

BIENVENIDOS

AE SENIOR THESIS

WELCOME

ANGELICA SANTANA

PRINCETON

NEUROSCIENCE &

PSYCHOLOGY

COMPLEX

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

BRANCH CIRCUITS

SHORT CIRCUIT

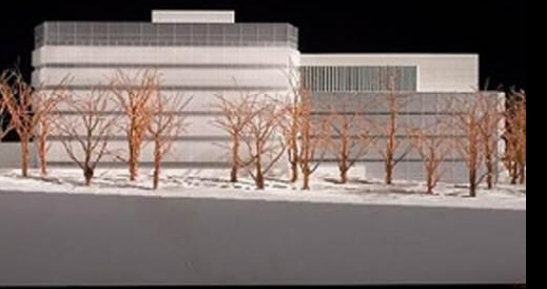
MOTOR CONTROL CENTER

BUS DUCTS



INTRODUCTION BUILDING STATISTICS

LIGHTING DEPTH
ELECTRICAL DEPTH
CONCLUSION



SIZE **248,000 SQ.FT.**
STORIES **5/6**
COST **\$180 MILLION**
CONSTRUCTION **SUMMER 2010 – SPRING 2013**
FUNCTION **EDUCATIONAL**

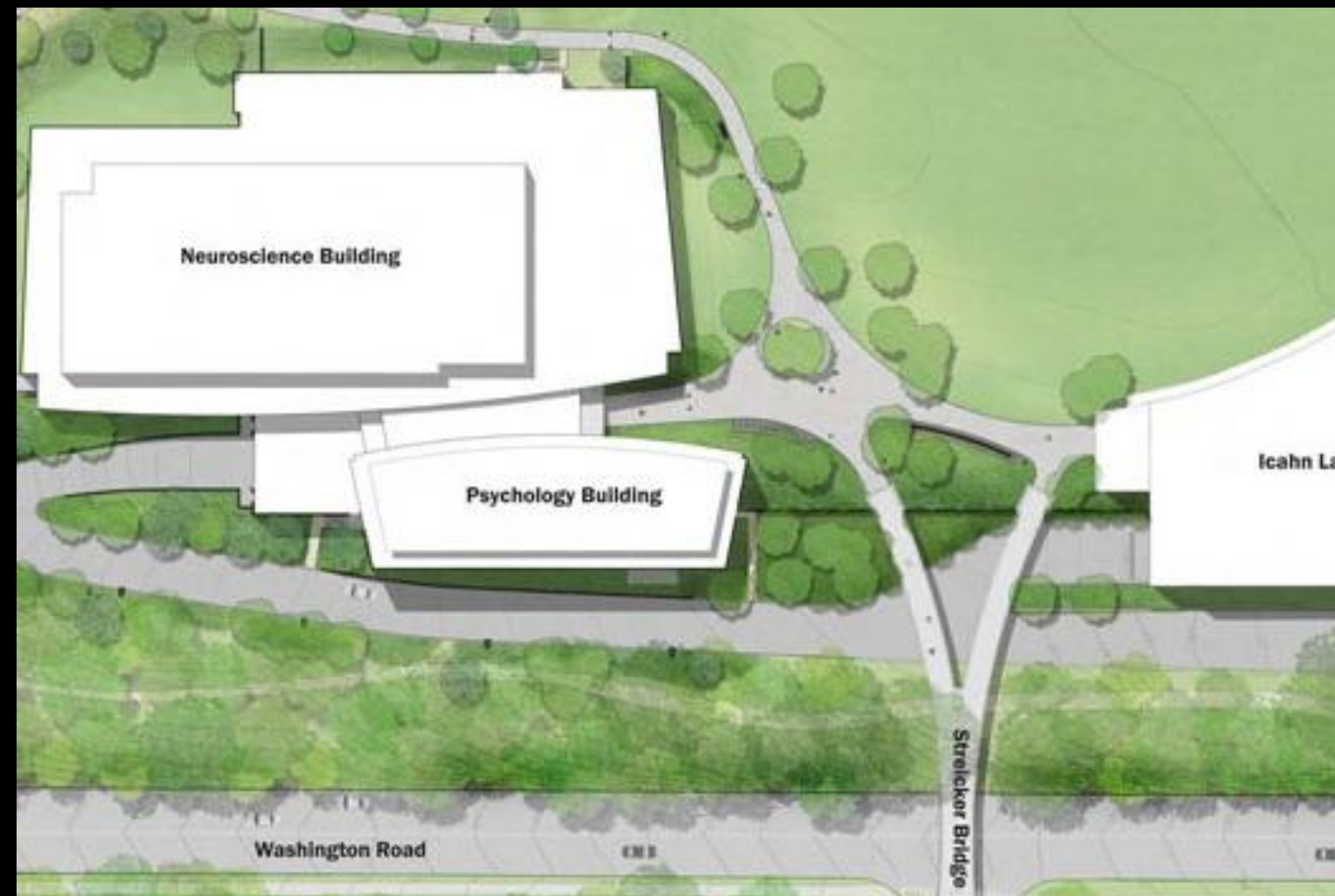
OCCUPANTS **NEUROSCIENCE INSTITUTE AND PSYCHOLOGY DEPARTMENT**

LOCATION **SOUTH OF ICAHN LAB, LOT 20**

ARCHITECT **RAFAEL MONEO VALLES
DAVIS BRODY BOND, LLP**

INTRODUCTION BUILDING STATISTICS

LIGHTING DEPTH
ELECTRICAL DEPTH
CONCLUSION



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INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

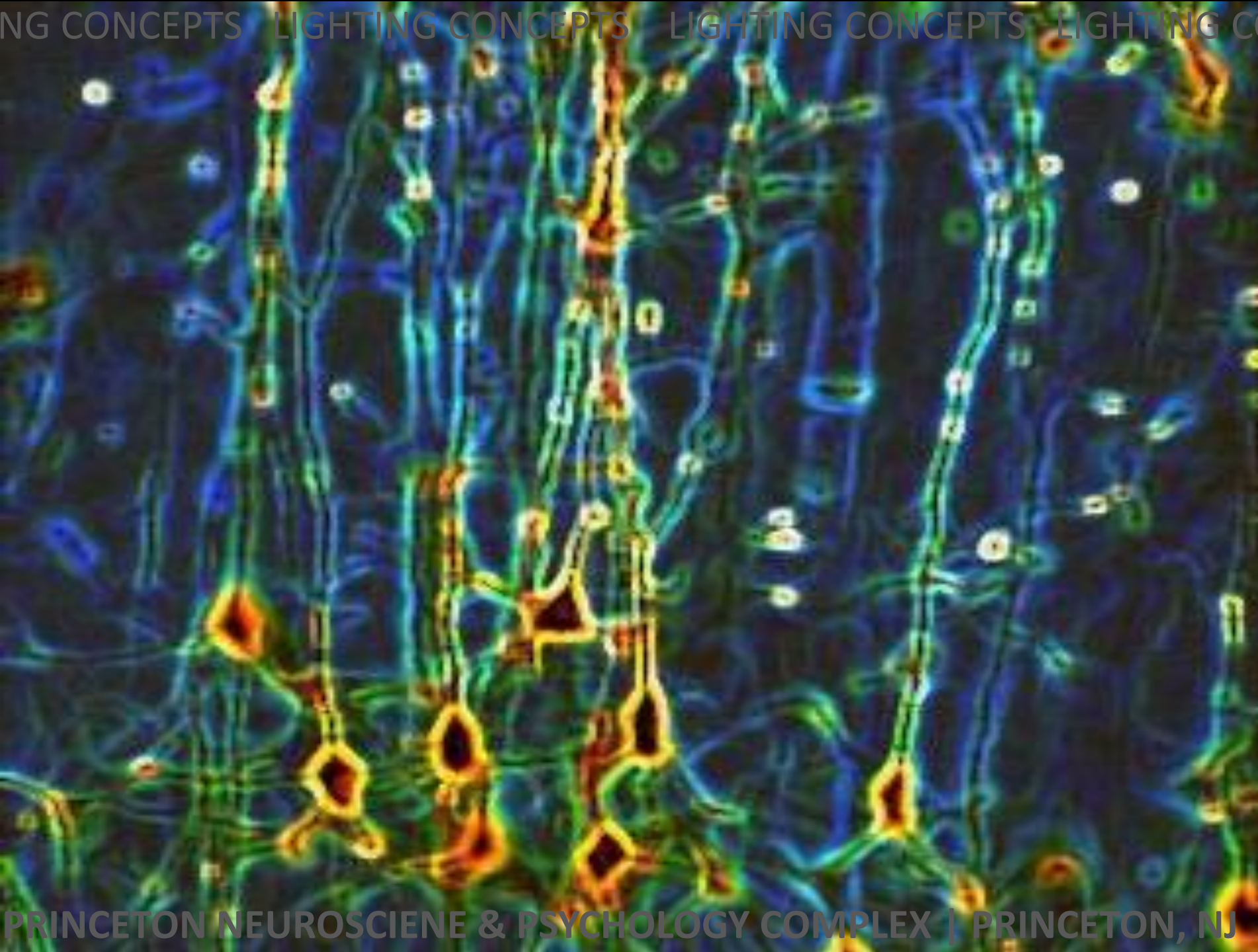
LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONNECTION

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

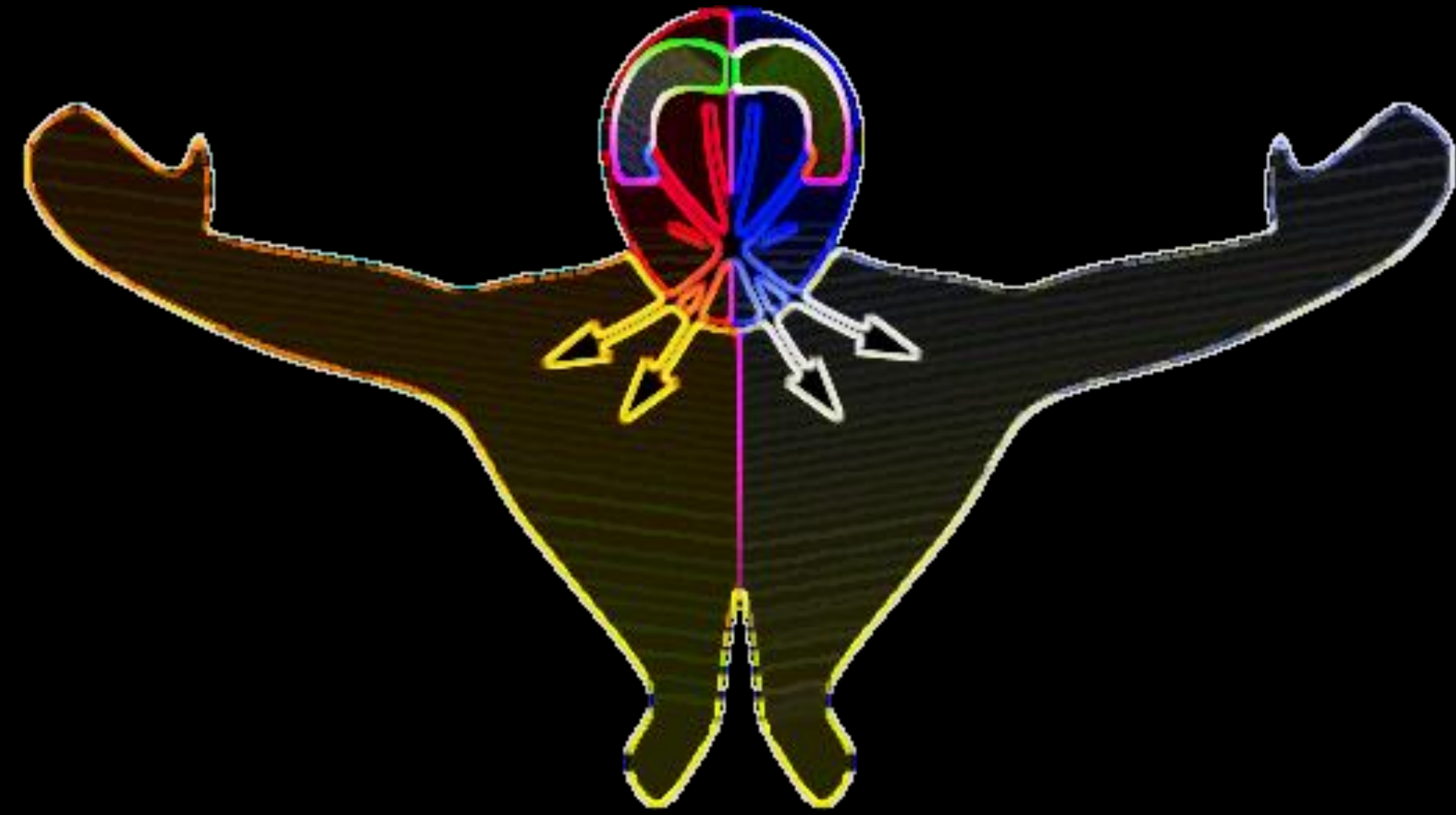
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LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONNECTION

MIRRORING OPPOSITES

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

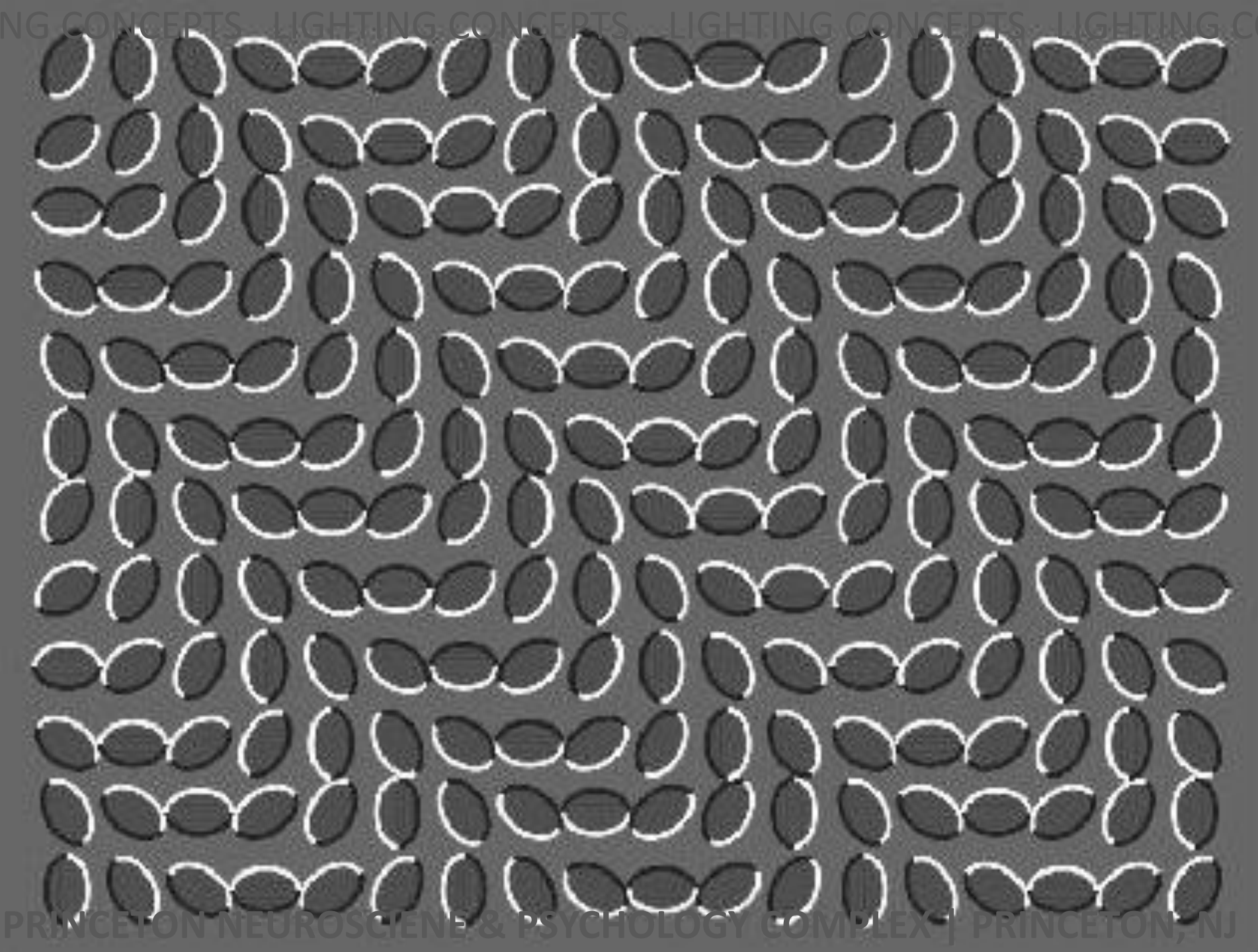
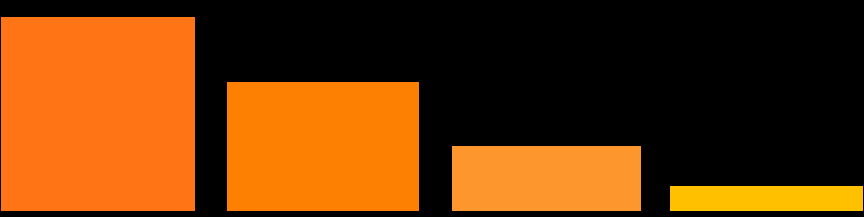
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LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



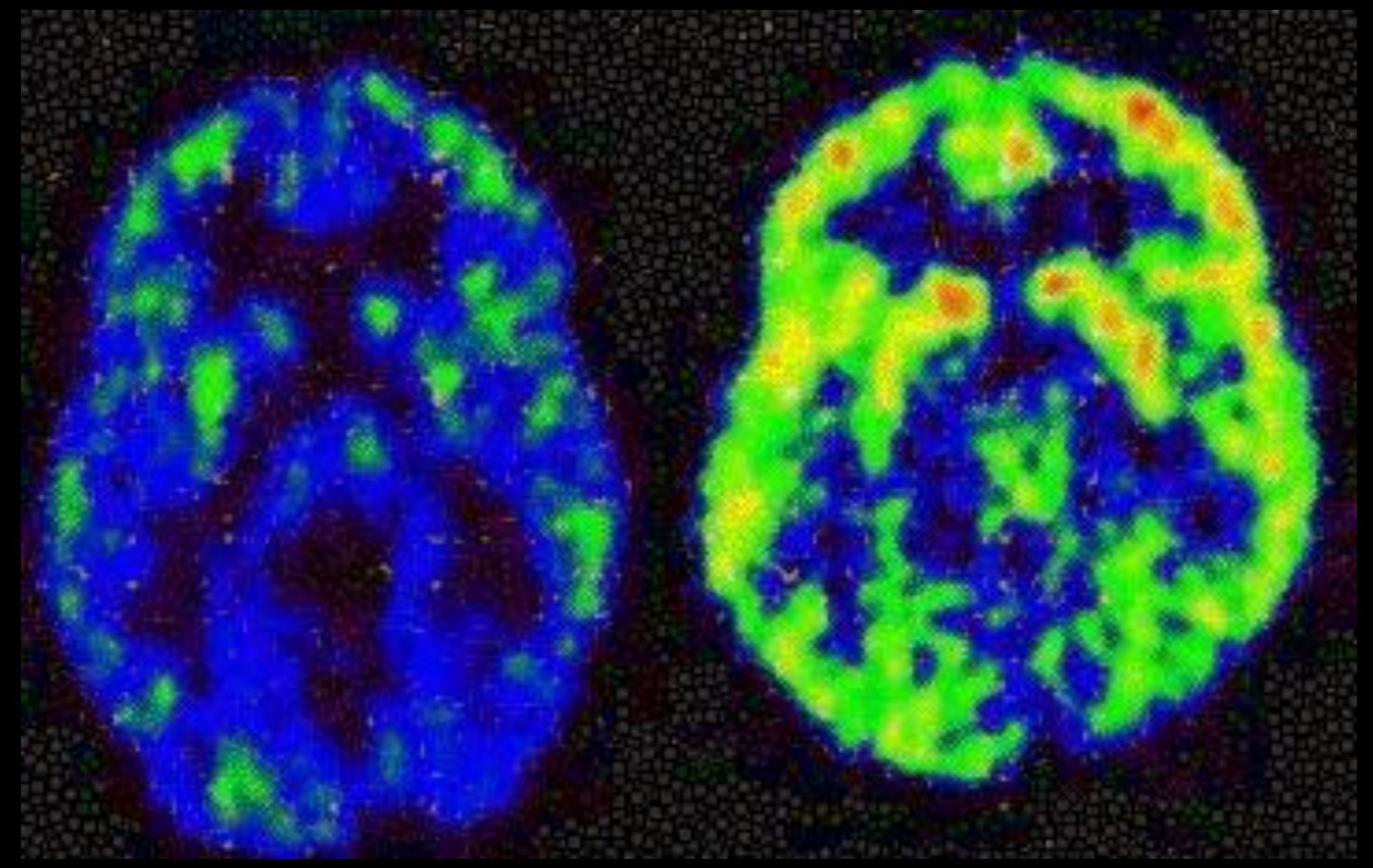
CONNECTION

MIRRORING OPPOSITES

STATIC MOTION

- INTRODUCTION
- LIGHTING DEPTH**
- ELECTRICAL DEPTH
- CONCLUSION

- CONCEPTS**
- NORTH ENTRY
- LOBBY
- LECTURE HALL
- ARCHITECTURAL BREADTH
- ACOUSTICAL BREADTH
- CAFETERIA



CONNECTION

MIRRORING OPPOSITES

STATIC MOTION

BUILDING AS BRAIN ACTIVITY

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



ARCHITECTURE
DOUBLE HEIGHT
WOODEN WALL
INTERIOR FAÇADE
BRIDGE

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONCEPTS

STATIC MOTION

MIRRORING OPPOSITES

ARCHITECTURE, NEUROSCIENCE, AND PSYCHOLOGY

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

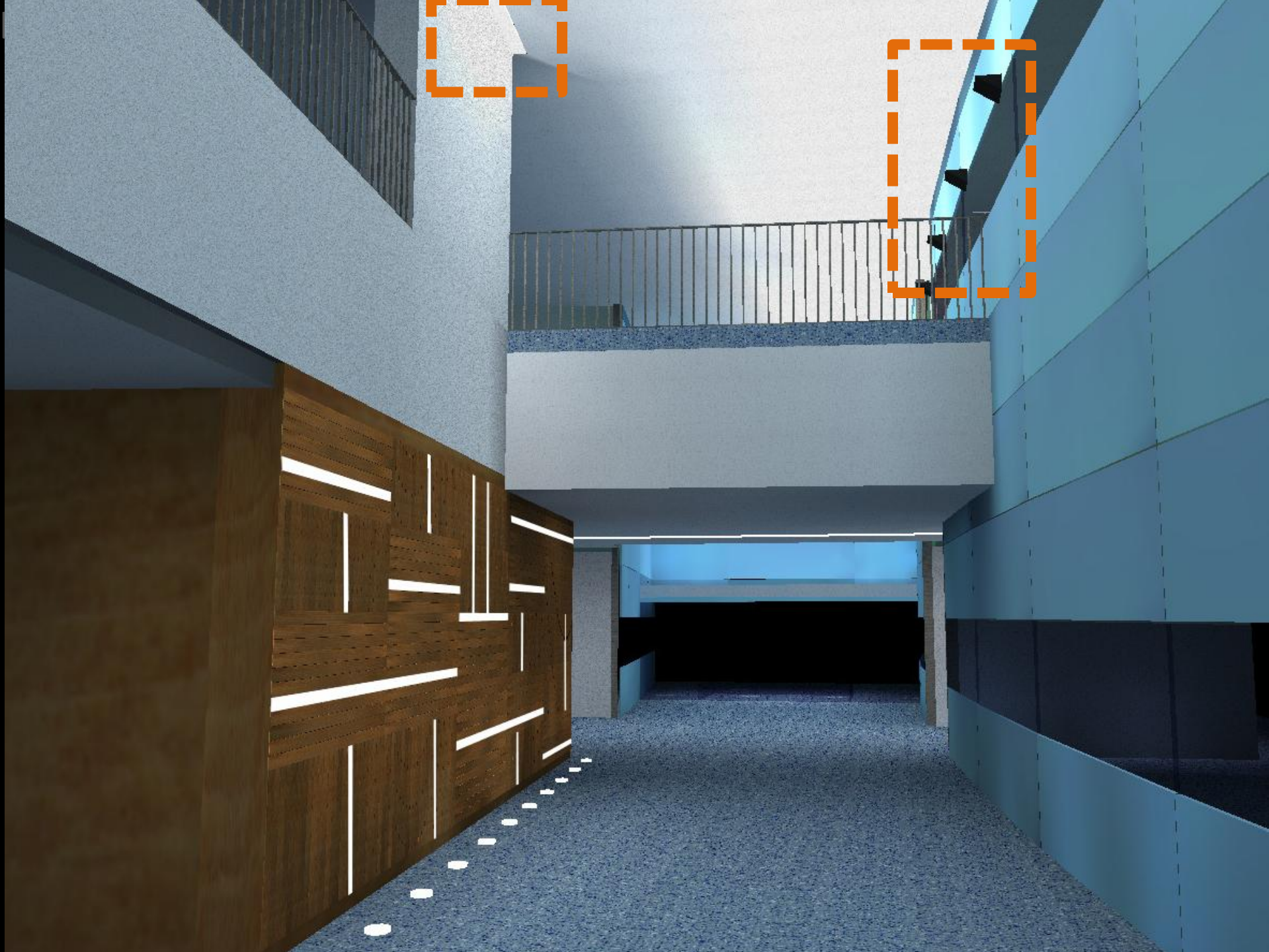
LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONCEPTS

STATIC MOTION

MIRRORING OPPOSITES

ARCHITECTURE, NEUROSCIENCE, AND PSYCHOLOGY

TOOLS



150W MH T6 96CRI 4200K



13.5W LED 83CRI 3000K

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

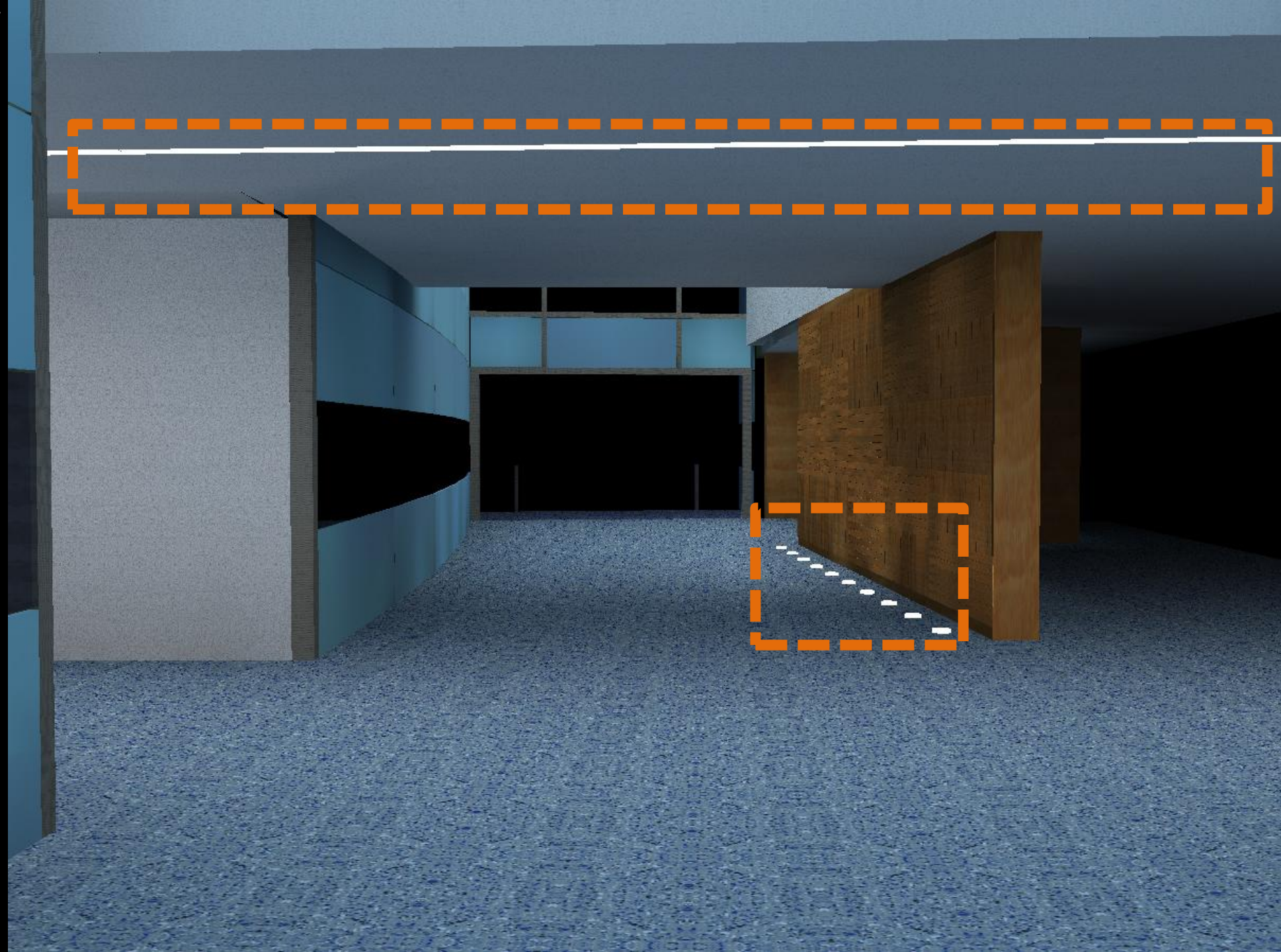
LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



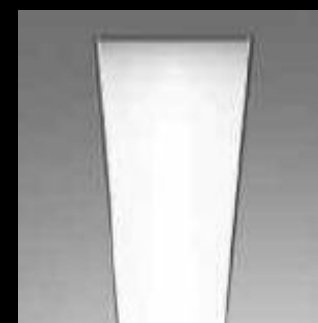
CONCEPTS

STATIC MOTION

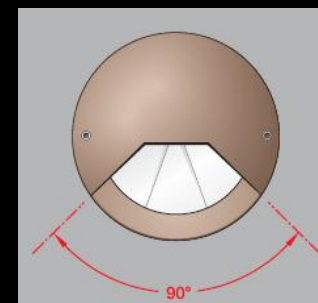
MIRRORING OPPOSITES

ARCHITECTURE, **NEUROSCIENCE**, AND PSYCHOLOGY

TOOLS



28W T5 FL 85CRI 3500K



10W LOW- VOLTAGE HALOGEN T3

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

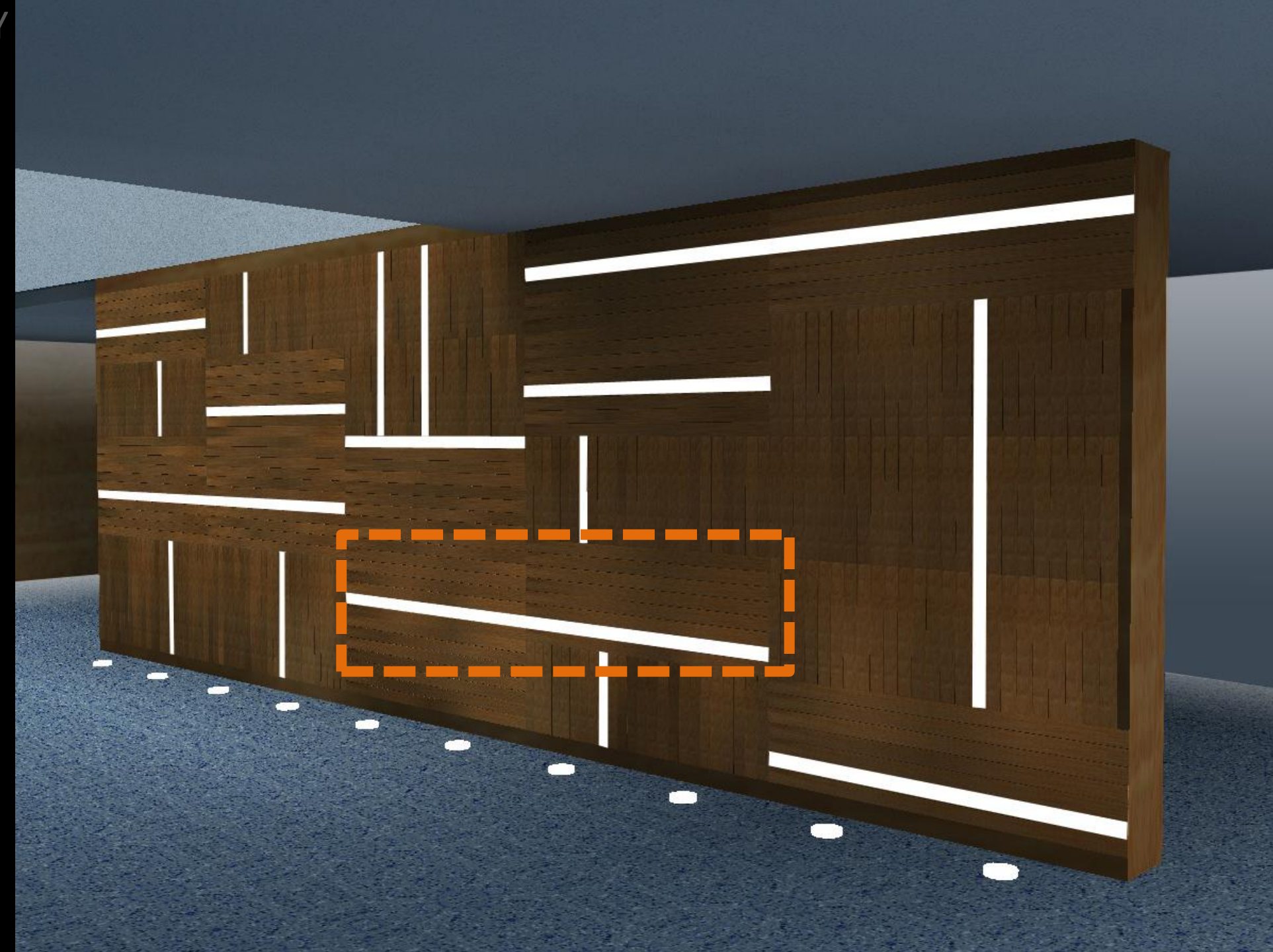
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LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



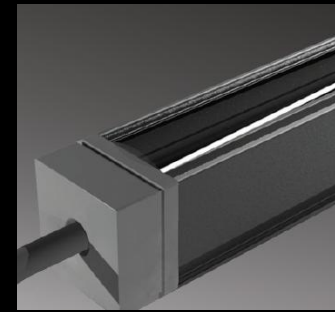
CONCEPTS

STATIC MOTION

MIRRORING OPPOSITES

ARCHITECTURE, NEUROSCIENCE, AND PSYCHOLOGY

TOOLS



2.92W/LF LED STRIP, HIGH CRI

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

- CONCEPTS
- NORTH ENTRY
- LOBBY
- LECTURE HALL
- ARCHITECTURAL BREADTH
- ACOUSTICAL BREADTH
- CAFETERIA**



CONCEPTS

- BUILDING AS BRAIN ACTIVITY
- FLYNN MODE OF RELAXATION

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

- CONCEPTS
- NORTH ENTRY
- LOBBY
- LECTURE HALL
- ARCHITECTURAL BREADTH
- ACOUSTICAL BREADTH
- CAFETERIA**



CONCEPTS
BUILDING AS BRAIN ACTIVITY
 FLYNN MODE OF RELAXATION

TOOLS



75W HALOGEN T4

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

- CONCEPTS
- NORTH ENTRY
- LOBBY
- LECTURE HALL
- ARCHITECTURAL BREADTH
- ACOUSTICAL BREADTH
- CAFETERIA**



- CONCEPTS
- BUILDING AS BRAIN ACTIVITY**
- FLYNN MODE OF RELAXATION

TOOLS



75W HALOGEN T4

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION



CONCEPTS

NORTH ENTRY

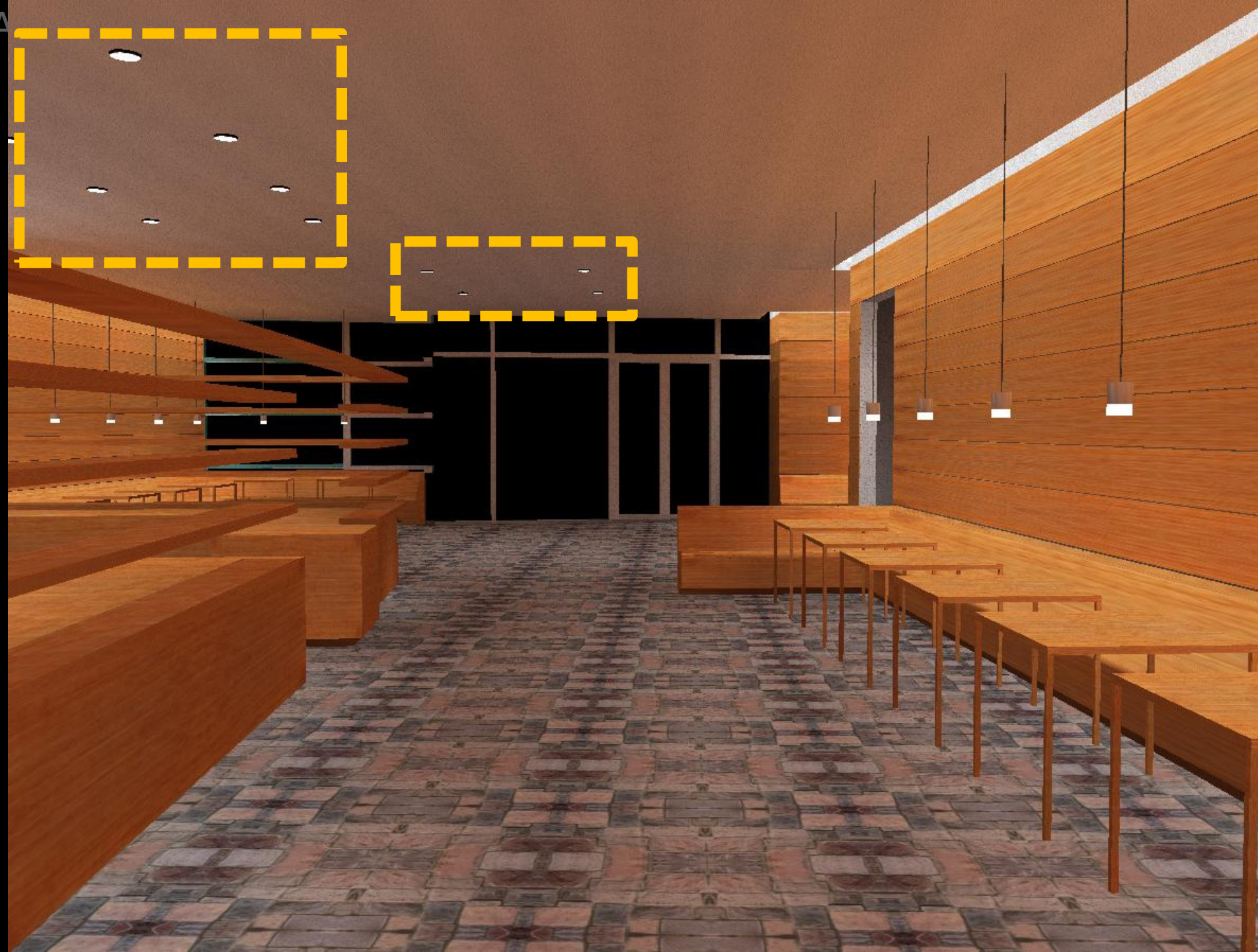
LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONCEPTS

BUILDING AS BRAIN ACTIVITY

FLYNN MODE OF RELAXATION

TOOLS



18W CFL TRIPLE 82CRI 3000K

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONCEPTS

BUILDING AS BRAIN ACTIVITY

FLYNN MODE OF RELAXATION

TOOLS



13.5W LED 83CRI 3000K

INTRODUCTION

LIGHTING DEPTH

ELECTRICAL DEPTH

CONCLUSION

CONCEPTS

NORTH ENTRY

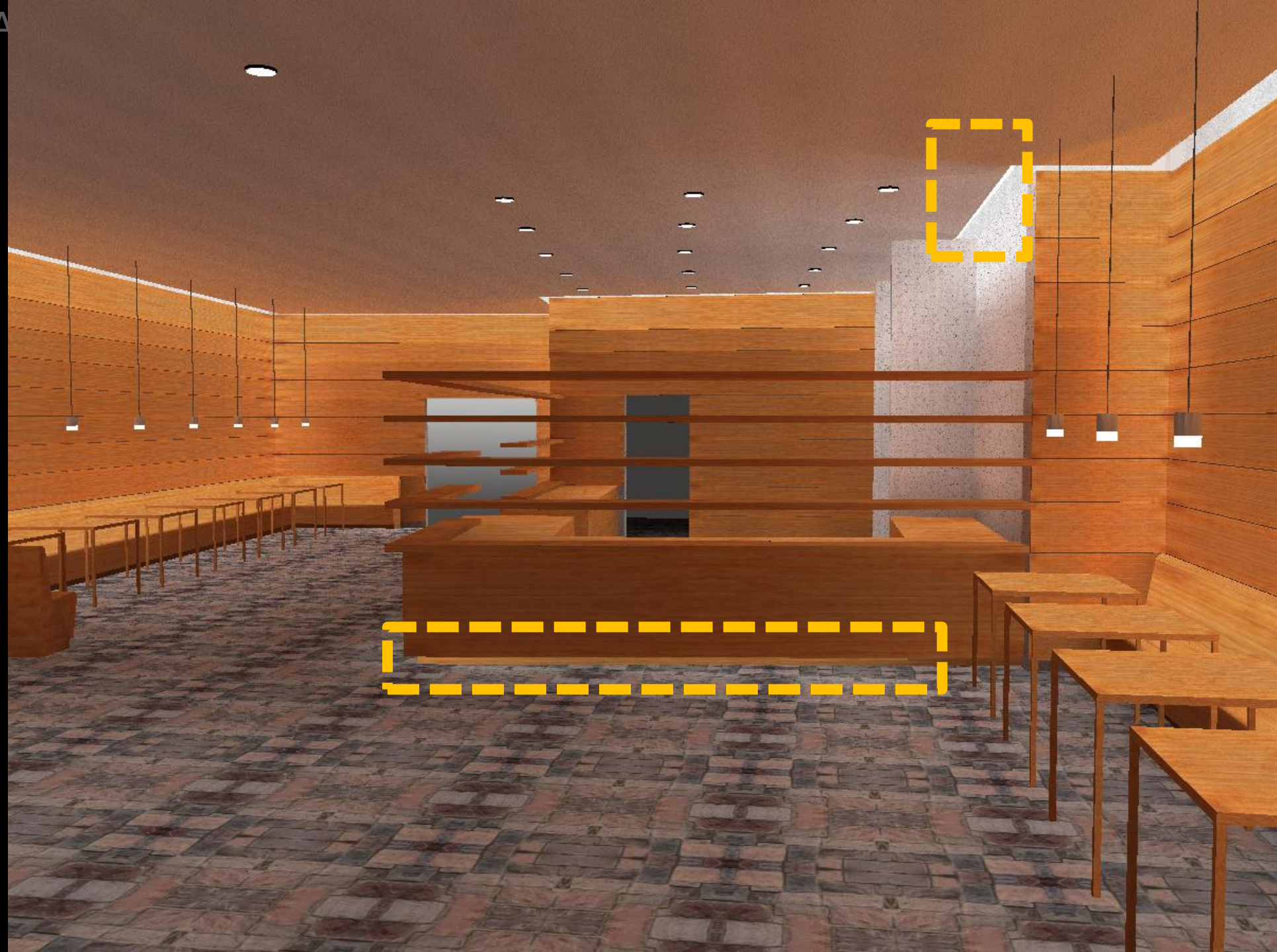
LOBBY

LECTURE HALL

ARCHITECTURAL BREADTH

ACOUSTICAL BREADTH

CAFETERIA



CONCEPTS

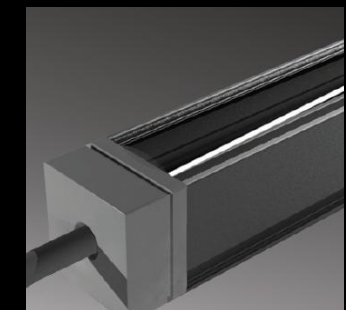
BUILDING AS BRAIN ACTIVITY

FLYNN MODE OF RELAXATION

TOOLS



10W/LF T6 FL 88CRI 3000K



2.92W/LF LED STRIP, HIGH CRI

INTRODUCTION
LIGHTING DEPTH
ELECTRICAL DEPTH
CONCLUSION

BRANCH CIRCUITS
SHORT CIRCUIT
MOTOR CONTROL CENTER
BUS DUCTS



LOCATION

PENTHOUSE 3RD FLOOR MER

PROBLEM

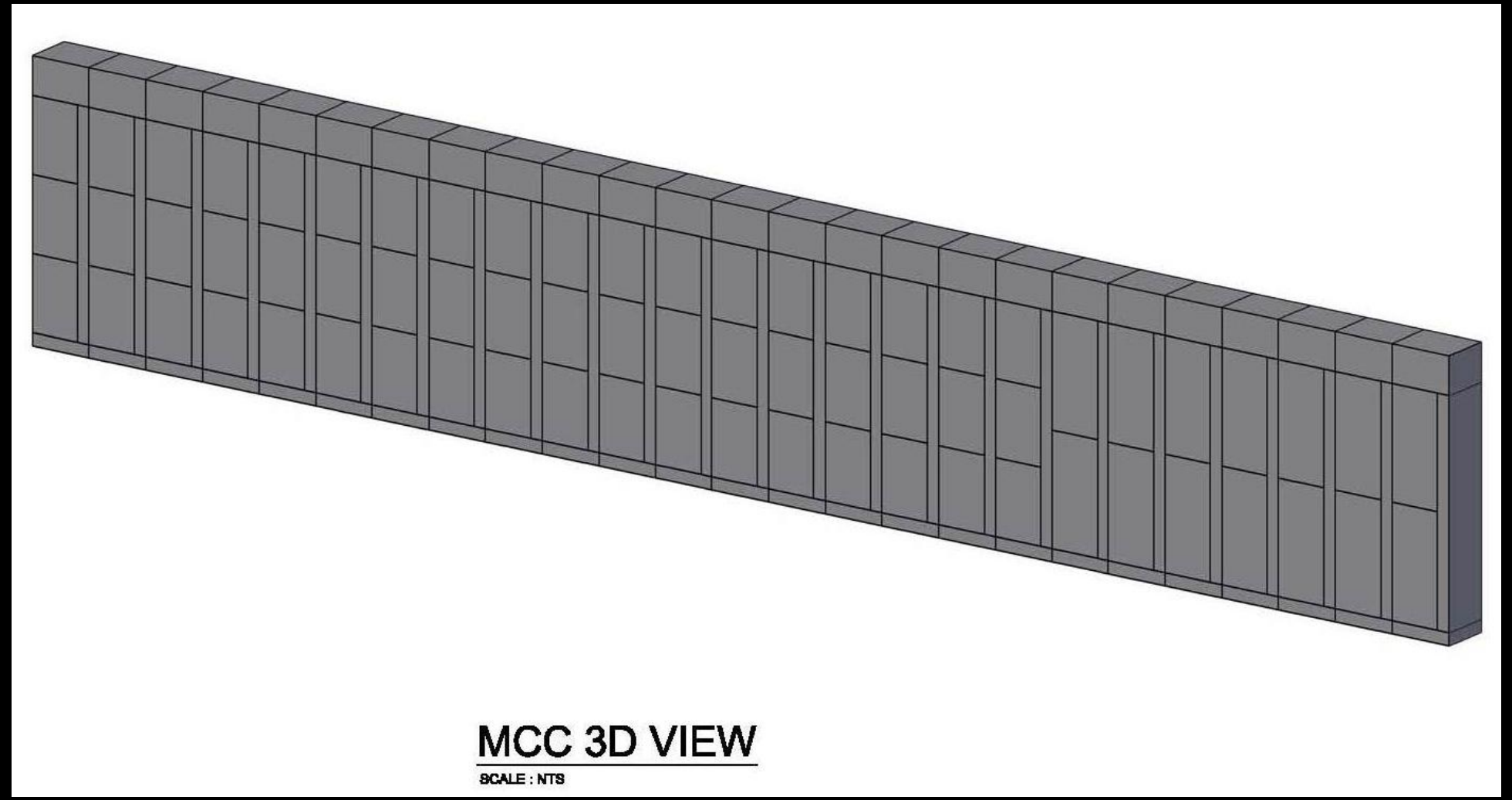
67 MOTORS IN ONE ROOM

SOLUTION

MOTOR CONTROL CENTER

OBJECTIVE

CONSOLIDATE MOTORS CONTROLS
SIMPLIFY FOR MAINTENANCE
SAFETY AND CONVENIENCE



MCC 3D VIEW
SCALE : NTS

- INTRODUCTION
- LIGHTING DEPTH
- ELECTRICAL DEPTH**
- CONCLUSION

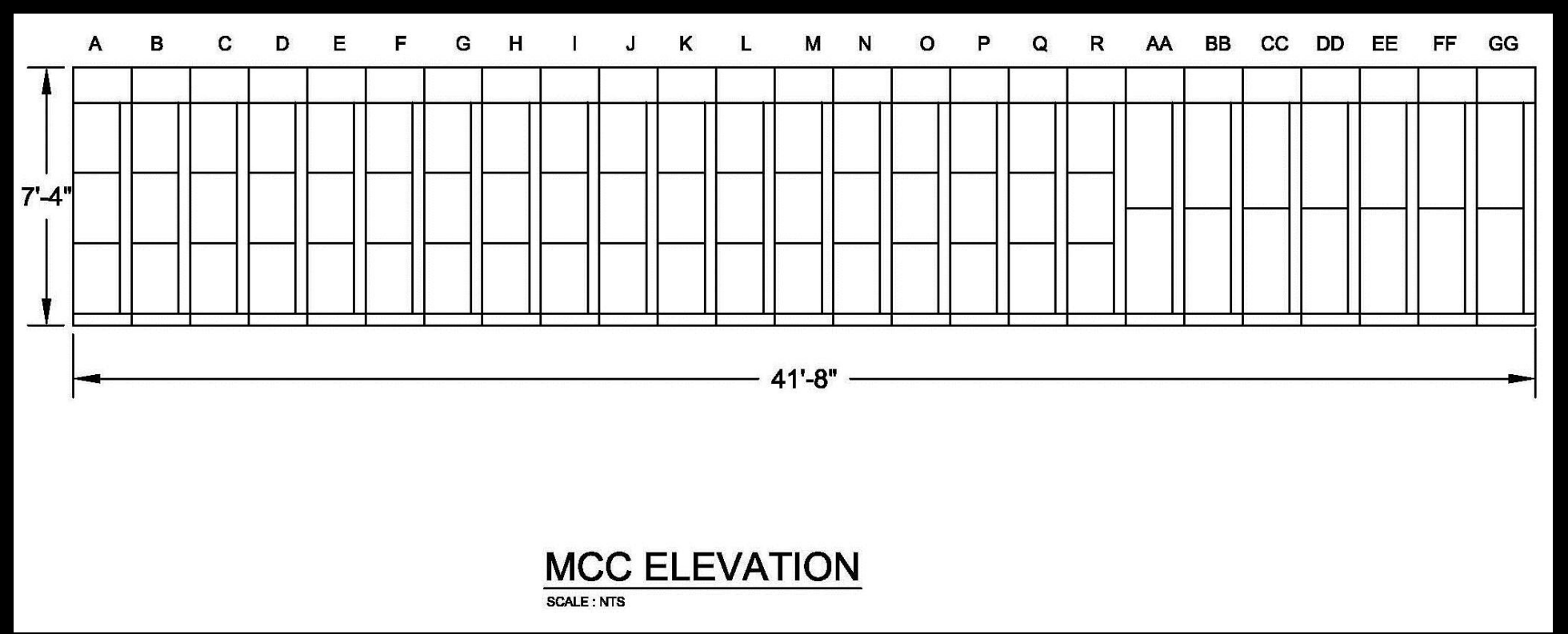
- BRANCH CIRCUITS
- SHORT CIRCUIT
- MOTOR CONTROL CENTER**
- BUS DUCTS



TOTAL LOAD AMPS
1279 A

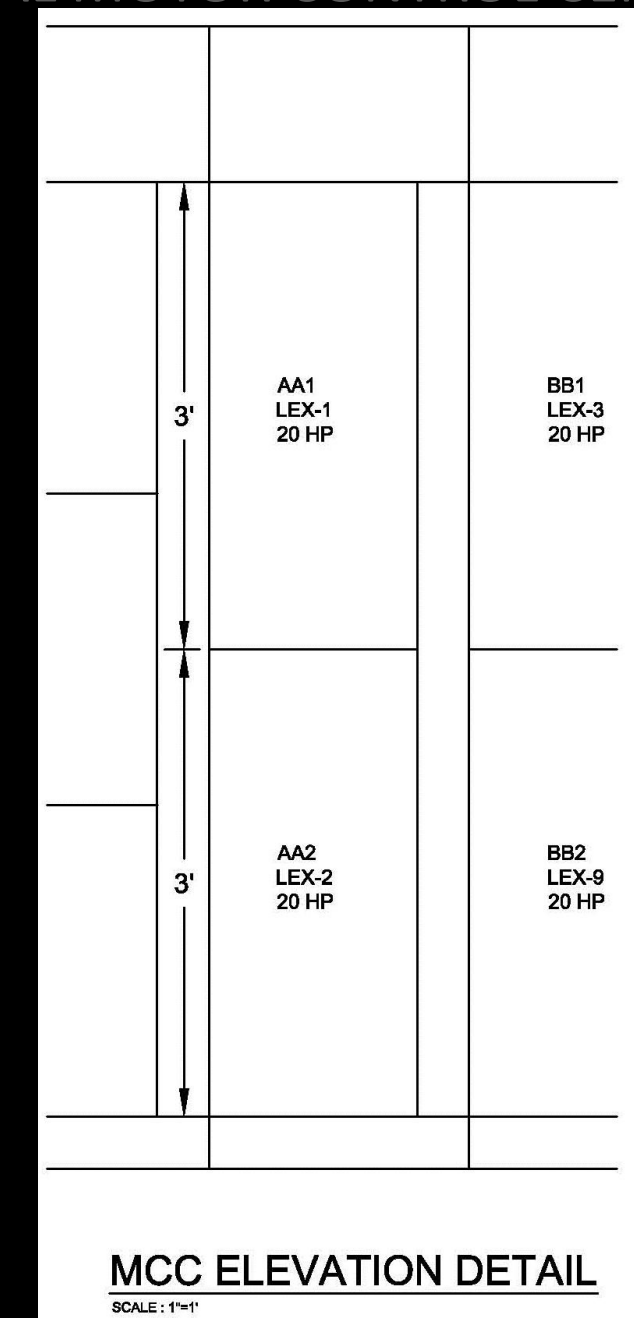
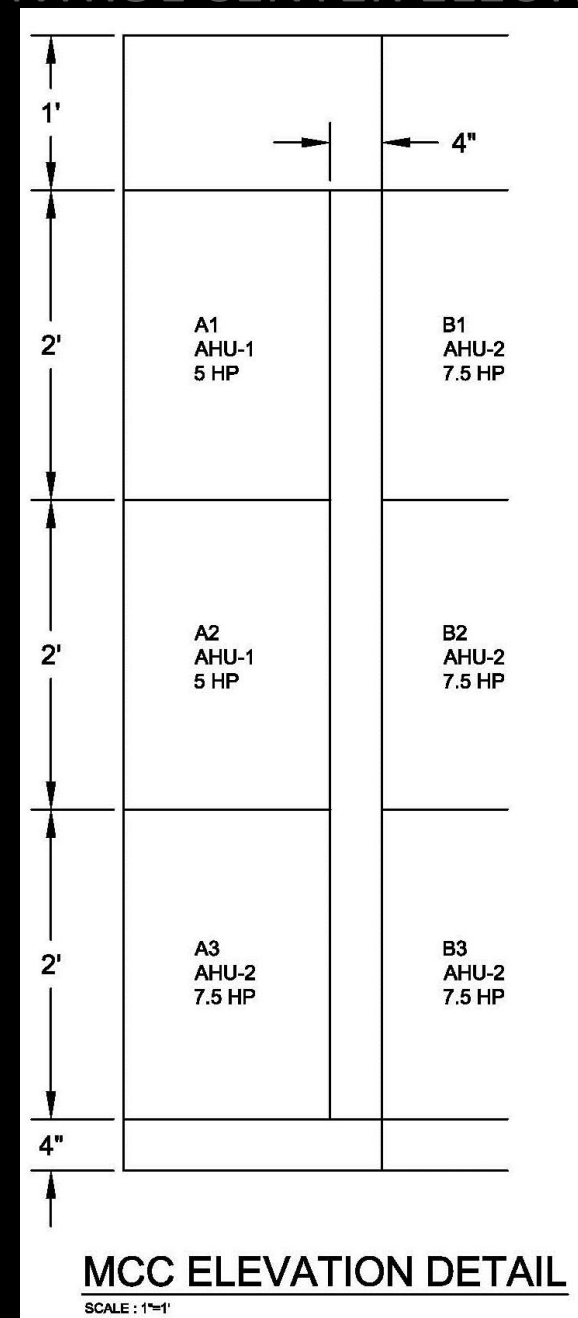
SUMMARY
SIZE 1600 A
480Y/277V 3PH 4W, 60HZ
NEMA 2
AIC 160,000

DIMMENSIONS
41'-8" X 7'-4" X 1'-4"



- INTRODUCTION
- LIGHTING DEPTH
- ELECTRICAL DEPTH**
- CONCLUSION

- BRANCH CIRCUITS
- SHORT CIRCUIT
- MOTOR CONTROL CENTER**
- BUS DUCTS



VERTICAL SECTIONS

25 TOTAL
18 WITH 24" UNITS
7 WITH 36" UNITS

QUANTITY OF 24" UNITS	QUANTITY OF 36" UNITS
53	14

- INTRODUCTION
- LIGHTING DEPTH
- ELECTRICAL DEPTH
- CONCLUSION**

- SUMMARY**
- ACKNOWLEDGEMENTS
- QUESTIONS



LIGHTING **FOLLOWS CONNECTION, MIRRORING OPPOSITES, STATIC MOTION, AND BUILDING AS BRAIN ACTIVITY CONCEPTS**

MEETS IESNA RECOMMENDATIONS AND ASHRAE ENERGY REQUIREMENTS

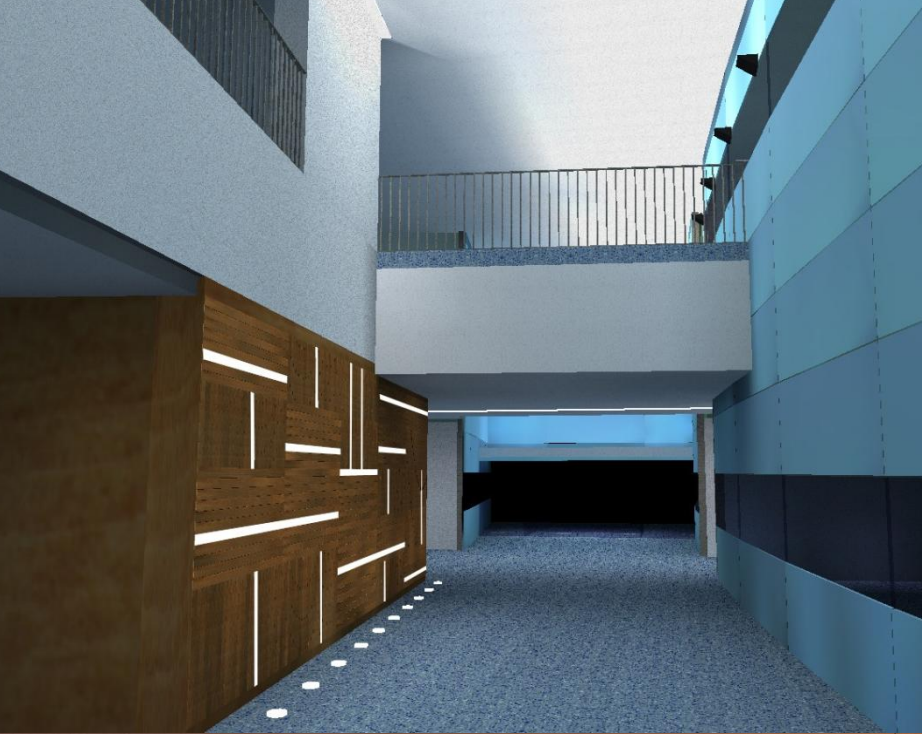
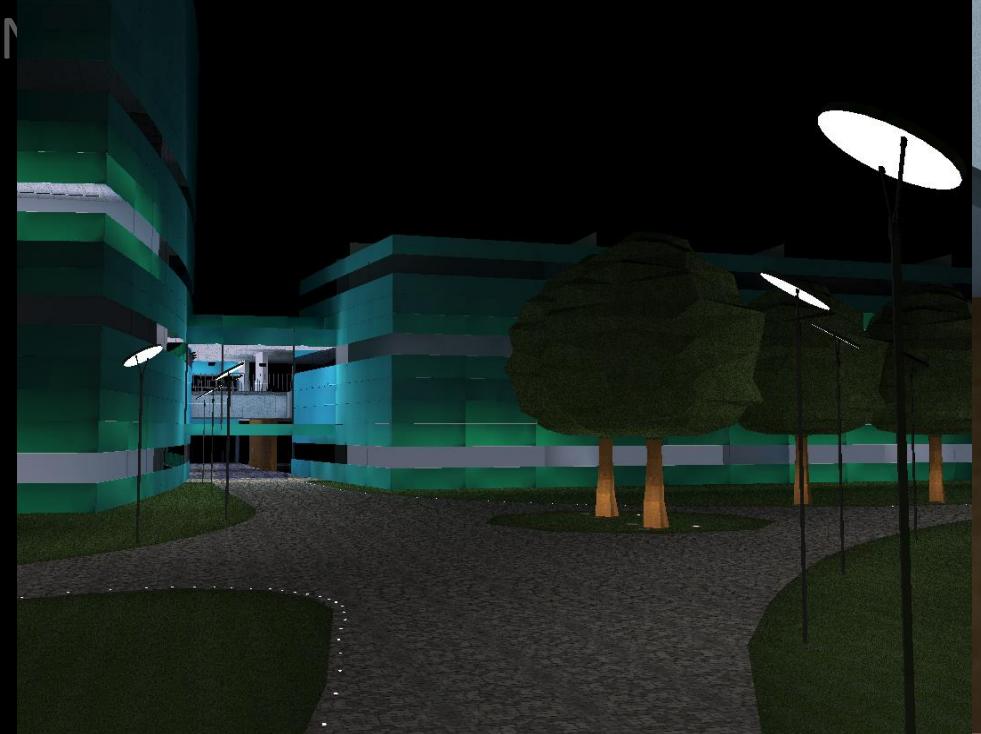
ADDRESSES HUMAN NEEDS WHILE ADDING INTEREST

ARCHITECTURAL **FOLLOWS LIGHTING CONCEPTS TO FULLY INTEGRATE WITH IT**

ELECTRICAL **CONSOLIDATES CONTROLS TO SIMPLIFY MAINTENANCE**

- INTRODUCTION
- LIGHTING DEPTH
- ELECTRICAL DEPTH
- CONCLUSION**

- SUMMARY**
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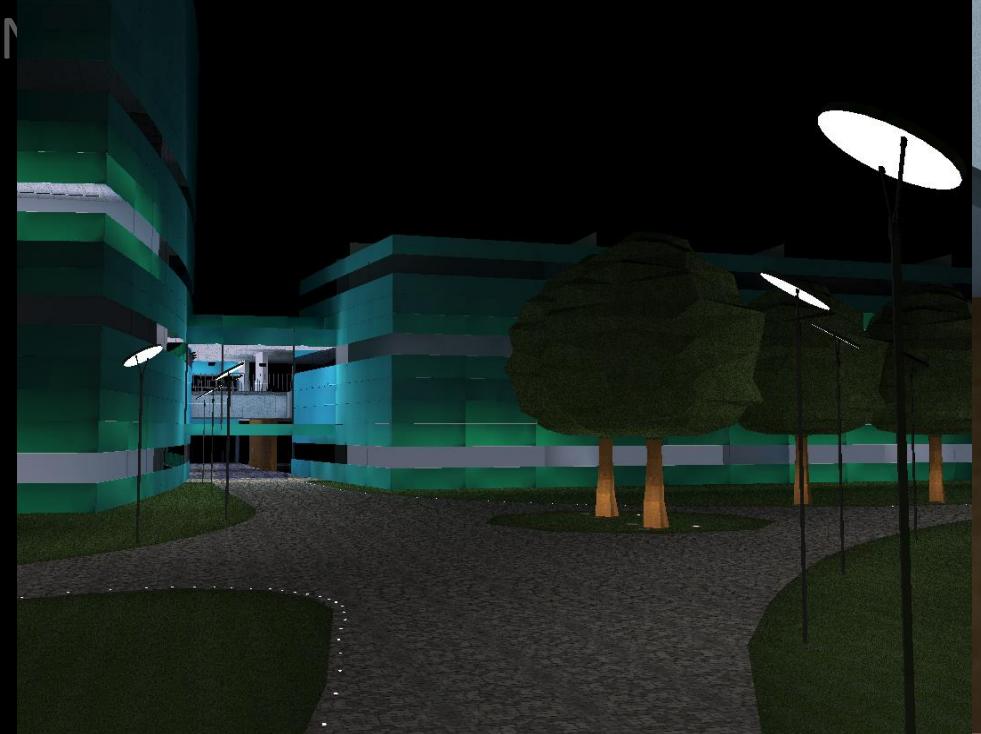
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ELECTRICAL CONSOLIDATES CONTROLS TO SIMPLIFY MAINTENANCE

INTRODUCTION
LIGHTING DEPTH
ELECTRICAL DEPTH

CONCLUSION SUMMARY
ACKNOWLEDGEMENTS
QUESTIONS



LIGHTING FOLLOWS CONNECTION, MIRRORING OPPOSITES,
STATIC MOTION, AND BUILDING AS BRAIN
ACTIVITY CONCEPTS

MEETS IESNA RECOMMENDATIONS AND ASHRAE
ENERGY REQUIREMENTS

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INTEREST

ARCHITECTURAL FOLLOWS LIGHTING CONCEPTS TO FULLY
INTEGRATE WITH IT

ELECTRICAL CONSOLIDATES CONTROLS TO SIMPLIFY
MAINTENANCE

INTRODUCTION
LIGHTING DEPTH
ELECTRICAL DEPTH
CONCLUSION

SUMMARY
ACKNOWLEDGEMENTS
QUESTIONS



PRINCETON **AHMED SULTAN**

FMS **MICHAEL LOMBARDI**
MICHAEL HEMMENWAY
CHARLES STONE

ARUP **DEANNA SCHMIDT**
CHRISTOPHER RUSH
GREGORY GIAMMALVO

AE FACULTY **KEVIN HOUSER**
RICHARD MISTRICK
TED DANNERT

L/E **CLASSMATES, ALUMNI, AND FRIENDS**



PRINCETON

NEUROSCIENCE &

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COMPLEX

QUESTION AND ANSWER SESSION

Type	Description	Lamp	Watt	Volt	Mfr	Catalog #	Location
AA	Surface mounted linear flourescent lamp and extrudeed aluminum housing with nominal 2.5" height by 2" wide, integral electronic ballast and T6 lamps for end-to-end smooth continous illumination mounted within architectural cove, 3000k. Lenghts as required by architecture.	NIPPO T6 FL 88CRI	9-10 W/lf	277	Nippo	SAL-UW-XXXX/FRT-XXXX-EL30	Café
AB	Recessed compact flourescent downlight with 6" nominal diameter apperture with aluminum, bright anodized reflector with plastic, translucent diffuser and integral electronic ballast, 3000k	PHILIPS PL-T 18W/830 /4P/ALTO 82CRI	18.4	277/120	Edison Price	TRPV 18/6	Café, Lecture Hall
AC	Surface mounted LED strip approximately 0.75"x0.75" in cross section and incremental nominal lenghts raning from 6" to 96" with extruded aluminum housing and acrylic optics, 96W driver supplied, 3000k. Consult factory for high CRI option availability.	High CRI option LED	2.92 W/lf	277	Cooper IO	0.03.1.3k.4 5.101.1.XX. 2.277V	Café, Lobby
AD	Surface mounted high-performance LED grazing fixture , 1.5" diameter by 2.1" high and 1ft increments with die-cast aluminum white powder coated finish housing and polycarbonate lens	LED 83CRI	13.5	277	Color Kinetics	eW Fuse Powercore 3000K, 10 by 60 degree beam angle	Café, Lobby
AE	Suspended halogen pendant with extruded and die-cast aluminum housing, grey finish, suspension cable included, designed by Roberto Pamio.	GE Q75G9	75	277	iGuzzini	Cup SM19	Café
AF	Recessed in-ground low-voltage halogen wall-washer with cast aluminum body and outer casing and double tempered glass and nominal 5" diameter with integral electronic transformer.	PHILIPS 10W/T3/12V	10	12-277	iGuzzini	I.B001-277-13	Lobby

AG	Recessed low voltate halogen wall luminaire with die-cast aluminum housing with integral wiring compartment, impact resistant satin matte crystal glass, requires a remote Class 2, 12V transformer, nominal 3 in square.	PHILIPS 10W/T3/12V	10	120/12	Bega	2303	Lecture Hall
AH	Recessed compact flourescent wall-washer with 6" nominal diameter apperture with aluminum, bright anodized reflector with plastic, translucent diffuser and integral electronic ballast, 3000k	(2) PHILIPS PL-T 26W/830/4P/ALTO 82CRI	46	120	Edison Price	WLX 226/6	Lecture Hall
AJ	Fully recessed and flangeless linear flourescent slotlight nominal 6" wide with extruded aluminum housing, pwer coated high-reflectance which finish, and joiner system allowing uniform appearance with frosted acrylic lens. Lenghts as required by architecture.	PHILIPS F28T5/835/ALTO 85CRI	30	277	Zumtobel	SLR6NX-XX-1285-XX-OLP-DX	"Lecture Hall"/LOBBY
AK	Fully recessed and flangeless linear flourescent slotlight nominal 6" wide with extruded aluminum housing, pwer coated high-reflectance which finish, and joiner system allowing uniform appearance with frosted acrylic lens. Lenghts as required by architecture.	PHILIPS F54T5/835/HO/ALTO 85CRI	57	120	Zumtobel	SLR6NX-XX-1545-XX-OLP-DX	Lecture Hall
AL	Surface wall mounted elliptipar metal halide ceiling uplight mounted to the moullions of the exterior façade inside the lobby with bright clear anodized aluminum reflector with mill finish aluminum door and end plates and black yoke/mounting plate and remote electronic ballast.	PHILIPS CDM150/T6/942 96CRI	150	277	The Lighting Quotient	1403-150G-W-00-2-00-0	Lobby
AM	Pole top metal halide exterior indirect adjustable luminaire with die-cast aluminum optical housing and 31.5" diameter and .25" thick aluminum plate secured by two die-cast aluminum "saddle" with maximum 30 degrees tilt and IP65 classification.	PHILIPS CDM Elite 70/T6/ 930 90CRI	88	277	Bega	8200MH	North Entry
AP	Recessed exterior round drive-over in-ground halogen uplight for folliage with stainless steel housing, convex tempered glass dissuser, annodized matte reflector, and natural bronze casting finish, rated IP67, with integral electronic transformer.	35W T4 GY6.35 12V	46	120/11.6	Bega	8702	North Entry
AR	Fully Recessed LED indicator in-ground luminaire for both outdoor and indoor applications, with remote contant 6V driver, stainless steel housing, rated IP67, and visible nominal diameter of 7/8" with the base being nominal 5".	0.1W LED	0.08	277	MP Lighting	L06-W527S-X-X-56	North Entry, could be everywhere else as connection element!!!!

Type	Location	PF	Input Current	Input Wattage	Lamp Wattage	Other	BF
AA	Nippo Specs	0.98	0.17 for 4ft section (1250cm)	47	39	Advance Xfmr, non-dimming	
AB	page 17-5 GE catalog	0.97	0.08	20	18	ProLine CFL Electronic Ballasts	1.05
AC		1.00		2.92 W/lf	2.92 W/lf		1
AD		1.00		13.5	13.5		1
AE	page 17-5 GE catalog	0.97	0.08	20	18	ProLine CFL Electronic Ballasts	1.05
AF		1		10	10		1
AG		1		10	10		1
AH	page 17-6 GE catalog	0.99	0.2	54	46	ProLine CFL Electronic Ballasts	1
AJ	page 13-3 GE	0.92	0.17	43		T5 High Efficiency - Programmed Start	1.22
AK	page 13-6 GE	0.97	0.26	71			1.11
AL	page 18-14 GE	0.9	0.7	186		86718 - GEM150MLTLC3D-5	1
AM	page 18-11 GE	0.9	0.4	88		86847	1
AP		1		46	46		1
AR		1		0.08	0.08		1

LIGHT LOSS FACTORS				
Luminaire Type	Lamp Lumen Depreciation	Ballast Factor	Lamp Dirt Depreciation	Total Light Loss Factors
AA	0.92	0.88	0.95	0.77
AB	0.86	1.05	0.95	0.86
AC	0.70	1.00	0.95	0.67
AD	0.70	1.00	0.95	0.67
AE	1.00	1.05	0.95	1.00
AF	1.00	1.00	0.95	0.95
AG	1.00	1.00	0.95	0.95
AH	0.86	1.00	0.95	0.82
AJ	0.95	1.22	0.95	1.10
AK	0.95	1.11	0.95	1.00
AL	0.70	1.00	0.95	0.67
AM	0.89	1.00	0.75	0.67
AP	1.00	1.00	0.75	0.75
AR	0.70	1.00	0.75	0.53
Luminaire Type	Lamp Lumen Depreciation	Ballast Factor	Lamp Dirt Depreciation	Total Light Loss Factors
AC	0.70	1.00	0.95	0.67
AD	0.70	1.00	0.95	0.67
AF	1.00	1.00	0.95	0.95
AJ	0.95	1.22	0.95	1.10
AL	0.70	1.00	0.95	0.67

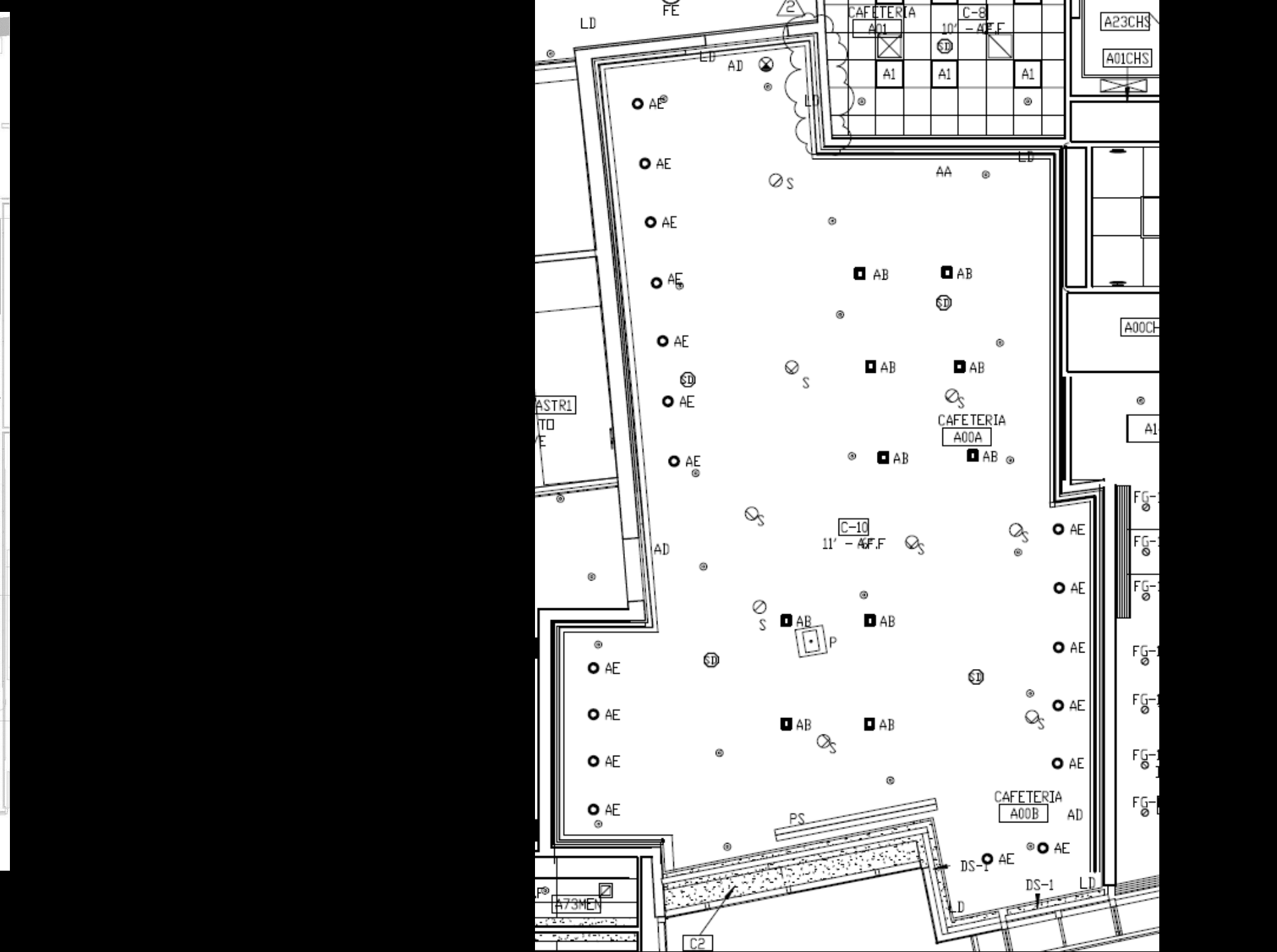
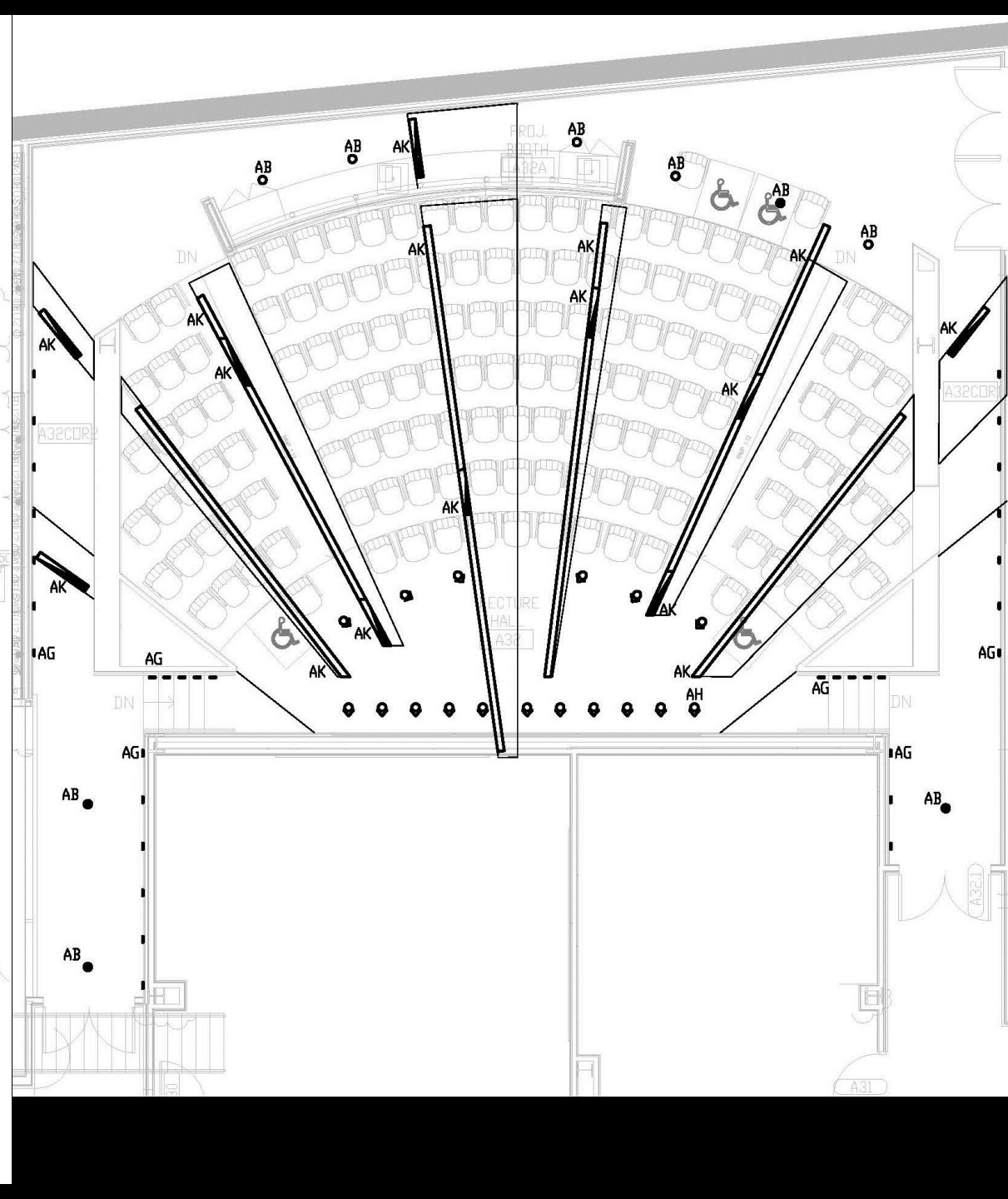
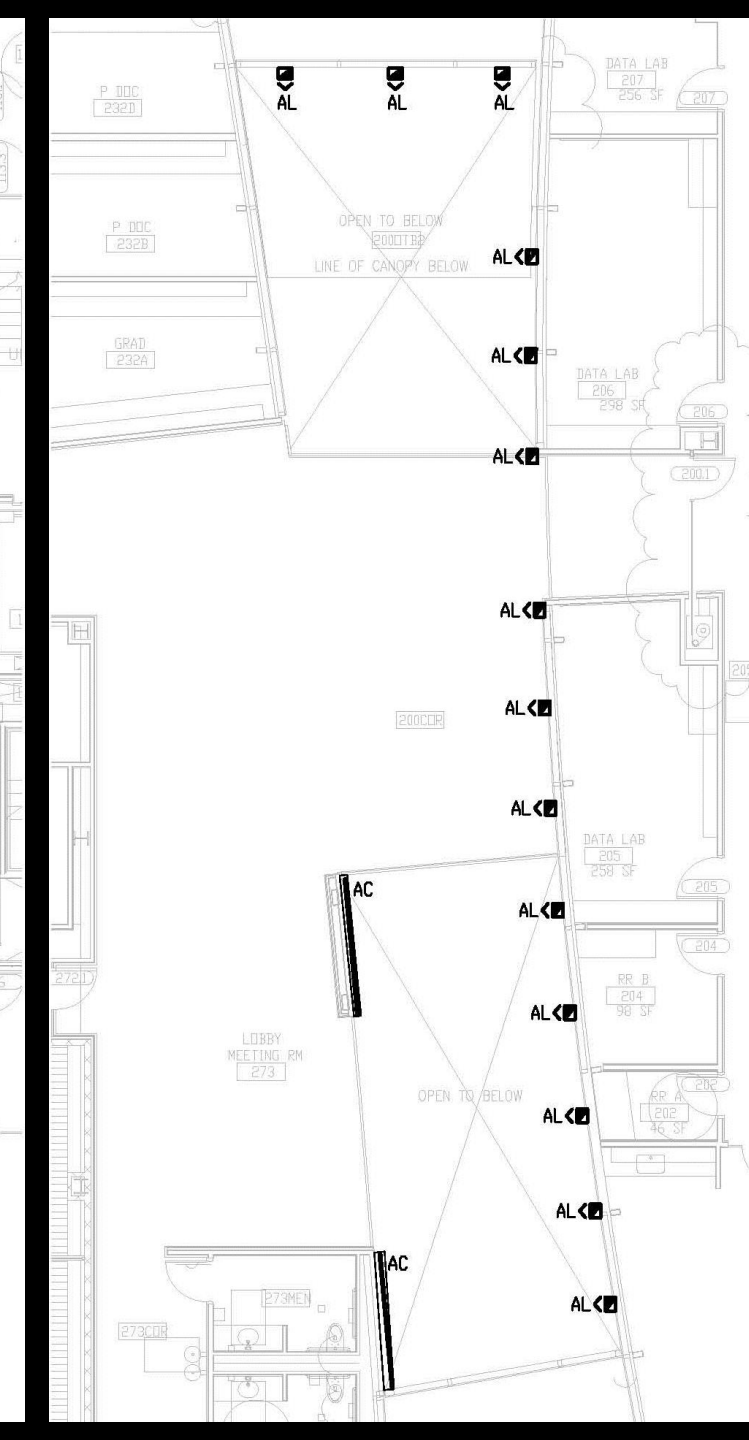
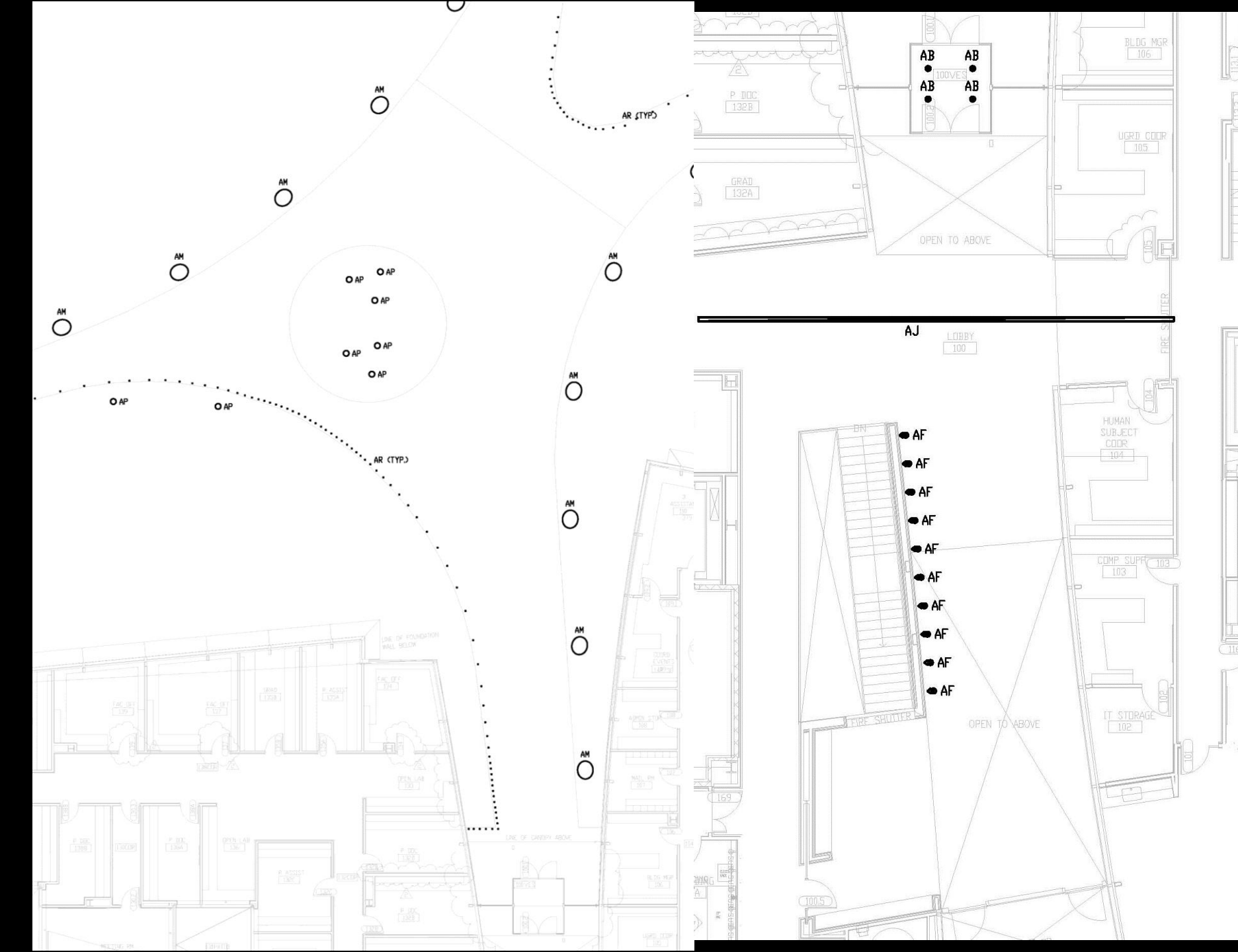
Results: LECTURE HALL

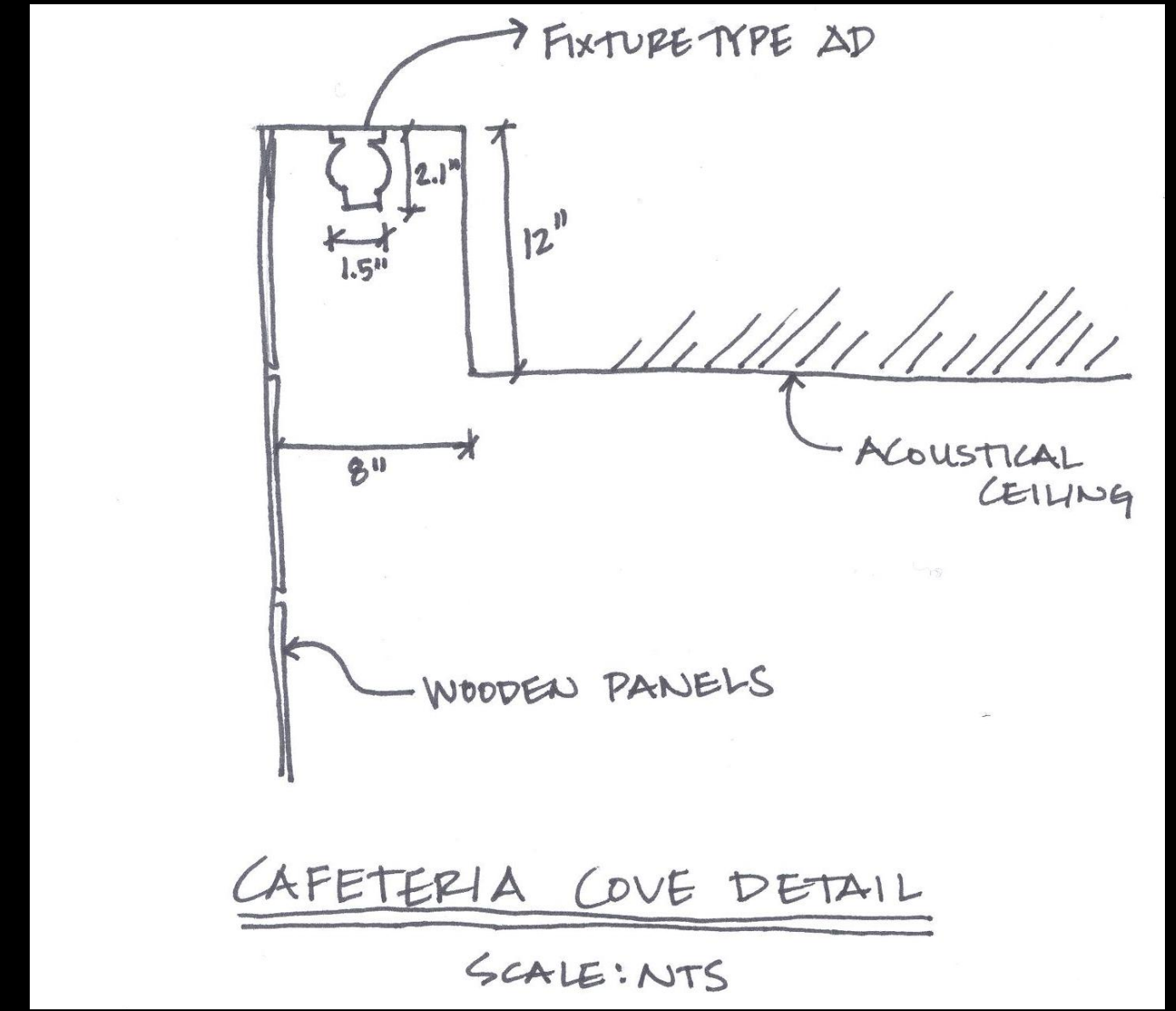
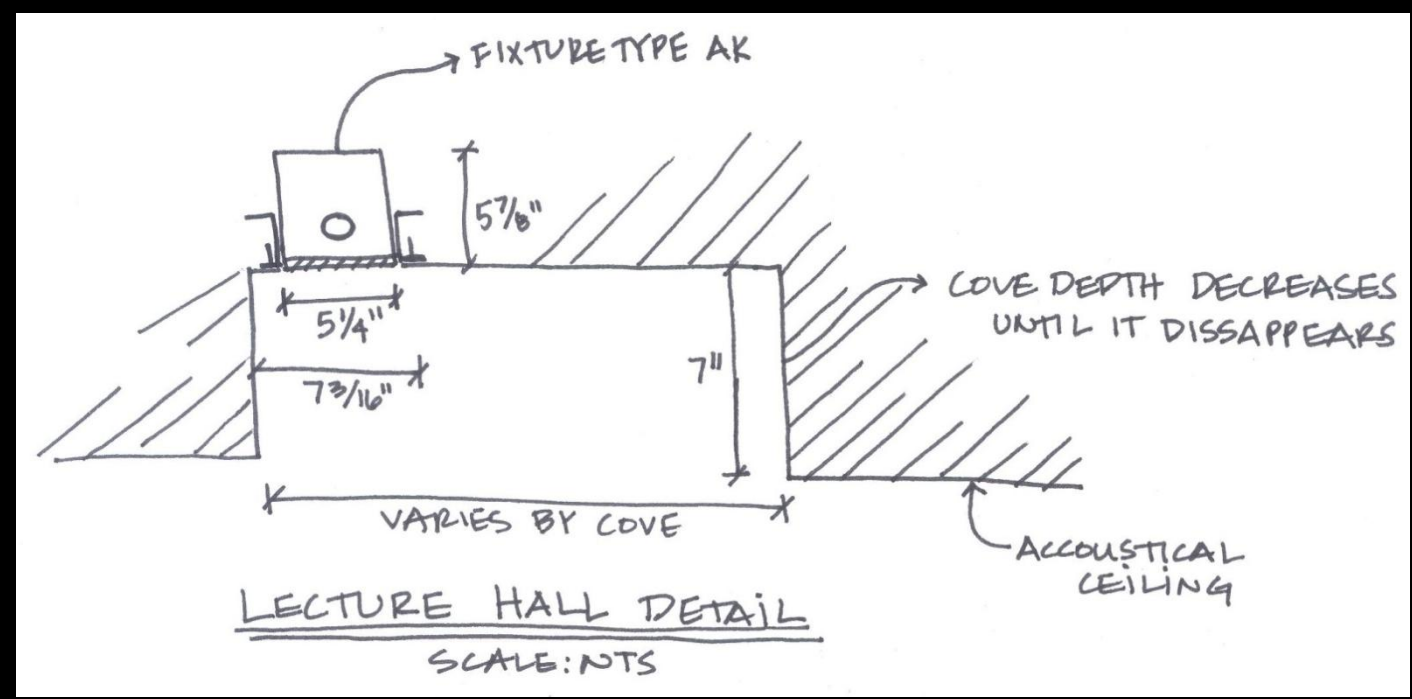
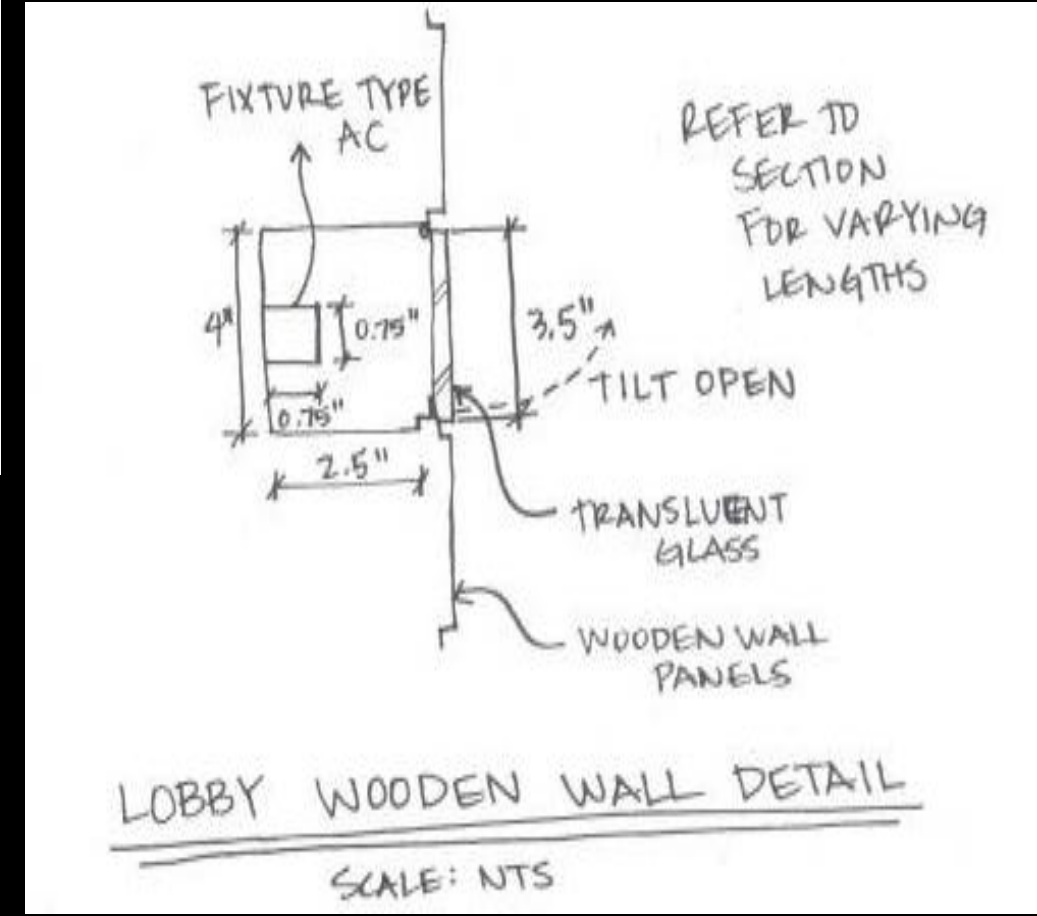
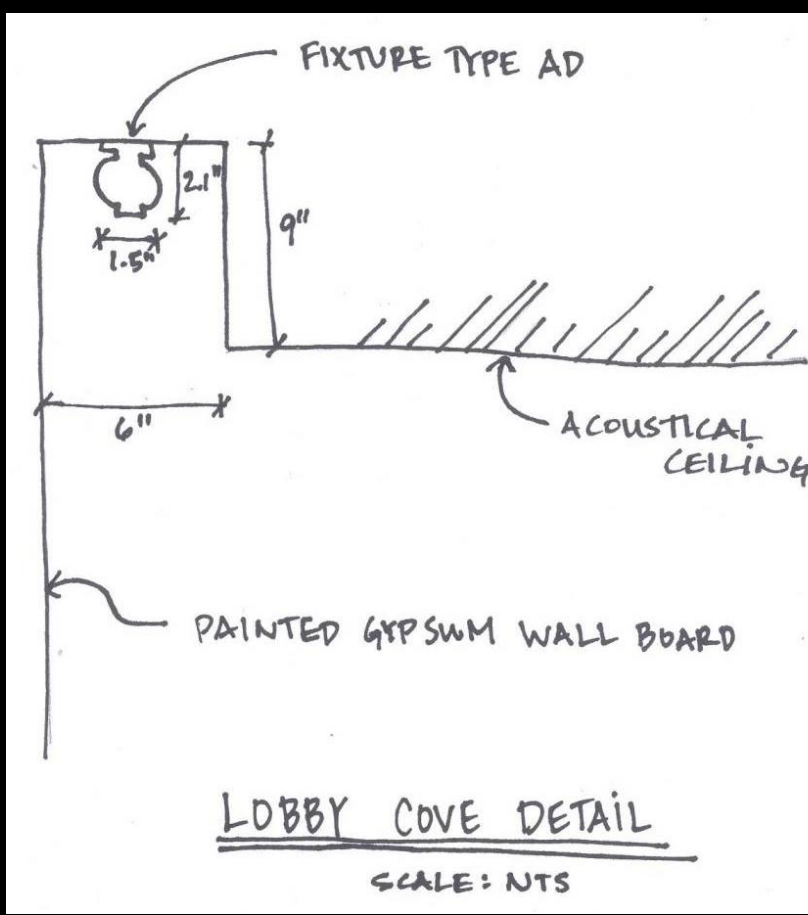
Zone	Average Illuminance	Maximum	Minimum	Max/Min	Coeff. Variation
Reading	28.48	59	9.1	6.48	
Lectern	67.82	83.2	47.9	1.74	
Lectern Vertical	30.81	36.1	19.7	1.83	
Stairs	6.72	10.4	4.6	2.26	
Corridors	6.57	15	2.7	5.56	
Chalkboard	45.88	83.7	19.6	4.27	0.36

Pendant luminaires OFF
Pendant luminaires ON

Zone	Average Illuminance	Maximum	Minimum	Max/Min	Coeff. Variation
Tables	9.05	27.20	2.00	13.60	0.61
Lounge	11.79	15.20	5.80	2.62	
Food Prep	30.55	41.10	15.50	2.65	

Zone	Average Illuminance	Maximum	Minimum	Max/Min	Coeff. Variation
Tables	39.74	62.00	25.90	2.39	0.20
Lounge	12.95	16.30	6.90	2.36	
Food Prep	31.11	41.40	16.30	2.54	





Model Number: QSGRJ-6P**Phase Control Zones**

Zone	Name	Load Type	No. Fixtures	Wattage/Fixture	Total Wattage
1	chalkboard	Fluorescent 0-10V	11	17	187
2	lectern	Fluorescent 0-10V	6	17	102
3	lines coves +	Fluorescent 0-10V	28	57	1596
4	proj booth +	Fluorescent 0-10V	6	18	108
5	corridor	Fluorescent 0-10V	3	57	171
6	steplights	Inc / Hal	33	10	330

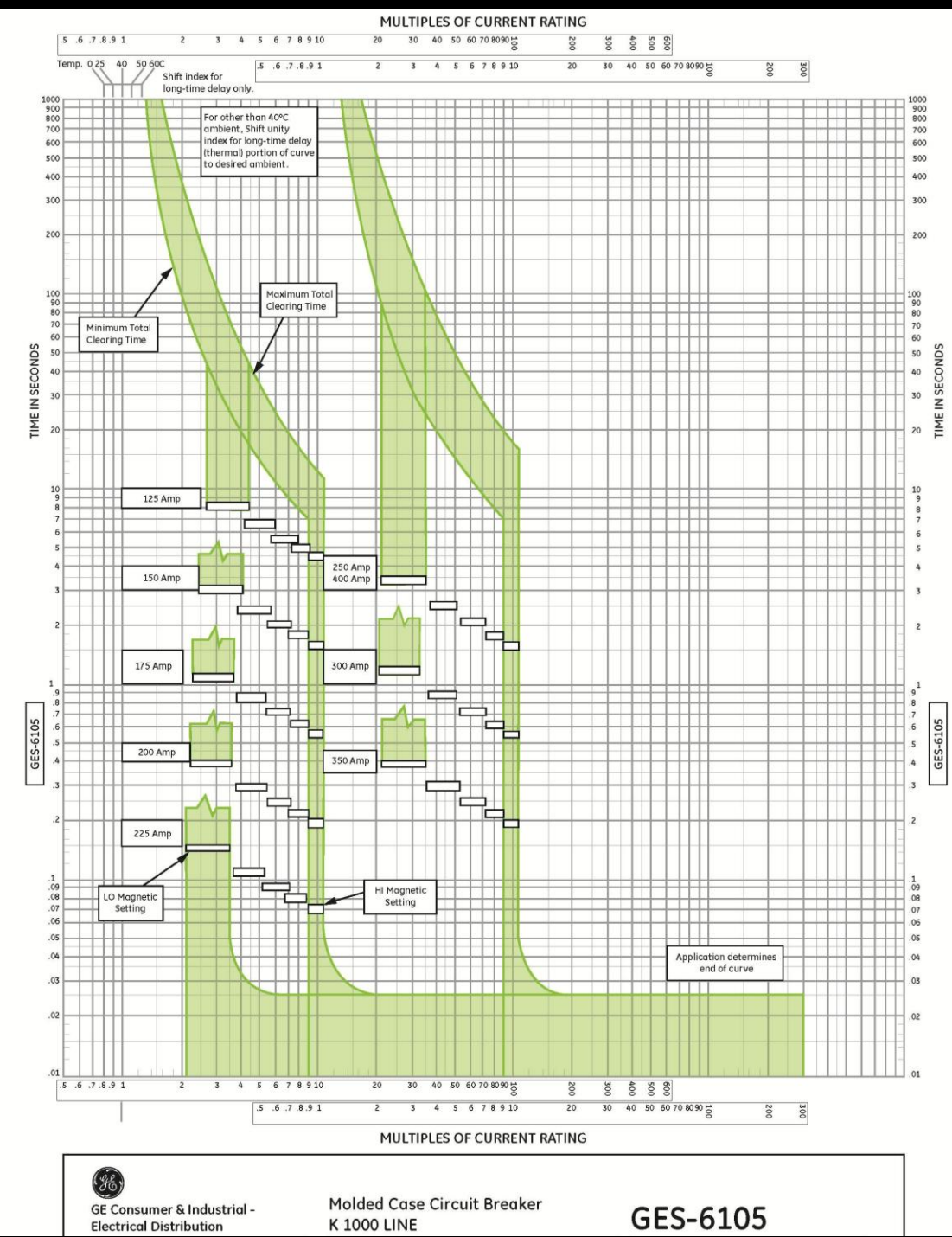
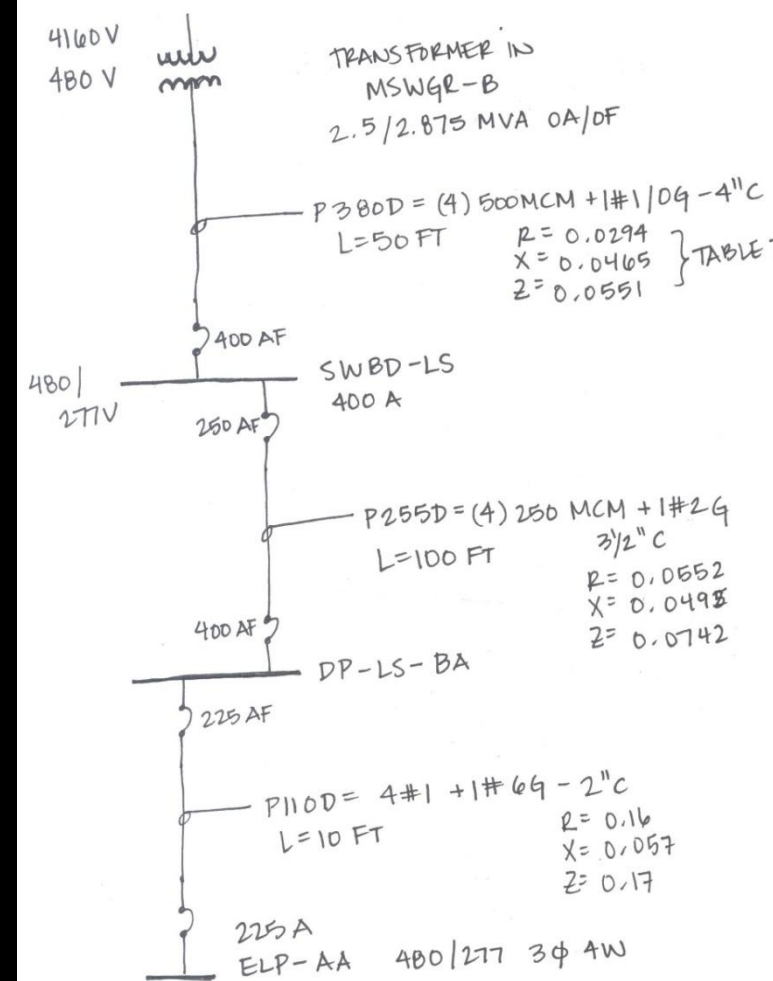
Cafeteria										
	Building Area	Space-by-Space	Area (sqft)	Luminaire Type	Watts/Luminaire	Amount	Total Wattage		*Decorative Allowance	
Allowable LPD (W/sqft)	1.2	1.4	2283	AA	37	13	481		1.0	
Actual LPD (W/sqft)	1.001	1.001		AB	18.4	19	349.6		0.591	
Percentage	16.586	28.503		AC	19.6	5	98		40.867	
				AD	11.9	114	1356.6			
				AE*	75	18	1350		TOTAL WATTAGE	
					TOTAL WATTAGE*					
						=	2285.2		3635.2	
Lecture Hall										
	Building Area	Space-by-Space	Area (sqft)	Luminaire Type	Watts/Luminaire	Amount	Total Wattage			
Allowable LPD (W/sqft)	1.2	1.4	3075	AB	18.4	9	165.6			
Actual LPD (W/sqft)	1.156	1.156		AG	10	33	330			
Percentage	3.669	17.431		AH	46	17	782			
				AJ	30	17	510			
				AK	57	31	1767			
					TOTAL WATTAGE =		3554.6			

Lobby												
	Building Area	Space-by-Space	Area (sqft)	Luminaire Type	Watts/Luminaire	Amount	Total Wattage		*Decorative Allowance			
Allowable LPD (W/sqft)	1.2	1.3	3447	AB	18.4	4	73.6		1.0			
Actual LPD (W/sqft)	0.816	0.816		AD	11.9	20	238		0.142			
Percentage	32.028	37.256		AF	10	10	100		85.785			
				AJ	30	5	150					
				AL	150	15	2250					
				AC	19.6	25	490		TOTAL WATTAGE	LOBBY+CAFÉ		
					TOTAL WATTAGE =		2811.6		3301.6	6936.8		
North Entrance												
	Walkways (>10ft wide) W/sqft	Main Entry W/lf	Canopies W/sqft	Building Façade W/sqft	Area Pathways	Main Enrtry Length	Canopy Area	Façade Area	Luminaire Type	Watts/Luminaire	Amount	Total Wattage
Allowable LPD	0.14	30	1.25	0.2	5461	7	352	0	AB	18.4	4	73.6
		Total Allowable Watts		1414.54					AM	88	9	792
		Actual Watts		1239.84					AP	46	8	368
		Percentage		12.350					AR	0.08	78	6.24
						TOTAL WATTAGE =						1239.84

Lighting Loads	
Space	VA = W/PF
Cafeteria	3747.6
Lecture Hall	3664.5
Lobby	3403.7
North Entrance	1278.2
* SINCE ALL ARE LESS THAN 10.6 KVA, EACH SPACE ONLY REQUIRES ONE CIRCUIT	
ALL SPACES - Building Area Method	
	Building Area
Allowable LPD (W/sqft)	1.2
Actual LPD (W/sqft)	0.803
Percentage	33.123

Summary Results of Fault Current

Point	Location	Available Fault (A)	Standard Breaker Rating (A)	Standard Breaker Rating (A) Existing
A	MSWGR-B	52318	65000	65000
B	SWBD-LS	35029	65000	65000
C	DP-LS-BA	24604	35000	18000
D	ELP-AA	15063	22000	



Panelboards						
Panel Tag	Voltage	System	North Entry	Lobby	Lecture Hall	Cafeteria
LP-AA	480Y/277V, 3P, 4W	N				X
ELP-AA	480Y/277V, 3P, 4W	N/E				X
LPD-AAL	208Y/120V, 3P, 4W	N			X	
ELPD-AAL	208Y/120V, 3P, 4W	N/E			X	
ELP-2B	480Y/277V, 3P, 4W	N/E	X	X		

Load Tag	Description	Magnitude	Units	NEC Motor Amps	Voltage	Phase	Assumed Power Factor	Load in KVA	Load in KW	Qty.	Total Load in KW	VFD	CB Type HMCP	Starter Type	NEMA Starter Size	Standard Unit Space (in)
AHU-1	air handling unit	5 HP	7.6	480	3	0.75	6.311	4.733	2	9.4666	X	15	AFD	1	24	
AHU-2	air handling unit	7.5 HP	11	480	3	0.95	9.134	8.678	9	78.099	X	30	AFD	1	24	
AHU-3	air handling unit	7.5 HP	11	480	3	0.95	9.134	8.678	9	78.099	X	30	AFD	1	24	
AHU-4	air handling unit	7.5 HP	11	480	3	0.95	9.134	8.678	9	78.099	X	30	AFD	1	24	
AHU-5	air handling unit	7.5 HP	11	480	3	0.95	9.134	8.678	9	78.099	X	30	AFD	1	24	
AHU-6	air handling unit	7.5 HP	11	480	3	0.95	9.134	8.678	6	52.066	X	30	AFD	1	24	
AHU-7	air handling unit	5 HP	7.6	480	3	0.75	6.311	4.733	8	37.866	X	15	AFD	1	24	
RF-1	return fan	10 HP	14	480	3	0.95	11.63	11.04	1	11.044	X	35	AFD	1	24	
LEX-1	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-2	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-3	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-9	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-8	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-7	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-6	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-5	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
LEX-4	exhaust	20 HP	27	480	3	0.95	22.42	21.3	1	21.3	X	50	AFD	2	36	
HDX-1	heat exchanger pump	25 HP	34	480	3	0.95	28.23	26.82	1	26.822	X	50	AFD	2	36	
HDX-2	heat exchanger pump	25 HP	34	480	3	0.95	28.23	26.82	1	26.822	X	50	AFD	2	36	
HDX-3	heat exchanger pump	25 HP	34	480	3	0.95	28.23	26.82	1	26.822	X	50	AFD	2	36	
HDX-4	heat exchanger pump	25 HP	34	480	3	0.95	28.23	26.82	1	26.822	X	50	AFD	2	36	
HRM-1	AHU-6	30 HP	40	480	3	0.95	33.25	31.59	1	31.592	X	100	AFD	3	36	

Motor Control Center: MCC										Location: PENTHOUSE 3RD FLOOR MECHANICAL ROOM						
Amps: 1600					Volts: 480Y/277 3PH 4W, 60HZ					NEMA: 2		AIC: 160,000				
Unit #	Circuit	HP	FLA	Starter		Circuit Protection		Feeder			Notes					
				Type	Size	Type	Trip									
A1	AHU-1	5	10AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-								
A2	AHU-1	5	10AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-								
A3	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
B1	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
B2	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
B3	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
C1	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
C2	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
C3	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
D1	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
D2	AHU-2	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
D3	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
E1	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
E2	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
E3	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
F1	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
F2	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
F3	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
G1	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
G2	AHU-3	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
G3	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
H1	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
H2	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
H3	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
I1	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
I2	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
I3	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
J1	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
J2	AHU-4	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
J3	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
K1	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
K2	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
K3	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
L1	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
L2	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								
L3	AHU-5	7.5	14AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-								

M1	AHU-5	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
M2	AHU-5	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
M3	AHU-6	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
N1	AHU-6	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
N2	AHU-6	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
N3	AHU-6	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
O1	AHU-6	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
O2	AHU-6	7.5	14 AFD	1	HMCP	30	3#10 + 1#10G AND 3/4"C	-
O3	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
P1	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
P2	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
P3	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
Q1	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
Q2	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
Q3	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
R1	AHU-7	5	10 AFD	1	HMCP	15	3#14 + 1#14G AND 3/4"C	-
R2	RF-1	10	20 AFD	2	HMCP	35	3#10 + 1#10G AND 3/4"C	-
AA1	LEX-1	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
AA2	LEX-2	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
BB1	LEX-3	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
BB2	LEX-9	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
CC1	LEX-8	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
CC2	LEX-7	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
DD1	LEX-6	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
DD2	LEX-5	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
EE1	LEX-4	20	36 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
EE2	HDX-1	25	45 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
FF1	HDX-2	25	45 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
FF2	HDX-3	25	45 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
GG1	HDX-4	25	45 AFD	2	HMCP	50	3#8 + 1#10G AND 3/4"C	-
GG2	HRM-1	30	53 AFD	3	HMCP	100	3#3 + 1#8G AND 1-1/4"C	-

Notes:
1. EATON 2100 Series Motor Control Centers, 30.1
2. SVX9000 1 - 30hp at 480 V Plug-in Adjustable Frequency Drive Units

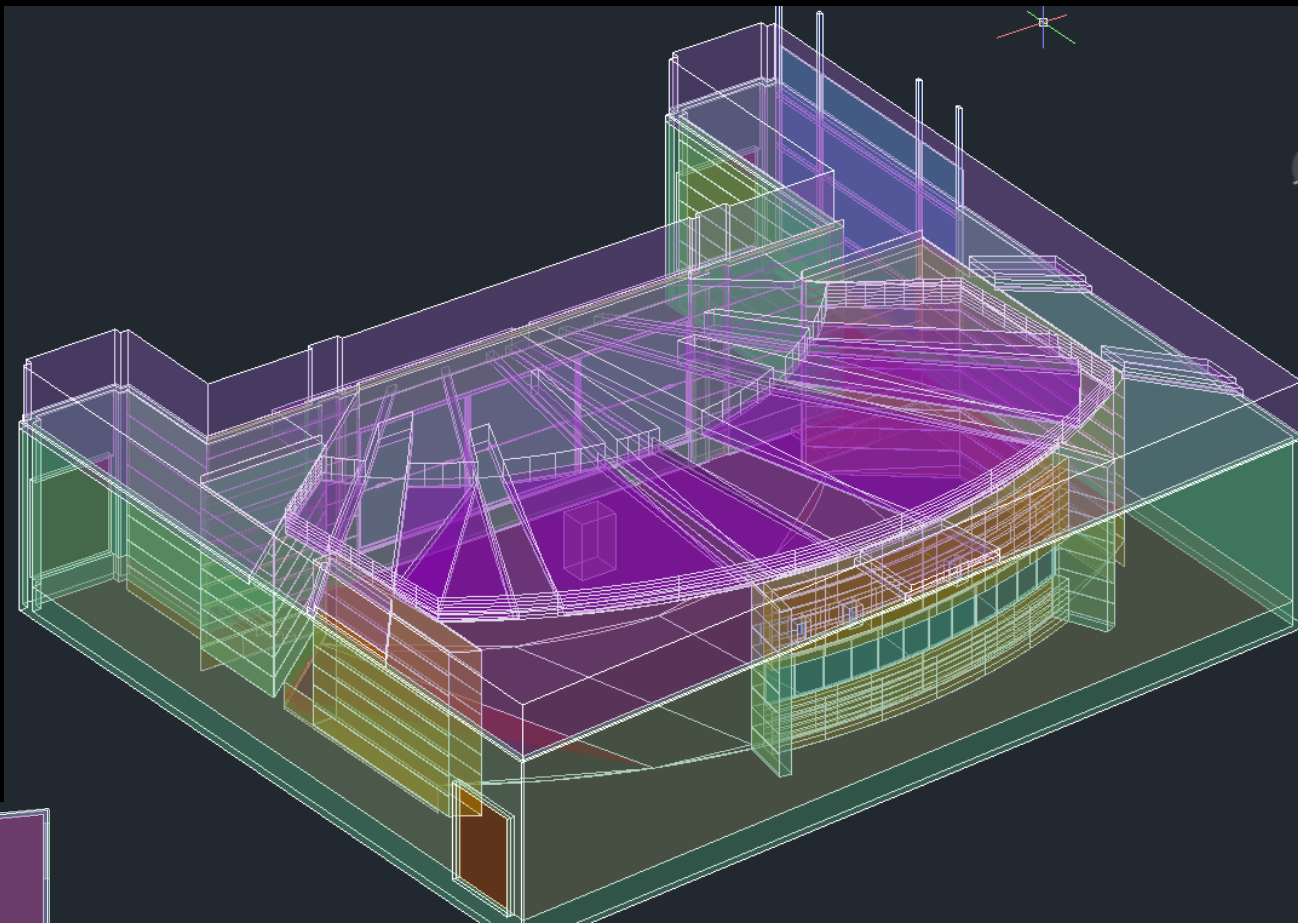
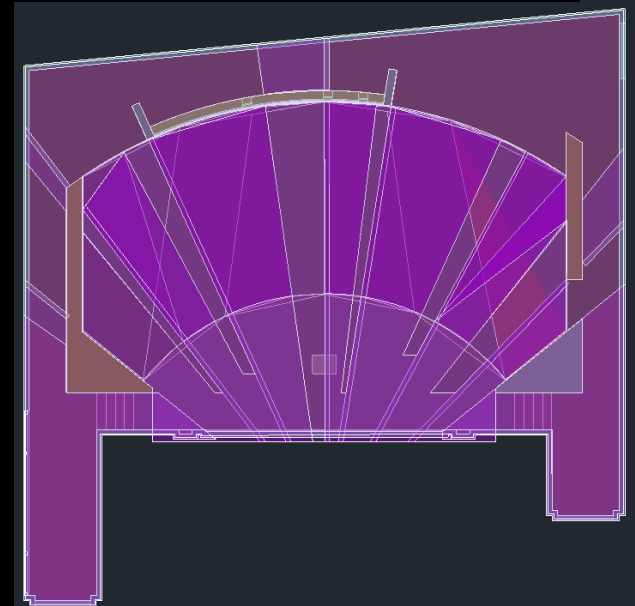
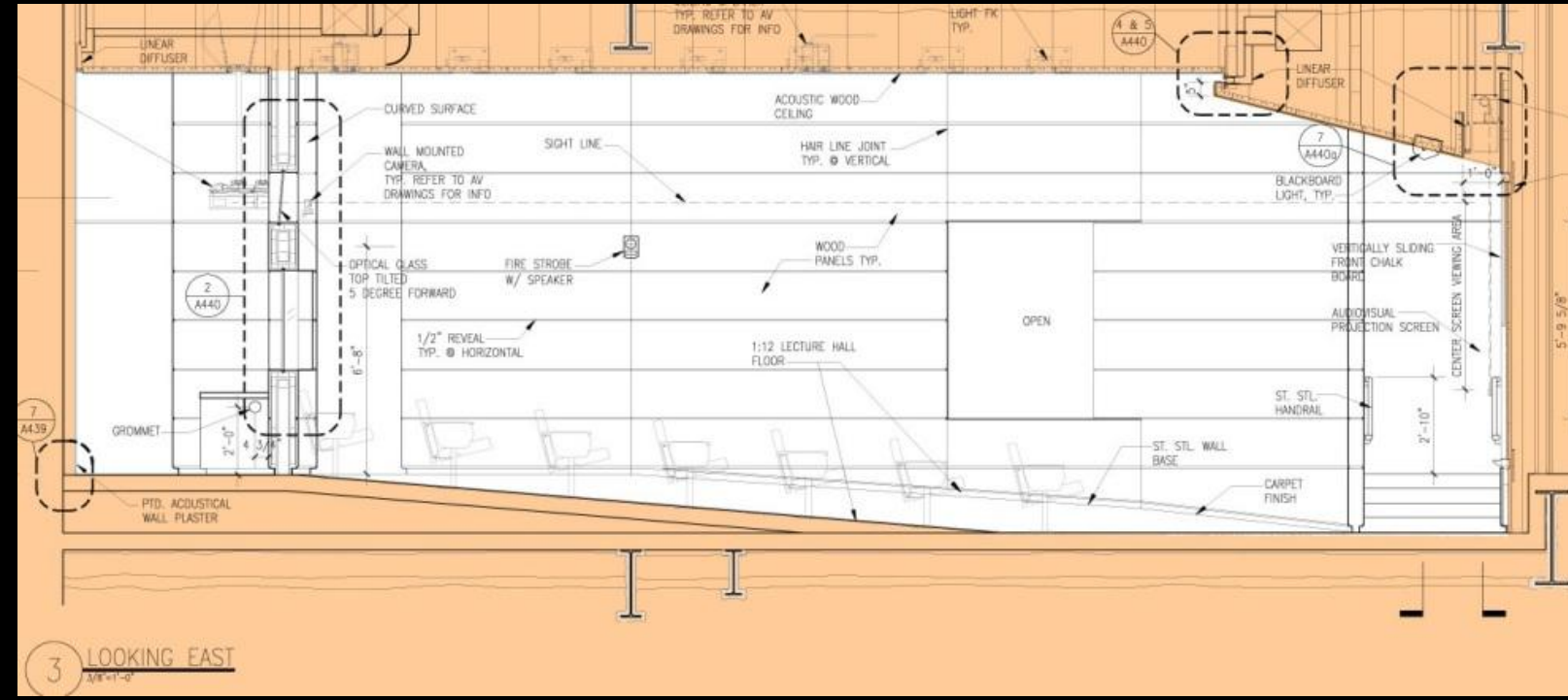
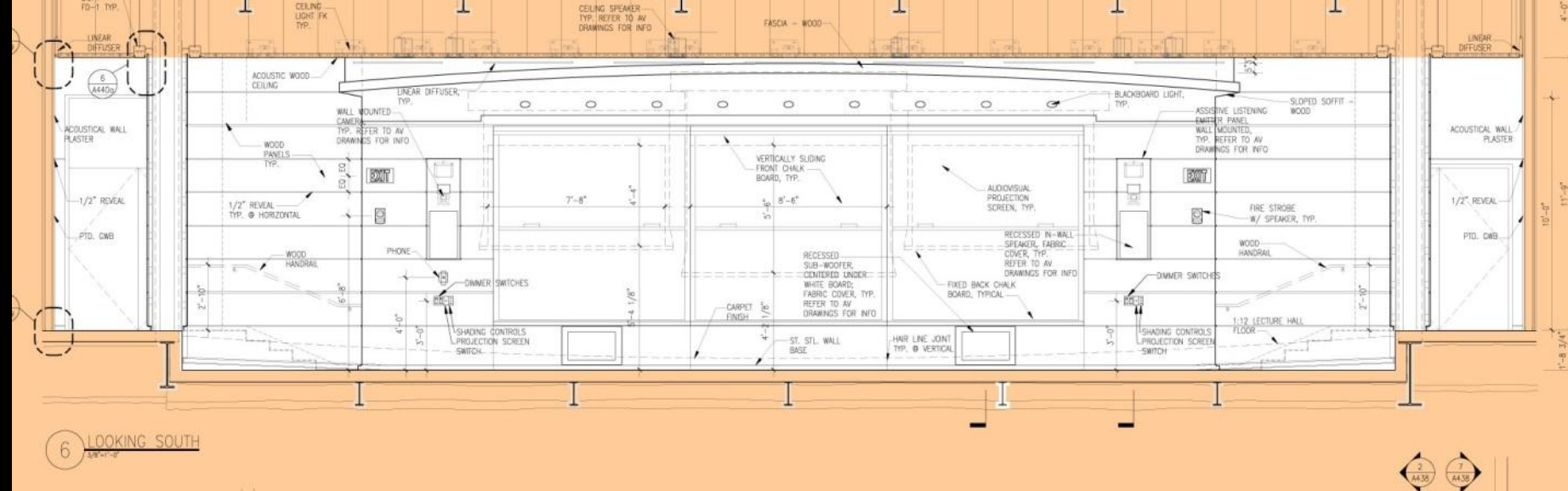
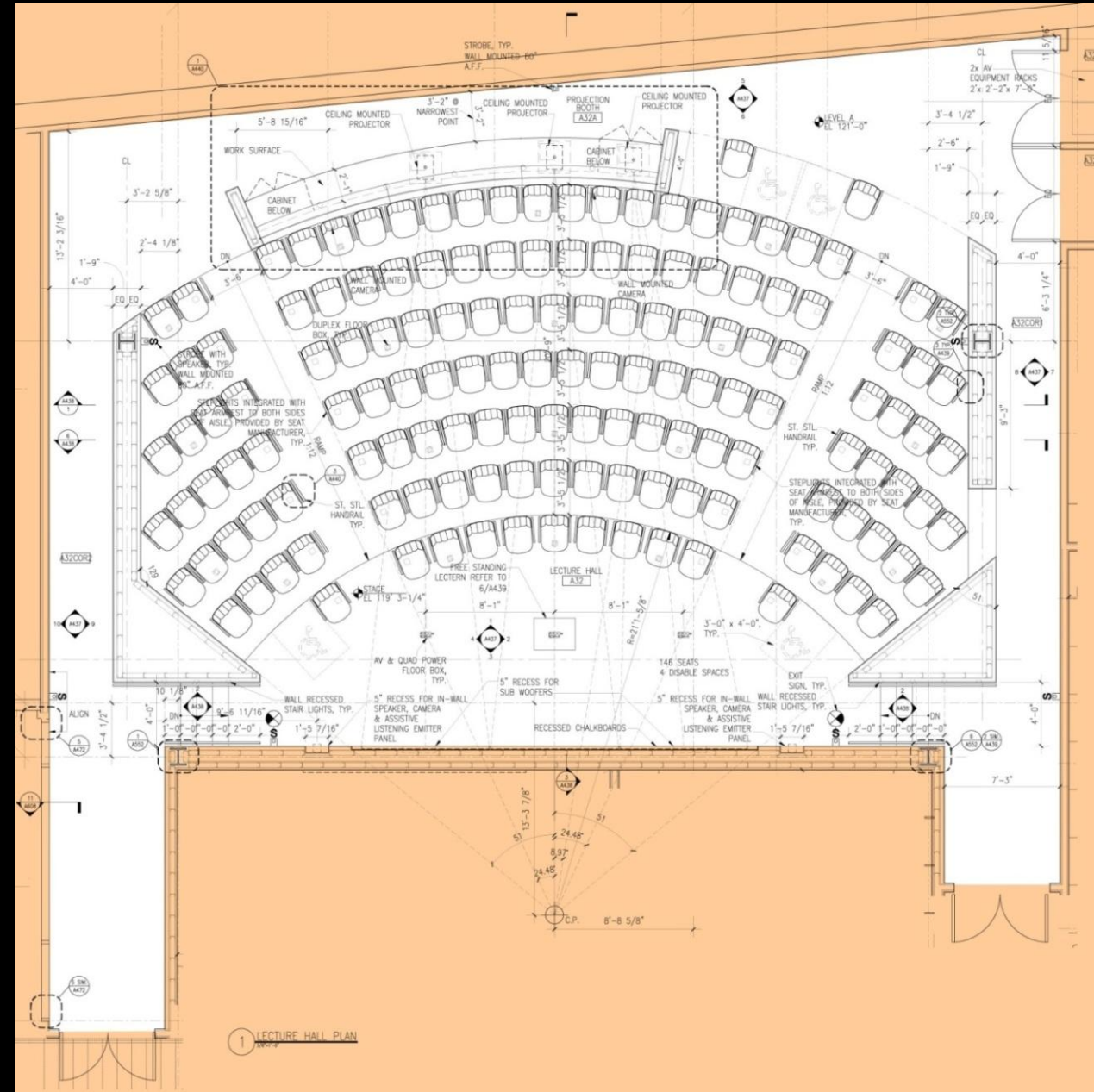
Existing Bus Ducts - Copper						
Tag	Amps	Voltage	Rating (kAIC)	Starting Level	Ending Level	Length (ft.)
A1	400	208Y/120V, 3P, 4W, 1G	22	A	5	74
A2	1000	480Y/277V, 3P, 4W, 1G	50	A	5	74
B9	400	480Y/277V, 3P, 4W, 1G	42	A	2	32
B11	1600	208Y/120V, 3P, 4W, 1G	50	A	2	32
C1	400	480Y/277V, 3P, 4W, 1G	42	A	3	46
C4	1600	208Y/120V, 3P, 4W, 1G	50	A	3	46



RSMeans Data 2011 (page 230-244)			
Aluminum Straight		Copper Straight	
Total Cost / 10LF	Total Cost	Total Cost / 10LF	Total Cost
\$220	\$1,628	\$247	\$1,827.80
\$295	\$2,183	\$340	\$2,516.00
\$220	\$704	\$247	\$790.40
\$495	\$1,584	\$545	\$1,744.00
\$220	\$1,012	\$247	\$1,136.20
\$495	\$2,277	\$545	\$2,507.00
	\$9,388		\$10,521
		Percent Difference : 10.8%	

RSMeans Data 2009 (page 227-241)			
Aluminum Straight		Copper Straight	
Total Cost / 10LF	Total Cost	Total Cost / 10LF	Total Cost
\$213	\$1,576	\$239	\$1,769
\$286	\$2,116	\$330	\$2,442
\$213	\$682	\$239	\$765
\$480	\$1,536	\$530	\$1,696
\$213	\$980	\$239	\$1,099
\$480	\$2,208	\$530	\$2,438
	\$9,098		\$10,209
		Percent Difference : 10.9%	





Existing Conditions:

α							
Absorption Coefficient of Materials							
Material	Frequency (Hz)						NRC #
	125	250	500	1000	2000	4000	
acoustic gypsum wall board	0.55	0.14	0.08	0.04	0.12	0.11	0.1
wood panels	0.42	0.21	0.10	0.08	0.06	0.06	0.1
acoustic wood ceiling	0.10	0.60	0.80	0.82	0.78	0.60	0.75
carpet	0.02	0.06	0.14	0.37	0.60	0.65	0.3
curved glass	0.35	0.25	0.18	0.12	0.07	0.04	0.15
opening	0.50	0.50	0.50	0.50	0.50	0.50	
auditorium seats with students	0.30	0.41	0.49	0.84	0.87	0.84	

a = S*α							
S Surface Area (sq.ft.)	Room Absorption (sabins)						
	Frequency (Hz)						
	125	250	500	1000	2000	4000	
279	153.5	39.1	22.3	11.2	33.5	30.7	
1194	501.5	250.7	119.4	95.5	71.6	71.6	
1608	160.8	964.8	1286.4	1318.6	1254.2	964.8	
441	8.8	26.5	61.7	163.2	264.6	286.7	
89	31.2	22.3	16.0	10.7	6.2	3.6	
517	258.5	258.5	258.5	258.5	258.5	258.5	
1167	350.1	478.5	571.8	980.3	1015.3	980.3	
	1464.3	2040.3	2336.2	2837.9	2904.0	2596.1	Σa

T = 0.05*(V/a)							
Room Volume (ft^3)	Reverberation Time						
	Frequency (Hz)						
	125	250	500	1000	2000	4000	
19296	0.7	0.5	0.4	0.3	0.3	0.4	

Scenario 3:

α							
Absorption Coefficient of Materials							
Material	Frequency (Hz)						NRC #
	125	250	500	1000	2000	4000	
gypsum wall board (0.5 in thick)	0.29	0.10	0.05	0.04	0.07	0.09	0.05
wood panels, 1 in paneling	0.19	0.14	0.09	0.06	0.06	0.05	0.1
plaster ceiling	0.14	0.10	0.06	0.05	0.04	0.03	0.05
carpet	0.02	0.06	0.14	0.37	0.60	0.65	0.3
curved glass	0.18	0.06	0.04	0.03	0.02	0.02	0.15
opening	0.50	0.50	0.50	0.50	0.50	0.50	
auditorium seats with students	0.30	0.41	0.49	0.84	0.87	0.84	

a = S*α							
S Surface Area (sq.ft.)	Room Absorption (sabins)						
	Frequency (Hz)						
	125	250	500	1000	2000	4000	
279	80.9	27.9	14.0	11.2	19.5	25.1	
1194	226.9	167.2	107.5	71.6	71.6	59.7	
1608	225.1	160.8	96.5	80.4	64.3	48.2	
441	8.8	26.5	61.7	163.2	264.6	286.7	
89	16.0	5.3	3.6	2.7	1.8	1.8	
517	258.5	258.5	258.5	258.5	258.5	258.5	
1167	350.1	478.5	571.8	980.3	1015.3	980.3	
	1166.3	1124.6	1113.5	1567.8	1695.7	1660.3	Σa

T = 0.05*(V/a)							
Room Volume (ft^3)	Reverberation Time						
	Frequency (Hz)						
	125	250	500	1000	2000	4000	
19296	0.8	0.9	0.9	0.6	0.6	0.6	