

# CAMPUS SQUARE

HARRISBURG, PENNSYLVANIA



ANDREW MARTIN | CONSTRUCTION MANAGEMENT | APRIL 12, 2010



## CAMPUS SQUARE

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### Presentation Outline

- Project Overview
- Prefabricated Exterior Wall Panels: Construction Sequence, Cost, and Schedule Impacts  
*(Construction Management Depth)*
- Thermal Performance of Exterior Wall Systems  
*(Mechanical Breadth)*
- Structural Redesign of Exterior Wall Panel Connections  
*(Structural Breadth)*
- Conclusions and Recommendations
- Questions and Acknowledgements

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## Presentation Outline

### ▪Project Overview

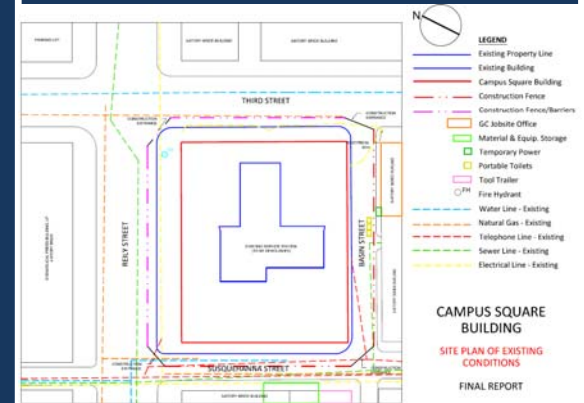
- Prefabricated Exterior Wall Panels  
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## CAMPUS SQUARE

### Project Overview

- Function Type:** Mixed Use – Retail/Office/Educational
- Size:** 75,000 square feet
- Height:** 65' (4 above grade, with mechanical basement space)
- Dates of Construction:** Core & Shell: June 26, 2008 – August 14, 2009
- Project Cost:** Core and shell - \$9 million (GMP)
- Project Delivery Method:** Design-Build

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## CAMPUS SQUARE

### Project Overview

- Structural steel moment resisting frame
- 46-well, closed loop hybrid geothermal system
- 220 panel, 47kW photovoltaic solar system
- High performance brick veneer façade, low-E windows and curtain wall
- LEED® Gold certification (LEED-CS v2.0)

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▪Project Overview

▪**Prefabricated Exterior Wall Panels**  
(*Construction Management Depth*)

▪Thermal Performance of Exterior Wall Systems  
(*Mechanical Breadth*)

▪Structural Redesign of Exterior Wall Panel Connections  
(*Structural Breadth*)

▪Conclusions and Recommendations

▪Questions and Acknowledgements

## CAMPUS SQUARE

### Prefabricated Exterior Wall Panels (*CM Depth*)

*Goals:*

- Determine building shell construction sequence
- Reduce overall construction schedule duration
- Formulate cost impacts of a prefabrication

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- Campus Square Site
- Dumpster Storage
- Contractor Parking Lot
- Material Storage & Lay-down

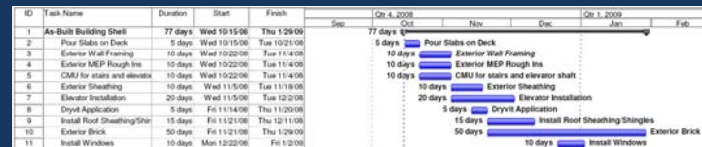
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### Original Exterior Wall Sequence

- 77 day building shell duration
- 50 days spent on exterior brick installation-(exceeded original schedule)
- Adjustable scaffolding, material/man lifts needed throughout



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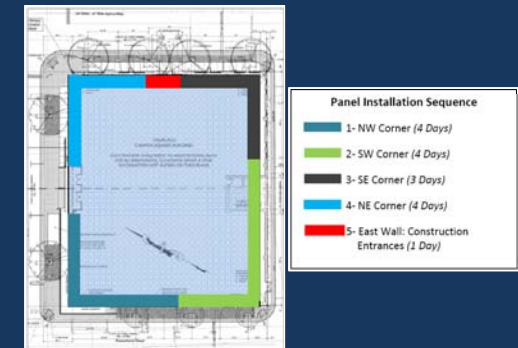
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### Proposed Exterior Wall Sequence

- 45 day building shell duration (6+ week schedule reduction)
- 3 week panel installation duration
- No scaffolding needed
- Addition of crane throughout panel installation



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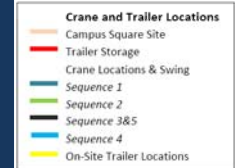
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## CAMPUS SQUARE

### Proposed Exterior Wall Panels: *Sequence 1 – NW Corner*



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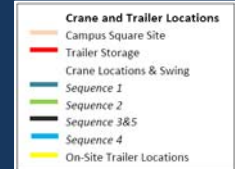
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### Proposed Exterior Wall Panels: *Sequence 2 – SW Corner*



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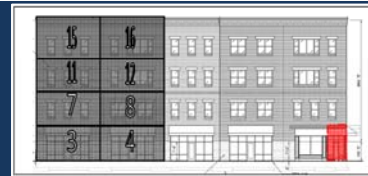


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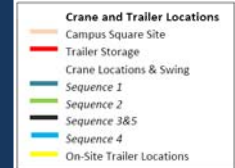
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## CAMPUS SQUARE

### Proposed Exterior Wall Panels: *Sequence 3 – SE Corner*



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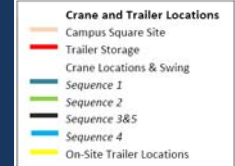
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## CAMPUS SQUARE

### Proposed Exterior Wall Panels: *Sequence 4 – NE Corner*



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## CAMPUS SQUARE

### Cost Impacts

- \$154,691 GC savings due to 9 week reduction in construction schedule

| General Conditions Estimate            |                    | Proposed General Conditions Estimate   |                    |
|--|--------------------|--|--------------------|
| Description                            | Cost               | Description                            | Cost               |
| Staffing                               | \$693,730          | Staffing                               | \$589,671          |
| Administrative Facilities and Supplies | \$50,150           | Administrative Facilities and Supplies | \$43,150           |
| Safety                                 | \$7,000            | Safety                                 | \$4,400            |
| Cleanup                                | \$129,255          | Cleanup                                | \$106,324          |
| Jobsite Work Requirements              | \$144,450          | Jobsite Work Requirements              | \$126,350          |
| Permitting                             | \$66,686           | Permitting                             | \$66,686           |
| Bonds and Insurance                    | \$105,488          | Bonds and Insurance                    | \$105,488          |
| <b>Total General Conditions Cost</b>   | <b>\$1,196,759</b> | <b>Total General Conditions Cost</b>   | <b>\$1,042,069</b> |

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- \$585,200 direct cost increase of prefabricated panels

- \$430,500 total scope increase of exterior facade

| As-Built Costs (Includes Installation) |                   |
|--|-------------------|
| Exterior Wall Assembly                 | \$ 600,000        |
| Pella® Windows                         | \$ 80,000         |
| <b>TOTAL</b>                           | <b>\$ 680,000</b> |
| <b>SF COSTS</b>                        | <b>\$ 25.56</b>   |

| Prefabrication Costs |                    |                        |                        |
|----------------------|--------------------|------------------------|------------------------|
|                      | Unit Cost (SF)     | Installation Cost (SF) | Cost                   |
| Prefabricated Panels | \$ 37              | \$ 10                  | \$ 1,250,200           |
| Truck Crane Costs    | \$ 5,000           | 3                      | \$ 15,000              |
|                      | Panel SF (Approx.) | <b>TOTAL</b>           | <b>\$ 1,265,200.00</b> |
|                      | 26600              | <b>SF COST</b>         | <b>\$ 47.56</b>        |

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## CAMPUS SQUARE

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### Thermal Performance of Exterior Wall Systems *(Mech. Breadth)*

#### *Goals:*

- Calculate heat loss through and as-built and prefabricated wall assemblies
- Demonstrate the thermal advantages of the proposed wall assembly over the as-built condition

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## CAMPUS SQUARE

### As-Built Masonry Veneer Assembly

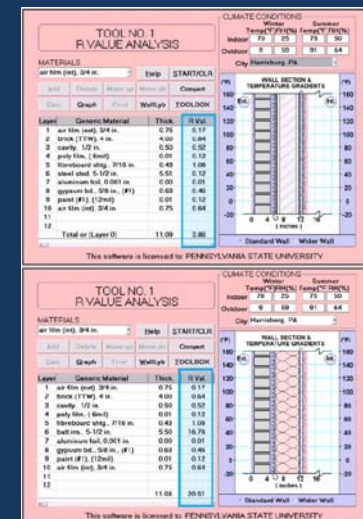
- ▀ 4" masonry brick with 7/16" DensGlass® sheathing
- ▀ 6" 16-gauge steel studs @ 16" o.c.
- ▀ 6" batt. insulation with foil backing
- ▀ ½" gypsum board

### R-Value Analysis

*Insulated Wall Sections:*                      20.51

*Uninsulated Wall Sections:*                3.86

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## CAMPUS SQUARE

### Prefabricated Panel Wall Assembly

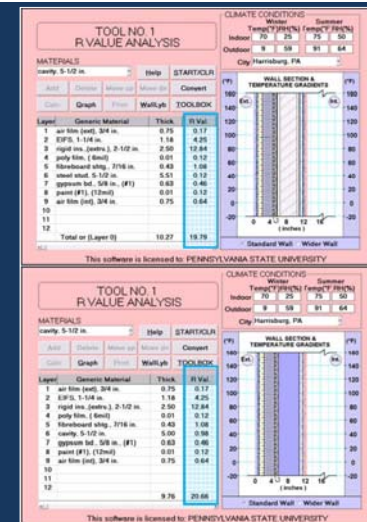
- 4" EIFS and simulated brick stucco face
- 7/16" DensGlass® sheathing
- 6" 16-gauge steel studs @ 16" o.c.
- ½" gypsum board

### R-Value Analysis

*Insulated Wall Sections:* 20.66

*Uninsulated Wall Sections:* 19.79

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## CAMPUS SQUARE

### Heat Loss Analysis

$$Q=(U)(A)(\Delta t) \text{ for each element}$$

U= U-factor for a given envelope component

A= Surface area of the envelope component

$\Delta t$  = The design temperature difference between inside and outside air

| Exterior Wall Heat Loss (Q) Comparison Table |           |                   |           |                 |          |                 |          |
|--|-----------|-------------------|-----------|-----------------|----------|-----------------|----------|
| As-Built (Q)                                 |           | Prefabricated (Q) |           | Difference      |          |                 |          |
| Summer                                       | Winter    | Summer            | Winter    | Summer $\Delta$ | % Summer | Winter $\Delta$ | % Winter |
| 90100.89                                     | 357092.64 | 77965.69          | 310827.18 | 12135.20        | 13.5%    | 46265.46        | 13.0%    |

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| Total Wall System |          |           | EIFS & Masonry Brick Comparison |          |           |
|-------------------|----------|-----------|---------------------------------|----------|-----------|
|                   | Summer   | Winter    |                                 | Summer   | Winter    |
| <b>AS-BUILT</b>   |          |           | <b>AS-BUILT</b>                 |          |           |
| Q                 | 90100.89 | 357092.64 | Q                               | 30250.34 | 115329.41 |
| A                 | 30293.97 | 30293.97  | A                               | 23232.74 | 23232.74  |
| $\Delta t$        | 16.00    | 61.00     | $\Delta t$                      | 16.00    | 61.00     |
| U                 | 0.19     | 0.19      | U                               | 0.08     | 0.08      |
| R                 | 5.38     | 5.17      | R                               | 12.29    | 12.29     |
| <b>PRE-FAB</b>    |          |           | <b>PRE-FAB</b>                  |          |           |
| Q=                | 77965.69 | 310827.18 | Q                               | 18115.13 | 69063.95  |
| A=                | 30293.97 | 30293.97  | A                               | 23232.74 | 23232.74  |
| $\Delta t$        | 16.00    | 61.00     | $\Delta t$                      | 16.00    | 61.00     |
| U                 | 0.16     | 0.17      | U                               | 0.05     | 0.05      |
| R                 | 6.22     | 5.95      | R                               | 20.52    | 20.52     |



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### Redesign of Exterior Wall Panel Connections *(Struct. Breadth)*

#### *Goal:*

- Redesign the connections of the prefabricated wall system to the superstructure of the building

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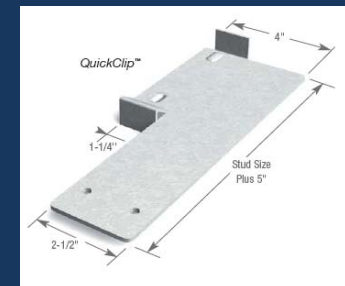
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## CAMPUS SQUARE

QuickClip™ (QC-Series™) 10 gauge, 33 ksi

- ASCE 7-05, Section 2.4: Combining Nominal Loading Using Allowable Stress Design
- Allowable Load of connection: **476lbs**
- Wall Assembly (per tributary area of): **233lbs**
- Allowable Shear (concrete): **335 lbs** (1 ½ screw embed)
- Design Shear: **264lbs**



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### Hilti™ Powder Driven Fasteners

- Allowable Shear (concrete): **335 lbs** (1 ½ screw embed)
- Design Shear (concrete): **264lbs**
- Allowable Tension (steel): **800 lbs**
- Design Tension (steel): **233 lbs**
- Fillet Weld at stud (per inch) allowable load: **606lbs**
- 16 gauge, 33 ksi steel studs

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### Conclusions

- Prefabrication will reduce the construction duration by 9 weeks
- Repetitive bay sizing / floor height
- Increase of building shell cost: \$430,500
- Increased thermal performance during peak loading by 13%
- Decrease in operational costs will further mitigate scope increase
- Prefabrication design considerations
- Implementation of a construction quality assurance program

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### Recommendations

- All three analysis topics should be used on Campus Square

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# Questions?



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### Acknowledgements

- Penn State Architectural Engineering Faculty**
- Wohlsein Construction Company**
  - Daryl Evans
  - William Sutton II
- GreenWorks Development**
  - Bobbie L. Van Buskirk
- TEAM Panels International**
  - Craig Fleischmann
- KERR Interior Systems Ltd. & Composite Building Systems Inc.**
  - Darryl Wiebe
- Family and Friends**