PENN STATE ARCHITECTURAL ENGINEERING SENIOR THESIS

CRYSTAL LAKE ELEMENTARY SCHOOL

LAKE MARY, FLORIDA

LEAH MATERN
LIGHTING/ELECTRICAL OPTION
FACULTY ADVISORS: DR. RICHARD MISTRICK AND TED DANNERTH
APRIL 7, 2011

Crystal Lake Elementary School

Project Team

Owner	Seminole County Public School
Architect	Shenkel Shultz
MEP	Matern Engineering
Structural	Burton, Braswell, Middlebrook
Contractor	R.E. Harris Construction

Architecture

- 11 acres of land in the residential area of Lake Mary, FL
- Exterior Walls: Red Brick Veneer, with one row of yellow soldier brick located above all rectangular walls
- Roofing Material:
  - Main and Exterior Covered Play Area: Prefinished 24 gauge standing seam metal deck with a 1/6 slope
  - Covered Entry: Metal deck on pre-engineered metal trusses
  - Exterior Covered Walkways: Flat roof of pre-engineered aluminum canopy system

Structural

- Reinforced concrete slab with vapor barrier
- Foundation supported by reinforced concrete footings
- Composite steel floor system
- Pre-fabricated cold formed steel truss system

Building Statistics

Location	Lake Mary, FL
Size	113,927 S.F.
	2 Stories
Cost	$11,765,100

Mechanical

- Four air handling units located in three different mechanical rooms on the first floor
- Two air handling units located in two different rooms on the second floor
- Two air cooled rotary screw compressor chillers located outside the building to provide cool air to the building
- Centrifugal Kitchen Exhaust Fan

Lighting

- Variety of Luminaires
- Variety of light sources including fluorescent, incandescent, HID, and LED lamps
- Battery powered emergency light sources include incandescent and fluorescent lamps

Electrical

- Pad Mounted Transformer provided by Utility: 277/480V, 3 Phase, 4 Wire
- 125 KW Emergency Diesel Generator: 480/277V, 3 phase, 4 Wire

Executive Summary

Crystal Lake Elementary School is a public educational facility that is financed by taxes from the surrounding community. Therefore, cost and energy efficiency is an important factor in designing this building. This report will focus on the lighting and electrical redesign of four different spaces within this elementary school. In addition, the emergency system was redesigned to include the chillers, a photovoltaic array was implemented on the roof, a roof structural analysis was performed, and the acoustics in the multipurpose room were evaluated.

The lighting design and electrical circuiting for these changes was redesigned for the covered entrance and covered walkways on the exterior entrance to the building, the lobby, the multipurpose room, and a primary classroom. The lighting is designed based on guidelines from the IESNA handbook, as well as the emphasis on energy efficiency throughout the building. To determine if the illuminance recommendations are met, computer calculations from AGI32 are performed.

Due to the excessive heat of the summers in Florida and the use of this space as a hurricane shelter in the summers, the emergency system is redesigned to include the two chillers located on the exterior of the building.

With the main design goal as energy efficiency, a photovoltaic array is implemented on the roof of this building to decrease the buildings reliability on the utility company. A study is performed to determine if this system is cost effective and worth the initial upfront cost of materials and labor. Since this system is being places on the roof of the building, a structural analysis of the existing roof structure is performed to determine if there are any additional construction costs to implement the photovoltaic system.

The multipurpose room is typically used as an auditorium space, making the acoustical performance of the space is important. Therefore, an acoustical analysis of the existing space is performed to determine if the reverberation time is desirable for this space type.

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Building Information and Statistics

Due to the increase in population in Lake Mary, Florida, there became the need for a new school. Seminole County decided to build a public elementary school that contains 780 student stations in the heart of Lake Mary, Florida on an 11 acre plot of land. This school is located in between two large residential neighborhoods. It will host students in this area from Kindergarten through the 5th grade.

The exterior of this building fits in well with the surrounding area. There is a covered entry in the center of this symmetric building supported by six 20'-6" structural columns. The exterior façade is brick veneer with many aluminum windows with tinted glazing to keep out the heat from the sun. On the side of the building, in a fenced in area, there is an exterior covered play area for the students.

Upon entrance to this building there is a two-story lobby space with an elevator in the center surrounded by the main staircase. From the main entrance there is access to the various corridors that provide circulation throughout the building. The first floor of this building contains a 5,250 SF multipurpose room with a 997 SF wooden stage where large assembly meetings are held and this is also used as the students dining area and auditorium. In addition, the first floor contains a 1,231 SF music room, many classrooms, and administrative offices. The second floor is mainly dedicated to classroom spaces.

Building Name: Crystal Lake Elementary School

Location: Lake Mary, FL

Building Occupant: students grades K-5, teachers, and administrators of the school.

Occupancy Type: The primary occupancy is Educational and the Secondary occupancy is assembly.

Size: 113,927 SF

Number of Stories: 2 stories

Project Team:

Owner: Seminole County Public Schools
Architect: Shenkel Shultz
Civil Engineer: Kilma Weeks
Construction Manager/ General Contractor: R.E. Harris Construction
Structural Engineer: Burton, Braswell, Middlebrooks
MEP Engineer: Matern Professional Engineering, Inc.

Dates of Construction: June 29, 2006-July 29, 2006

Cost: $11,765,100

Project Delivery Method: The overall project delivery method was Design-Bid-Build.

Covered Entrance and Covered Walkways

Spatial Description

The covered entrance and covered walkways are located on the west façade of the building. It is an architectural focal point that can be seen by any person approaching the building. This is a good transition space that connects the interior and exterior spaces. There are six columns that are both functional and aesthetically pleasing that support the structure.

The entrance to the building consists of three sets of double doors with large windows above each set of doors, which are visually pleasing. There is also one door on the north side of this space that gives direct access into the administrative offices. All visitors must enter the bulding through this space, since the covered entrance is the only public entrance to the school.

Space Category:

Exterior Space/Building Façade

Materials:

Location	Material	Reflectance
Ceiling	Exterior Drywall	0.89
Column	White Latex Paint	0.93
	Brick Veneer	0.1
Floor	Reinforced Concrete Slab	0.25
Building Façade Wall	Windows	
	Doors	0.8
	Brick Veneer	0.1

Figure 1: Building Façade Surface Materials

Dimensions: 37’6” x 31’6” with 23’ high ceilings

Area: 1,397 ft^2

Tasks/Activities:

The Covered Entrance and Walkways are primarily circulation spaces. There are no gathering areas within this space and the purpose is to successfully move people from the exterior to the interior.

Covered Entrance and Walkway Plans and Elevations:

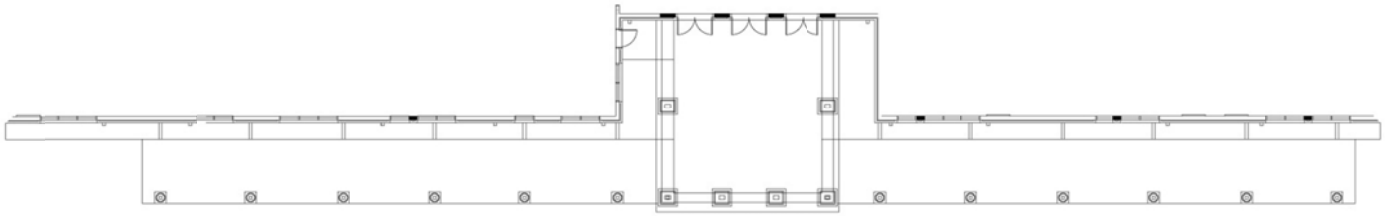


Figure 2: Covered Entrance and Walkway Floor Plan

Figure 3: Covered Entrance and Walkway Elevation

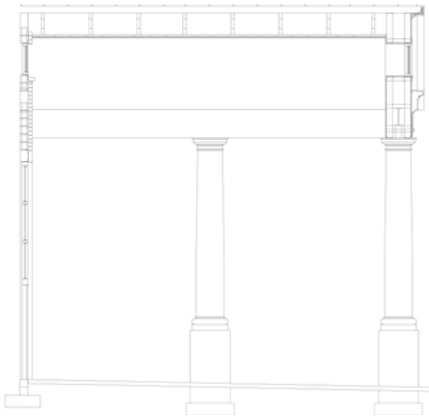


Figure 4: Covered Entrance Section

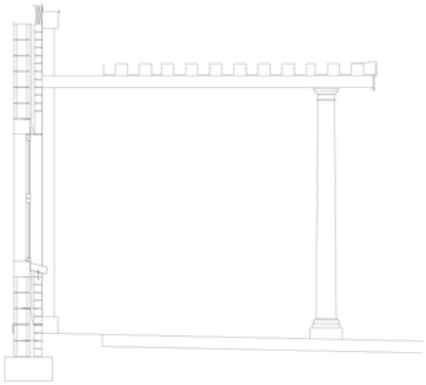


Figure 5: Covered Walkway Section

Lighting Design Criteria and Considerations

Outdoor, Educational Facilities, Building Exteriors, Entrances, Active (pedestrian/conveyance)-(IESNA Lighting Handbook, 9th Ed.)

- **Appearance of Space and Luminaires**
  - The entrance is the first space visitors, faculty, and students see as they approach the school. Therefore, the entrance must enhance the design and architecture of the space to create a welcoming environment. The lighting should direct the circulation of people into the building entrance and not create "visual clutter" that might distract the visitors. The lighting layout should be uniform and create a pattern that helps direct the flow of pedestrian traffic into the building.

- **Color Appearance (and Color Contrast)**
  - When this building is being used for events at night the only exterior lighting on the building is in the covered entrance. It is important that the color rendering enhance the visibility of visitors. The space should have a CCT of around 3000K and a CRI of around 80 to create a welcoming atmosphere within the space.

- **Direct Glare**
  - Direct glare should be avoided at any spot within the space. Therefore, luminaires should be chosen so that there is not a direct line of sight to the bare lamp. Lenses on all luminaires should be used to help prevent this.

- **Light Distribution on Surfaces**
  - Excessive brightness and noticeable shadows should be avoided. The layout of luminaires should follow a pattern throughout the space. Uniform brightness should be avoided. The lighting design should help draw people in. Since this space is open to the exterior on three sides the use of reflected light is limited. There needs to be both direct and indirect lighting within this space to limit shadowing.

- **Light Pollution/Trespass**
  - The light from this exterior space must not trespass into the surrounding properties or interfere with the natural dark sky.

- **Modeling of Faces or Objects**
  - It is important to model faces so that facial expressions can be seen. Multidirectional lighting should be used to help model faces by creating depth, shape, and texture. It is important to have both horizontal and vertical illuminance in this space.

- **Peripheral Detection**
  - Anyone within these spaces needs to have to ability to see an oncoming threat in the dark. The lighting design should illuminate the perimeter of the covered entrance so that anyone within this space can see an oncoming threat in their peripheral vision.

- **Point(s) of Interest**
  - The points of interest are the Crystal Lake Elementary School Sign on the exterior of this space as well as the entrance to the building. Both of these should be clearly visible to attract attention

- **Reflected Glare**
  - Reflected glare from surrounding polished or glossy surfaces should be avoided so that circulation is not inhibited. The large amount of glass on the façade of the building has the potential to produce reflected glare. Luminaires should not be aimed toward the glass.

- **Shadows**
  - Harsh shadows should be avoided so that they do not interfere with the circulation through the space. The use of linear or area light sources should be used to minimize sharp shadows.

- **Source/Task/Eye Geometry**
  - The source should not obstruct the person's ability to walk clearly though the space. It is important to use lenses on the luminaires so that the source does not have an effect on pedestrians.

- **Sparkle/Desirable Reflected Highlights**
  - To make the space visually pleasing, there should be small points of visual interest. The use of decorative luminaires, such as wall sconces, to highlight the texture of the building façade is desirable.

- **Surface Characteristics**
  - This space is used as both a school and a hurricane shelter. Therefore, at times of emergency this entrance will be the main circulation space to move people in and out of the building. It is important that the lighting be designed so that the quick movement of large numbers of people is smooth and easy.

- **Illuminance (Horizontal)**
  - Category B: Performance Simple orientation for short visits, 5 fc.
- **Illuminance (Vertical)**
  - Category A: Public Spaces, 3 fc

- **Power Allowance** (ASHRAE/IESNA Std. 90.1)
  - Space-by-Space Method: Main Entries=30 W/linear ft. of door width
    : Canopies and Overhangs=1.2

- **Controls**
  - Lighting is only necessary in this space from dusk to dawn. For safety, minimal lighting will be required during all nighttime hours, which will be controlled by a photocell. When the building is in use for nighttime activities, all lighting will be on and be controlled by a time clock.

- **Luminance Ratios**
  - Ceilings and walls should have a luminance ratio of 3:1

- **Psychological Aspect**
  - The space should feel open, welcoming, and public. It should be a good transition from the wide open outdoors into the building. The lighting design should give visitors a sense of excitement as they enter the space. Visual Clarity is very important to this space. It is necessary that the lighting design create uniformity on the floor for circulation and provide good perimeter lighting for safety.

Luminaire Information

Luminaire Schedule										
Type	**Image**	**Manufacturer**	**Catalog Number**	**Description**	**Mounting**	**Mounting Height**	**Ballast/Power Supply**	**Voltage**	**Lamp**	**Wattage**
A1		Ligman	91123-SFMB-70	Surface Mounted Luminaire for canopy mounting. Aluminum housing with high corrosion resistance. High quality reflector for broad spread light distribution.	Ceiling Surface	10’-6”	Magnetic	277	GE CMH70/C/U/830MED	90 W
B1		Lumux	UD410/PL42/277/BLACK	Wall Mounted luminaire for outfoor application. Fully shielded light source for up and down lighting . Low copper aluminum die cast housing with tempered clear glass.	Wall Surface	8’-0”	Electronic	277	GE F42TBX/830/A/ECO	90 W
C1		Ligman	80036-M-35	Recessed luminaire designed for exterior lighting. Aluminum powder painted front frame with a die-cast aluminum housing with corrosion resistance.	Ceiling Recessed	24’-6”	Electronic	277	GE CMH39TUVCU830G12	45 W
*Luminaire, Lamp, Ballast Specification Sheets are located in Appendix A										

Light Loss Factors					
Type	**LLD**	**LDD**	**RSDD**	**BF**	**LLF Total**
A1	0.667	0.77	N/A	1.00	0.513
B1	0.841	0.77	N/A	1.00	0.648
C1	0.677	0.77	N/A	1.00	0.521

Controls

The exterior lighting within the covered entrance and walkways that is not required for emergency and safety lighting will be controlled by a LP8 Peanut Lighting Control Panel. The lighting necessary from dusk to dawn for security and emergency lighting purposes will be controlled by a EM exterior photocell located on the north side of the building. Specification sheets for these controls are located in Appendix A.

Type	Manufacturer	Product Name	Catalog Number	Description	Location
TC-1	Watt Stopper	LP8 Peanut Lighting Control Panel	LP8F-4-115	Effective zone-based control of exterior lighting. This panel controls up to 4 zones of lighting. Zones respond to control signals from the system clock to turn the lighting on or off.	Covered Walkways and Covered Entrance
EM-1	Wattstopper	EM Exterior Photocell	EM-24D2	Photocell will work with a power pack to signal a change in light level to the panel to determine when the exterior lighting needs to be on.	Covered Walkways and Covered Entrance

Table 1: Control Schedule

Lighting Design

Design Concept

The architecture of the main entrace façade consists of brick with painted concrete columns with a symmetric layout. Therefore, the lighting design will provide the recommended amount of light while drawing the attention of oncoming visitors to the entrance of the building. The lighting design should be energy efficient and cost effective.

The primary elements of this space are the architectural columns, the brick veneer façade, and the tall covered entrance. The lighting design should highlight these features, while remaining and energy efficient design. It is necessary to provide perimeter lighting on the building for security purpose; therefore, direct/indirect luminaires will be used that will graze the brick veneer to highlight this building element. The covered entrance should create a glow will create a glow and immediate draw attention to oncoming guests to this space by creating a welcoming atmosphere where recessed luminaires will be used so that the light source cannot be scene until people are in this space. The columns will be highlighted by not applying light directly to them. The glow from the space behind the columns will cause them to pop out and create a pleasant dark/bright contrast. The covered walkways will be lit from canopy mounted luminaires to create a well-lit circulation space.

Performance Data

The following contains renderings and calculation data that was calculated using AGI32 for the proposed lighting design.

Figure 6: Covered Entrance and Covered Walkways with Type A1 ,B1, C1 Luminaires on

Figure 7: Covered Entrance with Type A1, B1, C1 Luminaire on

Figure 8: Covered Walkways with Type A1, B1, and C1 Luminaire on

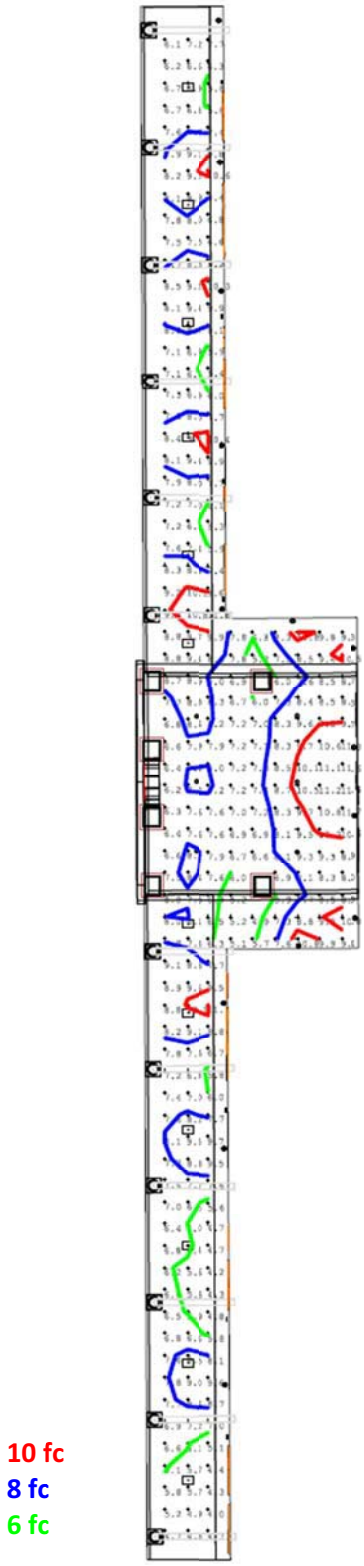


Figure 9: Covered Entrance and Covered Walkways for illuminance levels with Type A1 ,B1, and C1 luminaires on

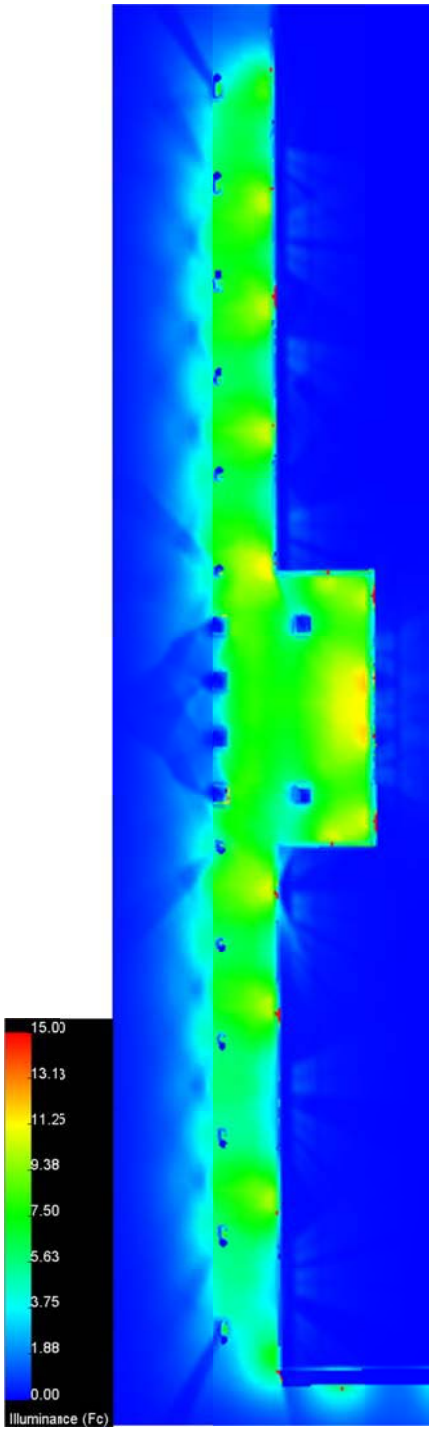


Figure 10: Covered Entrance and Covered Walkways Psuedo Diagram for illuminance levels with Type A1 ,B1, and C1 luminaires on

Illuminance Levels						
Location	**Average (fc)**	**Max (fc)**	**Min (fc)**	**Max/Min**	**Coeff. Variation**	**Meets Recommendations**
Walkways	7.78	11.8	4.0	2.95	0.2	Yes

Table 2: Illuminance levels throughout space

Power Allowance			
Total Size	**Power Allowance**	**Total Power Allowed (Watts)**	**Total Power Used (Watts)**
3205 ft^2	1.2 W/ft^2	3846	2700
18 ft	30W/linear ft	540	360

Table 3: Power Allowance

This lighting design meets ASHRAE 90.1/IESNA Standandes for power allowances.

Performance Summary

The redesign of this space meets the recommended lighting levels set forth by IESNA. The lighting design in this space is designed to create an inviting space that directs circulation to the entrance of the building. To achieve this, all of the ambient lighting in the space is achieved from a surface mounted canopy luminaire for the covered walkway and recessed downlights for the covered entrance. Also, it was necessary to provide security lighting to the perimeter of the space, which is achieved from direct/indirect luminaires on the façade of the building.

The luminaires selected work with both the canopy roof above the covered walkways and the exterior drywall ceiling of the covered entrance. The intent was to use luminaires that can be placed in an exterior environment, and that will provide an energy efficient lighting design, while maintaining a welcoming entrance to this school. All the luminaires used are lensed, so that there is no direct line of sight to any lamp and therefore will not cause any discomfort to its occupants. All the luminaires selected are either fluorescent of metal halide light sources and have a CCT of 3000K and a high CRI.

The symmetric lighting layout provides the recommended amount of light on the circulation plane by achieving the IESNA recommendation of 5 fc.

The covered entrance and covered walkways meets the requirements set by IESNA, and achieves the welcoming aspect desired. The lighting Plan for this space is located in Apendix B. The controls in this space meet the shutoff requirements set by ASHRAE 90.1/IESNA.

Lobby

Spatial Description

Upon entrance into the school, the lobby is the first space that people encounter. It is the central cirulation space that connects all the corridors in the building and also host the main staircase and elevator. It has direct access into the administrative offices on the north side.

The main purpose of this space is to welcome students and visitors to the school, as well as guide them to their desired destination. The rectangular layout of this space combined with the high ceilings is welcoming and inviting. The high ceiling creates a spacious feeling as students and visitors enter and helps accent the main architectural feature of this space: the central staircase. On a display wall in the center of this space, students works are displayed and meant to attract the attention of passing people.

Space Category:

Interior Space/ Circulation Space

Materials:

	Material	Reflectance
Ceiling	Acoustical Ceiling Tile	0.75
	White Painted Gypsum Wall Board	0.89
Walls	White Epoxy Paint	0.93
	Vinyl Cove Base	0.83
Doors	Gray Painted Doors	0.80
Floor	Vinyl Composition Tile	0.81

Table 4: Lobby Surface Materials

Dimensions:

45’4” x 52’8” with 28’ high ceilings
Area: 2342 ft^2
Perimeter: 196 ft

Tasks/Activities:

The Lobby is designed for circulation purposes; it is not meant to be a gathering space.

Lobby Plans and Elevations

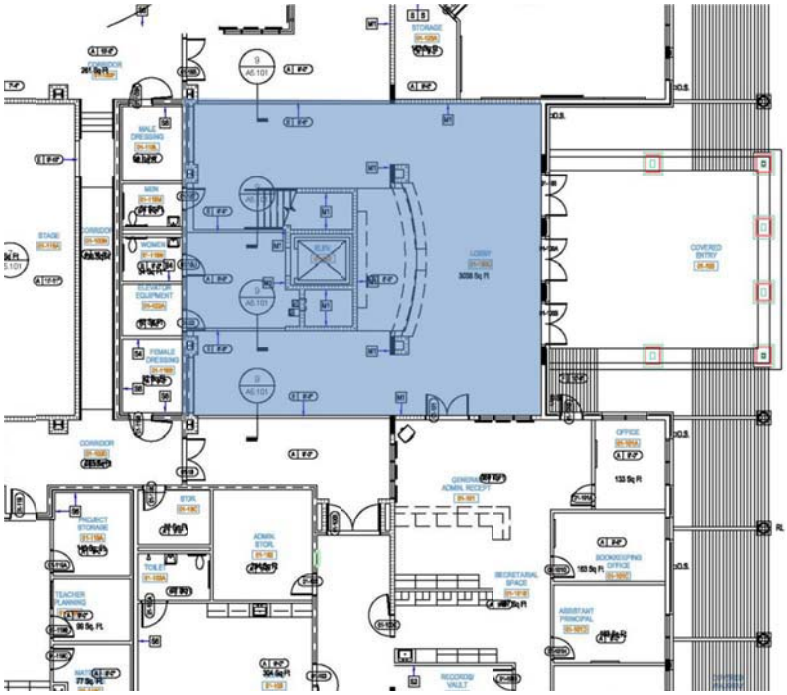


Figure 11: Lobby Floor Plan

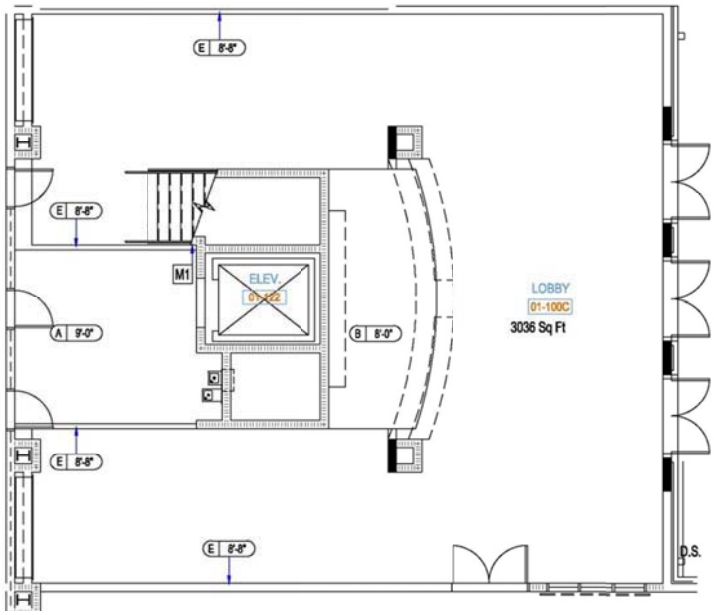


Figure 12: Detailed Lobby Floor Plan

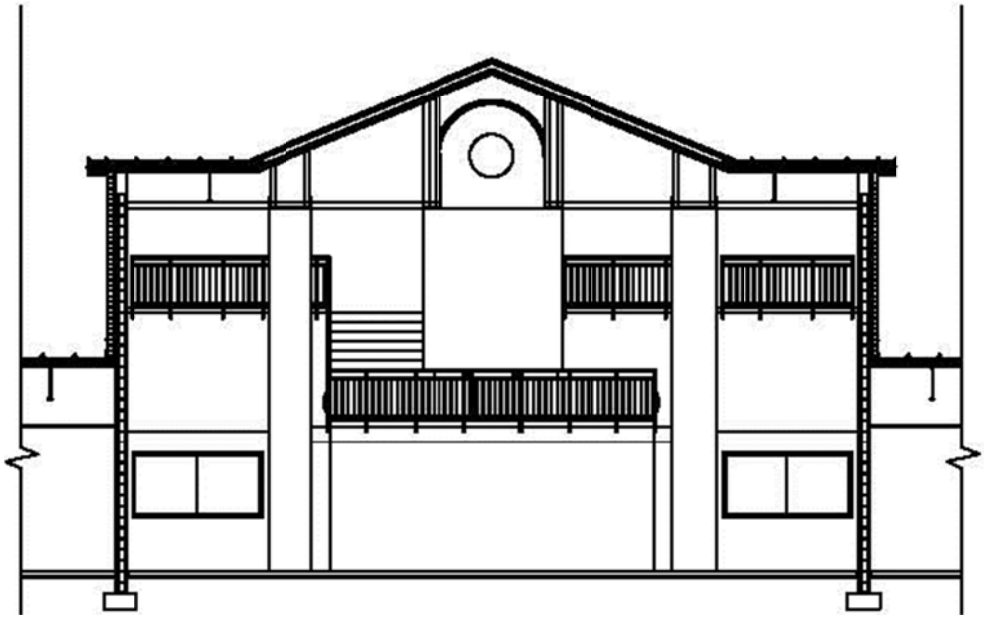


Figure 13: East Section

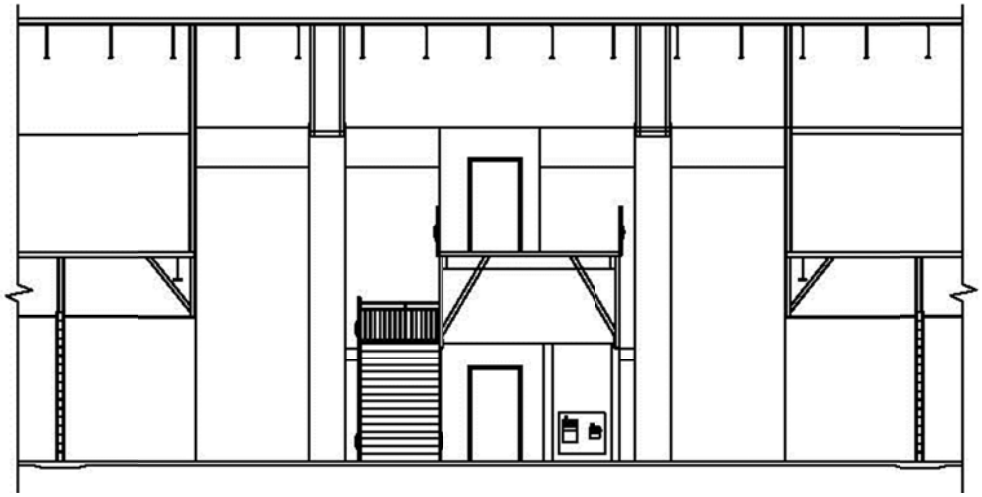


Figure 14: West Section

Lighting Design Criteria and Considerations

Interior, Educational Facilities, Corridors
Interior, Service Spaces, Stairways and corridors (IESNA Lighting Handbook, 9th Ed.)

- **Color Appearance (and Color Contrast)**
  - The lobby should welcome visitors in and give them direction to where they are headed in the building. Therefore, the color appearance is important to ensure the visibility and aesthetics of the space, while assuring that circulation is smooth. A CRI of 80 or more should be used to accentuate the appearance of skin tones, and surrounding displays.

- **Direct Glare**
  - Direct glare can cause visitors to feel uncomfortable in the space and can affect their visibility within the space. Therefore, people should not be able to have a direct line of sight to the lamp.

- **Light Distribution on Surfaces**
  - Circulation throughout the space needs to be smooth and uninhibited. The luminaires should be placed to avoid shadows on the floor so that visibility is not affected. The different surfaces should not have significant variations in brightness, but pure uniformity should be avoided so that there is some visual interest. Wall washers should be used on the wall where student work and create a variation in surface illuminance.

- **Modeling of Faces or Objects**
  - Objects and faces need to be modeled in order to see depth and texture. Nonverbal communication is very important for faculty and administrators to successfully help students. To achieve this, both vertical and horizontal illumination is needed. Along with downlight and angled lighting to fully model the objects and faces, reflected light of the surfaces can be utilized.

- **Points on Interest**
  - The main point of interest in this room is the student work display on central wall. Therefore, wall washing luminaire should be used so walls have a higher illuminance level to draw the attention of passing people.

- **Shadows**
  - Shadows can affect a person's ability to move though the space uninhibited. To avoid this linear luminaires or area sources should be used to create diffuse shadows. Fluorescent lamps with white reflectors are recommended as the area source.

- **Illuminance (Horizontal)**
  - Category C: Working spaces where simple visual tasks are performed, 10 fc

- **Illuminance (Vertical)**
  - Category C: Working spaces where simple visual tasks are performed, 10 fc

- **Power Allowance** (ASHRAE/IESNA Std. 90.1)
  - Space-by-Space Method: Lobby=1.3 W/ft^2

- **Luminance Ratios**
  - Luminance ratio between the ceiling and walls should be 3:1

- **Psychological Aspects**
  - Students first time in school is in Elementary school, so it is expected that student will be scared and uneasy to be away from the parents for the first time. The first interior space the students see is the lobby. Therefore, the psychological impression should be spacious and public. Students and visitors should feel welcome and comfortable upon entrance inside the school. The lighting design should assist in making them feel at ease and create an environment where they feel safe.

Luminaire Information

Luminaire Schedule										
Type	**Image**	**Manufacturer**	**Catalog Number**	**Description**	**Mounting**	**Mounting Height**	**Ballast/Power Supply**	**Voltage**	**Lamp**	**Wattage**
D1		Lightolier	8011 CL	Recessed Luminaire with an aluminum reflecter and medium distribution. Clear white flange.	Ceiling Recessed	9'-0" unless otherwise noted	Electronic	277	GE F32TBX/841/ A/ECO	36 W
E1		ELP	Duplux 226/8	Recessed Luminaire with a clear finish reflector. 8" aperture.	Ceiling Recessed	24'-6"	Electronic	277	GE F26DBX/841/ ECO4P	54 W
B1		Lumex	UD410/PL42/2 77/Black	Wall Mounted luminaire for outfoor application. Fully shielded light source for up and down lighting . Low copper aluminum die cast housing with tempered clear glass.	Wall Surface	8'-0"	Electronic	277	GE F42TBX/830/ A/ECO	90 W
F1		ELP	114 T-5WW-MPTB	Small, recessed linear wall washing luminaire. The reflector is high-purity aluminum with 95% reflectance.	Ceiling Recessed	8'-0"	Electronic	277	F14W/T5/841 /ECO	23 W
*Luminaire, Lamp, Ballast Specification Sheets are located in Appendix A										

Light Loss Factors					
Type	**LLD**	**LDD**	**RSDD**	**BF**	**LLF Total**
D1	0.85	0.75	0.964	0.98	0.602
E1	0.85	0.75	0.964	0.9	0.553
B1	0.841	0.79	0.915	0.98	0.596
G1	0.919	0.75	0.964	1.2	0.797

Controls

The lobby lighting will be controlled by a LP8 Peanut Lighting Control Panel. This system will provide multiple zones so that all required lighting will be on during the hours of operation. This will also control the emergency lighting for this space. Specification sheets for these controls are located in Appendix A.

Type	Manufacturer	Product Name	Catalog Number	Description	Location
TC-1	Watt Stopper	LP8 Peanut Lighting Control Panel	LP8F-4-115	Effective zone-based control of exterior lighting. This panel controls up to 4 zones of lighting. Zones respond to control signals from the system clock to turn the lighting on or off.	Lobby

Table 5: Control Schedule

Lighting Design

Design Concept

Since this is the first spacethe visitors encouter in Crystal Lake Elementary School, the lighting design needs to welcome visitors to the building and facilitate their circulation throughout the space.

In order to bring people into the building smoothly, the lighting design "brings the outside in." To achieve this, the same direct/indirect luminaire that is on the exterior façade of the building as people enter is on the two large columns. This direct/indirect luminaire accentuates the height of the space by highlighting its vertical features of the columns and makes this space feel spacious and welcoming.

Circulation is the main purpose of this space and therefore uniformity is necessary on the horizontal surfaces in the space. To make this space function, recessed downlights were used to create uniformity throughout the space.

Visual interest is an important category within this space. Also, this space typically displays current student works and important details of the school. Therefore, there is a wall of visual interest located under the main staircase. To draw attention to this wall, the wall is washed with a surface mounted luminaire to increase the illuminance on this wall and draw the immediate attention of visitors as they enter this space.

The walls and ceilings are highly reflective materials and help distribute reflected light to the workplane.

Performance Data

The following cantains renderings and calculation data that was calculated using AGI32 for the proposed lighting design.

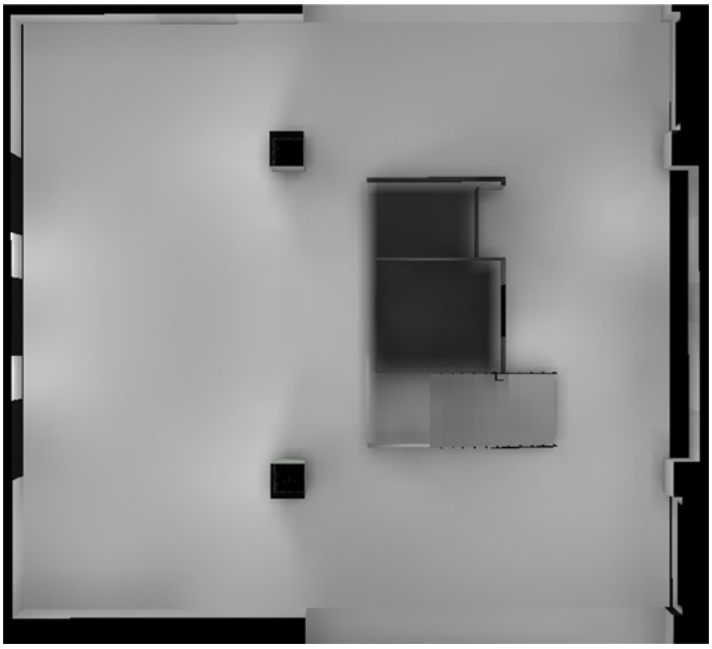


Figure 15: Lobby with Type B1, E1, D1, F1 luminaires on

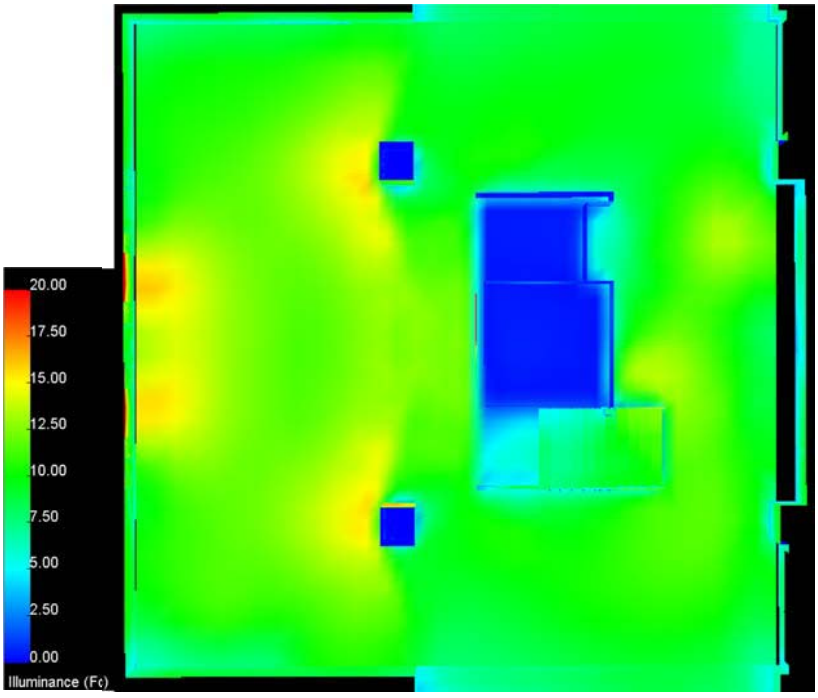


Figure 16: Lobby Psudo Rendering with Type B1, D1, E1, F1 luminaires on

Figure 17: Lobby with Type B1, D1, E1, F1 luminaires on

Figure 18: East Elevation

Figure 19: Lobby North-East Isometric view

Illuminance Levels						
Location	**Average (fc)**	**Max (fc)**	**Min (fc)**	**Max/Min**	**Coeff. Variation**	**Meets Recommendations**
Circulation Space	11.07	15.9	7.6	2.09	0.15	Yes

Table 6: Illuminance levels throughout space

Power Allowance			
Total Size	**Power Allowance**	**Total Power Allowed (Watts)**	**Total Power Used (Watts)**
2281 ft^2	1.3 W/ft^2	2965	1141

Table 7: Power Allowance

This lighting design meets ASHRAE 90.1/IESNA Standandes for power allowances.

Performance Summary

The redesign of this space meets the recommended lighting levels set forth by IESNA. The lighting design in this space is designed to create a spacious feel. To achieve this, the vertical elements are highlighted. Also, it was necessary to achieve uiniformity throughout the space that can be achieved by using a uniform lighting layout to assure that circulation through the space is smooth.

The luminaires selected easily fit into the existing gypsum wall board ceiling. The intent was to use luminaires that work well with the transition from exterior to interior. All the luminaires selected are fluorescent light sources and have a CCT of 4100 and a high CRI.

The uniform lighting layout of recessed downlight succeeds in providing uniformity throughout this circulation space, while achieving the IESNA recommendation of 5 fc on the floor. In addition, this added light will direct visitors attention to the informational wall in the center of this space, due to the higher levels of luminance.

The lobby meets the requirements set forth by IESNA, while creating a welcoming environment. The lighting Plan for this space is located in Apendix B. The controls in this space meet the shutoff requirements set by ASHRAE 90.1/IESNA.

Multipurpose Room

Spatial Description

The Multipurpose Room two main uses: assemblies and cafeteria area. Additionally, when necessary, this room is used as a hurricane shelter for the surrounding community. There are multiple entrances from the north, south and west. This room is located near the center of the building directly east of the main lobby, with direct access on the east side to the kitchen space. There is a large stage located on the west side. If necessary, there is a partition wall that can separate the space so that both dining and a presentation can occur concurrently.

The Multipurpose Room is designed to be a suitable presentation space and lunch space on a regular basis. Typically, only students, faculty, and administrators have access to this room; however, in the chance of an emergency this space is open to the public.

Space Category:

Interior Space/ Special Purpose Space

Materials:

Location	Material	Reflectance
Ceiling	Acoustical Ceiling Tile	0.75
	White Painted GWB	0.89
Walls	White Epoxy Paint	0.93
	Vinyl Cove Base	0.83
	Partition Wall	0.93
	Gray Painted Doors	0.80
Cafeteria Furniture	Table and Chairs	0.22
Auditorium Furniture	Chairs	0.22
Floor	Vinyl Composition Tile	0.81

Table 8: Multipurpose Room Surface Materials

Dimensions:

Aproximately 64'-4" x 85'-1" with 11'-1" ceilings where acoustical ceiling tile is used and 10'-5" ceiling where gypsum wall board is used.

Area: 5250 ft^2

Stage Area: 997 ft^2

Perimeter: 244 ft

Tasks/Activities:

The Multipurpose Room is designed to be a suitable presentation space and cafeteria space on a regular basis. Movable furniture is available in this space to provide an easy change from one use to another. There is also a partition wall that can separate the space so that both dining and a presentation can occur concurrently.

Multipurpose Room Plans and Elevations

Figure 20: Multipurpose Room Floor Plan

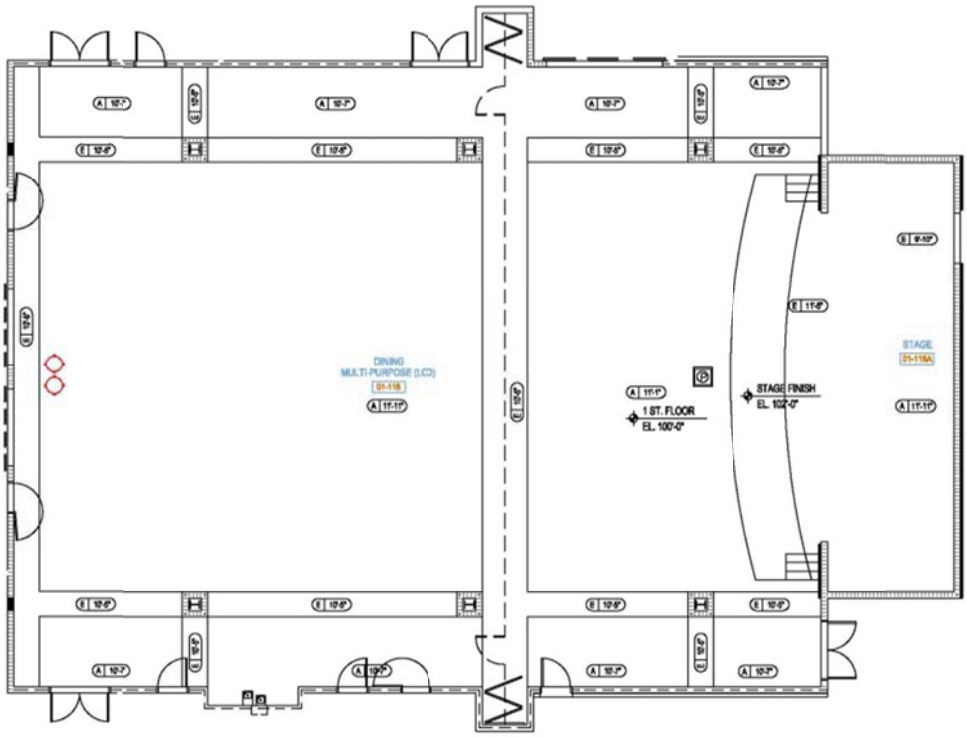


Figure 21: Detailed Multipurpose Room Floor Plan

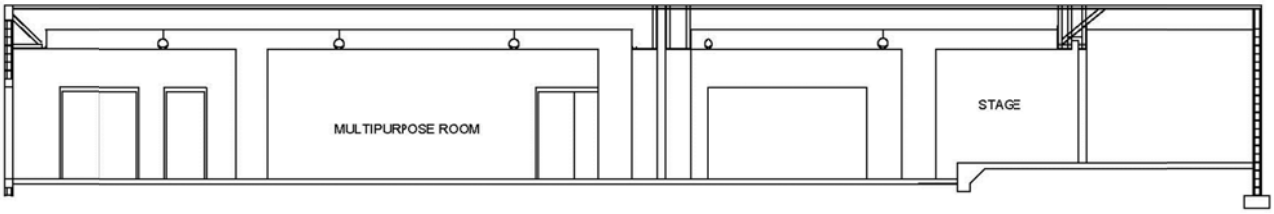


Figure 22: South Section

Lighting Design Criteria and Considerations

Interior, Auditoriums, Assembly
Interior, Reading, Printed Tasks, 8-and10-point type
Interior, Food Services Facilities, Dining (IESNA Handbook)

- **Appearance of Space and Luminaires**
  - Since this is a multipurpose space and the furniture layout has the ability to change, the use of a uniform lighting layout is desired to avoid "visual clutter" as the space changes. When this space is being used as an assembly area, the lighting on the stage should be brighter than the surrounding area to draw the attention of the audience. To achieve this, track lighting luminaires should be used to direct light to the stage and the lighting throughout the multipurpose room should have various scenes to change the light levels within the room.

- **Color Appearance (and Color Contrast)**
  - The appearance of skin tones and food is critical in this space for both the stage and the general area; therefore, a CRI of greater than 80 should be used.

- **Direct Glare**
  - Direct glare should be avoided for all possible room uses. Luminaires should be chosen so that there is no direct line of sight to the lamps. When available, lenses and shielding devices can be used to block the direct line of sight.

- **Light Distribution on Surfaces**
  - Shadows should be avoided as to not interfere with the visibility within the space and create a comfortable environment for all. The design will be in a regular pattern so that it is neither confusing nor distracting.

- **Modeling of Faces or Objects**
  - Face modeling is important for the nonverbal communication within the space and on the stage. Both vertical and horizontal illumination should be used to create depth in faces and objects. Some of this multidirectional Illumination can come from the

reflected light off the different surfaces within the space. To achieve this on the stage track lighting is used.

- **System Control and Flexibility**
  - This space has many functions; therefore, the system control needs to be able to create many different light levels for the various tasks. The lighting control should have different lighting settings for eating, presentations, and presentations utilizing the projection screen.

- **Illuminance (Horizontal)**- Important
  - Multipurpose Space
    Category C: Working Spaces where simple visual tasks are performed, 10fc
  - Stage
    Category C: Working Spaces where simple visual tasks are performed, 10fc

- **Illuminance (Vertical)** – Important
  - Category A: Public Spaces, 3 fc

- **Power Allowance** (ASHRAE/IESNA Std. 90.1)
  - Space-by-Space Method: Multipurpose=1.3 W/ft^2

Luminaire Information

Luminaire Schedule										
Type	**Image**	**Manufacturer**	**Catalog Number**	**Description**	**Mounting**	**Mounting Height**	**Ballast/Power Supply**	**Voltage**	**Lamp**	**Wattage**
D1		Lightolier	8011 CL	Recessed Luminaire with an aluminum reflecter and medium distribution. Clear white flange.	Ceiling Recessed	10'-7"	Electronic	277	GE F32TBX/841/A/ECO	36 W
G1		Ledalite	7306-F01-I-N-4-1-2-E-W	Suspended luminaire with optical acrylic lens to provide high-angle glare control. High efficiency.	Ceiling Suspended	10'-8"	Electronic	277	GE F28W/T5/835/ECO	37 W
H1		Intense Lighting	ITH637-W-PS	Surface mounted theatrical luminaire track head. It is adjustable for precision aiming.	Ceiling Surface	11'-5"	Electronic	120	GE CMH70PAR30L830SP	90 W
*Luminaire, Lamp, Ballast Specification Sheets are located in Appendix A										

Light Loss Factors					
Type	**LLD**	**LDD**	**RSDD**	**BF**	**LLF Total**
D1	0.85	0.88	0.975	0.98	0.715
G1	0.92	0.86	0.926	1.09	0.799
H1	0.77	0.88	0.975	1.00	0.661

Controls

The redesign of the lighting in this space, also requires a redesign of the current control system to operate the new lighting design. Both Luminaire Type D1 and E1 will be wired through six duel-technology occupancy sensors within the room. Since this is a rectangular space, wall mounted sensors will be used. The duel-technology occupancy sensor is located at the four corners of the room and will work well for all three uses of the room. The occupancy sensor will be a WattStopper DT-200 series duel technology ceiling/wall mounted sensor, and the equipment schedule and cut sheets are located at the end of this report. In addtion there will be a five preset scene controller that will control the luminaire settings within the room

The stage lighting will be on a separate control system that has five preset scenes for the stage. This gives flexibility within the space to allow for a variety of lighting possiblities depending on the use of the stage. The control system is a Watt Stopper LMSW-105 digital 5-button scene switch. Specification sheets for these controls are located in Appendix A and a wiring diagram for this system is located in Appendix B.

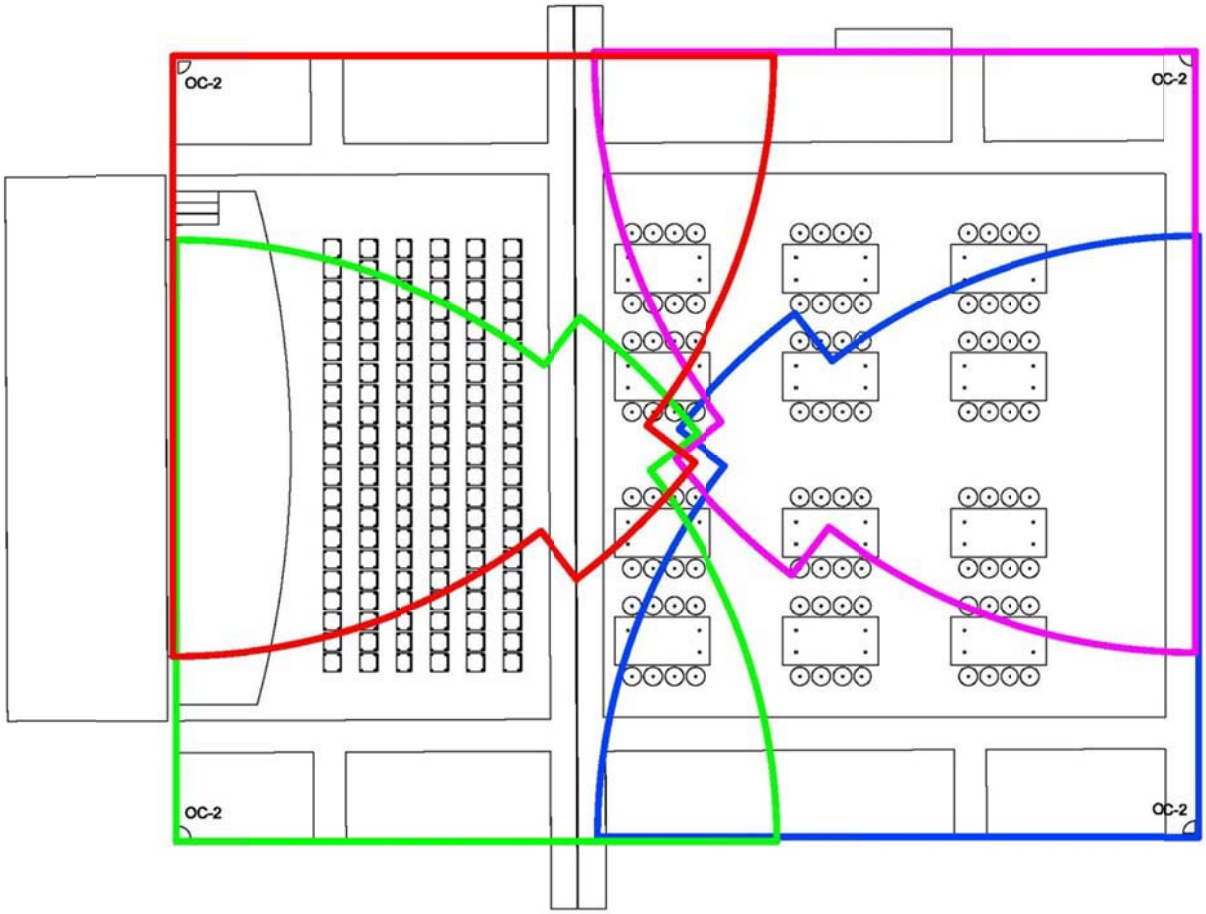


Figure 23: Schematic for Ocuupancy Sensor Coverage Area

Type	Manufacturer	Product Name	Catalog Number	Description	Location
OC-2	Watt Stopper	DT-200 Series Dual Technology Ceiling/Wall Sensor	DT-200	Passive infrared (PIR) and ultrasonic technologies utilized.	Multipurpose Room
DS-1	Watt Stopper	LMSW-105 Digital 5-Button Scene Switch	LMSW-105-W	Low Voltage device that recalls preset lighting scenes to change the level of lighting.	Multipurpose Room

Table 9: Multipurpose Room Equipment Schedule

Lighting Design

Design Concept

Due to the multiple uses of the multipurpose room, the lighting design should be designed to fit the needs of the three space types: auditorium space, cafeteria space, and when the partition is separating the space into both a cafeteria space and an auditorium space. When students are in this space using it as a cafeteria, they should feel the openness and become comfortable within the space. When it is used as an auditorium, observers should feel relaxed and the attention should be drawn to the stage. As an emergency shelter, the lighting design will create a uniformly lit space with no furniture present. To achieve all of these things a lighting design was created that uses track lighting to put emphasis on the stage with an increase in illuminance on the stage as well as recessed downlights that can be used to achieve uniformity on the stage when needed. Semi-Indirect pendant luminaires were used to emphasize the height of the ceiling by placing light uniformly on the ceiling as well as applying uniformity throughout the space for all three settings. Downlights were used to emphasise the walkways within the space and create uniformity around the edge of the room.

The walls and ceilings are highly reflective materials and help distribute reflected light to the workplane.

Performance Data

The three different uses of this space utilize different combinations of the luminaires available. The following performance data will show illuminance data and renderings for the different lighting scenes.

The following cantains renderings and calculation data that was calculated using AGI32 for the proposed lighting design.

Lighting design for multipurpose room as cafeteria

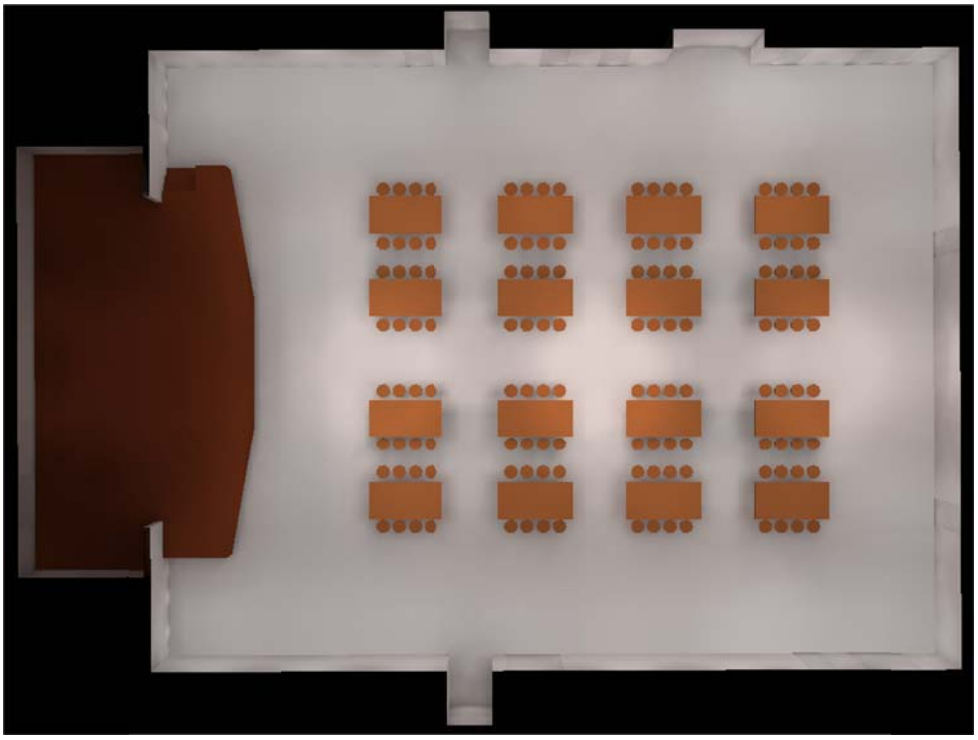


Figure 24: Multipurpose Room as Cafeteria with Type D1 and G1 lights on

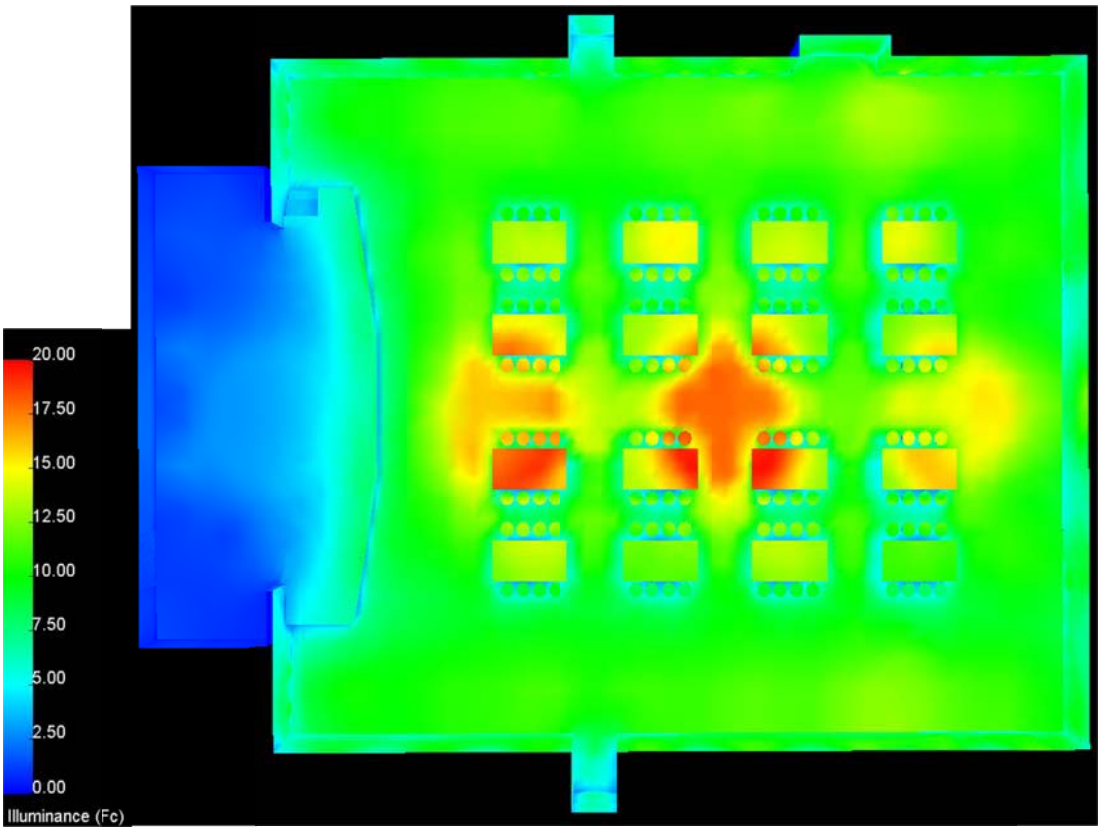
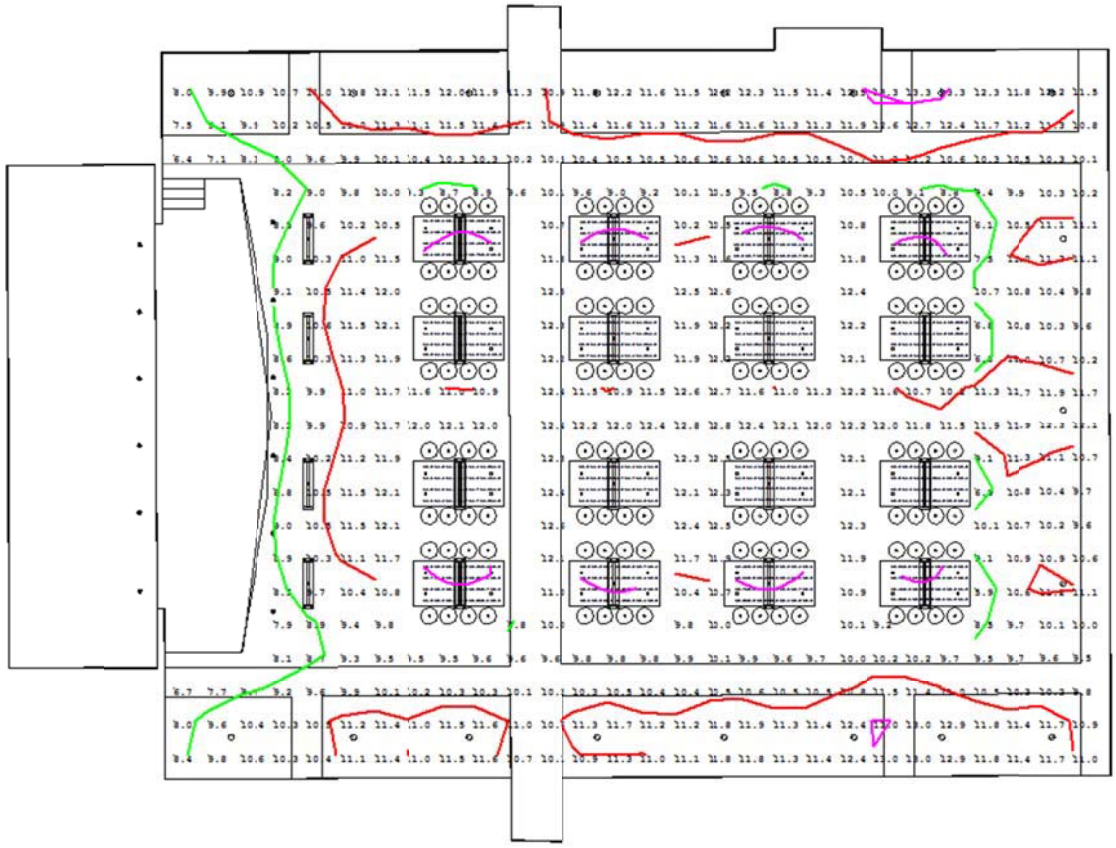


Figure 25: Multipurpose Room as Cafeteria with Type D1 and G1 lights on



Scale:
15 fc
13 fc
11 fc
9 fc

Figure 26: Multipurpose Room as Cafeteria with Type D1 and G1 lights on

Figure 27: Multipurpose Room North Elevation

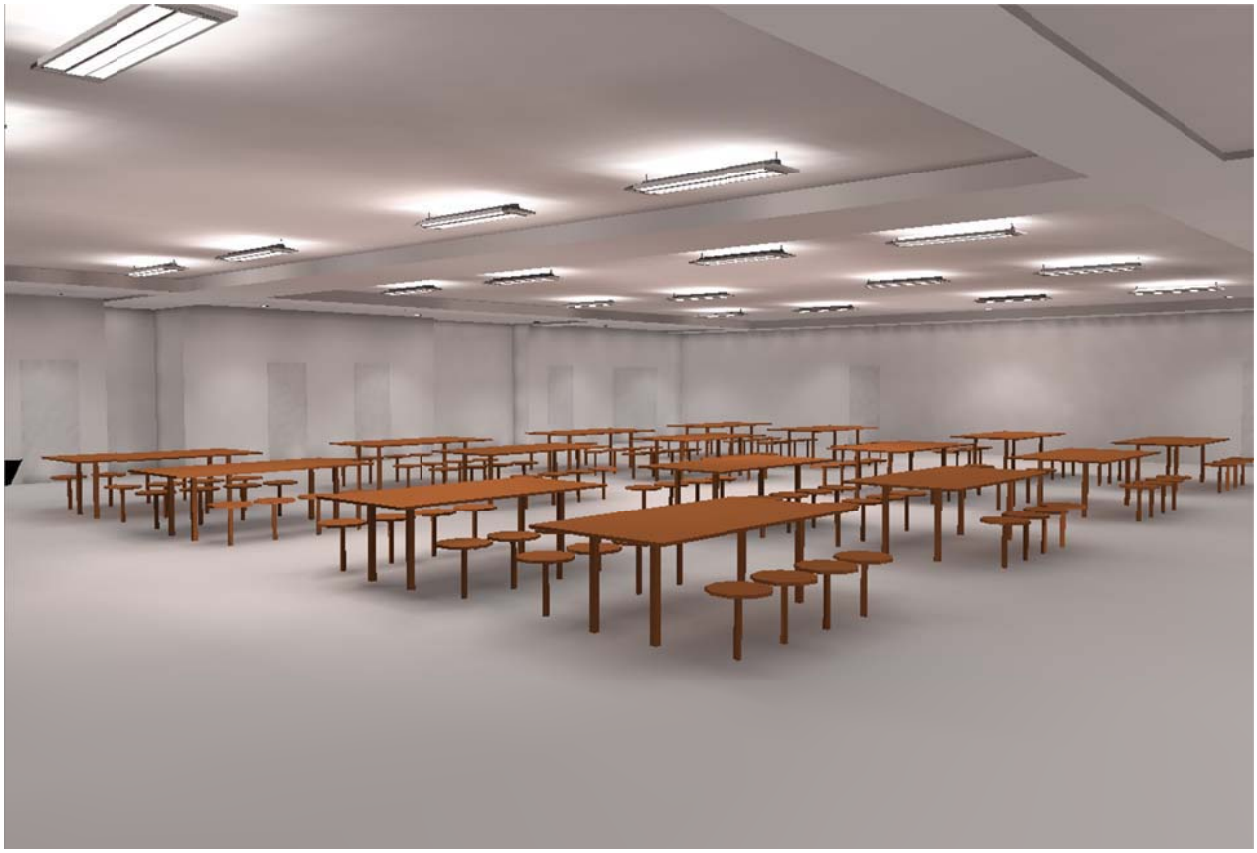


Figure 28: Multipurpose Room North-East Isometric view

Illuminance Levels						
Location	**Average (fc)**	**Max (fc)**	**Min (fc)**	**Max/Min**	**Coeff. Variation**	**Meets Recommendations**
Cafeteria Table	13.60	14.19	12.78	1.11	0.03	Yes
Circulation Space	10.72	13.3	5.9	2.25	0.12	Yes

Table 10: Illuminance levels throughout space

Lighting Design for Cafeteria as Auditorium

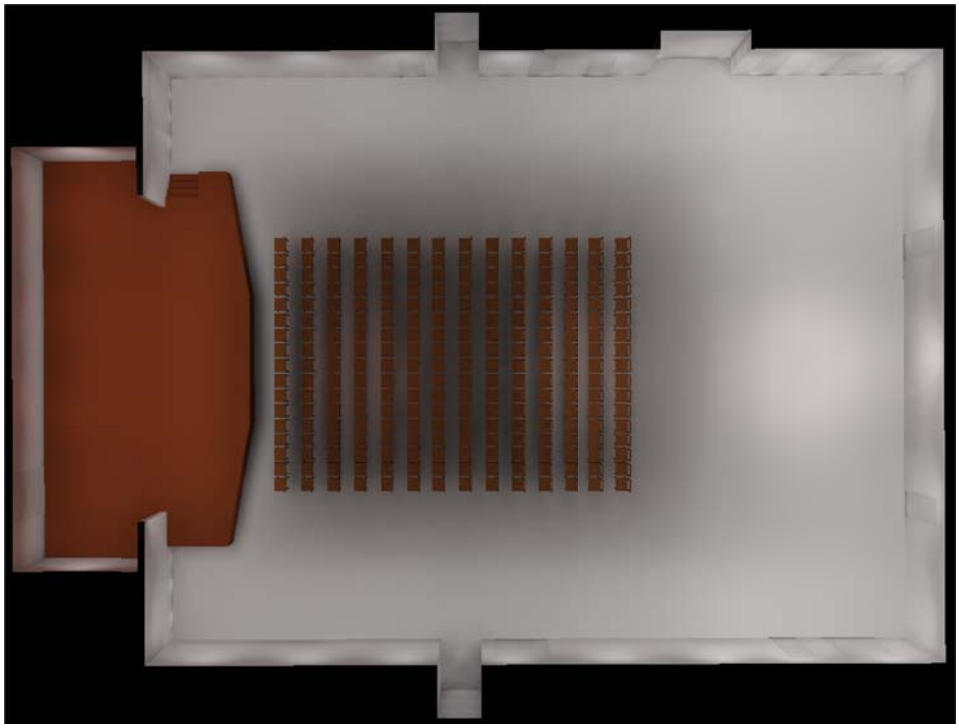


Figure 29: Multipurpose Room as Auditorium with Type D1, and G1 lights on

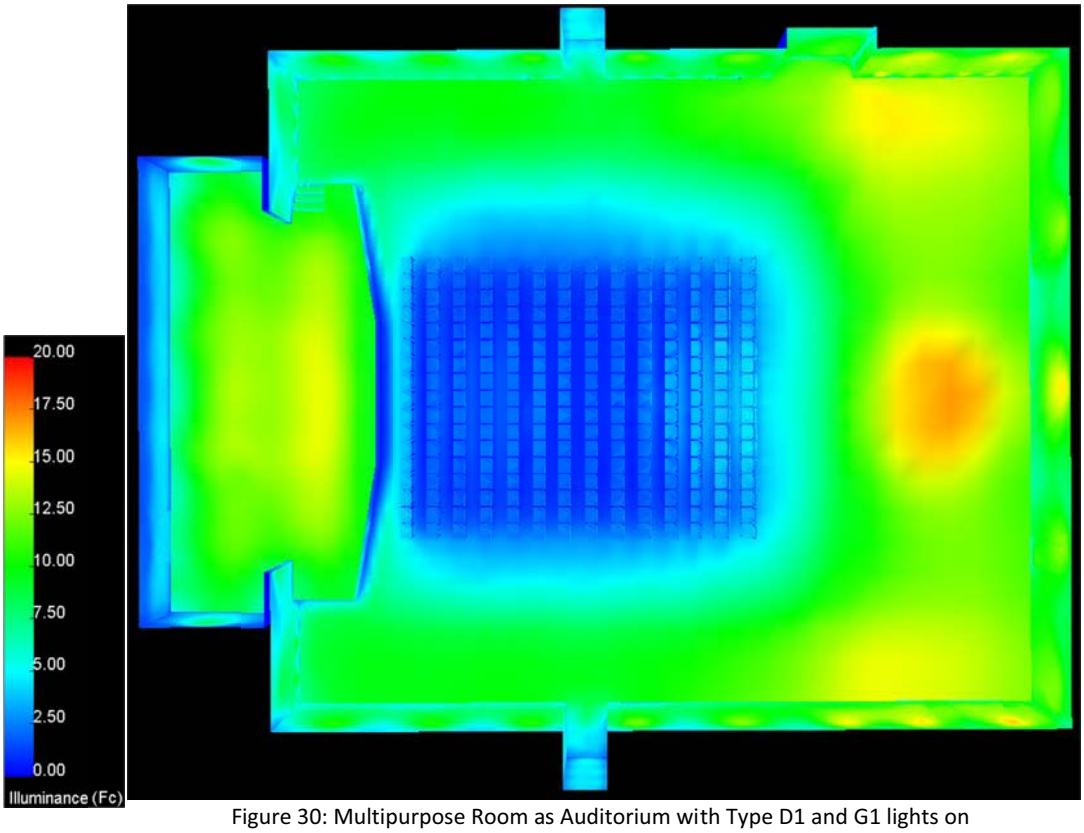


Figure 30: Multipurpose Room as Auditorium with Type D1 and G1 lights on

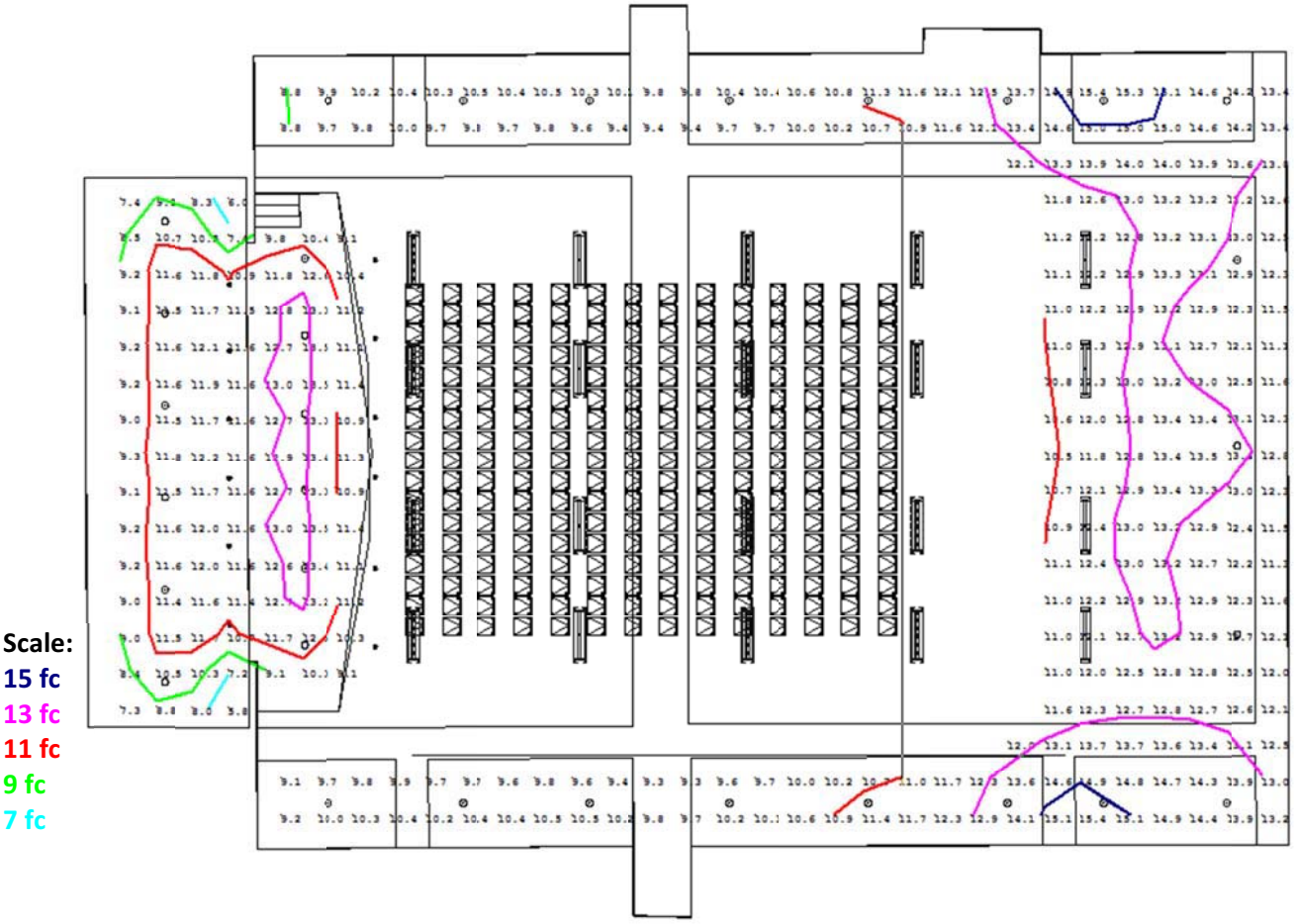


Figure 31: Multipurpose Room as Auditorium with Type D1 and G1 lights on

Figure 32: Multipurpose Room North Elevation

Figure 33: Multipurpose Room North-East Isometric view

Illuminance Levels						
Location	**Average (fc)**	**Max (fc)**	**Min (fc)**	**Max/Min**	**Coeff. Variation**	**Meets Recommendations**
Circulation Space	12.02	15.4	8.8	1.75	0.13	Yes
Stage	10.92	13.5	5.8	2.33	0.16	Yes

Table 11: Illuminance levels throughout space

Lighting Design for Multipurpose Room with partition wall separating the room into both an auditorium space and a cafeteria

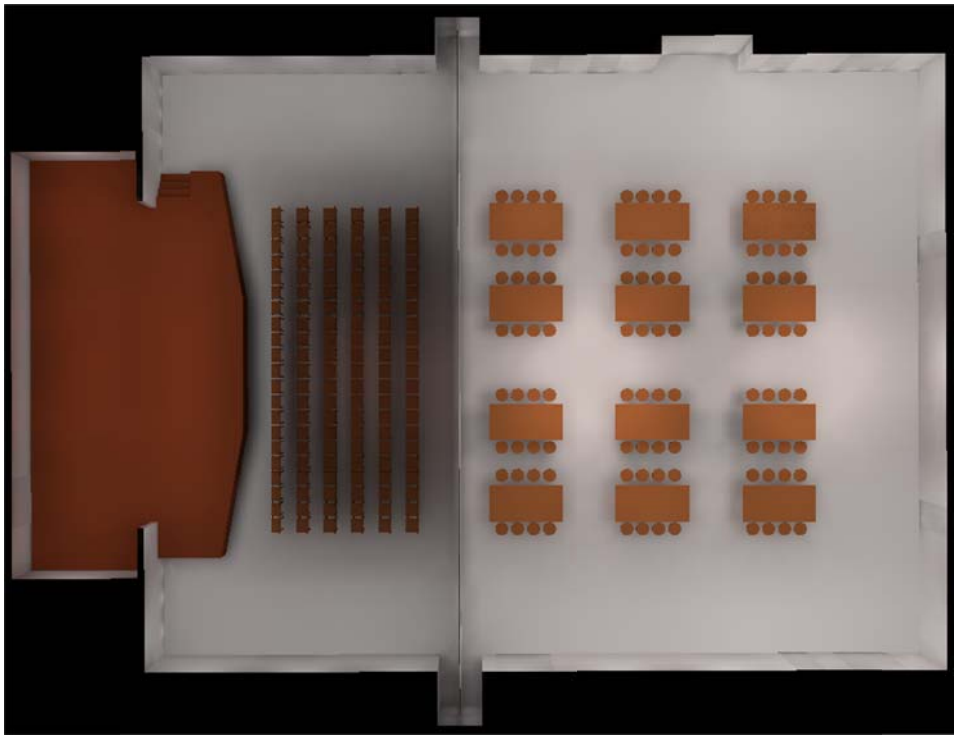


Figure 34: Multipurpose Room as Cafeteria and Auditorium with Type D1 and G1 lights on

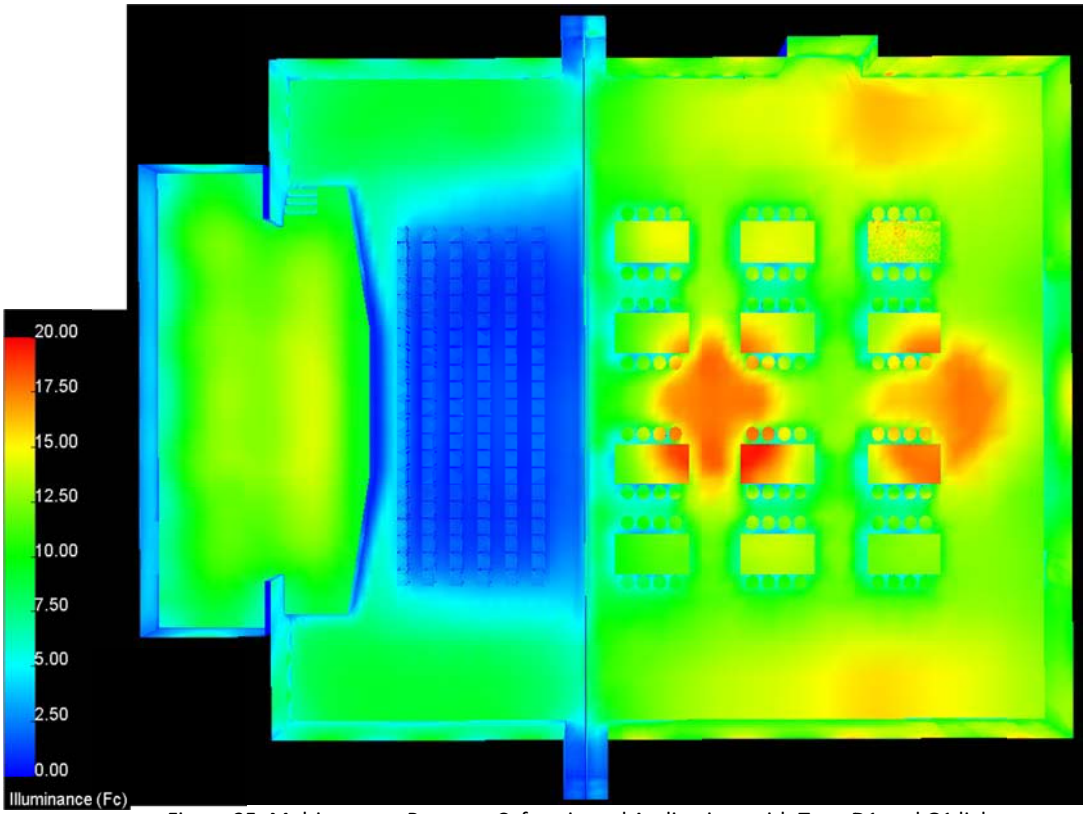


Figure 35: Multipurpose Room as Cafeteria and Auditorium with Type D1 and G1 lights on

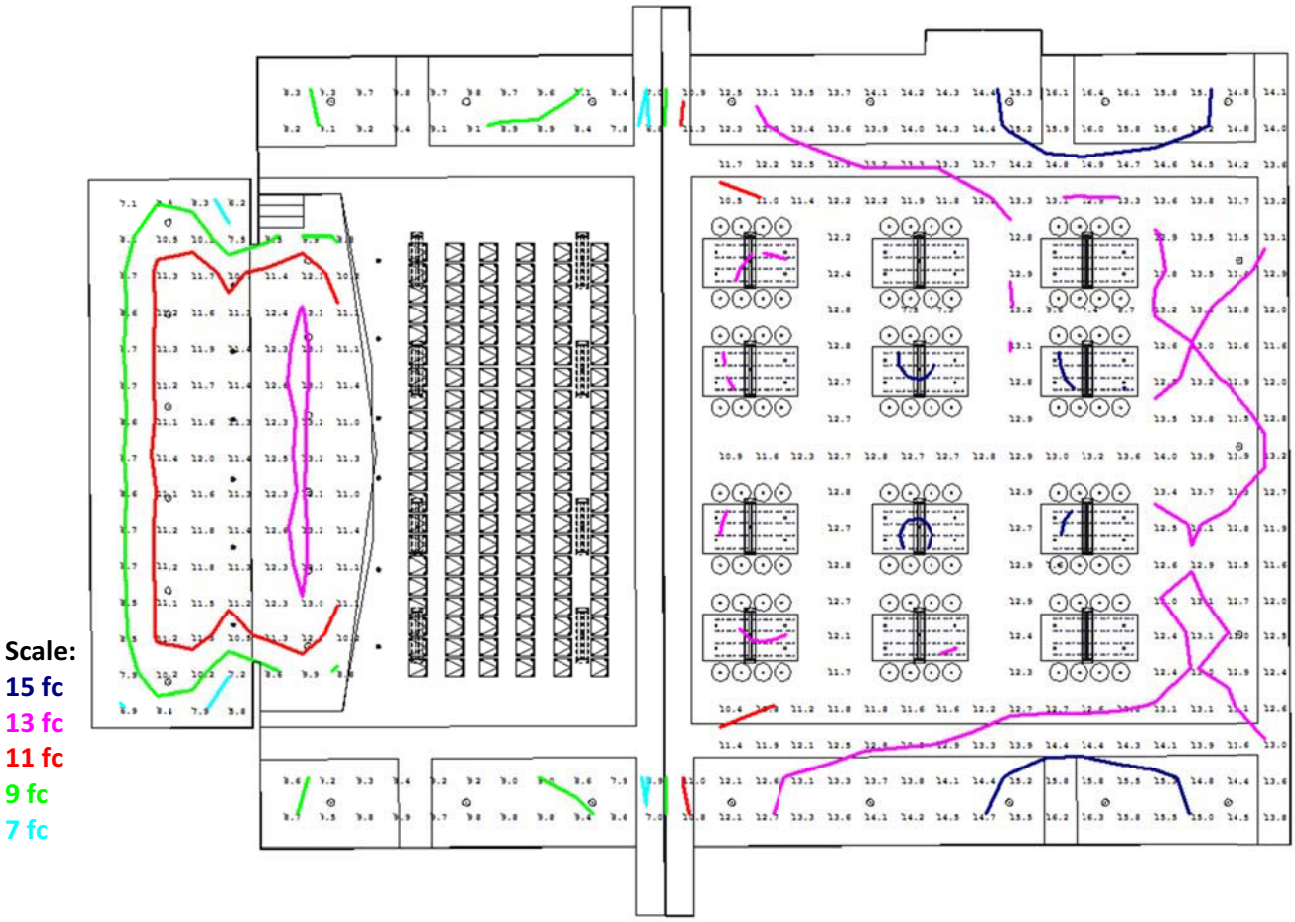


Figure 36: Multipurpose Room as Cafeteria and Auditorium with Type D1 and G1 lights on

Figure 37: Multipurpose Room North Elevation

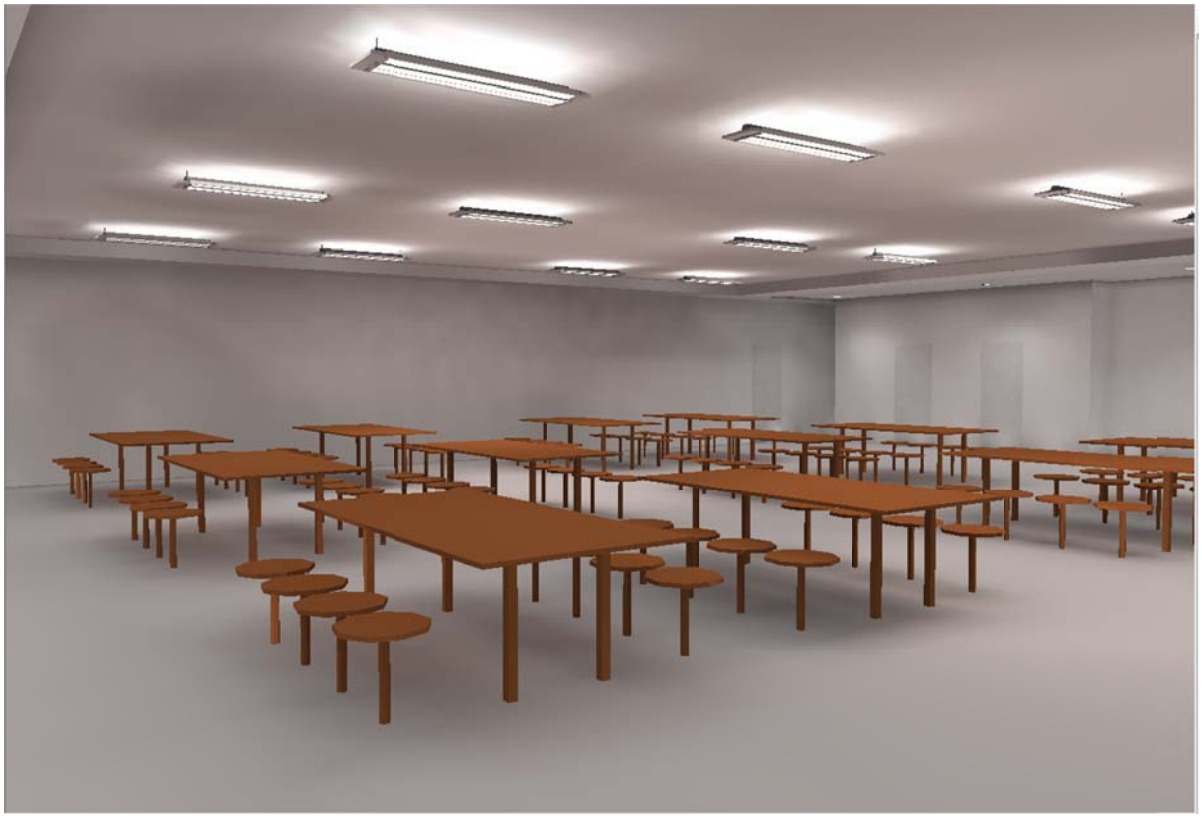


Figure 38: Multipurpose Room South-East Isometric view

Figure 39: Multipurpose Room South-East Isometric view

Illuminance Levels						
Location	**Average (fc)**	**Max (fc)**	**Min (fc)**	**Max/Min**	**Coeff. Variation**	**Meets Recommendations**
Cafeteria Table	14.04	14.58	13.2	1.11	0.03	Yes
Circulation Space	12.45	16.4	6.8	2.41	0.17	Yes
Stage	10.65	13.3	5.8	2.29	0.16	Yes

Table 12: Illuminance levels throughout space

Power Allowance			
Total Size	**Power Allowance**	**Total Power Allowed (Watts)**	**Total Power Used (Watts)**
6252 ft^2	1.3 W/ft^2	8127.6	2936

Table 13: Power Allowance

This lighting design meets ASHRAE 90.1/IESNA Standandes for power allowances.

Performance Summary

The redesign of this space meets the recommended lighting levels set forth by IESNA. The lighting design in this space is designed to compliment all of the different uses of this space: auditorium, cafeteria, auditorium and cafeteria, and emergency shelter.

The luminaires selected fit a specific purpose . Recessed downlights are used to highlight the cirulation spaces in the room. The luminaires also provide scalloping on the walls for visial interest on the perimeter. The intend was to maximize the ceiling height where people will be standing and use pendant fixtures where people will be seated. Therefore, semi-indirect luminaires are used in the center of the space where the cafeteria tables and auditorium seating is located. Alos, adjustable track lighting is used to light the stage. The luminaires selected in the spae are fluorescent light with the stage lighting being metal halide. The fluorescent light sources have a CCT of 3500K, while the metal halide light sources are 3000K; both have a high CRI.

The lighting layout provides uniformity along the cirulation spaces, as well as, the cafeteria tables, while achieving the IESNA recommendation of 10 fc throughout the space. The lighting Plan for this space is located in Apendix B. The controls in this space meet the shutoff requirements set by ASHRAE 90.1/IESNA.

Primary Classroom

Spatial Description:

Students and faculty can find themselves wondering through the various corridors on the first and second floor that direct them to many different classroom spaces. This primary classroom is a typical classroom space in Crystal Lake Elementary School that can accommodate 25 students. This particular classroom is located on the north side of the building on the first floor.

Space Category:

Interior Space/ Workspace

Materials:

Location	Material	Reflectance
Ceiling	2x2 Acoustical Ceiling Tile	0.75
Walls	White Latex Paint	0.93
	Whiteboard	0.8
	Tack Board	0.17
	Vinyl Cove Base	0.83
	Combination of Windows (made with laminated, tinted glass that is solar gray with a U value of 1.10 in the winter 1.13 in the summer and has a shading coefficient of 0.64)	
Doors	Light Gray Painted Door	0.8
Floor	Carpet	0.43
	Vinyl Composition Tile	0.83

Table 14: Primary Classroom Surface Materials

Dimensions:

Aproximately 27'-7" x 40'-0" with 9' ceilings, exterior wall south facing

Area: 969 ft^2

Perimeter: 135'-2"

Tasks/Activities:

This classroom is designed to provide a suitable learning environment for its students. Since this is a learning area, the primary tasks include reading and writing. With student desks, teaching equipment, and the propsed lighting design, this space creates a good educational environment. Only students, faculty members, and admistrators are permitted in this space during school hours.

Furniture:

(Manufacturer information was not provided. Reflectance levels are estimated based on equipment schedule)

Equipment	Reflectance
1 Marker board	0.8
2 Tack boards	0.17
4' x 4' Tack Board	0.17
8' x 4' Tack Board	0.17
Custom Cubby and Coat Hooks (Wood-Oak)	0.22
TMI Base Unit- B2052 30" X 36" X 24" (Wood-Oak)	0.22
TMI - B2542 30" X 36" X 24" (Wood-Oak)	0.22
TMI WALL UNIT – W2052 32" x 36" x 14" (Wood-Oak)	0.22
Student Chair/Desk (Wood-Oak)	0.22
Desk and Chair (Wood top with metal base desk with plastic chairs)	Desk=0.5, Chair=0.62
Table and Chair (Wood-Oak)	0.22

Table 15: Primary Classroom Furniture Material and Reflectance

Classroom Plans and Elevations:

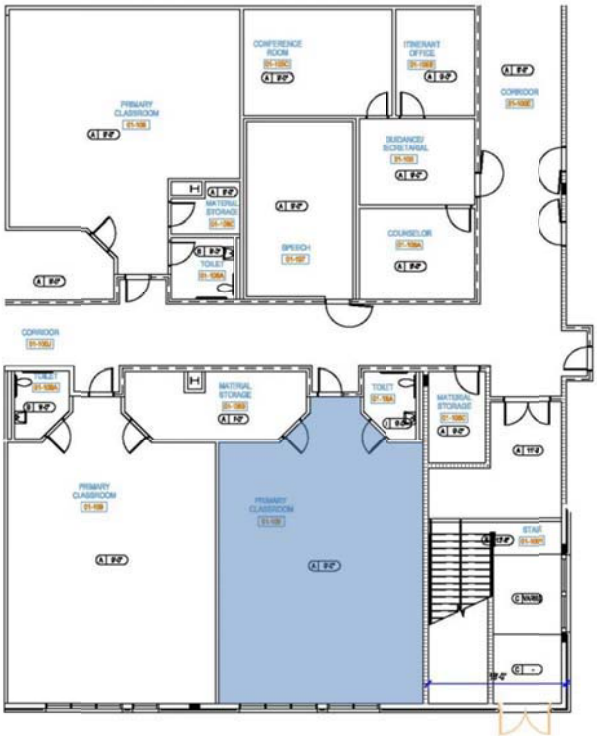


Figure 40: Primary Classroom Floor Plan

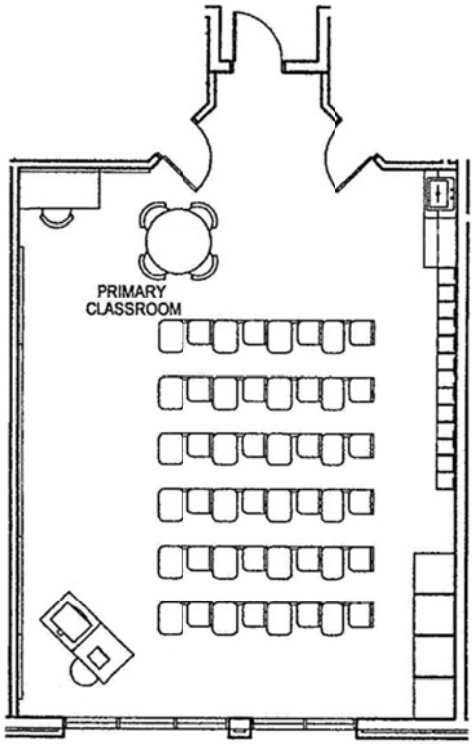


Figure 41: Detailed Primary Classroom Floor Plan

Note: Sections and Elevations of this space are unavailable

Lighting Design Criteria and Considerations

Interior, Educational Facilities, Classrooms, General
Interior, Reading, Printed Tasks, 8-and10-point type
Interior, Handwritten Task, White boards (IESNA Lighting Handbook)

- **Appearance of Space and Luminaires**
  - The luminaires and furnishings within this space will provide a visual cue as to the function of the space. Since eyes are drawn to the brightness, the luminaires will create bright areas where students should direct their attention to learn, mainly the front room where the teacher will be teaching. The luminaires will provide suitable light, while not creating a distraction for the students.

- **Color Appearance (and Color Contrast)**
  - For students to successfully complete their work environment needs to be visually pleasing. A CRI of 70 or above is desired to create an acceptable work environment with good color rendering, but a CRI of 80 or above will be used within this space.

- **Daylighting Integration and Control**
  - Having natural daylight present in the classroom will be good for the student's psychology. For this particular room we have north facing windows, but typically shading devices will be used all year round. Since this building is located in a warm climate, the sun will add a large amount of extra heat to the room, which will create an uncomfortable environment for its occupants. Although, the use of sunlight would be desirable to decrease the reliance on electric light, it will increase the energy usage in the form of air condition and therefore will not be implemented in this design.

- **Direct Glare**
  - Direct glare will create an uncomfortable environment for students and affect their ability to complete tasks. Since direct light is needed to provide enough illuminance on the work plane a lens will be used to reduce this glare.

- **Flicker (and Strobe)**
  - Flicker can be a distraction to the eye and affect students' ability to focus on their teacher and/or work. To reduce the flicker of the light source, high frequency electronic ballast can be used.

- **Light Distribution on Surfaces**
  - Shadows from objects will be avoided, so not to affect visibility, comfort, or perception. Both the horizontal plane and instructional wall need to be uniformly lit to provide a good work environment. However, total uniformity within the space will be avoided so that there is visual interest.

- **Light Distribution on Task Plane (Uniformly)**
  - The task plane is the student desks. Shadows will be avoided on the desks, so that it does not affect visibility, comfort, or perception. A lighting layout that provides uniformity across the task plane will be utilized.

- **Luminances of Room Surfaces**
  - Since this room is painted with white latex paint, the luminance of the room surface will be affected by the reflectance of this material. It is important that the whiteboard have uniform luminance to enhance the students' ability to clearly view the whiteboard. The lighting design will assist in directing focus to the instructional wall by directing light to this wall by using wall washers. To reduce the shadows on the work plane created by hands, both direct and diffuse light will be incorporated.

- **Modeling of Faces or Objects**
  - The ability of the teacher to be able to effectively read the facial expressions of students is important to his/her effectiveness as a teacher. Therefore, it is important that the lighting enhance the areas around the mouth and eyes of the students. Concentrated downlighting will be avoided and multidirectional lighting will be implemented, while incorporating the reflected illuminance from the walls and ceilings to help model students' faces.

- **Points on Interests**
  - The point of interest is the front center of the room, on the east wall, where teaching will occur and the whiteboard is present. The lighting design will create uniform illumination across the whiteboard. In relationship to the surrounding surfaces, the instructional wall will draw the focus by having higher brightness.

- **Reflected Glare**
  - Glare from the glossy surfaces and veiling reflections will be avoided through the use of lensed luminaires over the workplane.

- **Shadows (Somewhat Important)**
  - Shadows on the work plane can cause issues in the ability for students to learn due to the distraction of the lighting design. Linear or area light sources will be used to create diffuse shadows.

- **Source/Task/Eye Geometry**
  - Occupants will not be able to have a clear view on the light source to prevent discomfort. The lighting design will make use of reflected light, and avoid having luminaires directly above the task plane.

- **Surface Characteristics**
  - Many of the surface materials in this task space have a high reflectance. This is desirable so that interreflection can occur to reduce the contrast of between the luminaires and the background, as well as, allow for the use of fewer luminaires at fewer watts. The lighting design will make use of the reflected light to create and the necessary wall light to enhance the environment.

- **System Control and Flexibility**
  - The tasks in this space vary and each task requires different light levels. Therefore, having multiple switches is desired to allow for various lighting levels. Occupancy sensors will be used ensure that energy for the electric lighting is not being wasted when people are not present in this room.

- **Illuminance (Horizontal)**
  - Category D: Performance of visual tasks of high contrast and large size, 30 fc.

- **Illuminance (Vertical)**
  - Category D: Simple orientation for short visits, 30 fc

- **Power Allowance** (ASHRAE/IESNA Std. 90.1)
  - Space-by-Space Method: Classroom=1.4 W/ft^2

- **Psychological Aspects**
  The primary classroom will be further investigated throughout the design to determine a suitable design to create the psychological impression of a public space.

  Elementary school students are typically struggling to get used to the feeling of being at school and being away from their parents. Therefore, a public feeling should be achieved when they are in one of their classrooms. They should feel that the space is open and inviting, so that they feel comfortable learning within this space.

  The lighting design should work with the current furniture layout to enhance the learning environment and ultimately promote productivity. The design should complement the function of the space.

Luminaire Information

Luminaire Schedule										
Type	**Image**	**Manufacturer**	**Catalog Number**	**Description**	**Mounting**	**Mounting Height**	**Ballast/Power Supply**	**Voltage**	**Lamp**	**Wattage**
I1		Litecontrol	LG-WWD-4414T5-SGL-CWM-EOR/LH-LP/ELB-277	Recessed luminaire with an optical system to provide uniform wall wash lighting. A extruded frosted acrylic soft glow lens diffuser. Semi-specular high reflectance aluminum primary optic reflector	Ceiling Recessed	9'-0"	Electronic	277	GE F28W/T5/841 /ECO	37 W
I2		Litecontrol	LG-WWD-4414T5-SGL-CWM-IND-LP/ELB-277	Recessed luminaire with an optical system to provide uniform wall wash lighting. A extruded frosted acrylic soft glow lens diffuser. Semi-specular high reflectance aluminum primary optic reflector	Ceiling Recessed	9'-0"	Electronic	277	GE F28W/T5/841 /ECO	37 W
I3		Litecontrol	LG-WWD-4414T5-SGL-CWM-INT-LP/ELB-277	Recessed luminaire with an optical system to provide uniform wall wash lighting. A extruded frosted acrylic soft glow lens diffuser. Semi-specular high reflectance aluminum primary optic reflector	Ceiling Recessed	9'-0"	Electronic	277	GE F28W/T5/841 /ECO	37 W
I4		Litecontrol	LG-WWD-4414T5-SGL-CWM-EOR/RH-LP/ELB-277	Recessed luminaire with an optical system to provide uniform wall wash lighting. A extruded frosted acrylic soft glow lens diffuser. Semi-specular high reflectance aluminum primary optic reflector	Ceiling Recessed	9'-0"	Electronic	277	GE F28W/T5/841 /ECO	37 W

Luminaire Schedule										
J1		Lightolier	2001CL	Open aperture compact fluorescent recessed downlight. Aluminum reflector with a matte white flange. Specular clear finish.	Ceiling Recessed	9'-0"	Electronic	277	GE F13TBX/841/ A/ECO	16 W
K1		Ledalite	3324-D1-ST-T232-S-1-2-E	Recessed Luminaire with an optical system with highly reflective painted interiors.	Ceiling Recessed	9'-0"	Electronic	277	GE F32T8/SP41/ECO/C	62 W
*Luminaire, Lamp, Ballast Specification Sheets are located in Appendix A										

Light Loss Factors					
Type	**LLD**	**LDD**	**RSDD**	**BF**	**LLF Total**
I1	0.92	0.88	0.974	0.96	0.757
I2	0.92	0.88	0.974	0.96	0.757
I3	0.92	0.88	0.974	0.96	0.757
I4	0.92	0.88	0.974	0.96	0.757
J1	0.94	0.89	0.974	1.00	0.815
K1	0.95	0.88	0.974	0.88	0.717

Controls

The redesign of the lighting in this space, also requires a redesign of the current control system to operate the new lighting design. The task lighting (Luminaire Type C) and the lighting at the entrance to the room (Luminaire Type B) and the wall washing luminairies (Luminaire Type A) will be located on a duel-technology occupancy sensor. Since this room is not a rectangular space, a ceiling mounted occupancy sensor will be used and preferred over a wall mounted occupancy sensor by the door. The duel-technology occupancy sensor is located so that the entrance to the room is visible as well as located above the students desk where the majority of activity within the space will occur. The occupancy sensor will be a WattStopper DT-300 series dual technology ceiling sensor, and the equipment schedule and cut sheets are located in Appendix B

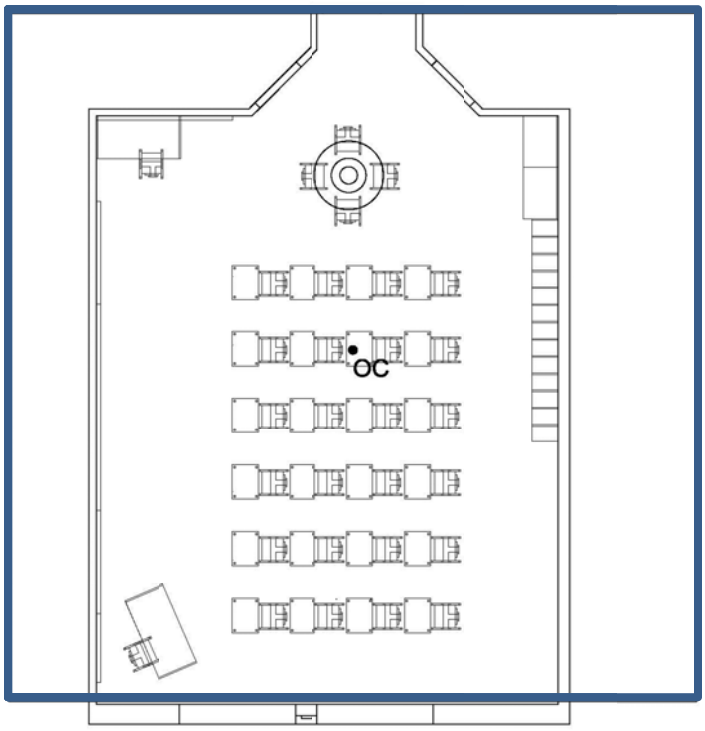


Figure 42: Schematic for Ocuupancy Sensor Coverage Area

Type	Manufacturer	Product Name	Catalog Number	Description	Location
OC-1	Watt Stopper	DT-300 Series Dual Technology Ceiling Sensor	DT-300-U	Passive infrared (PIR) and ultrasonic technologies utilized. Flat appearance of sensor with a 360 degrees of coverage	Primary Classroom

Table 16: Primary Classroom Equipment Schedule

Lighting Design

Design Concept

The primary classroom should promote learning within the space. Students should feel comfortable and attentive while in this space. The lighting design should provide uniform lighting on the workplane of the students desks, while avoiding glare. To achieve this, lensed luminaires will be used directly above the workplane. Energy efficient lamps and ballasts are used. The uniform, high levels of light will provide a public feeling within the space to enhance the students ability to learn.

The walls and ceilings are highly reflective materials and help distribute reflected light to the workplane.

Performance Data

The following cantains renderings and calculation data that was calculated using AGI32 for the proposed lighting design.

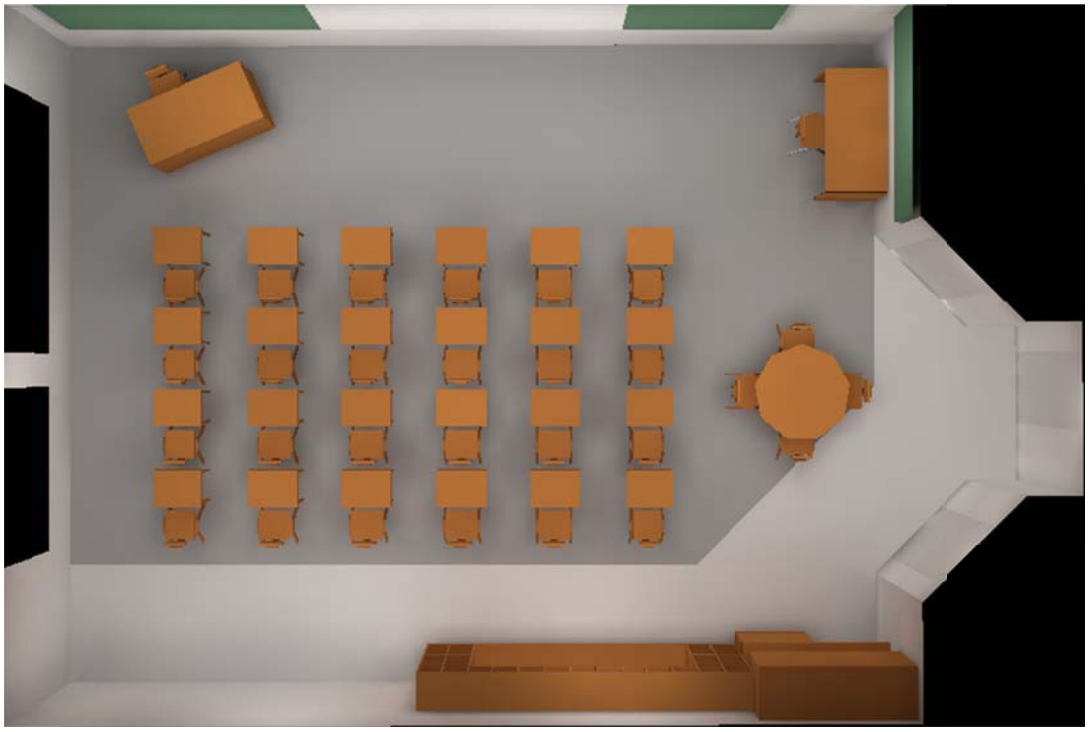


Figure 43: Primary Classroom with Type I1 ,I2, I3, I4, J1 And K1 lights on

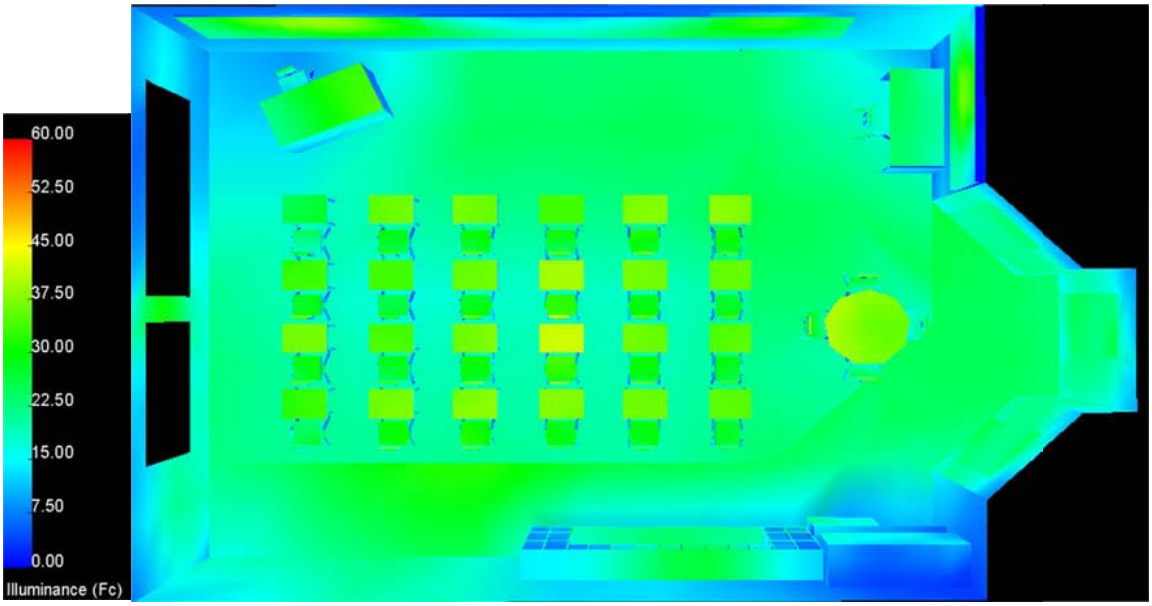


Figure 44: Primary Classroom Illumininance Pseudo Color Rendering with Type I1 ,I2, I3, I4, J1, And K1 lights on

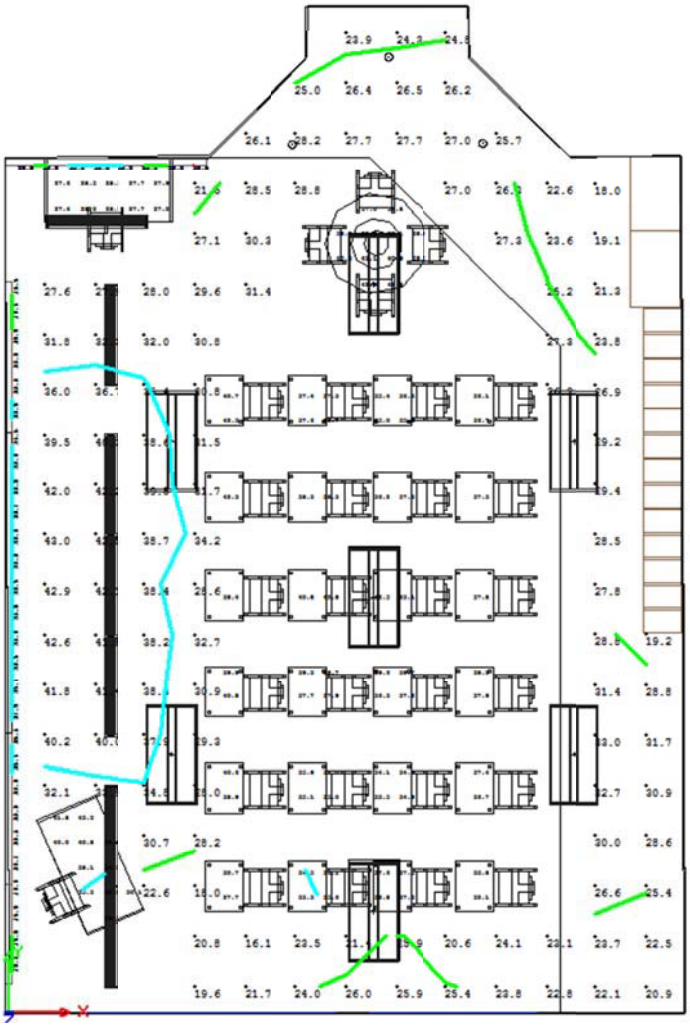


Figure 45: Primary Classroom Isolines for illuminance levels with Type A1 ,A2, A3, B, And C lights on

Figure 46: Primary Classroom East Elevation

Figure 47: Primary Classroom South-West Isometric view

Illuminance Levels						
Location	**Average (fc)**	**Max (fc)**	**Min (fc)**	**Max/Min**	**Coeff. Variation**	**Meets Recommendations**
Students Desk	37.16	43.1	27.7	1.56	0.08	Yes
Teacher's Desk	32.46	39.7	26.0	1.54	0.12	Yes
Table	39.55	42.0	36.8	1.14	0.04	Yes
Circulation Path	29.44	43	16.1	2.67	.22	Yes
White Board	36.51	40.3	28.9	1.39	0.07	Yes
Tack Baords	28.63	34.83	21.8	1.70	0.13	N/A

Table 17: Illuminance levels throughout space

Power Allowance			
Total Size	**Power Allowance**	**Total Power Allowed (Watts)**	**Total Power Used (Watts)**
975 ft^2	1.4 W/ft^2	1365	741

Table 18: Power Allowance

This lighting design meets ASHRAE 90.1/IESNA Standandes for power allowances.

Performance Summary

The redesign of this space meets the recommended lighting levels set forth by IESNA. The lighting design in this space is designed to create the Flynn Impession of a Public space. To achieve this, all of the luminaires used are recessed so that the space feels as open a possible. Also, it was necessary to achieve uniformity throughout the space, uniformity on the workplane, or students desks, as well as create a uniform lighting design.

The luminaires selected easily fit into the current grid ceiling layout with 2x2 ceiling tile. The intent was to use luminaires that work well with this learning environment. To acheive this, luminaires above the work plane have a lense so that there is no direct line of sight to the lamp. Also, the luminaires that are lighting the taskboards in the front of the room are also lensed so that the teacher does not have a direct line of sight to the lamp, as well as a spline to avoid any discomforter from the onlooking students. All the luminaires selected are fluorescent light sources and have a CCT of 4100 and a high CRI.

The uniform lighting layout above the students desks provides an even distribution of light, while achieving the IESNA recommendation of 30 fc on the students desks. The recessed wall washing luminaires at the front of the classroom have many purposes. Although not required by IESNA, I wanted to reach an average illuminance level of 30 fc on the task boards at the front of the room that will display class information, to assure there is enough illuminance that students can read these boards with ease. In addition, this added light will direct the students attention to the front of the classroom, due to the higher levels of illuminance on the east wall. The whiteboard in the front of the classroom needs 30 fc per IESNA recommendations, which was meet. Uniformity on the whiteboard was achieved and there should be no issue with glare.

The primary classroom meets the requirements set forth by IESNA, and achieves the public psychological impress desired, while creating a comfortable learning environment. The controls in this space meet the shutoff requirements set by ASHRAE 90.1/IESNA.

Electrical Redesign for Lighting Spaces

The redesigning of the lighting spaces requires a redesign of the branch circuit distribution within these four spaces. The fours spaces that the branch circuiting is redesigned for are the covered walkways and entrance, the lobby, the multipurpose room, and a primary classroom. The overall purpose of the lighting redesign of these spaces is to lower the energy consumption within these spaces to save this school money on electrical costs.

For the covered entrance and covered walkways, the lighting redesign uses a symmetric design with canopy mounted luminaires under the covered walkways that lead a visitor to the covered entrance that welcomes them into the building. The covered entrance has recessed downlights to light this space. In addition to the necessary lighting to reach the IESNA recommended illuminance values, direct/indirect luminaires are places on the façade of the building that will remain on throughout the night to provide security for the school.

For the lobby, the lighting design is meant to create a smooth transition from the exterior of the building to the first interior space that occupants see. Therefore, the direct/indirect luminaire on the exterior façade is located on the columns of this space. Also, to meet IESNA recommended illuminance values recessed downlights are places on the ceiling. There is a wall located under the main staircase in the center of this building, where the school displays current works from the students and important school information. To draw attention to this wall, higher illuminance levels are produced by using linear wall washing luminaires.

For the multipurpose room, the lighting design must work for both the cafeteria space, the auditorium space, when the partition wall is in use, and when this space is used as an emergency shelter. Therefore the center of the space where auditorium and cafeteria seating is located is lit by semi-indirect pendant luminaires. The circulation space throughout the room is illuminated by recessed downlights in a linear pattern. In addition, the stage is illuminated by two rows of adjustable track luminaires that are controlled by a scene controller for the different needs of the stage.

For the primary classroom, the lighting design uses recessed linear luminaires to provide adequate lighting on the work plane. In addition, wall washing luminaires are used to light both the whiteboard and the tackboards. Recessed downlights are used to light the exits from the room.

The redesigning of lighting in four spaces has changed both the circuiting and controls in these spaces. All of the lighting that has been changed is 277 V. The lighting affected is located on both normal and emergency/normal panels. The panels affected by the lighting redesign are highlighted in the table below.

Panelboards						
Panel Tag	Voltage	System	Entrance	Lobby	Multipurpose Room	Classroom
1EH1	480Y/120V, 3P, 4W	N/E	X	X		
1H1	480Y/120V, 3P, 4W	N	X	X	X	X
1L1	208Y/120V, 3P, 4W	N			X	

Table 19: Panels affected by lighting design

Controls

Controls for all of the redesigned lighting spaces can be found under the controls section of the space desired.

Lighting Layouts

Lighting layouts for the four spaces that have been redesigned are located in Appendix B.

Exising Panelboard Schedules

The following are the existing panel schedules for Panel 1H1, Panel 1HE1, and Panel 1L1, which note the circuits that will be affected by the four spaces redesigned.

Panel 1H1

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VOLTS L/N: 277				DEPTH(IN.): 5.75	
VOLTS PH.: 480	<------AIC RATING------->	PANEL: 1H1		SECTIONS: 1	
PHASE: 3	SERIES RATED: 65 KA(*)	MLO(***): 225		SECTION WIDTH(IN.): 20	
MOUNTING: SURF	FULLY RATED: ______KA	MCB: ______		PLUG-IN: N/A	
TYPE: NF	(*)NOTE: MAY REQUIRE FULL	SH. TRIP: ______		BOLT-ON: YES	
MFR: SQ D	RATING TO ACHIEVE.	BUS: COPPER		NEMA 3R: _____	

GENERAL NOTES:
(1) ALL C.B.'S FEEDING HVAC EQUIPMENT TO BE HACR TYPE.
(2) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SHUNT-TRIP TYPE.
(3) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SIZED AS REQUIRED BY MFR.
(4) ALL C.B.'S FEEDING HID LTG TO BE HID RATED.

_____ NOTE: NON-LINEAR PNL, 200% NEUTRAL
_____ NOTE: ISOLATED GROUND BUS
_____ NOTE: SHUNT TRIP C.B.
_____ NOTE: GFI C.B.
_____ NOTE: SIZE CB PER MFR. RECOMMENDATIONS.

			MAIN SERVICE: NO			
163	TOTAL AMPS A PHASE	(***) NOTE: SIZE SHOWN IS MINIMUM	ACTUAL CONN. LOAD:	136	163	AMPS
163	TOTAL AMPS B PHASE	ACCEPTABLE MLO AMPERAGE. INCREASE	NEC LOAD/DEMAND:	136	163	AMPS
163	TOTAL AMPS C PHASE	SIZE IF REQUIRED FOR QUANTITY OF	NEC DIVERSITY	136	163	AMPS
NONE	ERROR CODE	POLES.	XFMR KVA: 0			

DESCRIPTION	LOAD CONN	TYPE	AMPS	AMPS	AMPS	C.B. AMPS	C.B. POLE	CKT. NO.	CKT. NO.	C.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
GEN. LTG.	3660	1	13			20	1	1	2	1	20	13			GEN. LTG.	3660	1
GEN. LTG.	3200	1		12		20	1	3	4	1	20		12		GEN. LTG.	3290	1
GEN. LTG.	3555	1			13	20	1	5	6	1	20			9	GEN. LTG.	2530	1
GEN. LTG.	2440	1	9			20	1	7	8	1	20	14			GEN. LTG.	3740	1
GEN. LTG.	2048	1		7		20	1	9	10	1	20		11		GEN. LTG.	2935	1
GEN. LTG.	2900	1			10	20	1	11	12	1	20			10	HALL LTG	2785	1
GEN. LTG.	315	1	1			20	1	13	14	1	20	11			HALL LTG	3085	1
EXTR LTG	2840	2		10		20	1	15	16	1	20		15		EXTR LTG	4030	2
SPARE	0				0	20	1	17	18	1	20			16	EXTR LTG	4340	2
SPARE	0		0			20	1	19	20	1	20	7			EXTR LTG	1860	2
SPARE	0			0		20	1	21	22	1	20		9		EXTR LTG	2480	2
SPARE	0				0	20	1	23	24	1	20			2	SCHOOL SIGN	500	2
SPARE	0		0			20	1	25	26	1	20	0			SPARE	0	
SPARE	0			0		20	1	27	28	1	20		0		SPARE	0	
SPARE	0				0	20	1	29	30	1	20			0	SPARE	0	
SPACE			0				1	31	32	1	20	0			SPARE	0	
SPACE				0			1	33	34	1	20		0		SPARE	0	
SPACE					0		1	35	36	1	20			0	SPARE	0	
SPACE			0				1	37	38	1		0			SPACE		
SPACE				0			1	39	40	1			0		SPACE		
SPACE					0		1	41	42	1				0	SPACE		
	0	14	0					S.F.	S.F.			0				0	14
----------	0	14		0		-----	-----	S.F.	S.F.	-----	-----		0		----------	0	14
----------	0	14			0	-----	-----	S.F.	S.F.	-----	-----			0	----------	0	14

Panel 1HE1

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VOLTS L/N: 277
VOLTS PH.: 480
PHASE : 3
MOUNTING : SURF
TYPE : NF
MFR : SQ D

<------AIC RATING------->
SERIES RATED : 65 KA(*)
FULLY RATED : ______KA
(*)NOTE: MAY REQUIRE FULL RATING TO ACHIEVE.

PANEL : 1EH1
MLO(***): 100
MCB : ______
SH. TRIP : ______
BUS : COPPER

DEPTH(IN.): 5.75
SECTIONS : 1
SECTION WIDTH(IN.): 20
PLUG-IN : N/A
BOLT-ON : YES
NEMA 3R : _____

GENERAL NOTES:
(1) ALL C.B.'S FEEDING HVAC EQUIPMENT TO BE HACR TYPE.
(2) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SHUNT-TRIP TYPE.
(3) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SIZED AS REQUIRED BY MFR.
(4) ALL C.B.'S FEEDING HID LTG TO BE HID RATED.

_____ NOTE: NON-LINEAR PNL, 200% NEUTRAL
_____ NOTE: ISOLATED GROUND BUS
_____ NOTE: SHUNT TRIP C.B.
_____ NOTE: GFI C.B.
_____ NOTE: SIZE CB PER MFR. RECOMMENDATIONS.

45 : TOTAL AMPS A PHASE
41 : TOTAL AMPS B PHASE
41 : TOTAL AMPS C PHASE
NONE : ERROR CODE

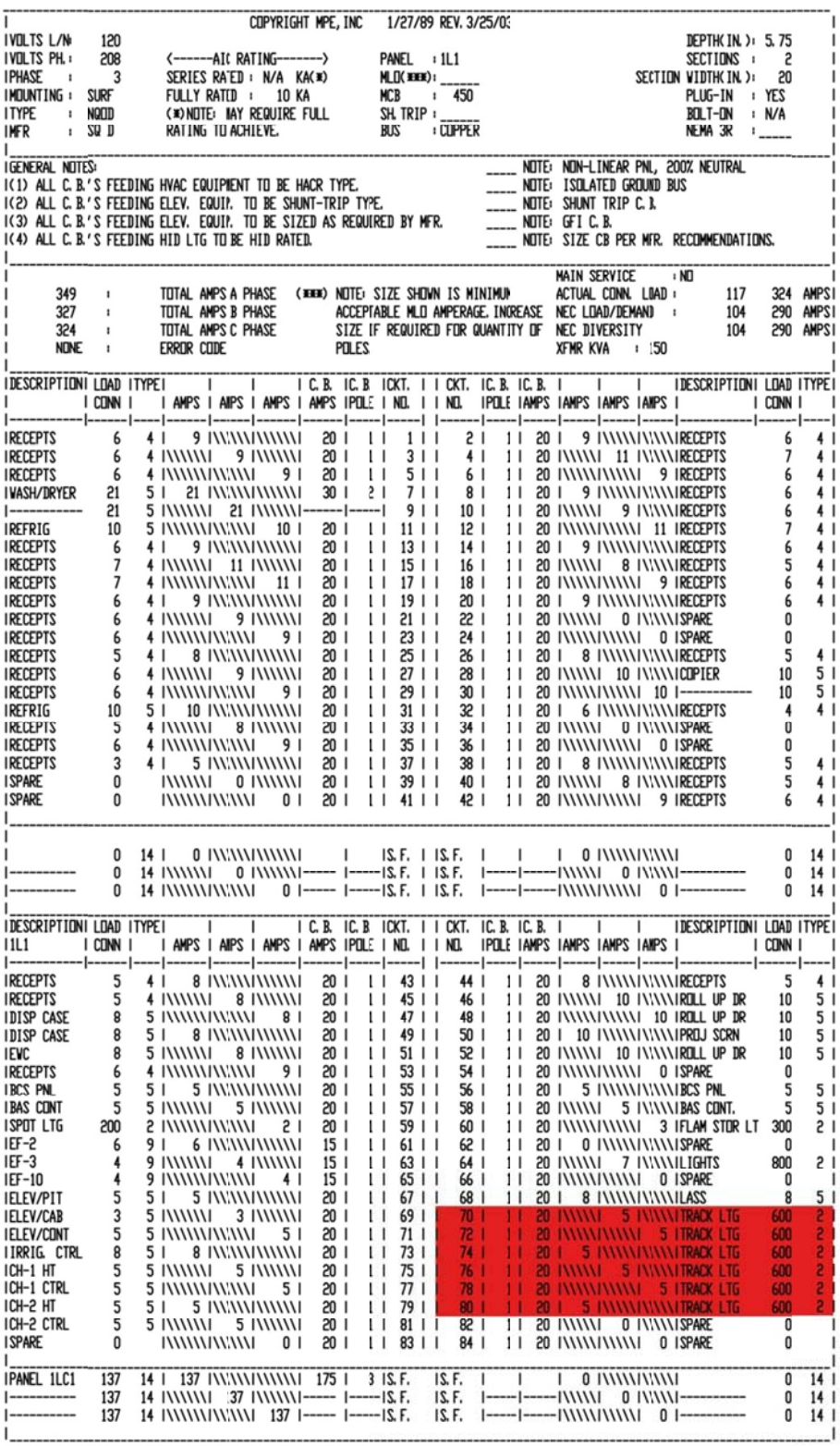
(***) NOTE: SIZE SHOWN IS MINIMUM ACCEPTABLE MLO AMPERAGE. INCREASE SIZE IF REQUIRED FOR QUANTITY OF POLES.

MAIN SERVICE : NO
ACTUAL CONN. LOAD : 34 41 AMPS
NEC LOAD/DEMAND : 34 41 AMPS
NEC DIVERSITY 34 41 AMPS
XFMR KVA : 0

DESCRIPTION	LOAD CONN	TYPE	AMPS	AMPS	AMPS	C.B. AMPS	C.B. POLE	CKT. NO.	CKT. NO.	C.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
HALL/RR LTG	1535	2	6			20	1	1	2	1	20	11			KITCH/OFFI	2985	2
HALL/RR LTG	2895	2		10		20	1	3	4	1	20		12		MULTI-PURP	3325	2
OFFICE/STOR	2705	2			10	20	1	5	6	1	20			10	LTG	2828	2
EXTR LTG	3210	2	12			20	1	7	8	1	20	0			SPARE	0	
SPARE	0			0		20	1	9	10	1	20		0		SPARE	0	
SPARE	0				0	20	1	11	12	1	20			0	SPARE	0	
SPARE	0		0			20	1	13	14	3	40	17			PANEL 1LE1	17	14
SPARE	0			0		20	1	15	16	-----	-----		17		-----------	17	14
SPARE	0				0	20	1	17	18	-----	-----			17	-----------	17	14
			0									0					
				0									0				
					0									0			
			0									0					
				0									0				
					0									0			
			0									0					
				0									0				
					0									0			
			0									0					
				0									0				
					0									0			

DESCRIPTION	LOAD CONN	TYPE	AMPS	AMPS	AMPS	C.B. AMPS	C.B. POLE	CKT. NO.	CKT. NO.	C.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
	0	14	0					S.F.	S.F.			0				0	14
----------	0	14		0		-----	-----	S.F.	S.F.	-----	-----		0		----------	0	14
----------	0	14			0	-----	-----	S.F.	S.F.	-----	-----			0	----------	0	14

Panel 1L1



COPYRIGHT MPE, INC 1/27/89 REV. 3/25/03					
VOLTS L/N	120		PANEL : 1L1	DEPTH(IN.)	5.75
VOLTS PH.	208	<------AIC RATING------>		SECTIONS	2
PHASE	3	SERIES RATED : N/A KA(*)	MLO(***): _____	SECTION WIDTH(IN.)	20
MOUNTING	SURF	FULLY RATED : 10 KA	MCB : 450	PLUG-IN	YES
TYPE	NQOD	(*)NOTE: MAY REQUIRE FULL	SH. TRIP : _____	BOLT-ON	N/A
MFR	SQ D	RATING TO ACHIEVE.	BUS : COPPER	NEMA 3R	_____

GENERAL NOTES:
(1) ALL C.B.'S FEEDING HVAC EQUIPMENT TO BE HACR TYPE.
(2) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SHUNT-TRIP TYPE.
(3) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SIZED AS REQUIRED BY MFR.
(4) ALL C.B.'S FEEDING HID LTG TO BE HID RATED.

_____ NOTE: NON-LINEAR PNL, 200% NEUTRAL
_____ NOTE: ISOLATED GROUND BUS
_____ NOTE: SHUNT TRIP C.B.
_____ NOTE: GFI C.B.
_____ NOTE: SIZE CB PER MFR. RECOMMENDATIONS.

349	:	TOTAL AMPS A PHASE	(***) NOTE: SIZE SHOWN IS MINIMUM	MAIN SERVICE : NO		
327	:	TOTAL AMPS B PHASE	ACCEPTABLE MLO AMPERAGE. INCREASE	ACTUAL CONN. LOAD :	117	324 AMPS
324	:	TOTAL AMPS C PHASE	SIZE IF REQUIRED FOR QUANTITY OF	NEC LOAD/DEMAND :	104	290 AMPS
NONE	:	ERROR CODE	POLES.	NEC DIVERSITY	104	290 AMPS
				XFMR KVA : 150		

DESCRIPTION	LOAD CONN	TYPE	AMPS	C.B. AMPS	IC.B POLE	CKT. NO.	CKT. NO.	IC.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
RECEPTS	6	4	9	20	1	1	2	1	20	9			RECEPTS	6	4
RECEPTS	6	4	9	20	1	3	4	1	20		11		RECEPTS	7	4
RECEPTS	6	4	9	20	1	5	6	1	20			9	RECEPTS	6	4
WASH/DRYER	21	5	21	30	2	7	8	1	20	9			RECEPTS	6	4
	21	5	21			9	10	1	20		9		RECEPTS	6	4
REFRIG	10	5	10	20	1	11	12	1	20			11	RECEPTS	7	4
RECEPTS	6	4	9	20	1	13	14	1	20	9			RECEPTS	6	4
RECEPTS	7	4	11	20	1	15	16	1	20		8		RECEPTS	5	4
RECEPTS	7	4	11	20	1	17	18	1	20			9	RECEPTS	6	4
RECEPTS	6	4	9	20	1	19	20	1	20	9			RECEPTS	6	4
RECEPTS	6	4	9	20	1	21	22	1	20		0		SPARE	0	
RECEPTS	6	4	9	20	1	23	24	1	20			0	SPARE	0	
RECEPTS	5	4	8	20	1	25	26	1	20	8			RECEPTS	5	4
RECEPTS	6	4	9	20	1	27	28	1	20		10		COPIER	10	5
RECEPTS	6	4	9	20	1	29	30	1	20			10		10	5
REFRIG	10	5	10	20	1	31	32	1	20	6			RECEPTS	4	4
RECEPTS	5	4	8	20	1	33	34	1	20		0		SPARE	0	
RECEPTS	6	4	9	20	1	35	36	1	20			0	SPARE	0	
RECEPTS	3	4	5	20	1	37	38	1	20	8			RECEPTS	5	4
SPARE	0		0	20	1	39	40	1	20		8		RECEPTS	5	4
SPARE	0		0	20	1	41	42	1	20			9	RECEPTS	6	4
	0	14	0			S.F.	S.F.			0				0	14
	0	14	0			S.F.	S.F.				0			0	14
	0	14	0			S.F.	S.F.					0		0	14

DESCRIPTION 1L1	LOAD CONN	TYPE	AMPS	C.B. AMPS	IC.B POLE	CKT. NO.	CKT. NO.	IC.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
RECEPTS	5	4	8	20	1	43	44	1	20	8			RECEPTS	5	4
RECEPTS	5	4	8	20	1	45	46	1	20		10		ROLL UP DR	10	5
DISP CASE	8	5	8	20	1	47	48	1	20			10	ROLL UP DR	10	5
DISP CASE	8	5	8	20	1	49	50	1	20	10			PROJ SCRN	10	5
EWC	8	5	8	20	1	51	52	1	20		10		ROLL UP DR	10	5
RECEPTS	6	4	9	20	1	53	54	1	20			0	SPARE	0	
BCS PNL	5	5	5	20	1	55	56	1	20	5			BCS PNL	5	5
BAS CONT	5	5	5	20	1	57	58	1	20		5		BAS CONT.	5	5
SPOT LTG	200	2	2	20	1	59	60	1	20			3	FLAM STOR LT	300	2
EF-2	6	9	6	15	1	61	62	1	20	0			SPARE	0	
EF-3	4	9	4	15	1	63	64	1	20		7		LIGHTS	800	2
EF-10	4	9	4	15	1	65	66	1	20			0	SPARE	0	
ELEV/PIT	5	5	5	20	1	67	68	1	20	8			CLASS	8	5
ELEV/CAB	3	5	3	20	1	69	70	1	20		5		TRACK LTG	600	2
ELEV/CONT	5	5	5	20	1	71	72	1	20			5	TRACK LTG	600	2
IRRIG. CTRL	8	5	8	20	1	73	74	1	20	5			TRACK LTG	600	2
CH-1 HT	5	5	5	20	1	75	76	1	20		5		TRACK LTG	600	2
CH-1 CTRL	5	5	5	20	1	77	78	1	20			5	TRACK LTG	600	2
CH-2 HT	5	5	5	20	1	79	80	1	20	5			TRACK LTG	600	2
CH-2 CTRL	5	5	5	20	1	81	82	1	20		0		SPARE	0	
SPARE	0		0	20	1	83	84	1	20			0	SPARE	0	
PANEL 1LC1	137	14	137	175	3	S.F.	S.F.			0				0	14
	137	14	37			S.F.	S.F.				0			0	14
	137	14	137			S.F.	S.F.					0		0	14

Feeder Sizing Worksheet

Panel Worksheet for Panel 1H1

PANELBOARD SIZING WORKSHEET

Panel Tag---------->	1H1	Panel Location:	RM 01-141		
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	GEN. LTG.	3	CLASS	3660	w	1.00	3660	3660	
2	A	GEN. LTG.	3	CLASS	3125	w	1.00	3125	3125	
3	B	GEN. LTG.	3	ART	3200	w	1.00	3200	3200	
4	B	GEN. LTG.	3	CLASS	3290	w	1.00	3290	3290	
5	C	GEN. LTG.	3	CLASS	3555	w	1.00	3555	3555	
6	C	GEN. LTG.	3	MEDIA	2530	w	1.00	2530	2530	
7	A	GEN. LTG.	3	MEDIA	2440	w	1.00	2440	2440	
8	A	GEN. LTG.	3	MEDIA	3740	w	1.00	3740	3740	
9	B	GEN. LTG.	3	LOBBY	2870	w	1.00	2870	2870	
10	B	GEN. LTG.	3	CLASS	2935	w	1.00	2935	2935	
11	C	GEN. LTG.	4	LOBBY	475	w	1.00	475	475	
12	C	HALL LTG.	3	CORR.	2785	w	1.00	2785	2785	
13	A	GEN. LTG.	3	LOBBY	324	w	1.00	324	324	
14	A	HALL LTG.	3	CORR.	3085	w	1.00	3085	3085	
15	B	EXTR. LTG	3	EXTERIOR	1980	w	1.00	1980	1980	
16	B	EXTR. LTG	4	EXTERIOR	4030	w	1.00	4030	4030	
17	C	GEN. LTG.	3	MULTI	438	w	1.00	438	438	
18	C	EXTR. LTG	4	EXTERIOR	4340	w	1.00	4340	4340	
19	A	GEN. LTG.	3	MULTI.	740	w	1.00	740	740	
20	A	EXTR. LTG	4	EXTERIOR	3472	w	1.00	3472	3472	
21	B	SPARE			3601	w	1.00	3601	3601	
22	B	EXTR. LTG	4	EXTERIOR	3580	w	1.00	3580	3580	
23	C	SPARE			3601	w	1.00	3601	3601	
24	C	SCHOOL SIGN	9	EXTERIOR	500	w	1.00	500	500	
25	A	SPARE			3601	w	1.00	3601	3601	
26	A	SPARE			3601	w	1.00	3601	3601	
27	B	SPARE			3601	w	1.00	3601	3601	
28	B	SPARE			3601	w	1.00	3601	3601	
29	C	SPARE			3601	w	1.00	3601	3601	
30	C	SPARE			3601	w	1.00	3601	3601	
31	A	SPACE			2770	w	1.00	2770	2770	
32	A	SPARE			3601	w	1.00	3601	3601	
33	B	SPACE			2770	w	1.00	2770	2770	

34	B	SPARE			3601	w	1.00	3601	3601		
35	C	SPACE			2770	w	1.00	2770	2770		
36	C	SPARE			3604	w	1.00	3604	3604		
37	A	SPACE			2770	w	1.00	2770	2770		
38	A	SPACE			2770	w	1.00	2770	2770		
39	B	SPACE			2770	w	1.00	2770	2770		
40	B	SPACE			2770	w	1.00	2770	2770		
41	C	SPACE			2770	w	1.00	2770	2770		
42	C	SPACE			2770	w	1.00	2770	2770		
PANEL TOTAL								121.6	121.6	Amps=	146.4

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					39.7	39.7	33%	143.3
PHASE TOTAL	B					44.6	44.6	37%	161.0
PHASE TOTAL	C					37.3	37.3	31%	134.8

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			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		40.7	40.7	1.25	50.9	50.9	1.00		
4	HID lighting		15.9	15.9	1.25	19.9	19.9	1.00		
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		65.0	65.0	1.00	65.0	65.0	1.00		
Total Demand Loads						135.8	135.8			
Spare Capacity			0%			0.0	0.0			
Total Design Loads						135.8	135.8	1.00	Amps=	163.4

Default Power Factor =	1.00	
Default Demand Factor =	100	%

Revised Panelboard 1H1

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A/3P C/B

PANEL TAG: 1H1
PANEL LOCATION: RM 01-141
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 65K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
GEN. LTG.	CLASS	3660	20A/1P	1	*			2	20A/1P	3125	CLASS	GEN. LTG.
GEN. LTG.	ART	3200	20A/1P	3		*		4	20A/1P	3290	CLASS	GEN. LTG.
GEN. LTG.	CLASS	3555	20A/1P	5			*	6	20A/1P	2530	MEDIA	GEN. LTG.
GEN. LTG.	MEDIA	2440	20A/1P	7	*			8	20A/1P	3740	MEDIA	GEN. LTG.
GEN. LTG.	LOBBY	2870	20A/1P	9		*		10	20A/1P	2935	CLASS	GEN. LTG.
GEN. LTG.	LOBBY	475	20A/1P	11			*	12	20A/1P	2785	CORR.	HALL LTG.
GEN. LTG.	LOBBY	324	20A/1P	13	*			14	20A/1P	3085	CORR.	HALL LTG.
EXTR. LTG	EXTERIOR	1980	20A/1P	15		*		16	20A/1P	4030	EXTERIOR	EXTR. LTG
GEN. LTG.	MULTI	438	20A/1P	17			*	18	20A/1P	4340	EXTERIOR	EXTR. LTG
GEN. LTG.	MULTI	740	20A/1P	19	*			20	20A/1P	3472	EXTERIOR	EXTR. LTG
SPARE		3601	20A/1P	21		*		22	20A/1P	3580	EXTERIOR	EXTR. LTG
SPARE		3601	20A/1P	23			*	24	20A/1P	500	EXTERIOR	SCHOOL SIGN
SPARE		3601	20A/1P	25	*			26	20A/1P	3601		SPARE
SPARE		3601	20A/1P	27		*		28	20A/1P	3601		SPARE
SPARE		3601	20A/1P	29			*	30	20A/1P	3601		SPARE
SPACE		2770		31	*			32	20A/1P	3601		SPARE
SPACE		2770		33		*		34	20A/1P	3601		SPARE
SPACE		2770		35			*	36	20A/1P	3604		SPARE
SPACE		2770		37	*			38		2770		SPACE
SPACE		2770		39		*		40		2770		SPACE
SPACE		2770		41			*	42		2770		SPACE

CONNECTED LOAD (KW) - A Ph.	39.70	TOTAL DESIGN LOAD (KW)	135.79
CONNECTED LOAD (KW) - B Ph.	44.60	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	37.34	TOTAL DESIGN LOAD (AMPS)	163

Panelboard Worksheet for Panel 1HE1

PANELBOARD SIZING WORKSHEET

Panel Tag---------->					1HE1	Panel Location:			RM 01-141A	
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	HALL LTG.	3	CORR.	1535	w	1.00	1535	1535	
2	A	KITCH/OFFICE	3	KITCH.	2985	w	1.00	2985	2985	
3	B	HALL LTG.	3	CORR.	2898	w	1.00	2898	2898	
4	B	MULTI-PURP	3	MULTI.	804	w	1.00	804	804	
5	C	OFFICE/STOR	3	OFFICE	2705	w	1.00	2705	2705	
6	C	GEN. LTG.	3	LOBBY	694	w	1.00	694	694	
7	A	EXTR. LTG	4	EXTERIOR	3686	w	1.00	3686	3686	
8	A	SPARE	9		3601	w	1.00	3601	3601	
9	B	SPARE	9		3601	w	1.00	3601	3601	
10	B	SPARE	9		3601	w	1.00	3601	3601	
11	C	SPARE	9		3601	w	1.00	3601	3601	
12	C	SPARE	9		3601	w	1.00	3601	3601	
13	A	SPARE	9		3601	w	1.00	3601	3601	
14	A	PANEL 1LEL	9	01-141A	3878	w	1.00	3878	3878	
15	B	SPARE	9		3601	w	1.00	3601	3601	
16	B	PANEL 1LEL	9	01-141A	3878	w	1.00	3878	3878	
17	C	SPARE	9		3601	w	1.00	3601	3601	
18	C	PANEL 1LEL	9	01-141A	3878	w	1.00	3878	3878	
PANEL TOTAL								55.7	55.7	Amps= 67.1

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	19.3	19.3	35%	69.6
PHASE TOTAL	B	18.4	18.4	33%	66.4
PHASE TOTAL	C	18.1	18.1	32%	65.3

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			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		11.6	11.6	1.25	14.5	14.5	1.00		
4	HID lighting		3.7	3.7	1.25	4.6	4.6	1.00		
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		40.4	40.4	1.00	40.4	40.4	1.00		
Total Demand Loads						59.6	59.6			

Spare Capacity		0%			0.0	0.0			
Total Design Loads					59.6	59.6	1.00	Amps=	71.7

Default Power Factor =	1.00	
Default Demand Factor =	100	%

Revised Panelboard 1HE1

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: 1HE1	MIN. C/B AIC: 65K
SIZE/TYPE BUS: 100A	PANEL LOCATION: RM 01-141A	OPTIONS:
SIZE/TYPE MAIN: 90A/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
HALL LTG.	CORR.	1535	20A/1P	1	*			2	20A/1P	2985	KITCH.	KITCH/OFFICE
HALL LTG.	CORR.	2898	20A/1P	3		*		4	20A/1P	804	MULTI.	MULTI-PURP
OFFICE/STOR	OFFICE	2705	20A/1P	5			*	6	20A/1P	694	LOBBY	GEN. LTG.
EXTR. LTG	EXTERIOR	3686	20A/1P	7	*			8	20A/1P	3601	0	SPARE
SPARE	0	3601	20A/1P	9		*		10	20A/1P	3601	0	SPARE
SPARE	0	3601	20A/1P	11			*	12	20A/1P	3601	0	SPARE
SPARE	0	3601	20A/1P	13	*			14	40A/3P	3878	01-141A	PANEL 1LEL
SPARE	0	3601	20A/1P	15		*		16		3878	01-141A	PANEL 1LEL
SPARE	0	3601	20A/1P	17			*	18		3878	01-141A	PANEL 1LEL

CONNECTED LOAD (KW) - A Ph.	19.29	TOTAL DESIGN LOAD (KW)	59.58
CONNECTED LOAD (KW) - B Ph.	18.38	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	18.08	TOTAL DESIGN LOAD (AMPS)	72

PANELBOARD SIZING WORKSHEET

Panel Tag---------->	1L1	Panel Location:	RM 01-141		
Nominal Phase to Neutral Voltage------->	120	Phase:	3		
Nominal Phase to Phase Voltage-------->	208	Wires:	4		

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
2	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
3	B	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
4	B	RECEPTS	1	CLASS	1260	w	1.00	1260	1260	
5	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
6	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
7	A	WASH/DRYER	8	KITCH	2520	w	1.00	2520	2520	
8	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
9	B	WASH/DRYER	8	KITCH	2520	w	1.00	2520	2520	
10	B	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
11	C	RECEPTS	1	CLASS	1200	w	1.00	1200	1200	
12	C	RECEPTS	1	CLASS	1980	w	1.00	1980	1980	
13	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
14	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
15	B	RECEPTS	1	CLASS	1260	w	1.00	1260	1260	
16	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
17	C	RECEPTS	1	CLASS	1260	w	1.00	1260	1260	
18	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
19	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
20	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
21	B	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
22	B	SPARE	9		1560	w	1.00	1560	1560	
23	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
24	C	SPARE	9		1560	w	1.00	1560	1560	
25	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
26	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
27	B	RECEPTS	1	OFFICE	1080	w	1.00	1080	1080	
28	B	COPIER	8	OFFICE	1200	w	1.00	1200	1200	
29	C	RECEPTS	1	OFFICE	1080	w	1.00	1080	1080	
30	C	COPIER	8	OFFICE	1200	w	1.00	1200	1200	
31	A	REFRIG	8	KITCH	1200	w	1.00	1200	1200	
32	A	RECEPTS	1	CLASS	720	w	1.00	720	720	
33	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
34	B	SPARE	9		1560	w	1.00	1560	1560	
35	C	SPARE	9		1560	w	1.00	1560	1560	
36	C	SPARE	9		1560	w	1.00	1560	1560	

37	A	RECEPTS	1	CLASS	540	w	1.00	540	540	
38	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
39	B	SPARE	9		1560	w	1.00	1560	1560	
40	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
41	C	SPARE	9		1560	w	1.00	1560	1560	
42	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
43	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
44	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
45	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
46	B	ROLL UP DR	8	MEDIA	1200	w	1.00	1200	1200	
47	C	DISP CASE	8	MEDIA	960	w	1.00	960	960	
48	C	ROLL UP DR	8	MEDIA	1200	w	1.00	1200	1200	
49	A	DISP CASE	8	MEDIA	960	w	1.00	960	960	
50	A	PROJ SCREEN	8	MEDIA	1200	w	1.00	1200	1200	
51	B	EWC	7	KITCH	960	w	1.00	960	960	
52	B	ROLL UP DR	8	MEDIA	1200	w	1.00	1200	1200	
53	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
54	C	SPARE	9		1560	w	1.00	1560	1560	
55	A	BCS PNL	8	MECH	600	w	1.00	600	600	
56	A	BCS PNL	8	MECH	600	w	1.00	600	600	
57	B	BAS CONT	8	MECH	600	w	1.00	600	600	
58	B	BAS CONT	8	MECH	600	w	1.00	600	600	
59	C	SPOT LTG	5	MECH	200	w	1.00	200	200	
60	C	FLAM STOR LT	5	MECH	300	w	1.00	300	300	
61	A	EF-2	6		720	w	1.00	720	720	
62	A	SPARE	9	MECH	800	w	1.00	800	800	
63	B	EF-3	6		480	w	1.00	480	480	
64	B	LIGHTS	5	MECH	960	w	1.00	960	960	
65	C	EF-10	6	MECH	480	w	1.00	480	480	
66	C	SPARE	9		600	w	1.00	600	600	
67	A	ELEV/PIT	8	MECH	600	w	1.00	600	600	
68	A	LASS	8	MECH	600	w	1.00	600	600	
69	B	ELEV/CAB	8	MECH	360	w	1.00	360	360	
70	B	TRACK LTG	4	MULTI	140	w	1.00	140	140	
71	C	ELEV/CONT	8	MECH	600	w	1.00	600	600	
72	C	TRACK LTG	4	MULTI	140	w	1.00	140	140	
73	A	IRRIG CTRL	8	MECH	960	w	1.00	960	960	
74	A	TRACK LTG	4	MULTI	140	w	1.00	140	140	
75	B	SPARE	9		1560	w	1.00	1560	1560	
76	B	TRACK LTG	4	MULTI	140	w	1.00	140	140	
77	C	SPARE	9		1560	w	1.00	1560	1560	
78	C	TRACK LTG	4	MULTI	140	w	1.00	140	140	
79	A	PANEL 1LC1	9	01-104	16440	w	1.00	16440	16440	
80	A	TRACK LTG	4	MULTI	140	w	1.00	140	140	
81	B	PANEL 1LC1	9	01-104	16440	w	1.00	16440	16440	

82	B	SPARE	9		1560	w	1.00	1560	1560	
83	C	PANEL 1LC1	9	01-104	16440	w	1.00	16440	16440	
84	C	SPARE	9		1560	w	1.00	1560	1560	
PANEL TOTAL								131.0	131.0	Amps= 363.9

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	40.8	40.8	31%	340.0
PHASE TOTAL	B	45.0	45.0	34%	375.3
PHASE TOTAL	C	45.2	45.2	34%	376.5

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		35.8	35.8	0.64	22.8	22.8	1.00		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		0.0	0.0		0.0	0.0			
4	HID lighting		0.8	0.8	1.25	1.1	1.1	1.00		
5	incandescent lighting		1.5	1.5	1.25	1.8	1.8	1.00		
6	HVAC fans		1.7	1.7	0.95	1.6	1.6	1.00		
7	heating		1.0	1.0	1.00	1.0	1.0	1.00		
8	kitchen equipment		20.9	20.9	0.65	13.6	13.6	1.00		
9	unassigned		69.4	69.4	1.00	69.4	69.4	1.00		
Total Demand Loads						111.2	111.2			
Spare Capacity			0%			0.0	0.0			
Total Design Loads						111.2	111.2	1.00	Amps=	309

Default Power Factor =	1.00	
Default Demand Factor =	100	%

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	1L1	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	400A	PANEL LOCATION:	RM 01-141	OPTIONS:	
SIZE/TYPE MAIN:	400A/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
RECEPTS	CLASS	1080	20A/1P	1	*			2	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	3		*		4	20A/1P	1260	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	5			*	6	20A/1P	1080	CLASS	RECEPTS
WASH/DRYER	KITCH	2520	30A/2P	7	*			8	20A/1P	1080	CLASS	RECEPTS
WASH/DRYER	KITCH	2520		9		*		10	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1200	20A/1P	11			*	12	20A/1P	1980	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	13	*			14	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1260	20A/1P	15		*		16	20A/1P	900	CLASS	RECEPTS
RECEPTS	CLASS	1260	20A/1P	17			*	18	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	19	*			20	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	21		*		22	20A/1P	1560		SPARE
RECEPTS	CLASS	1080	20A/1P	23			*	24	20A/1P	1560		SPARE
RECEPTS	CLASS	900	20A/1P	25	*			26	20A/1P	900	CLASS	RECEPTS
RECEPTS	OFFICE	1080	20A/1P	27		*		28	20A/1P	1200	OFFICE	COPIER
RECEPTS	OFFICE	1080	20A/1P	29			*	30	20A/1P	1200	OFFICE	COPIER
REFRIG	KITCH	1200	20A/1P	31	*			32	20A/1P	720	CLASS	RECEPTS
RECEPTS	CLASS	900	20A/1P	33		*		34	20A/1P	1560		SPARE
SPARE		1560	20A/1P	35			*	36	20A/1P	1560		SPARE
RECEPTS	CLASS	540	20A/1P	37	*			38	20A/1P	900	CLASS	RECEPTS
SPARE		1560	20A/1P	39		*		40	20A/1P	900	CLASS	RECEPTS
SPARE		1560	20A/1P	41			*	42	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	900	20A/1P	43	*			44	20A/1P	900	CLASS	RECEPTS
RECEPTS	CLASS	900	20A/1P	45		*		46	20A/1P	1200	MEDIA	ROLL UP DR
DISP CASE	MEDIA	960	20A/1P	47			*	48	20A/1P	1200	MEDIA	ROLL UP DR
DISP CASE	MEDIA	960	20A/1P	49	*			50	20A/1P	1200	MEDIA	PROJ SCREEN
EWC	KITCH	960	20A/1P	51		*		52	20A/1P	1200	MEDIA	ROLL UP DR

RECEPTS	CLASS	1080	20A/1P	53			*	54	20A/1P	1560		SPARE
BCS PNL	MECH	600	20A/1P	55	*			56	20A/1P	600	MECH	BCS PNL
BAS CONT	MECH	600	20A/1P	57		*		58	20A/1P	600	MECH	BAS CONT
SPOT LTG	MECH	200	20A/1P	59			*	60	20A/1P	300	MECH	FLAM STOR LT
EF-2		720	15A/1P	61	*			62	20A/1P	800	MECH	SPARE
EF-3		480	15A/1P	63		*		64	20A/1P	960	MECH	LIGHTS
EF-10	MECH	480	15A/1P	65			*	66	20A/1P	600		SPARE
ELEV/PIT	MECH	600	20A/1P	67	*			68	20A/1P	600	MECH	LASS
ELEV/CAB	MECH	360	20A/1P	69		*		70	20A/1P	140	MULTI	TRACK LTG
ELEV/CONT	MECH	600	20A/1P	71			*	72	20A/1P	140	MULTI	TRACK LTG
IRRIG CTRL	MECH	960	20A/1P	73	*			74	20A/1P	960	MULTI	TRACK LTG
SPARE		1560	20A/1P	75		*		76	20A/1P	140	MULTI	TRACK LTG
SPARE		1560	20A/1P	77			*	78	20A/1P	140	MULTI	TRACK LTG
PANEL 1LC1	01-104	16440	20A/1P	79	*			80	20A/1P	140	MULTI	TRACK LTG
PANEL 1LC1	01-104	16440	20A/1P	81		*		82	20A/1P	1560		SPARE
PANEL 1LC1	01-104	16440	20A/1P	83			*	84	20A/1P	1560		SPARE

CONNECTED LOAD (KW) - A Ph.	40.80	TOTAL DESIGN LOAD (KW)	111.22
CONNECTED LOAD (KW) - B Ph.	45.04	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	45.18	TOTAL DESIGN LOAD (AMPS)	309

Feeder Sizing

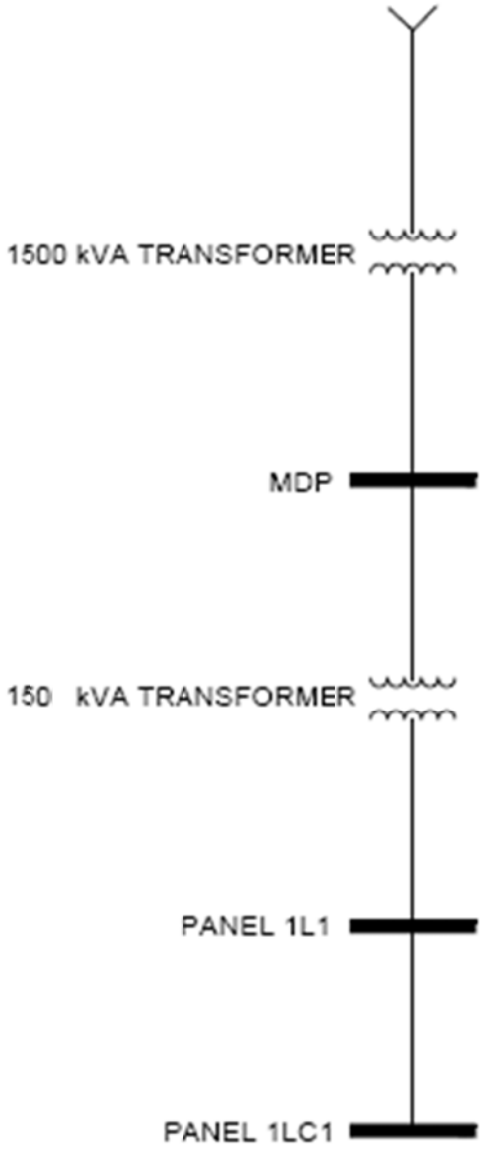
Panelboards			
Tag	Panel 1H1	Panel 1HE1	Panel 1L1
Voltage System	480/277	480/277	208/120
Calculated Design Load (kW)	135.8	59.6	111.2
Calculated Power Factor	1.00	1.00	1.0
Calculated Design Load (kVA)	135.8	59.6	111.2
Calculated Design Load (A)	163.4	71.7	309
Feeder			
Feeder Protection Size			
Number of Sets	1	1	2
Wire Size			
Phase	#3/0 AWG	#3 AWG	#3/0 AWG
Neutral	#3/0 AWG	#3 AWG	#3/0 AWG
Ground	#4 AWG	#8 AWG	#4 AWG
Wire Area			
Each Phase	0.2679	0.0973	0.3970
Total – All phases	0.8037	0.2919	2.382
Neutral	0.2679	0.0973	0.794
Ground	0.0824	0.0366	0.2316
Total – All Wires	1.154	0.4258	3.4076
Minimum Conduit Area	2.885	1.065	8.519
Conduit Size	2.00" RMC	1.25" RMC	3.00" RMC
Conduit Size (Table C.1)	2.00" RMC	1.00" RMC	2.50" RMC
Feeder Length	23'-6"	19'-10"	26'-6"
Final Voltage Drop (V)	0.625	0.591	0.717
Final Voltage Drop (%)	0.130	0.123	0.344
Was feeder re-sized?	Yes	Yes	Yes

Panelboard

Panel Specifications can be found in Appendix A

Overcurrent Device Coordination Study and Short Circuit

Determine whether the protection devices in this electrical system are important components required by NEC. Short circuit calculations are performed to determine whether the protective devices are sufficient. Short-circuit is the highest amperage that a device can run at. Therefore, NEC requires that the overcurrent device be able to endure this worst case scenario. The following information will determine the short circuit current of various segments of the electrical system. The following diagram shows the path that is examined to determine the available faults at various sections of this system. A coordination study is performed for the circuit breakers along the path examined.



Available fault at Secondary of Utility Transformer to MDP			
Inputs		**Outputs**	
System Voltage (V_{L-L})	480	$I_{FLA}=(KVA*1000)/(V_{L-L}*\sqrt{3})$	1804.22
Line Neutral Voltage (V_{L-N})	277	$I_{L-L-L}=)(I_{FLA}*100)/(Z))/PF$	53065.28
Utility Transformer (KVA)	1500	$f=(\sqrt{3}*L*I_{L-L-L})/(C*n*V_{L-L})$	0.053945
X/R Ratio	12	$M=1/(1+f)$	0.948816
Impedance(Z) in %	4		
Length (L) in ft.	50		
Number of Sets (n)	8		
Phase Conductor	500 kcmil		
Neutral Conductor	500 kcmil		
Conductor Constant	22,185		
Power Factor (PF)	0.85	**$I_{SCA-1}=I_{L-L-L}*M$**	**50349.2**
Available fault at MDP to Transformer 1L1			
Inputs		**Outputs**	
System Voltage (V_{L-L})	480	$f=(\sqrt{3}*L*I_{SCA-1})/(C*n*V_{L-L})$	0.424359
Line Neutral Voltage (V_{L-N})	277	$M=1/(1+f)$	0.70207
Length (L) in ft.	30		
Number of Sets (n)	1		
Phase Conductor	#3/0		
Neutral Conductor	#3/0		
Conductor Constant	12,844	**$I_{SCA-2}=I_{SCA-1}*M$**	**35348.68**
Available Fault at Transformer 1L1 to Panel 1L1			
Inputs		**Outputs**	
System Voltage (V_{L-L})	208	$f=(I_{SCA2}*V_P*\sqrt{3}*Z)/(100000*KVA)$	8.836095
Line Neutral Voltage (V_{L-N})	120	$M=1/(1+f)$	0.101666
Transformer (KVA)	150		
Impedance(Z) in %	4.51		
Length (L) in ft.	20		
Number of Sets (n)	2		
Phase Conductor	#3/0		
Neutral Conductor	#3/0		
Conductor Constant	12,844	**$I_{SCA-3}=(V_P/V_S)*M*I_{SCA-2}$**	**8293.32**

Available fault at PNL 1L1 To Panel 1LC1			
System Voltage (V_{L-L})	208	$f=(\sqrt{3}*L*I_{SCA-1})/(C*n*V_{L-L})$	0.161305
Line Neutral Voltage (V_{L-N})	120	M=1/(1+f)	0.861101
Length (L) in ft.	30		
Number of Sets (n)	1		
Phase Conductor	#3/0		
Neutral Conductor	#3/0		
Conductor Constant	12,844	**$I_{SCA-4}=I_{SCA-1}*M$**	**7141.382**

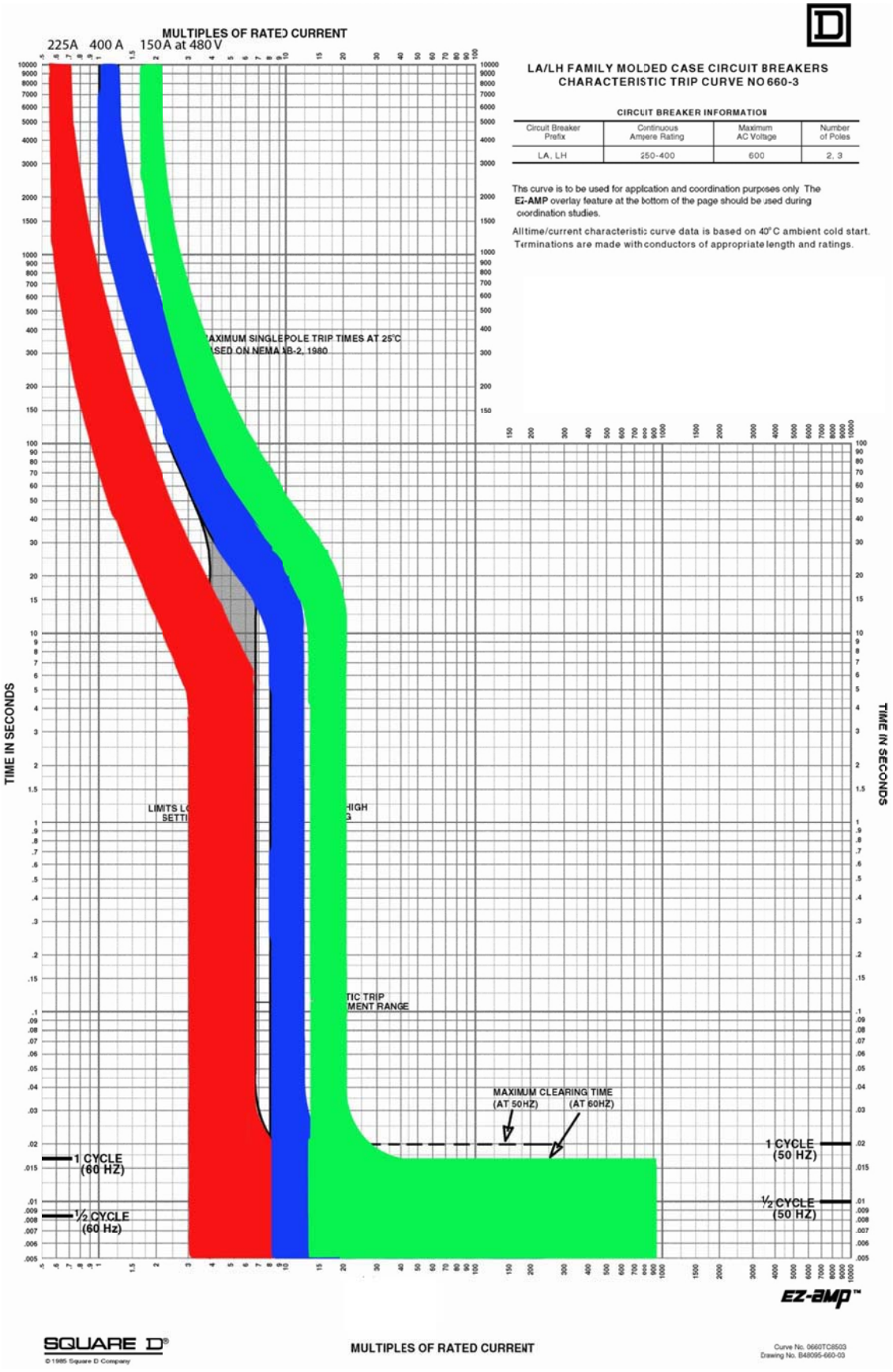
Short Circuit Study Results

Location	Available Fault	Existing AIC Rating	Standard Rating
MDP	50349 A	65 kA	60kA
Panel 1L1	8293 A	10kA	10kA
Panel 1LC1	7141 A	10 kA	10kA

Based on the analysis above, the existing design will protect the fault current. In the study conducted, panel 1L1 and Panel 1LC1 will have the same AIC Rating that currently exists. However, the calculations show that the AIC Rating of the MDP could decrease from 65kA to 60 kA.

Over-Current Device Coordination Study

The trip curves for the selected coordination devices have been are shown in the diagram below on the same graph to show their coordination. The 225A and 400A circuit breakers are 120/208V and the 150A breaker is 277/480V. The variation in voltage was needed to determine the proper location of each trip curve. The downstream 225A breaker will trip first followed by the upstream 400A breaker and the 150A breaker. The 400A breaker and the 150A breaker have a slight overlap and therefore are not completely coordinated but this is not an issue since they both feed the same load and when either breaker trips the power is lost to the load. The trip curves for these breakers are located in Appendix A.


MULTIPLES OF RATED CURRENT
225A 400 A 150A at 480V
LA/LH FAMILY MOLDED CASE CIRCUIT BREAKERS
CHARACTERISTIC TRIP CURVE NO 660-3
CIRCUIT BREAKER INFORMATION
Circuit Breaker Prefix
Continuous Ampere Rating
Maximum AC Voltage
Number of Poles
LA, LH
250-400
600
2, 3
This curve is to be used for application and coordination purposes only. The Ez-AMP overlay feature at the bottom of the page should be used during coordination studies.
All time/current characteristic curve data is based on 40°C ambient cold start. Terminations are made with conductors of appropriate length and ratings.
TIME IN SECONDS
MAXIMUM CLEARING TIME
(AT 50HZ) (AT 60HZ)
1 CYCLE (60 HZ)
½ CYCLE (60 Hz)
1 CYCLE (50 HZ)
½ CYCLE (50 HZ)
EZ-AMP™
SQUARE D®
© 1985 Square D Company
MULTIPLES OF RATED CURRENT
Curve No. 0660TC8503
Drawing No. B48095-660-03

Electrical Depth #1: Emergency System Redesign

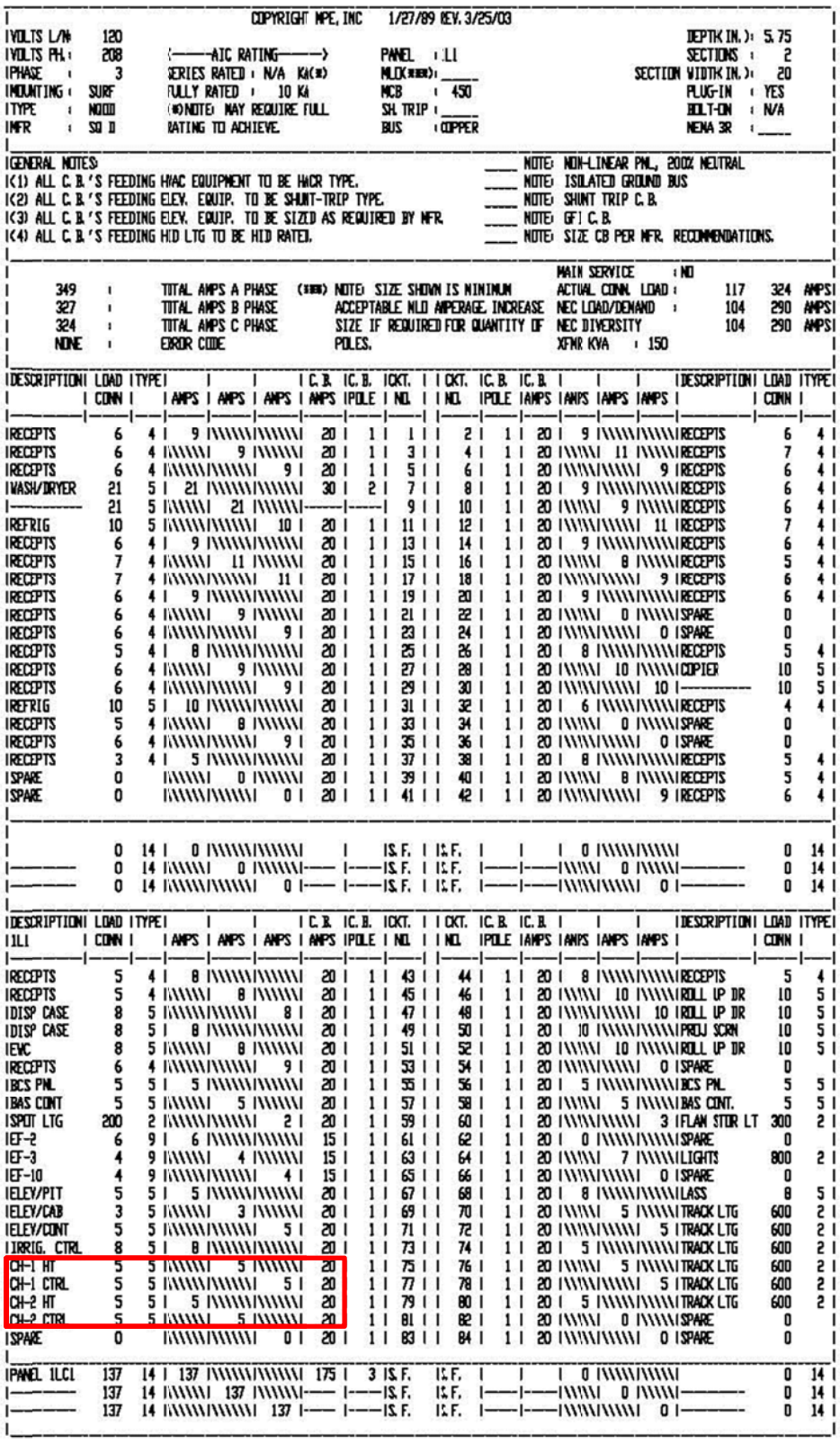
Emergency System Redesign

In addition to this building being an elementary school, it is used as an emergency shelter for the surrounding community. The majority of this time the emergency shelter will be used is during hurricane season, which takes place during the summer months. In terms of air circulation, the emergency system currently only has the fans from the air handling units fed from the emergency generator. Since the conditions during this time of the year in Florida are harsh, it might be beneficial to include the two chillers on the emergency system so that cool air may be circulated through the emergency shelter. This has the added benefit of providing humidity control during the power outage.

Currently the chillers are directly fed from the utility transformer. The redesign will allow the chillers to be fed from the generator. The chiller controls will be moved from a normal panel to an emergency panel and these panels and their branches will be resized.

Moving Chiller Controls to the Emergency System

There are four circuits on Panel 1L1 that are controls for the two chillers. These four circuits will be removed from this panel and moved to emergency equipment branch Panel 1LQ1. The four circuits removed from Panel 1L1 are outlined in red in the existing Panel Schedule below.



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VOLTS L/N	120					DEPTH IN.)	5.75
VOLTS PH.	208	<——AIC RATING——>	PANEL	LL		SECTIONS	2
PHASE	3	SERIES RATED	N/A KA(##)	MLO(####)	____	SECTION WIDTH IN.)	20
MOUNTING	SURF	FULLY RATED	10 KA	MCB	450	PLUG-IN	YES
TYPE	NEMA	(##)NOTE: MAY REQUIRE FULL		SH. TRIP	____	BOLT-ON	N/A
MFR	SQ D	RATING TO ACHIEVE.		BUS	COPPER	NEMA 3R	____

GENERAL NOTES:
(1) ALL C.B.'S FEEDING HVAC EQUIPMENT TO BE HACR TYPE.
(2) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SHUNT-TRIP TYPE.
(3) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SIZED AS REQUIRED BY MFR.
(4) ALL C.B.'S FEEDING HID LTG TO BE HID RATED.

____ NOTE: NON-LINEAR PNL, 200% NEUTRAL
____ NOTE: ISOLATED GROUND BUS
____ NOTE: SHUNT TRIP C.B.
____ NOTE: GFI C.B.
____ NOTE: SIZE CB PER MFR. RECOMMENDATIONS.

349	TOTAL AMPS A PHASE	(###) NOTE: SIZE SHOWN IS MINIMUM	MAIN SERVICE	NO		
327	TOTAL AMPS B PHASE	ACCEPTABLE NLO AMPERAGE INCREASE	ACTUAL CONN. LOAD	117	324	AMPS
324	TOTAL AMPS C PHASE	SIZE IF REQUIRED FOR QUANTITY OF	NEC LOAD/DEMAND	104	290	AMPS
NONE	ERROR CODE	POLES.	NEC DIVERSITY	104	290	AMPS
			XFMR KVA 150			

DESCRIPTION	LOAD CONN	TYPE	AMPS	AMPS	AMPS	C.B. AMPS	C.B. POLE	CKT. NO.	CKT. NO.	C.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
RECEPTS	6	4	9	\\\\\\	\\\\\\	20	1	1	2	1	20	9	\\\\\\	\\\\\\	RECEPTS	6	4
RECEPTS	6	4	\\\\\\	9	\\\\\\	20	1	3	4	1	20	\\\\\\	11	\\\\\\	RECEPTS	7	4
RECEPTS	6	4	\\\\\\	\\\\\\	9	20	1	5	6	1	20	\\\\\\	\\\\\\	9	RECEPTS	6	4
WASH/DRYER	21	5	21	\\\\\\	\\\\\\	30	2	7	8	1	20	9	\\\\\\	\\\\\\	RECEPTS	6	4
————	21	5	\\\\\\	21	\\\\\\	————	————	9	10	1	20	\\\\\\	9	\\\\\\	RECEPTS	6	4
REFRIG	10	5	\\\\\\	\\\\\\	10	20	1	11	12	1	20	\\\\\\	\\\\\\	11	RECEPTS	7	4
RECEPTS	6	4	9	\\\\\\	\\\\\\	20	1	13	14	1	20	9	\\\\\\	\\\\\\	RECEPTS	6	4
RECEPTS	7	4	\\\\\\	11	\\\\\\	20	1	15	16	1	20	\\\\\\	8	\\\\\\	RECEPTS	5	4
RECEPTS	7	4	\\\\\\	\\\\\\	11	20	1	17	18	1	20	\\\\\\	\\\\\\	9	RECEPTS	6	4
RECEPTS	6	4	9	\\\\\\	\\\\\\	20	1	19	20	1	20	9	\\\\\\	\\\\\\	RECEPTS	6	4
RECEPTS	6	4	\\\\\\	9	\\\\\\	20	1	21	22	1	20	\\\\\\	0	\\\\\\	SPARE	0	
RECEPTS	6	4	\\\\\\	\\\\\\	9	20	1	23	24	1	20	\\\\\\	\\\\\\	0	SPARE	0	
RECEPTS	5	4	8	\\\\\\	\\\\\\	20	1	25	26	1	20	8	\\\\\\	\\\\\\	RECEPTS	5	4
RECEPTS	6	4	\\\\\\	9	\\\\\\	20	1	27	28	1	20	\\\\\\	10	\\\\\\	COPIER	10	5
RECEPTS	6	4	\\\\\\	\\\\\\	9	20	1	29	30	1	20	\\\\\\	\\\\\\	10	————	10	5
REFRIG	10	5	10	\\\\\\	\\\\\\	20	1	31	32	1	20	6	\\\\\\	\\\\\\	RECEPTS	4	4
RECEPTS	5	4	\\\\\\	8	\\\\\\	20	1	33	34	1	20	\\\\\\	0	\\\\\\	SPARE	0	
RECEPTS	6	4	\\\\\\	\\\\\\	9	20	1	35	36	1	20	\\\\\\	\\\\\\	0	SPARE	0	
RECEPTS	3	4	5	\\\\\\	\\\\\\	20	1	37	38	1	20	8	\\\\\\	\\\\\\	RECEPTS	5	4
SPARE	0		\\\\\\	0	\\\\\\	20	1	39	40	1	20	\\\\\\	8	\\\\\\	RECEPTS	5	4
SPARE	0		\\\\\\	\\\\\\	0	20	1	41	42	1	20	\\\\\\	\\\\\\	9	RECEPTS	6	4
	0	14	0	\\\\\\	\\\\\\			S.F.	S.F.			0	\\\\\\	\\\\\\		0	14
————	0	14	\\\\\\	0	\\\\\\	————	————	S.F.	S.F.	————	————	\\\\\\	0	\\\\\\	————	0	14
————	0	14	\\\\\\	\\\\\\	0	————	————	S.F.	S.F.	————	————	\\\\\\	\\\\\\	0	————	0	14

DESCRIPTION 1L1	LOAD CONN	TYPE	AMPS	AMPS	AMPS	C.B. AMPS	C.B. POLE	CKT. NO.	CKT. NO.	C.B. POLE	C.B. AMPS	AMPS	AMPS	AMPS	DESCRIPTION	LOAD CONN	TYPE
RECEPTS	5	4	8	\\\\\\	\\\\\\	20	1	43	44	1	20	8	\\\\\\	\\\\\\	RECEPTS	5	4
RECEPTS	5	4	\\\\\\	8	\\\\\\	20	1	45	46	1	20	\\\\\\	10	\\\\\\	ROLL UP DR	10	5
DISP CASE	8	5	\\\\\\	\\\\\\	8	20	1	47	48	1	20	\\\\\\	\\\\\\	10	ROLL UP DR	10	5
DISP CASE	8	5	8	\\\\\\	\\\\\\	20	1	49	50	1	20	10	\\\\\\	\\\\\\	PROJ SCRN	10	5
EWC	8	5	\\\\\\	8	\\\\\\	20	1	51	52	1	20	\\\\\\	10	\\\\\\	ROLL UP DR	10	5
RECEPTS	6	4	\\\\\\	\\\\\\	9	20	1	53	54	1	20	\\\\\\	\\\\\\	0	SPARE	0	
BCS PNL	5	5	5	\\\\\\	\\\\\\	20	1	55	56	1	20	5	\\\\\\	\\\\\\	BCS PNL	5	5
BAS CONT	5	5	\\\\\\	5	\\\\\\	20	1	57	58	1	20	\\\\\\	5	\\\\\\	BAS CONT.	5	5
SPOT LTG	200	2	\\\\\\	\\\\\\	2	20	1	59	60	1	20	\\\\\\	\\\\\\	3	FLAN STOR LT	300	2
EF-2	6	9	6	\\\\\\	\\\\\\	15	1	61	62	1	20	0	\\\\\\	\\\\\\	SPARE	0	
EF-3	4	9	\\\\\\	4	\\\\\\	15	1	63	64	1	20	\\\\\\	7	\\\\\\	LIGHTS	800	2
EF-10	4	9	\\\\\\	\\\\\\	4	15	1	65	66	1	20	\\\\\\	\\\\\\	0	SPARE	0	
ELEV/PIT	5	5	5	\\\\\\	\\\\\\	20	1	67	68	1	20	8	\\\\\\	\\\\\\	LASS	8	5
ELEV/CAB	3	5	\\\\\\	3	\\\\\\	20	1	69	70	1	20	\\\\\\	5	\\\\\\	TRACK LTG	600	2
ELEV/CONT	5	5	\\\\\\	\\\\\\	5	20	1	71	72	1	20	\\\\\\	\\\\\\	5	TRACK LTG	600	2
IRRIG. CTRL	8	5	8	\\\\\\	\\\\\\	20	1	73	74	1	20	5	\\\\\\	\\\\\\	TRACK LTG	600	2
CH-1 HT	5	5	\\\\\\	5	\\\\\\	20	1	75	76	1	20	\\\\\\	5	\\\\\\	TRACK LTG	600	2
CH-1 CTRL	5	5	\\\\\\	\\\\\\	5	20	1	77	78	1	20	\\\\\\	\\\\\\	5	TRACK LTG	600	2
CH-2 HT	5	5	5	\\\\\\	\\\\\\	20	1	79	80	1	20	5	\\\\\\	\\\\\\	TRACK LTG	600	2
CH-2 CTRL	5	5	\\\\\\	5	\\\\\\	20	1	81	82	1	20	\\\\\\	0	\\\\\\	SPARE	0	
SPARE	0		\\\\\\	\\\\\\	0	20	1	83	84	1	20	\\\\\\	\\\\\\	0	SPARE	0	
PANEL 1LC1	137	14	137	\\\\\\	\\\\\\	175	3	S.F.	S.F.			0	\\\\\\	\\\\\\		0	14
————	137	14	\\\\\\	137	\\\\\\	————	————	S.F.	S.F.	————	————	\\\\\\	0	\\\\\\	————	0	14
————	137	14	\\\\\\	\\\\\\	137	————	————	S.F.	S.F.	————	————	\\\\\\	\\\\\\	0	————	0	14

PANELBOARD SIZING WORKSHEET

Panel Tag---------->	1L1	Panel Location:	RM 01-141		
Nominal Phase to Neutral Voltage------->	120	Phase:	3		
Nominal Phase to Phase Voltage-------->	208	Wires:	4		

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
2	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
3	B	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
4	B	RECEPTS	1	CLASS	1260	w	1.00	1260	1260	
5	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
6	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
7	A	WASH/DRYER	8	KITCH	2520	w	1.00	2520	2520	
8	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
9	B	WASH/DRYER	8	KITCH	2520	w	1.00	2520	2520	
10	B	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
11	C	RECEPTS	1	CLASS	1200	w	1.00	1200	1200	
12	C	RECEPTS	1	CLASS	1980	w	1.00	1980	1980	
13	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
14	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
15	B	RECEPTS	1	CLASS	1260	w	1.00	1260	1260	
16	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
17	C	RECEPTS	1	CLASS	1260	w	1.00	1260	1260	
18	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
19	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
20	A	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
21	B	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
22	B	SPARE	9		1560	w	1.00	1560	1560	
23	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
24	C	SPARE	9		1560	w	1.00	1560	1560	
25	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
26	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
27	B	RECEPTS	1	OFFICE	1080	w	1.00	1080	1080	
28	B	COPIER	8	OFFICE	1200	w	1.00	1200	1200	
29	C	RECEPTS	1	OFFICE	1080	w	1.00	1080	1080	
30	C	COPIER	8	OFFICE	1200	w	1.00	1200	1200	
31	A	REFRIG	8	KITCH	1200	w	1.00	1200	1200	
32	A	RECEPTS	1	CLASS	720	w	1.00	720	720	
33	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
34	B	SPARE	9		1560	w	1.00	1560	1560	
35	C	SPARE	9		1560	w	1.00	1560	1560	
36	C	SPARE	9		1560	w	1.00	1560	1560	

37	A	RECEPTS	1	CLASS	540	w	1.00	540	540	
38	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
39	B	SPARE	9		1560	w	1.00	1560	1560	
40	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
41	C	SPARE	9		1560	w	1.00	1560	1560	
42	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
43	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
44	A	RECEPTS	1	CLASS	900	w	1.00	900	900	
45	B	RECEPTS	1	CLASS	900	w	1.00	900	900	
46	B	ROLL UP DR	8	MEDIA	1200	w	1.00	1200	1200	
47	C	DISP CASE	8	MEDIA	960	w	1.00	960	960	
48	C	ROLL UP DR	8	MEDIA	1200	w	1.00	1200	1200	
49	A	DISP CASE	8	MEDIA	960	w	1.00	960	960	
50	A	PROJ SCREEN	8	MEDIA	1200	w	1.00	1200	1200	
51	B	EWC	7	KITCH	960	w	1.00	960	960	
52	B	ROLL UP DR	8	MEDIA	1200	w	1.00	1200	1200	
53	C	RECEPTS	1	CLASS	1080	w	1.00	1080	1080	
54	C	SPARE	9		1560	w	1.00	1560	1560	
55	A	BCS PNL	8	MECH	600	w	1.00	600	600	
56	A	BCS PNL	8	MECH	600	w	1.00	600	600	
57	B	BAS CONT	8	MECH	600	w	1.00	600	600	
58	B	BAS CONT	8	MECH	600	w	1.00	600	600	
59	C	SPOT LTG	5	MECH	200	w	1.00	200	200	
60	C	FLAM STOR LT	5	MECH	300	w	1.00	300	300	
61	A	EF-2	6		720	w	1.00	720	720	
62	A	SPARE	9	MECH	800	w	1.00	800	800	
63	B	EF-3	6		480	w	1.00	480	480	
64	B	LIGHTS	5	MECH	960	w	1.00	960	960	
65	C	EF-10	6	MECH	480	w	1.00	480	480	
66	C	SPARE	9		600	w	1.00	600	600	
67	A	ELEV/PIT	8	MECH	600	w	1.00	600	600	
68	A	LASS	8	MECH	600	w	1.00	600	600	
69	B	ELEV/CAB	8	MECH	360	w	1.00	360	360	
70	B	TRACK LTG	4	MULTI	140	w	1.00	140	140	
71	C	ELEV/CONT	8	MECH	600	w	1.00	600	600	
72	C	TRACK LTG	4	MULTI	140	w	1.00	140	140	
73	A	IRRIG CTRL	8	MECH	960	w	1.00	960	960	
74	A	TRACK LTG	4	MULTI	140	w	1.00	140	140	
75	B	SPARE	9		1560	w	1.00	1560	1560	
76	B	TRACK LTG	4	MULTI	140	w	1.00	140	140	
77	C	SPARE	9		1560	w	1.00	1560	1560	
78	C	TRACK LTG	4	MULTI	140	w	1.00	140	140	
79	A	PANEL 1LC1	9	01-104	16440	w	1.00	16440	16440	

80	A	TRACK LTG	4	MULTI	140	w	1.00	140	140	
81	B	PANEL 1LC1	9	01-104	16440	w	1.00	16440	16440	
82	B	SPARE	9		1560	w	1.00	1560	1560	
83	C	PANEL 1LC1	9	01-104	16440	w	1.00	16440	16440	
84	C	SPARE	9		1560	w	1.00	1560	1560	
PANEL TOTAL								131.0	131.0	Amps= 1091.8

PHASE LOADING		kW	kVA	%	Amps
PHASE TOTAL	A	40.8	40.8	31%	340.0
PHASE TOTAL	B	45.0	45.0	34%	375.3
PHASE TOTAL	C	45.2	45.2	34%	376.5

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		35.8	35.8	0.64	22.8	22.8	1.00		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		0.0	0.0		0.0	0.0			
4	HID lighting		0.8	0.8	1.25	1.1	1.1	1.00		
5	incandescent lighting		1.5	1.5	1.25	1.8	1.8	1.00		
6	HVAC fans		1.7	1.7	0.95	1.6	1.6	1.00		
7	heating		1.0	1.0	1.00	1.0	1.0	1.00		
8	kitchen equipment		20.9	20.9	0.65	13.6	13.6	1.00		
9	unassigned		69.4	69.4	1.00	69.4	69.4	1.00		
Total Demand Loads						111.2	111.2			
Spare Capacity			0%			0.0	0.0			
Total Design Loads						111.2	111.2	1.00	Amps=	309

Default Power Factor =	0.80	
Default Demand Factor =	100	%

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 400A
SIZE/TYPE MAIN: 400A/3P C/B

PANEL TAG: 1L1
PANEL LOCATION: RM 01-141
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
RECEPTS	CLASS	1080	20A/1P	1	*			2	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	3		*		4	20A/1P	1260	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	5			*	6	20A/1P	1080	CLASS	RECEPTS
WASH/DRYER	KITCH	2520	20A/1P	7	*			8	20A/1P	1080	CLASS	RECEPTS
WASH/DRYER	KITCH	2520	20A/1P	9		*		10	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1200	20A/1P	11			*	12	20A/1P	1980	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	13	*			14	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1260	20A/1P	15		*		16	20A/1P	900	CLASS	RECEPTS
RECEPTS	CLASS	1260	20A/1P	17			*	18	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	19	*			20	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	1080	20A/1P	21		*		22	20A/1P	1560		SPARE
RECEPTS	CLASS	1080	20A/1P	23			*	24	20A/1P	1560		SPARE
RECEPTS	CLASS	900	20A/1P	25	*			26	20A/1P	900	CLASS	RECEPTS
RECEPTS	OFFICE	1080	20A/1P	27		*		28	20A/1P	1200	OFFICE	COPIER
RECEPTS	OFFICE	1080	20A/1P	29			*	30	20A/1P	1200	OFFICE	COPIER
REFRIG	KITCH	1200	20A/1P	31	*			32	20A/1P	720	CLASS	RECEPTS
RECEPTS	CLASS	900	20A/1P	33		*		34	20A/1P	1560		SPARE
SPARE		1560	20A/1P	35			*	36	20A/1P	1560		SPARE
RECEPTS	CLASS	540	20A/1P	37	*			38	20A/1P	900	CLASS	RECEPTS
SPARE		1560	20A/1P	39		*		40	20A/1P	900	CLASS	RECEPTS
SPARE		1560	20A/1P	41			*	42	20A/1P	1080	CLASS	RECEPTS
RECEPTS	CLASS	900	20A/1P	43	*			44	20A/1P	900	CLASS	RECEPTS
RECEPTS	CLASS	900	20A/1P	45		*		46	20A/1P	1200	MEDIA	ROLL UP DR
DISP CASE	MEDIA	960	20A/1P	47			*	48	20A/1P	1200	MEDIA	ROLL UP DR
DISP CASE	MEDIA	960	20A/1P	49	*			50	20A/1P	1200	MEDIA	PROJ SCREEN
EWC	KITCH	960	20A/1P	51		*		52	20A/1P	1200	MEDIA	ROLL UP DR

RECEPTS	CLASS	1080	20A/1P	53			*	54	20A/1P	1560		SPARE
BCS PNL	MECH	600	20A/1P	55	*			56	20A/1P	600	MECH	BCS PNL
BAS CONT	MECH	600	20A/1P	57		*		58	20A/1P	600	MECH	BAS CONT
SPOT LTG	MECH	200	20A/1P	59			*	60	20A/1P	300	MECH	FLAM STOR LT
EF-2		720	15A/1P	61	*			62	20A/1P	800	MECH	SPARE
EF-3		480	15A/1P	63		*		64	20A/1P	960	MECH	LIGHTS
EF-10	MECH	480	15A/1P	65			*	66	20A/1P	600		SPARE
ELEV/PIT	MECH	600	20A/1P	67	*			68	20A/1P	600	MECH	LASS
ELEV/CAB	MECH	360	20A/1P	69		*		70	20A/1P	140	MULTI	TRACK LTG
ELEV/CONT	MECH	600	20A/1P	71			*	72	20A/1P	140	MULTI	TRACK LTG
IRRIG CTRL	MECH	960	20A/1P	73	*			74	20A/1P	960	MULTI	TRACK LTG
SPARE		1560	20A/1P	75		*		76	20A/1P	140	MULTI	TRACK LTG
SPARE		1560	20A/1P	77			*	78	20A/1P	140	MULTI	TRACK LTG
PANEL 1LC1	01-104	16440	20A/1P	79	*			80	20A/1P	140	MULTI	TRACK LTG
PANEL 1LC1	01-104	16440	20A/1P	81		*		82	20A/1P	1560		SPARE
PANEL 1LC1	01-104	16440	20A/1P	83			*	84	20A/1P	1560		SPARE

CONNECTED LOAD (KW) - A Ph.	40.80	TOTAL DESIGN LOAD (KW)	111.22
CONNECTED LOAD (KW) - B Ph.	45.04	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	45.18	TOTAL DESIGN LOAD (AMPS)	309

The four circuits removed from Panel 1L1 are being placed on Panel 1LQ1. The circuits affected are highlighted in the existing Panelboard below.

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---------------------------------------------------------------------------------------------------------
|                              COPYRIGHT MPE, INC    1/27/89 REV. 3/25/03                                |
|VOLTS L/N:    120                                                              DEPTH(IN.): 5.75         |
|VOLTS PH.:    208       <------AIC RATING------->    PANEL    : 1LQ1           SECTIONS   :    1         |
|PHASE    :      3       SERIES RATED :   10 KA(*)    MLO(***):  225    SECTION WIDTH(IN.):   20         |
|MOUNTING :  SURF        FULLY RATED  : ______KA      MCB      : ______         PLUG-IN    : YES         |
|TYPE     :  NQOD        (*)NOTE: MAY REQUIRE FULL    SH. TRIP : ______         BOLT-ON    : N/A         |
|MFR      :  SQ D        RATING TO ACHIEVE.           BUS      : COPPER         NEMA 3R    : _____       |
|_______________________________________________________________________________________________________|
|GENERAL NOTES:                                                 _____ NOTE: NON-LINEAR PNL, 200% NEUTRAL |
|(1) ALL C.B.'S FEEDING HVAC EQUIPMENT TO BE HACR TYPE.         _____ NOTE: ISOLATED GROUND BUS          |
|(2) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SHUNT-TRIP TYPE.     _____ NOTE: SHUNT TRIP C.B.              |
|(3) ALL C.B.'S FEEDING ELEV. EQUIP. TO BE SIZED AS REQUIRED BY MFR. _____ NOTE: GFI C.B.                |
|(4) ALL C.B.'S FEEDING HID LTG TO BE HID RATED.                _____ NOTE: SIZE CB PER MFR. RECOMMENDATIONS. |
|_______________________________________________________________________________________________________|
|                                                                      MAIN SERVICE      : NO            |
|     138    :       TOTAL AMPS A PHASE  (***) NOTE: SIZE SHOWN IS MINIMUM    ACTUAL CONN. LOAD :   45   126  AMPS|
|     138    :       TOTAL AMPS B PHASE        ACCEPTABLE MLO AMPERAGE. INCREASE NEC LOAD/DEMAND :  36    99  AMPS|
|     126    :       TOTAL AMPS C PHASE        SIZE IF REQUIRED FOR QUANTITY OF NEC DIVERSITY       36    99  AMPS|
|     NONE   :       ERROR CODE                POLES.                 XFMR KVA    :    0                   |
|_______________________________________________________________________________________________________|
|DESCRIPTION| LOAD |TYPE|      |      |      | C.B. |C.B. |CKT. | | CKT. |C.B. |C.B. |     |     |     |DESCRIPTION| LOAD |TYPE|
|           | CONN |    | AMPS | AMPS | AMPS | AMPS |POLE | NO. | | NO.  |POLE |AMPS |AMPS |AMPS |AMPS |           | CONN |    |
|-----------|------|----|------|------|------|------|-----|-----| |------|-----|-----|-----|-----|-----|-----------|------|----|
|COOLER COMP     9    7 |    9 |\\\\\\|\\\\\\|   20 |   3 |   1 | |    2 |   2 |  20 |  10 |\\\\\|\\\\\|ROLL REF       10    7 |
|-----------     9    7 |\\\\\\|    9 |\\\\\\|------|-----|   3 | |    4 |-----|-----|\\\\\|  10 |\\\\\|-----------    10    7 |
|-----------     9    7 |\\\\\\|\\\\\\|    9 |------|-----|   5 | |    6 |   2 |  20 |\\\\\|\\\\\|   8 |RECEPTS         5    4 |
|FREEZER COMP   21    7 |   21 |\\\\\\|\\\\\\|   30 |   3 |   7 | |    8 |-----|-----|  12 |\\\\\|\\\\\|RECEPTS         8    4 |
|-----------    21    7 |\\\\\\|   21 |\\\\\\|------|-----|   9 | |   10 |   1 |  20 |\\\\\|   8 |\\\\\|MLK COOL,REC    8    7 |
|-----------    21    7 |\\\\\\|\\\\\\|   21 |------|-----|  11 | |   12 |   1 |  20 |\\\\\|\\\\\|   6 |COLD SERV CO    6    7 |
|FREEZER EVAP   25    7 |   25 |\\\\\\|\\\\\\|   40 |   2 |  13 | |   14 |   1 |  20 |  10 |\\\\\|\\\\\|ROLL UP DR     10    5 |
|-----------    25    7 |\\\\\\|   25 |\\\\\\|------|-----|  15 | |   16 |   1 |  20 |\\\\\|  10 |\\\\\|ROLL UP DR     10    5 |
|COOLER EVAP     3    7 |\\\\\\|\\\\\\|    3 |   20 |   1 |  17 | |   18 |   1 |  20 |\\\\\|\\\\\|   0 |SPARE           0      |
|SLICER         10    7 |   10 |\\\\\\|\\\\\\|   20 |   1 |  19 | |   20 |   1 |  20 |  13 |\\\\\|\\\\\|COOLER         13    7 |
|SPARE           0      |\\\\\\|    0 |\\\\\\|   20 |   1 |  21 | |   22 |   1 |  20 |\\\\\|  13 |\\\\\|FREEZER        13    7 |
|SPARE           0      |\\\\\\|\\\\\\|    0 |   20 |   1 |  23 | |   24 |   1 |  20 |\\\\\|\\\\\|   5 |CLG REC         3    4 |
|SPARE           0      |    0 |\\\\\\|\\\\\\|   20 |   1 |  25 | |   26 |   1 |  20 |   8 |\\\\\|\\\\\|RECEPTS         5    4 |
|SPARE           0      |\\\\\\|    0 |\\\\\\|   20 |   1 |  27 | |   28 |   2 |  35 |\\\\\|  22 |\\\\\|CU-1           22   12 |
|ICE MACH       14    7 |\\\\\\|\\\\\\|   14 |   20 |   1 |  29 | |   30 |-----|-----|\\\\\|\\\\\|  22 |-----------    22   12 |
|KEF-1           8    9 |    8 |\\\\\\|\\\\\\|   20 |   3 |  31 | |   32 |   2 |  15 |   5 |\\\\\|\\\\\|FCU-1           5   10 |
|-----------     8    9 |\\\\\\|    8 |\\\\\\|------|-----|  33 | |   34 |-----|-----|\\\\\|   5 |\\\\\|-----------     5   10 |
|-----------     8    9 |\\\\\\|\\\\\\|    8 |------|-----|  35 | |   36 |   1 |  20 |\\\\\|\\\\\|   0 |SPARE           0      |
|KSF-1           7    9 |    7 |\\\\\\|\\\\\\|   20 |   3 |  37 | |   38 |   1 |  20 |   0 |\\\\\|\\\\\|SPARE           0      |
|-----------     7    9 |\\\\\\|    7 |\\\\\\|------|-----|  39 | |   40 |   1 |  20 |\\\\\|   0 |\\\\\|SPARE           0      |
|-----------     7    9 |\\\\\\|\\\\\\|    7 |------|-----|  41 | |   42 |   1 |  20 |\\\\\|\\\\\|   0 |SPARE           0      |
|_______________________________________________________________________________________________________|
|                                                                                                       |
|                0   14 |    0 |\\\\\\|\\\\\\|      |     |S.F. | |S.F.  |     |     |   0 |\\\\\|\\\\\|               0   14 |
|----------      0   14 |\\\\\\|    0 |\\\\\\|----- |-----|S.F. | |S.F.  |-----|-----|\\\\\|   0 |\\\\\|----------     0   14 |
|----------      0   14 |\\\\\\|\\\\\\|    0 |----- |-----|S.F. | |S.F.  |-----|-----|\\\\\|\\\\\|   0 |----------     0   14 |
|_______________________________________________________________________________________________________|
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Revised Panel 1LQ1

PANELBOARD SIZING WORKSHEET

Panel Tag---------->	1LQ1	Panel Location:	Kitchen		
Nominal Phase to Neutral Voltage------->	120	Phase:	3		
Nominal Phase to Phase Voltage-------->	208	Wires:	4		

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	COOLER COMP	8	KITCH	1080	w	1.00	1080	1080	
2	A	ROLL REF	8	KITCH	1200	w	1.00	1200	1200	
3	B	COOLER COMP	8	KITCH	1080	w	1.00	1080	1080	
4	B	ROLL REF	8	KITCH	1200	w	1.00	1200	1200	
5	C	COOLER COMP	8	KITCH	1080	w	1.00	1080	1080	
6	C	RECEPTS	1	KITCH	900	w	1.00	900	900	
7	A	FREEZER COMP	8	KITCH	2520	w	1.00	2520	2520	
8	A	RECEPTS	1	KITCH	1440	w	1.00	1440	1440	
9	B	FREEZER COMP	8	KITCH	2520	w	1.00	2520	2520	
10	B	MLK COOL, REC	8	KITCH	960	w	1.00	960	960	
11	C	FREEZER COMP	8	KITCH	2520	w	1.00	2520	2520	
12	C	COLD SERV CO	8	KITCH	720	w	1.00	720	720	
13	A	FREEZER EVAP	8	KITCH	3000	w	1.00	3000	3000	
14	A	ROLL UP DR	8	KITCH	1200	w	1.00	1200	1200	
15	B	FREEZER EVAP	8	KITCH	3000	w	1.00	3000	3000	
16	B	ROLL UP DR	8	KITCH	1200	w	1.00	1200	1200	
17	C	COOLER EVAP	8	KITCH	360	w	1.00	360	360	
18	C	SPARE	9		1560	w	1.00	1560	1560	
19	A	SLICER	8	KITCH	1200	w	1.00	1200	1200	
20	A	COOLER	8	KITCH	1560	w	1.00	1560	1560	
21	B	SPARE	9		1560	w	1.00	1560	1560	
22	B	FREEZER	8	KITCH	1560	w	1.00	1560	1560	
23	C	SPARE	9		1560	w	1.00	1560	1560	
24	C	CLG REC	1	KITCH	540	w	1.00	540	540	
25	A	SPARE	9		1560	w	1.00	1560	1560	
26	A	RECEPTS	1	KITCH	900	w	1.00	900	900	
27	B	SPARE	9		1560	w	1.00	1560	1560	
28	B	CU-1	8	KITCH	2640	w	1.00	2640	2640	
29	C	ICE MACHINE	8	KITCH	1680	w	1.00	1680	1680	
30	C	CU-1	8	KITCH	2640	w	1.00	2640	2640	
31	A	KEF-1	6	KITCH	960	w	1.00	960	960	
32	A	FCU-1	8	KITCH	600	w	1.00	600	600	
33	B	KEF-1	6	KITCH	960	w	1.00	960	960	
34	B	FCU-1	8	KITCH	600	w	1.00	600	600	
35	C	KEF-1	6	KITCH	960	w	1.00	960	960	
36	C	CH-1 HT	9	KITCH	600	w	1.00	600	600	

37	A	KSF-1	8	KITCH	840	w	1.00	840	840		
38	A	CH-1 CTRL	9	KITCH	600	w	1.00	600	600		
39	B	KSF-1	8	KITCH	840	w	1.00	840	840		
40	B	CH-2 HT	9	KITCH	600	w	1.00	600	600		
41	C	KSF-1	8	KITCH	840	w	1.00	840	840		
42	C	CH-2 CTRL	9	KITCH	600	w	1.00	600	600		
PANEL TOTAL								55.5	55.5	Amps=	462.5

PHASE LOADING									
						kW	kVA	%	Amps
PHASE TOTAL	A					18.7	18.7	34%	155.5
PHASE TOTAL	B					20.3	20.3	37%	169.0
PHASE TOTAL	C					16.6	16.6	30%	138.0

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		3.8	3.8	1.00	3.8	3.8	1.00		
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		0.0	0.0		0.0	0.0			
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		2.9	2.9	0.95	2.7	2.7	1.00		
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		38.6	38.6	0.65	25.1	25.1	1.00		
9	unassigned		10.2	10.2	1.00	10.2	10.2	1.00		
Total Demand Loads						41.8	41.8			
Spare Capacity			0%			0.0	0.0			
Total Design Loads						41.8	41.8	1.00	Amps=	116.2

Default Power Factor =	0.80	
Default Demand Factor =	100	%

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 225A
SIZE/TYPE MAIN: 225A MLO

PANEL TAG: 1LQ1
PANEL LOCATION: Kitchen
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
COOLER COMP	KITCH	1080	20A/1P	1	*			2	20A/1P	1200	KITCH	ROLL REF
COOLER COMP	KITCH	1080	20A/1P	3		*		4	20A/1P	1200	KITCH	ROLL REF
COOLER COMP	KITCH	1080	20A/1P	5			*	6	20A/1P	900	KITCH	RECEPTS
FREEZER COMP	KITCH	2520	20A/1P	7	*			8	20A/1P	1440	KITCH	RECEPTS
FREEZER COMP	KITCH	2520	20A/1P	9		*		10	20A/1P	960	KITCH	MLK COOL, REC
FREEZER COMP	KITCH	2520	20A/1P	11			*	12	20A/1P	720	KITCH	COLD SERV CO
FREEZER EVAP	KITCH	3000	20A/1P	13	*			14	20A/1P	1200	KITCH	ROLL UP DR
FREEZER EVAP	KITCH	3000	20A/1P	15		*		16	20A/1P	1200	KITCH	ROLL UP DR
COOLER EVAP	KITCH	360	20A/1P	17			*	18	20A/1P	1560		SPARE
SLICER	KITCH	1200	20A/1P	19	*			20	20A/1P	1560	KITCH	COOLER
SPARE		1560	20A/1P	21		*		22	20A/1P	1560	KITCH	FREEZER
SPARE		1560	20A/1P	23			*	24	20A/1P	540	KITCH	CLG REC
SPARE		1560	20A/1P	25	*			26	20A/1P	900	KITCH	RECEPTS
SPARE		1560	20A/1P	27		*		28	20A/1P	2640	KITCH	CU-1
ICE MACHINE	KITCH	1680	20A/1P	29			*	30	20A/1P	2640	KITCH	CU-1
KEF-1	KITCH	960	20A/1P	31	*			32	20A/1P	600	KITCH	FCU-1
KEF-1	KITCH	960	20A/1P	33		*		34	20A/1P	600	KITCH	FCU-1
KEF-1	KITCH	960	20A/1P	35			*	36	20A/1P	600	KITCH	CH-1 HT
KSF-1	KITCH	840	20A/1P	37	*			38	20A/1P	600	KITCH	CH-1 CTRL
KSF-1	KITCH	840	20A/1P	39		*		40	20A/1P	600	KITCH	CH-2 HT
KSF-1	KITCH	840	20A/1P	41			*	42	20A/1P	600	KITCH	CH-2 CTRL

CONNECTED LOAD (KW) – A Ph.	18.66	TOTAL DESIGN LOAD (KW)	41.83
CONNECTED LOAD (KW) - B Ph.	20.28	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C Ph.	16.56	TOTAL DESIGN LOAD (AMPS)	116

Tag	Panel 1L1	Panel 1LQ1
Voltage System	208/120	208/120
Calculated Design Load (kW)	111.2	41.8
Calculated Power Factor	1.0	1.0
Calculated Design Load (kVA)	111.2	41.8
Calculated Design Load (A)	309	116.2
Feeder Protection Size		
Number of Sets	2	1
Phase	#3/0 AWG	#1/0 AWG
Neutral	#3/0 AWG	#1/0 AWG
Ground	#4 AWG	#6 AWG
Each Phase	0.3970	0.1855
Total – All phases	2.382	0.5565
Neutral	0.794	0.1855
Ground	0.2316	0.0507
Total – All Wires	3.4076	0.7927
Minimum Conduit Area	1.065	1.9818
Conduit Size	1.25” RMC	1.5” RMC
Conduit Size (Table C.1)	1.00” RMC	1.25” RMC
Feeder Length	19’-10”	151’-10”
Final Voltage Drop (V)	0.591	3.971
Final Voltage Drop (%)	0.123	1.91
Was feeder re-sized?	Yes	Yes

Single-Line Diagram

A revised single line diagram can be found in Appendix C. This will include a revised feeder schedule and include the resized disconnects and circuit breakers.

Sizing Generator

To size the generator, Generac’s Power Design Pro was used. The generator is feeding three different loads: the life safety branch, the equipment branch, and the two chillers. For this design, an engineering decision was made to only load the generator between 70% and 80% of its capacity. Therefore, based on the loads of the three circuits fed by the generator, the best solution is to use a 700kW generator that will run at 72% of its capacity.

Electrical Depth #2: Photovoltaic Study

Photovoltaics were not initially installed in Crystal Lake Elementary school to decrease its need for electric power. This analysis will develop a suitable Photovoltaic array system for this building that will be mounted on the roof and will determine the benefits of implementing this system and analyze how many years until the system pays for itself. To determine the payback period RETscreen4 was used to perform the energy analysis of the system to be implemented.

Background

This photovoltaic array will be located on the roof of Crystal Lake Elementary School in Lake Mary, FL. The desired size of this system was 500kW; however, the limited roof space decreased the size of the photovoltaic array. It will be mounted on the west facing roof that has a slope of .17. The best scenario would be to have the array facing south; however, due to the design of the roof structure this was impossible to achieve. If this system is implemented it should significantly decrease the reliance of this building on power from Progress Energy.

This analysis will use the maximum size system possible for this rooftop to produce the maximum amount of power possible. Then, the energy savings will be compared to the cost of electricity from the utility to determine how many years until the system pays for itself in savings. This will determine whether this system is a viable option for Crystal Lake Elementary School. The figure below shows the amount of sunny days in Orlando, Florida (which is 10 miles north of Orlando, FL).

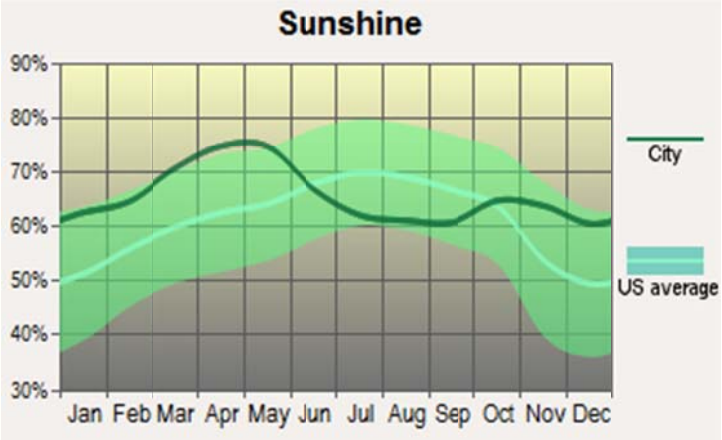


Figure 48: Percent of sunny days in Orlando, FL
http://www.city-data.com/city/Orlando-Florida.html

Typically, this region has more sunny days than the average United States city and the results of implementing a PV array should be positive.

System

The desired design would give a Photovoltaic array that can produce 500KW of power, decreasing the utility usage by 600A. However, the roof area does not provide enough surface area to place the necessary number of panels to produce 500kW of energy. Therefore, utilizing the entire surface area of the west roof, the system will produce 322.56kW of power. This will be done using four arrays: two with 31 strings of 8 modules and two with 32 strings of 8 modules. There will be four circuit breaks (one for each array) and four inverters (one for each array) that will feed into a photovoltaic panel that will send energy back to the Main Distribution Panel.

The designed system will use 1,008 SunPower series E19/ 320 solar panels and 4 Selectria PVI 95kW inverters to supply the desired 322.56kW. The number of panels used was determined by the available roof area and the module area. The roof area is 24,115.65 ft^2 and the panel area is 17.56 ft^2. Based on the specifications of the inverter, which can be found at the end of this report, there are 2-48 available poles on the specified inverter. For this particular design, there will be 2 arrays that use 31 poles and 2 arrays that use 32 poles.

To determine the maximum number of modules per string it was necessary to calculate the maximum voltage of the array and compare it to the maximum input voltage. The maximum voltage of the array will occur at the lowest temperature. Therefore, the minimum design temperature was determined from ASHRAE 90.7 based on the location of this building: Lake Mary, FL. It was determined that the minimum design temperature for this area is 5.7°C. The open circuit voltage change for the module selected is -.1766V/°C. The calculation to determine the maximum number of modules per string follows.

V_{oc}=64.8V at 25ºC from the Module Specifications that can be found at the end of this report.
Rate of Change=-.1766V/ ºC
ASHRAE min. Temperature=5.7ºC
Change in temperature from STC: 5.7ºC-25ºC=-19.3ºC

Change in V_{oc}:
-.1766V/ ºC* -19.3ºC = 3.41V

New V_{oc}:
64.8V + 3.41 V = 68.21V at 5.7ºC

There are 8 modules in series with a max input voltage of 68.21
8 * 68.21V = 545.67 V

The maximum input voltage of the inverter must be greater than 545.67V in order to work properly. The inverter chosen has a maximum input voltage of 600V and therefore is sufficient.

Due to the size of this system it is necessary that each string be fused. Therefore this system will require 126 fuses. The calculation to determine the size of the fuses follows.

I_{sc}=6.24 A , which is found on the manufacturers specification sheet at the end of this report

Sizing: 6.24 A * 1.25 * 1.25 = 9.75 A per String

One 15 amp fuse will be used on each string due to the manufacturers fuse rating.

This system will have 1 disconnect for each array with a total of 4 arrays. The calculation to determine the size of the disconnect is below.

Two arrays have 31 strings.

I_{sc}=6.24 A

Sizing: 6.24 A * 31 Strings * 1.25 * 1.25 = 302.25 A

Two arrays have 32 strings.

I_{sc}=6.24 A

Sizing: 6.24 A * 32 Strings * 1.25 * 1.25 = 312 A

Based on this calculations all four arrays will use a 350A disconnect switch.

As a check to ensure that this system will function correctly a calculation to determine if the array meets the maximum current specifications of the inverter was performed. This calculation follows.

Max Input current of the inverter = 287 A

Maximum Input Current of Connected PV array with NEC 125% factor = 287*1.25 = 358.75 A

Short Circuit current at STC = 6.24 A

Total Current of 31 string array = 6.24 * 31 = 193.44 A

Total Current of 32 string array = 6.24 * 32 = 199.68 A

The Maximum Current is 125% greater than the current at STC.

Maximum Current of 31 string array at STC = 193.44 A * 1.25 = 241.8 A

Maximum Current of 32 string array at STC = 199.68 A * 1.25 = 249.6 A

Therefore, the maximum input current of the inverter used is 358.75 A and both the 31 string and the 32 string array produce well under this maximum, and this system will work.

It is recommended that the power loss in the wire be less than 2%. Therefore, it is necessary to determine the maximum length that the wire between the modules and the inverter can be before it reaches this limit. The calculation for the wire sizing and this maximum length follows.

Amps the wire is rated for: 6.24A * 1.25 * 1.25 = 9.75 A

At 90°C, use a 18 AWG wire rated for 14 amps is adequate. However, the minimum recommended size is 12 AWG rated for 30 A and therefore this will be used instead.

Using 62 wires for the 31 string array, with 12 AWG wire loses 2.05 ohms/kFT

Using 64 wires for the 32 string array, with 12 AWG wire loses 2.05 ohms/kFT

Maximum Power current at STC from the module specifications = 5.86 A

Watts/(8 modules per string strings * 320 watts per module)=0.02

Watts=51.2 W

$2 * (2.05 \text{ ohms/kFT}) * (\text{kFT}) * (5.86 \text{ A})^2 = 51.2 \text{ W}$

0.2287 Kft=363.66 feet is the length when the wire reaches 2%. Therefore, the maximum length that this wire can be is 363.66 ft.

Finally, it is necessary to size the circuit breaker of the PV system. This calculation follows.

Output current of inverter: 92 A

92A * 1.25 = 115 A

Therefore, use the next size up circuit breaker which is a 125 A circuit breaker. There will be four circuit breakers: one for each inverter.

Figure 49: Location of Proposed Photovoltaic Array

A wiring diagram of the photovoltaic array can be found at the end of this report.

RETscreen was used to generate the financial analysis of this system. Following are various screen shots from the program to show the required inputs of the analysis system to determine the payback period.

Photovoltaic			
Power capacity	kW	322.56	
Manufacturer		Sunpower	
Model		E19/320	1008 unit(s)
Capacity factor	%	24.3%	
Electricity exported to grid	MWh	686.6	

Figure 50: RETscreen Input data for the PV array used for Crystal Lake Elementary School.

	Unit	Climate data location	Project location
Latitude	°N	28.8	28.8
Longitude	°E	-81.2	-81.2
Elevation	m	17	17
Heating design temperature	°C	5.7	
Cooling design temperature	°C	33.9	
Earth temperature amplitude	°C	12.2	

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	15.6	70.4%	3.22	101.9	3.3	15.3	74	174
February	16.3	68.1%	3.86	101.8	3.7	16.8	48	176
March	18.4	65.2%	4.94	101.7	3.9	18.7	0	260
April	21.2	64.6%	6.08	101.6	3.7	21.0	0	336
May	24.4	66.0%	6.50	101.5	3.3	24.3	0	446
June	26.5	72.4%	6.09	101.5	3.0	26.3	0	495
July	27.6	71.7%	6.28	101.6	2.6	27.1	0	546
August	27.2	74.3%	5.76	101.5	2.6	26.8	0	533
September	26.0	74.8%	4.97	101.4	2.9	25.6	0	480
October	23.1	72.9%	4.23	101.6	3.1	22.5	0	406
November	19.5	72.4%	3.39	101.7	3.3	19.3	0	285
December	16.0	72.4%	2.90	101.9	3.1	16.0	62	186
Annual	21.8	70.4%	4.86	101.6	3.2	21.7	184	4,324
Measured at	m				10.0	0.0		

Figure 51: RETscreen climate Information for Lake Mary, FL

Cost Analysis

The following information indicates the initial cost of a 167 W grid connected system according to RS Means 2011. This system was chosen for analysis since it is the only grid connected system available in RS Means. Therefore, it is assumed that this data is similar to that of the system used for this study.

Initial Cost Data					
Type	Quantity of Modules	Price per Quantity	Price for one unit	Total Number of Units Used	Total Cost
167 W Photovoltaic Module	60	96,500	1,608.33	1,008	$1,621,200

Table 20: Price data include material cost, and instillation cost. (RS Means 2011, Section D5090 430 0100)

According to a report generated by the Powering the South, Renewable Energy Policy Project, January 2003, the annual average PV capacity is 23.4%. This assumes 13 cents/kWh peak and 3% escalation. Reference: http://www.repp.org/articles/static/1/binaries/REPP_FL_100202.pdf

Utility Savings			
Size of Array	Amount of Electricity Produced by Array (MWh)	Utility rate per MWh*	Total Savings
322.56 KW (1008 units)	686.6	$115.14	79,055.124
***Utility rate is based on the rates of Progress Energy. The average annual cost for Crystal Lake Elementary school from July 2009-June 2010.**			

Since this building requires more energy than the photovoltaic arrays are supposed to produce. It is not anticipated that this building will receive any utility credits for a surplus of energy.

There are many incentives to installing a PV array in Lake Mary, FL. As of 2006, the Florida Energy Act provides a Solar Energy Systems Incentives Program that encourages businesses to purchase solar photovoltaic systems.

Incentives		
	$/Watt Rebate	**Total Savings**
Florida State Grants[1]	$4/Watt (322.56 kW)[2]	$100,000
	% Credit	**Total Savings**
Federal Grants[3]	30% of initial cost	$486,360
[1]Florida State Grants are provided by the Solar Energy Systems Incentives Program and can be found here: http://www.epa.gov/renewableenergyland/incentives/fl_incentives.pdf **[2]Florida State Grants provide $4/Watt to a maximum of $100,000** **[3]Federal Grants are provided from the federal government under U.S. Code Title 26 (Section 48(a)(3)) and can be found at: http://www.getsolar.com/commercial_federal-incentives-for-commercial-solar.php**		

Annual O&M cost is 0.35% of the total installed cost for this grid tied system. This data can be found at: http://www.nrel.gov/docs/fy10osti/48853.pdf

The following screen shots are from RETscreen and provide the output information for the financial analysis of the photovoltaic array used.

Financial Analysis

Financial parameters		
Inflation rate	%	3.0%
Project life	yr	20
Debt ratio	%	0%
Initial costs		
Power system	$	1,621,200
Other	$	
Total initial costs	$	1,621,200
Incentives and grants	$	586,360
Annual costs and debt payments		
O&M (savings) costs	$	5,674
Fuel cost - proposed case	$	0
	$	
Total annual costs	$	5,674
Annual savings and income		
Fuel cost - base case	$	0
Electricity export income	$	79,058
	$	
Total annual savings and income	$	79,058
Financial viability		
Pre-tax IRR - assets	%	6.7%
Simple payback	yr	14.1
Equity payback	yr	11.6

Figure 52: RETsceen financial analysis output information

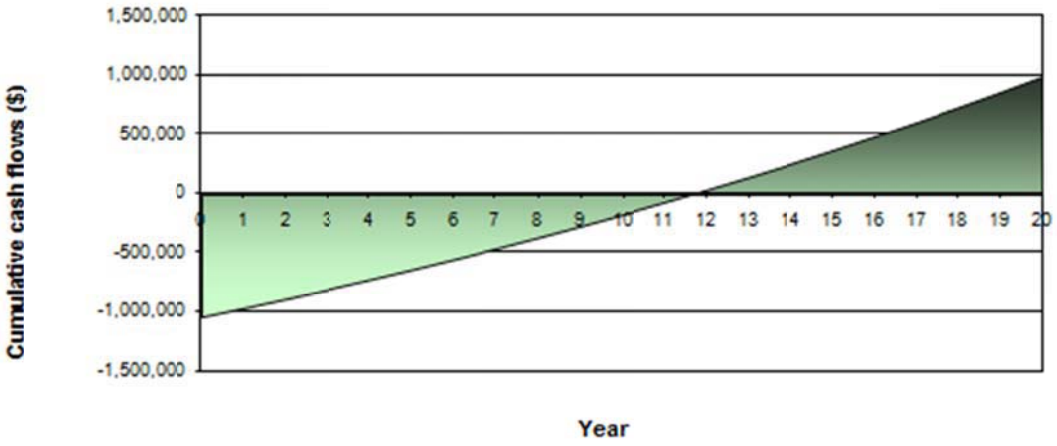


Figure 53: RETsceen payback analysis graph

Recommendations

Due to the location of this building in Lake Mary, FL, this building is in a prime location to receive a large amount of sunlight. This location is generally above the average. After using RETscreen4 to determine the payback period for this system in Lake Mary, FL, it was determined that to place a 323.56 kW photovoltaic array on the roof of Crystal Lake Elementary School will pay for itself in 14.1 years. After analyzing this data, it would be recommended that this school implement a photovoltaic array.

According to the manufacturer's data, the modules selected are guaranteed to work for 25 years. With a 14.1 year payback period, this school will have 10.9 years of financial profit from applying this system.

A significant factor in the financial success of this photovoltaic array is the significant amount of incentives offered from both Florida State and the Federal Government. Without these incentives the payback would have been much worse and possibly this system would not be recommended.

Acoustical Breadth

Overview

The Multipurpose Room has three primary functions: auditorium space, cafeteria space, and emergency shelter. It is located in the center of the first floor of the building and is accessible from the main lobby at the entrance of the building. This is a large open space with a partition wall to give the option of dividing the room into two spaces.

Due to the large amounts of open space, there is a danger of having an acoustical problem that would be undesirable for all three functions of this space. In order to ensure that acoustics in not a problem within this space the reverberation time will be calculated to determine if it is at the desirable level for this multipurpose room. Proposed solutions will be provided to improve the acoustical conditions within the space.

Space Overview

Area: 5250 ft^2

Length: Approximately 99 ft.

Width: Approximately 65 ft.

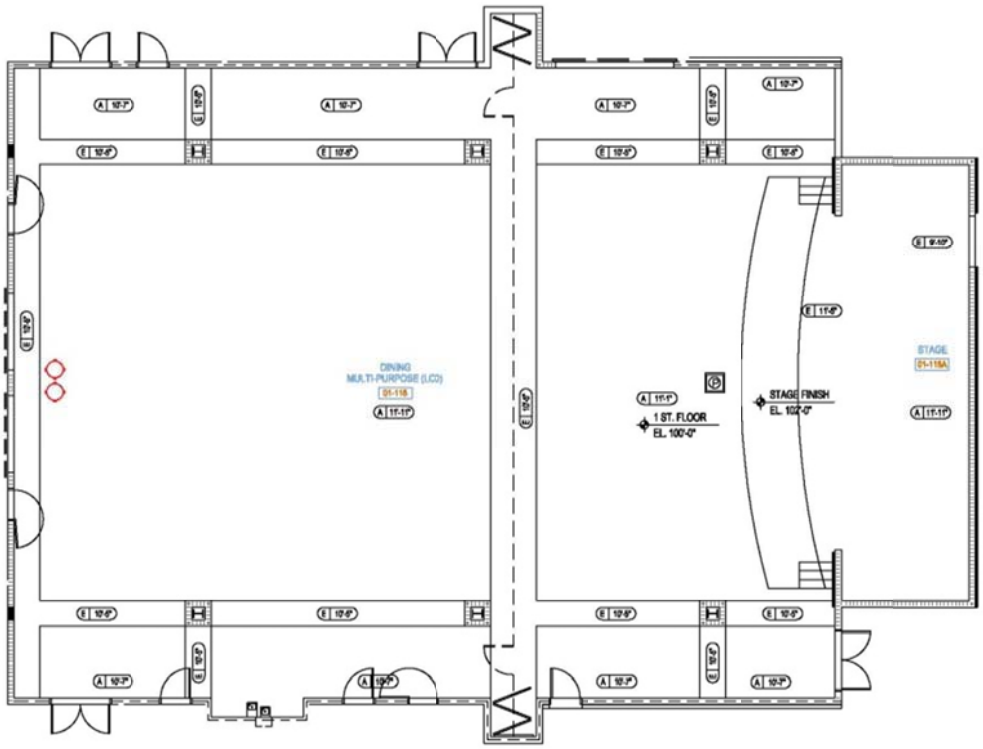
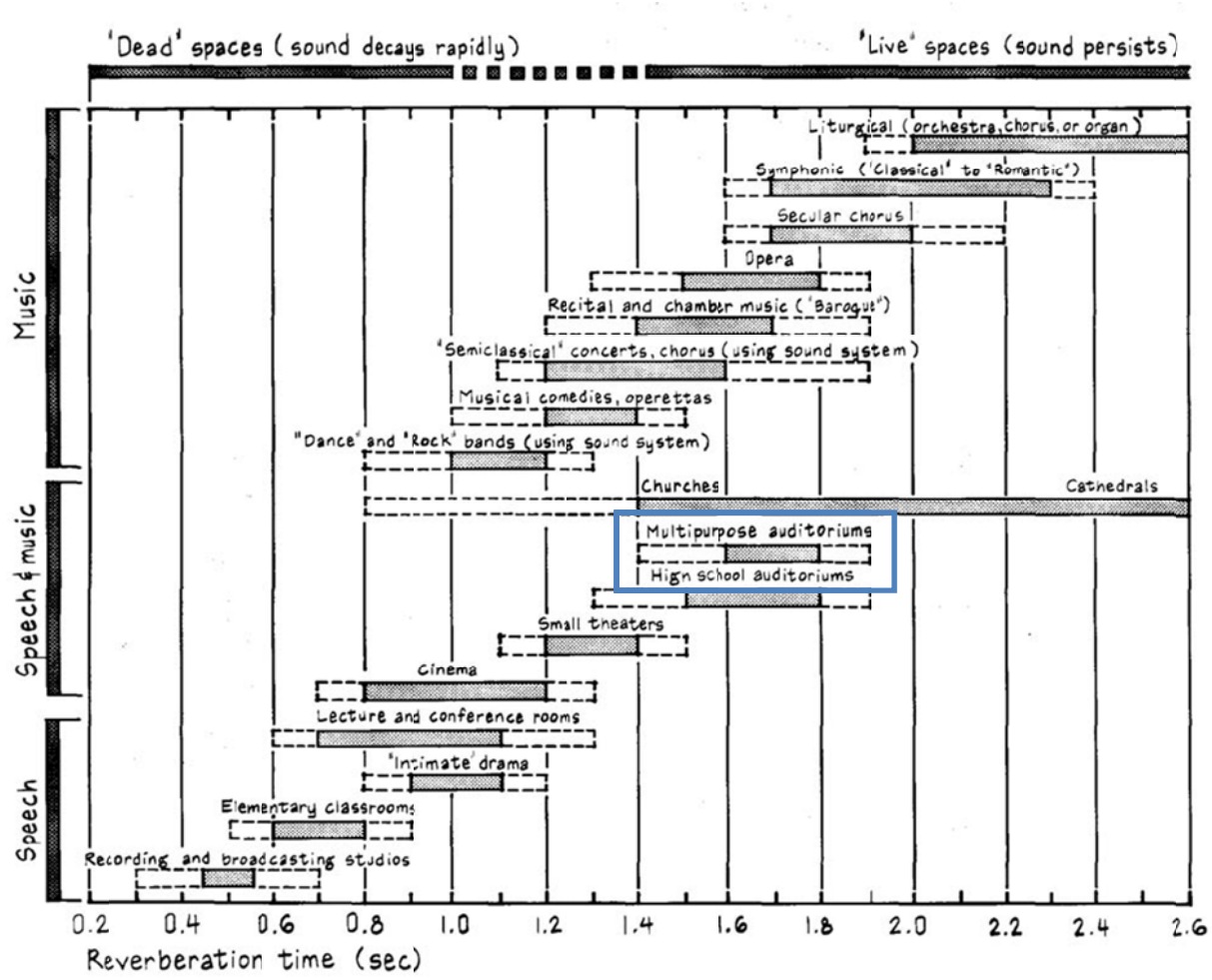


Figure 54: Multipurpose Room Floor Plan

Design Criteria



This space is a Multipurpose Auditorium, and must be designed to the appropriate reverberation time. Since this space will be used for speech and musical purposes, a moderate reverberation time is desired. The desired mid-frequency is 1.7 seconds, this is the average of the reverberation time at 500 Hz and 1000 Hz. However, the acceptable range is 1.4 seconds to 1.9 seconds. The chart above indicates the desirable reverberation time range for all room types. To determine the existing reverberation time, Sabine's formula will be used to determine the reverberation times at 500 and 1000 Hz. The chart below gives all the target values used for this acoustical study

Existing Acoustical Conditions

Location	Material	Hz	Absorption Coefficient (α)	Area (ft^2)	Sα
Ceiling	Acoustical Ceiling Tile	**500**	0.83	4217	3500
		1000	0.99		4175
Ceiling	Gypsum board	**500**	0.05	2006	100
		1000	0.04		80
Wall	Gypsum Wall Board	**500**	0.05	3369	337
		1000	0.04		236
Floor	Vinyl Composition Tile	**500**	0.03	5250	158
		1000	0.03		158
Stage Floor	Wood	**500**	0.10	1193	119
		1000	0.07		84
Seats	Assume values similar to students, informally dressed, seated in tablet-arm chairs	**500**	0.49	498	244
		1000	0.84		418
Air (Coefficient per 1000 ft^2)		**500**	0	69,200 ft^3	0
		1000	8 sabins/1000ft^3		554
Total Absorption $\Sigma S\alpha$		**500**	4458		
		1000	5603		
Reverberation Time=0.05*(V/Sα) V=69,200		**500**	0.78		
		1000	0.62		

Analysis of Results

Based on the existing conditions, the average reverberation time is 0.725 seconds. This is much lower than the desired 1.7 seconds. 0.725 seconds is adequate for spaces where speech is the only concern However, this multipurpose room needs to be designed to be adequate for both speech and music. Therefore, changes need to be made to the existing materials in order to achieve and average reverberation time in 500 and 100 Hz to be 1.7 seconds. In order to achieve this, the highlighted sections above will be edited; this change will be shown in the Revised Design section below. The ceiling plan below shows the current layout of the acoustical ceiling tile in green and gypsum board in white.

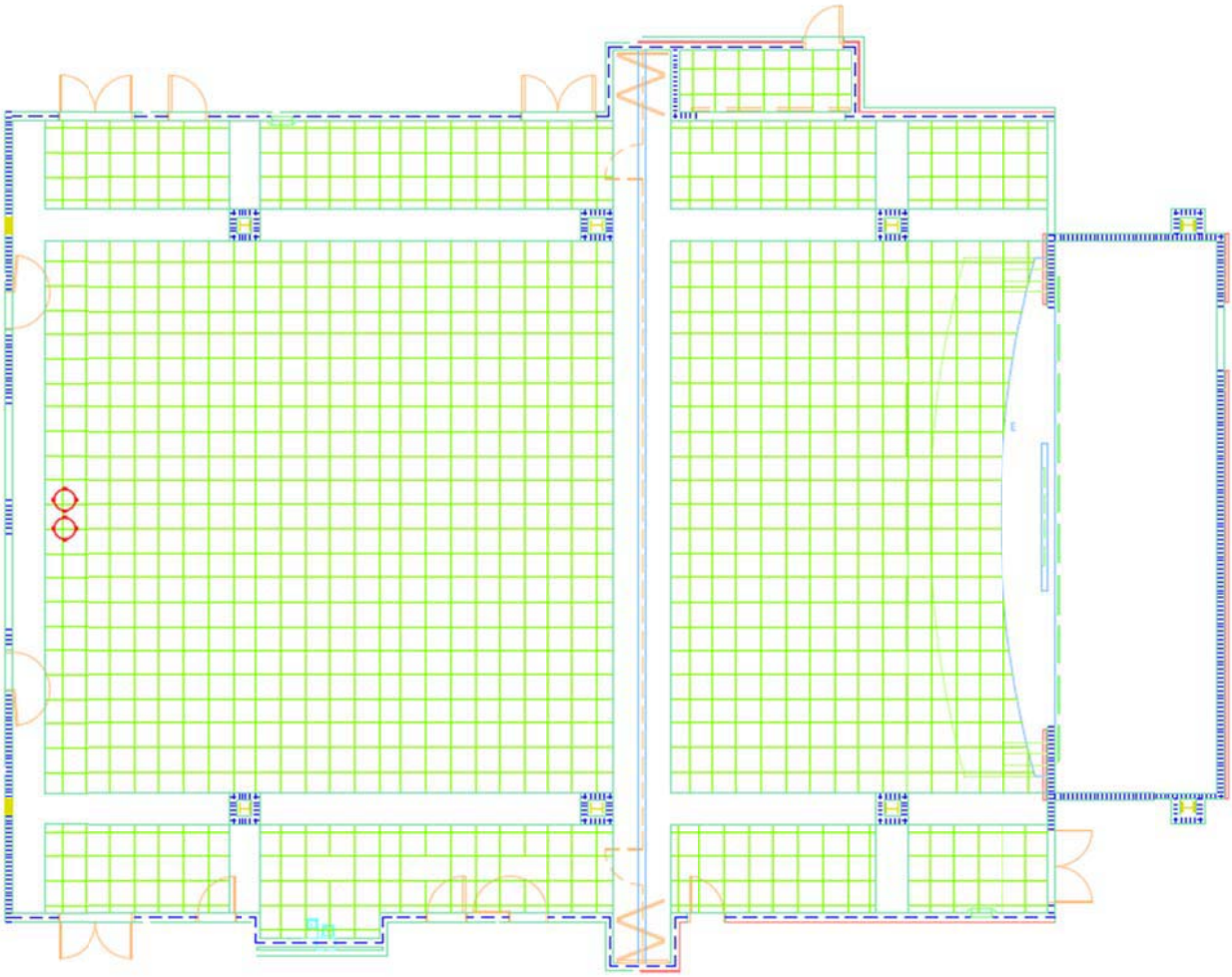


Figure 55: Multipurpose Room Exiting Ceiling Plan

Revised Design

In order to increase the reverberation time to the desired level, the area of the acoustical ceiling tile and gypsum wall board used will be changed to the numbers below.

Location	Material	Hz	Absorption Coefficient (α)	Area (ft^2)	Sα
Ceiling	Acoustical Ceiling Tile	**500**	0.83	1081	898
		1000	0.99		1071
Ceiling	Gypsum board	**500**	0.05	5142	257
		1000	0.04		206
Wall	Gypsum Wall Board	**500**	0.05	3369	337
		1000	0.04		236
Floor	Vinyl Composition Tile	**500**	0.03	5250	158
		1000	0.03		158
Stage Floor	Wood	**500**	0.10	1193	119
		1000	0.07		84
Seats	Assume values similar to students, informally dressed, seated in tablet-arm chairs	**500**	0.49	498	244
		1000	0.84		418
Air (Coefficient per 1000 ft^2)		**500**	0	69,200 ft^3	0
		1000	8 sabins/1000ft^3		554
Total Absorption Σ Sα		**500**	1810		
		1000	2624		
Reverberation Time=0.05*(V/Sα) V=69,200		**500**	1.91		
		1000	1.32		

The new design gives an average reverberation time of 1.62 seconds, which is very close to the desired level of 1.7 seconds and still within the optimal range of 1.6 seconds to 1.8 seconds. Making these changes is advantageous to this elementary school. The optimal design concept is to ensure that this building is cost effective and efficient, since it is a government building. Therefore, there are no new building materials added to the design, just an adjustment to the existing design. This changes the appearance of the space. The reflected ceiling plan below shows the new ceiling plan. The acoustical ceiling tile is shown in green and the gypsum board is shown in white.

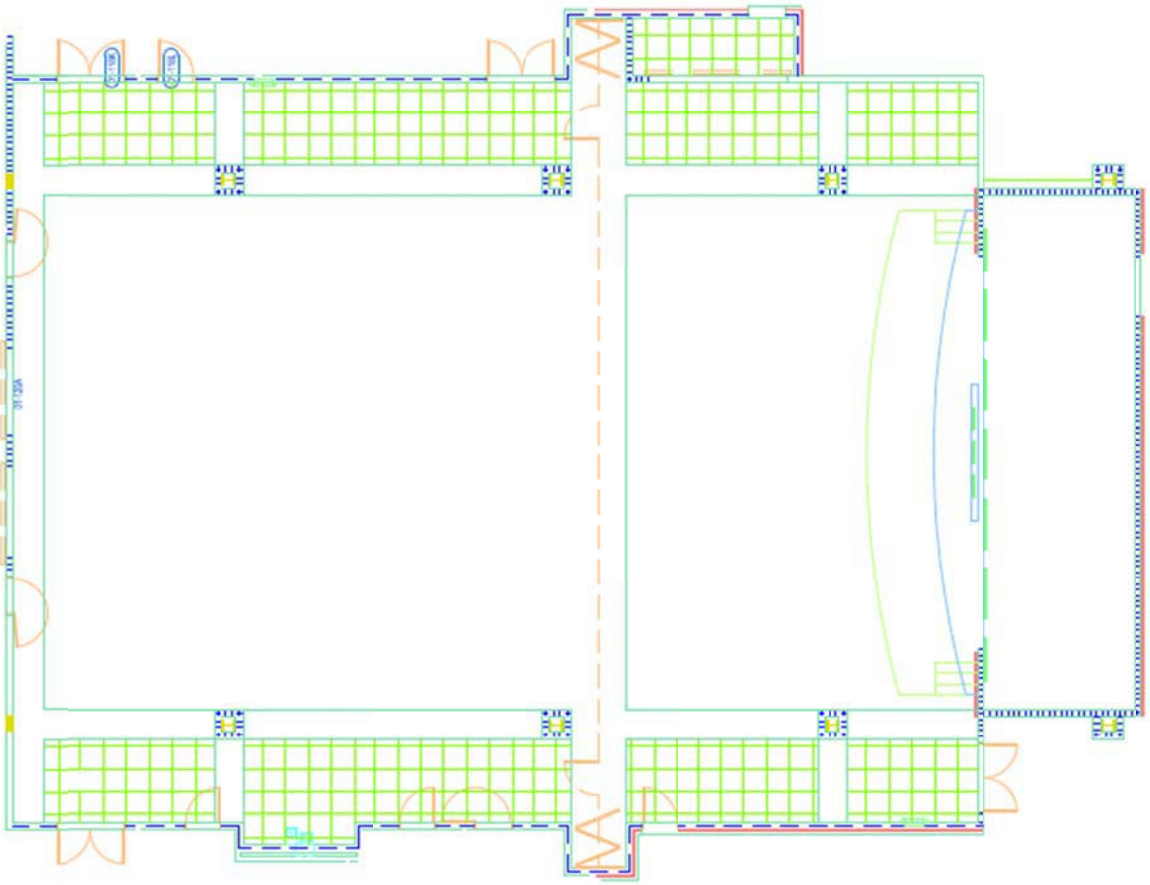


Figure 56: Multipurpose Room Revised Ceiling Plan

Noise Reduction is Revised Design

The noise reduction between the original design and the revised design can be calculated using the formula:

$$NR = 10*\log (a_1/a_2), \text{ where } a_1=\sum S\alpha_1 \text{ and } a_2=\sum S\alpha_2$$

$$NR=+3.56$$

There will be an increase in noise by 3.56 dB. Humans are capable of noticing a change in loudness of 3dB or more; therefore, people within this space will notice that is louder in the revised design as opposed to the existing design.

Structural Breadth

Introduction

After analyzing the addition of photovoltaic panels to one-half of the roof of Crystal Lake Elementary School, it was determined that the use of photovoltaics is cost effective and will save this school in energy costs. However, a structural analysis of the joists and joist girders is needed to determine if the existing roof system can handle this added load or if the increased load will change the structural materials and ultimately increase the cost of adding a photovoltaic system. This study will focus on the joists and joists girders that support the roof.

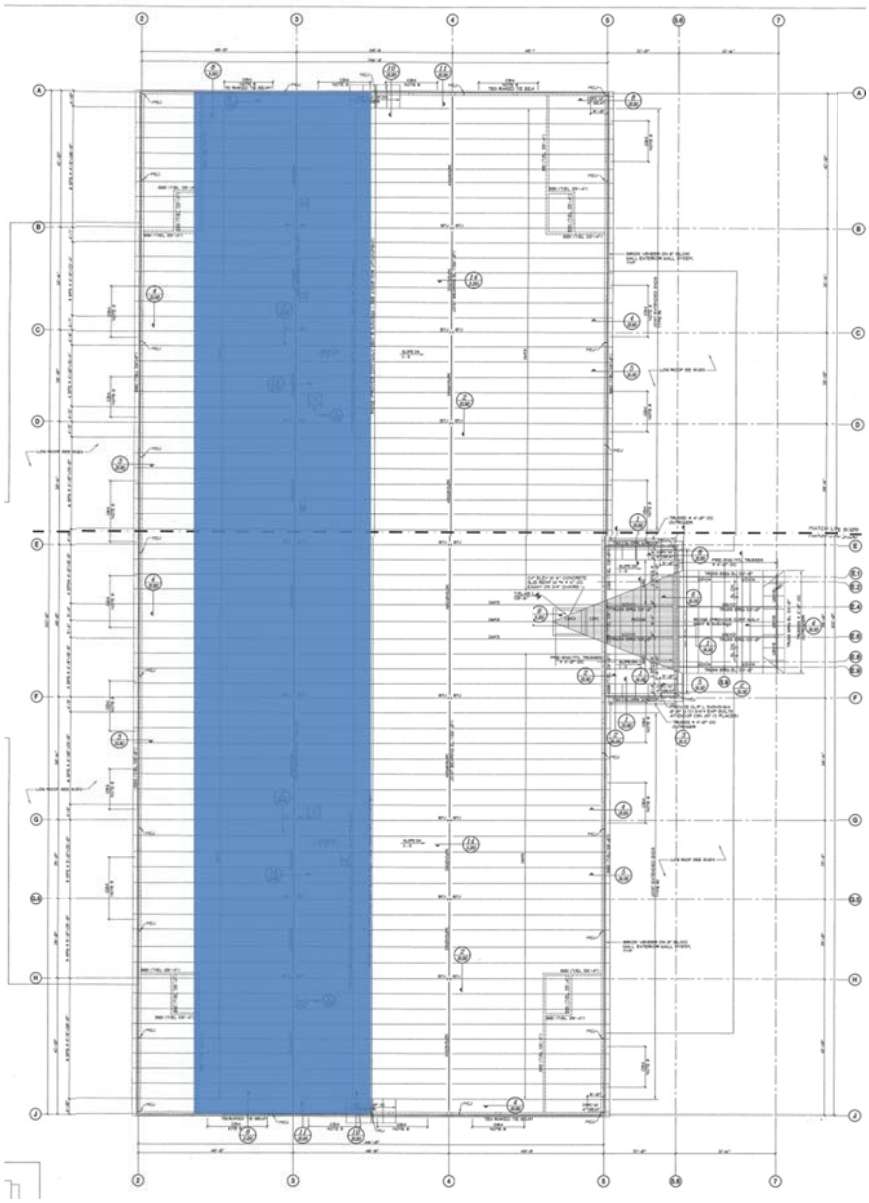


Figure 57: Existing Roof Structure with PV Panel Location

Loads

Adding Photovoltaic panels on my roof will increase my roof load. According to manufacturer information 1 panel weighs 41 lbs and has an area of 17.56 ft^2. The panels cover the majority of my rooftop and for a conservative calculation a uniform load of 41 lbs/17.56 ft^2 (or 2.33 lbs/ft^2) will be applied.

To determine whether the existing structure can support the additional load, all the different joist girders and joist combinations will be analyzed. This information is presented below.

Materials						
Segment	Material	**Size**	**Self-Weight (plf)**	**Tributary Width**	**Self-Weight (psf)**	**Supported Load**
A	**Existing Joist**[1]	26K9	12.2 plf	4'-10"	2.52	330 plf
	Existing Joist Girder[2]	44G9N9.0K	28 plf	48'-8"	0.575	9 kips
B	**Existing Joist**[1]	26K9	12.2 plf	4'-7"	2.66	330 plf
	Existing Joist Girder[2]	32G7N9.0K	24 plf	48'-8"	0.493	9 kips
C	**Existing Joist**[1]	26K9	12.2 plf	4'-9"	2.57	330 plf
	Existing Joist Girder[2]	28G5N9.0K	16 plf	48'-8"	0.329	9 kips
D	**Existing Joist**[1]	26K9	12.2 plf	4'-9"	2.57	330 plf
	Existing Joist Girder[2]	40G8N9.0K	26 plf	48'-8"	0.534	9 kips
E	**Existing Joist**[1]	26K9	12.2 plf	4'-9"	2.57	330 plf
	Existing Joist Girder[2]	48G10N9.0K	37 plf	48'-8"	0.760	9 kips
F	**Existing Joist**[1]	26K9	12.2 plf	4'-9"	2.57	330 plf
	Existing Joist Girder[2]	28G6N9.0K	20 plf	48'-8"	0.411	9 kips

[1]Data from Steel Joist Institute LRFD Load Table for Open Web Steel Joists, K-series
[2]Data from Steel Joist Institute LRFD Weight Table for Joist Girders

The table below shows the loads used to determine the roof load.

Loads		
Dead Load	Superimposed Dead Load	15 psf
	Self-weight	Varies[2]
	Prefinished 24 Ga. Metal Roof Decking	2.26 psf≈3 psf
	Roofing Material[1]	5 psf
	Photovoltaic Panel Load	2.33 psf≈3psf
Live Load	Live Load	20 psf

[1]The roofing material is unknown and 5 psf is assumed for calculation purposes.
[2]Self Weight is found in Table Above

Analysis of Segment A

Joist

1.2*Dead Load + 1.6*Live Load

W=1.2*(15 psf + 3 psf + 5 psf + 3 psf + 2.52 psf)+ 1.6*(20 psf) = 66.224 psf

W*Tributary Width = 66.224 psf * 4.58 ft = 303.53 plf < 330 plf ; good for live load deflection

Joist Girder

Supported Load = Load*Tributary Width/2

66.224 psf*4.83 ft = 319.86*(48.66ft/2) = 7.782 kips < 9 kips ; therefore will support

Analysis of Segment B

Joist

1.2*Dead Load + 1.6*Live Load

W=1.2*(15 psf + 3 psf + 5 psf + 3 psf + 2.66 psf)+ 1.6*(20 psf) = 66.392 psf

W*Tributary Width = 66.392 psf * 4.83 ft = 303.53 plf < 330 plf ; good for live load deflection

Joist Girder

Supported Load = Load*Tributary Width/2

66.392 psf*4.83 ft = 320.01*(48.66ft/2) = 7.786 kips < 9 kips ; therefore will support

Analysis of Segment C, D, E, F

Joist

1.2*Dead Load + 1.6*Live Load

W=1.2*(15 psf + 3 psf + 5 psf + 3 psf + 2.57 psf)+ 1.6*(20 psf) = 66.284 psf

W*Tributary Width = 66.284 psf * 4.75 ft = 314.849 plf < 330 plf ; good for live load deflection

Joist Girder

Supported Load = Load*Tributary Width/2

66.284 psf*4.75 ft = 314.849*(48.66ft/2) = 7.660 kips < 9 kips ; therefore will support

After calculation the loads above, it is determined that the existing joist can support 330 plf and this structural support does not need to be changed to support the added girders can support the new design with photovoltaic panels. Therefore, all of the joist girders will remain the same and they can all support 9 kips.

After calculation the loads above, it is determined that the existing joists can support 330 plf and therefore this structural support does not need to be changed for the implementation of the new photovoltaic system on the roof.

Analysis

After analyzing the effects of adding a photovoltaic system to the room of Crystal Lake Elementary School, it has been determined that there will not be an additional construction cost since the existing structural system will remain as designed.

The calculations above have determined that the existing joists can support 330 plf and the added load does not exceed this amount. Therefore, the joists will not be changed. The existing joist girders can support 9 kips and the added load does not exceed this amount. Therefore, the joist girders will not be changed. Thus, the implementation of a Photovoltaic system is cost effective and will still have a payback period of 14.1 years on a system that is expected to last for 25 years as described in the electrical depth #2: Photovoltaics.

Conclusions

This report emphasizes the lighting and electrical redesign for four different types of spaces. The design emphasis is on energy efficiency and cost effectiveness. The covered entrance and covered walkway lighting design is meant to provide security to the school, as well as graze the building facade material while lighting up the pathways leading to the entrance to the building. Once a visitor has entered the building the lighting in the lobby brings the outside in by using the same wall sconce luminaire making a smooth transition from the exterior to the interior. In the multipurpose room the lighting design provides a solution that is sufficient for an auditorium, cafeteria, and emergency shelter, while maintaining an energy efficient design. Lastly, the primary classroom lighting design provides a bright, uniform space to promote learning.

For comfort purposes, the chillers are placed on the emergency system so that cool air can be circulated during times when the multipurpose room is used as a shelter. An acoustical study in the multipurpose room is performed to determine that the existing ceiling material should be changed to satisfy the reverberation time requirements of this space type.

With an emphasis on energy efficiency, a photovoltaic array is designed for the roof to decrease the energy usage of the building. The results determine that the use a photovoltaic array will be beneficial to this building and will eventually save Seminole County in energy costs. Additionally, a structural analysis of the roof structure with the designed photovoltaic array on the roof is performed to determine that the existing roof structure can support the added load from the photovoltaic system.

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