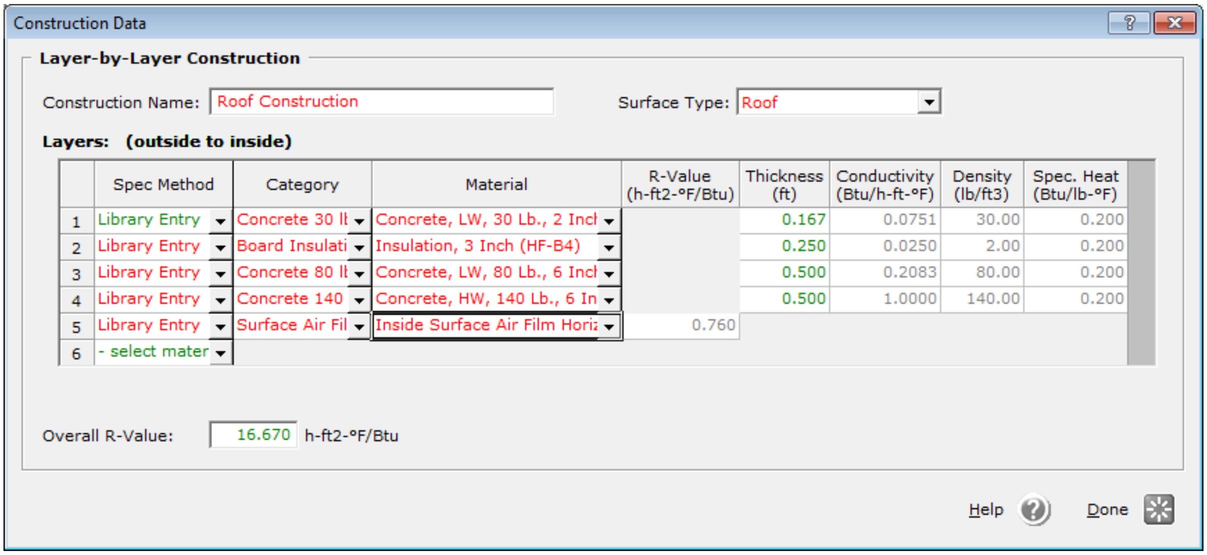


Figure 69 Existing Mechanical Equipment

Basic Roof U-Value Calculation

eQUEST software was used to determine a rough U-value for the construction of the roof including the concrete tiled flooring, the insulation, lightweight concrete, and structural reinforced concrete. This can be seen in the figure below followed by another figure showing the roof in section. With an overall R-Value of 16.670, the approximate U-Value would be 0.06.


Construction Data

Layer-by-Layer Construction

Construction Name: Roof Construction Surface Type: Roof

Layers: (outside to inside)

	Spec Method	Category	Material	R-Value (h-ft2-°F/Btu)	Thickness (ft)	Conductivity (Btu/h-ft-°F)	Density (lb/ft3)	Spec. Heat (Btu/lb-°F)
1	Library Entry	Concrete 30 lt	Concrete, LW, 30 Lb., 2 Incl		0.167	0.0751	30.00	0.200
2	Library Entry	Board Insulati	Insulation, 3 Inch (HF-B4)		0.250	0.0250	2.00	0.200
3	Library Entry	Concrete 80 lt	Concrete, LW, 80 Lb., 6 Incl		0.500	0.2083	80.00	0.200
4	Library Entry	Concrete 140	Concrete, HW, 140 Lb., 6 In		0.500	1.0000	140.00	0.200
5	Library Entry	Surface Air Fil	Inside Surface Air Film Horiz	0.760				
6	- select mater							

Overall R-Value: 16.670 h-ft2-°F/Btu

Help Done

Figure 70 eQUEST Roof Construction

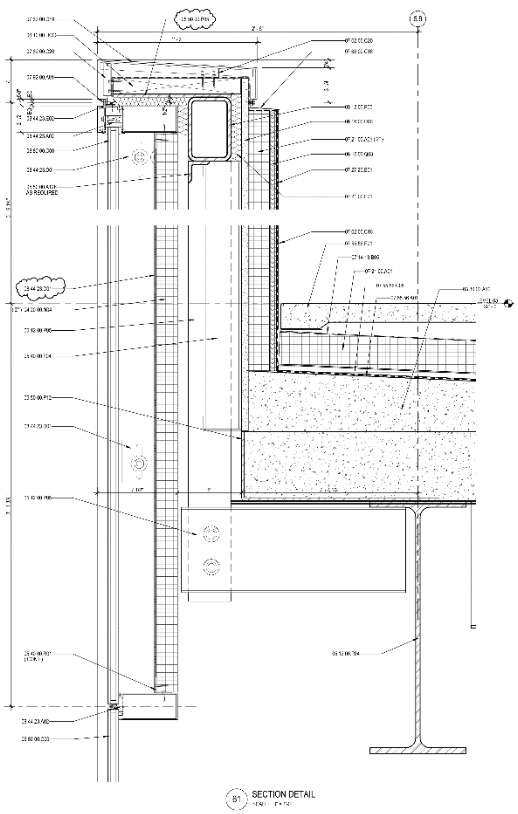


Figure 71 Roof Construction Section

Some Kalwall Technical Data

The panels chosen are the 2-3/4" panels with Crystal exterior and White interior and a visual light transmission of 20%. For the pre-engineered Skyroof product chosen, the panels with added Lumira aerogel are not available to use, which would have increased the insulation properties immensely. Because of this, the U-Value is 0.23 instead of 0.05 which was originally going to be used.

FACE SHEET COMBINATIONS		% LIGHT TRANSMISSION 2¾" (70 mm) thick panels note 1					SOLAR HEAT GAIN COEFFICIENT @0° ∠ note 3				
EXTERIOR COLOR	INTERIOR COLOR	0.53 "U"	0.29 /0.23 "U" note 2	0.22 /0.14 "U" note 2	0.18 /0.10 "U" note 2	0.05 "U" note 2	0.53 "U"	0.29 /0.23 "U" note 2	0.22 /0.14 "U" note 2	0.18 /0.10 "U" note 2	0.05 "U" note 2
Greenish Blue	White	25	14	5	3	12	0.50	0.23	0.14	0.10	0.19
Aqua	White	29	17	6	4	13	0.45	0.24	0.14	0.10	0.21
Rose	White	30	18	6	4	14	0.46	0.24	0.15	0.10	0.21
Ice Blue	White	35	20	8	6	18	0.54	0.28	0.17	0.12	0.26
White	White	20	15	8	5	14	0.38	0.23	0.15	0.11	0.18
Crystal	White	35	20	12	8	20	0.52	0.28	0.17	0.13	0.25
Crystal	Crystal	50	30	15	10	NA	0.65	0.33	0.18	0.13	NA

Figure 72 Kalwall Product Table; Crystal/White Chosen

U Value = 0.23 Btu/hr/ft^2/°F

SHGC = 0.28

SC = 1.15 * SHGC = 1.15 * 0.28 = 0.322

For the input into SkyCalc, the exact dimensions and shape of the skylights could not be used. However, the approximation was made to be as close to the real situation as possible. The dimensions of the skylights in plan are eight feet by twenty feet and in elevation they are ridged to about two feet in height with hipped ends. This shape was approximated in the program with the same plan dimensions and height but using a domed shape with a well.

SkyCalc: Skylight Design Assistant - Optional Inputs	
Company Name:	John Conley
Project Description:	Oakland University Engineering Center

Skylights	Default	User Revisions	Design Input
Skylight shape	Flat	Dome	Dome
Height of dome (Rise) (ft)	2	2	2
Visible transmittance	8%	20%	20%
Solar heat gain coefficient	6%	28%	28%
Curb type	Wood	Integral frame	Integral frame
Frame type	Metal w/ thermal brk	Metal w/ thermal brk	Metal w/ thermal brk
Unit U-value (Btu/h•°F•ft^2)	0.607	0.230	0.230
Dirt light loss factor	70%		70%
Screen or safety grate factor	100%		100%
Light well reflectance	70%		70%
Well factor (WF)	78%		78%
Bottom of light well:			
Width (ft)	8.00	8.00	8.00
Length (ft)	20.00	20.00	20.00
Diffuser on bottom of well?	No	Yes, / No (selected)	No

Figure 73 SkyCalc Skylights Input

Additional Information for SkyCalc Input

Electricity Cost

On-Peak = $0.0567 per KWh

Off-Peak = $0.0537 per KWh

Natural Gas Rate

Average Annual Gas Cost = $6.10 per MMBtu = $0.61 per Therm

Transportation cost to Oakland University = $0.75 per MMBtu = $0.075 per Therm

Total = $0.685 per Therm

Heating and Air Conditioning Systems

Air Conditioning = Evaporative Cooling

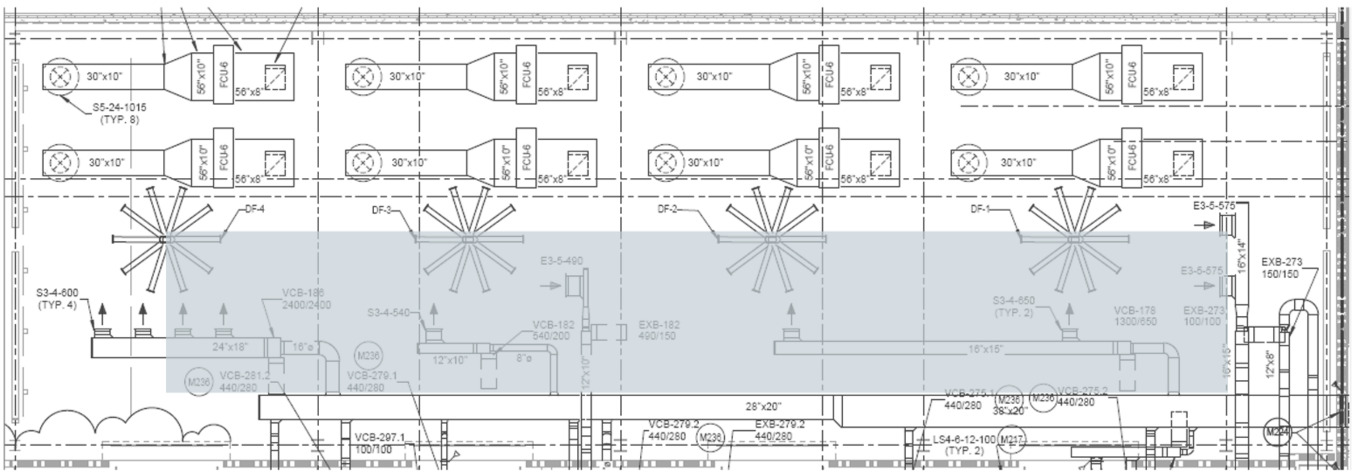
Heating System = Gas/Oil Boiler

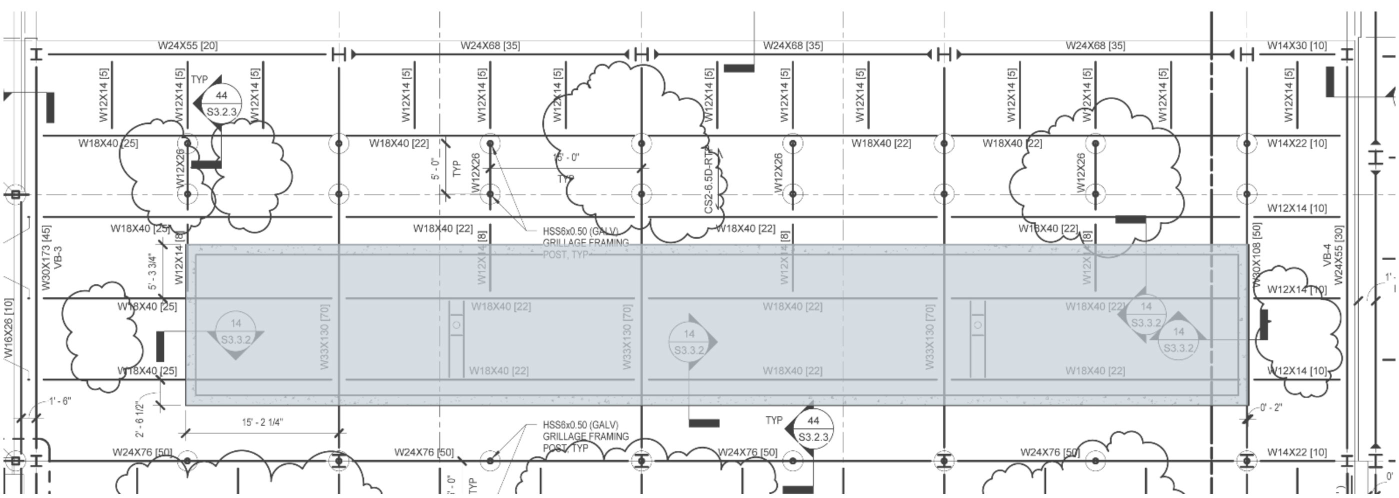
SkyCalc Analysis

Before the decision was made to limit the changes in mechanical equipment layout, a case in which one large skylight was used to span most of the length of the project labs was analyzed. This case proved to be much better for the overall savings in the space. This case was however determined to be too disruptive of the other existing systems in the space including mechanical equipment and structural beams. A more integrative solution was then devised which would still give energy savings as well as daylighting improvement.

Large Skylight Trial

The original plan was to use a single 14.5 ft by 103 ft sized Skyroof which would essentially sit in the area which is now occupied by the extensive greenroof, which is shown in the images below.





As you can see, this solution would require an extensive rerouting of mechanical equipment and a fairly in depth redesign of the structure to allow for a clean opening into the space below the skylights. But, for the purpose of analyzing all options, this solution was analyzed in SkyCalc. The results are as follows.

SkyCalc: Skylight Design Assistant - Tabular Results

Company Name:	John Conley
Project Description:	Oakland University Engineering Center

Electric Lighting Usage	**kWh/yr**		
Ltg. Energy without Skylights	20,163	Lighting Fraction Saved	
Lighting Energy w/ Skylights	20,163	Full daylighting (h/yr)	1,474

Update Results

Savings from Design Skylighting System

Savings	**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting		
Cooling	-139	-$7
Heating	11,809	$276
Total	**11,670**	**$269**

Skylighting System Description

Skylight unit size (ft^2)	1,467.8
Number of Skylights	1
Total Skylight Area (ft^2)	1,468
Skylight to Floor Ratio (SFR)	25.7%
Effective Aperture	2.8%
Floor Area per Skylight	5,704
Skylight U-value	0.230
Skylight SHGC	28%
Skylight T_{vis}	20%
Well Efficiency (WF)	78%
Dirt and Screen Factor	70%
Overall Skylight System Tvis	11%
Skylight CU	66%

Site Description

Climate Location	Pontiac.wea3	
Climate Zone	CZ5 (cool, 5,400 < HDD65°F <= 7,200)	
Building Type	University 9 mo	
Building Area	5,704	(ft^2)

Elecric Lighting System Description

Lighting Type	Industrial fluorescent	
Lighting Control	No Daylight Control	
Light Level Setpoint	50	fc
Lighting Density	1.03	W/ft^2
Connected Load	5.9	kW
Fraction Controlled	50%	

3 Smaller Skylight Units

After weighing the different factors at play and analyzing the daylighting with the large Skyroof, it was decided to use three smaller skylights which fit more nicely within the existing mechanical equipment and structure. These skylights were deemed to be good enough after studying the daylighting in DAYSIM and the structure through hand calculations and were then input into SkyCalc. The results of which are below. The results show that there will still be savings in heating and losses in cooling which was seen with the large skylight. The savings are about 60% less than the large skylight case, but the initial cost would be much greater and this would have to be taken into consideration. A simple payback period is calculated below.

SkyCalc: Skylight Design Assistant - Tabular Results

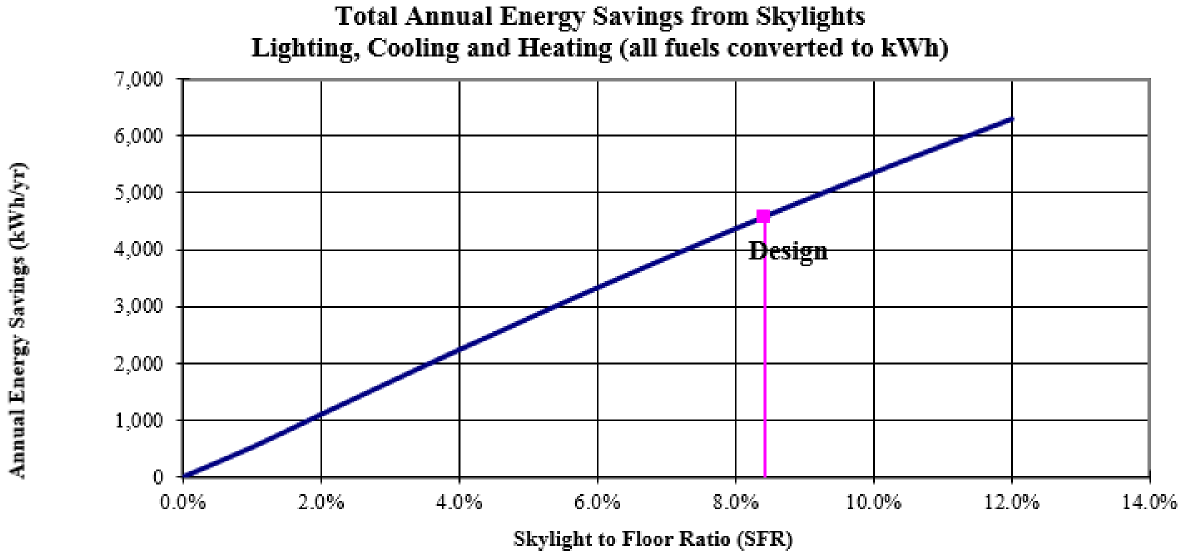
Company Name:	John Conley
Project Description:	Oakland University Engineering Center

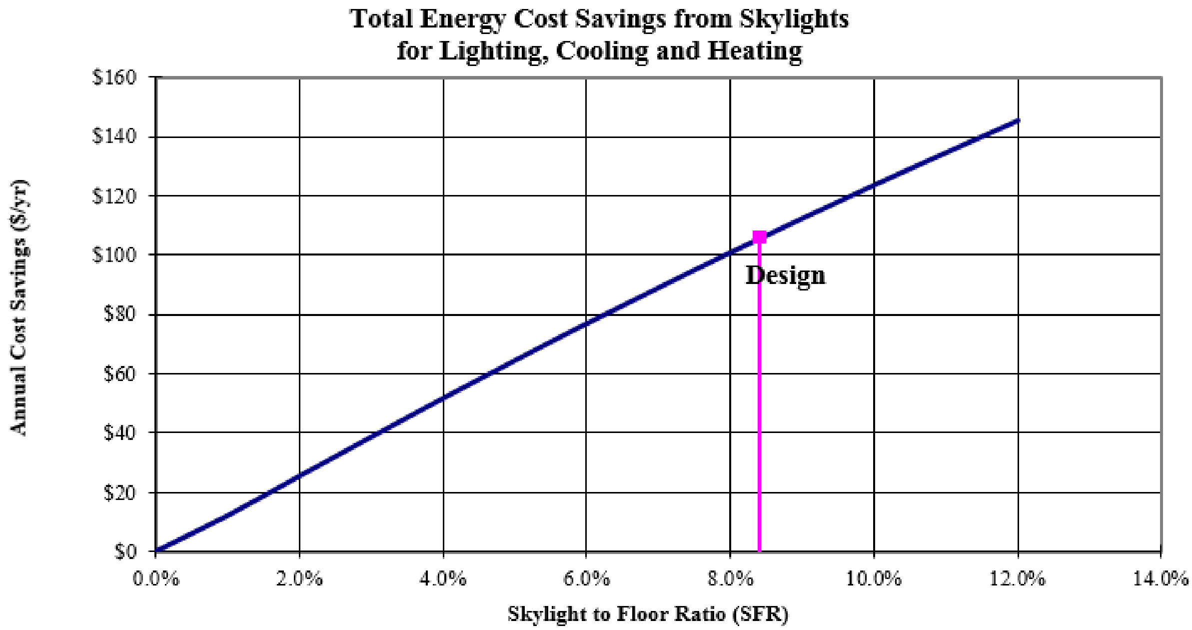
Electric Lighting Usage	**kWh/yr**		
Ltg. Energy without Skylights	20,163	Lighting Fraction Saved	
Lighting Energy w/ Skylights	20,163	Full daylighting (h/yr)	112

Update Results

Savings from Design Skylighting System

Savings		**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting			
Cooling		-49	-$3
Heating		4,632	$108
Total		**4,582**	**$106**





Skylighting System Description

Skylight unit size (ft^2)	160.0
Number of Skylights	3
Total Skylight Area (ft^2)	480
Skylight to Floor Ratio (SFR)	8.4%
Effective Aperture	0.9%
Floor Area per Skylight	1,901
Skylight U-value	0.230
Skylight SHGC	28%
Skylight T_{vis}	20%
Well Efficiency (WF)	78%
Dirt and Screen Factor	70%
Overall Skylight System Tvis	11%
Skylight CU	66%

Site Description

Climate Location	Pontiac.wea3	
Climate Zone	CZ5 (cool, 5,400 < HDD65°F <= 7,200)	
Building Type	University 9 mo	
Building Area	5,704	(ft^2)

Elecric Lighting System Description

Lighting Type	Industrial fluorescent	
Lighting Control	No Daylight Control	
Light Level Setpoint	50	fc
Lighting Density	1.03	W/ft^2
Connected Load	5.9	kW
Fraction Controlled	50%	

Payback Period Calculation

In many projects, what seems good from a design standpoint can often be discarded when the cost is accounted into the analysis. For the simple payback period calculation, the following factors were incorporated:

Initial Kalwall Product Cost (See Appendix VI)

Initial Project Cost Reductions of the Greenroof and Structural Members

Annual Lighting, Cooling, and Heating Savings

Kalwall was contacted and an official quote was given for the size and specified panels. This initial cost was much larger than expected, at $30,700.00. For a panel with a U value of 0.14 instead of 0.23, the cost would be $31,585.00. The 0.14 U value option is not going to be considered due to the reduction in visual light transmittance.

For the initial cost reductions, the greenroof area difference was calculated and the tonnage reduction calculated in the structural breadth were used. The greenroof was downsized by 480 ft^2 by subtracting the areas of the three skylights. A nominal price per square foot for a greenroof in America was found on multiple websites of \$20/ft^2. For the tonnage cost of steel, the SteelBenchmarker Report #216 was used for the current cost of steel at \$473/ton.

The SkyCalc results for the three skylights without lighting control were used for the cooling and heating savings. For the lighting savings, it was decided to use the SkyCalc approximation for 5% dimming instead of the DAYSIM results due to the fact that most likely both lighting zones could be dimmed rather than just the one. The results for SkyCalc with electric light dimming are shown below.

SkyCalc: Skylight Design Assistant - Tabular Results

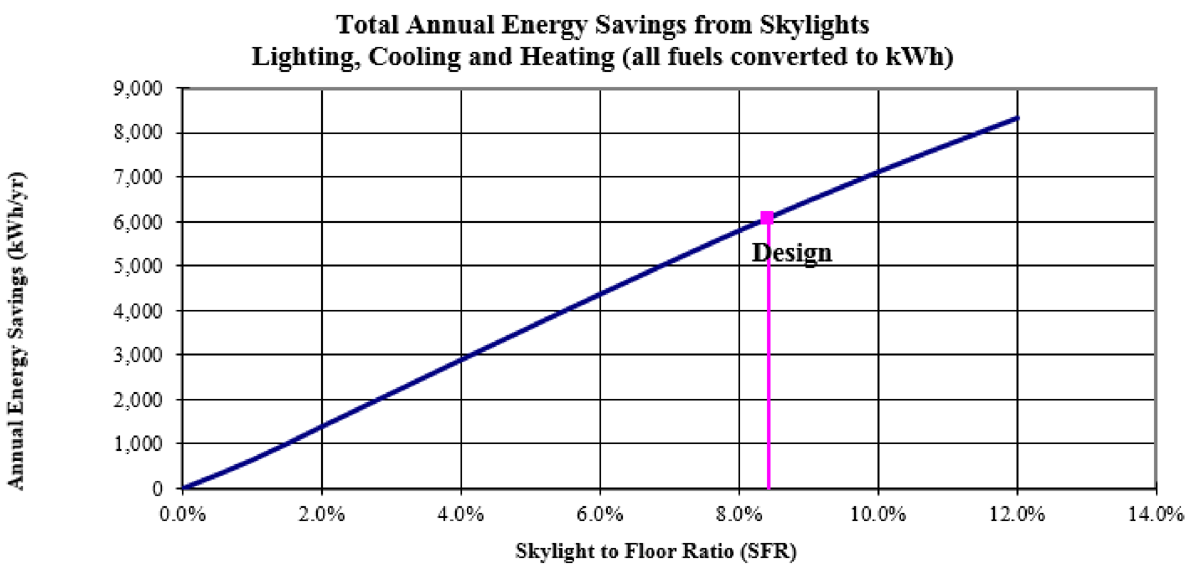
Company Name:	John Conley
Project Description:	Oakland University Engineering Center

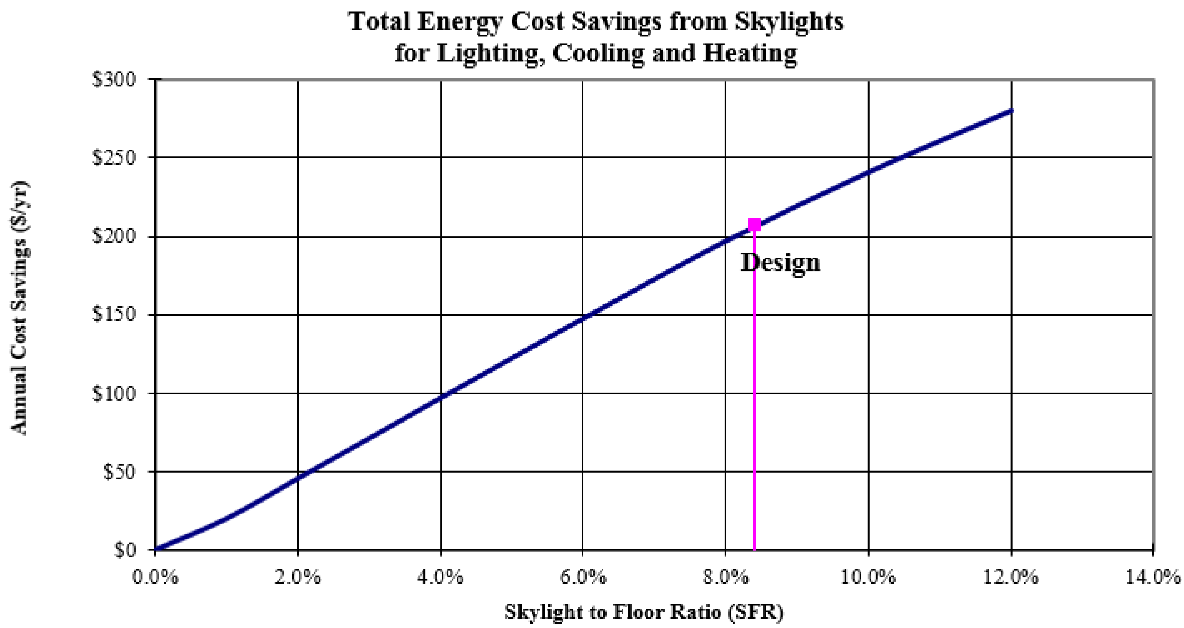
Electric Lighting Usage	**kWh/yr**		
Ltg. Energy without Skylights	20,163	Lighting Fraction Saved	11%
Lighting Energy w/ Skylights	17,998	Full daylighting (h/yr)	112

Update Results

Savings from Design Skylighting System

Savings	**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings (\$/yr)**
Lighting	2,165	\$116
Cooling	-37	-\$2
Heating	3,948	\$92
Total	**6,077**	**\$207**





Company Name: John Conley

Project Description: Oakland University Engineering Center

Dome Skylight Effective Aperture = 0.92%, Skylight to Floor Ratio (SFR) = 8.42%

Average daylight footcandles (fc)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	0	2	8	15	19	20	20	16	11	4	1	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	1	5	13	20	25	28	27	23	17	9	3	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	4	12	20	27	32	33	34	31	22	14	6	1	0	0	0	0	0
Apr	0	0	0	0	0	0	3	10	20	30	38	40	42	42	37	28	21	11	3	0	0	0	0	0
May	0	0	0	0	0	1	7	17	30	38	44	47	49	50	45	34	26	16	6	1	0	0	0	0
Jun	0	0	0	0	0	2	9	19	29	38	46	50	54	50	48	40	32	19	9	3	0	0	0	0
Jul	0	0	0	0	0	1	7	16	28	36	47	48	53	51	44	38	29	20	9	3	0	0	0	0
Aug	0	0	0	0	0	0	4	13	25	36	43	47	48	46	40	34	28	15	6	1	0	0	0	0
Sep	0	0	0	0	0	0	2	8	17	27	36	41	44	40	36	27	16	7	2	0	0	0	0	0
Oct	0	0	0	0	0	0	0	4	11	20	27	29	32	28	23	16	8	2	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	1	5	12	17	21	21	18	14	8	3	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	2	7	13	16	19	17	13	7	2	0	0	0	0	0	0	0

Design Illuminance = 50 fc

< 1 fc; < 25 fc; < 50 fc; > 50 fc;

Location = Pontiac

Once all of this information was collected, the simple payback period was calculated in the table below.

	No. Units	Price per Unit	Dollar Amount
Initial Cost For 3 Pre-Engineered Kalwall SkyRoof Products			$ 30,700.00
Initial Cost Reductions			
Reduction in the Area of GreenRoof	480	$ 20.00	$ 9,600.00
Reduction in the Tonnage of Steel Beams	0.33975	$ 473.00	$ 160.70
Total Initial Cost			$ 20,939.30
Annual Savings From SkyCalc			
Lighting Dimming Savings			$ 116.00
Heating Savings			$ (3.00)
Cooling Savings			$ 108.00
Total Annual			$ 221.00
Payback Period (Years)			**94.7**

Table 5 Payback Period with Greenroof Reduction

Since this payback period of almost 95 years is outrageous, a payback period for the addition of the skylights while taking the whole greenroof was looked into.

	No. Units	Price per Unit	Dollar Amount
Initial Cost For 3 Pre-Engineered Kalwall SkyRoof Products			$ 30,700.00
Initial Cost Reductions			
Reduction in the Area of GreenRoof	1436.2	$ 20.00	$ 28,723.85
Reduction in the Tonnage of Steel Beams	0.33975	$ 473.00	$ 160.70
Total Initial Cost			$ 1,815.45
Annual Savings From SkyCalc			
Lighting Dimming Savings			$ 116.00
Heating Savings			$ (3.00)
Cooling Savings			$ 108.00
Total Annual			$ 221.00
Payback Period (Years)			**8.2**

Table 6 Payback Period with No Greenroof

This payback period of 8.2 years is much more reasonable to go to the owner with as a suggestion.

Conclusion

After analyzing the effects of the skylights on the heating and cooling of the space and most importantly on the costs involved, the following recommendations are made for using the Kalwall skylights. Because of the daylighting benefits of the skylights as well as the heating cost reduction, it is recommended that the owner consider adding the skylights to the project. The skylights would only be 0.0539% of the total project cost so it may be reasonable to justify the cost mainly on the qualitative benefits. Because of the large payback period though, if the cost is a problem, this would not be recommended. And if cost is a problem, since these skylights are considered a great addition to the space, it would be recommended that the greenroof be taken out completely. The result of this would be a payback period of 8.2 years with a continuous savings afterwards and the University would see the benefit in a decent time-frame.

SUMMARY + CONCLUSIONS |

SUMMARY |

Through the course of this senior thesis project, the wide base of knowledge acquired from the past five years was utilized in a manner to show individual capabilities in the Architectural Engineering field. The lighting, electrical, mechanical, and structural systems of the Engineering Center as well as the daylighting aspects of the project were studied to explore many aspects of real world engineering problems to come up with appropriate conclusions.

This project, even though not perfect, was a very valuable process to go through at the end of my studies here at Penn State. I have to admit that I am not fully satisfied with my own quality of work or range of studies done in the course of this report. That being said, the determination that it took to spend many upon many hours of work on a project that ends up losing its feeling of excitement towards the end is an invaluable attribute that I feel I have acquired throughout this project. In the future there are bound to be long workdays and long nights working on projects with difficulties. I have a more realistic and more broad mindset having completed this report and I look forward to moving on to real world projects with the knowledge I have from my time here at Penn State.

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Software Used

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Autodesk 3DS Max Design 2014

Autodesk AutoCAD 2015

Autodesk Revit 2015

DaysimPS

eQUEST 3-65

SkyCalc Excel Program from energydesignresources.com

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Many others have supported me throughout the whole process and I am very grateful for the multitude of amazing people in my life.

My parents, Douglas and Carrie Conley for forming me into the adult that I am now and supporting all of my decisions that led me to the AE program at Penn State

My lovely girlfriend Deirdre for making sure that I stayed sane throughout this long 5th year journey

My amazing AE friends and the support, help, and opinions they have provided and good times we have had these past few years

My Lord and Savior with whom all of this was possible

I'm going to miss Penn State and the Architectural Engineering department and I know I'll cherish these times. I'm eternally grateful for the broad range of knowledge and experiences that this program has given me and I'm extremely excited to take this knowledge into the real world starting this summer with the Lighting Practice in Philadelphia.

And finally, I could not have gotten through the semester without my old friend Netflix who is my loyal and mindless help through all of the tough times.

APPENDICES |

Appendix I | Full Lighting Schedule

Oakland University Engineering Center Fixture Schedule							
Type	**Description**	**Manufacturer**	**Model**	**Load**	**Lamp**	**Voltage**	**Mounting**
L1	Handrail detail encapsulated LED strip light, IP67 plug in connectors at both ends, 4000K, 85 CRI, 3-Step MacAdam binning	LED Linear	VarioLED HYDRA LD5 W830/A IP67	4.8 W/m	LED	24	Surface Mount
L2	Recessed 6" round LED downlights, tempered clear glass enclosure, anodized aluminum reflector, Outdoor rating IP65, 4000K, 85CRI	Bega	Bega 6650 LED K4	23 W	LED	277	Recessed
L3	8" square wall mounted assymmetric LED, die-cast aluminum housing, semi-specular anodized aluminum internal reflector, weather tight IP65 rating, 4000K, 85 CRI	Bega	Bega 3238 LED	32 W	LED	277	Wall Mount
L4	30" tall two sided bollard with 21-5/8" illuminated height per side, 1/4" thick aluminum extruded housing with electrostatically applied powder coat finish, 1/4" polycarbonate lens, UL/CUL Wed Location rated, 4000K	A-Light	X2-2-LL-40-2-P-HH-M-B	10 W/ft	LED	277	Bollard
L5	20-7/8" x 3-1/2" linear LED ingrade symmetrical floodlight, extruded stainless steel with 1/4" tempered matte safety glass cover, IP67 rating, 4000K, 80 CRI	Bega	Bega 7915 LED	27 W	LED	277	Ingrade Recessed
L6	4' x 2.64" Recessed linear LED downlight, flush mount, extruded aluminum housing, white powder coat steel reflector, frosted acrylic lens, replaceable LED modules and drivers from below, 4000 K, 80 CRI	Focal Point	FSM2L-FL-375LF-40K-1C-277-LD1	21 W	LED	277	Recessed
L7	Linear surface mounted LED, 11-5/16" length segments, anodized aluminum extrusion with injection molded end caps, clear high strength acrylic lens, 3500K, 85 CRI	USAI	TOLVW1-H12-35S-CL-FM-LPSDC3-100-L1N	6.3 W/ft	LED	277	Surface Mount Detail
L8	8' linear LED pendant, aluminum extrusion with a matte anodized finish, frosted white acrylic lens diffuser, suspended with adjustable aircraft cable with push button glider, 4000K, 90 CRI	Delray Lighting Inc.	ST1P8-2-LOW40-BDIM-W-SLRD	48 W	LED	277	Pendant
L9	Same product as L6 with a modified wall to ceiling housing and flex whip connector	Focal Point	FSM2L-FL-625LF-40K-1C-277-LD1-CXFF-WH-4C4W	8 W	LED	277	Recessed
L10	7' x 2.25" x 3.375" Mullion mounted assymmetric LED fixture, aluminum extruded housing, precision milled endcaps, 4000K	A-Light	ACL4-M72-M1-LS-40-N-D-2-T-R	5 W/ft	LED	277	Mullion Mounted
L11	1' x 1.5" x 2.1" linear LED wall grazing fixture, narrow 10 x 60 degree beam angle, 4000K, 84 CRI	Philips Color Kinetics	523-000065-19	12.5 W/ft	LED	277	Surface Mount
L12	Cove lighting LED fixture with a 4" opening from ceiling grid and total 7.3" depth above ceiling, extruded aluminum housing with polyester poweder coat, frosted lens, 3500K	Focal Point	FTRL-AC-LL1-35K-1C-277-LD1	22.9 W	LED	277	Cove Detail
L13	66.7" x 66.7" x 3.1" Ceiling mounted direct LED fixture, polished aluminum housing finish, integrated acrylic cover, fabric covering as a light and acoustic diffuser, 4000K	Sattler	814-69-51-22-Z70	87 W	LED	277	Ceiling Mounted
L14A	4" Square recessed LED downlight, self-flanged semi-specular reflector, highly transmissive lens, 20 degree beam angle, 3500K	Gotham	ICOSQ-35-30-4AR20D-277	42 W	LED	277	Recessed
L14B	4" Square recessed LED downlight, self-flanged semi-specular reflector, highly transmissive lens, 60 degree beam angle, 3500K	Gotham	ICOSQ-35-05-4AR60D-277	8 W	LED	277	Recessed
L15	3.15' x 9.18" x 4.63" Industrial high-bay LED pendant, 6' cable length, heavy duty extruded anodized aluminum construction, protective optical lumen maintenance tray, 4000K, 73 CRI	Big Ass Lights	BAL-HBL1-20-04-01-02-06-03-01	194 W	LED	277	Pendant
L16	11' x 3.5" x 2.5" Bottom mounted assymmetric LED fixture, aluminum extruded housing, 4000K	A-Light	D4-M132-LH-40-2-N-D-O	10 W/ft	LED	277	Surface Mount
L17	11' x 2-3/8" x 3-9/16" Surface mounted Linear LED fixture, extruded aluminum housing with aluminum endcaps, polyester powder coating, extruded impact resistant acrylic lens, 4000K, 80 CRI	Selux	L60-1A35-40-LW-F-11-BK-277	8.4 W/ft	LED	277	Surface Mount

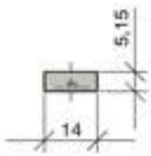
Appendix II | Lighting Cut Sheets

VarioLED™ Flex HYDRA LD5 IP67

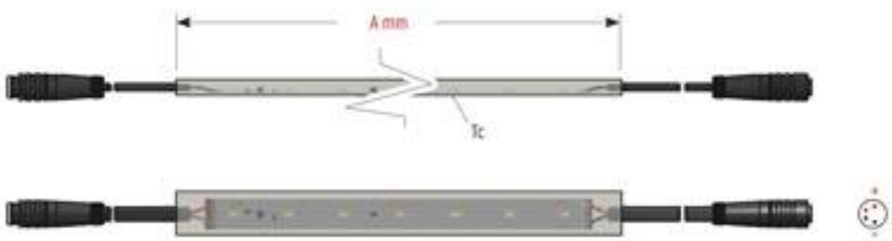
Wasser- und UV-geschützte flexible Linearleuchte in bis zu 7,5 m Länge im Polyurethanverguss mit 110 mm IP67 Steckverbinder an beiden Enden.

Fully flexible water & UV resistant linear LED Luminaire up to 7.5 m in polyurethane encapsulation with 110 mm IP67 plug in connectors on both ends.

Abmessungen & Längen Dimensions & available length



Tc-Punkt: Gesamte Rückseite des vergossenen LED Bands
Tc-point: Entire encapsulated flexboard rear side



$A = N \times 125 + 19$; $N = 1 \dots 60$; $A_{min} = 1 \times 125 + 19 = 144$; $A_{max} = 60 \times 125 + 19 = 7.519$

Bestellnummer Order Code: VarioLED Flex HYDRA LD5 Wxxx/A IP67

Elektrische & Optische Betriebsdaten Electrical & optical data

VarioLED™ Flex HYDRA LD5 IP67	lumen/meter (lm/m)	Farbtemperatur* Color Temperature* (K)
W824	267	3.000
W827	294	3.400
W830	314	3.800
W835	330	4.300
W840	338	5.900
W850	355	9.400

* Bei IP67 Produkten können Toleranzen bei der Farbtemperatur auftreten. Nähere Erläuterung dazu finden Sie auf S. 584.

* In case of IP67 products, tolerances in the color temperature can occur. For further explanation, please see page 584.

Es gelten die selben Daten wie für VarioLED™ Flex HYDRA LD5 mit folgenden Ausnahmen: 30% Lichtverlust und Farbverschiebung im Vergleich zum nicht vergossenen LED Strip.

Nähere Erläuterung zu den technischen Daten des PU-Schutzes im LED Linear™ Systemkatalog, Seite 584.

Same data as for VarioLED™ Flex HYDRA LD5 apply, except: 30% light loss and color shift compared to non encapsulated LED strip.

More details regarding the PU-protection in the LED Linear™ system catalogue, page 584.

Bitte sprechen Sie uns an für kundenspezifische Anpassungen, wie z. B. Kabellängen und Stecker.

Please ask for custom specific adaptions like cable length and plugs.

Zubehör Accessories

erforderlich required

Konverter Power supply unit

Buchse Female connector

optional optional

Steuer-protokoll Power control system

Details siehe Seite 456 ff. Details on page 456 ff.

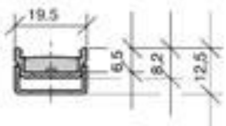
Sicherheits- und Montagehinweise: LED Linear™ Systemkatalog, Seite 534 ff. Safety and assembly information: LED Linear™ system catalogue, page 536 ff.

VarioLED™ HYDRA LD5 IP67

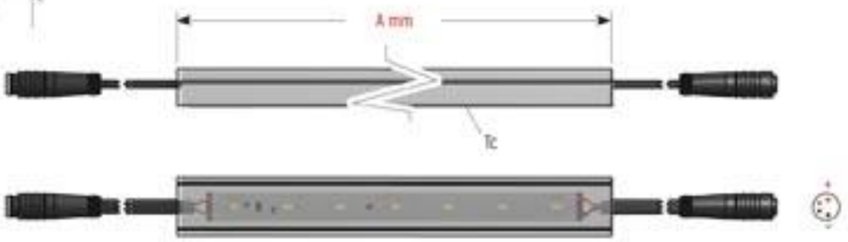
Wasser- und UV-geschützte Linearleuchte im Aluminiumprofil in bis zu 2 m Länge im Polyurethanverguss mit 110 mm IP67 Steckverbinder an beiden Enden.

Up to 2 m length, water & UV resistant LED Luminaire with polyurethane encapsulation in AL profile and 110 mm IP67 plug in connectors on both ends.

Abmessungen & Längen Dimensions & available length



Tc-Punkt: Gesamte Profilrückseite
Tc-point: Entire Al-profile rear side



$A = N \times 125 + 19$; $N = 1 \dots 15$; $A_{min} = 1 \times 125 + 19 = 144$; $A_{max} = 15 \times 125 + 19 = 1.894$

Übersicht VarioContour IP67 ab Seite 474.
Overview VarioContour IP67 from page 474.

Bestellnummer Order Code: VarioLED HYDRA LD5 Wxxx/A IP67

Elektrische & Optische Betriebsdaten Electrical & optical data

VarioLED™ HYDRA LD5 IP67	lumen/meter (lm/m)	Farbtemperatur* Color Temperature* (K)
W824	253	3.000
W827	279	3.400
W830	298	3.800
W835	314	4.300
W840	321	5.900
W850	337	9.400

* Bei IP67 Produkten können Toleranzen bei der Farbtemperatur auftreten. Nähere Erläuterung dazu finden Sie auf S. 584.

* In case of IP67 products, tolerances in the color temperature can occur. For further explanation, please see page 584.

Es gelten die selben Daten wie für VarioLED™ Flex HYDRA LD5 mit folgenden Ausnahmen: 30% Lichtverlust und Farbverschiebung im Vergleich zum nicht vergossenen LED Strip.

Nähere Erläuterung zu den technischen Daten des PU-Schutzes im LED Linear™ Systemkatalog, Seite 584.

Same data as for VarioLED™ Flex HYDRA LD5 apply, except: 30% light loss and color shift compared to non encapsulated LED strip.

More details regarding the PU-protection in the LED Linear™ system catalogue, page 584.

Bitte sprechen Sie uns an für kundenspezifische Anpassungen, wie z. B. Kabellängen und Stecker.

Please ask for custom specific adaptions like cable length and plugs.

Zubehör Accessories

erforderlich required	optional optional
Konverter Power supply unit; Buchse Female connector	Steuer-protokoll Power control system

Details siehe Seite 456 ff. Details on page 456 ff.

Sicherheits- und Montagehinweise: LED Linear™ Systemkatalog, Seite 534 ff. Safety and assembly information: LED Linear™ system catalogue, page 536 ff.

Recessed ceiling downlights with symmetrical ligth distribution · narrow beam

L2

Type: L2
BEGA Product:
Project: Oakland Engineering Center
Voltage: 277 V
Color: 4000K
Options:
Modified:

Housing: Constructed of die-cast and extruded aluminum. Housing is provided with mounting clamps that provide a vibration proof installation in ceilings up to 1 3/8" total thickness. Rough-in housing constructed of glavanized steel with through wiring box. Fough-in housing included. Die castings are marine grade, copper free (≤ 0.3% copper content) A360.0 aluminum alloy.

Enclosure: Tempered clear glass, retained by a one piece, die-cast aluminum step baffle frame that is treaded into luminaire housing. Internal reflector made from pure, anodized aluminum. Fully gasketed for weather tight operation using a molded silicone rubber gasket.

Electrical: 19.5W LED luminaire, 23 total system watts, -30°C start temperature. EldoLED 0-10V dimmable driver mounted to the junction box of the ceiling pan for easy maintenance. The LED driver provides smooth and flicker free dimming down to 0.1% and is compatible with both sink and current source controllers. Optional Dali dimmable driver available, consult factory for details. LED module(s) are available from factory for easy replacement. Standard LED color temperature is 3000K with an 85 CRI. Available in 4000K (85 CRI); add suffix K4 to order.

Note: LEDs supplied with luminaire. Due to the dynamic nature of LED technology, LED luminaire data on this sheet is subject to change at the discretion of BEGA-US. For the most current technical data, please refer to www.bega-us.com.

Finish: All BEGA standard finishes are polyester powder coat with minimum 3 mil thickness. Available in four standard BEGA colors: Black (BLK); White (WHT); Bronze (BRZ); Silver (SLV). To specify, add appropriate suffix to catalog number. Custom colors supplied on special order.

CSA certified to U.S. and Canadian standards, suitable for wet locations. Protection class IP65

Weight: 4.0 lbs.

Luminaire Lumens: 1195
Tested in accordance with LM-79-08

	Lamp	β	A	B	C
6650 LED	19.5 W LED	41°	7	9⅝	18

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Wall luminaires with directed light

L3

Type: L3
BEGA Product: 3238 LED
Project: Oakland University Engineering
Voltage: 277 V
Color: 4000K
Options:
Modified:

Housing: One piece die-cast aluminum supplied with universal mounting bracket for direct attachment to 3½" or 4" octagonal wiring box. Die castings are marine grade, copper free (≤ 0.3% copper content) A360.0 aluminum alloy.

Enclosure: One piece die-cast aluminum cover frame secured by captive socket head, stainless steel screws threaded into stainless steel inserts. Semi-specular, anodized aluminum internal reflector. Safety glass with optical texture. Fully gasketed for weather tight operation using a molded silicone rubber O-ring gasket.

Electrical: 26W LED luminaire, 32 total system watts, -30°C start temperature. Integral 120V through 277V electronic LED driver, 0-10V dimming. LED module(s) are available from factory for easy replacement. Standard LED color temperature is 3000K with an 85 CRI. Available in 4000K (85 CRI); add suffix K4 to order.

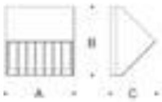
Note: LEDs supplied with luminaire. Due to the dynamic nature of LED technology, LED luminaire data on this sheet is subject to change at the discretion of BEGA-US. For the most current technical data, please refer to www.bega-us.com.

Finish: All BEGA standard finishes are polyester powder coat with minimum 3 mil thickness. Available in four standard BEGA colors: Black (BLK); White (WHT); Bronze (BRZ); Silver (SLV). To specify, add appropriate suffix to catalog number. Custom colors supplied on special order

CSA certified to U.S. and Canadian standards, suitable for wet locations. Protection class IP65

Weight: 4.4 lbs.

Luminaire Lumens: 1241
Tested in accordance with LM-79-08



	Lamp	A	B	C
3238 LED	26W LED	8	8	5¼

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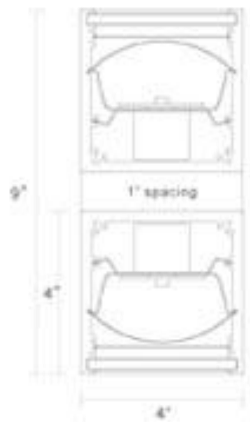
L4

X2 | aire²

elements

direct

ground mount
bollard

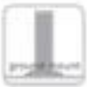


LED	2 boards in cross (1 per side)	
per foot	watts/ft	lumens/ft
LL	4	240
LS	10	1200

specifications subject to change
* lumens at 4000k

Available Light Platforms:

Available Mounting:



L4

X2 | aire²

project

type L4

quantity 6

interior **exterior**

Mounting:
The aire2 is a combination of two aire1 luminaires set into a common base, back-to-back set apart 1".

Ground Mount: Free standing milled mounting plate and stainless steel anchor platform. Form and frame by others. No grout required. Chamfered or square base is 7-3/4" x 12-11/16".

Direct Burial: Free standing square base with concealed mounting plate and stainless steel anchor platform for a clean, simple aesthetic. Concrete base must be cast up to 4" lower than grade allowing material to be backfilled over the concrete and mounting base. Form and frame by others. No grout required.

Top accessible lamp/ballast tray is the length of the housing and slides out for servicing. Clearance above bollard must be in excess of the actual bollard height, therefore a 4ft fixture requires an additional 4ft clearance. Integral plug connects to site wiring and unplugs when tray is removed.

Optics:
Each pattern contains an optical platform engineered for maximum light output. Precision-formed reflector design and optimal staggered lamp or LED spacing minimizes socket shadow and maximizes even light output.

Lengths:
All length dimensions are nominal and used for general length identification purposes. Actual lengths may vary by several inches. Luminaires are individual fixtures and are not connectable.

Overall height = luminous height + 8.375" from ground, including base. Direct burial option reduces overall height above-ground up to 4".

LED:
5yr warranty. >60,000hr LED life. Tested to LM-79 and LM-80. See wattage/lumen table for specifications per foot. All specifications are subject to change.

T5/T5HO:
Single, dual or single staggered lamps in cross section. Program start is factory standard.

Construction:
60% recycled aluminum extruded housing, 1/4" thick. Precision-milled 3/8" endcaps. Impact-resistant, 1/4" tempered glass or polycarbonate outer lens. Neoprene gasketed. Free standing milled mounting plate and stainless steel anchor platform.

Finish:
Electrostatically applied powder coat finish.

Listing:
UL/CUL. Wet Location.

Companion Luminaires:
X1 bollard, X3 bollard, X4 wall, X7 recessed

Legend:
1. LED optics
2. T5/T5HO optics
3. Direct burial option reduces above-ground height up to 4" once backfilled.

Series: X2

Dimension: 2
nominal 2' = 30" overall height | 2
nominal 3' = 42" overall height | 3
nominal 4' = 54" overall height | 4

Lamping (each side): LL
LED low output | LL
LED standard output | LS
T5 (1) | S
T5HO (1) | H
T5 (2) | D
T5HO (2) | O

LED Temp (if applicable): 40
3000k | 30
3500k | 35
4000k | 40

Voltage: 2
universal 120V - 277V | U
120V | 1
277V | 2
347V | 3

Lens: P
clear glass | G
polycarbonate | P

Optics: HH
HTLO™ vertical pattern [1] | HV
HTLO™ horizontal pattern [1] | HH
HTLO™ vertical+horizontal pattern [1] | HVH
a·cirrus™ + HTLO™ [1] | AH
a·cirrus™ lens [2] | A
HTLO™ lens [2] | H

Mounting: M
chamfered base | M
square base | S
direct burial [3] | DR

Finish: B
a·lightanium™ | T
satin black | B
dark bronze | DB
other - specify RAL# | O

Options:
dimming - specify manufacturer, model/series and voltage | D
external fusing | F
new york city code | N

site

nomenclature	2	3	4
illuminated height	21-5/8"	33-5/8"	45-5/8"
baseplate height	8-3/8"	8-3/8"	8-3/8"
overall height	30"	42"	54"

dimensions are approximate

4ft example:

Drive-over in-grade linear floodlights with LEDs - Symmetrical

L5

Type: L5
BEGA Product: Bega 7915 LED
Project: Oakland Engineering
Voltage: 277 V
Color: 4000 K
Options:
Modified:

Enclosure: Outer housing: Constructed of high tensile strength, copper free die-cast aluminum alloy.

Inner housing: Constructed of extruded stainless steel. Trim/Faceplate is heavy gauge, machined stainless steel secured to the inner housing by stainless steel threaded welded studs. Maintenance requires removal of inner housing/trim/faceplate assembly from outer housing by means of two flush, socket head stainless steel screws. ¼" thick tempered matte safety glass machined flush to faceplate. One piece molded U-channel, high temperature silicone gasket. Reflector is aluminum with high gloss coating.

Electrical: 22 W LED luminaire, 27 total system watts, -30° C start temperature. Integral 120 V through 277 V electronic LED driver, 0-10 V dimming. Standard LED color temperature is 4000K with a >80 CRI. Available in 3000K (>80 CRI); add suffix K3 to order. Inner housing pre-wired with nine (9) feet of 18/5 water stopper cable, cable clamp, and waterproof cable gland entry into housing. A separate weatherproof single gang wiring box for power supply must be proved (by contractor).
Due to the dynamic nature of LED technology, LED luminaire data on this sheet is subject to change at the discretion of BEGA-US. For the most current technical data, please refer to www.bega-us.com.

Finish: #4 brushed stainless steel. Custom colors are not available.

CSA certified to U.S. and Canadian standards, suitable for wet locations. Protection class IP67.

Note: A foundation and proper drainage must be supplied by the contractor. These luminaires are designed to bear pressure loads up to 2,200 lbs. from vehicles with pneumatic tires. The luminaires must not be used for traffic lanes where they are subject to horizontal pressure from vehicles braking, accelerating and changing direction.

Luminaire Lumens: 1360

Floodlights · **Symmetrical**			
	Lamp	A	B
7915 LED	19.8 W LED	20⅞ x 3½	5

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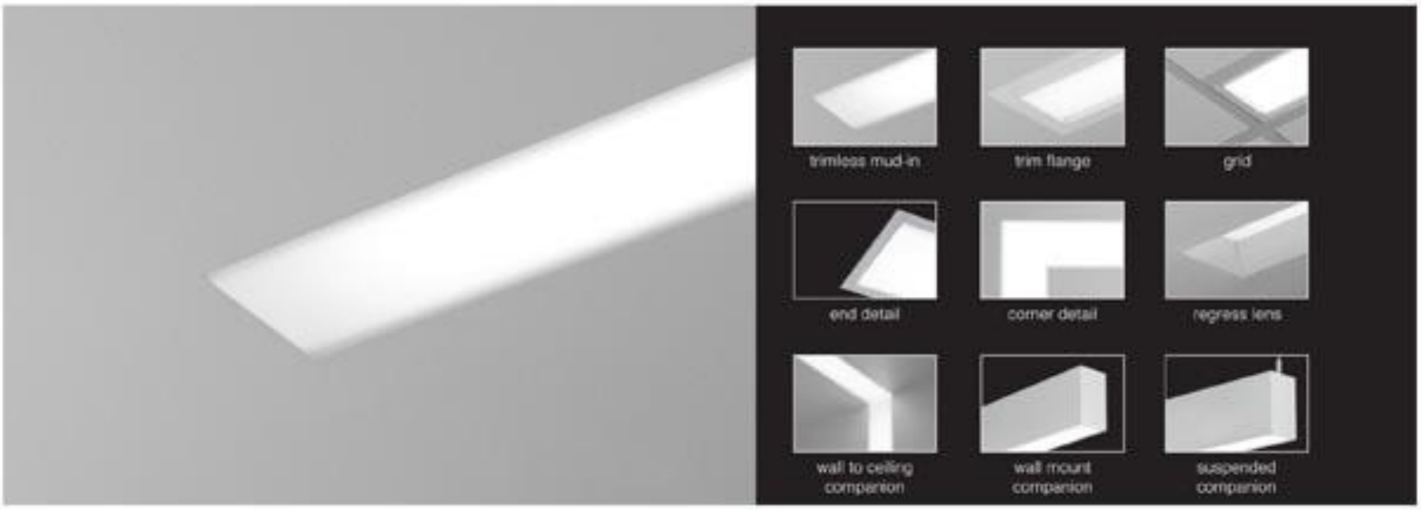
L6

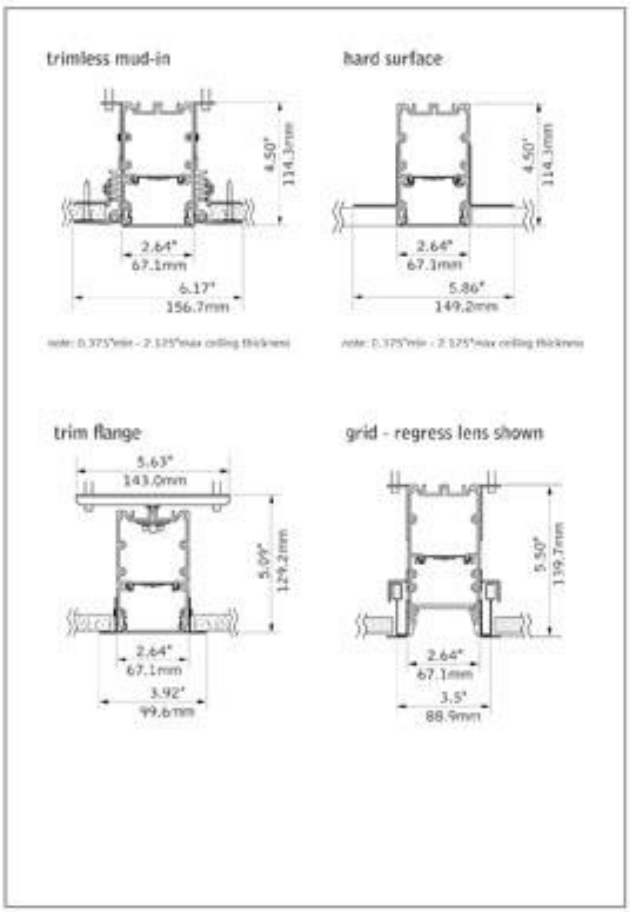
Seem™ 2

LED

FOCAL POINT®



DIMENSIONAL DATA



FEATURES

Narrow extruded aluminum 2.5" aperture recessed slot LED.

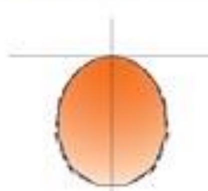
Integrates with ceiling or wall in a variety of mounting styles for a clean, unobtrusive aesthetic.

Individual units and continuous runs in 1' increments.

Continuous frosted acrylic lens provides uninterrupted illumination, without pixels or shadows.

LED position and lens material optimized to provide the perfect blend of high performance and visual comfort.

PERFORMANCE



4' Flush Lens
Nominal output:
250 Lumens per foot

Delivered Lumens: 990lm

Total System Watts: 14W

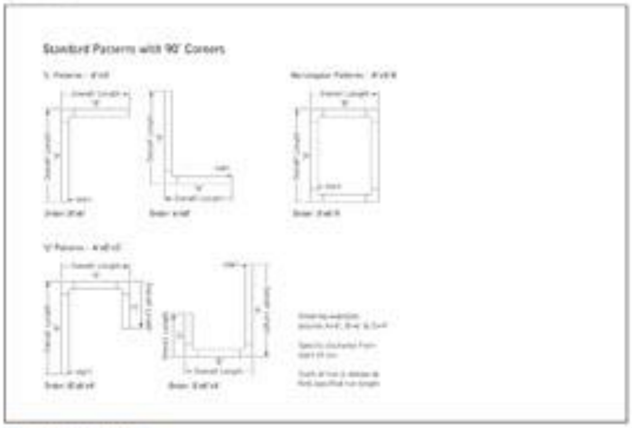
PRODUCT OVERVIEW

Lumen Output:	500-2475lm
Wattage:	8-38W
LPW:	63-71
SDCM:	3
Lumen Maintenance:	L70 @ 50,000hrs

L6

fixture: project:

DETAILS



SPECIFICATIONS

LED System
Proprietary linear LED module incorporates premium LEDs on a robust platform to achieve excellent thermal management. LEDs are placed to promote a uniform appearance. Available in 3000K, 3500K, 4000K with CRI>80, 3SDCM. LED modules and drivers are replaceable from below.

Construction
One piece extruded aluminum housing. 20 Ga. steel end caps. Housing for new construction applications. 2' unit weight: 5.1 lbs., 3' unit weight: 7.6 lbs., 4' unit weight: 10.1 lbs., 5' unit weight: 12.6 lbs.

Optic
Reflectors fabricated of 22 Ga. steel finished in High Reflectance White powder coat. Extruded acrylic lens .07" thick with satin finish.

Electrical
Luminaires are pre-wired with factory installed branch circuit wiring and over-molded quick connects. Standard 120-277V constant current driver includes 0-10V analog dimming Power factor > .9. Emergency battery: IOTA CP-10. Emergency output - 10 watts for 90 minutes.

Labels
UL and cUL listed. Suitable for Dry or Damp Locations, indoor use only.

Finish
Polyester powder coat applied over a 5-stage pre-treatment.

Lumen Maintenance
L70 at 50,000 hours.

Warranty
LED system rated for operation in ambient environments up to 25°C. 5 year limited warranty.

PERFORMANCE CHART

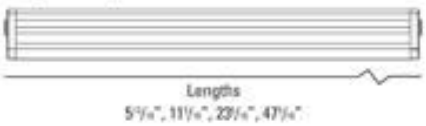
Shielding	Nominal Output	Tested System Watts	Delivered Lumens
Flush Lens	125LF	8	500
	250LF	14	990
	375LF	21	1463
	625LF	38	2475
Regress Lens	125LF	10	500
	250LF	20	994
	375LF	30	1469
	625LF	56	2449
Regress High Performance Lens	125LF	8	486
	250LF	16	984
	375LF	23	1488
	625LF	41	2475

ORDERING

Luminaire Series		FSM2L
Seem 2 LED	FSM2L	
Shielding		FL
Flush Satin Lens	FL	
Regress Lens	SR	
Regress High Performance Lens	SRXP	
Nominal Output		375LF
125 Lumens per foot	125LF	
250 Lumens per foot	250LF	
375 Lumens per foot	375LF	
625 Lumens per foot	625LF	
Color Temperature		40K
3000K	30K	
3500K	35K	
4000K	40K	
Circuit		1C
Single Circuit	1C	
Voltage		277
120 Volt	120	
277 Volt	277	
UNV Volt	UNV	
Driver		LD1
0-10V - 10% Dimming	LD1	
Lutron A-Series- Eco System	L3D	
0-10V - 1% Dimming		
Ceiling Configuration		
Std. 15/16" Lay-in	G1	
Std. 15/16" Tegular	T1	
Std. 9/16" Lay-in	G2	
Std. 9/16" Tegular	T2	
9/16" Slot-tee Tegular	G3	
Tall 15/16" Lay-in	G4	
Tall 15/16" Tegular	T4	
Tall 9/16" Lay-in	G5	
Tall 9/16" Tegular	T5	
Node 9/16" Tegular	T6	
Trim Flange Drywall	TF	
Mud-in Trimless, pre-set for 1/2" Drywall	XF1	
Mud-in Trimless, pre-set for 5/8" Drywall	XF2	
Mud-in Trimless, set thickness in field	XFF	
Non-Drywall Hard Surface	XFN	
Hard Surface, Wood	XFW	
Factory Options		
Chicago Plenum	CP	
Emergency Circuit*	EC	
Emergency Battery Pack*	EM	
Flex Whip*	FW	
Finish		WH
Matte White Housing	WH	
Luminaire Length		4'
Specify luminaire/row length in 1' increments	X'	
Pattern Options		
'L' pattern	A' x B'	
'U' pattern	A' x B' x C'	
Rectangular pattern	A' x B' R	

L7

High Output



LUMINAIRE INFORMATION

APPLICATION: Cove lighting, display cases, shelf lighting, inaccessible areas and heat or UV sensitive installations.

LUMENS: Approximate total lumens per foot shown.

	Clear Lens	Frosted Lens
3000K	323 lm/ft	289 lm/ft
3500K	327 lm/ft	300 lm/ft

Consult factory for additional information.

POWER CONSUMPTION:
Varies. See Power Supply information on page 3.

COLOR RENDERING INDEX:
85+ Typical CRI

DIMMING:
Dimmable 24VDC driver available. See chart on page 3 for compatible dimmers.

COLOR TEMPERATURE: Available in:
3000K 3030 ±100K
3500K 3455 ±125K

LENS:
High strength Acrylic available in clear or frosted.

HOUSING:
Anodized aluminum extrusion w/ injection molded end caps.

LIGHT ENGINE:
High power white LEDs, tightly binned for fixture to fixture color consistency.

RATED LIFE:
Based on IESNA LM80-2008 50,000 HRS@70% lumen maintenance (L70)

LISTING:
Dry/damp location
IBEW Union made

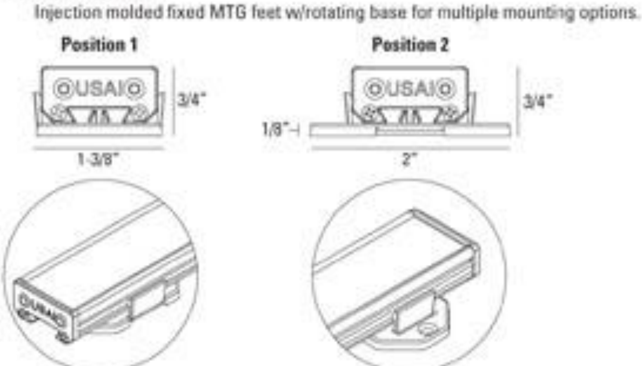
DIMENSIONS (shown with fixed mounting option)

Mounting Feet Per Length:
Mounting feet can be positioned at any position along the length of the fixture.

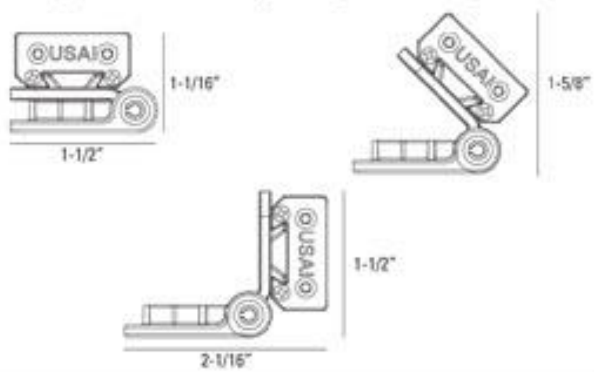
H06 - 2 Mounting Feet
H12 - 2 Mounting Feet
H24 - 2 Mounting Feet
H48 - 3 Mounting Feet

MOUNTING OPTIONS

FM - Fixed Mounting
Injection molded fixed MTG feet w/rotating base for multiple mounting options.



RM - Rotating Mounting
Injection molded self-locking rotating mounts 0-90 degree tilt.



HOW TO SPECIFY

Series	Length	Color Temperature	Lens	Mounting	Connector Options	Power Supplies (Page 3)*
TOLVW1	H12	35S	CL	RM		
TOLVW1 Low Voltage Linear LED	**H06** - 5-13/16" **H12** - 11-5/16" **H24** - 23-9/16" **H48** - 47-3/16"	**30S** - 3000K **35S** - 3500K	**CL** - Clear **FL** - Frosted	**FM** - Fixed **RM** - Rotating	**LVSJ** - Straight Connector 11/16" **LVSJR** - Straight Joiner Rotating Mounts **LVFJ6** - Flexible Corner Connector 6" **LVFJ12** - Flexible Corner Connector 12" **LVFJ24** - Flexible Corner Connector 24" **LVJW-480** - Mini spool 480" 18 AWG Wire **LVCA** - Conduit Adapter **LVDT** - Dovetail Connector	**LPSDC1-100-J1D*** - 100W 120/24V DC Dimming **LPSDC1-50-J1D*** - 50W 120/24V DC Dimming **LPSDC1-300-J1D*** - 300W 120/24V DC Dimming **LPSDC3-100-E1D** - 100W 100-277/24V DC Dimming **LPSDC3-100-L1N** - 100W 100-277/24V DC **LPSDC3-60-L1N** - 60W 100-277/24V DC

*Also available in 277V (LPSDC2)

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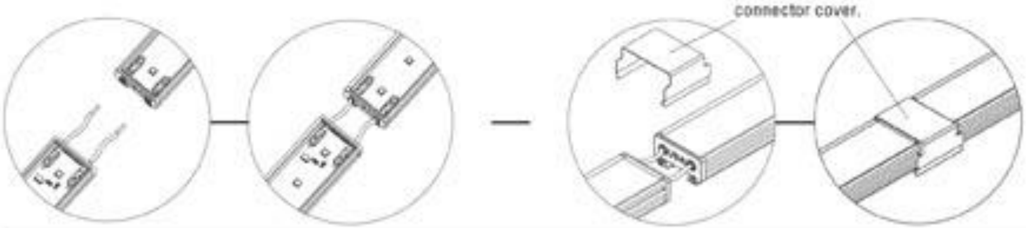
L7

THE ONE LV Linear LED

Connector Options

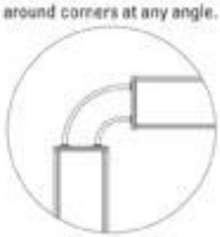
MULTIPLE CONNECTOR OPTIONS

STRAIGHT CONNECTOR: LVSJ



FLEXIBLE CONNECTOR: LVFJ

Allows connection of fixtures around corners at any angle.

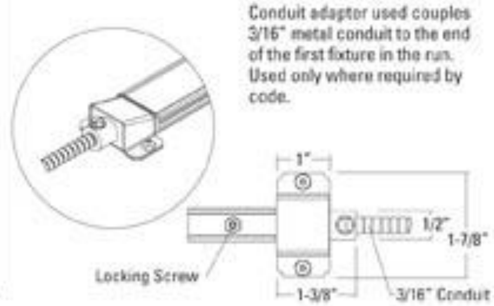


DOVETAIL JOINER: LVDT

Unique dovetail connector allows the ability to mechanically connect multiple lengths on the floor & lift as one coupled unit to mounting location. Also, works with RM to rotate multiple lengths as one unit.

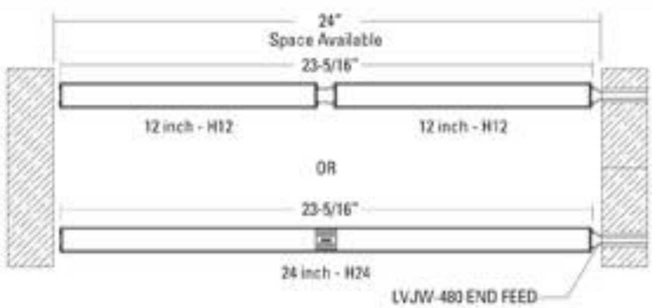
CONDUIT ADAPTER: LVCA

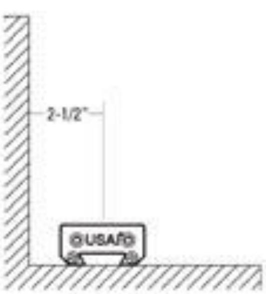
Conduit adapter used couples 3/16" metal conduit to the end of the first fixture in the run. Used only where required by code.



LAYOUT INFORMATION

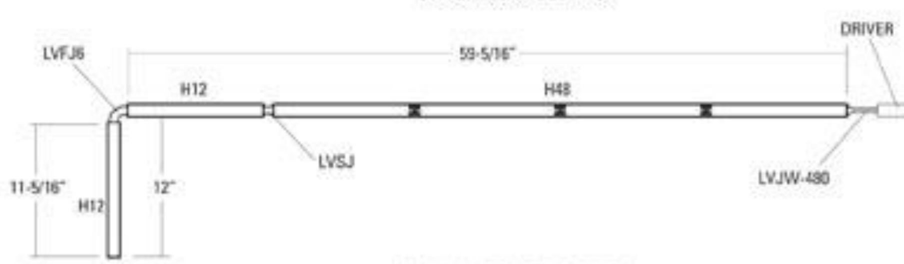
- Recommended as primary usage for indirect cove and under cabinet installations in accordance with recommended minimum setback.
- Applications that require less than recommended minimum setback, edge lighting or back lighting may experience marginal color shift color shift due to individual LED pixel variation within ANSI sub-bin.
- This potential variation would be most noticeable to the human eye @ 2700K, less pronounced @ 3000K and barely noticeable @ 3500K.





RECOMMENDED
MINIMUM SET BACK

TYPICAL CONFIGURATION



SHOWN WITHOUT MOUNTING

www.usailighting.com
info@usailighting.com
1126 River Road
New Windsor, NY 12553
T 845-565-8500
F 845-561-1130

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08/03/2011

L7

THE ONE LV Linear LED

Driver for use with TheOne series TOLVW1 only

DRIVER INFORMATION

APPLICATION: For use with TheOne® linear LED fixtures.

DIMMING:
Dimmable 24VDC drivers available.
See chart below for compatible supply and dimmers.

MATERIAL:
Transformer housing is made of metal construction.

OPERATING TEMPERATURE:
Maximum ambient operating temperature is 50°C.

LISTING:
Dry/damp location. All drivers are UL Class 2 listed. All drivers are ETL listed for use with TheOne® product family.
IBEW Union made.

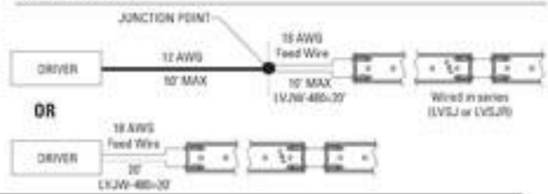
DRIVER SELECTION CHART

	DRIVER	PRIMARY VOLTAGE	WATTS	MAX RUN LENGTH[2]	POWER[3] (W/FT)	DIMMER TYPE	DRIVER PER DIMMER SWITCH[4] 600VA	DRIVER PER DIMMER SWITCH[4] 1000VA	FIGURE
DIMMING	LPSDC3-100-E1D	100-277VAC	100	18'	6.3	0-10V	N/A	N/A	Fig. 3
DIMMING	LPSDC1-100-J1D	120VAC	100	18'	7.37	MLV	1	1	Fig. 1
DIMMING	LPSDC1-300-J1D	120VAC	3X 100[1]	3X 18'	7.37	MLV	1	1	Fig. 4
DIMMING	LPSDC1-50-J1D	120VAC	50	9'	7.37	MLV	1	1	Fig. 1
DIMMING	LPSDC2-100-J1D	277VAC	100	18'	7.37	MLV	1	1	Fig. 1
DIMMING	LPSDC2-300-J1D	277VAC	3X 100[1]	3X 18'	7.37	MLV	1	1	Fig. 4
DIMMING	LPSDC2-50-J1D	277VAC	50	9'	7.37	MLV	1	1	Fig. 1
NON-DIM	LPSDC3-100-L1N	100-277VAC	100	18'	6.3	N/A	N/A	N/A	Fig. 2
NON-DIM	LPSDC3-60-L1N	100-277VAC	60	11'	6.3	N/A	N/A	N/A	Fig. 2

1. All 3 runs must dim as one.
2. Assumes no excessive jumper lengths and driver is wired as shown in remote driver wiring diagram.
3. Power consumption values are given for a fully loaded power supply.
4. For 0-10V dimming, driver limitation is dependent on AC power switch.

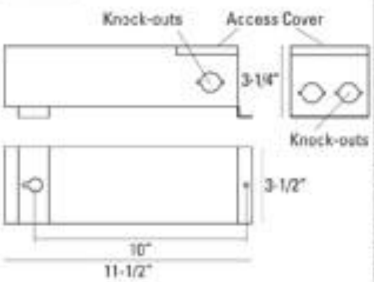
NOTES:
- Must use USAI drivers
- Do not install in wet locations.
- See table for maximum run length of drivers.
- Drivers must be installed in accordance to national and local electrical codes.
- Equipped with secondary overload protection.
- **Ordering Information on page 1.**

REMOTE DRIVER WIRING



DIMENSIONS

FIGURE 1



DIMMER COMPATIBILITY

Model	Measured Light Output
J1D - DRIVERS	
Lutron: RFD-6NA	2-100%
Lutron: GP (Hamlet) Card	8-100%
Lutron: Grafik Eye QS Main Unit	1-100%
Lutron: HW/LP-RPM-4U-120	1-100%
Lutron: HW/LP-RPM-4A-120	1-100%
Lutron: PHPM-WBX W/DVF 103P	8-100%
Lutron: N2V-600	7-100%
E1D - DRIVERS	
Crestron: CLS-EXP-DIMFLV	1-100%
Crestron: DIN-4DIMFLV4	1-100%
Crestron: GLX-DIMFLV8	1-100%
Crestron: GLXP-DIMFLV8	1-100%
Crestron: DIN-A08	1-100%
Lutron: QSN-4T16-S	2-100%
Lutron: GRX-TVI with QSG-BULK-6E120	3-99%
Lutron: DVTV/NFTV/NTFTV with PP-20	1-100%
TVM2 Module	5-100%

FIGURE 3

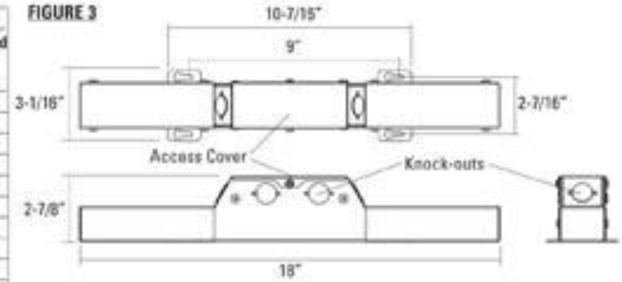


FIGURE 2

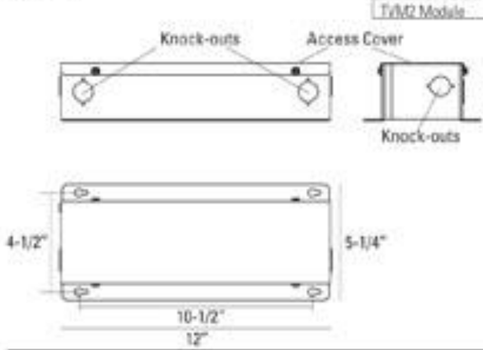
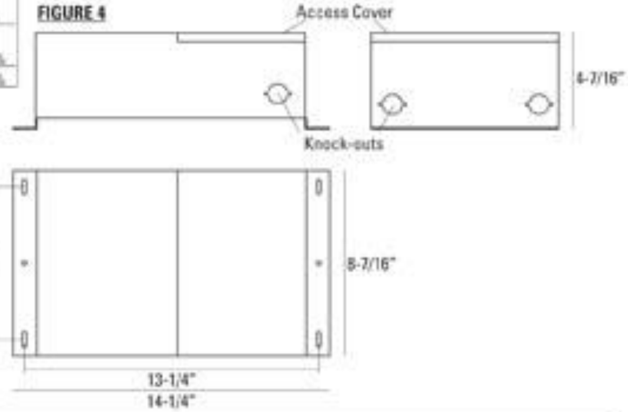


FIGURE 4



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L8

DELRAY LIGHTING INCORPORATED

MEDIA-LED.LUX

STICK MEDIA SEAMLESS LED.LUX

TYPE:

ORDER NUMBER:

PROJECT:

Model #	Voltage	LED*	LED Options*	Other Options
ST1P8	2	LOW40	BDIM-W	Select
	1–120V **2**–277V	**LOW30** **LOW35** **LOW40** **HOW30** **HOW35** **HOW40**	**BDIM-W**	**SLRD** **S100P**

**See back page for details.*

Please review mounting info before ordering.

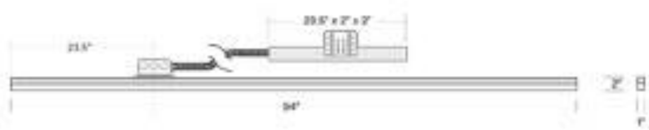
Run Length: 8'
(enter in multiples of 4 ft.)

8 ft. PENDANT
ST1P8

8 ft. PENDANT, middle
ST1PM8

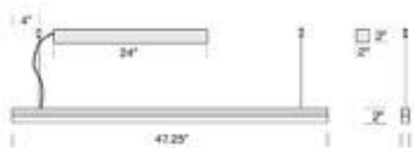
8 ft. SURFACE
ST1S8

8 ft. SURFACE, middle
ST1SM8



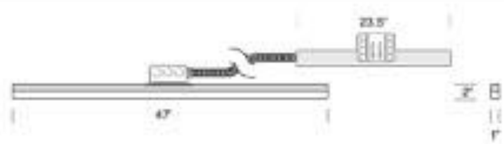
4 ft. PENDANT
ST1P4

4 ft. PENDANT, middle
ST1PM4



4 ft. SURFACE
ST1S4

4 ft. SURFACE, middle
ST1SM4



NOTE: Rail Mount available in T5 Fluorescent *Media* ONLY.

BURBANK, CALIFORNIA, 91505
WWW.DELRAYLIGHTING.COM

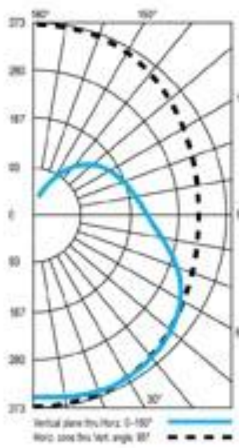
MAY 2014

L8

4' LED

ST1P4HOW40

CP DISTRIBUTION



COEFFICIENTS

% CEILING 80	(20% FLOOR)		
% WALL 70		50	30
0	112	112	112
1	99	93	88
2	89	79	71
3	80	69	60
4	73	60	51
5	67	53	44
6	61	48	38
7	57	43	34
8	53	39	30
9	49	35	27
10	46	32	24

NOTES

ST1P4HOW40
White LEDs
Total fixture lumens: 2,163
CRI: 90.0
R9 ≥ 50.0

WATTAGE

Per 4 ft. fixture.

White LED	Watts	Lumens
LO	24	1,168
HO	46.95	2,163

STICK MEDIA LUX CONSTRUCTION

INLINE PENDANT

- *Media* is a stand-alone 2, 3, 4, 6 or 8 ft. dual inline pendant fixture. Each fixture requires its own power feed.
- Aluminum extrusion, with a matte anodized finish.
- Diffuser is extruded, frosted white acrylic.
- Suspended with field-adjustable aircraft cable, with push-button glider.
- 8' gray 18 AWG power cord.
- Standard driver, constant voltage, 100W/24V, 120/277V, 50/60 Hz Class 2, in a remote housing.
- Back plate has a 7/8" opening for direct conduit feed and is not intended for J-box mount.
- cUL listed for dry locations.

LUX

Delray's *Lux* fixtures are second-generation LED luminaires that provide conventional lumen levels at less than or equal to 1.4W/FT2.

Lux features Nichia Corp. NFSL757 linear board chips, available in 6W per foot (**LO**–Low Output), or 11.2W per foot (**HO**–High Output). White color temperatures include **W30** (3000K), **W35** (3500K), and **W40** (4000K); matching the traditional CCT of existing incandescent, fluorescent, and metal halide lamps.

- CRI: 90.0
- R9 ≥ 50.0

Lux provides the best lumen/watt ratio per fixture, as well as precise color temperature matching for multiple fixtures. Standard options include dimming, for scene control and energy management.

LM-79 TEST SUMMARY - *MEDIA* ST1LP448.W41HO

Driver:	100W/24V UNV
Total Lumens:	2163.52
Input Voltage (VAC/60Hz):	120
Input Power (W):	46.95
Efficacy:	46.08
Color Rendering Index (CRI):	90.0

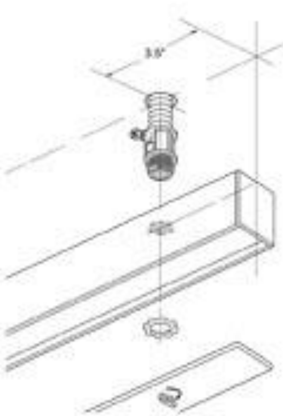
DIMMING DRIVER

BDIM-White

- For white LEDs only.
- Driver: 100W/24V constant voltage, 120/277.
- Use with 0–10V, purple/gray wire analog dimmers.

DRIVER/RAIL MOUNT INFO

Media driver and rail housings are shipped with one opening for direct connection to conduit with a third party 1/2" fitting (as shown below). To locate input power elsewhere, an alternate 7/8" opening may be drilled at the job site anywhere along the top of the aluminum rail housing.



RECESSED DRIVER

Driver must be accessible after installation. Order **SLRD**.

Max. Wiring Distance (at full load)

Wire Size (AWG)	Distance (ft.)
18	18
16	29
14	46
12	71
10	120

OPTIONAL J-BOX COVER

Cover plate mounts to maximum 4" square J-box. Driver housing mounts to wall on top of cover plate, which may be painted to match ceiling or wall, and includes two mounting spacers to offset cover thickness. Order **S100P**.

L9

Seem™ 2

LED WALL TO CEILING CORNER

FOCAL POINT®

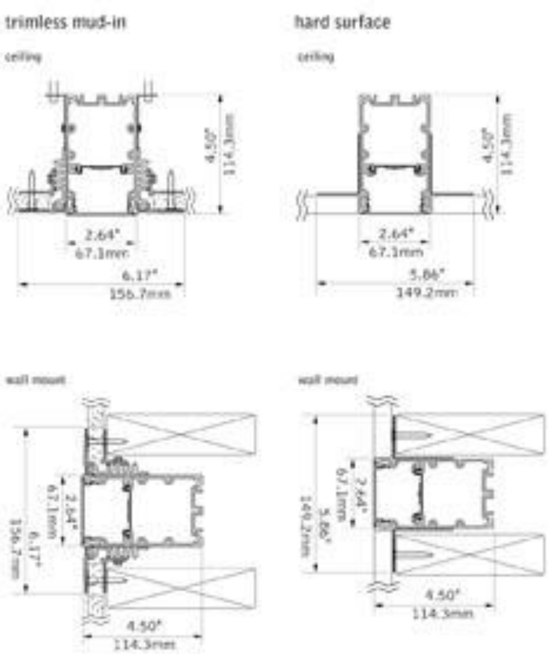
end detail

recessed

wall mount companion

suspended companion

DIMENSIONAL DATA



notes: designed for 2"x6" construction
0.375"min - 2.125"max material thickness

FEATURES

Narrow extruded aluminum 2.5" aperture recessed slot LED that transitions from wall to ceiling.

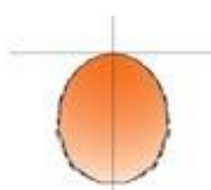
Clean and minimal trimless drywall mounting.

Continuous frosted acrylic lens provides uninterrupted illumination, without pixels or shadows.

LED position and lens material optimized to provide the perfect blend of high performance and visual comfort.

Choice of output levels to meet a wide variety of application needs.

PERFORMANCE



4' Flush Lens
Nominal output:
250 Lumens per foot

Delivered Lumens: 990lm

Total System Watts: 14W

PRODUCT OVERVIEW

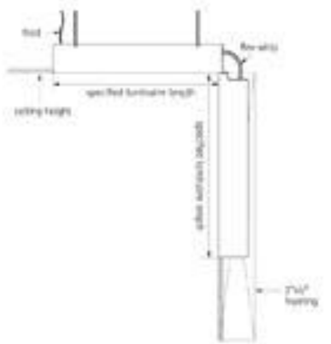
Lumen Output:	500-2476lm
Wattage:	8-38W
LPW:	63-71
SDCM:	3
Lumen Maintenance:	L70 @ 50,000hrs

Photometric performance is measured in accordance with IESNA LM-79
visit focalpointlights.com for complete photometric data.

L9

fixture: project:

MOUNTING INFORMATION



SPECIFICATIONS

LED System
Proprietary linear LED module incorporates premium LEDs on a robust platform to achieve excellent thermal management. LEDs are placed to promote a uniform appearance. Available in 3000K, 3500K, 4000K with CRI>80, 3SDCM. LED modules and drivers are replaceable from below.

Construction
One piece extruded aluminum housing. 20 Ga. steel end caps. Housing for new construction applications. XFW acceptable for use with wood, consult factory for Type IC availability. 2' unit weight: 5.1 lbs., 3' unit weight: 7.6 lbs., 4' unit weight: 10.1 lbs., 5' unit weight: 12.6 lbs.

Optic
Reflectors fabricated of 22 Ga. steel finished in High Reflectance White powder coat. Extruded acrylic lens .07" thick with satin finish.

Electrical
Luminaires are pre-wired with factory installed branch circuit wiring and over-molded quick connects. Standard 120-277V constant current driver includes 0-10V analog dimming. Power factor > .9. Emergency battery: IOTA CP-10. Emergency output - 10 watts for 90 minutes.

Labels
UL and cUL listed. Suitable for Dry or Damp Locations, indoor use only.

Finish
Polyester powder coat applied over a 5-stage pre-treatment.

Lumen Maintenance
L70 at 50,000 hours.

Warranty
LED system rated for operation in ambient environments up to 25°C. 5 year limited warranty.

PERFORMANCE CHART

Shielding	Nominal Output	Tested System Watts	Delivered Lumens
	125LF	8	500
	125LF	8	500
Flush Lens	250LF	14	990
	375LF	21	1463
	625LF	38	2476

*Based on 3500K 4' lengths. *Lumen output may vary +/- 5%. Actual wattage may vary +/- 5%.

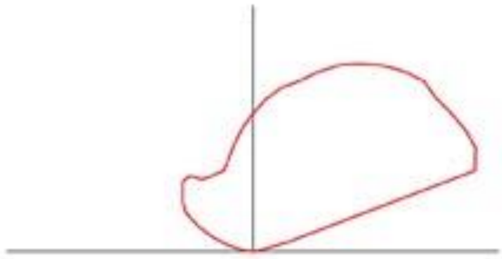
ORDERING

Luminaire Series			FSM2L
	Seem 2 LED	FSM2L	
Shielding			FL
	Flush Satin Lens	FL	
Nominal Output			125
	125 Lumens per foot (Not available with L3D driver, 4' minimum)	125LF	
	250 Lumens per foot	250LF	
	375 Lumens per foot	375LF	
	625 Lumens per foot	625LF	
Color Temperature			40k
	3000K	30K	
	3500K	35K	
	4000K	40K	
Circuit			1C
	Single Circuit	1C	
Voltage			277
	120 Volt	120	
	277 Volt	277	
	UNV Volt (Cannot be specified with EM option)	UNV	
Driver (See driver reference for driver quantities)			LD1
	0-10V - 10% Dimming	LD1	
	Lutron A-Series- Eco System (Consult factory for 3-wire control)	L3D	
	0-10V - 1% Dimming (Consult factory)		
Ceiling Configuration			
	Wall to Ceiling corner, pre-set for 1/2" Drywall	CXF1	
	Wall to Ceiling corner, pre-set for 5/8" Drywall	CXF2	
	Wall to Ceiling corner, set drywall thickness in field (Mounting equipment assembled in field)	CXFF	
	Wall to Ceiling corner, Hard Surface, Non-Drywall	CXFN	
	Wall to Ceiling corner, Wood	CXFW	
Factory Options			
	Chicago Plenum	CP	
	Emergency Circuit*	EC	
	Emergency Battery Pack* (4' lengths or longer)	EM	
	Flex Whip*	FW	
Finish			WH
	Matte White Housing	WH	
Luminaire Length			
	Specify luminaire/row length in 1' increments	X'CX'W	

L10

accoLED⁴ project type quantity

Optics



Total Lumens Delivered: 2236
Total Watts: 38
Lumens Per Watt: 58
CRI: 80+
Diode: Nichia 757
60,000+ hrs
numbers based on a 4' fixture with dust cover

suspended

Additional Integrations Selections

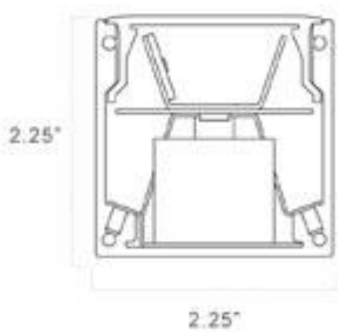
Lengths:
non-standard nominal individual lengths: 5', 6', 7', 9', 10', 11'
nominal rows longer than 24'
exact lengths to the nearest 100th of an inch

Options:
custom finish
endcap feed

Design-Assist:
in-house design-assist team manages your unique project

Mounting:
wall blocks
+
custom mounting
precise lengths
window mullion mount
full span mount
patterns
- custom angles
- precise lengths
- wall-to-wall specification
- fully tig-welded corners, sanded smooth to eliminate light leaks
- fully lit corners with mitered lenses
- seamless transitions between sections and various mounting types

Cross Section



Available Light Platforms

Available Mounting

L10

accoLED[4]

integrations

Linear Dimensions:
Standard lengths available are located on the 'elements' spec sheet. All other lengths should be specified as follows.

Nominal Row
R___: *Specify in nominal* **feet**
Choose when nominal length is acceptable.
Actual length will be shorter or longer due to metric lamp lengths. Lengths over 12' are comprised of multiple sections.

Examples: a *nominal* 54ft row begins as **ACL1R54**; a 7ft individual as **ACL1R7**.

Exact Row
M___: *Specify overall length in* **inches** *to the nearest hundredth.*
Choose when exact lengths are required as determined by space constraints, etc.
Submittals required. Lengths over 12' are comprised of multiple sections.

Examples: an *exact* 54ft row begins as **ACL1M648.00**; a 7ft individual as **ACL1M84.00**

Pattern Dimensions:
Each pattern contains a precision-formed optical platform engineered for maximum light output and even distribution.

Pattern
P___x___: *Specify overall length of each section in* **inches** *to the nearest hundredth.*
Choose when multiple angles are necessary. Submittals required: contact our design-assist team and submit architectural drawings with precise lengths and angles required.

Examples: an *exact* 54ft section angling into a 7ft section begins as **ACL1P648.00x84.00.** Continue with another "x___" for subsequent sections.

Lamping:
5yr warranty. >60,000hr LED life. Tested to LM-79 and LM-80. See wattage/lumen table for specifications per foot. All specifications are subject to change. Built with high-performance Nichia® LED's. Heat sync designed to ensure proper performance. LED boards are replaceable, built in foot-long increments. Board position/quantity to be determined by factory.

Driver:
Constant Current LED Systems:
Inherent dimming
Power Factor > 90%
90°C case rating
Inherent short-circuit protection
<20% total harmonic distortion
Extreme low-temperature performance to -40°C
Sound rating A
UL/CSA Listed Class 2 rating
IP66 rated
Universal 120-277V

Output:

LS__: LED standard output	600 lm/ft	5 watts/ft
LH__: LED high output	1200 lm/ft	10 watts/ft

Color Temp:
85CRI is standard; 90+ is available upon request. Insert a 2-digit number for color temp after the LED nomenclature.
30 = 3000 K
35 = 3500 K
40 = 4000 K
Consult factory for special order color temperatures.

Mounting:
Milled Blocks. Milled aluminum blocks are used to mount fixture to wall or window mullion. Choose 1/2" or 1" deep. ADA compliant. (2) blocks provided per fixture, lengths 8ft or less; (3) blocks per 12ft.

Standard Wall: power typically runs through back of housing and special powerfeed block into wall.

Window Mullion: Power typically runs through special endcap into adjacent wall. Choose Right or Left End Feed in Options (as viewed facing fixture on wall). Notify our design-assist team for window mullion applications - submittals may be required.

Finish:
Electrostatically applied powder coat finish.

Construction:
60% recycled aluminum extruded housing. Precision milled endcaps.

Listing:
UL/CUL. Damp or Wet Location.

Wet Label:
Specify in Options. Lens required.

Wet label standards ACL4

fixture is gasketed on endcaps with drilled weep holes

fixture is gasketed on endcaps, and all joining sections with drilled weep holes.

Family Luminaires:
accoLED1 suspended, accoLED2 suspended/wall, accoLED3 suspended/ceiling/wall, accoLED5 recessed

Companion Luminaires:
D4 wall, G4 wall, E4 wall.

L10

accoLED⁴

project type quantity

interior **exterior**

suspended

Series: ACL4

Dimension: M6

for standard lengths available: see 'elements' specification sheet

nominal length (specify length in feet)	R___
exact length (specify length in inches to the nearest 100th)	M___
pattern (specify length in inches to the nearest 100th)	P_x_

Mounting: R

standard wall mount	R
wall mount blocks 1"	M1
wall mount blocks 1/2"	M5
bottom mount	O
full span	J
custom	C

Lamping: LS

LED standard output	LS
LED high output	LH

LED Temp: 40

3000k	30
3500k	35
4000k	40

Voltage: 2

universal 120V - 277V	U
120V	1
277V	2

Distribution: N

symmetric	M
symmetric wall grazing [4]	G
asymmetric	N

Optics: D

open/no lens	O
clear dust cover	D
HTLO™ lens	H
WISP™ lens	S

Finish: T

a lightanium™	T
satin white	W
satin black	B
other - specify RAL#	O
custom	C

Options: ______

3.325" extrusion height option [5]	3
dimming - specify manufacturer, model/series and voltage	D
emergency - specify model/series or lumens [1]	E
external fusing	F
multi-circuit [2]	M
new york city code	N
natatorium application [3]	K
wet label [3]	Q
right endcap feed	R
left endcap feed	L

Legend:

1. Emergency ballast not applicable on lengths 3ft or less.
2. Multi-circuiting: submit multi-circuiting requirements during submittal process.
3. Lens is required for use in wet or natatorium locations.
4. Symmetric Wall Graze uses a single board in cross section.
5. Not available for direct wall mount. Must choose **M1**, **M5**, or **O** mounting option.

L11

Date: ______________ Type: ______________

Firm Name: ______________

Project: ______________

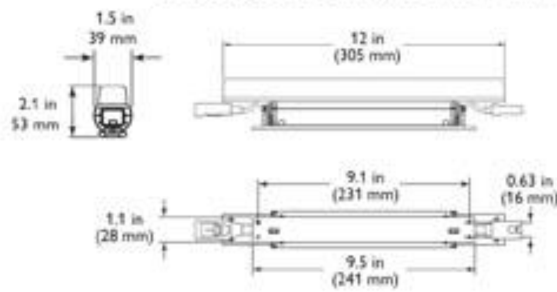
eW Fuse Powercore

1 ft (305 mm), 12.5 W / ft, 4000 K, 10° x 60° beam angle

Linear interior LED wall grazing fixture with solid white light

With narrow and medium beams of intense white light, eW Fuse Powercore is an excellent choice for a full range of surface grazing and wall-washing applications. Its ultra-compact form factor permits installation in tight spaces too small to accommodate conventional grazing fixtures. Meets or exceeds the performance of comparable linear fluorescent fixtures while lowering installation, energy, and maintenance costs. Offers environmentally-conscious buyers a green, energy-efficient grazing fixture with industry-leading light quality and quantity.

- Lower cost than comparable fluorescent grazing fixtures — With long useful source life and low-maintenance operation, eW Fuse Powercore represents a cost-effective alternative to traditional grazing fixtures.
- High-performance illumination and beam quality — eW Fuse Powercore is available in 1 ft (305 mm) and 4 ft (1.2 m) die-cast aluminum housings with a 10° x 60° or 30° x 60° beam angle. Interlocking connectors accommodate end-to-end placement without visible light scalloping between fixtures.
- Multiple color temperatures — Available in 2700 K, 3000 K, 3500 K, and 4000 K color temperatures for applications calling for warm, neutral, or cool white light
- Integrates patented Powercore technology — Powercore rapidly, efficiently, and accurately controls power directly from line voltage, eliminating the need for an external power supply. Contractor-friendly installation dramatically simplifies installation and lowers total system cost.
- Support for multiple voltages — Accepts power input of 100 – 277 VAC for consistent installation and operation from line voltage in a variety of locations.
- Dimming capability — Patented DIMand technology offers smooth dimming capability with selected commercially available reverse-phase ELV-type dimmers.
- Simple installation — Powercore integrated power management technology simplifies installation and allows long product runs. Easy-to-install 4 ft (1.2 m) mounting tracks allow quick project setup in linear applications.
- Easy mounting and positioning — With end-to-end locking power connectors that can make 180° turns, eW Fuse Powercore fixtures are easy to position in even the most challenging mounting circumstances. Fixtures rotate in 10° increments through 180° for precise aiming and color mixing. Optional mounting tracks support vertical and overhead positioning. 1 ft (305 mm) and 5 ft (1.5 m) jumper cables can add extra space between fixtures.



For detailed product information, please refer to the eW Fuse Powercore Product Guide at www.philipscolorkinetics.com/ls/essentialwhite/ewfusepc/

PHILIPS

L11

Specifications

Due to continuous improvements and innovations, specifications may change without notice.

Item	Specification	Details
Output	Lumens†	697
	Efficacy (lm / W)	58.1
	CRI	84
	Lumen Maintenance‡	50,000 hours L_{70} @ 25° C 37,000 hours L_{70} @ 50° C 90,000 hours L_{50} @ 25° C 80,000 hours L_{50} @ 50° C
Electrical	Input Voltage	100 – 277 VAC, auto-switching, 50 / 60 Hz
	Power Consumption	12.5 W maximum at full output, steady state
	Power Factor	.99 @ 120 V
Control	Dimming	Compatible with selected commercially available reverse-phase ELV-type dimmers§
Physical	Dimensions (Height x Width x Depth)	2.1 x 12 x 1.5 in (53 x 305 x 39 mm)
	Weight	0.98 lbs (.45 kg)
	Housing	Die-cast aluminium, white powder-coated finish
	Lens	Polycarbonate
	Fixture Connections	Integral male / female connectors
	Temperature Ranges	-40° – 122° F (-40° – 50° C) Operating -4° – 122° F (-20° – 50° C) Startup -40° – 176° F (-40° – 80° C) Storage
	Humidity	0 – 95%, non-condensing
	Fixture Run Lengths	To calculate fixture run lengths and total power consumption for your specific installation, download the Configuration Calculator from www.philipscolorkinetics.com/support/install_tool/
Certification and Safety	Certification	UL / cUL, FCC, Class B, CE, C-Tick, CCC
	Environment	Dry / Damp Location, IP20

* Color temperatures conform to nominal CCTs as defined in ANSI Chromaticity Standard C78.377A.

† Lumen measurement complies with IES LM-79-08 testing procedures.

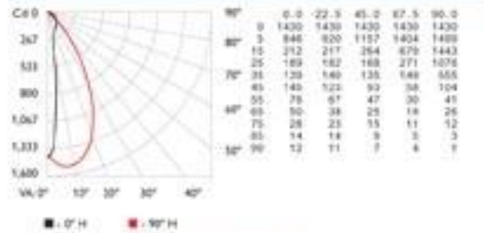
‡ L_{70} = 70% lumen maintenance (when light output drops below 70% of initial output). L_{50} = 50% lumen maintenance (when light output drops below 50% of initial output). Ambient luminaire temperatures specified. Lumen maintenance calculations are based on lifetime prediction graphs supplied by LED source manufacturers. Calculations for white-light LED fixtures are based on measurements that comply with IES LM-80-08 testing procedures. Refer to www.philipscolorkinetics.com/support/appnotes/lm-80-08.pdf for more information.

§ Refer to www.philipscolorkinetics.com/support/appnotes/ for specific details.

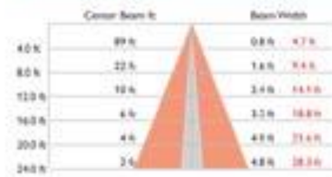
Photometrics

1 ft (305 mm), 12.5 W / ft, 4000 K, 10° x 60° beam angle

Polar Candela Distribution



Illuminance at Distance



37.8 ft (11.5 m)
1 fc maximum distance

Lumens	697
Efficacy	58.1 lm / W

For lux multiply fc by 10.7

OPTIBIN CK TECHNOLOGY | POWERCORE CK TECHNOLOGY | DIMAND CK TECHNOLOGY

Accessories

Item	Type		Item Number	Philips 12NC
Leader Cable with terminator and strain relief	UL / cUL	10 ft (3 m)	108-000047-00	910503700972
	CE / CCC	10 ft (3 m)	108-000047-01	910503700973
Wiring Compartment with terminator	UL / cUL		120-000077-01	910503700994
Jumper Cable	UL / cUL	1 ft (305 mm)	108-000048-00	910503700974
		5 ft (1.5 m)	108-000048-01	910503700975
	CE / CCC	1 ft (305 mm)	108-000048-02	910503700976
		5 ft (1.5 m)	108-000048-03	910503700977
Terminators	10 / box		120-000099-00	910503701120
Mounting Track, White	Quantity 1	4 ft (1219 mm)	120-000124-00	910503701787

Fixtures

Type	Beam Angle	Item Number	Philips 12NC
1 ft (305 mm) 2700 K	10° x 60°	523-000065-08	910503701717
	30° x 60°	523-000065-12	910503701721
1 ft (305 mm) 3000 K	10° x 60°	523-000065-09	910503701718
	30° x 60°	523-000065-13	910503701722
1 ft (305 mm) 3500 K	10° x 60°	523-000065-10	910503701719
	30° x 60°	523-000065-14	910503701723
1 ft (305 mm) 4000 K	10° x 60°	523-000065-11	910503701720
	30° x 60°	523-000065-15	910503701724
4 ft (1.2 m) 2700 K	10° x 60°	523-000065-16	910503702617
	30° x 60°	523-000065-20	910503702621
4 ft (1.2 m) 3000 K	10° x 60°	523-000065-17	910503702618
	30° x 60°	523-000065-21	910503702622
4 ft (1.2 m) 3500 K	10° x 60°	523-000065-18	910503702619
	30° x 60°	523-000065-22	910503702623
4 ft (1.2 m) 4000 K	10° x 60°	523-000065-19	910503702620
	30° x 60°	523-000065-23	910503702624

Use Item Number when ordering in North America.

PHILIPS
Philips Color Kinetics
3 Burlington Woods Drive
Burlington, Massachusetts 01803 USA
Tel 888.385.5742
Tel 617.423.9999
Fax 617.423.9998
www.philipscolorkinetics.com

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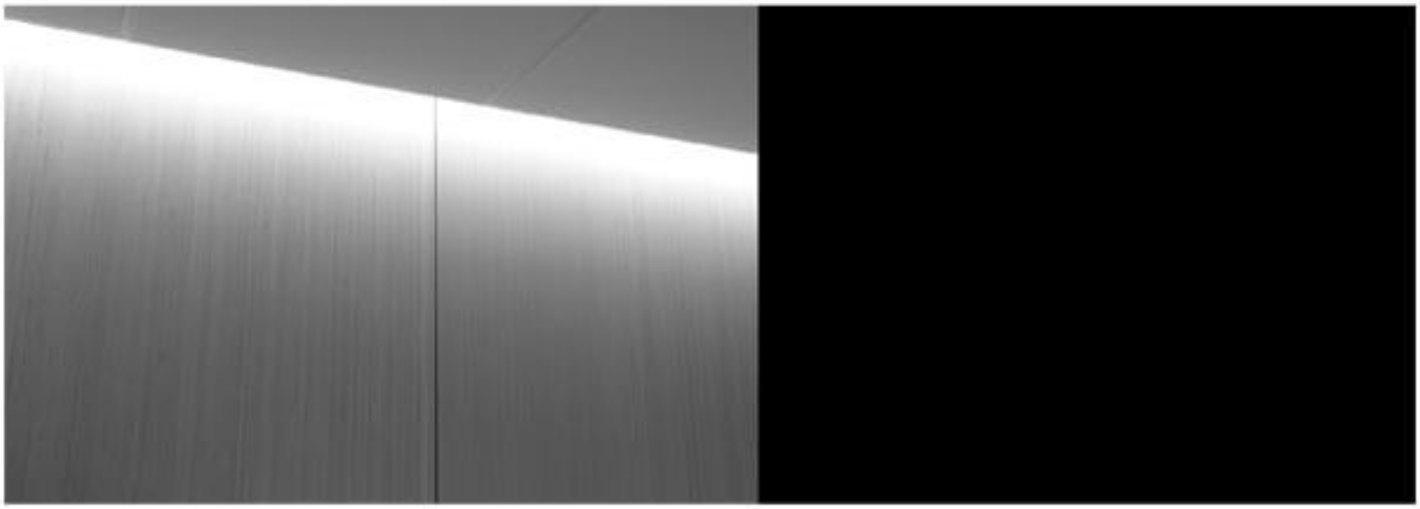
L12

Trace™

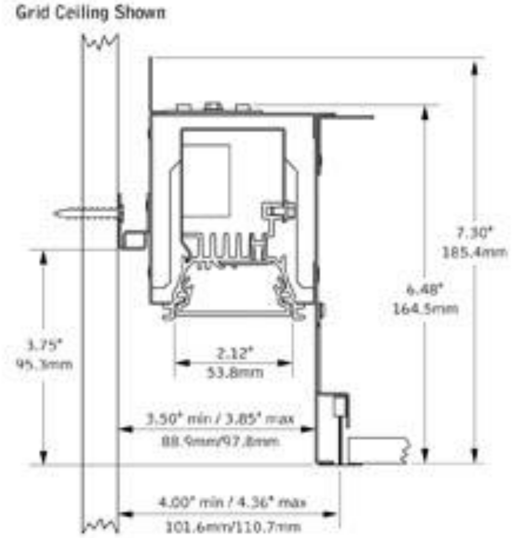
LED

FOCAL POINT



DIMENSIONAL DATA

Grid Ceiling Shown



Mounting Details

Grid
15/16" or 9/16" Flat Tee main runner required at edge.

Drywall
Ceiling mounts below housing.

FEATURES

Low wattage LED slot provides glowing transition between wall and ceiling.

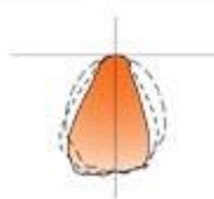
Frosted lens with linear micro prism pattern obscures visibility to LED's and provides continuous, shadow-free illumination.

Housing creates 3" architectural slot.

Premium LEDs operate efficiently on a solid-core module platform to achieve excellent thermal management and reliable operation.

L70 at 50,000 hours

PERFORMANCE



4' Luminaire

Delivered Lumens: 1207lm

Total System Watts: 22.9W

PRODUCT OVERVIEW

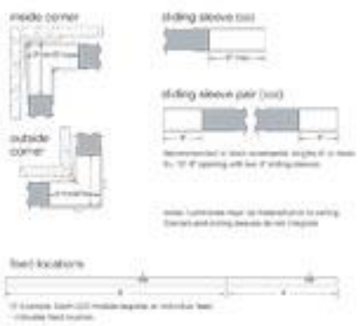
Lumen Output:	1207lm
Wattage:	23W per 4'
LPW:	53
SDCM:	3
Lumen Maintenance:	L70 @ 50,000hrs

Photometric performance is measured in accordance with IESNA LM-79. Visit focalpointlights.com for complete photometric data.

L12

fixture: project:

DETAILS



SPECIFICATIONS

LED System
Proprietary linear LED module incorporates premium LEDs on a solid-core platform to achieve excellent thermal management. Module is available in 3000K, 3500K or 4000K with CRI > 80. 0-10V dimming driver standard. LED module and driver are replaceable from below.

Construction
One piece .07" thick LED module housing of extruded aluminum. 20 Ga. steel outer housing creates floating ceiling effect and adjusts for alignment with walls. 20 Ga. steel internal bulkheads. 20 Ga. steel sliding sleeves and corners. 4' unit weight: 26 lbs.

Optic
Continuous illumination enabled by linear LED modules shielded by ribbed extruded frosted acrylic lens .06" thick with opal satin finish. Extended outer housing provides cutoff to illuminated lens.

Electrical
Standard 120-277V driver includes 0-10V analog dimming. Power factor > .9.

Labels
UL and cUL listed. Suitable for Dry or Damp Locations, indoor use only. Suitable for wood ceiling applications.

Finish
Polyester powder coat applied over a 5-stage pre-treatment.

Lumen Maintenance
L70 at 50,000 hours.

Warranty
LED system rated for operation in ambient environments up to 25°C. 5 year limited warranty.

ORDERING

Luminaire Series		FTRL
Trace	FTRL	
Shielding		AC
Frosted Acrylic Diffuser	AC	
LED System		LL1
Standard Output	LL1	
Color Temperature		35
3000K	30K	
3500K	35K	
Circuits		1C
Single Circuit	1C	
Voltage		277
120 Volt	120	
277 Volt	277	
Driver		LD1
0-10V Dimming	LD1	
Mounting		G
Grid	G	
Drywall	XF	
Factory Options		
Chicago Plenum	CP	
Emergency Circuit*	EC	
Flanged Ends	FL	
HLR/GLR Fuse	FU	
Sliding Sleeve	SS	
Sliding Sleeve Pair (2' minimum length)	SSB	
Finish		WH
Matte White Housing	WH	
Luminaire Length		4'
Specify luminaire/row length in 1' increments (2' minimum)	XX'	
Corner Options		
90-degree Inside Corner	FTRL-IC90	
90-degree Outside Corner	FTRL-OC90	

Focal Point LLC reserves the right to change specifications for product improvement without notification.

*For more information visit focalpointlights.com/reference or consult factory.

L13

SATTLER

North-American Version

SOFT QUADRA
LIGHT + ACOUSTIC

Housing: Aluminum profile, integrated acrylic cover. Fabric covering as a light and acoustic diffuser.
Design: SATTLER

	Size: L x W x H mm	inches	LED Watt	Lumen ¹	Weight kg ² / lbs ²	Item No.	LED	Dimming		Finishes	Power Supply cable	Mounting Version
Sizes	**1250 x 1250 x 80**	**49.2 x 49.2 x 3.1**	65	8.100	15 / 33.1	**802.**	x x.	x x.	x x.	x x.	x x x.	x
	1694 x 1694 x 80	**66.7 x 66.7 x 3.1**	87	10.900	17 / 37.5	**814.**	x x.	x x.	x x.	x x.	x x x.	x

LED				Item No.	LED	Dimming		Finishes	Power Supply cable	Mounting Version
LED	**Neutral-white**	**4000 K**	**(Standard)**	x x x.	**69.**	x x.	x x.	x x.	x x x.	x
	Cold-white	**5000 K**	(Optional)	x x x.	**62.**	x x.	x x.	x x.	x x x.	x
	Warm-white	**3000 K**	(Optional)	x x x.	**63.**	x x.	x x.	x x.	x x x.	x
	Extra warm-white	**2700 K**	(Optional)	x x x.	**61.**	x x.	x x.	x x.	x x x.	x
RGB	**RGB color control via dmx**		(Optional)	x x x.	**60.**	**31.**	**00.**	x x.	x x x.	x
	RGB + Neutral-White (dmx)	**4000 K**	(Optional)	x x x.	**60.**	**32.**	**69.**	x x.	x x x.	x

Combinations up to two strips of LED possible

Dimming			Item No.	LED	Dimming		Finishes	Power Supply cable	Mounting Version
	Dimmable 0 - 10 V	**(Standard)**	x x x.	x x.	**51.**	**00.**	x x.	x x x.	x
	DMX	(Optional)	x x x.	x x.	**31.**	**00.**	x x.	x x x.	x
	LUTRON (contact factory)	(Optional)	x x x.	x x.	**71.**	**00.**	x x.	x x x.	x

Finishes

(Standard): **11** white

(Optional): **22** aluminum polished; **30** anthracite; **27** brush-finished aluminum; **32** crocodile black; **33** sand silver fine textured; **35** gold; **36** brass; **37** bronze fine textured; **38** copper; **39** architectural bronze; **40** brass patinated; **42** bronze patinated; **44** wood veneer, white borders; **XX** Custom finish

Item No.	LED	Dimming		Finishes	Power Supply cable	Mounting Version
x x x.	x x.	x x.	x x.	. .	x x x.	x

Power Supply Cable

(Standard): **Z 70** Silver

(Optional): **Z 71** white; **Z 72** grey; **Z 73** black; **Z 74** orange; **Z 75** red; **Z 76** green

Item No.	LED	Dimming		Finishes	Power Supply cable	Mounting Version
x x x.	x x.	x x.	x x.	x x.	. . .	x

1) The stated lumen output of the lights is without considering the acrylic covers or reflectors
2) Weight of lights without remote technical unit or canopy

IP 20

Light distribution direct

www.sattler-lighting.com

- Custom sizes • Individual finishes
- Project-specific electrical adjustments

Conforms to UL-STD 1598
Certified to CSA-STD C22.2
No.250.0-08

26.1.15 SOFT QUADRA LIGHT + ACOUSTIC

L13

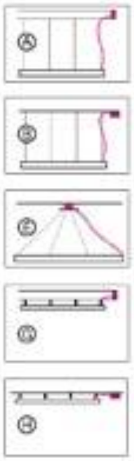
SATTLER

North-American Version

SOFT QUADRA
LIGHT + ACOUSTIC

Housing: Aluminum profile, integrated acrylic cover. Fabric covering as a light and acoustic diffuser.
Design: SATTLER

Mounting Version



Mounting		Item No.	LED	Dimming	Finishes	Power Supply cable	Mounting Version
4-point suspension with external power supply unit in suspended ceiling	**(Standard)**	X X X.	X X.	X X. X X.	X X.	X X X.	A
4-point suspension with external power supply unit in separate canopy	(Optional)	X X X.	X X.	X X. X X.	X X.	X X X.	B
suspension through canopy	(Optional)	X X X.	X X.	X X. X X.	X X.	X X X.	E
Direct ceiling mounting (white) 50mm / 1.9" with external power supply unit in suspended ceiling	(Optional)	X X X.	X X.	X X. X X.	X X.	X X X.	G
Direct ceiling mounting (white) 50mm / 1.9" with external power supply unit in separate canopy	(Optional)	X X X.	X X.	X X. X X.	X X.	X X X.	H

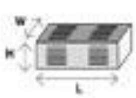
A, B, G, H = Distance of external power supply unit to light fixture max. 10m / 394".

E = Power supply unit in canopy Max. suspension height approx. 2.5 times diameter of light.

Mounting versions with steel cable length 5000mm / 197" and power supply cable silver, length 5000mm / 197"

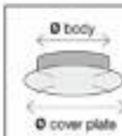
X X X.	X X.	X X. X X.	X X.	X X X.	X

Complete order number



Dimensions of external power supply units

Typ	Size mm / inch L W H	For use with Mounting Version
DE 1F	360 x 150 x 85 mm / 14.7 x 5.9 x 3.3"	**A, G**



Dimensions of canopies

Typ	Size mm / inch Ø cover plate / body	For use with Mounting Version
DB 290	Ø 290 / 260 mm / 11.4 x 10.2"	**B, E, H** (1250 mm)
DB 350	Ø 350 / 320 mm / 13.7 x 12.6"	**B, E, H** (1694 mm)

Canopy finish: white (11)
contact factory for other finishes

USA/Canada: Canopy mounts to 4" octagonal junction box.

Input voltage for all external power supply units and canopies is **120 / 277 VAC 50 / 60 Hz**

1) The stated lumen output of the lights is without considering the acrylic covers or reflectors
2) Weight of lights without remote technical unit or canopy

IP 20

Light distribution direct

www.sattler-lighting.com

- **Custom sizes + Individual finishes**
- **Project-specific electrical adjustments**

Conforms to UL STD 1598
Certified to CSA STD C22.2
No.250.0-08

26.1.15 SOFT QUADRA LIGHT + ACOUSTIC

L14A

gotham®

Luminaire Type:					
Catalog Number (autopopulated):	ICO SQ	40/30	4AR	25D	277

Gotham Architectural Downlighting
LED Downlights

4" Incito® Square

Downlight

Solid-State Lighting
(US and International Patents Pending)

FEATURES

OPTICAL SYSTEM

- Eleven preset distribution patterns allow designers to achieve various objectives.
- Self-flanged semi-specular or matte-diffuse, metal-clad lower reflector utilized in combination with a highly transmissive lens.
- Patented Bounding Ray™ Optical Principle design (U.S. Patent No. 5,800,050) provides 45° cut-off to source and source image for a smooth transition from top of the reflector to bottom.
- Field interchangeable optics.

MECHANICAL SYSTEM

- Light engine and driver are accessible from above or below ceiling.
- 16-gauge black painted steel mounting frame with C-channel mounting bars included. Post-installation adjustment possible from above or below ceiling.
- Galvanized steel junction box with hinged access covers and spring latch. Three combination 1/2"-3/4" and one 1/2" knockout for straight-through conduit runs. Capacity: 8 (4in, 4out) No. 12 AWG conductors rated for 90°C.
- Accommodates up to 1½"-thick ceilings.
- Patented adjustable aperture allows 1/4" adjustments in all directions and up to 5° of rotation allowing post-installation adjustments to ensure trim to trim alignment.

ELECTRICAL SYSTEM

- IC-rated up to 1250 lumens.
- Solid-state LED light engine available in 2700 K, 3000 K, 3500 K or 4000 K color temperatures. CRI: 83 typical.
- eldoLED SOLOdrive 0-10V driver standard with <1% dimming level.
- eldoLED SOLOdrive DALI driver available with <1% dimming level.
- eldoLED POWERdrive DMX with RDM (remote device management) available with <1% dimming level.
- Rated system life of 50,000 hours at 70% output.
- Emergency battery pack with remote test switch available.

LISTINGS

- Fixtures are CSA certified to meet US and Canadian standards; wet location, covered ceiling.

WARRANTY

- 5-year limited warranty. Complete warranty terms located at: www.acuitybrands.com/CustomerResources/Terms_and_conditions.aspx

ORDERING INFORMATION

EXAMPLE: ICO SQ 30/50 4AR 20D 120 EZB

ICO SQ	40/30		4AR		25D	277
Series	Color temperature	Nominal lumen values	Aperture/Trim color	Finish	Beam	Voltage
ICO SQ	27/ 2700 K 30/ 3000 K 35/ 3500 K 40/ 4000 K	05 500 lumens 07 750 lumens 10 1000 lumens 12 1250 lumens 15 1500 lumens 20 2000 lumens 25 2500 lumens 30 3000 lumens	4AR Clear 4PR Pewter 4WTR Wheat 4WR[2] White 4BR[1] Black	(blank) Semi-specular LD Matte diffuse	10D[2] 10° beam angle 15D 15° beam angle 20D 20° beam angle 25D 25° beam angle 30D 30° beam angle 35D 35° beam angle 40D 40° beam angle 45D 45° beam angle 55D 55° beam angle 60D 60° beam angle 65D 65° beam angle	120 277 347[3]

Driver		Options			
EZB	eldoLED SOLOdrive 0-10V dimming driver. Minimum dimming level <1%	SF	Single fuse	NPS80EZ	nLight® dimming pack controls 0-10V eldoLED drivers.
EDAB	eldoLED SOLOdrive DALI dimming driver. Minimum dimming level <1%	TRW[4]	White painted flange	NPS80EZ ER[8]	nLight® dimming pack controls 0-10V eldoLED drivers. ER controls fixtures on emergency circuit.
EDXB	eldoLED POWERdrive DMX with RDM (remote device management). Minimum dimming level <1%. Includes termination resistor.	TRBL[5]	Black painted flange	RRL_	RELOC®-ready luminaire connectors enable a simple and consistent factory installed option across all ABL luminaire brands. Refer to RRL for complete nomenclature.
		ELR[6]	Emergency battery pack with remote test switch		
		CP[7]	Chicago plenum		

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gotham®

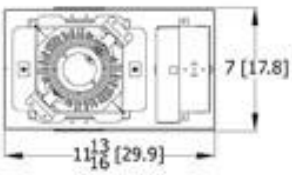
L14A

4" INCITO SQUARE
Open Reflector
Solid-State Lighting

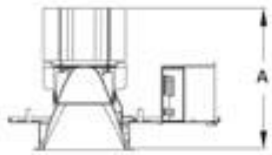
gotham

DIMENSIONAL DATA

All dimensions are inches (centimeters) unless otherwise noted.



Aperture: 4-1/2 [11.4]
Ceiling Opening: 5-1/8 [13]
Overlap Trim: 5-1/2 [14]



LUMENS	A
Up to 1000	6 [15.2]
Up to 1500	7 [17.8]
Above 1500	8 [20.3]

ELECTRICAL

WATTAGE CONSUMPTION MATRIX	
LUMENS	**WATTAGE**
500	8
750	12
1000	17
1250	18
1500	23
2000	27
2500	35
3000	42

LUMEN OUTPUT MULTIPLIER PER COLOR TEMPERATURE	
CCT	**FACTOR**
2700K	0.938
3000K	0.973
3500K	1
4000K	1.035

EL/ELR AVAILABILITY / COMPATIBILITY – Initial Lumens				
LED			Initial Lumens	
Product	Lumens	Watts	EL/ ELR	ELRHL
ICO 4"	500-3000	7-42	530	N/A

nLight® Control Accessories:
Order as separate catalog number. Visit www.sensorswitch.com/nLight for complete listing of nLight controls.

WallPod stations	Model number	Occupancy sensors	Model number
On/Off	nPODM [color]	Small motion 360°, ceiling (PIR / dual tech)	nCM 9 / nCM PDT 9
On/Off & Raise/Lower	nPODM DX [color]	Large motion 360°, ceiling (PIR / dual tech)	nCM 10 / nCM PDT 10
Graphic Touchscreen	nPOD GFX [color]	Wide view (PIR / dual tech)	nWV 16 / nWV PDT 16
Photocell controls	**Model number**	Wall Switch w/ Raise/Lower (PIR / dual tech)	nWSX LV DX / nWSX PDT LV DX
On/Off & Dimming	nCM ADCX	**Cat-5 cables (plenum rated)**	**Model number**
		10', CAT5 10FT	CAT5 10FT J1
		15', CAT5 15FT	CAT5 15FT J1

NOTES

ORDERING NOTES

1. Not available with finishes.
2. Only available 1000lm and below.
3. Not available with ELR emergency option.
4. Not required for WR reflector.
5. Not required for BR reflector.
6. Must specify 120 or 277V. Not available with 347V.
7. Above ceiling access required for use with ELR option.
8. For use with generator supply EM power. Will require an emergency hot feed and normal hot feed.

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L15

The Big Ass High Bay LED

The Big Ass High Bay LED is a high performance, high efficiency LED luminaire engineered to be the ideal fixture for your environment. Designed with long-term performance and energy efficiency in mind, the Big Ass High Bay LED is sold with a 7-year warranty.

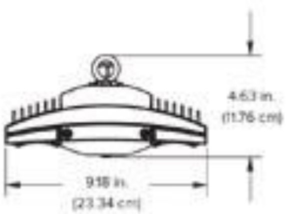
The Big Ass High Bay LED features a single piece housing of anodized, extruded aluminum which provides superior heat dissipation and impact resistance. Our patent pending lumen maintenance tray not only protects the fixture from dirt and debris, it also provides optimal light distribution.

Features and benefits

- Complete 7-year product warranty
- Patent pending lumen maintenance tray directs light from 55 to 105 degrees
- Heavy duty anodized, extruded aluminum construction
- DLC listed
- Certified by TUV SUD to UL and CSA standards
- Single piece aluminum housing for improved heat dissipation
- Energy efficient; up to 110 lumens/watt
- Most aesthetically pleasing LED product on the market
- Predicted to maintain 70% of initial output for up to 150,000 hours

L15

High Bay LED Series | TECHNICAL SPECIFICATIONS



Ordering Information

Lighting	Series	Lumen Output	Color Temperature	System Voltage	Lumen Maintenance Tray	Cord Length[1]	Mounting Hardware[2]	Controls
BAL	HBL1	20: 20,000 lm	04: 4000 K 05: 5000 K	01: 120–277 V 02: 347–480 V	00: None 01: Narrow 02: Regular 03: Wide	00: No cord 06: 6 ft (1.83 m) 10: 10 ft (3.05 m)	01: Aircraft cable, 10 ft (3.05 m) 02: Aircraft cable, 20 ft (6.10 m) 03: Pendant mount, ½ in. (12.7 mm) NPT 04: Pendant mount, ¾ in. (19.05 mm) NPT	00: None 01: Occupancy/ Photo, with dimming 03: External dimming

Note: Lead times may vary depending on options selected

Light Efficiency[3]

High Bay LED Series	Wattage	Efficacy[4]	Color Temperature	CRI
20,000 Lumen Model	194 W	108 lumens/watt	4000 K, 5000 K	73+

Note: Light output numbers reflect fixture without lumen maintenance tray

Weight	25 lb (11.34 kg)
Power Input	120–277 V; 347–480 V[5]
Dimming	0–10 V
Sensors	Optional programmable, onboard occupancy/photo sensor with wireless remote
Reliability	L70 predicted to exceed 150,000 hours at 25°C (77°F)
Environment	Suitable for dry and damp interior environments
Construction	Extruded anodized aluminum housing (single piece)
Maintenance	Zero tool access to lumen maintenance tray[6]; hinged door access to power supplies
Temperature Rating	-35 to 55°C (-31 to 131°F)
Warranty	7 year complete fixture warranty; warranty includes power supplies
Certifications	Certified by TÜV SÜD to UL 1598 and CSA C22.2 No.250.0; DLC listed

[1] Please consult manufacturer for custom cord lengths
[2] Please consult manufacturer for any pendant mounting distances in excess of 25 feet
[3] Measured at 25° C ambient
[4] Measured at 5,000 K color temperature
[5] Additional transformer required for 347–480 V; consult manufacturer for details
[6] Acrylic lumen maintenance tray may not be suitable for all industrial environments; please contact manufacturer for details

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BIG ASS LIGHT

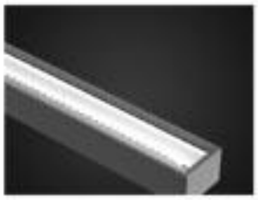
L16

D4 | accolade⁴

project type quantity

Optics

WISP™



sawtooth

Additional Integrations Selections

wall

cove

Lengths:
non-standard nominal individual lengths: 5', 6', 7', 9', 10', 11'
nominal rows longer than 24'
exact lengths to the nearest 100th of an inch

Optons:
custom finish
endcap feed
MRI configuration

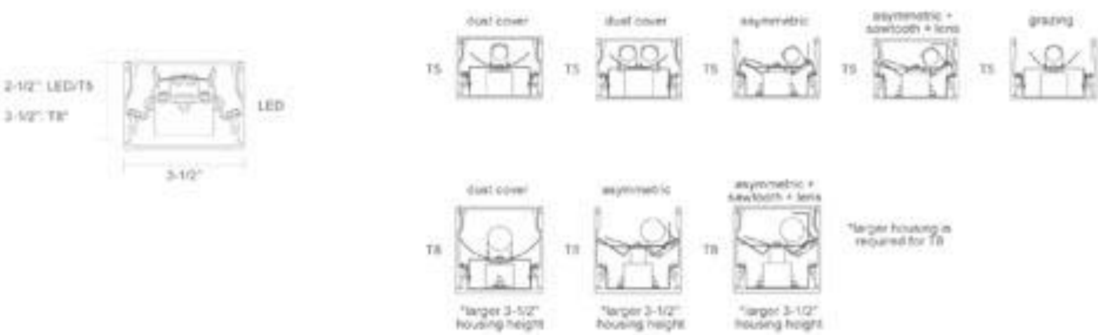
Design-Assist:
in-house design-assist team manages your unique project

Mounting:
wall blocks or set-off brackets
+

custom mounting
precise lengths
window mullion mount
full span mount
patterns
- custom angles
- precise lengths
- wall-to-wall specification
- fully tig-welded corners, sanded smooth to eliminate light leaks
- fully lit corners with mitered lenses
- staggered trays eliminate socket shadows
- seamless transitions between sections and various mounting types
- LED recommended for patterns

Cross Sections

Multiple configurations available - sampling shown



Available Light Platforms

Available Mounting

L16

D4 | accolade⁴

integrations

Linear Dimensions:
Standard lengths available are located on the 'elements' spec sheet. All other lengths should be specified as follows...

Nominal Row
R___: *Specify in nominal* ***feet***.
Choose when nominal length is acceptable.
Actual length will be shorter or longer due to metric lamp lengths. Lengths over 12' are comprised of multiple sections.

Examples: a *nominal* 54ft row begins as **D4R54**; a 7ft individual as **D4R7**.

Nominal Wet Location Run
G___: *Specify in nominal* ***feet***.
Choose when nominal length is acceptable and wet location is necessary.
Actual length will be shorter or longer due to metric lamp lengths. Lengths over 12' are comprised of multiple sections with minimal endcaps, joined via wet rated connectors (by others).
Examples: a *nominal* 54ft row begins as **D4G54**; a 7ft individual as **D4G7**.

Exact Row
M___: *Specify overall length in* ***inches*** *to the nearest hundredth.*
Choose when exact lengths are required as determined by space constraints, etc.
Submittals required. Lengths over 12' are comprised of multiple sections.

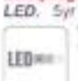
Examples: an *exact* 54ft row begins as **D4M648.00**; a 7ft individual as **D4M84.00**.

Pattern Dimensions:
Each pattern contains a precision-formed optical platform engineered for maximum light output and even distribution.

Pattern
P___x___: *Specify overall length of each section in* ***inches*** *to the nearest hundredth.*
Choose when multiple angles are necessary. Submittals required: contact our design-assist team and submit architectural drawings with precise lengths and angles required.

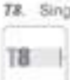
Examples: an *exact* 54ft section angling into a 7ft section begins as **D4P648.00x84.00.** Continue with another "x___" for subsequent sections.

Lamping:
LED. 5yr warranty. >60,000hr LED life. Tested to LM-79 and LM-80. See wattage/lumen table for specifications per foot. All specifications are subject to change.



T5/T5HO. Single or dual lamps in cross section or staggered single lamping. Low-profile electronic, high power factor, program start, sound rating A, inherent thermal protection, UL listed Class P, <10% THD. Dimming: specify manufacturer/model.

T8. Single or dual lamps in cross section or staggered single lamping. Low-profile electronic, choose low, standard or high power factor, instant start, sound rating A, inherent thermal protection, UL listed Class P, <10% THD. Specify if program start or custom ballast factor required. Dimming: specify manufacturer/model.



Mounting:
Standard Wall Mount. Fixture mounts directly to wall. Power connects inside fixture using BX or MX style wiring. ADA compliant.

Milled Blocks. Milled aluminum blocks are used to mount fixture to wall or window mullion. Choose 3/8", 1/2", 1" or 2" deep. ADA compliant with 3/8" or 1/2" blocks. (2) blocks provided per fixture: lengths 8ft or less; (3) blocks per 12ft.

Standard Wall: power typically runs through back of housing and special powerfeed block into wall.

Window Mullion: Power typically runs through special endcap into adjacent wall. Choose Right or Left End Feed in Options (as viewed facing fixture on wall). Notify our design-assist team for window mullion applications - submittals may be required.

Horizontal Set-Off Brackets. Fixture mounts via 1" or 1/2" set-off bracket to single gang box (by others). ADA compliant with 1/2" set-off. (2) brackets provided per length up to 12ft.

Bottom Mount. Fixture sits on cove, shelf, beam, mullion or other. Power connects inside fixture using BX or MX style wiring, typically though housing back, unless otherwise specified. Other options may include endfeed, power through bottom of housing or via powercord though top of housing, consult factory.

Full Span. Fixture spans from wall-to-wall or other object. Utilizes endfeed with sit-in brackets at each wall. Center suspension cables required for support if longer than 16'. Individual fixtures, as a single length extrusion longer than 12' up to 16', require special-order housings. Consult factory with architecture details - submittals required.

Finish:
Electrostatically applied powder coat finish.

Construction:
60% recycled aluminum extruded housing. Precision milled endcaps.
Optional MRI housing configuration is specially built with all non-ferrous materials.

Listing:
UL/CUL. Damp or Wet Location.

Companion Luminaires:
D1 suspended, D2 suspended/wall, D3 suspended/ceiling/wall, D5 recessed, D6 recessed.

Legend:
1. Emergency ballast not applicable on lengths 3ft or less.
2. Multi-circuiting: submit multi-circuiting requirements during submittal process.
3. Standard on/off occupancy sensor: Wattstopper FS-205 with minimal 1" diameter.
4. Standard occupancy sensor with photocell: Wattstopper FS-205 wired for daylight harvesting. Requires 0-10V dimming ballast.
5. T8 requires larger housing: 3-1/2"x 3-1/2".
6. Fluorescent only. Not available with staggered or dual lamping.
7. Lens is required for use in wet or natatorium locations.
8. Staggered lamping not recommended with HTLO™.
9. Staggered lamping not available on lengths less than 8ft. 8ft length uses 3-3ft lamps. 12ft uses 2-3ft and 2-4ft lamps.
10. LED configuration uses (2) boards in cross section, doubling lumen output.
11. LED or fluorescent 1 lamp in cross section. Not available with staggered or dual lamping.

L16

D4 | accolade[4]

project type quantity

interior

Series: D4

Dimension: R11

for standard lengths available see 'elements' specification sheet

damp location nominal length (specify length in feet)	R___
wet location nominal length (specify length in feet)	G___
exact length (specify length in inches to the nearest 100th)	M___
pattern (specify length in inches to the nearest 100th)	P_x_

Lamping: LH

LED standard output	LS
LED high output	LH
T5 (1)	S
T5HO (1)	H
T5 (2)	D
T5HO (2)	O
T5 staggered	2
T5HO staggered	4
T8 (1) low output	T8L
T8 (1) standard output	T8S
T8 (1) high output	T8H

LED Temp (if applicable): 40

3000k	30
3500k	35
4000k	40

Voltage: 2

universal 120V - 277V	U
120V	1
277V	2
347V	3

Distribution: N

symmetric	M
symmetric wall grazing (narrow reflector)	G
asymmetric w/ sawtooth	T
asymmetric w/o sawtooth	N

Optics: D

open/no lens	O
clear dust cover	D
a-cirrus™ lens	A
HTLO™ lens	H
WiSP™ lens	S
custom	C

Mounting: O

standard wall mount	R
wall mount blocks 1"	M1
wall mount blocks 2"	M2
wall mount blocks 3/8"	M3
wall mount blocks 1/2"	M5
horizontal setoff bracket 1"	H1
horizontal setoff bracket 1/2"	H5
bottom mount	O
full span	J
custom	C

Finish: T

a-lightanium™	T
satin white	W
satin black	B
textured eggshell white	E
other - specify RAL#	O
custom	C

Options:

dimming - specify manufacturer, model/series and voltage	D
emergency (fluorescent only) - specify model/series or lumens	E
external fusing	F
multi-circuit	M
new york city code	N
occupancy sensor	O
photocell/daylight sensor	P
natatorium application	K
wet label	Q
right endcap feed	R
left endcap feed	L
MRI housing configuration	MRI

wall

cove

LED	symmetric *2 boards in cross*		asymmetric *1 board in cross*	
per foot	watts/ft	lumens/ft	watts/ft	lumens/ft
LS	10	1200	5	600
LH	20	2400	10	1200

Lumens at board at 4000k.
Consult IES files online for delivered lumens.

Specifications subject to change.

L17

selux

Date: ________ Customer: ________

Project: Oakland University Engineering Center

Type: ________ Qty: ________

M60
LED Direct

Order Code: L60 - 1A35 - 40 - LW - F - 11 - SV - 277 - ___ - ___ - ___ - ___

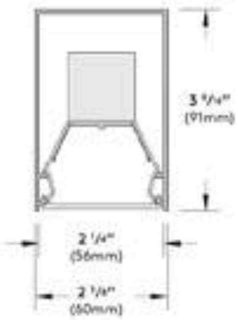
L60	Series	L60 M60 LED Direct							
1A35	Light Engine	1A35[1] 628lm/8.4W per foot	1A30[1,2] 552lm/7.2W per foot	1A25[1,2] 464lm/6.0W per foot	1A20[1,2] 376lm/4.9W per foot				[1]Values calculated from a 4' fixture @4000K using LW Shielding and standard driver. For additional information please see page 2. [2]Available starting at 2' and up
40	CCT	27 2700K	30 3000K	35 3500K	40 4000K				
LW	Shielding	LW LED Optimized white lens							
F	Mounting	C Cable	S Swivel Stem	RS Rigid Stem	W[3] Wall Mount	F[4] Surface Mount (w/Flex Whip)			[3]Consult factory for lengths under 2' [4]Over 8' supplied with 2 or more housings that are joined in the field
11	Nominal Fixture Length	01 1 ft. 02 2 ft. 03 3 ft. 04 4 ft.	05 5 ft. 06 6 ft.	07 7 ft. 08 8 ft. 09 9 ft.	10 10 ft. 11 11 ft. 12 12 ft.	XX Runs (over 12') & Configurations, round up to the nearest foot and replace the "xx" with the # (i.e. 13=13' nominal)			*Individual fixtures, Runs and Configurations are supplied in nominal lengths to ensure full, even, illumination. See pages 2 thru 6 for additional details*
SV	Finish	WH White	BK Black	SV Silver	SP Specify Premium Color	*Custom colors are available, Please consult factory*			
277	Voltage	120 120 Volt	277 277 Volt	UNV 120 thru 277 50/60hz capable					
	Fixture Options	DL[5] Damp Location Rated	FS[5] In-line Fuse	SS[5] Separate Switching					[5]See page 8 for full details and restrictions
	Dimming Options	DM[6,7] eldoLED 0-10V (Linear)	DML[6,7] eldoLED 0-10V (Logarithmic)	DMD[6,7] eldoLED DALI (Logarithmic)	DC2[6,7,8] Lutron 2 Wire	DC3[6,7] Lutron 3 Wire	DCE[6,7] Lutron Eco System		[6]See page 7 for full details [7]Not available for 1' length [8]120V only
	Emergency Options	EC[9] Emergency Circuit Wiring							[9]See page 8 for full details and restrictions
	Configuration Options	IL90[10] Lit Horizontal 90° Corner	V90[10] Lit Inverted 90° Corner	IT90[10] Lit "T" section	IX90[10] Lit "X" section				[10]See page 9 for full details and restrictions

NRTL ARRA Compliant ADA Compliant RoHS

L17

M60
LED Direct

selux



Construction:

Housing - Continuous, low copper 6063-T6 extruded aluminum profile with aluminum endcaps, available as Individual fixtures (up to 12') or Runs.

Geartray - Low copper 6063-T6 extruded aluminum profile

Shielding - Extruded, impact resistant acrylic lens:
- LED optimized white lens (LW)

Mounting(s) - 1/16" Aircraft Cable, Ø5/8" Swivel or Rigid Steel Stem, Wall Bracket, Surface mounting (see pages 3 thru 6 for details).
** Cable, Stem and Wall mountings may not be symmetrical for Runs and Configurations due to the use of modular housing lengths. If symmetrical suspensions are required please consult the factory.

Standard Luminaire lengths - All standard luminaires are supplied in nominal lengths to ensure full, even, illumination. Runs and Configurations are available in approximately 1/4" increments starting at the nominal 12' fixture length.
** Individual luminaires are not joinable in the field.

Exact length luminaires - Individual luminaires, runs, and configuration are available in exact lengths to meet your project needs. Please consult factory with your requirements.
** Lens luminance may soften at the very ends of the straight sections for exact length luminaires.

L60 Joiner(s) - Runs and configurations are supplied in multiple housing that are joined together in the field using the supplied L60 Joiner System. This allows ease of installation and ensures a uniform appearance (see page 8 for detail).

Electrical/Performance:

LED Light Engine - Brand-name mid-power LEDs create a high efficiency LED light engine able to provide a lumen maintenance of 96% at 25,000 hours and 93% at 60,000 hours per TM-21 report.

LED Life - Calculated L70 greater than 398,000 hours and Reported L70 greater than 60,000 hours @ 25°C per TM-21

Delivered Lumens - Due to LED manufacturer's tolerances the listed output has a ±5% tolerance. For outputs based on different shielding or CCT please see photometry section at the end.

CCT - Available in 2700K, 3000K, 3500K and 4000K, tolerance within a 3-step MacAdam ellipse.

CRI - Min. 80

All Drivers - High efficiency, constant current, soft start, Electronic Class 2 with a PFC>0.90. For more detailed information on the available drivers please see page 7.

Thermal Performance:

Ambient Operating Temperature - Luminaires suitable for Max. ambient temperature of 35° C (95° F) for all drivers, standard and optional.

Min. ambient temperature of:
-20°C (-4°F) for the Standard driver and optional DML and DMD drivers.
0°C (32°F) for the optional DC2, DC3 and DCE drivers.

Luminaire Finish:

Powder Coat - All Selux luminaries are finished in high quality polyester powder coating in our Tiger Drylac certified facility and are tested in accordance with test specifications for coatings from ASTM and PCI.

All products undergo a five stage intensive pretreatment process where product is thoroughly cleaned, phosphated, and sealed. Selux powder coated products provide excellent salt and humidity resistance as well as ultra violet resistance for color retention.

Standard interior colors are White (WH), Black (BK), and Silver (SV). Selux premium colors (SP) are available, please specify from your Selux color selection guide.

Warranty:

5 Year Limited LED Luminaire Warranty - Selux offers a 5 Year Limited Warranty to the original purchaser that the M60 series LED luminaire shall be free from defects in material and workmanship for up to five (5) years from date of shipment. This limited warranty covers the LED driver and LED light engine when installed according to Selux instructions and operated within the Ambient Temperature. For additional details and exclusions, see "Selux Terms and Condition of Sale."

Certifications and Compliance:

NRTL - For Dry and Damp location
(I.E. cULus; cCSAus)
ADA Compliant
ARRA Compliant
RoHS Compliant

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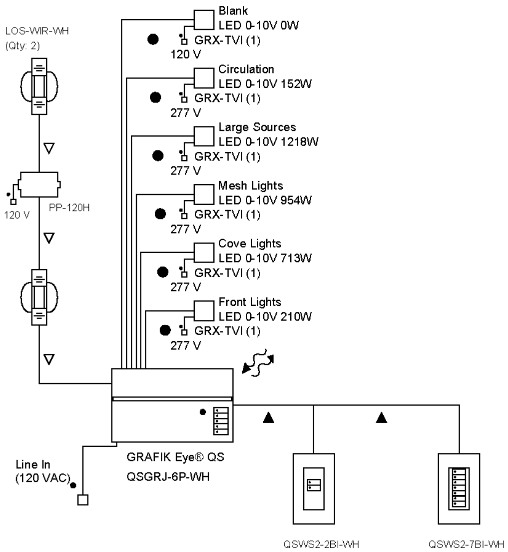
In a continuing effort to offer the best product possible, we reserve the right to change, without notice, specifications or materials that in our opinion will not alter the function of the product. Specification sheets found at www.selux.us are the most recent versions and supercede all other printed or electronic versions.

Appendix IV | Electrical Controls Sheets

GRAFIK Eye® QS	One Line Diagram



Wiring Notes:	● 2 #12 AWG (2.5 mm 2)	▼ 2 #18 AWG (1.0 mm 2)	■ 277 VAC Input Power	▲ Lutron GRX-CBL-346S or GRX-PCBL-346S
	▽ 3 #18 AWG (1.0 mm 2)	☐ 120 VAC Input Power	* Only connect 3 wires (Common, mux, mux)	

Lutron

Project Name: Oakland University Engineering Center	
Project Number:	**Page:** 1

GRAFIK Eye. QS

Bill of Materials

Description	Model Number	Qty.
GRAFIK Eye® QS Wireless Control Unit	QSGRJ-6P-WH	1
Occupancy Sensor, Infrared, 2500 sq ft, active high, 20-24 VDC, white	LOS-WIR-WH	2
Occupancy Sensor Power Pack	PP-120H	1
Power Module	GRX-TVI	6
QS 7-Button Wallstation, insert	QSWS2-7BI-WH	1
QS 2-Button Wallstation, insert	QSWS2-2BI-WH	1

Lutron

Project Name: Oakland University Engineering Center

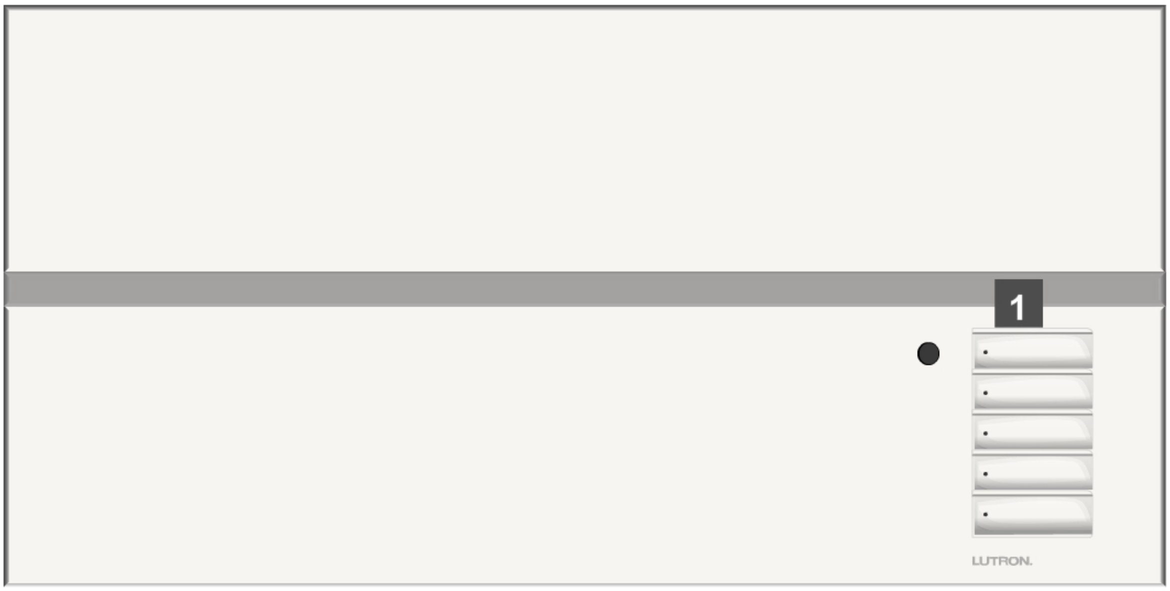
Project Number: **Page:** 2

GRAFIK Eye® QS

Button Kit Engraving Form

Project Information
Project Name: Oakland University Engineering Center
Installer Company: ______
Installer Name: ______
Phone: ______

Shipping Information
Name: ______
Company: ______
Address: ______
City: ______ State: ______ Zip: ______
Phone: ______ Fax: ______



	Type:	Model Number:	Engraving Certificate Number:	Button color:
1	Scene Control			white (WH)

Lutron Electronics Co. Inc.
Dept 309 engraving
7200 Suter Road
Coopersburg, PA 18036
www.lutron.com
Phone: 610.282.3800

LUTRON®

Project Name: Oakland University Engineering Center

Lutron Project #:

P.O.#:

Lutron Order #:

Page: 3

GRAFIK Eye. QS Load Schedule

Model Number: QSGRJ-6P-WH

Phase Control Zones

Zone	Name	Load Type	No. Fixtures	Wattage/Fixture	Total Wattage
1	Front Lights	LED 0-10V	5	42	210
2	Cove Lights	LED 0-10V	31	23	713
3	Mesh Lights	LED 0-10V	159	6	954
4	Large Sources	LED 0-10V	14	87	1218
5	Circulation	LED 0-10V	19	8	152
6	Blank	LED 0-10V	0	0	0

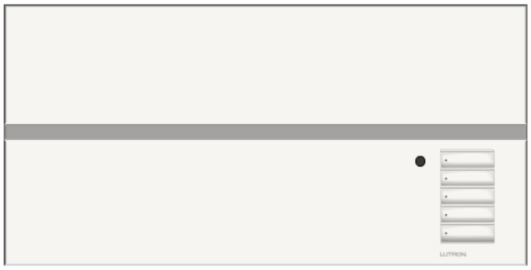
Lutron

Project Name: Oakland University Engineering Center

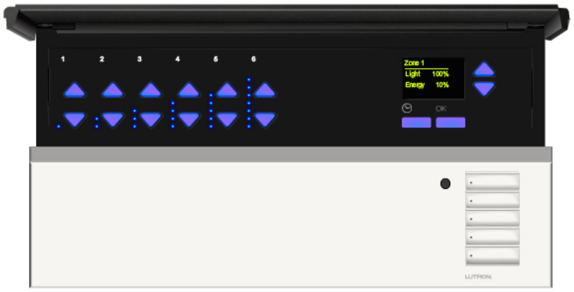
Project Number: **Page:** 4

GRAFIK Eye® QS

Preset Dimming Control



GRAFIK Eye® QS with lid closed.



GRAFIK Eye® QS with lid open.

Actual colors may vary slightly.

Light Zones:
6

Shade Groups:
0

Colors:	
Faceplate:	white (WH)
Stripe:	gray (GR)
Buttons:	white (WH)

Model Number:			
Unit:	QSGRJ-6P-WH	**Quantity:**	1

LUTRON SPECIFICATION SUBMITTAL

Project Name: Oakland University Engineering Center

Project Number: **Page:** 5

GRAFIK Eye® QS — Full-size Image

Actual colors may vary slightly.

Selected Wall Color

Benjamin Moore® Paints	**Affinity Colors:** Fusion www.myaurapaints.com	

*Actual color may differ slightly; please refer to paint chips for most accurate representation.

LUTRON

Project Name:	Oakland University Engineering Center		
Project Number:		**Page:**	6

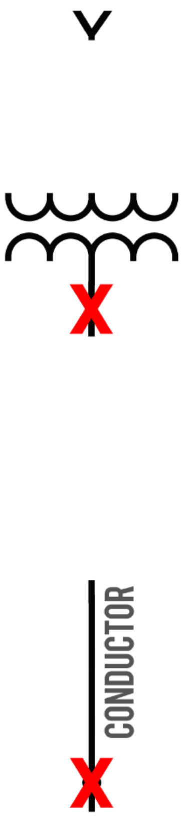
Appendix V | Cooper Bussmann FC^2 Short Circuit Calculation

COOPER Bussmann

FC² | available fault current calculator

Your System Details

Project Name: Oakland University Engineering Center
System Type: Three-Phase
Creator Name: John Conley
Creator Email: jonley8@gmail.com
Creator Company/Organization: Penn State
Creator Title/Position: Student
Creation Date: Mar 28, 2015 @ 10:31pm



INFINITE PRIMARY SOURCE	

TRANSFORMER - T1	
KVA	1,500
Voltage $_{secondary}$	480
%Z	3.50
%Z TOL	-10% (Max Fault)

FAULT - X1	
$I_{total\ s.c.\ (L-L-L)}$	57,279 AMPS
Voltage (L-L)	480 V

CONDUCTOR RUN - C1	
LENGTH	18 FT
SIZE	600
QTY (per phase)	2
TYPE	Three-Conductor Cable
CONDUIT	Steel
WIRE	Cu, 600 V

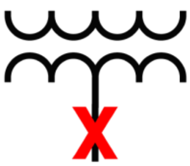
FAULT - X2	
$I_{total\ s.c.\ (L-L-L)}$	53,751 AMPS
Voltage (L-L)	480 V

COOPER Bussmann

FC² available fault current calculator

CONDUCTOR RUN - C2	
LENGTH	54 FT
SIZE	4
QTY (per phase)	1
TYPE	Three-Conductor Cable
CONDUIT	Steel
WIRE	Cu, 600 V

FAULT - X3	
$I_{total\ s.c.\ (L-L-L)}$	14,049 AMPS
Voltage (L-L)	480 V



TRANSFORMER - T2	
KVA	45
Voltage $_{secondary}$	208
%Z	1.00
%Z TOL	No Change

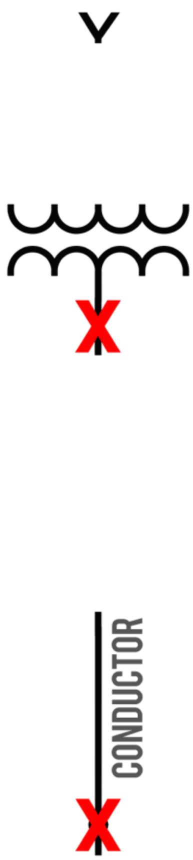
FAULT - X4	
$I_{total\ s.c.\ (L-L-L)}$	9,017 AMPS
Voltage (L-L)	208 V

CONDUCTOR RUN - C3	
LENGTH	3 FT
SIZE	12
QTY (per phase)	1
TYPE	Three-Conductor Cable
CONDUIT	Steel
WIRE	Cu, 600 V

FAULT - X5	
$I_{total\ s.c.\ (L-L-L)}$	6,462 AMPS
Voltage (L-L)	208 V

Your System Details

Project Name: Oakland University Engineering Center
System Type: Three-Phase
Creator Name: John Conley
Creator Email: jonley8@gmail.com
Creator Company/Organization: Penn State
Creator Title/Position: Student
Creation Date: Mar 28, 2015 @ 10:23pm



INFINITE PRIMARY SOURCE

TRANSFORMER - T1	
KVA	1,500
Voltage $_{secondary}$	480
%Z	3.50
%Z TOL	No Change

FAULT - X1	
$I_{total\ s.c.\ (L\text{-}L\text{-}L)}$	51,551 AMPS
Voltage (L-L)	480 V

CONDUCTOR RUN - C1	
LENGTH	18 FT
SIZE	600
QTY (per phase)	2
TYPE	Three-Conductor Cable
CONDUIT	Steel
WIRE	Cu, 600 V

FAULT - X2	
$I_{total\ s.c.\ (L\text{-}L\text{-}L)}$	48,680 AMPS
Voltage (L-L)	480 V

COOPER Bussmann

FC² | available fault current calculator

CONDUCTOR RUN - C2	
LENGTH	54 FT
SIZE	4
QTY (per phase)	1
TYPE	Three-Conductor Cable
CONDUIT	Steel
WIRE	Cu, 600 V

FAULT - X3	
$I_{total\ s.c.\ (L\text{-}L\text{-}L)}$	14,443 AMPS
Voltage (L-L)	480 V

TRANSFORMER - T2	
KVA	45
Voltage $_{secondary}$	208
%Z	1.00
%Z TOL	-10% (Max Fault)

FAULT - X4	
$I_{total\ s.c.\ (L\text{-}L\text{-}L)}$	9,799 AMPS
Voltage (L-L)	208 V

CONDUCTOR RUN - C3	
LENGTH	3 FT
SIZE	12
QTY (per phase)	1
TYPE	Three-Conductor Cable
CONDUIT	Steel
WIRE	Cu, 600 V

FAULT - X5	
$I_{total\ s.c.\ (L\text{-}L\text{-}L)}$	6,853 AMPS
Voltage (L-L)	208 V

Appendix VI | Kalwall Information

KALWALL®

high performance translucent building systems

LIGHT TRANSMISSION & SOLAR HEAT GAIN COEFFICIENT

FOR 2 ¾" (70mm) PANELS

(For 4" (100mm) Light Transmission & Solar Heat Gain Coefficent values, see Page 9.10)

FACE SHEET COMBINATION note 1,5		% LIGHT TRANSMISSION note 2					WALL SYSTEM SOLAR HEAT GAIN COEFFICIENT AT 0° note 3				
EXTERIOR COLOR	INTERIOR COLOR	0.53 "U" note 4	0.29/0.23 "U"	0.22/0.14 "U"	0.18/0.10 "U"	0.05 "U"	0.53 "U"	0.29/0.23 "U"	0.22/0.14 "U"	0.18/0.10 "U"	0.05 "U"
Greenish Blue	White	25	14	5	3	14	0.50	0.23	0.14	0.10	0.19
Aqua	White	29	17	6	4	15	0.45	0.24	0.14	0.10	0.21
Rose	White	30	18	6	4	16	0.46	0.24	0.15	0.10	0.21
Ice Blue	White	35	20	8	6	21	0.54	0.28	0.17	0.12	0.26
Greenish Blue	Crystal	37	20	7	4	NA	0.53	0.26	0.16	0.11	NA
Aqua	Crystal	43	23	7	4	NA	0.55	0.27	0.16	0.11	NA
Rose	Crystal	48	24	8	5	NA	0.57	0.28	0.17	0.12	NA
Ice Blue	Crystal	53	27	10	6	NA	0.68	0.32	0.19	0.13	NA
White	Crystal	30	18	12	8	NA	0.46	0.24	0.14	0.10	NA
White	White	20	15	8	5	14	0.38	**0.23**	**0.15**	**0.11**	**0.18**
Crystal	White	35	20	12	8	20	0.52	**0.28**	**0.17**	**0.13**	**0.25**
Crystal	Crystal	50	30	15	10	NA	0.65	**0.33**	**0.18**	**0.13**	NA
Crystal SWC	White	29	16	9	6	16	0.47	0.25	0.15	0.10	0.23
Crystal SWC	Crystal	44	22	11	8	NA	0.58	0.29	0.17	0.12	NA

1. Other combinations available.
2. Approximate values by ASTM E-972. Light transmission values over 30% not recommended for most applications.
3. At 0° incident angle. **Bold** values are NFRC Certifed, others are calculated based on tests. Shading Coefficient (SC) is equal to 1.15 times the Solar Heat Gain Coefficient (SHGC). Refer to Page 9.30 for complete NFRC System Values.
4. "U" Values determined by NFRC test method (ASTM C-1363, E-1423 and C-1199 or simulation at certified lab). Expressed as BTU/(ft²·h·°F) for aluminum grid / thermally broken grid, nominal 12" x 24". Perimeter aluminum excluded. Test temperature at 15 mph wind (6.7 m/s): 0°F (-18°C) cold side & 70°F (21°C) warm side.
5. SW, Type A, and White High Impact face sheets are similar in light transmission and solar heat gain properties.

Check with Technical Services Department for further clarification. Since this table is of a very technical nature, please consult your heating and ventilation engineer for proper interpretation.

Metric U Value Conversions									
English	0.53	0.29	0.23	0.22	0.18	0.14	0.10	0.05	Btu/(ft²·h·°F)
SI	3.01	1.65	1.31	1.25	1.02	0.79	0.57	0.28	W/(m²·K)

Kalwall®

CORPORATION P.O. Box 237, Manchester, NH

(603) 627-3861

Technical Summary

Kalwall is a composite sandwich; various combinations are possible and test data should be interpreted from this point of view. Contact us for further clarification. Listed below are the light transmissions, solar heat gain coefficients, and U-factors for some Kalwall panel face sheet combinations. Others are available. Highlighted values indicate thermally broken panels.

FACE SHEET COMBINATIONS		% LIGHT TRANSMISSION 2¾" (70 mm) thick panels note 1					SOLAR HEAT GAIN COEFFICIENT @0° ∠ note 3				
EXTERIOR COLOR	INTERIOR COLOR	0.53 "U"	0.29 /0.23 "U" note 2	0.22 /0.14 "U" note 2	0.18 /0.10 "U" note 2	0.05 "U" note 2	0.53 "U"	0.29 /0.23 "U" note 2	0.22 /0.14 "U" note 2	0.18 /0.10 "U" note 2	0.05 "U" note 2
Greenish Blue	White	25	14	5	3	12	0.50	0.23	0.14	0.10	0.19
Aqua	White	29	17	6	4	13	0.45	0.24	0.14	0.10	0.21
Rose	White	30	18	6	4	14	0.46	0.24	0.15	0.10	0.21
Ice Blue	White	35	20	8	6	18	0.54	0.28	0.17	0.12	0.26
White	White	20	15	8	5	14	0.38	0.23	0.15	0.11	0.18
Crystal	White	35	20	12	8	20	0.52	0.28	0.17	0.13	0.25
Crystal	Crystal	50	30	15	10	NA	0.65	0.33	0.18	0.13	NA

Kalwall 100

Kalwall 4" (100 mm) thick panels

NEW Kalwall 100™ Panels for even greater energy performance!

FACE SHEET COMBINATIONS		% LIGHT TRANSMISSION			SOLAR HEAT GAIN COEFFICIENT		
EXTERIOR COLOR	INTERIOR COLOR	0.55 "U"	0.15 "U"	0.08 "U"	0.55 "U"	0.15 "U"	0.08 "U"
White	White	20	12	5	0.38	0.06	NA
Crystal	White	35	14	7	0.52	0.08	0.04
Crystal	Crystal	50	17	8	0.65	0.10	0.07

U-value SI conversion: 1.0 W/m²K = 0.176 Btu/hr/ft²/°F

1. Approximate values by ASTM E-972. Light transmission values over 30% not recommended for most applications.
2. Panel U-values include grid by NFRC 100 or 102. Certified system U-values vary depending on framing.
3. Shading Coefficient (SC) is equal to 1.15 times the Solar Heat Gain Coefficient (SHGC).

NFRC CERTIFIED SYSTEMS: Kalwall systems provide the best overall U-values as low as .10 (.56 W/m²K)! With light transmission up to 20%. Includes perimeter system.

BOND STRENGTH: Panels and adhesives are tested according to the stringent requirements of "Criteria for Sandwich Panels" issued by ICC (International Code Council). ES-AC177.
Before specifying alternates, insist on actual field proof of bond integrity over a 20-year period.
Caution is urged in accepting look-alikes as equivalents.

WEIGHT: Most panels and systems weigh under 3 p.s.f. (14.65 kg/m²).

FIRE TESTS: Although some Kalwall panels contain combustible binder resins (ignition temperature greater than 800°F), they will withstand a 1200°F flame for one hour with no flame penetration; pass the Class "A" Burning Brand Test (ASTM E-108), or UL 790 listed Class A Roof system. All interior faces are CC-1 by ASTM D-635. Optional flame-spread/smoke developed ratings by UL 723 tunnel tests, including Class A. Kalwall is listed by: ICC #PFC-1705 and ATI-CCRR-0173; British Standard 476, Parts 3, 6, 7. NFPA 268 – Radiant Panel Test-Exterior Walls.

Whenever reference is made to fire tests, the numerical rating is not intended to reflect hazards presented by this or any other material under actual fire conditions.

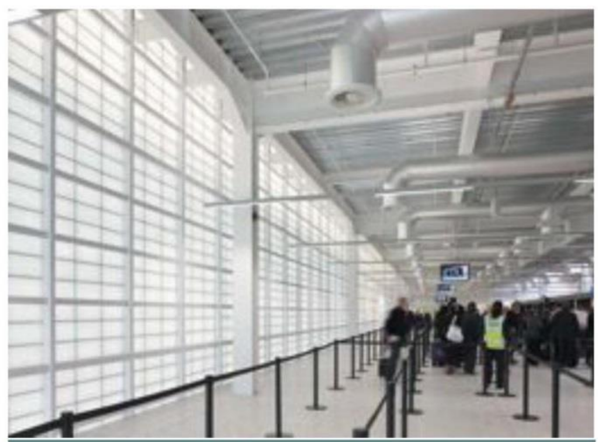
IMPACT: The shatterproof standard superweathering exterior face will withstand 70 ft.-lbs. (81J) impact. Optional extra-hi-impact faces will withstand 230 ft.-lbs. (311J) impact by UL 972; also small and large missile; resistance even higher.

Kalwall+

U = 0.05 Panel, R-20

with... Lumira aerogel

The World's Most Powerful Daylighting System!



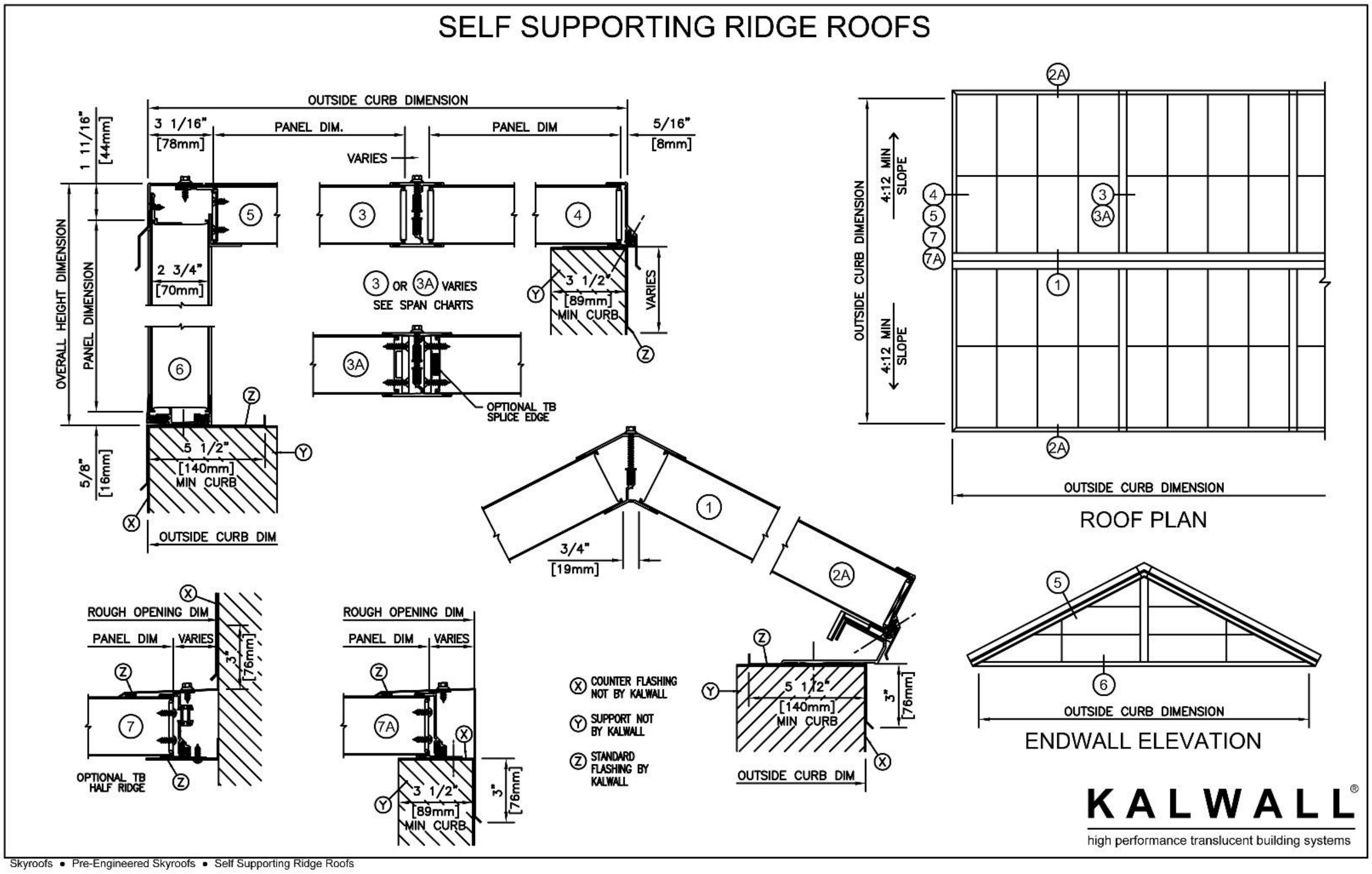
DoD and GSA ANTI-TERRORISM COMPLIANT!

UFC 4-010-01

BLAST-RESISTANT CONSTRUCTION

SPECIAL APPROVALS & LISTINGS:

- FM Explosion Venting Walls standard 4440
- FM Wall and Roof Systems standards 4881 and 4471
- Hurricane-Resistant Systems
- NFRC Certified Products Listing
- UL Listings for Class A Roof System and Faces
- UFC 4-010-01 DoD Anti-Terrorism Specifications
- ETA-07/0244 Wall Systems



Skyroofs • Pre-Engineered Skyroofs • Self Supporting Ridge Roofs

Kalwall CORPORATION Since 1955®

1111 Candia Rd
Manchester, NH 03109

Fax: 603-627-7905
Phone: 603-627-3861

MAILING ADDRESS
Post Office Box 237
Manchester, NH 03105

4/7/2015

BUDGET
Estimate #: B103-0415

Mr. John Conley
Pennsylvania State University
Architectural Engineering
University Park, PA

Project: Oakland University Engineering Center
Location: ~~Pittsburgh, PA~~
Architect: Penn.State Univ. Architectural Engineering

MATERIAL COST -- $30,700.00
Packed F.O.B. Shipping Point, Freight Prepaid.

We propose to furnish and deliver Kalwall 2 ¾" translucent panel system for:
(3) self-supported ridge skyroofs 20'-0" x 8'-0" wide OCD flat (27.25°) with hipped ends

Notes: 1) Roofs are designed for 20 PSF live load, 30 PSF snow load, 25 PSF wind load and 0 PSF drift load with L/60 deflection.
A) This estimate is not valid if loads are greater than those listed herein.
2) Curbs must be designed to withstand the thrust load from Kalwall's Roof System.
3) Price includes curb cap and flashing.
4) Price is based on using maximum number of standard 4'-0" wide modules.
5) For .14 "U" factor in lieu of .23 "U" factor, ADD ------- $825.00

All exposed aluminum to be Kalwall corrosion resistant finish color selected from Kalwall standard colors which meet performance requirements of AAMA 2604.

Thermally broken translucent panels to have .070" super-weathering Crystal exterior faces, .045" White S-171 interior faces, standard 12" x 24" shoji grid pattern and .23 "U" factor.

Curbs are not included by Kalwall.

Pricing excludes field labor, final fasteners and caulking between edge perimeter and building.
Pricing is issued in accordance with requirements transmitted through our sales representative Bruce Farber, but subject to Kalwall details and construction.
Warranty: Standard (1) year, unless otherwise indicated herein.

Terms: Net 30 from date of invoice with credit approval.
No retainage allowed.
Service charge of 1 1/2 % will
accrue and become payable on all invoices
not paid within thirty days from date of issue.

Billie Jo Quintal

Billie Jo Quintal
Estimating Manager (GS)
CC: Control, Montgomery, Farber

This Quote must be refigured after 30 days. Delivery can be scheduled only on receipt of firm order and approved drawings. This is subject to change without notice.
All shipments are F.O.B. our plant and State Sales and Use Taxes are not included. If Exemption information is not issued to Kalwall Corporation, or on file, tax will be added to our invoice.
CANCELLATIONS: In the event of Buyers Cancellation of an order, Seller reserves the right to assess cancellation fees.