



## **Lighting Design for the Built Environment II**

**Design Project: Outdoor Lighting Models in AGi32**

**Sustainable Outdoor Parking Lot Lighting Design**

**Student: Yahya Sogodok**

**Instructor: Prof Kevin Houser**

**10/14/2024**



## **EXECUTIVE SUMMARY**

This project aimed to design a sustainable outdoor parking lot lighting system that complies with IES RP-8-22, LEED SS Credit, and ANSI-ASHRAE-IES 90.1 standards. The design incorporated GLN Galleon II luminaires from COOPER Lighting Solutions, with poles spaced 60 feet horizontally and 57 feet vertically across a 660 x 352 square foot area. The lighting system achieved energy efficiency, with a result of 0.34 W/ft<sup>2</sup>, closely complying with the 0.026 W/ft<sup>2</sup> requirement of ANSI/ASHRAE-IES 90.1. Additionally, the design passed the LEED SS Credit for Light Pollution Reduction, with a 0.0% light trespass result, well below the maximum 1.5% threshold. Parametric analysis revealed that increasing pole height reduced average and maximum illuminance but improved light uniformity, aligning with the goal of achieving uniform lighting distribution across the outdoor parking lot. While vertical illuminance complied with the IDA/IES MLO-2011 standards for poles under 30 feet, adjustments may be required for higher pole configurations because pole height is proportional to the pole spacing. Overall, the project successfully designed a sustainable and environmentally friendly parking lot lighting system.

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## **INTRODUCTION**

Commercial, residential, institutional, and public facilities often have adjacent parking lots designed for individuals to safely park their cars. The project involves designing an outdoor lighting system for a parking lot that meets sustainability and lighting standards, with a focus on compliance with LEED Sustainable Sites Credit for Light Pollution Reduction. The design aims to minimize light trespass, reduce sky-glow, and improve nighttime visibility, following guidelines from organizations like IES, ANSI/ASHRAE 90.1, and Darksky International (IDA/IES MLO 2011). The project is implemented using AGi32 lighting software, with pole height and pole spacing used as independent variables, while horizontal average, maximum, and uniformity, along with vertical maximum and average illuminance, serve as dependent variables. The goal is to create a sustainable outdoor parking lot lighting design.

# METHODS

## Description of the Space

### 1. Geometry and Assumptions:

The parking lot is approximately 660' x 352'. It is bounded by a roadway to the west and south, while the east side is bordered by green space. To the north, the parking lot is adjacent to a residential neighborhood. The lot has two main entrances: one on the west side and another on the south side. A complete AutoCAD file, containing detailed site dimensions and layout, was provided.

### 2. Assumptions for Pavement and Islands:

It is assumed that the island areas within the parking lot are covered with grass, while the pavement is covered with asphalt.

## Programming

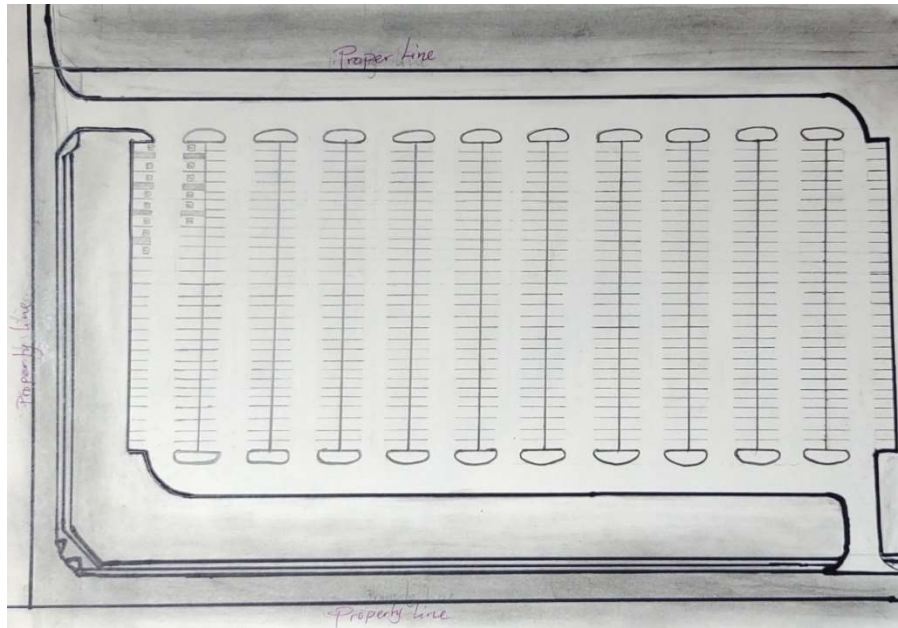
The first step of the lighting design process consists of setting the objectives and defining the desired outcome. Here, I establish key design considerations, such as location targets, illuminance, uniformity, energy sustainability, color rendering, visual comfort/glare, and compliance with relevant codes and standards, including LEED and IES guidelines.

### Prioritized List of Lighting Design consideration and Criteria

Considerations	Criteria	Reference Standard
Location Targets	The designer shall lay out a grid of points on the pavement at a maximum spacing of one-third the light fixture mounting height, commencing within one-half the grid spacing from the perimeter boundary.	RP-8-22, pg 17-9
Photometric Targets	Illuminance Vertical: 0.1 fc min Horizontal: 0.2 fc min	RP-8-22, pg 17-10
	Uniformity Vertical: 20:1 fc Max:Min Horizontal: 0.2 fc Max:Min	RP-8-22, pg 17-10
Time and Durations	Lighting controls: Luminaires shall be turned off or the power reduced automatically by a minimum of 75% during nonoperating hours	ANSI-ASHRAE-IES 90.1
Colorimetric Properties	<b>CCT selection</b> in achieving the desired lighting performance, safety, and visual comfort is important. 2700-3000 K.	RP-8-22 and Prof Kevin Houser Preference
Energy efficiency	Exterior lighting power allowance is 200 W/ft <sup>2</sup> or 0.026 W/ft <sup>2</sup>	ANSI-ASHRAE-IES 90.1
Lighting Maintenance: Light loss factor	LLF: 0.8	RP-36-24
<u>Uplight</u>	Upward Waste Light Ratio (UWLR) : 1.5%	LEED v4
Vertical Illuminance	0.3fc	IDA/IES MLO-2011

## Schematic Design

This step addresses important considerations such as the type of light sources, light direction and distribution, luminaire placements, and the choice of pavement materials. Before transitioning to a detailed CAD drawing, it can be helpful to create a hand sketch to visualize the space. This step allows designers to explore the interplay of light and shadow, ensuring the final layout meets both functional and aesthetic goals. It is essential to consider the transformative nature of light: how it will enhance safety and security by improving visibility, minimizing glare, and ensuring visual comfort. Additionally, the design needs to comply with international guidelines for outdoor lighting, such as those set by the Illuminating Engineering Society (IES), LEED, and IES Standard 90.1.



## Design Development

The lighting design process involved detailed computer modeling, equipment selection, calculations, and implementing programming and schematic design goals. This precision ensured that once the lighting direction and distribution were determined, the ideal luminaire could be chosen to execute the schematic design and programming decisions.

For the outdoor parking lot, I decided to use a type II short luminaire with a lumen output of 4,384 and a correlated color temperature of 2,700K. The BUG rating for this simulation is B1-U0-G1, as the parking lot is located in Lighting Zone 2, where lower light levels are typically required to minimize light pollution. I initially considered using the B2-U0-G2 luminaire, but the horizontal illuminance it produced was too high for the area's requirements. This discrepancy may have resulted from the luminaire's high lumen output and power rating, which were excessive for this particular application.

The final layout included 60 back-to-back luminaires and 10 single-sided luminaires. This combination provided adequate coverage while ensuring we stayed within the appropriate lighting levels for the zone. Overall, by carefully selecting the luminaires and adjusting for

lumen output, I was able to create a balanced lighting plan that met the necessary criteria for both efficiency and regulatory compliance.

**Controls Narrative**

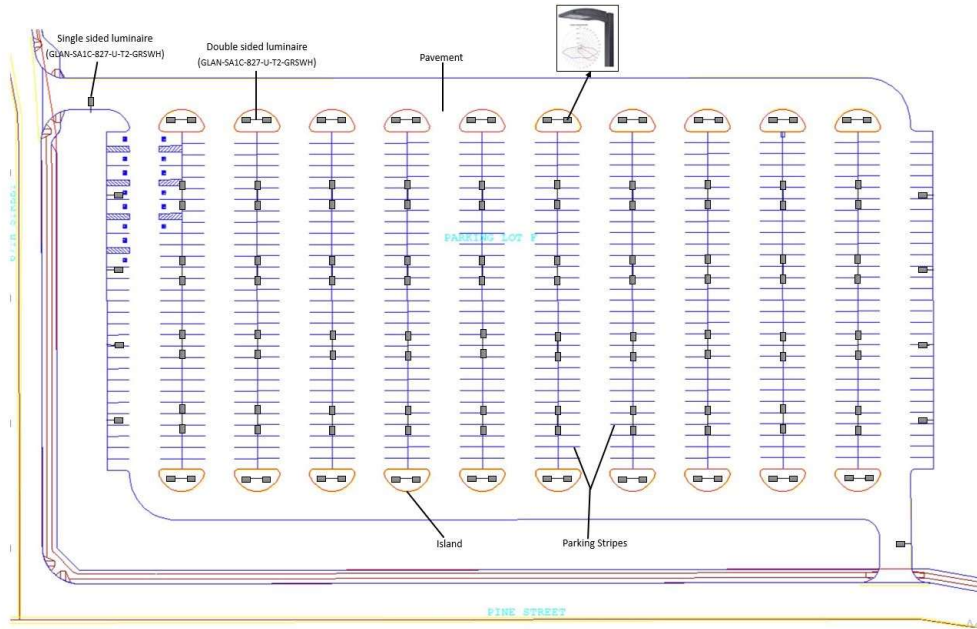
Lighting control is a vital component for outdoor parking lots, especially when designing for sustainability. To achieve energy efficiency, it is necessary to implement time switches, dimmers, and other automated lighting control devices. Since parking lots typically operate at night and require adequate illumination, it is essential to establish a lighting schedule that automatically turns the lights on from 6 pm to 6 am and off during the day. Automating this process will help reduce energy consumption in line with standards such as ASHRAE 90.1 and IES RP-8-22, which focus on energy efficiency and best practices for outdoor lighting.

The lighting control system should automatically reduce lighting levels by at least 75% during non-business hours to further conserve energy. Additionally, all lighting systems except for general safety lighting should be turned off during non-business hours. This ensures the parking lot remains safe while minimizing unnecessary energy use.

## RESULTS

In this section, we will present the findings from the design of a sustainable outdoor parking lot lighting system, created using the Agi32 lighting design software. The goal of this design is to provide an energy-efficient and environmentally friendly solution that complies with key industry standards, including ANSI-ASHRAE-IES 90.1, LEED SS Credit, IES-IDA recommendations, and IES RP-8-22 guidelines.

### Specification of the Design



The design plan for a parking lot with lighting elements are indicated above.

**Parking Stalls:** Rows of parking spaces are shown, with each row marked to accommodate vehicles.

**Light Poles or Fixtures:** The placement of these light poles ensures that the parking lot is illuminated uniformly.

**Annotations and Details:** There are labels providing additional details about the type of lighting fixtures used, pole heights, and possibly power or control system details.

The parking lot plan illustrates the luminaire locations, with each pole spaced 60 feet horizontally and 57 feet vertically, covering a surface area of 660 x 352 square feet. The luminaires used are the GLN Galleon II from COOPER Lighting Solutions.

### Luminaire Schedule

Fixture Type	Description	Fixture (Manufacturers and Models)	Light Source	Total Delivered Lumens	Fixt. Load (W)	Driver	Mounting height	Function
Pole mounted	Galleon area and roadway luminaire (1) 80 cri, 2700k, 1050ma light square with 16 LEDS and type ii optics With white glare reduction shield	Cooper lighting solutions (FORMERLY EATON) GLAN-SA1C-827-U-T2-GR5WH	CCT: 2700K, 80 CRI	4386 lm X 130 pieces 60 Back-Back luminaires 10 single luminaires	57	Electronic Driver	variable	Parking lot lighting

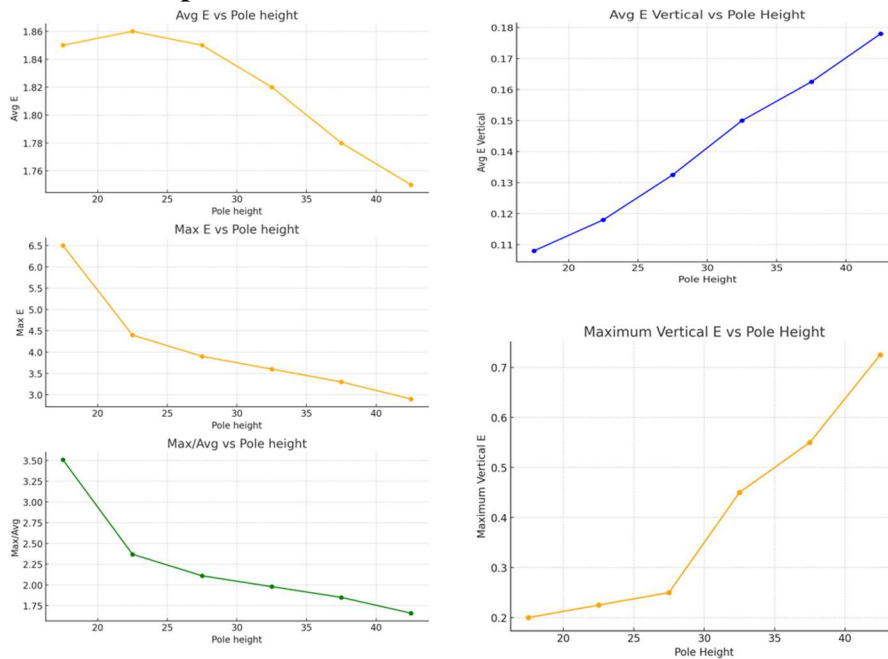
## Quantitative Performance Summary of Final Solution

Quantitative Performance Summary of the final solution				
Criteria		Reference Standard	Compliance	Pass/Fail
The designer shall lay out a grid of points on the pavement at a maximum spacing of one-third the light fixture mounting height, commencing within one-half the grid spacing from the perimeter boundary.		RP-8-22, pg 17-9	Grid of points on the pavement is 10 x 10	/
Illuminance	Vertical: 0.1 fc min	RP-8-22, pg 17-10		Fail
	Horizontal: 0.2 fc min			
Uniformity	Vertical: 20:1 fc Max:Min	RP-8-22, pg 17-10		Fail
	Horizontal: 0.2 fc Max:Min			
Lighting controls: Luminaires shall be turned off or the power reduced automatically by a minimum of 75% during nonoperating hours		ANSI-ASHRAE-IES 90.1	Time switches are used to switch on and off light automatically. Lighting schedule for the night is from 6pm to 6am.	/
CCT selection in achieving the desired lighting performance, safety, and visual comfort is important. 2700-3000 K.		RP-8-22 and Prof Kevin Houser Preference	2700 K	/
Exterior lighting power allowance is 200 W/ft <sup>2</sup> or 0.026 W/ft <sup>2</sup>		ANSI-ASHRAE-IES 90.1	0.034 W/ft <sup>2</sup>	Pass
LLF: 0.8		RP-36-24	0.8	/
Upward Waste Light Ratio (UWLR) : 1.5%		LEED v4	0.0%	Pass

Criteria	Reference Standard	Pole height	Compliance	Pass/Fail
0.3fc	IDA/IES MLO-2011	17.5	0.2	Pass
		22.5	0.225	Pass
		27.5	0.25	Pass
		32.5	0.45	Fail
		37.5	0.55	Fail
		42.5	0.725	Fail

The LEED v4 and ANSI ASHRAE IES 90.1 standards passed with a LEED compliance maximum threshold of 1.5%, although my simulation result was 0.0%, which suggests a passed value within the range. For Standard 90.1, the required compliance value is 0.026 W/ft<sup>2</sup>, and my simulation produced a similar result at 0.34 W/ft<sup>2</sup>, indicating the design is performing close to expectations in terms of energy efficiency. Vertical illuminance levels complied with the IDA/IES MLO-2011 standards for pole heights under 30 feet, but as the pole height increased, the system failed to meet the required thresholds. A Light Loss Factor (LLF) of 0.8, based on the RP-36-24 guidelines, was used for the design. The lighting design uses a correlated color temperature (CCT) of 2700 K, providing a warm.

## Parametric Comparisons



The graph in the top-left corner shows the relationship between average horizontal illuminance (Avg E) and pole height. As the pole height increases, the average illuminance decreases. Similarly, the graph comparing maximum horizontal illuminance and pole height demonstrates a clear trend: higher poles result in lower maximum lighting intensity. This implies that, at specific points in the parking lot, the lighting becomes less concentrated as the poles grow taller. Additionally, the Max/Avg ratio steadily declines with increasing pole height, indicating a more uniform lighting distribution across the parking lot, with less difference between the brightest and average-lit areas.

## DISCUSSION

The results of the sustainable outdoor parking lot lighting system design demonstrate successful compliance with key industry standards, including LEED SS Credit, ANSI-ASHRAE IES 90.1, IES RP-8-22, and IDA/IES MLO-2011. The luminaire layout, consisting of GLN Galleon II luminaires from COOPER Lighting Solutions, was implemented in AGi32 software, with poles spaced 60 feet horizontally and 57 feet vertically over a 660 x 352 square foot area. The lighting design demonstrate some energy efficiency performance, as shown in the simulation result of 0.34 W/ft<sup>2</sup>. This value closely aligns with the recommended ANSI/ASHRAE IES 90.1 threshold of 0.026 W/ft<sup>2</sup>. In addition, in term of air pollution, the design passed LEED compliance with a 0.0% light trespass value, which is within the maximum threshold of 1.5%.

We access the vertical illuminance by using the MLO illuminance calculation method. The results revealed that the system complied with the IDA/IES MLO-2011 standards for pole heights under 30 feet, but failed to comply at heights greater than 30. A Light Loss Factor (LLF) of 0.8, based on RP-36-24 guidelines and recommendation from Prof. Kevin Houser, was used throughout the design. The use of 2700K, 80 CRI luminaires resulted in warm.

Parametric comparisons revealed that increasing pole height reduced both average and maximum horizontal illuminance, indicating that taller poles distribute light over a broader area but reduce intensity at specific points. Additionally, the Max/Avg ratio decreased with pole height, demonstrating improved uniformity in light distribution. This trade-off between intensity and uniformity is key to achieving a balanced, energy-efficient design.

## CONCLUSIONS

The design of the sustainable outdoor parking lot lighting system successfully complied with some key standards, such as LEED SS Credit, ANSI-ASHRAE IES 90.1, and IDA/IES MLO-2011. The simulation results revealed a low light trespass value of 0.0%, and an energy performance of 0.34 W/ft<sup>2</sup>, aligning with ANSI/ASHRAE IES 90.1 recommendations. The parametric analysis highlighted the impact of pole height on lighting distribution, demonstrating that higher poles reduce both average and maximum illuminance but improve uniformity, which is crucial for energy efficiency and even lighting distribution. While the design met vertical illuminance standards for poles under 30 feet, further adjustments may be needed for higher poles to maintain compliance. Overall, the project provides a solid framework for creating energy-efficient, environmentally responsible parking lot lighting solutions.

# APPENDIX A

## IDA/IES MLO 2011 compliance test

**Obtrusive Light - Compliance Report**  
 IDA/IES MLO-2011, LZ2 - Moderate Ambient Lighting  
 Filename: Final\_simulation  
 10/13/2024 6:05:19 PM

**Illuminance** Pole Height: 17.5 ft  
 Maximum Allowable Value: 0.3 Fc

Calculations Tested (5):

Calculation Label	Test Results	Max. Illum.
MLO_Calculation_III_Seg1	PASS	0.2
MLO_Calculation_III_Seg2	PASS	0.3
MLO_Calculation_III_Seg3	PASS	0.1
MLO_Calculation_III_Seg4	PASS	0.2
MLO_Calculation_III_Top	FAIL	0.7

**Obtrusive Light - Compliance Report**  
 IDA/IES MLO-2011, LZ2 - Moderate Ambient Lighting  
 Filename: Final\_simulation  
 10/13/2024 8:01:37 PM

**Illuminance** Pole Height: 22.5 ft  
 Maximum Allowable Value: 0.3 Fc

Calculations Tested (5):

Calculation Label	Test Results	Max. Illum.
MLO_Calculation_III_Seg1	PASS	0.2
MLO_Calculation_III_Seg2	PASS	0.3
MLO_Calculation_III_Seg3	PASS	0.2
MLO_Calculation_III_Seg4	PASS	0.2
MLO_Calculation_III_Top	FAIL	0.7

**Obtrusive Light - Compliance Report**  
 IDA/IES MLO-2011, LZ2 - Moderate Ambient Lighting  
 Filename: Final\_simulation  
 10/13/2024 5:47:23 PM

**Illuminance** Pole Height: 27.5 ft  
 Maximum Allowable Value: 0.3 Fc

Calculations Tested (5):

Calculation Label	Test Results	Max. Illum.
MLO_Calculation_III_Seg1	PASS	0.2
MLO_Calculation_III_Seg2	PASS	0.3
MLO_Calculation_III_Seg3	PASS	0.2
MLO_Calculation_III_Seg4	PASS	0.3
MLO_Calculation_III_Top	FAIL	0.7

**Obtrusive Light - Compliance Report**  
 IDA/IES MLO-2011, LZ2 - Moderate Ambient Lighting  
 Filename: Final\_simulation  
 10/13/2024 7:01:51 PM

**Illuminance** Pole Height: 32.5 ft  
 Maximum Allowable Value: 0.3 Fc

Calculations Tested (5):

Calculation Label	Test Results	Max. Illum.
MLO_Calculation_III_Seg1	PASS	0.2
MLO_Calculation_III_Seg2	FAIL	0.4
MLO_Calculation_III_Seg3	FAIL	0.5
MLO_Calculation_III_Seg4	FAIL	0.7
MLO_Calculation_III_Top	FAIL	0.7

**Obtrusive Light - Compliance Report**  
 IDA/IES MLO-2011, LZ2 - Moderate Ambient Lighting  
 Filename: Final\_simulation  
 10/13/2024 7:20:40 PM

**Illuminance** Pole Height: 37.5 ft  
 Maximum Allowable Value: 0.3 Fc

Calculations Tested (5):

Calculation Label	Test Results	Max. Illum.
MLO_Calculation_III_Seg1	PASS	0.3
MLO_Calculation_III_Seg2	FAIL	0.4
MLO_Calculation_III_Seg3	FAIL	0.7
MLO_Calculation_III_Seg4	FAIL	0.8
MLO_Calculation_III_Top	FAIL	0.7

**Obtrusive Light - Compliance Report**  
 IDA/IES MLO-2011, LZ2 - Moderate Ambient Lighting  
 Filename: Final\_simulation  
 10/13/2024 7:40:27 PM

**Illuminance** Pole Height: 42.5 ft  
 Maximum Allowable Value: 0.3 Fc

Calculations Tested (5):

Calculation Label	Test Results	Max. Illum.
MLO_Calculation_III_Seg1	FAIL	0.6
MLO_Calculation_III_Seg2	FAIL	0.5
MLO_Calculation_III_Seg3	FAIL	0.9
MLO_Calculation_III_Seg4	FAIL	0.9
MLO_Calculation_III_Top	FAIL	0.7

Ernergy Consumption

Area = 232796 Sq.ft  
 Total Watts = 7812  
 LPD = 0.034 Watts/Sq.ft  
 UWLR = 0.000

**LEED v4 COMLIANCE RESULTS FOR POLE HEIGHT 22.5 ft**  
**Upward Waste Light Ratio (UWLR)**  
 Maximum Allowable Value: 1.5 %


Calculated UWLR: 0.0 %  
 Test Results: **PASS**

**Results for vertical and Horizontal illuminance**

Pole height (ft)	Horizontal illuminance			Vertical Illuminance	
	Avg E (fc)	Max E (fc)	Max/Avg	Avg E Vertical (fc)	Max E Vertical (fc)
17.5	1.85	6.5	3.51	0.108	0.2
22.5	1.86	4.4	2.37	0.118	0.225
27.5	1.85	3.9	2.11	0.1325	0.25
32.5	1.82	3.6	1.98	0.15	0.45
37.5	1.78	3.3	1.85	0.1625	0.55
42.5	1.75	2.9	1.66	0.178	0.725

**Cut Sheets**

Summary of the luminaires used in the project and their specification sheets

		Quantity
The parking lot was design using the GLN Galleon luminaire		130 pieces

Signify Classified - Internal  
 Cooper Lighting Solutions Photometric Lab  
 1121 Highway 74 South  
 Peachtree City, GA 30269

Scaled Data Report



**Test Information**

Test Method: LM-79-08  
 Report Number: P526680  
 TEST IS SCALED FROM IESNA LM-79-08 TEST DATA (G3-2011-057-14)  
 Test Lab: INNOVATION CENTER  
 Issue Date: 5/27/2021  
 Manufacturer: COOPER LIGHTING SOLUTIONS (FORMERLY EATON)  
 Product Line: STREETWORKS  
 Catalog Number: GLAN-5A1C-B27-U-T2-GRSWH  
 Description: GALLEON AREA AND ROADWAY LUMINAIRE  
 (1) 80 CRI, 2700K, 1050mA LIGHTSQUARE WITH 16 LEDS AND TYPE II OPTICS  
 WITH WHITE GLARE REDUCTION SHIELD  
 Light Source: -  
 Ballast/Driver: ELECTRONIC DRIVER

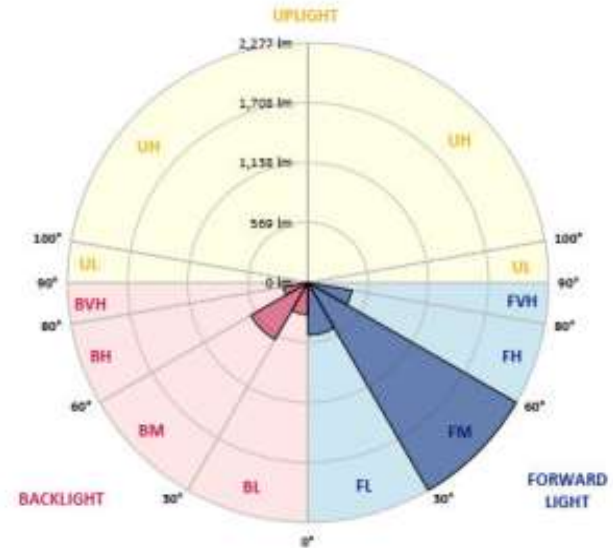
**Summary**  
 Lumens per Lamp: N/A  
 Luminaire Lumens: 4386 lumens  
 Efficiency: N/A  
 Efficacy: 76.9 lumens/watt  
 Luminous Opening: Rectangular (W 0.5' x L: 0.5' x H: 0')  
 IES Classification: Type II - Short  
 BUG Rating: B1 - U0 - G1

Input Watts (W): 57  
 Input Voltage (V): NR  
 Input Current (Ain): NR  
 Voltage Rise (V): NR  
 Power Factor: NR  
 Total Harmonic Distortion (THDi): NR  
 Frequency (hertz): 60  
 Stabilization Time: NR  
 Operation Time: NR  
 Ambient Temperature (°C): NR  
 Test Distance: 24 FT

**LUMINAIRE CLASSIFICATION, SYSTEM LUMEN TABLE AND BUG RATING:**

Zone	Lumens	% Fixture	Zone Rating/Lumen Limit		
			B	U	G
FL (30°-60°)	496.4	11.4			
FM (30°-60°)	2276.9	51.9			
FH (60°-90°)	421.2	9.6			G0/900
FVH (80°-90°)	10.3	0.2			G1/100
BL (0°-30°)	305.4	6.9	B1/500		
BM (30°-60°)	624.9	14.2	B1/1000		
BH (60°-90°)	237.3	5.4	B1/500		G1/500
BVH (80°-90°)	13.6	0.3			G1/100
UL (90°-100°)	0.0	0.0		U0/0	
UH (100°-180°)	0.0	0.0		U0/0	

BUG Rating: B1-U0-G1  
 Type II Short

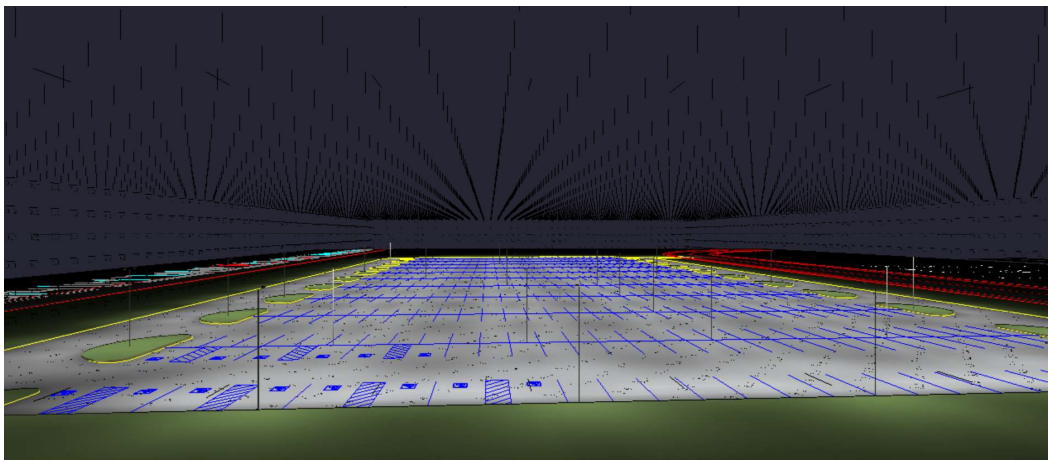
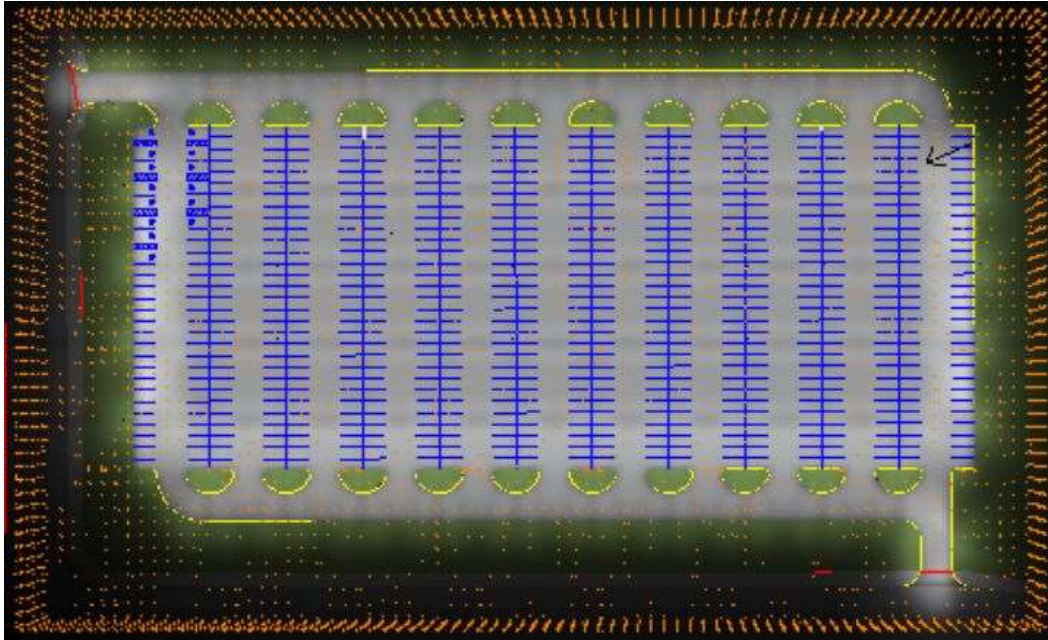


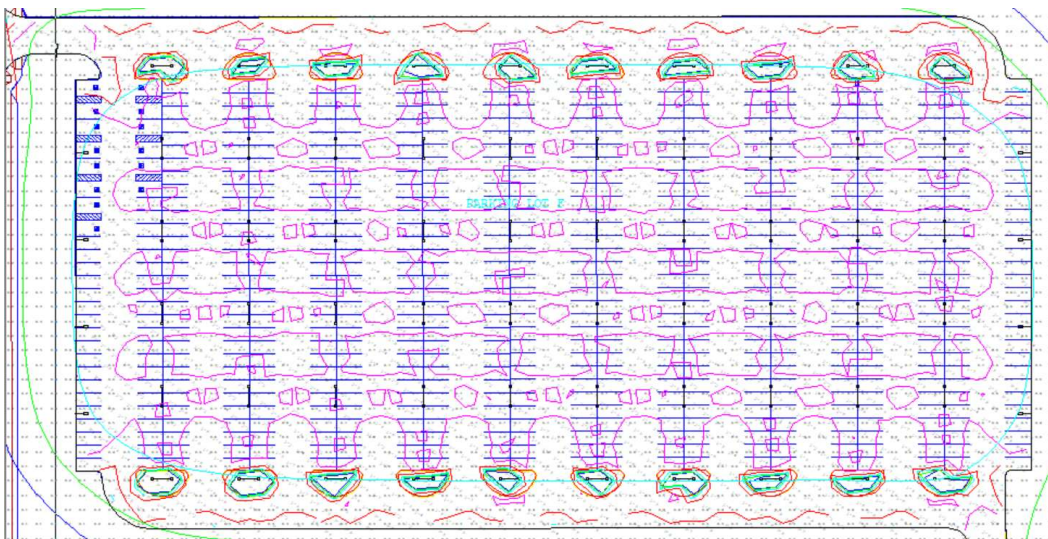
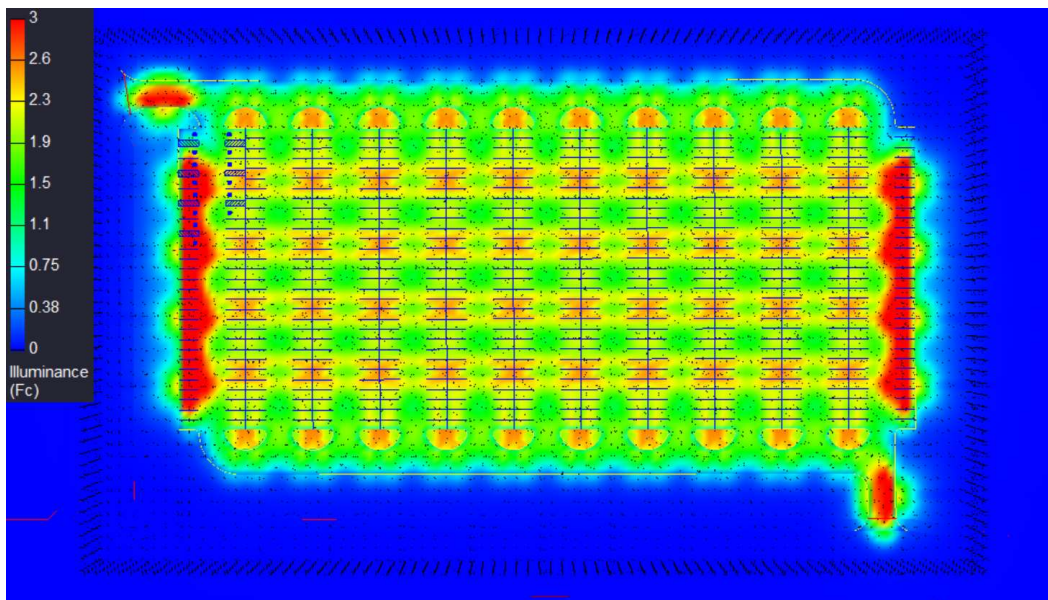
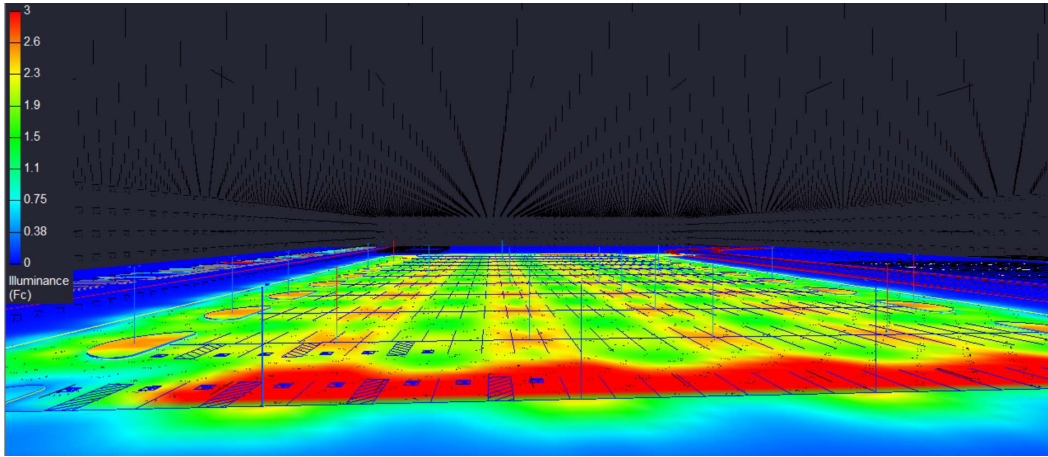
FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE

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Simulations Results

This section displaces the rendered parking lot





## Energy Consumed

Luminaire Schedule									
Symbol	Qty	Label	Arrangement	Description	LLF	Luminaire Lumens	Luminaire Watts	Total Watts	
□	60	GLAN-SA1C-827-U-T2-GRSWH_4386_1	Back-Back	GLAN-SA1C-827-U-T2-GRSWH-B!U0G1-4000-B2B	0.800	4386	57	6840	
□	10	GLAN-SA2C-830-U-T2-GRSWH2U0G	Single	GLAN-SA2C-830-U-T2-GRSWH	0.800	9424	108	1080	

### Limitations of the Design

While the sustainable outdoor parking lot lighting design was thoughtfully developed, there were several limitations. Notably, the color temperature (CCT) and the spacing of the luminaires were not considered in this version of the design. Additionally, the BUG rating selected was B1-U0-G1, rather than B2-U0-G2, because the parking lot was assumed to be in Lighting Zone 2. This decision was made to minimize light pollution and comply with zone-specific requirements.

### Future Considerations

For future iterations of the design, it will be important to explore different color temperature (CCT) values to enhance both visual comfort and aesthetics. Additionally, adjusting the spacing between luminaires, rather than relying solely on pole height adjustments, should be considered to optimize lighting distribution and efficiency.

## References

ANSI\_ASHRAE\_IES 90.1-2022

ANSI\_IES RP-8-22.

ANSI\_IES RP-36-24.

LEED SS Credit