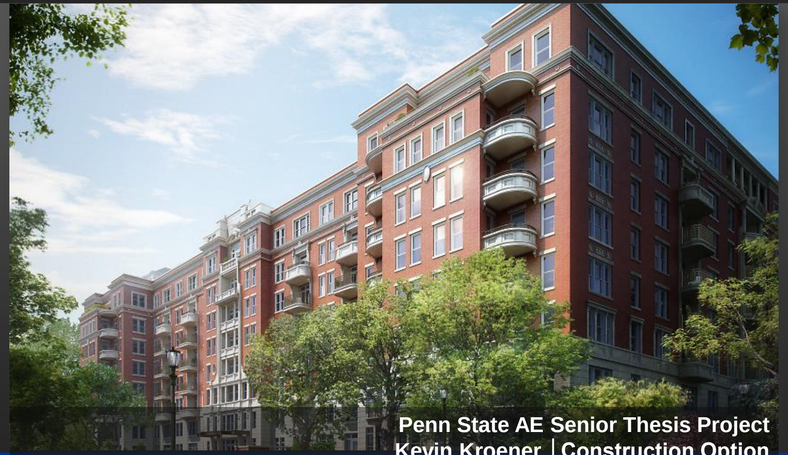
Wardman West Residential



Penn State AE Senior Thesis Project
Kevin Kroener | Construction Option
Faculty Advisor | Ray Sowers

Introduction

Project Background

Location | Woodley Park, NW Washington, DC
Building Type | Midrise Luxury Apartment Building
Project Size | 321,000 GSF (132,500 SF Below Grade)
Number of Stories | 8 Above - Grade / 2 Below - Grade
Contract Value | $88 million
Contract Type | Negotiated GMP
Dates of Construction | June 16, 2011 – March 14, 2014
GC | Clark Construction Group, LLC
Owner/Developer | The JBG Companies
Architect | Cooper Carry

Courtesy of Clark Construction

Introduction

Courtesy of Clark Construction

Thesis Focus

Slow Exterior Brick Masonry Work

Courtesy of Clark Construction

Introduction

Courtesy of Clark Construction

Thesis Focus

Slow Exterior Brick Masonry Work

Analysis Overview

Analysis 1: Architectural Precast Concrete Wall Panels

- Thermal Performance Study
- Structural Feasibility & Redesign Study

Analysis 2: SIPS (Short Interval Production Schedule)

Analysis 3: Safety Evaluation

Analysis 4: General Contractor Implementation Plan for APC Wall Panels

Wardman West Residential
Woodley Park, NW Washington, DC

Courtesy of Clark Construction

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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Problem:

Lagging Exterior Brick Masonry Work

Proposed Solution:

Substitute Architectural Precast Concrete Wall Panels for Brick Veneer Wall

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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Overview

Problem:
Lagging Exterior Brick Masonry Work

Proposed Solution:
Substitute Architectural Precast Concrete Wall Panels for Brick Veneer Wall

Benefits to Architectural Precast Concrete Wall Panels

- Aesthetic Flexibility
- Product Quality
- Energy Performance
- Cost Savings
- Schedule Acceleration

Courtesy of PCI

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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

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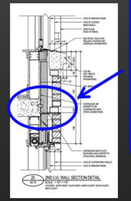
- Energy Performance
- Cost Savings
- Schedule Acceleration

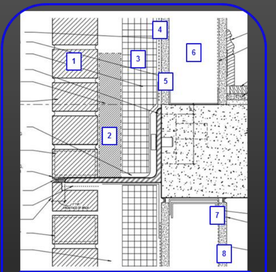
Courtesy of PCI

Existing Wall System

Material	Thickness (inches)
1. Standard Brick (Glen Gery 52 DD)	4
2. Air Cavity	2
3. Rigid Insulation (Dow EPS)	3
4. Permeable Air Barrier	--
5. Exterior Sheathing	5/8
6. Cold-Formed 18 Ga. Metal Stud (16'' OC)	4
7. Polyethylene Vapor Barrier	--
8. 5/8'' Gypsum Wall Board	5/8

Courtesy of Clark Construction





Typical Relieving Angle Detail

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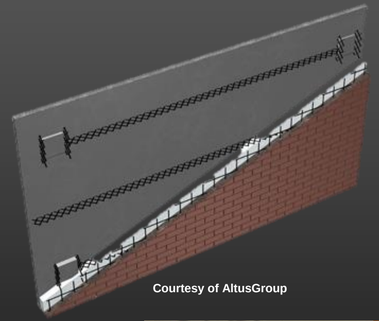
APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Product Selection

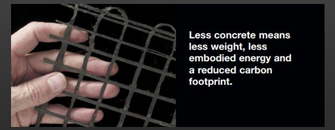
Selection:
CarbonCast Insulated Architectural Cladding

Product Advantages:
- Reduced load on building structure
- Lower transportation cost
- Smaller cranes can be used to pick and erect CarbonCast panels
- Lower carbon footprint
- Aesthetic Versatility
- Meets ASHRAE requirement for continuous insulation



Courtesy of AltusGroup

C-GRID Carbon Fiber Grid:
- Shear connector between concrete wythes
- Minimum wythe thickness of 1 ¾”
- Up to 40% lighter



altusgroup carboncast C-GRID

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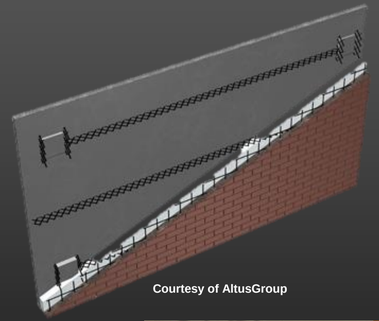

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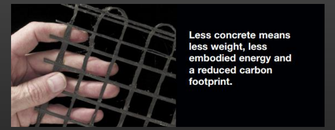
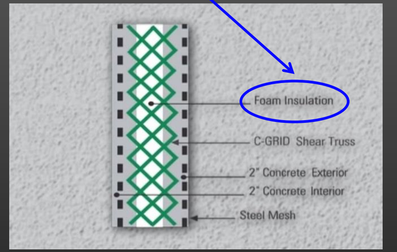


EPS, XPS or Poly-Iso foam Rigid Insulation



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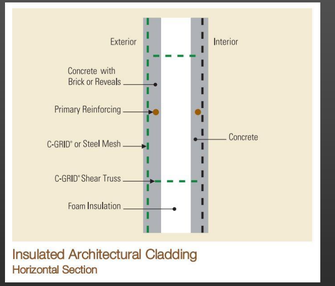

Courtesy of AltusGroup

APC Wall Panel Prefabrication

Crane Use

Mobile Crane

- Precast Subcontractor

20 ton Tower Crane

- Clark Concrete
- Jib Length shorten from 213' to 180'
- Capacity increased from 11,680 lb. to 17,200 lb.

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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

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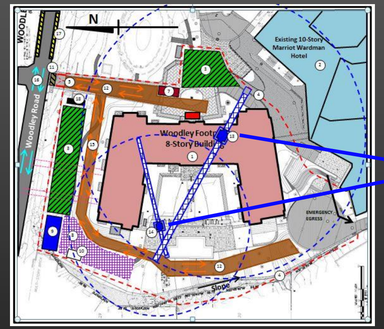
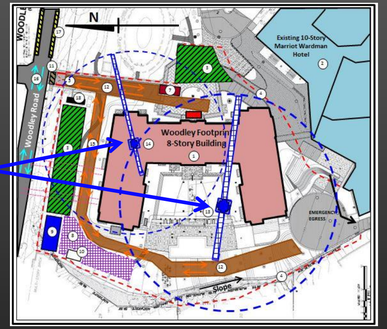
Tower Crane Relocation





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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

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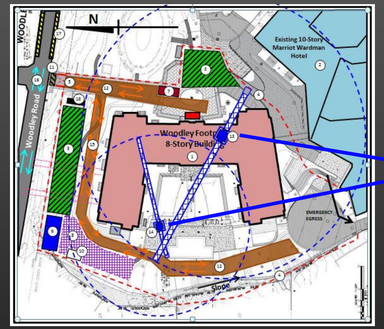
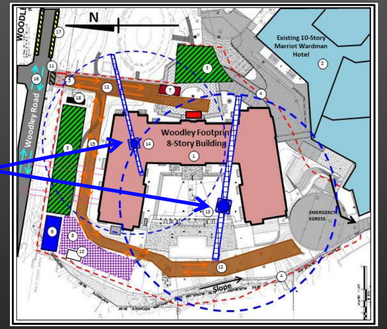
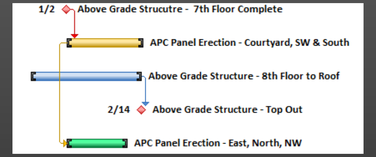




Workflow Sequence

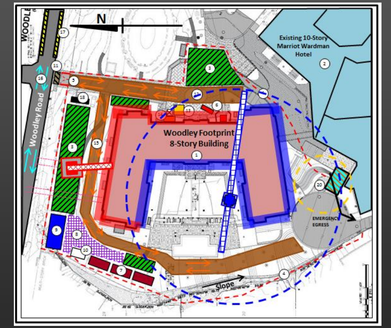


Mobile Crane

Elevations
- North
- East

Tower Crane

Elevations
- South
- Courtyard



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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Transportation

Flatbed or Low-deck Trailers:

- Used for precast panels < 12’ x 40’

Courtesy of Oldcastle

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Kevin Kroener | Construction Option

APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

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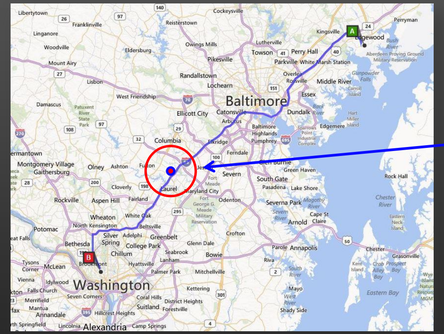
Delivery

Shipping:

- Oldcastle Precast Building Systems
- Plant Location – Edgewood, Maryland



Rest Stop Staging

- I-95 Maryland Rest and Welcome Area
- 32 Miles from Beltway (I-495)

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Kevin Kroener | Construction Option

APC Wall Panel Prefabrication

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Woodley Park, NW Washington, DC

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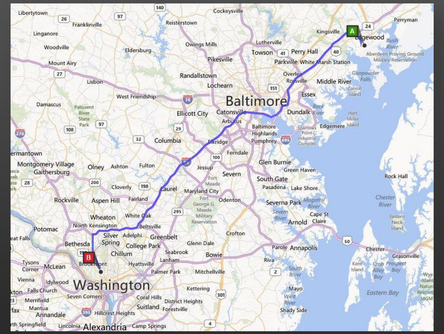
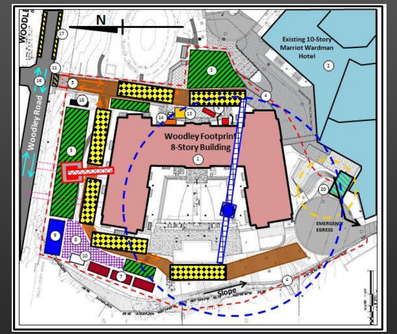


Site Staging

Staging Area

Mobile Crane

Tower Crane



APC Wall Panel Prefabrication

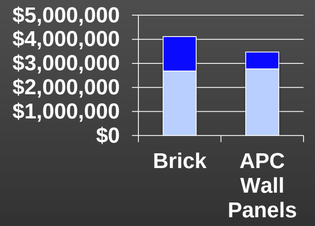
Cost Savings

Existing Brick Veneer Wall System

Item	Amount
Brick	$2,676,060
Backup, Sheathing and Insulation	$55,834
Metals	$292,500
Misc.	$246,375
Limestone	$843,570
Total	$4,114,339

APC Wall Panels

Item	Amount
Architectural Precast Concrete Panels (including attachment hardware)	$2,768,480
Penthouse Brick	$205,905
Metals	$292,500
Misc.	$407,355
Total	$3,468,335



GATE PRECAST COMPANY

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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

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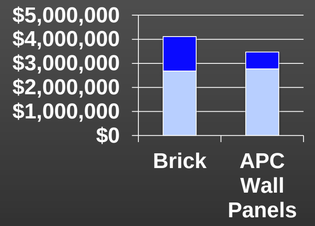

GATE PRECAST COMPANY

Schedule Acceleration

Original Duration for Brick Work:

145 Days

Accelerated Duration for APC Wall Panels:

32 Days

Activity	Start	Finish	Duration (Work Days)
APC Wall Panels	2 Jan 2012	15 Feb 2013	32
Windows	18 Jan 2013	14 Jun 2013	105
Stone	6 Mar 2013	17 Aug 2013	118
Penthouse Brick	11 Jul 2013	7 Aug 2013	20
Balcony Front Brick	10 Jul 2013	10 Aug 2013	23
Revised Ext. Skin Total Duration	2 Jan 2012	17 Aug 2013	163
Schedule Acceleration w/ Earlier Finish Date			46

Activity	Duration (Work Days)
APC Wall Panels (Raw)	57
APC Wall Panel w/ Phasing	32
Schedule Acceleration	88
w/ Phasing	113

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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Results

SAVINGS = $646,000

- 16 % Cost Compared Existing System
- 5 % Cost of Building Enclosure
+ 46 Days to Project Schedule

Cost Savings

Existing Brick Veneer Wall System

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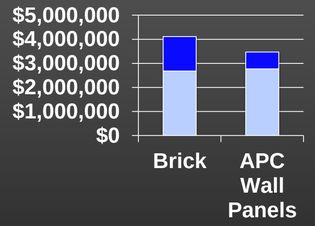

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AE Senior Thesis Project
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APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Wind & Seismic Loading

Code:
IBC 2006 / ASCE 7-05

Assumption:
Panel Weight (12' x 30' @ 40 PSF) – 14,400 lb.

Wind:

Windward exposure

$$P = q_h \times (+GC_p) - q_h \times (-GC_{pi}) \left(lb/ft^2\right)$$

$$P = 18.3 \times (+0.62) - 18.3 \times (-0.18) = 14.64 \ lb/ft^2$$

Leeward exposure

$$P = q_h \times (-GC_p) - q_h \times (+GC_{pi}) \left(lb/ft^2\right)$$

$$P = 18.3 \times (-1.1) - 18.3 \times (+0.18) = 23.4 \ lb/ft^2$$

Max Suction Force = 8,424 lb.

Seismic:

$$F_p = \left(\frac{0.4 \, a_p \, S_{DS} W_p}{\left(R_p / I_p \right)} \right) \times \left(1 + \left(2 \times z/h \right) \right)$$

Horizontal Seismic Force = 850 lb. (*10% of Wind Load*)

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Kevin Kroener | Construction Option

APC Wall Panel Prefabrication

Wardman West Residential
Woodley Park, NW Washington, DC

Hardware Selection

Courtesy of JVI

Working Capacity = 2,680 lb. < 2,106 lb. (Max Suction Force per attachment point)

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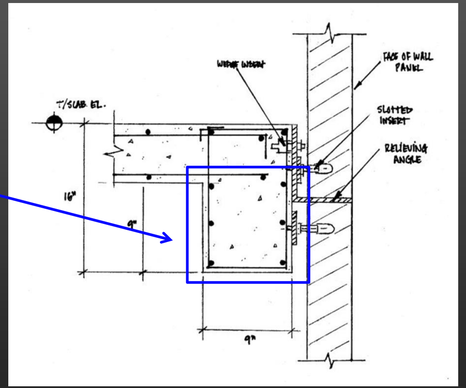
Lateral Attachment & Spandrel Beam Redesign

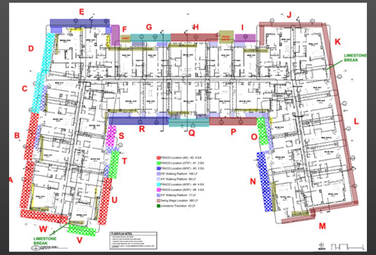
16" x 9" Spandrel Beam

Added Cost:

$ 54,000

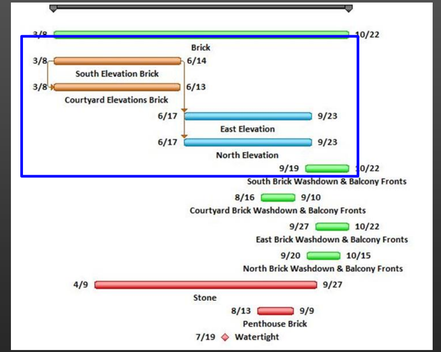


SIPS



Courtesy of Clark Construction

Original Brick Masonry Schedule



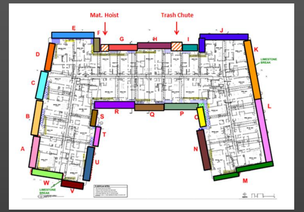
Elevation	Activity	Start	Finish	Duration
South	Brick	8 Mar 2013	15 June 2013	71
	Washdown & Balcony Fronts	19 Sept 2013	22 Oct 2013	33
Court	Brick	8 Mar 2013	13 June 2013	69
	Washdown & Balcony Fronts	16 Aug 2013	10 Sept 2013	25
East	Brick	15 June 2013	20 Sept 2013	69
	Washdown & Balcony Fronts	27 Sept 2013	22 Oct 2013	25
North	Brick	15 June 2013	20 Sept 2013	69
	Washdown & Balcony Fronts	20 Sept 2013	15 Oct 2013	25
Total		8 Mar 2013	22 Oct 2013	162
Total (excluding washdown & balcony fronts)		8 Mar 2013	27 Sept 2013	145

Total Brick Duration – 145 Days

Typical Elevation Duration – 70 Days

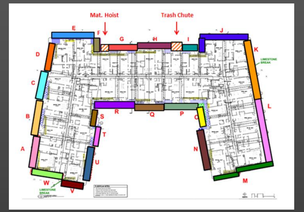
SIPS

Brick SIPS Schedule



Floor Level	Productivity Rate (per mason)
1	175 brick/day
2	175 brick/day
3	175 brick/day
4	170 brick/day
5	165 brick/day
6	160 brick/day
7	155 brick/day
8	150 brick/day

SIPS



Brick SIPS Schedule

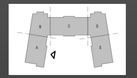
Floor Level	Productivity Rate (per mason)
1	175 brick/day
2	175 brick/day
3	175 brick/day
4	170 brick/day
5	165 brick/day
6	160 brick/day
7	155 brick/day
8	150 brick/day

Sample Calculation:

4th Floor – Zone E (East Elevation)
Total Area – 375 S.F.

375 S.F. × (6.55 brick)/(S.F.) = 2,457 brick

2,457 ÷ (170 (brick)/(per mason) × 3 masons) × 1.25 (6 hrs. of labor) = 6 days



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SIPS

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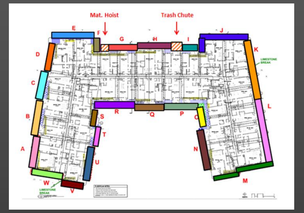
Woodley Park, NW Washington, DC



Floor Level	Productivity Rate (per mason)
1	175 brick/day
2	175 brick/day
3	175 brick/day
4	170 brick/day
5	165 brick/day
6	160 brick/day
7	155 brick/day
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Brick SIPS Schedule

Sample Calculation:

4th Floor – Zone E (East Elevation)
Total Area – 375 S.F.

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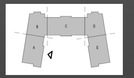

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Brick Exterior Skin SIPS Schedule

ITEM OF WORK	MONTH	March	March	March	March	April	April	April	April	May	May	May
	WEEK	3/4/2013	3/11/2013	3/18/2013	3/25/2013	4/1/2013	4/8/2013	4/15/2013	4/22/2013	4/29/2013	5/6/2013	5/13/2013
	DAY	M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F M T W R F										
South, Southwest, East												
Zone J - 10 Masons												
Zone K - 10 Masons												
Zone L - 10 Masons												
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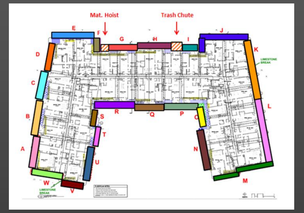
SIPS

Wardman West Residential
Woodley Park, NW Washington, DC



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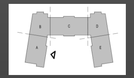
5	165 brick/day
6	160 brick/day
7	155 brick/day
8	150 brick/day

Brick SIPS Schedule

Total Brick SIPS Duration - 133 Days

Schedule Acceleration - 12 Days



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Brick Exterior Skin SIPS Schedule

ITEM OF WORK	MONTH	March	March	March	March	April	April	April	April	May	May	May
	WEEK	3/4/2013	3/11/2013	3/18/2013	3/25/2013	4/1/2013	4/8/2013	4/15/2013	4/22/2013	4/29/2013	5/6/2013	5/13/2013
	DAY	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F
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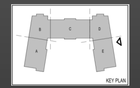
SIPS

APC Wall Panel SIPS Schedule

Construction Zone	Elevation	# of Panels	Crane	Duration (Days)
A1	East	22	Mobile	4
A2	East	26	Mobile	5
A3	East	22	Mobile	4
B	North	38	Mobile	7
C	Northwest	21	Mobile	4
D	South Courtyard	29	Tower	5
E	West Courtyard	34	Tower	6
F	North Courtyard	26	Tower	5
G1	South	26	Tower	5
G2	South	25	Tower	5
H	Southwest	21	Tower	4
Total		290		54



Average # of Panels per Zone - 27

Panel Erection Productivity Rate – 6 panels/day

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SIPS

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APC Wall Panel SIPS Schedule

Construction Zone	Elevation	# of Panels	Crane	Duration (Days)
A1	East	22	Mobile	4
A2	East	26	Mobile	5
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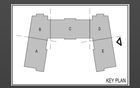
F	North Courtyard	26	Tower	5
G1	South	26	Tower	5
G2	South	25	Tower	5
H	Southwest	21	Tower	4
Total		290		54

Total APC Wall Panel SIPS Duration - 54 Days

Schedule Acceleration - 3 Days



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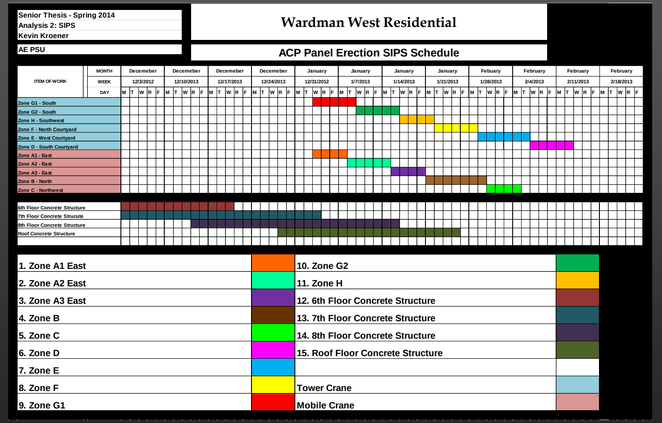

Safety Evaluation

Scoring Criteria:

Scoring Value	Level of Concern
1	Safety Category is considered fairly safe with a low level of safety concern involved.
2	Safety Category is considered somewhat hazardous with a moderate level of safety concern involved.
3	Safety Category is considered very dangerous with a high level of safety concern involved.

Safety Category	Precast Wall Panel Erection & Installation	Brick Masonry Installation
Fall Protection	3	3
Equipment Inspection	2	3
Safety Training	2	1
Hazardous Materials	2	2
Incidents/Injuries	3	2
Total Score	12	11

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Safety Evaluation

Wardman West Residential
Woodley Park, NW Washington, DC

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Incidents/Injuries	3	2
Total Score	12	11

Safety Category 1: Fall Protection

Activity	Safety Concerns	Score	Activity	Safety Concerns	Score
Precast Wall Panel Erection & Installation	• Commonly Precast Wall Panel erection requires laborers to work off of electric boom lifts, engine powered boom lifts or scissor lifts to secure panels once a crane picks the load to the desired location. • Work on these JLG's requires laborers to be tied off at all times	3	Brick Masonry Installation	• Exterior Enclosure brick work is performed on scaffolding. • If all required guardrails are properly in place per OSHA, masons are not required to tie off due to the protected fall exposure.	3

Safety Category 5: Incidents/Injuries

Activity	Safety Concerns	Score	Activity	Safety Concerns	Score
Precast Wall Panel Erection & Installation	• Fall • Falling objects • Crush injuries • Struck by hazard from crane superstructure • Swinging loads over other employees • Swinging or out of control load • Material handling (crush, caught in between, lifting, etc.) • Crane collapse • Faulty sling (load drop) • Rigging failure • Contact with overhead power line	3	Brick Masonry Installation	• Fall • Falling debris • Material handing (crush, lifting, cuts) • Scaffolding Collapse/Tipping/Hit by equipment • Windblown debris, contact with cement when mixing mortar • Burns and explosion when heating water and sand	2

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Safety Evaluation

Wardman West Residential
Woodley Park, NW Washington, DC

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Activity Hazard Analysis:

- Principle Steps
- Potential Hazards
- Recommended Controls
- Required Equipment
- Inspection Requirements
- Training Requirements

ACTIVITY HAZARD ANALYSIS

ACTIVITY: LIFTING PRECAST CONCRETE WALL PANELS

Project: AE Senior Thesis
Prepared By: Kevin Kroener
Date: 4/9/2014

Scope of Work: Precast Concrete Wall Panels

PRINCIPAL STEPS	POTENTIAL HAZARDS	RECOMMENDED CONTROLS
1. Select and Inspect Rigging	1.a. Damaged or unsafe rigging	1.a. & 1.b. Inspect rigging on a daily basis for safe working conditions. Remove form service and discharge any rigging if as necessary. Competent groundman, assisted by Erection Foreman, will select appropriate rigging for each lift.
	1.b. Under sized rigging or incorrect rigging	
2. Lift wall panel load	2.a. Crane malfunction or failure	2.a. Operator must perform daily inspections to ensure that crane is in safe working condition. Inspections will also be documented in the a crane logbook.
	2.b. Improper crane setup leading to tipping or failure	2.b. Ensure crane is on stable and level ground per the manufacturers specifications/recommendations. Proper boom radius as specified in crane capacity chart.
	2.c. Struck by hazard from crane superstructure	2.c. Barricade tail swing of crane
	2.d. Swinging of loads other employees	2.d. Ensure swing path is clear. Groundman and Erection Foreman will control area within swing radius of crane boom with assistance from GC field supervision. Swing path perimeter will be marked or barricaded to prevent employees from walking beneath load. The CAZ (Controlled Access Zone) will be set at an appropriate distance and the Groundman and Erection Foreman will remain alert to personnel entering restricted areas to keep people out of the swing path.
	2.e. Swinging or out of control panel load	2.e. Only one person at a time will give signals and have radio communication with crane operator. Taglines will be used to control loads

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
1. Tower Crane 2. Mobile Crane 3. Rigging 4. Tag lines 5. PPE - hard hat, safety glasses, steel-toe boots, reflective vests	1. Annual crane inspection 2. Daily crane inspection 3. Crane inspection upon arrival at site 4. Posted Certificate of Compliance on Crane 5. Daily rigging inspection	1. Certified Crane Operator 2. Erection Foreman has completed PCI's Certified Erector course 3. All erectors and riggers have completed rigging training ***** GC is responsible for training of all non- precast/erector personnel to remain clear of the precast work area and to obey warning signs and barricades.***

Conclusions & Recommendations

Analysis 1: Architectural Precast Concrete Wall Panels

- Accelerated Schedule – 46 Days
- Saved $ 646,000
- Improved Quality
- Structurally Feasible

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Conclusions & Recommendations

Analysis 1: Architectural Precast Concrete Wall Panels

- Accelerated Schedule – 46 Days
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Analysis 2: SIPS (Short Interval Production Schedule)

- Accelerated Schedule
  - Brick – 12 Days
  - APC Wall Panels – 3 Days
- Improved Productivity

Conclusions & Recommendations

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Analysis 2: SIPS (Short Interval Production Schedule)

- Accelerated Schedule
  - Brick – 12 Days
  - APC Wall Panels – 3 Days
- Improved Productivity

Analysis 3: Safety Evaluation

- Identified Safety Concerns
- Improved Site Safety w/ AHA

Acknowledgements

Academic Acknowledgments

Ray Sowers – Faculty Advisor &

The Architectural Engineering Department

Industry Acknowledgements

THE JBG COMPANIES
CLARK CONSTRUCTION
GATE PRECAST COMPANY
altusgroup
FRACO
Oldcastle

Special Thanks

Abe Vogel - Clark Construction Group, LLC

Sara Hand - Clark Construction Group, LLC

Wardman West Residential Project Team

John O'Keefe – Atkinson Construction

Matt Quigg – Gate Precast Company

Ed Kroener – WorleyParsons

Julia Gamble

My Family and Friends

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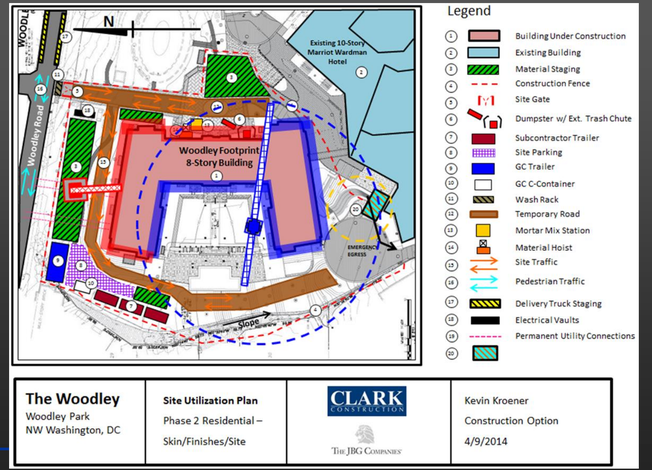
Questions?

Item	Unit	Quantity	Unit Price	Amount
Architectural Precast Concrete Panels				
APC Wall Panels	sf	69,212	$40.00	$ 2,768,480
*** includes attachment hardaware*				
Subtotal				**$ 2,768,480**
Metals				
Slab edge shelf angles	lf	11,700	$25.00	$ 292,500
Subtotal				**$ 292,500**
Misc.				
Caulking	sf	294,900	$0.50	$ 147,450
Brick at Penthouses	sf	5,883	$35.00	$ 205,905
Spandrel Beam	Cu Yd	72	$750.00	$ 54,000
Subtotal				$ 407,355
Total				**$3,468,335**

Item	Unit	Quantity	Unit Price	Amount
Brick				
Brick at Balconies	sf	1,130	$35.00	$ 39,540
Birck Soldier Course	sf	821	$45.00	$ 36,927
Brick Standard Size Running Bond	sf	74,274	$35.00	$ 2,599,593
Subtotal				**$ 2,676,060**
Backup, Sheathing and Insulation				
Metal Stud Backup with Sheathing	sf	111,669	$3.50	$ 390,841
Gypsum Board and Batt Insulation	sf	111,669	$2.25	$ 251
Rigid Insualtion	sf	111,669	$1.50	$ 255
Exterior Tyvek Wrap	sf	111,669	$0.50	$ 167,503
Subtotal				**$ 55,834**
Metals				
Slab edge shelf angles	lf	11,700	$25.00	$ 292,500
Subtotal				**$ 292,500**
Misc.				
Wall Flashings	sf	147,450	$1.00	$ 147,450
Caulking	sf	147,450	$0.50	$ 73,725
Scaffolding	mon.	9	$ 2,800.00	$ 25,200
Subtotal				**$ 246,375**
Limestone				
Headers and Sills	lf	3915	75	$ 293,625
Jambs	lf	4275	75	$ 320,625
Install of Headers, Sills and Jambs	lf	8190	28	$ 229,320
Subtotal				**$ 843,570**
Total				**$4,114,339**



The Woodley
Woodley Park
NW Washington, DC

Site Utilization Plan
Phase 2 Residential – Skin/Finishes/Site

CLARK CONSTRUCTION
The JBG Companies

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4/9/2014

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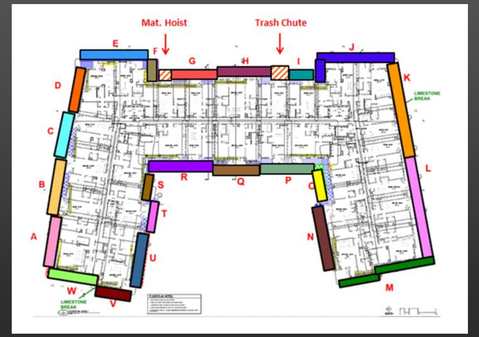

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Brick Exterior Skin SIPS Schedule

ITEM OF WORK	MONTH	March	March	March	March	April	April	April	April	May	May	May
	WEEK	3/4/2013	3/11/2013	3/18/2013	3/25/2013	4/1/2013	4/8/2013	4/15/2013	4/22/2013	4/29/2013	5/6/2013	5/13/2013
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5. Zone E		18. Zone R	
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10. Zone J		23. Zone W	
11. Zone K			
12. Zone L			
13. Zone M			

Wardman West Residential

Woodley Park, NW Washington, DC

ITEM OF WORK	MONTH	May	May	June	June	June	June	July	July	July	July	August
	WEEK	5/20/2013	5/27/2013	6/3/2013	6/10/2013	6/17/2013	6/24/2013	7/1/2013	7/8/2013	7/15/2013	7/22/2013	7/29/2013
	DAY	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F	M T W R F
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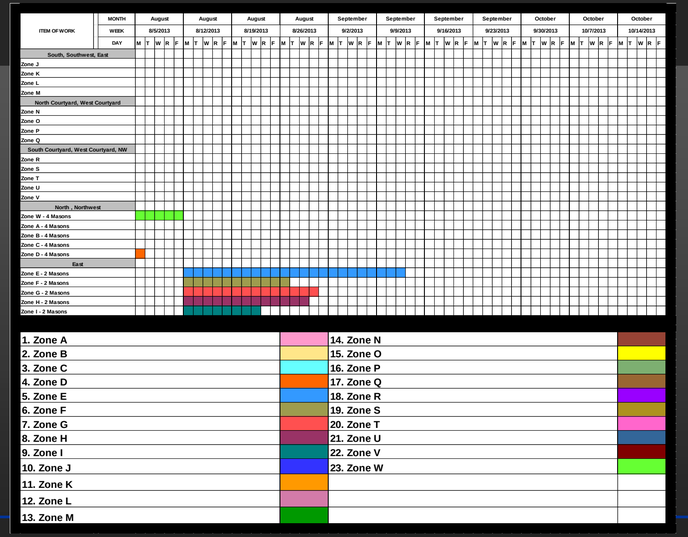

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