Intramural Building Addition and Renovation – Phase I

University Park, PA

Penn State AE Senior Capstone Project

Gonzalo Lay– Construction Management Option

Advisor: Ray Sowers

Project Summary

Building Information

Addition: 48,000 SF New Construction
Renovation: 100,000 SF
2-Stories Above Grade
Structural Steel Frame
Function: Recreational Use, Gymnasium

Construction Information

Schedule: Start | February 2013
End | February 2014 *Turned Over March, 2014
Delivery Method: CM @ Risk
Contract: Guaranteed Maximum Price
Cost: Project | $ 26.1 Million
Construction | $ 19 Million

MOODY•NOLAN RESPONSIVE ARCHITECTURE

Mortenson construction

Project Summary

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Project Summary

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Analysis #1 – Prefabrication of Building Enclosure

Looks into the use of prefabricated brick panels and unitized curtain wall to accelerate the schedule and reduce project costs.

Mechanical Breadth – Thermal properties and moisture performance were analyzed.

Analysis #2 – Prefabrication Structural Effects

Looks into the structural implications of using prefabricated brick panels on the building frame.

Structural Breadth – Resizing of exterior structural columns and beams.

Analysis #3 – Integrated Project Delivery Implementation

Looks into the use of a different delivery method to improve the planning, coordination and outcome of the project

Analysis #4 – Occupied vs. Vacant Renovation

Evaluates the decision making of the owner on how the project should be constructed, while implementing construction standards to improve the health and safety of occupants.

Analysis #1 – Prefabricated Building Enclosure

Problem Identification

Exterior Enclosure duration 20 weeks
Critical Path
Finished before Interior activities begins

Background

Contractor performance issues
Coordination between trades during installation

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PROJECT DELAYS

Potential Solutions

Use of prefabrication would lead to faster installation, lower labor costs, improve quality and lower risks of onsite accidents.

Prefabrication of Building Enclosure

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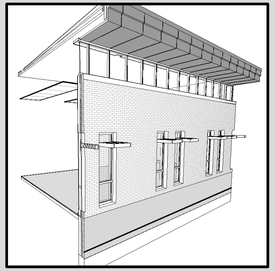
Location of Brick Façade on Mtl stud

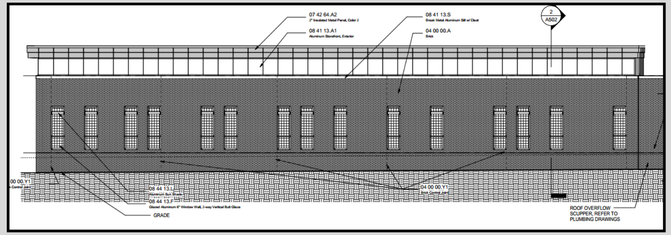
CURRENT BRICK FACADE

3 5/8" Norman Brick
Thermal Insulation (Rigid & Spray on)
6" Metal Stud back-up framing

7090 SF of brick installed
ESTIMATED COST: $372,934

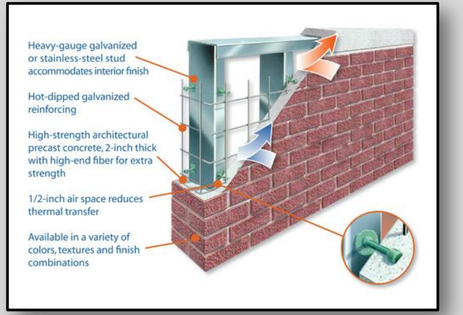
DURATION: 92 days





PROPOSED – SLENDERWALL SYSTEM

½" Thin Brick
2" Reinforced Precast concrete layer
Batt Insulation
6" Galv. Steel Studs
Lightweight Design – 30 lbs./ft^2
Increased Floor Space
Reduced installation time
Variety of finishes and textures



Prefabrication of Building Enclosure

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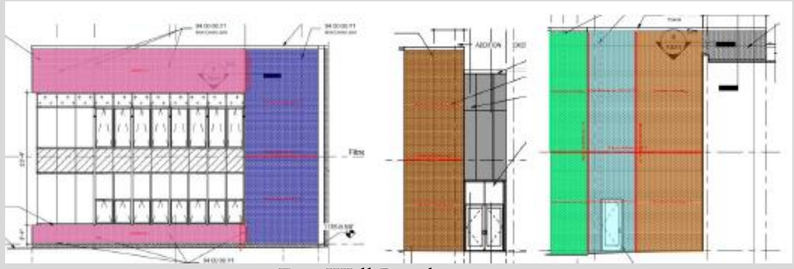
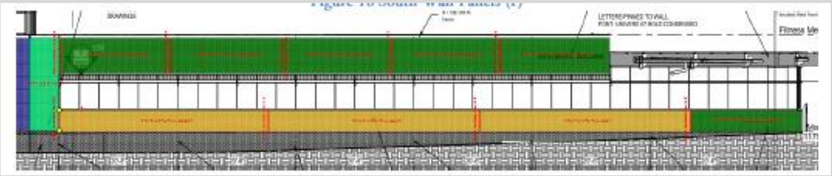
PANEL SIZES

Building not designed for panel application
8 Different Widths & 5 Different Heights
Layout of panels designed to avoid architectural changes
Productivity can be increased and cost of panels reduced if
Multipurpose room windows re-arranged



East Wall Panels



South Wall Panels

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COST EVALUATION

Cavity Wall Cost

Includes all building components not required by SlenderWall
Total: $ 372,934

SlenderWall Cost

Based on avg cost of $42/SF
Includes delivery, erection and insulation

General Conditions

Scaffolding eliminated
Crane rental required
Material Hoist eliminated

Total Savings

$75,613

SlenderWall System Breakdown Cost				
Panel System	SF	7,090.00	42.0	$ 291,060.00
Gypsum Board 5/8" (3 Layers)	SF	7,090.00	1.5	$ 10,395.00
TOTAL				$ 301,455.00

System Cost Comparison				
	Unit	Quantity	Cost/Unit	Total
Panel System	SF	7,090.00	43.5	$301,455.00
Current System	SF	7,090.00	52.6	$372,934.00
			Difference	$71,479.00

Additional Costs Benefits/Implements				
Scaffolding	CSF	148.8	$ 130.13	$ 19,363.34
Crane	Mo	-1.0	$ 17,289.00	$ (17,289.00)
Material Hoist	Ea.	1.0	$ 2,060.00	$ 2,060.00
			Difference	$ 4,134.34

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SCHEDULE EVALUATION

Installation Sequence

Begin after steel erection is completed and floor slabs are poured
Start at West façade in a counterclockwise direction
Install one floor at the time, spandrel and wall panels

Schedule Impact

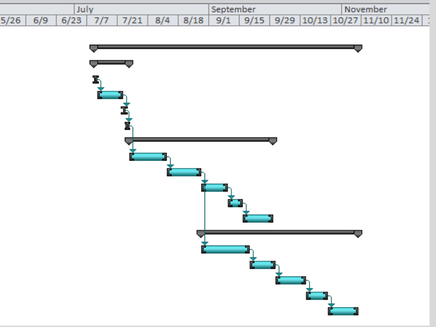
2 hr. installation per panel - modified
Original duration: 92 days
SlenderWall duration: 13 days

Building Enclosure Schedule

Reduced by 12 Days

Elevation	Quantity	Productivity (hr.)/ Panel	Duration (hr.)	Days
West	6	2	12.0	1.5
South	31	2	62.0	7.8
East	6	2	12.0	1.5
North @ East	6	2	12.0	1.5
			Total	13

Task Name	Duration	Start	Finish
Building Enclosure	**87.3 days**	**Wed 7/10/13**	**Fri 11/8/13**
Prefabricated Panels	**12.3 days**	**Wed 7/10/13**	**Fri 7/26/13**
Install West Elevation	1.5 days	Wed 7/10/13	Thu 7/11/13
Install SouthElevation	7.8 days	Thu 7/11/13	Tue 7/23/13
Install East Elevation	1.5 days	Tue 7/23/13	Wed 7/24/13
Install North Elevation	1.5 days	Wed 7/24/13	Fri 7/26/13
Metal Wall Panel	**46 days**	**Fri 7/26/13**	**Mon 9/30/13**
Metal Wall Panel W	11 days	Fri 7/26/13	Mon 8/12/13
Metal Wall Panel S-E	12 days	Mon 8/12/13	Wed 8/28/13
Metal Wall Panel S-W	8 days	Wed 8/28/13	Mon 9/9/13
Metal Wall Panel E	5 days	Mon 9/9/13	Mon 9/16/13
Metal Wall Panel A	10 days	Mon 9/16/13	Mon 9/30/13
Glazing	**52 days**	**Wed 8/28/13**	**Fri 11/8/13**
Glazing S-E	16 days	Wed 8/28/13	Thu 9/19/13
Glazing W	8 days	Thu 9/19/13	Tue 10/1/13
Glazing S-W	10 days	Tue 10/1/13	Tue 10/15/13
Glazing E	8 days	Tue 10/15/13	Fri 10/25/13
Glazing A	10 days	Fri 10/25/13	Fri 11/8/13



Prefabrication of Building Enclosure

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THERMAL PERFORMANCE

R-Value Comparison

Cavity Wall: 27.335
SlenderWall: 27.090

Heat Transfer

Summer

Cavity Wall: 3,600 Btu/hr.
SlenderWall: 3,632 Btu/hr.

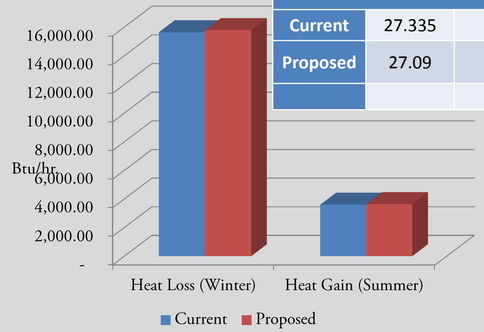
Winter

Cavity Wall: 15,642 Btu/hr.
SlenderWall: 15,783 Btu/hr.

Conclusion

Thermal performance of SlenderWall system will not affect the design of mechanical system

Heat Transfer				
Summer				
	R-Value	Change in Temp	Area	Heat Transfer
	∑ R	Δ T	SF	Btu/Hr
Current	27.335	14.2	6,930.00	3,600.00
Proposed	27.09	14.2	6,930.00	3,632.56
			Difference	(32.56)
Winter				
Current	27.335	61.7	6,930.00	15,642.25
Proposed	27.09	61.7	6,930.00	15,783.72
			Difference	(141.47)



Mechanical Breadth

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MOISTURE PERFORMANCE

Conditions

Winter

Indoor 70F | 25% RH
Outdoor 8.3F | 67% RH

Summer

Indoor 70F | 50% RH
Outdoor 84.2F | 72% RH

Cavity Wall

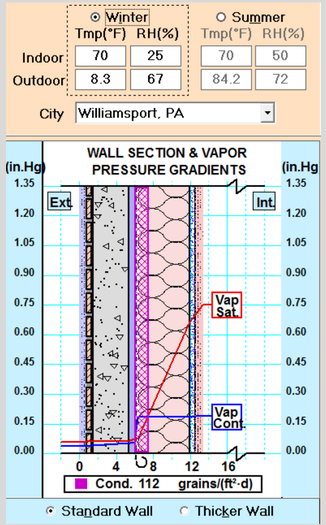
Summer: No Condensation
Winter: Chance of 17 grains/(ft2-day) in vapor barrier

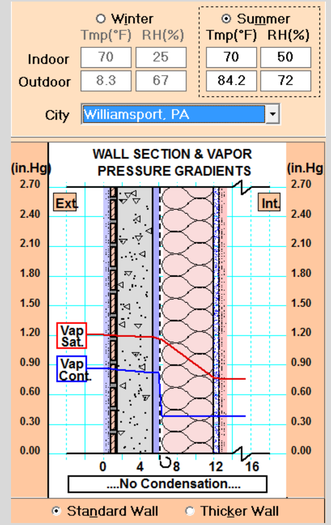
SlenderWall

Summer: No Condensation
Winter: Chance of 112 grains/(ft2-day) in air cavity

Preventions

Apply vapor barrier to back of studs





Mechanical Breadth

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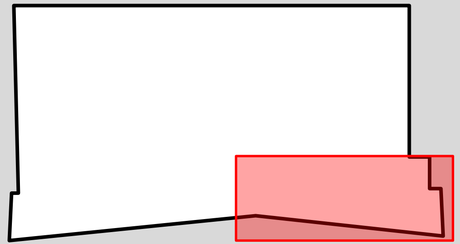
Problem Identification

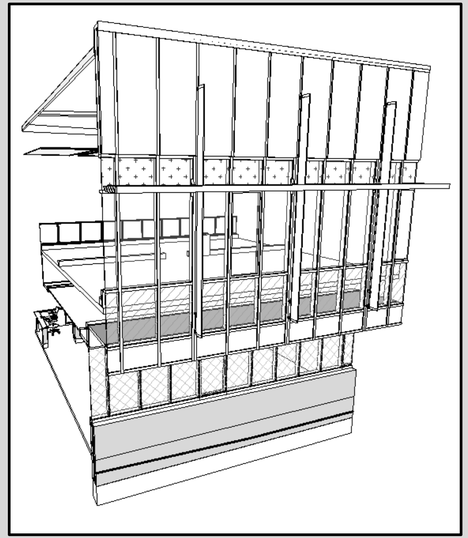
Stick-built curtain wall system leads to longer on-site installation and increased labor costs

Potential Solutions

Implementing a unitized curtain wall panel system that can be delivered on time



Location of Major Curtain Wall Area



Prefabrication of Building Enclosure

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STICK BUILT CURTAIN WALL

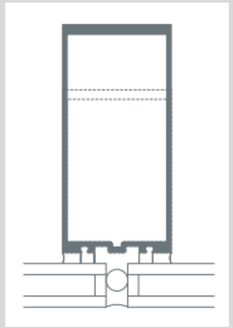
Pros

- Efficient Delivery
- Flexibility and Ease of Installation
- Lower costs of materials

Cons

- Longer installation times
- Limited quality of product
- Site Congestion

Current – Kawneer 1600 Wall System



PROPOSED UNITIZED SYSTEM

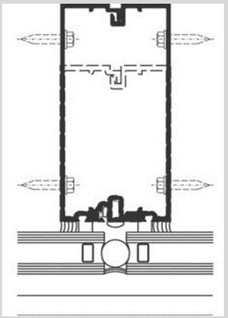
Pros

- Faster installations
- Higher quality product
- Decreased site congestion

Cons

- Multiple deliveries
- Higher costs of materials
- Equipment required

Proposed – Kawneer 1600 SS (Pre-glazed system)



Prefabrication of Building Enclosure

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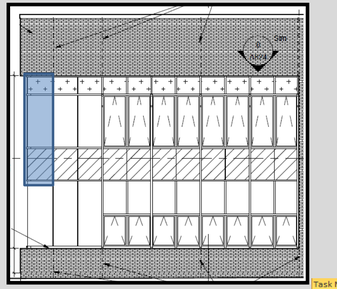
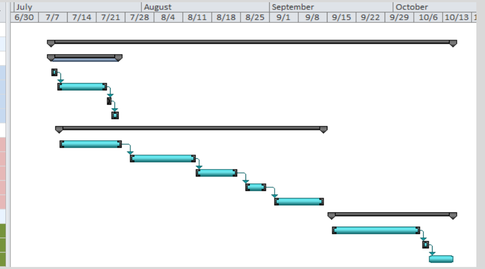


Elevation	Productivity panels/day	No. Panels	Duration
South	15	140	9.33
South	7	41	5.86
East	15	22	1.47
Atrium	15	30	2.00
Atrium	7	15	2.14
		Total	20.80

Task Name	Duration	Start	Finish
Building Enclosure	**69.61 days**	**Wed 7/10/13**	**Tue 10/15/13**
Prefabricated Panels	**12.3 days**	**Wed 7/10/13**	**Fri 7/26/13**
Install West Elevation	1.5 days	Wed 7/10/13	Thu 7/11/13
Install South Elevation	7.8 days	Thu 7/11/13	Tue 7/23/13
Install East Elevation	1.5 days	Tue 7/23/13	Wed 7/24/13
Install North Elevation	1.5 days	Wed 7/24/13	Fri 7/26/13
Metal Wall Panel	**46 days**	**Fri 7/12/13**	**Fri 9/13/13**
Metal Wall Panel W	11 days	Fri 7/12/13	Fri 7/26/13
Metal Wall Panel S-E	12 days	Mon 7/29/13	Tue 8/13/13
Metal Wall Panel S-W	8 days	Wed 8/14/13	Fri 8/23/13
Metal Wall Panel E	5 days	Mon 8/26/13	Fri 8/30/13
Metal Wall Panel A	10 days	Mon 9/2/13	Fri 9/13/13
Unitized Curtain Wall	**21.61 days**	**Mon 9/16/13**	**Tue 10/15/13**
Glazing South	15.2 days	Mon 9/16/13	Mon 10/7/13
Glazing East	1.47 days	Tue 10/8/13	Wed 10/9/13
Glazing Atrium	4.14 days	Wed 10/9/13	Tue 10/15/13



Schedule

Original Duration 99 days
Proposed Duration 70 days

Accelerated building enclosure schedule by 29 Days

Cost

Item	Quantity	Unit	Unit Total	Total
Stick Built System	8,663.00	SF	$ 110.00	$ 952,930.00
			Subtotal	$ 952,930.00
Unitized System	8,663.00	SF	$ 132.00	$ 1,143,516.00
			Subtotal	$ 1,143,516.00
			Difference	$ (190,586.00)

$190,586 added to Project Cost

Prefabrication of Building Enclosure

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Analysis #3 - IPD Implementation

Problem Identification

Discrepancies between design team and contractors caused project
Contractor performance issues
Coordination between trades during installation

Potential Solutions

Early involvement of project main members will result in better project planning and diminish the risk of project delays and changes.

IPD Implementation

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CM AT RISK

Construction Manager holds risks of construction

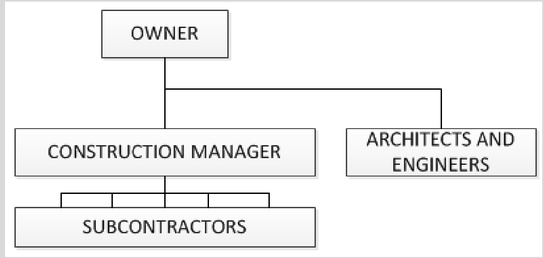
Holds contracts with subcontractors to perform work

Guarantees completion of project for a negotiated GMP

CM not involved in project until Design Development Phase

RFIs and change orders are likely

Success is measured by self interests



INTEGRATED PROJECT DELIVERY

Collaborative efforts to succeed as a team

Shared risks between owner, design team and construction manager

High quality for reasonable price

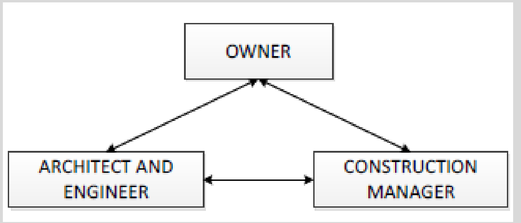
CM involved early in project

Change Orders likelihood diminishes

RFIs have faster response rates

Construction Schedule Reduced

Higher level of planning eases flow of construction



IPD Implementation

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MAIN BENEFITS

Early contributions to design

Reduced design conflicts

Improved schedule management

Reduced design document time

Traditional Project Delivery		Integrated Project Delivery
Fragmented, ad-hoc, hierarchical, controlled	**Participants**	Team of project constituencies, open and collaborative
Linear, segregated, limited information exchange	**Process**	Concurrent, project life-cycle oriented, shared information, collaborative
No	**Early Contractor Involvement**	Yes
Individually managed	**Risk**	Managed and shared risks in a collective manner
Cost-based, individually focused	**Compensation**	Performance and value based
Not shared, Minimal communication	**Documentation**	Shared, Open Communication

SUCCESS CRITERIA

Meet owners criteria
Budget and Schedule met
Improved overall quality

SUCCESS FACTORS

Clearly defined scope
Contractor experience
Synergy and good relationships
Owner participation

IPD Implementation

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IPD IMPLEMENTATION

Team Selection	RFQ to A/E's and CMs
Team Interview Process	Representative from each party – Day workshop | project related
Response to Proposal	Project design ideas | approval by BOT
Shared Risk Contract	Must be signed by all parties (Owner, CM, AE) – later involve Subs
Planning Between Key Members	Design, budgeting, scheduling, planning activities takes place
Construction	Collaboration enforced throughout project

IPD Implementation

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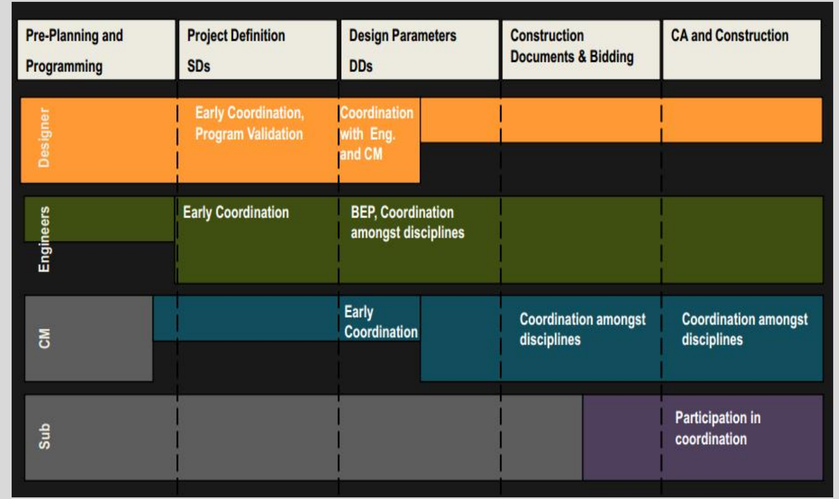
EVALUATION

DURATION

Construction schedule is reduced.
Design phase is extended



Courtesy of http://network.aia.org

IPD Implementation

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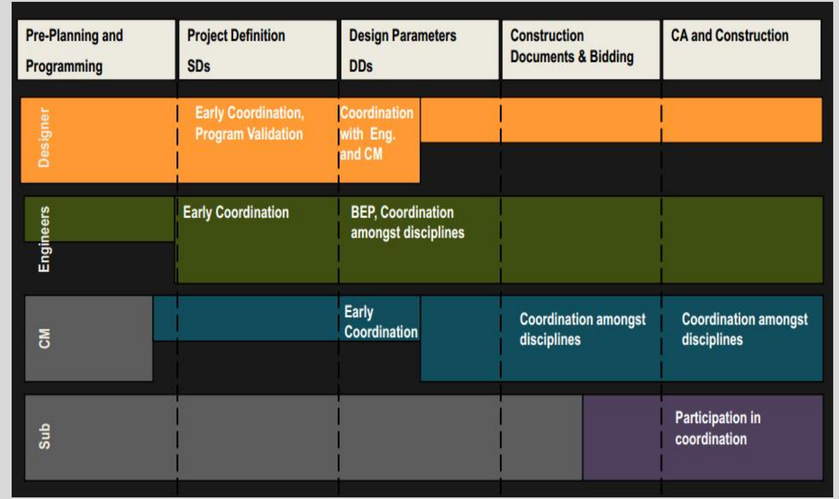
EVALUATION

DURATION

Construction schedule is reduced.
Design phase is extended

COLLABORATION

Big room – daily team interaction



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IPD Implementation

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EVALUATION

DURATION

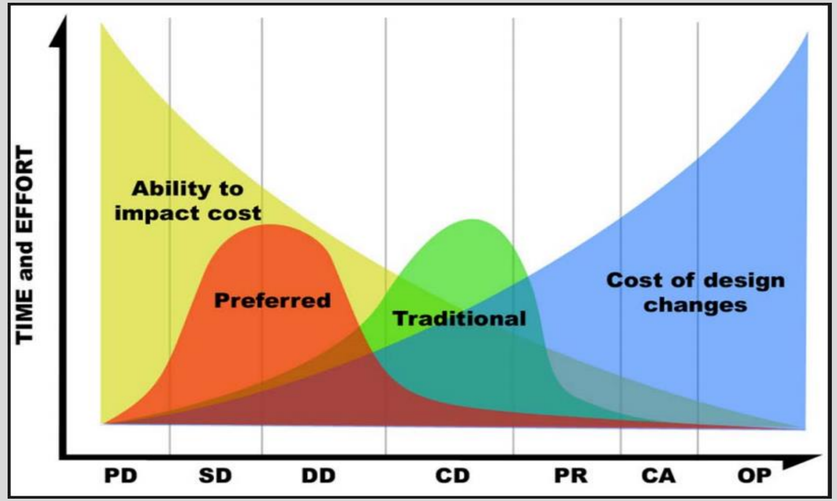
Construction schedule is reduced.
Design phase is extended

COLLABORATION

Big room – daily team interaction

COST

Elimination of RFIs and Change Orders during construction
Project costs are more controlled



IPD Implementation

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EVALUATION

DURATION

Construction schedule is reduced.
Design phase is extended

COLLABORATION

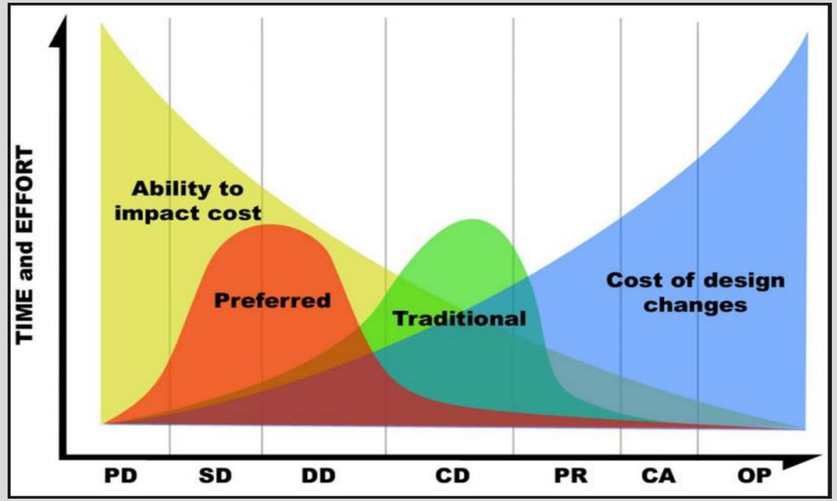
Big room – daily team interaction

COST

Elimination of RFIs and Change Orders during construction
Project costs are more controlled

QUALITY

Improved work coordination
Access to information



IPD Implementation

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TAKEAWAYS

Early Team Involvement ✓
- Improved synergy
- Reduced issues (Design and Construction)

Collaboration ✓
- Shared information
- Ease of coordination
- Increased productivity

Shared Risks ✗
- Working towards same goal
- Cost savings (litigations and lawsuits)

Efficient Construction ✓
- Less waste
- No change orders

Experience ✗
- Owner must be have prev. experience
- Time involvement

Contract ✗
- Owner must generate a contract or use standard
- Liabilities and shared risks must be evaluated

IPD Implementation

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Analysis #4 - Occupied vs Vacant Renovations

Problem Identification

Unexpected construction activities can disrupt the comfort of building occupants in a phased renovation.

Background

Building occupants are expected to work together with the construction crews to prevent disturbances and allow to perform daily work.

Potential Solutions

Alternative to vacate the existing building and allow construction activities to be ongoing

Produce construction guidelines for improved occupant health and safety

Occupied vs Vacant Renovations

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VACANT RENOVATION

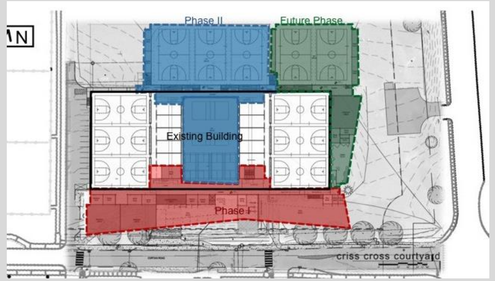
Larger scope of work
Funding available*

Decreased project duration

Lowered Risks of Accidents/Injuries/Complains

Improved Quality of work

Ease of coordination and planning



Occupant relocation

Building use demands

Conflict of activities

Project costs

Occupied vs Vacant Renovations

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OCCUPIED RENOVATION – Controlling Noise and Vibration

Stationary Equipment

Mobile Equipment

Affected phases

TABLE G-16 - PERMISSIBLE NOISE EXPOSURES (1)

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

Courtesy of OSHA

Occupied vs Vacant Renovations

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OCCUPIED RENOVATION – Productivity

Disruptive sounds

High / low frequencies
Intermittent /Continuous

Tasks

Simple / Complex

Effects

Stress
Frustration
Adaptation – Increase HR
Blood Pressure
Adrenaline and Cortisol

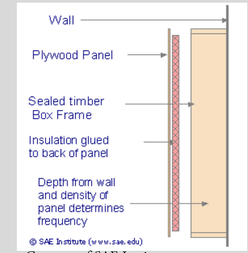
PREVENTION

Hours of Operations and Noise levels

Mobile Equipment	Time	Educational Facility	Residential
Daily	7:00 am to 5:00 pm	85 dBA	70 dBA
Weekends	9:00 am to 5:00 pm	65 dBA	60 dBA
Stationary Equipment			
Daily	7:00 am to 5:00 pm	70 dBA	60 dBA
Weekend	9:00 am to 5:00 pm	60 dBA	50 dBA

Communication

Low Frequency Panel absorber



Courtesy of SAE Institute

Occupied vs Vacant Renovations

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ADAPTED CONSTRUCTION STANDARDS

Communication
- Primary Contact, weekly meetings
- Look ahead schedule, coordination
- Occupant/Contractor feedback

Fire Safety
- Evacuation layout plan, means of egress
- Signage and frequent interaction with shutdown systems

House Keeping
- Wet cleaning techniques and HEPA vacuum
- Contractor work area clean

Weather
- Door mats required @ means of egress
- Signage for identified hazards

Interior Traffic
- Airtight temp. partitions – travel paths
- Physical barriers for penetrations

Indoor Air Quality
- Negative air pressure (cont.) in construction area
- Daily cleaning
- HVAC temp. shutdown when high levels of pollutants

Noise
- Appropriate worker volume communication
- High Noise level activities must be approved by PM
- Acoustical enclosures for noisy equipment

Vibration
- Logistics, vehicular traffic far from bldg. footprint
- Sequencing activities

Occupied vs Vacant Renovations

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Final Recommendations

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ANALYSIS #1 – Prefabrication of Building Enclosure

SlenderWall Panels –reduce exterior enclosure schedule by 12 days
reduce project costs by $75,613
quality product, increase floor space, less safety concerns ✓

Unitized Curtain Wall – reduce exterior enclosure schedule by 29 days
adds $190,586 to project costs
better use if larger area ✗

ANALYSIS #3 – Integrated Project Delivery Implementation

Co-location of project party ease communication
Early involvement improves project outcome
Reduced risks of change orders and RFIs ✗
Shared-risk and liabilities questionable

Recommended applications

Collaboration – big room
Early involvement ✓

ANALYSIS #4 – Occupied vs Vacant Renovation

Vacant – allow for larger scopes of work, reduced risks
facilitates planning and coordination
funding must be available ✗

Occupied – helps meet recreational student demand
Construction Standards
Improve the health and safety of building occupants ✓

THANKS!

ACADEMIC ACKNOWLEDGEMENTS

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Penn State AE Faculty

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EASI-SET BUILDINGS
Harmon Innovative Façade Solutions™
sto

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Office of Physical Plant
Intramural Building Staff

Acknowledgements

Questions

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Width (ft.)	Height (ft.)	Area (SF)	# Panels	Total Area (SF)	Opening?	Location	Weight per SF	Panel Weight (lbs.)
10.0	15.5	155.0	1	155.0	N	East Wall	30.0	4,650.0
10.0	18.5	185.0	1	185.0	N	East Wall	30.0	5,550.0
12.0	15.5	186.0	1	186.0	N	East Wall	30.0	5,580.0
12.0	18.5	222.0	1	222.0	N	East Wall	30.0	6,660.0
38.0	3.5	133.0	1	133.0	N	East Wall	30.0	3,990.0
38.0	8.0	304.0	1	304.0	N	East Wall	30.0	9,120.0
6.0	15.5	93.0	1	93.0	N	North @ Ea.	30.0	2,790.0
6.0	18.5	111.0	1	111.0	N	North @ Ea.	30.0	3,330.0
8.0	15.5	124.0	1	124.0	Y	North @ Ea.	30.0	3,720.0
8.0	18.5	148.0	1	148.0	N	North @ Ea.	30.0	4,440.0
10.0	15.5	155.0	1	155.0	N	North @ Ea.	30.0	4,650.0
10.0	18.5	185.0	1	185.0	N	North @ Ea.	30.0	5,550.0
10.0	13.5	135.0	5	675.0	Y	South Mech	30.0	20,250.0
6.0	15.5	93.0	1	93.0	N	South Wall	30.0	2,790.0
8.0	15.5	124.0	6	744.0	Y	South Wall	30.0	22,320.0
12.0	15.5	186.0	6	1,116.0	Y	South Wall	30.0	33,480.0
20.0	3.5	70.0	1	70.0	N	South Wall	30.0	2,100.0
20.0	6.0	120.0	5	600.0	N	South Wall	30.0	18,000.0
30.0	3.5	105.0	1	105.0	N	South Wall	30.0	3,150.0
40.0	3.5	140.0	6	840.0	N	South Wall	30.0	25,200.0
6.0	15.5	93.0	3	279.0	N	West Wall	30.0	8,370.0
6.0	18.5	111.0	2	222.0	Y	West Wall	30.0	6,660.0
10.0	13.5	185.0	1	185.0	Y	West Wall	30.0	5,550.0
Total			49	6930				187,320.00

Current Exterior Brick Veneer System Breakdown Cost				
	Unit	Quantity	Cost/Unit	Total
Brick	SF	7,090.00	23.0	$ 163,070.00
Rigid 2.5" Insulation	SF	7,090.00	2.5	$ 17,725.00
Vapor Retardant	SF	7,090.00	3.5	$ 24,815.00
Spray-On Insulation	SF	7,090.00	4.0	$ 28,360.00
6" Mtl Stud	SF	7,090.00	12.0	$ 85,080.00
Caulking & Sealants	SF	7,090.00	0.3	$ 1,772.50
Gypsum Board	SF	7,090.00	7.3	$ 51,402.50
Misc. Metals	SF	7,090.00	0.1	$ 709.00
TOTAL				$ 372,934.00
Nitterhouse Concrete Brick Veneer System Breakdown Cost				
Panel System	SF	6,930.00	40.0	$ 277,200.00
Sheathing, 6" Mtl Stud, Gyp	SF	6,930.00	12.0	$ 83,160.00
Rigid 2.5" Insulation	SF	6,930.00	2.5	$ 17,325.00
Vapor Retardant	SF	6,930.00	3.5	$ 24,255.00
Spray-On Insulation	SF	6,930.00	4.0	$ 27,720.00
Gypsum Board	SF	7,090.00	7.3	$ 51,402.50
Misc. Metals	SF	7,090.00	0.1	$ 709.00
TOTAL				$ 429,660.00
SlenderWall System Breakdown Cost				
Panel System	SF	6,930.00	42.0	$ 291,060.00
Gypsum Board 5/8" (3 Layers)	SF	6,930.00	1.5	$ 10,395.00
TOTAL				$ 301,455.00
StoPanel System Breakdown Cost				
Panel System	SF	6,930.00	72.0	$ 498,960.00

Elevation	Quantity	Productivity (hr)/ Panel	Duration (hr.)	Days
West	6	2	12.0	1.5
South	31	2	62.0	7.8
East	6	2	12.0	1.5
North @ East	6	2	12.0	1.5
			Total	13

Appendix

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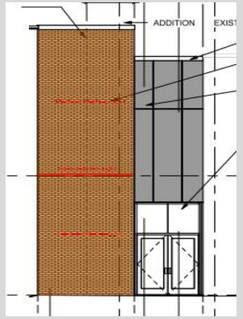

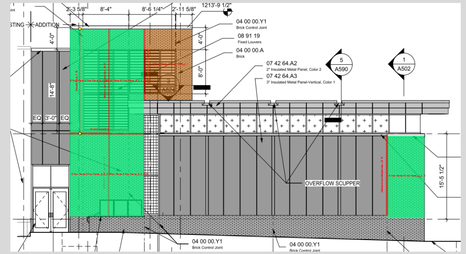

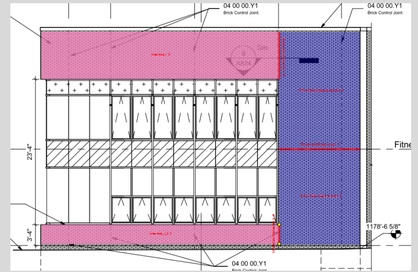

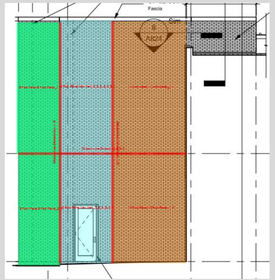

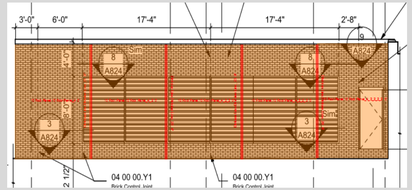

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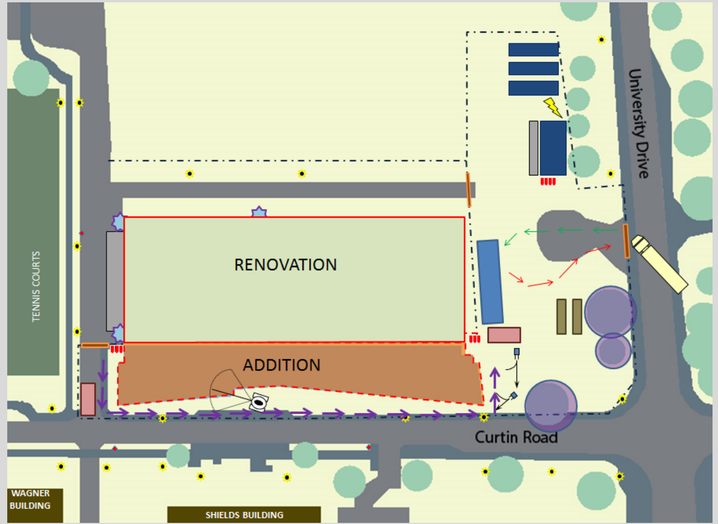
System Cost Comparison				
	Unit	Quantity	Cost/Unit	Total
Panel System	SF	6,930.00	43.5	$301,455.00
Current System	SF	7,090.00	52.6	$372,934.00
			Difference	$71,479.00

Additional Costs Benefits/Implements						
Scaffolding	CSF	148.8	$	130.13	$	19,363.34
Crane	Mo	-1.0	$	17,289.00	$	(17,289.00)
Material Hoist	Ea.	1.0	$	2,060.00	$	2,060.00
			Difference		$	4,134.34

Total Savings	
SlenderWall Savings	$71,479.00
Crane Usage	($17,289.00)
Removal of Scaffold	$19,363.00
Removal of Hoist	$2,060.00
	$75,613.00



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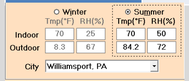
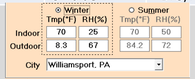
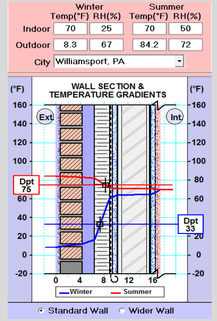
Intramural Building Project

Existing System				
Component	Thickness (in)	Unit R-Value	Unit	Total R-Value
Inside Air Layer	N/A	0.68	Ea.	0.68
Gypsum Board	0.625	0.56	Ea.	0.56
Metal Stud	6.00	0.98	Ea.	0.98
1.5 Spray Ins	1.50	5.75	In.	8.625
Sheathing	0.625	0.56	Ea.	0.56
Rigid Insulation	2.50	12.00	Ea.	12.00
Air Cavity	2.00	1.68	In.	3.36
Brick	3.625	0.40	Ea.	0.40
Exterior Air Layer	N/A	0.17	Ea.	0.17
Total Thickness	15.375	R-Value	hr.-SF-F/BTU	27.335
		U-Value	BTU/hr.-SF-F	0.0365

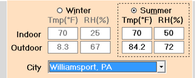


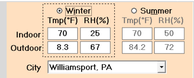


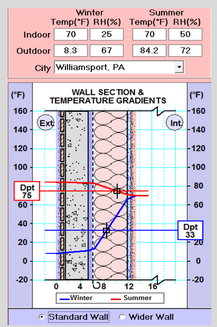
Heat Transfer				
Summer				
	R-Value	Change in Temp	Area	Heat Transfer
	∑ R	Δ T	SF	Btu/Hr.
Current	27.335	14.2	6,930.00	3,600.00
Proposed	27.09	14.2	6,930.00	3,632.56
			Difference	(32.56)
Winter				
Current	27.335	61.7	6,930.00	15,642.25
Proposed	27.09	61.7	6,930.00	15,783.72
			Difference	(141.47)



Proposed System				
Component	Thickness (in)	Unit R-Value	Unit	Total R-Value
Inside Air Layer	N/A	0.68	Ea.	0.68
Gypsum Board	0.50	0.56	Ea.	0.56
Vapor Barrier	N/A	0.12	Ea.	0.12
Batt. Insulation	6.00	21.00	Ea.	21.00
Air Gap	0.50	1.68	In.	1.68
Precast Concrete	2.00	2.80	In.	2.80
Brick veneer	0.50	0.15	In.	0.08
Exterior Air Layer	N/A	0.17	Ea.	0.17
Total Thickness	9.50	R-Value	hr.-SF-F/BTU	27.09
		U-Value	BTU/hr.-SF-F	0.0369







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Elevation	Length of Glazing (ft.)	Avg. Glass Width (ft.)	SF of Glazing
South	130.00	3	807.00
	150.00	3	1,105.00
	280.00	3	4,035.00
	12.00	3	173.00
East	36.75	3	858.00
Atrium	40.00	3	701.00
	15.00	3	342.00
	27.00	3	430.00
	20.00	3	212.00
		Total	8,663.00

Elevation	Size		SF	No. Panels	Total SF
	Width	Height			
South	3	2.66	7.98	93	742.14
South	6	2.66	15.96	1	15.96
East	3	2.66	7.98	11	87.78
South	3	7	21.00	141	2961.00
East	3	7	21.00	11	231.00
South	3	4.5	13.50	70	945.00
East	3	4.5	13.50	11	148.50
South	3	8.75	26.25	3	78.75
East	3	8.75	26.25	11	288.75
Atrium	3	9	27.00	15	405.00
Atrium	3	8.75	26.25	15	393.75
Atrium	3	2.66	7.98	15	119.70
Atrium	3	4.5	13.50	30	405.00
Atrium	3	3.66	10.98	6	65.88
South	3.5	4.5	15.75	38	598.50
South	3.5	2.66	9.31	10	93.10
			Total	481	7703.00

Elevation	Size		SF	No. Panels	Total SF
	Width	Height			
South	3.00	14.25	42.75	70	2,992.50
South	3.00	10.75	32.25	23	741.75
South	3.00	9.00	27.00	3	81.00
South	3.00	7.00	21.00	47	987.00
South	3.50	7.00	24.50	10	245.00
South	3.50	6.00	21.00	28	588.00
East	3.00	14.25	42.75	11	470.25
East	3.00	9.00	27.00	11	297.00
Atrium	3.00	13.00	39.00	15	585.00
Atrium	3.00	10.00	30.00	6	180.00
Atrium	3.00	8.00	24.00	15	360.00
Atrium	3.00	6.50	19.50	9	175.50
			Total	248	7,703.00

Elevation	Productivity panels/day	No. Panels	Duration
South	15	140	9.33
South	7	41	5.86
East	15	22	1.47
Atrium	15	30	2.00
Atrium	7	15	2.14
		Total	20.80

Item	Quantity	Unit	Unit Total	Total
Stick Built System	8,663.00	SF	$ 110.00	$ 952,930.00
			Subtotal	$ 952,930.00
Unitized System	8,663.00	SF	$ 132.00	$ 1,143,516.00
			Subtotal	$ 1,143,516.00
			Difference	$ (190,586.00)

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