



Senior Thesis Presentation



Jason Weaver
5th Year – Architectural Engineering
Lighting/ Electrical Option
Advisors: Dr. Mistrick & Prof. Dannerth

ANN AND RICHARD BARSHINGER
LIFE SCIENCES & PHILOSOPHY BUILDING
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Building Overview

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- **Size:** 104, 000 square feet on 4 levels (3 stories above grade and basement)
- **Project Cost:** approx. \$39 million
- **Dates of Construction:** December 2005 – August 2007

- **Owner:** Franklin & Marshall College
- **Construction Manager:** Turner Construction Company
- **Architect and Major Engineering Services:** Einhorn Yaffee Prescott

- **Departments Housed in Building:**
 - Biology
 - Psychology
 - Philosophy
 - Two Interdisciplinary Programs

Outline

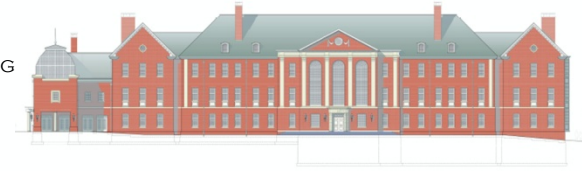
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- Lighting Depth
 - East Entry and Façade
 - Frey Atrium
 - Ecology Teaching Lab
 - Bonchek Lecture Hall
- Electrical Depth
 - Branch Circuits Affected by Lighting Design
 - Central vs. Distributed Transformers
 - Aluminum vs. Copper Feeders
 - Protective Device Coordination and Fault Current Analysis Studies
- Acoustical Breadth – Analysis of Effects of New Ceiling on Lecture Hall
- Mechanical Breadth – New Diffuser Layout for Lecture Hall

Outline

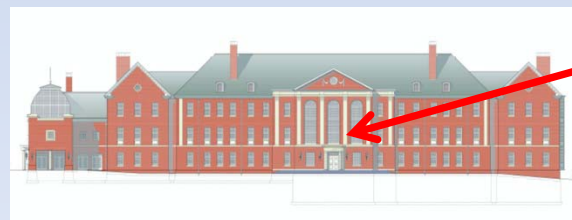
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- **Acoustical Breadth** – Analysis of Effects of New Ceiling on Lecture Hall
- **Mechanical Breadth** – New Diffuser Layout for Lecture Hall

Campus Map

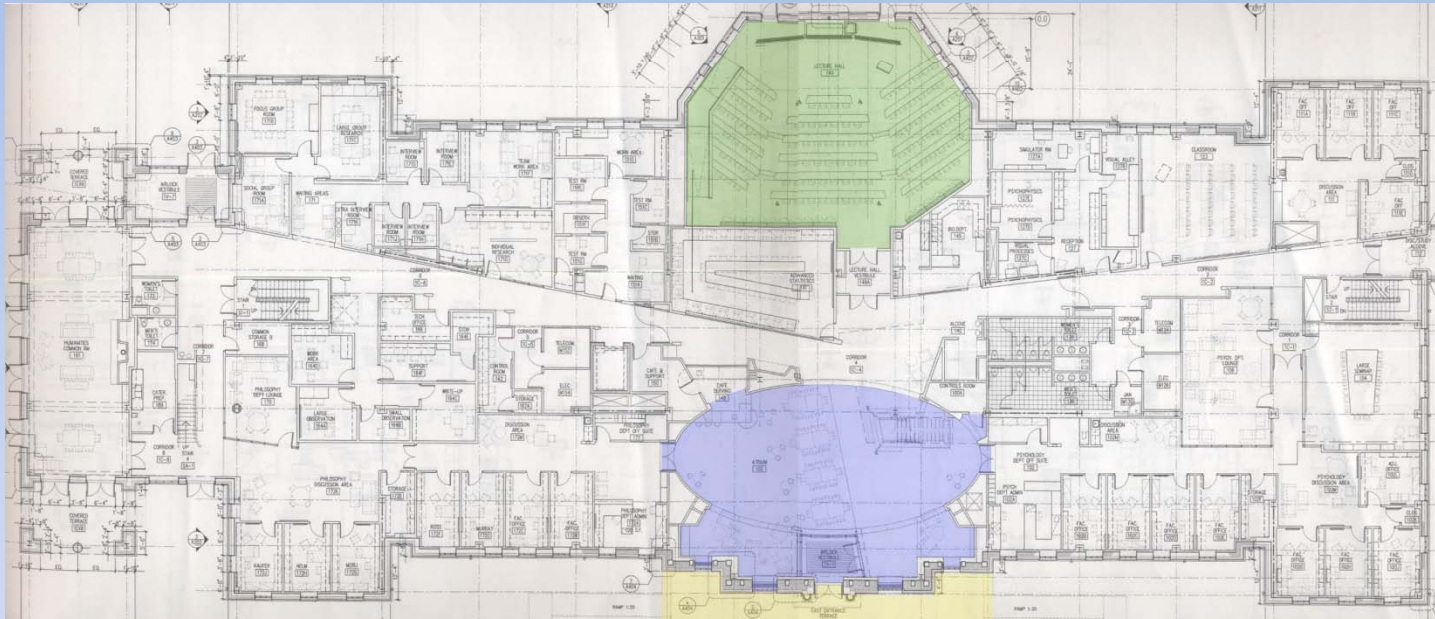
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Main Entry

Spatial Relationships

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Laboratory

Atrium

Lecture Hall

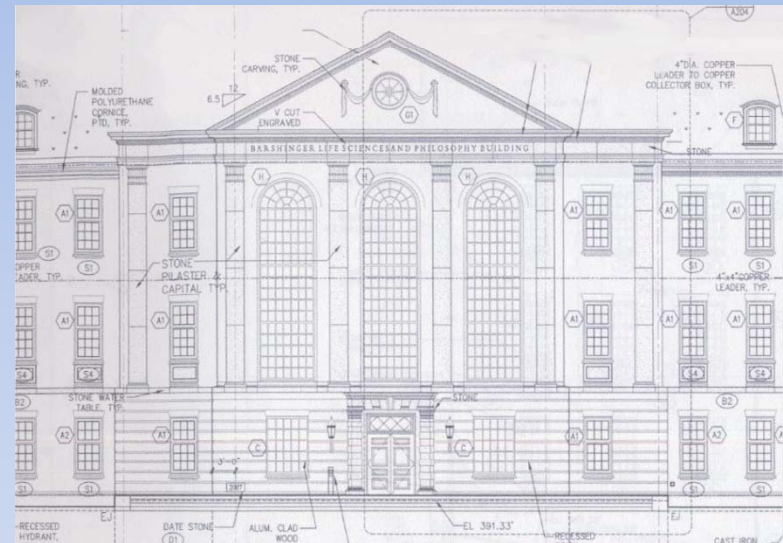
Façade

East Entry & Facade

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- Design Criteria
 - Appearance of Space and Luminaires
 - Modeling of Faces and Objects
 - Points of Interest
 - Pilasters, Pediment, Main Entrance
 - Special Considerations
 - Dark-Sky Compliance



East Entry & Facade

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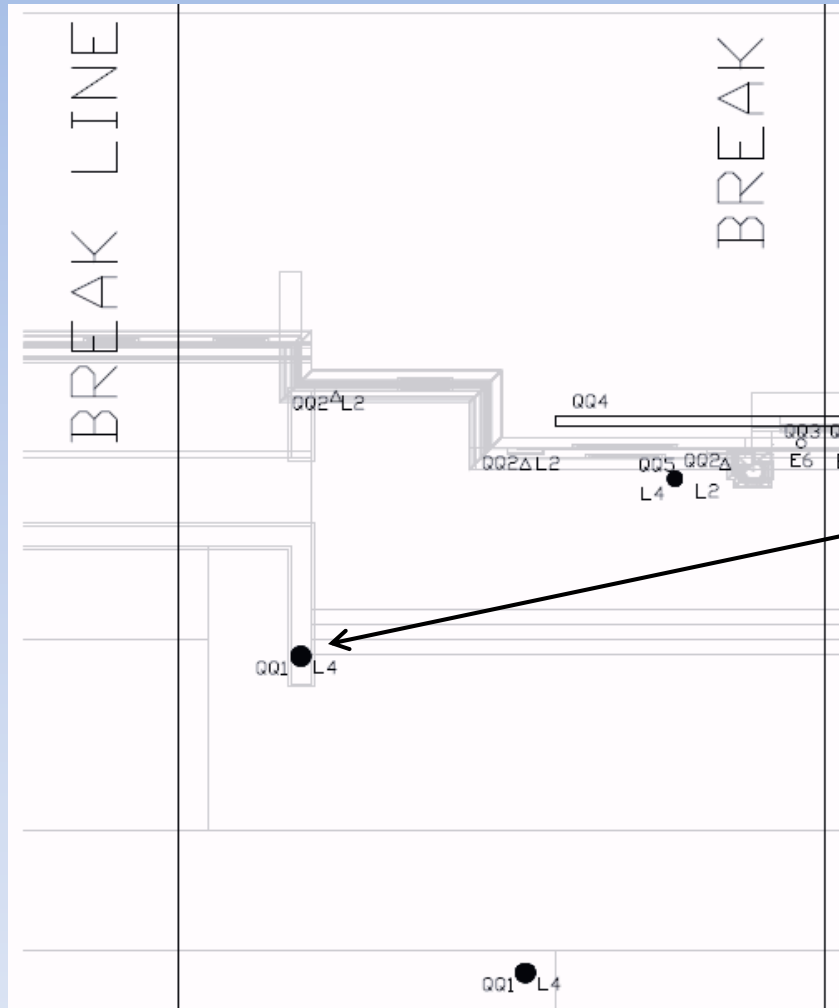
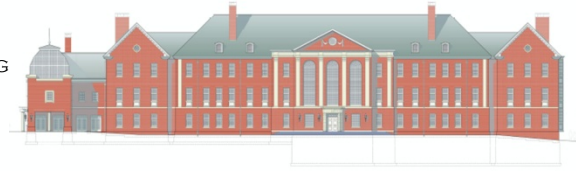
Schematic Design

- Glow from within
- Highlight pilasters and main pediment
- Focus attention to entry
- Cut-off optics without cut-off appearance



East Entry & Facade

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Luminaires Used:

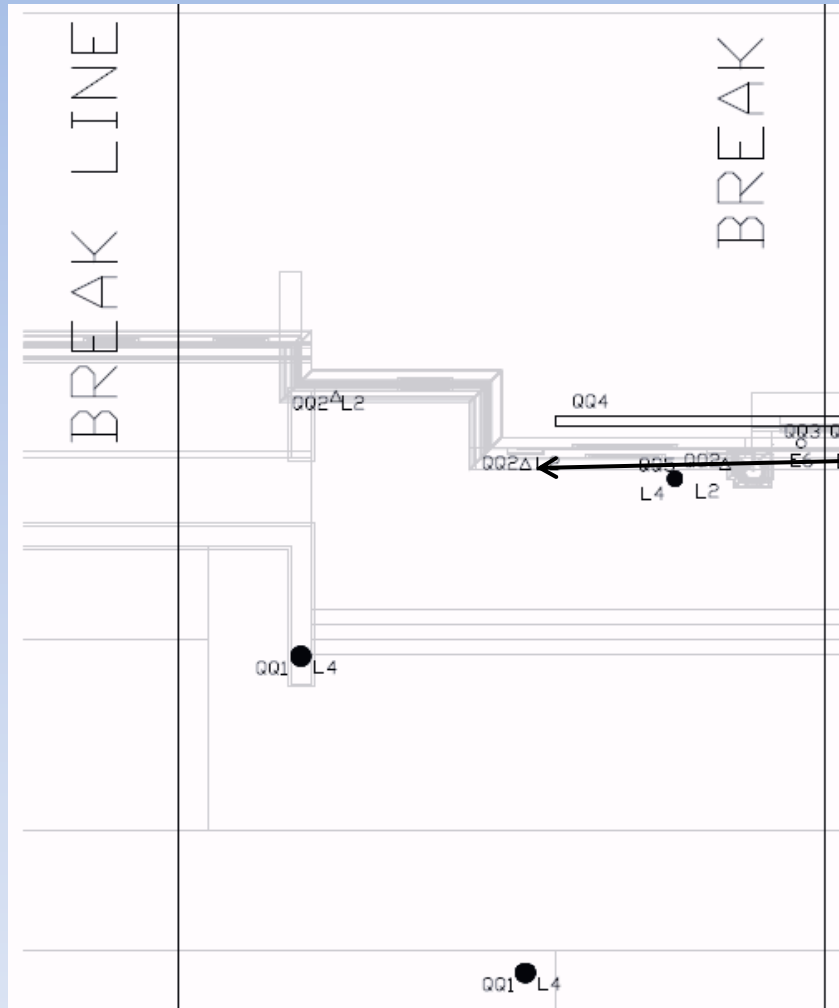
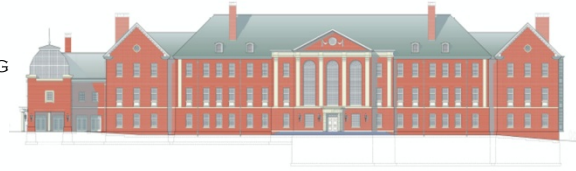


QQ1

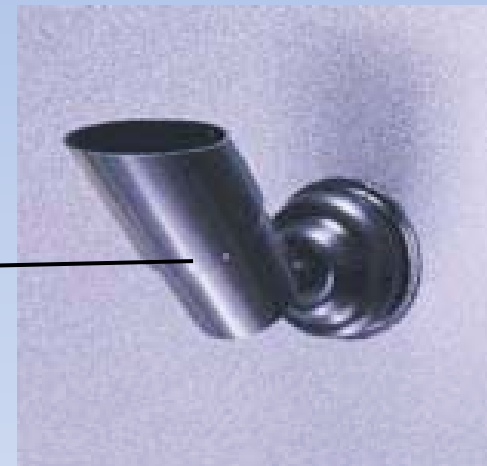
Street "acorn" pole fixture with
internal reflector to meet
"Cutoff" criteria

East Entry & Facade

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Luminaires Used:

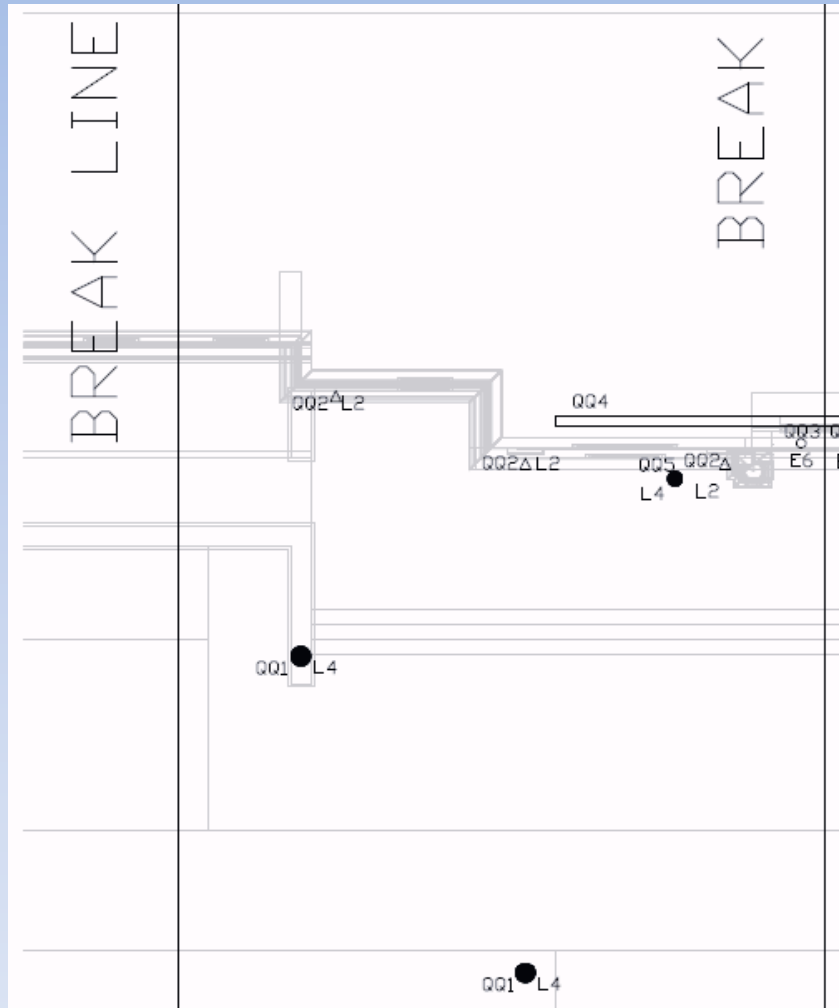
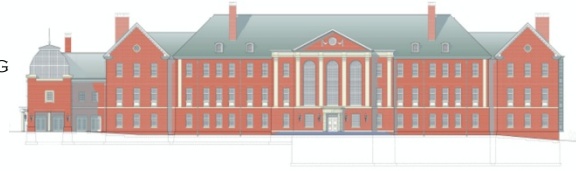


QQ2

Wall-mounted HID projector with
10-degree beam spread and
45-degree shielding

East Entry & Facade

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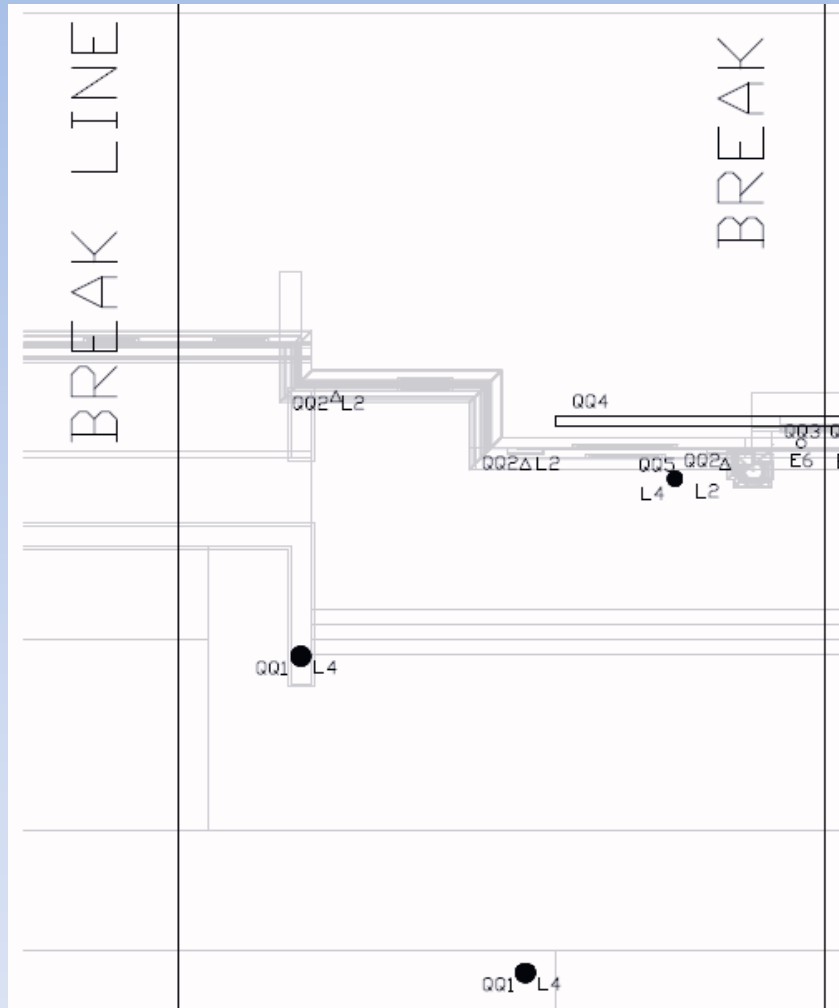
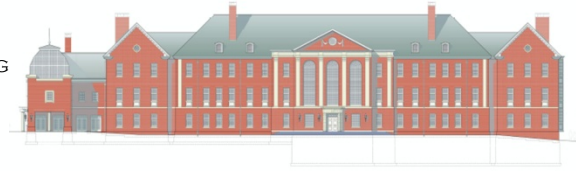


QQ3

Recessed exterior HID downlight

East Entry & Facade

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Luminaires Used:

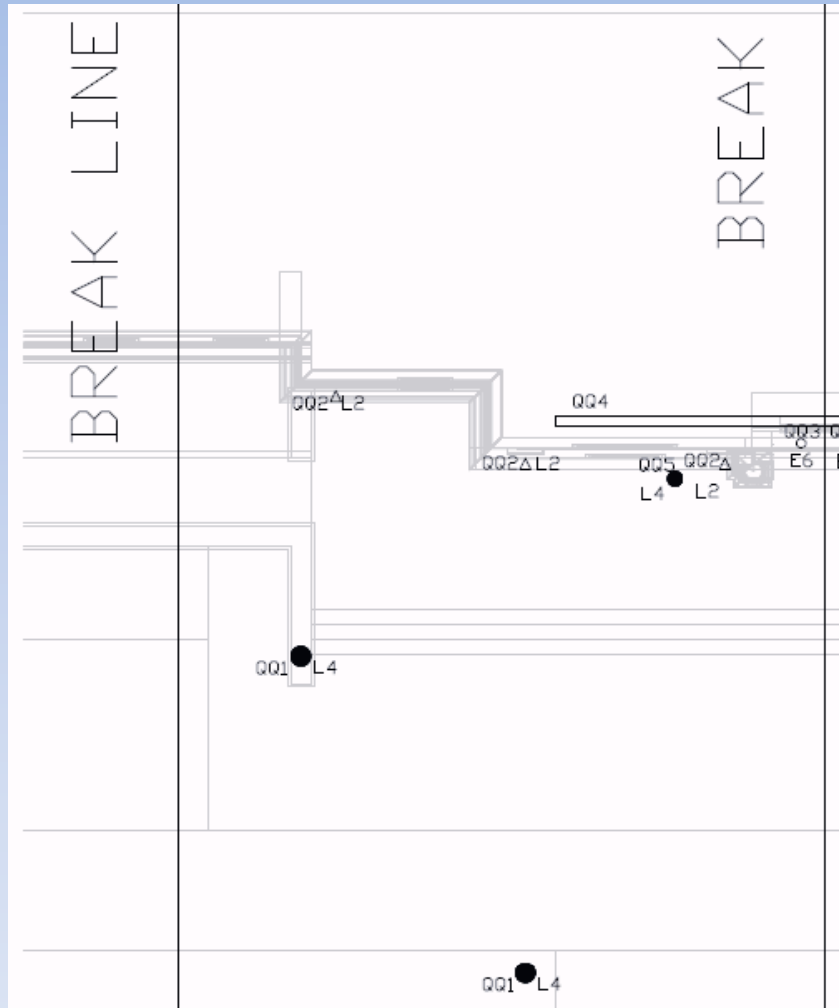
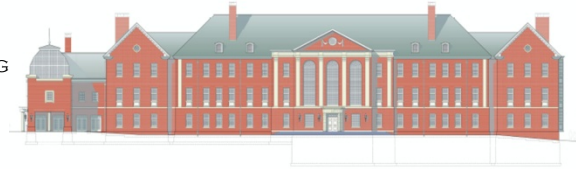


QQ4

Linear LED floodlight luminaire
with asymmetric optics

East Entry & Facade

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Luminaires Used:

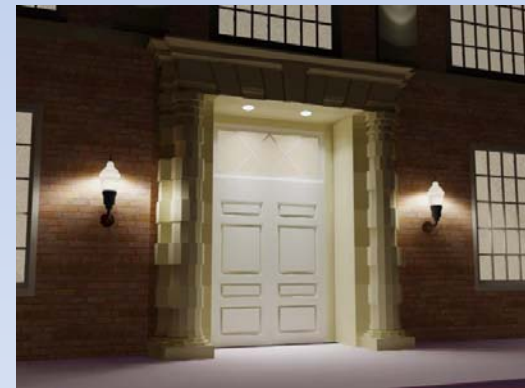


QQ5

Exterior wall-mounted acorn fixture
at smaller scale than pole fixture

East Entry & Facade

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East Entry & Facade

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East Entry & Facade

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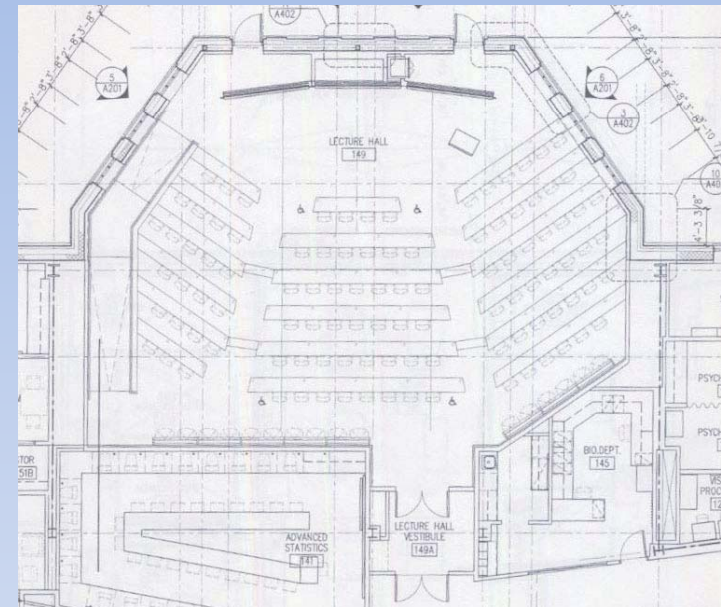


Bonchek Lecture Hall

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- Design Criteria
 - Appearance of Space and Luminaires
 - Modeling of Faces and Objects
 - Special Considerations
 - Projection Screen
 - System Flexibility



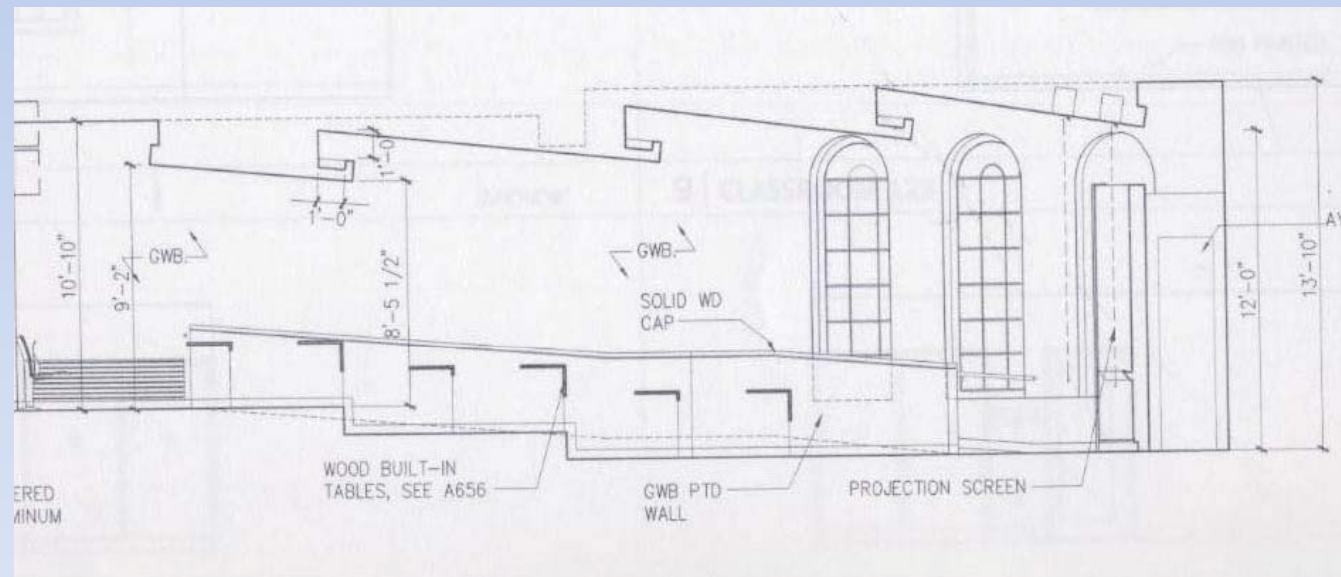
Bonchek Lecture Hall

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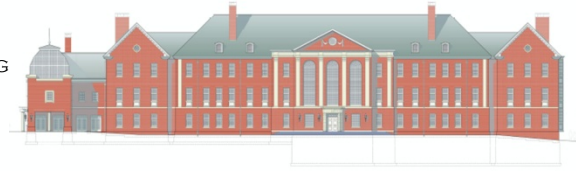
Ceiling Redesign

- Flow better with furnishing and lighting
- Coves relatively inefficient
- Add interest
- Acoustics



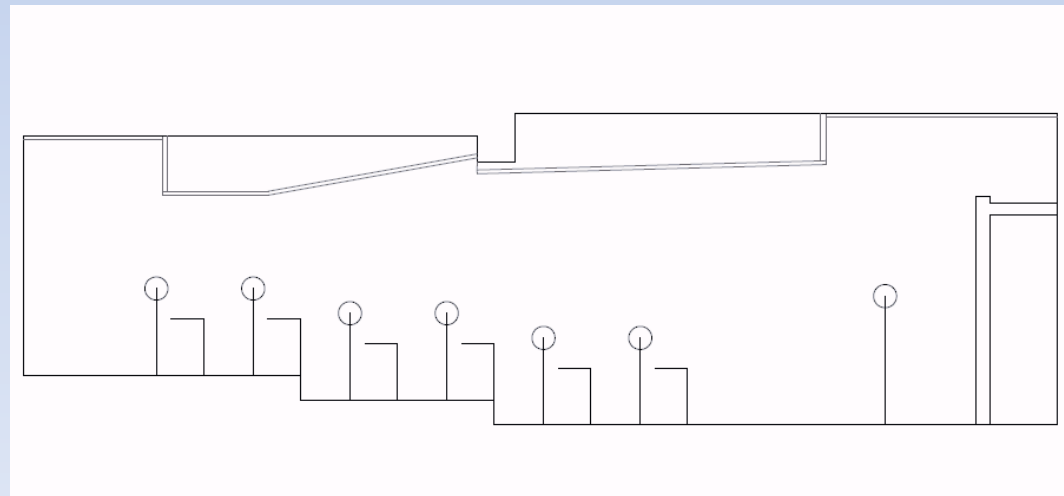
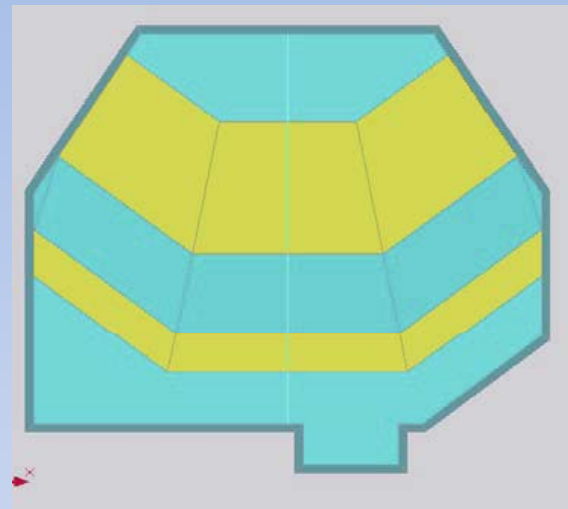
Bonchek Lecture Hall

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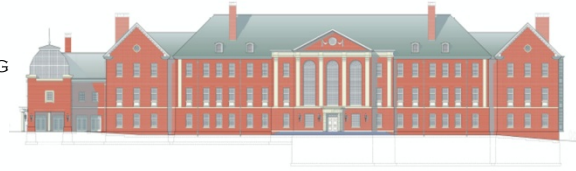
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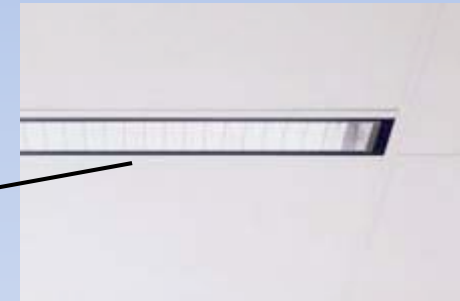
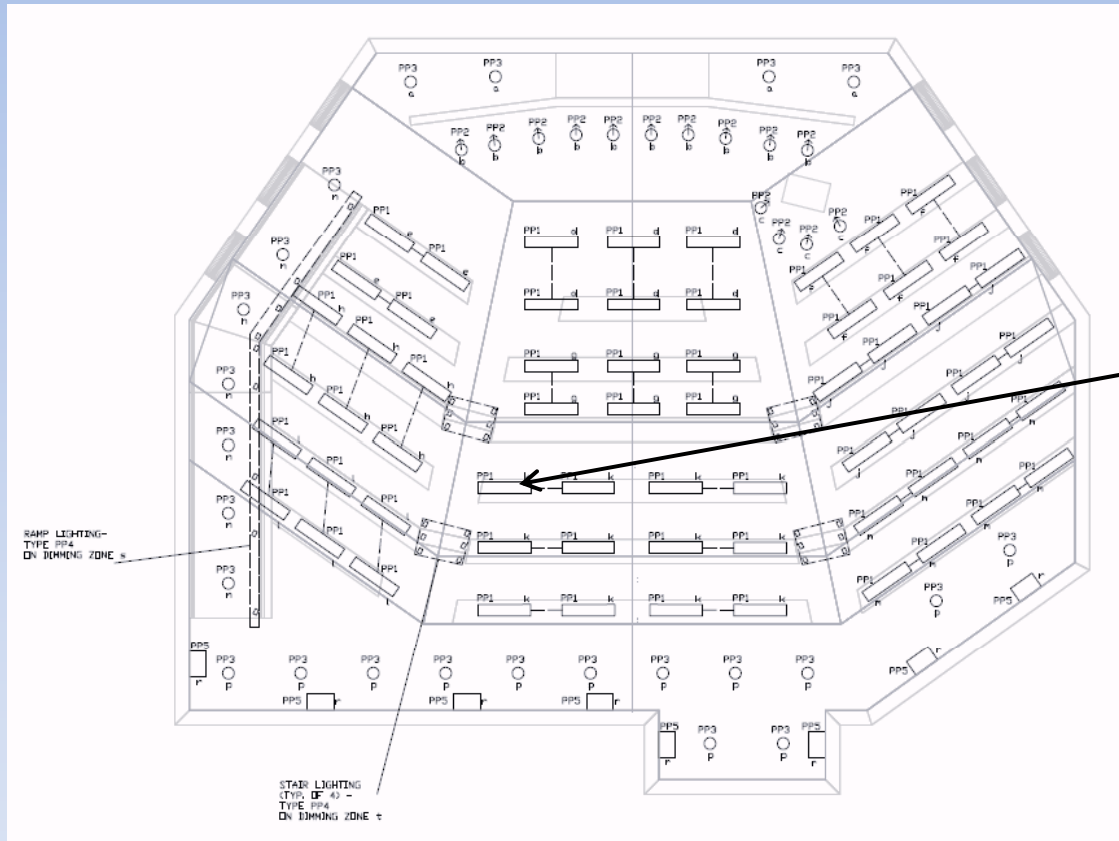


Bonchek Lecture Hall

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Luminaires Used:

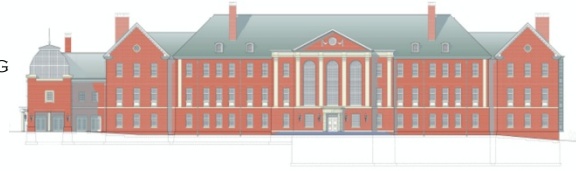


PP1

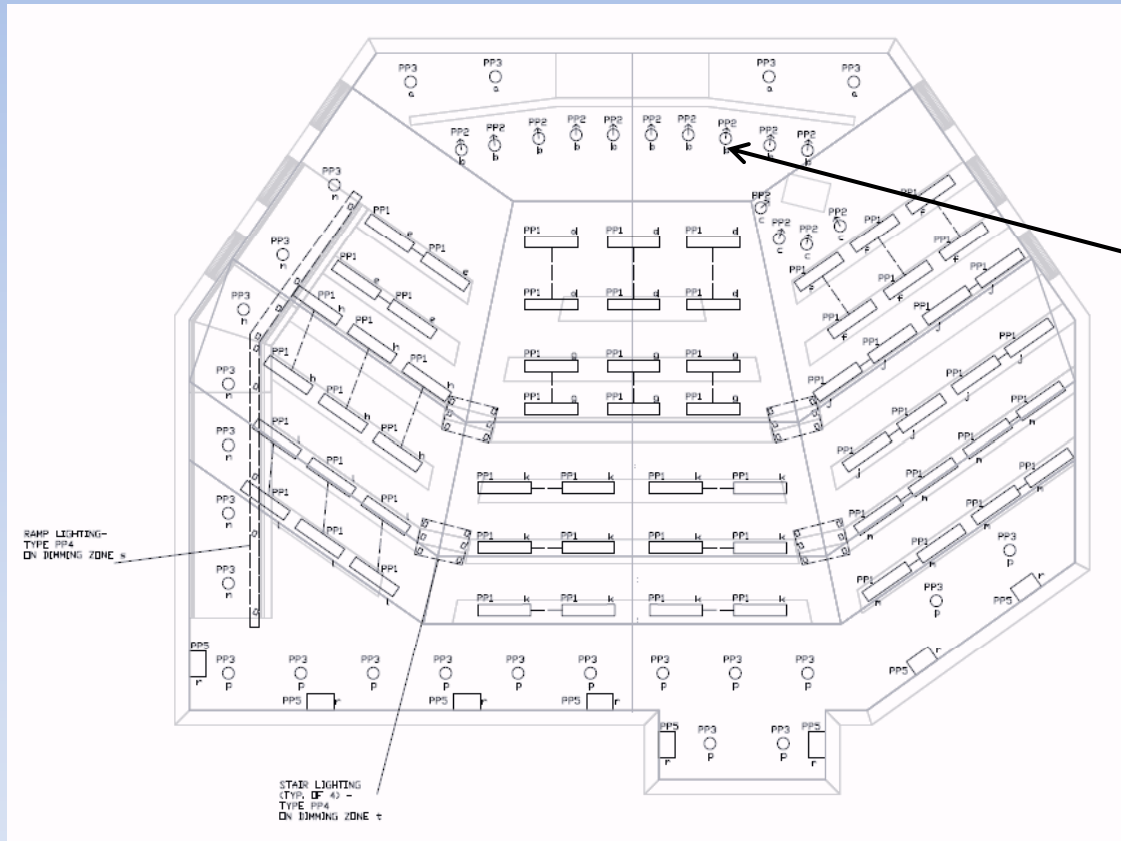
Recessed linear fluorescent
downlight

Bonchek Lecture Hall

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Luminaires Used:

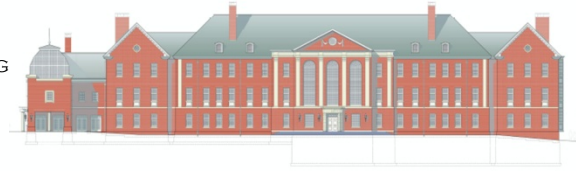


PP2

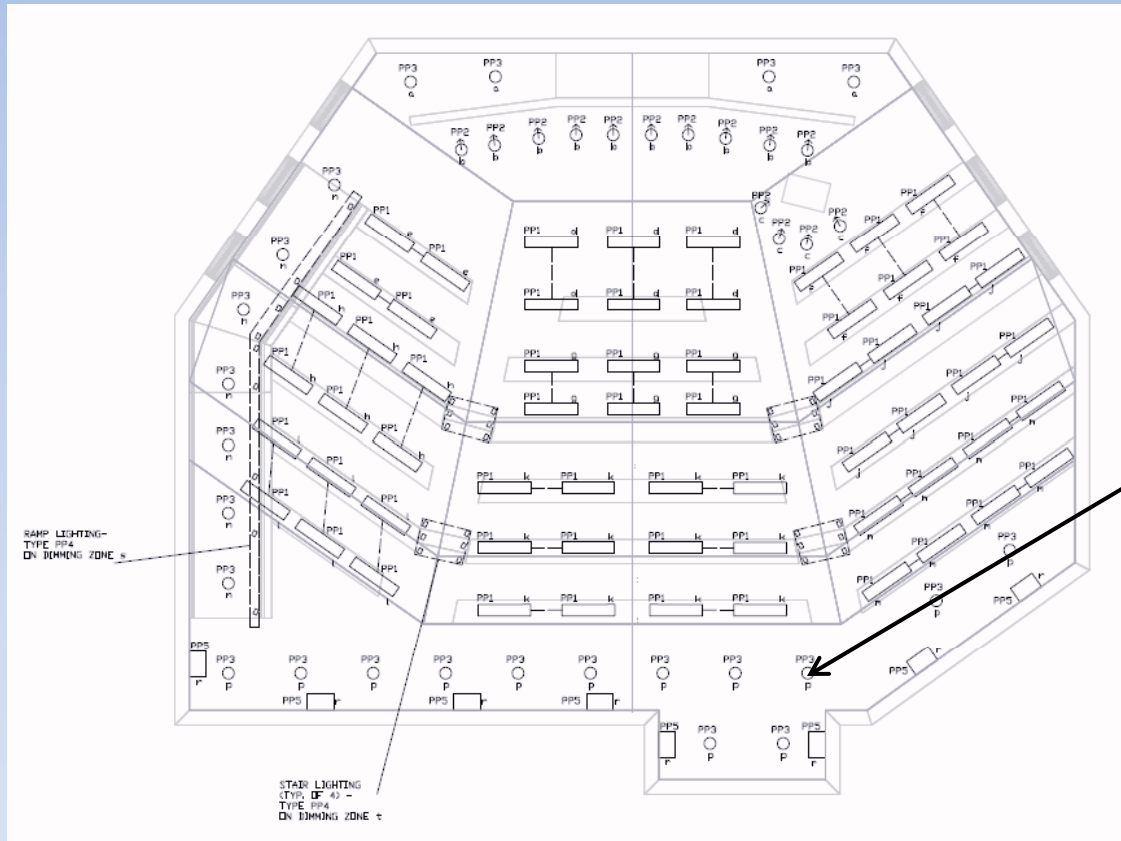
Recessed compact fluorescent
wallwasher

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Luminaires Used:

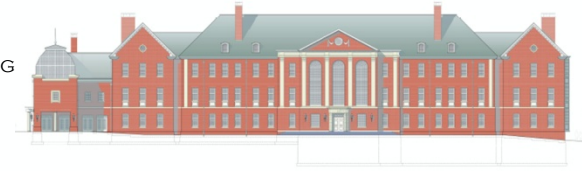


PP3

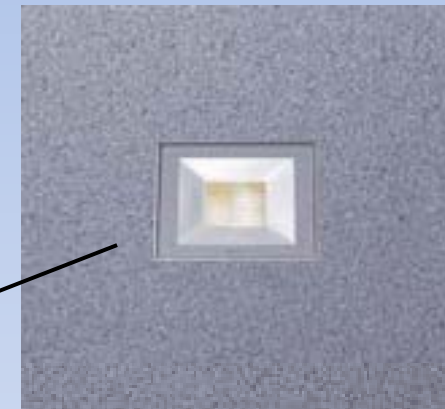
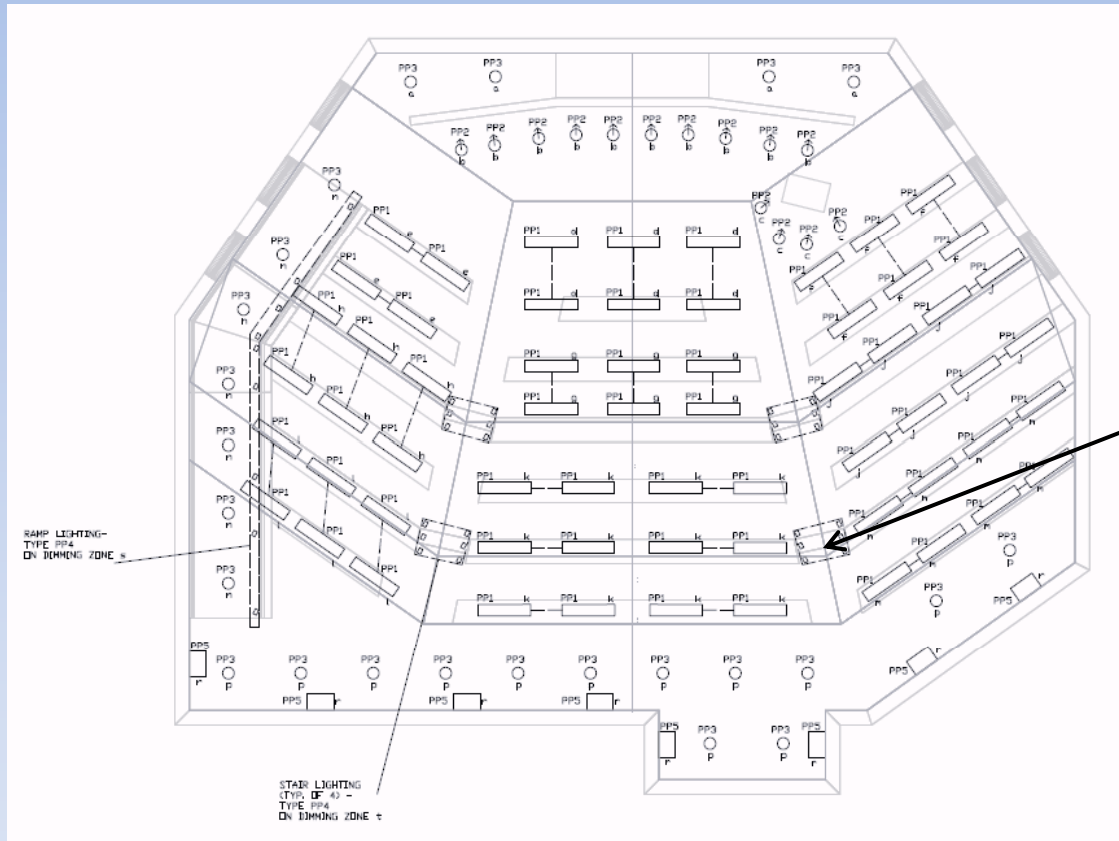
Recessed compact fluorescent
downlight

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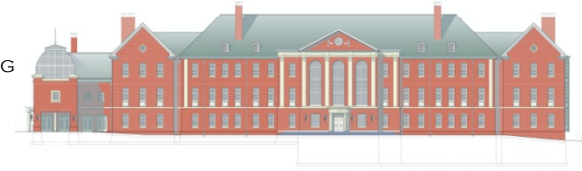


PP4

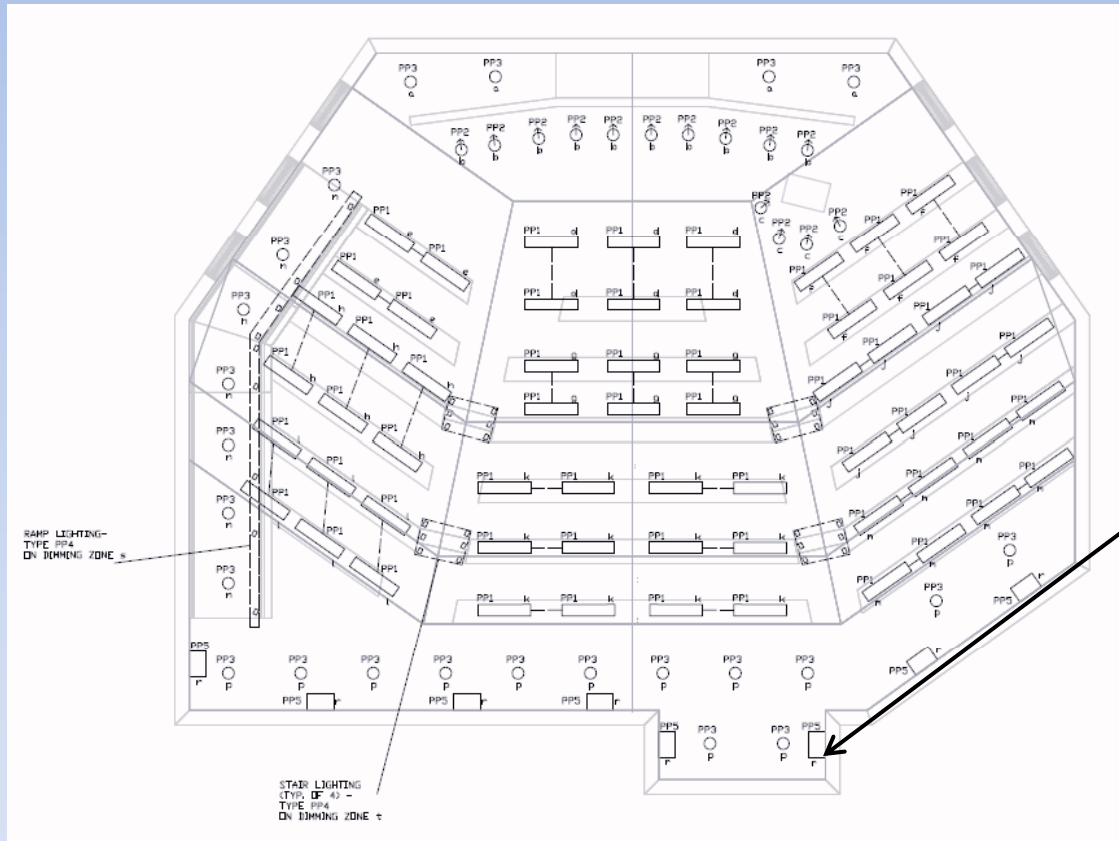
Floor recessed LED uplight for
ramp and stairs

Bonchek Lecture Hall

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Luminaires Used:



PP5

Luminous wall sconce with
brass trim

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“Lecture” Scene:



Bonchek Lecture Hall

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“A/V” Scene:



Bonchek Lecture Hall

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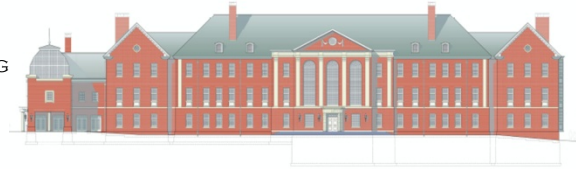


“Movie” Scene:



Bonchek Lecture Hall

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“Maintenance” Scene:



Energy Consumption

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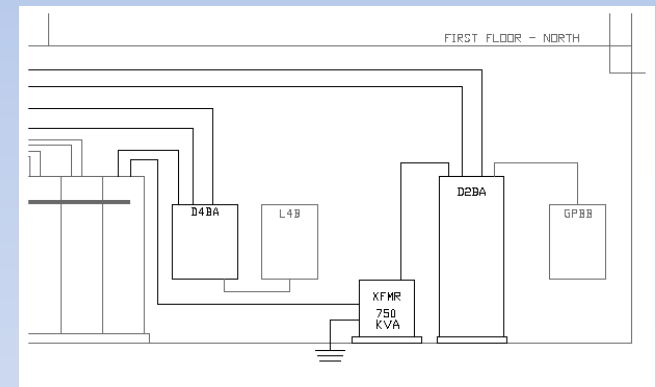
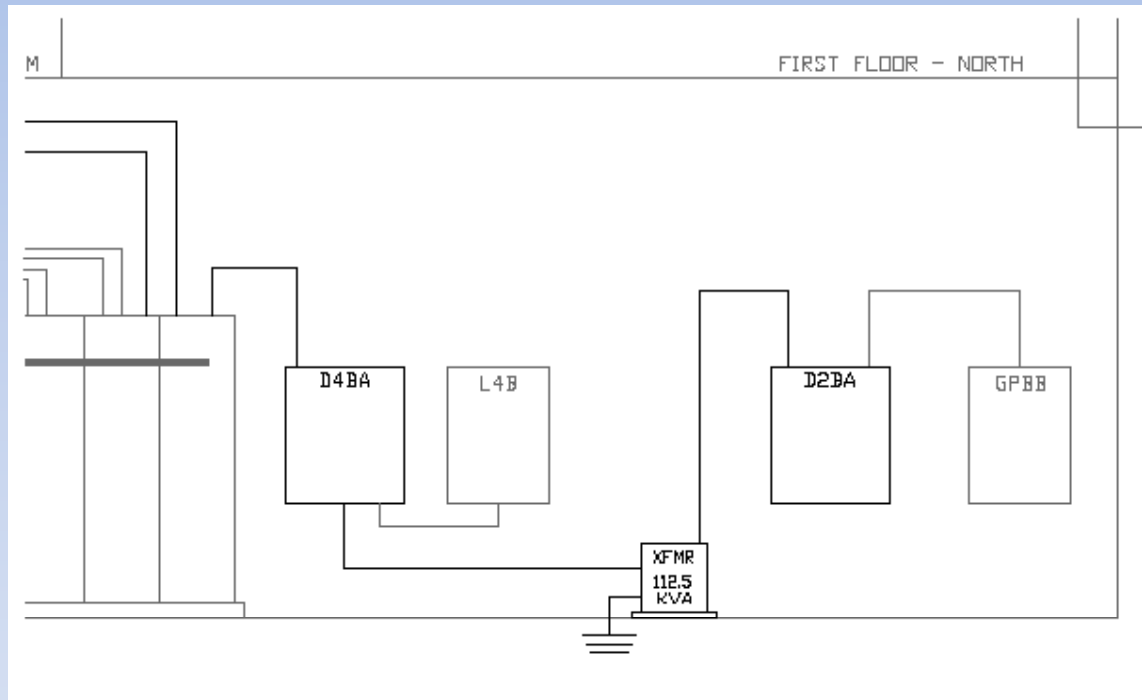
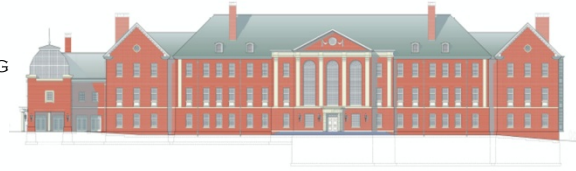
<u>Space</u>	<u>Energy Allowance</u>	<u>Energy Consumed</u>
East Entry and Façade - Tradable	1295 W	1286 W
Frey Atrium - Non-Decorative	1603 W	1776 W
Ecology Teaching Laboratory	1624 W	1430 W
Bonchek Lecture Hall	3500 W	3491 W
<u>Total</u>	<i>8022 W</i>	<i>7983 W</i>

<u>Space</u>	<u>Energy Allowance</u>	<u>Energy Consumed</u>
East Entry and Façade - Non-Tradable	1824 W	1336 W
Frey Atrium - Decorative	2672 W	450 W

Meets ASHRAE 90.1-2004 by Space-by-Space Method

Central vs. Distributed

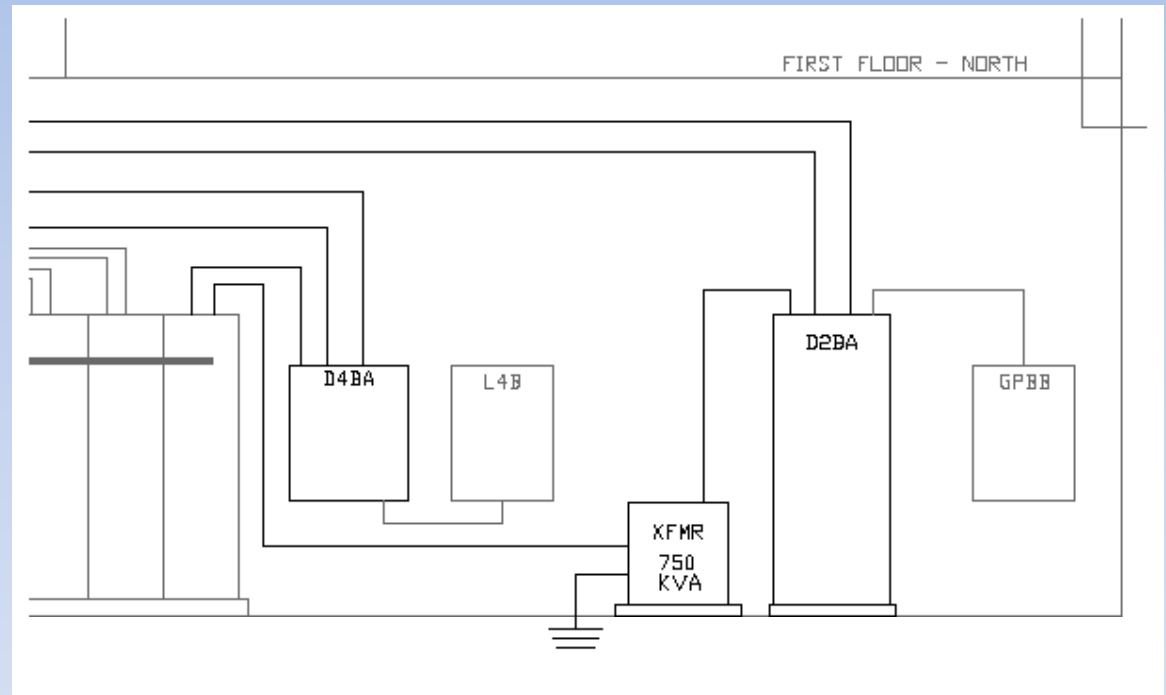
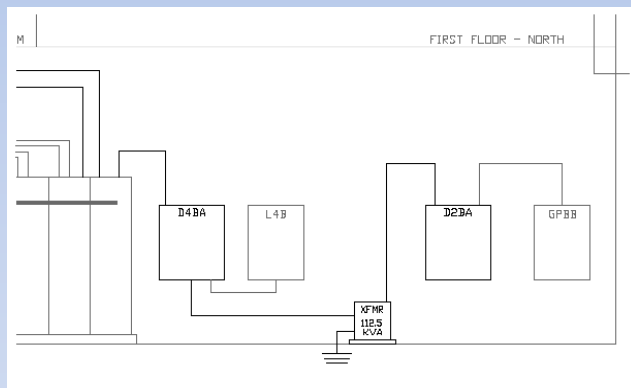
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Existing System – Main Electrical Room

Central vs. Distributed

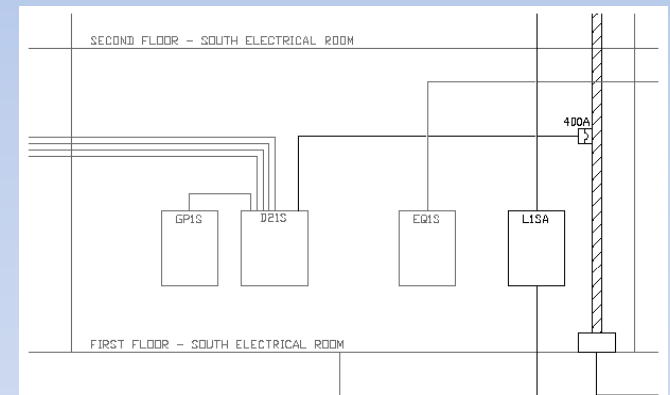
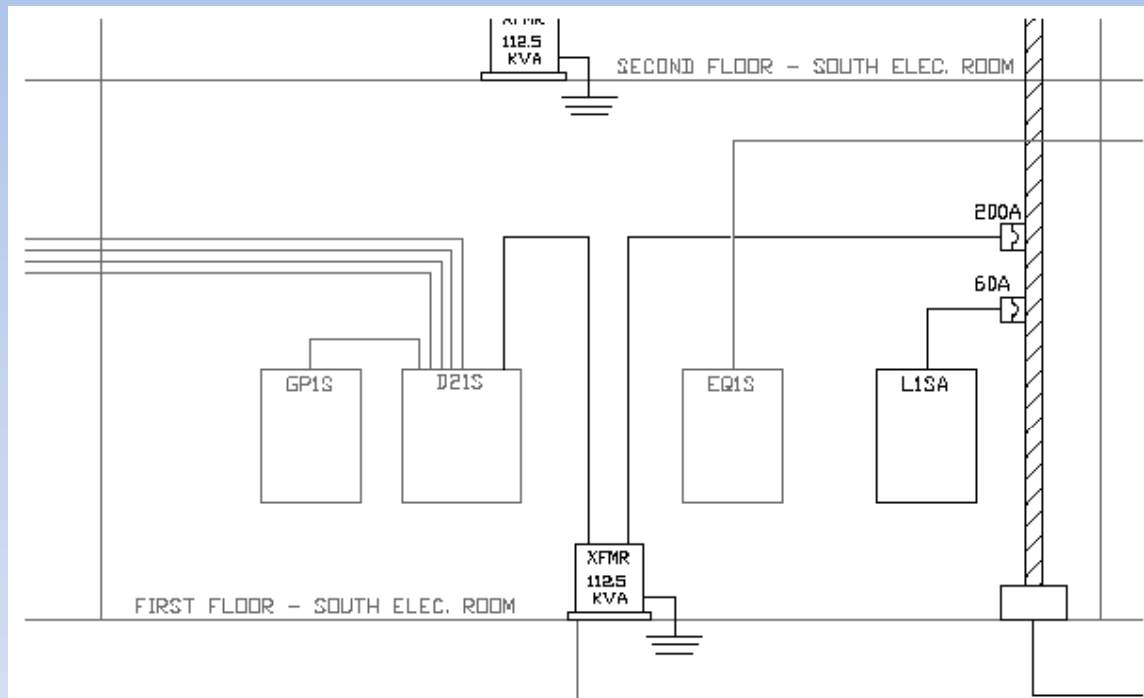
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Proposed System – Main Electrical Room

Central vs. Distributed

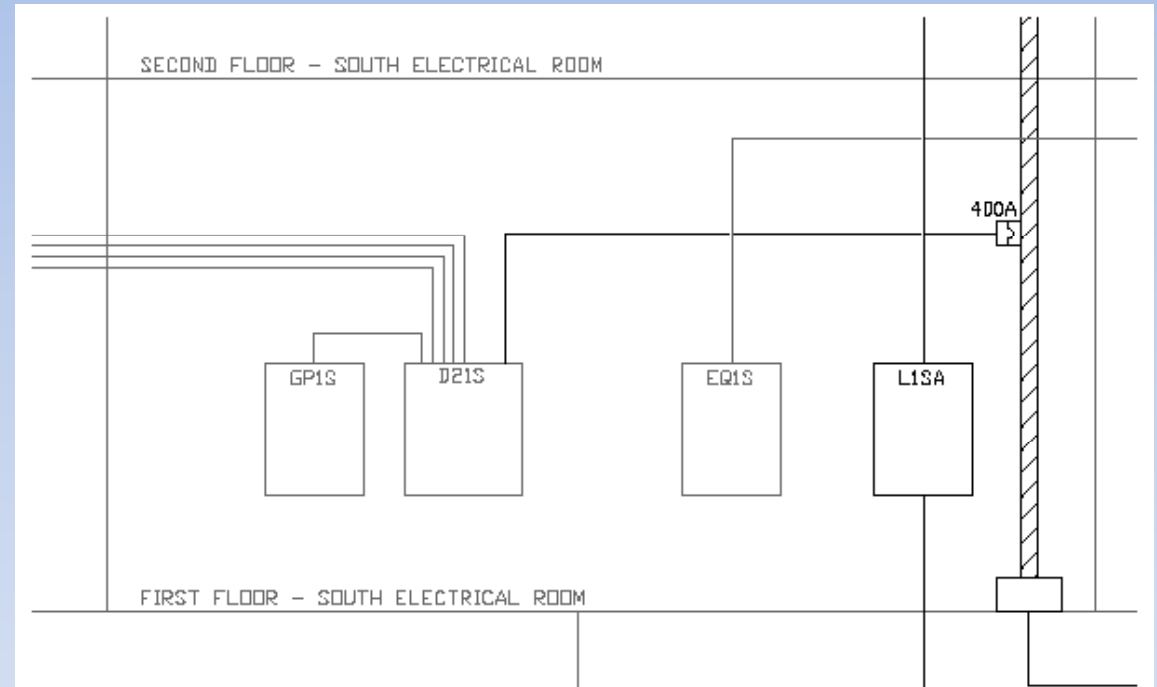
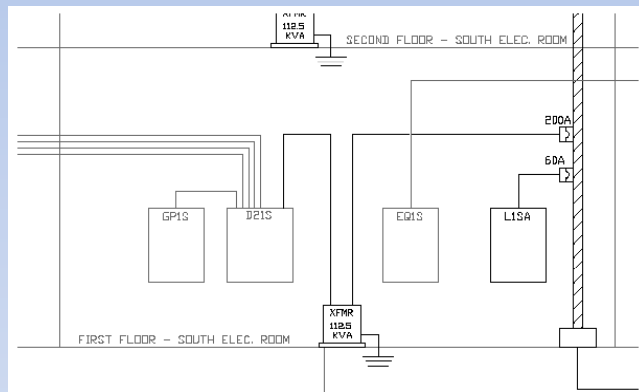
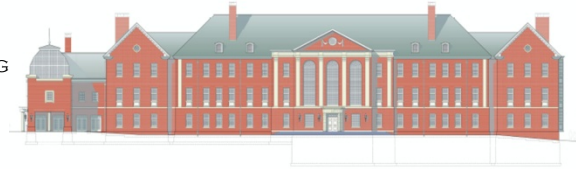
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Existing System – Auxiliary Electrical Rooms

Central vs. Distributed

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Proposed System – Auxiliary Electrical Rooms

Central vs. Distributed

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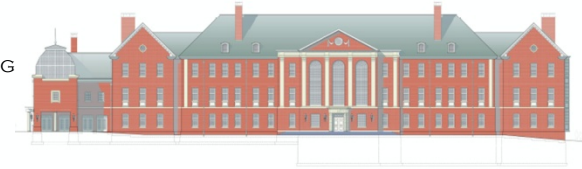


<u>Category</u>	<u>Cost of Existing System</u>	<u>Cost Of New System</u>	<u>Difference</u>
Feeders	\$61,096.37	\$141,472.34	\$80,375.97
Transformers	\$56,832.30	\$46,737.00	(\$10,095.30)
Breakers	\$23,222.70	\$36,720.00	\$13,497.30
Bus Ducts	\$22,680.00	\$36,720.00	\$14,040.00
Panelboards	\$30,341.25	\$49,762.35	\$19,421.10
<u>TOTAL</u>	\$194,172.62	\$311,411.69	\$117,239.07
<u>TOTAL w/ Location Factor</u>	<i>\$177,862.12</i>	<i>\$285,253.11</i>	<i>\$107,390.99</i>

Proposed System is not economically feasible

Aluminum Feeders

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Pros:

- Much less expensive
- Lighter
- Labor can be easier and potentially less time consuming

Cons:

- Larger wire size
- More prone to oxidation
- Use in residential and branch circuits banned (can expand and loosen terminations, can result in fire)

Proper Installation:

- Only use for feeders
- Must be cleaned and have antioxidant joint compound applied
- Properly torqued at terminations

Aluminum Feeders

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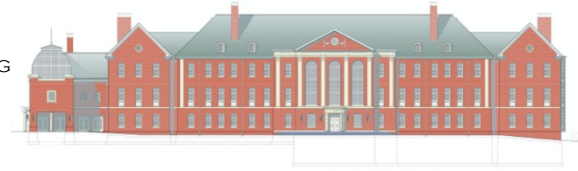
Start	End	Wires (LF)	Conduit (LF)	Copper Pricing						Aluminum Pricing					
				# of Sets	Phase	Neutral	Ground	Conduit	Total	# of Sets	Phase	Neutral	Ground	Conduit	Total
					Size	Size	Size	Size			Size	Size	Size	Size	
SWB-1	SOUTH DUCT	240	230	2	350KCMIL	350KCMIL	1AWG	3"	38623.77	2	500KCMIL	500KCMIL	2/0AWG	3"	25294.41
SWB-1	D4P	200	190	2	350KCMIL	350KCMIL	1AWG	3"	32101.65	2	500KCMIL	500KCMIL	2/0AWG	3"	20993.85

Type of Wiring	Total Cost
Copper	\$203,531.07
Aluminum	\$144,210.32

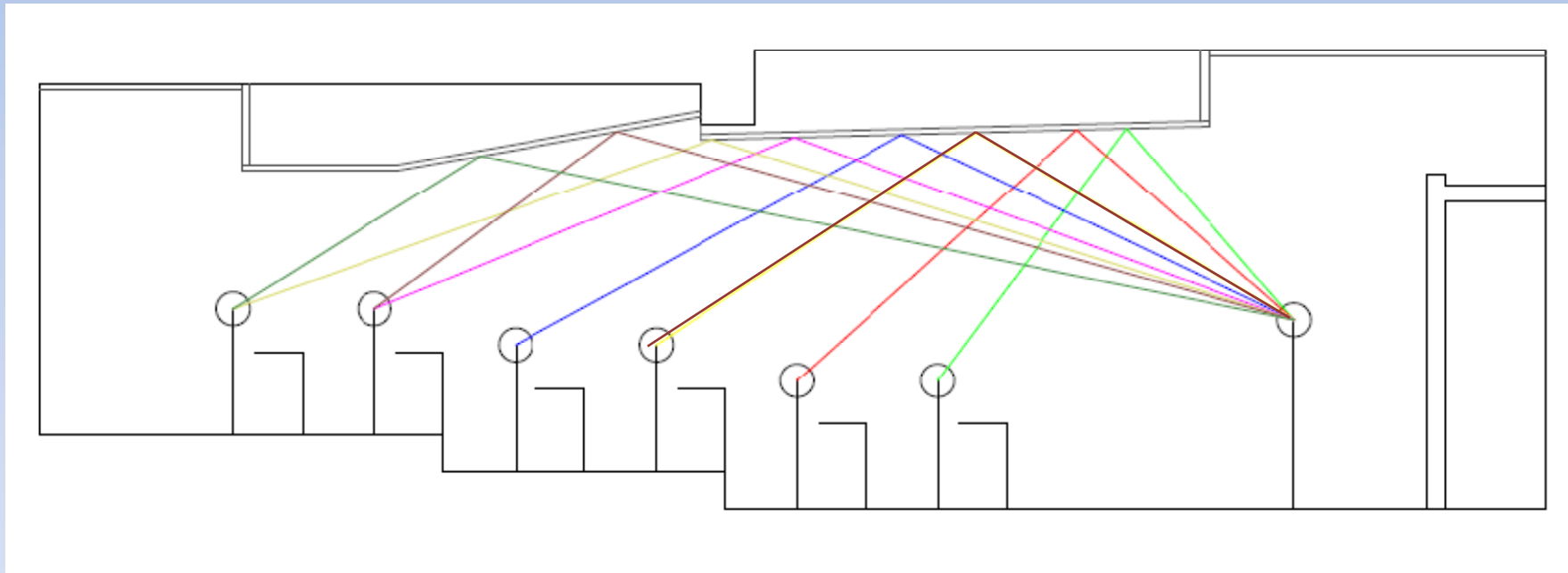
Aluminum feeders are a practical option for this building

Acoustics Breadth

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Sound Reflection:



Acoustics Breadth

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Reverberation Time:

Target – 0.7 to 1.1 seconds Ideal
0.5 seconds Acceptable

<u>Frequency (Hz)</u>	<u>Lowest Ideal</u> <u>α</u>	<u>Highest Ideal</u> <u>α</u>
500	0.68	1.50
1000	0.26	1.05
2000	0.15	0.50
4000	0.08	0.43

Acoustics Breadth

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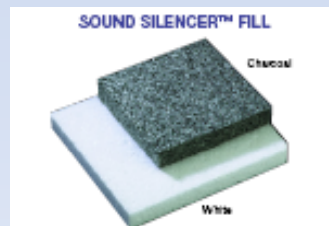


Material Selected:



Perforated Metal with Insulation

- Adds interest
- Solid and somewhat specular material allows sound to reflect to back of room
- No gaps in layout – space is unique but not overly modern
- White finish – best fit for color scheme of space and allows more light to inter-reflect



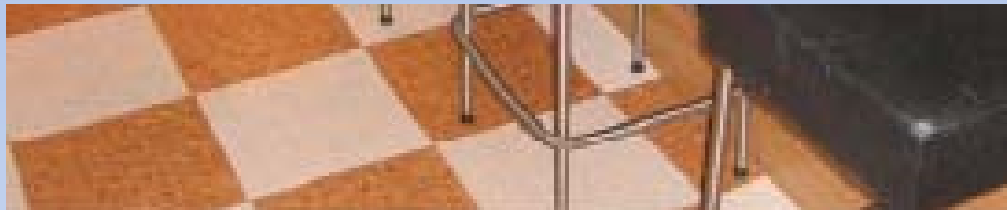
Frequency (Hz)	500	1000	2000	4000
Sound Absorp. (α)	0.81	0.85	0.93	0.88
Reverb. Time (sec)	0.65	0.57	0.51	0.50

Acoustics Breadth

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Airborne and Structure-borne Sound Insulation:



STC Target – 50

- Current structure meets criteria even without ceiling

IIC Target – 50

- Current structure does not meet criteria
- Solution: Replace VCT flooring for lab above with cork flooring
- New IIC is approx. 73

Conclusions

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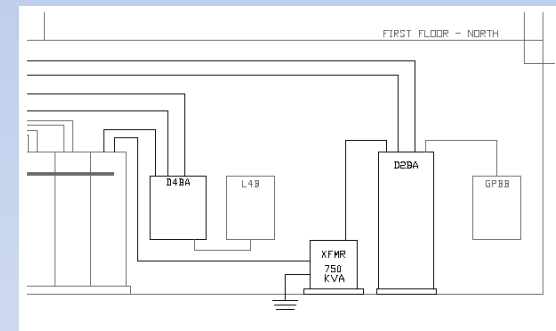
Lighting Depth

- Created a pleasing exterior environment with more dark-sky friendly luminaires
- Used energy-efficient luminaires in simple layouts to allow features of spaces to stand out



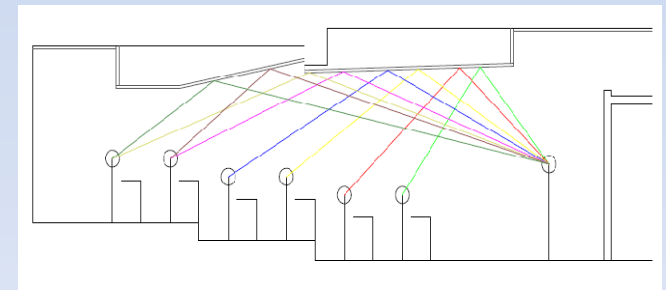
Electrical Depth

- Central transformer is impractical in environment with long, large feeders
- Aluminum feeders allow for substantial cost savings



Acoustics Breadth

- New ceiling reflects sound well
- Reverberation time is reasonable for a lecture hall
- Sound Insulation is appropriate with change to cork flooring for lab above lecture hall





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Thank You!

Questions?

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