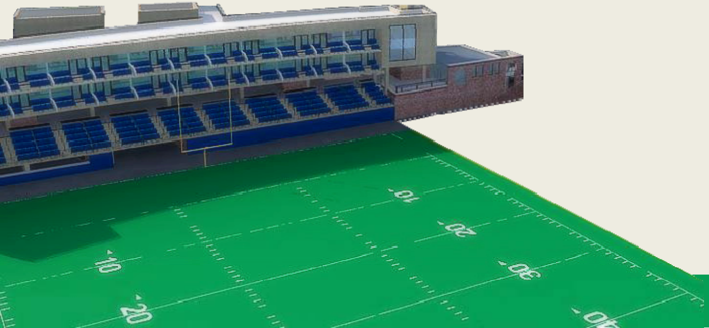


# Game Day Building

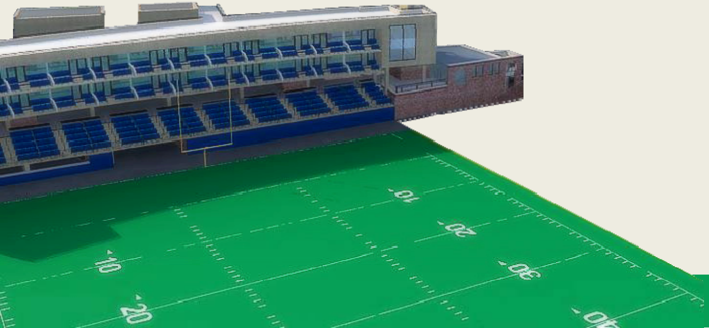
## Post Tensioned Redesign

AE Senior Thesis Spring 2009

Matthew Haapala

BAE/MAE Structural Option

Faculty Consultant: Dr. Hanagan




# Presentation Outline

- Existing Conditions
- Thesis Proposals and Goals
- Gravity System Redesign
- Lateral System Redesign
- Foundation Optimization
- Cost & Schedule Analysis
- Lighting Redesign
- Conclusions
- Question and Answer

# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Building Statistics

Building Name: Foreman Field Game Day Building

Project Team:

- Owner - Old Dominion University
- General Contractor - S.B. Ballard Construction Company
- Architect - Ellerbe Becket
- Engineer - Clark Nexsen

Size : Gross Floor Area = 54,877 sq. ft. , Height = 47 ft.

- $1^{st}$ Floor = 16,500 sq. ft.
- $2^{nd}$ Floor = 16,100 sq. ft.
- $3^{rd}$ Floor = 11,500 sq. ft.
- $4^{th}$ Floor = 10,800 sq. ft.

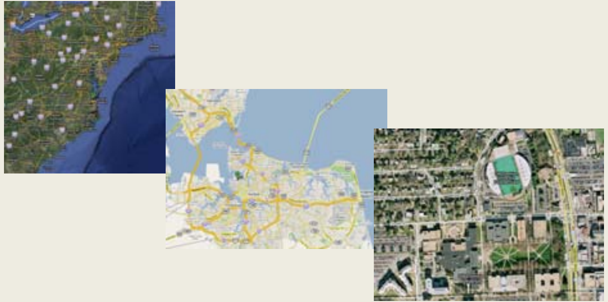
Construction: Dates of February 22, 2008 thru July 22, 2009

Cost: $11.9 million

Project Delivery Method: Design-Building

# Building Statistics

Location: The Game Day building is currently under construction in the south end zone of Foreman Field on the campus of Old Dominion University in Norfolk Virginia.



# Game Day Building Post Tensioned Redesign

By: Matthew Haapala



# Existing Gravity System

Cast in Place Reinforced Concrete Flat Plate

- Typical bay size 31'-6" x 17'-0"
- Typical slab depth 12"
- No shear caps or drop panels
- Shear stud rails used to resist punching shear

Cast in Place Reinforced Concrete Beams

- Located around openings and seating

Cast in Place Concrete Columns

- 18" x 18" typical

# 3RD Floor Structural Plan


Blue: Beam Location
Red: Column or Load Bearing Wall Location

# Game Day Building Post Tensioned Redesign

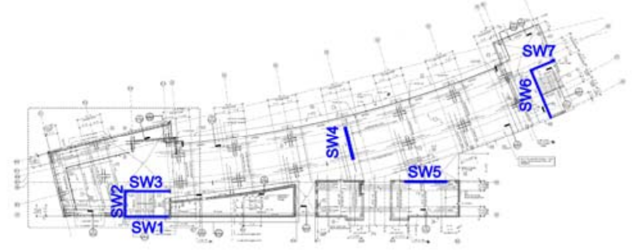
By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Existing Lateral System

- Seven Cast in Place Reinforced Concrete Shear Walls
- Located  in Architecturally Convenient Locations

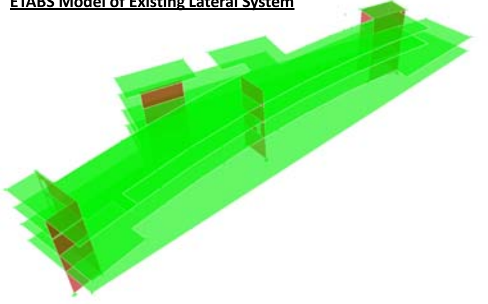
**Shear Wall Location Plan**




# Existing Lateral System

- Capacity Significantly Exceeds Lateral Loading Demands
- Column & Slab Moment Frames' Stiffness not Considered

**ETABS Model of Existing Lateral System**



# Game Day Building Post Tensioned Redesign

By: Matthew Haapala



# Existing Foundations

- Square Precast Prestressed Concrete (SPPC) Piles
- 100’ long from Tip to Cutoff
- 183 Piles Total
- Typically Driven in Clusters of 4 Below Most Columns
- Clusters of Up to 18 Below Shear Walls
- Topped With 36” - 40” Deep Pile Caps
- Grade Beams Below Exterior Walls & Between Pile Caps

| Sub-Surface Soild Conditions | |
|---|---|
| **Average Depth (ft.)** | **Description** |
| 0 to 1 | Topsoil or Asphalt |
| 0 to 4 | Fill of fibrous organics and wet sand |
| 2 to 18 | Sand with varying amounts of silt and clay |
| 18 to 53-84 | Gray, wet clay with varying amounts of sand and marine shell fragments |
| 53-84 to 110 | Gray, wet, silty, fine sand with marine shell fragments and varying amounts of clay |

# Existing Foundations

**Foundation Plan**

# Game Day Building Post Tensioned Redesign

By: Matthew Haapala



## Structural Depth Proposal

Study 1 Gravity System Redesign

Problem: Two-way flat plate is structurally inefficient floor system

Solution: Replace with one-way slabs on post tensioned beams

Goals:

- Reduce slab depth
- Develop understanding of post tensioned concrete design
- Use post tensioning to minimize beam depth
- Reduce self weight of the structure

## Structural Depth Proposal

Study 2 Lateral System Redesign

Problem: Shear walls' excess capacity suggests reduction possible

Solution: Consider Moment Frames in Lateral Design and Remove Existing Shear Walls Where Practical

Goals:

- Utilize Post Tensioned Beams in Ordinary Concrete Moment Frames
- Reduce The Number of Shear Walls

Study 3 Foundation Optimization

Problem: With poor soils extensive deep foundations required

Solution: Analyze foundation requirements of redesigned structure to determine possible foundation reductions

Goal: Reduce the number of piles

# Game Day Building
# Post Tensioned Redesign

By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## C.M. Breadth Proposals

Problem: Unknown cost, constructability, and construction schedule impacts of structural redesign

Solution: Conduct cost and schedule analyses comparing of the original and redesigned structure

Goals:

- Lower the price of the structure
- Develop a construction sequence that satisfies the unique demands of post tensioning
- Do not Increase the Overall Project Duration

## C.M. Breadth Proposals

# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Lighting Breadth Proposal

Problem: Original lighting design predominantly inexpensive troffers and cans

Solution: Create an alternate lighting scheme for the scholarship lounge

Goals:

- Integrate the structural redesign into the redesigned lighting scheme
- Make the room seem more spacious have emphasizing the peripherals by having a high luminance on the Walls and Ceiling.
- Increase flexibility by specifying dimmable fixtures
- Satisfy ASHRE 90.1 and IESNA Lighting Handbook requirements
- Use attractive or concealed luminaries

# Lighting Breadth Proposal

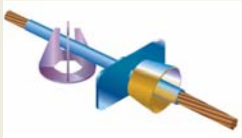
# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala


- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions


# Gravity System Redesign

| Reference Design Codes and Standards | |
|---|---|
| Original Design Code | Substitutions |
| 2003 Virginia Uniform Statewide Building Code | 2006 IBC |
| ASCE 7-02 | ASCE 7-05 |
| ACI 318-02 | ACI 318 08 |



| Concrete Material Properties | Original | | New | |
|---|---|---|---|---|
| Location | f'c (psi) | Cement Type | f'c (psi) | Cement Type |
| Pile Caps and Grade Beams | 3000 | I | 3000 | I |
| Slabs on Grade | 3000 | I | 3000 | I |
| Structural Slabs and Beams | 5000 | I | 6000 | III |
| Walls and Columns | 5000 | I | 6000 | III |

# Game Day Building Post Tensioned Redesign

By: Matthew Haapala

- Existing Conditions
- Thesis Proposal & Goals
- Gravity System Redesign
- Lateral System Redesign
- Foundation Optimization
- Cost & Schedule Analysis
- Lighting Redesign
- Conclusions

# Gravity Loading Assumptions

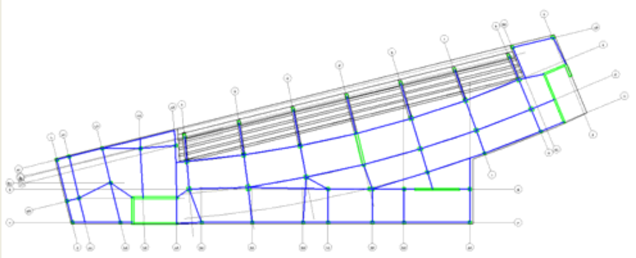
| GRAVITY LOADING DESIGN VALUES | | |
|---|---|---|
| **Loading** | **Design Value** | **ASCE 7-05 Req'd** |
| **Dead Loads** | | |
| Normal Weight Concrete | 150 pcf | |
| Masonry Walls | 40 psf | |
| Curtin Walls | 15 psf | |
| Mechanical/Electrical/Plumbing | 5 psf | |
| 100% Outdoor Air Handling Unit | 750 lbs | |
| Variable Refrigerant Volume Heat Pump | 350 lbs | |
| Gas Fired DX Package Roof top Unit | 500 lbs | |
| DX Split System Heat Pump | 250 lbs | |
| **Live Loads** | | |
| ROOF | 20 psf | 20 psf |
| STAIRS | 100 psf | 100 psf |
| CORRIDORS | 100 psf | 100 psf |
| TERRACES | 100 psf | 100 psf |
| SEATING | 100 psf | 60 psf |
| STORAGE | 125 psf | 125 psf |
| MECH./ELEC. ROOMS | 125 psf | |
| **Snow Loads** | | |
| Pg | 10 psf | 10 psf |
| Pf | 11 psf | 11 psf |

# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## Trial Layout Development

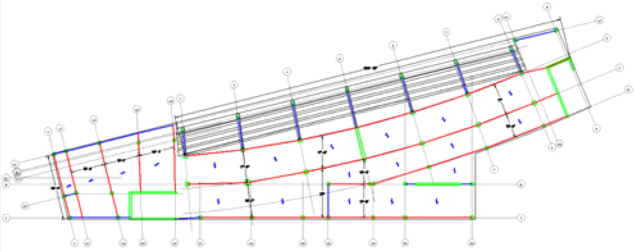


= Post Tensioned Concrete Beam

= Reinforced Concrete Beam

= Support Column or Wall

## Trial Layout Development



= Post Tensioned Concrete Beam

= Reinforced Concrete Beam

= Support Column or Wall

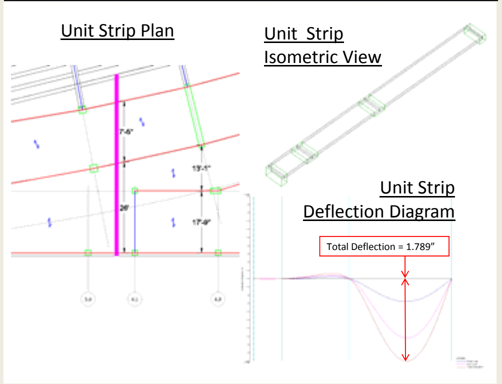
# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

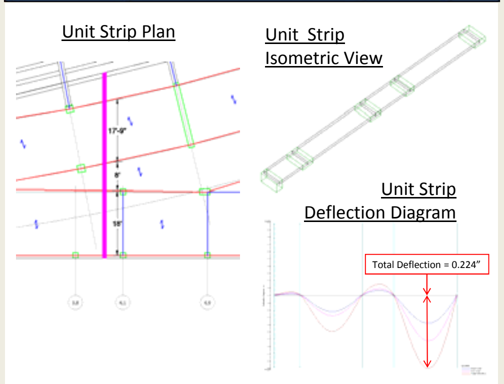
# PCA Slab Analysis & Design

PCA Slab Unit Strip 2nd Floor Between Gridlines 3.8 and 4.1 w/ Initial Beam Layout




# PCA Slab Analysis & Design

PCA Slab Unit Strip 2nd Floor Between Gridlines 3.8 and 4.1 w/ Final Beam Layout



# Game Day Building Post Tensioned Redesign

## By: Matthew Haapala



# PT Beam Hand Calculations

Calculations

- Designed in accordance with ACI 318-08 for:
  - Flexural serviceability
  - Ultimate flexural strength
  - Shear and torsion
  - Deflection
- Every post tensioned beam analyzed at supports and midspan
- Member loads determined by iterative moment distribution
  - Pattern loading not critical
  - Moment redistribution not performed
    - $\varepsilon_t$>.0075 (ACI 318-08 Sect. 8.4.2)
- Beam/Slab effective T beams considered

# Game Day Building Post Tensioned Redesign

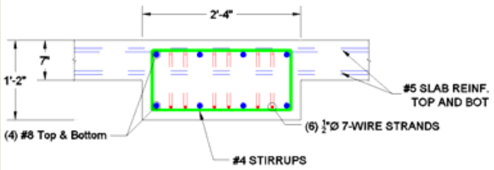
By: Matthew Haapala

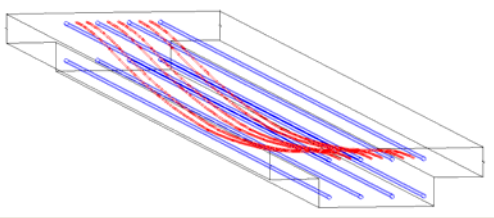

•Existing Conditions
•Thesis Proposal & Goals
•Gravity System Redesign
•Lateral System Redesign
•Foundation Optimization
•Cost & Schedule Analysis
•Lighting Redesign
•Conclusions


## PT Beam Hand Calculations

- Interior beams
  - Depth: 14” = 2x slab depth of 7”
  - Width: 12” - 40”, typ. 28”
  - # Tendons: (5) - (13), typ. (6)
  - Longitudinal Rebar: (3) - (5) #8 Top & Bottom , typ. (4)
- Perimeter beams: depth 18”
  - Depth 18” - 29”
  - Width 12” - 24”, typ. 18”
  - # Tendons: (4) - (6), typ. (4)
  - Longitudinal Rebar : (2) - (4) #8 Top & Bottom, typ. (2)
- On average76% dead load balanced after losses
- Average Compressive Stress 164psi – 475psi, typ. 250 psi
  - > Code required 125psi
  - < 500psi  reasonable maximum

## PT Beam Hand Calculations



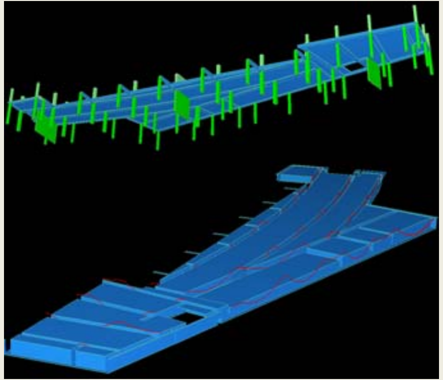



# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## RAM Concept Analysis

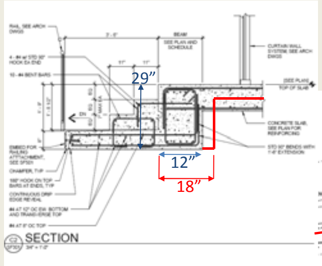


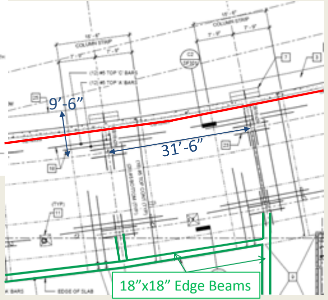
# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •**Gravity System Redesign**
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## Torsion & Deflection Design



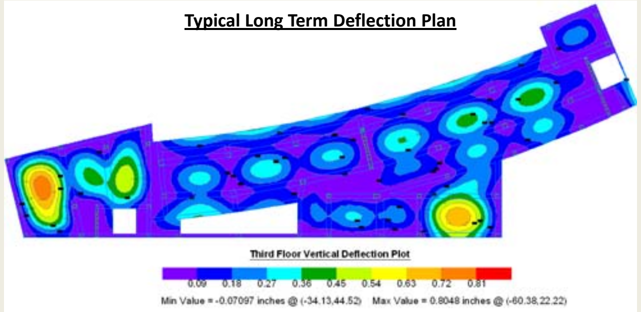



# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Torsion & Deflection Design

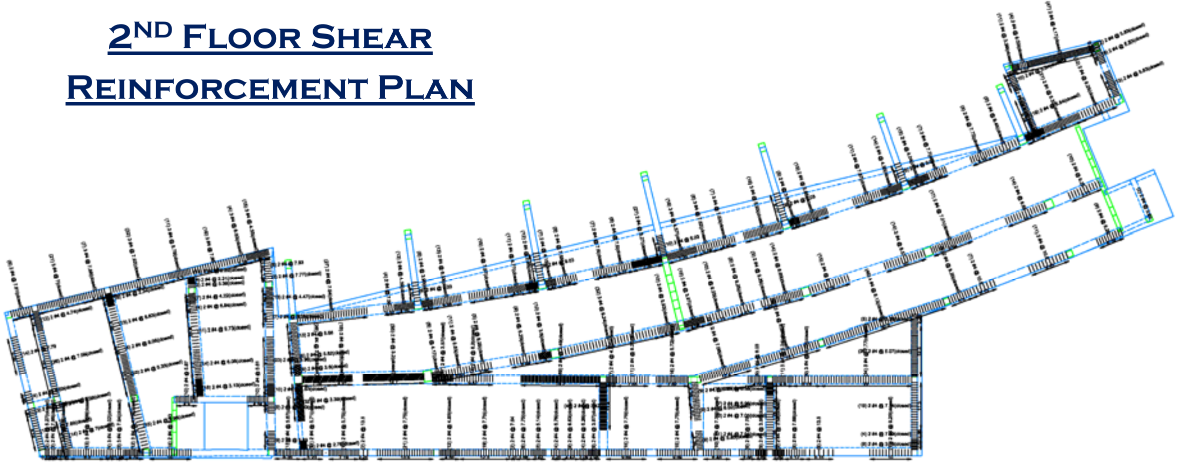


# Game Day Building
# Post Tensioned Redesign

By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## 2nd Floor Shear Reinforcement Plan

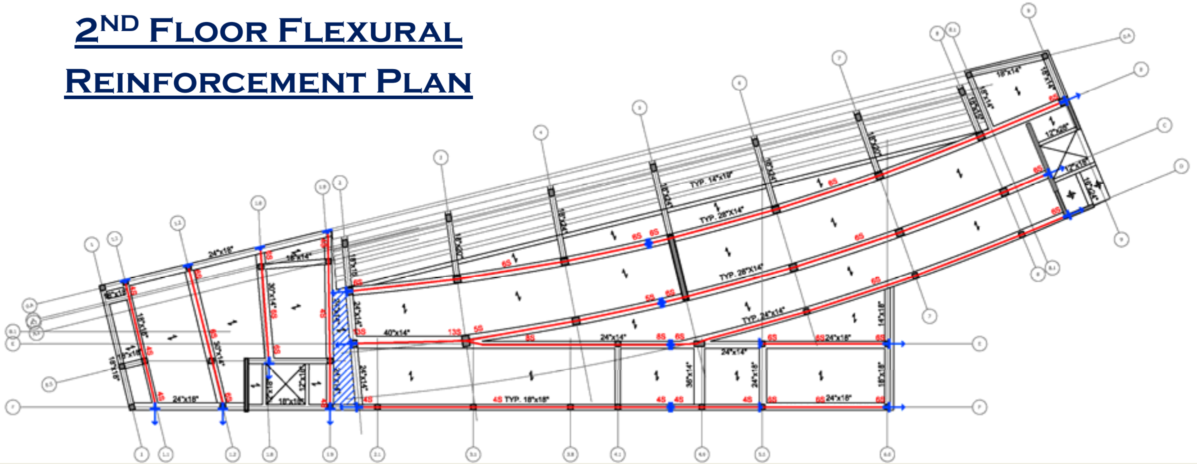


# Game Day Building Post Tensioned Redesign

**By: Matthew Haapala**

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## 2nd Floor Flexural Reinforcement Plan

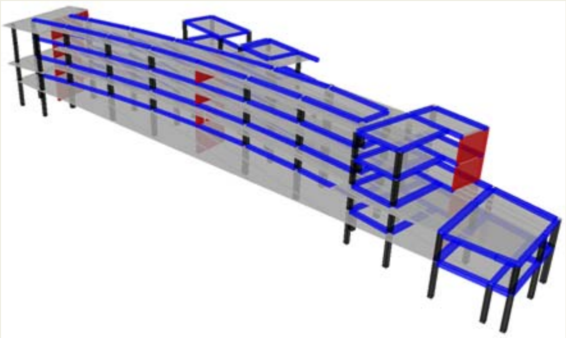


# Game Day Building
# Post Tensioned Redesign

**By: Matthew Haapala**

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •**Lateral System Redesign**
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## Lateral System Redesign



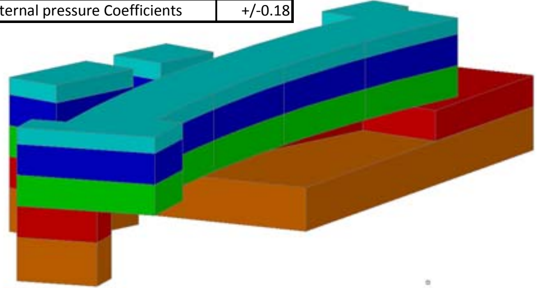
# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

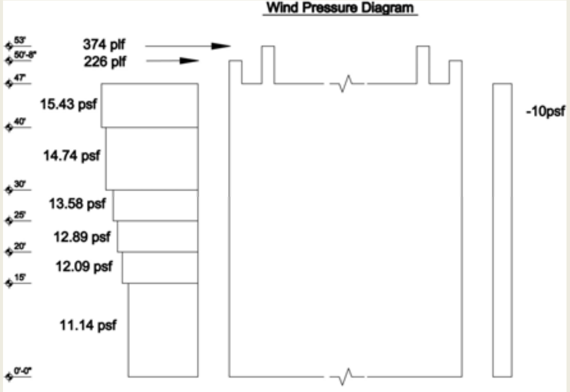
- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •**Lateral System Redesign**
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Wind Loading

| Wind Loading Design Values | |
|---|---|
| Basic Wind Speed | 110MPH |
| Wind Importance Factor | 1.15 |
| Wind Exposure Category | B |
| Gust Response Factor | 0.85 |
| Internal pressure Coefficients | +/-0.18 |



# Wind Loading



# Game Day Building
# Post Tensioned Redesign

**By: Matthew Haapala**



## Seismic Loading

| Seismic Design Values | |
|---|---|
| Site Class | D |
| Importance Factor, I | 1.25 |
| $S_s$ | 0.118 |
| $S_1$ | 0.048 |
| $F_a$ | 1.6 |
| $F_v$ | 2.4 |
| $S_{DS}=(2/3)*F_a*S_s$ | 0.126 |
| $S_{D1}=(2/3)*F_v*S_1$ | 0.0768 |
| Seismic Design Category | B |
| Building Height, h | 47' |
| $C_t$ | 0.02 |
| x | 0.75 |
| $Ta = Ct*h^x$ | 0.359 |
| Cu | 1.7 |
| CuTa | 0.61 |
| $T_L$ | 8 |

## Seismic Loading

**Design Coefficients for Seismic Force Resisting Systems**

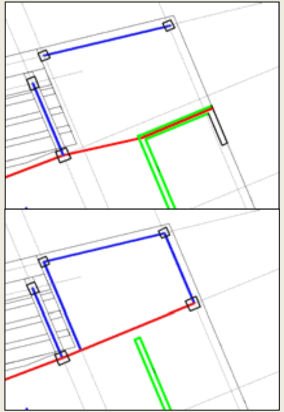
| Seismic Force Resisting System | Response Modification Coefficient, R | Deflection Amplification Factor, $C_d$ |
|---|---|---|
| Ordinary Reinforced Concrete Moment Frames | 3 | 2.5 |
| Ordinary Reinforced Concrete Shear Walls | 5 | 4.5 |
| Ordinary Reinforced Concrete Moment Frames and Ordinary Reinforced Concrete Shear Walls | 4.5 | 4 |

# Game Day Building
# Post Tensioned Redesign

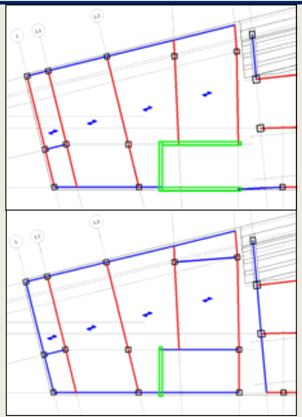
By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## Shear Wall 7 Removal



## Shear Walls 1 & 3 Removal

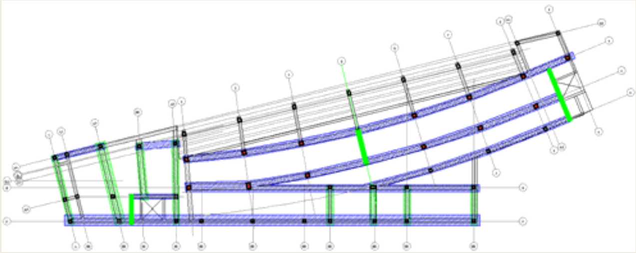


# Game Day Building Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Lateral System Plan



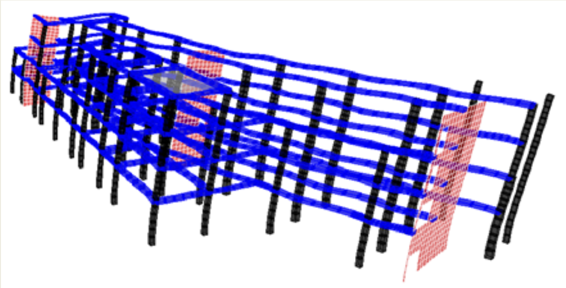
- = Columns Sections Increased
- = Plan East/West Direction Lateral System Components
- = Plan North/South Direction Lateral System Components

# Game Day Building
# Post Tensioned Redesign


## By: Matthew Haapala

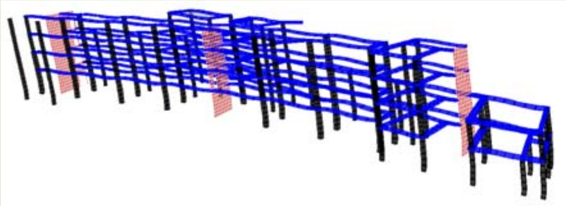

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

## South Wind Deflected Shape



| Max Deflections Caused By Wind Loading | | | | |
|---|---|---|---|---|
| Story | Max Deflection X (in.) | Max Deflection Y (in.) | h/600 (in.) | Deflection Check (OK or NG) |
| Roof | 0.0686 | 0.0868 | 0.2133 | OK |
| Floor 4 | 0.0709 | 0.0401 | 0.2133 | OK |
| Floor 3 | 0.0707 | 0.0376 | 0.2133 | OK |
| Floor 2 | 0.0684 | 0.0340 | 0.3000 | OK |

## Seismic Deflected Shape



| Seismic Drift Analysis | | | | | | |
|---|---|---|---|---|---|---|
| East/West Direction | | | | | | |
| Story | Cd | Average Diaphragm Drift | Max Diaphragm Drift | Seismic Drift Limit | Drift Limit Exceded | Torsional Irregularity |
| Roof | 2.5 | 0.002915 | 0.002953 | 0.02 | No | No |
| Floor 4 | 2.5 | 0.003378 | 0.003418 | 0.02 | No | No |
| Floor 3 | 2.5 | 0.003383 | 0.003418 | 0.02 | No | No |
| Floor 2 | 2.5 | 0.002220 | 0.002245 | 0.02 | No | No |
| North South Direction | | | | | | |
| Story | Cd | Average Diaphragm Drift (Y) | Max Diaphragm Drift (Y) | Seismic Drift Limit | Drift Limit Exceded | Torsional Irregularity |
| Roof | 4 | 0.001120 | 0.001204 | 0.02 | No | No |
| Floor 4 | 4 | 0.000816 | 0.000960 | 0.02 | No | No |
| Floor 3 | 4 | 0.000816 | 0.000884 | 0.02 | No | No |
| Floor 2 | 4 | 0.000396 | 0.000472 | 0.02 | No | No |

# GAME DAY BUILDING
# POST TENSIONED REDESIGN


## BY: MATTHEW HAAPALA


- •EXISTING CONDITIONS
- •THESIS PROPOSAL & GOALS
- •GRAVITY SYSTEM REDESIGN
- •LATERAL SYSTEM REDESIGN
- •FOUNDATION OPTIMIZATION
- •COST & SCHEDULE ANALYSIS
- •LIGHTING REDESIGN
- •CONCLUSIONS

# SHEAR WALL DESIGN

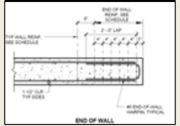
| Loading | | | | |
|---|---|---|---|---|
| Load Combo | 1.2D+1.6W+L | 0.9D+1.6W | 1.2D+1.0E+L | 0.9D+1.0E |
| $P_u$ (Kips) | 1127 | 606 | 1128 | 606 |
| $V_u$ (Kips) | 174 | 201 | 27 | 54 |
| $M_u$ (K-ft) | 8001 | 7965 | 3370 | 3333 |

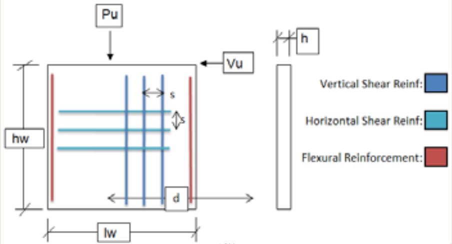
| Φ Design Values | |
|---|---|
| Φ Tension | 0.9 |
| Φ Shear | 75 |
| Φ Comp. | 0.65 |
| **Geometry** | |
| $l_w$ (in) | 222 |
| h (in) | 18 |
| $h_w$ (in) | 180 |
| d % | 80.00% |
| A (in^2) | 3996 |
| S (in^3) | 147852 |
| I (in^4) | 16411572 |
| **Material Properties** | |
| f'c | 6000 |
| $f_y$ | 60000 |

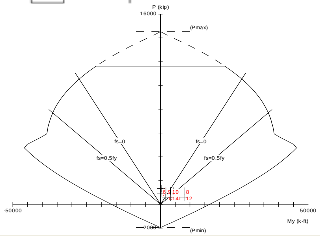
| Shear Reinforcement Req'd | |
|---|---|
| # of Curtains Req'd | 1 |
| As min (in^2/ft) | 0.54 |
| Max Spacing (in) | 13.78 |
| **Shear Reinforcement Design** | |
| # of Curtains | 2 |
| Bar Size | #5 |
| Bar Spacing (in) | 12 |
| $\alpha_c$ | 3 |
| $\rho_t$ | 0.006 |
| ΦVn (Kips) | 268 |
| Vu/ΦVn | 75% |

| Flexural Reinforcement Req'd | |
|---|---|
| Boundary Zone | No |
| **Flexural Reinforcement Design** | |
| # of Bars | 7 |
| Bar Size | #9 |
| ΦMn>Mu,ΦPn>Pu | Yes |

**Flexural Reinforcement Detail**



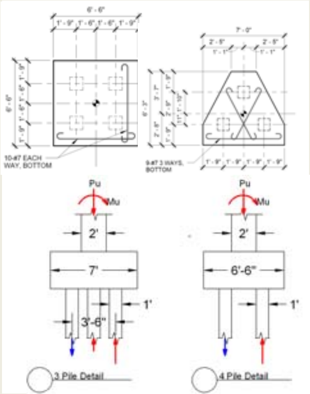



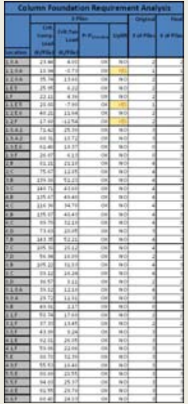
# Game Day Building Post Tensioned Redesign

By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Foundation Optimization




# Foundation Optimization

| Shear Wall Base Shear Comparison Chart | | | | | |
|---|---|---|---|---|---|
| Original Base Shear | | New Design Base Shear | | | |
| Seismic | Wind | Seismic | | Wind | |
| (Kips) | (Kips) | (Kips) | % Orig. | (Kips) | % Orig. |
| 72 | 99 | 62 | 86% | 95 | 96% |
| 129 | 162 | 106 | 82% | 158 | 98% |
| 102 | 81 | 67 | 66% | 77 | 95% |

**Shear Wall Foundation Analysis**

| Wall | Critical Comp. Load (K/Pile) | Critical Tensile Load (K/Pile) | Critical Shear Load (K/Pile) | $P<P_{Allowab}$ | $V<V_{Allowable}$ | Uplift | Original # of Piles | Final # of Piles |
|---|---|---|---|---|---|---|---|---|
| SW 1, SW 3, SW 5, & SW7 | | | | | | | 22 | 0 |
| SW 2 | 77 | -29 | 9 | OK | OK | YES | 10 | 10 |
| SW 4 | 142 | -27 | 12 | OK | Fail* | YES | 10 | 10 |
| SW 6 | 61 | -21 | 8 | OK | OK | YES | 12 | 12 |

**Foundation Redesign Summary**

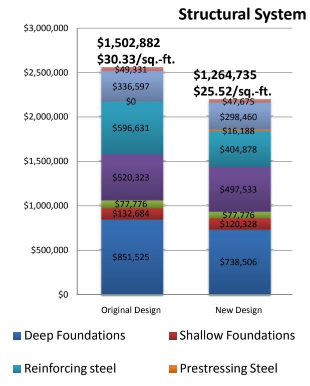
| Supporting | Original # of Piles | Final # of Piles | Difference |
|---|---|---|---|
| Columns | 113 | 110 | -3 |
| Shear Walls | 54 | 32 | -22 |
| Façade | 16 | 16 | 0 |
| Total | 183 | 158 | -25 |

# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Cost Analysis




**Cost Savings**

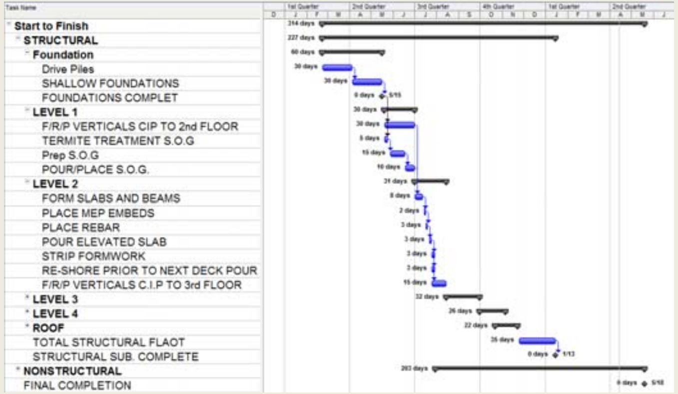
$238,147
$4.80/sq.-ft
16% Reduction in Structure Cost
2% Reduction in Overall Project Cost

# Game Day Building Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions

# Original Design Schedule

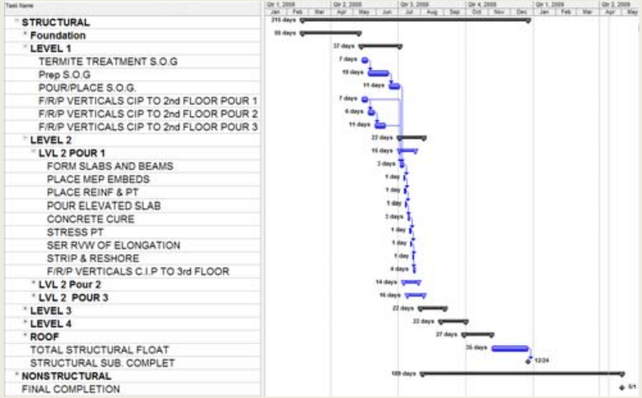


# Game Day Building Post Tensioned Redesign

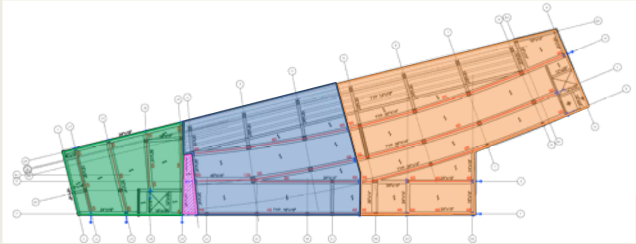
## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •**Cost & Schedule Analysis**
- •Lighting Redesign
- •Conclusions

## New Design Schedule




## Construction Sequence



Sequence 2 Sequence 1 Sequence 3

# Game Day Building
# Post Tensioned Redesign


## By: Matthew Haapala



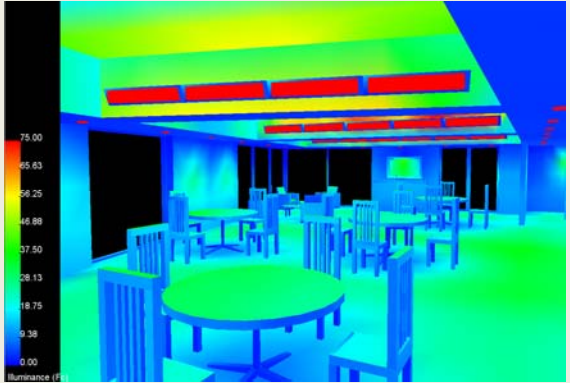

## Lighting Redesign

# Game Day Building
# Post Tensioned Redesign

By: Matthew Haapala

- Existing Conditions
- Thesis Proposal & Goals
- Gravity System Redesign
- Lateral System Redesign
- Foundation Optimization
- Cost & Schedule Analysis
- Lighting Redesign
- Conclusions

## Pseudo Color Rendering



# Game Day Building
# Post Tensioned Redesign

By: Matthew Haapala



## Conclusions

Gravity System Redesign

- ✓ Slab depth reduced by 5”
- ✓ Floor depth increase at beams only 2”
- ✓ Buildings weight reduced by 36%

Lateral System Redesign

- ✓ 4 out of 7 shear walls removed
- ✓ Lateral loading does not control beam design

Foundation Optimization

- ✓ Number of Piles Reduced by 15%

Cost and Schedule Analysis

- ✓ $238,000 in savings
- ✓ Structural erection expedited

Lighting Redesign

- ✓ Non uniform floor depth can improve aesthetics

# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions


# Acknowledgements

Professional Consultants

- Rich Apple — Holbert Apple Associates
- Peter A. Allen — Clark Nexsen
- Brian M. Barna — Clark Nexsen
- Alicia B, Udovich — Clark Nexsen
- John Wilson — Clark Nexsen

AE Dept. Faculty

- Dr. Walter Schneider III
- Dr. Andres Lepage
- Dr. Linda Hanagan
- Dr. Ali Memari
- Dr. John Messner

Classmates, Friends, and Family

# Game Day Building
# Post Tensioned Redesign

## By: Matthew Haapala

## Questions?

- •Existing Conditions
- •Thesis Proposal & Goals
- •Gravity System Redesign
- •Lateral System Redesign
- •Foundation Optimization
- •Cost & Schedule Analysis
- •Lighting Redesign
- •Conclusions