Steidle Building Renewal Project
Architectural Engineering Senior Thesis

Presenter: Jeffrey Duclos

Construction Option

Advisor: Dr. John Messner

April 13th, 2016

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Analysis #2: Prefabricating the South Façade

Analysis #3: Process Development for Executing 3D Coordination

Industry Research Topic: Best-Value Selection Processes for Subcontractors

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Areas of Investigation:

Analysis #1: Alternate Vertical Transportation Processes (Not Presented)

- Resequencing the construction of the stairwells
- Accelerating the installation of the elevator

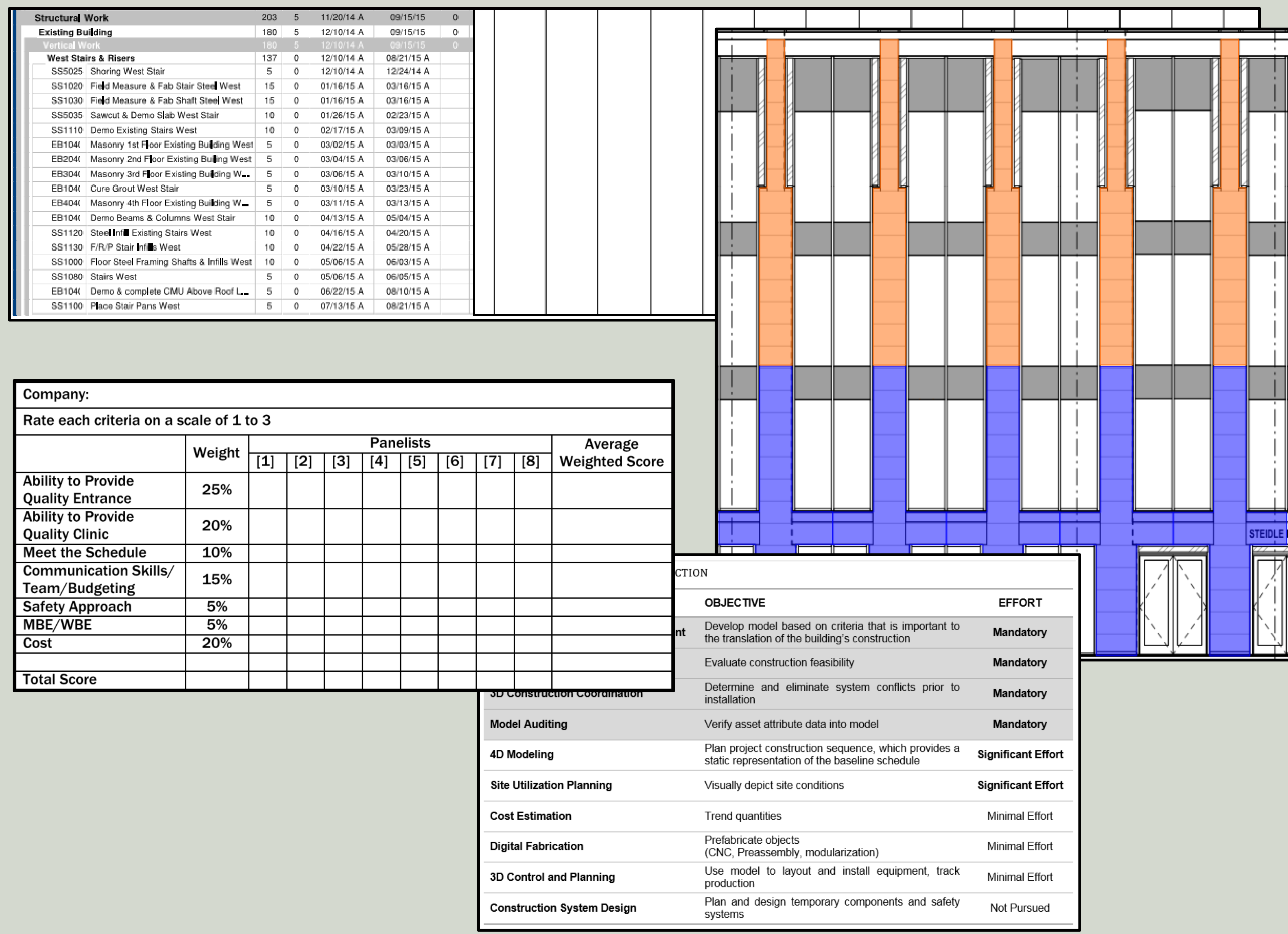
Analysis #2: Prefabrication of the South Facade

- *Structural Breadth – Connections Check*
- *Mechanical Breadth – Thermal and Moisture Protection Check*

Analysis #3: Process Development for Executing 3D Coordination

- Masters Degree Requirement – Based on AE 597G: BIM Execution Planning

Industry Research Topic: Best-Value Selection Processes for Subcontractors



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- Acknowledgements

Project Team

PennState

EYP/

mascaro construction
. . . build with the best

KEAST & HOOD
STRUCTURAL ENGINEERS

Pennoni

Project Overview

Building Name:
Edward G. Steidle Building

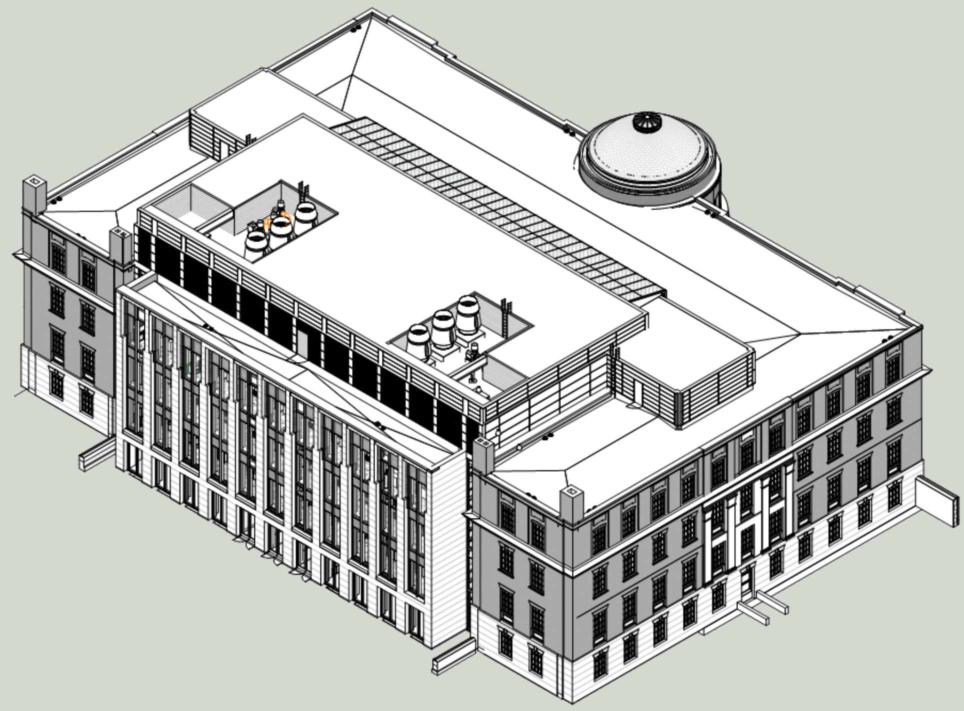
Owner:
The Pennsylvania State University

Occupant:
Materials Science and Engineering Department

Total Size:
100,000 sq. ft.

Project Budget:
$52 million

Project Schedule:
June 2014 – June 2016



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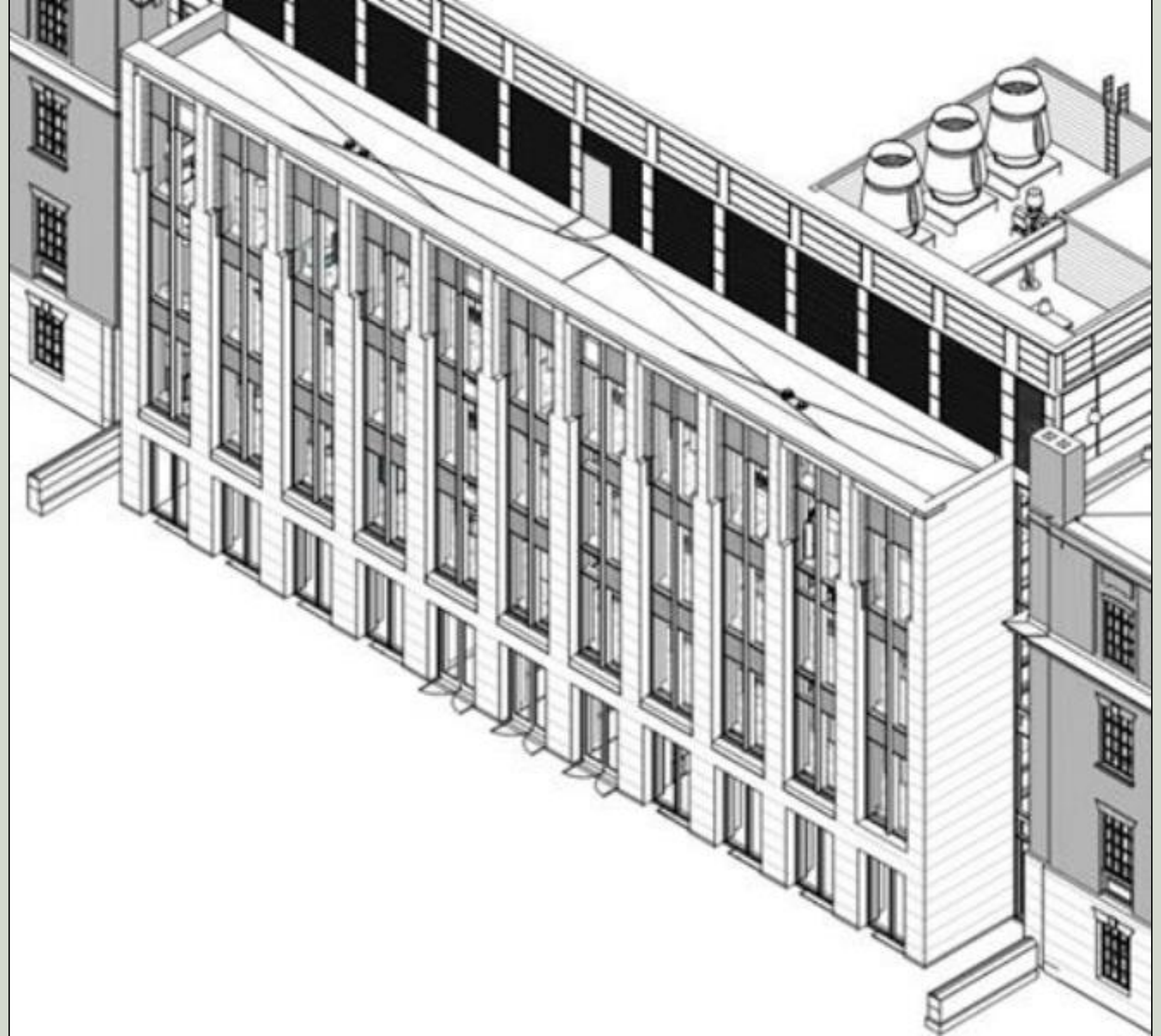
Analysis #2: Prefabricating the South Facade

Opportunities:

1) Limestone is an expensive and heavy material – changing to a lighter, less expensive material can save both time and money
2) The façade contains 10 uniformly designed columns, making them amenable to prefabrication

Goals:

1) Propose an alternative prefabricated column design that maintains the architectural integrity of the original design
2) Analyze the two façades to determine which is more viable.



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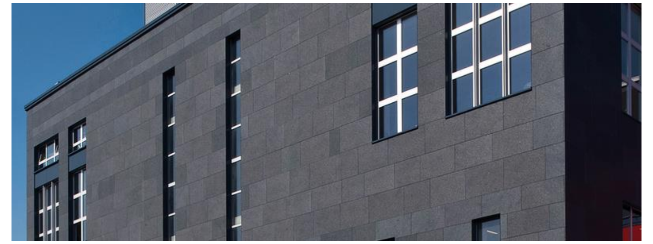
Façade Materials

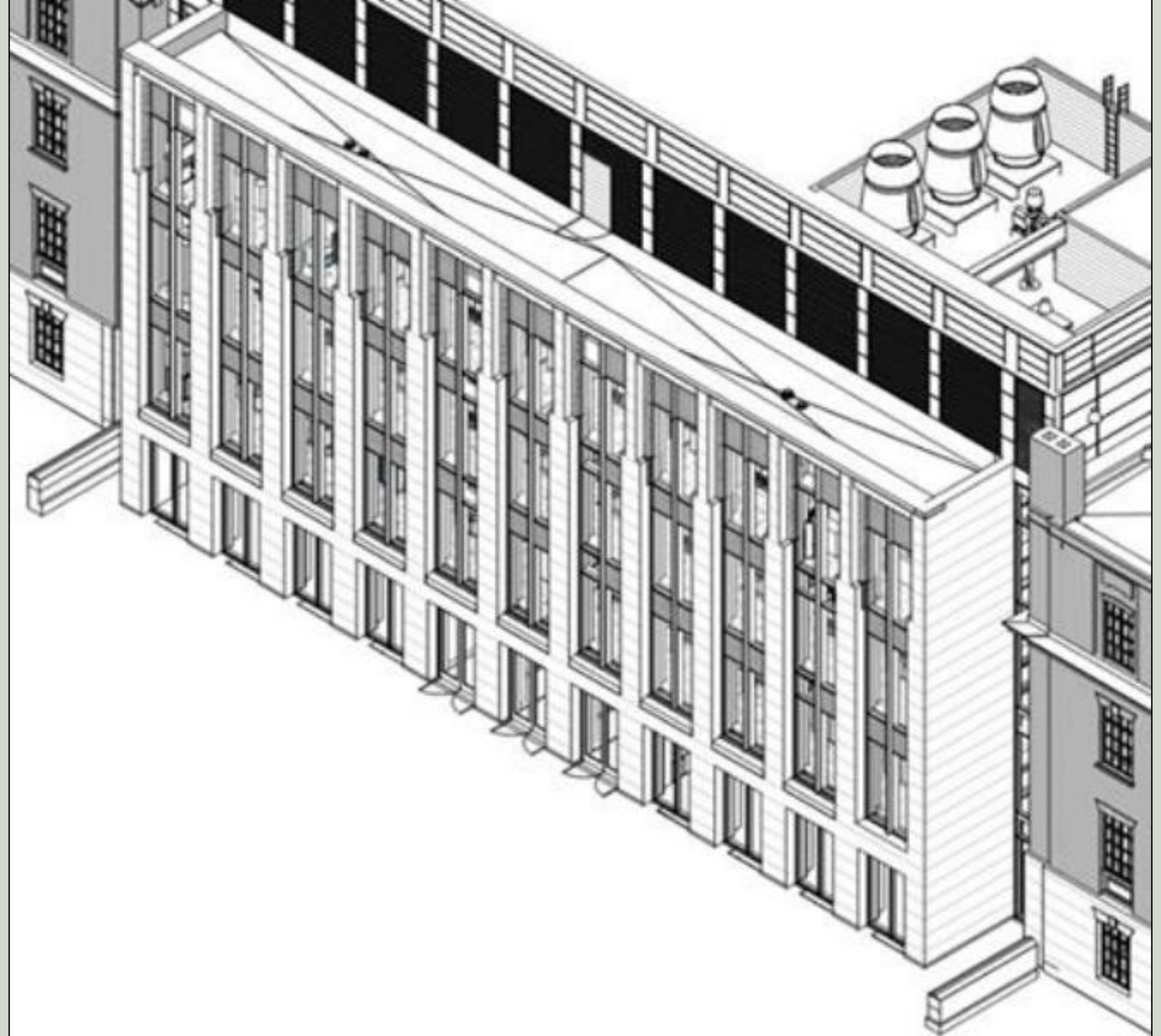


Granite

Brick Masonry

Limestone

Precast Concrete



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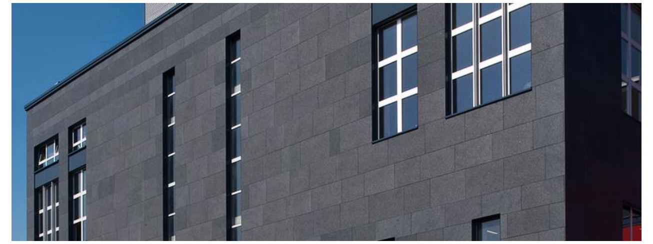


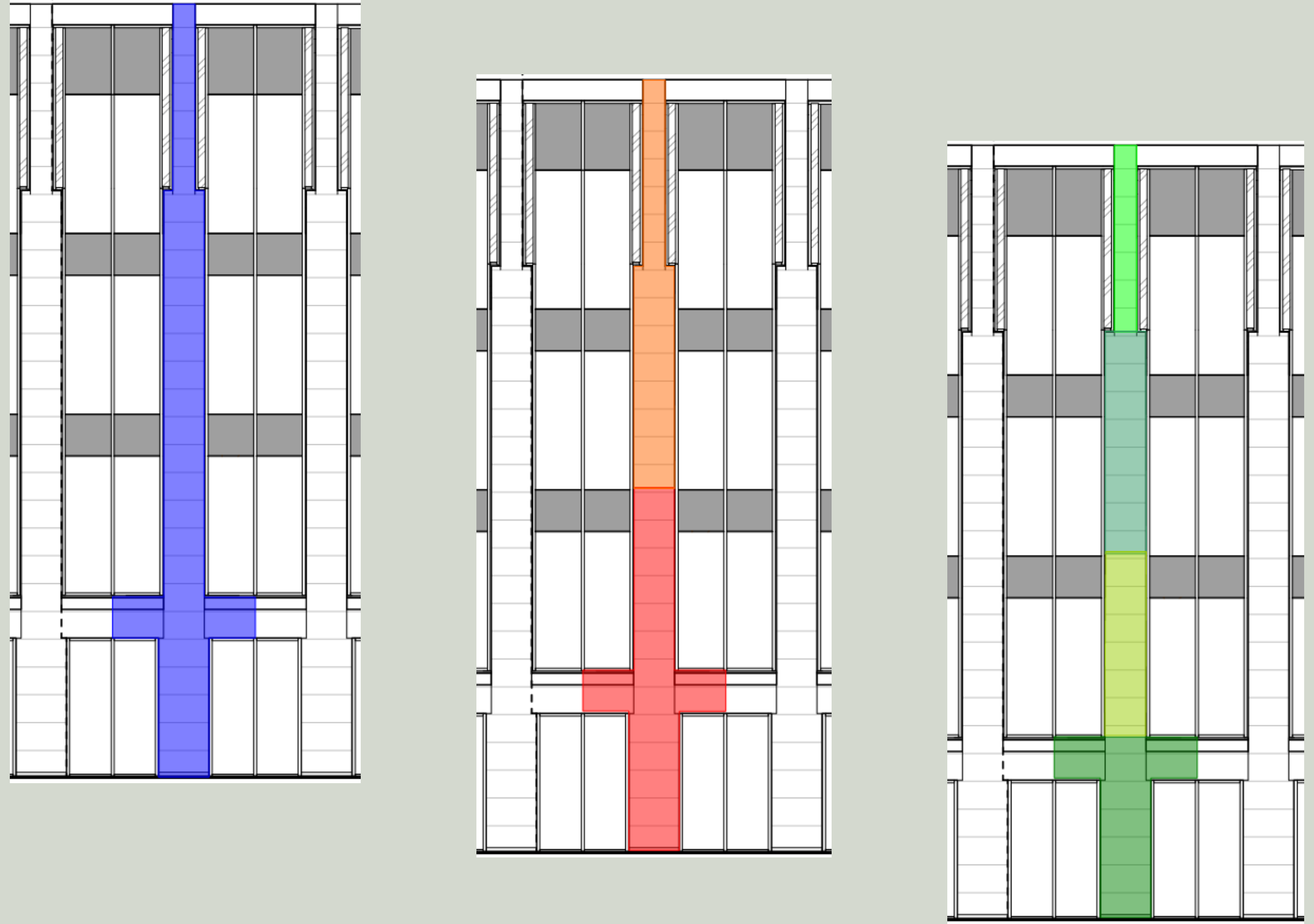
Granite

Brick Masonry

Limestone

Precast Concrete

Column Design



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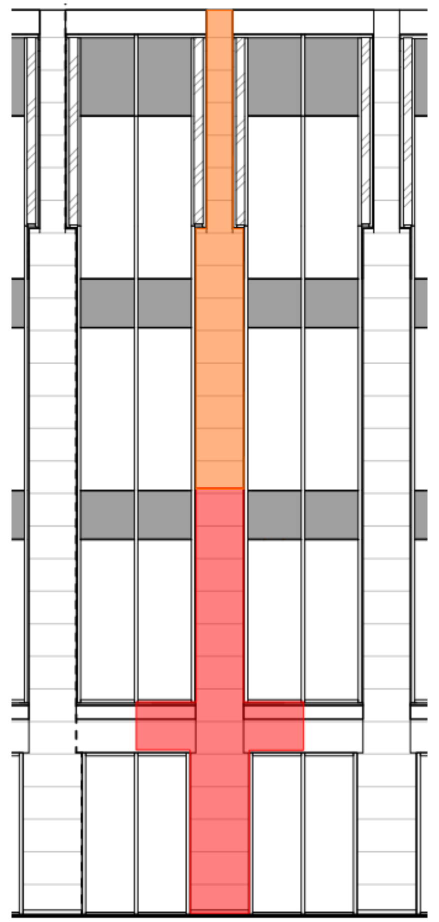
Final Design Solution



- Large yet Easily Transportable
- Lightweight
- 50+ year lifespan
- Architecturally versatile

Precast Concrete

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Structural Breadth: Connections Design Check

Goal: Determine if the proposed design change significantly affects the structural capacity of the façade's designed connections.

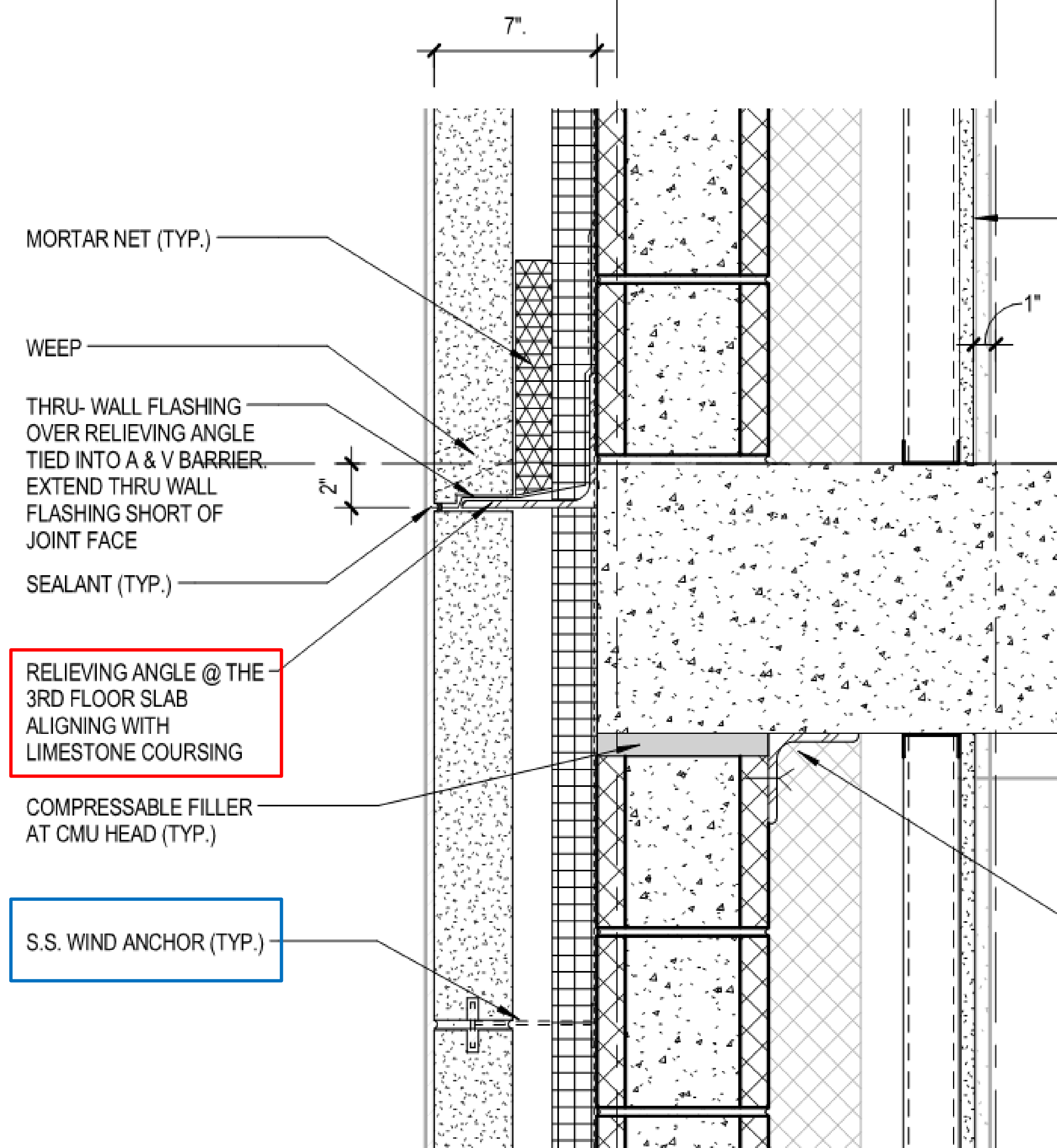
Process:

1. **Determine the shear and moment capacity of the relieving angle.**
2. Test the original façade for correct angle sizing
3. Calculate the shear and moment of the precast concrete façade and determine if the relieving angle can support it

A36 L6"x6"x3/8" Properties	
Elastic Modulus (E)	29e6 psi
Yield Strength (f_y)	36,000 psi
Unit Width (b)	1"
Height (h)	3/8"
Moment of Inertia (I)	0.0044 in^4
Section Modulus (S)	0.023 in^3
Shear Capacity	**7794 lbs.**
Moment Capacity	**69 ft.-lbs.**

L6"x6"x3/8"
A36 Angle

Lateral Anchor
(No structural support)



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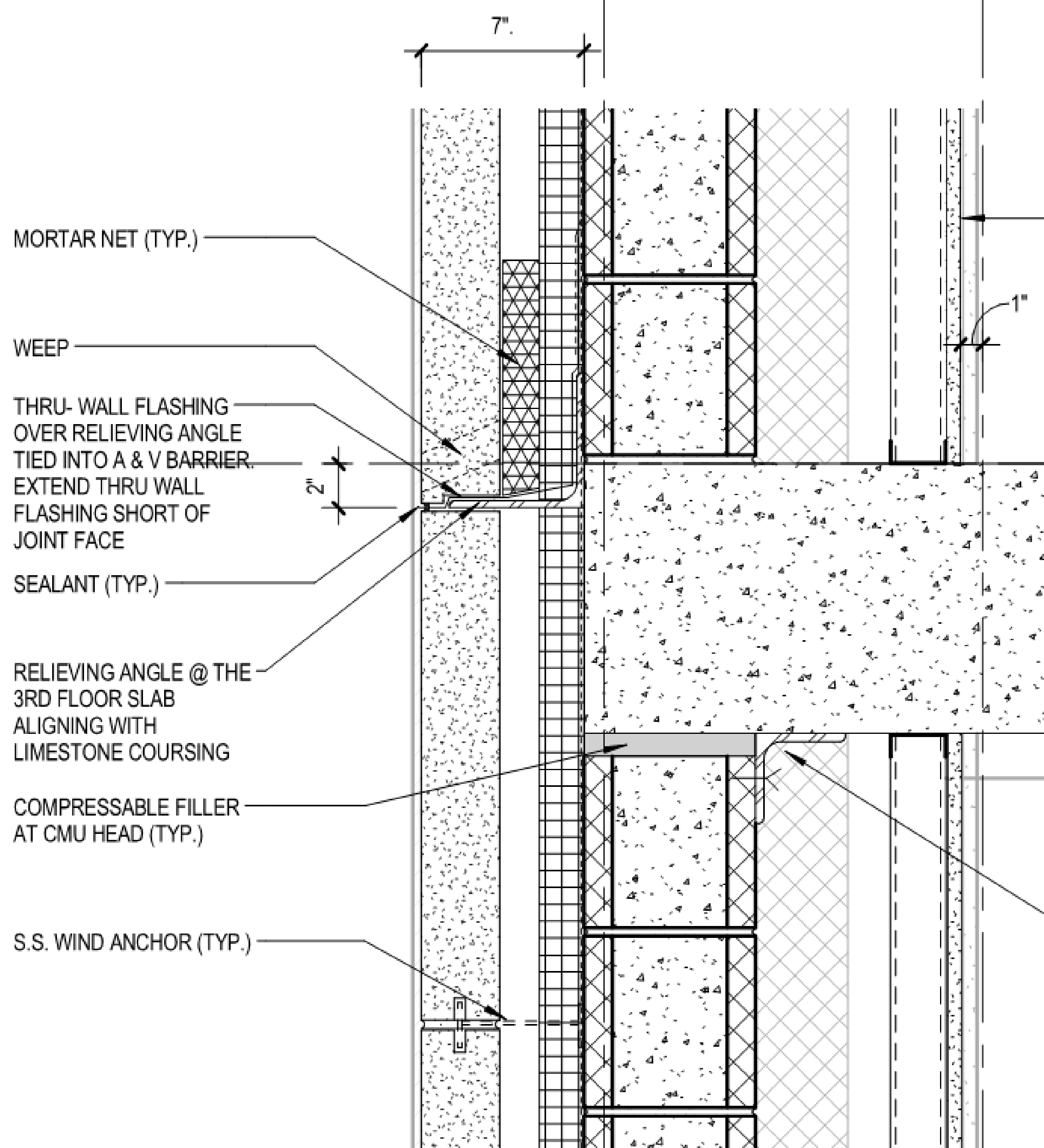
Process:

1. Determine the shear and moment capacity of the relieving angle.
2. **Test the original façade for correct angle sizing**
3. Calculate the shear and moment of the precast concrete façade and determine if the relieving angle can support it

Limestone Column Design	
Height	13 ft
Thickness	3 ½”
Unit Weight (b)	156 pcf
Total Load	49.3 lbs.
Distance from the fixed end	5 ¼”
Max Shear	**49.3 lbs.**
Max Moment	**21.6 ft.-lbs.**
Max Deflection	**0.0043 in.**



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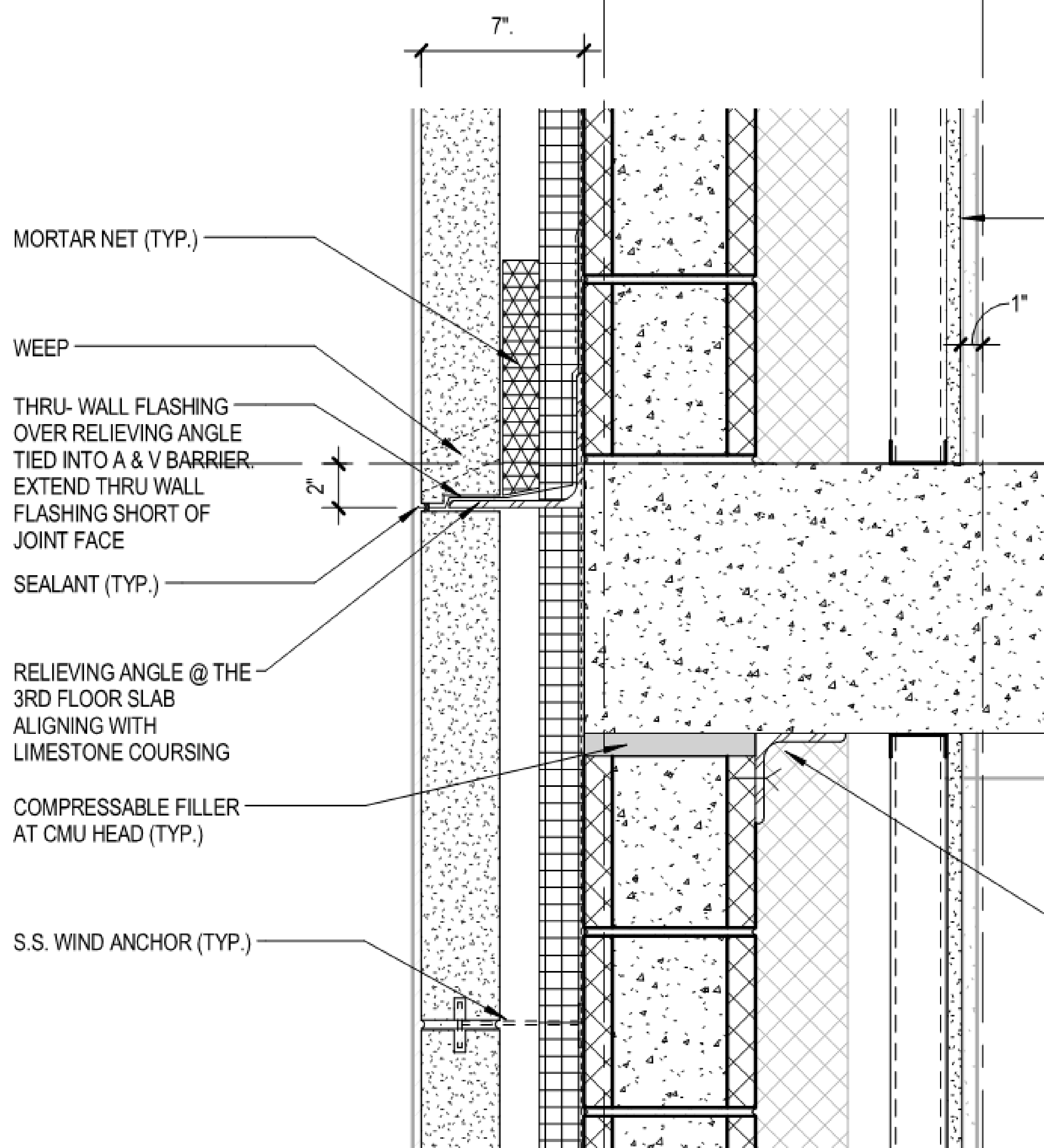
Process:

1. Determine the shear and moment capacity of the relieving angle.
2. Test the original façade for correct angle sizing
3. **Calculate the shear and moment of the precast concrete façade and determine if the relieving angle can support it**

Precast Concrete Column Design	
Height	29.5 ft
Thickness	4"
Unit Weight (b)	125 pcf
Total Load	102.4 lbs.
Distance from the fixed end	5"
Max Shear	**102.4 lbs.**
Max Moment	**42.7 ft.-lbs.**
Max Deflection	**0.043 in.**



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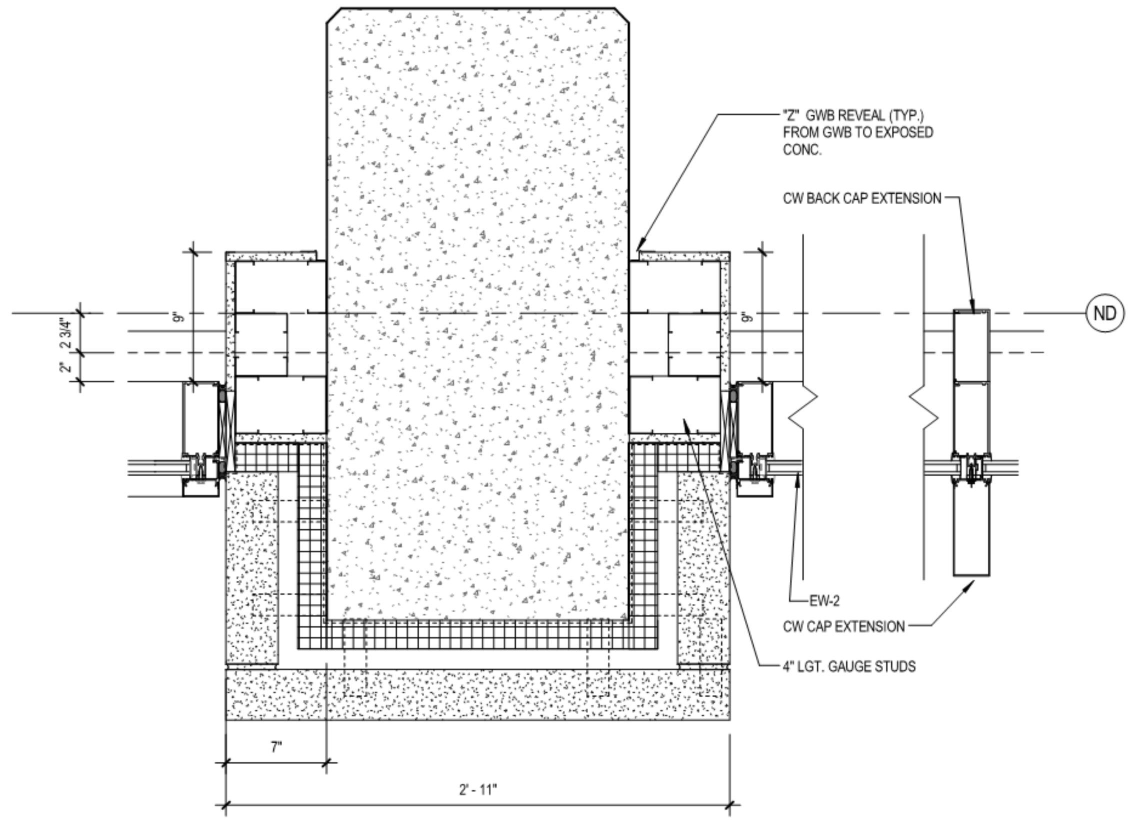
Mechanical Breadth: Thermal And Moisture Protection

Goal: Determine if the proposed design change significantly affects the thermal and moisture protection performance of the façade.

Process:

1. **Determine the U-Value for the Limestone Façade**
2. Determine the U-Value for the Precast Concrete Façade
3. Analyze any changes to the vapor barrier for potential deficiencies



Thermal Performance of the LimestoneFaçade		
Material	**R-Values**	
	Concrete Backing	*Gypsum Backing*
Outside Air Film	0.17	0.17
3-½" Limestone	0.39	0.39
1-½" Air Space	1.00	1.00
2" Rigid Insulation	12.00	12.00
Concrete Column (42.5")	3.40	—
12" Air Space	—	1.00
5/8" Gypsum Wall Board (x2)	—	1.12
Inside Air Film	0.68	0.68
Overall R-Value	**17.64**	**16.36**
U-Value	0.057	0.061
Percent Façade Area	60%	40%
Assembly U-Value	**0.586**	

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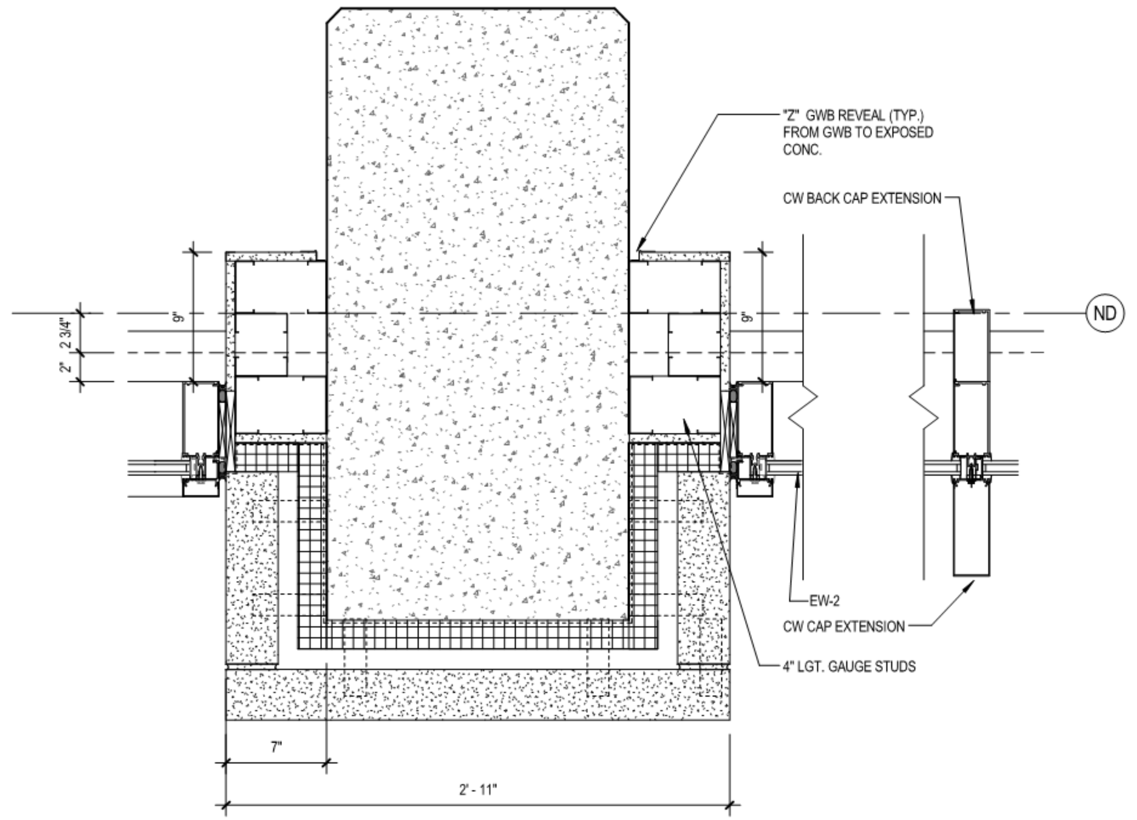

Thermal Performance of the Precast Concrete Façade		
Material	**R-Values**	
	Concrete Backing	*Gypsum Backing*
Outside Air Film	0.17	0.17
4” Precast Concrete	0.32	0.32
1-½” Air Space	1.00	1.00
2” Rigid Insulation	12.00	12.00
Concrete Column (42.5”)	3.40	—
12” Air Space	—	1.00
5/8” Gypsum Wall Board (x2)	—	1.12
Inside Air Film	0.68	0.68
Overall R-Value	**17.57**	**16.29**
U-Value	0.057	0.061
Percent Façade Area	60%	40%
Assembly U-Value	**0.588**	

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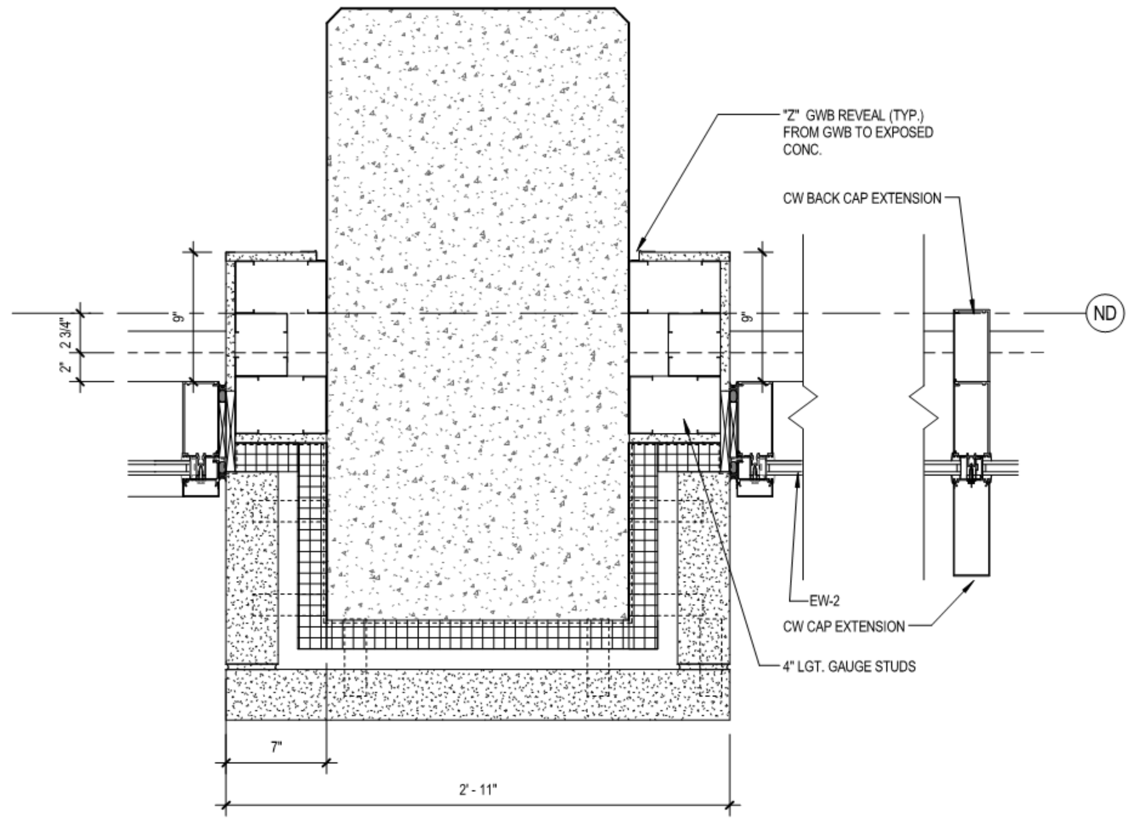

Dew Point Identification for the Precast Concrete Façade				
Location Description	***Distance***	***Cumulative R-Value***	***Temperature at Location (°F)***	***Past Dew Point? (Y/N)***
Precast Exterior Face	0"	0.17	10.63	N
B/w Precast & 1st Air Space	4"	0.49	11.80	N
B/w 1st Air Space & Insulation	**5"**	**1.49**	**15.49**	**N**
B/w Insulation & 1st GWB	**7"**	**13.49**	**59.69**	**Y**
B/w 1st GWB & 2nd Air Space	7-5/8"	14.05	61.75	Y
B/w 2nd Air Space and 2nd GWB	19-5/8"	15.05	65.43	Y
2nd GWB Interior Face	20-1/4"	15.61	67.50	Y

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Cost Analysis – Per Sq. Ft.

- Since the architectural design remained unchanged between the two, the square foot costs between the two can be directly compared.

Façade System	*Material Cost / SF*	*Labor Cost / SF*	*Equipment Cost / SF*	*Total Cost / SF*
Limestone Course Veneer, 3.5" Thick	$26.25	**$5.35**	**$1.72**	**$33.32**
Precast Architectural Concrete, Low-Rise Use, 4" Thick	**$20.50**	$11.70	$5.65	$37.85

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Results – Cross-Comparison

Façade System	*Connections Check*	*Thermal Performance – Assembly U-Value*	*Moisture Protection*	*Total Cost / SF*
Limestone Courses	**Pass**	**0.586**	**Pass**	**$33.32**
Precast Concrete	**Pass**	0.588	**Pass**	$37.85

Conclusion:

NOT RECOMMENDED

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Proposed Solution

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Analysis #3: Process Development for Executing 3D Coordination

Issue:

- At the time the project went to bid, the BIM model contained about 42,000 unresolved clashes, resulting in additional coordination needing to be performed by the subcontractors

Goals:

- Identify the root causes for the excessive number of clashes
- Propose changes to the project's BIM process design that could limit the number of clashes when bidding occurs

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Responses from the Project Team

+	Δ
Highly collaborative environment created during construction	**Difficulty navigating OPP's hierarchy led to breakdowns in communication**
Effective coordination with the subcontractors	Limited involvement from Penn State for 3D Coordination
Work involving underground utilities and tree protection went very well	OPP didn't conduct design review until 100% CD's

Key Components for Implementation

According to interviewed industry professionals,

1) There will be an increased number of clashes due to unmodeled or undocumented conditions

2) Getting an early start on coordination makes the process run much more smoothly

3) **Communication is paramount to successfully implementing BIM on a project**

4) **BIM Success is fairly independent of the project delivery method or the execution plan**

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The Root Problem

Breakdowns in Communication due to Mascaro's and EYP's unfamiliarity with OPP's staffing structure

Communication procedures need to be defined at the start of coordination

Penn State needs to be more involved in coordination processes, at least for first-time architects and construction managers

Communication needs to be promoted, especially between Mascaro and EYP directly

Key Components for Implementation

According to interviewed industry professionals,

1) There will be an increased number of clashes due to unmodeled or undocumented conditions

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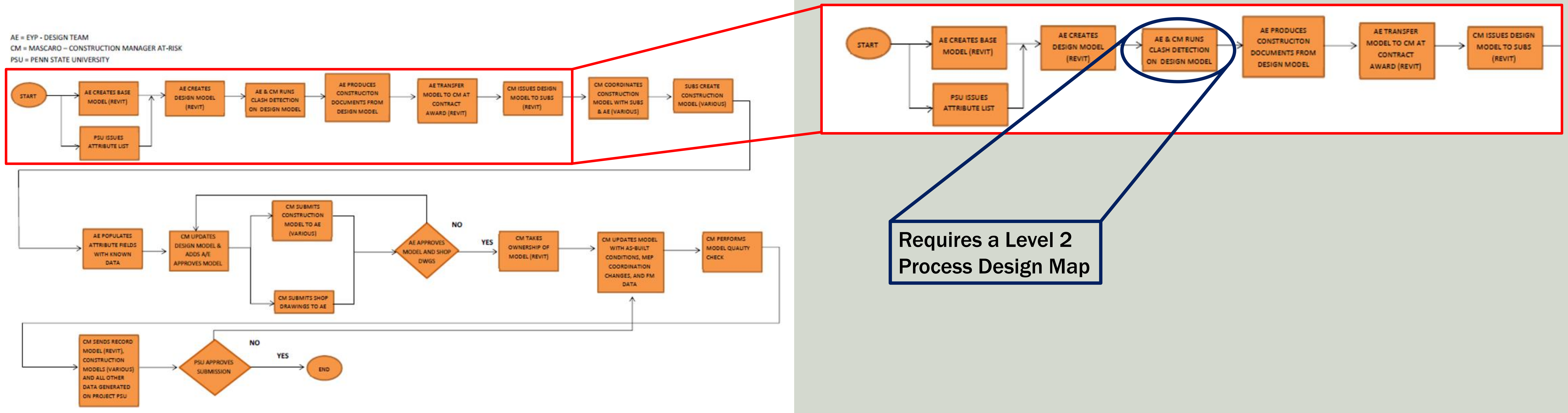
Level 1 Process Design



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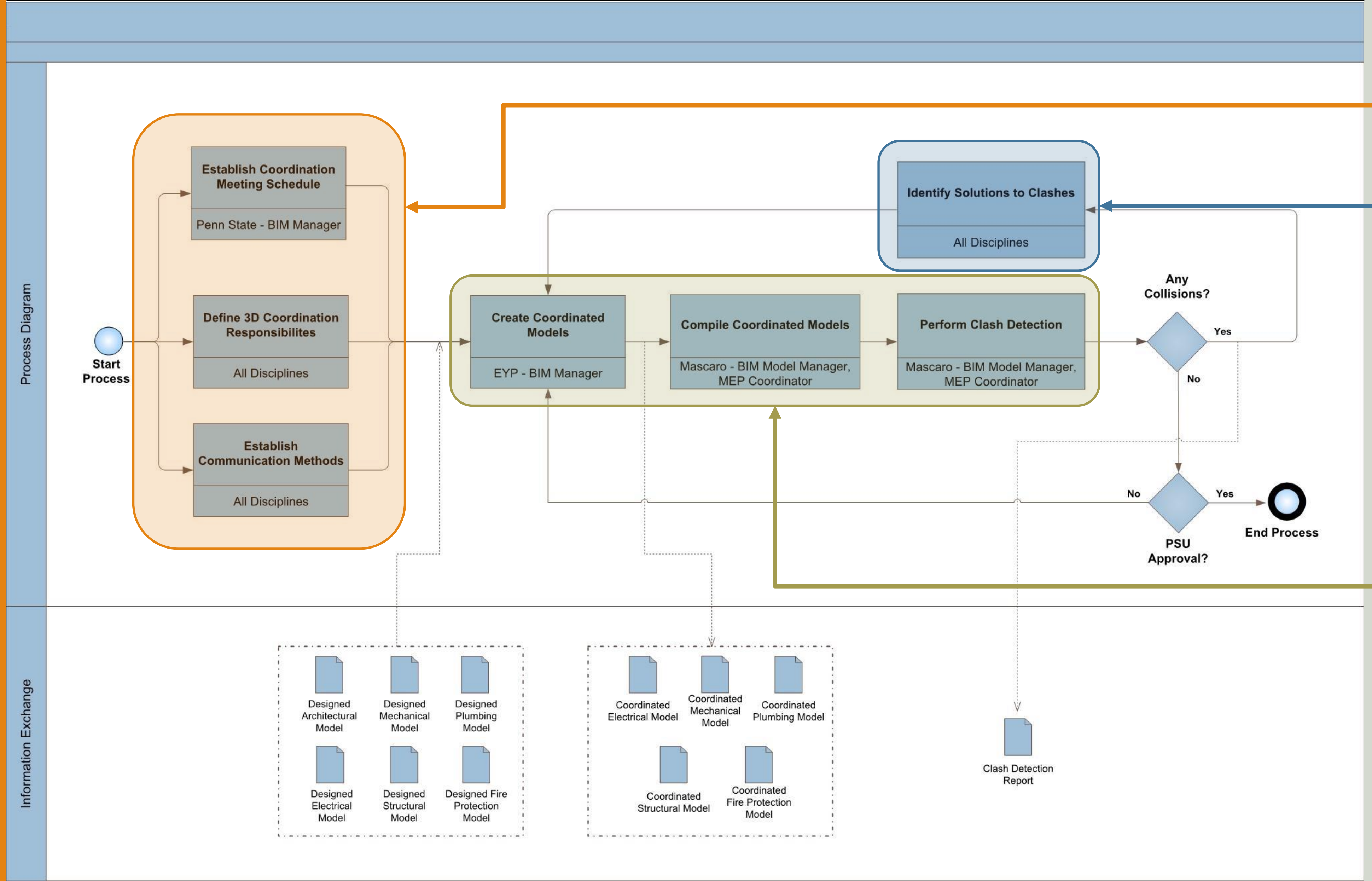
Level 2 Process Design for 3D Coordination



Early leadership on the part of Penn State

Direct Interaction between EYP and Mascaro during Design and Coordination

Collaborative problem-solving between all three parties to resolve clashes

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Industry Research Topic: Best-Value Selection Processes for Subcontractors

Challenge:

- Choosing subcontractors based purely off of the lowest bid may not actually result in the lowest overall cost

Goals:

- Gain a better understanding of Best-Value Analysis
- Propose a set of Best-Value criteria for the Office of Physical Plant's use on their future construction projects

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Defining "Best-Value Selection"

"Selecting a contractor on the basis of something other than Price alone."

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Penn State's Current Usage

Nursing School Project – Design-Build Team Selection

Company:										
Rate each criteria on a scale of 1 to 3										
	Weight	Panelists								Average Weighted Score
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	
Ability to Provide Quality Entrance	25%									
Ability to Provide Quality Clinic	20%									
Meet the Schedule	10%									
Communication Skills/ Team/Budgeting	15%									
Safety Approach	5%									
MBE/WBE	5%									
Cost	20%									
Total Score										

Defining "Best-Value Selection"

Best Value Selection is defined by the following requirements:

1) Separate Design and Construction Contracts
2) Design is assumed to be substantially complete
3) Total cost is a weighted criterion for final selection
4) Additionally, final selection is based on other weighted criteria **as well**

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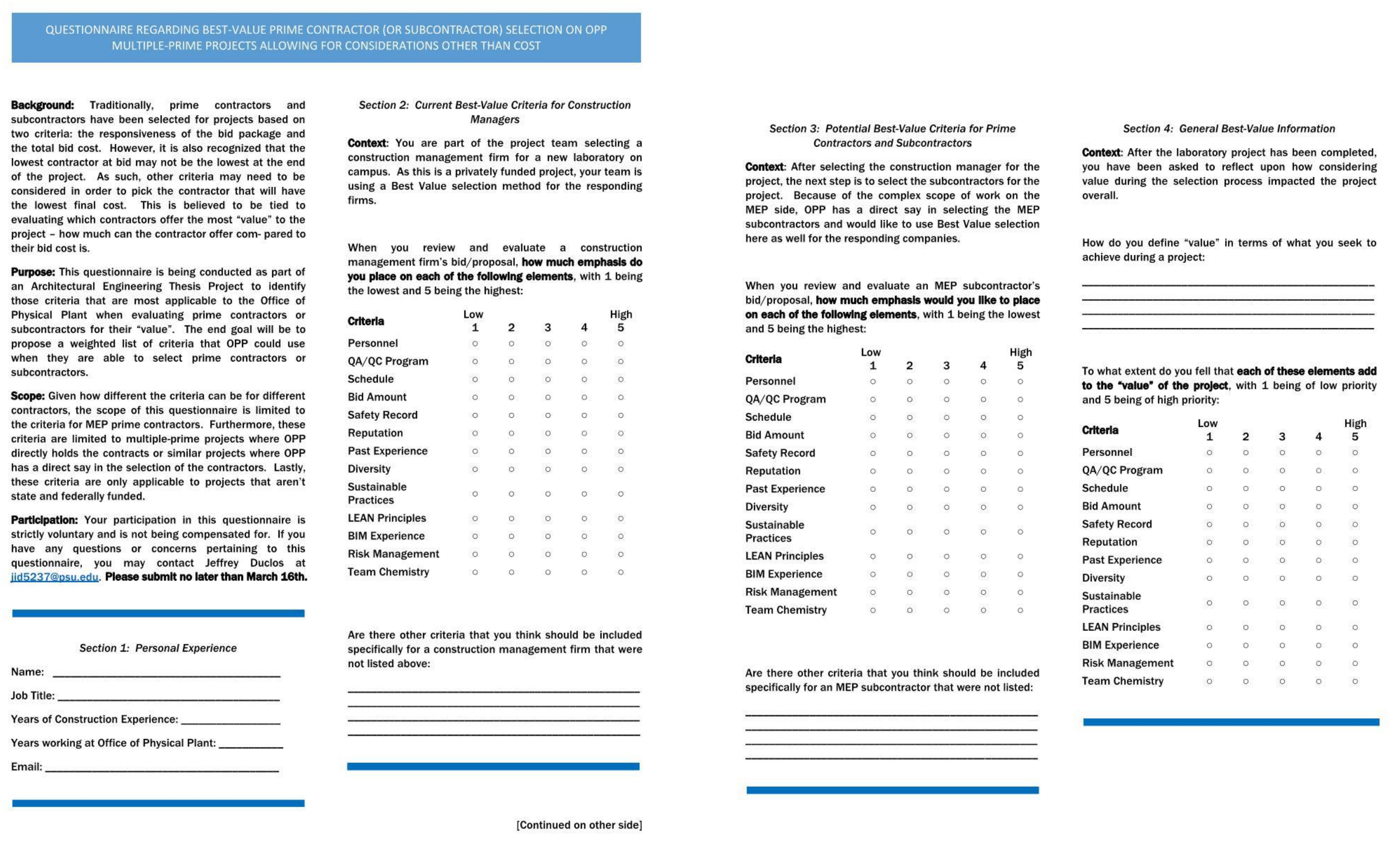

QUESTIONNAIRE REGARDING BEST-VALUE PRIME CONTRACTOR (OR SUBCONTRACTOR) SELECTION ON OPP MULTIPLE-PRIME PROJECTS ALLOWING FOR CONSIDERATIONS OTHER THAN COST

Background: Traditionally, prime contractors and subcontractors have been selected for projects based on two criteria: the responsiveness of the bid package and the total bid cost. However, it is also recognized that the lowest contractor at bid may not be the lowest at the end of the project. As such, other criteria may need to be considered in order to pick the contractor that will have the lowest final cost. This is believed to be tied to evaluating which contractors offer the most "value" to the project – how much can the contractor offer com- pared to their bid cost is.

Purpose: This questionnaire is being conducted as part of an Architectural Engineering Thesis Project to identify those criteria that are most applicable to the Office of Physical Plant when evaluating prime contractors or subcontractors for their "value". The end goal will be to propose a weighted list of criteria that OPP could use when they are able to select prime contractors or subcontractors.

Scope: Given how different the criteria can be for different contractors, the scope of this questionnaire is limited to the criteria for MEP prime contractors. Furthermore, these criteria are limited to multiple-prime projects where OPP directly holds the contracts or similar projects where OPP has a direct say in the selection of the contractors. Lastly, these criteria are only applicable to projects that aren't state and federally funded.

Participation: Your participation in this questionnaire is strictly voluntary and is not being compensated for. If you have any questions or concerns pertaining to this questionnaire, you may contact Jeffrey Duclos at jid5237@psu.edu. **Please submit no later than March 16th.**

Section 1: Personal Experience

Name: ____________

Job Title: ____________

Years of Construction Experience: ____________

Years working at Office of Physical Plant: ____________

Email: ____________

Section 2: Current Best-Value Criteria for Construction Managers

Context: You are part of the project team selecting a construction management firm for a new laboratory on campus. As this is a privately funded project, your team is using a Best Value selection method for the responding firms.

When you review and evaluate a construction management firm's bid/proposal, **how much emphasis do you place on each of the following elements**, with 1 being the lowest and 5 being the highest:

Criteria	Low 1	2	3	4	High 5
Personnel	○	○	○	○	○
QA/QC Program	○	○	○	○	○
Schedule	○	○	○	○	○
Bid Amount	○	○	○	○	○
Safety Record	○	○	○	○	○
Reputation	○	○	○	○	○
Past Experience	○	○	○	○	○
Diversity	○	○	○	○	○
Sustainable Practices	○	○	○	○	○
LEAN Principles	○	○	○	○	○
BIM Experience	○	○	○	○	○
Risk Management	○	○	○	○	○
Team Chemistry	○	○	○	○	○

Are there other criteria that you think should be included specifically for a construction management firm that were not listed above:

[Continued on other side]

Section 3: Potential Best-Value Criteria for Prime Contractors and Subcontractors

Context: After selecting the construction manager for the project, the next step is to select the subcontractors for the project. Because of the complex scope of work on the MEP side, OPP has a direct say in selecting the MEP subcontractors and would like to use Best Value selection here as well for the responding companies.

When you review and evaluate an MEP subcontractor's bid/proposal, **how much emphasis would you like to place on each of the following elements**, with 1 being the lowest and 5 being the highest:

Criteria	Low 1	2	3	4	High 5
Personnel	○	○	○	○	○
QA/QC Program	○	○	○	○	○
Schedule	○	○	○	○	○
Bid Amount	○	○	○	○	○
Safety Record	○	○	○	○	○
Reputation	○	○	○	○	○
Past Experience	○	○	○	○	○
Diversity	○	○	○	○	○
Sustainable Practices	○	○	○	○	○
LEAN Principles	○	○	○	○	○
BIM Experience	○	○	○	○	○
Risk Management	○	○	○	○	○
Team Chemistry	○	○	○	○	○

Are there other criteria that you think should be included specifically for an MEP subcontractor that were not listed:

Section 4: General Best-Value Information

Context: After the laboratory project has been completed, you have been asked to reflect upon how considering value during the selection process impacted the project overall.

How do you define "value" in terms of what you seek to achieve during a project:

To what extent do you fell that **each of these elements add to the "value" of the project**, with 1 being of low priority and 5 being of high priority:

Criteria	Low 1	2	3	4	High 5
Personnel	○	○	○	○	○
QA/QC Program	○	○	○	○	○
Schedule	○	○	○	○	○
Bid Amount	○	○	○	○	○
Safety Record	○	○	○	○	○
Reputation	○	○	○	○	○
Past Experience	○	○	○	○	○
Diversity	○	○	○	○	○
Sustainable Practices	○	○	○	○	○
LEAN Principles	○	○	○	○	○
BIM Experience	○	○	○	○	○
Risk Management	○	○	○	○	○
Team Chemistry	○	○	○	○	○

Developed Set of Criteria

Personnel	QA/QC Program	Schedule	Bid Amount	Safety Record
Reputation	Past Experience	Diversity	Sustainable Practices	LEAN Principles
	BIM Experience	Risk Management	Team Chemistry	

- ❑ Focus on MEP Subcontractors – "value" can vary depending on the trade
- ❑ Differences between Construction Managers, Subcontractors, and Overall Value?
- ❑ Are there any other criteria that people feel are valuable?

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- Questionnaire Development
- ***Questionnaire Results***
- Conclusions and Deliverable

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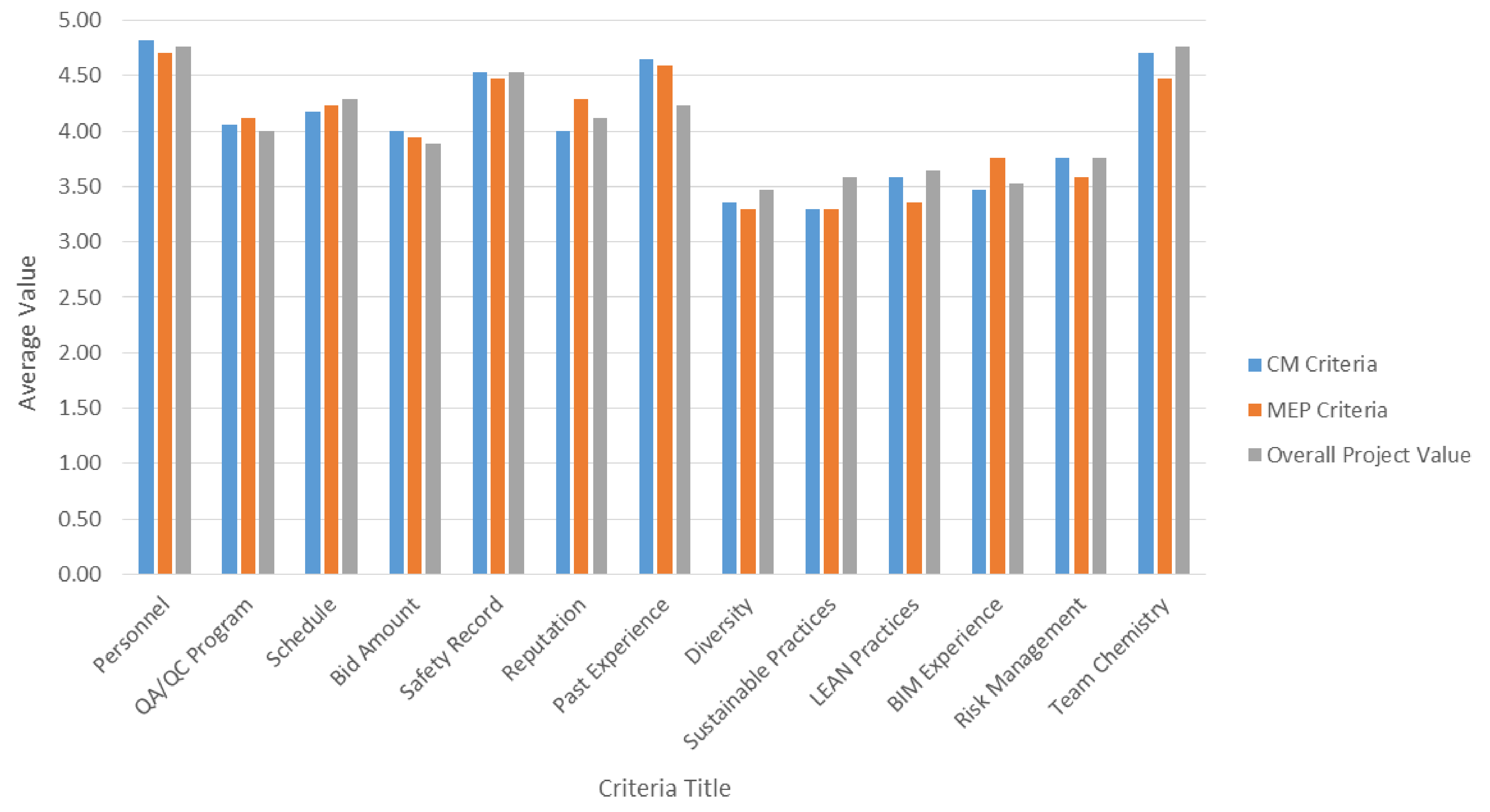
Average Criteria Importance Based on Returned Questionnaires



Additional Criteria

Construction Managers	MEP Subcontractors
• Experience working with Penn State or similar Project Types • Highlighting Key Project Leadership	• Experience working with Penn State • Knowledgeable about Building Automation Systems (BAS) • Familiarity with the Commissioning Process

What's Valuable to a Project?

- Fulfilling the Requirements of the Contract
  - Meeting the Schedule
  - Meeting the Budget
  - Ensuring a Safe Project
  - Delivering a High Quality Project
- Having a Collaborative Team
- Attaining High End-User Satisfaction

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Proposed Set of Weighted Criteria

Company:										
Rate each criteria on a scale of 1 to 3										
	Weight	Panelists								Average Weighted Score
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	
Personnel	15%									
Team Chemistry	15%									
Safety Record	15%									
Past Experience	15%									
QA/QC Program	10%									
Schedule	10%									
Reputation	10%									
Cost	5%									
BIM Experience	5%									
Total Score	100%									

Conclusions

1) Best-Value Selection for OPP will need to be conducted as a 2-step process
   - A. Generate a short-listing of subcontractors based on all of the proposed criteria and any other project-specific criteria
   - B. Interview the remaining subcontractors and evaluate them on the proposed criteria

2) The weighting of the proposed criteria is highly subject to change based on what each project team wants to focus on

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In Summary…

Analysis #1: Alternate Vertical Transportation Processes

- Resequenced Stairwell Erection: Recommended
- Accelerated Elevator Installation: Not Recommended

Analysis #2: Prefabrication of the South Facade

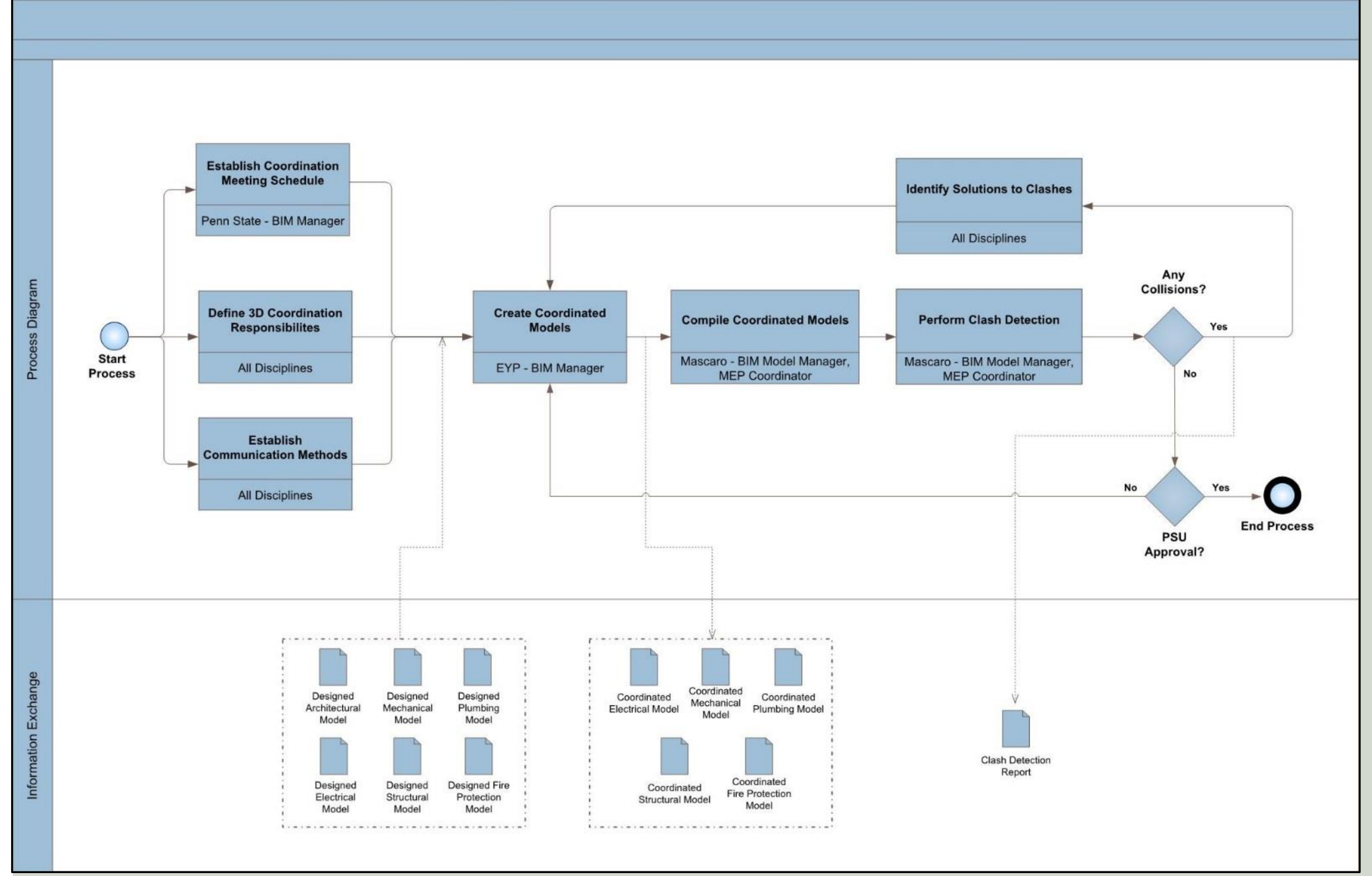
- Prefabricated Concrete Façade: Not Recommended

Analysis #3: Process Development for Executing 3D Coordination

- Proposed Level 2 Process Design: Recommended

Industry Research Topic: Best-Value Selection Processes for Subcontractors

- Proposed set of Best-Value Criteria for OPP: Recommended



Company:										
Rate each criteria on a scale of 1 to 3										
	Weight	Panelists								Average Weighted Score
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	
Personnel	15%									
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Safety Record	15%									
Past Experience	15%									
QA/QC Program	10%									
Schedule	10%									
Reputation	10%									
Cost	5%									
BIM Experience	5%									
Total Score	100%									

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Acknowledgements

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I will now field questions from the gallery at this time.