Penn State University

Tech Report 1B: Existing Conditions

The HUB Addition

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9-28-2015

Tech Report 1

EXECUTIVE SUMMARY

The following report is an analysis of four spaces within the Pennsylvania State University's Hetzel Union Building or HUB. Design criteria were established and prioritized to fit each of the spaces unique needs and assets. IES, ASHRAE 90.1- 2013, LEED V4, and general good practice principles were used to evaluate each of the spaces

Spaces included are:

- Special Purpose Space – Flex theater
- Circulation Space – Atrium
- Outdoor Space – Green Roof and Surroundings
- Large Work Space – Bookstore

The current design solutions all met or exceeded energy codes and proved to be an energy efficient design, especially with the addition of controls and dimming. Some of the spaces also have additional controls to dim lights based on available daylight, further decreasing energy use. The impressions created by the lighting design all tend to be one of public, clarity, and spaciousness. This makes sense due to the large amount of traffic the building receives and its central location on campus.

All of the spaces could be improved aesthetically with a little contrast and by establishing a clear hierarchy within the space. This would also help to invoke an emotional response from occupants, adding to the quality of the spaces.

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Building overview

Name | The Hetzel Union Building (HUB)
Location | University Park, State College, PA 16801
Occupant Type | Something
Size | 107,000 S.F.
Number of Stories | Three stories above grade and two basement levels
Construction Dates | May 2013 – May 2015
Estimated Building Cost | $44,600,000
Project Delivery Method | Design-Bid-Build

Project Team

Owner: Penn State University
Construction Manager: Gilbane Building Company
Architect: Gund Partnership
Landscape Architect: Andropogon Associates, Ltd.
MEP Engineer: Vanderweil Engineers
Civil Engineer: Sweetland Engineering and Assoc.
Structural Engineer: LeMessurier Consultants
Acoustic Consultant: Acentech Incorporated
AV/IT Consultant: Vantage Technology Group
Lighting Consultant: Horton Lees Brogden Lighting Design

Overview of existing lighting

The current lighting in the building is primarily in LED with a few exceptions for decorative fixtures. Spaces are mainly lit for the specific task performed within. The most common being way-finding and circulation. Everything is evenly lit with little hierarchy within the space to draw people's attention to areas of interest. All of the spaces meet or exceed ASHRAE Standards.

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Special Purpose Space | Flex Theater

Existing Conditions

Dimensions

Area – 2000 ft^2

Approximate width – 38 ft

Approximate length – 55 ft

Ceiling Height – 21 ft, 18 ft to suspended ceiling

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Floor Plan

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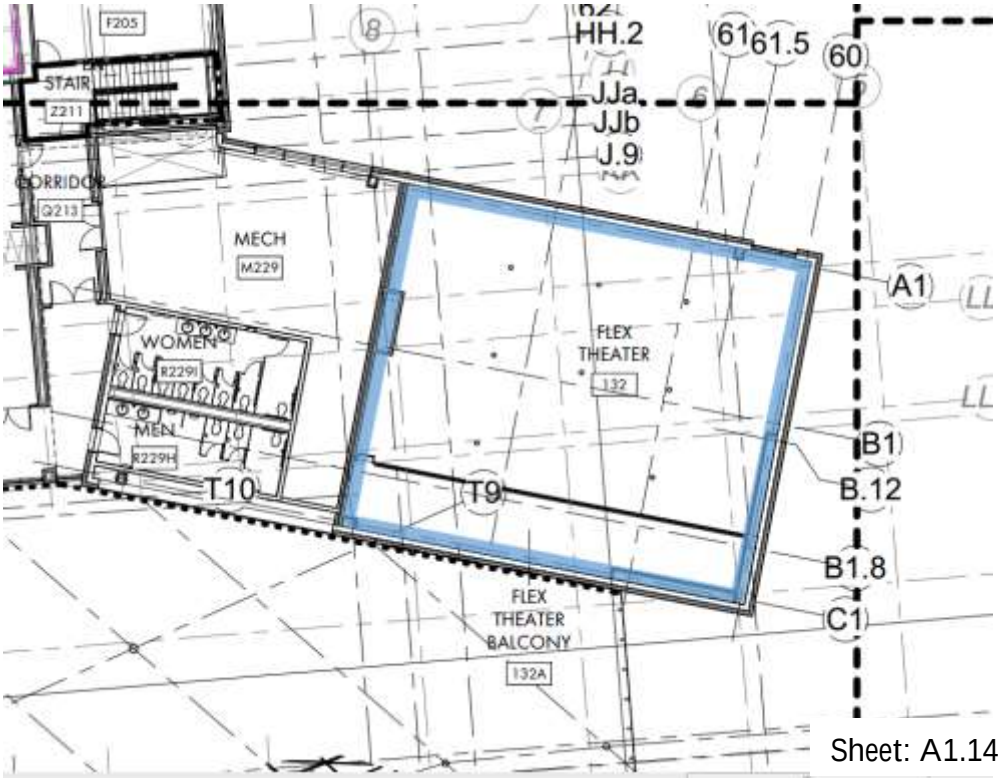
Enlarged Floor Plan



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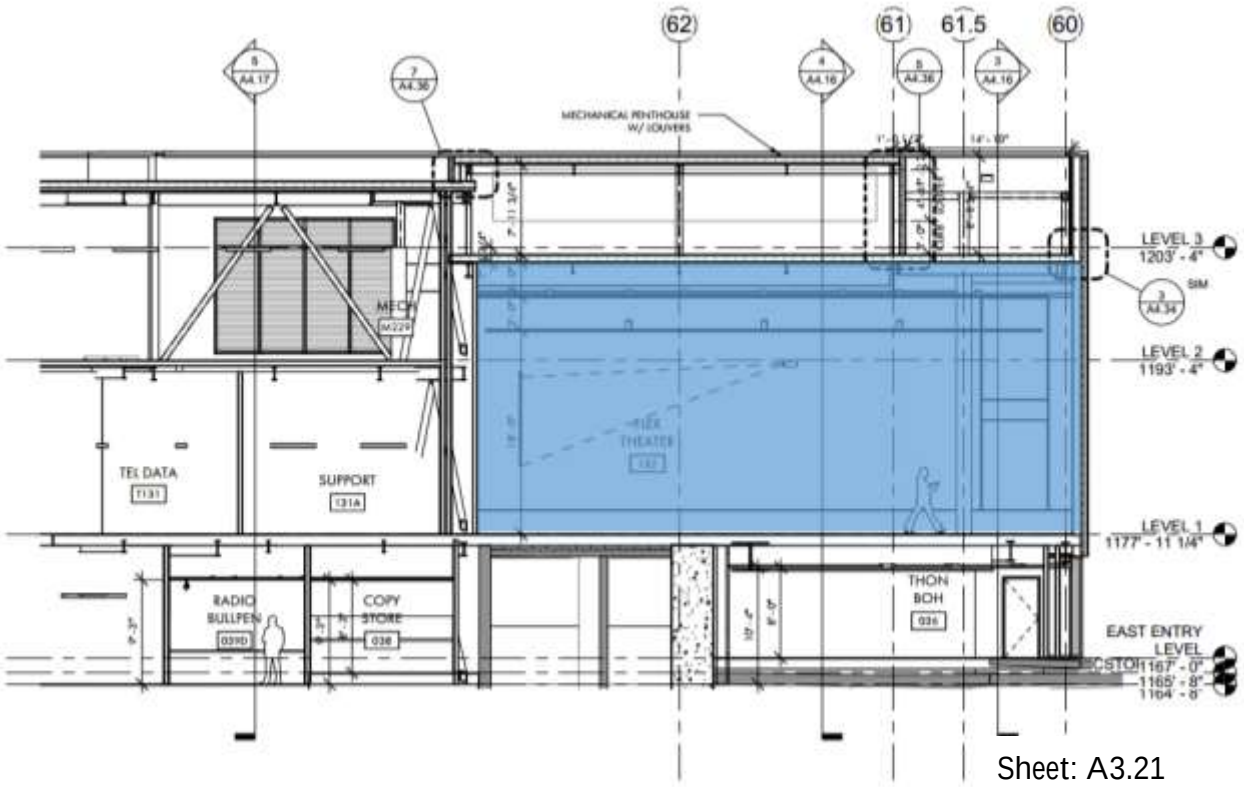
East West Section



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Finishes

The floors are clad in ebony wood paneling which have a low reflectance. The walls are painted gypsum wall board. The ceiling is acoustic ceiling tile that is dyed black to absorb as much light as possible. The space as a whole is very absorptive to keep the audience portion of the theater dim and the focus on the stage.

Flex Theater Materials				
Surface	**Material**	**Description**	**Color**	**Reflecance (ρ)**
Ceiling	ACT-2	Fine Fissured #1729 black, 2x4, min NRC .55 & CAC35	Black	0.2
Walls	GWB/PTD	Painted gypsum wall board	Grey	0.5
Floor	WD	Robbins Bio-Channel Classic - White Oak w/ Ebony Stain	Ebony	0.15

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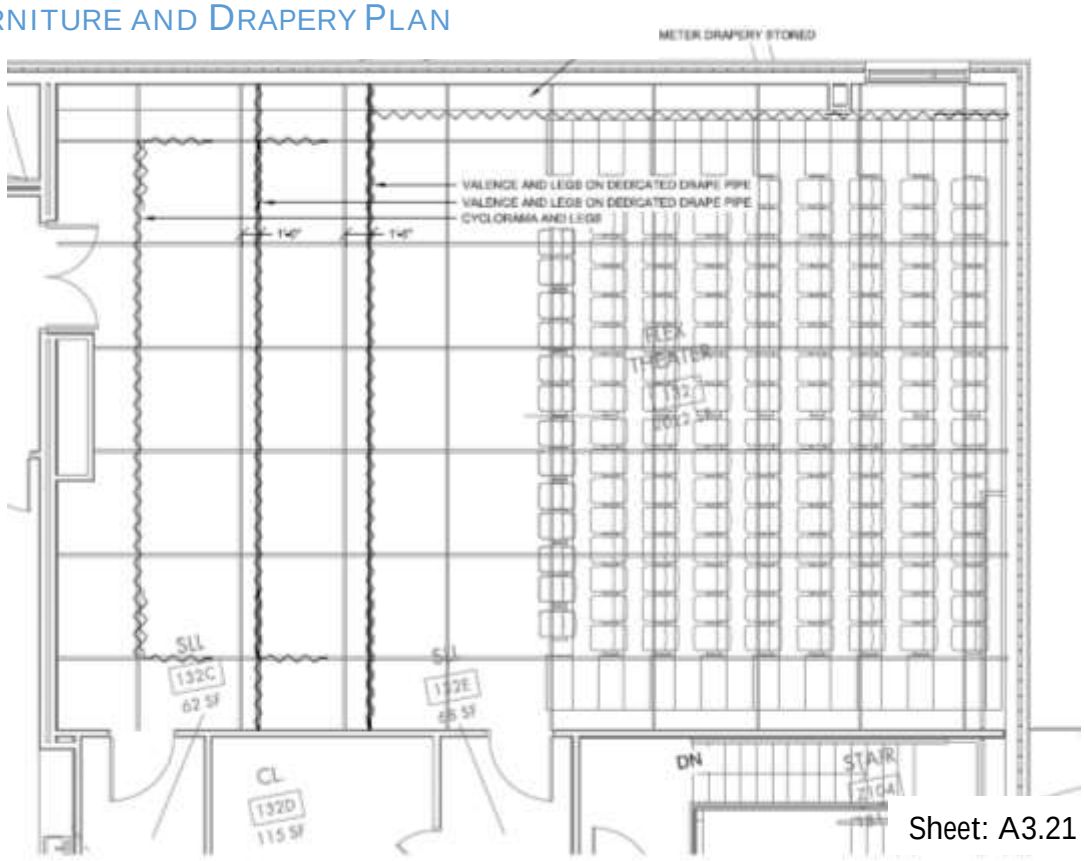
Furniture and Drapery Plan



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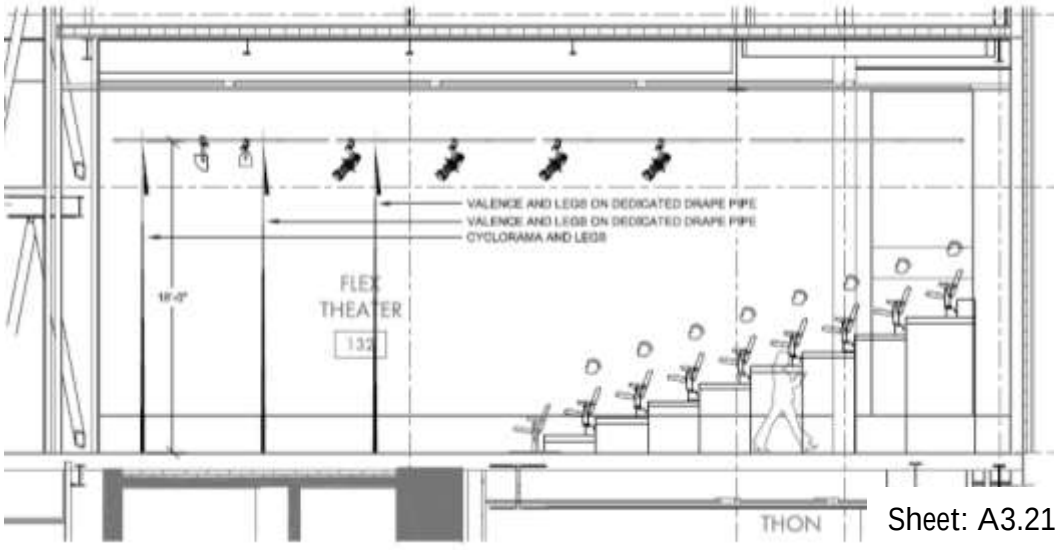
Furniture Plan



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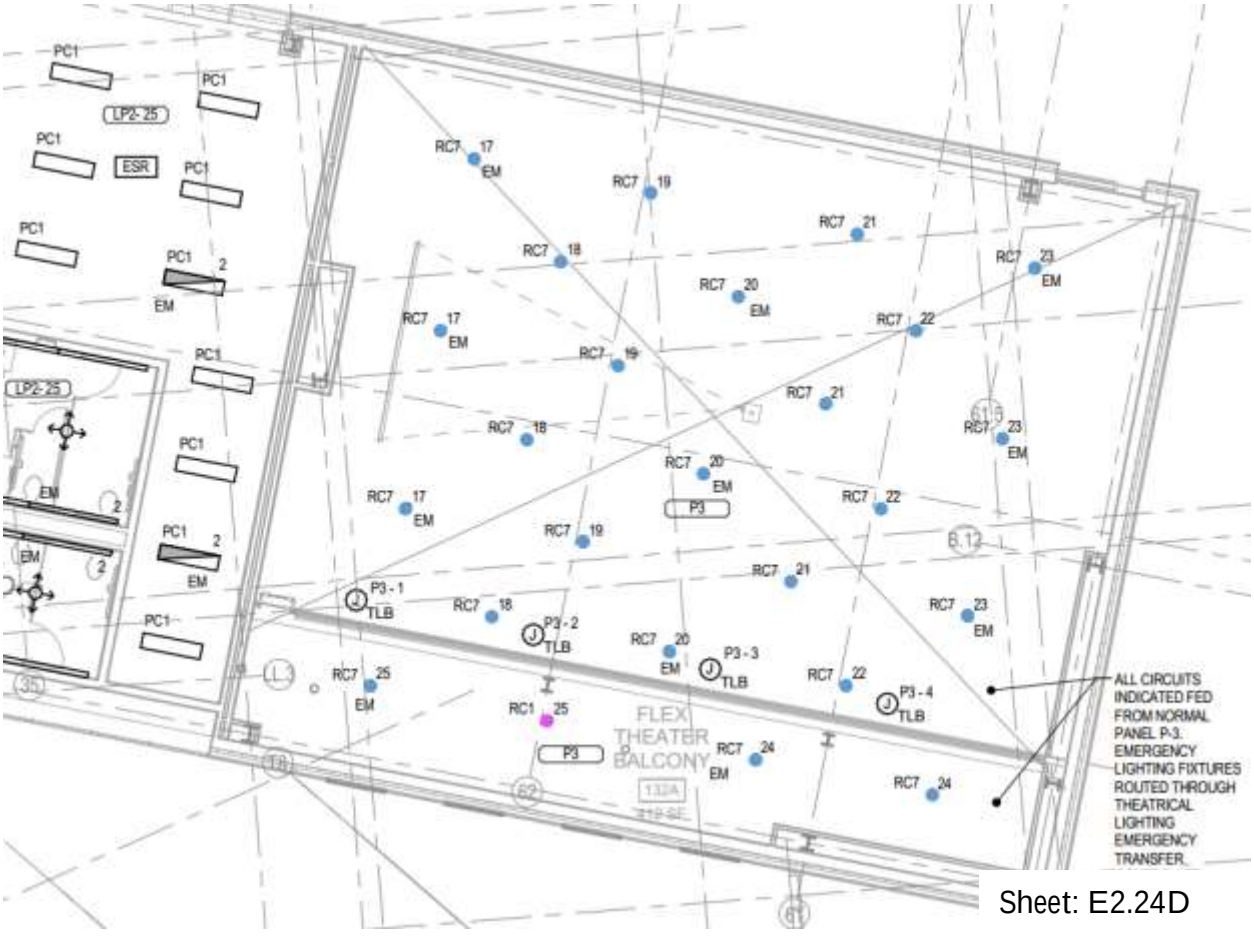
Furniture and Equipment

The theater has a capacity to seat 142 people in fixed theater seating. There is one projector that is placed on the centerline of the room. It can project on the projection screen located at the front of the room. There are also several layers of drapes to accommodate various stage areas and backdrops.

Tasks

The primary tasks in the space consist of acting and media viewing, as well as seeing the stage. This space could also be used to give presentations and the lighting redesign should account for that. In the case of presentations, it may be desired to take notes on what's being presented. The possibility of the projection screen being used as a presenting tool should also be considered and an effort to ensure adequate viewing of the speaker and screen during such time should be made.

Existing Lighting Plan



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Flex Theater Existing Lighting								
Color	Type	Description	Manu.	Model	Lamp	Mount	Watts	Voltage
	RC1	6" Downlight	Philips	Calculite	LED	Recessed	27W	120V
	RC7	6" High lumen downlight 45° beam angle	Gotham	Incito	LED	Recessed	83W	120V

The flex theater lighting comprises entirely of LED lighting for general illuminance. The Gotham recessed downlight (RC7) provides all of the general illumination in the space. The one Philips downlight (RC1) is located above the theater balcony. In addition to the general lighting, there is supplemental theatrical lighting for the various performances that may occur in the space. All fixtures in the space are dimmable using 0-10V dimming.

Controls/Drivers

For the LED fixtures specified dimming compatible drivers were specified as well. All of the LED fixtures are dimmable using 0-10V dimming. The theatrical fixtures are controlled using DMX controllers provided by ETC. Specifically, the mosaic system was specified to act as the DMX controller. The space is broken up into three zones; cue, work, and house lights.

Emergency Lighting

For emergency lighting, every other row of Gotham fixtures, starting with circuit 17, will be turned on to provide egress lighting. These rows are assumed to be on an emergency circuit, so they may operate in an emergency situation.

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Design Criteria/Considerations

Qualitative Criteria

Most Important

- Lighting the Stage
  - Actors should be adequately illuminated when on stage
  - Presenters faces should be lit so that they are seen from the back of the room
- Glare
  - Occupants of the theater should not be exposed to glare from fixtures, since this would detract from the overall experience of a performance or presentation
- Controls
  - The control system should allow for various scenes to be called up at any given time, depending on the current function of the space
  - The controls should be able to communicate with the theatrical fixtures, to the point that various cues could be set and compiled into a production
- Dimming Levels
  - Specified fixtures should be able to provide adequate light levels for occupants to navigate through the space while a performance is ongoing, while not detracting from the show itself

Not Applicable

- Daylighting
  - There are no daylight portals in the space, therefore daylighting is a nonfactor.

Psychological Impression

The chosen John Flynn impression for this space will be one of relaxation. The lower reflectances of the space lend itself to this impression and I feel that in an entertainment setting, the occupants should feel relaxed. To accomplish this, non-uniform peripheral lighting coupled with lower luminance levels will be present in the space.

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Quantitative Criteria

Recommended Horizontal Illuminance

- Classification – Hospitality and Entertainment
  - During Production
    - Category B: 2 lux (.2 fc) at floor
    - Avg/Min: 2:1
  - Pre/Post-show, Intermission
    - Category M: 100 lux (10 fc) at floor
    - Avg/Min: 2:1

Recommended Vertical Illuminance

- Classification – Hospitality and Entertainment
  - During Production
    - Category A: 1 lux (.1 fc) at floor
    - Avg/Min: 2:1
  - Pre/Post-show, Intermission
    - Category I: 30 lux (3 fc) at floor
    - Avg/Min: 2:1

LEED BD&C V4

EAP: Minimum Energy Performance Required

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

EAC: Optimize Energy Performance (Major Renovation)

- Reduce overall energy consumption by 4% - 40% for 1 – 16 points.

EQC: Interior Lighting

- For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with

at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions). For all shared multioccupant spaces, meet all of the following requirements.

- Have in place multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel).
- Lighting for any presentation or projection wall must be separately controlled.
- Switches or manual controls must be located in the same space as the controlled luminaires. A person operating the controls must have a direct line of sight to the controlled luminaires.

Energy Allowances

The following table shows the energy allowance for the flex theater space according to ASHRAE 2013 space by space method.

Energy Allowance			
Space	**Area (SF)**	**W/SF**	**Allowed Wattage**
Performing Arts Theater	2000	2.43	4860 W

ASHRAE 2013 Standards*

9.4.1.1(a),(b),(d),(e),(f),(h)

*See Appendix A for code description.

Design Criteria Selected

1) Meet ASHRAE Energy Code requirements
2) Create an impression of relaxation and comfort in the space for audience
3) Control light to meet various demands of the space
4) Provide adequate light on stage to illuminate actors and presenters
5) Meet LEED requirements

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Evaluation

Current Lighting Solution Analysis

The current lighting system is little more than downlights that flood the entire space with light. This provides a layer of uniform general illuminance on the floor and stage area. The theatrical lighting is focused to light the stage only, so it doesn't contribute much to the overall space, but rather act as a specialized layer of light for the stage. Overall, the lighting lends itself to an impression visual clarity, with all of the lighting being provided by direct overhead sources.

Methods

To generate this lighting calculation the space was modelled in AGi32. Within AGi32 light fixtures were placed into the model using the appropriate photometric files. These were placed according to the existing fixture layout. Light loss factors (LLFs) were applied to each fixture to ensure accuracy in the model. Simplified layouts and materials were used to get a baseline calculation. The fixtures used and LLFs can be found in the next section. Both a realistic and pseudo color rendering were produced using AGi32, to help better visualize what is happening within the space for analysis purposes. In addition to renders, AGi32 output various data about the lighting in the space.

Model Inputs

Lighting Fixtures Used				
Type	**Lamp**	**Qty**	**Input watt**	**Total watt**
RC1	LED, 1500 lm	1	27 W	27 W
RC7	LED, 5000 lm	24	83 W	1992 W

These are the fixtures that were input into the model with the appropriate quantities, lamps, and input wattage.

Light Loss Factors						
Type	**Lamp Lumens**		**LLD**	**LDD**	**BF**	**Total**
	Initial	**Mean**				
RC1	1500	-	0.8	0.94	-	0.752
RC7	5000	-	0.8	0.94	-	0.752

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RENDERINGS

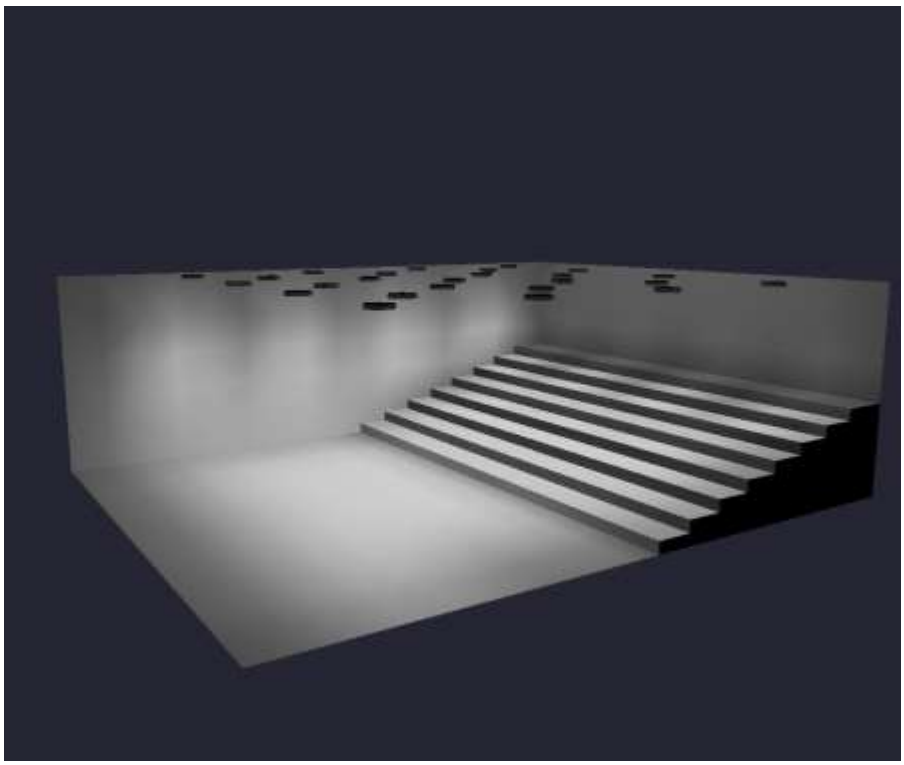

Figure 1: Flex Theater Render

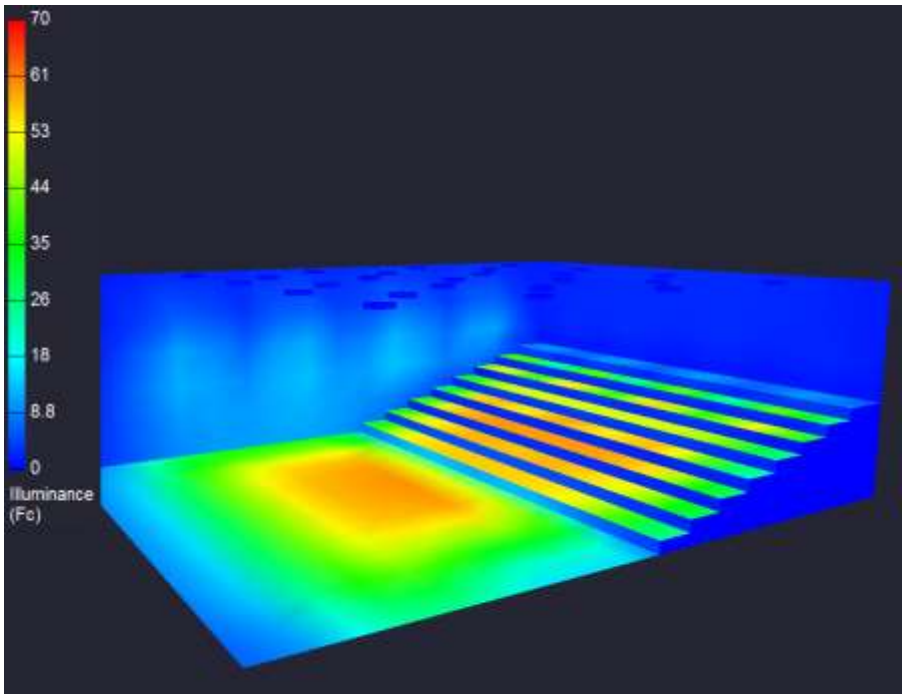

Figure 2: Flex Theater Pseudo Color Render

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Quantitative Comparison

Energy Consumption (ASHRAE/IESNA 90.1 - 2013)		
Category	**Allowable**	**Calculated**
Area (SF)	-	2000
Input Wattage	4860	2020
Power Density (W/SF)	2.43	1.01

Illuminance (FC) - Intermission		
Category	**Recommended**	**Calculated**
Avg. Eh	10	41.3
Avg. Ev	3	9.0
Max Eh	-	60.2
Min Eh	-	2.4
Avg/Min Eh	2:1	2.8:1
Max/Min Eh	-	6.2:1

Performance Analysis

The current solution is way under the LPD allowable. This is due to the fact that I didn't take into account the theatrical fixtures at this time. They were not made available in the drawings I was given and I don't have the knowledge to estimate what they might be. My guess is that once those fixtures are included the LPD will be much closer to the allowable. This won't affect the house lighting, however, since both the systems wouldn't be on at the same time consistently. Just considering the house lighting, the codes for ASHRAE 2013 are not only met but exceeded.

The illuminance values within the space exceeded the IES recommendations in all but one case. The space is really bright according to the intermission values that IES recommends. Glare shouldn't be an issue due to the 45° cutoff of the fixture.

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Areas of Improvement

The lighting in the space could be a little more uniform. The current solution doesn't quite get to the back row of bleachers. The space could also use something to create visual interest and perhaps play with the materials in the space. Overall the light levels could probably be reduced to save energy as well.

Circulation Space | Large Atrium

Existing Conditions

The atriums primary use is seating, for the food area, and circulation. This space connects the east entrances as well as the parking deck traffic to the rest of the HUB. There is also a gathering space that connects the 1st floor to the mezzanine level, which features both stairs and bleacher style seating. At times of lower traffic, it could act as a gathering space as well for various clubs or other student activities. There is an abundance of daylight through the exterior gazing and skylight aperture.

Dimensions

Area – 3800 ft^2

Approximate width – 78 ft

Approximate length – 165 ft

Approximate ceiling height – 38 ft

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Floor Plan

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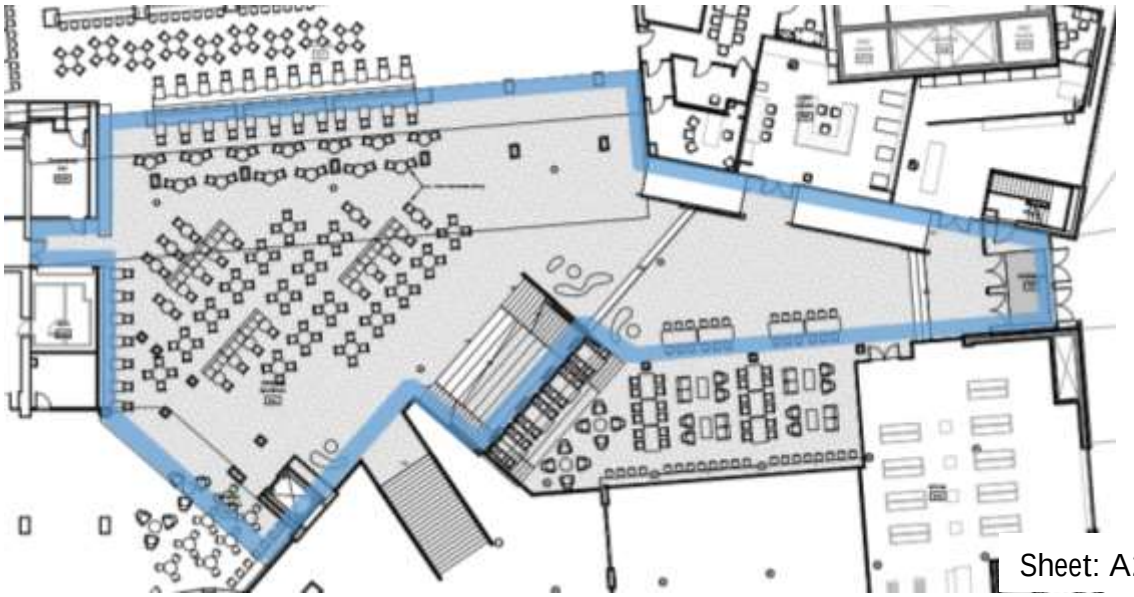
Enlarged Floor/Furniture Plan



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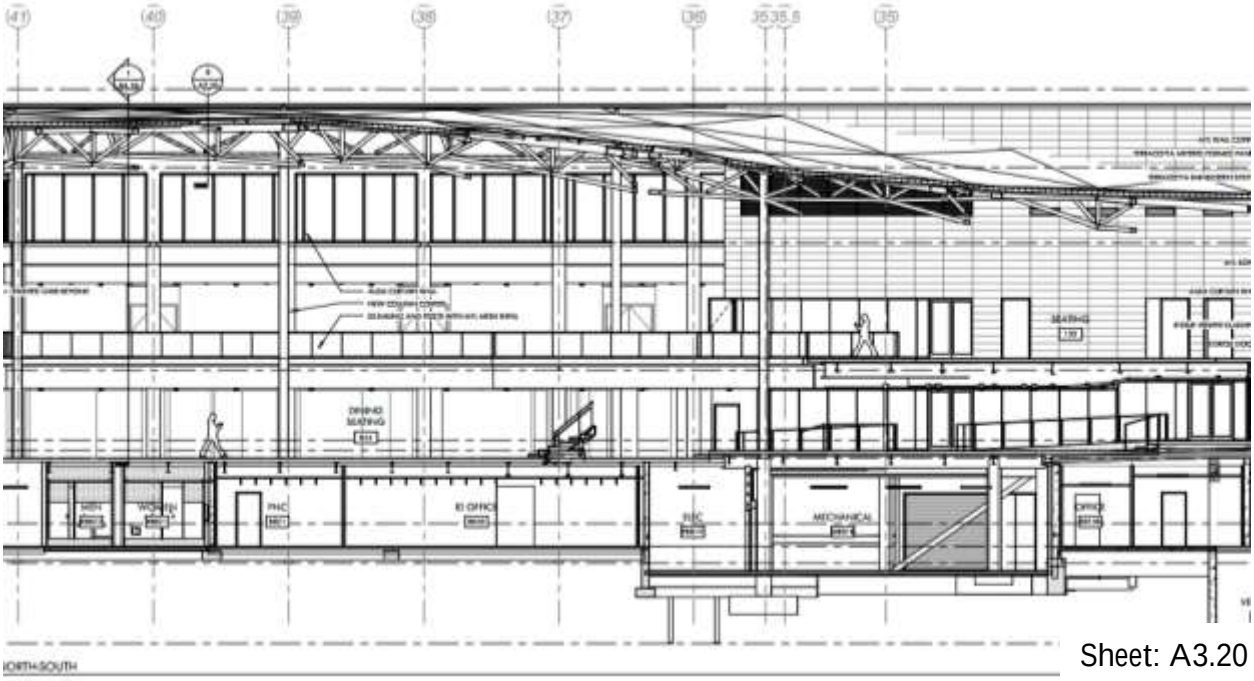
North South Section



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Finishes

The floors are made up of terrazzo tiles that have a high reflectance to aid daylights contribution deep in the space. The walls are primarily painted gypsum wall board, but also consist of terracotta and glazing. The terracotta blocks vary from smooth to grooved at a ratio of 4:1. The curtain walls range in opacity from completely clear to partially obscured due to the presence of frit on the upper panels. The ceiling is exposed steel panels mixed with glass skylight panels, which also contain frit.

Atrium Materials				
Surface	**Material**	**Description**	**Color**	**Reflectance(ρ)**
Ceiling	GSRD	3" Galvanized steel roof deck	Eggshell	0.85
Wall	GWB/PTD, GCW	Painted gypsum and aluminum framed curtain wall	Eggshell	0.91
Floor	Terr	Terr	Eggshell	0.85

Glazing

The glazing spanning the north, west, and south side is comprised of low-E glass. Frit is introduced in the panels on the mezzanine floor and increases in density as they get closer to the ceiling. The visibility ranges from roughly 70% to 50% transmittance.

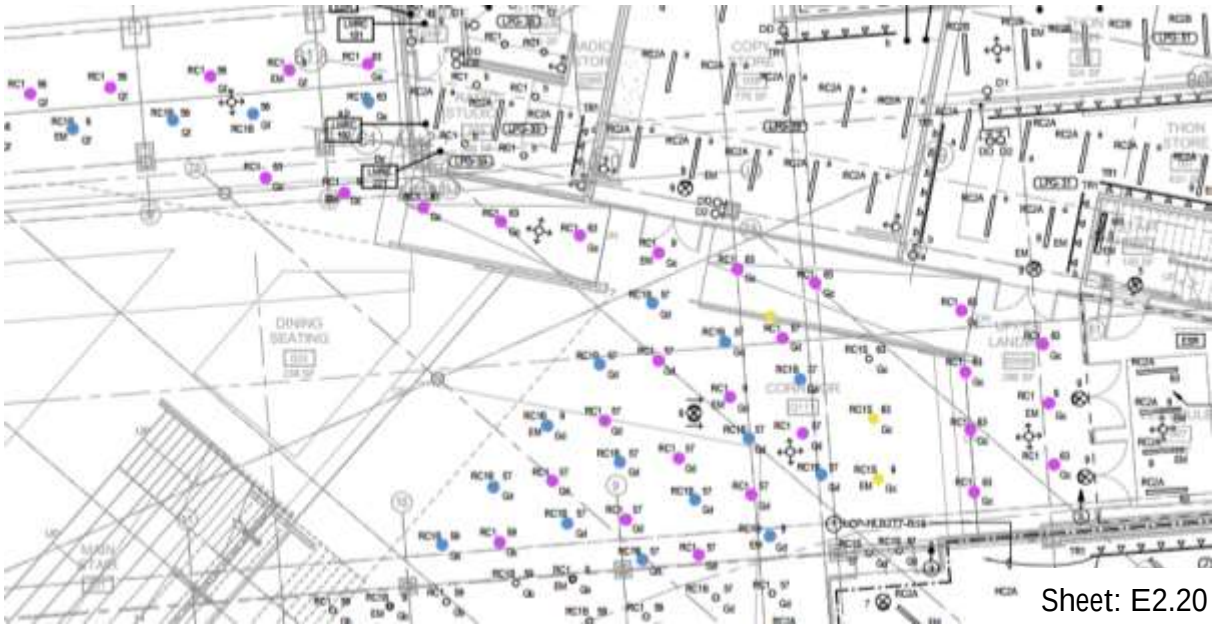
Furniture and Equipment

This area needs to accommodate a wide variety of uses, from collaboration space to dining areas. The solution was to have mobile furniture to allow this to be a dynamic space, shaped by its occupants. Most of the tables and chairs are free to move about the space with the exception of a few fixed raised restaurant style benches. On the north western end of the space is a line of fixed benches that act to separate this space from the food court area.

Tasks

The atrium's main purpose is a transition space and entrance to the building, linking several entrances to the main portion of the building. Because of this way-finding is paramount in this area. Reading and eating will also be occurring within the atrium, as well as general conversation.

Ground Floor Lighting Plan



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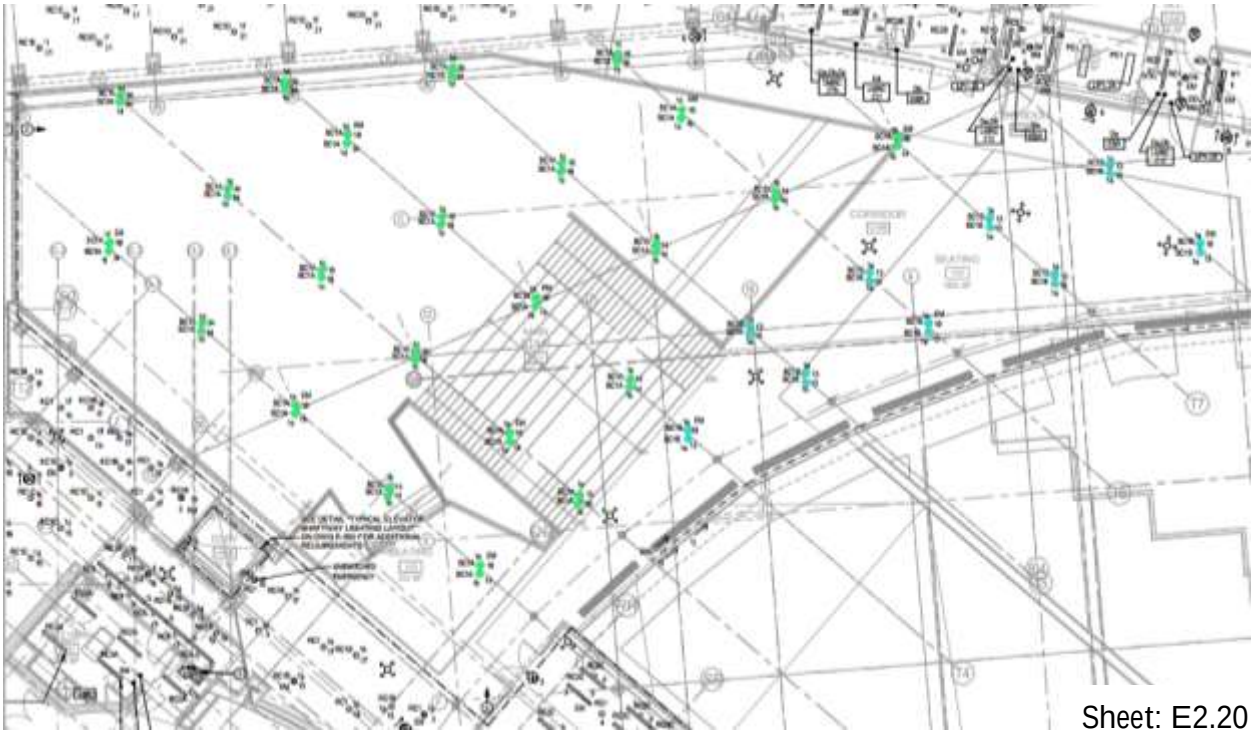
Atrium Lighting Plan



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Flex Theater Existing Lighting								
Color	Type	Description	Manu.	Model	Lamp	Mount	Watts	Voltage
	RC1	6" Downlight	Philips	Calculite	LED	Recessed	27W	120V
	RC1B	6" Downlight with glass trim	Philips	Calculite	LED	Recessed	27W	120V
	RC1S	6" Downlight with sloped ceiling adapter	Philips	Calculite	LED	Recessed	27W	120v
	SC1A	6" High output downlight	Gotham	Incito	LED	Surface Mounted	101W	120V
	SC1B	6" Medium output downlight	Gotham	Incito	LED	Surface Mounted	40W	120V

The atrium lighting consists entirely of LED fixtures, which lend themselves to efficiency. The CCT was kept at 3500K throughout the space, so there would be uniformity in that aspect. Due to the amount of natural light in the space, all of these fixtures are able to dim based on the amount of daylight coming into the space.

The punch of the Gotham fixtures allows them to be suspended from the steel trusses and provide most of the general illumination throughout the main concourse. The Philips fixtures supplement underneath the mezzanine level, where a high bay fixture would be too much light.

Controls/Drivers

All LED fixtures in the space require a driver. This driver must support dimming, since the fixtures will be dimmed according to the abundance of natural light in the space. The method of dimming is 0-10V.

There is a timeclock that turns on the exterior pathway lighting before dusk. During this time walkway lighting will dim to preset levels. Occupancy sensors dim or turn off fixtures when there are no occupants nearby during the evening. During the day, there is an open loop photocell that will determine the amount of daylight in the space and dim the three zones of electric light accordingly. All lighting as manual controls as well.

Emergency Lighting

Various light fixtures are designated as emergency lighting to help light a path of egress in an emergency. There are also exit signs to aid occupants in finding their way out of the building.

Design Criteria

Qualitative Criteria

Most Important

- Way-Finding

- Since this is a major entrance area to the building it might be difficult for occupants to orient themselves at first. The lighting should help alleviate this as much as possible.

❖ Daylighting Controls
- Since daylighting is so abundant throughout the space, the lighting within the space should respond accordingly, allowing for increased energy savings.

❖ Overall Appearance of Space
- The lighting should enhance the architecture and provide a nice environment for occupants to come into as they enter the building.

❖ Glare Control
- Due to the extensive use of glass in the space, it is imperative that glare from the sun be controlled. This is especially important for the southern and southwestern facades.

Important

❖ Color Rendering
- The light sources in the space should render colors in a natural and pleasing manner.

Psychological Impression

The Flynn mode that I feel is most appropriate for a redesign of this space would be one of spaciousness and clarity.

Quantitative Criteria

Recommended Horizontal Illuminance

❖ Classification – Educational Facilities
- Auditoria, No AV
  - Category R: 500 lux (50 fc) at 2.5'
  - Avg/Min: 3:1

Recommended Vertical Illuminance

❖ Classification – Hospitality and Entertainment
- Auditoria, No AV
  - Category O: 200 lux (20 fc) at floor

- Avg/Min: 3:1

LEED

EAP: Minimum Energy Performance Required

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

EAC: Optimize Energy Performance (Major Renovation)

- Reduce overall energy consumption by 4% - 40% for 1 – 16 points.

EQC: Interior Lighting

- For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions). For all shared multioccupant spaces, meet all of the following requirements.
  - Have in place multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel).
  - Lighting for any presentation or projection wall must be separately controlled.
  - Switches or manual controls must be located in the same space as the controlled luminaires. A person operating the controls must have a direct line of sight to the controlled luminaires.

EQC: Daylight

- Demonstrate through annual computer simulations that spatial daylight autonomy300/50% (sDA300/50%) of at least 55%, 75%, or 90% is achieved. Use regularly occupied floor area. Healthcare projects should use the perimeter area

determined under EQ Credit Quality Views.

EQC: Quality Views

- Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area. View glazing in the contributing area must provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

Additionally, 75% of all regularly occupied floor area must have at least two of the following four kinds of views:

- multiple lines of sight to vision glazing in different directions at least 90 degrees apart;
- views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing;
- unobstructed views located within the distance of three times the head height of the vision glazing; and
- views with a view factor of 3 or greater, as defined in "Windows and Offices; A Study of Office Worker Performance and the Indoor Environment."

Energy Allowances

The following table shows the energy allowance for the atrium according to ASHRAE 2013 space by space method. The watts per square foot is equal to the height (38') times 0.03 W/ft to give you 1.14 W/SF.

Energy Allowance			
Space	**Area (SF)**	**W/SF**	**Allowed Wattage**
Atrium	3800	1.8	6840 W

ASHRAE 2013 Standards

9.4.1.1(a),(b),(d),(e),(f),(h)

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Design Criteria Selected

1) Meet ASHRAE Standards
2) Implement daylighting controls
3) Control glare
4) Create a visually pleasing environment
5) Meet LEED criteria

Evaluation

Current Lighting Solution Analysis

The lighting in the lobby provides rather uniform illuminance throughout the space, as I've observed. The fixtures themselves are tucked away within the structure and ceiling, concealing them from anyone who isn't looking for them. The space is very bright both during the day and evening hours. There is a large amount of daylight coming into the space through all of the glazing. Glare doesn't seem to be too much of an issue, due to the extensive use of frit in key glass panels. The curtain walls offer interesting views of College Avenue and the HUB lawn, as well as the green roof over the book store. Due to the exclusive use of downlights, one would get the impression of clarity and perhaps spaciousness. The high reflectivity in the space helps brighten everything up even when no daylight is present. There isn't much of a hierarchy in the space created by the lighting.

Quantitative Comparison

Lighting Fixtures Used				
Type	**Lamp**	**Qty**	**Input watt**	**Total watt**
SC1A	LED, 6500 lm	46	101 W	4646 W
SC1B	LED, 2500 lm	18	40 W	720 W
RC1	LED, 1500 lm	31	27 W	837 W
RC1B	LED, 1500 lm	18	28 W	486 W
RC1S	LED, 1500 lm	3	29 W	81 W

Energy Consumption (ASHRAE/IESNA 90.1 - 2013)		
Category	**Allowable**	**Calculated**
Area (SF)	-	3800
Input Wattage	6840	6770
Power Density (W/SF)	1.8	1.78

The allowable power density was calculated by adding the allowable LPD for atriums, 1.14, and adding the allowable LPD for corridors, 0.66.

Performance Analysis

The current lighting solution is straight forward and gets the job done. A high illuminance level is achieved throughout the space in a uniform manner. Signage helps occupants navigate to other parts of the building effectively. The high bay fixtures are a logical choice for the ceiling height and the recessed downlights under the mezzanine are a common solution for low ceiling applications as well.

ASHRAE 90.1 – 2013 Standards are met in the atrium space. The use of a photocell to dim zones of fixtures based on available daylight helps the design become more energy efficient. This is important since the current design at full output is rather close to the maximum power density. The automatic dimming based on occupancy after hours helps drive the energy usage down further in the evening hours. All LEED credits are applicable in this space, especially daylighting and views.

Areas of Improvement

The height change between the corridor and atrium could be used in some way to add interest in the space and perhaps have contrasting psychological impressions. A different design approach for underneath the mezzanine should be investigated to cut down on the current energy usage and add some interest to the space, as well as help with way-finding. The grand stair case could also be used to establish a hierarchy in the space and be a feature and landmark to help ground the large space.

With the large amount of glass in the space, daylighting is a very important factor. The current control scheme is effective and should be used in the redesign of the space. Alternative solar

shading device could be purposed to try and create a more dynamic facade that's able to adapt to the shifting daylight conditions throughout the day and year. The views should be maintained or enhanced if possible.

Outdoor Space | Green Roof and Surroundings

Existing Conditions

The green roof consists of two parts, an occupiable and non-occupiable portion. The non-occupiable is primarily typical green roof plantings of low hardy plant life with gravel paths for maintenance. The occupiable portion is designated by a hardscaped area in the northern corner. It features perimeter seating and direct building access. The surrounding areas consist of sidewalks with plant beds on either side.

Dimensions

Area of grounds (occupiable) – 4700 ft^2

Approximate width of site – 60 ft

Approximate length of site – 130 ft

Finishes and Glazing

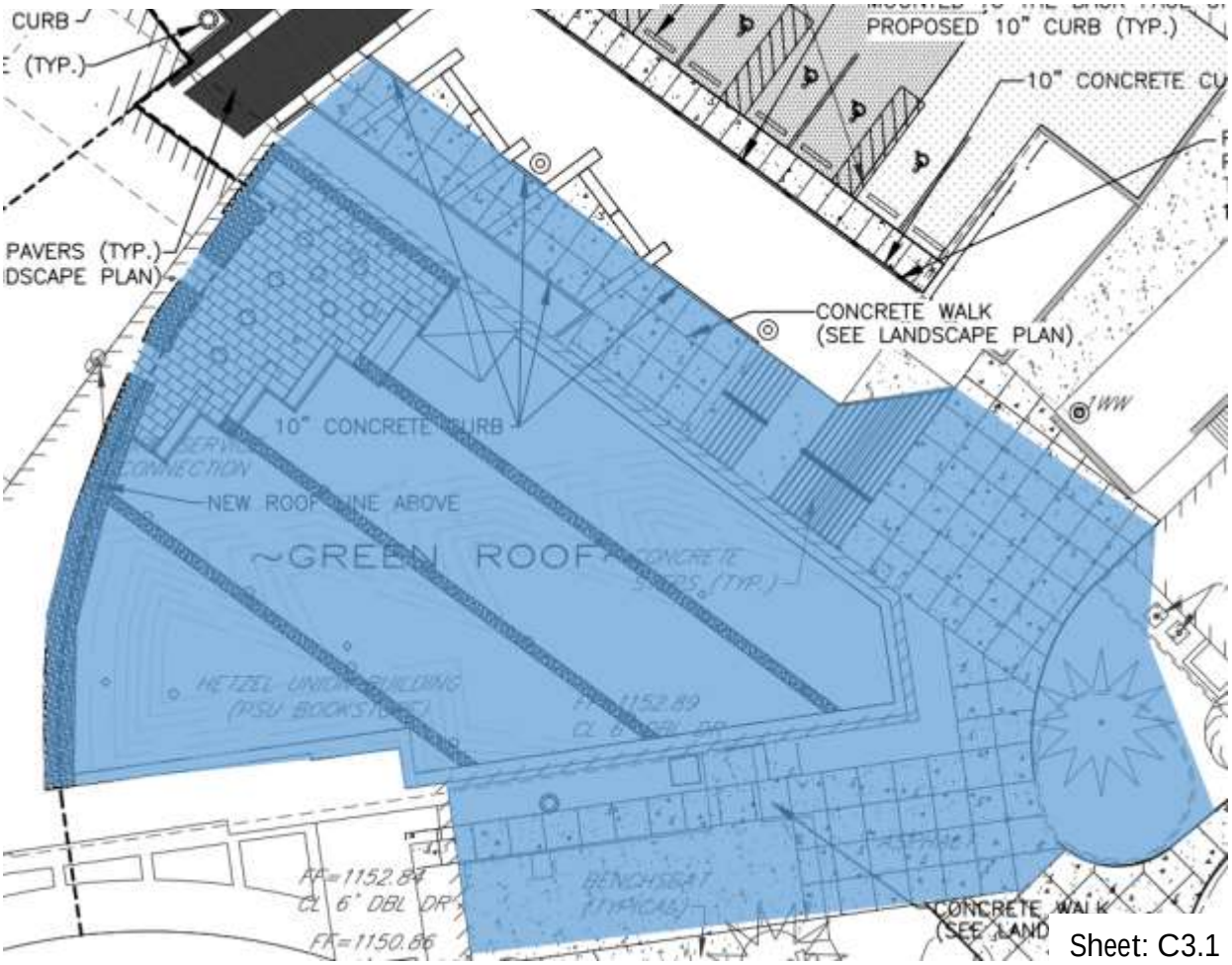
The façade consists of two materials, terracotta bricks and aluminum curtain wall. The terracotta bricks are one of two kinds, smooth or grooved. The pavers that make up the occupiable area are made of granite and the sitting walls are poured concrete. The curtain wall glazing is the same low-e glass as the atrium space (see atrium finishes). The pedestrian walkways are also made of concrete.

Green Roof & Site Materials

Surface	Material	Description	Color	Reflectance(ρ)
Exterior Walls	Terra/ACW	Terracotta Panels and aluminum curtain wall	Red	0.41
Site	Cnt	Poured concrete	Gray	0.4
Green Roof	Pavers	4" x 8" pavers	Grey	0.4

Tech Report 1

Site Plan



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Plantings

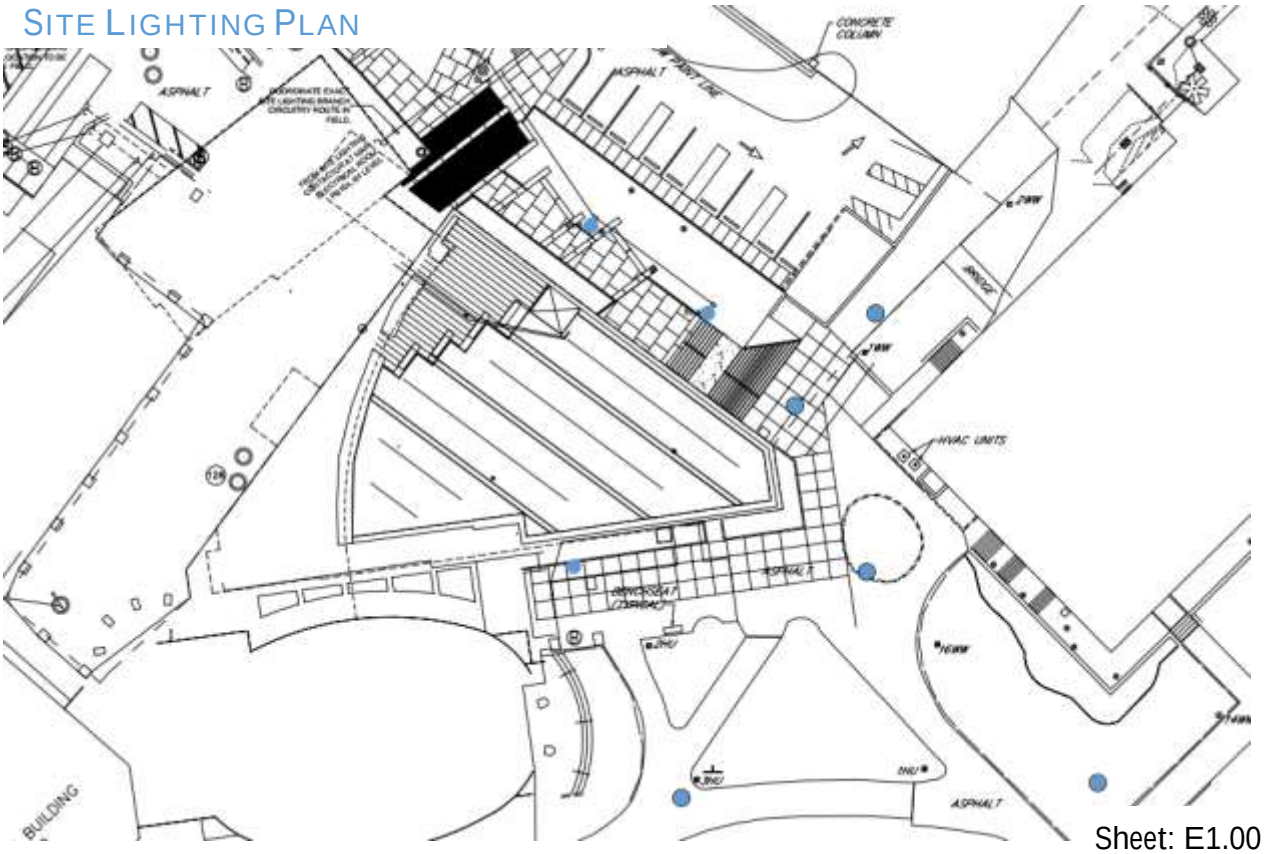
There are a variety of plantings that will be used throughout the site and on the green roof. The main types of trees that will be planted are the blackgum, eastern redbud, and pagoda dogwood trees. The green roof will be home to stonecrop, gold sedum, dragon's blood sedum, and southern stonecrop to name a few.

Tasks

Way-finding and security in the evening hours are very important on the pathways. The outdoor lighting should ensure that pedestrians can not only navigate the area, but feel safe while doing

so. The entrances into the space should also be made apparent through lighting. The green roof will primarily be a gathering space.

Site Lighting Plan



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Site Lighting Fixtures								
Color	Type	Description	Manu.	Model	Lamp	Mount	Watts	Voltage
	SC-A	Ceramic metal halide low profile conical shaped fixture	Louis Poulson	KIPP	HID	Pole Mounted	120W	277V

Following OPP standards, the site lighting will be done by the Louis Poulson KIPP fixture. This fixture has a symmetrical type V distribution provides glare free illumination. This fixture is also vandal resistant. The light source is a ceramic metal halide with a CRI of at least 92 and a CCT of 4000K.

Controls/Ballasts

The outdoor lighting will be controlled by a time clock that will turn the lights on at dusk and off at dawn. The ballasts will be electrical high BF to cut down on harmonics.

Design Criteria/Considerations

Qualitative Criteria

Very Important

- Adequate lighting of area
  - Lighting the area to appropriate levels to ensure safety and security of the building and pedestrians
  - Provide lighting for green roof area such that it can be occupied during evening hours

Important

- Provide interest to the space
  - Lighting some of the architectural features on the façade may add interest to the area and enhance the visual experience of bystanders
- Continuity of existing lighting
  - To ensure a smooth transition from outside areas fixtures specified should comply with campus codes and design practices

Psychological Impression

The goal of the lighting redesign is to create a space that follows the Flynn impression of privacy and relaxation, promoting a tranquil and calm atmosphere on the green roof. This will be done by providing non-uniform peripheral lighting with lower illuminances.

Quantitative Criteria

Recommended Horizontal Illuminance

- Classification – Common Applications
  - Building Entries, Canopied entries/exit, medium activity, LZ2
    - Category F: 10 lux (1 fc) at ground

        - Avg/Min: 2:1
    - Building Entries, Canopied entries/exit, medium activity, LZ2
        - Category C: 4 lux (.4 fc) at ground
        - Avg/Min: 3:1

Recommended Vertical Illuminance

- Classification – Hospitality and Entertainment
    - During Production
        - Category B: 2 lux (.2 fc) at floor
        - Avg/Min: 2:1
    - Pre/Post-show, Intermission
        - Category M: 50 lux (5 fc) at floor
        - Avg/Min: 2:1

LEED

SSC: Light Pollution Reduction

- Meet uplight and light trespass requirements, using either the backlight-uplight-glare (BUG) method (Option 1) or the calculation method (Option 2). Projects may use different options for uplight and light trespass

Meet these requirements for all exterior luminaires located inside the project boundary (except those listed under "Exemptions"), based on the following:

- the photometric characteristics of each luminaire when mounted in the same orientation and tilt as specified in the project design; and
- the lighting zone of the project property (at the time construction begins). Classify the project under one lighting zone using the lighting zones definitions provided in the Illuminating Engineering Society and International Dark Sky Association (IES/IDA) Model Lighting Ordinance (MLO) User Guide.

EAP: Minimum Energy Performance Required

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

EAC: Optimize Energy Performance (Major Renovation)

- Reduce overall energy consumption by 4% - 40% for 1 – 16 points.

Model Lighting Ordinance

Energy Allowances

The following table shows the energy allowance for the outdoor space according to ASHRAE 2013 Table 9.4.2-2.

Energy Allowance			
Space	**Area (SF)**	**W/SF**	**Allowed Wattage**
Outdoor area	4700	0.16	752 W
Façade	3640	0.15	546 W

ASHRAE 2013 Standards

9.4.1.4

Design Criteria Selected

1) Create a safe outdoor environment with proper lighting
2) Meet ASHRAE energy code requirements
3) Limit uplight to comply with MLO and limit light pollution
4) Meet LEED requirements

Evaluation

Current Lighting Solution Analysis

The current outdoor lighting along the pedestrian pathways does a reasonable job of creating a secure feeling area at night. Other than functionality, however, it doesn't add much else to the building. All new construction projects on campus feature the same outdoor fixtures, but there is

no real emotional response generated by the current layout. Some highlighting of the façade or the solar shading devices on the southern façade of the bookstore could add interest to the space. These options will be explored in later assignments. The green roof currently has no lighting layout making it a blank slate.

Quantitative Comparison

Lighting Fixtures Used				
Type	**Lamp**	**Qty**	**Input watt**	**Total watt**
SC-A	120 W CMH	5	120	600 W

*Only 5 fixtures were considered to be on-site

Performance Analysis

The current exterior lighting solution does provide adequate light levels for one to feel safe and secure, due to the distribution of the fixtures lighting the vertical plan and beyond the walkways.

Energy Consumption (ASHRAE/IESNA 90.1 - 2013) - Façade		
Category	**Allowable**	**Calculated**
Area (SF)	-	3800
Input Wattage	546	0
Power Density (W/SF)	0.15	0.00

Energy Consumption - Green Roof and Grounds		
Category	**Allowable**	**Calculated**
Area (SF)	-	4700
Input Wattage	752	600
Power Density (W/SF)	0.16	0.13

These fixtures are also very good at not projecting a lot of uplight, helping to avoid light pollution. Light trespass doesn't seem to be an issue due to the tight cut offs of the fixture. The ASHRAE Standards are met with a little room to spare for additional fixtures if needed. The design does little in the way of aesthetics with function being the primary concern. Since all the

outdoor lighting is on timers it not only meets ASHRAE codes, but could earn some LEED credits as well.

Areas of Improvement

Although the system performs up to standards there is room for improvement in the outdoor lighting. The façade of the building, the overhang, and the façade itself could be used to create some interest for in the area and perhaps help with way-finding. The green roof currently has no lighting at all as well. There are various things that could be done to integrate the lighting on the green roof with the façade and site lighting, strengthening their connection.

Large Work Space | Bookstore

Existing Conditions

The bookstore is a large open retail area. The entrance is open to the second story, creating a clear entryway into the space. Most of the products are on the first floor with the book section in a separate space in the back. The mezzanine level has a small library and reading area. The southern façade sports floor to ceiling windows that have solar shading louvers attached to the outside.

Dimensions

Area – 22000 ft^2

Approximate width – 136 ft

Approximate length – 200 ft

Approximate height – 20 ft from 1st to ceiling and 9 ft from 1st to mezzanine

Floor Plan

Sheet: A2.11D

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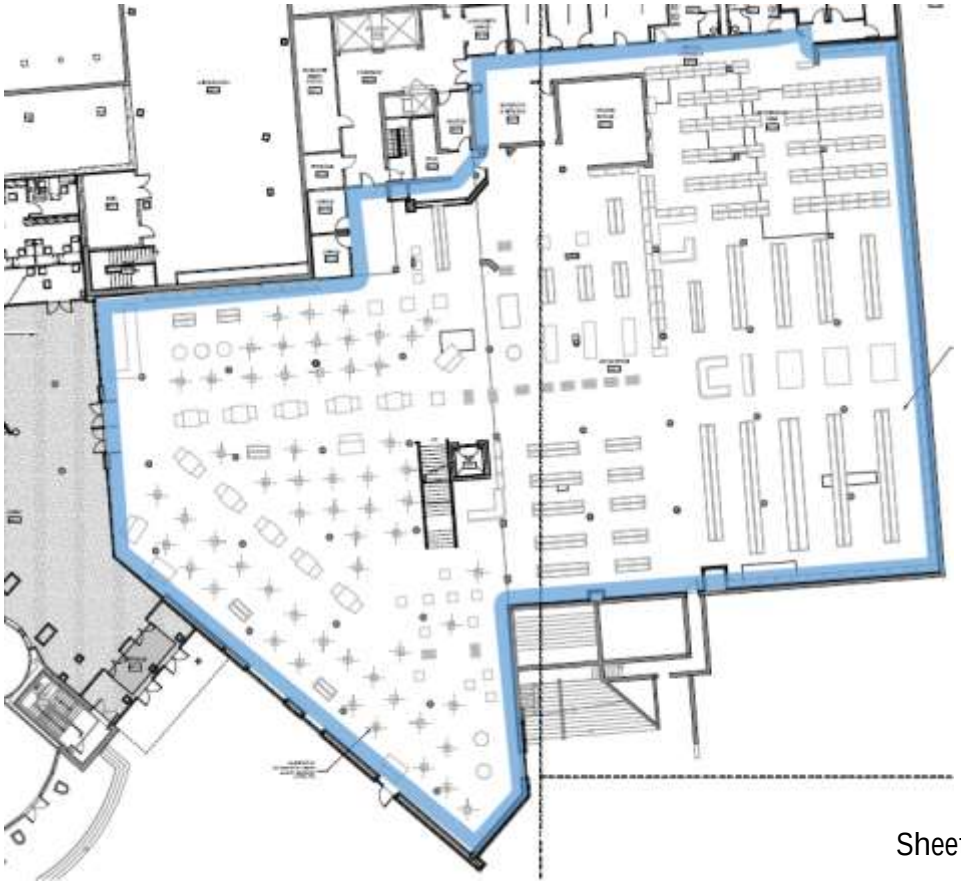
Enlarged Floor/Furniture Plan



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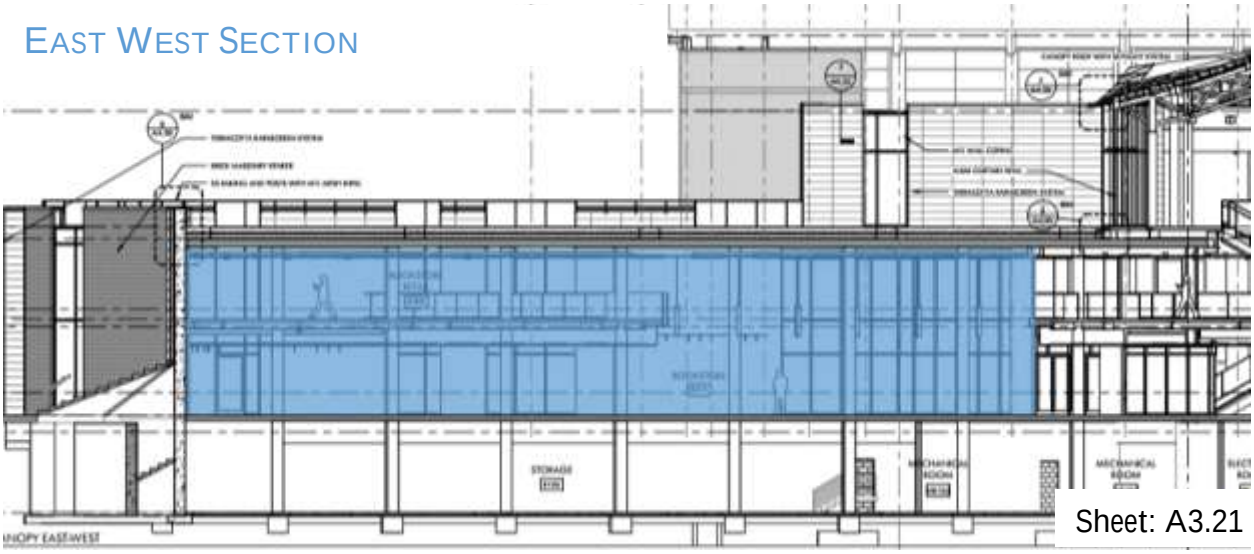
East West Section



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Finishes

The bookstore has two levels, the main level and mezzanine. Both floors have a mix of carpet, wood, and tile flooring. The walls are a grey painted GWB and glazing. The ceiling is made up entirely of acoustic ceiling tile for both the main and mezzanine floor.

Bookstore Materials				
Surface	**Material**	**Description**	**Color**	**Reflectance(ρ)**
Floor	CPT TILE, WD, LIN	Carpet tile, wood, and linoleum	Grey, white	.19*
Exterior Walls	GWB/PTD	Painted gypsum wall board	Grey	0.37
Ceiling	ACT-1	4" x 8" pavers	Eggshell	0.4

*This is a combination of all floor materials

Glazing

The glazing consists of floor to ceiling low-e clear insulated glass. These units have a visibility of 74%. The upper third of the windows have solar shading louvers that help project light deeper into the space, while preventing direct glare.

Furniture/Equipment

The majority of furniture in the main retail area are racks and shelves for apparel, supplies, and other Penn State merchandise. The bookstore portion has a main counter and shelves for books. The mezzanine level furniture is similar to the bookstore.

Tasks

The bookstore is primarily a retail space, so browsing and shopping will be the two major tasks in the space. The clerks will need to be able to read and write, as well as use computers.

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Lighting Plan

Sheet: E2.21D

Flex Theater Existing Lighting								
Color	Type	Description	Manu.	Model	Lamp	Mount	Watts	Voltage
	TR2	LED track fixture	Lightolier	Alcyon	LED	Recessed	23W	120V
	PC2	8" Diameter cylidrical fluorescent pendent	Visa Lighting	Sequence	(2) T8	Pendent	70W	MVOLT
	RC2A	4"x4' linear troffer	Axis	Beam4	LED	Recessed	55W	120v
	HC2A	4"x4' linear troffer	Axis	Beam4	LED	Recessed	55W	277V
	HC5	4' Linear wall washer	Axis	Beam4	LED	Recessed	43W	277V

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The main source of illuminance is the HC2A linear fixture. RC2A fixtures are sprinkled in and also act as the emergency lighting. The perimeter walls are lit by either the PC2 track fixture, on the main retail floor, or by the HC5 linear wall washer, in the bookstore. The entrance area not covered by the mezzanine features the PC2 cylindrical pendant in addition to the linear troffers.

Controls/Ballasts/Drivers

Electronic T8 ballasts with 0 – 10V dimming are used in the pendent fixtures. The LED fixtures all have 0-10V dimming drivers as well.

Emergency Lighting

RC2A fixtures provide the emergency lighting for the bookstore space. They are scattered throughout the room.

Design Criteria/Considerations

Qualitative Criteria

Very Important

- Direct glare
    - Glare from daylight should be controlled to create a positive, non-disruptive, and comfortable space for occupants and customers.
- Daylighting controls
    - The controls in the space should react to the amount of sunlight, thus saving energy and not over lighting the space.

Important

- Aesthetics
    - The fixtures in the space should add to and enhance the architecture, rather than take away from it. Clutter should be avoided and overall fixture appearance should be considered.
- Hierarchy

- It may be desired to highlight merchandise using light, making it stand out from the surroundings.

Psychological Impression

The bookstore is a public space and the psychological impression should reflect that. The lighting redesign will focus on making this space feel spacious using peripheral lighting and uniform high levels of general illumination.

Quantitative Criteria

Recommended Horizontal Illuminance

- Classification – Retail
  - General Retail
    - Category R: 500 lux (50 fc) at 2.5'
    - Avg/Min: 3:1

Recommended Vertical Illuminance

- Classification – Retail
  - General Retail
    - Category M: 100 lux (10 fc)
    - Avg/Min: 6:1

LEED

EAP : Minimum Energy Performance Required

- Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

EAC: Optimize Energy Performance (Major Renovation)

- Reduce overall energy consumption by 4% - 40% for 1 – 16 points.

EQC: Interior Lighting

- For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions). For all shared multioccupant spaces, meet all of the following requirements.
  - Have in place multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel).
  - Lighting for any presentation or projection wall must be separately controlled.
  - Switches or manual controls must be located in the same space as the controlled luminaires. A person operating the controls must have a direct line of sight to the controlled luminaires.

EQC: Daylight

- Demonstrate through annual computer simulations that spatial daylight autonomy300/50% (sDA300/50%) of at least 55%, 75%, or 90% is achieved. Use regularly occupied floor area. Healthcare projects should use the perimeter area determined under EQ Credit Quality Views.

EQC: Quality Views

- Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area. View glazing in the contributing area must provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

Additionally, 75% of all regularly occupied floor area must have at least two of the following four kinds of views:

  - multiple lines of sight to vision glazing in different directions at least 90 degrees apart;
  - views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing;

- unobstructed views located within the distance of three times the head height of the vision glazing; and
- views with a view factor of 3 or greater, as defined in "Windows and Offices; A Study of Office Worker Performance and the Indoor Environment."

Energy Allowances

The following table shows the energy allowance for the bookstore according to ASHRAE 2013 space by space method.

Energy Allowance			
Space	**Area (SF)**	**W/SF**	**Allowed Wattage**
Bookstore	22000	1.44	31680 W

ASHRAE 2010 Standards

9.4.1.1(a), (b), (d), (e), (f), (i)

Design Criteria Selected

1) Meet ASHRAE Standards
2) Implement daylighting controls
3) Create a hierarchy within the space
4) Control glare and daylight
5) LEED credits

Evaluation

Lighting Design Analysis

The lighting is the bookstore provides high light levels that allows occupants to peruse the wares and clerks to carry out their tasks. The walls are highlighted by specific point source or wall washing fixtures. The daylight filters into the space without being too harsh, due to the louvres bouncing the daylight into the space. The main space feels open and comfortable, however, the

bookstore portion can feel sterile due to the high illuminance and extensive use of high reflectance materials.

Method/Process

Same as flex theater space. (See page 13)

Model Inputs

Lighting Fixtures Used				
Type	**Lamp**	**Qty**	**Input watt**	**Total watt**
PC2	LED, 1500 lm	31	70	2170
TR2	LED, 1200 lm	24	23	552
HC2A	LED, 1000 lm	208	55	11440
RC2A	LED, 1000 lm	62	55	3410
HC5	2 T8	35	43	1505

Light Loss Factors						
Type	**Lamp Lumens**		**LLD**	**LDD**	**BF**	**Total**
	Initial	**Mean**				
PC2	1500	-	0.8	0.94	-	0.752
TR2	1200	-	0.8	0.94	-	0.752
HC2A	1000	-	0.8	0.94	-	0.752
RC2A	1000	-	0.8	0.94	-	0.752
HC5	2800	2500	0.8	0.94	0.8	0.6016

These are the fixtures that were input into the model with the appropriate quantities, lamps, and input wattage.

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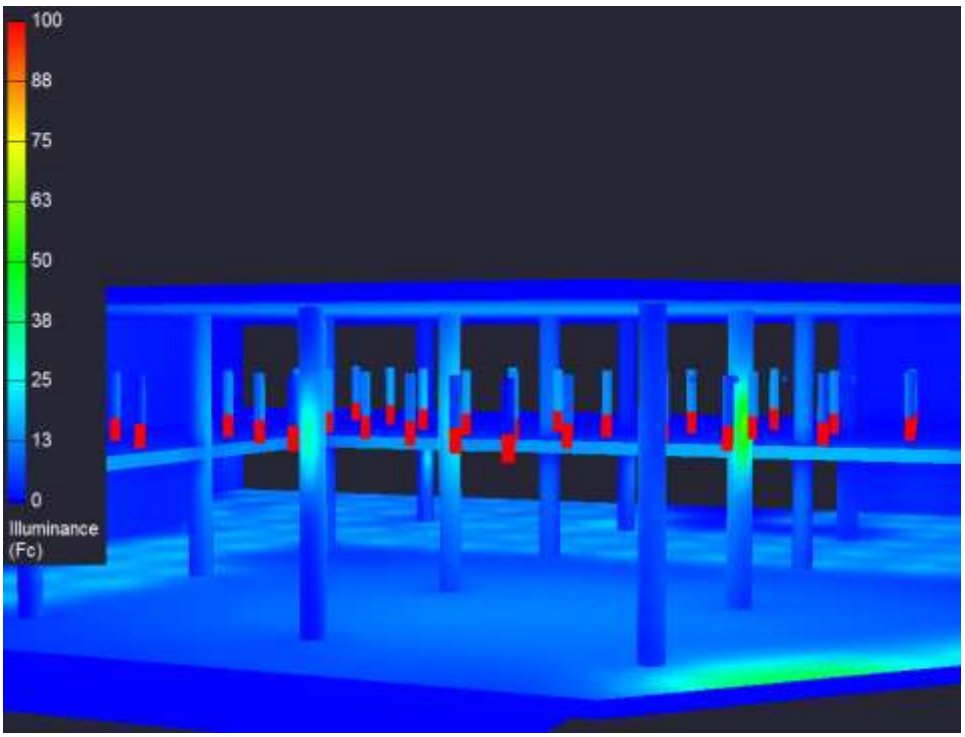
RENDERINGS



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Quantitative Comparison

Energy Consumption (ASHRAE/IESNA 90.1 - 2013)		
Category	**Allowable**	**Calculated**
Area (SF)	-	22000
Input Wattage	31680	19077
Power Density (W/SF)	1.44	0.87

Illuminance (FC) - Intermission		
Category	**Recommended**	**Calculated**
Avg. Eh	50	11.2
Avg. Ev	10	5.0
Max Eh	-	388.5
Min Eh	-	0.0
Avg/Min Eh	2:1	NA
Max/Min Eh	-	NA

Performance Analysis

Despite the large amount of fixtures in the space the LPD is still well below the allowable. The LED fixtures used are very efficient. If daylighting controls would be implemented, the LPD could probably be cut down to half of the allowable. This could definitely earn some LEED credits for energy optimizing energy performance. The amount of natural light in the space could also earn LEED credits for daylighting.

The illuminance levels seem to be very low in the space. This could be from the simplifications that I needed to make to construct the model. The main issue seems to be in the front of the space where the decorative fixtures are. If there were light to supplement them, then I suspect that the space would come closer to meeting IES recommendations. The other thing to keep in mind is that there is generally quite a bit of daylight in the space that can help to raise the overall light levels.

One thing to note is that the actual space is quite bright, so the fault must be with the model used to perform the calculations. I didn't expect to get such low levels and will look into improving the model to more closely match reality.

Areas of Improvement

First and foremost, the light levels need to increase drastically before anything else. The illuminance values are well under the recommendations from IES. Once that's taken care of, the next area to look at would be improving the aesthetics of the lighting. The array of troffers looks cluttered and the space is generally washed with light. Adding some drama to the space could not only look interesting, but perhaps draw people into the store and toward merchandise. These are all things to consider in the redesign.

APPENDIX A | ASHRAE CODES

9.4.1 Lighting Control

Building lighting controls shall be installed to meet the provisions of Sections 9.4.1.1, 9.4.1.2, 9.4.1.3, and 9.4.1.4.

9.4.1.1 Interior Lighting Controls

(a) There shall be one or more manual lighting controls in the space that controls all of the lighting in the space. Each control device shall control an area (1) no larger than 2500 ft2 if the space is less than or equal to 10,000 ft2 and (2) no larger than 10,000 ft2 otherwise. The device installed to comply with this provision shall be readily accessible and located so that the occupants can see the controlled lighting when using the control device.

(b) None of the lighting shall be automatically turned on.

(d) The general lighting in the space shall be controlled so as to provide at least one intermediate step in lighting power or continuous dimming in addition to full ON and full OFF. At least one intermediate step shall be between 30% and 70% (inclusive) of full lighting power.

(e) In any space where the combined input power of all general lighting completely or partially within the primary sidelighted areas is 150 W or greater, the general lighting in the primary sidelighted areas shall be controlled by photocontrols. In any space where the combined input power of all general lighting completely or partially within the primary and secondary sidelighted areas is 300 W or greater, the general lighting in the primary sidelighted areas and secondary sidelighted areas shall be controlled by photocontrols.

The control system shall have the following characteristics:

1. The calibration adjustments shall be readily accessible.
2. At minimum, general lighting in the secondary sidelighted area shall be controlled independently of the general lighting in the primary sidelighted area.
3. The photocontrol shall reduce electric lighting in response to available daylight using continuous dimming or with at least one control point between 50% and 70% of design lighting power, a second control point between 20% and 40% of design lighting power or the lowest dimming level the technology allows, and a third control.

(f) In any space where the combined input power for all general lighting completely or partially within daylight areas under skylights and daylight areas under roof monitors is 150 W or greater, general lighting in the daylight area shall be controlled by photocontrols having the following characteristics:

1. The calibration adjustments shall be readily accessible.
2. The photocontrol shall reduce electric lighting in response to available daylight using continuous dimming or with at least one control point that is between 50% and 70% of design lighting power, a second control point between 20% and 40% of design lighting power or the lowest dimming level the technology allows, and a third control point that turns off all the controlled lighting.
3. General lighting in overlapping toplighted and sidelighted daylight areas shall be controlled together with general lighting in the daylight area under skylights or daylight areas under roof monitors.

(h) All lighting shall be automatically shut off within 20 minutes of all occupants leaving the space. A control device meeting this requirement shall control no more than 5000 ft2.

(i) All lighting in the space not exempted by Exception (1) to Section 9.1.1 shall be automatically shut off during periods when the space is scheduled to beunoccupied using either (1) a time-of-day operated control device that automatically turns the lighting off at specific programmed times or (2) a signal from another automatic control device or alarm/security system. The control device or system shall provide independent control sequences that (1) control the lighting for an area of no more than 25,000 ft2, (2) include no more than one floor, and (3) shall be programmed to account for weekends and holidays. Any manual control installed to provide override of the scheduled shutoff control shall not turn the lighting on for more than two hours per activation during scheduled off periods and shall not control more than 5000 ft2.

9.4.1.4 Exterior Lighting Control.

Lighting for exterior applications not exempted in Section 9.1 shall meet the following requirements:

a. Lighting shall be controlled by a device that automatically turns off the lighting when sufficient daylight is available.

b. All building façade and landscape lighting shall be automatically shut off between midnight or business closing, whichever is later, and 6 a.m. or business opening, whichever comes first, or between times established by the authority having jurisdiction.
c. Lighting not specified in Section 9.4.1.4(b) and lighting for signage shall be controlled by a device that automatically reduces the connected lighting power by at least 30% for at least one of the following conditions:
1. From 12 midnight or within one (1) hour of the end of business operations, whichever is later, until 6 a.m. or business opening, whichever is earlier.
2. During any period when no activity has been detected for a time of no longer than 15 minutes

All time switches shall be capable of retaining programming and the time setting during loss of power for a period of at least ten hours.