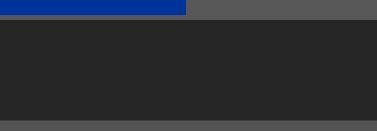


# Wardman West Residential

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



- Project Background
- Analysis Overview
- Depth 1: APC Panel Prefabrication
- Depth 2: SIPS
- Depth 3: Safety Evaluation
- **Conclusions & Recommendations**
- Acknowledgements



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**CLARK** CONSTRUCTION



# 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





- Project Background
- Analysis Overview
- II. Depth 1: APC Panel Prefabrication
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## AE Senior Thesis Project Kevin Kroener | Construction Option



# Introduction

## **Thesis Focus**

Slow Exterior Brick Masonry Work





- Project Background
- Analysis Overview
- Depth 1: APC Panel Prefabrication
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- **Conclusions & Recommendations**
- Acknowledgements VI.



### AE Senior Thesis Project Kevin Kroener | Construction Option



# Introduction

## **Thesis Focus**

Slow Exterior Brick Masonry Work

## Analysis Overview

Analysis 1: Architectural Precast Concrete Wall Panels

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





## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
- Product Selection
- **Transportation & Logistics**
- Cost Savings & Schedule Acceleration
- Structural Feasibility Study
- III. Depth 2: SIPS
- IV. Depth 3: Safety Evaluation
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## ×57

# AE Senior Thesis Project Kevin Kroener | Construction Option

## Problem:

Lagging Exterior Brick Masonry Work

## **Proposed Solution:**

Substitute Architectural Precast Concrete Wall Panels for Brick Veneer Wall



# **APC Wall Panel Prefabrication**



## Depth 1: APC Panel Prefabrication

- **Overview & Existing Wall System**
- Product Selection
- **Transportation & Logistics**
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# AE Senior Thesis Project Kevin Kroener | Construction Option

## **Problem:**

<u>\_\_\_\_</u>

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

# **APC Wall Panel Prefabrication**

## Overview



Courtesy of PCI



## Depth 1: APC Panel Prefabrication

- **Overview & Existing Wall System**
- Product Selection
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### AE Senior Thesis Project Kevin Kroener | Construction Option

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

# **APC Wall Panel Prefabrication**

## Overview



Courtesy of PCI

## **Existing Wall System**

| Material                                  | Thickness (inc |
|---|----------------|
| 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            |

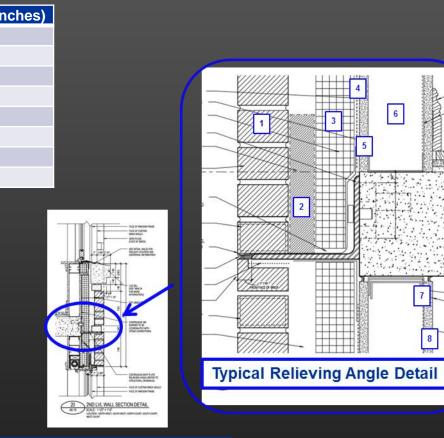


Courtesy of Clark Construction

## Wardman West Residential

Woodley Park, NW Washington, DC





## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
- Product Selection
- **Transportation & Logistics**
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AE Senior Thesis Project Kevin Kroener | Construction Option

## 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



# **APC Wall Panel Prefabrication**

## **Product Selection**



## C-GRID Carbon Fiber Grid:

- Shear connector between concrete wythes
- Minimum wythe thickness of 1 <sup>3</sup>/<sub>4</sub>"
- Up to 40% lighter



**a**carboncast°

Less concrete means less weight, less embodied energy and a reduced carbon



## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
- **Product Selection**
- **Transportation & Logistics**
- **Cost Savings & Schedule Acceleration**
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AE Senior Thesis Project Kevin Kroener | Construction Option

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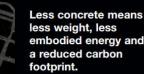
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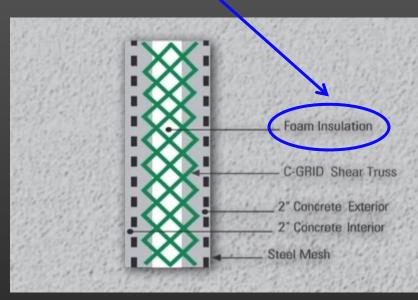


## **C-GRID Carbon Fiber Grid:**

- Shear connector between concrete wythes
- Minimum wythe thickness of 1 <sup>3</sup>/<sub>4</sub>"
- Up to 40% lighter



EPS, XPS or Poly-Iso foam Rigid Insulation



**Courtesy of AltusGroup** 

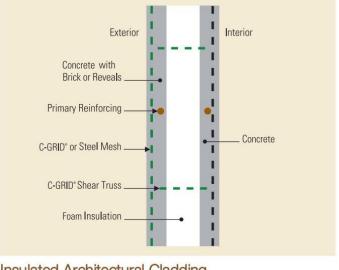


**a**carboncast°

embodied energy and

### Wardman West Residential Woodley Park, NW Washington, DC





Insulated Architectural Cladding Horizontal Section

Courtesy of AltusGroup

## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
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## 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.



# **APC Wall Panel Prefabrication**



# Depth 1: APC Panel Prefabrication Overview & Existing Wall System

- Product Selection
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# AE Senior Thesis Project Kevin Kroener | Construction Option

## Crane Use

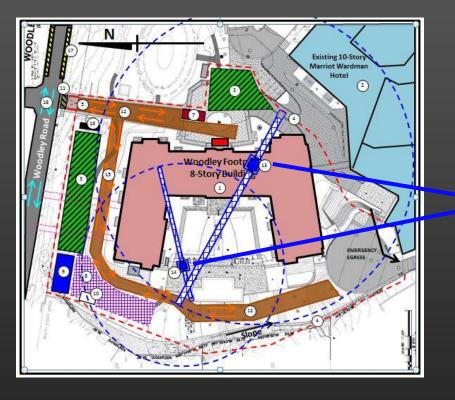


## Mobile Crane

Precast Subcontractor

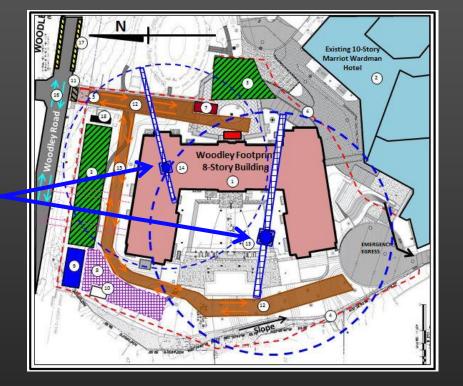
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# **APC Wall Panel Prefabrication**

## **Tower Crane Relocation**





## Depth 1: APC Panel Prefabrication

- Overview & Existing Wall System
- Product Selection
- Transportation & Logistics
- Cost Savings & Schedule Acceleration
- Structural Feasibility Study
- II. Depth 2: SIPS
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### AE Senior Thesis Project Kevin Kroener | Construction Option

## Crane Use

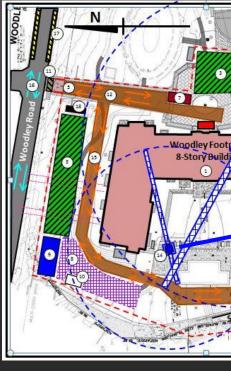


## Mobile Crane

Precast Subcontractor

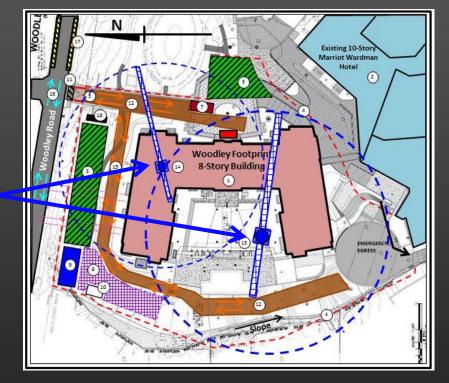
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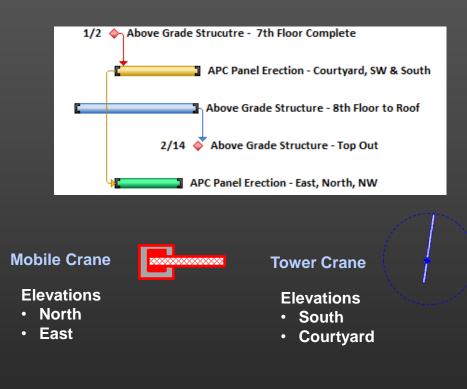
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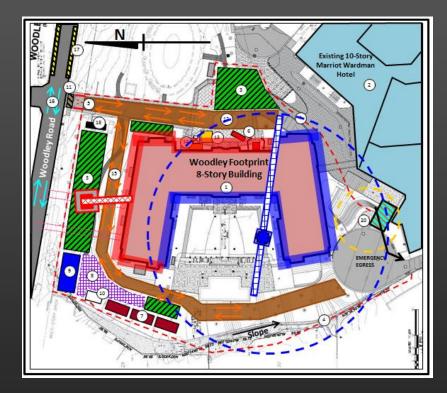




### Wardman West Residential Woodley Park, NW Washington, DC



## Workflow Sequence



## Depth 1: APC Panel Prefabrication

- **Overview & Existing Wall System**
- Product Selection
- **Transportation & Logistics**
- Cost Savings & Schedule Acceleration
- Structural Feasibility Study
- Depth 2: SIPS Ш./
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## <u>\_\_\_\_</u>

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## Transportation

## Flatbed or Low-deck Trailers:

• Used for precast panels < 12' x 40'



Courtesy of Oldcastle

# **APC Wall Panel Prefabrication**



## Depth 1: APC Panel Prefabrication

- **Overview & Existing Wall System**
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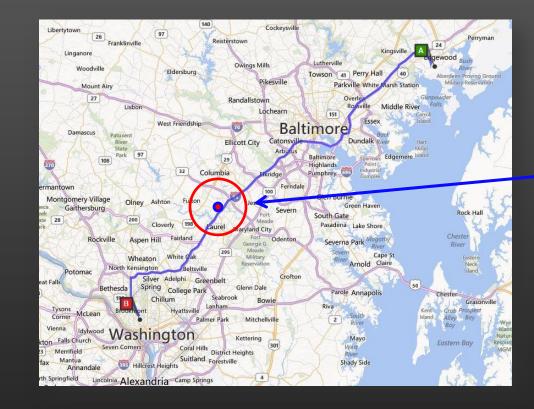
## Shipping:

- Oldcastle Precast Building Systems
- Plant Location Edgewood, Maryland



# **APC Wall Panel Prefabrication**

## Delivery





## **Rest Stop Staging**

### Wardman West Residential Woodley Park, NW Washington, DC



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

## Depth 1: APC Panel Prefabrication

- Overview & Existing Wall System
- Product Selection
- Transportation & Logistics
- Cost Savings & Schedule Acceleration
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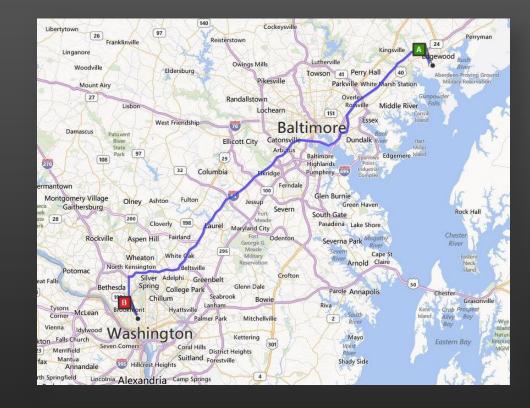


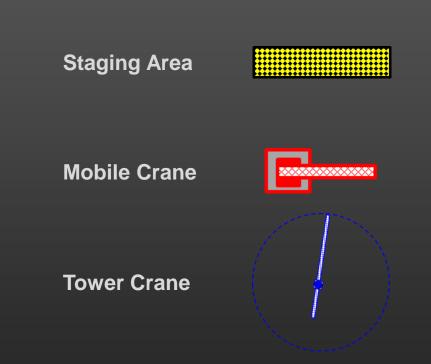
# **APC Wall Panel Prefabrication**

## Delivery

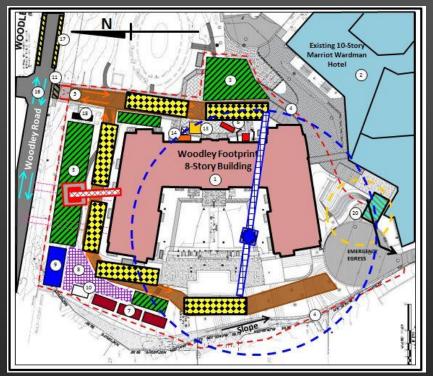
## Site Staging

Building Systems dgewood,









## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
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- **Transportation & Logistics**
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## 

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## Existing Brick Veneer Wall System

| ltem                        |
|-----------------------------|
| Brick                       |
| Backup, Sheathing and Insul |
| Metals                      |
| Misc.                       |
| Limestone                   |
| Total                       |

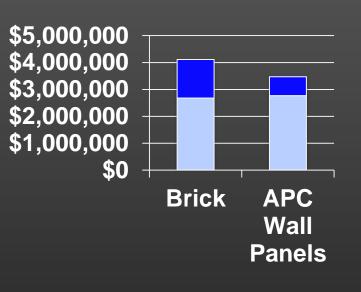
## APC Wall Panels

| ltem                          |
|-------------------------------|
| Architectural Precast Concret |
| (including attachment hardwa  |
| Penthouse Brick               |
| Metals                        |
| Misc.                         |
| Total                         |

# **APC Wall Panel Prefabrication**

## **Cost Savings**

|       | Amount      |
|-------|-------------|
|       | \$2,676,060 |
| ation | \$55,834    |
|       | \$292,500   |
|       | \$246,375   |
|       | \$843,570   |
|       | \$4,114,339 |
|       |             |



|           | Amount      |
|-----------|-------------|
| te Panels | \$2,768,480 |
| are)      |             |
|           | \$205,905   |
|           | \$292,500   |
|           | \$407,355   |
|           | \$3,468,335 |





## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
- Product Selection
- **Transportation & Logistics**
- **Cost Savings & Schedule Acceleration**
- Structural Feasibility Study
- Depth 2: SIPS
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### AE Senior Thesis Project Kevin Kroener | Construction Option

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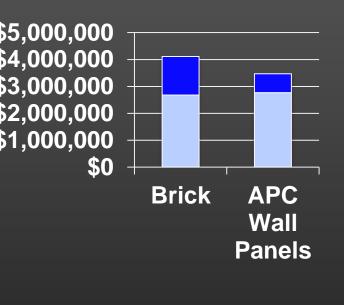
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|           | \$205,905   |
|           | \$292,500   |
|           | \$407,355   |
|           | \$3,468,335 |





## **Schedule Acceleration**

|                   | Activity                  | Start       | Finish      | Duration<br>(Work Days) |
|-------------------|---------------------------|-------------|-------------|-------------------------|
| Original Duration | APC Wall Panels           | 2 Jan 2012  | 15 Feb 2013 | 32                      |
| for Brick Work:   | Windows                   | 18 Jan 2013 | 14 Jun 2013 | 105                     |
|                   | Stone                     | 6 Mar 2013  | 17 Aug 2013 | 118                     |
| 145 Days          | Penthouse Brick           | 11 Jul 2013 | 7 Aug 2013  | 20                      |
| 145 Days          | Balcony Front Brick       | 10 Jul 2013 | 10 Aug 2013 | 23                      |
|                   |                           |             |             |                         |
|                   | Revised Ext. Skin Total   | 2 Jan 2012  | 17 Aug 2013 | 163                     |
|                   | Duration                  |             |             |                         |
| Accelerated       | Schedule Acceleration w/  |             |             | 46                      |
| Duration for APC  | Earlier Finish Date       |             |             |                         |
| Wall Panels:      |                           |             |             |                         |
|                   | Activity                  | Duration    |             |                         |
|                   |                           | (Work Days) |             |                         |
| 32 Days           | APC Wall Panels (Raw)     | 57          |             |                         |
|                   | APC Wall Panel w/ Phasing | 32          |             |                         |
|                   | Schedule Acceleration     | 88          |             |                         |
|                   | w/ Phasing                | 113         |             |                         |

## Wardman West Residential

Woodley Park, NW Washington, DC



## epth 1: APC Panel Prefabrication

- **Overview & Existing Wall System**
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### **AE Senior Thesis Project** Kevin Kroener | Construction Option

## Results

## SAVINGS = **\$646,000**

- Cost Compared **Existing System**
- Cost of Building Enclosure
- + 46 Days to Project Schedule

## Existing Brick Veneer Wall System

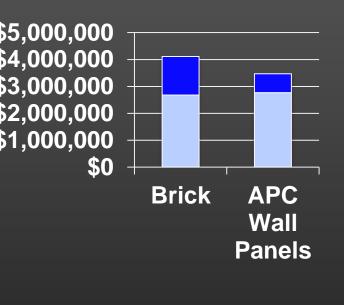
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| Brick                            | \$2,676,060 |
| Backup, Sheathing and Insulation | \$55,834    |
| Metals                           | \$292,500   |
| Misc.                            | \$246,375   |
| Limestone                        | \$843,570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

## **APC Wall Panels**

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

# **APC Wall Panel Prefabrication**

## **Cost Savings**





## **Schedule Acceleration**

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## Wardman West Residential

Woodley Park, NW Washington, DC



## **Depth 1: APC Panel Prefabrication**

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Code: IBC 2006 / ASCE 7-05

Assumption:

Windward exposure

Leeward exposure

Max Suction Force =

# **APC Wall Panel Prefabrication**

## Wind & Seismic Loading

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

### Wind:

 $P = q_h \times (+GC_p) - q_h \times (-GC_{pi})(lb./ft.^2)$  $P = 18.3 \times (+0.62) - 18.3 \times (-0.18) = 14.64 \ lb./_{ft^2}$  $P = q_h \times (-GC_p) - q_h \times (+GC_{pi})(\frac{lb}{ft^2})$  $P = 18.3 \times (-1.1) - 18.3 \times (+0.18) = 23.4 \ lb./_{ft^2}$ 

Seismic:

$$F_{p} = \begin{pmatrix} 0.4 a_{p} S_{DS} W_{p} \\ / \begin{pmatrix} R_{p} / I_{p} \end{pmatrix} \end{pmatrix} \times (1 + (2 \times z / h))$$

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



## **Depth 1: APC Panel Prefabrication**

- **Overview & Existing Wall System**
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## Hardware Selection

## **SERIES 4500**



Courtesy of JVI

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

Code: IBC 2006 / ASCE 7-05

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**AE Senior Thesis Project** Kevin Kroener | Construction Option

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## Max Suction Force =

# **APC Wall Panel Prefabrication**

## Wind & Seismic Loading

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

### Wind:

Seismic:

$$F_{p} = \begin{pmatrix} 0.4 a_{p} S_{DS} W_{p} \\ / \begin{pmatrix} R_{p} \\ I_{p} \end{pmatrix} \end{pmatrix} \times (1 + (2 \times Z/h))$$

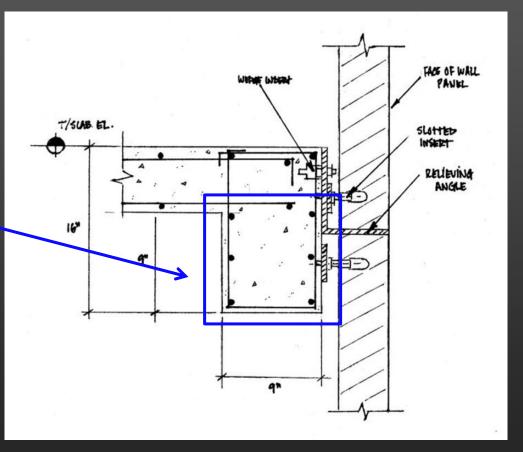
Horizontal Seismic Force = 850 lb. (10% of Wind Load)

## Lateral Attachment & Spandrel Beam Redesign

16" x 9" Spandrel Beam

Added Cost:

\$ 54,000





- II. Depth 1: APC Panel Prefabrication
  III. Depth 2: SIPS
  IV. Depth 3: Safety Evaluation
  V. Conclusions & Recommendations
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## 

# AE Senior Thesis Project Kevin Kroener | Construction Option



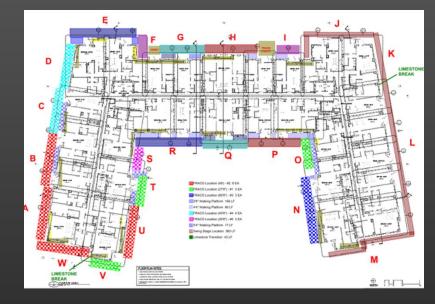
II. Depth 1: APC Panel Prefabrication

## Depth 2: SIPS

- Original Schedule Analysis
- Brick SIPS
- APC Panel SIPS
- IV. Depth 3: Safety Evaluation
- **Conclusions & Recommendations**
- VI. Acknowledgements



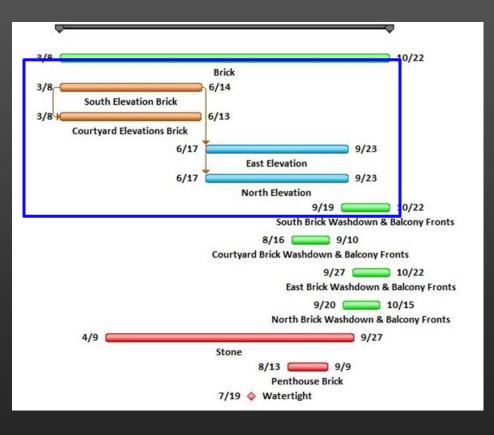
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Courtesy of Clark Construction

# SIPS

## **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 wa | ashdown & balcony fronts) | 8 Mar 2013   | 27 Sept 2013 | 145      |

**Total Brick Duration – 145 Days** 

**Typical Elevation Duration – 70 Days** 

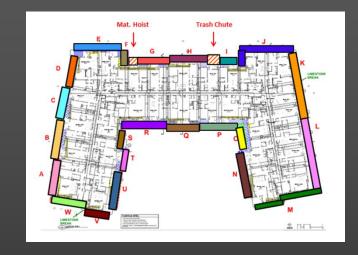


II. Depth 1: APC Panel Prefabrication III. Depth 2: SIPS

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| Floor Level | Productivity Rate (per<br>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**



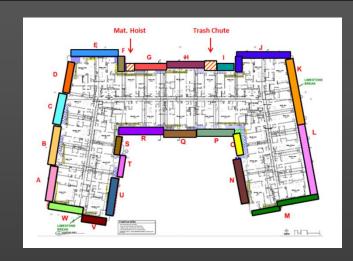
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|-------------|----------------------------------|
| 1           | 175 brick/day                    |
| 2           | 175 brick/day                    |
| 3           | 175 brick/day                    |
| 4           | 170 brick/day                    |
| 5           | 165 brick/day                    |
| 6           | 160 brick/day                    |
| 7           | 155 brick/day                    |
| 8           | 150 brick/day                    |

## Sample Calculation:

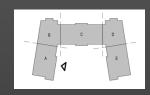
4th Floor – Zone E (East Elevation) Total Area – 375 S.F.

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

# SIPS

## **Brick SIPS Schedule**









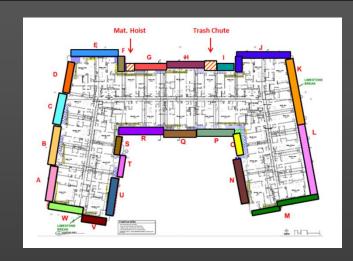
II. Depth 1: APC Panel Prefabrication

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- Original Schedule Analysis
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| Floor Level | Productivity Rate (per<br>mason) |
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| 1           | 175 brick/day                    |
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| 3           | 175 brick/day                    |
| 4           | 170 brick/day                    |
| 5           | 165 brick/day                    |
| 6           | 160 brick/day                    |
| 7           | 155 brick/day                    |
| 8           | 150 brick/day                    |

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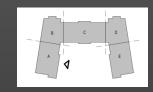
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# SIPS

## **Brick SIPS Schedule**







| Senior Thesis - Spr<br>Analysis 2: SIPS<br>Kevin Kroener | ing 2014    |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      | I    | N   | a   | rd  | ln   | na | n   | V  | N      | e   | st | R  | e    | si    | d  | er | nti | ia    | 1   |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
|--|-------------|---|----|-------------------|----|----|----|--------|------|---|---|------|-------|----|---|----|------|------|-----|-----|-----|------|----|-----|----|--------|-----|----|----|------|-------|----|----|-----|-------|-----|-----|----|-------|------|---|---|----|-------|----|-----|----|--------|------|---|--|
| AE PSU   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      | F    | Rri | icl | k F | Ξv   | te | ri  | ٦r | S      | ki  | n  | SI | P    |       | Sc | h¢ | ed  | ш     | Δ   |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
|  |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     | _^   |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
|  | MONTH       |   | Ν  | Marc              | h  |    |    | Mar    | ch   |   |   | М    | arch  | I  |   |    | Mar  | ch   |     |     | A   | pril |    |     |    | Apr    | il  |    |    | A    | pril  |    |    |     | Apri  | I   |     |    | Ма    | ay   |   |   |    | May   |    |     |    | Ма     | iy   |   |  |
| ITEM OF WORK   | WEEK        |   | 3/ | 4/20 <sup>.</sup> | 13 |    | 3  | 3/11/2 | 2013 |   |   | 3/18 | 8/201 | 13 |   | 3  | 25/2 | 2013 |     |     | 4/1 | /201 | 3  |     | 4  | 1/8/20 | 013 |    |    | 4/15 | 5/201 | 3  |    | 4/2 | 22/20 | 013 |     |    | 4/29/ | 2013 |   |   | 5/ | 6/201 | 3  |     | 5  | 5/13/: | 2013 |   |  |
|  | DAY         | м | т  | w                 | RI | FM | ۱т | w      | R    | F | м | т    | WR    | ۲  | N | ιт | w    | R    | F   | м   | т   | w    | RF | : N | т  | w      | R   | F  | м  | т١   | N R   | F  | м  | т   | w     | RF  | : N | ١Т | · w   | / R  | F | м | т  | w     | RF | - N | ιт | w      | R    | F |  |
| South, Southwest,  | East        |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone J - 10 Masons                                       |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone K - 10 Masons                                       |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone L - 10 Masons                                       |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone M - 10 Masons                                       |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| North Courtyard, West (                                  | Courtyard   |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone N - 5 Masons  |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone O - 5 Masons  |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone P - 5 Masons  |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone Q - 5 Masons  |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| South Courtyard, West Co                                 | urtyard, NW |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone R   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone S   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone T   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone U   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone V   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| North , Northwe  | st          |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone W   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone A   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone B   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone C   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone D   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| East   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone E   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    | T   |    |        |      |   |  |
| Zone F   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone G   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone H   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
| Zone I   |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |
|  |             |   |    |                   |    |    |    |        |      |   |   |      |       |    |   |    |      |      |     |     |     |      |    |     |    |        |     |    |    |      |       |    |    |     |       |     |     |    |       |      |   |   |    |       |    |     |    |        |      |   |  |



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Floor Level Productivity Rate (per mason) 175 brick/day 175 brick/day 175 brick/day 170 brick/day 165 brick/day 160 brick/day 155 brick/day 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

# SIPS

## **Brick SIPS Schedule**

Total Brick SIPS Duration - 133 Days

Schedule Acceleration - 12 Days





| Senior Thesis - Spr<br>Analysis 2: SIPS<br>Kevin Kroener | ing 2014    |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   | N  | Va  | ar | dı    | m   | a  | n  | N   | le   | es  | <b>t</b> ] | R   | es    | 5 <b>i</b> ( | de  | en | ti  | a    | 1  |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
|--|-------------|---|----|-------|----|-----|----|-------|-----|---|-----------|------|-------|---|---|-----|-------------------|----|-----|----|-------|-----|----|----|-----|------|-----|------------|-----|-------|--------------|-----|----|-----|------|----|---|----|-------|------|---|---|-----------|--------|----|---|--------|-------|-----|-----------|--|
| AE PSU   |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   | Bı | ric | :k | E     | xt  | er | io | r S | Sk   | rin | 1 5        | SIF | s     | S            | Scl | ne | dı  | JI   | e  |   |    |       |      |   |   |           |        | 7  |   |        |       |     |           |  |
|  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       | ~~~ |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   | _         | _      |    |   |        |       |     |           |  |
|  | MONTH       |   | Ν  | larc  | h  |     |    | Marc  | ch  |   |           | Ма   | rch   |   |   | М   | arch              | 1  |     |    | Арі   | il  |    |    | Α   | pril |     |            |     | Ар    | ril          |     |    | A   | pril |    |   |    | Ма    | ay   |   |   | ,         | May    |    |   |        | Mag   | у   |           |  |
| ITEM OF WORK   | WEEK        |   | 3/ | 4/201 | 13 |     | 3  | /11/2 | 013 |   |           | 3/18 | /2013 |   |   | 3/2 | 5/20 <sup>-</sup> | 13 |     | 4  | 4/1/2 | 013 |    |    | 4/8 | /201 | 3   |            | 4   | 4/15/ | 2013         | ;   |    | 4/2 | 2/20 | 13 |   | 4  | 1/29/ | 2013 | ; |   | 5/6       | 6/2013 | 3  |   | 5      | /13/2 | 013 |           |  |
|  | DAY         | м | т  | w     | RF | = M | ιт | w     | R   | F | мт        | v    | V R   | F | м | т   | w                 | ۲F | M   | ١Т | w     | R   | F  | м  | т١  | w    | RF  | FN         | иΤ  | w     | R            | F   | м  | т   | w    | RF | м | ιТ | w     | R    | F | м | т         | W F    | RF | м | Т      | w     | R   | F         |  |
| South, Southwest,  | East        |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       | 1            |     |    |     |      |    |   |    | +     |      |   |   |           |        |    |   | +      | 1     |     | $\square$ |  |
| Zone J - 10 Masons                                       |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     | Π         |  |
| Zone K - 10 Masons                                       |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| Zone L - 10 Masons                                       |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| Zone M - 10 Masons                                       |             |   |    |       |    |     |    |       |     |   |           | Т    |       |   |   |     |                   |    | Т   |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| North Courtyard, West (                                  | Courtyard   |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| Zone N - 5 Masons  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| Zone O - 5 Masons  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| Zone P - 5 Masons  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| Zone Q - 5 Masons  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |
| South Courtyard, West Co                                 | urtyard, NW |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   | ┶      |       |     |           |  |
| Zone R   |             | _ |    |       |    |     |    |       |     |   |           |      | _     |   |   |     |                   |    | _   |    | _     |     |    |    |     |      |     |            |     |       |              | _   |    |     |      |    |   |    |       | _    | _ |   |           |        | _  |   | _      |       | 4   |           |  |
| Zone S   |             | _ |    |       |    |     | _  |       |     |   |           |      |       |   |   |     |                   |    | _   |    | _     |     |    |    |     |      |     |            |     |       |              | _   |    |     |      |    |   | _  |       | _    | _ |   |           | _      | _  | _ | _      |       | 4   | $\square$ |  |
| Zone T   |             | _ |    |       |    | _   | _  | _     |     |   |           | _    |       |   |   |     |                   |    | _   |    | _     | _   |    |    |     |      |     |            |     |       |              | _   |    |     |      |    |   | _  |       | _    | _ |   | $\square$ | _      | _  | _ | 4      |       | 4   |           |  |
| Zone U   |             | _ |    |       |    |     | _  | _     |     |   |           |      |       |   |   |     |                   |    | _   |    | _     | _   |    |    |     |      |     |            |     |       | _            | _   |    |     |      |    |   | _  |       | _    | _ |   |           | _      | _  | _ | 4      | _     | 4   | $\square$ |  |
| Zone V   |             |   |    |       |    | _   | _  | _     |     |   |           | _    | _     |   |   |     |                   |    | _   |    | _     | _   |    |    |     | _    |     | _          |     |       | _            | _   |    |     |      |    |   | _  | _     | _    | _ |   | $\square$ | _      | +  | _ | +      | _     | ╞   | $\vdash$  |  |
| North , Northwe  | st          | - |    |       |    | _   | _  | _     |     |   |           | _    | _     |   |   |     |                   |    | _   |    | _     | _   |    |    |     | _    |     | _          |     |       | _            | _   |    |     |      |    |   | _  | _     | _    | _ |   | $\square$ | _      | +  | _ | +      | _     | ╞   | $\vdash$  |  |
| Zone W   |             | - | _  |       |    | _   | _  |       |     |   |           |      | _     | - |   |     |                   |    | +   | -  | _     | _   |    |    |     | -    |     |            | -   | -     | _            | _   |    |     |      |    |   | _  |       | _    | - |   | $\vdash$  | 4      | _  | _ | +      | +-    | +   | $\vdash$  |  |
| Zone A   |             | - |    |       |    | _   | _  | _     |     |   |           | _    | _     | - |   |     |                   |    | +   |    | _     | _   |    |    |     | -    | _   | _          | -   |       | -            |     |    |     |      |    |   | _  | _     | _    | - |   | $\vdash$  | -      | _  | _ | +      | +     | +   | $\square$ |  |
| Zone B   |             | - |    |       |    | _   | _  | _     |     |   |           | _    | _     |   |   |     |                   |    | -   | -  | _     | -   |    |    |     | -    |     | _          | -   | -     | -            | _   |    |     |      |    | _ | _  | _     | _    | _ |   | $\vdash$  | —      | +  | _ | +      | +     | +   | +         |  |
| Zone C<br>Zone D   |             | - | -  |       | _  |     | _  | -     |     |   |           | -    | _     |   |   |     |                   | _  | -   | -  | _     | -   |    |    |     | -    | _   | _          | -   | -     | -            | _   |    |     |      |    | _ |    | +     | _    | - |   |           | -      | +  | _ | +      | +     | +   | +         |  |
| East   |             |   |    |       | -  | -   | -  | +     |     |   |           | +    | +     |   |   | _   |                   |    | +   |    | -     | +   |    |    | -   | +    | -   |            | +   |       | +            | -   |    |     | _    |    |   | +  | +     | -    | + |   |           | +      | +  |   | +      | +     | +   | ⊢         |  |
| Zone E   |             | T |    |       |    | -   |    |       |     |   |           | +    | +     |   |   |     |                   |    | +   |    |       |     |    |    |     | +    |     |            |     |       | +            |     |    |     |      |    |   |    | +     |      |   |   |           |        | +  |   | +      | +     |     | +         |  |
| Zone F   |             |   |    |       |    |     | +  |       |     |   |           |      |       |   |   |     |                   |    | +   |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    | + |    |       |      |   |   | H         | +      | +  |   | +      | +     |     | $\square$ |  |
| Zone G   |             | 1 |    |       |    |     |    | 1     |     |   | $\square$ |      |       |   |   |     |                   |    | +   |    |       | T   |    |    |     |      |     |            |     |       | 1            |     |    |     |      |    | + |    | +     | +    | 1 | t | H         |        | -  |   | +      | +     |     | $\square$ |  |
| Zone H   |             |   | 1  |       |    |     |    |       |     |   |           | +    |       |   |   |     | +                 |    | t   |    |       | t   |    |    |     |      |     |            |     |       |              |     |    |     |      |    | t |    |       |      |   |   | H         | +      |    |   | +      | +     |     | $\square$ |  |
| Zone I   |             | 1 |    |       |    |     |    |       |     |   | H         |      |       |   |   |     | 1                 |    |     |    |       | T   |    |    |     |      |     |            |     |       |              | 1   |    |     |      |    |   |    | T     |      |   |   |           |        |    |   | $\top$ | 1     |     | $\square$ |  |
|  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        | ه ا   |     |           |  |
|  |             |   |    |       |    |     |    |       |     |   |           |      |       |   |   |     |                   |    |     |    |       |     |    |    |     |      |     |            |     |       |              |     |    |     |      |    |   |    |       |      |   |   |           |        |    |   |        |       |     |           |  |



II. Depth 1: APC Panel Prefabrication

## Depth 2: SIPS

- Original Schedule Analysis
- Brick SIPS
- APC Panel SIPS
- IV. Depth 3: Safety Evaluation
- **Conclusions & Recommendations V**.
- VI. Acknowledgements



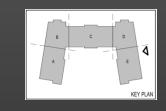
# AE Senior Thesis Project Kevin Kroener | Construction Option

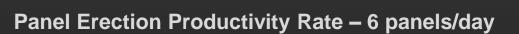
| Construction | Elevation | # of   | Crane  | Duration |
|--------------|-----------|--------|--------|----------|
| Zone         |           | Panels |        | (Days)   |
| A1           | East      | 22     | Mobile | 4        |
| A2           | East      | 26     | Mobile | 5        |
| A3      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

## Average # of Panels per Zone - 27

# SIPS

## APC Wall Panel SIPS Schedule









II. Depth 1: APC Panel Prefabrication

## Depth 2: SIPS

- Original Schedule Analysis
- Brick SIPS
- APC Panel SIPS
- IV. Depth 3: Safety Evaluation
- V. Conclusions & Recommendations
- VI. Acknowledgements



# AE Senior Thesis Project Kevin Kroener | Construction Option

| Construction<br>Zone | Elevation | # of<br>Panels | Crane  | Duration<br>(Days) |
|----------------------|-----------|----------------|--------|--------------------|
| A1                   | East      | 22             | Mobile | (Day3)<br>4        |
| A2                   | East      | 26             | Mobile | 5                  |
| A3                   | East      | 20             | Mobile | 4                  |
|                      | North     | 38             | Mobile | 4                  |
| В                    |           |                |        | -                  |
| C                    | Northwest | 21             | Mobile | 4                  |
| D                    | South     | 29             | Tower  | 5                  |
|                      | Courtyard |                |        |                    |
| E                    | West      | 34             | Tower  | 6                  |
|                      | Courtyard |                |        |                    |
| F                    | North     | 26             | Tower  | 5                  |
|                      | Courtyard |                |        |                    |
| G1                   | South     | 26             | Tower  | 5                  |
| G2                   | South     | 25             | Tower  | 5                  |
| Н                    | Southwest | 21             | Tower  | 4                  |
| Total                |           | 290            |        | 54                 |

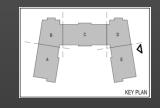
## Average # of Panels per Zone - 27

# SIPS

## **APC Wall Panel SIPS Schedule**

Total APC Wall Panel SIPS Duration - 54 Days

Schedule Acceleration - 3 Days





|           | [ |    | TH       | İ.          |          |    |    | ПП | /    |       |    | -      | <b>4</b> 1113 |
|-----------|---|----|----------|-------------|----------|----|----|----|------|-------|----|--------|---------------|
|           |   |    | <u>ب</u> | <b>F</b>    | <b>H</b> | H  | H  |    | Ŧ    | ¦⊞j   | F  | B      | ĺΠ.           |
| ल्ता ल्यी |   |    |          | m.          | 兩        | Η  |    |    | 園    | B     | B  | 田田     |               |
| 国田        |   | z  | one      | G1          |          |    |    |    | Zo   | one G | 2  | е<br>Т |               |
| 田田        |   |    | 圕        |             |          | 日田 | 圕田 |    |      | 日田    | 田田 | H      |               |
|           |   | B  | 8        | <u>ل</u> تو | 'III     | B  |    | ΞŦ | 'III | Ð     |    |        |               |
| Ħ         |   | į. | B/       |             |          | Ē  | ₿  |    |      | Î     | Ħ  | Ħ      |               |

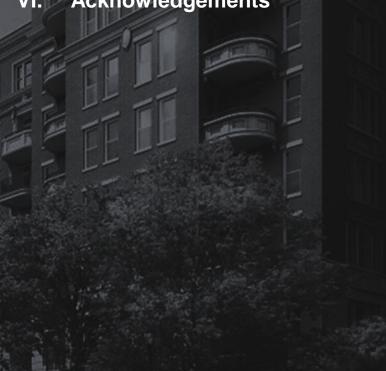
| Senior Thesis - Spr<br>Analysis 2: SIPS<br>Kevin Kroener | ing 2014 |   |              |     |   |   | Wardman West Residential<br>ACP Panel Erection SIPS Schedule |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
|--|----------|---|--------------|-----|---|---|--|---|----|----|---|------|---|---|-------|----|-----------------------------|----|-------|------|------|-----|-----|-------|-----|------|-----|-------|-----|-----|------------|-------|----|---|---|-------|---|---|---|------|-----|---|---|------|----|----|---|-------|---|---|
| AE PSU   |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       | A  | C                           | Р  | Pa    | ne   | i l  | Er  | ec  | tic   | on  | S    | SIF | s     | S   | ch  | ec         | łu    | le |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
|  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | -  |       |      | _    |     |     |       |     |      |     |       |     | -   |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
|  | MONTH    | _ | Decen        |     |   |   | ecem   |   |    |    |   | nebe |   |   | Decer | _  |                             |    | Janu  |      |      |     |     | nuary | _   |      |     | anua  | · · |     |            | anua  | -  | _ |   | ouary |   |   |   | orua |     |   |   | brua |    |    |   | ebru  | - |   |
| ITEM OF WORK   | WEEK     |   | 12/3/<br>T W |     |   |   | 2/10/2   |   |    |    |   | 2013 | _ |   | 12/24 |    |                             |    | 12/31 |      |      |     |     | /2013 |     | _    |     | 14/20 |     | _   |            | /21/2 |    |   |   | /201  |   |   |   | /201 |     | _ |   | 1/20 |    |    |   | /18/2 |   |   |
|  | DAY      | м | тw           | / R | F |   | w  | R | FN | ит | w | R    | F | м | т и   | VR | F                           | м  | TW    | R    | F    | м   | т   | WR    | F   | м    | Т   | w     | RF  | FN  | <u>и</u> т | w     | RF | M | т | NR    | F | м | т | WF   | ₹ F | м | т | w    | RI | FN | T | w     | R | F |
| Zone G1 - South  |          |   |              |     |   | - |  |   | _  |    | + |      |   |   | _     | -  |                             |    |       |      |      |     |     |       |     |      |     |       | -   |     | -          | -     |    | _ |   | -     |   | - |   | _    | _   | - |   |      | -  |    | + | _     |   |   |
| Zone G2 - South<br>Zone H - Southwest                    |          |   |              | +   |   |   | +  |   |    |    | + | -    |   |   | -     |    |                             |    |       | +    | 1    |     |     |       |     |      |     |       |     |     |            | +     |    | - | + | +     |   | + |   |      |     |   |   |      | -  |    | + |       |   |   |
| Zone F - North Courtyard                                 |          |   |              | +   |   | - | -  |   | -  | -  | + | -    |   |   | -     | +  | +                           |    |       | +    | 1    |     |     | -     | +   | +    |     |       |     |     |            |       |    |   |   | +     | - |   |   |      |     | - |   |      | -  |    | + |       |   |   |
| Zone E - West Courtyard                                  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Zone D - South Courtyard                                 |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Zone A1 - East   |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Zone A2 - East   |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Zone A3 - East   |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Zone B - North   |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Zone C - Northwest                                       |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 6th Floor Concrete Structure                             | ,        |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 7th Floor Concrete Strucute                              |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 8th Floor Concrete Structure                             | )        |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| Roof Concrete Structure                                  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
|  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
|  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 1. Zone A1 East  | t        |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | 10 | ). Z  | on   | e (  | G2  | 2   |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 2. Zone A2 East  | ŀ        |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | 11 | . z   | on   | e I  | н   |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
|  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       | -    | -    |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 3. Zone A3 East  | 1        |   |              |     |   |   |  |   |    |    |   |      | _ |   |       |    |                             | 12 | 2. 6  | tn   | FI   | 00  | rc  | or    | ncr | rete | e   | Stru  | uc  | tui | re         |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 4. Zone B  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | 13 | 3. 7  | th   | Fle  | 00  | r C | Cor   | ncr | rete | e S | Stru  | uct | tuı | re         |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 5. Zone C  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | 14 | . 8   | th   | Fle  | 00  | r C | Cor   | ncı | rete | e S | Stru  | uct | tuı | re         |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 6. Zone D  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | 15 | . R   | 00   | of F | Flo | oor | C     | on  | cre  | ete | e St  | tru | ıct | ure        | e     |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 7. Zone E  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 8. Zone F  |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    |                             | то | owe   | er ( | Cra  | ane | е   |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |
| 9. Zone G1   |          |   |              |     |   |   |  |   |    |    |   |      |   |   |       |    | Tower Crane<br>Mobile Crane |    |       |      |      |     |     |       |     |      |     |       |     |     |            |       |    |   |   |       |   |   |   |      |     |   |   |      |    |    |   |       |   |   |



- II. Depth 1: APC Panel Prefabrication
- III. Depth 2: SIPS

# Depth 3: Safety Evaluation • Scoring System Comparison

- Conclusions & Recommendations
- VI. Acknowledgements





# AE Senior Thesis Project Kevin Kroener | Construction Option

## Scoring Criteria:

| Scoring<br>Value | Level of Concern   | Safety Cat         |
|------------------|--|--------------------|
|                  | Safety Category is considered fairly safe with a   | Fall Protection    |
| 1                | low level of safety concern involved.  | Equipment Inspec   |
|                  | Safety Category is considered somewhat   | Safety Training    |
| 2                | hazardous with a moderate level of safety concern involved.                                | Hazardous Materi   |
|                  |  | Incidents/Injuries |
| 3                | Safety Category is considered very dangerous with a high level of safety concern involved. |                    |
|                  | with a high level of safety concern involved.  | Total Score        |

# Safety Evaluation

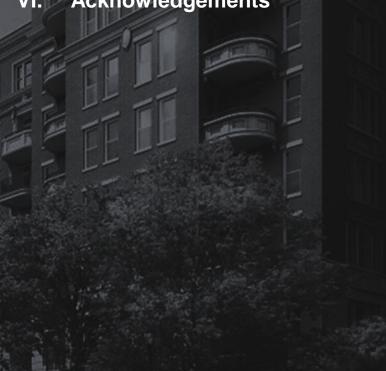
| tegory | Precast Wall Panel<br>Erection & Installation | Brick Masonry Installation |
|--------|---|----------------------------|
|        | 3   | 3                          |
| ction  | 2   | 3                          |
|        | 2   | 1                          |
| ials   | 2   | 2                          |
| 5      | 3   | 2                          |
|        |   |                            |
|        | 12  | 11                         |



- II. Depth 1: APC Panel Prefabrication
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# AE Senior Thesis Project Kevin Kroener | Construction Option

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|                  |  | Incidents/Injuries |
| 3                | Safety Category is considered very dangerous with a high level of safety concern involved. |                    |
|                  | ,  | Total Score        |

# Safety Evaluation

| tegory | Precast Wall Panel<br>Erection & Installation | Brick Masonry Installation |
|--------|---|----------------------------|
|        | 3   | 3                          |
| ection | 2   | 3                          |
|        | 2   | 1                          |
| rials  | 2   | 2                          |
| S      | 3   | 2                          |
|        |   |                            |
|        | 12  | 11                         |

### Safety Category 1: Fall Protection

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

### Safety Category 5: Incidents/Injuries

| Activity  | Safety Concerns   | Score | Activity                         | Safety Concerns  | Score |
|---|---|-------|----------------------------------|--|-------|
| Precast<br>Wall Panel<br>Erection &<br>Installation | <ul> <li>Swinging or out of control load</li> <li>Material handling (crush, caught</li> </ul> | 3     | Brick<br>Masonry<br>Installation | <ul> <li>Falls</li> <li>Falling debris</li> <li>Material handing (crush,<br/>lifting, cuts)</li> <li>Scaffolding<br/>Collapse/Tipping/Hit by<br/>equipment</li> <li>Windblown debris, contact<br/>with cement when mixing<br/>mortar</li> <li>Burns and explosion when<br/>heating water and sand</li> </ul> | 2     |

## Wardman West Residential

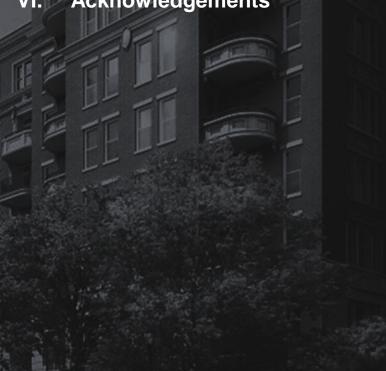


| Woodley Park, | NW Was | hington, | DC |
|---------------|--------|----------|----|
|---------------|--------|----------|----|

- **Depth 1: APC Panel Prefabrication**
- Depth 2: SIPS .....

## **Depth 3: Safety Evaluation**

- Scoring System Comparison
- **Conclusions & Recommendations**
- VI. Acknowledgements





# AE Senior Thesis Project Kevin Kroener | Construction Option

## Scoring Criteria:

| Scoring<br>Value  | Level of Concern   |                      | Safety Category     | Precast Wall Panel<br>Erection & Installation | Brick Masonry Installation |
|---|--|----------------------|---------------------|---|----------------------------|
|   | Safety Category is considered fairly safe with a               |                      | Fall Protection     | 3   | 3                          |
| 1         Iow level of safety concern involved.                                       |  | Equipment Inspection | 2                   | 3   |                            |
| 2 Safety Category is considered somewhat<br>hazardous with a moderate level of safety |  |                      | Safety Training     | 2   | 1                          |
|   | hazardous with a moderate level of safety<br>concern involved. |                      | Hazardous Materials | 2   | 2                          |
|   | Safety Category is considered very dangerous                   |                      | Incidents/Injuries  | 3   | 2                          |
| 3   |  |                      |                     |   |                            |
|   |  |                      | Total Score         | 12  | 11                         |

# Safety Evaluation

- Principle Steps
- Potential Hazards
- Recommended Controls

Activity Hazard Analysis:

- Required Equipment
- Inspection Requirements
- Training Requirements

### Wardman West Residential Woodley Park, NW Washington, DC



### 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 i  |
|  | 1.b. Under sized rigging or incorrect rigging  | as necessary. Competent groundman, assisted by Erection  |
|  |  | Foreman, will select appropriate rigging for each lift.  |
| 2. Lift wall panel load                      | 2.a. Crane malfunction or failure  | 2.a. Operator must perform daily inspections to ensure that<br>crane is in safe working condition. Inspections will also be<br>documented in the a crane logbook.  |
|  | 2.b. Improper crane setup leading to tipping or<br>failure                           | 2.b. Ensure crane is on stable and level ground per the<br>manufacturers specifications/recommendations. Proper<br>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<br>2.e. Swinging or out of control panel load | 2.d. Ensure swing path is clear.<br>Groundman and Erection Foreman will control area within<br>swing radius of crane boom with assistance from GC field<br>supervision. Swing path perimeter will be marked or<br>barricaded to prevent employees from walking beneath loa<br>The CA2 (Controlled Access Zone) will be set at an<br>appropriate distance and the Groundman and Erection<br>Foreman will remain alert to personnel entering restricted<br>areas to keep people out of the swing path.<br>2.e. Only one person at a time will give signals and have rad<br>communication with crane operator. Taglines will be used t<br>control loads |
| EQUIPMENT TO BE USED                         | INSPECTION REQUIREMENTS  | TRAINING REQUIREMENTS  |
| 1. Tower Crane                               | 1. Annual crane inspection   | 1. Certified Crane Operator  |
| 2. Mobile Crane                              | 2. Daily crane inspection  | 2. Erection Foreman has completed PCI's Certified Erector  |
| 3. Rigging                                   | 3. Crane inspection upon arrival at site   | course   |
| 4. Tag lines                                 | 4. Posted Certificate of Compliance on Crane   | 3. All erectors and riggers have completed rigging training  |
| 5. PPE - hard hat, safety glasses, steel-toe | 5. Daily rigging inspection  | ** GC is responsible for training of all non- precast/erector  |
|  |  | personnel to remain clear of the precast work area and to  |
| boots, reflective vests                      |  |  |

## I. Introduction

- II. Depth 1: APC Panel Prefabrication
- III. Depth 2: SIPS
- IV. Depth 3: Safety Evaluation
- V. Conclusions & Recommendations
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### AE Senior Thesis Project Kevin Kroener | Construction Option

# **Conclusions & Recommendations**

Analysis 1: Architectural Precast

Concrete Wall Panels

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



## I. Introduction

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## 

### AE Senior Thesis Project Kevin Kroener | Construction Option

# **Conclusions & Recommendations**

| nalysis 1: Architectural Precast | Ana |
|----------------------------------|-----|
| oncrete Wall Panels              |     |
| Accelerated Schedule – 46 Days   |     |
| Saved \$ 646,000                 |     |
| Improved Quality                 |     |
| Structurally Feasible            |     |

nalysis 2: SIPS (Short Interval Production Schedule)

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



- II. Depth 1: APC Panel Prefabrication
- III. Depth 2: SIPS
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## 

# AE Senior Thesis Project Kevin Kroener | Construction Option

# **Conclusions & Recommendations**

| nalysis 1: Architectural Precast | Analysis 2: SIPS (Short Interval Production Schedule) |
|----------------------------------|---|
| oncrete Wall Panels              | Accelerated Schedule                                  |
| Accelerated Schedule – 46 Days   | ➢ Brick – 12 Days                                     |
| Saved \$ 646,000                 | > APC Wall Panels – 3 Days                            |
| Improved Quality                 | Improved Productivity                                 |
| Structurally Feasible            |   |

Analysis 3: Safety Evaluation



**Depth 1: APC Panel Prefabrication** 

- Depth 2: SIPS
- **Depth 3: Safety Evaluation**
- **Conclusions & Recommendations**
- Acknowledgements



AE Senior Thesis Project Kevin Kroener | Construction Option

## Academic Acknowledgments

Ray Sowers – Faculty Advisor &

The Architectural Engineering Department





# Acknowledgements

## Industry Acknowledgements











Wardman West Residential Woodley Park, NW Washington, DC



## **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

- Introduction
- **Depth 1: APC Panel Prefabrication**
- III. Depth 2: SIPS
- IV. Depth 3: Safety Evaluation
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# Wardman West Residential

## **Questions?**





- II. Depth 1: APC Panel Prefabrication
- III. Depth 2: SIPS
- IV. Depth 3: Safety Evaluation
- **Conclusions & Recommendations**
- VI. Acknowledgements

## 

# AE Senior Thesis Project Kevin Kroener | Construction Option

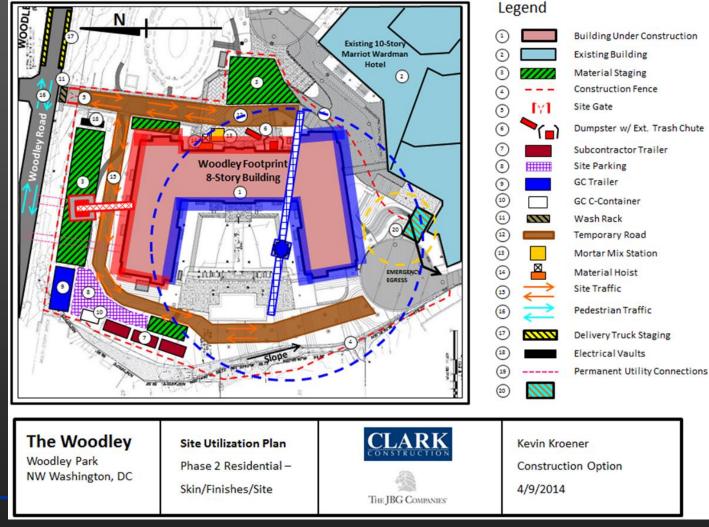
| Brick |    |
|-------|----|
| Brick | at |
| Birck | So |

Brick St

| Item                              |         | Unit  | Quantity | <b>Unit Price</b> | Amount          |           |
|-----------------------------------|---------|-------|----------|-------------------|-----------------|-----------|
|                                   |         |       |          |                   |                 | Backup, S |
| Architectural Precast Concrete Pa | nels    |       |          |                   |                 | Metal St  |
| APC Wall Panels                   |         | sf    | 69,212   | \$40.00           | \$<br>2,768,480 | Gypsum    |
| ** includes attachment hardawa    | ire     |       |          |                   |                 | Rigid Ins |
| Su                                | ubtotal |       |          |                   | \$<br>2,768,480 | Exterior  |
|                                   |         |       |          |                   |                 |           |
| Metals                            |         |       |          |                   |                 |           |
| Slab edge shelf angles            |         | lf    | 11,700   | \$25.00           | \$<br>292,500   | Metals    |
| Su                                | ubtotal |       |          |                   | \$<br>292,500   | Slab edg  |
|                                   |         |       |          |                   |                 | 5105 6 08 |
| Misc.                             |         |       |          |                   |                 |           |
| Caulking                          |         | sf    | 294,900  | \$0.50            | \$<br>147,450   | Misc.     |
| Brick at Penthouses               |         | sf    | 5,883    | \$35.00           | \$<br>205,905   | Wall Fla  |
| Spandrel Beam                     |         | Cu Yd | 72       | \$750.00          | \$<br>54,000    | Caulking  |
| Su                                | ubtotal |       |          |                   | \$<br>407,355   | Scaffold  |
|                                   |         |       |          |                   |                 | Scarrolu  |
| Total                             |         |       |          |                   | \$3,468,335     |           |
|                                   |         |       |          |                   |                 | limeston  |

imesto Header Jambs Install c

| Item                        | Unit | Quantity | Unit Price  | Amount          |
|-----------------------------|------|----------|-------------|-----------------|
|                             |      |          |             |                 |
|                             |      |          |             | <br>            |
| t Balconies                 | sf   | 1,130    | \$35.00     | 39,540          |
| oldier Course               | sf   | 821      | \$45.00     | \$<br>36,927    |
| tandard Size Running Bond   | sf   | 74,274   | \$35.00     | \$<br>2,599,593 |
| Subtotal                    |      |          |             | \$<br>2,676,060 |
|                             |      |          |             |                 |
| Sheathing and Insulation    |      |          |             |                 |
| Stud Backup with Sheathing  | sf   | 111,669  | \$3.50      | \$<br>390,841   |
| m Board and Batt Insulation | sf   | 111,669  | \$2.25      | \$<br>251       |
| nsualtion                   | sf   | 111,669  | \$1.50      | \$<br>255       |
| or Tyvek Wrap               | sf   | 111,669  | \$0.50      | \$<br>167,503   |
| Subtotal                    |      |          |             | \$<br>55,834    |
|                             |      |          |             |                 |
|                             |      |          |             |                 |
| dge shelf angles            | lf   | 11,700   | \$25.00     | \$<br>292,500   |
| Subtotal                    |      |          |             | \$<br>292,500   |
|                             |      |          |             |                 |
|                             |      |          |             |                 |
| lashings                    | sf   | 147,450  | \$1.00      | \$<br>147,450   |
| ng                          | sf   | 147,450  | \$0.50      | \$<br>73,725    |
| lding                       | mon. | 9        | \$ 2,800.00 | \$<br>25,200    |
| Subtotal                    |      |          |             | \$<br>246,375   |
|                             |      |          |             |                 |
| ne                          |      |          |             |                 |
| rs and Sills                | lf   | 3915     | 75          | \$<br>293,625   |
|                             | lf   | 4275     | 75          | \$<br>320,625   |
| of Headers, Sills and Jambs | lf   | 8190     | 28          | \$<br>229,320   |
| Subtotal                    |      |          |             | \$<br>843,570   |
|                             |      |          |             |                 |
|                             |      |          |             |                 |
|                             |      |          |             | <br>\$4.114.339 |



\$4,114,339



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## 

# AE Senior Thesis Project Kevin Kroener | Construction Option



| 1             | Senior Thesis - Spring | 2014 |
|---------------|------------------------|------|
| Kevin Kroener | Analysis 2: SIPS       |      |
|               | Kevin Kroener          |      |

### AE PSU

| ITEM OF WORK             | MONTH<br>VVEEK |                  |               | arch<br>2013 |     | _      |           | la rch<br>1/201 |   |          |                  | la rch<br>8/201 |              |               |         | Mar<br>3/25/2 |    |          |                  | Ap<br>4/1/ | pril        |    |   |                  | A pril<br>8/201 |               |      |           | Apri<br>15/20 |          |        |          | April<br>22/20 |               | _ |      | M<br>4/29 | lay |          |        |          | May<br>6/201: | 2 |       |           | May<br>13/2 |          | _      |
|--------------------------|----------------|------------------|---------------|--------------|-----|--------|-----------|-----------------|---|----------|------------------|-----------------|--------------|---------------|---------|---------------|----|----------|------------------|------------|-------------|----|---|------------------|-----------------|---------------|------|-----------|---------------|----------|--------|----------|----------------|---------------|---|------|-----------|-----|----------|--------|----------|---------------|---|-------|-----------|-------------|----------|--------|
| HEM OF WORK              | DAY            | М                |               | 2013<br>V R  |     | -      |           | W R             |   | М        |                  |                 | R F          | - 1           |         |               |    | E        | мт               |            | 2013<br>V R |    |   |                  |                 |               |      | 4/<br>I T |               |          |        |          |                |               | _ |      |           |     |          |        |          |               |   |       |           |             |          | E .    |
| South, Southwest         |                | M                |               | v rt         | r r | m      | ľ         | vv R            | - | m        | ľ                | VV P            |              |               | -       |               | ĸ  | r -      | m 1              |            |             | r. | m | <u> </u>         | 9.0             |               | - 14 |           | vv            | rt F     | M      | <u> </u> | 44             |               | 1 | nt 1 |           |     | <u> </u> | M      | <u> </u> |               |   | rvi - | -         | vv          | A.       | r*     |
| Zone J - 10 Masons       | Last           | H                | +             | +            |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 | +             | +    | +         | $\vdash$      | $\vdash$ | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | +      | +        | +             | + | +     | +         | $\vdash$    |          |        |
| Zone K - 10 Masons       |                | $\square$        | +             | +            |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 | +             | ╈    | +         |               |          | +      | +        | $\square$      | +             | + | +    | +         | +   | +        | +      |          |               | + | +     | +         | $\vdash$    |          |        |
| Zone L - 10 Masons       |                | $\square$        | $\neg$        |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          | +      | 1        | $\square$      | +             | + |      | +         | +   | +        | $\top$ |          |               |   |       | $\top$    |             |          |        |
| Zone M - 10 Masons       |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    | Т | Π                |                 |               | T    |           |               |          | $\top$ |          |                |               | 1 |      |           | 1   |          | Т      |          |               |   |       | $\square$ |             |          |        |
| North Courtyard, West    | Courtyard      |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| Zone N - 5 Masons        |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| Zone O - 5 Ma sons       |                |                  |               |              |     |        |           |                 | _ |          |                  |                 | $\downarrow$ |               |         |               |    |          |                  |            |             |    | 1 |                  |                 |               |      |           |               |          |        |          |                |               | _ |      |           | 4   |          | ⊢      |          |               |   |       |           |             |          |        |
| Zone P - 5 Masons        |                |                  | $\rightarrow$ | +            | +   | +      |           |                 | _ |          |                  |                 | +            | +             | +       | _             | _  | -        | $\square$        | +          | +           |    | ⊢ |                  |                 | $\rightarrow$ |      |           |               |          |        |          |                |               | _ |      |           |     |          | -      |          |               |   |       |           |             |          |        |
| Zone Q - 5 Masons        |                | $\vdash$         | +             | +            | +   | +      | +         | +               | + |          |                  |                 | +            | +             | +       | _             | +- | -        | $\vdash$         | +          | +           | +  | ╀ | $\square$        |                 | +             |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          | _      |
| South Courtyard, West Co | ourtyard, NW   | H                | +             | +            | +   | +      | +         | _               | + |          | $\left  \right $ |                 | +            | +             | +       | -             | +  | -        | $\left  \right $ | +          | +           | +  | ╀ | $\left  \right $ |                 | +             | +    | +         |               |          | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | ╋      | -        |               | + | +     | ┢         | +           |          | _      |
| Zone R                   |                | +                | +             | +            | +   |        | +         | +               | + |          | $\left  \right $ |                 | +            | +             | +       | +             | +  | ⊢        | +                | +          | +           | +  | ╀ | $\left  \right $ |                 | +             | +    | +         |               |          | +      | +        | $\vdash$       | +             | ╉ | +    | +         | +   | +        | ╋      | +        | $\vdash$      | + | +     | ⊢         | $\vdash$    | $\vdash$ | _      |
| Zone S<br>Zone T         |                | +                | +             | +            | +   |        | +         | +               | + |          | $\vdash$         | +               | +            | +             | +       | -             | +  | +        | +                | +          | +           | -  | ╀ | +                | $\vdash$        | +             | +    | +         | $\vdash$      | $\vdash$ | +      | +        | $\vdash$       | +             |   | -    | +         | +   | +        | +      | +        | +             | + | +     | +         | $\vdash$    | $\vdash$ | $\neg$ |
| Zone U                   |                | +                | +             | +            | +   | +      | +         | +               | + |          |                  | +               | +            | +             | +       | -             | +  | +        | +                | +          | +           | +  | t | $\square$        |                 | +             | +    | +         | $\square$     | $\vdash$ | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | +      | +        | +             | + | +     | +         | 1           |          | -      |
| Zone V                   |                |                  |               |              |     | $\top$ |           |                 |   |          |                  |                 | +            |               |         |               |    | T        |                  |            |             |    |   |                  |                 |               | t    |           |               |          |        |          |                |               | + |      |           | +   |          |        |          |               |   |       |           |             |          |        |
| North , Northwe          | est            |                  |               |              |     | $\top$ | Π         |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    | Τ |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          | Τ      |          |               |   |       |           |             |          |        |
| Zone W                   |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| Zone A                   |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| Zone B                   |                |                  | $\rightarrow$ |              | +   | 4_     | $\square$ |                 | _ |          |                  |                 | +            | $\rightarrow$ | $\perp$ | _             | _  | ⊢        | $\square$        | $\perp$    | _           |    | ⊢ |                  |                 | $\rightarrow$ | +    | _         |               |          | _      | _        | $\square$      | $\rightarrow$ | _ |      | +         |     | $\perp$  | ╇      |          |               |   | _     | ⊢         |             |          |        |
| Zone C                   |                | $\left  \right $ | +             | +            | +   | +      | $\square$ | _               | + |          |                  |                 | +            | +             | +       | _             | +- | ⊢        | $\vdash$         | +          | +           | +  | ╀ | $\square$        |                 | +             | +    | +         |               |          | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | ╀      | -        |               | _ | _     | ⊢         |             |          | _      |
| Zone D                   |                | $\vdash$         | +             | +            | +   | +      | +         | +               | + |          | $\left  \right $ |                 | +            | +             | +       | +             | +- | ⊢        | $\vdash$         | +          | +           | +  | ╀ | $\left  \right $ |                 | +             | +    | +         |               |          | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | ╀      | +        | $\vdash$      | + | +     | ⊢         | +           |          | _      |
| East<br>Zone E           |                | H                | +             | +            | +   | +      | +         | +               | + | $\vdash$ | $\left  \right $ |                 | +            | +             | +       | +             | +  | +        | $\vdash$         | +          | +           | +  | ╀ | +                | $\vdash$        | +             | ╉    | +         | +             | $\vdash$ | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | ╀      | +        | $\vdash$      | + | +     | ┢         | $\vdash$    |          | -      |
| Zone F                   |                | +                | +             | +            | +   | +      | +         | +               | + |          | $\left  \right $ |                 | +            | +             | +       | +             | +  | +        | +                | +          | +           | +  | ╋ | +                | $\square$       | +             | ╉    | +         |               | +        | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | ╋      | +        | $\vdash$      | + | +     | +         | $\vdash$    |          |        |
| Zone G                   |                | +                | +             | +            | +   | +      | H         | +               | + |          | $\left  \right $ |                 | +            | +             | +       | +             | +  | +        | +                | +          | +           | +  | + |                  |                 | +             | +    | +         |               |          | +      | +        | $\vdash$       | +             | + | +    | +         | +   | +        | ╈      | +        |               | + | +     | +         | +           |          | -      |
| Zone H                   |                | $\square$        | +             | +            | +   | 1-     | H         | +               | + |          |                  |                 | +            | +             | +       | +             | +  | $\vdash$ |                  | +          | +           | +  | + |                  |                 | +             | +    | +         |               |          | +      | 1        | $\square$      | +             | + | +    | +         | +   | +        | +      |          |               | + | +     | +         | $\vdash$    |          |        |
| Zone I                   |                |                  |               |              |     | 1-     | Π         |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    | T |                  |                 |               | T    |           |               |          |        |          |                |               |   |      |           |     |          | Т      |          |               |   |       | $\square$ |             |          |        |
|                          |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 1. Zone A                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 14               | I. Z       | Zor         | ne | Ν |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 2. Zone B                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 15               | 5. Z       | Zor         | ne | 0 |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 3. Zone C                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 16               | 5. Z       | or          | ne | Р |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 4. Zone D                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 17               | '. Z       | Zor         | ne | Q |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 5. Zone E                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 18               | 3. Z       | <u>cor</u>  | ne | R |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 6. Zone F                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 19               | ). Z       | Zor         | ne | s |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 7. Zone G                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 20               | ). Z       | <u>cor</u>  | ne | т |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 8. Zone H                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 21               | . Z        | or          | ne | U |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 9. Zone I                |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 22               | 2. Z       | or          | ne | V |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 10. Zone J               |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          | 23               | 3. Z       | <u>or</u>   | ne | W |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 11. Zone K               |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 12. Zone L               |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |
| 13. Zone M               |                |                  |               |              |     |        |           |                 |   |          |                  |                 |              |               |         |               |    |          |                  |            |             |    |   |                  |                 |               |      |           |               |          |        |          |                |               |   |      |           |     |          |        |          |               |   |       |           |             |          |        |

## Wardman West Residential

### Brick Exterior Skin SIPS Schedule

| ITEM OF VIORK VIEEK 5/20/2013 5/27/2013 6/3/2013 6/10/2013 6/17/2013 6/24/20   |                   |      | MONTH       | _        |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
|--|-------------------|------|-------------|----------|---|----------|----------|----------|---|----------|---|----------|----------|----------|----------|----------|----------|----------|----------|---|---|----------|---|----------|----------|----------|----|----------|----------|----------|----------|---|
| Day     H     T     W     R     F     H     T     W     R     R  | ITEN OF HORK      |      |             |          | _ | _        |          |          |   | _        | _ |          |          |          | _        | -        | _        |          | -        | _ | _ | -        |   | ⊢        | _        |          |    |          | ⊢        | _        |          |   |
| South, Southward, East         Image: Control of the second s | TEMOPWORK         |      |             | н        |   | _        | _        | E        |   |          |   |          |          |          |          |          |          | E        |          | _ | _ |          | E |          | _        | _        | _  | E        |          |          |          |   |
| Zone J.       Image: Solution of the second se         | South Southword   |      |             | m        |   |          | ×        | Ľ        | m | ľ        |   | ×        | ľ        | m        | <u> </u> |          |          | <u> </u> | m        | ľ |   | N.       | ľ | m        | Ľ        |          | N. | Ľ        | m        | Ľ        |          | ł |
| Zane K     Image: Source Contract   |                   | ., 1 | .as         |          |   |          | $\vdash$ | $\vdash$ | t | +        |   |          |          |          |          |          |          |          | $\vdash$ |   |   |          |   |          | $\vdash$ | $\vdash$ |    | ┢        | $\vdash$ | $\vdash$ |          | ł |
| Zone II     North Courtyard, West Courtyard     North Courty and West Court  |                   |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    | T        |          |          |          | t |
| Noth Courty and, West Courty and, NW       Note       Not   | Zone L            |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | Γ |
| Zone N-1 Masons       Image: Control of the second se         | Zone M            |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | L |
| Zone O S Masons       Image: Content of the second of the            |                   | C    | ourtyard    |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | L |
| Zore P 5 Masons       A  |                   |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          | <u> </u> |   |   |          |   | -        |          | -        |    | ⊢        | -        |          |          | ┞ |
| Zone Q - 5 M asons       M   |                   | _    |             |          |   |          | $\vdash$ | $\vdash$ | - | -        |   | -        | -        | -        | -        | -        |          |          | -        |   |   | -        |   | ┢        | -        | ⊢        | -  | ⊢        | ⊢        | -        |          | ┞ |
| South Courtyard, We st Courtyard, NW       Image: South South South Courtyard, NW       Image: South                   |                   |      |             |          |   | -        | $\vdash$ | $\vdash$ | ⊢ | +        | - | $\vdash$ | -        | $\vdash$ | -        | -        | $\vdash$ | -        | $\vdash$ |   |   | $\vdash$ | - | ⊢        | $\vdash$ | ⊢        | -  | ⊢        | ⊢        | $\vdash$ | -        | ┝ |
| Zone R - 4 Masons       Image: Solution of the sons       Image: Solution of the sons       Image: Solution of the s                           |                   | ~    | rhand MM    | $\vdash$ |   | $\vdash$ | $\vdash$ | $\vdash$ | ⊢ | +        |   | $\vdash$ | ┢        | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$ | ┢        |   |   | ┝        | - | ┢        | ┢        | ┢        | -  | ┢        | ┢        | $\vdash$ | $\vdash$ | ┝ |
| Zone S - 3 Masons       Image: Construction of the sector of         |                   | 00   | nyanu, nivi |          |   |          | $\vdash$ | $\vdash$ | F |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | t |
| Zone T - 4 Masons       Image: Construction of the construction of         |                   |      |             |          |   |          | $\vdash$ | $\vdash$ | t |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | t |
| Zore V - 5 Masons       Image: Construction of the sector of         |                   |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | ľ |
| North, Northwest       Image: Construction of the sector of          | Zone U - 4 Masons |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
| Zone W - 4 Masons       A       A       A sons       A<  | Zone V - 5 Masons |      |             |          |   |          |          |          |   |          |   |          |          | _        |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
| Zone A - 4 Ma sons       A   |                   | e s  | t           |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | ļ |
| Zone B - 4 Ma sons       Image: C - 4 Ma sons       I  |                   |      |             |          |   |          | -        | -        |   | -        |   |          | -        |          |          |          |          |          | _        |   |   |          |   | -        |          | $\vdash$ |    | ⊢        | ⊢        |          |          | ┞ |
| Zone C - 4 Ma sons       Image: Constant of the sons of the so         |                   | _    |             |          |   |          | $\vdash$ | $\vdash$ |   | -        |   | -        | -        | _        | -        | -        |          |          | -        |   |   | -        |   | ┢        | -        | ⊢        |    | ⊢        | ⊢        | -        |          | ┞ |
| Zone D - 4 Masons       Image: Construction of the construction of         |                   | _    |             |          |   | $\vdash$ | ⊢        | $\vdash$ | ⊢ | +        | - | $\vdash$ | ⊢        | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$ |   |   | ┝        | - | ⊢        | ⊢        | ⊢        | -  | ⊢        | ⊢        | $\vdash$ | -        | ┝ |
| East       Image: Constraint of the sector of          |                   |      |             | $\vdash$ |   | $\vdash$ | $\vdash$ | $\vdash$ | ⊢ | +        | - | $\vdash$ | ┢        | $\vdash$ | ┝        | $\vdash$ | $\vdash$ | $\vdash$ | ┝        |   |   | ┝        | - | ┢        | ┢        | ┢        | -  | ┢        | ┢        | $\vdash$ | $\vdash$ | ┝ |
| Zone E       Zone F       Image: Construction of the sector of th                  |                   |      |             |          |   |          | $\vdash$ | $\vdash$ |   | +        |   | $\vdash$ | +        |          | -        | -        |          |          | ⊢        |   |   | -        | - | $\vdash$ | +        | ┢        | -  | ┢        | ┢        | ⊢        | -        | ┢ |
| Zone G       Zone H       Image: Constraint of the second                   |                   |      |             |          |   |          | $\vdash$ | $\vdash$ |   | $\vdash$ |   |          | $\vdash$ |          | $\vdash$ | $\vdash$ |          |          | $\vdash$ |   |   | $\vdash$ |   | 1-       | $\vdash$ | $\vdash$ |    | $\vdash$ | $\vdash$ | $\vdash$ |          | t |
| Zone H       Zone I       14. Zone N         2. Zone B       15. Zone O         3. Zone C       15. Zone O         4. Zone D       16. Zone P         4. Zone E       17. Zone Q         5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone V         9. Zone I       22. Zone V         10. Zone J       23. Zone V         11. Zone K       23. Zone V  | Zone F            |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
| Zone I       14. Zone N         1. Zone A       15. Zone O         2. Zone B       15. Zone O         3. Zone C       16. Zone P         4. Zone D       17. Zone Q         5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone I       23. Zone W         11. Zone K       12. Zone L   | Zone G            |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | Γ |
| 1. Zone A       14. Zone N         2. Zone B       15. Zone O         3. Zone C       16. Zone P         4. Zone D       17. Zone Q         5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone I       22. Zone V         10. Zone J       23. Zone W         11. Zone K       11. Zone L   |                   |      |             |          |   |          |          |          |   |          |   |          |          | _        |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          | L |
| 2. Zone B       15. Zone O         3. Zone C       16. Zone P         4. Zone D       17. Zone Q         5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone J       23. Zone W         11. Zone K       11. Zone L  | Zone I            |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
| 3. Zone C       16. Zone P         4. Zone D       17. Zone Q         5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone J       23. Zone W         11. Zone K       11. Zone L   | 1. Zone A         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 1        | 4.       | Zo       | on | e l      | Ν        |          |          |   |
| 4. Zone D       17. Zone Q         5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone J       22. Zone V         10. Zone J       23. Zone W         11. Zone K       10. Zone L  | 2. Zone B         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 1        | 5.       | Zo       | on | e (      | 0        |          |          |   |
| 5. Zone E       18. Zone R         6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone I       22. Zone V         10. Zone J       23. Zone W         11. Zone K       11. Zone L   | 3. Zone C         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 1        | 6.       | Zo       | on | e l      | Ρ        |          |          |   |
| 6. Zone F       19. Zone S         7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone I       22. Zone V         10. Zone J       23. Zone W         11. Zone K       10. Zone L  | 4. Zone D         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 1        | 7.       | Zo       | n  | e        | Q        |          |          |   |
| 7. Zone G       20. Zone T         8. Zone H       21. Zone U         9. Zone I       22. Zone V         10. Zone J       23. Zone W         11. Zone K       10         12. Zone L       10   | 5. Zone E         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 1        | 8.       | Zo       | n  | e l      | R        |          |          |   |
| 8. Zone H       21. Zone U         9. Zone I       22. Zone V         10. Zone J       23. Zone W         11. Zone K       10         12. Zone L       10  | 6. Zone F         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 1        | 9.       | Zo       | n  | e        | S        |          |          |   |
| 9. Zone I       22. Zone V         10. Zone J       23. Zone W         11. Zone K       11. Zone L   | 7. Zone G         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 2        | 0.       | Zo       | on | e        | Т        |          |          |   |
| 10. Zone J     23. Zone W       11. Zone K     11. Zone L  | 8. Zone H         |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 2        | 1.       | Zo       | n  | e١       | U        |          |          |   |
| 11. Zone K<br>12. Zone L   | 9. Zone I         | _    |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 2        | 2.       | Zo       | on | e١       | V        |          |          |   |
| 12. Zone L   | 10. Zone J        |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   | 2        | 3.       | Zo       | on | e١       | W        |          |          |   |
|  | 11. Zone K        |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
| 13. Zone M   | 12. Zone L        |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |
|  | 13. Zone M        |      |             |          |   |          |          |          |   |          |   |          |          |          |          |          |          |          |          |   |   |          |   |          |          |          |    |          |          |          |          |   |



|   |        |          | 74       | July<br>1/20 | 42 |   |          | 74       | July<br>3/20 | 42       |          |          | 7/4      | July<br>5/2( | 142 |   |   | 7/2      | July<br>2/2 | 142 |          |          | A         | ugu<br>29/20 | st       |    |
|---|--------|----------|----------|--------------|----|---|----------|----------|--------------|----------|----------|----------|----------|--------------|-----|---|---|----------|-------------|-----|----------|----------|-----------|--------------|----------|----|
| 1 | F      | М        |          |              |    | F | м        | 7/8<br>T | s/20<br>W    | 13<br>R  | F        | м        |          | 5/20<br>W    |     |   | м |          |             |     |          | м        |           |              | R        | F  |
|   | -      |          |          |              |    | ŕ |          | -        |              | _        | -        |          |          |              |     |   |   |          |             |     | Ë        |          | Ĥ         |              |          | ř. |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | _      |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | _      |          |          |              |    |   |          |          |              |          |          | _        |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | _      |          |          |              |    | - |          |          |              |          |          | _        |          |              |     |   | - |          |             |     | $\vdash$ |          | $\vdash$  |              |          |    |
|   | -      |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | _      |          |          |              | _  |   |          |          |              |          |          | $\vdash$ |          |              |     |   | _ |          |             |     | $\vdash$ |          | $\square$ |              |          | -  |
|   | $\neg$ | $\vdash$ | $\vdash$ | -            |    |   | $\vdash$ | -        | $\vdash$     | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$ | $\vdash$     | -   | - | - | $\vdash$ | -           | -   | $\vdash$ | $\vdash$ | $\vdash$  | $\vdash$     | $\vdash$ | -  |
|   |        |          |          | -            |    |   |          |          | $\vdash$     | $\vdash$ |          | $\vdash$ |          |              | -   |   | - |          |             | -   | $\vdash$ | $\vdash$ | $\vdash$  | $\vdash$     | H        | -  |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | $\neg$ |          | $\vdash$ | -            |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | -      |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              | H        |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   | _      |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     | $\vdash$ |          |           |              |          |    |
|   | _      |          |          | -            | -  |   |          | -        |              |          |          | $\vdash$ |          |              | -   | - | — |          | -           | -   | $\vdash$ |          | $\vdash$  |              |          | -  |
|   | $\neg$ |          | $\vdash$ | -            |    |   |          |          | $\vdash$     | $\vdash$ |          | $\vdash$ |          |              | -   |   |   |          |             |     | $\vdash$ | $\vdash$ | $\vdash$  | $\vdash$     | H        | ⊢  |
| ļ |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     | -        |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     | _        |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     | $\neg$   |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     | -        |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
| _ |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     | _        |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          | _  |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |
|   |        |          |          |              |    |   |          |          |              |          |          |          |          |              |     |   |   |          |             |     |          |          |           |              |          |    |

- II. Depth 1: APC Panel Prefabrication
  III. Depth 2: SIPS
  IV. Depth 3: Safety Evaluation
  V. Conclusions & Recommendations
  VI. Acknowledgements

## 

# AE Senior Thesis Project Kevin Kroener | Construction Option

|                                      | MONTH       |
|--------------------------------------|-------------|
| ITEM OF WORK                         | WEEK        |
|                                      | DAY         |
| South, Southwest,                    | East        |
| Zone J                               |             |
| Zone K                               |             |
| Zone L                               |             |
| Zone M                               |             |
| North Courtyard, West O              | Courtyard   |
| Zone N<br>Zone O                     |             |
| Zone P                               |             |
| Zone Q                               |             |
| South Courtyard, West Co             | urtyard, NW |
| Zone R                               |             |
| Zone S                               |             |
| Zone T                               |             |
| Zone U                               |             |
| Zone V                               |             |
| North , Northwe<br>Zone W - 4 Masons | st          |
| Zone A - 4 Masons                    |             |
| Zone B - 4 Masons                    |             |
| Zone C - 4 Masons                    |             |
| Zone D - 4 Masons                    |             |
| East                                 |             |
| Zone E - 2 Masons                    |             |
| Zone F - 2 Masons                    |             |
| Zone G - 2 Masons                    |             |
| Zone H - 2 Masons                    |             |
| Zone I - 2 Masons                    |             |
|                                      |             |
| 1. Zone A                            |             |
| 2. Zone B                            |             |
| 3. Zone C                            |             |
| 4. Zone D                            |             |
| 5. Zone E                            |             |
| 6. Zone F                            |             |
| 7. Zone G                            |             |
| 8. Zone H                            |             |
| 9. Zone I                            |             |
| 10. Zone J                           |             |
| 11. Zone K                           |             |
| 12. Zone L                           |             |
| 13. Zone M                           |             |
|                                      |             |

|   |   | Au   | gu | st |   |   |   | Au           | gu   | st |   |   |    |   | ıgu  |   |   |   |        | Augi | ust |   |   | Se | pte | mbe     | r |   |   | epte  |      |    |   | S | ept      | eml  | ber |   | 1 | Sep | otem  | ber | r |          | C | ctol | ber      |   |   | ( | Oct  | tobe | er |   |   | 0 | ctob | er        | 1 |
|---|---|------|----|----|---|---|---|--------------|------|----|---|---|----|---|------|---|---|---|--------|------|-----|---|---|----|-----|---------|---|---|---|-------|------|----|---|---|----------|------|-----|---|---|-----|-------|-----|---|----------|---|------|----------|---|---|---|------|------|----|---|---|---|------|-----------|---|
|   |   | 8/5/ | 20 | 13 | _ |   | 8 | 8/12         | 2/20 | 13 |   |   | _  | _ | 9/20 | _ | _ |   | -      | 26/2 | -   | - |   | _  | -   | 013     | _ |   | 9 | 9/9/: | 201: | 3  |   | 9 | 9/16     | 6/20 | 13  |   |   |     | 23/20 |     |   |          | - | 30/2 | -        | _ |   |   | 10/7 | 7/20 | 13 |   |   | _ | 14/2 | 013       |   |
|   | м | v    | N  | R  | F | м | т | •            | N    | R  | F | м | ιт | 1 | w    | R | F | м | т      | w    | R   | F | м | т  | w   | R       | F | м | т | v     | / R  | ₹F | м | т | <u>۱</u> | w    | R   | F | м | т   | w     | R   | F | м        | т | w    | R        | F | м | т | •    | N    | R  | F | м | т | w    | RF        |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   | _     |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           | _ |
|   |   | +    |    |    | - | _ | _ | _            |      |    |   | + | +  | _ | _    |   |   |   | -      |      |     |   | - |    | _   | +       | _ | _ | _ | +     | _    | _  | + | _ | _        |      | _   | _ | _ |     |       |     |   |          | - |      |          |   |   | + |      | _    |    |   |   |   |      |           |   |
|   |   | +    | _  |    | + | - | + | +            | _    |    |   | + | +  | + | _    |   |   |   | +      | _    | -   |   | - | -  | -   | +       | - | - | + | +     | -    |    | + | - | -        |      | _   | _ | _ |     |       |     |   |          | + |      | -        | - | - | + |      | _    |    |   |   |   |      |           |   |
|   |   | +    |    |    | + | ł | + | +            |      |    |   | + | +  | - |      |   |   | ┢ | +      |      | -   |   | + | +  | -   | +       | - | ┢ | + | +     | +    |    | + | + | +        |      | -   |   |   |     |       |     |   | -        | + | -    | -        |   | - | + |      | -    |    |   |   |   |      |           | - |
|   |   |      |    |    |   | t |   | +            |      |    |   | t | +  |   |      |   |   | T | +      |      |     |   | T |    |     | ┢       |   | T | + | +     |      |    | t |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   | 1 | + |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   | _ |      |    |    | 1 | L |   | $\downarrow$ |      |    |   | 1 |    |   |      |   |   | L |        | _    | 1   |   | L | 1  |     |         | _ |   |   |       |      |    | 1 |   |          |      |     |   |   |     |       |     |   | <u> </u> | 1 | 1    | 1        |   |   |   |      |      |    |   |   |   |      |           | _ |
|   | _ |      |    |    | 1 | L | _ | +            |      |    |   |   | +  | _ |      |   |   |   | $\bot$ | _    | 1   |   | 1 | 1  | _   | +       | _ |   | _ | +     |      |    | 1 |   |          |      |     |   |   |     |       |     |   | <u> </u> | 1 | 1    | $\vdash$ |   | 1 |   |      |      |    |   |   |   |      |           | _ |
|   |   | +    |    | -  | + | ╞ | + | +            | _    |    | ⊢ | + | +  | + | _    | - | - | - | +      | -    | +   | - | ╞ | -  | -   | +       | - | + | + | +     | +    | _  | + | + | -        |      |     |   |   |     |       | -   | - | -        | + | -    | $\vdash$ | - | + | + |      | _    |    |   | - |   |      |           | - |
|   |   | +    |    |    | + | - | + | +            | _    |    |   | + | +  | + | -    |   |   |   | +      |      | -   |   |   | -  | -   | ╈       | - | - | + | +     | -    |    | + | - | -        |      | -   | _ | - |     |       |     |   |          | + |      | -        |   |   | + |      | -    |    |   |   |   |      |           | - |
|   |   | +    |    |    | + | ŀ | + | +            |      |    |   | + | +  | + |      |   |   |   |        |      | 1   |   |   |    |     | ╈       |   |   | + | +     |      |    |   |   |          |      |     |   |   |     |       |     |   |          | + |      |          |   |   | + |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   | T |   |              |      |    |   | T |    |   |      |   |   |   |        |      |     |   | 1 |    |     | T       |   | T |   | T     |      |    | T |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           | _ |
|   |   | _    |    |    |   | - | _ | _            |      |    |   | _ | _  | _ | _    |   |   | _ | -      |      |     |   | _ | -  |     | _       |   | _ | _ | _     | _    | _  | _ | _ | _        |      | _   | _ | _ |     |       |     |   |          |   |      |          |   | _ | + |      | _    |    |   |   |   |      |           | _ |
|   |   | +    | _  |    | + | - | + | -            | _    |    |   | + | +  | - | _    |   |   |   | -      | _    | -   |   |   | -  | -   | +       |   | - | + | +     | -    |    |   |   | -        |      | _   | _ | _ |     |       |     |   |          | + |      | -        |   | - | + |      | _    | _  |   |   |   |      |           | - |
|   |   | +    |    |    | + | - | + | +            | _    |    |   | + | +  | + | _    |   |   | - | +      |      | -   |   | - | -  | -   | +       | - | + | + | +     | -    |    | + | - | -        |      |     |   | _ |     |       |     |   | -        | + |      | -        |   | - | + |      |      |    |   |   |   |      |           | - |
|   |   | +    |    |    | + | t | + | +            |      |    |   | ╈ | +  | + |      |   |   |   | ┢      |      |     |   | ŀ |    |     | ┢       |   | 1 | + | ╈     | +    |    | + | + |          |      |     |   |   |     |       |     |   |          | + |      | +        |   | ╞ | ╈ |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   | 1 |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   | 1 |   |      |      |    |   |   |   |      |           | - |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   | _ | _    |    |    | 1 |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      | _   |   | L |    | _   | $\perp$ | _ |   | _ | +     |      | _  |   |   |          |      |     |   |   |     |       |     |   | _        | 1 | 1    | -        |   |   |   |      |      |    |   |   |   |      | $\square$ | _ |
| _ |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   | 1      |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   | 1 |   |      |      |    |   |   |   |      |           | J |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     |         |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   | 1 | 4. | Z   | on      | е | Ν |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     | on      |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   | 1 | 6. | Z   | on      | е | Ρ |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   | 1 | 7. | Z   | on      | е | Q |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   | 1 | 8. | Z   | on      | е | R |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           |   |
|   |   |      |    |    |   |   |   |              |      |    |   |   |    |   |      |   |   |   |        |      |     |   |   |    |     | on      |   |   |   |       |      |    |   |   |          |      |     |   |   |     |       |     |   |          |   |      |          |   |   |   |      |      |    |   |   |   |      |           | Π |

|  | 17. Zone Q |  |
|--|------------|--|
|  | 18. Zone R |  |
|  | 19. Zone S |  |
|  | 20. Zone T |  |
|  | 21. Zone U |  |
|  | 22. Zone V |  |
|  | 23. Zone W |  |
|  |            |  |
|  |            |  |
|  |            |  |
|  |            |  |



- II. Depth 1: APC Panel Prefabrication
- III. Depth 2: SIPS
- IV. Depth 3: Safety Evaluation
- V. Conclusions & Recommendations VI. Acknowledgements

## 

# AE Senior Thesis Project Kevin Kroener | Construction Option

