Wisconsin Place Residential

Chevy Chase, MD

Jenna Marcolina

Construction Management

Senior Thesis Presentation 2008

The Pennsylvania State University

Presentation Outline

- Overall Theme: The Building Envelope
  - **Project Overview**
    - Building information, project team, architecture
  - Prefabrication
    - Software, new technology, precast comparison
  - Precast Brick Façade
    - Design considerations, structural connection, thermal, cost, schedule
  - PV Glass Replacement
    - Logistics, life cycle cost comparison, Energy 10 results
  - Conclusion & Lessons Learned
  - Questions

Project Overview

- WPR is part of a 1.1 million SF mixed use development





Project Overview

- Size
  - 485,000 SF; 15 stories
- Cost
  - $90 million
- Schedule
  - June 2007 - February 2009
- Structure
  - Post-tensioned concrete
- Façade
  - Brick, stone, glass, metal
- 4 CM's and 3 developers working on a single podium

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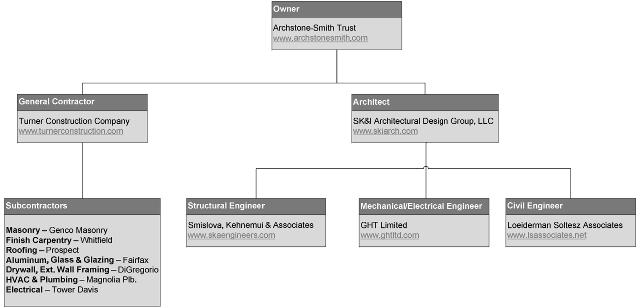
Project Overview



Project Overview

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Prefabrication: Software

- MODEX & Neoromodex
  - Performs prefab feasibility study for industrial plants
  - 5 Categories
    - Plant location
    - Environment
    - Labor
    - Plant characteristics
    - Project risks
  - Easily be translated to construction

Prefabrication: Software

- 2000 Study
  - Software use 13% over past 15 years
  - Top driving factors for prefabrication
    - Cost, schedule, workforce issues
  - Barriers to prefabrication
    - Additional planning, increased transportation, design inflexibility, procurement requirements

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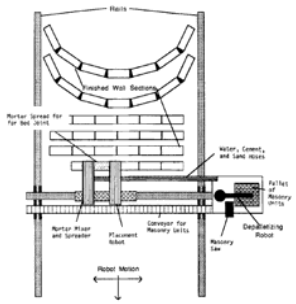
Prefabrication: New Technology

- The Brick Robot
  - University of Maryland design team
  - Automated brick placement system
  - Accurate placement
  - Issues with bond strength

Prefabrication: New Technology



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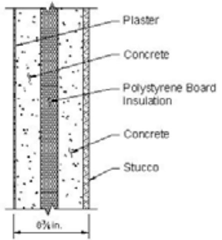
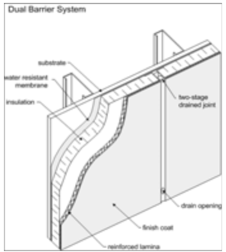
Prefabrication: Precast Comparison

- Sandwich Panel
  - Closed-cell insulation between 2 concrete panels
    - Do not have the best thermal properties because insulation is so thin
  - Pre-finished interiors could get damaged during placement



Prefabrication: Precast Comparison

- EIFS
  - Exterior Insulating Finishing System
  - Synthetic stucco panel
  - Thin and lightweight
  - Outermost layer protects against moisture penetration
    - Mold can be an issue



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Precast Brick Façade

Precast Brick Façade

- Problems
  - Many constraints: time, money, resources, space
- Goals
  - Simplify façade construction by unitizing components
  - Maintain envelope integrity while reducing cost and schedule
- Expected Outcome
  - Alleviate site congestion by switching to a precast system
  - Eliminate need for masonry hoist and scaffolding

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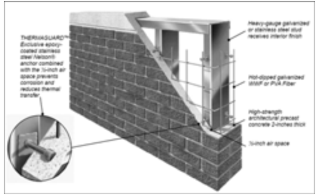
Precast: Product Selection

- Slenderwall Panel System
  - By Smith-Midland

SLENDERWALL®
Architectural Precast Concrete/Steel Stud Building Panels



Precast: Product Selection

- Slenderwall Components
  - 16 gauge 6” galvanized steel studs on 2’ centers
  - ½” air space
  - 2” concrete facing
- Second Nature Precast Concrete Brick

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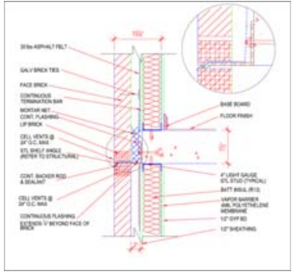
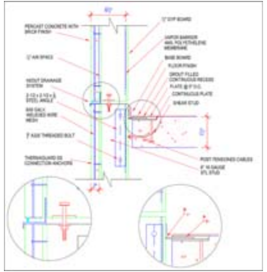
Precast: Design Considerations

- Typical Brick Veneer System



Precast: Design Considerations

- Typical Slenderwall Construction



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Precast: Design Considerations

- Weight Comparison
  - 62 psf difference
  - Potential structural system reduction not analyzed because the slab is already crowded with various building elements

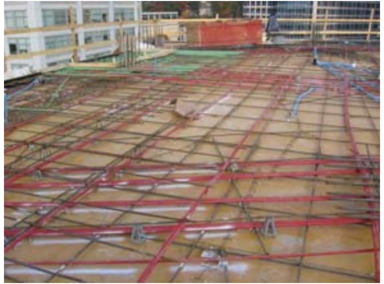
Existing System

Component	Weight (psf)
Gypsum Board	2
Steel Studs	18
Sheathing	50
Mortar	39
Brick	35
Total Weight	144

Proposed System

Component	Weight (psf)
Slenderwall Panel	30
Gypsum Board	2
Sheathing	50
Total Weight	82

Precast: Design Considerations



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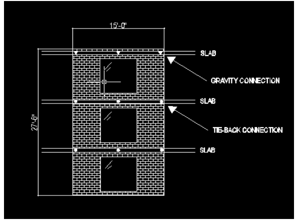
Precast: Structural Connection

- Typical Panel Connection Design
  - 15’ x 27.5’ vertical panel containing (3) 6’ x 6’ window openings
  - Tributary Area = 10’ x 27.5’ = 275 SF
  - Gravity connections spaced at 5’
  - Point Load = 275 SF x 87.75 PSF = 24.13 kips

Precast: Structural Connection



- Angle Design
  - L2.5” x 2.5” x 3/16”
- Bolt Design
  - A325 ¾” threaded bolt

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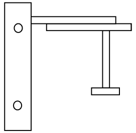
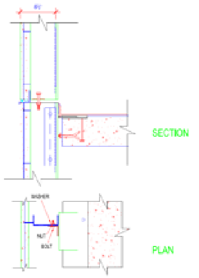
Precast: Connection Details

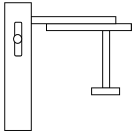
- Typical Slenderwall Gravity Connection

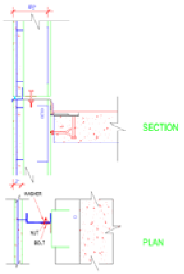




Precast: Connection Details

- Typical Slenderwall Tie-Back Connection





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Precast: Thermal Analysis

- R-Value Calculation for Existing System

Existing System

Component	Thickness (inches)	Unit R-Value	Unit	Total R-Value
Inside air layer	N/A	0.68	ea	0.68
Gypsum board	0.5	0.45	ea	0.45
R-13 insulation	4	13	ea	13
Sheathing	0.5	1.09	ea	1.09
Asphalt felt	N/A	0.12	ea	0.12
Air gap	2	1.68	inch	3.36
Standard 4" brick	4	0.44	ea	0.44
Outside air layer	N/A	0.17	ea	0.17
Total Thickness	11	R-Value	hr-sf-F/BTU	19.31
		U-Value	BTU/hr-sf-F	0.0518

Precast: Thermal Analysis

- R-Value Calculation for Proposed System

Proposed System

Component	Thickness (inches)	Unit R-Value	Unit	Total R-Value
Inside air layer	N/A	0.68	ea	0.68
Gypsum board	0.5	0.45	ea	0.45
Vapor barrier	N/A	0.12	ea	0.12
R-13 insulation	6	13	ea	13
Air gap	0.5	1.68	inch	0.84
Foamed-in-place insulation	0.5	6.25	inch	3.125
Concrete w/ admixtures	2	2.615	ea	2.615
Outside air layer	N/A	0.17	ea	0.17
Total Thickness	9.5	R-Value	hr-sf-F/BTU	21
		U-Value	BTU/hr-sf-F	0.0476

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Precast: Thermal Analysis

- Summer Heating Loads: To = 90F, Ti = 75F
- ΔT = 15F

Summer Heat Gain

System	Area (SF)	U-Value	ΔT (°F)	Heat Gain (BTU/hr)	
Standard Brick	79208	0.0518	15	61544.616	
Slenderwall Panels	79208	0.0476	15	56554.512	
			Difference	4990.104	
				8.11%	Reduction of Heat Gain

Precast: Thermal Analysis

- Winter Cooling Loads: To = 15F, Ti = 70F
- ΔT = 55F

Winter Heat Loss

System	Area (SF)	U-Value	ΔT (°F)	Heat Loss (BTU/hr)	
Standard Brick	79208	0.0518	55	225663.592	
Slenderwall Panels	79208	0.0476	55	207366.544	
			Difference	18297.048	
				8.11%	Reduction of Heat Loss

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Precast: Cost Review

- Cost at a glance…

Wall System Cost Comparison

System	Quantity	Unit	Cost/SF	Total Cost	
Brick w/ Metal Studs	79208	SF	$35	$2,772,280	
Slenderwall	79208	SF	$50	$3,960,400	
		Difference		$1,188,120	
				42.86%	**Increase in Cost**

Precast: Cost Review

- Cost Considerations for…

Scaffolding Cost

Cost	Unit	Surface Area	Total Cost
$252	SFCA	2700	$680,400

Masonry Hoist Cost

Cost	Unit	Rental Period	Total Cost
$4,775	month	10	$47,750

Tower Crane Cost

Cost	Unit	Rental Period	Total Cost
$35,200	month	2	$70,400

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Precast: Cost Review

- All things considered…

Costs	
Slenderwall Cost Differential	$1,188,120
Crane Usage (2 months)	$70,400
Total Cost	$1,258,520
Savings	
Scaffolding Removal	$680,400
Hoist Removal	$47,750
Cancel Ext. Framing Contract	$1,940,000
Total Savings	$2,668,150

Net Money Saved
$1,409,630

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Precast: Schedule Review

Durations

System	Quantity	Unit	Daily Output	Days	
Brick w/ Metal Studs	79208	SF	565	140.2	
Slenderwall	79208	SF	2500	31.7	
		Difference:		108.5	Day Reduction

22 Week Schedule Reduction

Precast: Constructability Review

- Crane Usage Calculations
  - 250 panels x .333 hours/panel = **83.33 hours of crane usage**
  - 83.33 hours/32 day duration = **2.6 hours/day of crane usage**

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Precast: Recommendation

- Replace the hand-laid brick façade with Slenderwall panels because:
  - It saves time and money
  - Thermal resistance is increased
  - It reduces site congestion by limiting the number of trades working on the façade

Precast: Recommendation

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PV Glass Replacement

PV Glass Replacement

- Problems
  - Building operating costs are expensive
  - Tenants pay for utilities individually
- Goals
  - Lower utility bills for tenants by implementing solar power
  - Reduce energy consumption of building by same token
- Expected Outcome
  - To save the owner money in the long run by investing a bit more upfront
  - To introduce a functional and value-enhancing façade alternative

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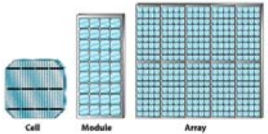
PV Glass: Defined

- Photovoltaic cells
  - Made of multicrystalline silicon
  - Convert solar radiation from the sun into electrical energy that can be used to power a building
  - Reliable and virtually maintenance free



PV Glass: Defined

- Building Integrated Photovoltaic (BIPV) System
  - PV panels replace window panes in aluminum frame
  - Serves form and function simultaneously
- Grid-Tied Systems
  - Connected to local utility
  - On-site production of solar electricity is greatest at the time of the building's peak utility loads
  - The state of Maryland allows net metering

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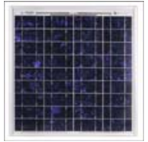
PV Glass: Product Information

- BP Solar 50 Watt Panels
  - 72 cells in a 4 x 18 matrix connected in 2 parallel strings of 36 in series

bp solar



Performance

Rated power (P_{max})	50W
Nominal voltage	12V
Limited Warranty[1]	25 years

Electrical Characteristics[2]	BP 350
Maximum power (P_{max})[3]	50W
Voltage at Pmax (V_{mp})	17.5V
Current at Pmax (I_{mp})	2.9A
Warranted minimum P_{max}	45W
Short-circuit current (I_{sc})	3.2A
Open-circuit voltage (V_{oc})	21.8V
Temperature coefficient of I_{sc}	(0.065±0.015)%/ °C
Temperature coefficient of V_{oc}	-(80±10)mV/°C
Temperature coefficient of power	-(0.5±0.05)%/ °C
NOCT (Air 20°C; Sun 0.8kW/m²; wind 1m/s)	47±2°C
Maximum series fuse rating	20A
Maximum system voltage	50V (U.S. NEC & IEC 61215 rating)

PV Glass: Product Information

- Xantrex GT5.0 Inverter

Model	Features	xantrex
GT2.8 Inverter	208VAC Max. Output: 2700W 240VAC Max. Output: 2800W Convection cooled (no fan) Outdoor Rated NEMA 3R 10 year warranty	 *Xantrex GT Series Inverter*
GT3.3N Inverter	208VAC Max. Output: 3100W 240VAC Max. Output: 3300W Convection cooled (no fan) Outdoor Rated NEMA 3R 10 year warranty	
GT4.0N Inverter	208VAC Max. Output: 3800W 240VAC Max. Output: 4000W Convection cooled (no fan) Outdoor Rated NEMA 3R 10 year warranty	
GT5.0 Inverter	208VAC Max. Output: 4500W 240VAC Max. Output: 5000W Convection cooled (no fan) Outdoor Rated NEMA 3R 10 year warranty	

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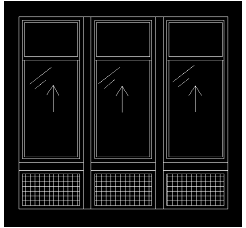
PV Glass: Logistics

- Replace all foot-level panels in aluminum window frames with PV panels
  - 2,342 panels total (33% façade glass)
  - View from apartment not obstructed
  - Panels will be shipped to window manufacturer and factory installed in frames, keeping windows unitized



PV Glass: Logistics

- Architectural Impact

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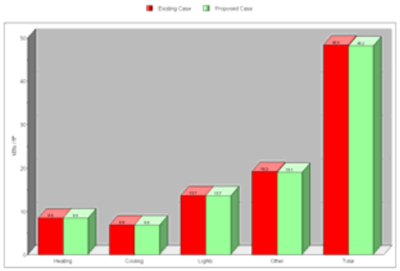
PV Glass: Mechanical Analysis

- Energy Use Comparison Report – 50 Watt Panels

Results	Existing Case	Proposed Case	% Change
Energy cost			
$/Therm	0.4	0.4	
$/kWh	0.078	0.078	
$/kW	2.47	2.47	
Simulation dates	01-Jan to 31-Dec	01-Jan to 31-Dec	
Energy use, kBtu	21765730	21693586	-0.33
Energy cost, $	546526	544872	-0.3
Saved by daylighting, kWh	-	-	
Unregulated/process loads	1071873	1071873	0
Peak Electric, kW	2973.2	2973.2	0
Annual Emissions			
CO_2, lbs	8572851	8544436	-0.33
SO_2, lbs	50391	50224	-0.33
NO_x, lbs	26152	26066	-0.33
Construction Costs	$82,087,992	$82,267,384	0.22
Life-Cycle Cost	$100,265,040	$100,374,976	0.11

Results	Existing Case	Proposed Case	% Change
Construction Costs	$82,087,992	$82,267,384	0.22
Life-Cycle Cost	$100,265,040	$100,374,976	0.11

- Annual Energy Use – 50 Watt Panels



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PV Glass: Results

- Annual Energy Savings = $1,654
- Payback Period = 108 years
- Construction cost of proposed system is $179,392 more than the existing system
- Life cycle cost of proposed system is $109,936   more than the existing system, so there is no savings over time

Presentation Outline

- Overall Theme: The Building Envelope
  - Project Overview
    - Building information, project team, architecture
  - Prefabrication
    - Software, new technology, precast comparison
  - Precast Brick Façade
    - Design considerations, structural connection, thermal, cost, schedule
  - **PV Glass Replacement**
    - Logistics, life cycle cost comparison, Energy 10 results
  - Conclusion & Lessons Learned
  - Questions

PV Glass: Recommendation

- The 50 Watt panels are not strong enough to produce any significant energy savings
- A simulation was run using 200 Watt panels, and this showed a reduction in life cycle cost as well as a $34,650 annual energy cost savings
- Use higher wattage panels in the form of solar shades or skylights

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Conclusions

- Prefabrication
  - Driving factors for industry
  - Technology to simplify prefab decision process
- Precast Brick Façade
  - Cost and schedule reduced
  - Thermal resistance increased
  - Site congestion alleviated through consolidation of trades
  - Exterior thickness decreased, floor space increased
- PV Glass Replacement
  - Must use higher power panels to achieve significant energy-saving results
  - Owner could introduce more solar panels to the building in the form of skylights or solar shades

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Lessons Learned

- Thesis ideas will evolve throughout the entire year, so don't sweat it if you don't have an analysis or your topic keeps changing
- Industry members are willing to help if you can get past the angry hang ups
  - HINT: Don't tell them you're a student
- You can teach an old dog new tricks
- You know a lot more than you think
  - You might just need to dust off the old textbooks
- Completing your thesis is an achievable goal

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Questions

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