#### ENGINEERING CENTER OAKLAND UNIVERSITY



#### JOHNCONLEY

#### AE SENIOR THESIS LIGHTING + ELECTRICAL

04.15.2015 OAKLANDSMITHGROUPJJR UNIVERSITY...

#### **BUILDING OVERVIEW**

BUILDING OVERVIEW

LIGHTING

concept

lobby + atrium

auditorium

ELECTRICAL DEPTH

SKYLIGHT ADDITION

daylighting

mechanical breadth

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QUESTIONS COMMENTS



nameengineering centerlocationrochester, miowneroakland university school of engineering and computer sciencesize136,653 sfcost\$57 millionarchitectsmithgroupjjrconstructionwalbridge aldinger company

#### **BUILDING LOCATION**

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#### LIGHTING

Exterior Walkway Lobby + Atrium Auditorium Project Labs

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## LIGHTING



#### ELECTRICAL

#### LIGHTING

Exterior Walkway Lobby + Atrium Auditorium Project Labs

#### ELECTRICAL

Branch Circuit Analysis Short Circuit Analysis

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#### SKYLIGHT ADDITION



#### ELECTRICAL

#### LIGHTING

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#### **SKYLIGHT ADDITION**



#### ELECTRICAL

#### LIGHTING

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#### ELECTRICAL

Branch Circuit Analysis Short Circuit Analysis

SKYLIGHT ADDITION Daylighting Mechanical Breadth Structural Breadth

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#### LOBBY + ATRIUM





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#### **PROJECT LABS**

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#### Paving the Road to Progress

Learning From the Past

Embracing the Present

Looking to the Future

Purpose + Direction

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## GOALS

Meet IES ILLUMINANCE recommendations and ASHRAE 90.1 lighting POWER DENSITIES, enhance the ARCHITECTURE through clean lines of light, enhance functions of TRANSITION and COLLABORATION through lighting fixture choices

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## GOALS

Meet IES ILLUMINANCE recommendations and ASHRAE 90.1 lighting POWER DENSITIES, EMBRACE the present state of the industry by creating an appropriate space for LEARNING and PRESENTATIONS, and create a VERSATILE design for a multitude of functions

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## All On Test Taking Scene



100% 100% 100% 100% 100%



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50%

50%

OFF

OFF

50%



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ninance (lx) 16.00 33.00 0.00

## Presenter Scene





50%

50%

OFF

100%

50%



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### ELECTRICAL BRANCH LOADS

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	Location: Supply From: Mounting: Enclosure:	ELEC 27 LDP-H11 Surface Type 1	3			
r	Circuit Description	Trip	Poles			
	Lighting	20 A	1	792		
	Lighting	20 A	1			
	Lighting STAIR _261X	20 A	1			
	Lighting	20 A	1	2697		
	Spare	20 A	1			
	Lighting Project Labs	20 A	1			
	Spare	20 A	1	0 VA		
	Spare	20 A	1			
	Spare	20 A	1			
	Space			0 VA		
	Space					
	Space					
	Space			0 VA		
	Space					
	Space					
		Tot	al Load:	753		
		Tota	I Amps:	27		
	Load Classification	Con	nected L	oad		
ng		16184 VA				
-		-				

Panelboard: H23 Updated

VA Normal Load Changes													
Circuit	Area		VA	VA Taken Out	VA Replaced	New Total							
H11-1	Auditorium		2005 VA	2005 VA	2544 VA	2544 VA							
H13-1	South Entry + Lobb	y 1	1732 VA	1022 VA	343 VA	1053 VA							
H13-3	Handrail + Exterior	1	322 VA	322 VA	368 VA	368 VA							
H13-12	Lobby 1		0 VA	0 VA	443 VA	443 VA							
H13LS-3	Lobby 1		757 VA	354 VA	104 VA	507 VA							
H21-1	North Entry		1395 VA	140 VA	162 VA	1417 VA							
H21-5	Handrail		173 VA	72 VA	384 VA	485 VA							
H23-1	Lobby 2		1059 VA	675 VA	408 VA	792 VA							
H23-5	Lobby 2		1237 VA	1237 VA	630 VA	630 VA							
H23-6	Project Labs		0 VA	0 VA	2587 VA	2587 VA							
H23-8	Project Labs		3420 VA	3420 VA	3018 VA	3018 VA							
H23-11	Project Labs		0 VA	0 VA	900 VA	900 VA							
H23LS-1	Exterior 2		92 VA	92 VA	320 VA	320 VA							
H23LS-5	Lobby 2		3455 VA	258 VA	53 VA	3250 VA							
H31-7	Atrium 3		2461 VA	280 VA	0 VA	2181 VA							
H31-8	Atrium 3		386 VA	386 VA	254 VA	254 VA							
H51-7	Atrium 5		3428 VA	450 VA	356 VA	3334 VA							
L11A-34	Auditorium	_	501 VA	501 VA	1113 VA	1113 VA							
	т	otals:	22.4 KVA	11.2 KVA	14.0 KVA	25.2 KVA							

	Volts:	480Y/27	7		14,000							
	Phases:	MCB										
	Wires:	4			Bus	Rating:	100 A					
	MCB Rating: 100 A											
	р			r	Polec	Trin	Circuit Description	скт				
	вс		-	i oles	p	circuit Description	CAI					
)26			1 20 A Lighting Ro		Lighting Room 179F, 297, 202, 212	2						
	4509	26 VA			1	20 A	Lighting MENS 265E	4				
			630	2587	1	20 A	Lighting Project Labs	6				
110					1	20.4	Linhting					

			50	100	-	2070	Lighting Project Labs	•
3018					1	20 A	Lighting	8
	0 VA	0 VA			1	20 A	Spare	10
			900 VA	0 VA	1	20 A	Spare	12
0 VA					1	20 A	Spare	14
	0 VA	0 VA			1	20 A	Spare	16
			0 VA	0 VA	1	20 A	Spare	18
0 VA					1	20 A	Spare	20
	0 VA	0 VA					Space	22
			0 VA	0 VA			Space	24
0 VA							Space	26
	0 VA	0 VA					Space	28
			0 VA	0 VA			Space	30
VA	453	5 VA	4116	5 VA				
A	16	A	15	A				

S	Panel Totals	Estimated Demand	Demand Factor
		12947 VA	80.00%
16184 VA	Total Conn. Load:		
12947 VA	Total Est. Demand:		
19 A	Total Conn.:		
16 A	Total Est. Demand:		

Load C	
	 18.0 KVA
	 16.0 KVA
	 14.0 KVA
	 12.0 KVA
	 10.0 KVA
VA Taken Out	 8.0 KVA
11.2 KVA	 6.0 KVA
	 4.0 KVA
	 2.0 KVA
	 0.0 KVA

#### Changes



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lobby + atri<u>um</u>

auditorium

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daylighting mechanical breadth CONCLUSION





I DaysimPS [C:\DAYSIM\Run1\Existing.hea]	
File Site Building Luminaires Simulation Analysis Help	
Annual Daylight Metrics	Color Bar Copy to file
Daylight Autonomy   Target Illum. 500.0 Cal	Contours
Percent of points above 50%: 27.58	
0.7	
	0.2000





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1 Translucent Fiberglass Reinforced Polymer (FRP) exterior face

2 Structural Grid Core (standard aluminum + thermally-broken options)

3 Translucent Insulation (TI) thermal packages including Lumira®aerogel

4 Translucent Fiberglass Reinforced Polymer (FRP) interior face



#### MAE TOPIC DAYLIGHTING

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DA<sub>500</sub> From 27.58% to 66.7%



#### MAE TOPIC DAYLIGHTING

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🛓 Energy Ta	Energy Tables (KWh)													
Controlled Zone Grand Total														
	January	February	March	April	May	June	July	August	September	October	November	December	Total	
Base	327.9	289.52	319.32	306.53	327.9	306.53	319.32	327.9	297.95	327.9	315.11	310.74	3776.65	
Optimal	181.33	149.76	161.95	153.86	164.11	153.39	159.72	164.39	150.11	170.5	174.93	186.99	1971.08	
Algorithm	179.36	149.45	161.91	153.89	164.11	153.41	159.76	164.38	150.05	169.7	172.63	182.99	1961.7	
Savings	148.53	140.06	157.4	152.63	163.78	153.11	159.55	163.52	147.89	158.2	142.48	127.75	1814.95	
													·	

## Savings of 1815 kWh With one dimmed zone

#### Dimmed Zone

\_

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SkyCa
Con
Project
Electric Lig
Ltg. Energy w
Lighting Energ

Ic: S	kyligh	t Desigr	n Assistant - Tabi	ular Results								
mpany	npany Name: John Conley											
t Desc	Description: Oakland University Engineering Center											
ghting Usage kWh/yr												
ithout S	Skylights	20,163	Lighting Fraction Saved									
gy w/ S	kylights	20,163	Full daylighting (h/yr)	112								
		Saving	js from Design Skylightin	g System								
			Annual Energy	Annual Cost								
la dete		Savings	Savings (kWh/yr)	Savings (\$/yr)								
Jpdate Results		Lighting										
(000110		Cooling	-49	-\$3								
		Heating	4,632	\$108								
		Total	4,582	\$106								

FACE SHEE COMBINAT	% LI( 2³/₄'	GHT TR. ' (70 mm)	ANSMIS ) thick pa	SION nels	note 1	SOLAR HEAT GAIN note 3 COEFFICIENT @0° ム					
EXTERIOR COLOR	INTERIOR COLOR	0.53 "U"	0.29 / <mark>0.23</mark> "U" note 2	0.22 / <mark>0.14</mark> "U" note 2	0.18 <mark>/0.10</mark> "U" note 2	<mark>0.05</mark> "U" note 2	0.53 "U"	0.29 / <mark>0.23</mark> "U" note 2	0.22 / <mark>0.14</mark> "U" note 2	0.18 <mark>/0.10</mark> "U" note 2	<mark>0.05</mark> "U" note 2
Greenish Blue	White	25	14	5	3	12	0.50	0.23	0.14	0.10	0.19
Aqua	White	29	17	6	4	13	0.45	0.24	0.14	0.10	0.21
Rose	White	30	18	6	4	14	0.46	0.24	0.15	0.10	0.21
Ice Blue	White	35	20	8	6	18	0.54	0.28	0.17	0.12	0.26
White	White	20	15	8	5	14	0.38	0.23	0.15	0.11	0.18
Crystal	White	35	20	12	8	20	0.52	0.28	0.17	0.13	0.25
Crystal	Crystal	50	30	15	10	NA	0.65	0.33	0.18	0.13	NA

#### U Value = 0.23 with VLT at 20%

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Initial Cost For 3 Pre-Engi

Initial Cost Reductions Reduction in th Reduction in th **Total Initial Co** 

Annual Savings From Sky Lighting Dimm **Cooling Losses** Heating Saving **Total Annual** Payback Period (Years)

## Payback Period Calculation

	No. Units	Price	per Unit	Do	llar Amount
jineered Kalwall SkyRoof Products				\$	30,700.00
he Area of GreenRoof	480	\$	20.00	\$	9,600.00
he Tonnage of Steel Beams	0.33975	\$	473.00	\$	160.70
ost				\$	20,939.30
yCalc					
ning Savings				\$	116.00
S				\$	(3.00)
gs				\$	108.00
				\$	221.00
					94.7

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ost				\$	20,939.30
yCalc					
ning Savings				\$	116.00
S				\$	(3.00)
gs				\$	108.00
				\$	221.00
					94.7

#### 94.7 Years!?

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ost			\$	20,939.30
yCalc				
ning Savings			\$	116.00
S			\$	(3.00)
gs			\$	108.00
			\$	221.00
				94.7



	No. Units	Price	e per Unit	Do	llar Amount
Initial Cost For 3 Pre-Engineered Kalwall SkyRoof Products				\$	30,700.00
Initial Cost Reductions					
Reduction in the Area of GreenRoof	1436.2	\$	20.00	\$	28,723.85
Reduction in the Tonnage of Steel Beams	0.33975	\$	473.00	\$	160.70
Total Initial Cost				\$	1,815.45
Annual Savings From SkyCalc					
Lighting Dimming Savings				\$	116.00
Cooling Losses				\$	(3.00)
Heating Savings				\$	108.00
Total Annual				\$	221.00
Payback Period (Years)					8.2



8.2 Years



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#### SKYLIGHT ADDITION



#### ELECTRICAL

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Enhanced the architecture

Improved space aesthetic

Used energy efficient sources

#### LIGHTING

- Met quantitative design criteria



**SKYLIGHT ADDITION** 

#### ELECTRICAL

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#### LIGHTING

#### Acknowledged lighting changes

Confirmed equipment sizing

#### ELECTRICAL

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#### **SKYLIGHT ADDITION**

Enhanced roof aesthetics

Increased daylight conditions

Energy savings through dimming and passive heating

ELECTRICAL



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#### ELECTRICAL

# Initial Savings of \$28,884 Annual Savings of \$221 8.2 year payback period

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COMING TOGETHER IS A BEGINNING. KEEPING TOGETHER IS PROGRESS. WORKING TOGETHER IS SUCCESS.

-HENRY FORD





# THANKYOU

My professors

My Parents

My girlfriend Deirdre

All of my AE friends

# A special thanks to

# SmithGroupJJR and Oakland University for letting me use this building

- For the knowledge they have shared and the support they have given me

## Lobby

Lobby Lighting Power Density						
Туре	Quantity	Input Watts	Lobby Watts	<b>Corridor Watts</b>	Elev. Lobby Watts	
L2	3	19.5	58.5			
L6	35	21	336	399		
L7	38 FT	6.3 W/FT	239.4			
L8	10	24	240			
L9	12	8			96	
		<b>Total Watts</b>	874	399	96	
		<b>Total Area</b>	1933	1564	176	
		Calculated LPD	0.45	0.26	0.55	
	ASHRAE 90.	1 LPD Allowed	0.90	0.66	0.64	
		Difference	0.45	0.40	0.09	

Values from ASHRAE 90.1	-2013
Lobby	0.9
Corridors <8ft wide	0.66
Elevator lobby	0.64
Seating Area, General	0.54

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/	Q_3"	~		3'	- 1"
	T	<u>]</u>	<u>\</u>		
			)   		
			₽ 		

Illuminance Criteria | According to the IES Lighting Handbook Lobbies | Circulation | Building Entries Day = 100 lux Eh, 50 lux Ev, 3:1 Avg:Min Night = 50 lux Eh, 20 lux Ev, 3:1 Avg:Min Lounges | Pleasure Reading = 200 lux Eh, 100 lux Ev, 1.5:1 Avg:Min Stairs | High Activity = 100 lux Eh, 50 lux Ev, 2:1 Avg:Min Dining Areas | Coffee Shops = 100 lux Eh, 30 lux Ev, 3:1 Avg:Min







bby + Atrium Fixture Schedule	
Description	Manufacturer
Recessed 6" round LED downlights, tempered clear glass enclosure, anodized aluminum reflector, Outdoor rating IP65, 4000K, 85CRI	Bega
4' x 2.64" Recessed linear LED downlight, flush mount, extruded aluminum housing, white powder coat steel reflector, frosted acrylic lens, replaceable LED modules and drivers from below, 4000 K, 80 CRI	Focal Point
Linear surface mounted LED, 11-5/16" length segments, anodized aluminum extrusion with injection molded end caps, clear high strength acrylic lens, 3500K, 85 CRI	USAI
8' linear LED pendant, aluminum extrusion with a matte anodized finish, frosted white acrylic lens diffuser, suspended with adjustable aircraft cable with push button glider, 4000K, 90 CRI	Delray Lighting Inc.
Same product as L6 with a modified wall to ceiling housing and flex whip connector 7' x 2.25" x 2.275" Mullion mounted	Focal Point
assymmetric LED fixture, aluminum extruded housing, precision milled endcaps, 4000K	A-Light
1' x 1.5" x 2.1" linear LED wall grazing fixture, narrow 10 x 60 degree beam angle, 4000K, 84 CRI	Philips Color Kinetic
Cove lighting LED fixture with a 4" opening from ceiling grid and total 7.3" depth above ceiling, extruded aluminum housing with	Focal Point

## Auditorium

Auditorium Lighting Power Density					
Туре	Quantity	Input Watts	Total Watts		
L7	159 FT	6.3 W/FT	1001.7		
L12	31	22.9	709.9		
L13	14	87	1218		
L14A	5	42	210		
L14B	19	8	152		
		<b>Total Watts</b>	3291.6		
		Total Area	4408		
	(	Calculated LPD	0.747		
	ASHRAE 90.	1 LPD Allowed	1.24		
		Difference	0.49		



Illuminance Criteria | According to the IES Lighting Handbook Educational Facilities | Auditoria

Lecture Hall | Audience | AV and Notes = 50 lux Eh, 15 lux Ev, 2:1 Avg:Min Lecture Hall | Audience | AV and No Notes = 10 lux Eh, 6 lux Ev 2:1 Avg:Min Lecture Hall | Speaker/Panel | AV = 30 lux Eh, 18 lux Ev (<3 times audience) Lecture Hall | Speaker/Panel | No AV = 500 lux Eh, 200 lux Ev, 3:1 Avg:Min Circulation | AV = 2 lux Eh, 10 lux Ev, 5:1/3:1 Avg:Min Circulation | All but AV = 10 lux Eh, 30 lux Ev, 10:1/3:1 Avg:Min Reading + Writing = 300 lux Eh



		Auditorium Fixt
Type Symbol	Image	Description
L7 L12	-184 5 T	Linear surface m segments, anodi injection molded acrylic lens, 3500 Cove lighting LED from ceiling grid ceiling, extruded
		polyester powed 66.7" x 66.7" x 3. fixture, polished
L13		integrated acrylic light and acousti
L14A		4" Square recess flanged semi-spe transmissive lens 3500K
L14B		4" Square recess flanged semi-spe transmissive lens 3500K

#### torium Fixture Schedule

ription	Manufacturer
ar surface mounted LED, 11-5/16" length nents, anodized aluminum extrusion with tion molded end caps, clear high strength ic lens, 3500K, 85 CRI	USAI
e lighting LED fixture with a 4" opening ceiling grid and total 7.3" depth above ng, extruded aluminum housing with ester poweder coat, frosted lens, 3500K	Focal Point
" x 66.7" x 3.1" Ceiling mounted direct LED re, polished aluminum housing finish, grated acrylic cover, fabric covering as a and acoustic diffuser, 4000K	Sattler
quare recessed LED downlight, self- jed semi-specular reflector, highly smissive lens, 20 degree beam angle, K	Gotham
quare recessed LED downlight, self-	

ged semi-specular reflector, highly smissive lens, 60 degree beam angle,

Gotham

#### Kalwall Info. + Quote

# RADIANCE "trans" model of a translucent panel assuming # only direct normal hemispherical transmittance is available #  $R_d = C_r = C_o = C_b = 0.21 = diffuse reflectance$ #  $R_a = A_i = 0.08 = specular reflectance$ # S<sub>r</sub> = 0.0 = surface roughness # T<sub>d</sub> = 0.24 = direct normal diffuse hemispherical transmittance # T<sub>s</sub> = 0 = transmitted specularity (ideal diffuser)  $\# A_7 = T_s / (T_s + T_s) = 0$  $\# A_6 = \{T_d + T_a\} / (R_d + T_d + T_a) = 0.5333$ # A. = S. = 0  $\# A_1 = A_2 = A_3 = R_d / ((1-R_s) * (1-A_s)) = 0.48913$  $\# S_{c} = A_{c} * A_{7} * (1 - A_{1}) * A_{4} = 0$ # resulting Radiance material: void trans PANEL

```
/ 0.48913 0.48913 0.48913 0.08 0 0.5333 0
            A3 A4 A5 A6
```



"The 0.05 Lumira aerogel is not available with Self-Supporting" Ridge Roofs. The minimum width on a SSRR with hip ends is 8'-0". The Crystal/White with U=0.23 will still provide the 20% LT you asked for. I will submit pricing for this alternative using the 8' as the width? Also I recommend 30 PSF snow load as minimum for the Michigan area. I will only be able to provide the Material only costs. A rule of thumb (conservative) is to double the material cost for M&L for now. You should have your price next week."

From email correspondence to specify Kalwall Skyroof



4/7/2015

Mr. John Conley Pennsylvania State University Architectural Engineering University Park, PA

MATERIAL COST Packed F.O.B. Shipping Point, Freight Prepaid.

We propose to furnish and deliver Kalwall 2 3/4" translucent panel system for: (3) self-supported ridge skyroofs 20'-0" x 8'-0" wide OCD flat (27.25°) with hipped ends

Notes: 1) Roofs are designed for 20 PSF live load, 30 PSF snow load, 25 PSF wind load and 0 PSF drift load with L/60 deflection.

A) This estimate is not valid if loads are greater than those listed herein. Curbs must be designed to withstand the thrust load from Kalwall's Roof System. Price includes curb cap and flashing. 4) Price is based on using maximum number of standard 4'-0" wide modules. 5) For .14 "U" factor in lieu of .23 "U" factor. ADD ------ \$825.00

All exposed aluminum to be Kalwall corrosion resistant finish color selected from Kalwall standard colors which meet performance requirements of AAMA 2604.

Thermally broken translucent panels to have .070" super-weathering Crystal exterior faces, .045" White S-171 interior faces, standard 12" x 24" shoji grid pattern and .23 "U" factor.

Curbs are not included by Kalwall.

Pricing excludes field labor, final fasteners and caulking between edge perimeter and building. Pricing is issued in accordance with requirements transmitted through our sales representative Bruce Farber, but subject to Kalwall details and construction.

Warranty: Standard (1) year, unless otherwise indicated herein

Billie Jo Ouinta Estimating Manager (GS) CC: Control, Montgomery, Farber

This Ouote must be refigured after 30 days. Delivery can be scheduled only on receipt of firm order and approved drawings. This is subject to change without notice All shipments are F.O.B. our plant and State Sales and Use Taxes are not included. If Exemption information is not issued to Kalwall Corporation, or on file, tax will be added to our invoice. CANCELLATIONS: In the event of Buyers Cancellation of an order, Seller reserves the right to assess cancellation fees

Fax: 603-627-7905 Phone: 603-627-3861

MAILING ADDRES Post Office Box 237 Manchester, NH 03105

> BUDGET Estimate #: B103-0415

Project: Oakland University Engineering Center Location: Pittsburgh, PA Architect: Penn.State Univ. Architectural Engineering

\$30,700.00

Terms: Net 30 from date of invoice with credit approval No retainage allowed Service charge of 1 1/2 % will accrue and become payable on all invoices

not paid within thirty days from date of issue.

#### DAYSIM



#### 🛓 Control Algorithm Settings

#### Control Algorithm Settings (Values are for Critical Point)

Night Condition	Illuminance (Elec)	434.7	Month/Day/Time: 12/22 9:3AM
	Target	434.7	Sky: Weather Tape
Daylight Condition	Daylight Illum.	99.0	
	Daylight Signal Non-Dimmed	26.0 102.4	Reset Daylight Condition
	Target Dimming Level	500.0 0.898	
	Signal Off Condition	436.7	

×

# 50 55 60 65 70 75 🛓 Energy Tables (KWh) Controlled Zone Grand Total

BaysimPS [C:\DAYSIM\Run4\_NewKalwall\Kalwall2.hea]

File Site Building Luminaires Simulation Analysis Help

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Base	327.9	289.52	319.32	306.53	327.9	306.53	319.32	327.9	297.95	327.9	315.11	310.74	3776.65
Optimal	181.33	149.76	161.95	153.86	164.11	153.39	159.72	164.39	150.11	170.5	174.93	186.99	1971.08
Algorithm	179.36	149.45	161.91	153.89	164.11	153.41	159.76	164.38	150.05	169.7	172.63	182.99	1961.7
Savings	148.53	140.06	157.4	152.63	163.78	153.11	159.55	163.52	147.89	158.2	142.48	127.75	1814.95



## SKYCALC

#### SkyCalc: Skylight Design Assistant - Optional Inputs

Company Name: John Conley Project Description: Oakland University Engineering Center

Skylights	Default	User Revisions	Design Input
Skylight shape	Flat	Dome 💌	Dome
Height of dome (Rise) (ft)	2	2	2
Visible transmittance	8%	20%	20%
Solar heat gain coefficient	6%	28%	28%
Curb type	Wood	Integral frame	Integral frame
Frame type	Metal w/ thermal brk	Metal w/ thermal brk	Metal w/ thermal brk
Unit U-value (Btu/h•°F•ft <sup>2</sup> )	0.607	0.230	0.230
Dirtlight loss factor	70%		70%
Screen or safety grate factor	100%		100%
Light well reflectance	70%		70%
Well factor (WF)	78%		78%
Bottom of light well:			
Width (ft)	8.00	8.00	8.00
Length (ft)	20.00	20.00	20.00
Diffuser on bottom of well?	No	🔿 Yes, 💿 No	No

#### Additional Information for SkyCalc Input

**Electricity Cost** On-Peak = \$0.0567 per KWh Off-Peak = \$0.0537 per KWh Natural Gas Rate Total = \$0.685 per Therm Heating and Air Conditioning Systems

- Average Annual Gas Cost = \$6.10 per MMBtu = \$0.61 per Therm
- Transportation cost to Oakland University = \$0.75 per MMBtu = \$0.075 per Therm
- Air Conditioning = Evaporative Cooling
- Heating System = Gas/Oil Boiler

SkyCalc: Skyligh	it Design	Assistant - Tab	ular Results				
Company Name:	John Conley	y					
Project Description: Oakland University Engineering Center							
Electric Lighting Usage	kWh/yr						
Ltg. Energy without Skylights	20,163	Lighting Fraction Saved					
Lighting Energy w/ Skylights	20,163	Full daylighting (h/yr)	112				
	Savings from Design Skylighting System						
		Annual Energy					
Undete	Savings	Savings (kWh/yr)	Savings (\$/yr)				
Update Results	Lighting						
results	Cooling	-49	-\$3				
	Heating	4,632	\$108				
	Total	4.582	\$106				
		.,	<b>•</b> • • •				
SkyCalc: Skyligh	t Design	Assistant - Tab	ular Results				
SkyCalc: Skyligh Company Name:	<b>t Design</b> John Conley	Assistant - Tab	ular Results				
SkyCalc: Skyligh Company Name: Project Description:	<b>t Design</b> John Conley Oakland Un	Assistant - Tabo y iversity Engineering Cen	ular Results				
SkyCalc: Skyligh Company Name: Project Description:	<b>t Design</b> John Conley Oakland Un	Assistant - Tab y iversity Engineering Cen	ular Results ter				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage	<b>t Design</b> John Conley Oakland Un <b>kWh/yr</b>	Assistant - Tab y iversity Engineering Cent	ular Results ter				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights	<b>t Design</b> John Conley Oakland Un <b>kWh/yr</b> 20,163	Assistant - Tab y iversity Engineering Cen Lighting Fraction Saved	ular Results ter 11%				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr)	ular Results ter 11% 112				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr)	ter 11% 112				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998 Saving	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr)	ular Results ter 11% 112 g System				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998 Saving	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr) s from Design Skylightin Annual Energy	ter 11% 112 g System Annual Cost				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998 Saving Savings	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr) s from Design Skylightin Annual Energy Savings (kWh/yr)	ter 11% 112 g System Annual Cost Savings (\$/yr)				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998 Savings Lighting	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr) s from Design Skylightin Annual Energy Savings (kWh/yr) 2,165	ter 11% 112 g System Annual Cost Savings (\$/yr) \$116				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights	t Design John Conley Oakland Un kWh/yr 20,163 17,998 Savings Lighting Cooling	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr) s from Design Skylightin Annual Energy Savings (kWh/yr) 2,165 -37	ter 11% 112 g System Annual Cost Savings (\$/yr) \$116 -\$2				
SkyCalc: Skyligh Company Name: Project Description: Electric Lighting Usage Ltg. Energy without Skylights Lighting Energy w/ Skylights Update Results	t Design John Conley Oakland Un kWh/yr 20,163 17,998 Savings Lighting Cooling Heating	Assistant - Tab y iversity Engineering Cent Lighting Fraction Saved Full daylighting (h/yr) s from Design Skylightin Annual Energy Savings (kWh/yr) 2,165 -37 3,948	ter 11% 112 g System Annual Cost Savings (\$/yr) \$116 -\$2 \$92				

#### REFERENCES

SmithGroupJJR for plans, building models, and renders

Google Images and Maps

Cooper Bussman Short Circuit Method

Kalwall Information

ASHRAE 90.1 Lighting Power Densities

IES Lighting Handbook for Illuminance Recommendations

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#### https://images.google.com/ and https://www.google.com/maps/