PHASE 2 NEW BUILDING

JOHN TYLER COMMUNITY COLLEGE

MIDLOTHIAN CAMPUS

Midlothian, VA

Dennis Walter Jr.

Construction Management

AE Senior Thesis Final Presentation, Spring 2010

The Pennsylvania State University

Presentation Outline

- Project Overview
- Introduction of Analyses
- Analysis I – Brick Façade
- Analysis II – Roofing System
- Analysis III – Transformer
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- Questions & Answers

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Client Information

Virginia Community College Systems

John Tyler Community College
Midlothian Campus

- Built in 2000
- Single Academic Building
- Fast expansion → additional academic space
- Campus-wide green initiative

Project Location

800 Charter Colony Parkway, Midlothian, VA
~16 miles to Richmond, VA

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Project Overview

Construction Manager:

- Gilbane

Architect:

- Burt Hill

Size:

- 3 Stories
- 60,000 SF

Cost:

- $18.5 million

Delivery Method:

- CM @ Risk; GMP Contract w/ contingency

Construction Schedule:

- May 2008 – July 2009; 14 Months; Classes begin August 24, 2009

Building Features:

- 8 Laboratory Classrooms
- 10,000 SF College Library
- Green Roof
- LEED Certified

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Introduction of Analysis

Analysis I – Brick Façade

- Hand-Laid Brick Exterior Façade vs. Precast Architectural Panels
- Structural Calculations to check design of typical exterior bay

Analysis II – Roofing System

- Green Roof and IRMA system vs. “Cool” Roof system
- LEED and Heat Transfer comparison

Analysis III – Transformer

- Research into building transformers
- Electrical Calculations to size building transformer

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Analysis I – Brick Façade

Structural Breadth

Problem Statement:

- Hand-Laid Masonry → time and space for construction
- Problems with through wall flashing and drip edge details & application of spray-on hot fluid applied vapor barrier.
- Alternative systems may eliminate problems and ease construction

Goal:

- Matching quality & performance
- Cost-effective
- Reduce site congestion and staging area

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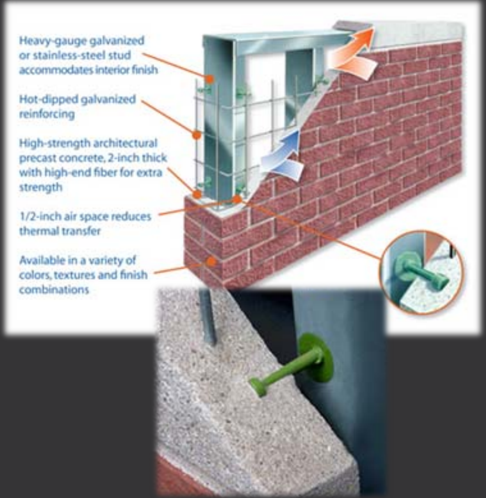
SlenderWall

Architectural Precast Concrete & Steel Stud Panel Wall System:

- Exterior Surface – Thin Architectural Brick Veneer
  - Veneer cast into 2 inches of reinforced precast concrete
- Inside Surface – 16 gauge, 6 inch steel studs @ 2 ft on center
- Connected with shear studs

SlenderWall Panel Replaces:

- Brick Veneer
- Spray-on Hot Fluid Applied Vapor Barrier
- Exterior Sheathing
- Exterior Metal Studs



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SlenderWall

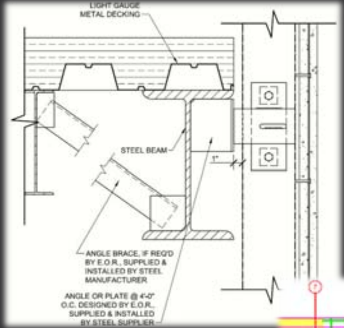
Panel Sizes:

- 122 Panels
- Most economical at 10’ x 35’ for shipping
- Not recommended over 13’ x 40’

Connection to Structure:

- Welded anchor or plate to exterior spandrel beams of floor above
- Bolted connection as soon as panel is set by crane

Panel Summary				
Elevation	QTY	Total SF	Unit Wt (PSF)	Panel Wt (lbs)
South	52	6052.8	30	181583
East	17	2141.7	30	64250
North	26	3972.50	30	119175
West	27	4236.64	30	127099
TOTAL	122	16404	30	492108



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Structural Implications

Check W 16x26 Beam for Moment:

φM_n = 234 ft*kips > M_u = 59.5 ft*kips √ **OK**

Check W 16x26 Beam for Deflection:

Construction Live Load:

$\Delta_{C\text{-}LL}$ = 0.0827 inches < L/360 = (21*12)/360 = 0.7 inches √ **OK**

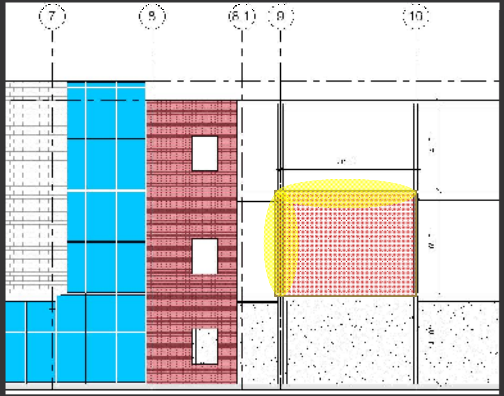
Live Load: Δ_{LL} = 0.0647 inches < 0.7 inches √ **OK**

Total Load: Δ_{Total} = 0.251 inches < 0.7 inches √ **OK**

Check W 10x45 Column for Axial Load:

P_u = 174.9 kips

W 10x45 → $\varphi_c P_n$ = 306 kips > P_u = 174.9 kips √ **OK**



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Schedule

Hand-Laid Brick – Building Enclosure Schedule:

- 79 days (start to finish)
- Constructed while elevated floor slabs being poured
- Site congestion and large prepping area required

SlenderWall – Building Enclosure Schedule:

- Fast erection time → 19 minutes per panel average
- 48 days (start to finish)
- Allows construction to begin after superstructure is complete
- Saves 16 total days in Building Enclosure Schedule
- Reduces site congestion
- Not on critical path → allows room for unforeseen delays or issues

Panel Installation Times			
Elevaton	QTY	Output/Panel (min)	Duration (days)
South	52	19	3.00
East	17	19	1.00
North	26	19	2.00
West	27	19	2.00

Building Skin Schedule Comparison			
System	Start	Finish	Duration (days)
Hand-Laid System	7/29/2008	11/14/2008	79
SlenderWall System	8/25/2008	10/29/2008	48
Total Days Saved			**16**

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Cost

Hand-Laid Brick Wall System:

- $40.97/SF
- Includes:
  - Utility brick
  - Exterior sheathing
  - Fluid applied vapor barrier
  - Exterior studs
  - Miscellaneous finishing
  - Precast sills

SlenderWall Precast System:

- $40.00/SF

System Cost Comparison				
Wall System	**QTY**	**Unit**	**Unit Cost**	**Cost**
Hand-laid Brick Wall	16404	SF	$40.97	$672,043
Precast SlenderWall	16404	SF	$40.00	$656,160
Cost Savings				**$15,883**

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Quality Comparison

Hand-Laid Brick Wall System:

- Cavity wall system
- Proven quality in construction and appearance
- Mortar joints wear over time → re-working required

Quality Comparison

SlenderWall Precast System:

- Barrier wall system
- High Quality Architectural Class “A” Brick Veneer
- Mock-up
- 100% water-tight and acts as vapor barrier
- No leaking or wearing mortar joints
- ¾” joint between panels:
  - ¾” backer-rod
  - ½” caulking layer
- Joints wear over time → re-working required

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Conclusions

SlenderWall Precast System:

- Building Enclosure Schedule reduction →16 days
- No Structural impact → reduction possible
- Less staging & begins after superstructure
  → Reduced site congestion
- Cost savings → $15,883

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Analysis II – Roofing System

M.A.E. Requirements

Problem Statement:

- Inverted Roof Membrane Assembly (IRMA) & Green Roof installed was expensive
- Alternative systems → may offer similar LEED requirements & upfront cost savings

Goal:

- Similar quality & weatherproofing
- Cost-effective
- Meet LEED requirements and provide positive impact

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"Cool" Roof

Single-Ply Thermoplastic Polyolefin (TPO) Membrane:

- Exterior Surface →White reflective "cool" TPO membrane
- Fully adhered to closed-cell poly. iso. insulation
- Poly. Iso. Insulation → R-6/inch
- Fully adhered to composite concrete slab

Replaces:

- 11,300 SF → Ballasted IRMA Roofing
- 8,300 SF → Extensive Green Roof over IRMA
- 19,600 SF → Hot Rubberized Asphalt Waterproofing membrane

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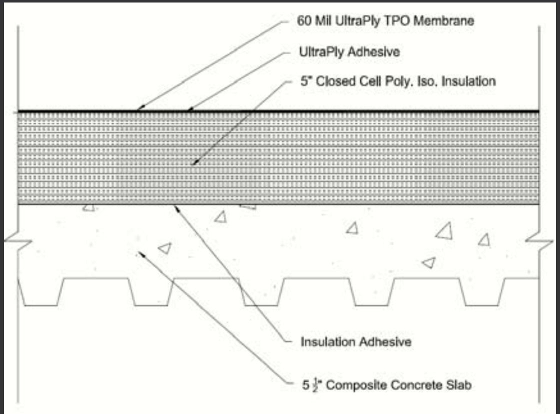
“Cool” Roof Design

Firestone Building Products:

- 60 Mil UltraPly TPO Membrane
- UltraPly Adhesive
- 5” Closed-cell Poly. Iso. Insulation (R-6/inch)
- Insulation Adhesive

Design:

- R-30 → 5” of R-6/inch Insulation
- 10-ft rolls overlapped and heat-welded at seams for continuous waterproof layer



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Thermal Properties

Design Temperatures → Richmond, VA:

- Summer: 75°F Indoor, 95°F Outdoor
- Winter: 70°F Indoor, 14°F Outdoor

Heat Transfer Through Roof			
	TPO "Cool" Roof	Average Green Roof	Difference
	BTU/ft^2*hr	BTU/ft^2*hr	%
Summer	0.64	0.40	37%
Winter	-1.78	-1.49	16%

TPO "Cool" Roof:

- 37% Increase in Summer Heat Gain
- 16% Increase in Winter Heat Losses

TPO "Cool" Roof Thermal Properties				
R-Value				
Material	Thickness (in) L	R-Value per inch °F*ft^2*h/Btu-in	R-Value °F*ft^2*h/Btu	U-Value Btu/°F*ft^2*h
Outside Air Film	-	-	0.17	5.88
UltraPly TPO Membrane	0.060	0.833	0.050	20.00
Poly. Iso Insulation	5.000	6.000	30.000	0.03
Composite Deck	5.500	0.100	0.550	1.82
Inside Air Film	-	-	0.610	1.64
		Total:	31.380	0.032
Heat Transfer				
Summer (75°F Indoor , 95°F Outdoor)				
∑R °F*ft^2*h/Btu		ΔT °F	A ft^2	Q Btu/hr
31.380		20	19,600	12,492
Winter (70°F Indoor , 14°F Outdoor)				
∑R °F*ft^2*h/Btu		ΔT °F	A ft^2	Q Btu/hr
31.380		-56	19,600	(34,978)

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LEED Comparison

LEED 2009 for New Construction:

Single-Ply TPO "Cool" Roof:

- Reduces Heat Island Effect
- Optimizes Energy Performance

Green Roof System:

- Reduces Heat Island Effect
- Optimizes Energy Performance
- Stormwater Management and Water Runoff
- Water Efficient Landscaping
- Improves environment → create educational laboratory

LEED Credit Comparison

LEED 2009 for New Construction and Major Renovations			Single-Ply TPO "Cool" Roof System			IRMA & Green Roof System		
Sustainable Sites		Possible Points:	Y	N	?	Y	N	?
Credit 6.1-2	Stormwater Design - Quantity & Quality Control	1 to 2		√		√		
Credit 7.2	Heat Island Effect - Roof	1	√			√		
Water Efficiency								
Credit 1	Water Efficient Landscaping	1 to 4		√		√		
Energy and Atmosphere								
Credit 1	Optimize Energy Performance	1 to 19	√			√		
Innovation and Design Process								
Credit 1.1	Innovation in Design - Educational Laboratory	1		√		√		
		Estimated Possible Credits:	2 to 6			6 to 16		

LEED Comparison Outcome:

- Green Roof → 4 to 10 additional LEED credits

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Schedule

IRMA & Green Roofing System:

- 23 Days → IRMA & Ballasts
- 10 Days → Green Roof plantings
- Multiple Mobilizations
- Large delivery, storage & staging area

Single-Ply TPO “cool” Roofing System:

- 23 Days → entire system
- Single Mobilization
- Less materials → delivered to & stored on roof
- Saves 10 days

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- Single Mobilization
- Less materials → delivered to & stored on roof
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Cost

IRMA & Green Roofing System:

- Green Roof $23.00/SF 8,300 SF
- IRMA System $12.00/SF 19,600 SF

Single-Ply TPO "cool" Roofing System:

- $8.00/SF
- Upfront Savings → $269,300

System Cost Comparison				
Wall System	**QTY**	**Unit**	**Unit Cost**	**Cost**
Green Roof & IRMA	19600	SF	$8.95	$426,100
Single-Ply TPO	19600	SF	$8.00	$156,800
Cost Savings				**$269,300**

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Conclusions

Single-Ply TPO "Cool" Roof System:

- Reduces site congestion, staging, and storage space
- Saves 10 days
- Upfront cost savings → $269,300
- 4 to 10 Fewer potential LEED credits
- Increases heat transfer → reduces Energy Efficiency

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Analysis III – Transformer

Electrical Breadth

Problem Statement:

- Building Transformer provided → undersized
- Suffered phase loss & damaged contacts for variable-frequency drives (VFD's) days before start of classes
- Costs incurred → overtime labor & materials
- Proper coordination can reduce risk of component failures

Goal:

- Research into sizing building transformers
- Perform Electrical Calculations → size transformer
- Provide best practices for design, install & maintenance

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Sizing Procedures

- Determine:
  - Expected Building Electrical Load
  - Voltage Required by Load
  - 1-Phase or 3-Phase?
- Determine Supply Amps
- Frequency of supply and electrical load → must be the same
- Calculate kVA rating
- Select transformer → standard capacity equal or great than that needed to operate building loads

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Electrical Calculations

Sizing Distribution Transformer:

Expected Electrical Load = 968.2 kW

Voltage required by Load = 480 V

Phase: 3-Phase

Current of Expected Load = 1165 A

kVA of 3-Phase Transformer Required:

kVA= √3 * 1165 A * 480 V = 968.6 kVA → Use 1000 kVA

Result: 1000 kVA, 3-Phase Distribution Transformer

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Building Distribution Transformer:

- Close coordination & quality control
- Calculations → 1000 kVA rated 3-Phase Transformer
  - Differs from 750 kVA transformer
  - Size reduction factors made by the Utility Company
- Adopt Best Practices for Design, Installation, and Maintenance →
  - minimize component failures & loss of rating efficiency

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Final Conclusions

<u>SlenderWall Precast Panels:</u>

- 16 day reduction
- Reduces site congestion & staging area
- Saves $15,883

<u>Single-Ply TPO “Cool” Roof :</u>

- 10 day reduction
- Reduces delivery, storage & staging area
- Saves $269,300 → Upfront costs
- Lost Energy Efficiency → increased summer heat gains and winter heat losses
- 4 to 10 Fewer Potential LEED Credits

<u>Building Distribution Transformer:</u>

- Coordination & quality control required during design
- Calculations → 1000 kVA rated 3-Phase Transformer
- Adopt Best Practices for Design, Installation, and Maintenance
  - Optimizes lifetime & performance

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QUESTIONS ?