BIOENGINEERING BUILDING

Eastern Region, USA

VICTORIA RIEDINGER

Lighting/Electrical

Advisor: Dr. Kevin Houser

Tech Report 1, Part 2

September 27, 2015

EXECUTIVE SUMMARY

The Bioengineering Building is a research and educational facility that contains labs, classrooms, and offices. A few grander spaces exist on the first floor and provide numerous unique design opportunities. The chosen spaces are all on the first floor of the building and connect to each other directly (highlighted in purple in the axonometric below). This will help with the flow of design from space to space and help maintain a consistent theme. Some of the chosen spaces provide opportunities to explore daylighting integration through the floor to ceiling curtain walls. Some areas will also require control systems to cater to the flexibility of the space. The four spaces are listed below and described in more detail in the following report.

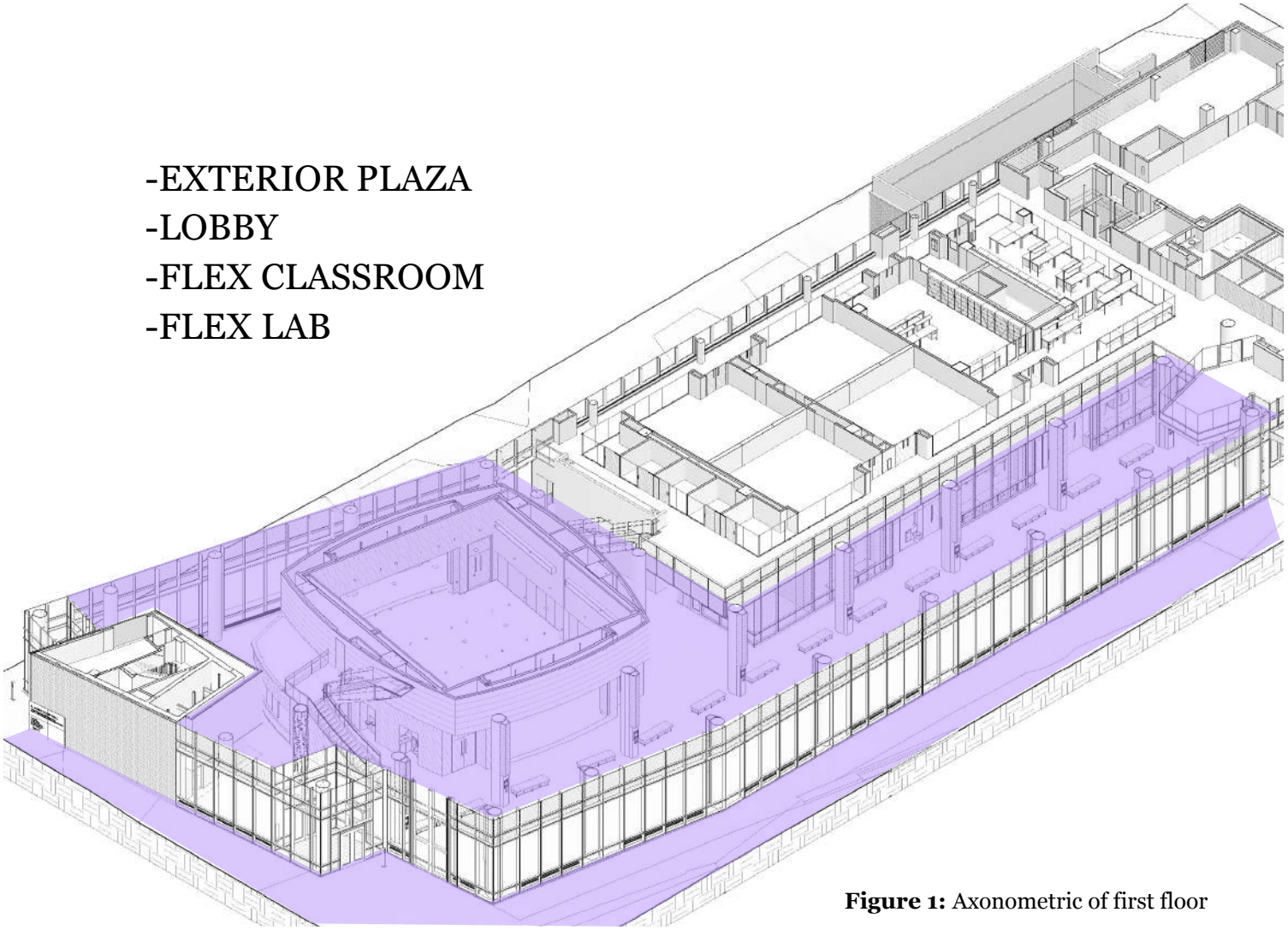

Figure 1: Axonometric of first floor

After studying the existing conditions of the Bioengineering Building, it was decided that the existing building achieved a smart design that met the needs of the occupants, but has a few areas where improvements could be made. The existing lighting in the spaces under question is mainly LED, besides a few of the exterior lighting fixtures used in the Exterior Plaza. The four spaces are directly linked to each other which allows for a high level of system integration. The flexibility of the spaces require a sophisticated controls system catering to each use. Daylighting is a main component of the Flex Lab and Lobby, and will require further evaluation of the effect the sun has on the internal work environment. Each space has a unique use, but together the space can be used for one purpose, making the flexibility of spaces a major consideration.

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BUILDING OVERVIEW

BUILDING NAME—CANNOT BE PUBLISHED

BUILDING LOCATION—CANNOT BE PUBLISHED

BUILDING OCCUPANT NAME—CANNOT BE PUBLISHED

OCCUPANCY TYPE—RESEARCH FACILITY

SIZE—183,000 GSF

FLOORS ABOVE GRADE—6

CONSTRUCTION DATES—JULY 2015-MARCH 2017

TOTAL COST—$120,000,000

PROJECT DELIVERY METHOD—DESIGN-BID-BUILD

PROJECT TEAM

OWNER—CANNOT BE PUBLISHED

GENERAL CONTRACTOR—CANNOT BE PUBLISHED

ARCHITECT

MECHANICAL ENGINEER—BALLINGER

PLUMBING ENGINEER http://www.ballinger-ae.com/

ELECTRICAL ENGINEER

LIGHTING DESIGNER—THE LIGHTING PRACTICE

http://thelightingpractice.com/

OVERALL EXISTING DESIGN STRATEGIES

The Bioengineering Building is a compelling project because of it's size and varying spaces throughout. It's primary use is for research, but the building contains offices, labs, classrooms, conference rooms, a café, and lecture halls. The diverse spaces require a careful study of criteria and codes to ensure each space satisfies lighting and requirements.

The illuminance design criteria for the existing building is consistent with the Owner's design criteria and standards, National Institutes of Health (NIH) Design Requirements Manual, and the recommendations published by the Illuminating Engineering Society of North America (IESNA) Lighting Handbook 10th Edition. Illuminance values are non-dimmed average, maintained footcandles measured on the horizontal plane at task level and 2'-6" above finished floor. The lighting power density requirements are derived from ASHRAE/IESNA Standard 90.1-2010. The individual interior spaces may exceed the listed lighting power density values as long as the total connected lighting load for the building does not exceed the total lighting allowance for the building (calculated by the Space-by-Space or Whole Building method).

LEED was a guiding factor in the design of the building and allowed the design to achieve a LEED Silver rating. Three LEED sections in particular were targeted with the design of the lighting system. The design team worked to limit light pollution for the Sustainable Sites category, optimize energy performance for the Energy & Atmosphere category, and increase the controllability of the lighting system for the Indoor Air Quality category. The selection of lighting fixtures is in accordance with The Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007.

The building was designed primarily with LED and fluorescent sources. LED fixtures were selected for durability, energy efficiency, and reduced maintenance, and required to have a CRI greater than 80. Drivers for the LED fixtures provide full range dimming from 100% to 1% light output. Lighting controls are used throughout the spaces based on function and flexibility required and include but are not limited to occupancy sensors, vacancy sensors, switches, and dimming. While designing the controls for the building, designers had to consider the hours of operation of the Bioengineering Building (shown below).

Daytime Hours: 7:00am - 10:29pm

Nightime Hours: 10:30pm - 6:59am

Weekend Hours: 10:29pm Friday - 6:59am Monday. Include Holidays

The overall design of the building required a careful attention to the tasks and occupants of each space. The varying spaces require different light levels and energy standards in order to produce a sustainable and aesthetically pleasing building. These criteria and standards will be discussed in more detail in the following report.

OVERALL FURNITURE PLAN

Figure 2: Exterior (Rendering courtesy of Ballinger)

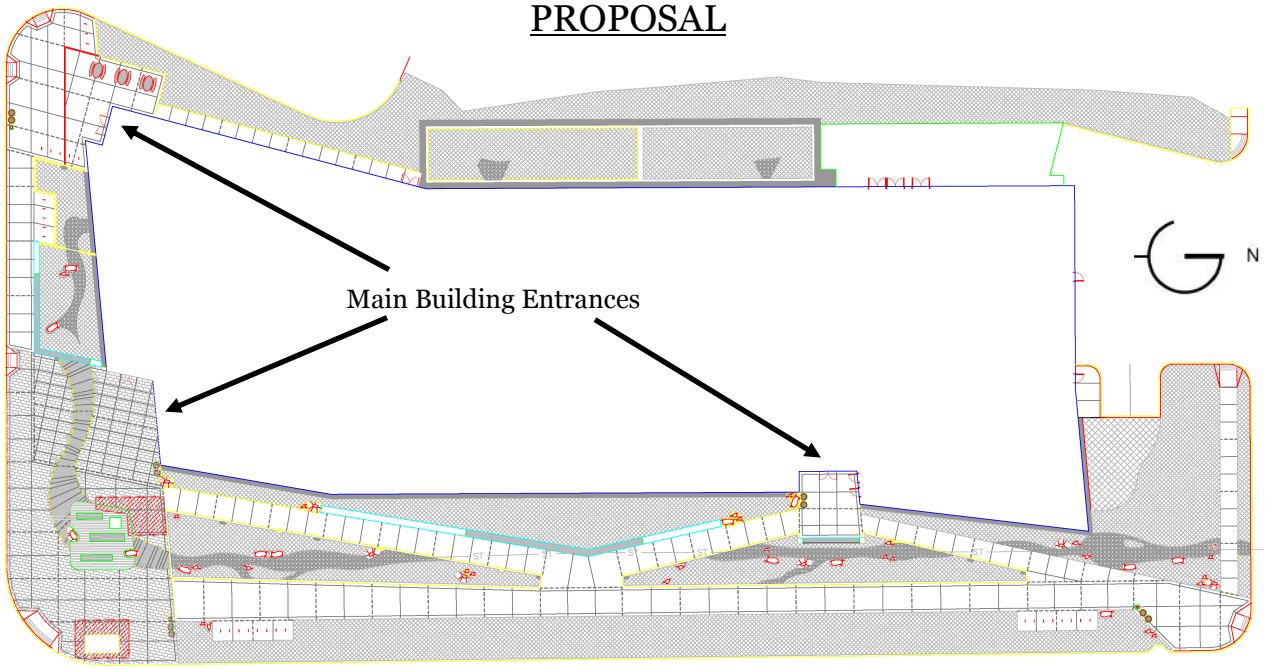


Figure 3: Site Plan

The Exterior Plaza wraps around the eastern and southern side of the Bioengineering Building and contains paths leading to all three of the main building entrances. Various paving materials mix with grasses and trees to create a landscaping fit for transition and gathering. One of the important design considerations for this space is the foot traffic from building to building. The proximity to the surrounding buildings requires a space that people can transition through simply and pleasantly. Benches along the paths make it easy for people to sit and enjoy the shade of the trees or meet up with others. When designing this space, it will be important to consider light pollution and the dark sky requirements, as well as the view from inside the building

AREA: approx. 48,000 sf

TASKS/ACTIVITIES: Transition, Group gathering & meeting place, relaxing

EXISTING CONDITIONS

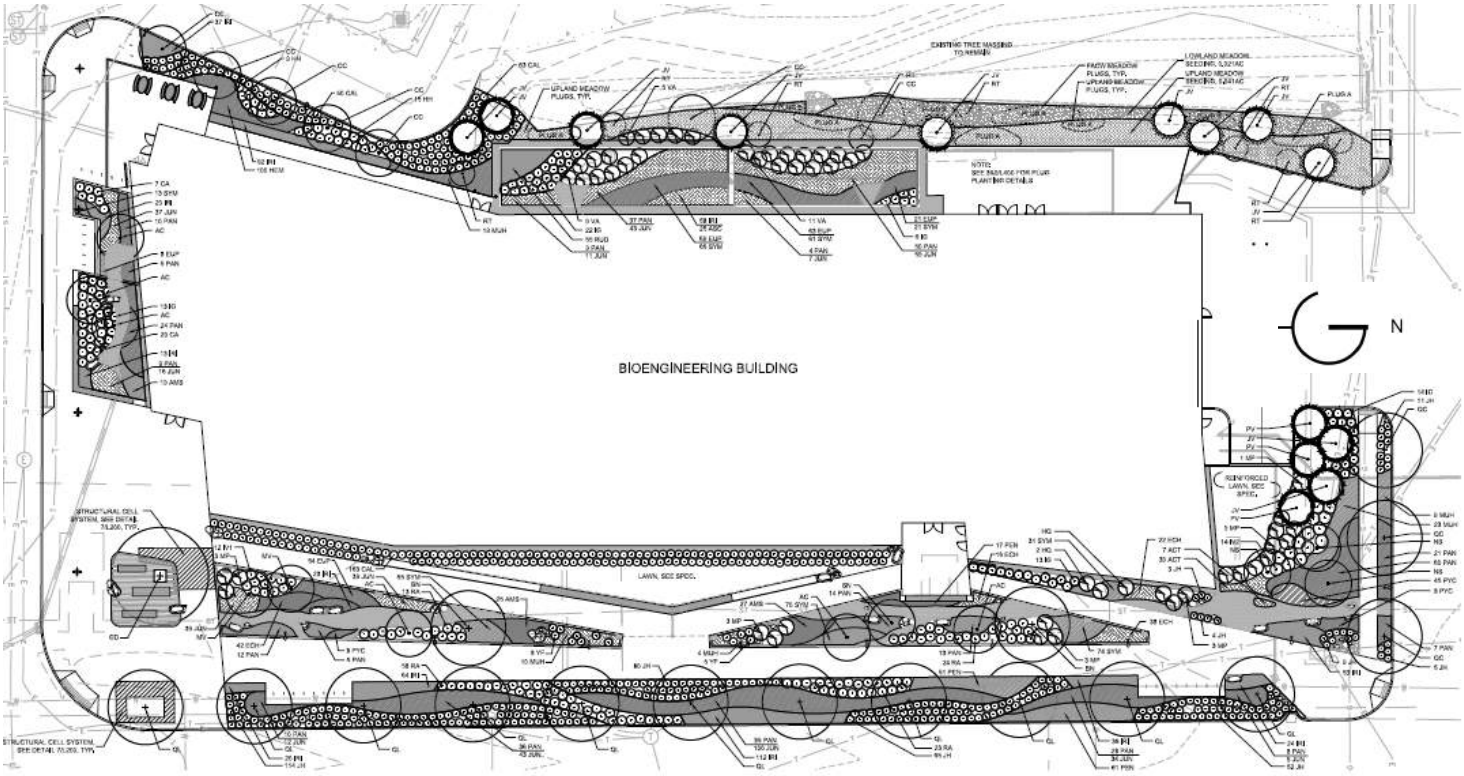


Figure 3: Planting Plan

Materials

The Exterior Plaza contains a mixture of paving and plantings that weave around the building, creating directional paths for people to travel. The landscaping contains Shade Trees, Ornamental Trees, Evergreen Trees, Shrubs, Groundcover, Ornamental Grasses, and Seed Mixes. The paving in the plaza is built mainly with concrete and concrete pavers with some beach pebble splash. The site contains boulders, benches, bike racks, dining tables and chairs, recycling receptacles.

The plaza also has a 'social table' which sits close to the main entrance to the building. This is a built up gathering spot containing benches for people to sit and relax. A section of this feature can be seen in Figure 4 below.

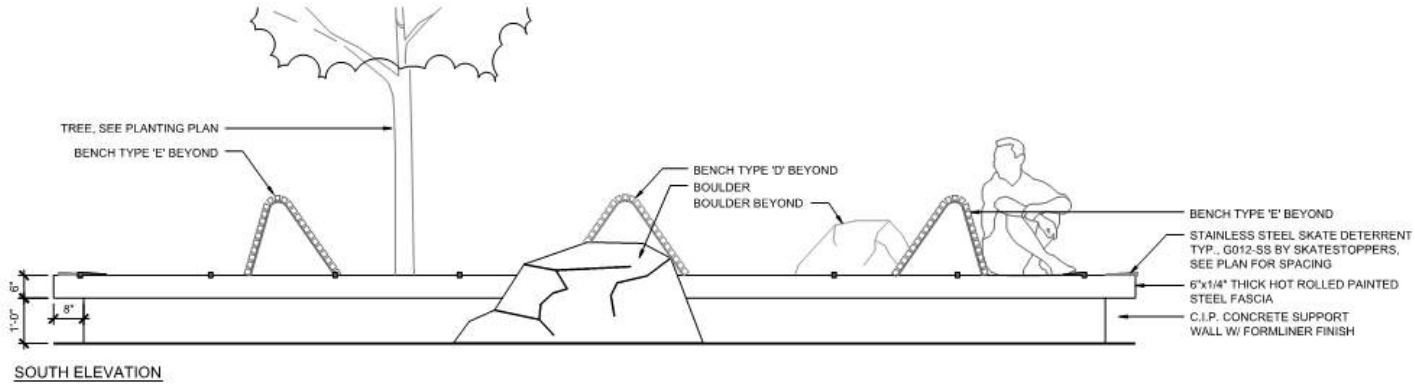
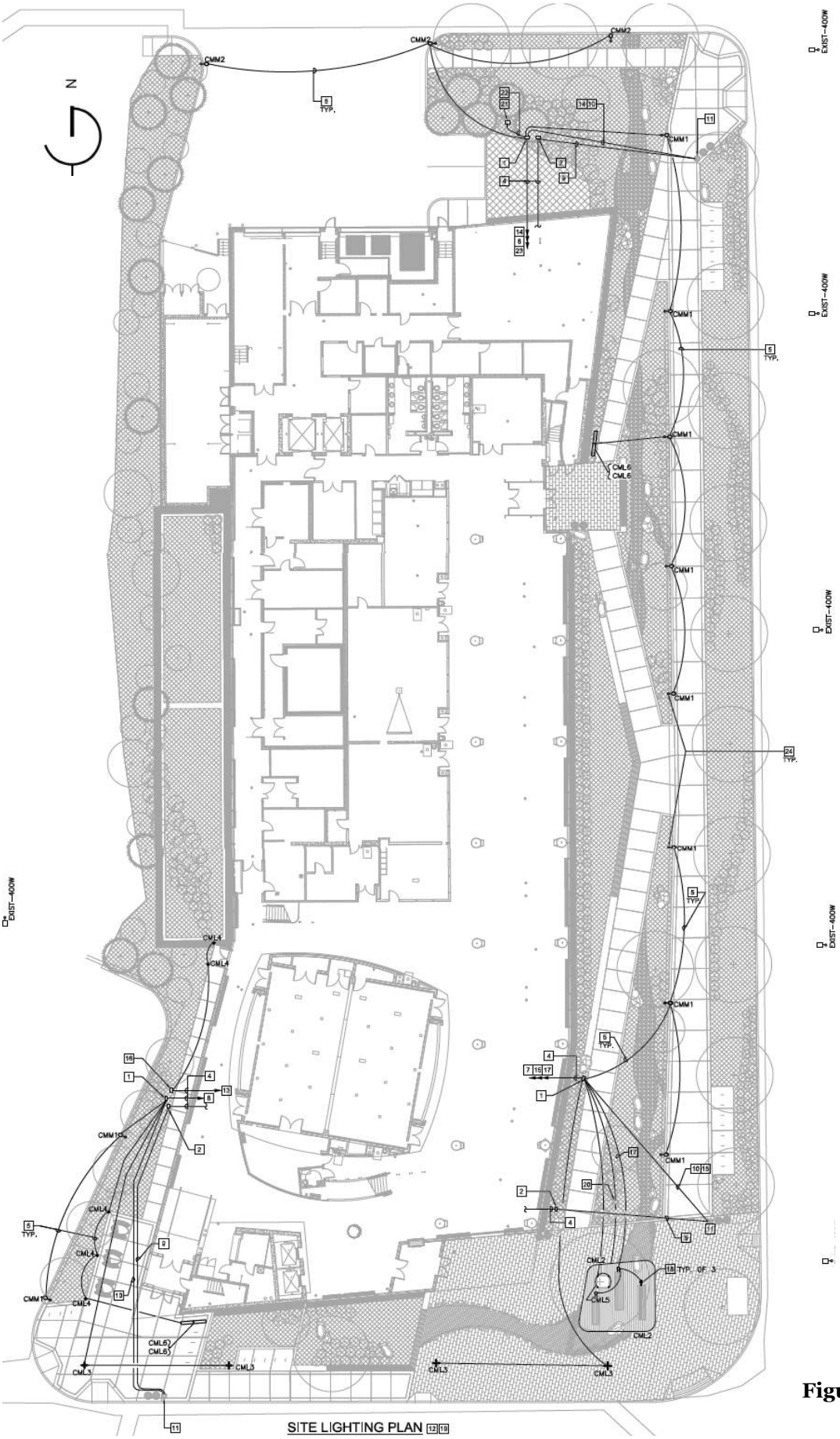


Figure 4: Social Table Elevation



Existing Lighting

The lighting in the Exterior Plaza complies with the standards set by the owner and location (to remain anonymous). Standard poles provide general illumination to the Exterior Plaza while recessed downlights at the entries and canopies illuminate the main entrances. Flexible LED tape light wraps around the Social Table and an uplight illuminates the tree on it. The site also has some Blue Light emergency phone towers for safety along with some sign lights.

Figure 5: Site Lighting Plan

OUTDOOR SPACE: EXTERIOR PLAZA

Existing Controls

The exterior lighting around the Bioengineering Building will be controlled with an astronomical time-clock along with a rooftop photocell connected to the building management system. The chart below describes the control operation.

SoO No.	Sequence of Operation (SoO) Descripton	SENSOR POWER SOURCE	Daytime (Operating Hours)	Nighttime (Off-Peak Hours)	Weekend (Off-Peak Hours)	Notes
17	Exterior Lighting and Signage	LOW VOLTAGE	OFF	ON 30 MINUTES BEFORE DUSK / OFF AT DAWN	SAME AS DAYTIME/NIGHTTIME	
20	Perimeter Lighting	LOW VOLTAGE	ON 1 HOUR BEFORE SUNSET	OFF AT 11:00 P.M.	SAME AS DAYTIME/NIGHTTIME	

DESIGN CRITERIA

Exterior Spaces	Average Illuminance (footcandles - fc)	ASHRAE/IESNA Standard 90.1 Lighting Power Density (watts/ft^2)
Walkways	0.5 (at grade)	0.2 (>=10' width) 1watt per ft of walkway length (<10' width)
Entries & Exits	1 (at grade)	30 watts per ft of door width (main entry) 20 watts per ft of door width (other entry)
Entry Canopies	4 (at grade)	0.4
Terraces	0.1 (at grade)	0.2

Table 1: Numerical criteria taken from the IES Handbook and ASHRAE 90.1

Because the Exterior plaza is an outdoor space, transition and safety are main concerns for occupants. The lighting in this space must satisfy the light levels and energy standards that will provide enough illumination for easy transition and visual acuity during the evening and night hours. The goal of the design of the Plaza will be to compliment the architecture of the building without throwing too much light on the façade. Because the façade is mostly curtain wall, light will spill out into the plaza. While over lighting is a concern, applying light to the transition areas and entryways will be necessary. Because people will be traveling from building to building, light focused on the pathways will help direct them. The space should also feel comfortable enough for people to stop and sit on the benches or gather in groups.

EVALUATION

Most of the overall illumination in the Exterior Plaza seems to come from pole mounted fixtures. Minimal lighting was placed at ground level and most was placed around the building entryways. This helps to emphasize the points of entry into the Bioengineering Building. Although the pole lighting provides overall illumination to the site, the pathways on the east side of the building aren't really highlighted. One of the main design considerations for this space is the proximity to surrounding buildings and the ease of transition and circulation between them. Pole lighting doesn't specifically call out those points of transition between buildings. The poles also reach 15, 20, and 30 feet tall which block some of the building façade. Because the majority of the building façade is a curtain wall system, the lighting in the plaza may be better served closer to the ground, allowing the building to glow.

CIRCULATION SPACE: LOBBY

Figure 6: Lobby (Rendering courtesy of Ballinger)

PROPOSAL

Figure 7: First Floor Plan section w/ Lobby

The two story lobby of the building serves as the main showpiece and centers around the grand staircase. People will enter into the building mainly through this lobby and transition through the building. Curtain walls surround the space on every side which makes daylighting a useful study for this design. The Flex Lab on the eastern side of the building opens directly into the lobby. This is an important consideration when designing this space because the relationship between each lighting scheme has to be coherent. A café is located by the elevator core at the southern end of the lobby. This also provides an opportunity to connect the interior lighting to the café seating on the exterior of the building. The design of the lobby will be developed through three schematic design concepts.

AREA: approx. 2,929 sf
HEIGHT: 26’ 3”

TASKS/ACTIVITIES: Circulation, Wayfinding, Event space, Group gatherings, Transition into Flex Lab, Showpiece for building

CIRCULATION SPACE: LOBBY

EXISTING CONDITIONS

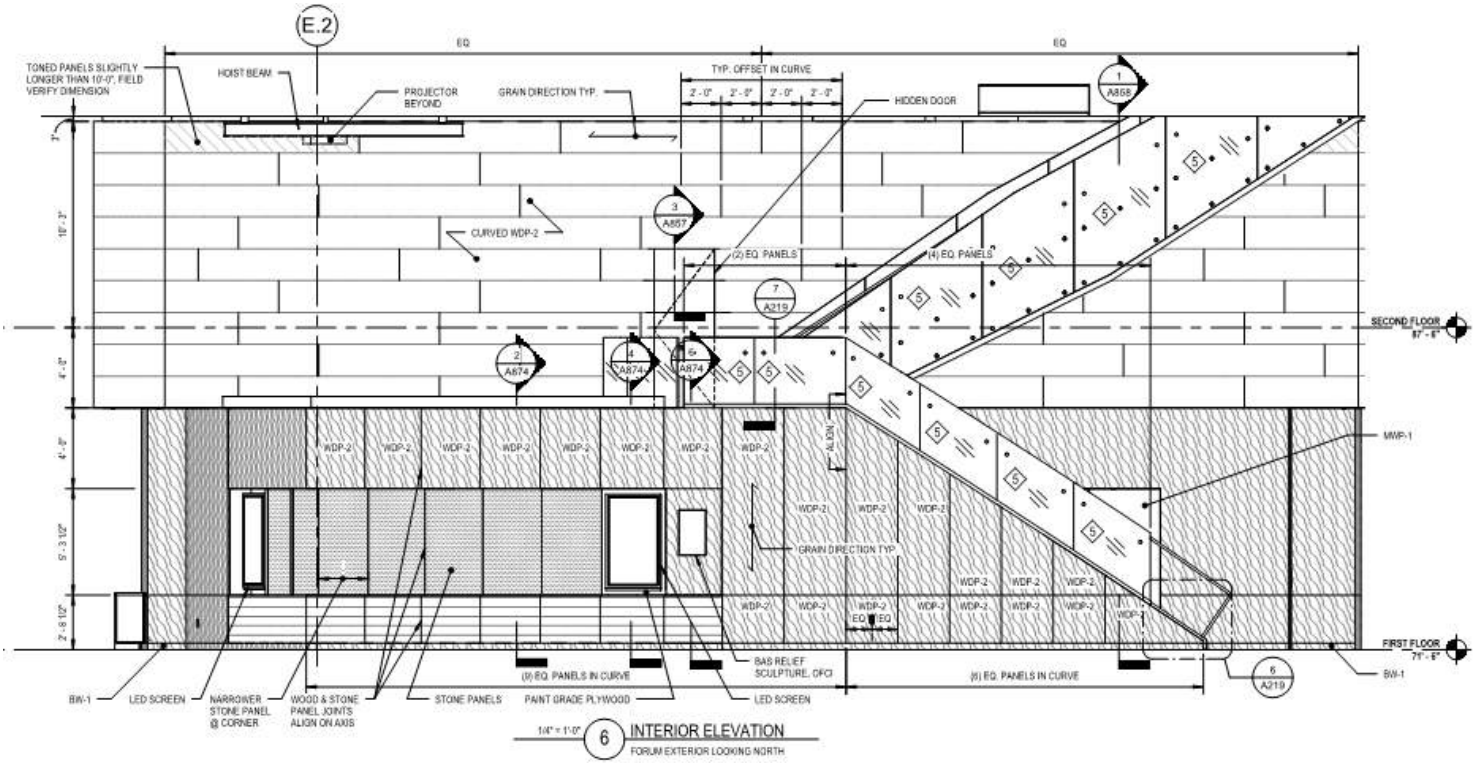


Figure 8: Staircase core in the center of Lobby

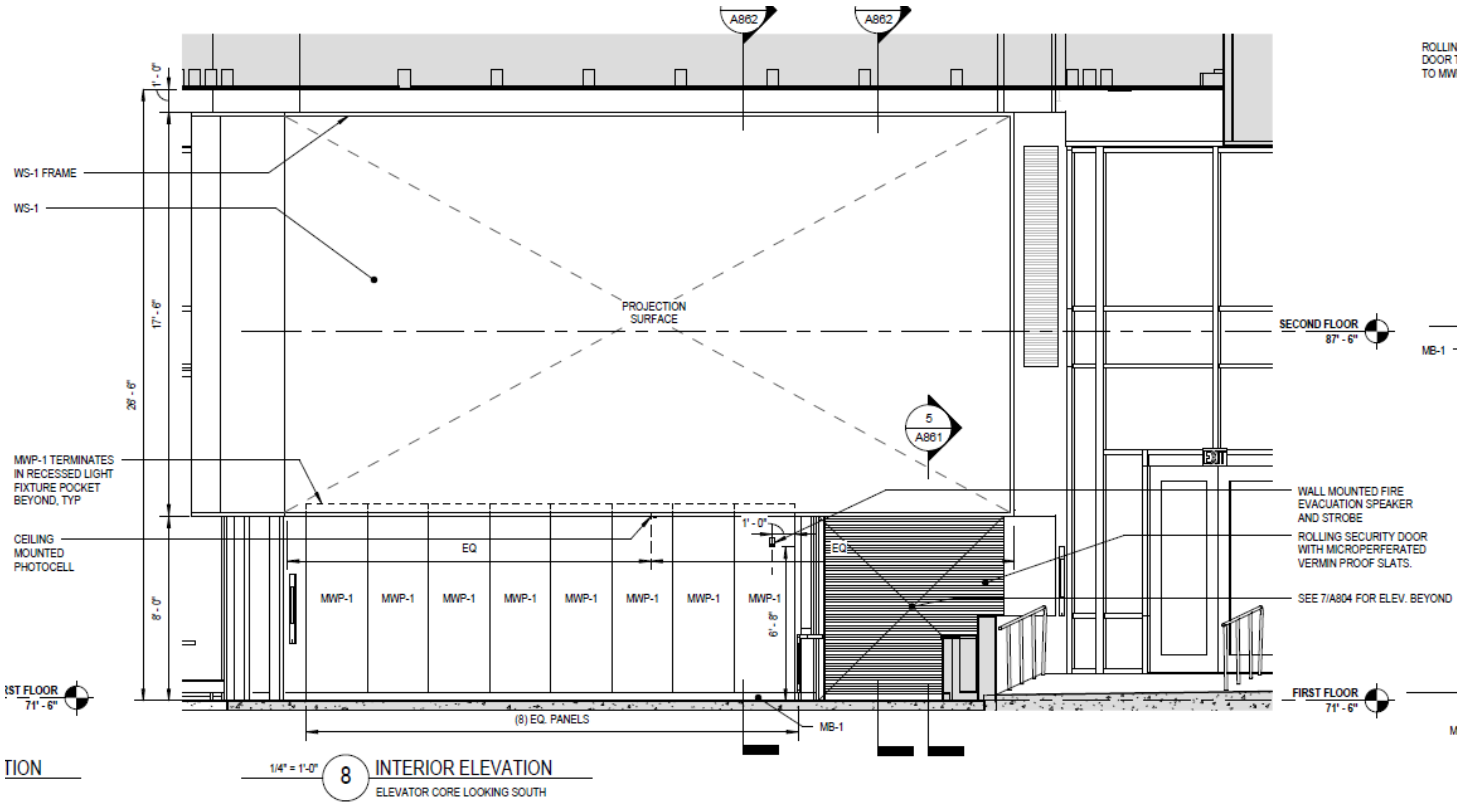


Figure 9: Elevator core at southern end of Lobby

Materials

The lobby of the Bioengineering Building has many different material types that make up the design of the large public space. The floor is made of sealed concrete. Wood panels, metal wall panels, gypsum wall board, and acoustical wall panels make up the wall design throughout the whole space. The stairway core is wrapped in the wood panels and micro-perforated acoustical metal wall panels as shown in the elevation on the previous page. A few LED screens sit in carved stone panels on the stairway core (shown in Figure 8 on the previous page). Glass panels line the stairs and serve as the railings for the grand staircase. The ceiling of the lobby is made of gypsum wallboard and acoustical ceiling panels. The elevator core at the south end of the lobby (shown in Figure 9 on the previous page) is lined on the bottom with metal wall panels, while large projection screens surround the top of the core.

Location	Material	Product	Manufacturer	Color	Reflectance
Floor	Sealed Concrete				.5
Wall	Wood Panel	Maple Wood on MDF			.4
	Acoustical Wall Panels	Maple Wood			.3
	Metal Wall Panel (2)				.7
	Metal Wall Panel (1)				.7
	Gypsum Wall Board 2				.85
	Stone Panels				.24
	Paint	Scuffmaster	Wolf Gordon	GOH 09796259	.74
	Paint	Harmony Series	Sherwin Williams	SW7018 Dovetail	.8
Base	Wood Base, Maple Stained				.4
	Rubber Base	Pinnacl Type TS	Roppe	178 Pewter	.1
	Metal Base				.7
Ceiling	Gypsum Wallboard 1				.85
	Gypsum Wallboard 2				.85
	Acoustical Ceiling Panel	Fiberglass		White	.3

Daylighting Properties

The west side of the lobby is lined with curtain wall system 4 (shown in section in the figure to the right) that runs along the west side of the building. The system is made of insulated glazing with mechanically retained horizontal joints, structurally glazed vertical joints, and 10.5" deep mullions with steel reinforcing. Low-E 1" insulating clear glass along with 1" thick fritted glass is used in the curtain wall system. An automated horizontal sunshade system is also used along the curtain wall to control direct sunlight.

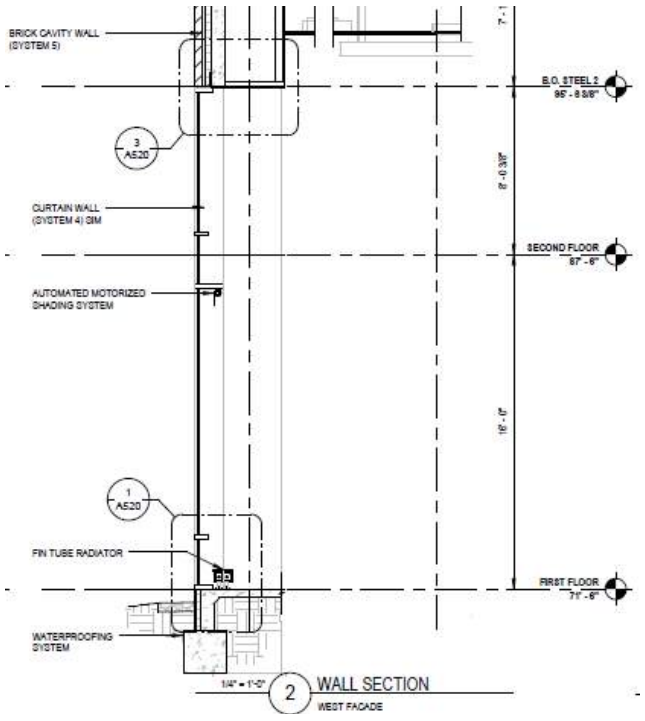


Figure 10: West Façade Curtain Wall Section

Existing Lighting

The lighting in the lobby consists of all LED fixtures that are designed to highlight various aspects of the space. Recessed wallwashers surround the staircase core to wash the wood wall panels with light. The wallwashers also circle the column in the entryway of the lobby. Color changing wall washers light the elevator core on the south side of the lobby while recessed downlights are scattered around the lobby to provide general illumination. The lighting design of this space considered the direct connection to the flex lab on the east side of the lobby. Because the flex lab doesn't have a wall on its west side, both the lab and the lobby lighting needed to compliment each other. Some of the downlights provide emergency lighting throughout the space. (See appendix for luminaire schedule)

Figure 11: First Floor Lighting Plan (with Lobby highlighted)

Existing Controls

Occupancy sensors are used in the space along with an automatic time clock by the building management system. The chart below describes the control operation.

SoO No.	Sequence of Operation (SoO) Descripton	SENSOR POWER SOURCE	Daytime (Operating Hours)	Nighttime (Off-Peak Hours)	Weekend (Off-Peak Hours)	Notes
1	Lobby	LOW VOLTAGE	SCHEDULED CENTRALLY CONTROLLED. AUTO-DIM TO NIGHTTIME LEVEL AT END OF DAYTIME HOURS, WITH MANUAL OVERRIDE	SCHEDULED CENTRALLY CONTROLLED. AUTO-RAISE TO DAYTIME LEVEL AT END OF NIGHTTIME HOURS, WITH MANUAL OVERRIDE	SAME AS NIGHTTIME	EMERGENCY FAIL-ON TO 100%

CIRCULATION SPACE: LOBBY

DESIGN CRITERIA

Interior Spaces	Average Illuminance (footcandles - fc)	Lighting Power Density (watts/ft^2)*
Atrium	20-30	1.36
Classrooms	40-50	1.24
Circulation	5-8 (at finished floor)	0.66
Collaboration Zone	30	1.24

Table 2: Numerical criteria taken from the IES Handbook and ASHRAE 90.1

The large lobby is the first thing people will see when they enter the Bioengineering Building. It serves as a transition space as well as a place for people to congregate and learn. Within the lobby there are a variety of spaces that can be classified as their own entity. The main atrium, the hallways on either side of the Flex Classroom, and the collaboration zone on the north side of the lobby will each require different illuminance levels (shown in Table 2 above). The café on the west side of the lobby will also need to be considered when designing the lighting in this space.

Because it's a double story lobby, the occupant should feel like they're walking into a grand and welcoming entry. The lighting should also help direct people toward their intended destination within the building. The carved stone wall, large column, and grand stairway are important points of interest in the space that require specific lighting to convey the information they're advertising. The LED screens on the walls need to be considered for glare, while the carved stone wall right next to them needs be illuminated enough for visitors to read. One of the main criteria for this space is the relationship to the surrounding rooms. From the exterior, the lobby is extremely visible and it also opens directly to the Flex Lab, which is a showpiece for the building. Minimal spill light should leave the lobby and fixtures should compliment the style and performance of the ones used in the lab. Controls may also be a criteria for this space if the design lends itself to the use of color-changing fixtures. These criteria will be explored through three design ideas.

EVALUATION

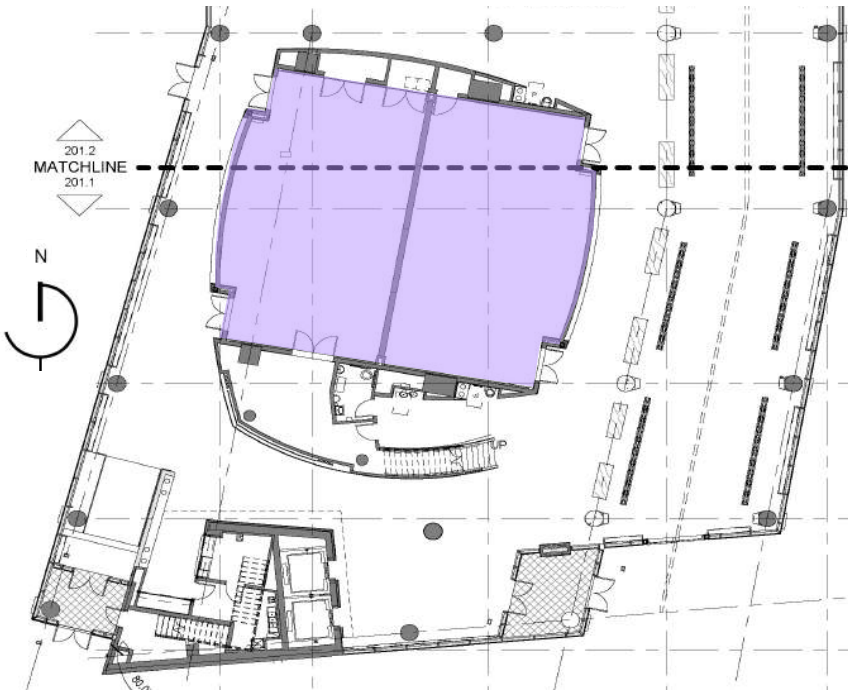
Because of the openness of the lobby, it had to be designed to compliment the surrounding spaces. A few features of the space include the elevator core, the column in the main entry, and the main stairway core. These elements are all highlighted with wallwashers, making them focal points of the space. These architectural features allow for this accent lighting, while the rest of the space is filled in with general illumination from downlights. The accent lighting highlights the various materials of the space such as the wood walls, the carved stone, and the media walls. This design compliments the purpose of the lobby by drawing focus to the various points of interest to visitors. Whether they want to use the elevators, stairs, or read the advertisements and announcements, the lighting helps direct them to where they may want to go.

Using wallwashers on the east side of the stairway core directs light away from the open flex lab. This helps minimize light spill that may affect people working in that space. The direct relationship between those two spaces is key for a successful design. The color-changing LED wallwashers lighting the top of the elevator core add a creative touch to the space that compliments the use of the building.

Figure 12: Flex Classroom (Rendering courtesy of Ballinger)

PROPOSAL

The Flex Classroom is a multipurpose space that can be used for lectures, large speaking events, classroom instruction, as well as formal events and banquets. It can be split into one, two, or four spaces according to need. The east and west walls of the room can also be opened up into the lobby space, making it fit for large events. Because the space has so many functions, it's very important to make the design flexible. Controls will be a major part of the design in order to create scenes needed for each task. This space will be designed according to one of the psychological impressions because of the contrasting uses of the space.



AREA: 2,760 sf
HEIGHT: 20' 9"

TASKS/ACTIVITES: Lectures, Meetings, Banquets, Group gatherings

Figure 13: First Floor Plan section w/ Flex Classroom

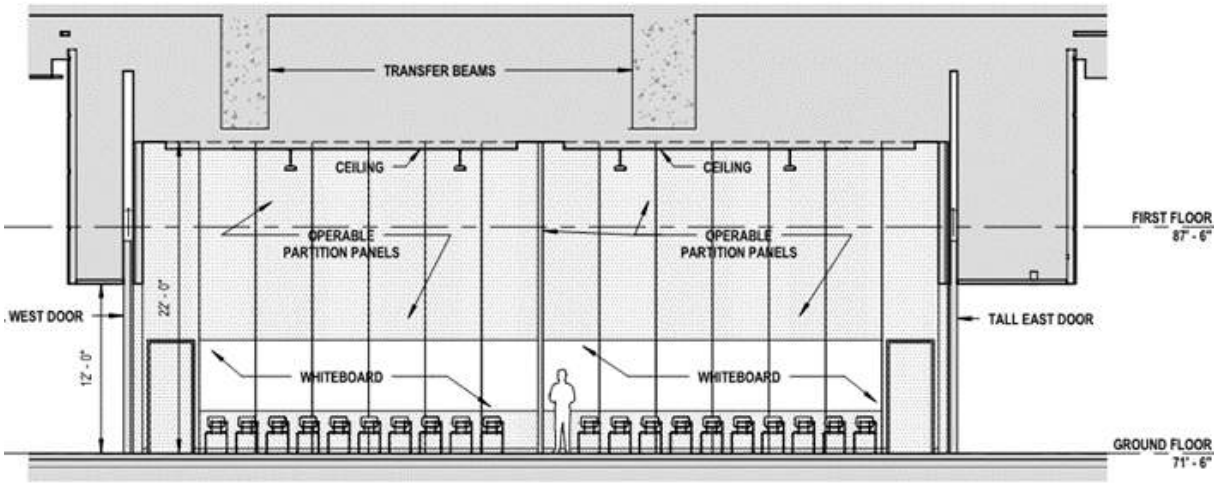
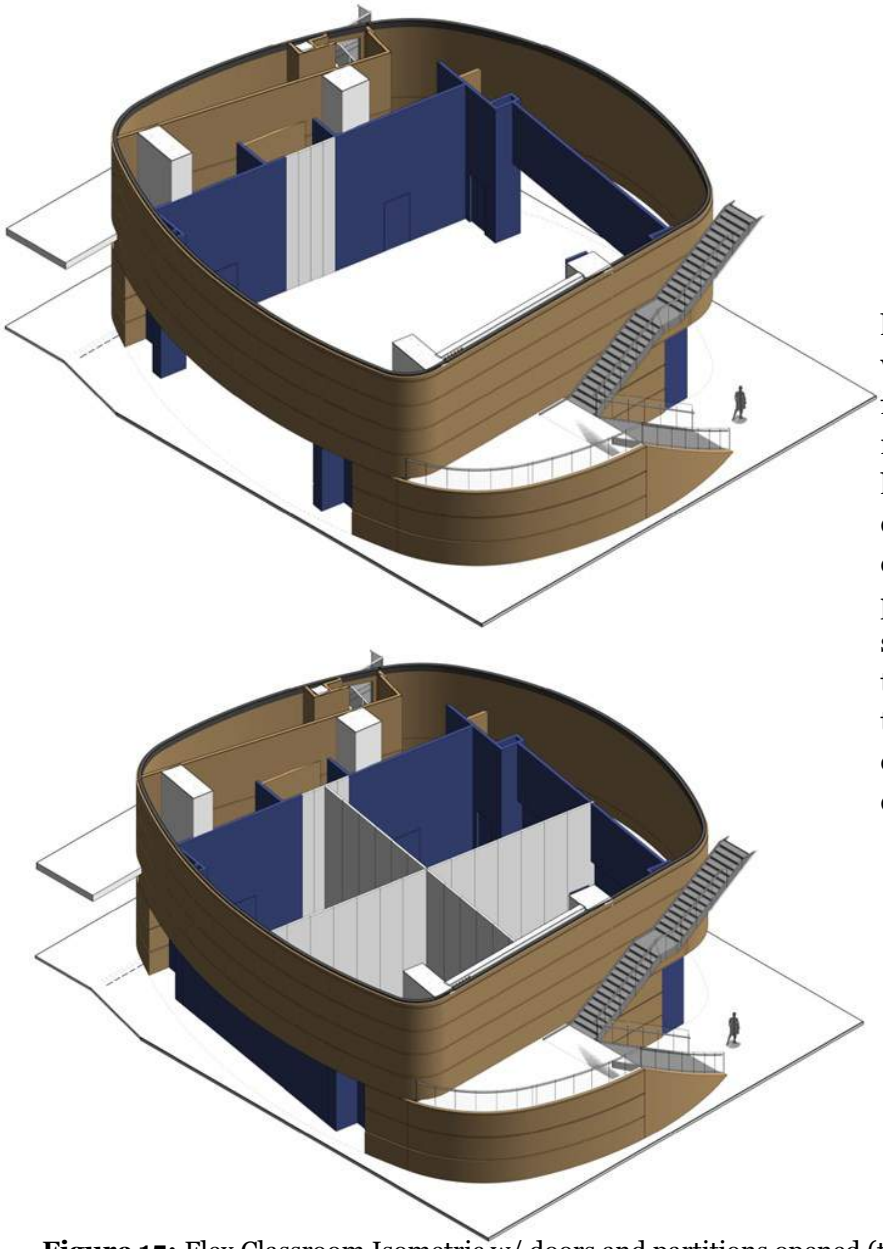


Figure 14: Flex Classroom Section



The isometrics on the left show how flexible the space can be. Partition walls can separate four or two classrooms for private instruction. They can also be removed to make one large room for lectures or formal events. The doors on either side of the room have the ability to open completely, making the entire space public. This flexibility means that this space must coordinate with the design of the lobby. When the large doors are open the lobby and the flex classroom become one large space, and people are meant to experience that grandeur.

Figure 15: Flex Classroom Isometric w/ doors and partitions opened (top)
Flex Classroom Isometric w/ doors and partitions closed (bottom)

EXISTING CONDITIONS

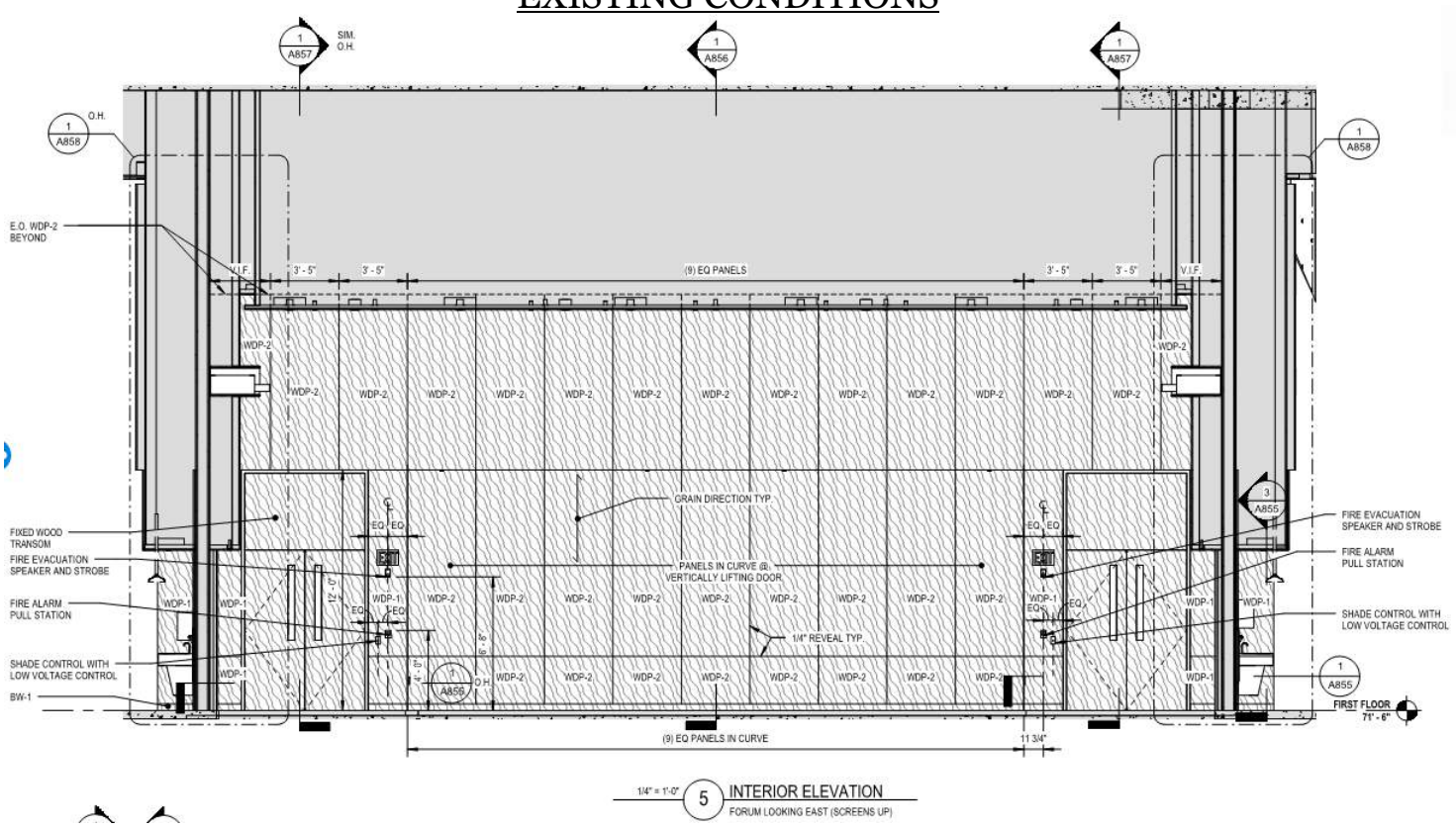


Figure 16: Flex Classroom Interior with Screens

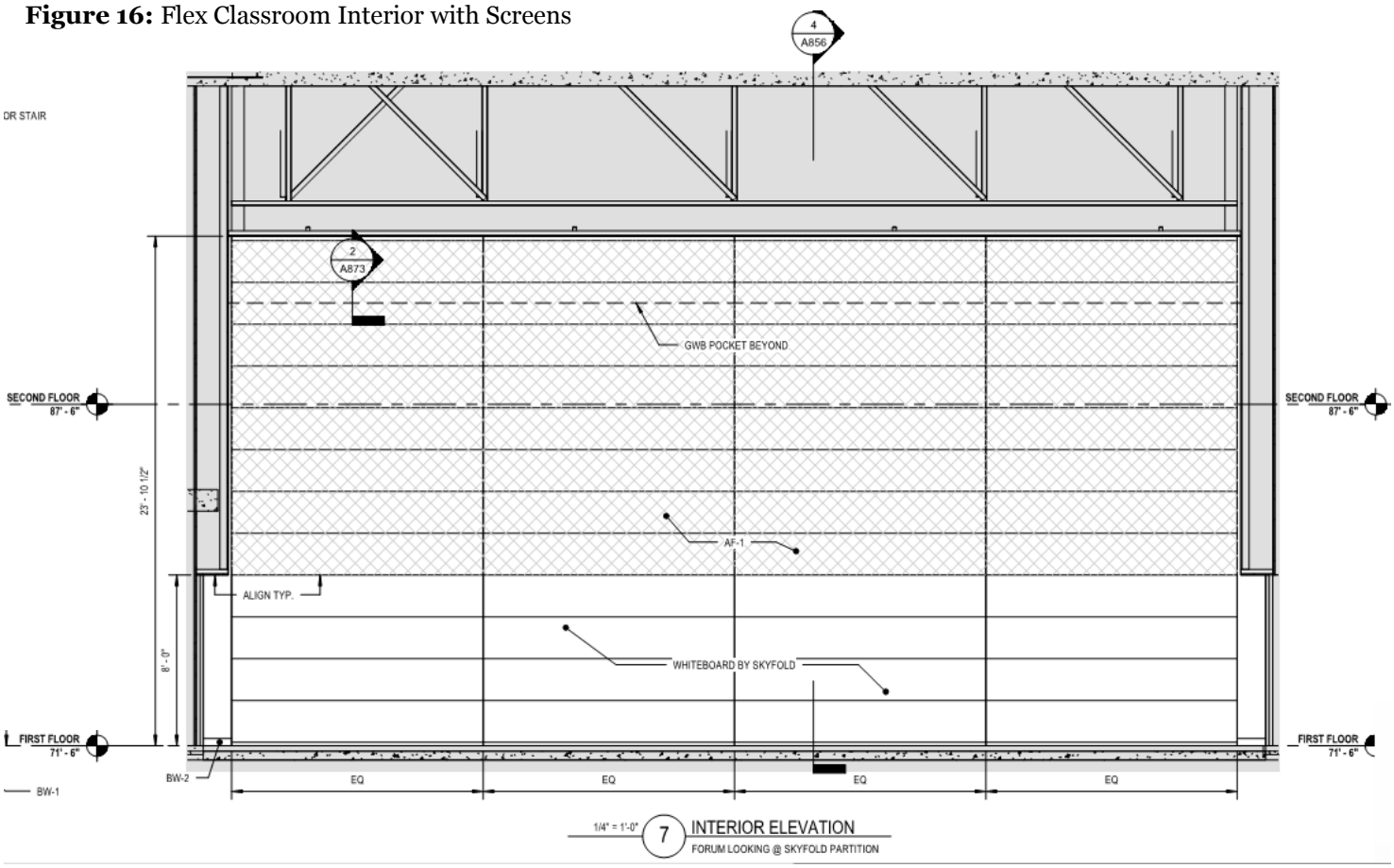


Figure 17: Flex Classroom Interior with North-South Partition Wall

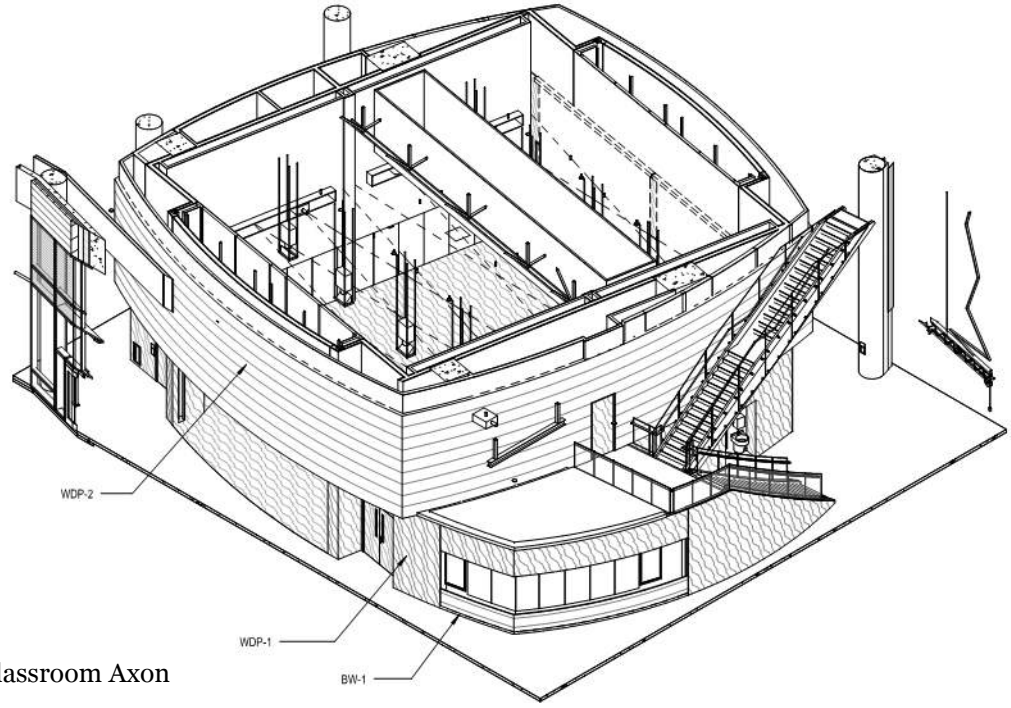


Figure 18: Flex Classroom Axon

Materials

Many different material types were used in the Flex Classroom in order to accommodate the various uses of the space. The walls have a variety of acoustical materials to help manage speech intelligibility for lectures. The partition wall running from North to South is made of gypsum with acoustical felt and has white boards on the lower ends for classroom instruction (shown in Figure 17 on the previous page). The interior elevations on the previous page show the two types of common walls in this space along with their materials. The partition walls that separate the space into four classrooms are called Teaching Walls (shown in Figure 19 below) and are made of white boards and gypsum with projection screen paint. This allows the use of projection screens in all four spaces, if needed, for class instruction.

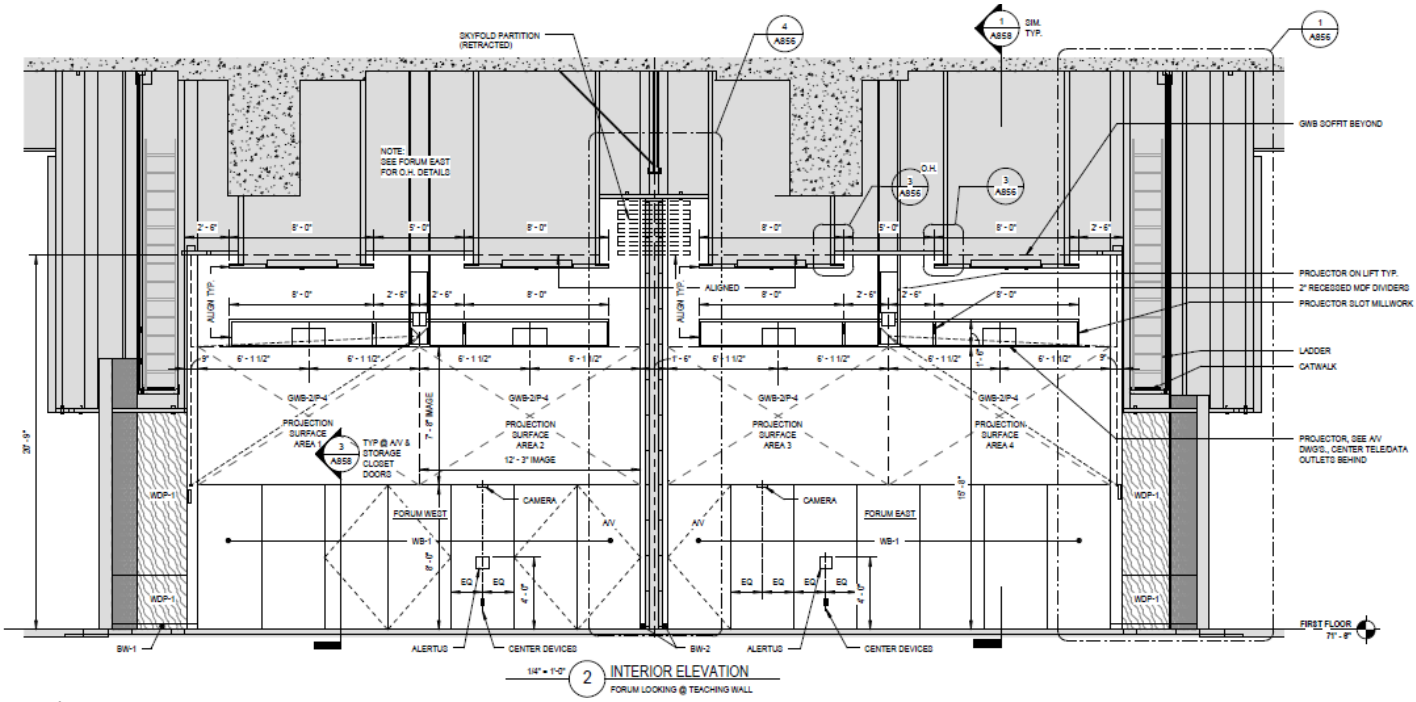


Figure 19: Flex Classroom Interior with 'Teaching Walls'

Materials

Location	Material	Product	Manufacturer	Color	Reflectance
Floor	Wood Floor	Rift & Quartered White Oak	Nydree	Natural	0.4
Wall	Wall Protection	Rigiid Vinyl Sheet	C/S Acrovyn	#265 fog, suede texture	.7
	Paint	Scuffmaster	Wolf Gordon	GOH 09796259	0.74
	Gypsum w/ Projection Screen Paint	Screen Goo	Goo Systems Global		.9
	Wood Panel	Maple Wood on MDF			.4
	Acoustical Wall Panels	Maple Wood			.3
	White Board				.9
	Acoustical Fabric	Ecoustic Felt	Unika Vaev	Light Grey	.3
	Fabric Wall Panel	Ecoustic Felt	Unika Vaev	Light Grey	.3
Base	Wood Base, Maple Stained				.4
	Wood Base, Painted				.7
Ceiling	Gypsum Wallboard 1				.85
	Gypsum Wallboard 2				.85
	Acoustical Ceiling Panels	Fiberglass		White	.3

Existing Lighting

The symmetric lighting in the Flex Classroom consists of all LED fixtures that have been designed for flexibility. LED slots run along the east and west walls of the room, providing light at the entryways which will spill in the lobby corridors when the doors are completely open. General illumination is provided by LED downlights that are recessed on both sides of LED lensed slots throughout the entire space. LED coves run the length of the room in the North-South direction. LED recessed multiples are also used to fill in the space between the lensed slots. (See appendix for luminaire schedule)

Figure 20: Flex Classroom Lighting Plan

Existing Controls

All LED fixtures in this space have full dimming capability along with vacancy sensors. The controls were provided by the Lutron Grafik Eye QS preset, multi-zone programmable dimming system with an AV interface and partition sensors. This allows for flexibility and versatility in the design and function of the space. The chart below describes the some of the control operation.

SoO No.	Sequence of Operation (SoO) Descripton	SENSOR POWER SOURCE	Daytime (Operating Hours)	Nighttime (Off-Peak Hours)	Weekend (Off-Peak Hours)	Notes
18	Flex Classroom	LOW VOLTAGE	VACANCY SENSOR. MANUAL-ON/AUTO-OFF IN 30 MIN. OR LESS	SAME AS DAYTIME	SAME AS DAYTIME	

DESIGN CRITERIA

Interior Spaces	Average Illuminance (footcandles - fc)	Lighting Power Density (watts/ft^2)*
Atrium	20-30	1.36
Classrooms	40-50	1.24

Table 3: Numerical criteria taken from the IES Handbook and ASHRAE 90.1

What separated the Flex Classroom from the other three spaces in the study is it's extreme versatility. The classroom itself has three different orientations that satisfy the different uses of the space. When all the partition walls are down there are four separate classrooms that need to be lit. Illuminance levels need to be high enough so that people can read and write, and lighting also needs to illuminate a speaker. When only the middle partition wall is down, two larger classrooms are formed which still need similar illuminance levels for the tasks. Whiteboards and projection screens need to be considered when designing the lighting of the space. Visual clarity is important on both the speaker and the presentation.

The most important criteria of this space is the flexibility of the systems being designed. The lighting needs to fit into every orientation of the space. Controls are also a necessary design for the space so that various scenes can be set for the different uses of the space. Like the Flex Lab, the Flex Classroom also has the ability to open directly to the lobby through the large openings on the east and west sides of the room. When those large doors are open, the first floor becomes one coherent space. This requires design coordination through all three of these spaces so that they can act as one space when needed. This space will be designed according to psychological impressions as studied by John Flynn. The versatility of the space gives the opportunity to produce a design that can be controlled for various scenes. The public/private uses of the space will be studied further to develop a design that satisfies both uses.

Figure 21: Flex Classroom (Rendering courtesy of Ballinger)

EVALUATION

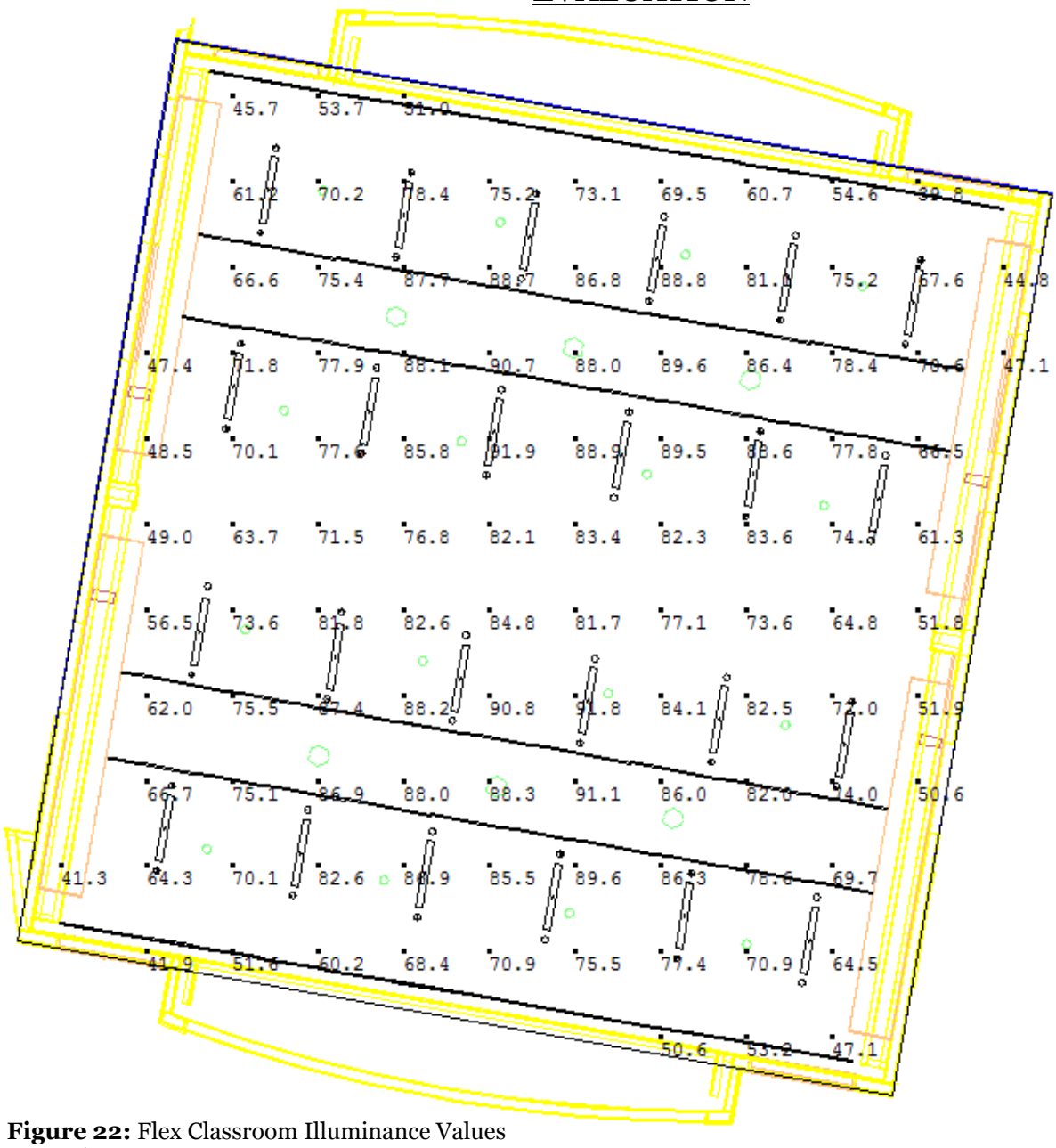


Figure 22: Flex Classroom Illuminance Values

Flex Classroom
Illuminance (Fc)
Average=72.72 Maximum=91.9 Minimum=39.8
Avg/Min=1.83 Max/Min=2.31

LPDArea_1
Area(Sq.ft)=2773 Total Watts=4084.811
LPD(Watts/Sq.ft)=1.473

The completed AGi model of the Flex Classroom produced extremely high light levels that were way over the design criteria for the space, but this result wasn't surprising. Because the Flex Classroom is designed for a variety of uses, multiple lighting scenes exist within the room. This calculation shows the light levels when every layer of light is on in the room, which typically won't occur when the space is actually being used.

The LPD was also over the allowed 1.24 W/sq.ft according to ASHRAE 90.1. The designers could have allowed this because of lower than required LPDs in other spaces, but this leaves room for improvement. A more efficient design could be implemented to lower the energy use. The illuminance is pretty even through-out. The layout caters to the flexibility of the space, making it easy to split up into two or four different areas.

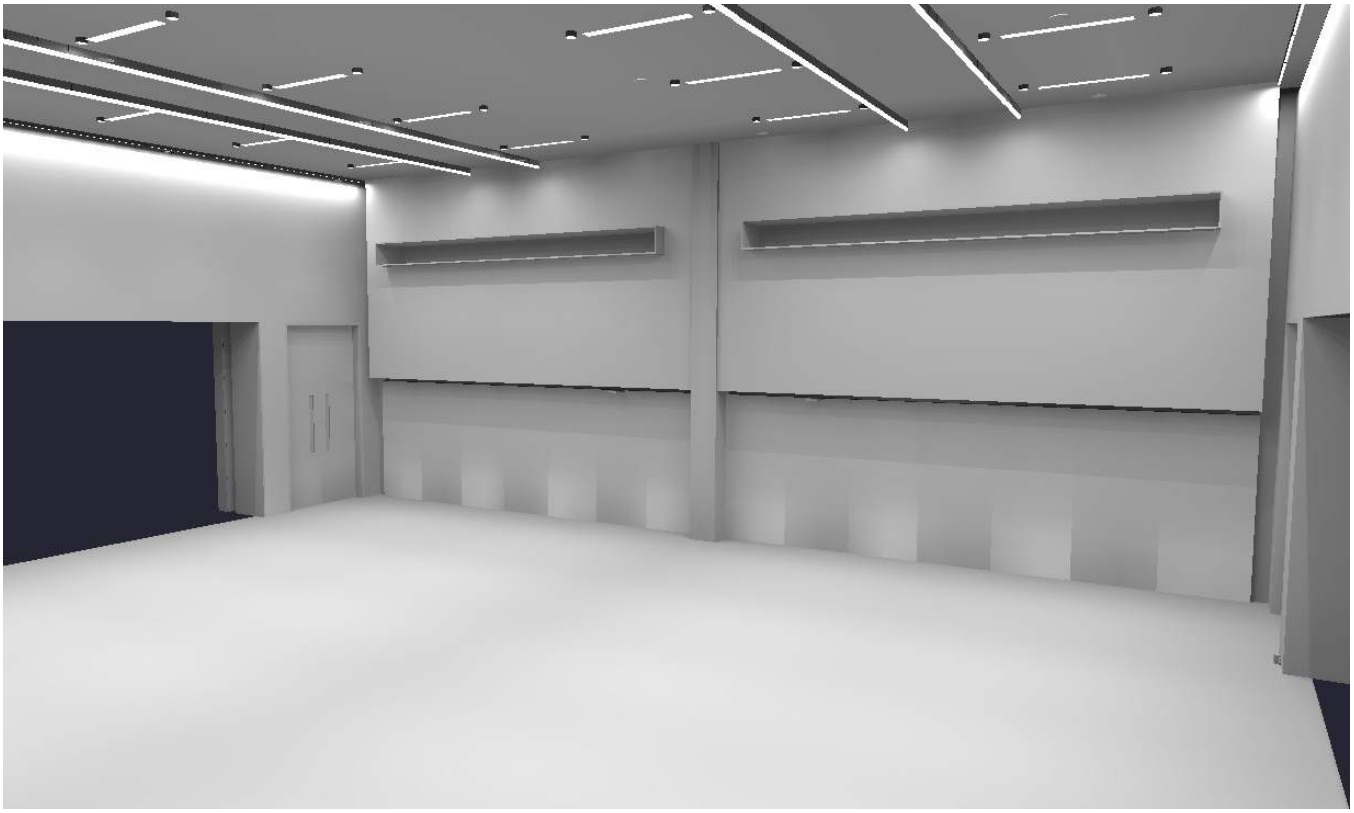


Figure 23: Flex Classroom Rendering

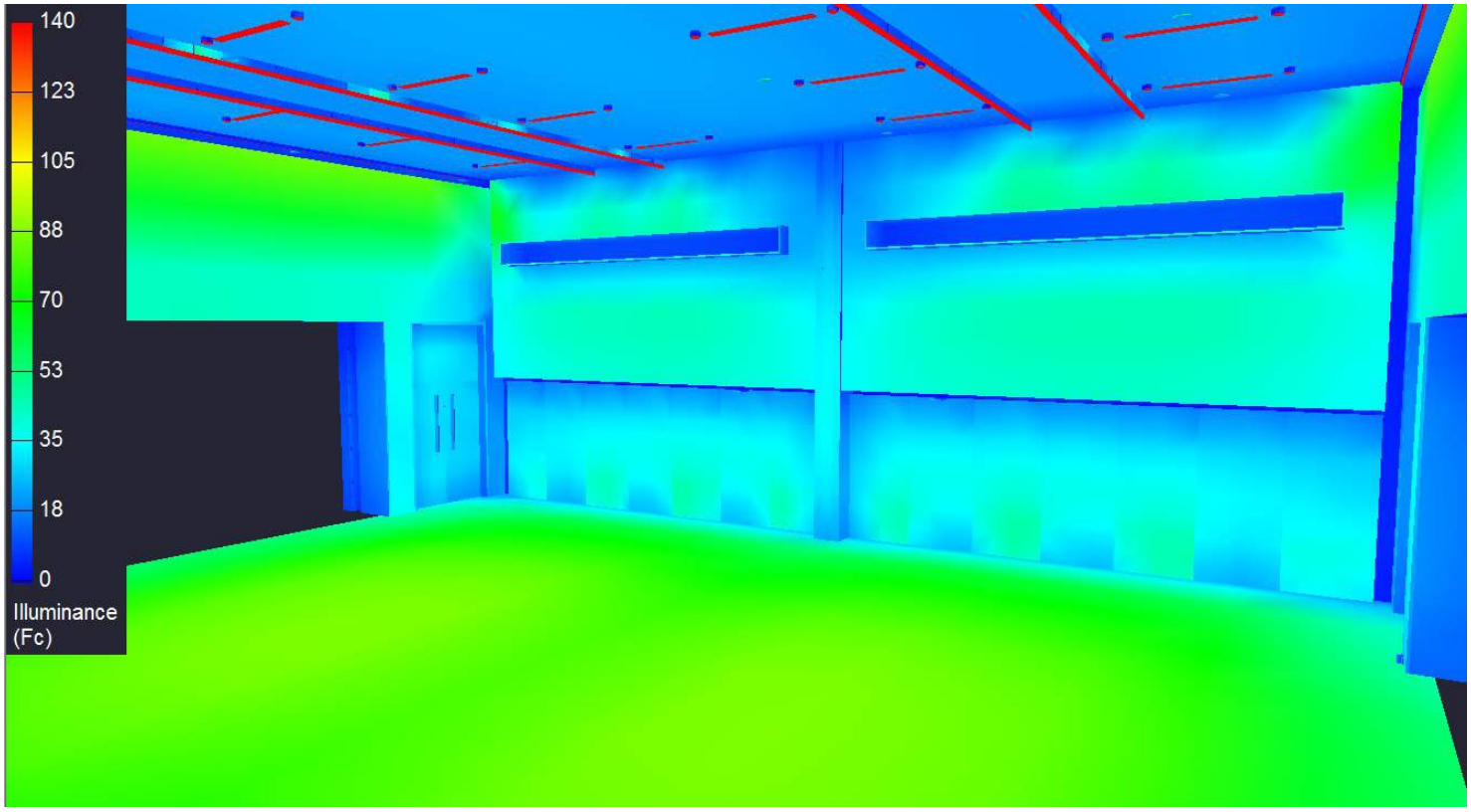


Figure 24: Flex Classroom Pseudo Color Rendering (with large doors open)

Figure 25: Flex Lab (Rendering courtesy of Ballinger)

PROPOSAL

The Flex Lab is also a very flexible space. There are no walls on the western side of the room, which makes the lab completely open to the lobby. It's meant to be a showpiece for the building, and an advertisement for the work that's done within. As mentioned before, the design of the lobby and the flex lab have to relate to one another in order for the entire first floor to be successful. Because it's a lab, this space has some interesting mechanical and structural systems in it. A beam runs through the entire room and out the main entrance for moving large machinery that may be needed or built in the lab. Fume hoods and ventilation systems are also in the space for any work that may be done. This provides potential for further structural or mechanical study.

The lab also has a curtain wall that runs down the entire eastern side of the room. This allows a lot of daylight into the space which may or may not need to be controlled. Glare control will be an important consideration for this work space.

AREA: 6,908 sf
HEIGHT: 30' 6"

TASKS/ACTIVITIES: Class instruction, Use of machinery and technical equipment, Research

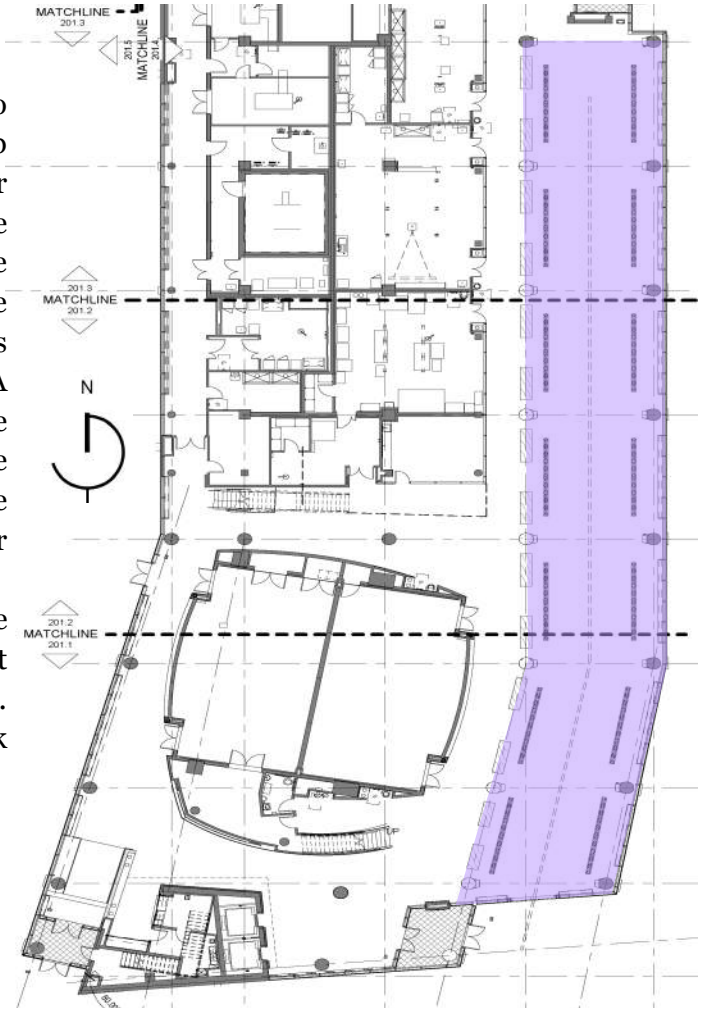


Figure 26: First Floor Plan section w/ Flex Lab

EXISTING CONDITIONS

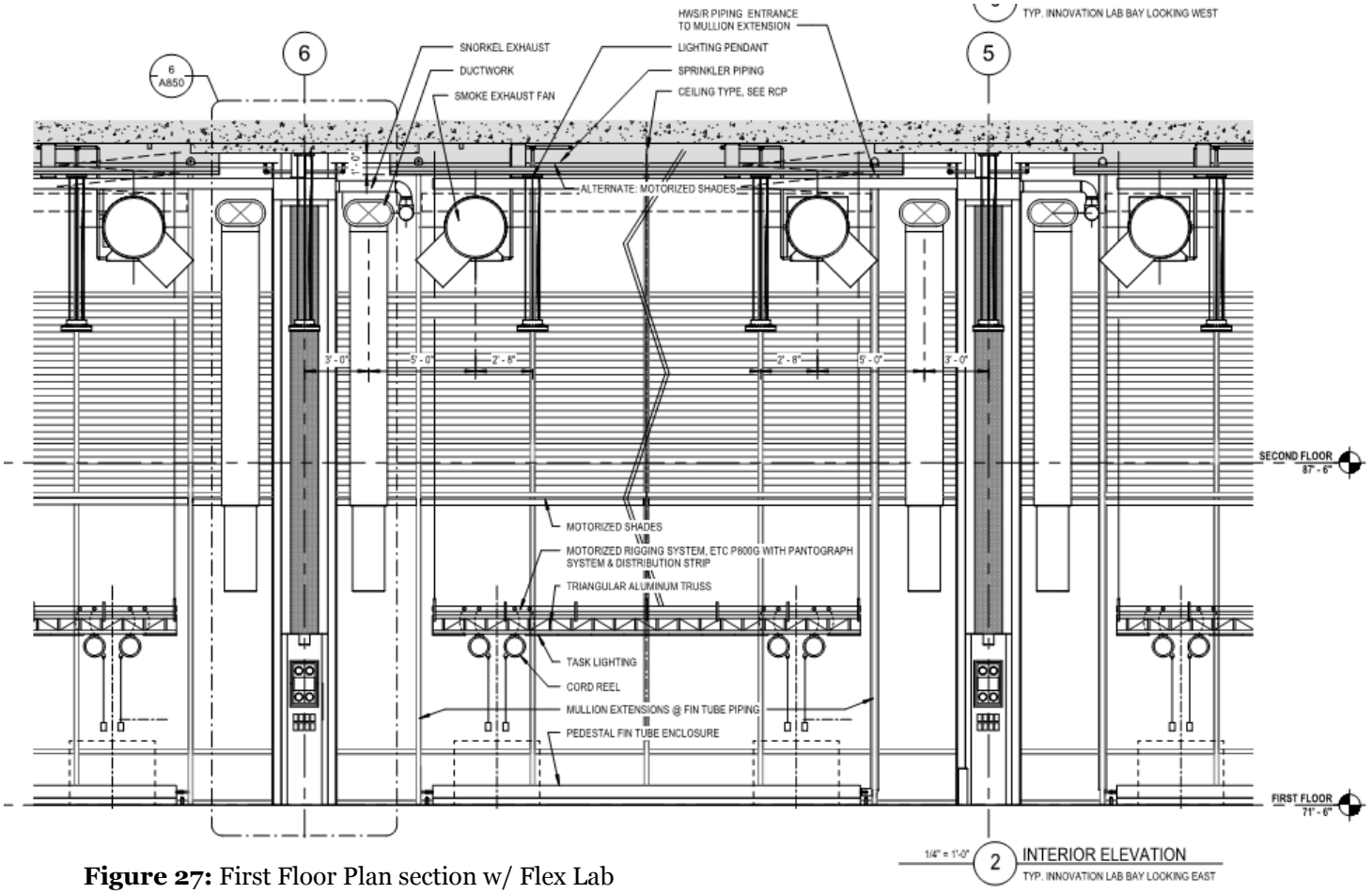


Figure 27: First Floor Plan section w/ Flex Lab

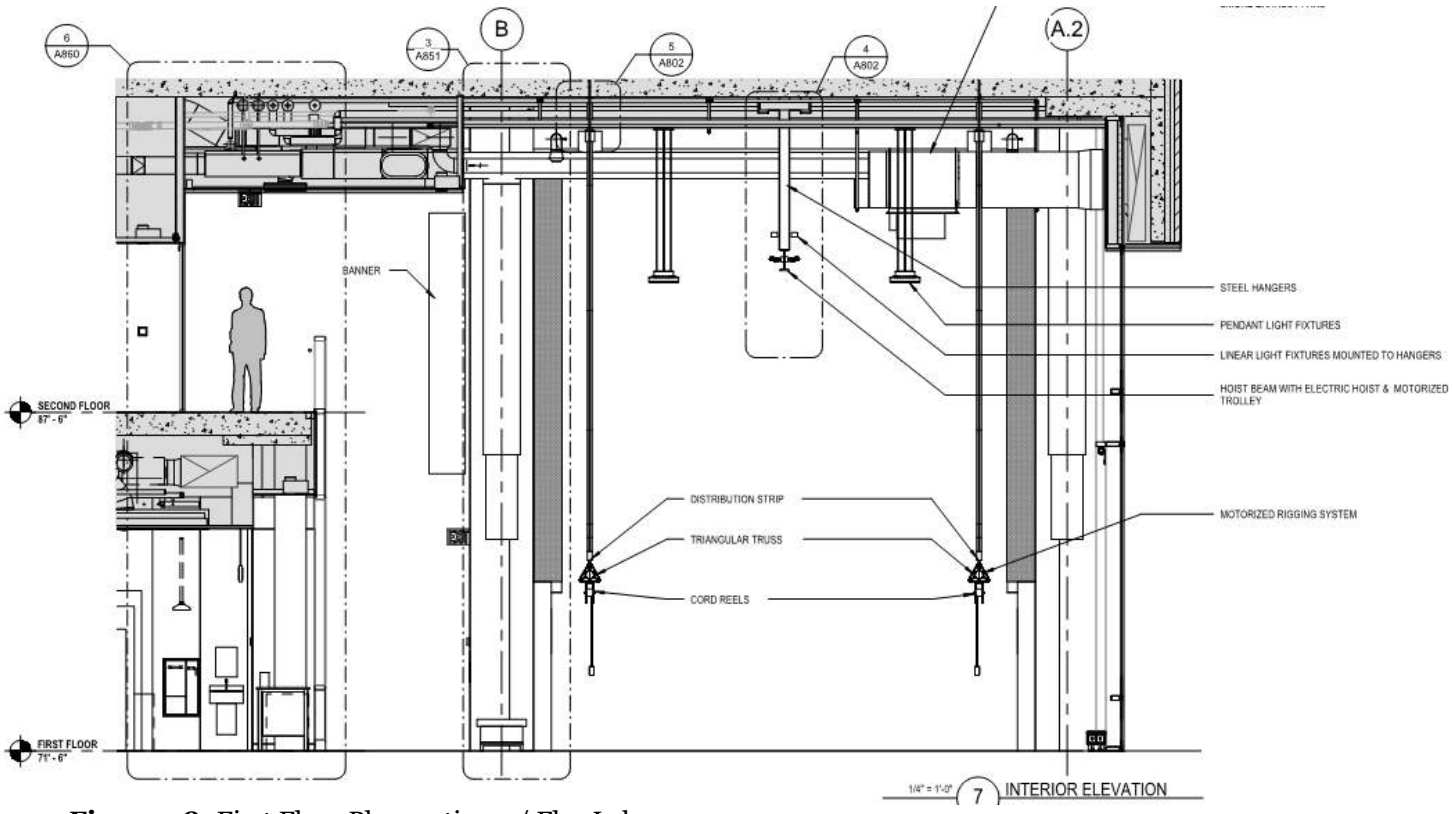


Figure 28: First Floor Plan section w/ Flex Lab

Materials

Because of the use of the Flex Lab, the design is more industrial looking with exposed mechanical equipment and lab equipment. The floor of the space is sealed concrete similar to the lobby. Aluminum trusses hang from the ceiling over the work station which assist with storage and movement of materials through the space. The west wall is open directly to the lobby and the east wall is a curtain wall running the entirety of the space. The ceiling is mainly acoustical ceiling panels which help control the noise from the equipment.

Location	Material	Product	Manufacturer	Color	Reflectance
Floor	Sealed Concrete				.5
Wall	Paint	Scuffmaster	Wolf Gordon	GOH 09796259	.74
	Metal Wall Panel				.7
Base	Rubber Base	Pinnacl Type TS	Roppe	178 Pewter	.1
Ceiling	Acoustical Ceiling Panel	Textured surface fiberglass back		White	.3
	Ceiling edge trim	Extruded aluminum		white	.7

Daylighting Properties

The east side of the flex lab is lined with curtain wall system 4 (refer to Lobby section).

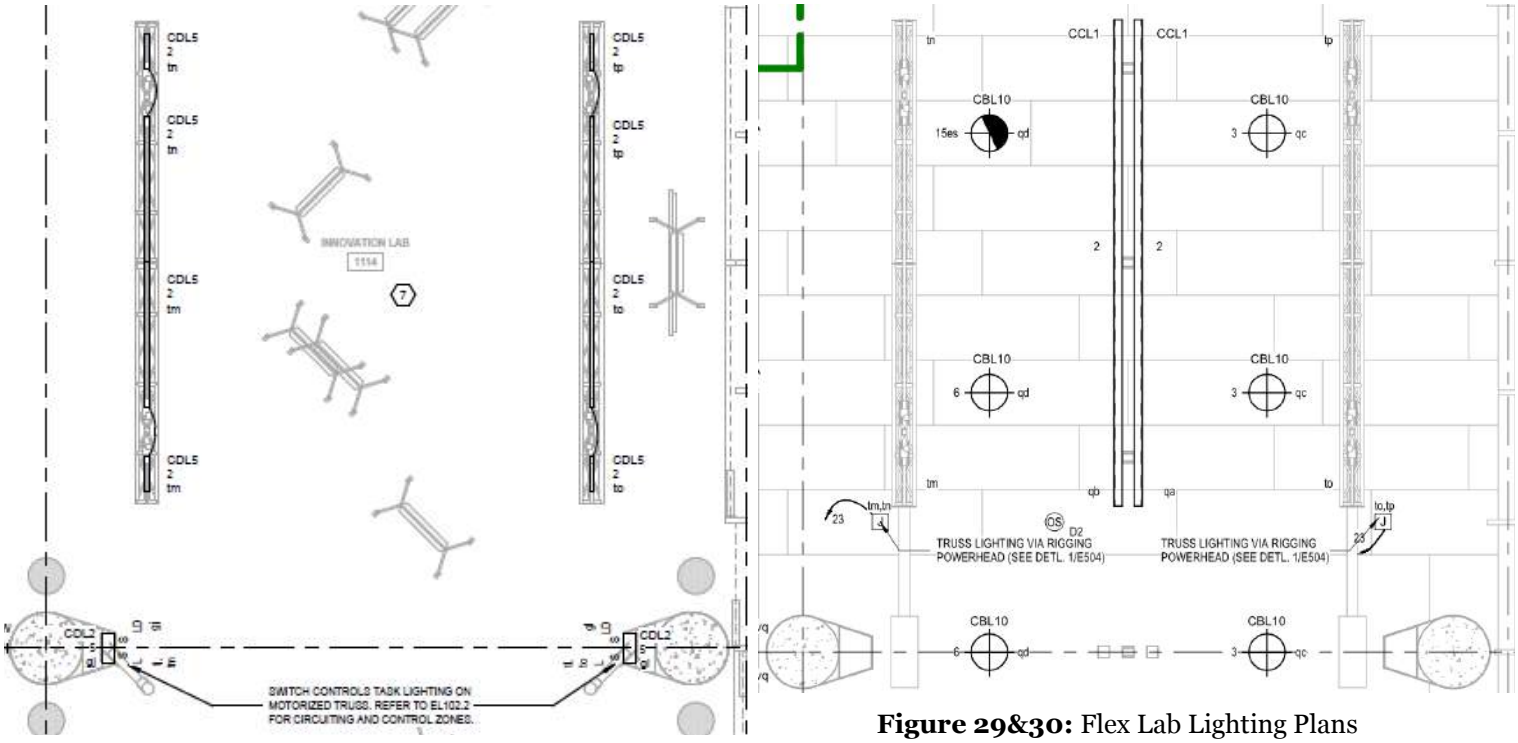


Figure 29&30: Flex Lab Lighting Plans

Existing Lighting

The Flex Lab consists of a series of work stations that are copied throughout the entire space. The lighting follows this repetition and can be represented in a plan of one of these stations as shown in Figure 29 & 30 above (lighting shown on two plans because of the double height space). The lab uses four types of dimmable LED fixtures in this space. Decorative LED pendants run through the center of the lab providing direct illumination to the work stations. An asymmetric LED uplight is installed along the large truss going through the center of the lab to illuminate the ceiling, preventing the tall ceiling from looking dark compared to the brightly lit work stations. Task lighting is also installed at each work station and each column for individual control. (See appendix for luminaire schedule)

Existing Controls

All LED fixtures in this space have full dimming capability. The controls are provided by wall-box dimmers, occupancy sensors, and an automatic time clock by the building management system. The chart below describes the some of the control operation.

SoO No.	Sequence of Operation (SoO) Descripton	SENSOR POWER SOURCE	Daytime (Operating Hours)	Nighttime (Off-Peak Hours)	Weekend (Off-Peak Hours)	Notes
7	Innovation Lab	LOW VOLTAGE	SCHEDULED CENTRALLY CONTROLLED. AUTO-DIM TO NIGHTTIME LEVEL AT END OF DAYTIME HOURS, WITH MANUAL OVERRIDE	SCHEDULED CENTRALLY CONTROLLED. AUTO-RAISE TO DAYTIME LEVEL AT END OF NIGHTTIME HOURS, WITH MANUAL OVERRIDE	SAME AS NIGHTTIME	

DESIGN CRITERIA

Interior Spaces	Average Illuminance (footcandles - fc)	Lighting Power Density (watts/ft^2)*
Laboratories & Support Spaces	50-60 Ambient 75-100 With Task Lights	1.81

The Flex Lab is both a showpiece and a work space for the building, but the priority for this room is the research work that will be done. This requires higher light levels than will be needed in many of the other spaces which also allows for a higher Lighting Power Density. Individual lighting control is important as well so that the occupants working in the space can make their it a comfortable place to work. Flexibility is also necessary for the lab because of the movement in the space. At times, large equipment may be moved through the space, so lighting needs to be out of the way or movable. The lighting also needs to integrate with the mechanical equipment needed in the space.

Daylighting is an important consideration for this space as well. Controls can be used to lower energy consumption and maximize the helpful sunlight coming into the building. A further analysis will also be done to minimize glare and visual discomfort in the work environment.

Figure 31: Flex Lab Section Looking East

EVALUATION

The completed AGi model of the Flex Lab produced light levels that satisfied the IES Handbook requirements. The average illuminance throughout the whole space was about 56 fc, and the light levels on the work stations was in the 80s. (A figure with the individual illuminance values throughout the spaces wasn't included because the figure was too large) The LPD also satisfied the code requirements for the lab. The uniformity in the space could be improved. The value calculated in AGi (Avg/Min= 6.59) is much larger than the IES recommended value of 1.5. Studies will also be done later to test glare from incoming daylight.

Flex Lab
Illuminance (Fc)
Average=56.02 Maximum=398 Minimum=8.5 Avg/Min=6.59
Max/Min=46.81 Uniform.Grad.=12.71

LPDArea_1
Area(Sq.ft)=8799 Total Watts=13103 LPD(Watts/Sq.ft)=
1.489

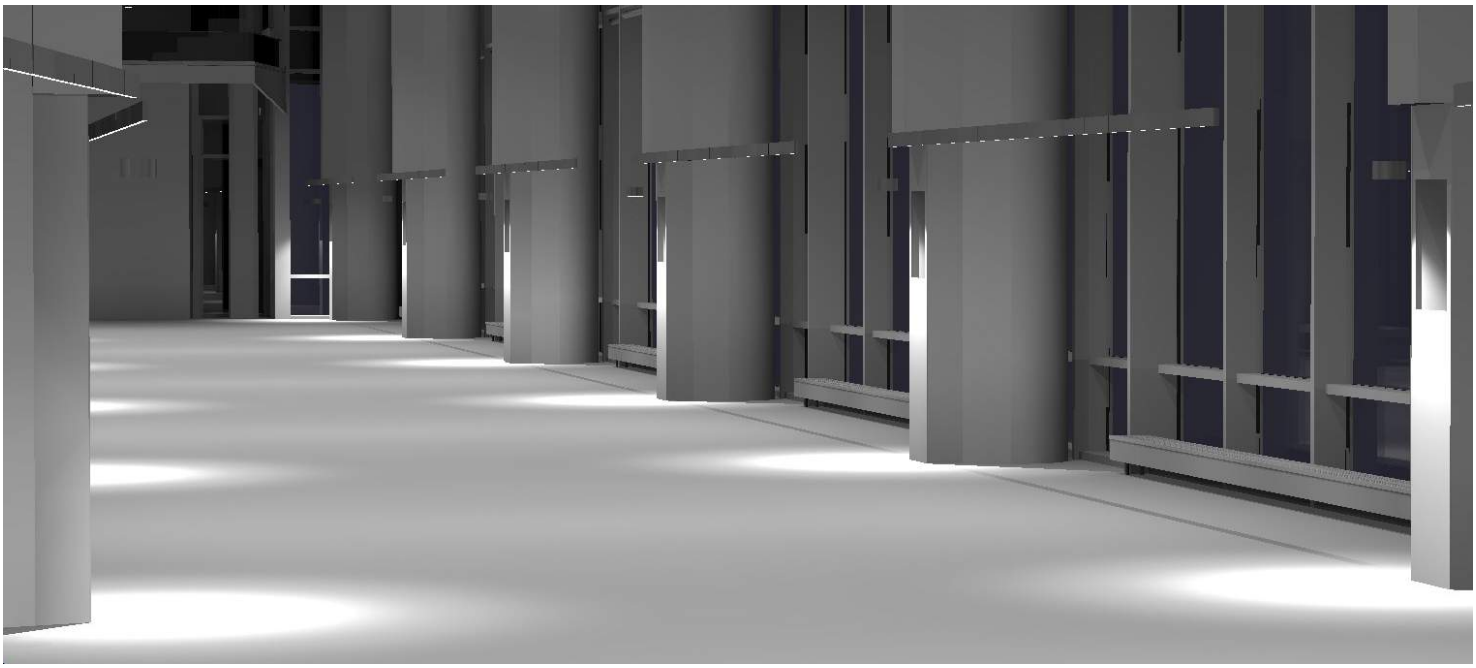


Figure 32: Flex Lab Rendering

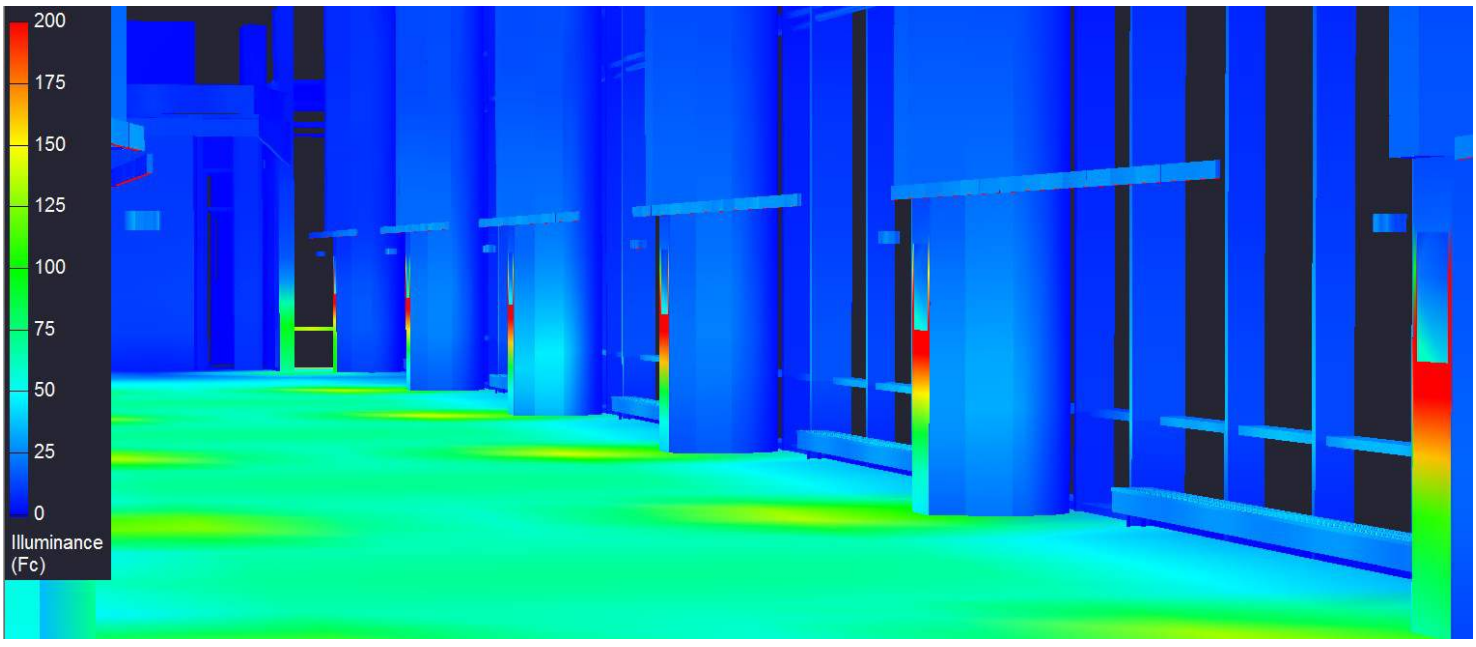


Figure 33: Flex Lab Pseudo Color Rendering

SUMMARY

After studying the existing conditions of the Bioengineering Building it's apparent that a sustainable design already exists. The building uses mostly LED lighting fixtures with various controls to monitor use and save energy.

The Exterior Plaza uses daylighting during the day and artificial lighting at night. The use of tall pole fixtures may be something to improve upon in order to minimize the interference with the look of the building façade.

The Lobby is a large area to light and has many opportunities to be creative. The grand stairway core serves as a focal point for the space along with the elevator core. Proximity to the Flex Lab requires an integrated design that compliments both spaces.

The Flex Lab also has a large influx of daylight into the space through the curtain wall which will be studied for glare and discomfort levels. Exposed mechanical equipment in this space provides a unique challenge for fixture placement and movability.

Like the Flex Lab, the Flex Classroom also can open up to the lobby. The large doors on either side allow for one large room to open out, creating a grand space for events. The classroom is also very flexible in its design and can be split into one, two, or four separate spaces. Lighting in this space needs to work with any room orientation or used and needs to consider the tasks being completed.

Overall the four spaces have a lot of interesting features that will provide unique design challenges.

REFERENCES

*All renderings and drawings in this report were produced by Ballinger

- IES Handbook, 10th Edition
- ASHRAE 90.1 (2010)

APPENDIX

OUTDOOR SPACE: EXTERIOR PLAZA LUMINAIRE SCHEDULE

TYPE	DESCRIPTION	MANUFACTURER	CATALOG NUMBER	LAMP TYPE	INPUT WATTAGE (FIXTURE)	INPUT VOLTAGE	MOUNTING
CML2	Flexible linear LED, nominal 1/2 inch wide x 3/4, field-cuttable to every 4 inches LED Requirements: Nominal 120 delivered lumens per foot, 4000K CCT, minimum 85 CRI, 70,000 hours to L70, 5 year warranty. Transformer: Magnetic remote transformer	ACCLAIM Q-TRAN	FIXTURE: FTB-123-AAEN-MOUNTING ACCESSORIES TRANSFORMER: QSET-MLED-(WATTS)-277/24+QVAULT5	LEDs	3.8W PER FOOT	277	SURFACE
CML3	Provide four (4) LED adjustable accent lights mounted to 20 ft round tapered aluminum pole, 40° flood optics, integral line voltage LED driver LED Requirements: nominal 1,400 delivered lumens, 4000K CCT, minimum 80CRI, 100,000 hours to L70, 5 year warranty Pole: round aluminum pole, 5 in diameter, 20 ft overall height	LUMENPULSE VALMONT	FIXTURE: (4) LBM-277-40K-FL-CCNO-SY POLE: R-200050506S4-D1-(COLOR)	LEDs	28W PER HEAD	277	POLE
CML4	LED Bollard, nominal 4 in diameter x 32 in tall stainless steel hohousing, frosted polycarbonate lens with rubber gasket, integral LED driver LED Requirements: nominal 480 delivered lumens, 3500K CCT, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	INTENSE	IVB40LED-6NW-ST-H1-32	LEDs	6W	277	BOLLARD
CML5	LED in-grade uplight, 4 in diameter brushed stainless steel, clear flat tempered glass lens, bronze and reinforced thermoplastic housing, medium flood optics, tilt kit for 5°, 10°, and 15°, integral LED power supply. LED Requirements: nominal 550 delivered lumens, 4100K CCT, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	HYDREL	PDX4-BSS-9LED-WHT41K-MVOLTMFL-FLC-(CONDUIT)-TKO-LPI	LEDs	1W	277	IN-GRADE
CML6	Linear LED in-grade, die-cast aluminum housing, high reflectance asymmetric wallwash reflector, tempered glass lens with anti-slip coating, integral LED driver with line voltage input Minimum LED Requirements: 4000K CCT, 1600 initial delivered lumens, 85 CRI	LUMENPULSE	FIXTURE: LOI RO-(LENGTH)-40K-WW-TS0-INTL-NO-ASL POWER BOX: PACBOX-277-24V-NO + LOI-RBO-(LENGTH)-GRD	LEDs	9W	277	IN-GRADE
CMM1	Metal Halide area light mounted to 15 foot tall pole, cast aluminum housing, tempered glass lens, IES type III light distribution, black paint finish overall, integral electronic ballast Pole: 15 foot tall x 5 in round aluminum pole, black paint finish overall	GARDCO	HEAD: CR20-1-3XL-60CMPE-277-(FINISH)-LR-BLP POLE: RA5-STB-15-D1-BLP	PHILIPS: CPO-T WHITE 60W/840 (1)	67W	277	POLE
CMM2	Metal halide area light mounted to 30 foot tall pole, cast aluminum housing, tempered glass lens, IES type III light distribution, black paint finish overall, integral electronic ballast Pole: 30 foot tall x 5 in round aluminum pole, black paint finish overall	GARDCO	HEAD: CR20-1-3XL-90CMPE-277-LR-BLP POLE: RA5-STB-30M-D1-BLP	PHILIPS: CPO-T WHITE 90W/840 (1)	99W	277	POLE

CIRCULATION SPACE: LOBBY LUMINAIRE SCHEDULE

TYPE	DESCRIPTION	MANUFAC.	CATALOG NUMBER	INPUT WATTAGE (FIXTURE)	INPUT VOLTAGE	MOUNTING	REMARKS
CAL2B	Linear LED lensed slot, aluminum housing, 3 in maximum overall height, frosted acrylic snap-in lens, integral LED driver with lin-voltage input, white finish LED Requirements: nominal 500 initial delivered lumens per linear foot, 3000K CCT with color variation not to exceed 3 step macadam ellipse, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	SELUX	L36-1L35-30-LW-SFX-(LENGTH)-WH-277-DME/DMD	9W PER FOOT	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL11	Continuous channel LED multiple head luminaire with 5 heads spaced 18 in on center, 20° beam with up to a 30° vertical tilt perpendicular to luminaire and up to 45° vertical tilt parallel to luminaire, black finish on housing, integral digitally addressable dimming driver with line voltage input LED Requirements per head: 1,800 initial delivered lumens, 4000K CCT, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	3G LIGHTING	3G-CSLED-29W-40K-20D-277-ELDOLED DALI/LUTRON ECOSYSTEM-WT-BG-BKS8FT-18-OA-STB70	29W PER LAMP	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL19	LED open downlight, spun aluminum parabolic Alzak reflector and return flange with diffuse clear low iridescen finish, integral digitally addressable dimming driver with line voltage input LED Requirements: nominal 1500 initial delivered lumens, 4000K CCT with color variation not to exceed 3 sep macadam ellipse, minimum 80 CRY, 50,000 hours to L70, 5 year warranty	PORTFOLIO	LD6A-15-DALI/ECOSYSTEM 1%-ERM6A15-8-40-6LM1-H	23W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL19A	Same as type CAL19 except nominal 2000 delivered lumens and narrow beam distribution	PORTFOLIO	LD6A-20-DALI/ECOSYSTEM 1%-ERN6A20-8-40-6LN1-H	32W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL20A	LED open wallwasher, nominal 6 in diameter aperature, integral digitally addressable LED driver with line-voltage input LED Requirements: nominal 2800 initial delivered lumens and 3000K CCT, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	PORTFOLIO	LD6A-30-DALI/ECOSYSTEM 1%-ERW6A30-9-30-6LW111-H	44W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL25	LED adjustbale accent, clear matte anodized aluminum reflector and returen flange, integral digitally addressable dimming driver with line voltage input LED Requirements: nominal 1500 initial delivered lumens, 4000K CCT with color variation not to exceed 2 sep macadam ellipse, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	USAI	3231A10-AC1-C-01-LRTA4-8424-C2-40KS-30-NC-277VDIML4/DIML7-AS61F	24W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CHL1B	LED adjustable trackhead with spot optic	ERCO	FIXTURE: 71145.023 SNOOT: 70633.00 SINGLET MOUNTING	12W	120	SURFACE	

SPECIAL PURPOSE SPACE: FLEX CLASSROOM LUMINAIRE SCHEDULE

TYPE	DESCRIPTION	MANUFAC.	CATALOG NUMBER	INPUT WATTAGE (FIXTURE)	INPUT VOLTAGE	MOUNTING	REMARKS
CAL1	Linear LED lensed slot, nominal 6 in wide x 4 ft long steel housing with extruded aluminum trim, 7 in maximum recess depth, 1.25 in regressed opal acrylic lens, integral digitally addressable dimming driver with line voltage input, provide flangeless mounting hardware as required for mounting in specified decoustic ceiling type, paint finish to be selected by design professional LED Requirements: nominal 3,300 initial delivered lumen output, 3000K CCT with color variation not to exceed 2.5 step macadam ellipse, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	MARK	S6LR-4FT-(DECOUSTIC CEILING)-H-30-ELDOLED DALI/LUTRON ECOSYSTEM-277-SW	48W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL6	Linear LED lensed slot, nominal 1.5 in wide extruded aluminum housing, 3 in overall height, frosted acrylic snap-in lens, integral LED driver with line-voltage input, overall paint finish to be white LED Requirements: nominal 280 initial delivered lumens per linear foot, 3000K CCT with color variation not to exceed 3 step macadam ellipse, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	SELUX	L36-1L20-30-LW-SFX-(LENGTH)-WH-277-DME/DMD	5W PER FOOT	277	RECESSED	Provide lengths as indicated on drawings. Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL10	3– light LED multiple head luminaire, nominal 5 in wide x 18 in long aperture, 9 in wide x 22 in long x 7.5 in deep steel housing, each head shall have 20° beam spread, integral digitally addressable dimming driver with line voltage input LED requirements per hear: 1,800 initial delivered lumens, with 6,000 center beam andlepower, 3000K CCT, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	3G LIGHTING	3G-RC3LED-29W-30K-20D-277-ELDOLED DALI/LUTRON ECOSYSTEM-WT-BG-BK-OA-STB70	87W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CAL21	LED downlight with 1 in regressed solite lens, nominal 4.5 in diameter aperture, 7 in maximum recess depth, housing dimensions shall not exceed 5.75 in wide x 22 in long, clear matte anodized aluminum reflector and return flange, integral digitally addressable dimming driver with line voltage input LED requirements: nominal 1450 delivered lumens, 3000K CCT with color variation not to exceed 2 step macadam ellipse, minimum 90 CRI, 50,000 hours to L70, 5 year warranty	USAI	3021-AC1-01-LRTD4-9024-C2 -30KH-30-NCSM-277V- DIML4/ DIML7	24W	277	RECESSED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CCL3	Linear LED cove fixture, 120° X 120° beam optics, integral LED driver and power supply LED RequirementsL nominal 300 delivered lumens per foot, 3000K CCT, 100,000 hours to L70, 10 year warranty	LUMENPULSE	LCN RO-277-(LENGTH)-30K-FR-WHDALI/ ECOSYSTEM-LUMENTALK	3W PER FOOT	277	SURFACE	

LARGE WORK SPACE: FLEX LAB LUMINAIRE SCHEDULE

TYPE	DESCRIPTION	MANUFAC.	CATALOG NUMBER	INPUT WATTAGE (FIXTURE)	INPUT VOLTAGE	MOUNTING	REMARKS
CBL10	Decorative LED Pendant, Nominal 18-inch diameter x 6-inch high die-cast aluminum housing, stainless steel hardware, five (5) LED lamps with specular facetted aluminum reflectors with clear lenses, decorative acrylic disc with openings for optics, four-point adjustable aircraft cable mounting, provide length cable as required for specified mounting height, integral digitally addressable dimming driver with line voltage input LED Requirements: nominal 11,000 delivered lumens, 10,000 center beam candlepower, 4000K CCT, minimum 80 CRI, 100,000 hours to L70, 5 year warranty	BETA CALCO	50 5524-(FINISH)-DD -DALI/ECOSYSTEM	140W	277	SUSPENDED	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CCL1	Linear LED asymmetric wall mounted uplight, nominal 3.5 wide x 2.5 in high extruded aluminum housing, integral asymmetric reflector, provide clear acrylic dust cover LED Requirements: nominal 400 delivered lumens per foot, 2150 maximum candela at 110°, 4000K CCT, 60,000 hours to L70, 5 year warranty	ALIGHT	D4-R(ROW LENGTH) -LS-40-2-N-D-R-(FINISH)-D(DALI/ ECOSYSTEM)	5W PER FOOT	277	SURFACE	Provide lengths as indicated on drawings. Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CDL2	LED wall mounted adjustable 4-lamp luminaire for task lighting	ARCHITECTURAL LIGHTING WORKS	LP9-V-XC8030-1300-DALI/ECOSYSTEM-4-F-277-SNT-SOL-(FINISH)-OS	92W	277	SURFACE MOUNTED TO WALL	Provide Eldoled DALI or Lutron Ecosystem dimming driver capable of providing continuous, flicker-free dimming from 100% to 1% light output, final dimming ballast type to be compatible with approved control system.
CDL5	Fixture to be provided by motorized rigging manufacturer, spec section 116133. Linear LET task light, nominal 1 in wide x 2 in deep aluminum housing with remote phosphor lens, overall finish to be selected by design preofessional, integral LED dimming driver. Provide quantity and size of electronic transformer with overall white finish. LED Requirements: nominal 500 delivered lumens per foot, 4000 K CCT, minimum 80 CRI, 50,000 hours to L70, 5 year warranty	TECH LIGHTING	FIXTURE: 700UCRD-(LENGTH)-8-MOD 40K-(FINISH)-LED + ACCESSORIES POWER SUPPLY: 700AT1524ELW	8W PER FOOT	277	SURFACE	