Presentation Outline

I. Project Background
II. Analysis 1: Delivery Method Study
III. Analysis 2: 4D Safety & Phase Plan
IV. Analysis 3: On-Site Renewable Energy
V. Analysis 4: Façade Redesign
VI. Mechanical Breadth
VII. Conclusions
VIII. Acknowledgements

Michael Beam

Senior Thesis
Final Presentation

Architectural Engineering
Construction Management
Advisor: Dr. Messner

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Presentation Outline

WOHLSEN CONSTRUCTION

MM architects | inc.

Unionville High School

Project Background

Unionville High School Building Information:

- Kennett Square, Pennsylvania
- Additions and Renovations
- Public Education
- 3 Stories
- 319,000 square feet

Project Information:

- Lump Sum Contract
  - $52 Million
- June 2009 – September 2012
- Single Prime Delivery Method

Project Location

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Analysis 1: Delivery Method Study

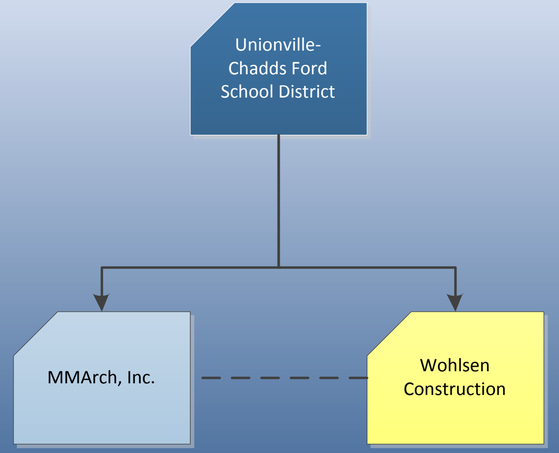
Background Information

- PA Law Mandates Multiple Prime Delivery Method
  - for PA public education projects
- UCFSD (Owner) desired alternate Delivery Method

Research Goal:

- Determine why UCFSD wanted Single Prime
- Determine best delivery method for this project
  - & PA Public Education projects

Project Staffing Plan



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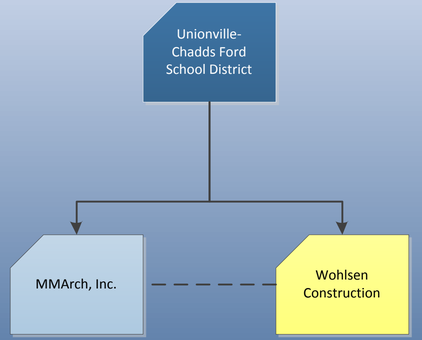

Analysis 1: Delivery Method Study

Delivery Method Used On Project:

- Single Prime Delivery Method
  - GC: Wohlsen Construction (Lancaster, PA)

Reason for Waiver Application:

- Past projects completed using Multiple Prime
  - Complications with these projects

- Success with Single Prime projects
  - Wohlsen GC on previous projects

Unionville High School Building 3D Massing Model

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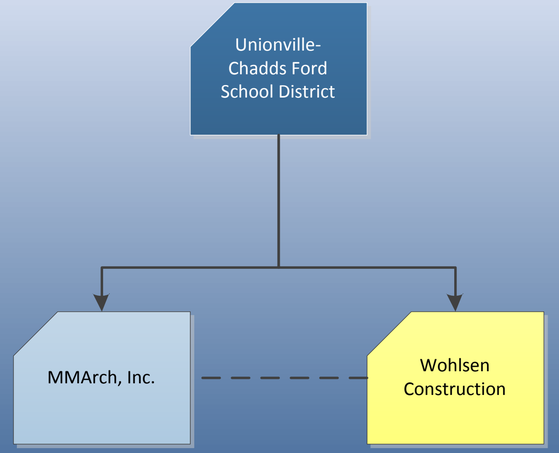
Analysis 1: Delivery Method Study

Conclusion:

- For UHS project, ***Single Prime is the best option***
  - Past experience, higher comfort level
    - Comfort level with Wohlsen Construction
  - Single Point of Contact for owner

- For other PA Public Education projects
  - Each project should select best delivery method
  - No delivery method should be mandated
    - Legislation needs amended

Project Staffing Plan



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Analysis 2: 4D Safety and Phase Plan

Background Information

- BIM not used on project
- Detailed Phasing with continuous phased building occupancy
- Little project information available to building occupants
  - No formal safety/transition plan available

Research Goal:

- Identify potential BIM uses for UHS project
  - 3D Model
  - 4D Safety and Phase plan
- Develop 3D model for the project
- Use model to develop 4D Phasing and Safety Plan
- Create an interactive website for use throughout the project

Unionville High School Building 3D Massing Model

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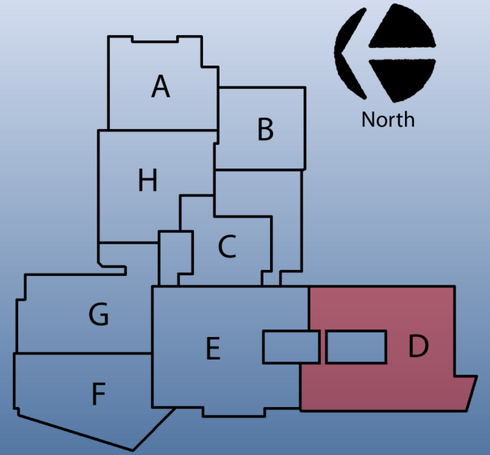
Analysis 2: 4D Safety and Phase Plan

Phasing Information:

- 4 Main Phases, 16 sub phases
  - Phase 1: June 2009 – June 2010
  - Phase 2: June 2010 – June 2011
  - Phase 3: June 2011 – December 2011
  - Phase 4: July 2011 – September 2012

- **Phase 1: Area D** will serve as example phase for this analysis
  - New Construction

UHS Project Building Area Key



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Analysis 2: 4D Safety and Phase Plan

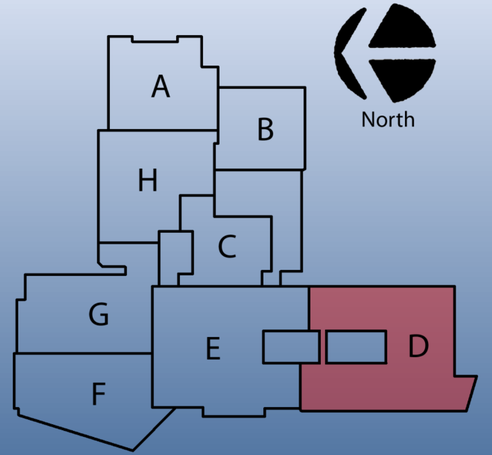
Safety/Phasing Plan - Interactive Website :

- Website will be updated continuously as phases change

- Contains information regarding current construction phase
  - Building Area Breakdown (Under Construction/Occupied)
  - Construction Area
  - Transition Plan

- Several kiosks available throughout the building

UHS Project Building Area Key



Analysis 2: 4D Safety and Phase Plan

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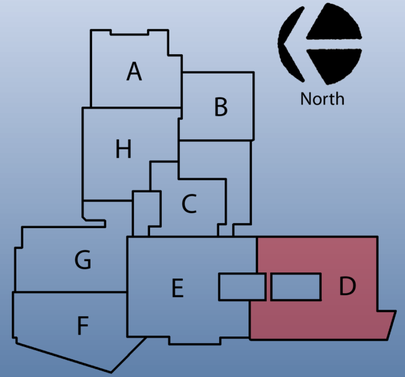

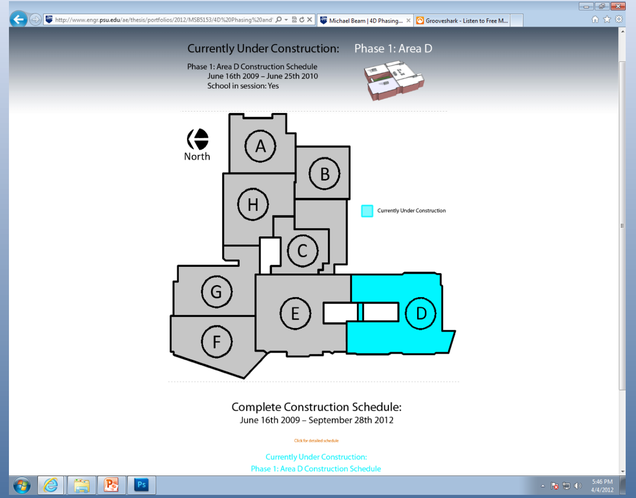

Website Examples

Analysis 2: 4D Safety and Phase Plan

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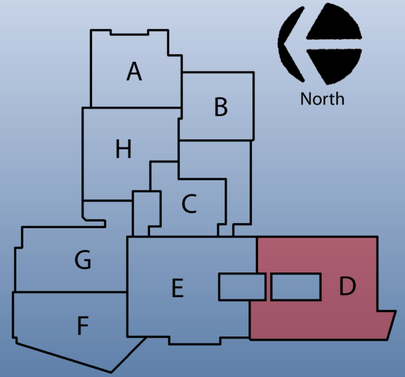

Conclusion:

- Implementation of BIM ***will provide value to owner***
  - Better visualization of project
  - Increased information available to building occupants

- Startup: Added cost to develop BIM model
- Learning curve: Time needed to learn software

Website Example

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http://www.ushbc.com

Analysis 3: On-Site Renewable Energy

Background Information:

- Sustainability a focus on UHS project
  - LEED 2007 silver certification targeted
    - LEED 2009 Certification
  - No renewable energy incorporated
    - Potential for additional LEED credits
- High building energy usage, opportunity for significant savings

Research Goal:

- Determine which renewable energy source is best option
  - Wind or Solar
- Design renewable energy system
- Determine potential savings and LEED impact

Michael Beam | Construction Management

Renewable Energy Source Options

http://www.stonesolar.com/product/skystream-37-24kw-system

http://us.sunpowercorp.com/small-medium-business/products-services/solar-panels/

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Solar Design Parameters	
Building Type	Educational
Location	Kennett Square, Pennsylvania
Latitude	39.84° N
Longitude	75.71° W
Elevation	310 feet above sea level
Roof Orientation	Directly South
Sun Hours per day	4.6

Analysis 3: On-Site Renewable Energy

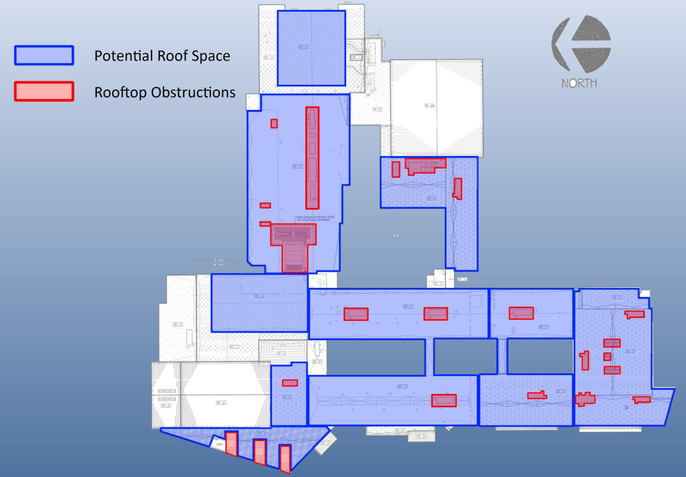
Renewable Energy Source Selection:

- **Solar** chosen (over Wind)
- Better suited for this project
  - More past applications to reference
  - Directly south facing roofs
    - Minimal obstructions (right screen)

Photovoltaic Panel Selection:

- SunPower E19/320 Solar Panel

Potential Roof Areas for PV Array



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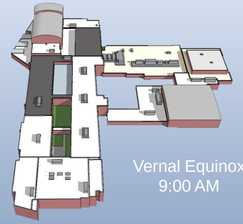
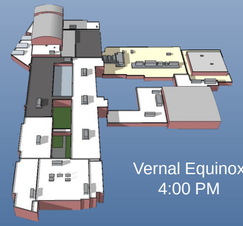
Analysis 3: On-Site Renewable Energy

Winter Solstice
9:00 AM



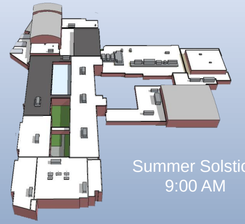
Vernal Equinox
9:00 AM

Winter Solstice
4:00 PM

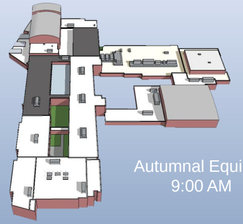


Vernal Equinox
4:00 PM

Shadow Analysis

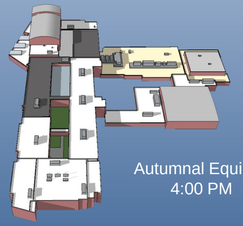


Summer Solstice
9:00 AM



Autumnal Equinox
9:00 AM

Summer Solstice
4:00 PM



Autumnal Equinox
4:00 PM

Analysis 3: On-Site Renewable Energy

Presentation Outline

Solar Design Parameters	
Building Type	Educational
Location	Kennett Square, Pennsylvania
Latitude	39.84° N
Longitude	75.71° W
Elevation	310 feet above sea level
Roof Orientation	Directly South
Sun Hours per day	4.6

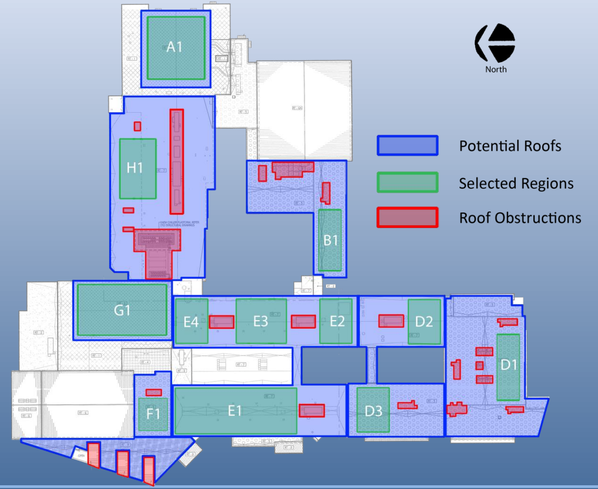
Available Roof Space:

- 13 regions available
  - roughly 100,000 square feet available

System Design:

- 12 regions selected
  - 50,000 square feet selected
- 1039 total solar panels
- system is **332.8 kW in size**

Potential Roof Areas for PV Array



Analysis 3: On-Site Renewable Energy

Presentation Outline

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Roof Orientation	Directly South
Sun Hours per day	4.6

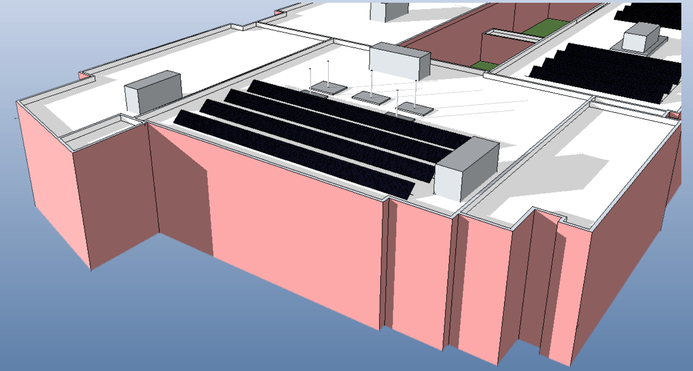
Cost Analysis:

- Project will employ a Power Purchase Agreement
  - Third party owns PV array
  - Incurs all up front costs
  - Array installed on UHS roof

- 25 year contract
- UHS purchases electricity from third party at discounted rate

- Total Savings over life of contract:
  - **$400,000**

PV Panels on Area D Roof



Analysis 3: On-Site Renewable Energy

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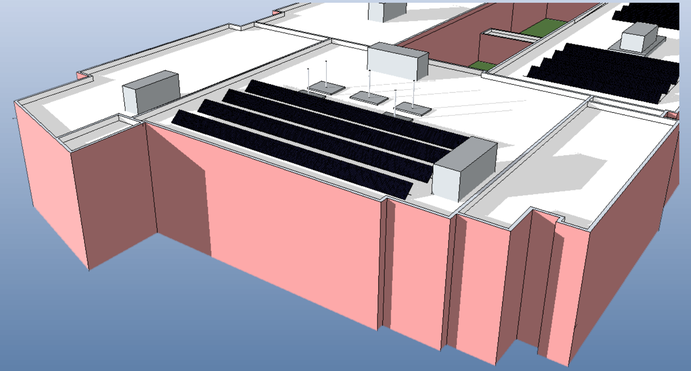
Roof Orientation	Directly South
Sun Hours per day	4.6

Conclusions:

- ***Would be beneficial*** to add on-site renewable energy to project
- Over $400,000 savings over life of contract
- No up front cost for UHS

- LEED
  - Opportunity to add up to 7 credits for renewable energy

PV Panels on Area D Roof



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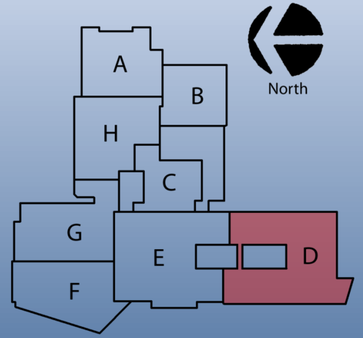


Analysis 4: Façade Redesign

Background Information:

- Original façade – stick built masonry (rock face CMU and brick)
  - Long duration: 3 months to complete
- **Area D**'s façade will be redesigned

Research Goal:

- Select precast panel to replace stick-built façade
- Determine schedule and cost impacts
- Mechanical Breadth: Compare existing and precast facades

Area D West Elevation

Presentation Outline

Analysis 4: Façade Redesign

Existing Façade:

- Made up primarily of Rock Face CMU and Face Brick
- Non-load bearing
  - CMU backup wall sits on steel structure

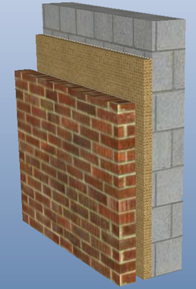
Precast Panel Selection:

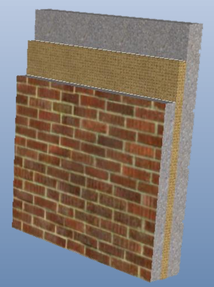
- Manufactured by Nitterhouse Concrete

- 9” Sandwich Panel
  - 3” exterior concrete (with thin red brick inlays)
  - 2” rigid insulation
  - 4” interior concrete

- 12’ x 40’ maximum size

Existing Façade | Precast Panel





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Mechanical Breadth

Mechanical Breadth:

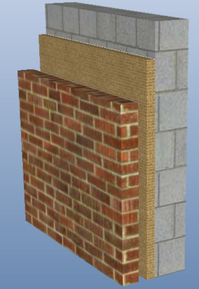
- Compare existing and precast panel facades
  - Determine façade impact on thermal properties
  - Aim to improve thermal properties

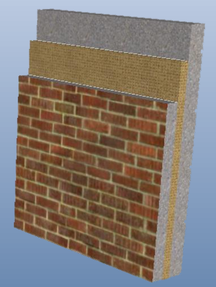
Façade Assemblies:

- Existing Facade:
  - 4” CMU/Face Brick
  - 2” Air Cavity
  - 2” Rigid Insulation
  - 8” CMU block

- Precast Panel Facade:
  - 3” Exterior Concrete
  - 2” Rigid Insulation
  - 4” Interior Concrete

Existing Façade | Precast Panel





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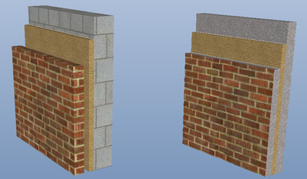


Existing | Panel

Mechanical Breadth

Original Façade Assembly

TOOL NO. 1
R VALUE ANALYSIS

MATERIALS

block, 8 in. | Help | START/CLR

Add | Delete | Move up | Move dn | Convert

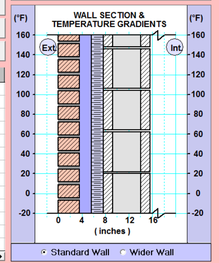
Calc | Graph | Print | WallLyb | TOOLBOX

CLIMATE CONDITIONS

	Winter Temp(°F)	Winter RH(%)	Summer Temp(°F)	Summer RH(%)
Indoor	70	25	75	50
Outdoor	10	66	93	68

City: Philadelphia, PA

Layer	Generic Material	Thick.	R Val.
1	brick, (unvntd), 4 in.	3.54	0.64
2	cavity, 2 in.	2.00	0.98
3	rigid ins.,(extru.), 2 in.	2.00	10.27
4	block, 8 in.	8.03	1.03
5			
6			
7			
8			
9			
10			
11			
12			
	Total or (Layer 0)	15.57	12.93



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Thickness	R-Value
16"	12.93

HAM Toolbox Façade Assembly Calculations

Precast Panel Façade Assembly

TOOL NO. 1
R VALUE ANALYSIS

MATERIALS

concrete wall, 4 in. | Help | START/CLR

Add | Delete | Move up | Move dn | Convert

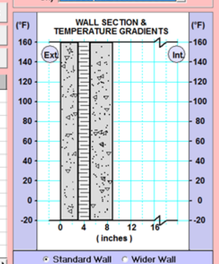
Calc | Graph | Print | WallLyb | TOOLBOX

CLIMATE CONDITIONS

	Winter Temp(°F)	Winter RH(%)	Summer Temp(°F)	Summer RH(%)
Indoor	70	25	75	50
Outdoor	10	66	93	68

City: Philadelphia, PA

Layer	Generic Material	Thick.	R Val.
1	concrete wall, 3 in.	3.00	0.44
2	rigid ins.,(expand.), 2 in.	2.00	7.90
3	concrete wall, 4 in.	4.00	0.58
4			
5			
6			
7			
8			
9			
10			
11			
12			
	Total or (Layer 0)	9.00	9.06



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Thickness	R-Value
9"	9.06

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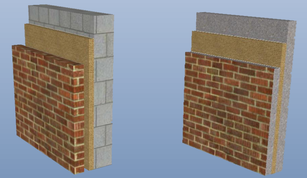
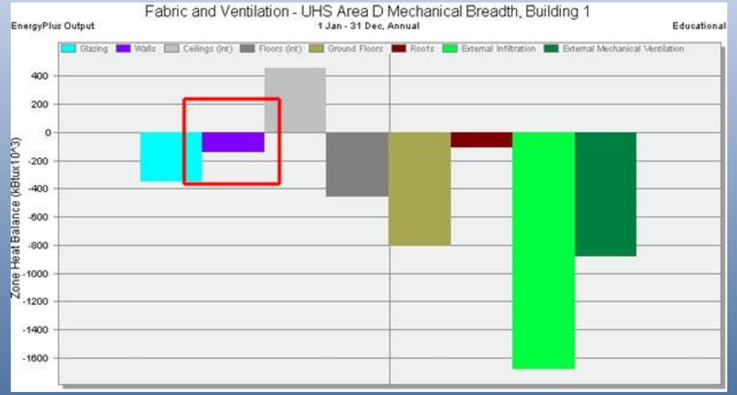
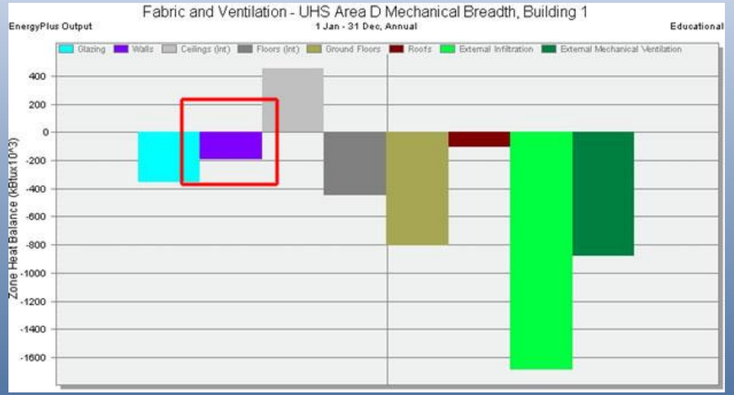


Existing | Panel

Annual Heat Loss: Original Façade Assembly



Annual Heat Loss: Precast Panel Façade Assembly



Presentation Outline

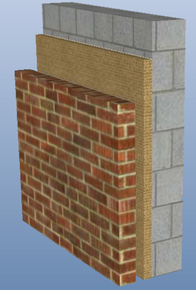
Mechanical Breadth

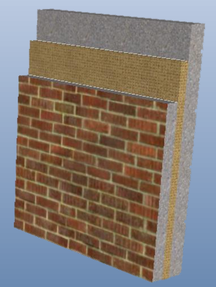
Conclusions:

- The proposed façade system **decreased thermal properties**
  - Lack of air cavity
  - Decrease in assembly thickness

- Increased thermal loss/gain
  - Increased loads
  - Cost increase

Existing Façade | Precast Panel





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V. Analysis 4: Façade Redesign
VI. Mechanical Breadth
VII. Conclusions
VIII. Acknowledgements

Analysis 4: Façade Redesign

Precast Panel Design:

- 37 different panel designs
  - Only 8 different sizes
  - Different window/door locations

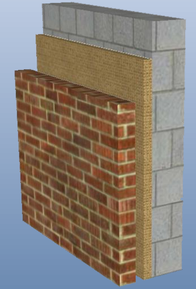
Duration Calculations:

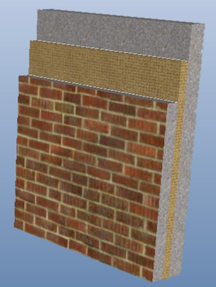
- **132 total panels** needed to complete façade

- 15 panels installed per day
  - 7 façades in 3 regions to install
  - 13 working days, 3 weeks to install precast panel façade

- Original façade: 3 months

Existing Façade | Precast Panel





Presentation Outline

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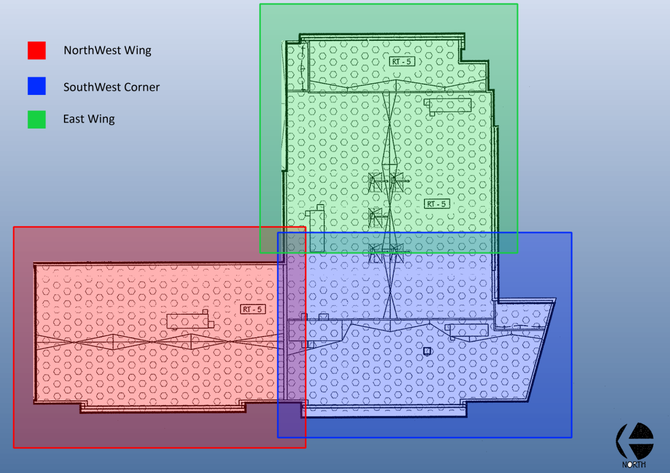
Panel Installation Breakdown

Area	Amount of Panels	Days Needed to Complete
North (Green)	10	1
East (Red)	17	2
East (Green)	18	2
South (Blue)	24	2
South (Green)	21	2
West (Red)	18	2
West (Green)	24	2

Façade Duration Comparison



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Analysis 4: Façade Redesign

Cost Calculations:

- $35 per square foot for precast panels
  - Includes manufacturing, delivery, and installation
- 35,500 square feet of façade
  - $35 * 35,500 = **$1.24 million**

- Original Façade: $1.17 million

-Cost Increase: **$70,000**

Façade Metrics Comparison

	Duration	Cost
Original Façade	13 days	$1.17 million
Precast Facade	71 days	$1.24 million

Presentation Outline

Analysis 4: Façade Redesign

Conclusions:

- ***Would elect not to implement*** new façade panels

- Advantages:
  - Reduced installation duration

- Disadvantages:
  - Increased Cost
  - Change in architecture
  - Reduced thermal properties

Façade Metrics Comparison

	Duration	Cost
Original Façade	13 days	$1.17 million
Precast Facade	71 days	$1.24 million

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Conclusions

Analysis 1: Delivery Method Study

- **Single Prime best for UHS**
- Each project should select best delivery method

Analysis 2: 4D Safety and Phase Plan

- **Adds value** to project
- Provides owner with increased information for building occupants

Analysis 3: On-Site Renewable Energy

- PV Array offers **considerable savings**
- Possibility for additional LEED credits

Analysis 4: Façade Redesign

- **Mechanical Breadth:**
  - **New façade had lower thermal properties**
  - Load and Cost increases likely

- **Would not implement**
  - Decreases duration

  - Increases cost
  - Changes architecture
  - Decreases thermal properties

Presentation Outline

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Acknowledgements

- Dr. John Messner
- PSU AE Staff
- PSU AE Classmates

- Mark Taylor
- Brian Laub
- Rick Hostetler
- Rick Vilello

- Family and friends

WOHLSEN CONSTRUCTION

MM architects | inc.

Unionville High School

Presentation Outline

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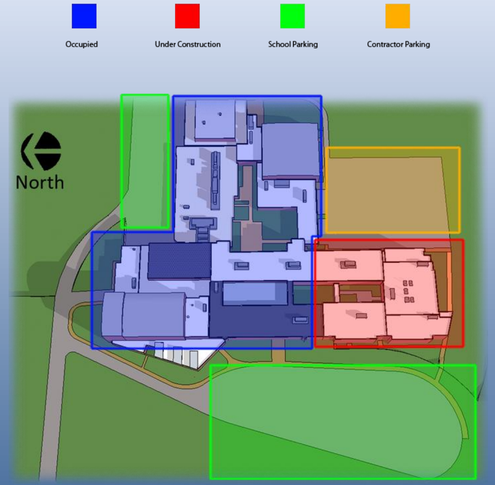
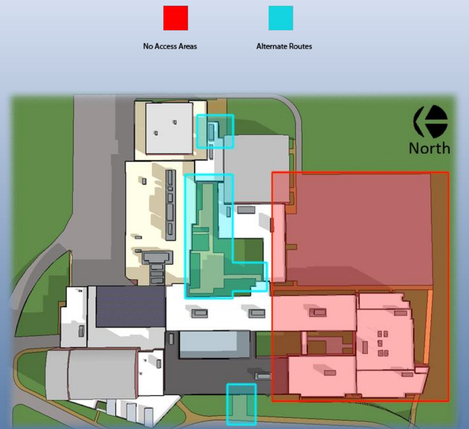
Questions?

Analysis 2

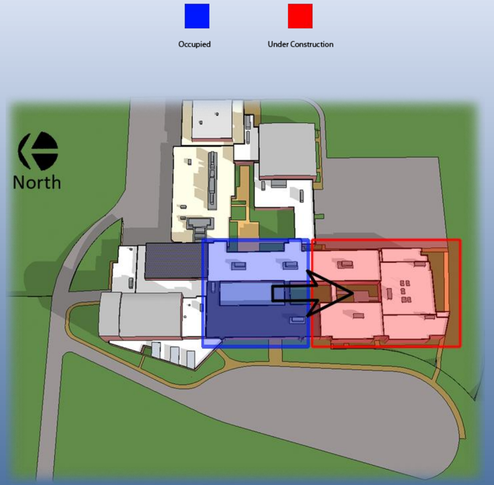
Interactive Website Link



Building Breakdown



Construction Area



Transition Plan

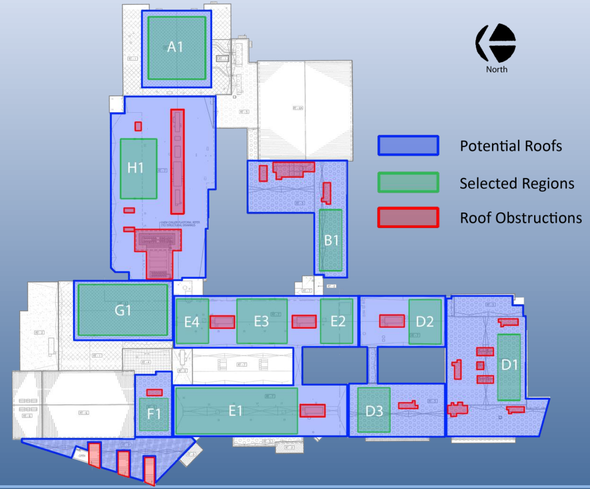
Analysis 3

Givens:

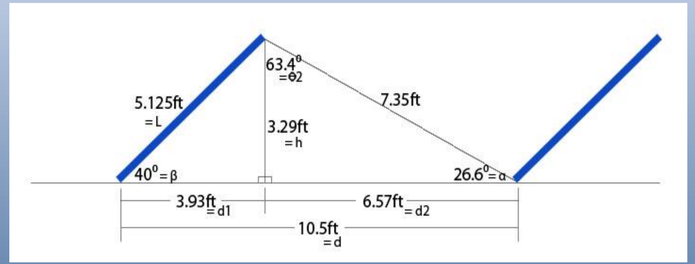
N-S Spacing: 12' from front to front
# of Rows = (Length)/(12' spacing) + 1 (front edge)
Panel width (E-W) = 3.42ft (Note will be installed edge to edge)

Building Area	Length (N-S) ft	Width (E-W) ft	Number of Rows in Area	Number of Panels in row	Number of Panels in Area
A1	96	86	9.00	25.15	225
B1	34	75	3.83	21.93	63
D1	40	90	4.33	26.32	104
D2	40	50	4.33	14.62	56
D3	36	52	4.00	15.20	60
E1	140	40	12.67	11.70	132
E2	36	50	4.00	14.62	56
E3	50	42	5.17	12.28	60
E4	24	40	3.00	11.70	33
F1	26	36	3.17	10.53	30
G1	90	52	8.50	15.20	120
H1	36	88	4.00	25.73	100
Total					1039

Panel Calculations



Selected Roof Regions for PV Array



Panel Spacing Calculation

Analysis 3

Winter Solstice – 9:00 AM

Winter Solstice – 4:00 PM

Analysis 3

Winter Solstice – 9:00 AM

Winter Solstice – 4:00 PM

Analysis 3

UHS Payback Period		
1	0.0960	$ 38,525.47
2	0.0970	$ 38,910.73
3	0.0979	$ 39,299.83
4	0.0989	$ 39,692.83
5	0.0999	$ 40,089.76
6	0.1009	$ 40,490.66
7	0.1019	$ 40,895.56
8	0.1029	$ 41,304.52
9	0.1040	$ 41,717.57
10	0.1050	$ 42,134.74
11	0.1060	$ 42,556.09
12	0.1071	$ 42,981.65
13	0.1082	$ 43,411.47
14	0.1093	$ 43,845.58
15	0.1103	$ 44,284.04
16	0.1115	$ 44,726.88
17	0.1126	$ 45,174.15
18	0.1137	$ 45,625.89
19	0.1148	$ 46,082.15
20	0.1160	$ 46,542.97
21	0.1171	$ 47,008.40
22	0.1183	$ 47,478.48
23	0.1195	$ 47,953.27
24	0.1207	$ 48,432.80
25	0.1219	$ 48,917.13
26	0.1231	$ 49,406.30
27	0.1243	$ 49,900.36
28	0.1256	$ 50,399.36
29	0.1268	$ 50,903.36
30	0.1281	$ 51,412.39
31	0.1294	$ 51,926.52
32	0.1307	$ 52,445.78
33	0.1320	$ 52,970.24
34	0.1333	$ 53,499.94
35	0.1346	$ 54,034.94
36	0.1360	$ 54,575.29
37	0.1374	$ 55,121.04
38	0.1387	$ 55,672.25
39	0.1401	$ 56,228.98
40	0.1415	$ 56,791.27
	Total Value	$ 1,883,370.61

40 Year Payback Period

Total System Cost:	$ 1,863,680.00
40 year payback period for UHS	

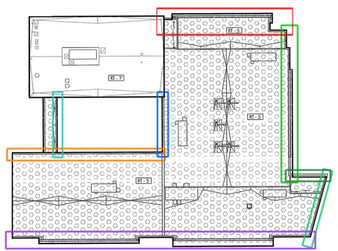
UHS Payback Period

Year	Discounted Energy Price	Savings (Standard less PV electricty)
1	$ 24,271.05	$ 14,254.42
2	$ 24,513.76	$ 14,396.97
3	$ 24,758.90	$ 14,540.94
4	$ 25,006.48	$ 14,686.35
5	$ 25,256.55	$ 14,833.21
6	$ 25,509.11	$ 14,981.54
7	$ 25,764.21	$ 15,131.36
8	$ 26,021.85	$ 15,282.67
9	$ 26,282.07	$ 15,435.50
10	$ 26,544.89	$ 15,589.85
11	$ 26,810.34	$ 15,745.75
12	$ 27,078.44	$ 15,903.21
13	$ 27,349.22	$ 16,062.24
14	$ 27,622.72	$ 16,222.86
15	$ 27,898.94	$ 16,385.09
16	$ 28,177.93	$ 16,548.94
17	$ 28,459.71	$ 16,714.43
18	$ 28,744.31	$ 16,881.58
19	$ 29,031.75	$ 17,050.39
20	$ 29,322.07	$ 17,220.90
21	$ 29,615.29	$ 17,393.11
22	$ 29,911.44	$ 17,567.04
23	$ 30,210.56	$ 17,742.71
24	$ 30,512.66	$ 17,920.14
25	$ 30,817.79	$ 18,099.34
Life of contract: 25 years		
Total Savings:		$ 402,590.56

$402,590.56
Savings over
25 year contract

UHS 25 Year Savings

Analysis 4



- New Classroom Wing East Elevation
- New Classroom Wing South Side (Elevation 3)
- New Classroom Wing South Side (Elevation 2)
- New Classroom Wing South Side (Elevation 4)
- New Classroom Wing West Side
- New Classroom Courtyard West Side (East Elevation)
- New Classroom Courtyard North Side
- Classroom Courtyard South Side

Panel Installation Area | Panel Type Information

Panel Type Information		
#	Panel Type	Size
1	A	12' X 13.5'
2	B	8' x 13.5'
3	C	12' X 28.5'
4	D	8' x 28.5'
5	E	6' x 13.5'
6	F	12' x 13.5'
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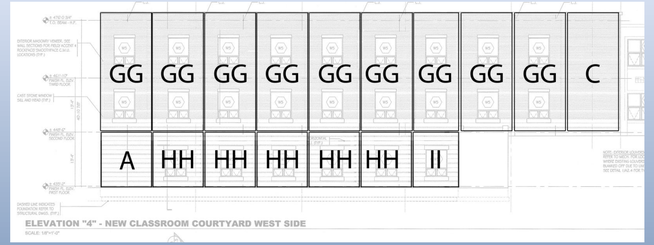
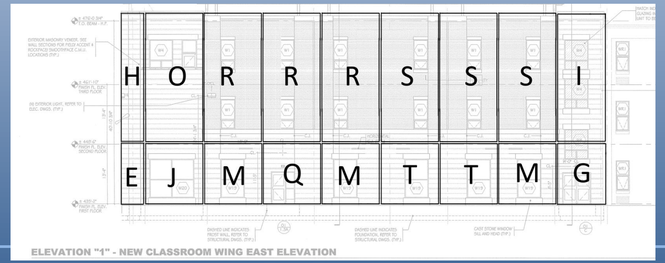
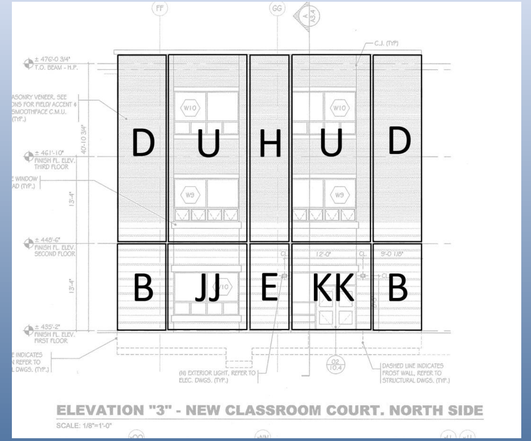


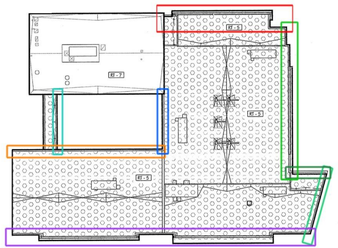


East Elevation



North Elevation

Analysis 4



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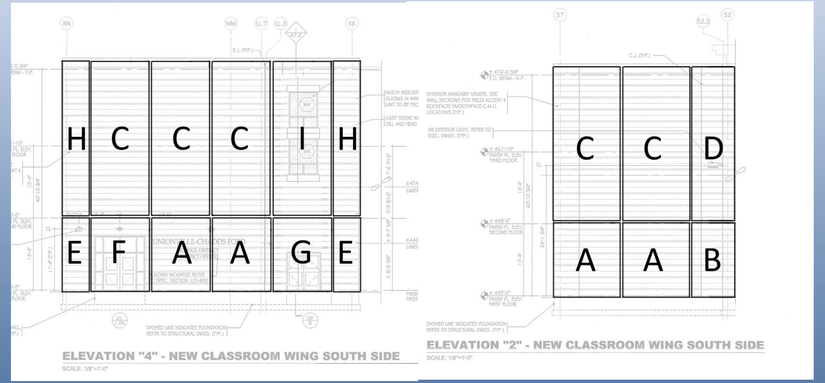
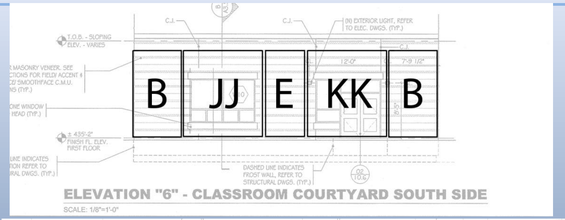
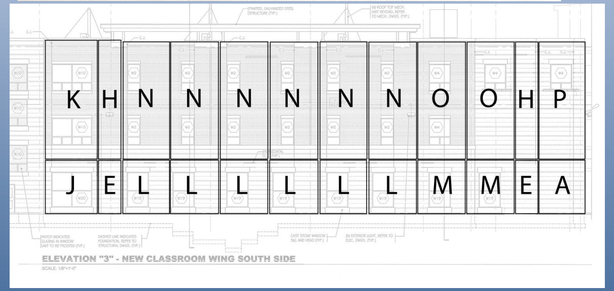


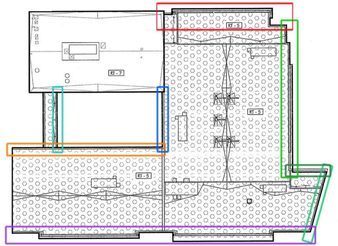
South Elevation





South Elevation

Analysis 4



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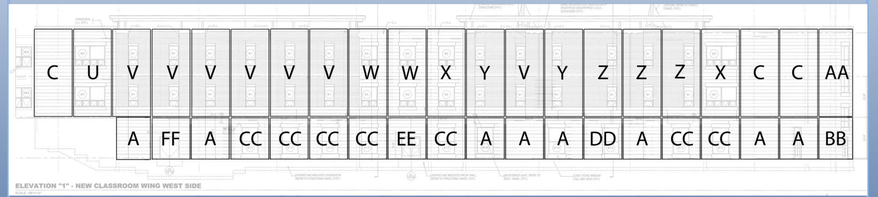

West Elevation