Steidle Building Renewal Project Architectural Engineering Senior Thesis

Presenter: Jeffrey Duclos

Construction Option



Advisor: Dr. John Messner

April 13th, 2016

Presentation Summary

Project Background

Analysis #2: Prefabricating the South Façade Analysis #3: Process Development for Executing 3D Coordination Industry Research Topic: Best-Value Selection Processes for Subcontractors Summary of Findings Acknowledgements

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

Analysis #2: Prefabrication of the South Facade

- Structural Breadth Connections 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

Areas of Investigation:

Resequencing the construction of the stairwells

Accelerating the installation of the elevator

• Mechanical Breadth – Thermal and Moisture Protection Check

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Safety Approach	5%									-	OBJECTIVE EFFORT	- 11
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Cost	20%									nt	te translation of the building's construction Mandatory	7
											Evaluate construction feasibility Mandatory	+
Total Score							30 (Construct	tion Coordination		Determine and eliminate system conflicts prior to Mandatory	
							Mod	lel Audit	ing		Verify asset attribute data into model Mandatory	
							4D I	Modeling	J		Plan project construction sequence, which provides a static representation of the baseline schedule Significant Effort	
							Site	Utilizati	on Planning		Visually depict site conditions Significant Effort	
							Cos	t Estima	tion		Trend quantities Minimal Effort	
							Digi	tal Fabri	cation		Prefabricate objects (CNC, Preassembly, modularization) Minimal Effort	
							3D (Control a	and Planning		Use model to layout and install equipment, track Minimal Effort	
							Con	structio	n System Design		Plan and design temporary components and safety Not Pursued systems	

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EYP



Project Team





... build with the best



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



Presentation Summary

Project Background

Analysis #2: Prefabricating the South Façade **Issue Summary Proposed Façade Structural Breadth: Connections Check** Mechanical Breadth: Thermal and Moisture Protection Check Cost Analysis **Results & Conclusion**

Analysis #3: Process Development for Executing 3D Coordination Industry Research Topic: Best-Value Selection Processes for Subcontractors Summary of Findings Acknowledgements

Analysis #2: Prefabricating the South Facade

Opportunities:

- 1)
- 2)

Goals:

- 1)

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

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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Analysis #2: Prefabricating the South Façade **Issue Summary Proposed Façade Structural Breadth: Connections Check** Mechanical Breadth: Thermal and Moisture Protection Check Cost Analysis **Results & Conclusion**

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Industry Research Topic: Best-Value Selection Processes for Subcontractors

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Façade Materials



Granite



Brick Masonry



Precast Concrete



Limestone

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Façade Materials



Granite



Brick Masonry



Precast Concrete

Column Design





Limestone





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Final Design Solution



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



Precast Concrete

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

Process:

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

Structural Breadth: Connections Design Check

A36 L6"x6"x3/8" Prop	perties
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 ftIbs.

	MORTAR NET (TYP.)
	WEEP
	THRU- WALL FLASHING OVER RELIEVING ANGLE TIED INTO A & V BARRIER. EXTEND THRU WALL FLASHING SHORT OF JOINT FACE
	SEALANT (TYP.)
L6"x6"x3/8" A36 Angle	RELIEVING ANGLE @ THE - 3RD FLOOR SLAB ALIGNING WITH LIMESTONE COURSING
	COMPRESSABLE FILLER
Lateral Anchor (No structural support)	S.S. WIND ANCHOR (TYP.) -



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Process:

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

Structural Breadth: Connections Design Check

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 1 ⁄4"					
Max Shear	49.3 lbs.					
Max Moment	21.6 ftlbs.					
Max Deflection	0.0043 in.					

MORTAR NET (TYP.)
WEEP
THRU- WALL FLASHING OVER RELIEVING ANGLE TIED INTO A & V BARRIER EXTEND THRU WALL FLASHING SHORT OF JOINT FACE
SEALANT (TYP.)
RELIEVING ANGLE @ THE
S.S. WIND ANCHOR (TYP.) -



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

Process:

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

Structural Breadth: Connections Design Check

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 ftlbs.					
Max Deflection	0.043 in.					

MORTAR NET (TYP.)
WEEP
THRU- WALL FLASHING OVER RELIEVING ANGLE TIED INTO A & V BARRIER. EXTEND THRU WALL FLASHING SHORT OF JOINT FACE
SEALANT (TYP.)
RELIEVING ANGLE @ THE
COMPRESSABLE FILLER
S.S. WIND ANCHOR (TYP.) -



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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:

- 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					
3-1/2" Limestone	0.39	0.39					
1- ¹ ⁄2" 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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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:

- 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 Performa	ce 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				
1-1/2" 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				

Presentation Summary

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Analysis #2: Prefabricating the South Façade **Issue Summary Proposed Façade Structural Breadth: Connections Check** Mechanical Breadth: Thermal and Moisture Protection Check Cost Analysis Results & Conclusion

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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:

- 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



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	Ν					
B/w Precast & 1 st Air Space	4"	0.49	11.80	Ν					
B/w 1 st Air Space & Insulation	5″	1.49	15.49	Ν					
B/w Insulation & 1 st GWB	7"	13.49	59.69	Y					
B/w 1 st GWB & 2 nd Air Space	7-5/8"	14.05	61.75	Y					
B/w 2 nd Air Space and 2 nd GWB	19-5/8"	15.05	65.43	Y					
2 nd GWB Interior Face	20-1/4"	15.61	67.50	Y					

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Analysis #2: Prefabricating the South Façade **Issue Summary Proposed Façade Structural Breadth: Connections Check** Mechanical Breadth: Thermal and Moisture Protection Check Cost Analysis **Results & Conclusion**

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

Façade S

Limestone Course Thick

Precast Architectu Low-Rise Use, 4" 1

Cost Analysis – Per Sq. Ft.

/stem	Material Cost / SF	Labor Cost / SF	Equipment Cost / SF	Total Cost / SF
Veneer, 3.5"	\$26.25	<u>\$5.35</u>	<u>\$1.72</u>	<u>\$33.32</u>
ral Concrete, hick	<u>\$20.50</u>	\$11.70	\$5.65	\$37.85

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Façade System Limestone Courses Precast Concrete

Results – Cross-Comparison

Connections Check	Thermal Performance – Assembly U-Value	Moisture Protection	Total Cost / SF
Pass	<u>0.586</u>	<u>Pass</u>	<u>\$33.32</u>
Pass	0.588	<u>Pass</u>	\$37.85

NOT RECOMMENDED



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Analysis #2: Prefabricating the South Façade

Analysis #3: Process Development for Executing 3D Coordination **Issue Summary** Identifying the Root Problem **Evaluation of the Current Process Proposed Solution**

Industry Research Topic: Best-Value Selection Processes for Subcontractors

Summary of Findings

Acknowledgements

Analysis #3: Process Development for Executing 3D Coordination

Issue:

Goals:

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

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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Acknowledgements

Highly collaborative during construction

Effective coordinati subcontractors

Work involving und tree protection wer

Responses from the Project Team

+	Δ
e environment created	Difficulty navigating OPP's hierarchy led to breakdowns in communication
ion with the	Limited involvement from Penn State for 3D Coordination
erground utilities and nt 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
- **BIM Success is fairly independent of the project 4**) delivery method or the execution plan

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Breakdowns	in
EYP's unfami	



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

The Root Problem

Communication due to Mascaro's and liarity with OPP's staffing structure

Communication procedures need to be defined at the start of coordination

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

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Level 1 Process Design

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Direct Interaction between EYP and Mascaro during Design and Coordination

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Industry Research Topic: Best-Value Selection Processes for Subcontractors **Issue Summary Research Findings Questionnaire Development** Questionnaire Results **Conclusions and Deliverable**

Summary of Findings

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Industry Research Topic: Best-Value **Selection Processes for Subcontractors**

Challenge:

Goals:

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

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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Industry Research Topic: Best-Value Selection Processes for Subcontractors

Issue Summary Research Findings Questionnaire Development **Questionnaire Results Conclusions and Deliverable**

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Industry Research Topic: Best-Value **Selection Processes for Subcontractors**

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Goals:

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

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

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

Defining "Best-Value Selection"

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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

Issue Summary Research Findings **Questionnaire Development** Questionnaire Results **Conclusions and Deliverable**

Summary of Findings

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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										
	Waight				Pan	elists				Average
	weight	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	Weighted Score
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:

- **Separate Design and Construction Contracts** 1)
- 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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IESTIONNAIRE REGARDING BEST-VALUE PRIME (MULTIPLE-PRIME PROJECTS ALLOWIN

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 <u>iid5237@psu.edu</u>. Please submit no later than March 16th.

	Section 1: Personal Experience
Name:	
lob Title: _	
lears of Co	nstruction Experience:
ears work	ng at Office of Physical Plant:
Email:	

ITRACTOR (OR SUBCONTRACTOR) SELECTION ON OP OR CONSIDERATIONS OTHER THAN COST

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	0	0	0	0	0
QA/QC Program	0	0	0	0	0
Schedule	0	0	0	0	0
Bid Amount	0	0	0	0	0
Safety Record	0	0	0	0	0
Reputation	0	0	0	0	0
Past Experience	0	0	0	0	O
Diversity	0	0	0	0	0
Sustainable Practices	0	0	0	0	0
LEAN Principles	0	0	0	0	0
BIM Experience	0	0	0	0	O
Risk Management	0	0	0	0	0
Team Chemistry	0	0	0	0	0

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				High
	1	2	3	4	5
Personnel	0	0	0	0	0
QA/QC Program	0	0	0	0	0
Schedule	0	0	0	0	0
Bid Amount	0	0	0	0	0
Safety Record	0	0	0	0	0
Reputation	0	0	0	0	0
Past Experience	0	0	0	0	0
Diversity	0	0	0	0	0
Sustainable Practices	0	0	0	o	0
LEAN Principles	0	0	0	0	0
BIM Experience	0	0	0	0	0
Risk Management	0	0	0	0	0
Team Chemistry	0	0	0	0	0

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	e eleme	ents add
to the "value"	of the	project,	with	1 being	of low	priority
and 5 being of	high pr	riority:				

Criteria	Low	2	3	4	High 5
Personnel	0	0	0	0	0
QA/QC Program	0	0	0	0	0
Schedule	0	0	0	0	0
Bid Amount	0	0	0	0	0
Safety Record	0	0	0	0	0
Reputation	0	0	0	0	0
Past Experience	0	0	0	0	0
Diversity	0	0	0	0	0
Sustainable Practices	o	0	0	0	0
LEAN Principles	0	0	0	0	0
BIM Experience	0	0	0	0	0
Risk Management	0	0	0	0	O
Team Chemistry	0	0	0	0	0

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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Average Criteria Importance Based on **Returned Questionnaires**

Additional Criteria

Construction Managers

- Experience working with Penn State Experience working with Penn State or similar Project Types
- Highlighting Key Project Leadership

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

MEP Subcontractors

- Knowledgeable about Building Automation Systems (BAS)
- Familiarity with the Commissioning Process

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Prop
Company:
Rate each criteria on a
Personnel
Team Chemistry
Safety Record
Past Experience
QA/QC Program
Schedule
Reputation
Cost
BIM Experience
Total Score

osed Set of Weighted Criteria

scale of 1 to 3

	Weight			Average						
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	Weighted Score
	15%									
	15%									
	15%									
	15%									
	10%									
	10%									
	10%									
	5%									
	5%									
	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
- 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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- Resequenced Stairwell Erection: Recommended
- Accelerated Elevator Installation: Not Recommended

• Prefabricated Concrete Façade: Not Recommended

• Proposed Level 2 Process Design: Recommended

In Summary...

Analysis #1: Alternate Vertical Transportation Processes

- Analysis #2: Prefabrication of the South Facade
- Analysis #3: Process Development for Executing 3D Coordination
- Industry Research Topic: Best-Value Selection Processes for Subcontractors • Proposed set of Best-Value Criteria for OPP: Recommended



teria on a scale of 1 to 3											
	Weight			Average							
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	Weighted Score	
	15%										
stry	15%										
d	15%										
nce	15%										
am	10%										
	10%										
	10%										
	5%										
ce	5%										
	100%										

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Acknowledgements

I would like to thank the following people:

Department of Architectural Engineering – Senior Thesis:

- Dr. Kevin Parfitt, Head of Thesis
- Dr. John Messner, Thesis Advisor

The Office of Physical Plant

- Mr. John Bechtel
- Mr. Dwayne Rush
- Ms. Rachel Prinkey

Mascaro Construction Company

- Mr. Ed Elinski
- Mr. Matt Morris
- □ Mr. Mike Scoeneman
- Ms. Penny Luck
- □ Ms. Erin Dunbar
- Mr. Chaz Ott

- EYP Architects and Engineers
- Mr. Hacig Tacvorian
- Mr. Ervin Kulenica

References

- □ Mr. Sean Flynn
- □ Mr. Jeremy Duckett
- Mr. Matthew Baker
- Dr. Ryan Solnosky
- Dr. Moses Ling

... And of course, all my friends and family who have been there to support me over the last 23 years!

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