

## SHERRERD HALL

### PRINCETON UNIVERSITY

JAMIE DEVENGER | THE PENNSYLVANIA STATE UNIVERSITY  
AE SENIOR THESIS | LIGHTING + ELECTRICAL | 04.14.2010



“LIGHT IS A CENTRAL THEME THROUGHOUT THE BUILDING. IT’S A KIND OF LANTERN, A LANTERN OF KNOWLEDGE AND CIRCULATION.” FREDERICK FISHER

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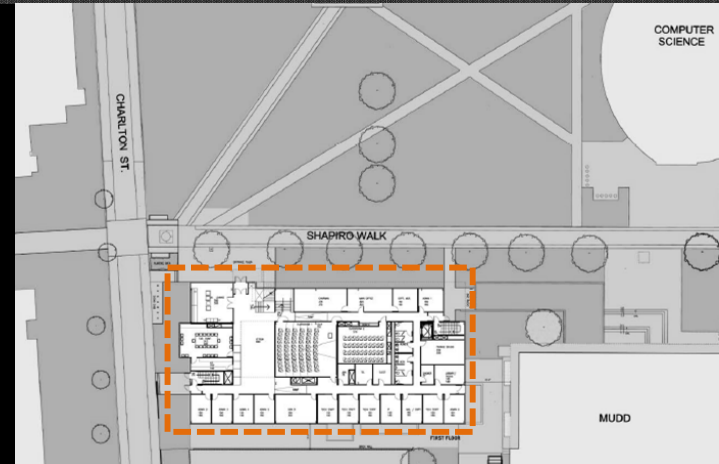
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ARCHITECTURAL CONCEPT  
SCOPE OF REDESIGN

SITE AND LOCATION	PRINCETON UNIVERSITY, NEW JERSEY
OCCUPANT	PRINCETON ORFE AND CITP DEPARTMENTS
SIZE	47,000 SQUARE FEET
LEVELS	4 (3 ABOVE GRADE)
DESIGN TEAM	
ARCHITECT	FREDERICK FISHER AND PARTNERS
LIGHTING DESIGNER	FISHER MARANTZ STONE
MEP ENGINEER	JOSEPH LORING ENGINEERS
STRUCTURAL ENGINEER	ROBERT SILMAN ASSOCIATES
CURTAIN WALL	W.J. HIGGINS AND ASSOCIATES
CONSTRUCTION MANAGER	BARR & BARR, INC., BUILDERS



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FREDERICK FISHER + PARTNERS

PHILOSOPHY A BUILDING HAS A COLLAGE-LIKE NATURE AS AN

# ASSEMBLAGE OF USE, MATERIAL, AND LIGHT

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“A BRIDGE BETWEEN SOCIAL SCIENCES  
AND ENGINEERING,” FREDERICK FISHER

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FAÇADE AND PERIMETER OFFICES  
LECTURE HALL  
OPEN WORK SPACE  
GRADUATE BULLPEN I

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NORTHWEST PERIMETER OFFICES  
GRADUATE BULLPEN I  
ATRIUM SKYLIGHT

ELECTRICAL DESIGN

FIVE SPACES  
COPPER VERSUS ALUMINUM FEEDERS  
ON-SITE GENERATOR DESIGN

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PERIMETER OFFICES + ATRIUM SKYLIGHT

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ROOF FRAMING FOR ATRIUM SKYLIGHT

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LIGHT AS A METAPHOR FOR KNOWLEDGE AND OPENNESS

LIGHT FILTERED THROUGH TRANSPARENT AND TRANSLUCENT ENCLOSURES

LIGHT TO SIMULATE MOVEMENT AND ENERGY FOR CIRCULATION



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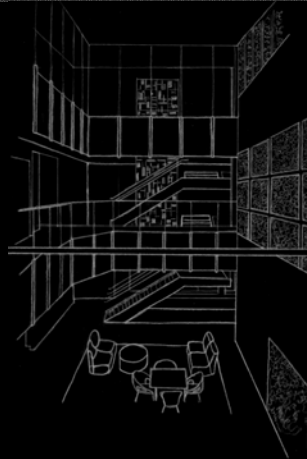
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3 STORY ATRIUM  
CORE ADMITS LIGHT  
TRANSPARENT MATERIALS  
VERTICAL BRIDGING

SPACE USE

MAIN ENTRANCE  
GATHERING SPACE  
LOUNGE AREAS AT EACH LEVEL  
PRIMARY CIRCULATION PATH  
PRIMARY OPEN STAIR





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REINFORCE BUILDING FUNCTIONS:

CORE PULSES WITH ENERGY AND MOVEMENT

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(1) 35W MH PAR 20 SURFACE-MOUNTED SPOTLIGHT



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(1) F28T5 RECESSED, LENSED DOWNLIGHT



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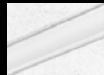
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(1) F28T5 RECESSED, LENSED DOWNLIGHT



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FLEXIBLE LED CHANNEL-MOUNTED GRAZING



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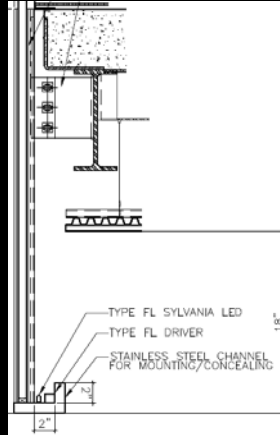
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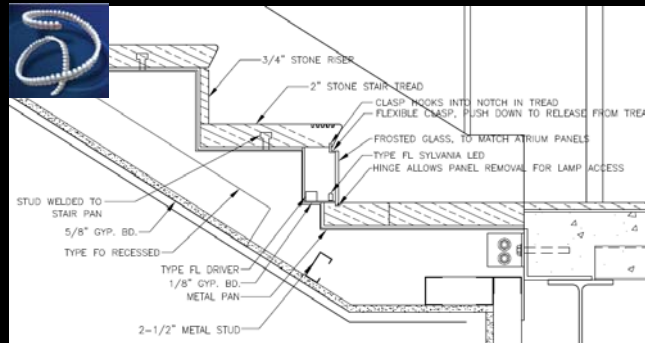
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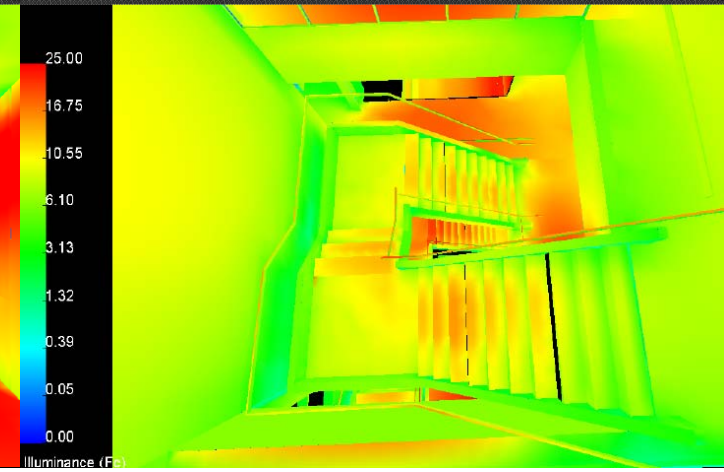
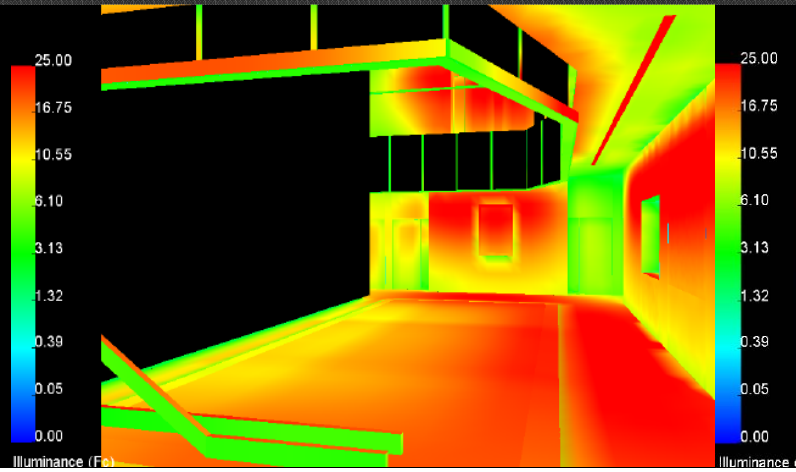
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DESIGN SUMMARY

ENHANCE ARCHITECTURE AND MATERIALS: LUMINAIRES SIMPLE,  
ORTHOGONAL, CONCEALED; BACKLIGHTING OF TRANSLUCENT PANELS  
AND FEATURE WALL

TRANSPARENCY

ENERGY AND MOVEMENT: LINEAR LUMINAIRES EVOKE MOVEMENT IN  
OPEN STAIR

EXPANSION: WALL AND PANEL GRAZING EVOKES EXPANSION

DESIGN SUMMARY

DESIGN MEETS IESNA RECOMMENDATIONS (SEE PS IMAGES)  
+ 5 FC HORIZONTAL IN CORRIDOR/STAIR  
+ 10 FC HORIZONTAL IN LOBBY

DESIGN MEETS ASHRAE 90.1 WITH TRADABLE WATTS

SPACE TYPE	POWER ALLOWANCE (w)	DESIGN (w)	DECORATIVE (w)	ENERGY CODE
LOBBY	1698.5	886.0	0	MEETS
CORRIDOR	3247.6	4357.0	0	EXCEEDS
STAIRS-ACTIVE	501.0	751.5	192.5	EXCEEDS
ATRIUM	694.7	441.0	0	MEETS

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MEET IESNA RECOMMENDATIONS AND ASHRAE STANDARD 90.1

ENHANCE ARCHITECTURE AND MATERIALS

CONSIDER INTERIOR SURFACE LUMINANCE AND DISTRIBUTION

REINFORCE DEPARTMENT IDEALS:

CONSTANTLY EVOLVING AESTHETIC

BI-DIRECTIONAL TRANSMISSION OF LIGHT AND IDEAS

BUILDING PULSES WITH ENERGY AND MOVEMENT

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LINEAR LED SLOT-MOUNTED GRAZING



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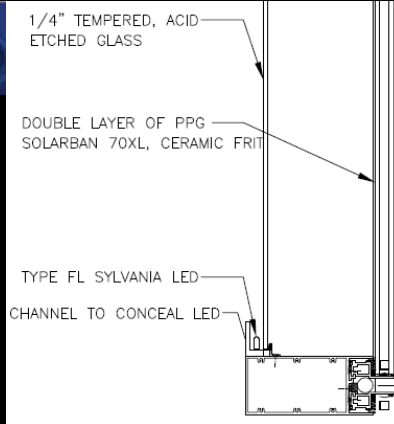
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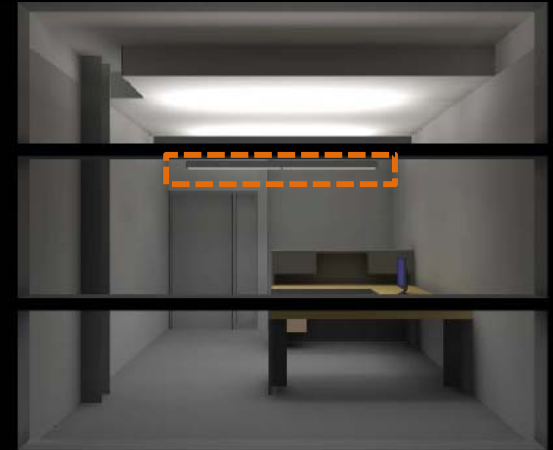
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(1) F28T5 SUSPENDED INDIRECT-DIRECT PENDANT



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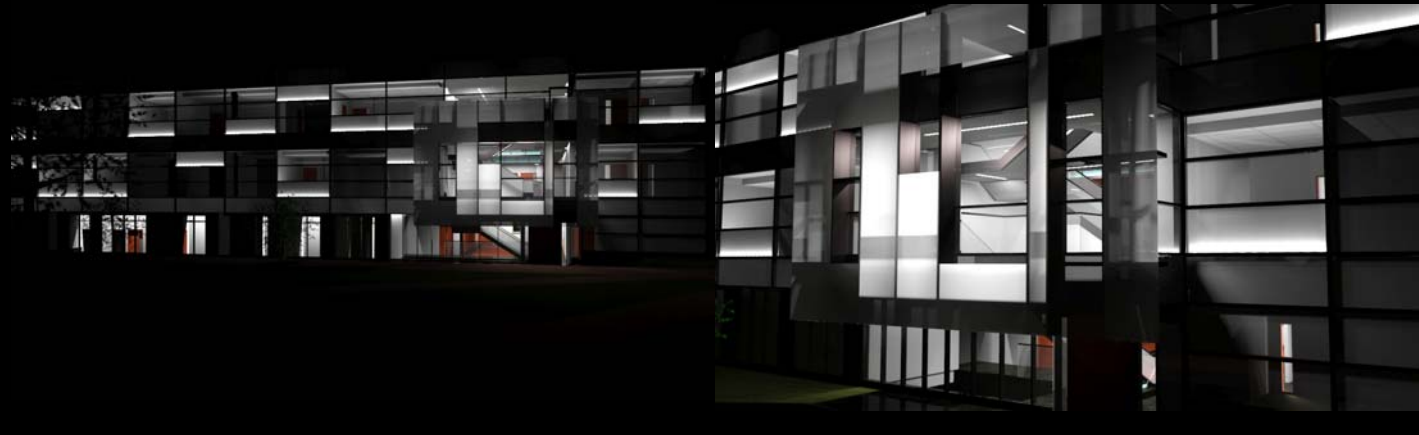
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ENHANCE ARCHITECTURE AND MATERIALS: BACKLIGHTING OF TRANSLUCENT PANELS TO CREATE GLOW

CONSIDER INTERIOR LUMINANCE AND DISTRIBUTION: OFFICE LIGHTING ILLUMINATES CEILING AND TOP OF WALLS

TRANSPARENCY: BACKLIGHTING PEOPLE /OBJECTS AT FIRST LEVEL

ENERGY AND MOVEMENT: RANDOM PANEL ILLUMINATION EVOKES MOVEMENT, DRAMA, AND EXCITEMENT

DESIGN SUMMARY

DESIGN MEETS IESNA RECOMMENDATIONS (SEE PS IMAGES)

SPACE TYPE	CALCULATION	CRITERIA (FC)	DESIGN (FC)	IESNA
PRIVATE OFFICE	HOR. 2.5'	30	29.66	MEETS

DESIGN MEETS ASHRAE 90.1

SPACE TYPE	POWER ALLOWANCE (W)	DESIGN (W)	DECORATIVE (W)	ENERGY CODE
OFFICE-ENCLOSED	5337.1	5273.3	0	MEETS

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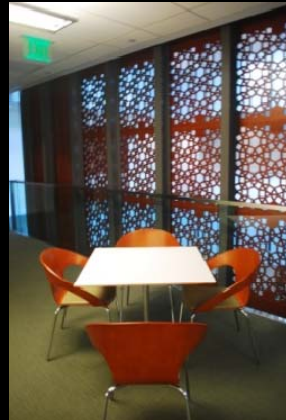
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OPEN AND FLEXIBLE

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PROVIDE A FLEXIBLE SOLUTION

EVOKE FLYNN PUBLIC AND RELAXATION IMPRESSIONS



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(1) 42W PL-T CFL RECESSED DOWNLIGHT



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(1) F28T5 RECESSED, LENSED DOWNLIGHT



(1) 42W PL-T CFL RECESSED DOWNLIGHT



(1) 42W PL-T CFL RECESSED WALLWASHER



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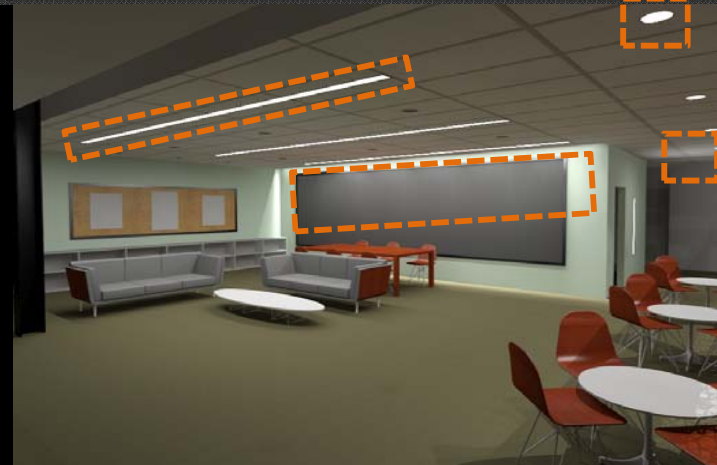
(1) 42W PL-T CFL RECESSED DOWNLIGHT



(1) 42W PL-T CFL RECESSED WALLWASHER



LED SLOT-MOUNTED GRAZING



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(1) 42W PL-T CFL RECESSED DOWNLIGHT

(1) 42W PL-T CFL RECESSED WALLWASHER

(1) 50W PAR 36 HALOGEN SPOTLIGHT



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(1) 42W PL-T CFL RECESSED DOWNLIGHT

(1) 42W PL-T CFL RECESSED WALLWASHER

(1) 50W PAR 36 HALOGEN SPOTLIGHT

(1) 20W MR-II HALOGEN SPOTLIGHT



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(1) 42W PL-T CFL RECESSED DOWNLIGHT



(1) 42W PL-T CFL RECESSED WALLWASHER



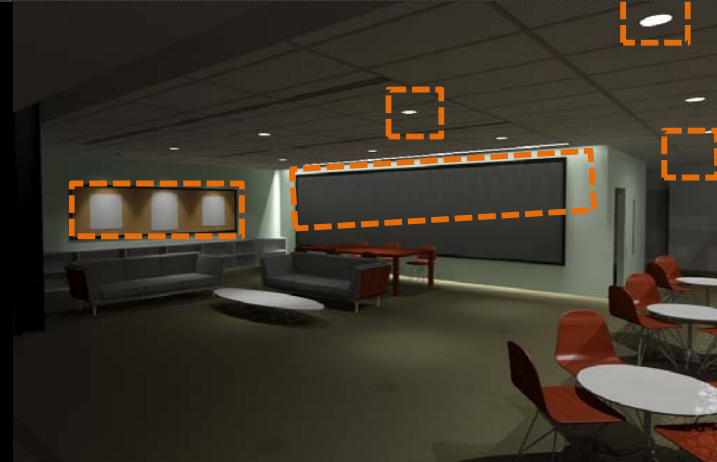
(1) 50W PAR 36 HALOGEN SPOTLIGHT



(1) 20W MR-II HALOGEN SPOTLIGHT



LED SLOT-MOUNTED GRAZING



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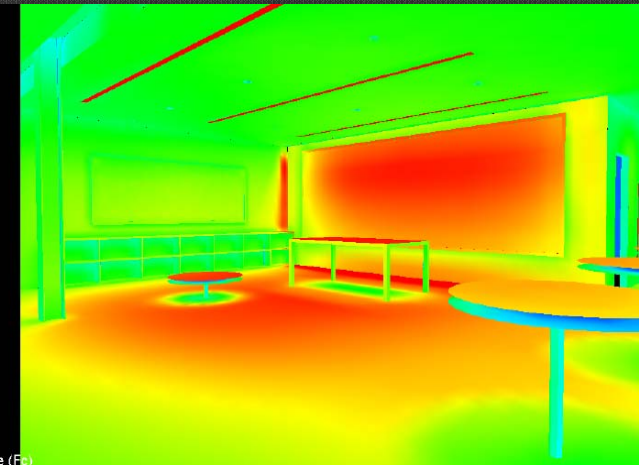
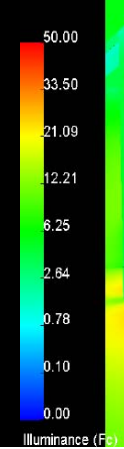
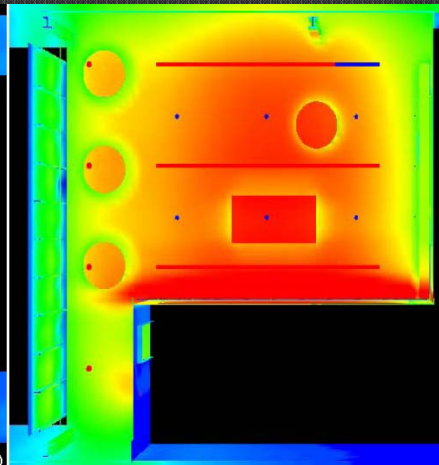
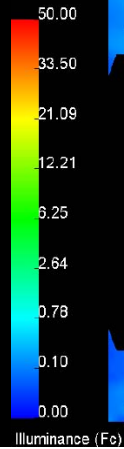
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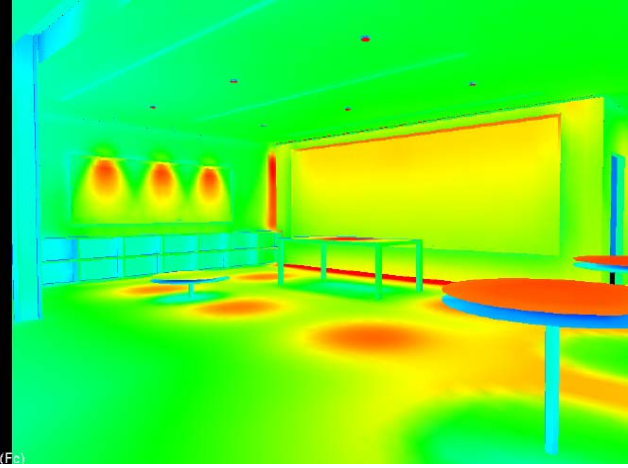
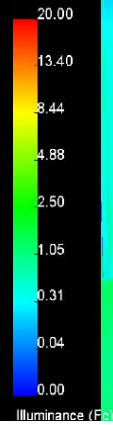
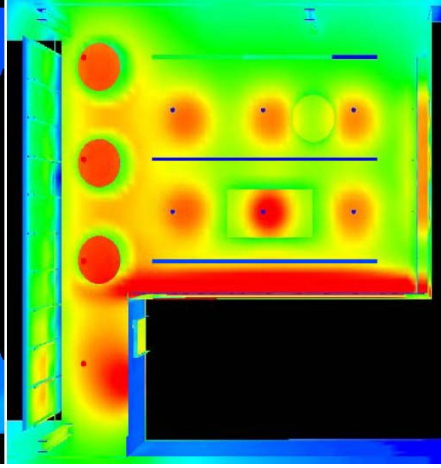
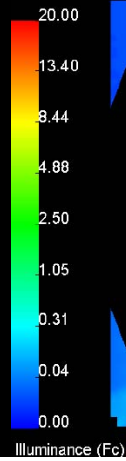
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1. 4' LINEAR FLUORESCENT
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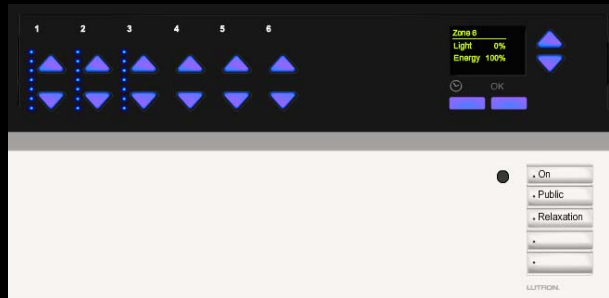
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DESIGN SUMMARY

ENHANCE ARCHITECTURE AND MATERIALS: LUMINAIRES ALL  
CONTAINED IN CEILING PLANE; SHADOWING WITH FEATURE WALL  
  
FLEXIBLE SOLUTION: DIGITAL CONTROL SYSTEM ALLOWS FOR QUICK  
RECALL OF TWO DESIGN SOLUTIONS; ON/OFF/DIM OF EACH ZONE  
PROVIDES ADDITIONAL FLEXIBILITY

PUBLIC IMPRESSION: DIFFUSE, OVERHEAD LIGHTING WITH HIGHER  
LIGHT LEVELS

RELAXATION IMPRESSION: SOFT POOLS OF LIGHT, PERIPHERAL  
EMPHASIS, LOWER LIGHT LEVELS

DESIGN SUMMARY

DESIGN MEETS IESNA RECOMMENDATIONS

SPACE TYPE	CALCULATION	CRITERIA (FC)	DESIGN (FC)	IESNA
GEN CLASS	HOR. 2.5'	30	35	MEETS
GEN CLASS	VERTICAL	50	45	UNDER

DESIGN MEETS ASHRAE 90.1 WITH TRADABLE WATTS

SPACE TYPE	POWER ALLOWANCE (W)	DESIGN (W)	DECORATIVE (W)	ENERGY CODE
CLASS/LECTURE /TRAINING	1243.2	1442	92.6	EXCEEDS

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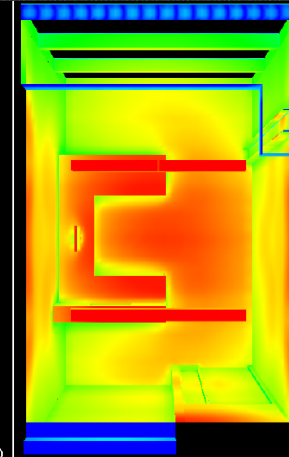
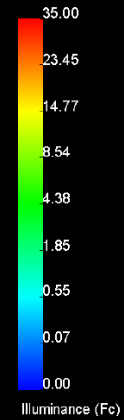
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OBJECTIVES

1. IMPROVE QUALITY OF DAYLIGHT DELIVERY SYSTEM BY MODIFYING THE CURTAINWALL SYSTEM
2. PROVIDE A CLOSED LOOP PROPORTIONAL DAYLIGHT RESPONSIVE DIMMING SYSTEM TO SAVE ENERGY THROUGHOUT THE YEAR

SPECIFICS

LOCATION: PRINCETON, NEW JERSEY  
 LATITUDE: 40.37  
 LONGITUDE: 74.67  
 ELECTRIC LIGHTING: INDIRECT-DIRECT PENDANT (T5-2900 LM)  
 TARGET ILLUMINANCE: 30 FC



TYPICAL 2<sup>ND</sup> AND 3<sup>RD</sup>  
 FLOOR OFFICE (SOME  
 ARE DOUBLE SIZE) WITH  
 ELECTRIC LIGHTING



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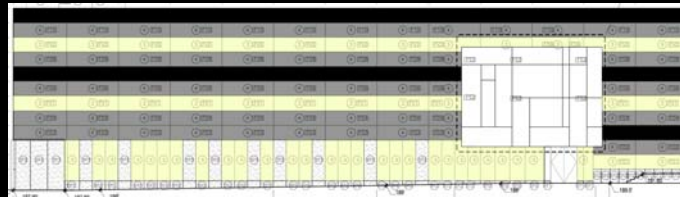
### EXISTING CURTAINWALL SYSTEM

COMBINATION OF OPAQUE, TRANSLUCENT, AND FRITTED SPANDREL PANELS:

BLACK: OPAQUE PANEL

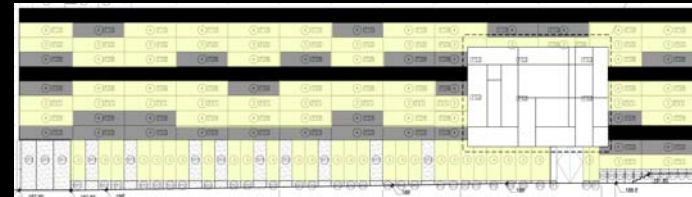
GREY: TRANSLUCENT PANEL

YELLOW: FRITTED PANEL, GLASS VISIBLE  $\tau = 0.70$



### MODIFIED CURTAINWALL SYSTEM IMPROVES QUALITY

30 TRANSLUCENT PANELS REPLACED WITH FRITTED TO INCREASE VIEWS AND REDUCE GLARE FROM GLOWING TRANSLUCENT PANELS.  
YELLOW: FRITTED PANEL, GLASS VISIBLE  $\tau = 0.64$ , EFF  $\tau = 0.62$   
(PPG SOLARBAN 70XL TO IMPROVE THERMAL PERFORMANCE)



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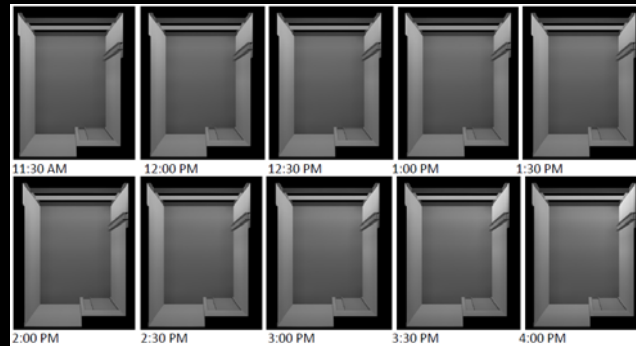
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### DIRECT SOLAR PENETRATION STUDIES

DECEMBER 21



NO PROBLEM WITH DIRECT SUN IN THE WINTER: SUN IS BELOW THE HORIZON BY THE TIME IT COMES BACK AROUND THE BUILDING TO FACE THE NORTHWEST FAÇADE

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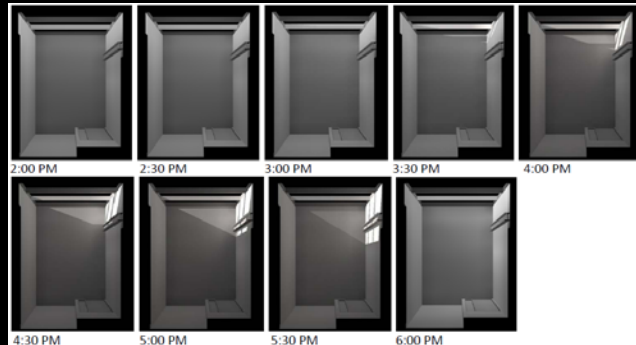
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### DIRECT SOLAR PENETRATION STUDIES

MARCH 21

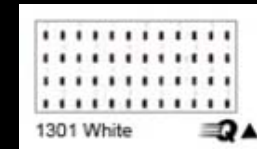


DIRECT SUN IS A PROBLEM FROM 3:30 TO 5:30 PM.

A SHADE MUST BE PROVIDED TO PREVENT DIRECT GLARE:

THERMOVEIL WHITE 1301

VISIBLE  $\tau$  = 0.11, OPENNESS FACTOR = 0.06



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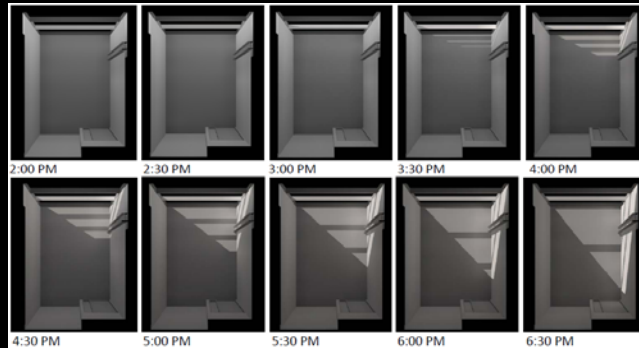
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### DIRECT SOLAR PENETRATION STUDIES

JUNE 21

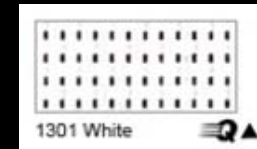


DIRECT SUN IS A PROBLEM FROM 3:30 TO 6:30 PM.

A SHADE MUST BE PROVIDED TO PREVENT DIRECT GLARE:

THERMOVEIL WHITE 1301

VISIBLE  $\tau$  = 0.11, OPENNESS FACTOR = 0.06



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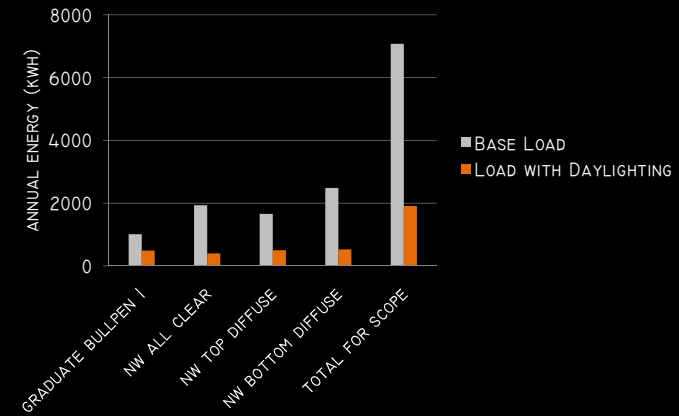
CONTROL SYSTEM

CLOSED LOOP PROPORTIONAL DIMMING SYSTEM

PHOTOSENSOR ON CEILING IN CENTER OF ROOM

TOTAL ENERGY SAVINGS OVER SCOPE OF REDESIGN

SPACE	BASE LOAD (KWH)	ENERGY SAVINGS (KWH)	PERCENT SAVINGS
GRADUATE BULLPEN I	1008.30	517.05	51.28%
NW OFFICES ALL CLEAR	1931.92	1534.05	79.41%
NW OFFICES TOP DIFFUSE	1655.94	1158.42	70.0%
NW OFFICES BOTTOM DIFFUSE	2483.91	1961.37	78.96%
TOTAL SCOPE OF REDESIGN	7080.08	5170.89	73.03%



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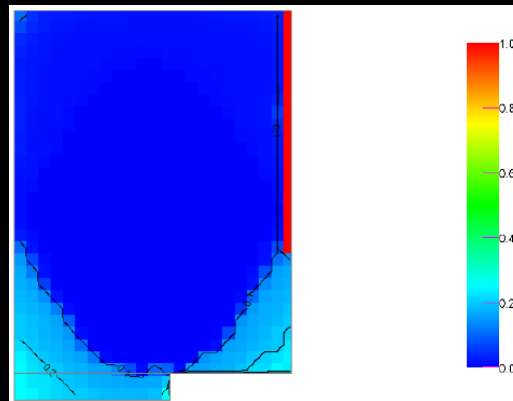
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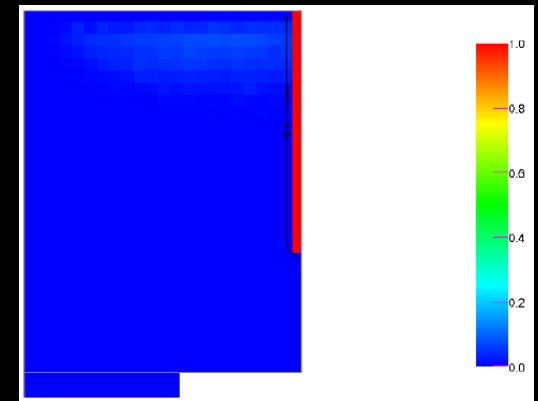
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QUALITY: THRESHOLD < 350 LUX



QUALITY: THRESHOLD > 4500 LUX





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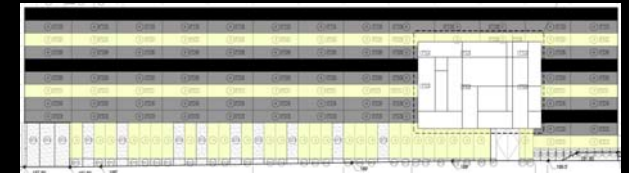
OBJECTIVES

1. IMPROVE QUALITY OF DAYLIGHT DELIVERY SYSTEM BY REPLACING 30 TRANSLUCENT SPANDREL PANELS WITH FRITTED PANELS
2. MINIMIZE THE THERMAL IMPACT OF CURTAINWALL MODIFICATIONS

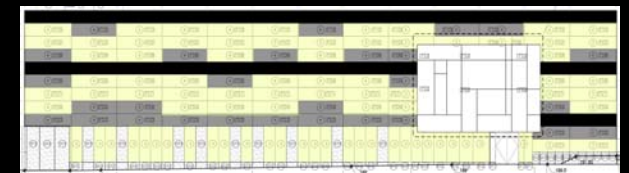
PANEL THERMAL PROPERTIES

MATERIAL	U-VALUE (BTU/HR-FT <sup>2</sup> -DEG F)	SHADING COEFFICIENT
OPAQUE PANEL (BLACK)	0.1	N/A
TRANSLUCENT PANEL (GREY)	0.25	0.2
FRITTED PANEL (YELLOW)	0.32	0.47

EXISTING NORTHWEST CURTAINWALL



PROPOSED NORTHWEST CURTAINWALL



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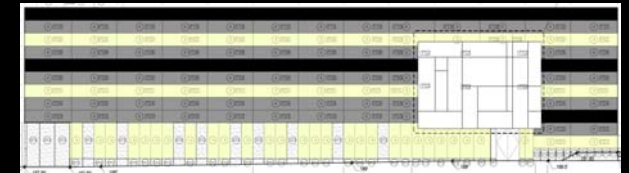
TRANSPARENT GLASS MATERIAL FOR FRITTED PANEL

FRITTED PANELS SHOW REDUCED THERMAL PERFORMANCE →

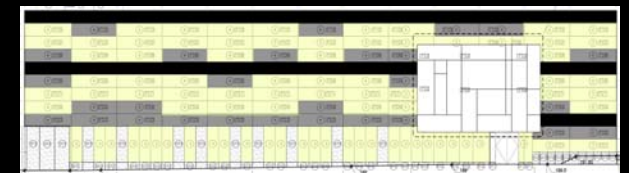
CONSIDER REPLACING GLASS IN FRITTED PANELS WITH PPG SOLARBAN 70XL, THERMAL PROPERTIES SHOWN BELOW

MATERIAL	U-VALUE (BTU/HR-FT <sup>2</sup> -DEG F)	SHADING COEFFICIENT
OPAQUE PANEL (BLACK)	0.1	N/A
TRANSLUCENT PANEL (GREY)	0.25	0.2
FRITTED PANEL (YELLOW)	0.32	0.47
PPG SOLARBAN 70XL	0.27	0.32

EXISTING NORTHWEST CURTAINWALL



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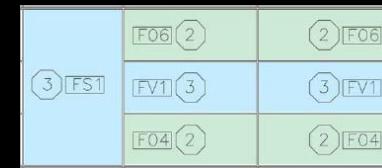
OBJECTIVES

1. IMPROVE QUALITY OF DAYLIGHT DELIVERY SYSTEM BY REPLACING 2 OPAQUE SPANDREL PANELS WITH FRITTED PANELS
2. MINIMIZE THE THERMAL IMPACT OF CURTAINWALL MODIFICATIONS

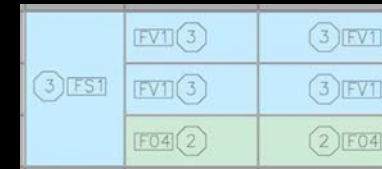
PANEL THERMAL PROPERTIES

MATERIAL	U-VALUE (BTU/HR-FT <sup>2</sup> -DEG F)	SHADING COEFFICIENT
OPAQUE PANEL (GREEN)	0.1	N/A
FRITTED PANEL (BLUE)	0.32	0.47

EXISTING SOUTHWEST CURTAINWALL AT GRAD BPI



PROPOSED SOUTHWEST CURTAINWALL AT GRAD BPI



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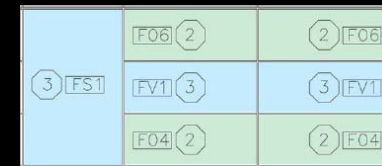
TRANSPARENT GLASS MATERIAL FOR FRITTED PANEL

FRITTED PANELS SHOW REDUCED THERMAL PERFORMANCE →

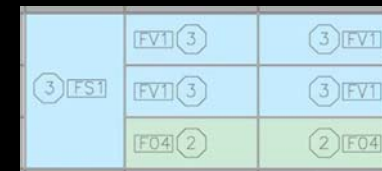
CONSIDER REPLACING GLASS IN FRITTED PANELS WITH PPG SOLARBAN 70XL, THERMAL PROPERTIES SHOWN BELOW

MATERIAL	U-VALUE (BTU/HR-FT <sup>2</sup> -DEG F)	SHADING COEFFICIENT
OPAQUE PANEL (GREEN)	0.1	N/A
FRITTED PANEL (BLUE)	0.32	0.47
PPG SOLARBAN 70XL	0.27	0.32

EXISTING SOUTHWEST CURTAINWALL AT GRAD BPI



PROPOSED SOUTHWEST CURTAINWALL AT GRAD BPI



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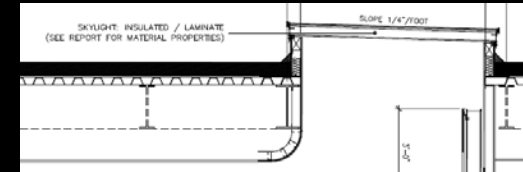
OBJECTIVES

- 1. IMPROVE QUALITY OF DAYLIGHT DELIVERY SYSTEM BY NEARLY DOUBLING SKYLIGHT WIDTH IN ATRIUM
- 2. DETERMINE THE THERMAL IMPACT OF THIS RESIZING

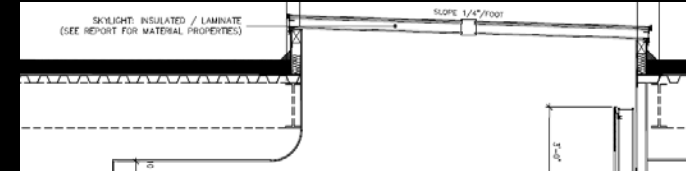
SKYLIGHT WIDTH INCREASED FROM 6'-4" TO 11'-6"

MATERIAL	U-VALUE (BTU/HR-FT <sup>2</sup> -DEG F)	SHADING COEFFICIENT
ROOF	0.042	N/A
SKYLIGHT-LAMINATED VISION	0.34	0.65

ORIGINAL SKYLIGHT



RESIZED SKYLIGHT



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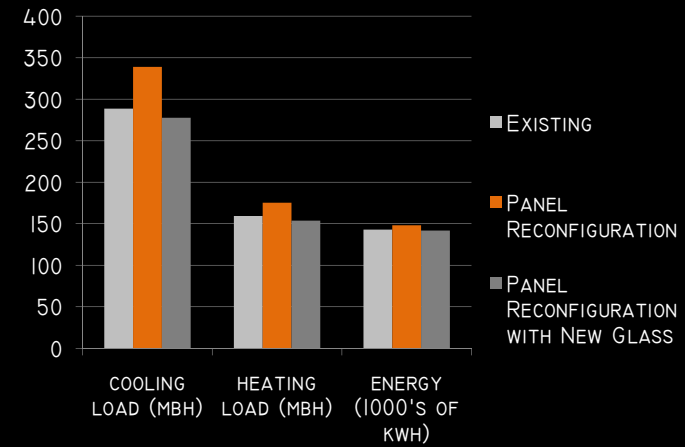
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TOTAL COOLING/HEATING LOADS AND ENERGY

ALTERNATIVE	COOLING LOAD (MBH)		HEATING LOAD (MBH)		ENERGY (KWH)		STEAM (THERMS)	
	Value	% Change	Value	% Change	Value	% Change	Value	% Change
EXISTING	288.7	-	159.3	-	142,985	-	813	-
PANEL/SKYLIGHT RECONFIGURATION	339	17.4%	175.3	10.0%	148,119	3.6%	1,281	57.6%
PANEL/SKYLIGHT RECONFIGURATION WITH NEW GLASS	277.6	-3.8%	153.8	-3.5%	141,818	-0.8%	661	-18.7%

\*NOTE: NEW PPG GLASS TYPE IS ONLY APPLIED TO CURTAINWALL





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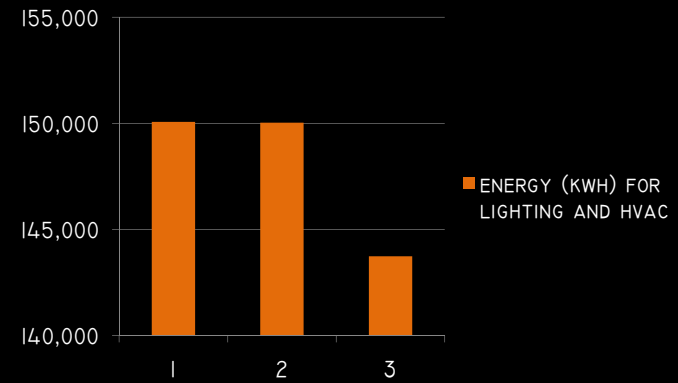
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TOTAL COMBINED THERMAL AND DAYLIGHT SAVINGS

DESIGN	BASE LOAD (KWH)	PERCENT SAVINGS
(1) EXISTING CONDITION	150,065	-
(2) NEW PANEL CONFIGURATION AND DAYLIGHT CONTROLS	150,028	0.02%
(3) NEW PANEL CONFIGURATION, PPG GLASS, AND DAYLIGHT CONTROLS	143,727	4.22%



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## ELECTRICAL

## COPPER VS. ALUMINUM FEEDERS



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FEEDER RESIZING AND COPPER VS. ALUMINUM

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### OBJECTIVES

1. CONSIDER THE PERFORMANCE RELATED IMPACT OF CHANGING THE ELECTRICAL FEEDERS FROM COPPER TO ALUMINUM
2. CONSIDER THE ECONOMIC IMPACT OF RESIZING THE ELECTRICAL FEEDERS TO MEET NEC REQUIREMENTS
3. CONSIDER THE ECONOMIC IMPACT OF CHANGING THE ELECTRICAL FEEDERS FROM COPPER TO ALUMINUM

### CURRENT VERSUS PROPOSED MATERIALS

CURRENT SYSTEM IS STRANDED COPPER THHN CONDUCTORS IN EMT

PROPOSED SYSTEM IS STRANDED ALUMINUM THHN CONDUCTORS IN EMT

OUTLINE

ELECTRICAL DESIGN

ELECTRICAL

COPPER VS. ALUMINUM FEEDERS



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ELECTRICAL DESIGN

CONCLUSION

## PERFORMANCE RELATED CONSIDERATIONS

- + CONVENTIONAL OPINIONS
- + HISTORICAL BACKGROUND
- + PRODUCT COST
- + MATERIAL WEIGHT
- + CONNECTIONS
- + ALUMINUM APPLICATIONS TODAY
- + NEWER ALUMINUM PRODUCTS
- + PROPER INSTALLATION



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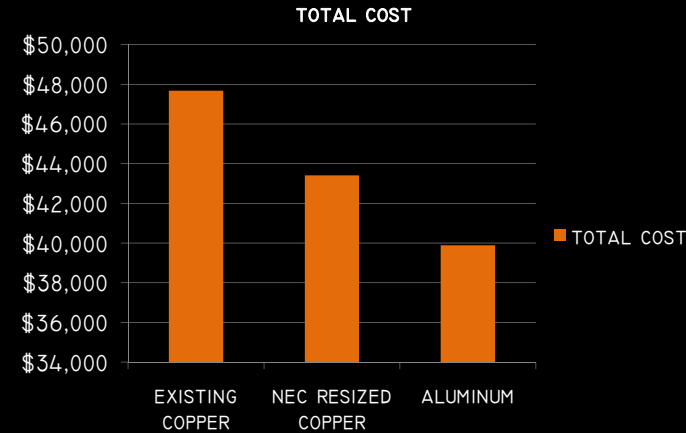
CONCLUSION

COMPARATIVE COSTS FOR EACH ALTERNATIVE

\* COSTS BASED ON RS MEANS 2010 DATA FOR CONDUCTOR AND CONDUIT PRICING, INCLUDING OVERHEAD AND PROFIT

DESIGN	TOTAL COST	COST REDUCTION FROM EXISTING	PERCENT REDUCTION
EXISTING COPPER	\$47,675	-	-
RESIZED COPPER	\$43,410	\$4,265	8.95%
ALUMINUM	\$39,889	\$7,786	16.33%

ALUMINUM FEEDERS ARE RECOMMENDED  
 COST REDUCTION FROM NEC RESIZING ALSO NOTABLE



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LIGHTING DESIGN DESIGNS EVOKE TRANSPARENCY, ENERGY,  
AND EXPANSION OF IDEAS

DESIGNS COMPLY WITH IESNA AND ASHRAE

DAYLIGHTING MODIFIED SKYLIGHT/CURTAINWALL IMPROVE  
QUALITY OF DAYLIGHTING

DAYLIGHT CONTROL SYSTEMS ALLOW FOR  
73% ENERGY SAVINGS

MECHANICAL LOADS MODIFIED PANELS ALLOW FOR REDUCED  
THERMAL LOADS

5% COMBINED LIGHTING/HVAC ENERGY ↓

ELECTRICAL DESIGN 16.33% COST SAVINGS WITH AL FEEDERS

OVERALL DESIGNS SUCCESSFULLY IMPROVE  
AESTHETICS AND PERFORMANCE

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SPECIAL THANKS



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AND TO MY FAMILY, FRIENDS, AND FELLOW AE



## QUESTION AND ANSWER SESSION



“LIGHT IS A CENTRAL THEME THROUGHOUT THE BUILDING. IT’S A KIND OF LANTERN, A LANTERN OF KNOWLEDGE AND CIRCULATION.” FREDERICK FISHER