CASINO GOLD

EAST COAST, USA

Photo Credit: Friedmutter Group

4/9/2014

Senior Thesis Spring 2014

Brad Robertson

Penn State Architectural Engineering – Lighting/Electrical Option

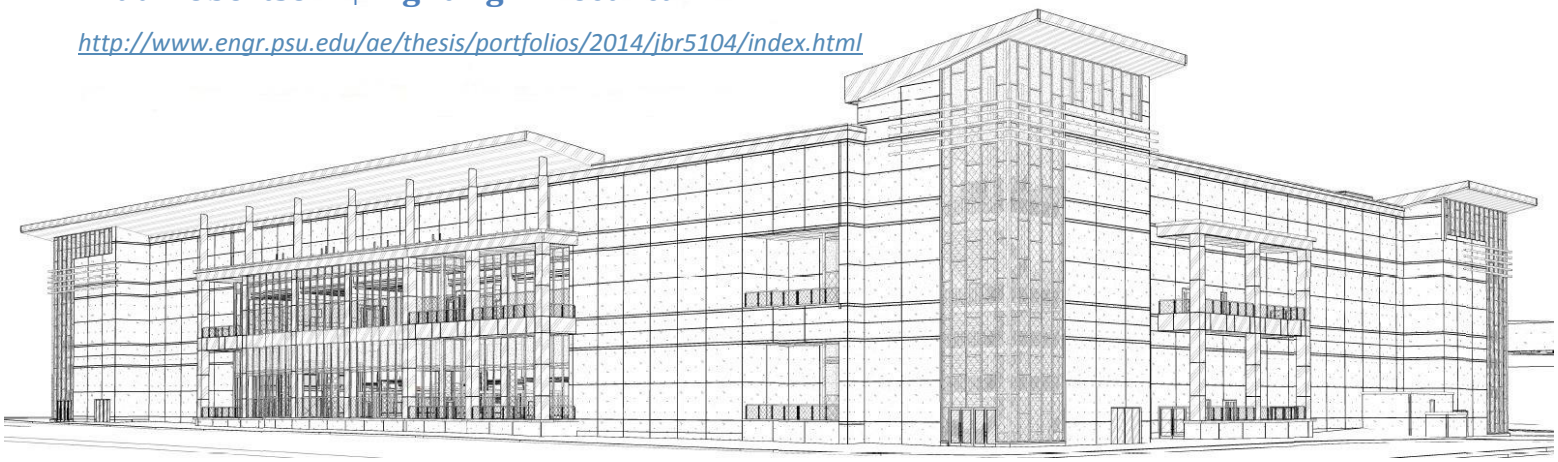
Faculty Advisor – Shawn Good

ABSTRACT

Casino Gold | East Coast, USA

Brad Robertson | Lighting + Electrical

http://www.engr.psu.edu/ae/thesis/portfolios/2014/jbr5104/index.html



The Team

Executive Architect: ka
Design/Interiors Architect: Friedmutter Group
Construction Manager: Whiting-Turner
Structural Engineer: Carroll Engineering, Inc.
MEPT Engineer: JBA Consulting Engineers
Lighting Design: The Lighting Practice

The Building

Occupancy Type: A2 Assembly, B, S1
Type of Construction: Type 1B sprinklered, Noncombustible
Size: 309,450 GSF
Levels Above Grade/Total Levels: 3/3
Approximate Cost: $400 Million
Dates of Construction: June 2013-September 2014

Casino Entrance at Night

Active Outdoor Plaza

The Systems

Lighting: The lighting in Casino Gold is a mix of pendant, recessed, and strip luminaires. The majority of sources are LED and there are multiple custom chandeliers.
Mechanical: A 15,000 sq. ft. central plant adjacent to the building houses the casino's hydronic systems. Rooftop air handling units and exhaust fans service the casino. Due to the nature of the building, special attention is paid to the smoke control system.
Structural: This is a steel structure with metal framed walls and architectural concrete covering the exterior.
Electrical: 480/277V service begins in the Central Plant with Utility Owned transformers. The service is distributed throughout the casino using both 480/277V and 120/208V panels located in defined electrical rooms.

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EXECUTIVE SUMMARY

The lighting depth covers the redesign of four spaces within the main casino building: The Outdoor Plaza, Pre-function space, Poker Room, and Player's Lounge. Each space has its own description in the lighting depth for recommended illuminance recommendations, code requirements, lighting equipment schedule, lighting plan, AGi.32 calculations and a summary. The illuminance recommendations are referenced from the IES Lighting Handbook, 10th Edition. ASHRAE 90.1 is used for the code requirements.

The final lighting design for the Outdoor Plaza guides casino guests towards the entrance while creating a safe environment through the use of overhead string lights. The Pre-Function space, adjacent to the multi-purpose room, uses cove lighting in the recessed ceilings areas to create a psychological impression of spaciousness. In the poker room an environment similar to a workspace has been designed through a combination of recessed down lights and large pendants. Finally, in the Player's Lounge an intimate social setting is the result of custom pendant luminaires and unique indirect linear luminaires.

In the electrical depth, four panels were modified to contain the new loads that resulted from the lighting redesign. While most loads fit on one branch circuit, a couple of them were spread across all three phases. Each new load was added so that the current fuses could remain on the panel. The lighting loads were not large enough to change any of the feeder sizes for the panels. Also in the electrical depth is an analysis of a proposed solar array for the roof of the casino. The analysis includes monthly data for the electrical production of the array based on TMY weather data.

With the new solar array comes a new load on the roof of the casino. A structural breadth evaluates the roof decking, roof joists, joist girders, and columns of the casino's third level. The calculations show that the members of the third level are adequate for the new load, except the roof joists. The roof joists had to be increased in size from 39LH09 to 39LH11. The written calculations are included in Appendix C.

A construction breadth is included in the report that details the labor and material costs of installing the new solar array. A 10 day schedule was achieved with the RS Means 2014 release values. The installation is not expected to significantly impact the 18 month construction schedule of the casino.

ACKNOWLEDGEMENTS

I would like to thank each and every individual who has helped me throughout this year long project.

A special thank you:

Mr. Shawn Good – Senior Thesis Advisor
Ms. Leslie Beahm – Senior Thesis Electrical Advisor
Dr. Kevin Houser – AE Lighting Professor
Dr. Richard Mistrick – AE Lighting Professor
Professor Kevin Parfitt – Director of Senior Thesis
JBA Consulting Engineers – Las Vegas, NV

*And of course a big thank you is in order for my family and fiancé. You have helped me the entire way through five years of Architectural Engineering with your love and support.

PROJECT OVERVIEW

Casino Gold is a three level casino located in the eastern United States. The building is 309,450 sf and has three levels. The first two levels house gaming, dining, a multi-function space, a World Series of Poker Room, and even private gaming areas. The third level is mainly offices for the employees of the casino.

The project site contains three structures. They include a main casino building, a large parking garage, and a separate central services plant. The parking structure is connected to the casino with two bridges. One bridge is for the guests while the other is a smaller, service bridge. The site plan seen below shows the layout of the site.

Note: The name of the casino and the location are withheld from this report per the owner's request.

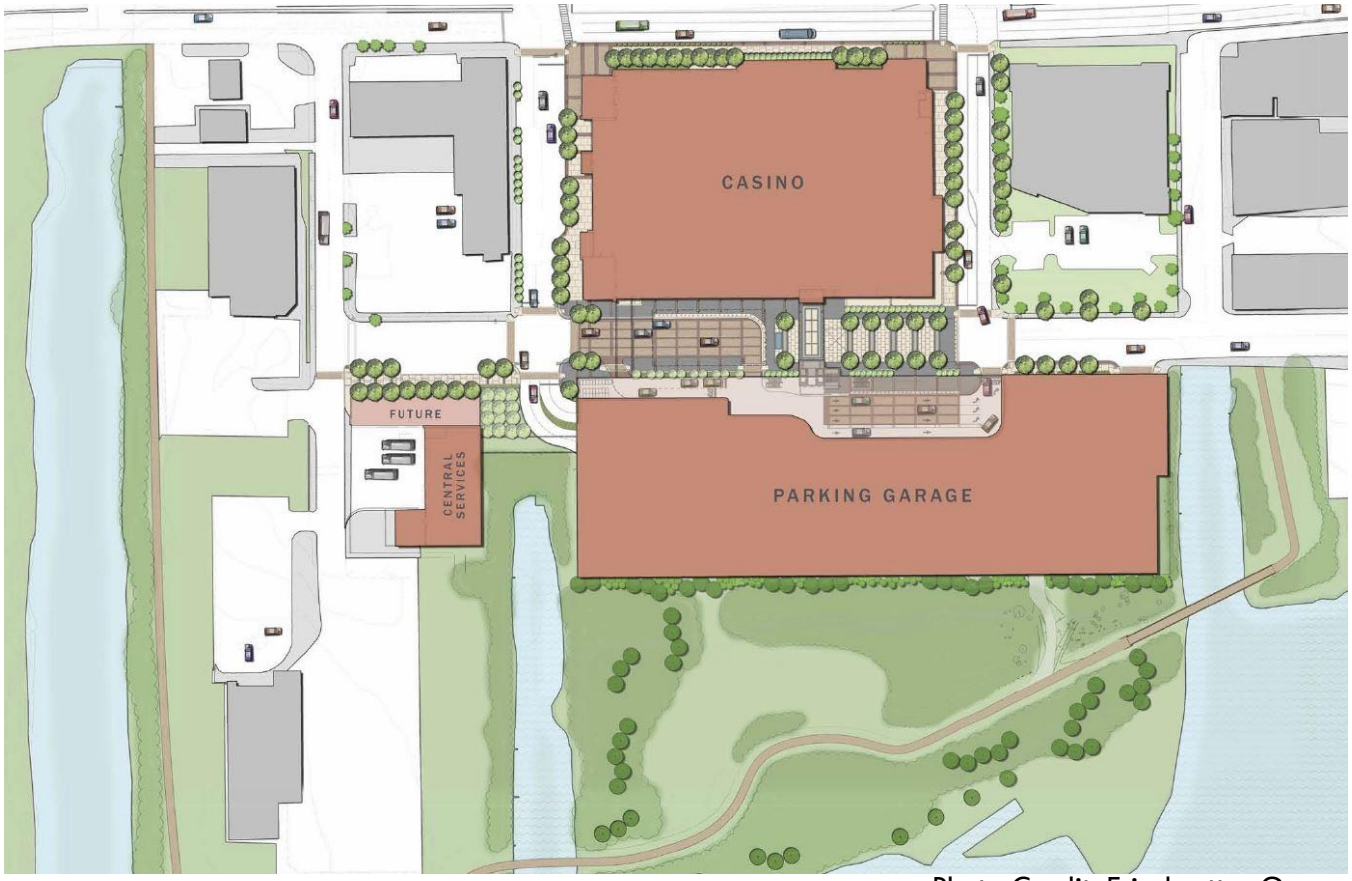


Photo Credit: Friedmutter Group

Project Team

Executive Architect: ka
Design/Interiors Architect: Friedmutter Group
Construction Manager: Whiting-Turner
Structural Engineer: Carroll Engineering, Inc.
MEPT Engineer: JBA Consulting Engineers
Lighting Design: The Lighting Practice

Construction and Cost

Approximate cost: $400 million
Approximate dates of construction: January 2013 – July 2014
Project delivery method: Design-Bid-Build

Codes

Major national codes: International Building Code
ASHRAE 90.1
International Mechanical Code
National Electric Code
International Plumbing Code

Building

Occupancy type: A2 Assembly, B, S1
Type of construction: Type 1B sprinklered, Noncombustible, Protected
Size: 309,450 sq. ft.
Levels above grade/Total levels: 3/3

Facade

The building façade is a mostly prefabricated architectural concrete on top of a vapor barrier, and metal studs, with batt insulation. The main entranceways of the casino have glass curtain wall systems with metal framing.

Roofing

The majority of the roofing for the casino is type RFA1, with the construction:

Single ply TPO roof membrane
R-25 minimum rigid insulation
Sheathing board
1 ½" Metal Decking on steel structure

The next largest area of roofing is type RFA2, with the construction:

Single ply TPO roof membrane
Protection Board
R-25 Minimum rigid insulation
Vapor Retarder
3 ¼" Concrete
3" Metal decking on steel structure

PROPOSAL OVERVIEW

The focus of my Senior Thesis Project is on the lighting and the electrical systems within the main casino. The following report will include a lighting re-design of four different spaces within the casino as well as changes to the electrical system. Breadth topics such as construction and structural will also be included. The goal of this capstone project is to provide alternative solutions to the great designs already in place, for the academic purpose of individual learning.

LIGHTING DEPTH

Concept

The atmosphere inside of a casino is very much centered on a social experience. Whether you are enjoying a night out with your friends or you end up meeting complete strangers while playing your favorite game, people are always connecting with each other. The concept for Casino Gold's lighting design will be "Connecting with People." During our daily lives we are constantly connected to others through social media, email, and messaging. With all of this technology it can be easy to forget that face-to-face interaction with others is still important. A strong design that focuses on intimacy in certain spaces, and excitement in others, will be able to bring people together.

Outdoor Plaza Lighting Design

The outdoor plaza for Casino Gold is one of the first parts of the casino that guests will encounter. It is important to create a great first impression with arriving guests. This will most likely be a meeting spot for many visitors and it will be used at all hours of the day. Due to the twenty-four hour nature of the casino, safety at night is a top priority for this space. The materials present in the Outdoor Plaza are relatively simple, as it is mostly concrete and stone work. The plaza is lined with tree planters that provide an extra element for the lighting design. The Outdoor Plaza is located between the parking garage and the casino at ground level.

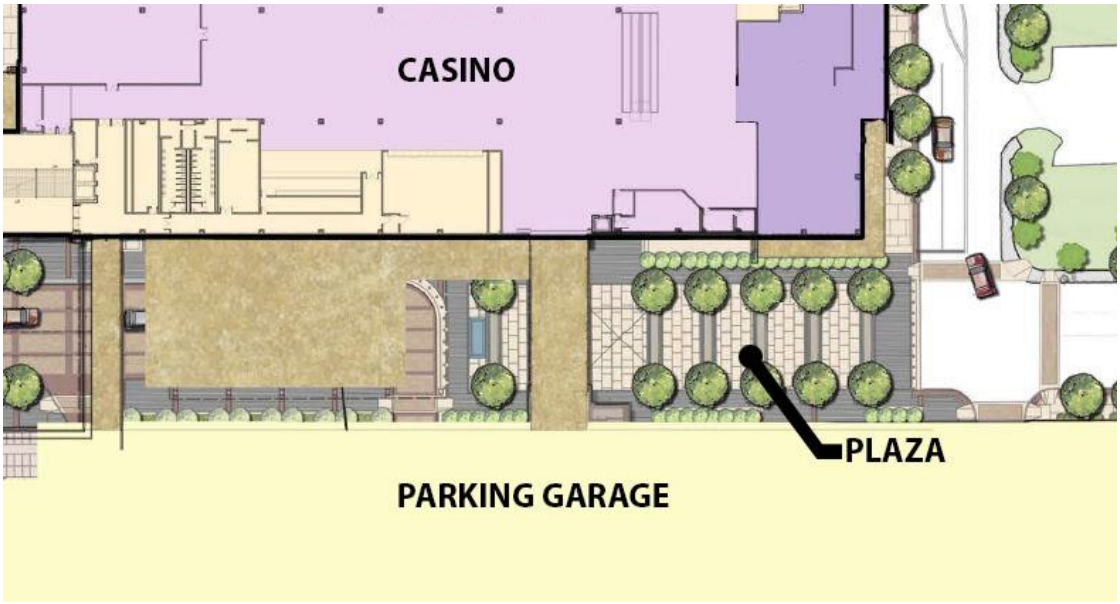


FIGURE 1 - PLAZA LOCATION

Recommended Illuminance Values

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10th Edition. The values for the outdoor plaza can be found in Table 34.2. For an outdoor plaza of a single commercial establishment the recommended illuminance values are taken from the low activity Plaza section.

Horizontal (E_h) Targets	Vertical (E_v) Targets	Average/Minimum Ratio
4 lux	2 lux	5:1

Required Power Density

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to exterior lighting is Table 9.4.3B. The plaza is considered a Zone 3 and the lighting power allowance is

Building grounds					
Walkways less than 10 ft wide	No allowance	0.7 W/linear foot	0.7 W/linear foot	0.8 W/linear foot	1.0 W/linear foot
Walkways 10 ft wide or greater Plaza areas Special feature areas	No allowance	0.14 W/ft^2	0.14 W/ft^2	0.16 W/ft^2	0.2 W/ft^2
Stairways	No allowance	0.75 W/ft^2	1.0 W/ft^2	1.0 W/ft^2	1.0 W/ft^2
Pedestrian tunnels	No allowance	0.15 W/ft^2	0.15 W/ft^2	0.2 W/ft^2	0.3 W/ft^2
Landscaping	No allowance	0.04 W/ft^2	0.05 W/ft^2	0.05 W/ft^2	0.05 W/ft^2

0.16 W/ft^2. The approximate area of the plaza is 17,600 ft^2.

Lighting Plan and Schedule

As a result of the additional criteria for safety and guidance, the lighting design for the Outdoor Plaza makes use of overhead string lights. This overhead light not only renders the faces of guests for safety, but it also creates an inviting atmosphere for people to gather under. Attracting guests to gather and socialize is a main goal of the overall lighting design for this project and ties into the concept of bringing people together quite well. Ground mounted bollard lighting is also used to line the plaza and create a pathway to the entrance of the main casino building. Manufacturer data sheets for the selected luminaires can be found in Appendix A.

Type	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
P1	KBA8	3ft tall, 8" round, LED bollard	Lithonia	LED	120	31	24
P2	ML2000-CA	String Light	Cali	LED	120	2.5	128

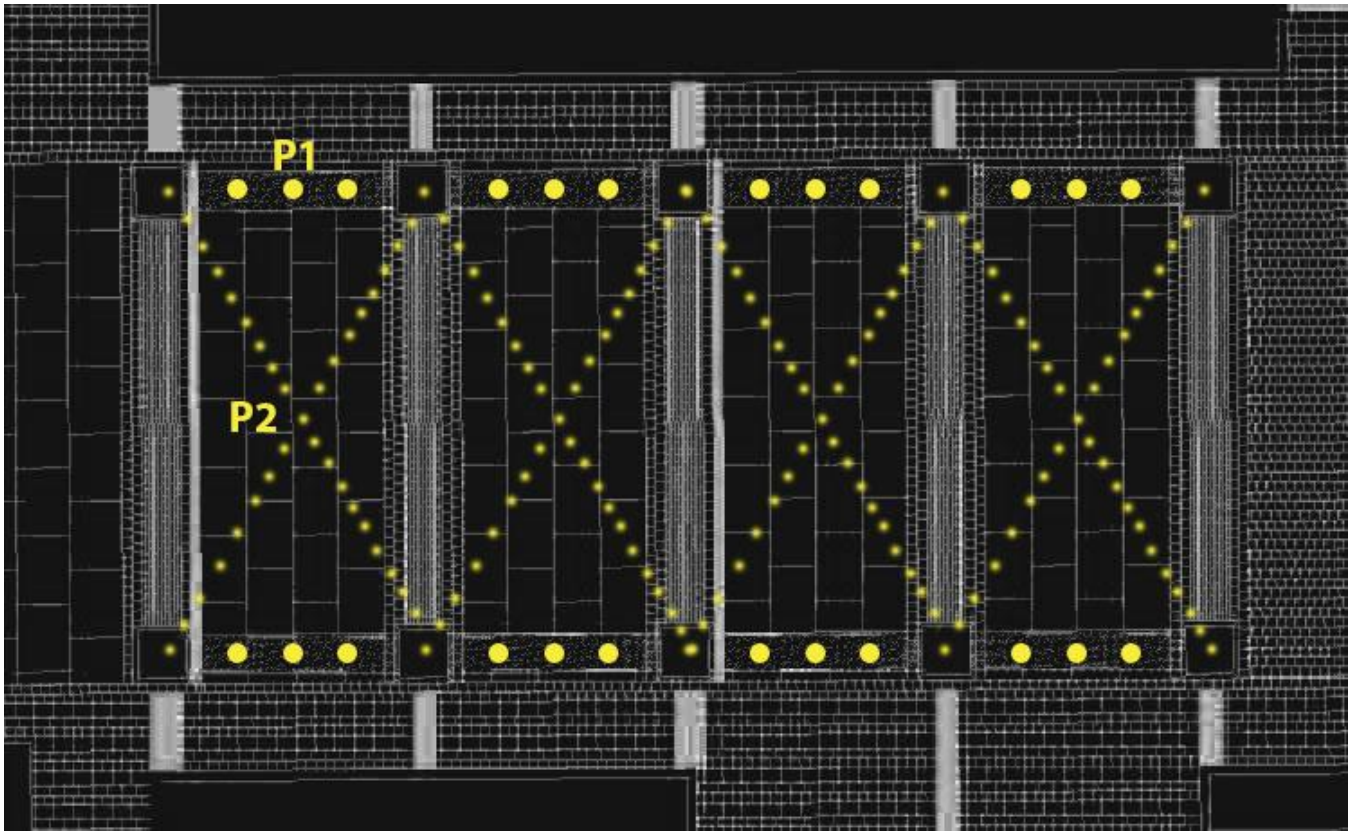
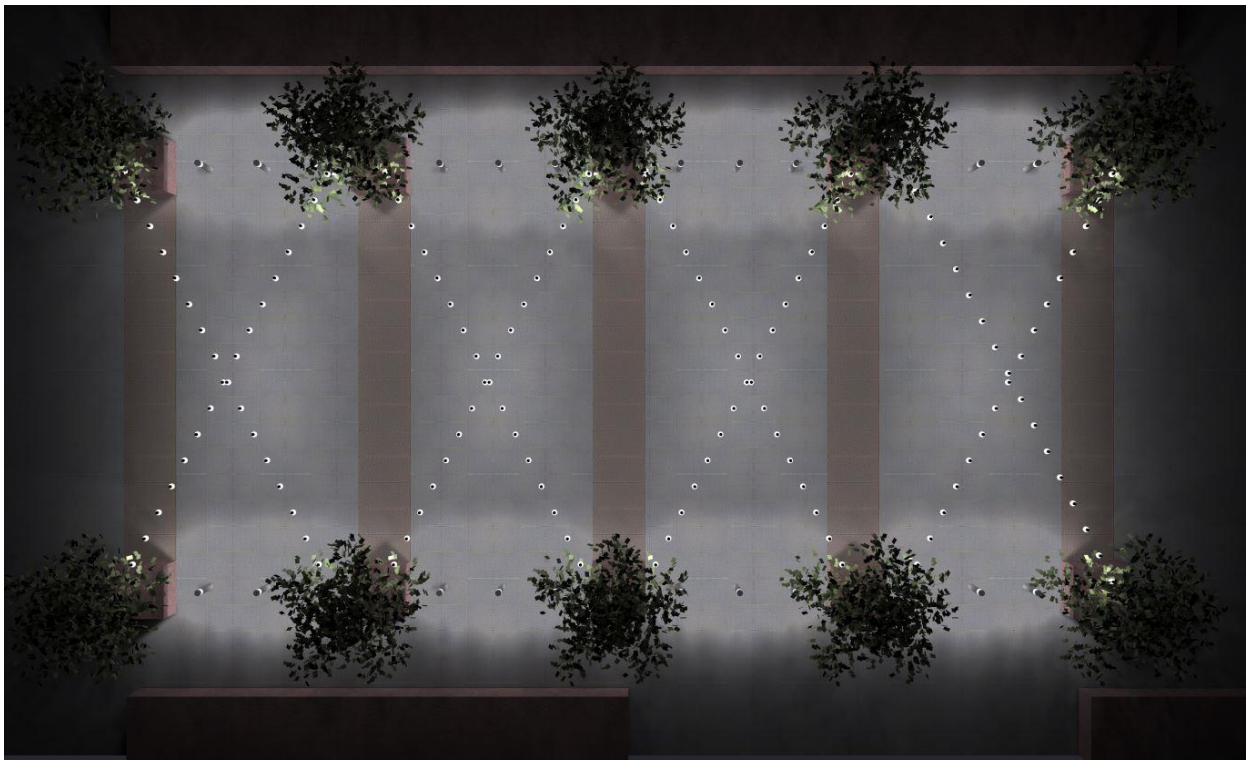


FIGURE 2 - PLAZA LIGHTING PLAN

The bollards have a height of 3ft and line the plaza. The string lights are stretched across the plaza from tree to tree using poles located in the planters. They are 12ft above the ground level in the plaza.



Calculations

AGi.32 was used to analyze the space and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the plaza.

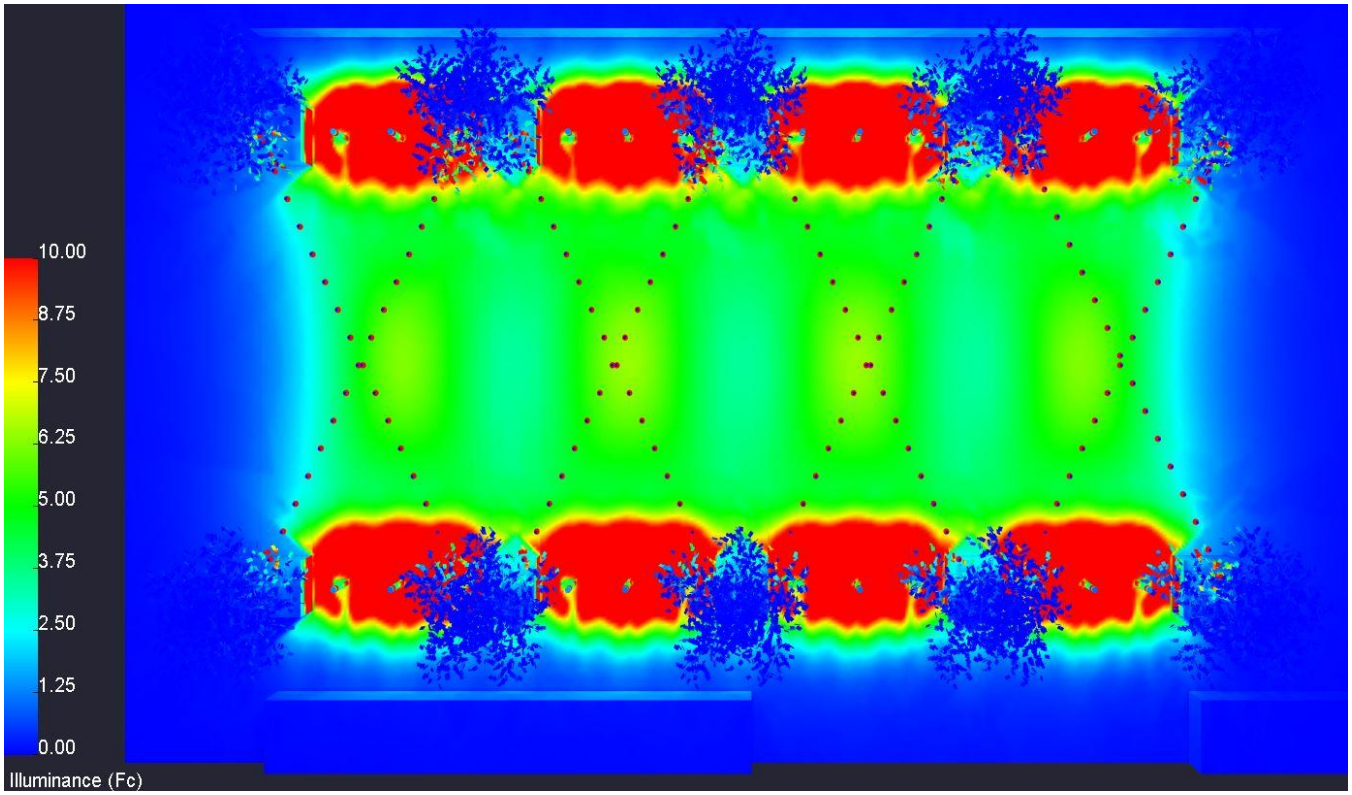
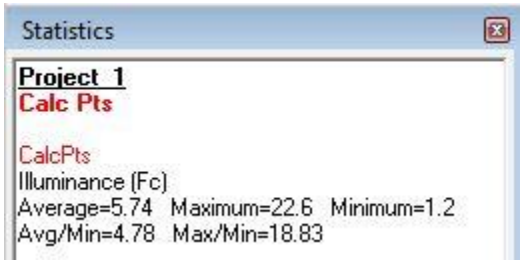


FIGURE 3 - PLAZA PLAN VIEW



The calculated illuminance average of 5fc meets the recommendation level. The average to minimum ratio is less than 5:1, showing that the plaza is appropriately designed. The total consumption of power for the plaza is approximately 1,064W and the area is 17,600ft^2. This leads to a calculated power density of 0.06 W/ft^2, well below the ASHRAE 90.1 requirement of 0.16 W/ft^2.

AGi.32 Rendering

FIGURE 4 - PERSPECTIVE

FIGURE 5 - GUEST VIEW

Summary

The final design for the outdoor plaza includes LED bollards as well as string lights. The lighting achieves the main criteria of safety and guidance. With the architectural lighting overhead, guests have an inviting place to meet and socialize with friends outside of the casino. The string lights also serve a functional purpose of helping to render guests faces for safety of others, and the bollards guide guests along the plaza to the main entrance of the casino. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 5fc. Finally, the 0.06 W/ft^2 power density of the plaza is well below the ASHRAE 90.1 code limit of 0.16 W/ft^2.

Pre-Function Lighting Design

Once guests have entered the first level of the casino, they may need to attend a dinner, meeting, or event in the multi-purpose room. While waiting for these events to begin it is likely that the guests will occupy the pre-function space. The Pre-Function space is located on the first level of the casino and it is adjacent to the multi-purpose room.

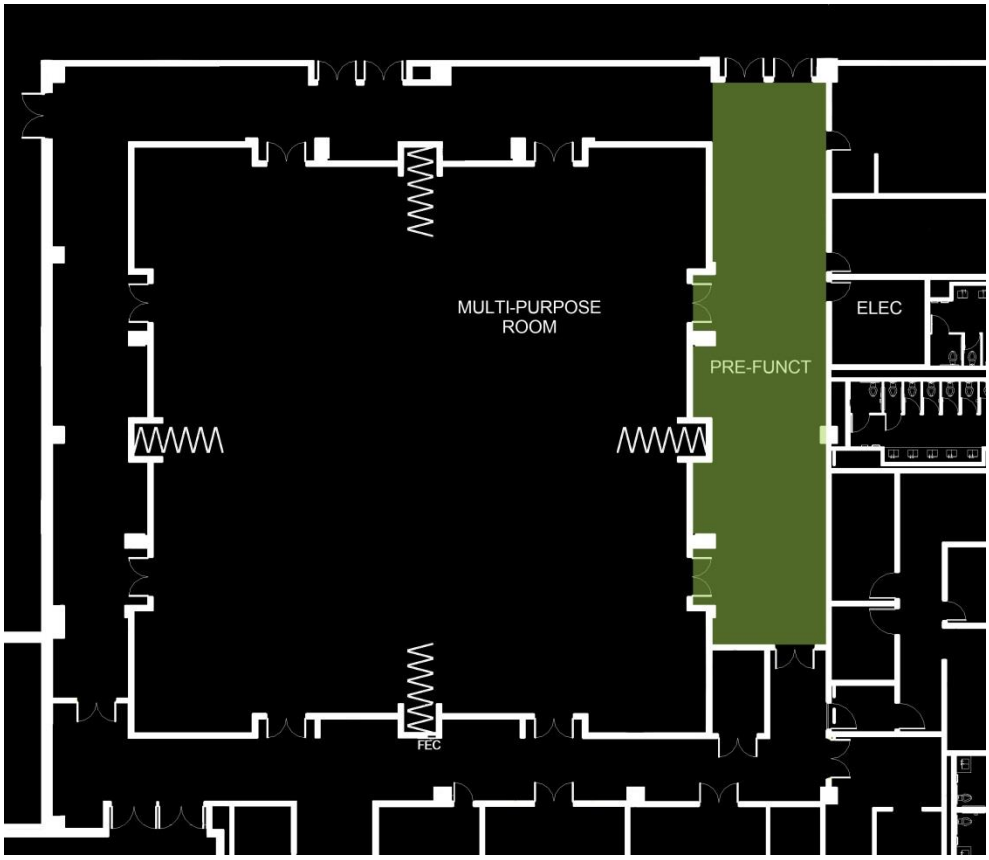


FIGURE 6 PRE-FUNCTION LOCATION

The lighting design in the Pre-Function space makes use of the architectural features present such as ceiling coves and overhangs. The materials include carpet flooring, painted GWB, and dark woodwork around the two entrances into the multipurpose room. The lighting design is meant to create an impression of spaciousness for the guests that will be gathering in the space during events.

Recommended Illuminance Values

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10th Edition. The values for the Pre-Function space can be found in Table 28.2. The recommended values for the space range from 50 lux with general circulation to 200 lux for registration tables. For this particular design the desired illuminance target is for times of high activity before and after functions in the multi-purpose room.

Horizontal (E_h) Targets	Vertical (E_v) Targets	Average/Minimum Ratio
300 lux (max)	2 lux	4:1

Required Power Density

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to space-by-space method interior lighting is Table 9.6.1. The Pre-Function space is assumed to be a common space type of Corridor/Transition for this analysis which results in a lighting power allowance of 0.66 W/ft^2. The approximate area of the Pre-Function space is 1,980 ft^2.

TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types[a]	LPD, W/ft^2	RCR Threshold
Corridor/Transition	0.66	Width<8 ft

Lighting Plan and Schedule

The lighting design for the Pre-Function space makes use of the given architectural features such as the overhangs above the doorways and the coves surrounding the recessed ceilings. Wall washing luminaires are used to highlight the areas of wall that will contain artwork. Recessed downlights are located above the entrances to the multi-purpose room to create a visual point of interest. Custom pendant luminaires line the middle of the Pre-Function space and add to the overall illumination level in the space without adding glare or significant shadows. Cove luminaires are used in the areas of recessed ceiling surfaces to create a psychological impression of spaciousness for the guests.

Type	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
F1	SQHZW	6" square lensed wallwash	Gotham	HID	120	86.6	4
F2	DoM6	6" round recessed downlight	Lithonia	LED	120	15.6	4
F3	107-P	Fabric covered pendant, square cylinder	Shaper	T5	120	93	4
F4	iW Cove MX	4ft cove accent with intelligent white light controls	Philips	LED	120	20.7	22

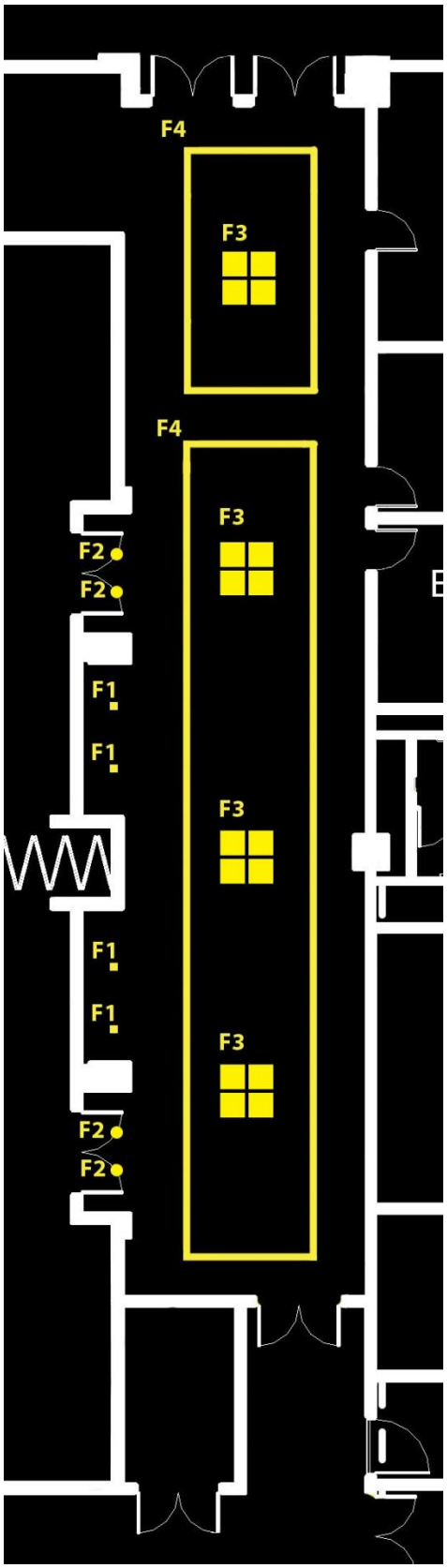


FIGURE 7 PRE-FUNCTION LIGHTING PLAN

Calculations

AGi.32 was used to analyze and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the Pre-Function space.

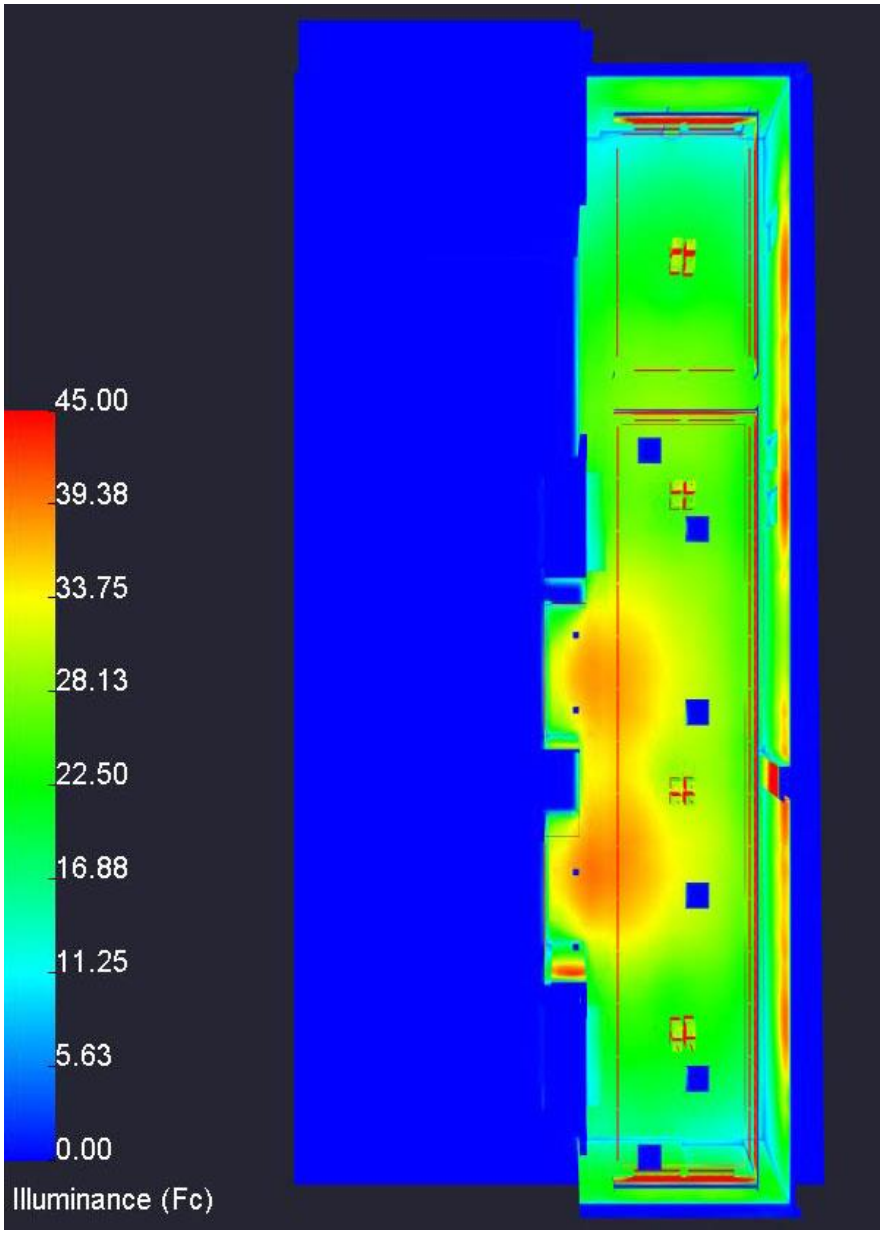


FIGURE 8 PRE-FUNCTION PLAN VIEW

The calculated illuminance average of 30fc meets the selected design criteria for the Pre-Function space. The average to minimum ratio is only 1.95, much less than the recommended 4:1 ratio. The total consumption of power for the Pre-Function space is approximately 1,236W and the area is 1,980ft^2. This leads to a calculated power density of 0.62 W/ft^2, which is just below the ASHRAE 90.1 requirement of 0.66 W/ft^2.

AGi.32 Rendering

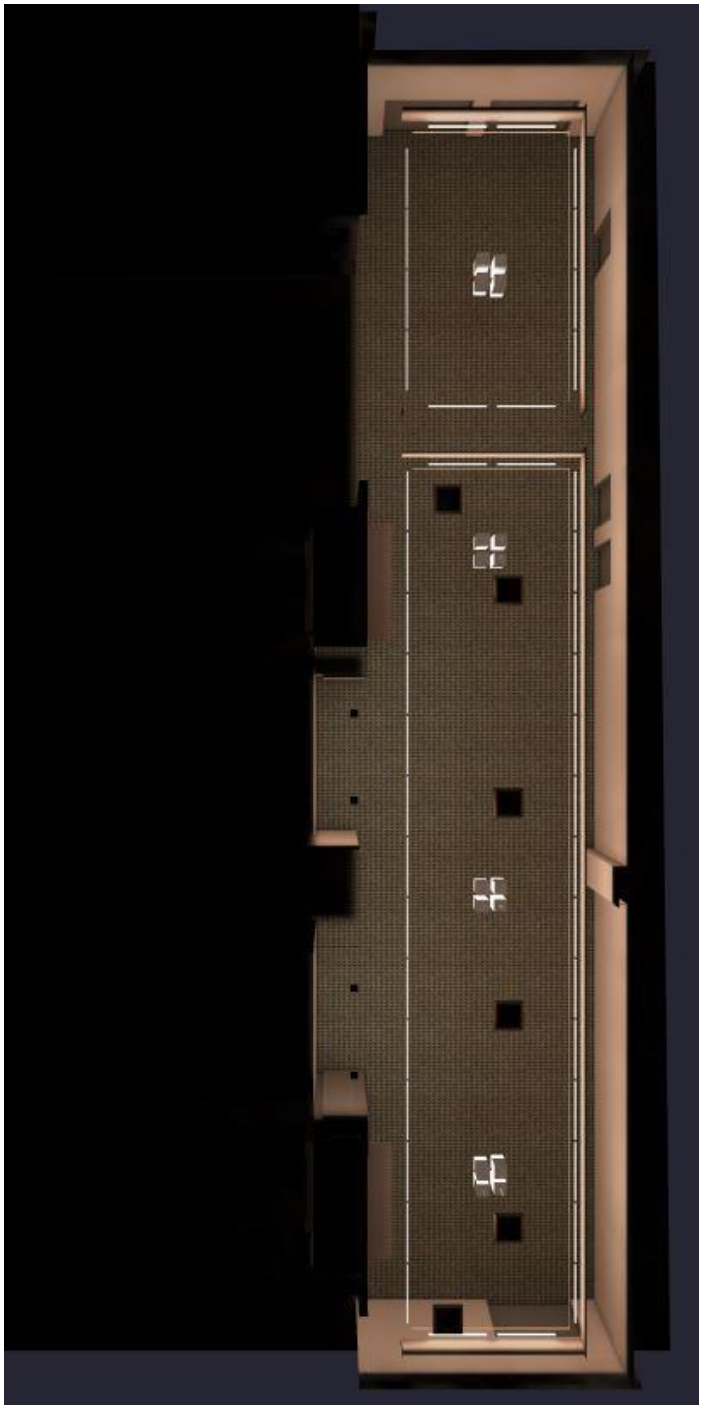


FIGURE 9 PRE-FUNCTION PLAN VIEW

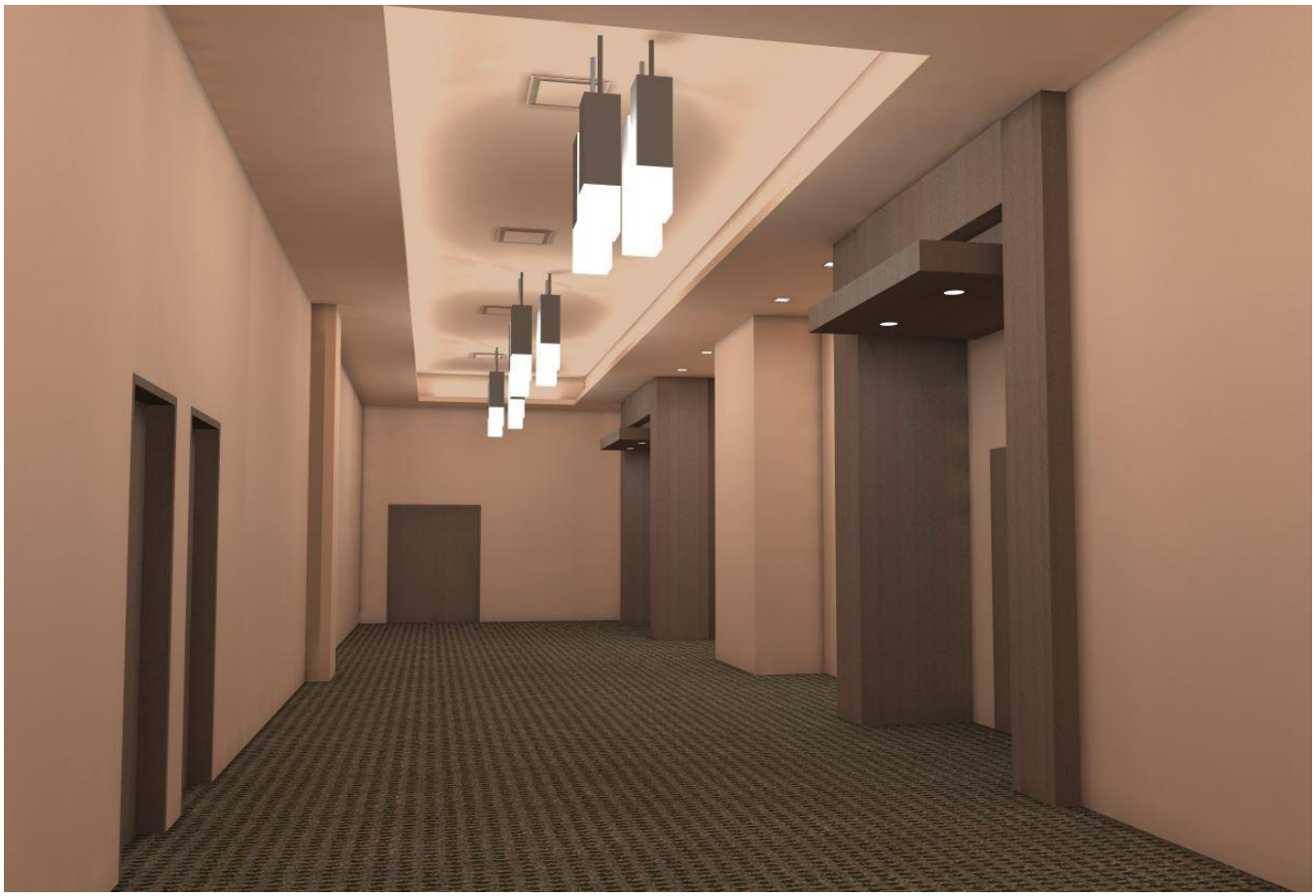


FIGURE 10 PRE-FUNCTION GUEST VIEW

Summary

The final design for the Pre-Function space meets the design goals and criteria. This is a flexible space that can be used for many different functions taking place inside of the adjacent multi-purpose room. The cove lighting for the recessed ceiling creates the feeling of a more spacious area for guests to enjoy their social interaction before events. The pendant luminaires are a great addition to the space with their unique fabric covers and alternating suspension lengths from the ceiling. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 30fc. Finally, the 0.62 W/ft^2 power density of the Pre-Function space is below the ASHRAE 90.1 code limit of 0.66 W/ft^2.

Poker Room Lighting Design

A poker room is about as close to a workspace as a casino will have. Players grind away at these tables for hours on end, often without leaving their seats. A space this heavily used must be visually comfortable so occupants will stick around for the long haul.

The World Series of Poker Room is located in the southeast quadrant of the second level in the casino. The floor space in the Poker Room is approximately 8,100 sq. ft. and is split into two areas. One area is for general poker games, while the other smaller area is for high-limit games or special events. The high-limit area is raised two steps above the main area and is bordered by a railing as well as an accessible ramp. The bar in the lower right corner of the plan view is not included in this design.

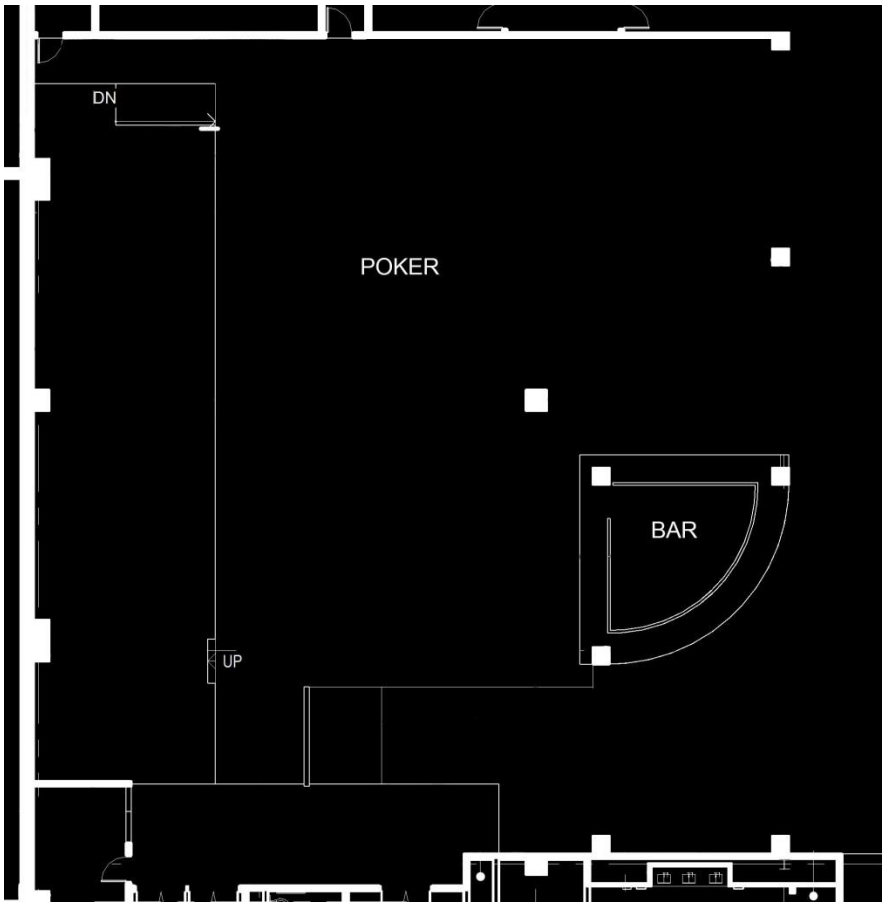


FIGURE 11 - POKER PLAN VIEW

The walls in the poker room use dark colored wood to border painted areas of GWB as well as artwork and televisions. Ceilings in the Poker Room are 15' tall with 16' recessed squares that are bordered with more dark wood trim.

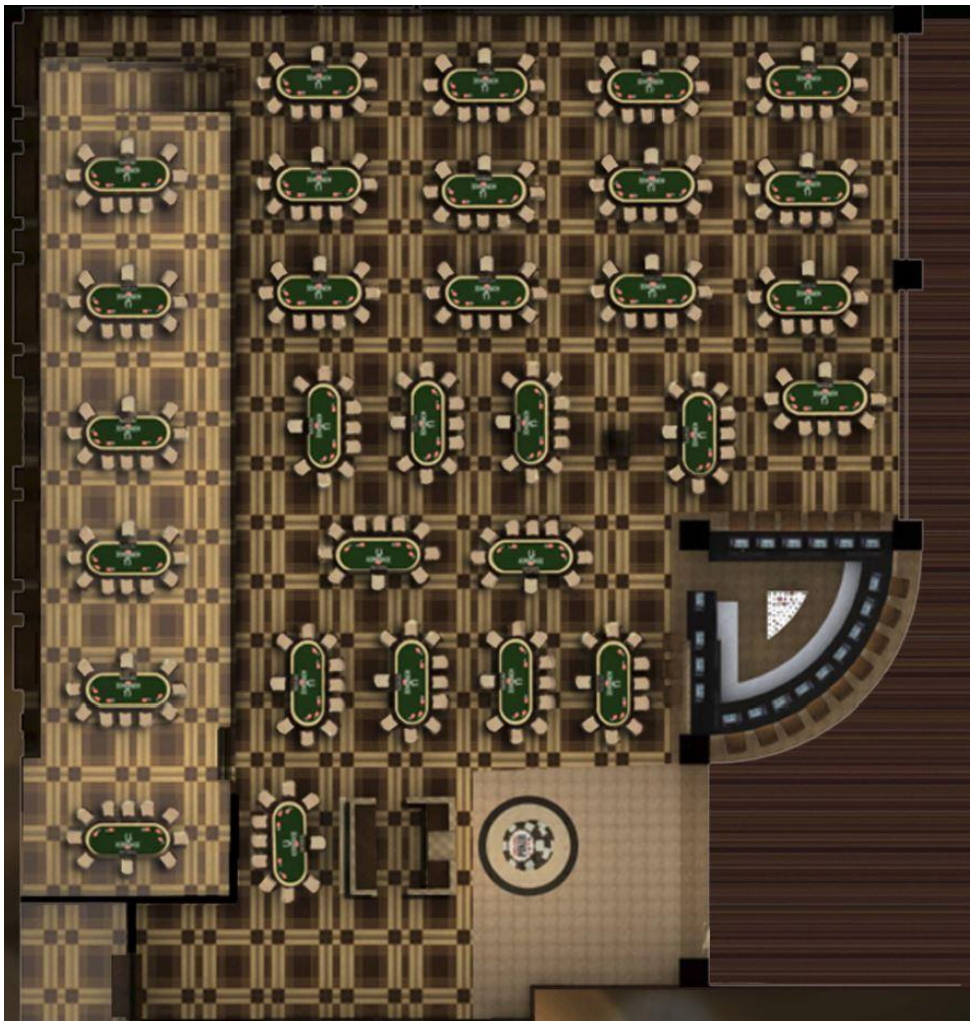


FIGURE 12 - POKER FURNITURE LAYOUT *IMAGE COURTESY OF FRIEDMUTTER GROUP AND DESIGN TEAM

The goal of the lighting design for the Poker Room is to provide a comfortable environment for the players, especially because many players can be there for hours on end. Discipline coordination is important for the construction of this space because the proposed lighting design cannot interfere with the view of security cameras. Mechanical devices such as diffusers have to be accounted for when designing the layout of the downlights and pendants in the space.

Recommended Illuminance Values

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10th Edition. The values for the Poker Room can be found in Table 28.2. The exact recommended values depend on the individual casino and their security specialist. With that in mind, the assumption is made that the Poker Room will follow the recommended illuminance values of lounges containing table games in Table 28.2. The average to minimum ratio is found in Table 12.6.

Horizontal (E_h) Targets	Vertical (E_v) Targets	Average/Minimum Ratio
300 lux	50 lux	5:1

Required Power Density

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to space-by-space method interior lighting is Table 9.6.1. A poker room is not a very typical space so it is not listed specifically in the table. For this design it is that the Poker Room has the same power density requirements of a classroom, which results in a lighting power allowance of 1.24 W/ft^2. The reason why the classroom/lecture/training designation is assumed is because the tasks for the space are similar. Players need appropriate levels of light to read the faces of cards just the same as a student needs to read a book in class. The approximate area of the Poker Room is 8,100 ft^2.

TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types[a]	LPD, W/ft^2	RCR Threshold
Classroom/Lecture/Training	1.24	4

Lighting Plan and Schedule

The lighting design for the Poker Room aims to create a workspace for players. Wall washing luminaires are used to highlight the areas of wall that will contain artwork. Compact fluorescent wall washing luminaires have been chosen for their color rendering qualities of the artwork and woodwork throughout the room. Recessed downlights are located throughout the entire poker room to avoid shadowing or pools of light as best as possible. Pendant luminaires are located in each of the recessed ceiling bays and provide indirect/direct light to the poker tables. Decorative wall drum luminaires are also included on the columns in the high-limits area of the lighting design.

Type	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
PK1	SQFW	6” Square Lensed Wallwash	Gotham	CFL	120	32.5	12
PK2	Ortwin	Decorative wall drum	Winona	CFL	120	32.2	3
PK3	DoM8	8” recessed round downlight	Lithonia	LED	120	27.5	123
PK4	Apollo	43” diameter bowl pendant	Winona	CFL	120	186	14

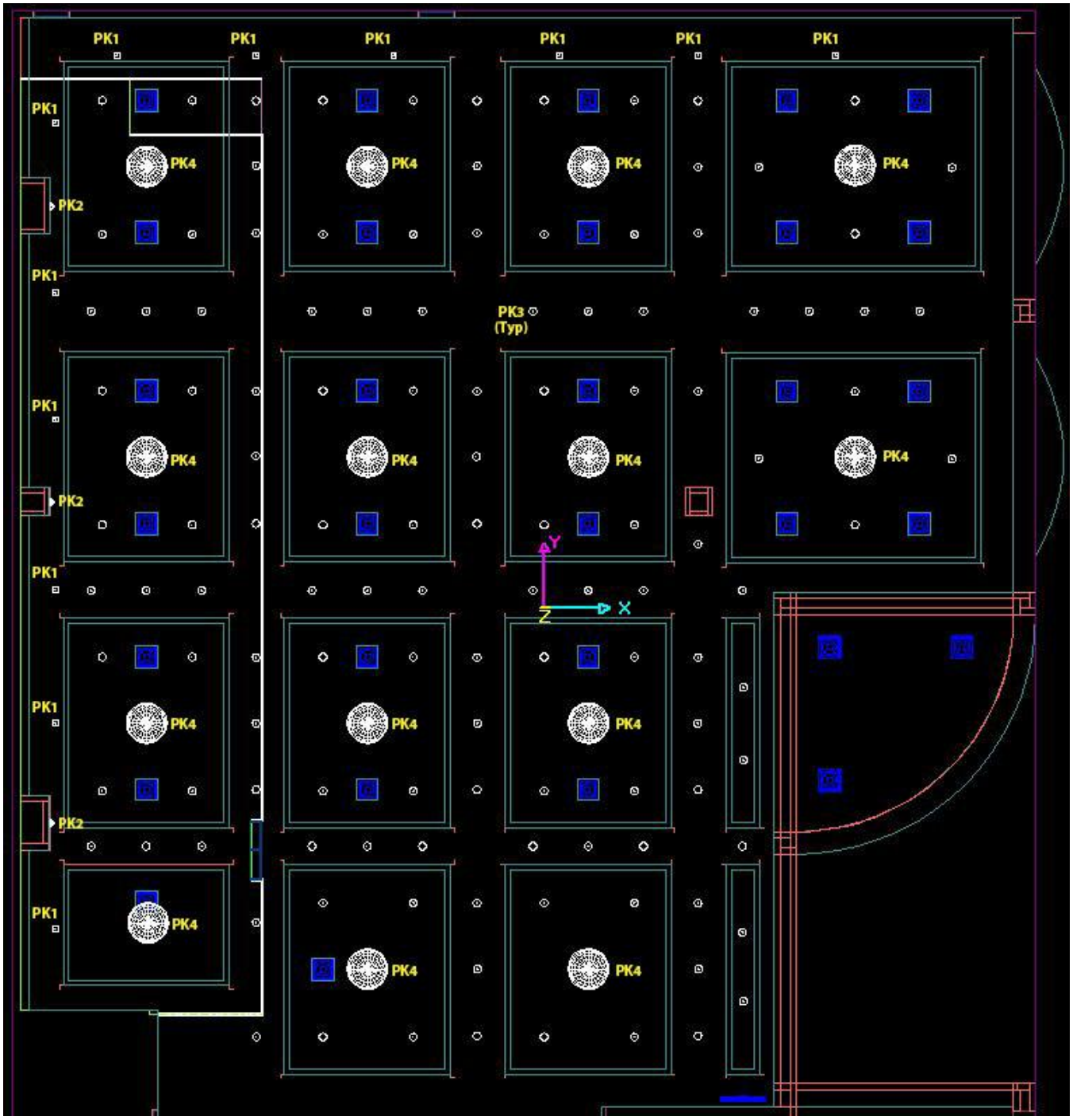


FIGURE 13 - POKER ROOM LIGHTING PLAN

Calculations

AGi.32 was used to analyze and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the Poker Room.

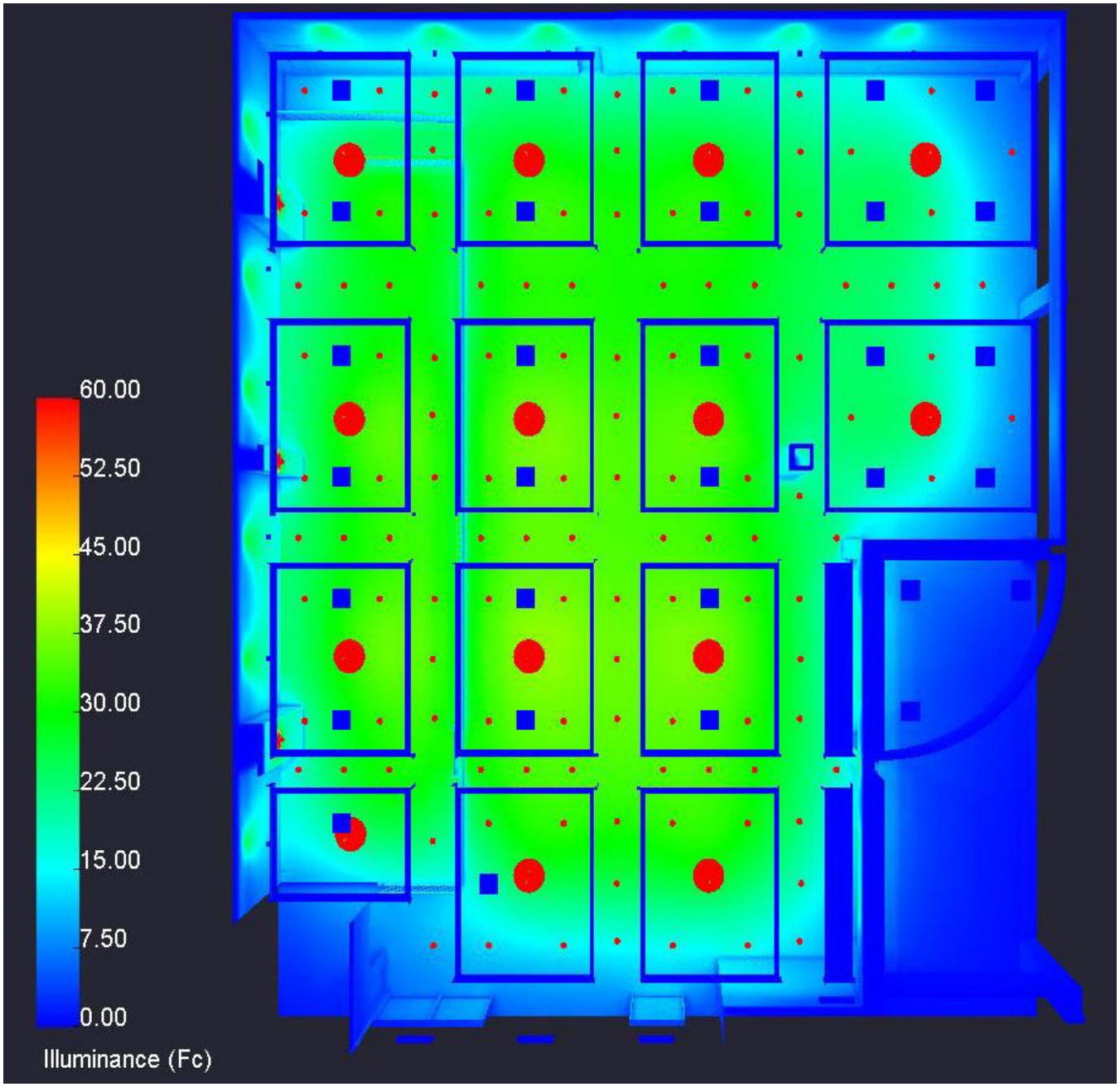


FIGURE 14 - POKER ROOM PLAN VIEW

The calculated illuminance average of 32fc meets the selected design value for the Poker Room. Also, the average to minimum ratio is only 1.85, which is much less than the recommended 5:1 ratio. The total consumption of power for the Poker Room is approximately 6,473W and with an area of 8,100ft^2 for this design. This leads to a calculated power density of 0.80 W/ft^2, which is below the ASHRAE 90.1 requirement of 1.24 W/ft^2.

AGi.32 Rendering

FIGURE 15 - POKER GUEST VIEW

Summary

The final lighting design for the Poker Room creates a workspace for the players. This is a room that will be used constantly by guests and the lighting will hold up to the task. With all of the wood finishes located throughout the Poker Room it was important to include fluorescent luminaires close to those surfaces to best render the wood color and texture. The LED downlights located across the entire ceiling ensure an even distribution of light to minimize shadows on the tables. This lighting design achieved that goal with a low average to minimum illuminance ratio of 1.85. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 32fc. Finally, the 0.80

W/ft^2 power density of the Poker Room is well below the assumed ASHRAE 90.1 code limit of 1.24 W/ft^2.

Player's Lounge Lighting Design

The Player's Lounge brings the "Connecting with People" concept full circle by creating an intimate setting for the guests to visit and interact with each other. This is one of the few places in the casino that the owner can make a profit from beverage sales, so the lighting design of the bar within the Player's Lounge is used to attract guests from outside of the lounge. It is located in the southwest quadrant of the casino's second level.

FIGURE 16 - PLAYER'S LOUNGE LOCATION

The goal of the lighting design for the Player's Lounge is to provide an inviting setting that draws guests into the space and keeps them there. The bar is the main focus from outside of the space and so is the wall surrounding the entrance. It gives guests a glimpse of the interior and tempts them to enter.

Recommended Illuminance Values

The recommended illuminance values are referenced from the Illuminating Engineering Society's *The Lighting Handbook*, 10th Edition. The values for the Player's Lounge can be found in Table 22.2. A lounge can be found under the section of Food Service for Common Applications.

Horizontal (E_h) Targets	Vertical (E_v) Targets	Average/Minimum Ratio
100 lux (lounge area)	50 lux	3:1
50 lux (back bar)	20 lux	3:1

Required Power Density

The code requirements for power density are referenced from ASHRAE 90.1. The table pertaining to space-by-space method interior lighting is Table 9.6.1. A lounge can be found under Dining Area, which results in a lighting power allowance of 1.31 W/ft^2. The approximate area of the Player's Lounge is 1,556 ft^2.

TABLE 9.6.1 Lighting Power Densities Using the Space-by-Space Method

Common Space Types[a]	LPD, W/ft^2	RCR Threshold
Dining Area	0.65	4
For Bar Lounge/Leisure Dining	1.31	4

Lighting Plan and Schedule

The lighting design for the Player's lounge is centered on the guest experience and social interaction. This connection with people is based directly off the casino's lighting concept. Pendant luminaires create intimate seating areas for small groups of guests in the lounge area. Cove lighting provides a soft glow while highlighting the unique architectural features of the ceiling above the guests. Suspended linear luminaires provide an indirect light about the space between the seating and the bar so that glare is not an issue. Behind the bar the coves are illuminated to draw attention to it from people just outside looking in.

Type	Model	Description	Manufacturer	Lamp Type	Input Volts	Input Watts	No. Used
L1	Ortwin	36” drum with custom finish	Winona	CF	120	94	2
L2	iW Cove MX	4ft linear cove with intelligent white light	Philips	LED	120	20.7	8
L3	LL1MA	Indirect/direct linear suspended	Peerless	T8	120	30.5	28

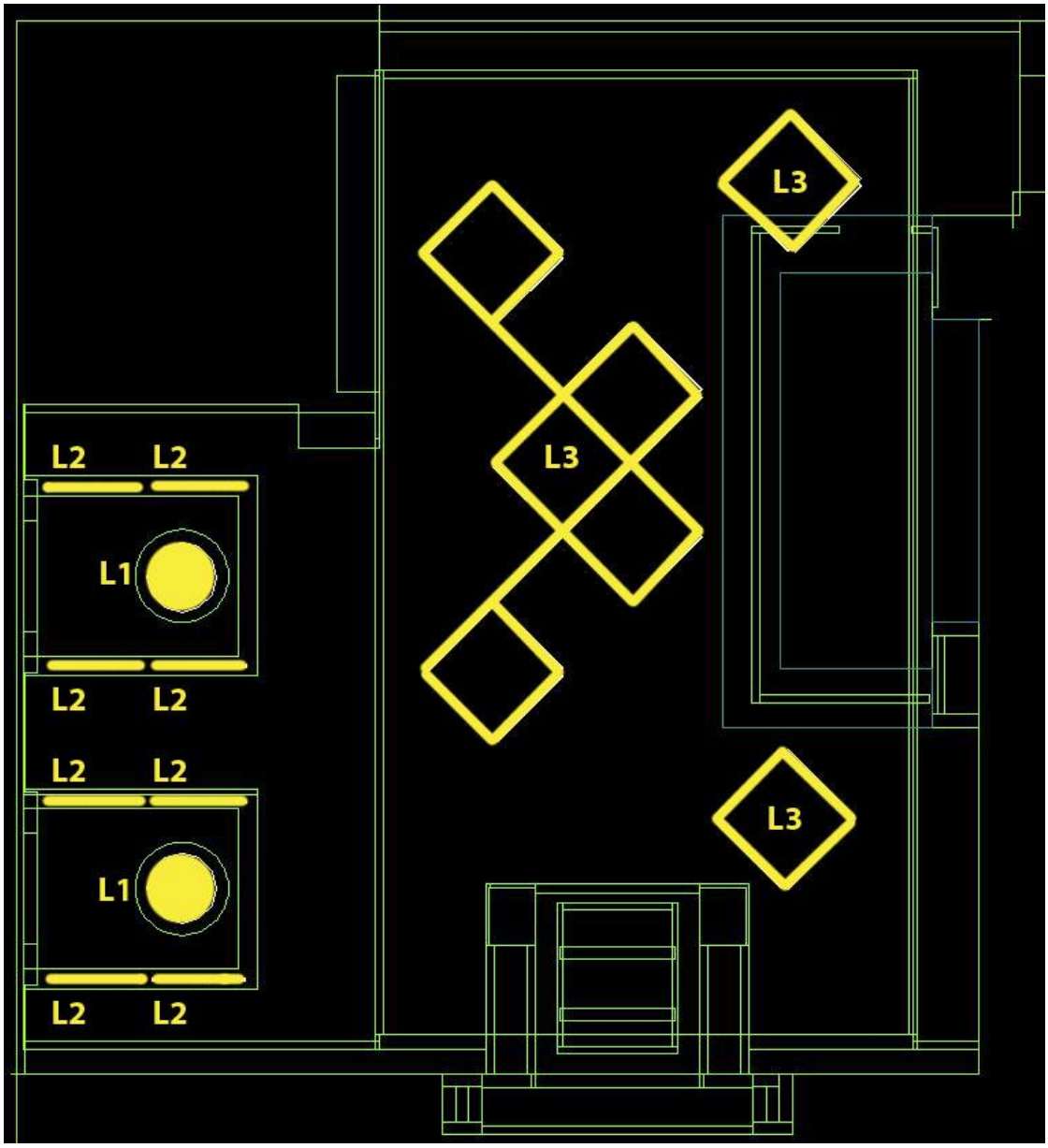


FIGURE 17 - LIGHTING PLAN

Calculations

AGi.32 was used to analyze and calculate the illuminance values of the final design. The following pseudo color rendering shows an even distribution of light across the Player's Lounge.

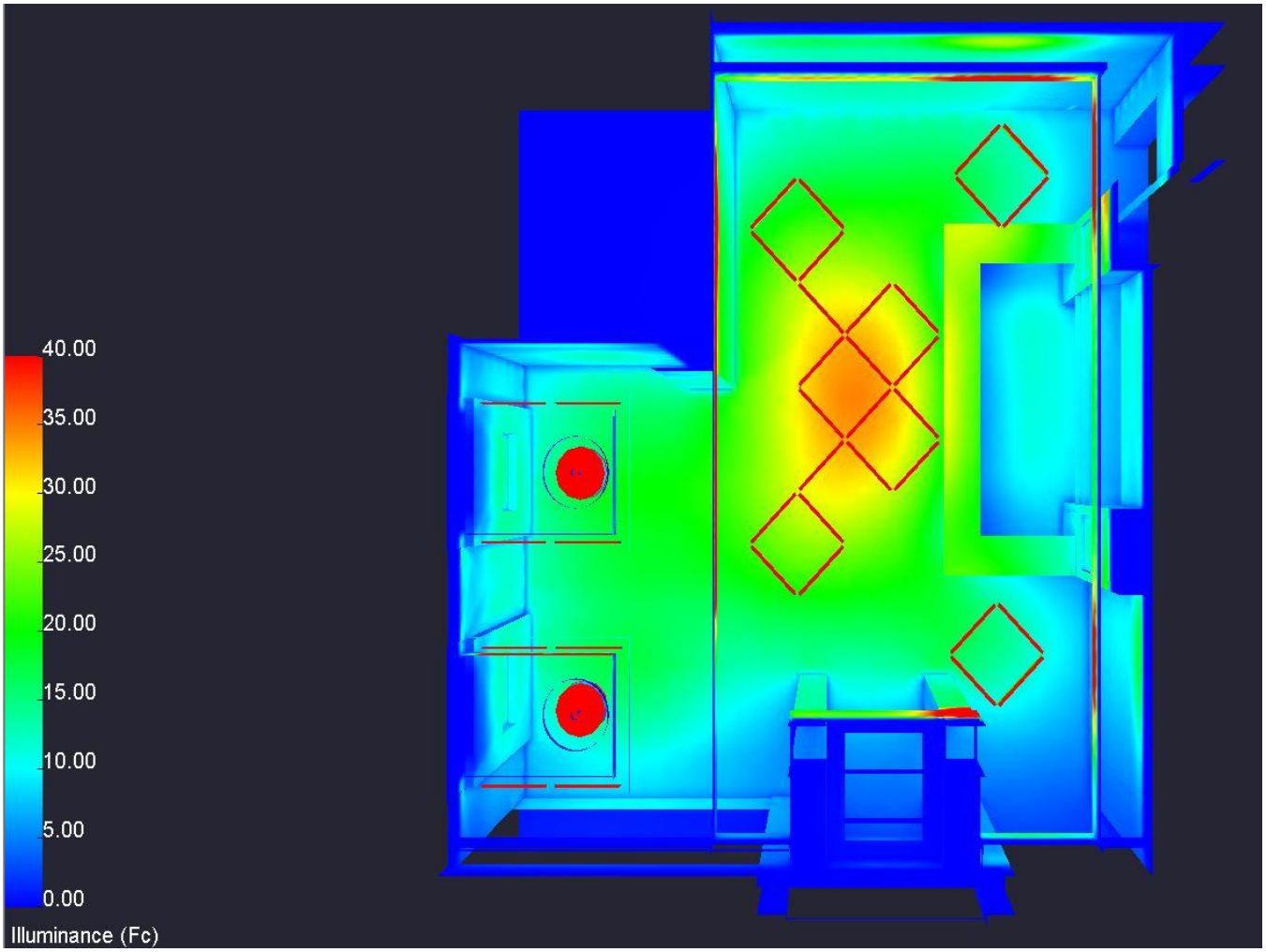
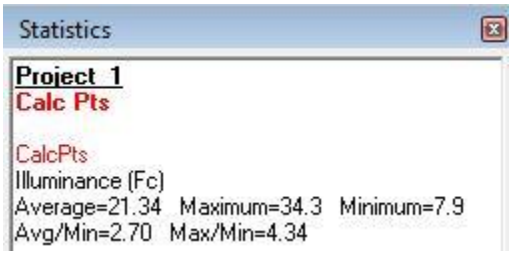


FIGURE 18 - LOUNGE PLAN VIEW



The calculated illuminance average of 21fc exceeds the selected recommended value for the Player's Lounge. The average to minimum ratio is only 2.70 which is just under the ASHRAE 90.1 requirement of 3:1. The total consumption of power for the lounge is approximately 1,208W with an area of 1,556ft^2. This leads to a calculated power density of 0.78 W/ft^2, which is below the ASHRAE 90.1 requirement of 1.31 W/ft^2.

AGi.32 Rendering

FIGURE 19 - PLAN VIEW

FIGURE 20 - FRONT VIEW

Summary

The final lighting design for the Player's Lounge creates a space for guests to interact without gambling. With all of the wood and stone finishes located throughout the lounge it was important to include fluorescent luminaires close to those surfaces to best render the wood color and stone textures. The LED cove lights used have an intelligent white control so that the color temperature can be adjusted by the user on site. The AGi.32 calculations show that the final design meets the IES recommendations with an average horizontal illuminance of 21fc. Finally, the 0.78 W/ft^2 power density of the Player's Lounge is below the ASHRAE 90.1 code requirement of 1.31 W/ft^2.

ELECTRICAL DEPTH

The electrical depth for Casino Gold focuses on the redesign of existing panels to meet the new lighting demands that have resulted from the Lighting Depth. The lighting loads were not a large enough change to require the resizing of any feeders.

Also included in the electrical depth is a photovoltaic array that has been added to the main roof of the casino. The evaluation of the solar resource was conducted in a software system known as SAM. SAM is a shortened version of System for Advisor Model. Monthly outputs of electricity produced by the array were calculated and a cost study is included in the Construction Breadth. The structural impacts are also evaluated in the Structural Breadth of this report.

Manufacturer's data sheets for the specified solar module and inverter are located in Appendix B.

Existing Electrical Information

Connected Building Loads

There are numerous distribution boards and panelboards throughout the casino. The distribution system can be somewhat simplified by tracing all of these connected loads back to the five main switchboards that service them. The main switchboards for Casino Gold are: MSA, MSB, MSC, MSD, and GMS1 (the generator switchboard. The loads for each of these are:

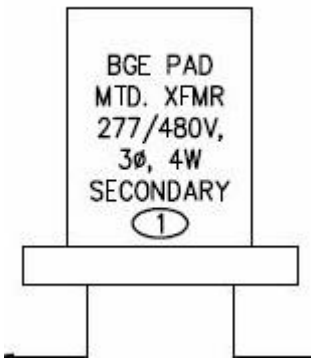
- MSA – 723 kVA
- MSB – 2226 kVA
- MSC – 1749 kVA
- MSD – 2482 kVA
- GMS1 – 318 kVA
- Total Building Load – 7498 kVA

Power Company Rate Schedule

Schedule GL – General Service Large-Electric, 480V Service Voltage

Building Utilization Voltages

The Power Distribution for Casino Gold begins in the Central Plant building located just outside the casino. Service from Baltimore Gas and Electric enters the Central Plant into multiple 480/277V Secondary transformers. These transformers are owned by Baltimore Gas and Electric even though they are inside of casino property. Adjacent to each transformer is a switchboard that begins a branch of the distribution system. Distributions panels are separated for emergency loads, lighting loads, high voltage loads, and low voltage loads.



- Building Utilization Voltage – 480/277 V
- Lighting – 120 volt, plus low voltage LED lighting
- Receptacle – 120 volt
- Mechanical – 480 volt 3 phase

- Special Equipment
    - IT Equipment – 120 volt
    - Fire Pumps – 208 volt
    - Elevators – 480 volt

Emergency Power Distribution System

The emergency power for Casino Gold originates at a diesel generator. This 500kVA generator has the capability to produce 400kw of power and operates on 277/480V. Loads connected to the emergency system include:

- Fire Pump (103kVA load)
- Switchboard GMS1 (318kVA load)
    - Distribution Board 'EDBHA'
    - Distribution Board 'EDBHCP'
    - Distribution Board 'ELEV1'

Each of the distribution boards listed above has a 4-pole automatic transfer switch connected to it that operates in the event of a power loss.

Changes to Existing Panels

Four electrical panels have been changed due to the new lighting loads. There is one modified panelboard for the Plaza, Pre-Function space, Poker Room, and Player's lounge. The lighting loads were not significant enough to change fuse size or feeder size on the panels and branch circuits.

Outdoor Plaza

PANEL: LCCB

JOB: XXXXXX

VOLTAGE: 120/208 Wye — 3Ø, 4W
BUS: 225A
MAINS: L.O.
AIC RATING: 10,000
LOCATION: CORRIDOR C131
MOUNTING: RECESSED

CIRCUIT CODE: blank or N: NON-CONTINUOUS
L: LONG-CONTINUOUS
R: DEMANDABLE RECEPTACLES
K: KITCHEN NO. OF EQUIPMENT:

CKT	CODE	TRIP	POLE	LOAD DESCRIPTION	M	R	L	NOTE	A	B	C	A	B	C	NOTE	L	R	M	LOAD DESCRIPTION	POLE	TRIP	CODE	CKT
1	R	20	1	RECEPTS		2			360			100						1	DDC	1	20	N	2
3	N	20	1	UH-2	1					100			100					1	AHU-1 DDC	1	20	N	4
5	N	20	1	UH-1	1						100			1176				1	EF-1 (1/2HP)	1	20	N	6
7	N	20	1	MOTORIZED DAMPER	1				100			0			--	--	--	--	SPARE	1	20	--	8
9	R	20	1	RECEPT		4				720			50					1	TERRACE HEATER	1	20	N	10
11	N	20	1	VAV	6						300			150				3	TERRACE HEATER	1	20	N	12
13	R	20	1	RECEPTS - POLE		1			180			540					3		REC - TERRACE	1	20	R	14
19	R	20	1	RECEPT - POLE		1			180			720					4		RECEPTS	1	20	R	20
21	R	20	1	RECEPT - POLE		1				180			720				4		RECEPTS	1	20	R	22
23	R	20	1	RECEPT - POLE		1					180			100					METERS	1	20	N	24
25	R	20	1	RECEPT - POLE		1			180			100							METERS	1	20	N	26
27	R	20	1	RECEPT - POLE		1				180			100						METERS	1	20	N	28
29	L	20	1	SIGN			1				500			744	--	--	--	--	PLAZA BOLLARD LTG	1	20	--	30
31	L	20	1	SIGN			1		500			320			--	--	--	--	PLAZA STRING LTG	1	20	--	32
33	L	20	1	SIGN			1			500			0		--	--	--	--	SPARE	1	20	--	34
35	L	20	1	SIGN			1				500			0	--	--	--	--	SPARE	1	20	--	36
37	L	20	1	SIGN			1		500			0			--	--	--	--	SPARE	1	20	--	38
39	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	40
41	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	42
43	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	44
45	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	46
47	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	48
49	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	50
51	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	52
53	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	54
55	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	56
57	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	58
59	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	60
61	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	62
63	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	64
65	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	66
67	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	68
69	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	70
71	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	72
73	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	74
75	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	76
77	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	78
79	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	80
81	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	82
83	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	84
				PHASE TOTALS					3780 VA		4090 VA		4650 VA						TOTAL CONNECTED VA		12520 VA		

PANEL NOTES:

CONNECTED VA (CODE N)	2476 VA
CONNECTED VA (CODE L)	2500 VA
CONNECTED VA (CODE R)	6480 VA
CONNECTED VA (CODE K)	0 VA
PANEL CONNECTED KVA	12.5 KVA
PANEL DEMAND KVA	13.1 KVA
PANEL DEMAND AMPS	36.5 A

The plaza lighting was added to branch circuits 30 and 32 of Panel LCCB. Using the power consumption data from the luminaire spreadsheets, and the quantity of luminaires from the light depth, a load for each circuit was calculated. The perimeter lighting is calculated to have a load of 733VA, while the string lights have a smaller load of 320VA. This lighting is considered to be a non-continuous load and each branch circuit will keep its 20A fuse.

Pre-Function

PANEL: LCAC

JOB: XXXXXX

VOLTAGE: 120/208 Wye — 3Ø, 4W

BUS: 225A

MAINS: L.O.

AIC RATING: 22,000

LOCATION: ELEC. RM. C105

MOUNTING: SURFACE

CIRCUIT CODE: blank or N: NON-CONTINUOUS; L: LONG-CONTINUOUS; R: DEMANDABLE RECEPTACLES; K: KITCHEN — NO. OF EQUIPMENT:

CKT	CODE	TRIP	POLE	LOAD DESCRIPTION	M	R	L	NOTE	A	B	C	A	B	C	NOTE	L	R	M	LOAD DESCRIPTION	POLE	TRIP	CODE	CKT
1	R	20	1	RECEPTS - IDF		5			900			409			--	--	--	--	PREFUNCTION PERIMETER	1	20	--	2
3	R	20	1	RECEPTS		2				360			455		--	--	--	--	PREFUNCTION COVE	1	20	--	4
5	R	20	1	RECEPT - PREFUNCTION		1					180			372	--	--	--	--	PREFUNCTION PENDANTS	1	20	--	6
7	R	20	1	RECEPT - PREFUNCTION		1			180			0			--	--	--	--	SPARE	1	20	--	8
9	R	20	1	RECEPT - PREFUNCTION		1				180			0		--	--	--	--	SPARE	1	20	--	10
11	R	20	1	RECEPT - PREFUNCTION		1					180			0	--	--	--	--	SPARE	1	20	--	12
13	R	20	1	RECEPT - PREFUNCTION		1			180			0			--	--	--	--	SPARE	1	20	--	14
15	R	20	1	RECEPT - PREFUNCTION		1				180			0		--	--	--	--	SPARE	1	20	--	16
17	R	20	1	RECEPT - PREFUNCTION		1					180			0	--	--	--	--	SPARE	1	20	--	18
19	R	20	1	RECEPT - JANUS		2			360			0			--	--	--	--	SPARE	1	20	--	20
21	R	20	1	RECEPT - ARTWORK		1				180			0		--	--	--	--	SPARE	1	20	--	22
23	R	20	1	RECEPT - ARTWORK		1					180			0	--	--	--	--	SPARE	1	20	--	24
25	R	20	1	RECEPT - ARTWORK		1			180			0			--	--	--	--	SPARE	1	20	--	26
27	R	20	1	RECEPT - ARTWORK		1				180			0		--	--	--	--	SPARE	1	20	--	28
29	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	30
31	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	32
33	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	34
35	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	36
37	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	38
39	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	40
41	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	42
43	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	44
45	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	46
47	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	48
49	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	50
51	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	52
53	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	54
55	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	56
57	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	58
59	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	60
61	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	62
63	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	64
65	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	66
67	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	68
69	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	70
71	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	72
73	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	74
75	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	76
77	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	78
79	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	80
81	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	82
83	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	84
						PHASE TOTALS			2209 VA		1535 VA		720 VA						TOTAL CONNECTED VA		4464 VA		

PANEL NOTES:

CONNECTED VA (CODE N)	0 VA
CONNECTED VA (CODE L)	0 VA
CONNECTED VA (CODE R)	3600 VA
CONNECTED VA (CODE K)	0 VA
PANEL CONNECTED KVA	4.5 KVA
PANEL DEMAND KVA	4.5 KVA
PANEL DEMAND AMPS	12.4 A

Three branch circuits were used on Panel LCAC for the lighting in the Pre-Function space. Existing receptacles in the Pre-Function space are already located on the left side of this panel. The perimeter lighting on branch circuit 2 includes the wallwash luminaires as well as the 6" LED downlights, both from the lighting depth report. The new cove lighting in the Pre-Function space is located on branch circuit 4 of this panel and is the largest of the three new loads at 455VA. Finally, the 4 pre-function pendants were

added to branch circuit 6 with a load of 372VA. All three of these loads are under 1920VA, meaning that they are able to stay on the current 20A circuits.

Poker Room

PANEL: LAAC

JOB: XXXXXX

VOLTAGE: 120/208 Wye | 3Ø, 4W | CIRCUIT CODE: blank or N: NON-CONTINUOUS
BUS: 100A | L: LONG-CONTINUOUS
MAINS: L.O. | LOCATION: SECURTTY B213 | R: DEMANDABLE RECEPTACLES
AIC RATING: 10,000 | MOUNTING: RECESSED | K: KITCHEN NO. OF EQUIPMENT:

CKT	CODE	TRIP	POLE	LOAD DESCRIPTION	M	R	L	NOTE	A	B	C	A	B	C	NOTE	L	R	M	LOAD DESCRIPTION	POLE	TRIP	CODE	CKT
1	R	20	1	RECEPTS - CORRIDOR		4			720			720							RECEPTS - CORRIDOR	1	20	R	2
3	R	20	1	RECEPTS - OFFICE		3				540			180					1	RECEPTS - ELEV EQ	1	20	R	4
5	R	20	1	RECEPTS - OFFICES		3					540			180				1	RECEPTS - COND	1	20	R	6
7	R	20	1	RECEPTS - OFFICES		4			720			0			--	--	--	--	SPARE	1	20	--	8
9	--	20	1	Poker Room Perimeter Ltg	--	--	--	--		457			720					4	RECEPTS - SECURITY	1	20	R	10
11	--	20	1	Poker Room Down Ltg	--	--	--	--			1128			200				2	DDC	1	20	N	12
13	--	20	1	-	--	--	--	--	1128			300						3	DDC	1	20	N	14
15	--	20	1	-	--	--	--	--		1128			100					1	DDC	1	20	N	16
17	--	20	1	Poker Room Pendants	--	--	--	--			868			0	--	--	--	--	SPARE	1	20	--	18
19	--	20	1	-	--	--	--	--	868			0			--	--	--	--	SPARE	1	20	--	20
21	--	20	1	-	--	--	--	--		868			0		--	--	--	--	SPARE	1	20	--	22
23	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	24
25	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	26
27	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	28
29	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	30
31	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	32
33	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	34
35	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	36
37	--	20	1	SPARE	--	--	--	--	0			0			--	--	--	--	SPARE	1	20	--	38
39	--	20	1	SPARE	--	--	--	--		0			0		--	--	--	--	SPARE	1	20	--	40
41	--	20	1	SPARE	--	--	--	--			0			0	--	--	--	--	SPARE	1	20	--	42
				PHASE TOTALS					4456 VA		4023 VA		2916 VA						TOTAL CONNECTED VA		11395 VA		

PANEL NOTES:

CONNECTED VA (CODE N)	600 VA
CONNECTED VA (CODE L)	0 VA
CONNECTED VA (CODE R)	4320 VA
CONNECTED VA (CODE K)	0 VA
PANEL CONNECTED KVA	11.4 KVA
PANEL DEMAND KVA	11.4 KVA
PANEL DEMAND AMPS	31.6 A

The additions to Panel LAAC for the Poker Room are different from the previous two panels because some of the loads were spread across 3 phases. The first load that was added to the panel was the Poker Room perimeter lighting, which includes the wallwash luminaires and the wall drum luminaires from the lighting depth. The perimeter lighting has a total load of 457VA. The next load is the 8" LED downlights that are arrayed across the space. These downlights totaled a load of 3383VA so the load was spread across the 3 phases evenly with 1128VA loads. This allows the downlights to be grouped together and stay on the current fuse of 20A. Finally, the Poker Room pendants were added to the panel in the same fashion. The pendants have their load spread across the 3 phases with 868VA on each phase.

Player's Lounge

PANEL: KLDBC

JOB: XXXXXX

VOLTAGE: 120/208 Wye — 3Ø, 4W
BUS: 225A
MAINS: L.O.
AIC RATING: 10,000
LOCATION: SERVICE BAR C260
MOUNTING: RECESSED

CIRCUIT CODE: blank or N: NON-CONTINUOUS; L: LONG-CONTINUOUS; R: DEMANDABLE RECEPTACLES; K: KITCHEN NO. OF EQUIPMENT:

CKT	CODE	TRIP	POLE	LOAD DESCRIPTION	M	R	L	NOTE	A	B	C	A	B	C	NOTE	L	R	M	LOAD DESCRIPTION	POLE	TRIP	CODE	CKT
1	K	20	1	E23-002 DISPLAY CASE		1			1440			180					1		CONV OUTLET	1	20	R	2
3	K	20	1	E23-018 COFFEE GRINDER		1				1128			180				1		CONV OUTLET	1	20	R	4
5	K	20	1	E23-012 BEV CTR	1						840			1920			1		E23-023 BOD UNIT	1	20	R	6
7	K	20	1	E23-084 LIQOUR GUN					1200			1800					1		E23-078 POS	1	20	R	8
9	K	20	1	E23-067 BLENDER	1	1				1920			1920				1		E23-087 CPU	1	20	R	10
11	K	20	1	E23-007 CARBONATOR		1					1800			1200			1		E23-083 CASH REGISTER	1	20	R	12
13	K	20	1	E23-091/041 CABINET/BAR TOP	2				1200			1800					1		E23-078 POS	1	20	R	14
15	K	20	1	E23-078 CARBONATOR		1				1800			1800				1		E23-083 CASH REGISTER	1	20	R	16
17	K	20	1	E23-070 REACH-IN COOLER		1					1020			1920			1		E23-043 PRINTER	1	20	R	18
19	K	20	1	E23-089 SS CABINET WITH STEPS	1				600			1920					3		E23-086 CPU	1	20	R	20
21	K	20	1	E23-081 REACH IN COOLER		1				1020			1800				1		E23-083 CASH REGISTER	1	20	R	22
23	K	20	1	E23-107/108/109 BCKBR STOR/CLR	5						941			3016			1		E23-015 COFFEE BREWER	2	40	K	24
25	K	20	1	E23-095 BAR TOP AND DIE		1			1200			3016			–	–	–	–	–	–	–	–	26
27	K	20	1	E23-064 LIQUOR STEPS		1				1200			3600					1	E23-034 ICE MAKER	3	40	K	28
29	K	20	1	E23-007 CARBONATOR		1					1800			3600	–	–	–	–	–	–	–	–	30
31	K	25	1	E23-100 BLENDER STATION	1	1			2400			3600			–	–	–	–	–	–	–	–	32
33	K	20	1	E23-084 SOLENOIDS		1				1200			1560				1		E23-063 FROZEN DRINK MACH	2	20	K	34
35	K	20	1	E23-007 CARBONATOR		1					180			1560	–	–	–	–	–	–	–	–	36
37	K	20	1	E23-095 BAR TOP AND DIE	1				1200			1560					1		E23-063 FROZEN DRINK MACH	2	20	K	38
39	K	40	1	E23-101 GLASSWASHER	1					3228			1560		–	–	–	–	–	–	–	–	40
41	R	20	1	RECEPTS - SERVICE BAR C260		3					540			1560			1		E23-088 GLASSWASHER	2	20	K	42
[illegible]												1560			–	–	–	–	–	–	–	–	44
45	–	20	1	BAR COVE LTG	–	–	–	–		166			180				1		CONV OUTLET	1	20	R	46
47	–	20	1	BAR PENDANT	–	–	–	–			168			180			1		CONV OUTLET	1	20	R	48
49	–	20	1	BAR OVERHEAD LTG	–	–	–	–	864			180					1		CONV OUTLET	1	20	R	50
51	–	20	1	SPARE	–	–	–	–		0			180				1		CONV OUTLET	1	20	R	52
53	–	20	1	SPARE	–	–	–	–			0			180			1		CONV OUTLET	1	20	R	54
55	–	20	1	SPARE	–	–	–	–	0			180					1		E23-103 CASH REGISTER	1	20	K	56
57	–	20	1	SPARE	–	–	–	–		0			180				1		E23-103 CASH REGISTER	1	20	R	58
59	–	20	1	SPARE	–	–	–	–			0			0	–	–	–	–	SPARE	1	20	–	60
61	–	20	1	SPARE	–	–	–	–	0			0			–	–	–	–	SPARE	1	20	–	62
63	–	20	1	SPARE	–	–	–	–		0			0		–	–	–	–	SPARE	1	20	–	64
65	–	20	1	SPARE	–	–	–	–			0			0	–	–	–	–	SPARE	1	20	–	66
67	–	20	1	SPARE	–	–	–	–	0			0			–	–	–	–	SPARE	1	20	–	68
69	–	20	1	SPARE	–	–	–	–		0			0		–	–	–	–	SPARE	1	20	–	70
71	–	20	1	SPARE	–	–	–	–			0			0	–	–	–	–	SPARE	1	20	–	72
73	–	20	1	SPARE	–	–	–	–	0			0			–	–	–	–	SPARE	1	20	–	74
75	–	20	1	SPARE	–	–	–	–		0			0		–	–	–	–	SPARE	1	20	–	76
77	–	20	1	SPARE	–	–	–	–			0			0	–	–	–	–	SPARE	1	20	–	78
79	–	20	1	SPARE	–	–	–	–	0			0			–	–	–	–	SPARE	1	20	–	80
81	–	20	1	SPARE	–	–	–	–		0			0		–	–	–	–	SPARE	1	20	–	82
83	–	20	1	SPARE	–	–	–	–			0			0	–	–	–	–	SPARE	1	20	–	84
								PHASE TOTALS		26610 VA			24622 VA						TOTAL CONNECTED VA		73677 VA		

PANEL NOTES:

CONNECTED VA (CODE N)	0 VA
CONNECTED VA (CODE L)	0 VA
CONNECTED VA (CODE R)	18780 VA
CONNECTED VA (CODE K)	53689 VA
PANEL CONNECTED KVA	73.7 kVA
PANEL DEMAND KVA	50.5 kVA
PANEL DEMAND AMPS	140.2 A

The final panel that was modified due to the new lighting loads is Panel KLDBC. Three branch circuits were used for the new lighting in the Player's lounge. The first load, the Bar Cove Lighting on circuit 45, has a small total of 166VA. Next, a branch circuit was used for the two pendants located in the seating area of the lounge. The pendants were placed on branch circuit 47 with a load of 168VA. Finally, the third load that has been created is on branch circuit 49. This load is the Peerless overhead lighting in the

Player's lounge and is the largest of the three loads at 854VA. All three of these new circuits have loads that will adequately fit on the current 20A branch circuits.

Photovoltaic Array

The proposed photovoltaic array for this project was designed using System Advisor Model, or SAM. SAM is solar design software from the National Renewable Energy Laboratory. The program takes various inputs from the user to determine weather data, size of the array, and financial details. For this electrical depth, a solar module and invertor are chosen based on a balance of cost and . Their manufacturer's data sheets can be found in Appendix B. The monthly energy produced by the array has also been calculated.

The following analysis will go through the beginning steps of setting up a simulation in SAM. This process leads to the chosen equipment and calculates the production data for the array.

Specify a Location

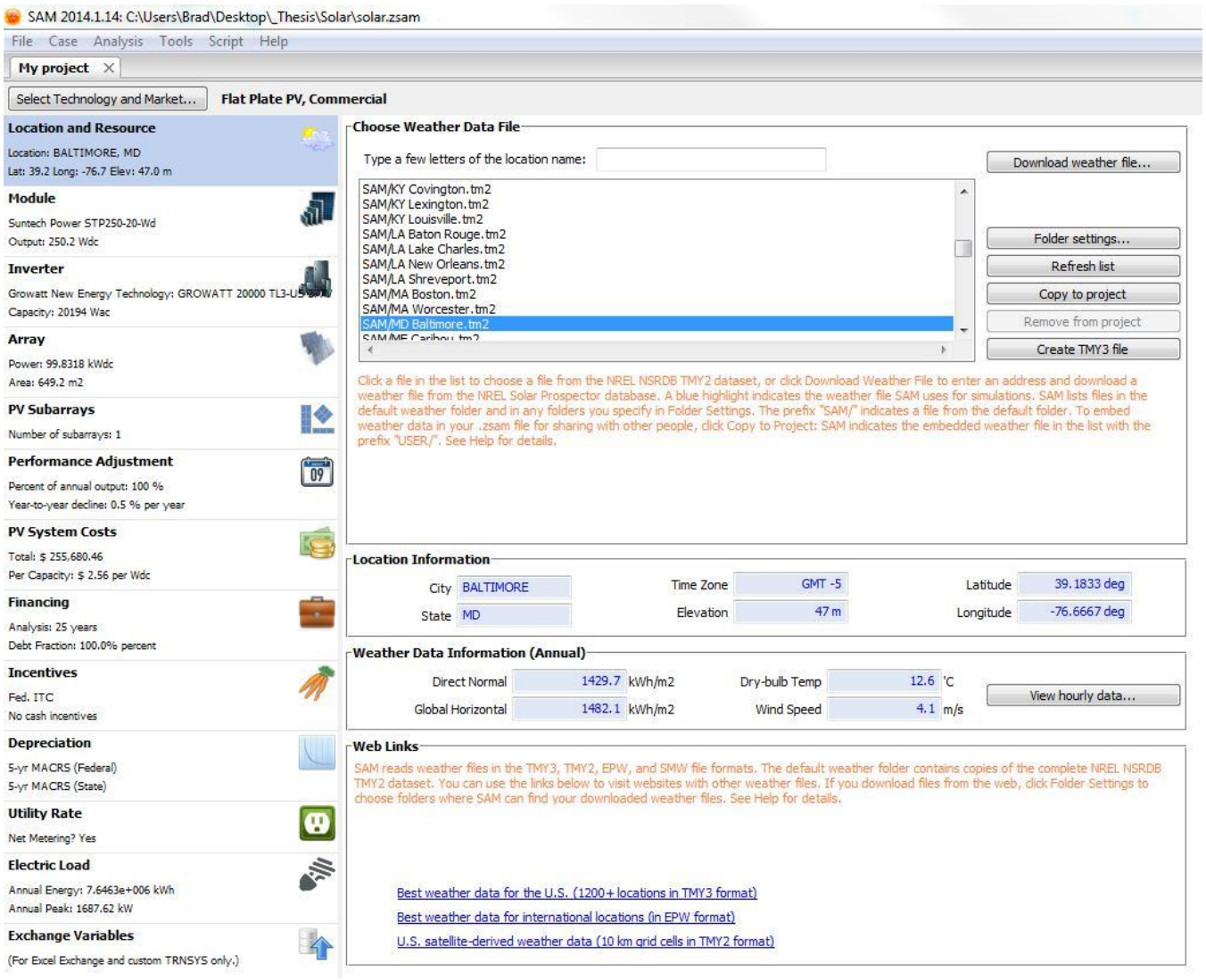


FIGURE 21 - SAM LOCATION AND RESOURCE PAGE

Selecting a Solar Module

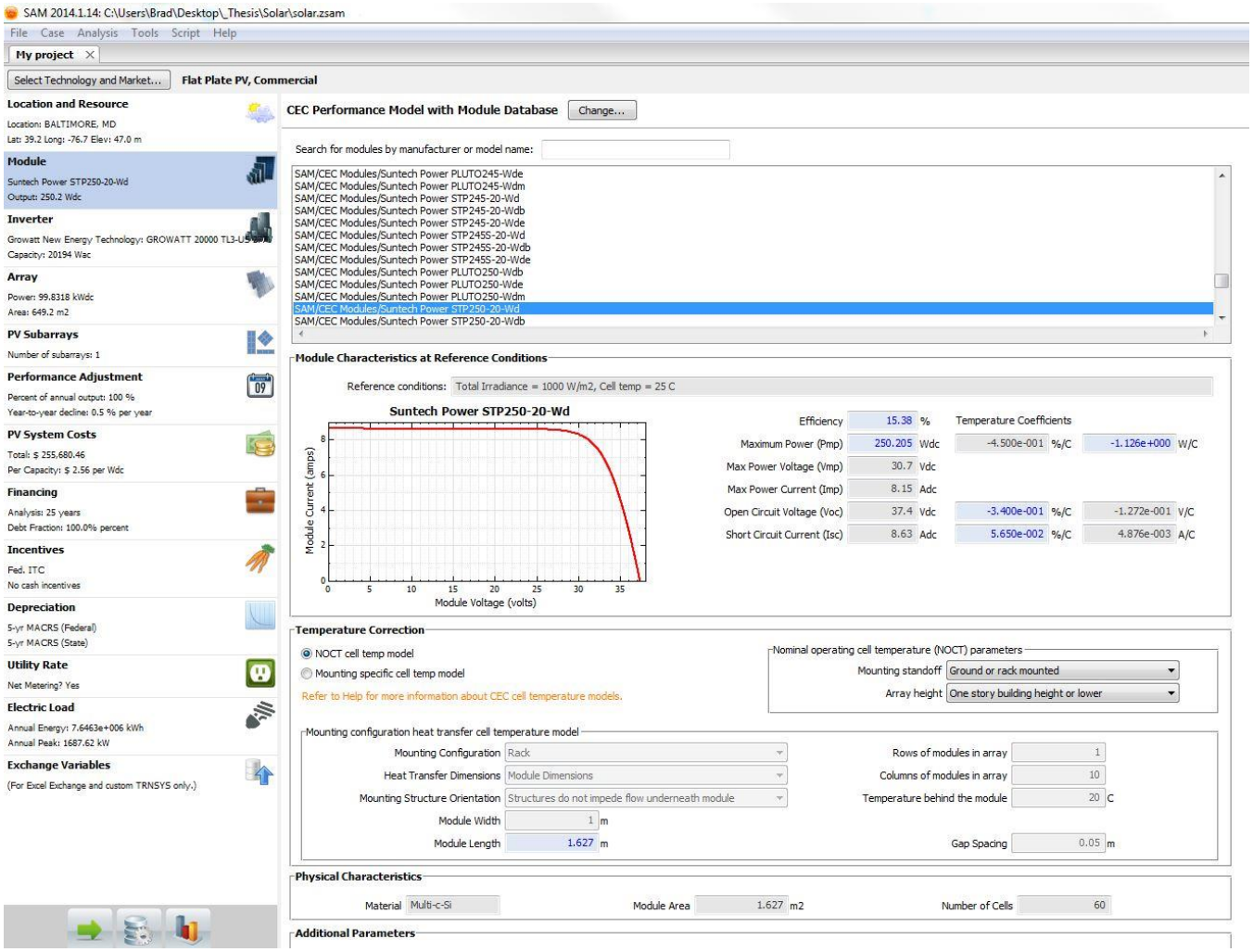


FIGURE 22 - SAM CHOOSING A SOLAR MODULE

A Suntech STP250 – 20/Wd was chosen as the solar module for the casino. This is a 250Watt, polycrystalline solar module. It has an open circuit voltage of 37.4A and an efficiency of 15.4%. The full specifications for the panel can be found in Appendix B.

Selecting an Inverter

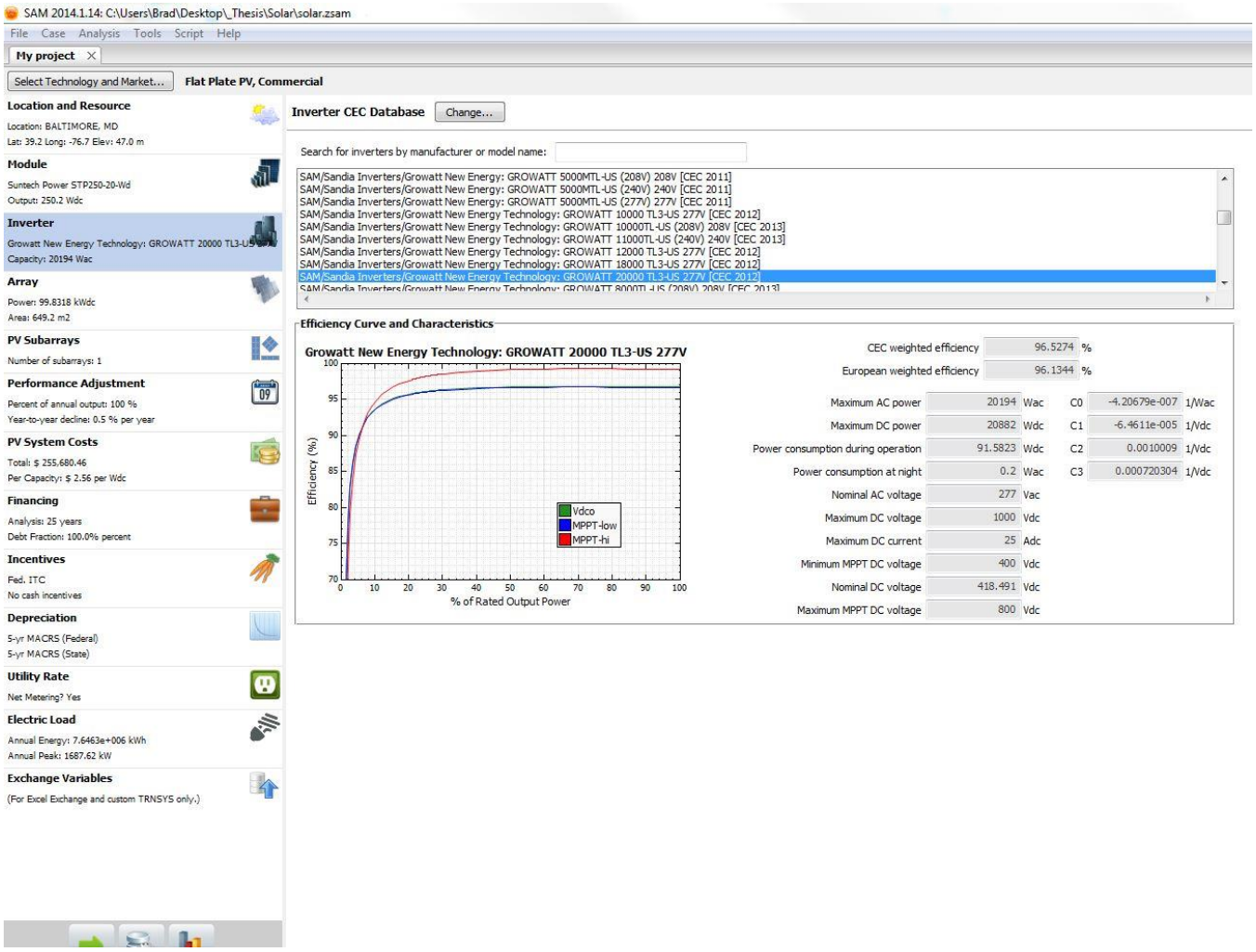


FIGURE 23 - SAM INVERTER SELECTION

The SAM software has a very large database of DC to AC inverters to choose from. When an inverter is selected the software will notify the user of any conflicts that may arise. It will often take a few tries to find an inverter that matches with the chosen solar module and the characteristics of the array. A Growatt inverter was selected for this study and a corresponding cut sheet is located in Appendix B.

Calculate Array Size

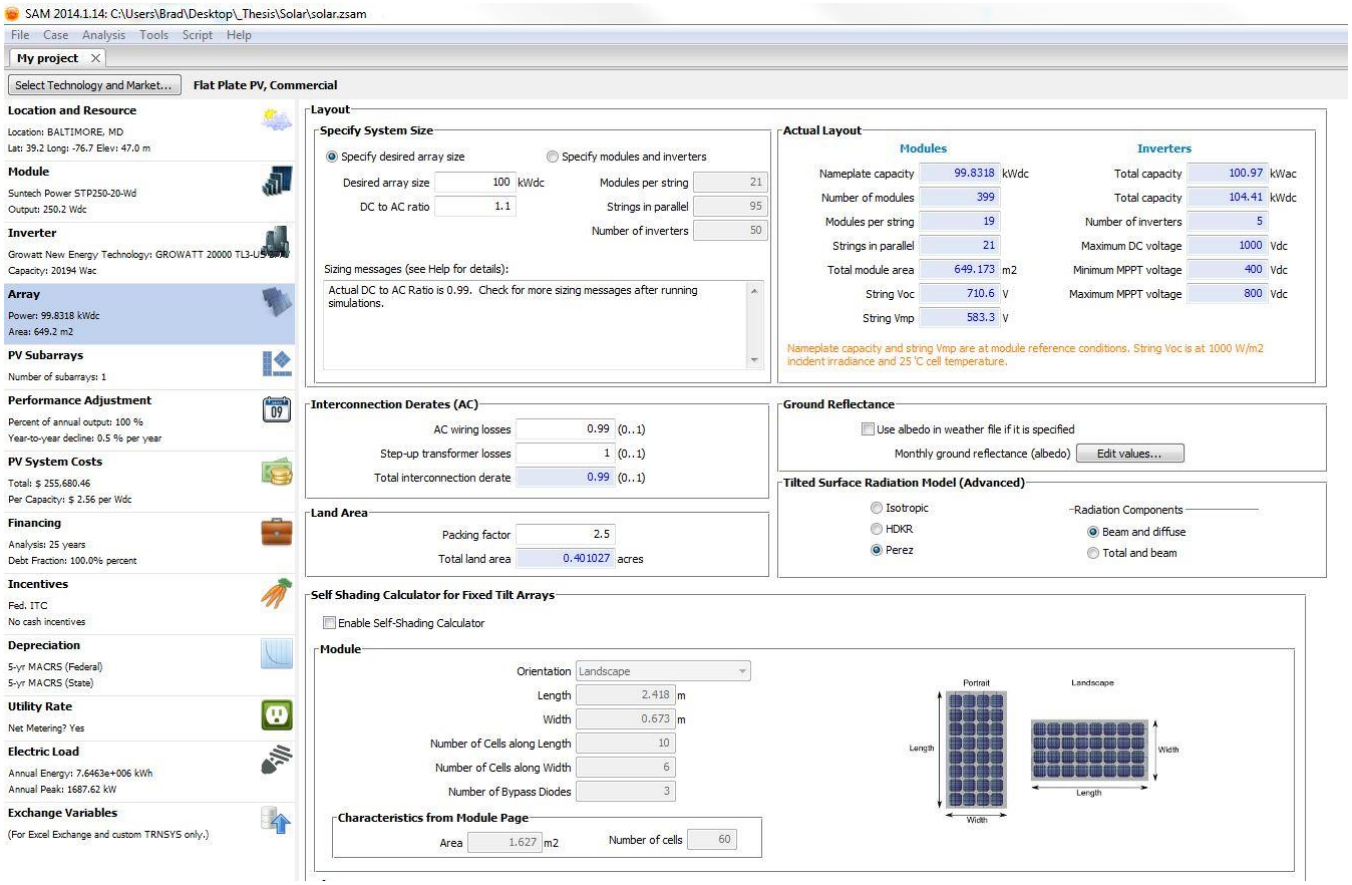


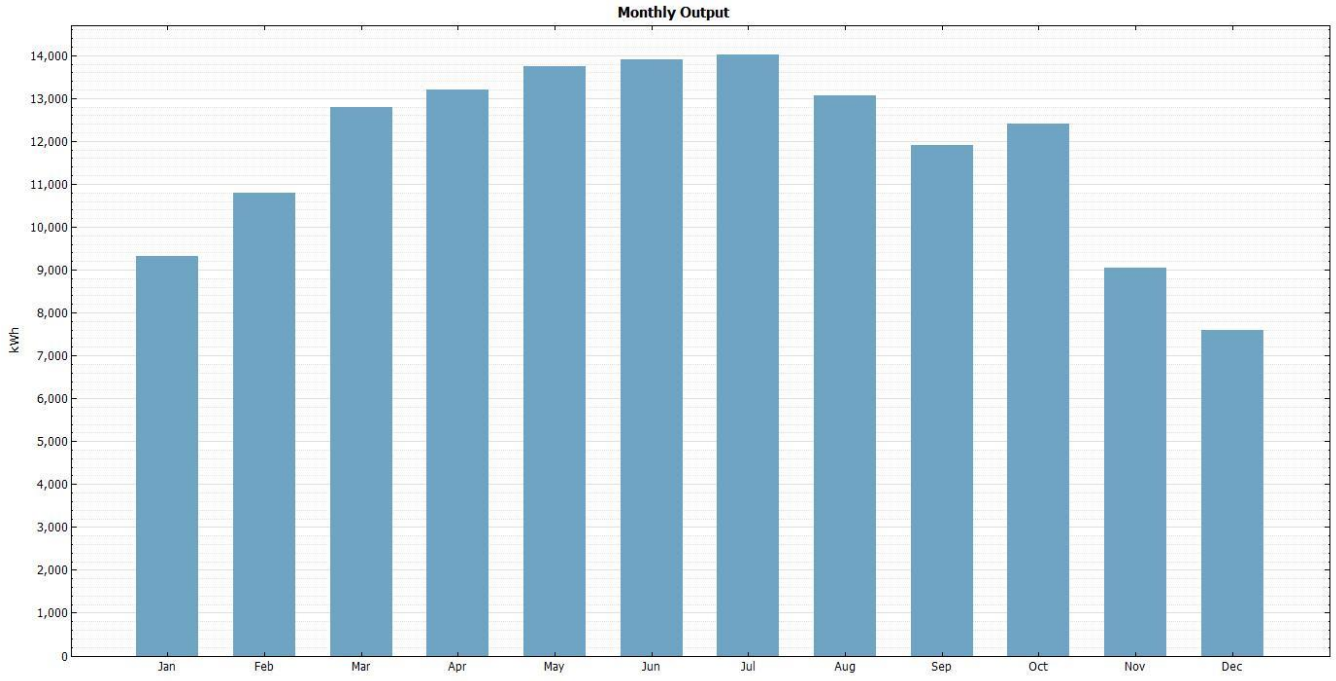
FIGURE 24 - SAM ARRAY SIZE

The section of SAM that works with the size of the array is the most interesting. For this study, an array of 400 panels was chosen based on the dimensions of the main casino roof. A 20 row array, with 20 panels in each row, will fit on the main casino roof. This is also taking into consideration inter-array shading and row spacing across the array. With 400 panels, five inverters will be needed.

Data Output

After loading the meteorological data for the project's location, specifying a solar module, and specifying an AC to DC inverter, SAM will run an annual simulation. The simulation ran for Casino Gold produced the following values. The numbers 1-12 represent the month of the calendar year.

	Monthly Energy (kWh)	Net ac output (kWh)	Net dc output (kWh)
1	9324.69	9324.69	9681.71
2	10785.1	10785.1	11175.7
3	12786	12786	13274.6
4	13206.1	13206.1	13724.6
5	13743.2	13743.2	14303.9
6	13895.6	13895.6	14481.4
7	14008.3	14008.3	14601.6
8	13070	13070	13626.9
9	11916.1	11916.1	12411.9
10	12397.3	12397.3	12885.2
11	9056.27	9056.27	9416.5
12	7594.67	7594.67	7912.91



Summary

The solar resource was analyzed at the location of the project, a solar module and inverter have been selected, and the array has been sized. The specified solar module is a Suntech STP250 – 20/Wd. The specified AC to DC inverter is a Growatt 20000TL3-US. The proposed array will contain a total of 400 panels and produce a peak load of about 14,000kWh in the month of June.

CONSTRUCTION BREADTH

Adding a solar array to the roof of the casino will result in an added cost for the project as well as extra work for the crew. The following analysis provides information related to the cost and schedule impacts of the new array.

Cost

The 2014 release of RS Means was used to find the following values. The Master Format 2010 section used for Photovoltaic Collectors is 263113500. The first table shows the values directly from RS Means, the second table shows the quantities estimated for this project.

RS Means Values

Description	Crew	Daily Output	Labor Hours	Bare Materials	Bare Labor	Bare Total	Total O&P
150W, 33V, PV Panel	1 Elec	8	1	645.00	53.50	698.50	790.00
48V, 5500W DC to AC inverter	1 Elec	2	4	3750.00	213.00	3963.00	4445.00
PV components, combiner box	1 Elec	4	2	189.00	107.00	296.00	368.00
Fuse, 15A for combiner box	1 Elec	40	0.2	16.40	10.65	27.05	34.00
PV Rack system, on steel framing, with standoff	R1A	11.00	1.455	55.00	64.00	119.00	157.50

Costs Specific to Casino Array

The following table uses RS Means values for pricing of materials and labor, except for the Suntech 250W panels. The Suntech STP250 – 20/Wd panel was priced at an average of $375 from multiple retailers. The data sheet for the Suntech panel can be found in the Appendix B. The number of crew members and corresponding daily output has been modified to finish the installation in 10 days. The breakdown of the construction time is found in the next section titled “Schedule.”

Description	No.	Crew	Daily Output	Labor Hours	Bare Materials	Bare Labor	Bare Total
250W, 37V, Suntech PV Panel	400	6 Elec	48	1	150,000	21,400	171,400
Growatt DC to AC inverter	5	5 Elec	10	4	18,750	1,065	19,815
PV components, combiner box	1	1 Elec	4	2	189.00	107.00	296.00
Fuse, 15A for combiner box	21	1 Elec	40	0.2	344.40	223.65	568.05
PV Rack system, on steel framing, with standoff	400	4 R1A	44	1.455	22,000	25,600	47,600

Schedule

Using the labor information gathered from the 2014 release of RS Means, an estimate for the length of time needed to install the new solar array can be calculated. The table below takes labor hours and daily output directly from the Photovoltaic Collectors section 263113500 in RS Means.

Description	No.	Crew	Daily Output	Labor Hours	Total Hours	Days
250W, 37V, Suntech PV Panel	400	1 Elec	8	1	400	50
Growatt DC to AC inverter	5	1 Elec	2	4	20	2.5
PV components, combiner box	1	1 Elec	4	2	2	0.25
Fuse, 15A for combiner box	21	1 Elec	40	0.2	4.2	0.5
PV Rack system, on steel framing, with standoff	400	R1A	11.00	1.455	582	37

The length of installation for each component calculated in the table above would have a significant impact on the schedule of the project. Assuming that the Suntech panels and the racks can be installed simultaneously, an installation of 8 to 10 days would be desirable. This much shorter installation time would not have a significant impact on the overall 18 month construction of the casino.

To achieve an 8-10 installation time for the array, the amount of workers needs to be increased. A 6 man crew, working in teams of two, will be able to handle the installation of the panels. An R1A crew consists of two workers already, so the project will need 4 of these crews totaling 8 workers. The total amount of workers assigned to the installation of the solar array will be 14.

Estimated Construction Times

Description	No.	Crew	Daily Output	Labor Hours	Days
250W, 37V, Suntech PV Panel	400	6 Elec	48	1	8.3
Growatt DC to AC inverter	5	5 Elec	10	4	0.5
PV components, combiner box	1	1 Elec	4	2	0.25
Fuse, 15A for combiner box	21	1 Elec	40	0.2	0.5
PV Rack system, on steel framing, with standoff	400	4 R1A	44	1.455	9.1

The number of days calculated from the Estimated Construction Times table shows that the solar array installation can be completed in less than 10 days. All 6 of the electricians will begin by installing the Suntech panels and that will take just over 8 days. The 9th day of installation will be for the electricians to

finish installing the panels and install the inverters. While the electricians are working, the 4 R1A crews will also be working on the installation of the PV rack system. The PV rack system will take about 9 days for the crew to install.

Conclusion

The total cost estimate for the materials of the proposed solar array is $191,283. The total cost of labor is estimated to be $48,396. Adding materials and labor together results in $239,680 estimated for the entire installation. This estimation does not include profit. The installation will take a total period of 10 days and will not significantly impact the 18 month construction schedule for Casino Gold.

STRUCTURAL BREADTH

The proposed solar array on the casino roof creates a new load and it requires an evaluation of the structural members supporting it. The main roof for the casino is the top of the third level. This roof has a width of 168 feet and a length of 300 feet. The chosen Suntech 250 watt polycrystalline solar module has a width of 3.25 feet and a length of 5.4 feet. With a weight of 40 pounds, the panel exerts a load of 3lbs/ft^2. The dimensions of both the roof and panel can be found in Appendix C.

The calculations for the following structural analysis can also be found in Appendix C. The structural calculations analyze the roof decking, a roof joist, joist girder, and the supporting column. All of the joists, joist girders, and columns for the roof structure are consistent throughout the third level.

Dead Loads

- 3psf - Suntech panel self-weight
- 1psf - 3-ply ready roofing (AISC Table 17-13, 14th Edition)
- 1.5psf - Rigid insulation, R-25 (AISC Table 17-13, 14th Edition)
- 3psf - ¾" wood sheathing (AISC Table 17-13, 14th Edition)
- 10psf - Superimposed dead load
- 1.78psf - Vulcraft 1.5B x 22 gauge roof decking (Vulcraft Roof Decking Table)

Live Loads

- 30psf – Snow Load

Roof Deck

The roof deck meets the requirements for a 3-span, unshored condition, determined form the Vulcraft Roof Deck table.

Current Roof Joist

- 21plf – 32LH09 Roof Joist (Steel Joist Institute Joist Catalog, LRFD Table)
- Span of 60ft, spacing of 5' 8"
- An LRFD load combination of [1.2D+1.6S] was used in evaluating the current roof joist.
- W_{utl} = 445plf
- W_{tl} = 310plf

Evaluation of the Roof Joist

- Use Steel Joist Institute Long Span Steel Joist LRFD Table
- 32LH09 joist designation and a clear span of 60ft
    - W_{utl} = 534plf (from table) > 445plf (from calculations), OK
    - W for L/360 = 180plf (from table)
    - W for L/240 = **270plf < 310plf** (from calculations), **current roof joist is not big enough for the new load of the solar array**

Choosing a New Roof Joist

- Increase size of joist to satisfy the deflection criteria that was not met in the previous section
    - Choose a new joist of 32LH11
        - W_{utl} = 643plf (from table) > 445plf (from calculations), OK
        - W for L/360 = 216plf (from table)
        - W for L/240 = 324plf > 313plf (from calculations), OK
- **New 32LH11 joist is adequate**
    - Self-weight of 5psf

Evaluation of Joist Girder

The current joist girder for the roof is a 60G10N20K. This notation shows that the joist girder is 60 inches deep, has 10 panels, and has an unfactored point load of 20 kips. The evaluation conducted in the attached calculations shows an actual point load of less than 20 kips, proving that the joist girder is adequate. The girder has a self-weight of 93plf, or 2psf, found in the Steel Joist Institute LRFD joist girder table.

Evaluation of a Column

The casino is designed with W8X48 columns on the third level, supporting the roof structure. The columns have a height of 13 feet. When evaluating the P_u on the column a tributary area of 3,360ft^2 is used. This leads to a P_u of 275 kips for the column. Using Table 4-1 in the AISC 14th Edition, a value of $\varnothing P_u$ = 421k for a W8X48 column is much larger than the calculated 275k. This proves that the columns in the current design are able to support the new loading condition.

Conclusion

After evaluating the structural members of the third level, the calculations determine that the current roof joists must increase in size. The roof joists must increase from 32LH09 to 32LH11. The current roof decking, joist girders and columns of the third level are adequately designed to support the new load of the solar array.

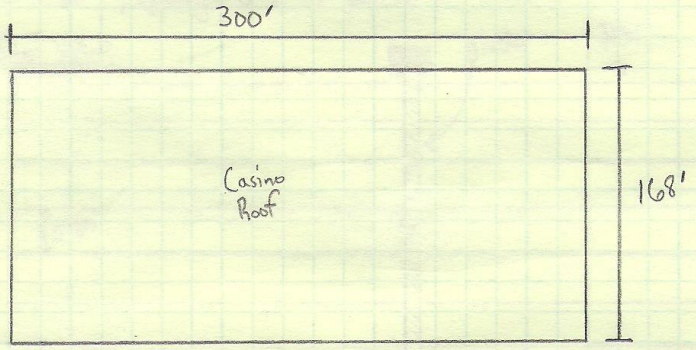
APPENDIX A – LUMINAIRE DATA SHEETS

APPENDIX B – SOLAR EQUIPMENT DATA SHEETS

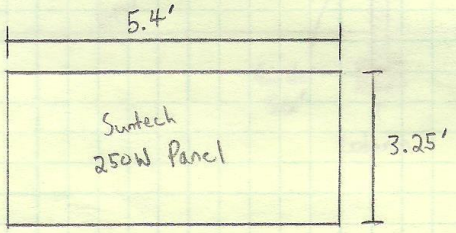
APPENDIX C – STRUCTURAL CALCULATIONS

Structural Calculations | Brad Robertson

Roof Dimensions



Panel Dimensions



Panel Weight: 40 lbs

Dead Load: $\frac{40 \text{ lbs}}{17.55 \text{ ft}^2} = 2.3 \text{ psf}$

Dead Loads

3 psf → Panel

1 psf → 3-ply ready roofing
1.5 psf → R-25 rigid insulation
3 psf → 3/4" wood sheathing
} AISC Table 17-3, 14th Edition

10 psf → Superimposed dead load

1.78 psf → 1.5B × 22 gauge roof decking (Vulcraft Roof Deck Table)

Live Load

30 psf → snow load

Total Loads

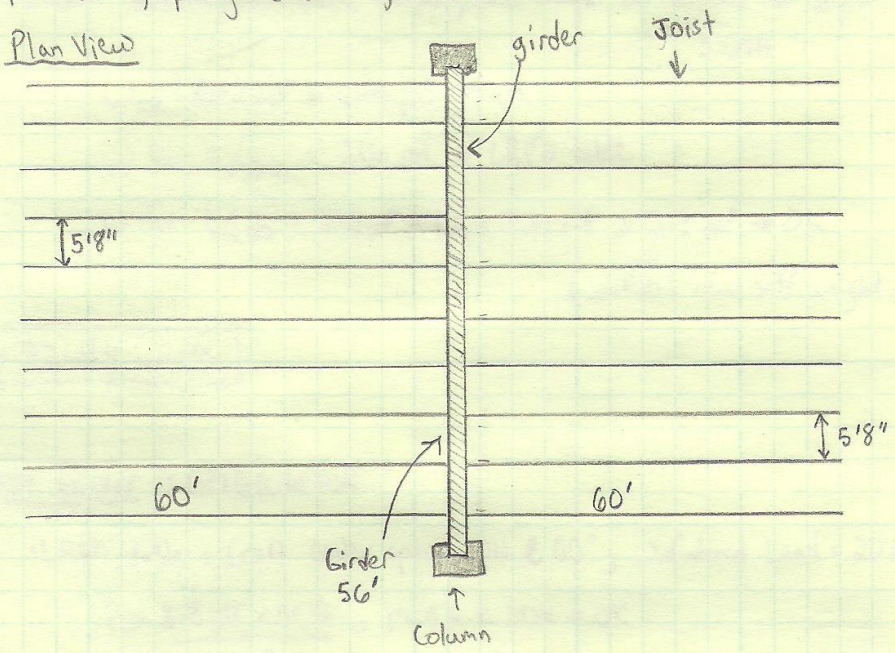
21 psf → Dead load
30 psf → Live load

Structural Calculations | Brad Robertson

Load Combination: 1.2D + 1.6S, assume no uplift or other live loads, LRFD

Span = 60', Spacing = 5'8" → joists

Plan View



Joist

32LH09 → 21 plf → Steel Joist Institute LRFD Table

$[1.2D + 1.6S] \times$ joist self wt $= [(1.2)(21psf) + (1.6)(30psf)] \times 5.67ft = 420\ plf$

$w_{ult} = 420\ plf + (1.2 \times \text{joist weight}) = 420\ plf + (1.2 \times 21plf) = 445\ plf$

$w_{+1} = (21psf + 30psf)(5.67ft) = 290plf + \text{joist wt} = 290plf + 21plf = 310plf$

- Use SJI Longr Span Steel Joist LRFD Table
- 32LH09 Joist designation and a clear span of 60'

$w_{ult} = 534\ plf > 445\ plf \rightarrow OK$

w for $L/360 = 180\ plf \rightarrow$ from table

w for $L/240 = 180plf \times 1.5 = 270\ plf < 310\ plf \rightarrow$ Joist does <u>not</u> work

- 32LH09 does <u>not</u> meet deflection criteria

Structural Calculations | Brad Robertson

New Joist

- Choose 32LH11 from LRFD table, self weight of $\frac{24\,plf}{5.67ft} \rightarrow 5\,psf$

$W_{u+l} = 643\,plf > 445\,plf \rightarrow OK$

W for $L/360 = 216\,plf \rightarrow$ LRFD table

W for $L/240 = 216\,plf \times 1.5 = 324\,plf > 313\,plf \rightarrow OK$

(includes new self weight of joist)

- 32LH11 works

Joist Girder : 60G10N20K

- LRFD Table : 60ft Girder span, 10N @ 60", Unfactored Load = 20k

$P_u = \frac{313\,plf \times 56ft}{1000} = 17.5k < 20k \rightarrow OK$

- LRFD Table : $93\,plf/60ft = 2\,psf$

- Girder 60G10N20K works

Column

- W8X48, height 13ft
- Tributary Area of $60' \times 56' = 3{,}360\,ft^2$

$P_u = [1.2D + 1.6S] \times area = [1.2(21psf + 5psf + 2psf) + 1.6(30)] \times 3360\,ft^2$

$P_u = \frac{274{,}176}{1000} = 275k$

- Table 4-1 in AISC, 14th Edition : $\phi P_n = 421k > 275k \rightarrow OK$

- Column W8X48 works