2010

Marie Ostrowski

Lighting/Electrical

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Science Building-Phase 1

Buffalo State College-Buffalo, NY

Wednesday, April 7, 2010

Final Summary Report

Science Building - Phase 1 Addition

Buffalo State College

Owner: Buffalo State College
General Contractor: Savarino Companies
Construction Manager: Bovis Lend Lease
Architect: Cannon Design
Engineers: Cannon Design
Wind/Snow Consultant: Gradient Microclimate Engineering
Commissioning Agent: Horizon Engineering
Size: 96,000 ft^2
Stories: 3 above ground
Cost: $34,807,000

Architecture + Construction

- Phase 1 is an addition to the existing science building and joins via an atrium.
- Phase 2 includes the demolition and renovation of the existing building. The final complex will be upwards of 224,000 ft^2.
- Phase 1 construction period is October 2009 - March 2012, with completion of both phases set for 2015.

Structural

- One-way reinforced concrete slab supported by cast-in-place concrete beams and columns, two-way reinforced concrete systems for the slab-on-grade
- Steel framed systems for mechanical penthouse, atrium, and link to the existing structure
- Foundations for the building are primarily composed of an H pile system, while the atrium is supported by spread footings

Mechanical

- Laboratory spaces supplied 100% outside air via heat recovery AHUs
- One dedicated VAV supply terminal unit minimum per lab; connected back to its associated fume hoods and exhaust valves
- One central, mixed air VAV AHU serves atrium
- Heating by a 10" 40 PSI metered steam line connected to the campus system
- Cooling by electric centrifugal chiller in penthouse

Electrical

- 5kV service from campus substation routed to unit substation within the building.
- Double-ended 480Y/277 V 3φ 4W substation located in the basement and 208Y/120 V 3φ 4W switchboard in the penthouse
- Dedicated normal, emergency, standby, and optional branches
- Emergency branch served by a 750 kW diesel-driven generator in basement;
- Lighting primarily 277V

Buffalo, NY

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EXECUTIVE SUMMARY

The following report is a technical analysis of the existing design for the Buffalo State College New Science Building Phase 1 addition. It consists of a focus on lighting and electrical redesign of four spaces, as well as detailed studies for a motor controller center design and electrical distribution system analysis through SKM software. In addition to satisfying the AE requirements for the option depths, associated areas or breadths have been studied with regards to daylighting (MAE), mechanical systems, acoustical performance, and LED luminaire performance.

Specifically, daylighting and mechanical systems were both addressed in the analysis of an open loop switching system for the atrium corridor lighting. Initial studies indicate proper daylight and electric light integration can reduce energy consumption associated with atrium lighting without having dramatic effects on the thermal loads within the space. The acoustical study is also situated in the atrium, to ensure the large volume and hard surfaces within the space do not detract from its purpose and evaluate an alternative flooring material.

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INTRODUCTION

The Science Building Phase 1 construction project is the first phase in a two-phase addition and renovation project for the School of Natural and Social Sciences at Buffalo State College. The 96,000 ft^2 LEED Gold addition is designed to reflect in its exterior, the high-tech education and research that occur within its laboratories and classrooms. Once completed in 2015 the addition and renovation will become the 224,000 ft^2 Mathematics and Science Complex.

Design elements of the addition are a conscious testament to the scientific and collaborative developments housed within its walls. Everything in the architectural elements, from materials and colors to proportions, has a purpose and hints towards different theories or scientific concepts.

The layout of the building is largely influenced by circulation, a practical and figurative indication of biological systems. The addition joins the existing building at a central atrium from which smaller corridors branch out to join the west corridor looking out onto the neighboring athletic play fields. The west corridor acts as a curtain wall skin to the building, with a seemingly random assortment of metal and glass panels that calls upon the principles of the Fibonacci sequence, genetics, and optics. The circulation spaces connect students and visitors to a multitude of research/teaching labs and offices where the lessons fuel ongoing developments in science.

FIGURE 1 – WESTERN FAÇADE (COURTESY OF CANNON DESIGN)

General Building Data

Building Name: Buffalo State College Science Building – Phase 1

Location: Buffalo, NY

Building Occupant Name: Buffalo State College – Biology, Chemistry, Earth Science and Science Education Departments

Occupancy Type: Education

Size: approximately 96,000 sq. ft.

Number of Stories: 4 above grade (including penthouse)/5 total

Project Team:

Owner: Buffalo State College/State University Construction Fund
http://www.buffalostate.edu/facilities/

General Contractor: Savarino Companies

Construction Manager: Bovis Lend Lease
http://www.bovislendlease.com/

Architect: Cannon Design
http://www.cannondesign.com/

MEP Engineers: Cannon Design
http://www.cannondesign.com/

Wind/Snow Consultant: Gradient Microclimate Engineering
http://gradientwind.com/

Commissioning Agent: Horizon Engineering
http://www.horizon-engineering.com/

Dates of Construction: October 15, 2009 – March 31, 2012 (Phase 1 Projected Completion Date 11/2/2010)

Cost: $36,064,000 budget overall project cost

Project Delivery Method: Design-Bid-Build

ARCHITECTURE

Codes:

IBC 2006
NEC 2008

Building Code of NYS 2007
New York State Energy Conservation Construction Code
Plumbing Code of NYS
Mechanical Code of NYS
Fuel Gas Code of NYS
SUCF Directives
ASCE 7-02
AISC 301, 303.1, 303-05
ACI 318-02
ANSI C2 – National Electrical Safety Code
NFPA

Zoning: Buffalo State College as an educational institution does not fall under City of Buffalo R-2 zoning requirements.

Historical Requirements: Not Applicable

The Science Building at Buffalo State College houses labs, offices, and classrooms for the school's natural science departments. The building exterior conveys the interior scientific inquiry and development through the materials and design. A high-tech appearance is achieved through numerous design features that cleverly express themes associated with the various science departments including: optics, geology, genetics, biology, and math.

The Phase 1 building project is an addition to the existing science complex and joins to the existing building via an atrium. The linear plan is broken on the western side with a vertex in the middle and two curtain wall segments that are slightly angled.

A combination of genetics and mathematics is portrayed in the arrangement and proportions of the glass and metal panels on the western curtain wall. Brightly colored walls are visible behind the glass panels of the western corridor to mimic the refraction of a prism. Throughout the building, striations, platforms and the linear atrium space refer to geologic forms such as mesas and gorges for proportions. Building circulation takes a cue from biology and creates a main thoroughfare through the atrium space to connect the academic and residential areas of campus. Additionally, the science curriculum is fostered by an environment that supports collaboration. Throughout the building there are gathering spaces for students with writable surfaces. Optimum floor space and flexibility is enabled by the concrete structural system and central utility spine.

BUILDING ENCLOSURE

The walls of the building are a combination of concrete masonry unit assemblies and curtain wall, both using cold metal framing to hang exterior paneling. The western façade uses cold metal framing and a combination of aluminum composite metal wall panels and high performance, insulated glazing. The very top level, the mechanical penthouse, is a shell composed of non-insulated metal panels.

The atrium permits natural light through a series of thirteen sloped glazing assembly clerestories, with condensation resistance and a solar heat gain coefficient ≤ 0.40. Roof structure is predominantly concrete deck except for the steel roof deck on the penthouse. Roofing layers are similar on each roof type with either a tapered or flat insulation (R-20), membrane underlayment board, and light-colored EPDM (ethylene propylene diene terpolymer) roof membrane.

SUSTAINABILITY FEATURES

The building design is required to satisfy LEED Silver certification and sustainability features are largely attributed to controls for the mechanical and electrical systems. Mechanical system design incorporates variable speed drive motors for air handling pumps and fans to increase efficiency. The lighting systems incorporate automatic lighting controls with occupancy and daylight sensors, as well as dimming systems to extend lamp life of incandescent sources.

The project will satisfy numerous LEED points from the beginning of construction, with strategies such as Construction IAQ Management, to completion with initial building performance being tested by a commissioning agent.

CONSTRUCTION

The Phase 1 addition for the Buffalo State College (BSC) Science Building is scheduled for October 15, 2009 – March 12, 2012. Phase 2 renovations (which would bring total complex area up to 224,000 ft^2) are projected to finish in 2015.

Site work throughout demolition and construction is to uphold standards set forth in the NY Guidelines for Urban Erosion and Sediment Control. Construction methods include plans for temporary mechanical services to the existing building following demolition, which comply with the IAQ management plan. Of all waste generated throughout construction, 50% (by weight) is to be salvaged or recycled and documented with progress reports submitted regularly.

ELECTRICAL

Medium voltage service enters the building at 5kV and is routed to a unit substation within the building. The double-ended 4.16kV 480Y/277 V 3ϕ 4W substation is located in the basement, feeding a 2,000A 208V/120V 3ϕ 4W switchboard in the basement and a 3,000A 480Y/277 V 3ϕ 4W switchboard situated in the penthouse. The basement switchboard feeds the normal power in the basement and a 1,000A 208V 3ϕ 4W bus duct serving laboratory loads on normal power throughout the building and future phase. The penthouse switchboard serves most of the mechanical equipment.

The building is served by four separate, switched branches: Normal, Emergency, Standby, and Optional. The emergency branch of the distribution system is served by a 750 kW diesel-driven generator enclosed in a separate room in the basement.

LIGHTING

General lighting within the building is supplied by linear fluorescent luminaires using T8 or T5 lamps predominantly at 277V. Classrooms and labs utilize pendant, direct/indirect linear fluorescent luminaires to provide even luminance levels across task planes while minimizing shadows. This is important due to the measuring and reading tasks that occur within the space. Corridors in the atrium combine a recessed wall-mounted fixture (switched for emergency power) as well as a decorative, compact fluorescent pendant. The atrium combines daylighting by means of clerestories and skylights with supplementary electric light from pendant, wall-washing, metal halide fixtures that illuminate the acoustical ceiling panels at the top of the space.

MECHANICAL

Heating for the Science Building is provided by a 10" 40 PSI metered steam supply connected to the campus system and distributed by redundant variable flow pumps. AHU preheat coils are energized by low pressure 15 PSI steam.

General cooling is supplied by a high efficiency, water-cooled, electric centrifugal chiller in the penthouse. The penthouse also houses the refrigerant monitoring and exhaust system. Primary/secondary pumping connects the chiller to the AHUs and heat is rejected by two induced draft cooling towers in the penthouse. Data rooms are also served by a back-up DX system while the main telecom room is served by a 10 ton split-system a/c unit.

Three AHUs supply 100% outside air to the labs and provide partial redundancy since they are sized to approximately 50% peak airflow. One AHU is connected to emergency power to prevent excessive negative pressurization. Each lab area has one dedicated VAV terminal unit with a hot water reheat coil and low velocity supply diffusers. The atrium has one mixed air VAV AHU with enthalpy control and outside air flow measuring. An array of nine 3,500 cfm fans is also dedicated to air handling in the atrium.

STRUCTURAL

The majority of the Science Building is composed of a cast-in-place concrete system with steel framing in connecting areas such as the atrium, the northeastern entrance, links to the existing building, and the mechanical penthouse. The foundation consists mainly of an H pile and cap (4' thick typically) system supporting the interior spaces, spread footings for the atrium, and several strip footings along the exterior walls.

The basement structural slab is 10" thick and supported by 2' square grade beams on the west, exterior edge of the building. The first level is a 5" thick, one-way concrete slab spanning north to south, primarily supported by concrete beams B4 24x30. The second and third levels are 8-1/2" one-way concrete slab supported by B1 24x30 beams, which are tapered and cantilevered into the atrium and west, exterior edge of the building. The cantilevers on the western edge of the building support the corridors and the metal and glass panel curtain wall.

Steel framing in the atrium consists of HSS10x.625 columns with a 21'-0" span. HSS8-5/8x.250 columns support the northeastern entrance. Atrium and penthouse framing consists of wide flange beams, primarily W12x14 and W18x50 respectively.

FIRE PROTECTION

Most areas within the building are protected by a wet sprinkler system except for rooms housing extensive electrical, voice, or data equipment which have a partition that is rated at least three hours. The fire command center is located in room 127 and houses the Fire Alarm Control Unit (FACU), Emergency Voice/Alarm Communication (EVAC), Graphic Smoke Control Panel (GSCP), and annunciator panels for the generator and elevators. Alarms are ADA compliant combined speaker/strobe.

Atrium fire protection consists of 175° sidewall sprinklers in the skylight and 135° dry pendant sprinklers in between skylights on the ceiling, as well as a manual smoke exhaust operation controlled by the GSCP. Elevator shafts contain sidewall sprinkler heads.

TRANSPORTATION

There are three passenger elevators in the Science Building addition, one adjacent to the north stairwell and two in the southwest corridor. The electric traction elevators specified are based on Otis Gen2 Machine Room-Less Elevators and are rated for 2500 lbs. The elevators are connected to the fire protection system for automatic recall and are also operable on standby power. The elevator controllers and ATS are located in the basement areaway.

TELECOMMUNICATIONS

The telecom service entrance room is connected to campus utilities by interbuilding, exterior fiber optic cabling. Individual telecom rooms are connected by intrabuilding backbone systems with 24 strand 50 micron cabling in 4" electrical metallic tubing (EMT) conduit. Horizontal cabling throughout the building telecom distribution system is copper. Telephone service for the existing building and addition is being updated from a Centrex phone system to VoIP.

Data outlets are available above counters in the lab spaces and throughout other work spaces. Within the lab furniture, 2" conduit is stubbed up for data and terminated in a furniture doghouse. The labs and offices also have electronic card reader door systems for security. Wireless access points are available in the labs and throughout most of the corridors.

Lighting Depth

Director's Office - Special Purpose Space

Space

The private office space in room 319A is occupied by the director of the Great Lakes Center and his administrative support. The Great Lakes Center (GLC) is an institute committed to research and education focused on the scientific understanding of the Great Lakes and holds a regional office at Buffalo State College. The layout of the approximately 350 ft^2 rectangular office space is specific to the director's day-to-day tasks and includes a table where he can hold small meetings. It is also directly connected to the secretary's office and the GLC research labs. Though all walls are interior, there is a window that looks into the daylit west corridor (transmittance of 0.75).

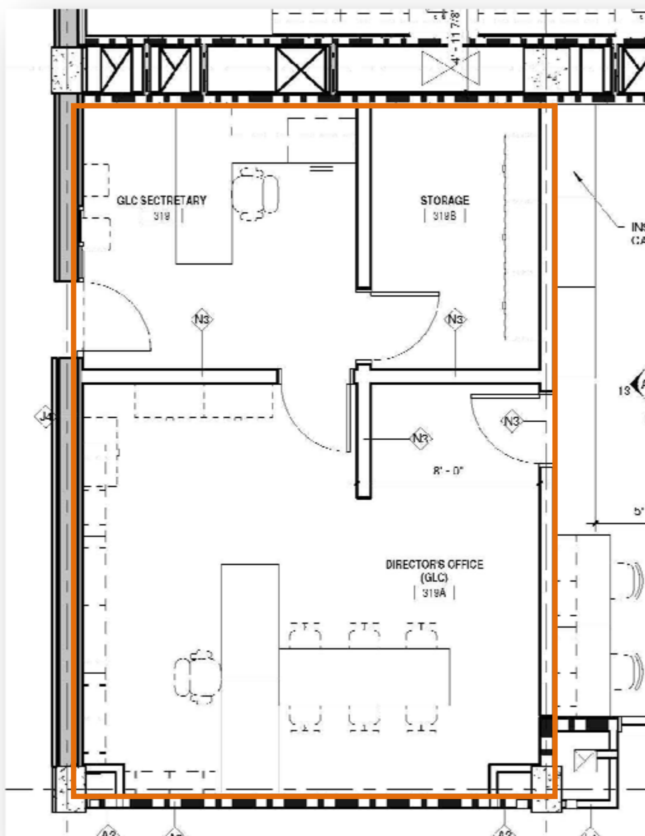


FIGURE 2-DIRECTOR'S OFFICE (ROOM 319A)

Program Statement

The objective of the lighting design within the GLC director's office unit is to provide a comfortable yet functional and flexible space. It must meet minimal illuminance levels for daily tasks but also adapt to meeting functions when guests are being entertained or conducting business. In order to achieve these qualities, the design incorporates diffuse ambient light, accent downlights, and wall-washing for presentation/conference functions.

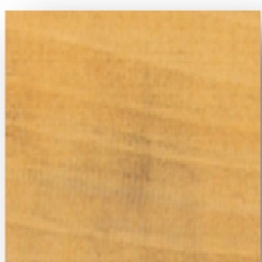
DIMENSIONS

- GLC Secretary's Office: 12' x 11'-6" = 138 ft^2
- Storage: 7'-6" x 11'-6" = 86.25 ft^2
- GLC Director's Office: approximately 20' x 17'-10" ≈ 356 ft^2
- Gross Area of GLC Unit = 593 ft^2
- Net Area of GLC Office Unit = 580.25 ft^2

MATERIALS

The director's office is furnished relatively simply. The walls are covered in off-white, matte paint except for the dry erase surfacing area. Cabinetry and shelves are an oak color, the floors are a medium-to-dark brown, and the ceiling is a light colored ACT grid. Swatches of the materials are below followed by their reflectance values.

Furniture



Flooring

Ceiling

TABLE 1 – OFFICE SPACE MATERIALS

MATERIALS								
Special Purpose Space			Director's Office			Room 319A		
	Item	**Key Name**	**Manufacturer**	**Series/Pattern**	**Style #**	**Color**	**Comments**	**Reflectance**
Floor	Carpet Tile	CPT-1	Interface FLOR	Entropy	7223	Wheat	2'x2' Tile	0.34
Floor	Carpet Tile	CPT-2	Interface FLOR	Cubic	6393	Height	2'x2' Tile	0.36
Wall	Paint	PNT-3	Sherwin Williams		SW 7014	Eider White		0.87
Wall	Dry Erase Surfacing	DE-1	MDC Flooring	Idea Paint		White		0.95
Ceiling	Acoustic Panel Ceiling	APC-2	Armstrong	Optima		White	2'x4' Panels	0.90
Ceiling								

Design Criteria

- **Lighting Power Density** (LPD) values for the enclosed office space must be **≤ 1.10 W/ft^2** according to the ASHRAE Standard 90.1-2007. (1)
- **Horizontal and vertical illuminance levels** should meet a minimum value of 50fc/500lux and 5fc/50lux respectively on task plane surfaces. [2]
- **Color Appearance**: CCT of 3500 K and CRI ≥ 85
- **Direct Glare:** Indirect luminaires with matte finishes provide a more comfortable visual environment by reducing contrast between the lamp and housing and eliminating direct view of the source.
- **Reflected Glare**: Specular finishes throughout the space are not an issue, and VDT screens are effectively shielded with luminaire classification and positioning.
- **Shadows**: Diffuse light should be used in the space to avoid creating shadows on the task plane. Overhead lighting must be positioned so shadows are not created on writing surfaces.
- **Appearance of Space & Luminaires**: The space should provide a corporate image in terms of luminaire style and lighting mood. Fixtures must be laid out in the room so as not to create viewing issues for the occupant.
- **Psychological Reinforcement**: Since the space functions as a "corporate" office and conference room, it should possess the lighting settings to create a relaxed environment. In order to achieve these lighting characteristics, a design incorporating low-level light and non-uniform perimeter accents is implemented.

Office Lighting Design

Luminaires, Lamping + Ballasts

The office lighting design incorporates a combination of indirect, direct, and accent lighting fixtures. A detailed list of the luminaires, lamps, and ballasts specified is provided below in Table 3. Please note that manufacturer provided cut sheets for all associated equipment can be found in Appendix A. This is true for all spaces considered for lighting redesign.

TABLE 2 – OFFICE LIGHT LOSS FACTORS

	LLD	LDD	RSDD	BF	LLF
F1	0.95	0.85	0.96	1.00	0.78
F2	0.90	0.84	0.96	0.99	0.72
F3	0.95	0.85	0.96	0.98	0.76
F4	0.90	0.81	0.96	1.02	0.72
F5	0.85	0.85	0.96	0.98	0.68
F6	0.81	0.81	0.96	1.05	0.66

Light Loss Factor Assumptions:

- 0.96 was used for the RSDD value for all luminaires in all spaces
- Evaluation of Operating Atmosphere: Clean
- Cleaning Interval: 1.5 years/18 months

TABLE 3 – OFFICE LUMINAIRES

LUMINAIRE SCHEDULE												
LUMINAIRE		CLASSIFICATION	MOUNTING	LAMP			# LAMPS	BALLAST	VOLTAGE	OPTICS	HOUSING	MANUFACTURER
F1		0'-3-1/4"X4'	7 FT. AFF	F54T5HO	Input Watts	117W	2	ELEC/T5	277V	DIRECT LIGHT THROUGH	ALUMINUM, SLIM PROFILE	LIGHTOLIER-ULTRAFLAT 2
		SEMI-INDIRECT	UNLESS	PHILIPS	Avg Lumens	2750		ICN2S5490C		PERFORATED SQUARE		SL103BPIU
		FLUORESCENT	OTHERWISE	28W/835	Initial Lumens	5000		PHILIPS		ALUMINUM AREA		
		PENDANT	NOTED	MIN BIPIN	CCT	3500K		ELEC, PS		INDIRECT LIGHT CONTROLLED		
				T5 HE	CRI	85				BY WIDE SPACING OPTIC		
				ALTO UNP	Maint. Category	V				EDGE SLOT PROJECTION		
F2		4FT. RECESSED	FLUSH WITH	F54T5HO	Input Watts	61W	1	ELEC/T5HO	277V	EXTRUDED, FROSTED	DIE-FORMED AND WELDED STEEL	LITECONTROL
		WALL WASH	FINISHED	PHILIPS	Avg Lumens	-		ICN4S5490C		ACRYLIC SOFT GLOW	MATTE WHITE FINISH	LG-WWD-4414T5HOS
		DIRECT	CEILING	54W/835	Initial Lumens	5000		2LSG		LENS,		GLCWMINDDA/MK7 277
				MIN BIPIN	CCT	3500K		PHILIPS		FORMED SEMI-SPECULAR		
				T5 H0	CRI	85		ADVANCE		REFLECTOR		
				ALTO UNP	Maint. Category	IV		ELEC, PS				
F3		7-3/8" DIAMETER	FLUSH WITH	F32WTT	Input Watts	36W	1	ELEC/F32TT	277	SPUN ALUMINUM REFLECTOR	ONE PIECE DIE CAST,	COOPER LIGHTING-PORTFOLIO
		RECESSED	FINISHED	GE	Avg Lumens	2040		ICF-2S26-M1		OPEN APERTURE	MATTE BLACK	CA7042ECP
		ADJUSTABLE	CEILING	F32TBX	Initial Lumens	2400		-BS		ADJUSTABLE 30 DEGREE		
		DOWNLIGHT		835/A/ECO	CCT	3500K		PHILIPS		ELEVATION AIMING		
					CRI	82		ADVANCE				
					Maint. Category	V		ELEC, PS				
F4		2FT., 1LAMP,	9.0 FT. AFF	F24T5	Input Watts	27	1	ELEC/T5	277V	OPEN, UNAPERTURED	20 GAUGE STEEL HOUSING WITH	PRUDENTIAL
		SURFACE	UNLESS	PHILIPS	Avg Lumens	-		ICN-2S24-277		STRIP LIGHT	WHITE ENAMEL FINISH	P-T5-STD-1T5-O2BWE277-B_
		MOUNTED STRIP	OTHERWISE	24W/835	Initial Lumens	2000		PHILIPS				
		FLUORESCENT	NOTED	MIN BIPIN	CCT	3500		ADVANCE				
				T5 HO	CRI	85		ELEC, PS				
				ALTO UNP	Maint. Category	IV						
F5		4-1/2" X 8-1/2"	FLUSH WITH	F32WTT	Input Watts	36W	1	ELEC/F32TT	277	SPECULAR PRIMARY	RIGID HOUSING WITH	KURT VERSEN
		RECESSED	FINISHED	GE	Avg Lumens	2040		ICF-2S26-M1		REFLECTOR;	PARABOLIC SPLAY TRIM	T4142
		DOWNLIGHT	CEILING	F32TBX	Initial Lumens	2400		-BS		MICROPRISM SPREAD LENS		
				835/A/ECO	CCT	3500K		PHILIPS				
					CRI	82		ADVANCE				
					Maint. Category	V		ELEC, PS				
F6		1' X 0'-6" WALL	6.0 FT. AFF	F18DBX	Input Watts	19	1	ELEC/CFQ	277	20 GAUGE C.R.S. REFLECTOR	STEEL HOUSING/REFLECTOR	FOCAL POINT
		SCONCE	WALL	GE	Avg Lumens	970		CFQ182/G24q		HIGH REFLECTANCE WHITE	DIE-CAST ALUMINUM END CAPS	SOFTLITE VI-FS611BX18
			MOUNTED	835/ECO	Initial Lumens	1200		GEC218-MVPS		POWDER COAT		
				4P	CCT	3500		3W				
					CRI	82		GE				
					Maint. Category	VI		ELEC,PS				

Lighting plan

The lighting layout for the office is irregular in plan and does not strive to achieve uniform light except for the main task areas. A detail for this lighting layout, and the remaining three spaces, can be found in Appendix B. The LPD values and limits for this space are easily achieved, even without the decorative sconce fixtures excluded from the calculations.

Performance

LIGHTING POWER DENSITY:

Luminaire Type	Quantity	Total Input Power (W)
F1	2	234
F2	1	61
F3	2	72
F4	1	27
F5	6	216

TOTAL INPUT POWER: 648 W
REMAINING AVAILABLE INPUT POWER: 4.3 W
LPD: 1.09 W/ft^2

The design complies with lighting power density requirements from ASHRAE 90.1 2007.

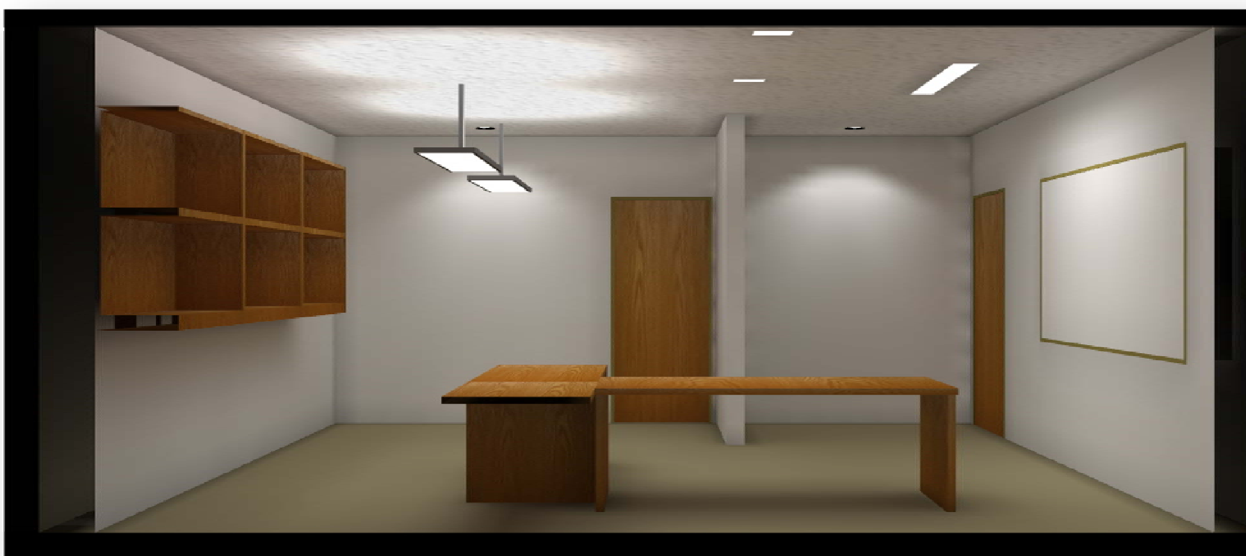
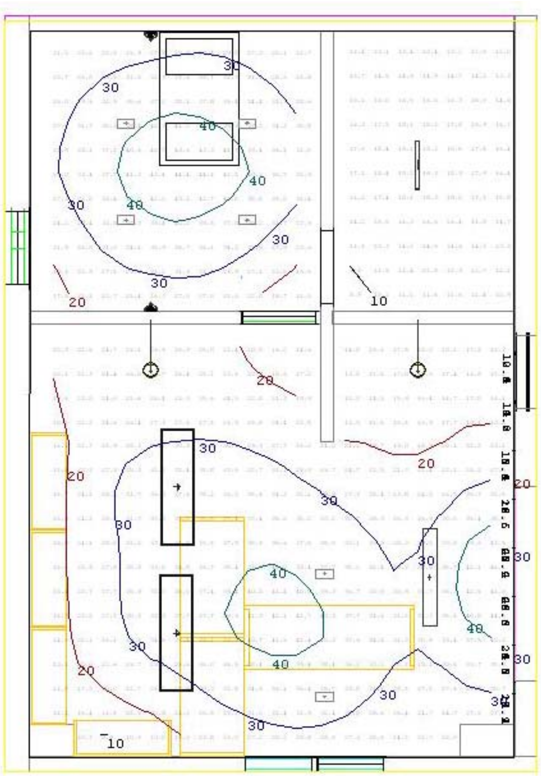


FIGURE 3 – INTERIOR PERSPECTIVE OF OFFICE WITH ALL LIGHTS ON

AVERAGE ILLUMINANCE: 11.7 FC | MAXIMUM 39.5 FC

The average illuminance levels for the space completely lit are clearly lower than the IESNA recommended levels for an office space. However, as can be illustrated in the following illuminance isolines, the design does provide sufficient levels at the desk and table areas. The non uniform lighting techniques and wall accents were implemented to highlight the space and functions with the room.



FIGRUE 4 - ALL ON

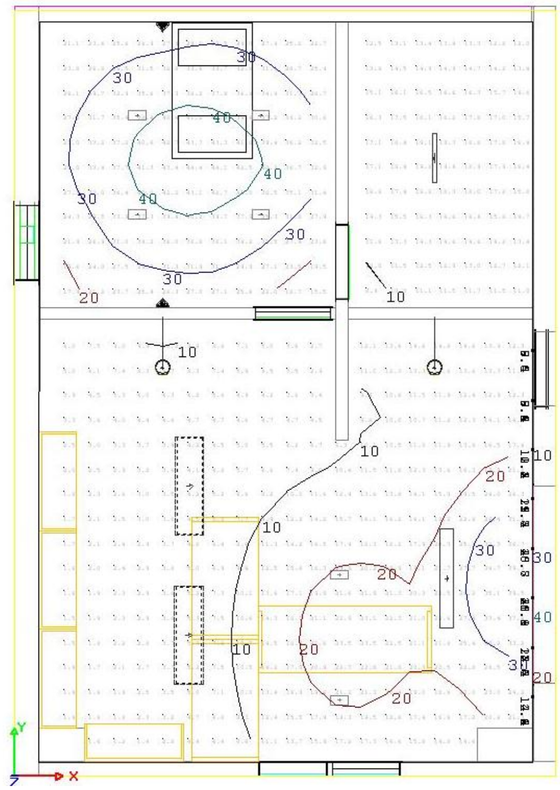
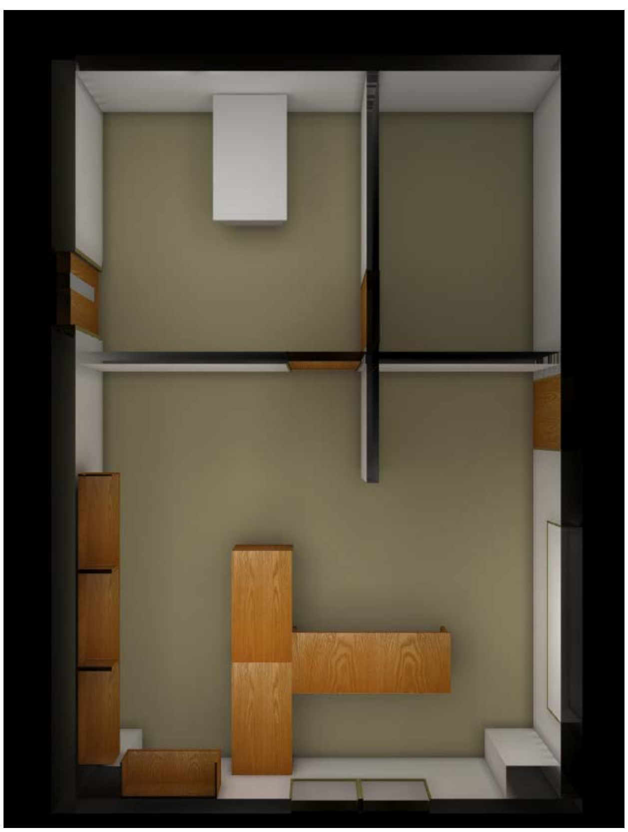


FIGURE 5 - TASK LIGHTS ABOVE DESK SWITCHED OFF



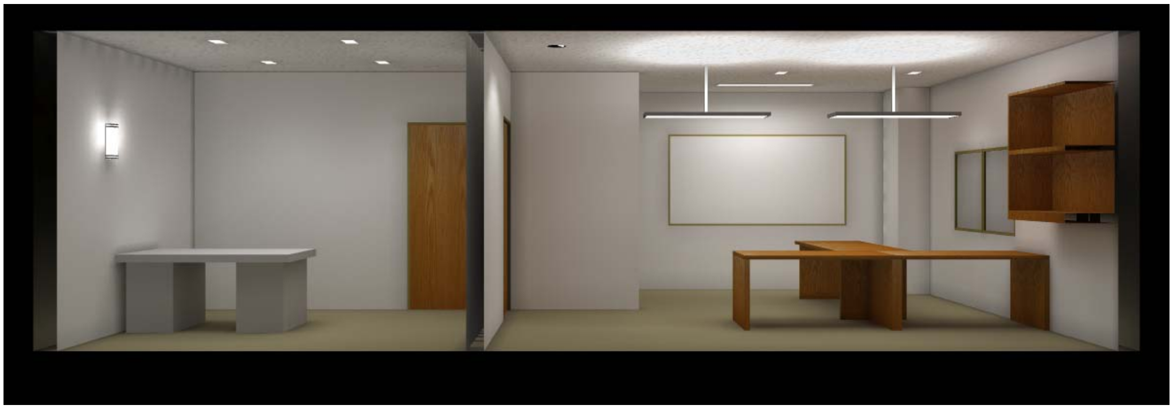


FIGURE 6 – SOUTH SECTION CUT OF OFFICE UNIT LOOKING, ALL ON

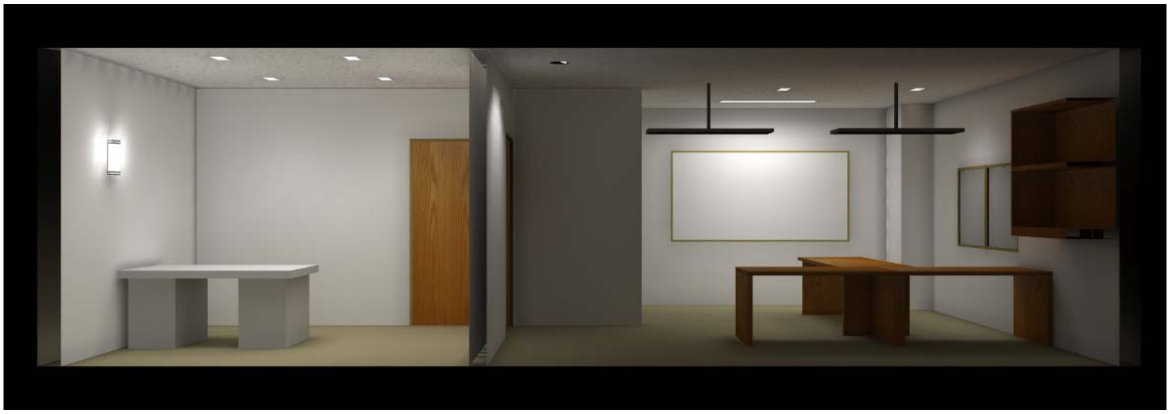


FIGURE 7 – SOUTH SECTION CUT OF OFFICE UNIT, TASK OFF/CONFERENCE SETTING

Genetics Teaching Lab – Work Space

Space

The Genetics Teaching Lab (Room 306) is located on the northwest end of the building and borders the corridor overlooking the central atrium. It is surrounded on all sides by corridors or rooms, and therefore does not receive any natural light. The rectangular space serves as a teaching and experimental lab and is furnished with numerous pieces of casework to house tools and equipment. Tables are oriented perpendicular to the long wall in order to facilitate presentations that occur at the front of the room between the two entrances. A portion of the wall is painted with dry-erase surfacing paint to provide the writing surface. Finishes are plain and simple to create a space that is easy to work in and maintain.

Program Statement

The objective of the lighting design within the Genetics Teaching Lab is to provide a bright, evenly lit environment without glare or shadows that would interfere with the visual tasks associated with experimentation and viewing. Since it also functions as a teaching lab, lighting should also highlight areas of presentation. In order to achieve these qualities, the design incorporates indirect/direct luminaires and baffled openings for ambient and board lighting fixtures. Task lighting is also incorporated in the rear and side of the room for experiment setup and cleaning.

DIMENSIONS

- 26'-11" x 41'-8"
- Area = 1157 ft^2

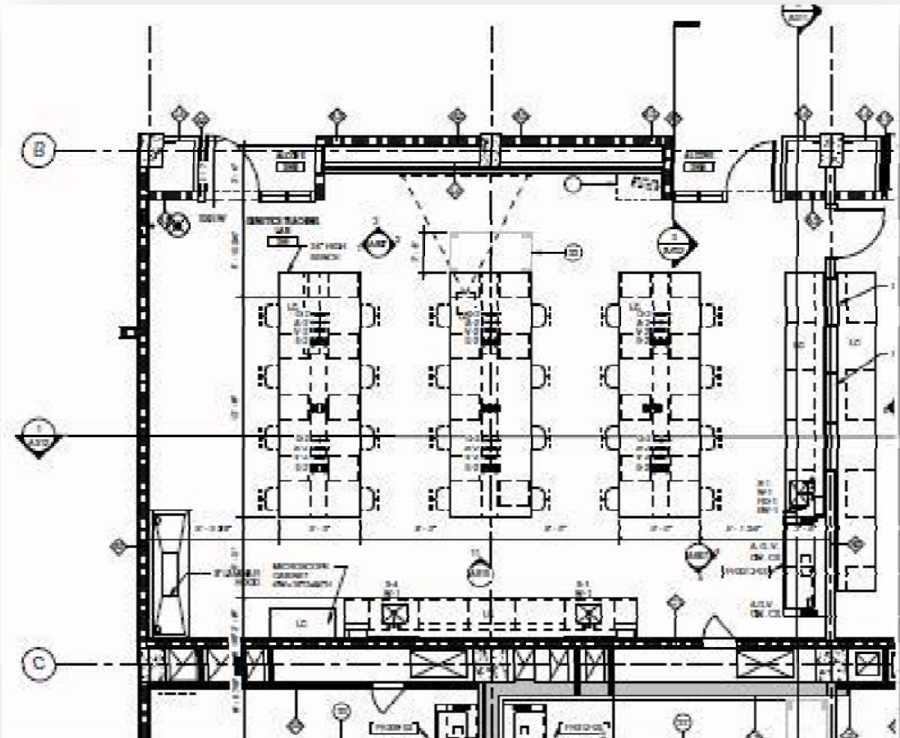


FIGURE 8– GENETICS TEACHING LAB FLOOR PLAN

MATERIALS

- The genetics lab is predominantly covered by a flat, matte white paint and light wood casework. However, the front of the room is painted a light yellow and hosts a white board surface. The ceiling is a light colored ACT grid and the floor is a gray, linoleum tile. Swatches of the materials are below followed by their reflectance values.

Furniture

Flooring

Walls

Ceiling

TABLE 4 –LAB CLASSROOM MATERIALS

MATERIALS								
Work Space			Genetics Teaching Lab			Room 306		
	Item	Key Name	Manufacturer	Series/Pattern	Style #	Color	Comments	Reflectance
Floor	Linoleum Tile Flooring	LTF-1	Forbo Flooring Systems	Marmoleum Composite Tile	MCT-621wt	Dove Gray	13"x13" tile	0.37
Floor								
Wall	Paint	PNT-1	Sherwin Williams		SW 7006	Extra White		0.94
Wall	Paint	PNT-2	Sherwin Williams		SW 6681	Butter up		0.88
Wall	Dry Erase Surfacing	DE-1	MDC Flooring	Idea Paint		White		0.95
Ceiling	Acoustic Panel Ceiling	APC-2	Armstrong	Optima		White	2'x4' Panels	0.90

DESIGN CRITERIA

- **Lighting Power Density**: Lighting power allowance for the space should not exceed **1.4 W/ft^2**. Automatic controls should be integrated with the manual control system.
- **Horizontal and vertical illuminance levels** should meet a minimum value of 50fc/500lux and 30fc/300lux respectively. The work plane height is raised to a value of three feet due to the taller lab tables in the space.
- **Color Appearance + Color Contrast:** Since the space demands experimentation involving various viewing methods and tools, color rendering should be of good quality. CCT values should be no smaller than 3000K and CRI should be ≥ 80.
- **Direct Glare:** Luminaires with matte louvers provide a more comfortable visual environment by reducing contrast between the lamp and housing and minimizing direct view of the source.
- **Light Distribution on Task Plane:** Centrally positioned luminaires with a direct/indirect distribution provide more even luminance levels on the horizontal task plane. Uniformity is essential at the task surfaces in order to avoid distracting patterns or fatigue caused by inadequate luminance ratios.
- **Reflected Glare:** Luminaires should not be positioned in direct line with the task surface. Specular finishes on the task plane should be avoided to minimize veiling reflections.
- **Shadows:** Diffuse, semi-indirect or indirect light should be used in the space to avoid creating shadows on the task plane.
- **Source/Task/Eye Geometry:** Luminaires should be positioned outside of normal viewing angles at work spaces.
- **Points of Interest:** Luminance levels on the dry-erase surface should be no less than 30 fc. Contrast for the overall space should satisfy a ratio of 5:1.
- **Flicker and Strobe:** Flicker should be minimized by employing electronic ballasts.
- **Luminances of Room Surfaces:** Surfaces in the room should be sufficiently illuminated so as not to create the sensation of dark spots. Direct and indirect/diffuse sources create more even light on the surfaces and increase visual comfort.
- **Modeling of Faces of Objects:** Lighting should provide sufficient contrast for visual understanding of object textures and depths.

- Visual clarity should be emphasized with higher luminance levels at work surfaces and moderate levels at the perimeter. Preparation and cleaning tasks performed at the room perimeter require sufficient light levels.

Genetics Teaching Lab Lighting Design

Luminaires, Lamping + Ballasts

The lab lighting design incorporates a combination of indirect, direct, and task lighting fixtures. A detailed list of the luminaires, lamps, and ballasts specified is provided below in Table 5. For equipment cut sheets, please see Appendix A.

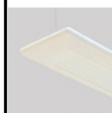
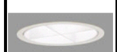
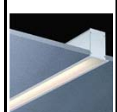
TABLE 5- LIGHT LOSS FACTORS

	LLD	LDD	RSDD	BF	LLF
F13	0.95	0.81	0.96	1	0.74
F14	0.95	0.87	0.96	1.00	0.79
F15	0.90	0.81	0.96	1.1	0.77
F16	0.95	0.87	0.96	1	0.79
F17	0.95	0.81	0.96	1	0.74

Light Loss Factor Assumptions:

- 0.96 was used for the RSDD value for all luminaires in all spaces
- Evaluation of Operating Atmosphere: Clean
- Cleaning Interval: 1.5 years/18 months

TABLE 6 – GENETICS TEACHING LAB LUMINAIRE SCHEDULE

LUMINAIRE SCHEDULE												
LUMINAIRE		CLASSIFICATION	MOUNTING	LAMP			# LAMPS	BALLAST	VOLTAGE	OPTICS	HOUSING	MANUFACTURER
F13		4FT. INDIRECT	7 FT. AFF	F28T5	Input Watts	62W	2	ELEC/T5	277V	PRECISION DIE-FORMED	EXTRUDED ALUMINUM	LIGHTOLIER
		LINEAR, PENDANT	UNLESS	PHILIPS	Avg Lumens	2750		ICN-2S28-N		SEMI-SPECULAR ALUMINUM		LSB-24A-28-277-WH
			OTHERWISE	28W/835	Initial Lumens	2900		PHILIPS		REFLECTOR		
			NOTED	MIN BIPIN	CCT	3500K		ADVANCE				
				T5 HE	CRI	85		ELEC, PS				
				ALTO UNP	Maint. Category	VI						
F14		4FT. WALL-MOUNTED	7FT. AFF	F28T5	Input Watts	31W	1	ELEC/T5	277V	DIE-FORMED STEEL WITH HIGH	DIE FORMED AND WELDED STEEL;	LITECONTROL
		CHALKBOARD	UNLESS	PHILIPS	Avg Lumens	2750		ICN-2S28-N		REFLECTANCE WHITE FINISH;	6" OPENING	W-D-66N14T5-PARSS-CWM-ELB-277
		FIXTURE	OTHERWISE	28W/835	Initial Lumens	2900		PHILIPS		PARABOLIC BAFFLE		
			NOTED	MIN BIPIN	CCT	3500K		ELEC, PS				
				T5 HE	CRI	85						
				ALTO UNP	Maint. Category	III						
F15		7" APERTURE	FLUSH	PLT26	Input Watts	29W	1	ELEC/PLT	277V	HYDROFORMED ALUMINUM,	1101F2642U FRAME IN KIT	LIGHTOLIER
		RECESSED CIRCULAR	WITH	PHILIPS	Avg Lumens	-		ICF-2S26-H1-LD		SEMI-SPECULAR FINISH		1132-1101F2642U
		DOWNLIGHT	FINISHED	26W/835	Initial Lumens	1800		PHILIPS		REFLECTOR; MATTE WHITE		
			CEILING	4P/ALTO	CCT	3500K		ELEC, PS		CROSS BLADE		
				1CT	CRI	82						
					Maint. Category	III						
F16		4FT. RECESSED	FLUSH	F28T5	Input Watts	31W	1	ELEC/T5	277V	MATTE PARABOLIC LOUVERS	CONTINUOUS 6063-T5 EXTRUDED	SELUX
		LINEAR FLUORESCENT	WITH	PHILIPS	Avg Lumens	2750		ICN-2S28-N			ALUMINUM PROFILE	M100-1T5-MA-004-WH-277
		FLANGED EXTRUSION	FINISHED	28W/835	Initial Lumens	2900		PHILIPS				
			CEILING	MIN BIPIN	CCT	3500K		ELEC, PS				
				T5 HE	CRI	85						
				ALTO UNP	Maint. Category	III						
F17		4FT. LINEAR	SURFACE	F28T5	Input Watts	31W	1	ELEC/T5	277V	EXTRUDED ACRYLIC	0.060" EXTRUDED ALUMINUM;	ALKCO/PHILIPS
		1" MODULAR	MOUNTED	PHILIPS	Avg Lumens	2750		ICN-2S28-N		LINEAR PRISM LENS	ENJECTION MOLDED	LINCS100FS46-277-WHG
		FLUORESCENT	UNDER	28W/835	Initial Lumens	2900		PHILIPS			POLYCARBONATE END CAPS	
		TASK LIGHTING	CASEWORK	MIN BIPIN	CCT	3500K		ELEC, PS				
				T5 HE	CRI	85						
				ALTO UNP	Maint. Category	VI						

Lighting plan

The drawings of the lab lighting layout can be found in Appendix B. In order to achieve the light levels within the space, two rows of indirect fluorescent lights were used to achieve the uniform levels of illuminance at the main work plane surface. Most luminaires are positioned within the space using typical mounting configurations. All pendant lights are offset from the floor surface (to the bottom of the luminaire) by a height of seven feet. The only luminaire specified with a mounting different from the standard recessed or surface mounting practice, is the chalkboard washer, which must be hung six inches from the wall surface with the factory provided bracket. An image of the mounting set up is provided in Figure 5.

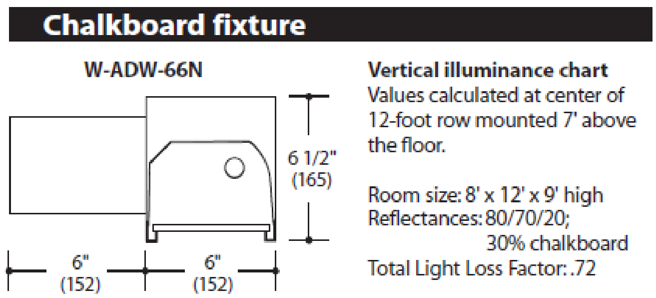


FIGURE 9 - BOARD WASH LUMINAIRE DETAIL

Though it was recommended that downlights be avoided for this type of space, several downlight luminaires are employed to supplement the dark spots resulting from the task/ambient lighting layout. Downlights have been positioned to maintain minimal direct and reflected glare and also include baffles or diffuse lenses for improved optics and light distribution.

Performance

LIGHTING POWER DENSITY:

Luminaire Type	Quantity	Total Input Power (W)
F13	16	992
F14	5	155
F15	9	261
F16	2	62
F17	1	31

TOTAL INPUT POWER: 1,501 W
REMAINING AVAILABLE INPUT POWER: 130 W
LPD: 1.29 W/ft^2

The design complies with lighting power density requirements from ASHRAE 90.1 2007.

FIGURE 10- PERSPECTIVE OF LAB LIGHTING (WITH ALL LUMINAIRES ON)

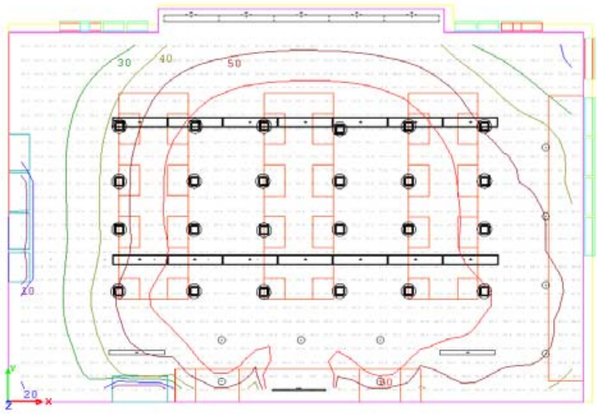
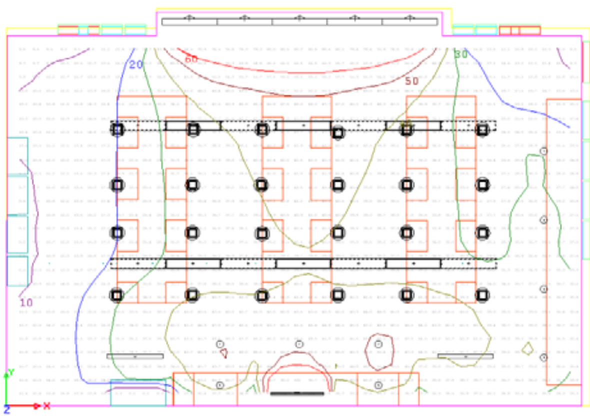


FIGURE 11 - AMBIENT AND TASK

AVERAGE ILLUMINANCE AT WORKPLANE: 52.64 FC



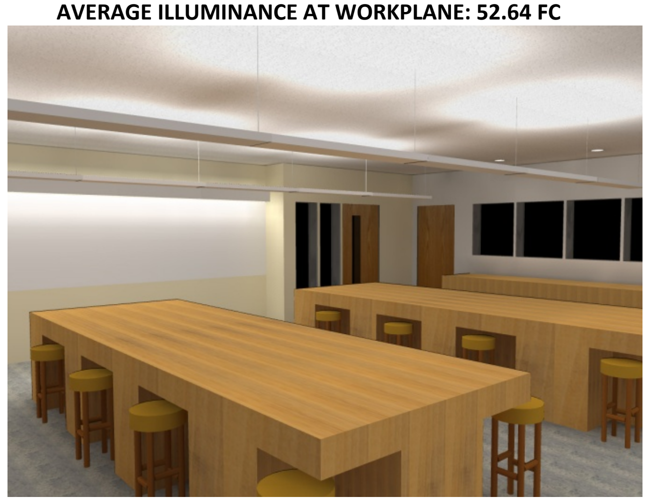


FIGURE 12 - SWITCHED AMBIENT, TASK + BOARD

AVERAGE ILLUMINANCE AT WORKPLANE: 33.75 FC

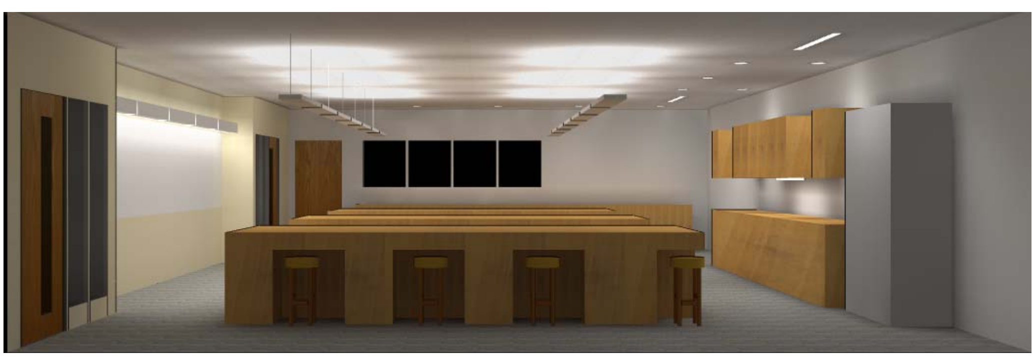


FIGURE 13 – SOUTH PERSPECTIVE SWITCHED AMBIENT

FIGURE 14 – EAST PERSPECTIVE SWITCHED AMBIENT

The average illuminance levels for the space completely lit are satisfy the IESNA recommended levels for a lab space, and exceed by only 5%. The switching allows for lower levels of light for different presentations and tasks within the room, while the perimeter lighting assists in maintaining high illuminance levels for preparatory and cleaning tasks.

FACADE

SPACE

The western curtain wall is the space considered for the outdoor redesign. The surface is composed of alternating metal and glass panels that vary in shape and depth. It runs parallel to a service road and athletic playing fields. Additionally, there is 286 ft. of sidewalk that runs from the main western entrance south to the end of the complex. The sidewalk and the main western entrance are also considered within the outdoor space lighting redesign.

PROGRAM STATEMENT

The façade is the defining architectural element of the BSC Science building and most thoroughly expresses the design goal and theme of the building. Consequently, the intent of the design is to accentuate and complement the existing architecture by highlighting the rectilinear geometries and creating a hierarchy of light. The western corridor which runs behind the curtain wall has a unique, multi-colored interior wall and creates a great deal of visual interest from exterior viewpoints. Bright, white highlights of the façade projections are incorporated to create a composition with depth and form that complements the seemingly irregular glazing and coloring patterns.

DIMENSIONS

Walkway = 286 ft. long
Main Entrance: 11 linear feet
Uppermost height of third level/roof = 43'

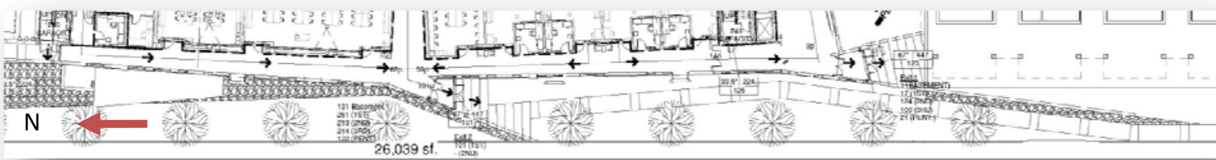


FIGURE 15 – EXTERIOR PLAN VIEW OF THE WESTERN FACADE

MATERIALS

The materials used for the façade are glass and aluminum curtain wall panels arranged in varying vertical shapes. The interior corridor walls that are visible from the exterior are gypsum wall board painted in several different matte colors.

DESIGN CRITERIA

- **Horizontal and vertical illuminance** levels should be **5fc and 3fc** respectively at the entrance and **5fc** on the walkway.
- **Lighting power allowance** for the walkway is 1 W/ft. Lighting power allowance for the main and alternate entrance door is 30 and 20 W/ft respectively.
- **Appearance of Space and Luminaires:** The area illuminated by the source should exhibit satisfactory contrast ratios and not interfere with the view of the landscape.
- **Direct Glare:** Luminaires should be mounted at proper heights and setbacks so as not to create glare issues for drivers or pedestrians.

- **Light Pollution/Trespass:** Any and all exterior luminaires should be shielded to cut off indirect light and prevent trespass into the building.
- **Reflected Glare:** Sources and aiming must be coordinated with surrounding surfaces to prevent visual impairment of viewers.
- **Modeling of Faces or Objects:** Light levels, CCT, CRI and distribution all must be considered in providing a light source that provides a secure environment.
- **Color Appearance + Color Contrast:** Sources with good/decent color rendering should be provided based on level of security needed for the area.

FACADE LIGHTING DESIGN

LUMINAIRES, LAMPING + BALLASTS

TABLE 7- LIGHT LOSS FACTORS

	LLD	LDD	RSDD	BF	LLF
L1	0.80	0.64	-	1.0	0.51
F11	0.80	0.60	-	1.0	0.47
F12	0.80	0.64	-	1.0	0.51

Light Loss Factor Assumptions:

- Evaluation of Operating Atmosphere: Dirty
- Value of LLD value assumed 0.80 due to lack of information

TABLE 8– FACADE LUMINAIRE SCHEDULE

LUMINAIRE SCHEDULE												
LUMINAIRE		CLASSIFICATION	MOUNTING	LAMP			# LAMPS	BALLAST	VOLTAGE	OPTICS	HOUSING	MANUFACTURER
L1		1 FT. SURFACE	SURFACE;	-	Input Watts	15		INTEGRAL	277V	POLYCARBONATE CLEAR	RIGID HOUSING; EXTRUDED	PHILIPS-COLOR KINETICS
		MOUNTED LED	HEIGHT VARIES		Avg Lumens	-	-	DRIVER/		LENS	ANODIZED ALUMINUM	eW GRAZE POWERCORE
		STRIP LIGHT	WITH WALL		Initial Lumens	477		TRANSFORMER				523-000030-09
			PROJECTIONS		CCT	4000						
					CRI	-						
					Maint. Category	VI						
F11		8" SURFACE	SURFACE	PLC-26	Input Watts	55W	2	ELEC/T4	277V	PARABOLIC CROSS BAFFLES;	SATIN BRUSHED ALUMINUM;	KURT VERSEN
		MOUNTED	MOUNTED	PHILIPS	Avg Lumens	-		INTEGRAL		PRIMARY LINEAR REFLECTOR	INTERIOR MATTE WHITE FINISH	P639CB
		DOWNLIGHT		ALTO	Initial Lumens	1760						
				26W/835	CCT	3500						
				2P	CRI	82						
					Maint. Category	IV						
F12		3FT. SURFACE	SURFACE	PLC-26	Input Watts	29W	1	ELEC/T4	277V	DIFFUSER LENS	316 MARINE GRADE STAINLESS	LUMASCAPE
		MOUNTED	MOUNT	PHILIPS	Avg Lumens	-		ICF-2S26-H1-LD			STEEL	LS482-262-F-A3-R-9
		BOLLARD	PLATE	ALTO	Initial Lumens	1760		PHILIPS				
				26W/835	CCT	3500		ELEC, PS				
				2P	CRI	82						
					Maint. Category	VI						

Lighting plan

A series of LED grazers are mounted six inches from the tops of the projected aluminum panels by "L" brackets. Walkway light is provided by bollards, and the interior glow from the corridor is integrated within the design to create an interesting, layered aesthetic. The layout of these fixtures and the other outdoor luminaires can be found in Appendix B. All luminaires around the façade are connected to a lighting control panel and switched via a photo cell positioned on the roof.

Performance

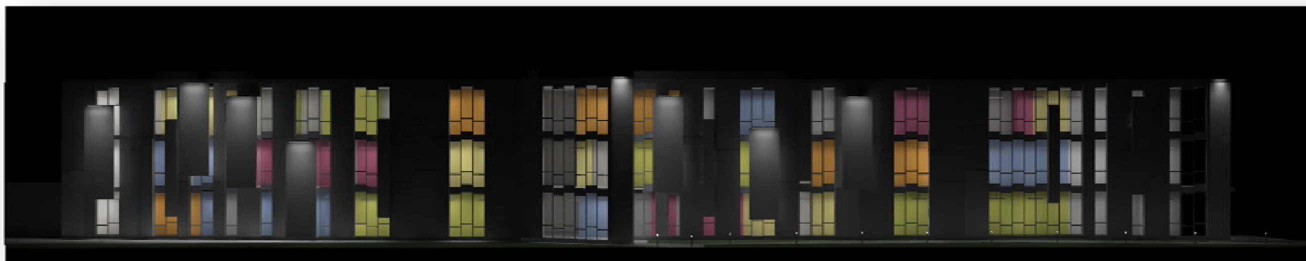


FIGURE 15 – WEST ELEVATION

LIGHTING POWER DENSITY:

Building Exterior Measured Areas		
Door	11	feet
Walkway	286	feet
Façade	2648.4	sq. ft

Luminaire Type	Quantity	Total Input Power (W)
L1	40	600
F11	1	55
F12	18	522

ASHRAE Allowance		Total Allowable Power		Actual Power	Net Difference
30	W/lin. Ft.	330		55	275
1	W/lin. Ft.	286		522	-236
0.2	W/sq. ft	529.68		600	-70.32
		1145.68	Grand Total	1177	-31.32
		1202.964	+ 5%	COMPLIES	25.964

TOTAL INPUT POWER: 1,177 W
REMAINING AVAILABLE INPUT POWER: 26 W (with 5% unrestricted allowance)

The design satisfies lighting power density requirements from ASHRAE 90.1 2007 on the condition that the excess allowable power from the building grounds is traded. The entrance has an excess of 275 W which is greater than the walkway net difference of -236W. Therefore, the trade between the two areas affords LPD compliance. Even though the building façade lighting is over the permitted levels, the grand total of the design is less than the total allowable levels (with the addition of the 5% unrestricted allowance).

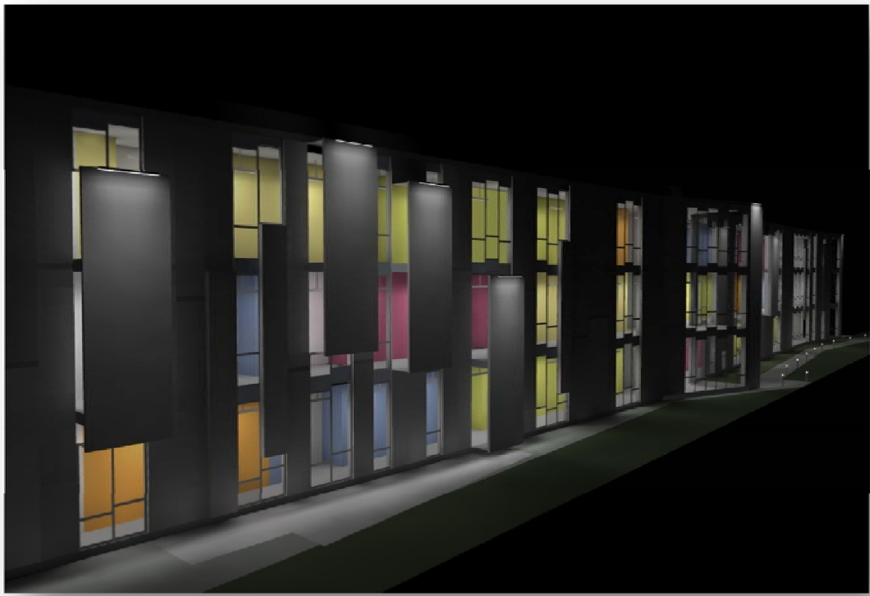


FIGURE 16 – SOUTHEAST PERSPECTIVE

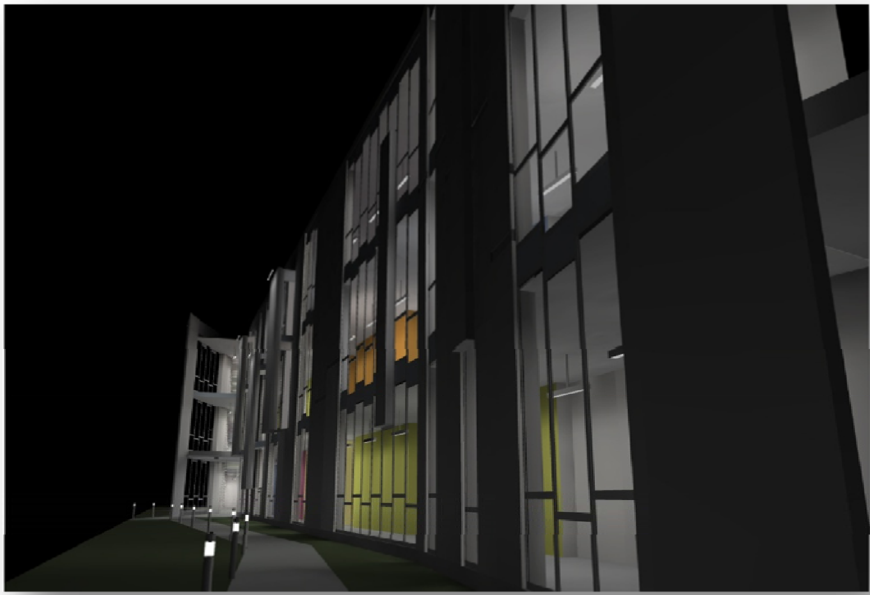
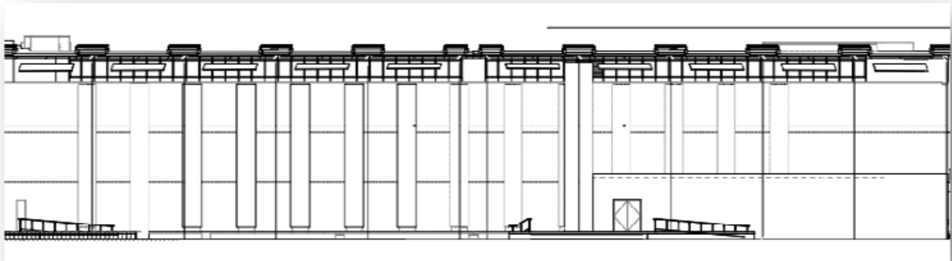


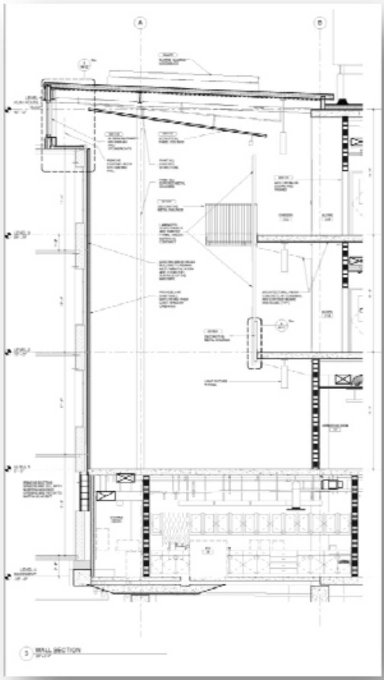
FIGURE 17 – NORTHWEST PERSPECTIVE VIEWING WEST MAIN ENTRANCE

ATRIUM

SPACE

The atrium space spans the length of the addition and covers 6,273 ft^2 at three levels. It serves primarily as a circulation space, though it is also intended for students to use as a casual meeting place. The atrium joins the existing Science 1 Building at its western façade, and therefore has an interior wall composed of brick with light colored acoustical wall panels on its eastern side. The western side of the atrium/lobby is essentially corridor space with a stair case extending from the second to third level. The roof of the atrium supplies daylighting into the space via a system of 12 sloped skylights and clerestories. The finishes of the majority of the atrium surfaces are presented in Table 9.





FIGURES 18 + 19 – EASTERN ATRIUM WALL AND SOUTHERN SECTION

PROGRAM STATEMENT

The atrium space is one of the most challenging design spaces within the Science Building. It functions as a means of conveyance, and has dimensions and volume that give the impression of a canyon. It is the location where the new building meets the old and where daylight mixes with electric light. Keeping all these traits and characteristics in mind when designing, yields a practical, geometric solution that emphasizes the shape and flow of the space with decorative and functional luminaires using fluorescent and HID sources. Additionally, the space is again considered for breadths and studies in daylighting, acoustics, and mechanical performance.

DIMENSIONS

Length = approximately 249 ft.
Width = approximately 33 ft at the center

MATERIALS

Walls

Ceiling

Floor, Accent Wall

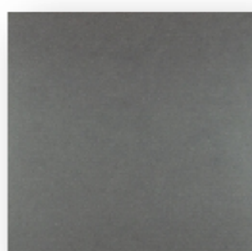


TABLE 9 – ATRIUM MATERIALS

MATERIALS								
Work Space			Atrium			Levels 1-3		
	Item	Key Name	Manufacturer	Series/Pattern	Style #	Color	Comments	Reflectance
Floor	Porcelain Tile	PT-1	Caesar	More		Eclipse	24"x48" Tile (1/16" Joint)	0.15
	Porcelain Tile	PT-2	Caesar	More		Eclipse	12"x48" Tile (1/16" Joint)	0.15
Wall	Existing Brick	BRK	Existing					0.25
	Painted Wall Board		Sherwin Williams					0.50
Ceiling	Acoustic Panel Ceiling	APC-2	Armstrong	Optima		White	2'x4' Panels	0.90
	Glazing	G-1						τ = 0.7

DESIGN CRITERIA

- **Illuminance:** Horizontal levels should meet a minimum value of 10fc/100 lux.
- **Lighting Power Density:** The level one floor area must not exceed **0.6 W/ft^2** while the upper corridor levels must remain under **0.5 W/ft^2**.
- **Daylighting Integration and Control:** Daylight penetration is the key function of an atrium. Since this atrium functions primarily as a circulation space, clear glazing is acceptable in the skylight assembly. Issues of glare must be addressed with proper orientation, shading, and positioning of glazing.
- **Direct Glare:** Luminaires at eyelevel or below must be addressed to ensure they will not create any discomfort to the viewer.
- **Light Distribution on Surfaces:** Distributions must meet the design intent of the space. Since the atrium is not a dedicated work space, the accent and decorative lighting creates more isolated spots of light to guide the viewer in a certain direction.
- **Luminances of Room Surfaces:** Horizontal and vertical luminances must be sufficient for circulation.
- **Shadows:** Shadows from any downlight fixtures must be limited so as not to interfere with work surfaces.
- **Color Appearance + Color Contrast:** Color matching is an important criterion in the atrium space. Light sources must be carefully matched so that CCT values do not create great differences in warm or cool light.
- **Modeling of Faces or Objects:** The atrium serves as a decorative space within the building, and therefore, aiming angles and sources must be coordinated with the surfaces to obtain the desired effect.
- **Reflected Glare:** Luminaires and interior glazing must be carefully located to prevent reflections of natural or interior light toward direct view of an occupant.

Atrium Lighting Design

Luminaires, Lamping + Ballasts

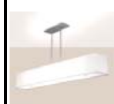
TABLE 10- LIGHT LOSS FACTORS

	LLD	LDD	RSDD	BF	LLF
F6	0.81	0.81	0.96	1	0.63
F7	0.88	0.81	0.96	1.00	0.69
F8	0.92	0.81	0.96	1.16	0.83
M1	0.79	0.84	0.96	1.00	0.63

Light Loss Factor Assumptions:

- 0.96 was used for the RSDD value for all luminaires in all spaces
- Evaluation of Operating Atmosphere: Clean
- Cleaning Interval: 1.5 years/18 months

TABLE 11 - ATRIUM LUMINAIRE SCHEDULE

LUMINAIRE SCHEDULE												
LUMINAIRE		CLASSIFICATION	MOUNTING	LAMP			# LAMPS	BALLAST	VOLTAGE	OPTICS	HOUSING	MANUFACTURER
F6		1' X 0'-6" WALL	6.0 FT. AFF	F18DBX	Input Watts	18	1	ELEC/CFQ	277	20 GAUGE C.R.S. REFLECTOR	STEEL HOUSING/REFLECTOR	FOCAL POINT
		SCONCE	WALL	GE	Avg Lumens	970		CFQ182/G24q		HIGH REFLECTANCE WHITE	DIE-CAST ALUMINUM END CAPS	SOFTLITE VI-FS611BX18
			MOUNTED	835/ECO	Initial Lumens	1200		GEC218-MVPS		POWDER COAT		
				4P	CCT	3500		3W				
					CRI	82		GE				
					Maint. Category	VI		ELEC,PS				
F7		1FT. TAPERED	SURFACE	FPC22	Input Watts	25	1	ELEC/T5	277V	INJECTION MOLDED	EXTRUDED ALUMINUM	LIGHTOLIER - OPTIMO SERIES
		SQUARE SURFACE	MOUNT	SYLVANIA	Avg Lumens	1585		INTEGRAL		POLYCARBONATE		ST12AL-S122U-22W-120/277V-1
		MOUNT	12 FT AFF	22W T5	Initial Lumens	1800				DIFFUSER		
				835	CCT	3500						
					CRI	82						
					Maint. Category	VI						
F8		3'-2" SUSPENDED	14' AFF	F21T5	Input Watts	31	1	ELEC/T5	277	MATTE WHITE ACRYLIC	COLD-ROLLED STEEL FRAME	SHAPER LIGHTING
		DECORATIVE	UNLESS	GE	Avg Lumens	1930		GE228MVPS-A		BOTTOM DIFFUSER, TOP	AND ALUMINUM BODY; DOUBLE	101-P FABRIQUE RECTILINEAR
			OTHERWISE	F21W/T5/	Initial Lumens	2100		GE		COVER	STEM SUSPENSION	101-P-38-T52-21-SWH (SCA FOR
			NOTED	835/ECO	CCT	3500		ELEC, PS			FABRIC SHADES	SLOPED CEILING)
					CRI	85						
					Maint. Category	VI						
M1		17-13/16"x8"	EXTERNAL	CMH150T6	Input Watts	186	1	MAG/CMH150	277V	HIGH PURITY ALUMINUM	SMOOTH STEEL HOUSING	ELLIPTIPAR
		LARGE MH WALL	YOKE WITH	GE	Avg Lumens	11000		GEM150ML		REFLECTOR AND END PLATES		STYLE M104
		WASHER	CANTILEVER	CMH150TU	Initial Lumens	14000		TLC3D-5		MICRO PRISMATIC TEMPERED		1104-150G-X-01-2-00-0
			PENDANT	830/G12	CCT	3000		GE		LENS		
			MOUNT		CRI	82		MAG				
					Maint. Category	IV						

Lighting plan

The ambient lighting in the atrium is provided by a linear arrangement of fluorescent pendant and surface mounted luminaires positioned over the corridors and centered along the center of the space by suspension from the ACT grids. The luminaires suspended through the center of level one have a cable length of 23' which is less than the manufacturer's listed maximum standard length of 25'. Accent lighting is provided by a series of six sconces (of the same style used in the office space). Wall washing is provided from a horizontal pendant-mounted metal halide aligned with the acoustical panel treatments over the existing brick wall. The metal halide lights are to be controlled by an astronomical time clock while the remainders are designed for photosensor switching control, which is analyzed in the daylighting breadth.

Performance

LIGHTING POWER DENSITY:

Building Measured Areas		
Atrium – Level One	6273	ft^2
Corridor – Level Two	2318	ft^2
Corridor – Level Three	2290	ft^2

Luminaire Type	Quantity	Location
F6	6	Level One
F7	26	Level One
	26	Level Two
F8	26	Level Three
	21	Level One
M1	14	Mounted to East Wall @ 35' AFF

ASHRAE Allowance		Total Allowable Power	Actual Power	Net Difference	LPD
Level One	$0.6W/ft^2$	3763.8 W	3905W	-141.2W	0.62
Level Two	$0.5W/ft^2$	1159W	650W	509W	0.28
Level Three	$0.5W/ft^2$	1145W	806W	339W	0.35

Since the total net difference of the level two and three corridors is greater than the power density deficit at Level One, the values can be traded to achieve LPD standards according to ASHRAE.

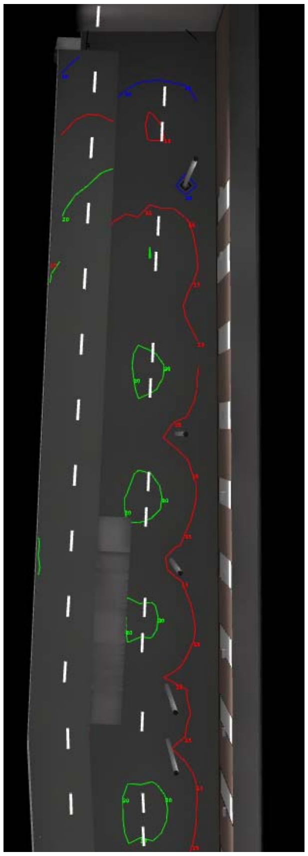


FIGURE 20 - NORTH SECTION AT NIGHT TIME

5fc	10fc	15fc	20fc

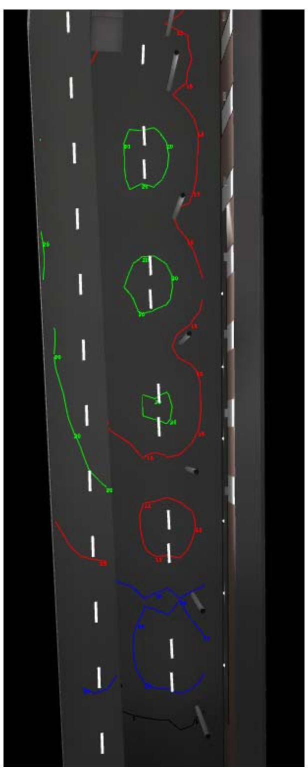


FIGURE 21 - NORTHWEST PERSPECTIVE FROM LEVEL ONE

ELECTRICAL REDESIGN

LIGHTING REDESIGN

Four spaces within the Buffalo State College New Science Building were chosen for a redesign of the lighting systems. The first, the Director's Office (Room 319A), houses the Great Lakes Center's Director, his secretary, and some small storage space. It functions as a work and meeting space and the proposed design incorporates a layout of switched, CFL spotlights and linear fluorescents to address the flexibility of the space while providing a pleasing environment. The second, the Genetics Teaching Lab (Room 306), employs a new switching scheme and additional task lighting at the perimeter lab counters along with possible incorporation of an ambient LED luminaire. The atrium redesign includes additional pendant fixtures within the open space floor area and decorative, fixtures within the corridor. The exterior redesign of the western facade relies primarily on interior glow, but also incorporates a grazing LED light to enhance and highlight façade projections.

For each of the spaces and affected areas, any and all adjustments to the branch circuits and distribution equipment has been recalculated and resized.

TABLE 12 – PANELBOARD CHANGES SUMMARY

Existing Panelboard Changes & Locations Served						
Panel Tag	Voltage	N/EM Indicators	Office	Gen. Lab.	Atrium	Façade
3LNH1	480/277	N	X	X		X
PPSH1	480/277	EM		X		
1LNH1	480/277	N			X	
2LNH1	480/277	N			X	
2LEH1	480/277	EM			X	X

DIRECTOR'S OFFICE

All lights within the space are controlled by line voltage switching. The manual switches are located next to the door leading into the director's office from the secretary's office. The wall-washer F2 fixture is controlled by a manual, single pole switch next to the whiteboard. A lighting plan for the director's office can be found in Appendix B.

The affected lighting loads for the Director's office and most of the other spaces can be found on panel 3LNH1.

PANELBOARD ADJUSTMENTS

PANEL 3LNH1 VOLTAGE 480 / 277 PH 3 WIRE 4 6/29/2009 10:14 AM

LOCATION ELEC 3027 FED FROM USSHV-B

LOAD	LOAD, KW LIGHT	LOAD, KW RCPT	LOAD, KW O/M	A	P	CIRC #	SEQUENCE 3Ø A	SEQUENCE 3Ø B	SEQUENCE 3Ø C	CIRC #	P	A	LOAD, KW LIGHT	LOAD, KW RCPT	LOAD, KW O/M	LOAD
LIGHTING 3012,3013,3014	~~1.1~~ 3.3			20	1	1	1.1			2	1	20				SPARE
LIGHTING 3010,3007,3006,3004,3001	2.5			20	1	3		2.5		4	1	20				SPARE
LIGHTING 3020,3021, 3022	3.2			20	1	5			3.2	6	1	20				SPARE
CORRIDOR	2.8			20	1	7	2.8			8	1	20				SPARE
CORRIDOR C301	1.7			20	1	9		1.7		10	1	20				SPARE
LIGHTING 3036,38,35,32,31,28	2.6			20	1	11			2.6	12	1	20				SPARE
CORRIDOR C301	3.5			20	1	13	3.5			14	1	20				SPARE
CORRIDOR C301	2.7			20	1	15		2.7		16	1	20				SPARE
SPACE						17			0.0	18	1	20				SPARE
SPACE						19	0.0			20	1	20				SPARE
SPACE						21		0.0		22	1	20				SPARE
SPACE						23			0.0	24	1	20				SPARE
SPACE						25	0.0			26	1	20				SPARE
SPACE						27		3.2		28	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						29			3.2	30	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						31	3.2			32	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						33		3.2		34	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						35			3.2	36	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						37	3.2			38	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						39		3.2		40	1	20	3.2			FUTURE PHASE 2C LIGHTING
SPACE						41			3.2	42	1	20	3.2			FUTURE PHASE 2C LIGHTING
SUB-TOTAL, CL, KW	20.1	0.0	0.0				14	17	15				25.6	0.0	0.0	SUB-TOTAL, CL, KW
SECTION 2, CL, KW	0.0	0.0	0.0													

LOAD TYPE	CONNECTED LOAD (kW) PH A	CONNECTED LOAD (kW) PH B	CONNECTED LOAD (kW) PH C	DEMAND FACTOR	DEMAND LOAD (kW) PH A	DEMAND LOAD (kW) PH B	DEMAND LOAD (kW) PH C	WIRE SIZE CALCULATIONS				
								LARGEST PHASE DEMAND		16.5 kW	MOUNTING	SURFACE
								NO. OF PHASES		3		
LIGHTING	13.8	16.5	15.4	1.0	13.8	16.5	15.4	DEMAND LOAD		45.7 kW	MAIN TYPE	MLO
RECEPTACLES	0.0	0.0	0.0	0.5	0.0	0.0	0.0	SPARE CAPACITY @	25%	11.4 kW		
MOTORS/OTHER	0.0	0.0	0.0	0.8	0.0	0.0	0.0	TOTAL DEMAND LOAD		57.1 kW	MAIN SIZE	225
TOTAL	13.8	16.5	15.4		13.8	16.5	15.4	SUPPLY VOLTAGE		480		
TOTAL CONNECTED LIGHTING LOAD			45.7 kW					POWER FACTOR @	0.90	0.90	A.I.C.	25K
TOTAL CONNECTED RECEPTACLE LOAD			0.0 kW					DEMAND AMPS		76 AMPS		
TOTAL CONNECTED MOTOR/OTHER LOAD			0.0 kW					MULT FACTOR		1.25	OTHER	42 POLE
TOTAL CONNECTED LOAD			45.7 kW					MINIMUM CCT AMPS		95 AMPS		

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W SIZE/TYPE BUS: 225A SIZE/TYPE MAIN: 200A/3P C/B	PANEL TAG: 3LNH1 PANEL LOCATION: ELEC. RM. 328 PANEL MOUNTING: SURFACE	MIN. C/B AIC: 25K OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG-LAB	306	3702	20A/1P	1	*			2	20A/1P	300	North End	LTG-FAÇADE
LTG	310	2500	20A/1P	3		*		4	20A/1P	300	South End	LTG-FAÇADE
LTG	320	3200	20A/1P	5			*	6	20A/1P	0		SPARE
LTG	CORR	2800	20A/1P	7	*			8	20A/1P	0		SPARE
LTG-ATRIUM	C301	806	20A/1P	9		*		10	20A/1P	0		SPARE
LTG - OFFICE	319	2600	20A/1P	11			*	12	20A/1P	0		SPARE
LTG-ATRIUM	C301	2604	20A/1P	13	*			14	20A/1P	0		SPARE
SPACE	0	0	20A/1P	15		*		16	20A/1P	0		SPARE
SPACE		0	20A/1P	17			*	18	20A/1P	0		SPARE
SPACE		0	20A/1P	19	*			20	20A/1P	0		SPARE
SPACE		0	20A/1P	21		*		22	20A/1P	0		SPARE
SPACE		0	20A/1P	23			*	24	20A/1P	0		SPARE
SPACE		0	20A/1P	25	*			26	20A/1P	0		SPARE
SPACE		0	20A/1P	27		*		28	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	29			*	30	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	31	*			32	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	33		*		34	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	35			*	36	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	37	*			38	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	39		*		40	20A/1P	3200	0	LTG-PHASE2
SPACE		0	20A/1P	41			*	42	20A/1P	3200	0	LTG-PHASE2

CONNECTED LOAD (KW) - A Ph.	15.81	TOTAL DESIGN LOAD (KW)	69.39
CONNECTED LOAD (KW) - B Ph.	13.21	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C Ph.	15.40	TOTAL DESIGN LOAD (AMPS)	93

3LNH1

Sizing Feeder

Spare(s) Contributio	55	(# of Spares*Breaker Size*0.25)
Design Ampacity	93	
Total	148	
OCPD	200	

Sets	1
Wire Size	
Phase	3/0
Neutral	3/0
"Table 250.122" Ground	6
Wire Area (table 5, sq. in.)	
Each Phase	0.2679
Total -Phase Conductors	0.8037
Neutral	0.2679
Ground	0.0507
Total Area	1.1223
Min. Conduit Area (above *2.5)	2.80575
Conduit Size (table 4)	2"
Conduit Size (table C.2)	2"
Remarks	

PANELBOARD SIZING WORKSHEET										
Panel Tag------------------------->				3LNH1	Panel Location:		ELEC. RM. 328			
Nominal Phase to Neutral Voltage------->				277	Phase:		3			
Nominal Phase to Phase Voltage-------->				480	Wires:		4			
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	LTG-LAB	3	306	3702	w		3702	4113	
2	A	LTG-FACADE		North End	300	w		300	333	
3	B	LTG	3	310	2500	w		2500	2778	
4	B	LTG-FACADE		South End	300	w		300	333	
5	C	LTG	3	320	3200	w		3200	3556	
6	C	SPARE			0	w		0	0	
7	A	LTG	3	CORR	2800	w		2800	3111	
8	A	SPARE			0	w		0	0	
9	B	LTG-ATRIUM	3	C301	806	w		806	896	
10	B	SPARE			0	w		0	0	
11	C	LTG - OFFICE	3	319	2600	w		2600	2889	
12	C	SPARE				w		0	0	
13	A	LTG-ATRIUM	4	C301	2604	w		2604	2893	
14	A	SPARE			0	w		0	0	
15	B	SPACE				w		0	0	
16	B	SPARE			0	w		0	0	
17	C	SPACE			0	w		0	0	
18	C	SPARE			0	w		0	0	
19	A	SPACE			0	w		0	0	
20	A	SPARE			0	w		0	0	
21	B	SPACE			0	w		0	0	
22	B	SPARE			0	w		0	0	
23	C	SPACE			0	w		0	0	
24	C	SPARE			0	w		0	0	
25	A	SPACE			0	w		0	0	
26	A	SPARE			0	w		0	0	
27	B	SPACE			0	w		0	0	
28	B	LTG-PHASE2	3		3200	w		3200	3556	
29	C	SPACE			0	w		0	0	
30	C	LTG-PHASE2	3		3200	w		3200	3556	
31	A	SPACE			0	w		0	0	
32	A	LTG-PHASE2	3		3200	w		3200	3556	
33	B	SPACE			0	w		0	0	
34	B	LTG-PHASE2	3		3200	w		3200	3556	
35	C	SPACE			0	w		0	0	
36	C	LTG-PHASE2	3		3200	w		3200	3556	
37	A	SPACE			0	w		0	0	
38	A	LTG-PHASE2	3		3200	w		3200	3556	
39	B	SPACE			0	w		0	0	
40	B	LTG-PHASE2	3		3200	w		3200	3556	
41	C	SPACE			0	w		0	0	
42	C	LTG-PHASE2	3		3200	w		3200	3556	
PANEL TOTAL								44.4	49.3	Amps= 59.4

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					15.8	17.6	36%	63.4
PHASE TOTAL	B					13.2	14.7	30%	53.0
PHASE TOTAL	C					15.4	16.8	34%	60.5

LOAD CATAGORIES		Connected			Demand				Ver. 104
		kW	kVA	DF	kW	kVA	PF		
1	receptacles	0.0	0.0		0.0	0.0			
2	computers	0.0	0.0		0.0	0.0			
3	fluorescent lighting	41.2	45.8	1.25	51.5	57.2	0.90		
4	HID lighting	2.6	2.9	1.25	3.3	3.6	0.90		
5	incandescent lighting	0.0	0.0		0.0	0.0			
6	HVAC fans	0.0	0.0		0.0	0.0			
7	heating	0.0	0.0		0.0	0.0			
8	kitchen equipment	0.0	0.0		0.0	0.0			
9	unassigned	0.6	0.7	1.25	0.8	0.8	0.90		
Total Demand Loads					55.5	61.7			
Spare Capacity		25%			13.9	15.4			
Total Design Loads					69.4	77.1	0.90	Amps=	92.8

Default Power Factor = 0.90
Default Demand Factor = 100 %

See Appendix B for lighting plans and Appendix C for associated equipment.

Genetics Teaching Lab

See existing copy of panel 3LNH1 and new panel 3LNH1 above for updated normal branch circuits and panelboard. The circuit for the teaching lab is in position one. The teaching lab also had minor loads on panel PPSH1 which were removed, see panel below.

PANEL PPSH1 VOLTAGE 480 / 277 PH 3 WIRE 4 6/26/2009 11:04 AM

LOCATION PENTHOUSE FED FROM BPSH1

LOAD	LOAD, KW LIGHT	RCPT	O/M	A	P	CIRC #	SEQUENCE 3Ø A	B	C	CIRC #	P	A	LOAD, KW LIGHT	RCPT	O/M	LOAD
AHU-2 (125 HP) VSD			35.0	225	3		36.3				1	20	1.3			PENTHOUSE P001
-			35.0	-	-	1		36.4		2	1	20	1.4			3RD FLOOR LIGHTING
-			35.0	-	-				36.5		1	20	1.5			2ND FLOOR LIGHTING
							0.8				3	15			0.8	EF-3 (2 HP)
						3		0.8		4	-	-			0.8	-
									0.8		-	-			0.8	-
PLSL1 (P-TS1)	0.0	2.0	0.0	30	3		2.0				3	15				EF-4 (2 HP) BACKUP TO EF-3
-	0.0	1.2	0.0	-	-	5		1.2		6	-	-				-
-	0.0	0.0	0.5	-	-				0.5		-	-				-
SERVICE ELEVATOR ************			14.4	100	3		23.3				3	80			8.9	SEF-1 (30 HP)
EST 50 HP			14.4	-	-	7		23.3		8	-	-			8.9	-
-			14.4	-	-				23.3		-	-			8.9	-
							8.9				3	80			8.9	SEF-2 (30 HP)
						9		8.9		10	-	-			8.9	-
									8.9		-	-			8.9	-
							27.5				3	200			27.5	LEF-1 (100 HP) VSD
						11		27.5		12	-	-			27.5	-
									27.5		-	-			27.5	-
							1.3				3	30	0.0	0.8	0.5	PLSL2 (P-TS2)
						13		1.7		14	-	-	0.0	1.2	0.5	-
									1.2		-	-	0.0	1.2	0.0	-
SUB-TOTAL, CL, KW	0.0	3.2	148.7				100	100	99				4.2	3.2	139.3	SUB-TOTAL, CL, KW
SECTION 2, CL, KW	0.0	0.0	0.0													

LOAD TYPE	CONNECTED LOAD (kW) PH A	PH B	PH C	DEMAND FACTOR	DEMAND LOAD (kW) PH A	PH B	PH C
LIGHTING	1.3	1.4	1.5	1.0	1.3	1.4	1.5
RECEPTACLES	2.8	2.4	1.2	0.5	1.4	1.2	0.6
MOTORS/OTHER	96.0	96.0	96.0	0.8	76.8	76.8	76.8
TOTAL	100.1	99.8	98.7		79.5	79.4	78.9
TOTAL CONNECTED LIGHTING LOAD	4.2 kW						
TOTAL CONNECTED RECEPTACLE LOAD	6.4 kW						
TOTAL CONNECTED MOTOR/OTHER LOAD	288.0 kW						
TOTAL CONNECTED LOAD	298.6 kW						

WIRE SIZE CALCULATIONS		
LARGEST PHASE DEMAND		79.5 kW
NO. OF PHASES		3
DEMAND LOAD		237.8 kW
SPARE CAPACITY @	10%	23.8 kW
TOTAL DEMAND LOAD		261.6 kW
SUPPLY VOLTAGE		480
POWER FACTOR @	0.90	0.90
DEMAND AMPS		350 AMPS
MULT FACTOR		1.25
MINIMUM CCT AMPS		438 AMPS

MOUNTING	SURFACE
MAIN TYPE	MLO
MAIN SIZE	600
A.I.C.	35K
OTHER	-

Atrium

THIRD LEVEL: Existing loads on 3LNH1 (ckts. 9, 13, and 15) for the general corridor lighting and ceiling uplighting have been edited and relocated. See above for 3LNH1 and below for panel 2LEH1.

PANEL 2LEH1 VOLTAGE 480 / 277 PH 3 WIRE 4 6/26/2009 11:02 AM

LOCATION ELEC. 2029 FED FROM BPEH1

LOAD	LOAD, KW LIGHT	LOAD, KW RCPT	LOAD, KW O/M	A	P	CIRC #	SEQUENCE 3Ø A	SEQUENCE 3Ø B	SEQUENCE 3Ø C	CIRC #	P	A	LOAD, KW LIGHT	LOAD, KW RCPT	LOAD, KW O/M	LOAD
1ST FL LIGHTING CORR	3.3			20	1	1	6.4			2	1	20	3.1			3RD FLOOR LIGHTING CORR.
EXIT SIGNS 1ST FL	0.3			20	1	3		0.6		4	1	20	0.3			EXIT SIGNS 3RD FL
1ST FL-ALCOVE C110, C110A	0.2			20	1	5			3.2	6	1	20	3.0			2ND FLOOR CORR LIGHTING
SPARE				20	1	7	0.3			8	1	20	0.3			EXIT SIGNS 2ND FL
SPARE				20	1	9		0.0		10	1	20				SPARE
SPARE				20	1	11			0.0	12	1	20				SPARE
SPARE				20	1	13	0.0			14	1	20				SPARE
SPACE						15		0.0		16						SPACE
SPACE						17			0.0	18						SPACE
SPACE						19	0.0			20						SPACE
SPACE						21		0.0		22						SPACE
SPACE						23			0.0	24						SPACE
SPACE						25	0.0			26						SPACE
SPACE						27		0.0		28						SPACE
SPACE						29			0.0	30						SPACE
SPACE						31	1.1			32	1	20	1.1			FUTURE PH 2C - LGTS
SPACE						33		1.1		34	1	20	1.1			FUTURE PH 2C - LGTS
SPACE						35			1.1	36	1	20	1.1			FUTURE PH 2C - LGTS
2LEL1	0.0	2.8	1.0	60	3	37	3.9			38	1	20	0.1			FUTURE PH 2C - EXITS
-	0.0	4.7	1.5	-	-	39		6.3		40	1	20	0.1			FUTURE PH 2C - EXITS
-	0.0	3.8	1.5	-	-	41			5.4	42	1	20	0.1			FUTURE PH 2C - EXITS
SUB-TOTAL, CL, KW	3.8	11.3	4.0				12	8	10				10.3	0.0	0.0	SUB-TOTAL, CL, KW
SECTION 2, CL, KW	0.0	0.0	0.0													

LOAD TYPE	CONNECTED LOAD (kW) PH A	CONNECTED LOAD (kW) PH B	CONNECTED LOAD (kW) PH C	DEMAND FACTOR	DEMAND LOAD (kW) PH A	DEMAND LOAD (kW) PH B	DEMAND LOAD (kW) PH C
LIGHTING	7.9	1.8	4.4	1.0	7.9	1.8	4.4
RECEPTACLES	2.8	4.7	3.8	0.5	1.4	2.4	1.9
MOTORS/OTHER	1.0	1.5	1.5	0.8	0.8	1.2	1.2
TOTAL	11.7	8.0	9.7		10.1	5.4	7.5

TOTAL CONNECTED LIGHTING LOAD	14.1 kW
TOTAL CONNECTED RECEPTACLE LOAD	11.3 kW
TOTAL CONNECTED MOTOR/OTHER LOAD	4.0 kW
TOTAL CONNECTED LOAD	29.4 kW

WIRE SIZE CALCULATIONS		
LARGEST PHASE DEMAND		10.1 kW
NO. OF PHASES		3
DEMAND LOAD		23.0 kW
SPARE CAPACITY @	25%	5.8 kW
TOTAL DEMAND LOAD		28.8 kW
SUPPLY VOLTAGE		480
POWER FACTOR @	0.90	0.90
DEMAND AMPS		38 AMPS
MULT FACTOR		1.25
MINIMUM CCT AMPS		48 AMPS

MOUNTING	SURFACE
MAIN TYPE	MLO
MAIN SIZE	100A
A.I.C.	25K
OTHER	*

SECOND LEVEL: Existing loads on 2LNH1 and 2LEH1 were updated for new lighting design.

PANEL 2LNH1 VOLTAGE 480 / 277 PH 3 WIRE 4 6/29/2009 10:14 AM

LOCATION ELEC 3029 FED FROM USSHV-B

LOAD	LOAD, KW					CIRC	SEQUENCE 3Ø			CIRC			LOAD, KW			LOAD
	LIGHT	RCPT	O/M	A	P	#	A	B	C	#	P	A	LIGHT	RCPT	O/M	
LIGHTING 2011,12,13	2.9			20	1	1	2.9			2	1	20				SPARE
LIGHTING 2017,22,23,24	3.3			20	1	3		3.3		4	1	20				SPARE
CORRIDORS	3.0			20	1	5			3.0	6	1	20				SPARE
CORRIDORS C201	1.7			20	1	7	1.7			8	1	20				SPARE
LIGHTING 2033,32,31,30	3.3			20	1	9		3.3		10	1	20				SPARE
LIGHTING 2009,08,05,04,01	2.5			20	1	11			2.5	12	1	20				SPARE
SPACE						13	0.0			14	1	20				SPARE
SPACE						15		0.0		16	1	20				SPARE
SPACE						17			0.0	18	1	20				SPARE
SPACE						19	0.0			20	1	20				SPARE
SPACE						21		0.0		22	1	20				SPARE
SPACE						23			0.0	24	1	20				SPARE
SPACE						25	0.0			26	1	20				SPARE
SPACE						27		3.4		28	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						29			3.4	30	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						31	3.4			32	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						33		3.4		34	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						35			3.4	36	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						37	3.4			38	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						39		3.4		40	1	20	3.4			FUTURE PHASE 2C LIGHTING
SPACE						41			3.4	42	1	20	3.4			FUTURE PHASE 2C LIGHTING
SUB-TOTAL, CL, KW	16.7	0.0	0.0				11	17	16				27.2	0.0	0.0	SUB-TOTAL, CL, KW
SECTION 2, CL, KW	0.0	0.0	0.0													

LOAD TYPE	CONNECTED LOAD (kW) PH A	PH B	PH C	DEMAND FACTOR	DEMAND LOAD (kW) PH A	PH B	PH C
LIGHTING	11.4	16.8	15.7	1.0	11.4	16.8	15.7
RECEPTACLES	0.0	0.0	0.0	0.5	0.0	0.0	0.0
MOTORS/OTHER	0.0	0.0	0.0	0.8	0.0	0.0	0.0
TOTAL	11.4	16.8	15.7		11.4	16.8	15.7

TOTAL CONNECTED LIGHTING LOAD	43.9 kW
TOTAL CONNECTED RECEPTACLE LOAD	0.0 kW
TOTAL CONNECTED MOTOR/OTHER LOAD	0.0 kW
TOTAL CONNECTED LOAD	43.9 kW

WIRE SIZE CALCULATIONS		
LARGEST PHASE DEMAND		16.8 kW
NO. OF PHASES		3
DEMAND LOAD		43.9 kW
SPARE CAPACITY @	25%	11.0 kW
TOTAL DEMAND LOAD		54.9 kW
SUPPLY VOLTAGE		480
POWER FACTOR @	0.90	0.90
DEMAND AMPS		73 AMPS
MULT FACTOR		1.25
MINIMUM CCT AMPS		91 AMPS

MOUNTING	SURFACE
MAIN TYPE	MLO
MAIN SIZE	225A
A.I.C.	25K
OTHER	42 POLE

LEVEL ONE: Existing loads on 1LNH1 and 2LEH1 were updated.

EXTERIOR: All lighting designed for the exterior has been added to 2LEH1 and 3LNH1.

PANEL 1LNH1 VOLTAGE 480 / 277 PH 3 WIRE 4 6/29/2009

LOCATION ELEC 1029 FED FROM USSHV-B 10:52 AM

LOAD	LOAD, KW LIGHT	RCPT	O/M	A	P	CIRC #	SEQUENCE 3Ø A	B	C	CIRC #	P	A	LOAD, KW LIGHT	RCPT	O/M	LOAD
LIGHTING 1006, 05, 08, 00	1.4			20	1	1	1.8			2	3	15			0.4	AC - 1 (2) - (1/2 HP MTRS)
LIGHTING 1011A,02,01	3.3			20	1	3		3.7		4	-	-			0.4	-
LIGHTING 1016,1015,03,33,30	2.7			20	1	5			3.1	6	-	-			0.4	-
ATRIUM 1011	3.3			20	1	7	3.3			8	1	20				SPARE
1011B,11C,20	3.4			20	1	9		3.4		10	1	20				SPARE
CORRIDORS	1.8			20	1	11			1.8	12	1	20				SPARE
LIGHTING 1021,22,23,24	3.1			20	1	13	3.1			14	1	20				SPARE
SPACE						15		0.0		16	1	20				SPARE
SPACE						17			0.0	18	1	20				SPARE
SPACE						19	3.6			20	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						21		3.6		22	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						23			3.6	24	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						25	3.6			26	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						27		3.6		28	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						29			3.6	30	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						31	3.6			32	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						33		3.6		34	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						35			3.6	36	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						37	3.6			38	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						39		3.6		40	1	20	3.6			FUTURE PHASE 2C LIGHTING
SPACE						41			3.6	42	1	20	3.6			FUTURE PHASE 2C LIGHTING
SUB-TOTAL, CL, KW	19.0	0.0	0.0				23	22	19				43.2	0.0	1.2	SUB-TOTAL, CL, KW
SECTION 2, CL, KW	0.0	0.0	0.0													

LOAD TYPE	CONNECTED LOAD (kW) PH A	PH B	PH C	DEMAND FACTOR	DEMAND LOAD (kW) PH A	PH B	PH C
LIGHTING	22.2	21.1	18.9	1.0	22.2	21.1	18.9
RECEPTACLES	0.0	0.0	0.0	0.5	0.0	0.0	0.0
MOTORS/OTHER	0.4	0.4	0.4	0.8	0.3	0.3	0.3
TOTAL	22.6	21.5	19.3		22.5	21.4	19.2

TOTAL CONNECTED LIGHTING LOAD	62.2 kW
TOTAL CONNECTED RECEPTACLE LOAD	0.0 kW
TOTAL CONNECTED MOTOR/OTHER LOAD	1.2 kW
TOTAL CONNECTED LOAD	63.4 kW

WIRE SIZE CALCULATIONS		
LARGEST PHASE DEMAND		22.5 kW
NO. OF PHASES		3
DEMAND LOAD		63.1 kW
SPARE CAPACITY @	25%	15.8 kW
TOTAL DEMAND LOAD		78.9 kW
SUPPLY VOLTAGE		480
POWER FACTOR @	0.90	0.90
DEMAND AMPS		105 AMPS
MULT FACTOR		1.25
MINIMUM CCT AMPS		131 AMPS

MOUNTING	SURFACE
MAIN TYPE	MLO
MAIN SIZE	225A
A.I.C.	25K
OTHER	-

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	2LEH1	MIN. C/B AIC:	25K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	SECOND FLOOR	OPTIONS:	
SIZE/TYPE MAIN:	125A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG-1ST FLOOR	CORR	2750	20A/1P	1	*			2	20A/1P	2600	ATR CORR	LTG-3RD FLOOR
EXIT SIGNS	1ST FL	300	20A/1P	3		*		4	20A/1P	300	3RD FL	EXIT SIGNS
LTG-ALCOVE	1ST FL	200	20A/1P	5			*	6	20A/1P	2449	2ND FL	LTG-CORR
LTG-CORR	1ST FL	114	20A/1P	7	*			8	20A/1P	300	2ND FL	EXIT SIGNS
LTG-GRNDS	Exterior	577	20A/1P	9		*		10	20A/1P	0		SPARE
SPARE		0	20A/1P	11			*	12	20A/1P	0		SPARE
SPARE		0	20A/1P	13	*			14	20A/1P	0		SPARE
SPACE		0	20A/1P	15		*		16	20A/1P	0		SPACE
SPACE		0	20A/1P	17			*	18	20A/1P	0		SPACE
SPACE		0	20A/1P	19	*			20	20A/1P	0		SPACE
SPACE		0	20A/1P	21		*		22	20A/1P	0		SPACE
SPACE		0	20A/1P	23			*	24	20A/1P	0		SPACE
SPACE		0	20A/1P	25	*			26	20A/1P	0		SPACE
SPACE		0	20A/1P	27		*		28	20A/1P	0		SPACE
SPACE		0	20A/1P	29			*	30	20A/1P	0		SPACE
SPACE		0	20A/1P	31	*			32	20A/1P	1100	FUTURE	PHASE 2 LTG
SPACE		0	20A/1P	33		*		34	20A/1P	1100	FUTURE	PHASE 2 LTG
SPACE		0	20A/1P	35			*	36	20A/1P	1100	FUTURE	PHASE 2 LTG
2LEL1	-	3800	60A/3P	37	*			38	20A/1P	1100	FUTURE	PHASE 2 LTG
-	-	6200	-	39		*		40	20A/1P	1100	FUTURE	PHASE 2 LTG
-	-	5300	-	41			*	42	20A/1P	1100	FUTURE	PHASE 2 LTG

CONNECTED LOAD (KW) - A Ph.	11.76	TOTAL DESIGN LOAD (KW)	44.14
CONNECTED LOAD (KW) - B Ph.	9.58	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C Ph.	10.15	TOTAL DESIGN LOAD (AMPS)	59

PANELBOARD SIZING WORKSHEET

Panel Tag------------------------->				2LEH1	Panel Location:			SECOND FLOOR		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	LTG-1ST FLOOR	3	CORR	2750	w	0.90	2750	3056	
2	A	LTG-3RD FLOOR	3	ATR CORR	2600	w	0.90	2600	2889	
3	B	EXIT SIGNS	9	1ST FL	300	w	0.90	300	333	
4	B	EXIT SIGNS	9	3RD FL	300	w	0.90	300	333	
5	C	LTG-ALCOVE	3	1ST FL	200	w	0.90	200	222	
6	C	LTG-CORR	3	2ND FL	2449	w	0.90	2449	2721	
7	A	LTG-CORR	3	1ST FL	114	w	0.90	114	127	
8	A	EXIT SIGNS	9	2ND FL	300	w	0.90	300	333	
9	B	LTG-GRNDS	3	Exterior	577	w	0.90	577	641	
10	B	SPARE			0	w	0.90	0	0	
11	C	SPARE			0	w	0.90	0	0	
12	C	SPARE			0	w	0.90	0	0	
13	A	SPARE			0	w	0.90	0	0	
14	A	SPARE			0	w	0.90	0	0	
15	B	SPACE			0	w	0.90	0	0	
16	B	SPACE			0	w	0.90	0	0	
17	C	SPACE			0	w	0.90	0	0	
18	C	SPACE			0	w	0.90	0	0	
19	A	SPACE			0	w	0.90	0	0	
20	A	SPACE			0	w	0.90	0	0	
21	B	SPACE			0	w	0.90	0	0	
22	B	SPACE			0	w	0.90	0	0	
23	C	SPACE			0	w	0.90	0	0	
24	C	SPACE			0	w	0.90	0	0	
25	A	SPACE			0	w	0.90	0	0	
26	A	SPACE			0	w	0.90	0	0	
27	B	SPACE			0	w	0.90	0	0	
28	B	SPACE			0	w	0.90	0	0	
29	C	SPACE			0	w	0.90	0	0	
30	C	SPACE			0	w	0.90	0	0	
31	A	SPACE			0	w	0.90	0	0	
32	A	PHASE 2 LTG	3	FUTURE	1100	w	0.90	1100	1222	
33	B	SPACE			0	w	0.90	0	0	
34	B	PHASE 2 LTG	3	FUTURE	1100	w	0.90	1100	1222	
35	C	SPACE			0	w	0.90	0	0	
36	C	PHASE 2 LTG	3	FUTURE	1100	w	0.90	1100	1222	
37	A	2LEL1	1	-	3800	w	0.90	3800	4222	
38	A	PHASE 2 LTG	3	FUTURE	1100	w	0.90	1100	1222	
39	B	-	1	-	6200	w	0.90	6200	6889	
40	B	PHASE 2 LTG	3	FUTURE	1100	w	0.90	1100	1222	
41	C	-	1	-	5300	w	0.90	5300	5889	
42	C	PHASE 2 LTG	3	FUTURE	1100	w	0.90	1100	1222	
PANEL TOTAL								31.5	35.0	Amps= 42.1

PHASE LOADING							kW	kVA	%	Amps
PHASE TOTAL	A						11.8	13.1	38%	47.2
PHASE TOTAL	B						9.6	10.6	31%	38.4
PHASE TOTAL	C						10.1	10.6	31%	38.1

LOAD CATAGORIES			Connected			Demand				Ver. 104
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		15.3	17.0	1.00	15.3	17.0	0.90		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		15.3	17.0	1.25	19.1	21.2	0.90		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.9	1.0		0.9	1.0	0.90		
Total Demand Loads						35.3	39.2			
Spare Capacity			25%			8.8	9.8			
Total Design Loads						44.1	49.0	0.90	Amps=	59.0

Default Power Factor =	0.90
Default Demand Factor =	100 %

2LEH1

Sizing Feeder	
Spares	35 (# of Spares*Breaker Size*0.25)
Design Ampacity	59
Total	94
OCPD	125

Sets	1
Wire Size	
Phase	1
Neutral	1
"Table 250.122" Ground	6
Wire Area (table 5, sq. in.)	
Each Phase	0.1562
Total -Phase Conductors	0.4686
Neutral	0.1562
Ground	0.0507
Total Area	0.6755
Min. Conduit Area (above *2.5)	1.68875
Conduit Size (table 4)	1.5"
Conduit Size (table C.2)	1.5"
Remarks	

PANELBOARD SCHEDULE

VOLTAGE: 480Y/208V,3PH,4W	PANEL TAG: 2LNH1	MIN. C/B AIC: 25K
SIZE/TYPE BUS: 225A	PANEL LOCATION: ELEC. RM. 227	OPTIONS:
SIZE/TYPE MAIN: 200A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG-2nd Floor	Classrooms	2900	20A/1P	1	*			2	20A/1P	0		SPARE
LTG-2nd Floor	Classrooms	3300	20A/1P	3		*		4	20A/1P	0		SPARE
LTG-2nd Floor	Corridors	3000	20A/1P	5			*	6	20A/1P	0		SPARE
LTG-2nd Floor	Atrium	600	20A/1P	7	*			8	20A/1P	0		SPARE
LTG-2nd Floor	Classrooms	3300	20A/1P	9		*		10	20A/1P	0		SPARE
LTG-2nd Floor	Classrooms	2500	20A/1P	11			*	12	20A/1P	0		SPARE
SPACE		0	20A/1P	13	*			14	20A/1P	0		SPARE
SPACE		0	20A/1P	15		*		16	20A/1P	0		SPARE
SPACE		0	20A/1P	17			*	18	20A/1P	0		SPARE
SPACE		0	20A/1P	19	*			20	20A/1P	0		SPARE
SPACE		0	20A/1P	21		*		22	20A/1P	0		SPARE
SPACE		0	20A/1P	23			*	24	20A/1P	0		SPARE
SPACE		0	20A/1P	25	*			26	20A/1P	0		SPARE
SPACE		0	20A/1P	27		*		28	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	29			*	30	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	31	*			32	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	33		*		34	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	35			*	36	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	37	*			38	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	39		*		40	20A/1P	3400	PHASE 2	LTG
SPACE		0	20A/1P	41			*	42	20A/1P	3400	PHASE 2	LTG

CONNECTED LOAD (KW) - A Ph.	10.30	TOTAL DESIGN LOAD (KW)	66.88
CONNECTED LOAD (KW) - B Ph.	16.80	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C Ph.	15.70	TOTAL DESIGN LOAD (AMPS)	89

PANELBOARD SIZING WORKSHEET

Panel Tag-------------------------->	2LNH1	Panel Location:	ELEC. RM. 227
Nominal Phase to Neutral Voltage------->	277	Phase:	3
Nominal Phase to Phase Voltage-------->	480	Wires:	4

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	LTG-2nd Floor	3	Classrooms	2900	w		2900	3222		
2	A	SPARE			0	w		0	0		
3	B	LTG-2nd Floor	3	Classrooms	3300	w		3300	3667		
4	B	SPARE			0	w		0	0		
5	C	LTG-2nd Floor	3	Corridors	3000	w		3000	3333		
6	C	SPARE			0	w		0	0		
7	A	LTG-2nd Floor	3	Atrium	600	w		600	667		
8	A	SPARE			0	w		0	0		
9	B	LTG-2nd Floor	3	Classrooms	3300	w		3300	3667		
10	B	SPARE			0	w		0	0		
11	C	LTG-2nd Floor	3	Classrooms	2500	w		2500	2778		
12	C	SPARE			0	w		0	0		
13	A	SPACE			0	w		0	0		
14	A	SPARE			0	w		0	0		
15	B	SPACE			0	w		0	0		
16	B	SPARE			0	w		0	0		
17	C	SPACE			0	w		0	0		
18	C	SPARE			0	w		0	0		
19	A	SPACE			0	w		0	0		
20	A	SPARE			0	w		0	0		
21	B	SPACE			0	w		0	0		
22	B	SPARE			0	w		0	0		
23	C	SPACE			0	w		0	0		
24	C	SPARE			0	w		0	0		
25	A	SPACE			0	w		0	0		
26	A	SPARE			0	w		0	0		
27	B	SPACE			0	w		0	0		
28	B	LTG	3	PHASE 2	3400	w		3400	3778		
29	C	SPACE			0	w		0	0		
30	C	LTG	3	PHASE 2	3400	w		3400	3778		
31	A	SPACE			0	w		0	0		
32	A	LTG	3	PHASE 2	3400	w		3400	3778		
33	B	SPACE			0	w		0	0		
34	B	LTG	3	PHASE 2	3400	w		3400	3778		
35	C	SPACE			0	w		0	0		
36	C	LTG	3	PHASE 2	3400	w		3400	3778		
37	A	SPACE			0	w		0	0		
38	A	LTG	3	PHASE 2	3400	w		3400	3778		
39	B	SPACE			0	w		0	0		
40	B	LTG	3	PHASE 2	3400	w		3400	3778		
41	C	SPACE			0	w		0	0		
42	C	LTG	3	PHASE 2	3400	w		3400	3778		
PANEL TOTAL								42.8	47.6	Amps=	57.2

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					10.3	11.4	24%	41.3
PHASE TOTAL	B					16.8	18.7	40%	67.4
PHASE TOTAL	C					15.7	17.1	36%	61.6

LOAD CATAGORIES			Connected			Demand				Ver. 104
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		42.8	47.6	1.25	53.5	59.4	0.90		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						53.5	59.4			
Spare Capacity			25%			13.4	14.9			
Total Design Loads						66.9	74.3	0.90	Amps=	89.4

Default Power Factor =	0.90	
Default Demand Factor =	100	%

2LNH1

Sizing Feeder

Spares	65	(# of Spares*Breaker Size*0.25)
Design Ampacity	89	
Total	154	
OCPD	200	

Sets	1
Wire Size	
Phase	3/0
Neutral	3/0
"Table 250.122" Ground	6
Wire Area (table 5, sq. in.)	
Each Phase	0.2679
Total -Phase Conductors	0.8037
Neutral	0.2679
Ground	0.0507
Total Area	1.1223
Min. Conduit Area (above *2.5)	2.80575
Conduit Size (table 4)	2"
Conduit Size (table C.2)	2"
Remarks	

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	1LNH1	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	ELEC. RM. 125	OPTIONS:	
SIZE/TYPE MAIN:	200A/3P C/B	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LTG-1st Floor	Classrms	1400	20A/1P	1	*			2	20A/1P	400		AC-1
LTG-1st Floor	Classrms	3300	20A/1P	3		*		4	20A/1P	400	0	AC-1
LTG-1st Floor	Classrms	2700	20A/1P	5			*	6	20A/1P	400	0	AC-1
LTG-1st Floor	Atrium	2901	20A/1P	7	*			8	20A/1P	0		SPARE
LTG-1st Floor	Classrooms	3400	20A/1P	9		*		10	20A/1P	0		SPARE
LTG-1st Floor	Corridors	1800	20A/1P	11			*	12	20A/1P	0		SPARE
LTG-1st Floor	Classrooms	3100	20A/1P	13	*			14	20A/1P	0		SPARE
SPACE		0	20A/1P	15		*		16	20A/1P	0		SPARE
SPACE		0	20A/1P	17			*	18	20A/1P	0		SPARE
SPACE		0	20A/1P	19	*			20	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	21		*		22	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	23			*	24	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	25	*			26	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	27		*		28	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	29			*	30	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	31	*			32	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	33		*		34	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	35			*	36	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	37	*			38	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	39		*		40	20A/1P	3600	Phase-2	LTG
SPACE		0	20A/1P	41			*	42	20A/1P	3600	Phase-2	LTG

CONNECTED LOAD (KW) - A Ph.	22.20	TOTAL DESIGN LOAD (KW)	97.76
CONNECTED LOAD (KW) - B Ph.	21.50	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C Ph.	19.30	TOTAL DESIGN LOAD (AMPS)	131

PANELBOARD SIZING WORKSHEET

Panel Tag------------------------->					1LNH1	Panel Location:			ELEC. RM. 125		
Nominal Phase to Neutral Voltage------->					277	Phase:			3		
Nominal Phase to Phase Voltage-------->					480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	A	LTG-1st Floor	3	Classrms	1400	w		1400	1556		
2	A	AC-1	6		400	w		400	444		
3	B	LTG-1st Floor	3	Classrms	3300	w		3300	3667		
4	B	AC-1	6		400	w		400	444		
5	C	LTG-1st Floor	3	Classrms	2700	w		2700	3000		
6	C	AC-1	6		400	w		400	444		
7	A	LTG-1st Floor	3	Atrium	2901	w		2901	3223		
8	A	SPARE			0	w		0	0		
9	B	LTG-1st Floor	3	Classrooms	3400	w		3400	3778		
10	B	SPARE			0	w		0	0		
11	C	LTG-1st Floor	3	Corridors	1800	w		1800	2000		
12	C	SPARE			0	w		0	0		
13	A	LTG-1st Floor	3	Classrooms	3100	w		3100	3444		
14	A	SPARE				w		0	0		
15	B	SPACE			0	w		0	0		
16	B	SPARE			0	w		0	0		
17	C	SPACE			0	w		0	0		
18	C	SPARE			0	w		0	0		
19	A	SPACE			0	w		0	0		
20	A	LTG	3	Phase-2	3600	w		3600	4000		
21	B	SPACE			0	w		0	0		
22	B	LTG	3	Phase-2	3600	w		3600	4000		
23	C	SPACE			0	w		0	0		
24	C	LTG	3	Phase-2	3600	w		3600	4000		
25	A	SPACE			0	w		0	0		
26	A	LTG	3	Phase-2	3600	w		3600	4000		
27	B	SPACE			0	w		0	0		
28	B	LTG	3	Phase-2	3600	w		3600	4000		
29	C	SPACE			0	w		0	0		
30	C	LTG	3	Phase-2	3600	w		3600	4000		
31	A	SPACE			0	w		0	0		
32	A	LTG	3	Phase-2	3600	w		3600	4000		
33	B	SPACE			0	w		0	0		
34	B	LTG	3	Phase-2	3600	w		3600	4000		
35	C	SPACE			0	w		0	0		
36	C	LTG	3	Phase-2	3600	w		3600	4000		
37	A	SPACE			0	w		0	0		
38	A	LTG	3	Phase-2	3600	w		3600	4000		
39	B	SPACE			0	w		0	0		
40	B	LTG	3	Phase-2	3600	w		3600	4000		
41	C	SPACE			0	w		0	0		
42	C	LTG	3	Phase-2	3600	w		3600	4000		
PANEL TOTAL								63.0	70.0	Amps=	84.2
PHASE LOADING								kW	kVA	%	Amps
PHASE TOTAL			A					22.2	24.7	35%	89.1
PHASE TOTAL			B					21.5	23.9	34%	86.2
PHASE TOTAL			C					19.3	21.0	30%	76.0
LOAD CATAGORIES				Connected			Demand				Ver. 104
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0	1.00	0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			61.8	68.7	1.25	77.3	85.8	0.90		
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			1.2	1.3	0.80	1.0	1.1	0.90		
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			0.0	0.0		0.0	0.0			
Total Demand Loads							78.2	86.9			
Spare Capacity				25%			19.6	21.7			
Total Design Loads							97.8	108.6	0.90	Amps=	130.7

Default Power Factor =	0.90
Default Demand Factor =	100 %

1LNH1

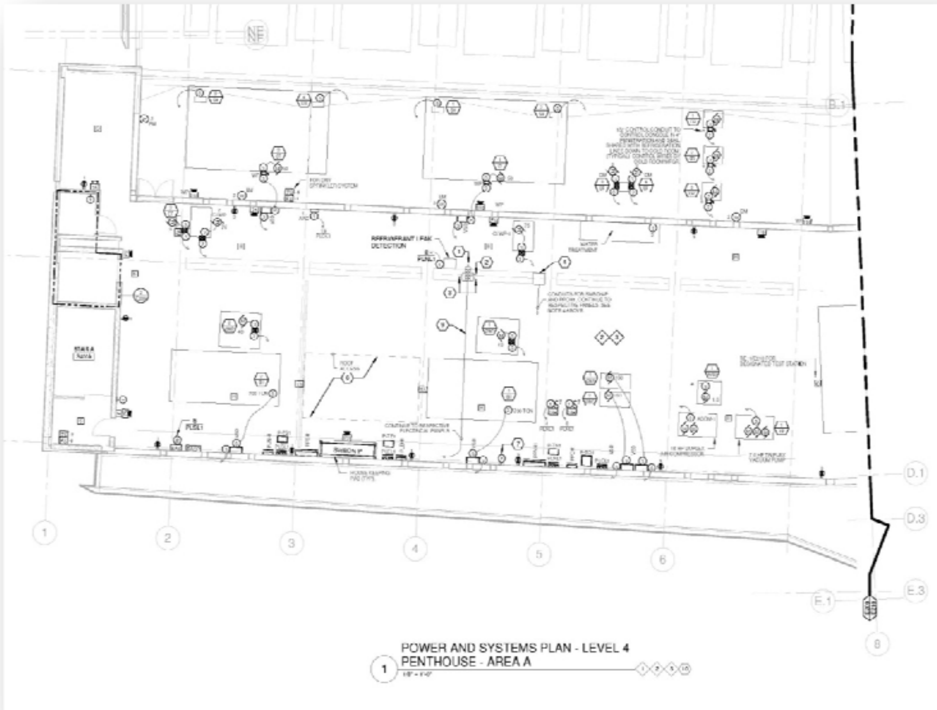
Sizing Feeder		
Spares	30	(# of Spares * Breaker Size * 0.25)
Design Ampacity	131	
Total	161	
OCPD	200	

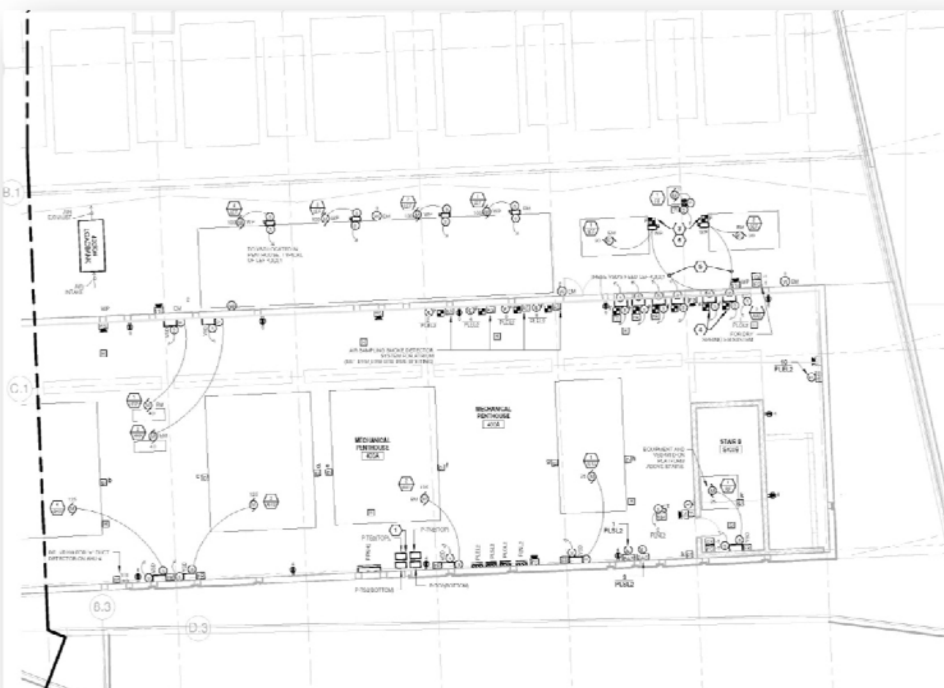
Sets	1
Wire Size	
Phase	3/0
Neutral	3/0
"Table 250.122" Ground	6
Wire Area (table 5, sq. in.)	
Each Phase	0.2679
Total -Phase Conductors	0.8037
Neutral	0.2679
Ground	0.0507
Total Area	1.1223
Min. Conduit Area (above *2.5)	2.80575
Conduit Size (table 4)	2"
Conduit Size (table C.2)	2"
Remarks	

Depth Topic 1: MCC Design

Depth Topic One includes the design and layout of a MCC (motor controller center) for the penthouse mechanical equipment as a substitute to the existing switchboard, SWBDN-P. A motor controller center design was initially proposed due to the extent of motors and mechanical equipment that are located in the penthouse. This study seeks to determine whether such a piece of equipment would be a better substitute for the existing configuration and switchboard. All equipment for the basis of the design is specified from the Allen-Bradley Centerline 2100 product series.

Images of the existing power plan and layout for the mechanical penthouse are shown in Figures 11 and 12.





FIGURES 22 + 23 – MECHANICAL PENTHOUSE POWER PLAN

The first step in this design process was to determine which loads would be housed within the MCC. First, the loads for all the mechanical equipment fed from the switchboard were calculated. Calculations provided a total motor load of 2867.9 A, with the largest motor load (the 700 Ton Chiller) being counted as 125% in accordance with the NEC. The existing switchboard has a 3000 A bus and if it were to be directly interchanged with a MCC that housed the same over current protective devices in addition to the starters for the equipment (highlighted in green in the table below), the MCC would also need a 3000A incoming feeder. The only manufacturer that could be found to regularly provide an incoming feeder bus of this size was Rockwell Automation through their Centerline MCC design. Due to the configuration of the horizontal bus, the sections have the capability to provide 300 A or 600 A above or below the horizontal bus, for a maximum 600 A or 1200 A in one section.

As a result of the design, panelboards PPNH1 and PPNH2 were removed. Their loads were primarily the mechanical motors which have been fed directly through the MCC. The remaining lighting panels in the penthouse are fed through three units: one feeder circuit breaker and two transformer units.

TABLE 13 – MCC MOTOR LOAD CALCULATIONS

MECHANICAL EQUIPMENT									
EQUIPMENT TAG	LOAD DESCRIPTION	LOAD MAGNITUDE	LOAD UNITS	MOTOR AMPS	VOLTAGE	PHASE	ASSUMED POWER FACTOR	LOAD IN KVA	LOAD IN KW
E1	AHU S-1	15	HP	46.2	208	3	0.95	11.8	11.19
E2	EXHAUST FAN EF-1	10	HP	30.8	208	3	0.95	7.85	7.46
E3	EXHAUST FAN EF-2	10	HP	30.8	208	3	0.95	7.85	7.46
E4	EXHAUST FAN EF-3	1	HP	4.6	208	3	0.85	0.88	0.75
E5	EXHAUST FAN EF-4	1/2	HP	2.4	208	3	0.85	0.44	0.37
E7	SUPPLY FAN S-9	3/4	HP	3.5	208	3	0.85	0.66	0.56
E10	EXHAUST FAN EF-5	1 1/2	HP	6.6	208	3	0.85	1.32	1.12
E13	CONDENSATE PUMP 14A	1 1/2	HP	6.6	208	3	0.85	1.32	1.12
E14	CONDENSATE PUMP 14B	1 1/2	HP	6.6	208	3	0.85	1.32	1.12
E15	CONDENSATE PUMP 16A	3/4	HP	3.5	208	3	0.85	0.66	0.56
E16	CONDENSATE PUMP 16B	3/4	HP	3.5	208	3	0.85	0.66	0.56
E17	AHU-1	10	HP	30.8	208	3	0.95	7.85	7.46
E20	RETURN FAN-1	10	HP	30.8	208	3	0.95	7.85	7.46
CRU-1	CONDENSATE RETURN UNIT	3/4	HP	3.50	480	3	0.85	0.66	0.56
CRU-2	CONDENSATE RETURN UNIT	3/4	HP	3.50	480	3	0.85	0.66	0.56
CRU-3	CONDENSATE RETURN UNIT	3/4	HP	3.50	480	3	0.85	0.66	0.56
CRU-4	CONDENSATE RETURN UNIT	3/4	HP	3.50	480	3	0.85	0.66	0.56
HWP-1	HOT WATER PUMP	75	HP	96.0	480	3	0.95	58.9	56.0
HWP-2	HOT WATER PUMP	75	HP	96.0	480	3	0.95	58.9	56.0
HRP-1	HEAT RECOVERY PUMP	40	HP	52.0	480	3	0.95	31.4	29.8
HRP-2	HEAT RECOVERY PUMP	40	HP	52.0	480	3	0.95	31.4	29.8
CT-1	COOLING TOWER FAN	40	HP	52.0	480	3	0.95	31.4	29.8
CT-2	COOLING TOWER FAN	40	HP	52.0	480	3	0.95	31.4	29.8
SH-1	CT-1 SUMP HEATER	9	KW	-	480	3	1.00	9.0	9.0
SH-2	CT-1 SUMP HEATER	9	KW	-	480	3	1.00	9.0	9.0
SH-3	CT-2 SUMP HEATER	9	KW	-	480	3	1.00	9.0	9.0
SH-4	CT-2 SUMP HEATER	9	KW	-	480	3	1.00	9.0	9.0
AHU-1	AIR HANDLING UNIT	75	HP	96.0	480	3	0.95	58.9	56.0
AHU-2	AIR HANDLING UNIT	125	HP	156	480	3	0.95	98.2	93.3
AHU-3	AIR HANDLING UNIT	125	HP	156	480	3	0.95	98.2	93.3
AHU-4	AIR HANDLING UNIT	125	HP	156	480	3	0.95	98.2	93.3
AHU-5	AIR HANDLING UNIT	10	HP	30.8	208	3	0.95	7.9	7.5
AHU-6	AIR HANDLING UNIT	1	HP	4.6	208	3	0.85	0.9	0.7
AHU-7	AIR HANDLING UNIT	1	HP	4.6	208	3	0.85	0.9	0.7
RF-1	INLINE RETURN FAN	25	HP	34.0	480	3	0.95	19.6	18.7
LEF-1	STROBIC TYPE EXHAUST FAN	100	HP	124.0	480	3	0.95	78.5	74.60
LEF-2	STROBIC TYPE EXHAUST FAN	100	HP	124.0	480	3	0.95	78.5	74.60
LEF-3	STROBIC TYPE EXHAUST FAN	100	HP	124.0	480	3	0.95	78.5	74.60
LEF-4	STROBIC TYPE EXHAUST FAN	100	HP	124.0	480	3	0.95	78.5	74.60
EF-1	EXHAUST FAN	1	HP	2.1	480	3	0.85	0.9	0.75
EF-2	EXHAUST FAN	3	HP	4.8	480	3	0.85	2.63	2.24
EF-3	EXHAUST FAN	2	HP	3.4	480	3	0.85	1.76	1.49
EF-4	EXHAUST FAN	2	HP	3.4	480	3	0.85	1.76	1.49
EF-5	EXHAUST FAN	3/4	HP	1.6	480	3	0.85	0.66	0.56
EF-6	EXHAUST FAN	15	HP	21.0	480	3	0.95	11.8	11.2
SEF-1	SMOKE EVAC FAN	30	HP	40.0	480	3	0.95	23.6	22.4
SEF-2	SMOKE EVAC FAN	30	HP	40.0	480	3	0.95	23.6	22.38
CH-1	700-TON CHILLER (.577KW/TON)	404	KW	-	480	3	0.95	425.3	404
CH-2	700-TON CHILLER (.577KW/TON)	404	KW	-	480	3	0.95	425.3	404
CWP-1	CHILLED WATER PUMP	40	HP	52.0	480	3	0.95	31.4	30
CWP-2	CHILLED WATER PUMP	40	HP	52.0	480	3	0.95	31.4	30
CLWP-1	CONDENSER WATER PUMP	75	HP	96.0	480	3	0.95	58.9	56
CLWP-2	CONDENSER WATER PUMP	75	HP	96.0	480	3	0.95	58.9	56
CWS-1	CHILLED WATER SUPPLY	150	HP	180.0	480	3	0.95	117.8	111.9
CWS-2	CHILLED WATER SUPPLY	150	HP	180.0	480	3	0.95	117.8	111.9
CR-1	COLD ROOM	10	KW	-	208	3	0.95	10.5	10.0
CR-2	COLD ROOM	10	KW	-	208	3	0.95	10.5	10.0
CR-3	COLD ROOM	10	KW	-	208	3	0.95	10.5	10.0
CR-1A	COLD ROOM	0.6	KW	-	120	1	0.9	0.67	0.60
CR-2A	COLD ROOM	0.6	KW	-	120	1	0.9	0.67	0.60
CR-3A	COLD ROOM	0.6	KW	-	120	1	0.9	0.67	0.60
A/C-1A	MAIN TELECOM ROOM A/C	69.8	FLA	-	208	3	0.95	26.5	25.1
A/C-1B	MAIN TELECOM ROOM A/C	69.8	FLA	-	208	3	0.95	26.5	25.1
A/C-2	NMR	7.2	FLA	-	208	3	0.85	3.1	2.6
A/C-3	XRD	7.2	FLA	-	208	3	0.85	3.1	2.6
ACCU-1A	MAIN TELECOM ROOM A/C	4.8	FLA	-	208	3	0.85	2.0	1.7
ACCU-1B	MAIN TELECOM ROOM A/C	4.8	FLA	-	208	3	0.85	2.0	1.7
ACCU-2	NMR	11.4	FLA	-	208	3	0.85	4.8	4.1
ACCU-3	XRD	11.4	FLA	-	208	3	0.85	4.8	4.1
ACCU-4	*SEE E7	-	-	-	208	3	-	-	-
FIRE PUMP	FIRE PUMP	40	HP	52.0	480	3	0.95	31.41	29.84
JOCKY	JOCKEY PUMP	3	HP	4.8	480	3	0.85	2.63	2.24
FOP-1	FUEL OIL PUMPS	1/2	HP	1.1	480	3	0.85	0.44	0.37
FOP-2	FUEL OIL PUMPS	1/2	HP	1.1	480	3	0.85	0.44	0.37
DI SYS A	DI WATER SYSTEM	1 1/2	HP	3.0	480	3	0.85	1.32	1.12
DBP-1	DOMESTIC BOOSTER PUMP	5	HP	7.6	480	3	0.9	4.14	3.73
DBP-2	DOMESTIC BOOSTER PUMP	5	HP	7.6	480	3	0.9	4.14	3.73
DSP-1	DUPLEX SUMP PUMP	1/2	HP	2.4	208	3	0.85	0.44	0.37
DSP-2	DUPLEX SUMP PUMP	1/2	HP	2.4	208	3	0.85	0.44	0.37
DSE-1	DUPLEX SEWAGE EJECTOR	2	HP	3.4	480	3	0.85	1.76	1.49
DSE-2	DUPLEX SEWAGE EJECTOR	2	HP	3.4	480	3	0.85	1.76	1.49
ACOM-1	AIR COMPRESSOR	15	HP	21.0	480	3	0.95	11.78	11.19
	AIR COMPRESSOR	15	HP	21.0	480	3	0.95	11.78	11.19
VP-1	VACUUM PUMP	7 1/2	HP	11.0	480	3	0.95	5.89	5.60
	VACUUM PUMP	7 1/2	HP	11.0	480	3	0.95	5.89	5.60
	VACUUM PUMP	7 1/2	HP	11.0	480	3	0.95	5.89	5.60
AWS-1	AREA WAY SUMP PUMP	1/2	HP	1.1	480	3	0.85	0.44	0.37
AWS-2	AREA WAY SUMP PUMP	1/2	HP	1.1	480	3	0.85	0.44	0.37
FDS-1	FOUNDATION DRAIN SUMP	1/2	HP	1.1	480	3	0.85	0.44	0.37
FDS-2	FOUNDATION DRAIN SUMP	1/2	HP	1.1	480	3	0.85	0.44	0.37
VAV 140	VAV ELEC. COIL	13.3	KW	-	208	3	1.00	13.3	13.30
VAV 141	VAV ELEC. COIL	2.3	KW	-	208	3	1.00	2.3	2.30
VAV 142	VAV ELEC. COIL	2.3	KW	-	208	3	1.00	2.3	2.30
VAV 143	VAV ELEC. COIL	2.3	KW	-	208	3	1.00	2.3	2.30
RAD-1	REFRIGERATED AIR DRYER	1.5	HP	3.0	480	3	0.85	1.3	1.12
								TOTAL LOAD	2449.2
NOTES:	Exisiting equipment denoted by gray font. (e.g. AHU S-1)								
			Motor Load	2867.4	A				

Proposed Design:

The following diagrams document the layout and equipment of the proposed MCC. With this configuration, the MCC is atypically large at a length of 35'. Though this is unusual, it would technically fit within the mechanical penthouse and still afford the clearance for NEC Condition 2 minimum clear distance for maintenance of 3'-6".

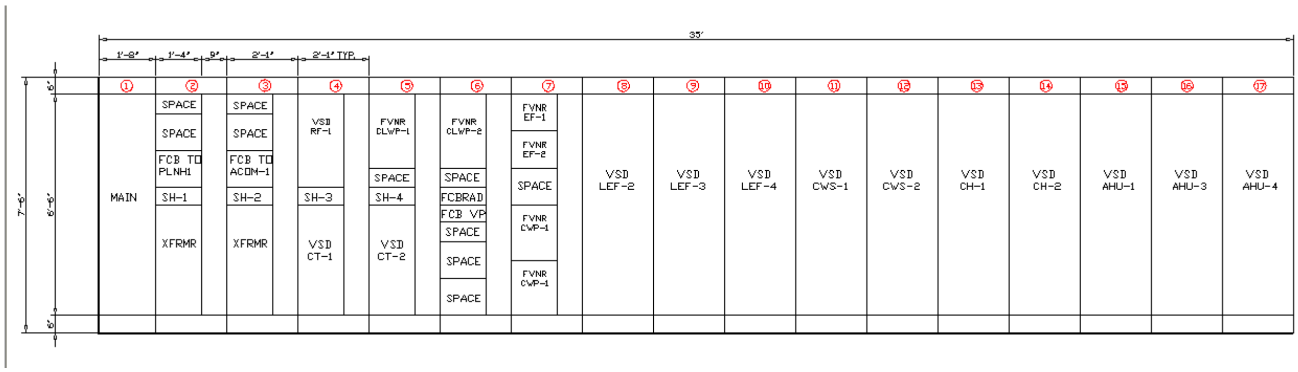


FIGURE 24 – MCC ELEVATION

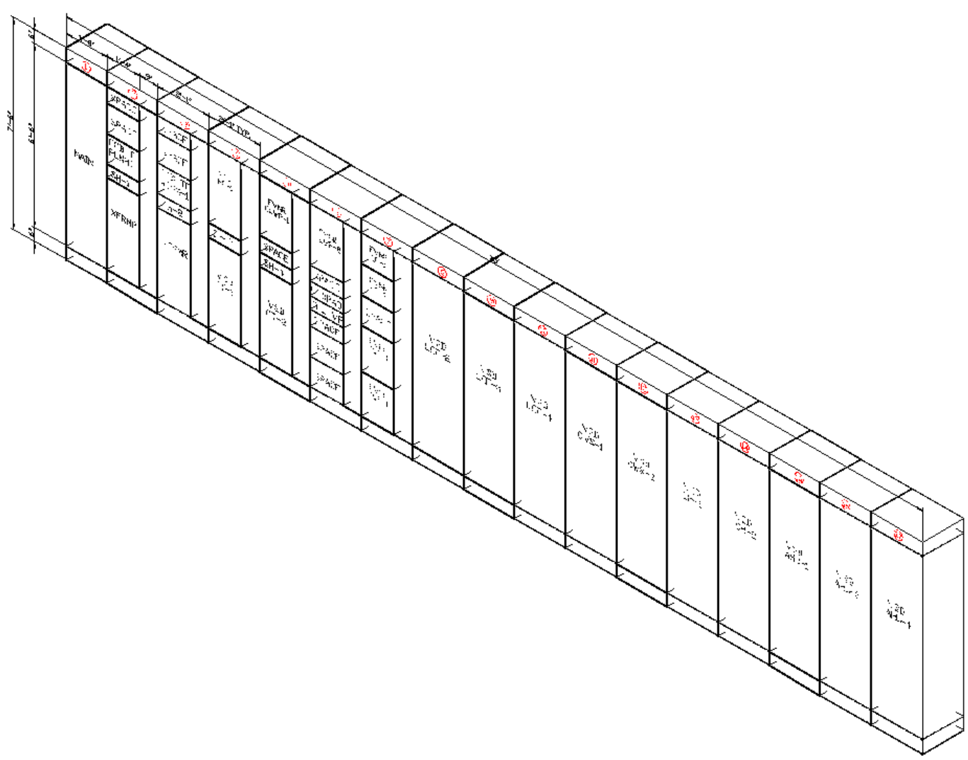


FIGURE 25 – MCC ISOMETRIC

TABLE 14 – MCC SCHEDULE

Motor Controller Center												
Section	Item Served	Load		Overcurrent Protection			Motor Controller			Transformer	†Space Factor	Catalog Number
		HP	FLA	Phase	Amps	Device	Type	NEMA SIZE	Control	kVA		
1	Main Lugs/Incoming		3000	3	3000	CB*	-	-	-		6	2191MB-MKC-60-88FNT
2	Sump Heater, SH-1	-	-	3	20	CB	Packaged	3R			0.5	2193FZ-AKC-32CB-79UT
2	Transformer, P-TN-1	-	-	3	50	CB	-	-	-	30	3	2197-TKBH-36CB
3	Sump Heater, SH-2	-	-	3	20	CB	Packaged	3R			0.5	2193FZ-AKC-32CB-79UT
3	Air Compressor, ACOM-1	(2) 15	(2)21	3	60	CB	Packaged				1	2193FZ-AKC-35CB-79UT
3	Transformer, P-TN-2	-	-	3	50	CB				30	3	2197-TKBH-36CB
4	Cooling Tower Fan, CT-1	40	52	3	90	CB	VSD	1			3	2163RA-052NKB-14HBA3-46CA-79UT
4	Sump Heater, SH-3	-	-	3	20	CB	Packaged	3R			0.5	2193FZ-AKC-32CB-79UT
4	Inline Return Fan, RF-1	25	34	3	70	CB	VSD				2.5	2163RA-034NKB-14DA1D-14HBA3-44CA-79UT
5	Condenser Water Pump, CLWP-1	75	96	3	125	MCP	ALC	4	H-O-A		2	2113B-EAB-6P-49CA-79UT
5	Cooling Tower Fan, CT-2	40	52	3	90	CB	VSD	1			3	2163RA-052NKB-14HBA3-46CA-79UT
5	Sump Heater, SH-4	-	-	3	20	CB	Packaged	3R			0.5	2193FZ-AKC-32CB-79UT
6	Condenser Water Pump, CLWP-2	75	96	3	125	MCP	ALC	4	H-O-A		2	2113B-EAB-6P-49CA-79UT
6	Refrigerated Air Dryer, RAD-1	1.5	3	3	15	CB	Packaged				0.5	2193FZ-AKC-32CB-79UT
6	Vacuum Pump, VP-1	(3) 7.5	(3)11	3	50	CB	Packaged				0.5	2193FZ-AKC-36CB-79UT
7	Bathroom Exhaust Fan, EF-1	1	2.1	3	15	MCP	ALC	1	H-O-A		1	2113B-EAB-6P-35CA-79UT
7	Exhaust Fan, EF-2	3	4.8	3	15	MCP	ALC	1	H-O-A		1	2113B-EAB-6P-38CA-79UT
7	Chilled Water Pump, CWP-1	40	52	3	90	MCP	ALC	3	H-O-A		1.5	2113B-DAB-6P-46CA-79UT
7	Chilled Water Pump, CWP-2	40	52	3	90	MCP	ALC	3	H-O-A		1.5	2113B-DAB-6P-46CA-79UT
8	Strobic Type Exhaust Fan, LEF-2	100	124	3	200	CB	VSD				6	2163QA-***NKB-50CA
9	Strobic Type Exhaust Fan, LEF-3	100	124	3	200	CB	VSD				6	2163QA-***NKB-50CA
10	LEF-4 (BACKUP)	100	124	3	200	CB	VSD				6	2163QA-***NKB-50CA
11	Chilled Water Supply, CWS-1	150	180	3	250	CB	VSD				6	2163QA-***NKB-52CA
12	CWS-2 (BACKUP)	150	180	3	250	CB	VSD				6	2163QA-***NKB-52CA
13	Chiller 1, CH-1	-	-	3	1200	CB	VSD				6	2163QA-***NKB-**CM
14	Chiller 2, CH-2	-	-	3	1200	CB	VSD				6	2163QA-***NKB-**CM
15	Air Handling Unit, AHU-1	75	96	3	125	CB	VSD				6	2163RA-096NKB-14DA1D-14HBA3-49CA
16	Air Handling Unit, AHU-3	125	156	3	225	CB	VSD				6	2163RA-156NKB-14DA1D-14HBA3-51CA
17	Air Handling Unit, AHU-4	125	156	3	225	CB	VSD				6	2163RA-156NKB-14DA1D-14HBA3-51CA
NOTES:	* Located in basement substation USSHV-B											
	† Space Factor of 1 = 13", 2 = 26", etc.											

This proposed design would most likely not be implemented since the MCC is so large and typically would be more expensive than switchboard units. Even if the two chillers and their VSDs were removed from the MCC, the overall length would only be reduced to 30'-4", which is not a significant savings in space or units. Though the feeder bus could be reduced from 3000A to 1400A or 1600A, separate sets of feeders would then need to be run to the two chiller VSDs.

DEPTH TOPIC 2: SKM ANALYSIS

The SKM Power Tools software was chosen for the second electrical depth in order to conduct several studies around the existing electrical distribution system. While the process of modeling the distribution system was very helpful in understanding all the components and settings of the system, several studies were conducted for a more focused analysis of the existing design. The three main studies conducted with the generated SKM model were arc flash evaluation, over-current device coordination study, and a fault current analysis. Copies of the printed reports can be found in the appendices.

When looking at the model created in SKM, one will notice it is not the full distribution system. This is due to the limit of bus components in the licensed copies of the software within the computer labs. Consequently, the system was modeled with the largest loads and normal branches only.

In working with the model and consulting with the project engineer, several assumptions and project specific conditions became evident. The largest issue discovered was managing voltage drop along the feeders and branches to within the 5% limit. The issues encountered were easily rectified by adjusting the primary taps of the transformers. By setting the taps to -2.5%, the entire system properly satisfied voltage drop conditions, even though the secondary voltage was slightly higher than usual.

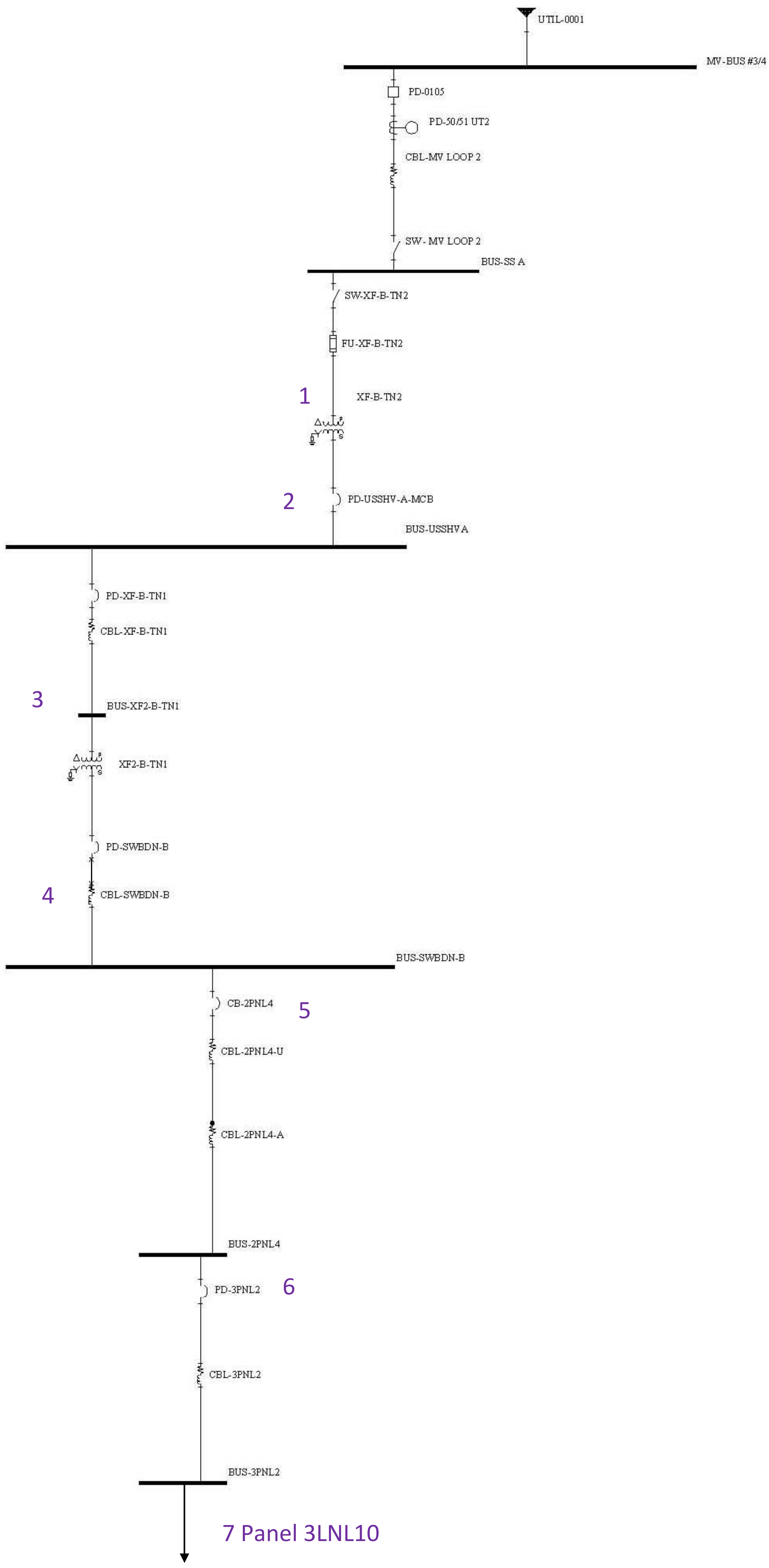
Interestingly, I was also able to learn some of the issues the project engineer encountered in the design phase. Because the building is large and comprised mostly of labs, it would not be likely that it operates at full capacity for any extended period of time. However, a diversity factor was unable to be applied, so the engineer created a "dummy load" to correct for the high voltage drop across the transformers in the full load calculations.

SHORT CIRCUIT STUDY + CALCULATIONS

Fault current calculations and overcurrent device coordination studies are important because they ensure the safe and proper function of protective devices for branch circuits and equipment. Short circuits within distribution systems can cause fault currents up to tens of thousands of amperes, and if they are not isolated within cycles the resulting damages could be very harmful to personnel and/or equipment. Primarily, the resulting damage is evident in thermal or mechanical stresses to connected equipment. The calculations presented in the following pages were conducted in addition to those run through SKM, and follow the same path. The whole branch indicated in Figure 26 was studied in SKM whereas the trip curve coordination in Figure 27 was generated with layered manufacturer's data for local panel 3LNL10 to 2PNL4 (points 5-7). A summarized list of the available fault current at each component (calculated in SKM) is available in Appendix D. A comparison of the SKM short circuit study and the calculated results follows.

POINT	LOCATION
1	XF-B-TN2
2	USSHV-A
3	XF-B-TN1
4	SWBDN-B
5	MDP-2PNL4
6	MDP-3PNL2
7	PANEL 3LNL10

FIGURE 26 – ISOLATED PATH FOR PROTECTIVE DEVICE COORDINATION STUDY



Given:	System Voltage	480
	Base kVA	2500
	Utility Company Available Fault	100000

Transformer Secondary Side (XF-B-TN2)

%Z	5.75	Zutil	2.304		mΩ
X/R	5.66	Rutil	0.400859		mΩ
X(%)	2.5	Xutil	0.394745		mΩ
R(%)	0.313	Rxfrmr	0.921975		mΩ
kVA	2500	Xxfrmr	5.218379		mΩ
		Ztotal	1.322834	5.613124	mΩ
		Isc	48033		A

BUS-USSHVA - SUBSTATION

FEEDER			
L	5		
Rcon	0.0124	mΩ	2.97 mΩ/100ft
Xcon	0.0160	mΩ	3.85 mΩ/100ft
Ztotal	1.3352	5.6292	
Isc	47880	A	

BTN1

FEEDER	4 Sets 500kcmil in plastic		
L	40		
Rfeed	0.22	mΩ	2.2 mΩ/100ft
Xfeed	0.303	mΩ	3.03 mΩ/100ft
Zpri	1.5552	5.9322	(At Primary Windings)
α	2.308		
Zsec	0.2920	1.1139	

TRANSFORMER

%Z	5				
X/R	4.9				
		Rxfrmr	0.865107		mΩ
kVA	500	Xxfrmr	4.239024		mΩ
		Ztotal	1.1571	5.3530	mΩ
		Isc	21911		A

SWBDN-B

FEEDER	6 Sets 400 kcmil in plastic		
L	30		
Rcon	0.205	mΩ	2.73 mΩ/100ft
Xcon	0.231	mΩ	3.08 mΩ/100ft
Ztotal	1.3619	5.5840	
Isc	20878	A	

At 2PNL4

L	125		
2 sets	#350 Copper		
2	3" Conduits		
	Assume Plastic Conduit		
R	1.944	mΩ	3.11 mΩ/100ft
X	1.944	mΩ	3.11 mΩ/100ft
Ztotal	3.3056	7.5277	
Isc	14596	A	

At 3PNL2

L	25		
2 SETS	3/0		
2	2" Conduits		
R	0.804	mΩ	6.43 mΩ/100ft
X	0.4	mΩ	3.20 mΩ/100ft
Ztotal	4.1094	7.9277	
Isc	13439		

At 3LNL10

L	25		
1 SET	1/0		
R	2.550	mΩ	10.2 mΩ/100ft
X	0.835	mΩ	3.34 mΩ/100ft
Ztotal	6.6594	8.7627	
Isc	10903		

SHORT CIRCUIT STUDY RESULTS:

POINT	LOCATION	AVAILABLE FAULT (A)	SKM AVAILABLE FAULT (A)	STANDARD BREAKER RATING (kA)	EXISTING DESIGN
1	XF-B-TN2	48,033	-	50	63
2	USSHV-A	47,880	43,312	50	100
3	XF-B-TN1	21,911	40,812	25	100
4	SWBDN-B	20,878	19,362	22	65
5	MDP-2PNL4	14,596	13,591	18	100
6	MDP-3PNL2	13,439	12,530	18	65
7	PANEL 3LNL10	10,903	-	18	25

One can see from the short circuit study results that values from SKM and those generated from the direct-ohmic method do not vary greatly except at Transformer B-TN1. This is most likely due to the assumptions associated with the reactance and resistance values of the transformer or the locations upstream. However, there are significant differences between the standard breaker rating column (based on column three values generated by the direct-ohmic method) and the existing design kAIC ratings. In all cases, the existing design values are higher. This is most likely due to the anticipated loads of the phase two addition. While these loads have been configured into existing panelboard layouts, they are still estimates and could considerably contribute to any overdrawn current throughout the system.

PROTECTIVE DEVICE COORDINATION STUDY

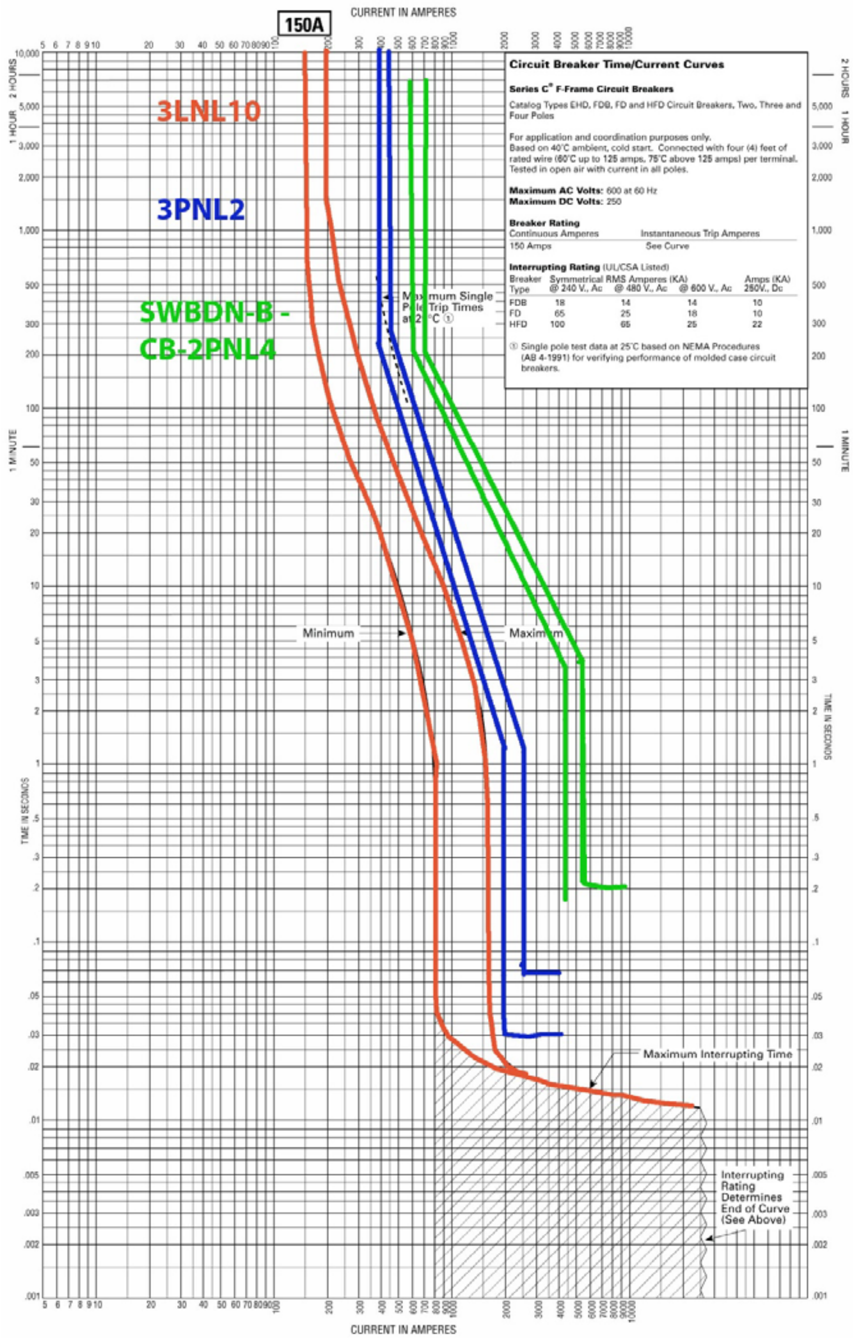
The trip curves in Figure 27, generated from overlaying manufacturer's information of points 5-7 highlighted above in orange, indicate the selected devices are coordinated properly. The load-side breaker (3LNL10) trips first at a rating between 150 A and 200 A followed by the devices upstream. Additional curves for points one through seven were studied in SKM and are included in Appendix D. These further validate the coordination of the overcurrent-protective devices along the path. Additionally, the trip/delay times are summarized in the arc flash evaluation reports (also generated in SKM and included in Appendix D).

Application Data
29-167F

Page 36

AB DE-ION Circuit Breakers

Types FDB, FD and HFD 150 Amperes



Curve No. SC-4149-87B

October 1997

EATON

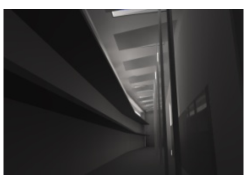
FIGURE 27 – COORDINATION STUDY FOR SPECIFIED OCPDS

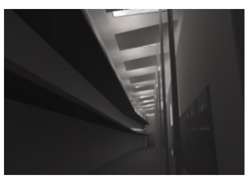
ARC FLASH EVALUATION STUDY

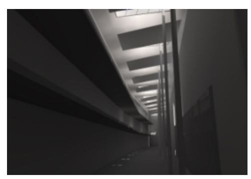
The arc flash evaluation report generated from SKM builds upon the short circuit study and coordination study to provide data for breaker opening times, arc flash boundaries, and the associated required protective clothing (for maintenance) among other data. The images below are an example of the information presented in the arc flash evaluation study for points six and seven. Since the trip/delay times and protective device arcing faults are smaller for 3LNL10 than 3PNL2, the study proves these components are satisfactorily coordinated.

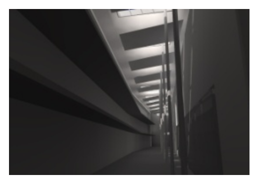
Bus Name	Protective Device Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category
BUS-3LNH1	PD-3LNH1	0.480	11.87	7.59	11.87	7.59	0.017	0.000	Yes	PNL	25	9	18	0.41	Category 0
BUS-3LNL1	CB-3LNL1	0.208	7.12	2.91	7.12	2.91	0.031	0.000	Yes	PNL	25	7	18	0.27	Category 0 (*N3)
BUS-3LNL10	CB-3LNL10	0.208	10.21	4.41	10.21	4.41	0.018	0.000	Yes	PNL	25	7	18	0.24	Category 0
BUS-3PNL2	PD-3PNL2	0.208	11.74	4.87	11.74	4.87	0.04	0.000	Yes	PNL	25	12	18	0.61	Category 0

Daylighting (MAE)


3/22 08:00


3/22 10:00


3/22 12:00


3/22 14:00


3/22 16:00

The objective of this study is to evaluate the existing toplighting and sidelighting systems in the atrium and the potential energy savings associated with a proposed photosensor controlled lighting system. The current lighting design for the atrium space does not provide any sensor-triggered automatic lighting controls, but has the potential to reach significant energy savings by properly integrating the daylight and electric lighting. In order to quantify the existing daylight conditions and measure energy savings, a model of the space was imported into the daylight analysis program, Daysim.

PROCEDURE:

- A model of the space was imported into Daysim and AGI32 to establish existing daylight values within the space at the vernal equinox, summer solstice, and winter solstice. While providing visual clues as to daylight penetration and the solar path, these calculations also indicated that the majority of daylight hours provide illuminance levels that surpass the minimum requirement of 10 fc.
    - o Inputs for the model were adjusted to keep the most accurate site representation for Buffalo, NY. For example, the scene building rotation was set for a +10°41’ to adjust for the difference between magnetic and polar north.

  - Building occupancy was modeled for 8:00am to 11:00 pm weekdays from January 10 to May 20; 8:00am to 5:00pm weekdays from May 21 to August 23; and 8:00am to 11:00pm again on weekdays from August 24 to December 23. These dates and times were chosen to represent the operation of the building as a college facility, which would be in session throughout fall, spring, and summer sessions.

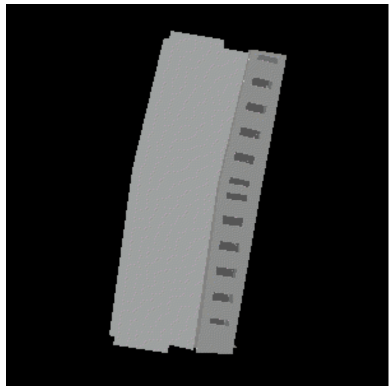
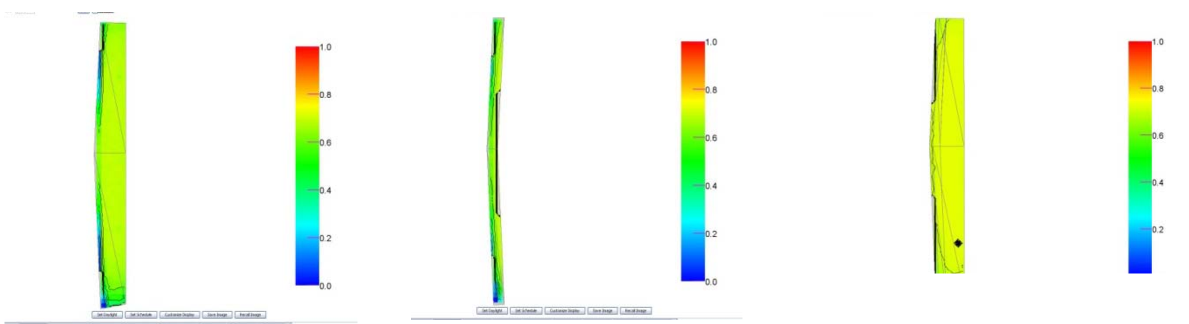


FIGURE 28 – BUILDING SET-UP IN DAYSIM

  - The adjacent mechanical penthouse was also modeled to provide more accurate results.
- From the initial daylight analyses in Daysim, it was determined that the month of December had the lowest numbers for useful daylight illuminance and daylight autonomy. Therefore, December 21 was chosen as the baseline date to use for the experimentation in determining the effects of daylight switching on the energy consumption.



Level One – DA 12/21 Level Two – DA 12/21 Level Three – DA 12/21

FIGURE 29 – DA VALUES BY FLOOR LEVEL

- Initially, the daylight and electrical light were going to be analyzed together with the application of a photosensor file and open switching algorithm. However, due to a discovered limitation of the current version of the software, the method was altered to rely solely on daylight autonomy.
- It has been discussed in the current Daylighting course (AE 565), that daylight autonomy can be used as an approximation of the percentage energy saved because it is very close to the values for the critical point, or the area in a space receiving the least contribution from daylight and electric light.
- Daysim calculations were conducted for sensor points at the first, second, and third floors to analyze the daylight signals at each level or zone. The proposed lighting control arrangement would divide each corridor area on each level into a separate zone controlled by a designated photosensor.

- Then results for daylight autonomy were converted into text and viewed with Excel. From here the value of the Daylight Autonomy at the critical point could be selected and applied to the total kilowatt-hrs of energy consumption for illuminating each zone to the target 10 fc/100 lux. The product is approximately equivalent to the energy saved.

CALCULATIONS:

JULIAN	# DAYS	HOURS	
10	131	15	1965
141	95	8	760
236	139	15	2085
365			
		Σ	4810
	TOTAL ANNUAL		3562

FIRST FLOOR:

DA @ CP	0.457			
			W	kW
Total Luminaire Input Power			1301	1.301
Hours of Operation			3562	
TOTAL kWh			4634.162	4634.162
Estimated Annual Savings (kWh)			2117.8	2117.812

SECOND FLOOR:

DA @ CP	0.499			
			W	kW
Total Luminaire Input Power			650	0.65
Hours of Operation			3562	
TOTAL kWh			2315.3	2315.3
Estimated Annual Savings (kWh)			1155.3	1155.33

THIRD FLOOR:

DA @ CP	0.506			
			W	kW
Total Luminaire Input Power			806	0.806
Hours of Operation			3562	
TOTAL kWh				2870.972
Estimated Annual Savings (kWh)			1452.7	1452.712

RESULTS:

- The switching arrangement for the fluorescent luminaires considered here provides an annual total savings of 4725.8 kWh.

MECHANICAL BREADTH

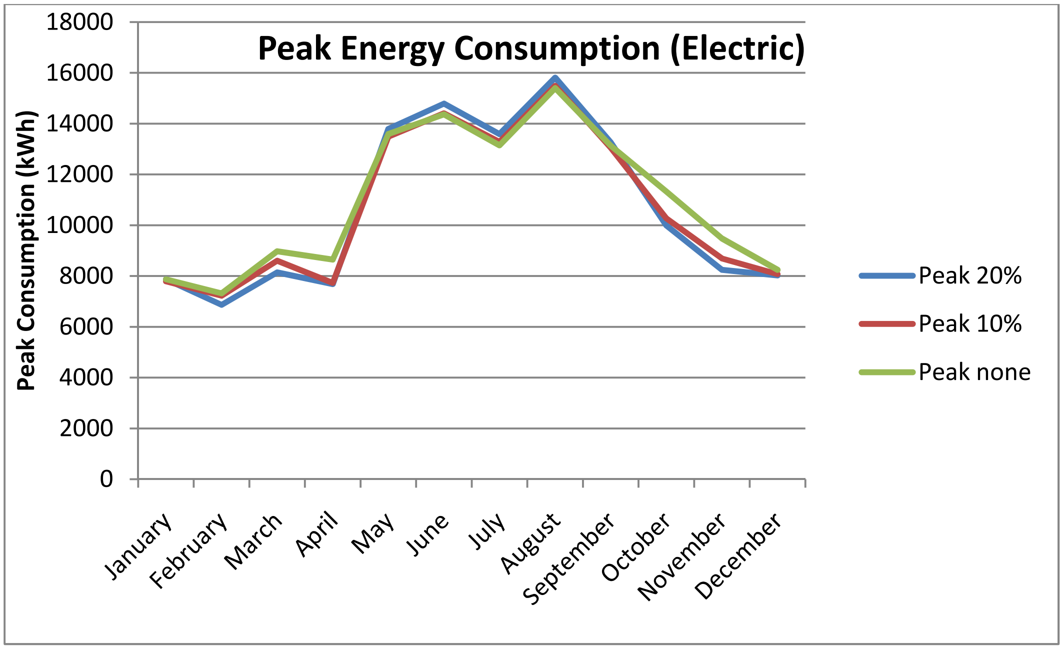
The purpose of this study is to analyze and understand how the heating and cooling loads are affected by toplighting, or skylights. More specifically, this study focuses on the effect of percent area of skylight glazing compared to the roof area. In order to perform this study, a model of the atrium space was created as a room in TRACE with a simultaneous study conducted in SkyCalc. Glazing for the studies is double, low-e clear glass with a SHGC of 0.38, U value of 0.28 Btu/h-°F-ft^2, and transmittance of 0.70.

After setting up the model with appropriate site and occupancy/operation schedules, calculations were run for the space for three different scenarios:

1. Existing Skylight Glazing (20.51% of the roof area)
2. Skylights at 10% of the roof area
3. No Skylights

The results are broken into heating and cooling consumption according to fuel type, gas versus electricity.

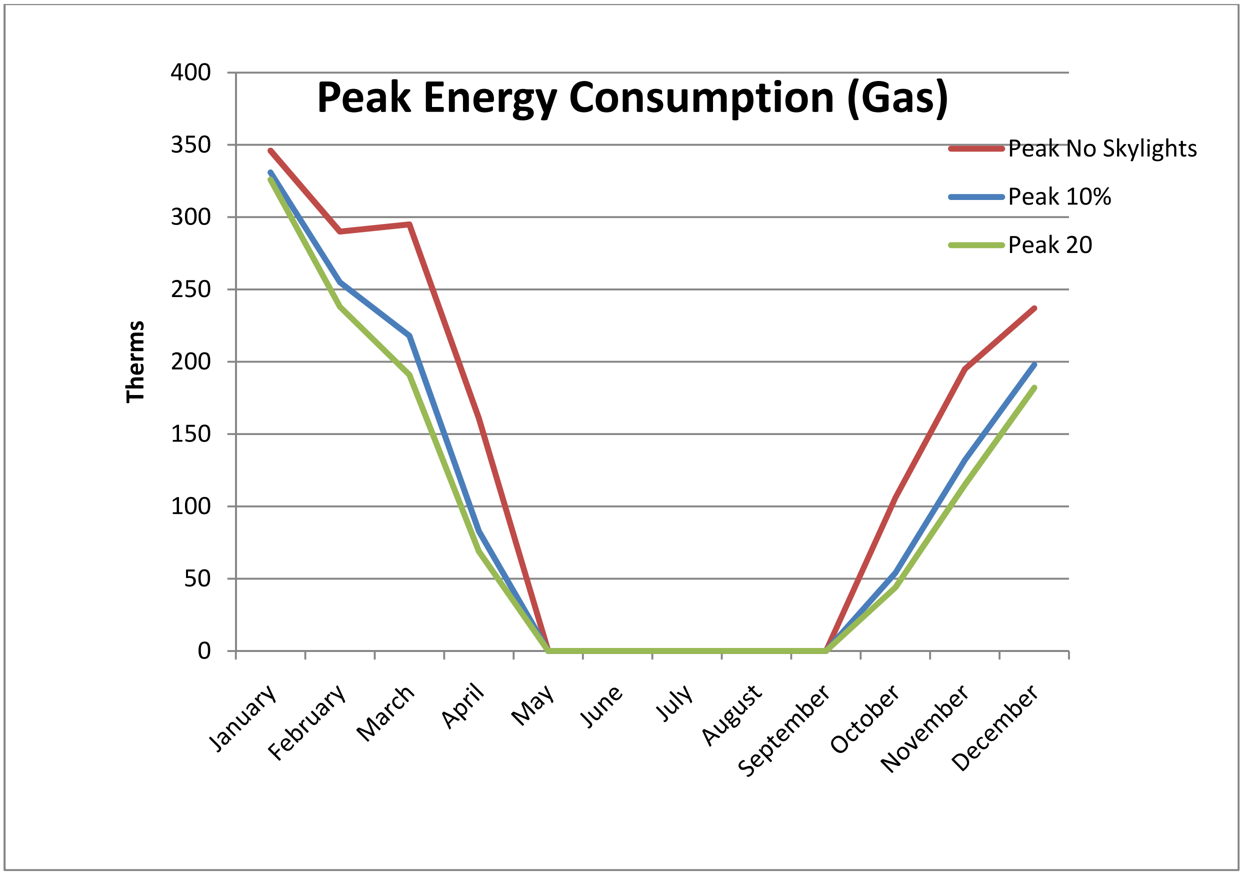
With Skylights modeled	(20.51% roof)											
	January	February	March	April	May	June	July	August	September	October	November	December
Electric												
On Pk (kWh)	7875	6866	8144	7685	13796	14793	13588	15811	13256	9986	8243	8022
Off Peak (kWh)	3439	3239	3928	3641	4635	5742	6118	6269	5265	4107	3927	3803
Demand (kW)	119	119	120	125	143	145	146	147	146	140	126	123
With Skylights modeled	(10% roof)											
	January	February	March	April	May	June	July	August	September	October	November	December
Electric												
On Pk (kWh)	7789	7224	8601	7726	13494	14408	13276	15487	13050	10266	8693	8074
Off Peak (kWh)	3429	3168	3934	3655	4525	5439	5758	6194	5227	4134	3944	3885
Demand (kW)	119	119	121	125	143	145	146	147	146	140	126	123
Without Skylights modeled												
	January	February	March	April	May	June	July	August	September	October	November	December
Electric												
On Pk (kWh)	7875	7319	8972	8648	13594	14368	13144	15404	13134	11327	9479	8241
Off Peak (kWh)	3445	3173	3958	3837	4409	5335	5619	6104	5209	4197	3987	3923
Demand (kW)	120	121	122	129	149	145	146	147	146	140	128	125



With Skylights Modeled (20.51%)												
	January	February	March	April	May	June	July	August	September	October	November	December
Gas												
Peak Cons. (therms)	326	238	191	69	0	0	0	0	0	44	115	182
Peak Demand (therms/hr.)	3	3	3	3	0	0	0	0	0	1	3	3

With Skylights modeled	(10% roof)											
	January	February	March	April	May	June	July	August	September	October	November	December
Gas												
Peak	331	255	218	83	0	0	0	0	0	54	132	198
Off Peak	3	3	3	3	0	0	0	0	0	1	3	3

Without Skylights												
	January	February	March	April	May	June	July	August	September	October	November	December
Gas												
Peak	346	290	295	161	0	0	0	0	0	106	195	237
Off Peak	2	2	2	2	0	0	0	0	0	2	2	2



The results from TRACE would suggest that the toplight glazing creates higher cooling (electric) loads in the summer. Also, the graph generated from these results would indicate there is a law of diminishing returns in terms of the effect the glazing has on expenditures for gas fuel. That is to say, the largest decrease in consumption of energy occurs in the winter months with 10% toplight glazing area, due to solar heat gain.

These trends are again achieved with the studies conducted in SkyCalc, which also account for lighting load alterations. In the SkyCalc evaluation of scenario one versus two, it is evident that scenario one has a larger overall heating energy consumption simply by direct comparison of the figures for annual energy savings (-17,321 kWh/yr < -7,178 kWh/yr). However, if comparing the percentages of heating to overall HVAC energy savings/costs, scenario two heating is more effective because it only accounts for 56% of the negative energy savings as opposed to 62% of negative energy savings in scenario one. In other words, scenario one heating consumption is greater than that of scenario two.

The addition of an on/off lighting control system provides even more proof that a smaller skylight area (in this case 10% of the roof) is more beneficial for this location. For scenario one, the inclusion of an automatic on/off lighting control for 70% of the lighting yields annual energy savings of -13,462 kWh/yr and annual cost savings of -$191. While annual energy savings for scenario two with the abovementioned lighting control are still negative overall, there is a positive annual cost savings of $627. The results for the SkyCalc simulations are presented below:

SCENARIO 1 VS. SCENARIO 2 – NO LIGHTING CONTROL

SCENARIO 1

Savings from Design Skylighting System		
Savings	**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings**
Lighting	0	$0
Cooling	-6,557	-$1,311
Heating	-10,764	-$367
Total	**-17,321**	**-$1,679**

Skylighting System Description		**Site Description**		
Skylight unit size (ft2)	107.2	Climate Location	Buffalo, NY	
Number of Skylights	12	Climate Zone	ASHRAE B-17	
Total Skylight Area (ft2)	1,286	Building Type	Class, Universi	
Skylight to Floor Ratio (SFR)	20.5%	Building Area	6,273	(ft2)
Effective Aperture	9.4%			
Floor Area per Skylight	523	**Elecric Lighting System Description**		
Skylight U-value	0.280	Lighting Type	Lensed fluorescent	
Skylight SHGC	38%	Lighting Control	No Daylight Control	
Skylight Tvis	70%	Light Level Setpoint	10	fc
Well Efficiency (WF)	82%	Lighting Density	0.50	W/ft2
Dirt and Screen Factor	80%	Connected Load	3.1	kW
Overall Skylight System Tvis	46%	Fraction Controlled	0%	

SCENARIO 2

Savings from Design Skylighting System		
Savings	**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting	0	$0
Cooling	-3,139	-$628
Heating	-4,040	-$138
Total	**-7,178**	**-$766**

Skylighting System Description		**Site Description**		
Skylight unit size (ft2)	107.2	Climate Location	Buffalo, NY	
Number of Skylights	6	Climate Zone	ASHRAE B-17	
Total Skylight Area (ft2)	643	Building Type	Class, University	
Skylight to Floor Ratio (SFR)	10.3%	Building Area	6,273	(ft2)
Effective Aperture	4.7%			
Floor Area per Skylight	1,046	**Elecric Lighting System Description**		
Skylight U-value	0.280	Lighting Type	Lensed fluorescent	
Skylight SHGC	38%	Lighting Control	No Daylight Control	
Skylight Tvis	70%	Light Level Setpoint	10	fc
Well Efficiency (WF)	82%	Lighting Density	0.50	W/ft2
Dirt and Screen Factor	80%	Connected Load	3.1	kW
Overall Skylight System Tvis	46%	Fraction Controlled	0%	
Skylight CU	52%			

SCENARIO 1 VS. SCENARIO 2 – WITH ON/OFF SWITCHED LIGHTING CONTROL

SCENARIO 1

Savings from Design Skylighting System		
Savings	**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting	7,236	$1,447
Cooling	-5,620	-$1,124
Heating	-15,079	-$515
Total	**-13,462**	**-$191**

Skylighting System Description		**Site Description**		
Skylight unit size (ft2)	107.2	Climate Location	Buffalo, NY	
Number of Skylights	12	Climate Zone	ASHRAE B-17	
Total Skylight Area (ft2)	1,286	Building Type	Class, University	
Skylight to Floor Ratio (SFR)	20.5%	Building Area	6,273	(ft2)
Effective Aperture	9.4%			
Floor Area per Skylight	523	**Elecric Lighting System Description**		
Skylight U-value	0.280	Lighting Type	Lensed fluorescent	
Skylight SHGC	38%	Lighting Control	On/Off	
Skylight Tvis	70%	Light Level Setpoint	10	fc
Well Efficiency (WF)	82%	Lighting Density	0.50	W/ft2
Dirt and Screen Factor	80%	Connected Load	3.1	kW
Overall Skylight System Tvis	46%	Fraction Controlled	70%	
Skylight CU	52%			

SCENARIO 2

Savings from Design Skylighting System		
Savings	**Annual Energy Savings (kWh/yr)**	**Annual Cost Savings ($/yr)**
Lighting	6,820	$1,364
Cooling	-2,254	-$451
Heating	-8,388	-$286
Total	**-3,823**	**$627**

Skylighting System Description		**Site Description**		
Skylight unit size (ft2)	107.2	Climate Location	Buffalo, NY	
Number of Skylights	6	Climate Zone	ASHRAE B-17	
Total Skylight Area (ft2)	643	Building Type	Class, University	
Skylight to Floor Ratio (SFR)	10.3%	Building Area	6,273	(ft2)
Effective Aperture	4.7%			
Floor Area per Skylight	1,046	**Elecric Lighting System Description**		
Skylight U-value	0.280	Lighting Type	Lensed fluorescent	
Skylight SHGC	38%	Lighting Control	On/Off	
Skylight Tvis	70%	Light Level Setpoint	10	fc
Well Efficiency (WF)	82%	Lighting Density	0.50	W/ft2
Dirt and Screen Factor	80%	Connected Load	3.1	kW
Overall Skylight System Tvis	46%	Fraction Controlled	70%	
Skylight CU	52%			

DISCUSSION:

The existing skylighting design provides up to 4,243 hours/year of full daylighting (according to SkyCalc). While this is greater than a design composed of less glazing area, the tradeoffs between energy consumption prove to be more economical for a smaller glazing area. Scenario two combined with automatic lighting control is the only condition in this study to provide net positive annual cost savings, and it is only when automatic lighting control is incorporated that any kind of positive savings is achieved.

LED LUMINAIRE OPTIONS (HONORS BREADTH)

The following section considers the viability of LED options for general illumination within the building's interior. A background of existing technical characteristics and considerations is presented, followed by a study specific to the building conducted in AGI32.

LED luminaires are quickly gaining momentum as marketable lighting solutions. They are seeing great demand in exterior and accent lighting due to their excellent capacity for colored and dynamic illumination. However, there is great concern among industry professionals about their proper integration within the lighting market, specifically with regards to designs that account for the unique characteristics associated with LED sources. These trends of research and development are comparable to the shift within lighting technology that occurred in the mid-20th century with the implementation of fluorescent sources. There is a great sense of urgency to implement the technology where possible because substantial energy savings and long life are advertised. Yet it should be recognized, that "LEDs still face difficult competition for general illumination because success is defined by correctly matching a technology with the needs of the application" [4].

The considerations for LED product selection should mimic those of any other source, but the designer must be cognizant of the limitations and performance of the source especially within the context of the application. There are numerous characteristics and metrics that need to be considered, including but not limited to: power supply, maintenance, thermal management, economics, and performance.

Performance encompasses numerous properties and characteristics associated with a lighting fixture including photometrics, color rendering, efficiency, and life/reliability. LEDs have the flexibility to accommodate numerous lighting tasks with proper optical design. However, they are also currently associated with issues of glare because of their intense point source. Color quality, rendering, and matching is a major issue associated with white LEDs. While RGB LEDs can be controlled to create a vivid spectrum of colors, binning and color rendering metrics create complications for standard white LED lighting. The CIE is presently developing a new standard for color comparison, because the existing CRI technique does not provide sufficient comparison among different sources. The R_a value does not provide an accurate representation for LEDs because their spectra possess sharp peaks and valleys atypical of other lighting sources whose broader spectra were used as the basis for the development of CRI [5, 6]. Reliability and length of life are perhaps the most marketable traits of an LED, yet they are still being tested. While many manufacturers claim lumen maintenance (of 70%) can be forecast to 60,000 hours, accelerated studies by the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute and others provide evidence this is not the case for all LEDs.

LED performance is inversely proportional to driving current and operating temperatures; as temperature and/or current decrease the lifetime of an LED increases. Since a lifetime of 60,000 hours is difficult to test in a lab, the LRC performed studies to extrapolate data from testing conditions of 6,000 hours. These preliminary studies conducted with phosphor-converted LEDs indicated that an LED downlight operating in open air conditions at 95°C can reach a lumen depreciation of 30% after approximately 5,000 hours [7]. Additionally, the study exhibited high levels of color shift in the test LEDs. The Department of Energy has also collected data on reliability testing via the CALiPER program which includes trends for a larger pool of test sources. A graph of the trends of lumen maintenance for 26 test sources is provided in Figure 30, and includes sources in addition to the phosphor-converted white LEDs of the LRC study [8]. While these studies rely on extrapolated data, they convincingly prove that not all LEDs and LED luminaire combinations existing today maintain lumen output greater than 70% until a operation of 50,000 hours.

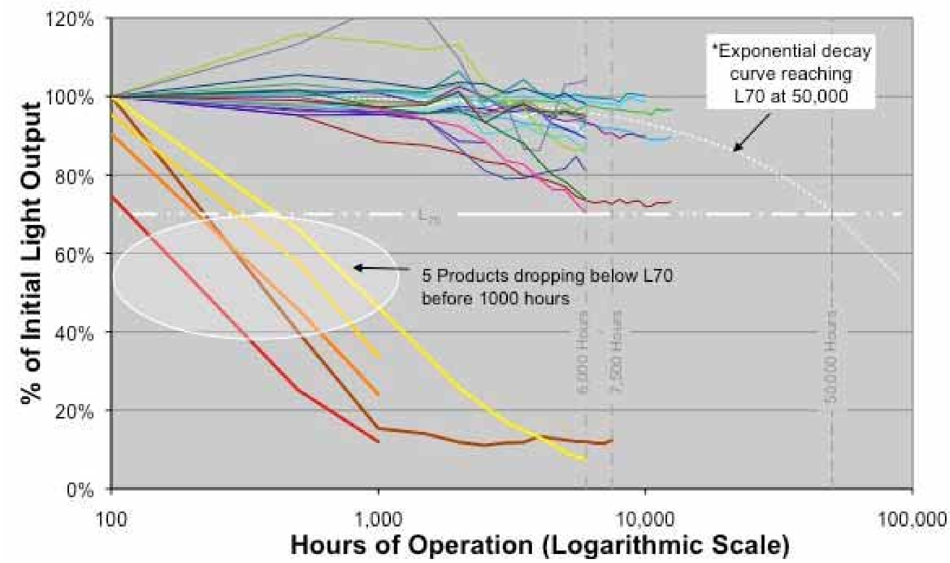


FIGURE 30 – FROM DOE CALIPER STUDY [8]

Finally, but not of least importance, the issue of economics must be considered with LED luminaire specification. While there are methods of computing energy savings and simple payback, there has yet to be a documented demonstration that LED lighting systems provide a total lower cost compared to standard lighting systems [4]. This is due to the fact that the incorporation of LED architectural lighting technology is so new, and LED luminaire production has not yet reached a point in development where it can take advantage of economies of scale.

While research and development are ongoing, marketable products are likewise growing in number. As mentioned previously, most existing LED solutions serve specific lighting applications such as display cases, signs, signal lighting, automotive lighting, task lighting, and accent lighting. The exterior design for the Science Building presented in previous sections already implements LED fixtures in exterior applications, where they have proven to provide light at a fraction of the energy consumption in comparison to an alternative source such as metal halide. This study investigates the options for general overhead illumination within commercial or institutional spaces, and presents an evaluation of performance in AGI32 and a simple payback study.

Research of available general illumination products yielded two opportunities for linear downlighting through manufacturers Albeo Technologies and Lunera. Lunera was chosen as the object for further study based on luminaire housing and optics, which are designed to provide a more evenly distributed light and easily fill in for standard four feet, linear luminaires. Based on product literature for the Lunera 6400 luminaire (available in Appendix A), it has an integrated power supply unit that supplies its strips of RGB white LEDs. It provides 1700 lumens at an input power of 30 watts, and can receive source voltage of 120/277 VAC.

FIGURE 31 – ALBEO LUMINAIRE

FIGURE 32– LUNERA 6400

The space chosen for the study is the genetics teaching lab, of which there occur a total of 10 identical spaces throughout the building. At an area of roughly 1,160 ft^2 the total illuminated area for this suggested design would be 11,600 ft^3. Two scenarios were simulated in AGI32 for:

1. 21 luminaires arranged perpendicular to lab table orientation
2. 16 luminaires parallel and in between lab tables

SCENARIO 1

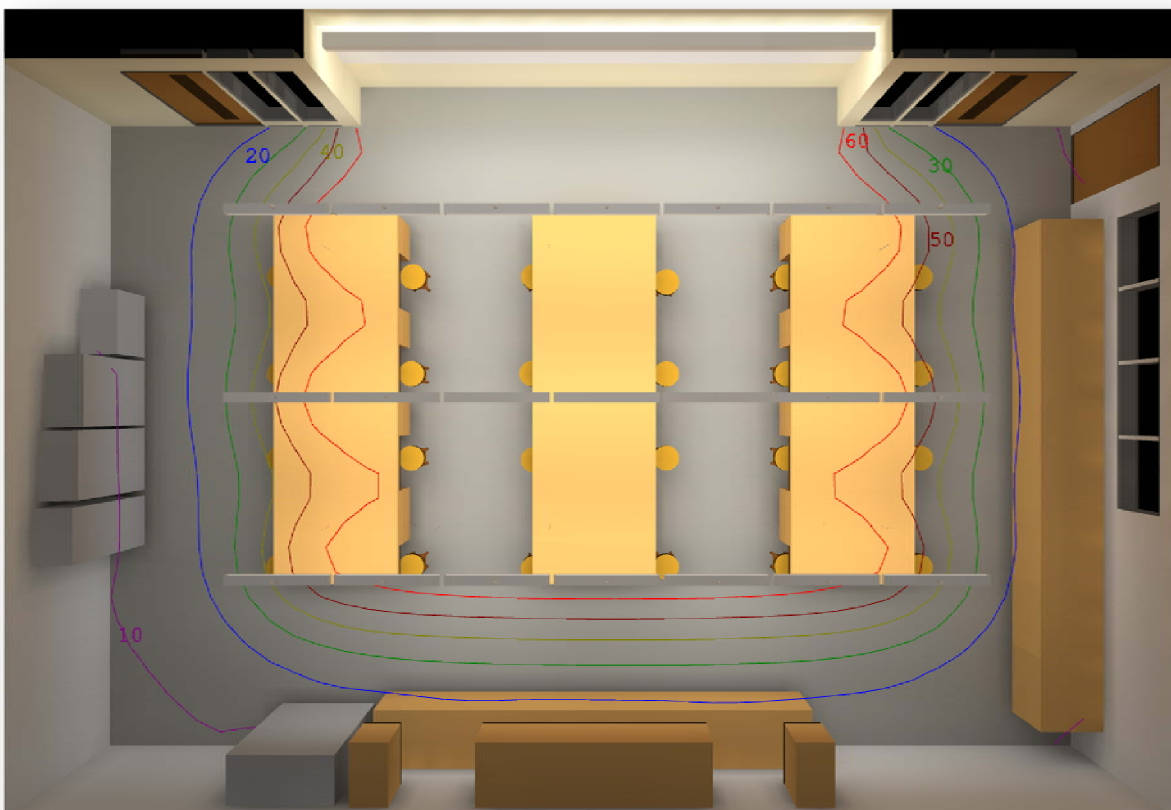


FIGURE 33 - SCENARIO 1

Results Scenario 1:

Average Illuminance = 44.4 fc

LPD = 0.681 W/ft^2

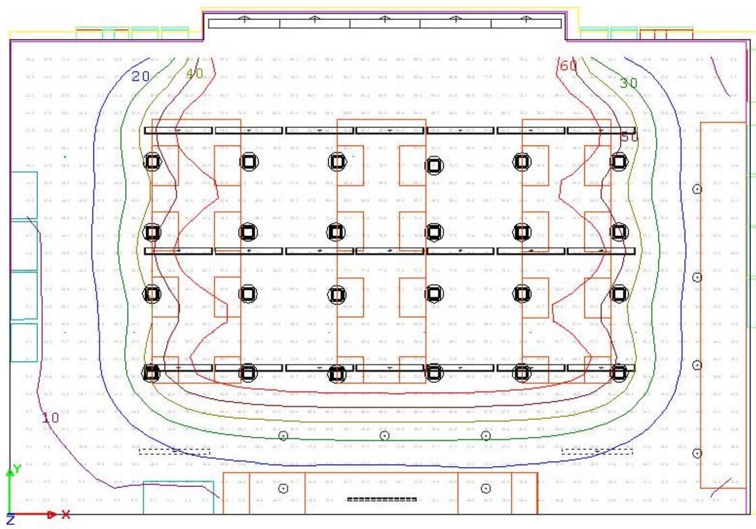


FIGURE 34 - SCENARIO 1 ISOLINES

SCENARIO 2

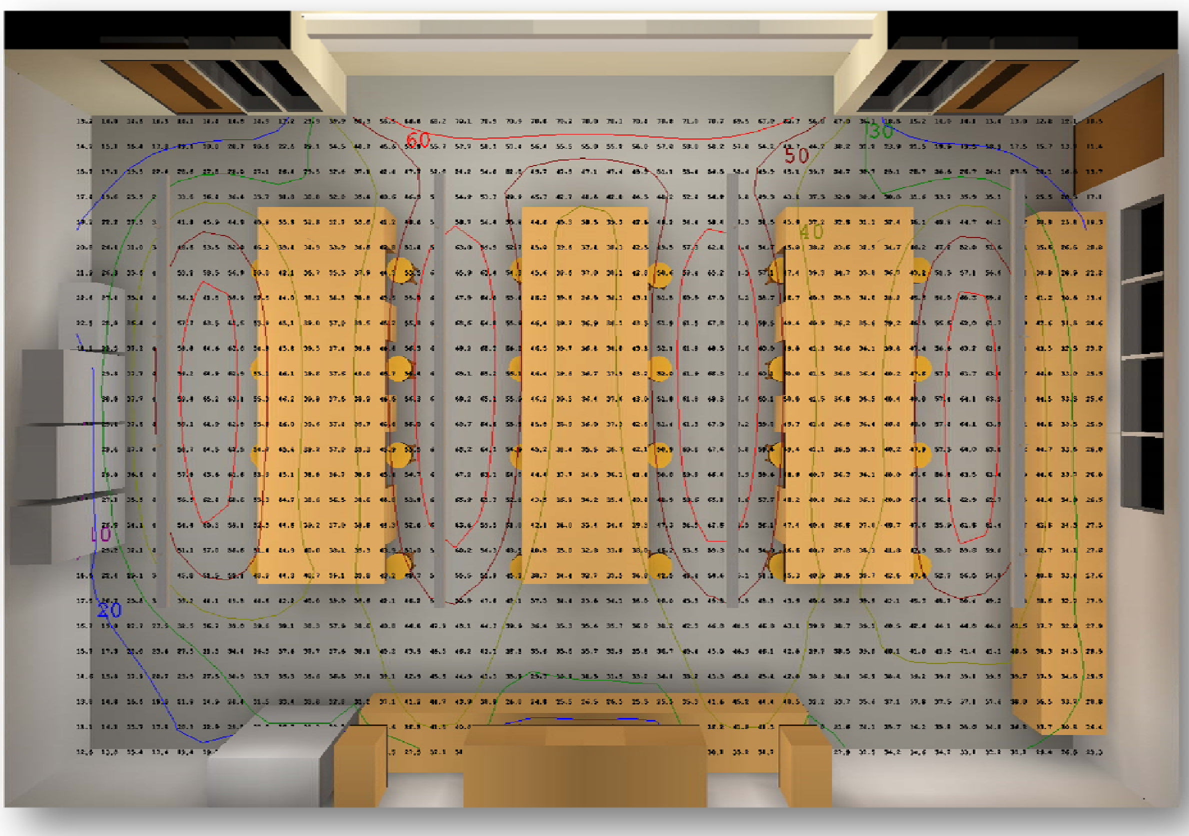


FIGURE 35 - SCENARIO 2

Results Scenario 2:

Average Illuminance = 41.5 fc
LPD = 0.753 W/ft^2

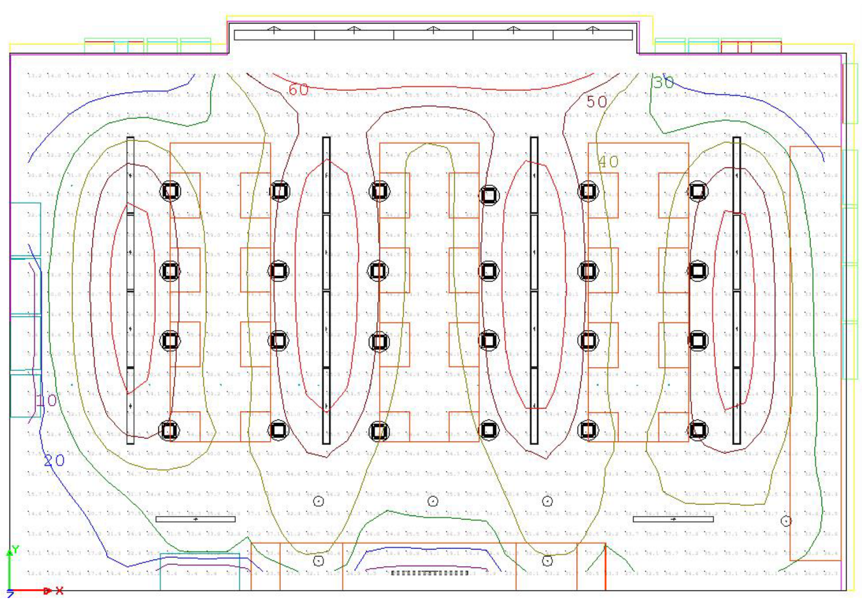


FIGURE 36 - SCENARIO 2 ISOLINES

Individual luminaire price data could not be obtained from Lunera, but their Web site (www.lunera.com) provides a payback calculator tool. Using the tool and applying the settings for a school project at 10,000 ft^2 in New York yields an estimated 1.9 years payback period. A payback period between one and two years can be a substantial incentive for a designer to employ a new system, however, the results from the rough estimates provided are significantly higher.

The calculations provided below indicate initial costs for the proposed scenarios at roughly half and one-third, respectively, of the price of the fluorescent system. However, the calculated payback period based on lighting energy savings is upwards of 16 years. If the LED system were run for 3,500 hours for 14 years it would reach the estimated 50,000 hour life. Since, the period of payback is greater than the potential luminaire life it would be disqualified as a potential solution. Even at a payback period of seven years, it would not be reasonable to utilize the LED design.

				Input Power		Annual Power Cons.	Annual Energy Costs	Annual Cash Flow	Payback Period	Initial System Cost		
	Existing	Luminaires	Total #	W	kW	kWh				Luminaires	Lamps	Ballasts
		LSB-2	140	8680	8.68	30,918	$ 3,091.82			24,500.00	103.25	4,200.00
1	Proposed	Lunera 6400	210	6300	6.3	22,441	$ 2,244.06	$ 847.76	16	13,597.50		
2	Proposed	Lunera 6400	160	4800	4.8	17,098	$ 1,709.76	$ 1,382.06	7	10,360.00		

Assumptions:

- Cost data for the fluorescent luminaires was obtained through distributor R.D. Wright. Estimate values/luminaire = $175. Ballast prices assumed $30/ballast (based on Lunera calculator assumptions). Lamp cost data taken from Grainger Supply: $14.75/lamp.

- Estimated initial costs for Lunera fixtures obtained from applying cost savings presented by Lunera (37% of fluorescent light cost).
- Energy costs assumed: $0.10/kWh
- Total annual operation hours: 3,562

DISCUSSION

The estimated and manufacturer generated payback periods vary too greatly to be effective in an economic analysis. The large difference in results is most likely the result of inconsistent assumptions between the two methods. If the payback period of 1.9 years could be confirmed, then the system could more reasonably be considered based on economics.

The proposed systems perform reasonably well in supplying the required illuminance levels at the task surfaces. While Scenario 1 performs better quantitatively, Scenario 2 would likely reduce direct and veiling glare since the luminaires are not located directly over the task areas. Scenario one and two both provide net savings in energy costs associated with lighting at 27% and 45% respectively.

CONCLUSIONS

While this system provides energy savings, it would not be a good investment for the building at this time. In addition to unconfirmed payback data, the color quality and reliability of the fixture is not provided. This leaves too many performance issues inadequately addressed. Furthermore, the direct, diffusing lens has the potential to create more issues of glare that could easily be avoided with a parabolic troffer or indirect fixture. It could perform well for a generic classroom, but since these classrooms also house lab activities, this could be a potential issue for the occupants.

ACOUSTICAL BREADTH

The atrium designed for the building serves primarily as a circulation space and a link between the existing building and the new addition. However, since it is a major open space within the academic core of the Buffalo State College campus, it also has the potential to serve as an event or gathering space for university functions such as workshops or information sessions. Therefore the nature and size of the space require an acoustical environment that provides proper reverberation time for speech.

There are numerous architectural characteristics to be considered for the acoustical performance of a space, such as finishes, layout, and dimensions. The volume of a space directly affects the average length of sound reflections, or mean free path. The existing design of the atrium accounts for the large volume and hard surfaces by providing acoustical panel treatments on the wall and suspended from the ceiling. This study evaluates the performance of the existing acoustical treatment for a target reverberation time (T) range of 1.3-1.9 seconds and compares the results with a proposed scenario implementing a more absorptive, carpet floor.

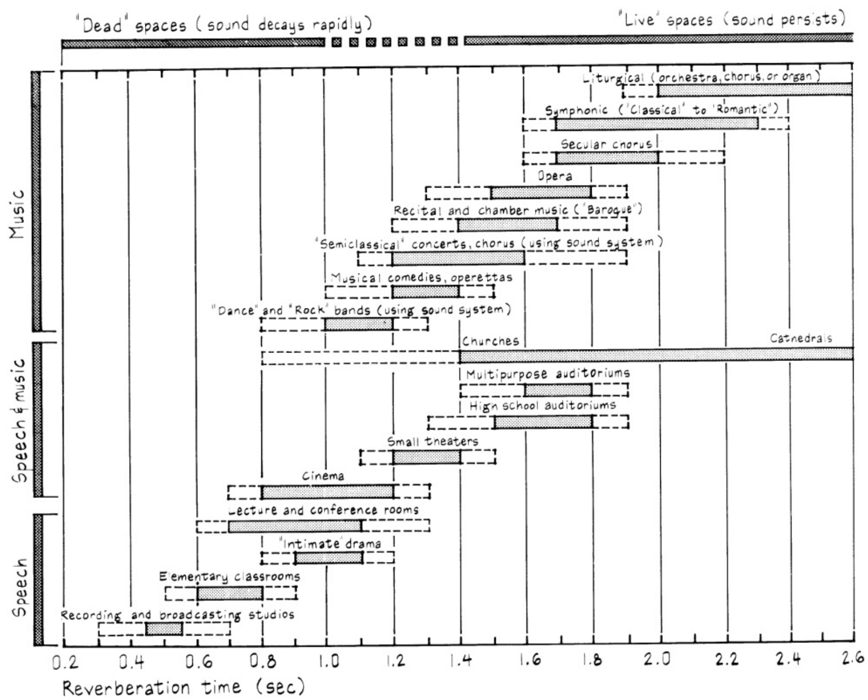
PROCEDURE:

The target T range of 1.3-1.9 seconds was selected based on optimal reverberation times for speech and music in a space [3] as presented in the figure below. In order to quantitatively evaluate the performance, the sound absorption coefficients (α) were first gathered for all the surface materials within the atrium. Then, using the surface area data and absorption coefficients, total room absorption, “a”, was calculated to be applied in Sabine’s

Formula. Note, in this study "a" is modified to account for the long shape of the atrium with a_{air}, which is equivalent to 8 sabins/1,000 ft^3.

$$a = \sum S\alpha + a_{air}$$

$$Sabine's\ Formula: \qquad T = 0.05 * \frac{V}{a}$$



OPTIMUM REVERBERATION TIMES ACCORDING TO SPACE AND AUDIO NEEDS

The calculations for T at 1,000 Hz are summarized in the tables below

Scenario 1	Existing Conditions

Location	Material	Absorption Coefficient	Surface Area	Sα
Floor	Tile	0.01	10881	108.81
Walls	Brick	0.04	5912	236.48
	Gyp Board	0.04	10795	431.8
	AWP	0.82	3082	2527.24
	Tile	0.01	1242.6	12.426
	Glass	0.12	550	66
Ceiling	Gyp Board	0.04	6568	262.72
	ACP	0.82	2166	1776.12
	Glass	0.03	1280	38.4
	Concrete	0.02	3843	76.86

ΣSα = a	5,537
Air Absorption	2,158
Adjusted a*	7,695
Atrium Volume	269,739

Reverberation Time

T = 0.05*(V/a)

T = 1.75

Satisfactory for Range of 1.3 - 1.9 Sec

Scenario 2	Replacing Level One Floor with Carpet

Location	Material	Absorption Coefficient	Surface Area	Sα
Floor	Tile	0.01	4608	46.08
	Carpet	0.37	6273	2321.01
Walls	Brick	0.04	5912	236.48
	Gyp Board	0.04	10795	431.8
	AWP	0.82	3082	2527.24
	Tile	0.01	1242.6	12.426
	Glass	0.12	550	66
Ceiling	Gyp Board	0.04	6568	262.72
	ACP	0.82	2166	1776.12
	Glass	0.03	1280	38.4
	Concrete	0.02	3843	76.86

ΣSα = a	7,795
Air Absorption	2,158
Adjusted a*	9,953
Atrium Volume	269,739

Reverberation Time

T = 0.05*(V/a)

T = 1.36

Significant Improvement

Satisfactory for Range of 1.3 - 1.9 Sec

Scenario 3	Replacing All Floors with Carpet

Location	Material	Absorption Coefficient	Surface Area	Sα
Floor				
	Carpet	0.37	10881	4025.97
Walls	Brick	0.04	5912	236.48
	Gyp Board	0.04	10795	431.8
	AWP	0.82	3082	2527.24
	Tile	0.01	1242.6	12.426
	Glass	0.12	550	66
Ceiling	Gyp Board	0.04	6568	262.72
	ACP	0.82	2166	1776.12
	Glass	0.03	1280	38.4
	Concrete	0.02	3843	76.86

ΣSα = a	9,454
Air Absorption	2,158
Adjusted a*	11,612
Atrium Volume	269739

Reverberation Time

T = 0.05*(V/a)

T = 1.16

Significant Improvement

< 1.3 - 1.9; comparable to cinema, lecture/conference room

RESULTS:

As indicated from the calculations above, all three scenarios fall within the range of 1.3 to 1.9 seconds, though the performance from scenario three is the best, as is to be expected. Additionally, the difference in noise levels (Noise Reduction) between the existing and second and third scenarios is calculated by:

$$NR = 10\ x\ log\frac{a_1}{a_2}$$

NR	dB
1:2	1.1
1:3	1.8

Again, these results indicate that scenario three performs the best. However, the noise reduction levels are too small to have a dramatic impact on the performance of the space. Human hearing can perceive changes in loudness beginning at 3 dB. Therefore, it is recommended that the initial design be maintained.

SUMMARY + CONCLUSIONS

The senior thesis project provided a unique experience for learning more about the performance and integration of systems within a building. The underlying goal of the work in these studies was to be comprehensive about the redesign and to incorporate as much of my existing knowledge and skills of building systems. As a result, daylighting, mechanical, and acoustical analyses were incorporated in the atrium space. The existing skylight system performs well for daylighting purposes but would not provide any economic benefit to the owner if not incorporated with an automatic switched lighting control system. Additionally, the current acoustical considerations for the atrium satisfy reverberation time requirements of speech. While carpeting would further improve these conditions, it is not necessary and could even conflict with the aesthetics and maintenance of the space. The study for the viability of LED luminaires for interior general illumination proves that existing technologies are not suitable for this classification of application at the present time.

Many of the existing systems perform well, and even above current standards or codes. However, the lighting levels within the existing design of the classrooms far exceed minimum requirements of the IESNA. Additionally, the electrical distribution system that supports the building has been engineered well and is prepared to cover all future loads for the second phase of the project. The proposed design of a MCC would just prove to be too difficult and expensive for this type of application.

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