T.C. Williams High School Structural Redesign

Christopher B. Deker
Structural Option
AE Senior Thesis
Spring 2008

Goals

- Reduce Building Costs
- Stay on Schedule
- Increase Number of Rooms Receiving Natural Light
- Decrease SF of Corridor Space

Introduction of Topics

- Architectural Changes
  - Roof System Redesign
  - Column Redesign
  - Foundation Redesign
  - Exterior Wall Redesigns
- Floor System Redesign
- Lateral Resisting System Redesign
- Cost Analysis
- Scheduling Analysis

Building Summary

- Three Stories – 45 Feet
- 461,000 Sq Ft
- $87,000,000
- Alexandria, VA
- Summer ‘04 – Summer ‘07
- 2,500 Student High School
- 1,200 Seat Auditorium
- 3,000 Seat Gymnasium

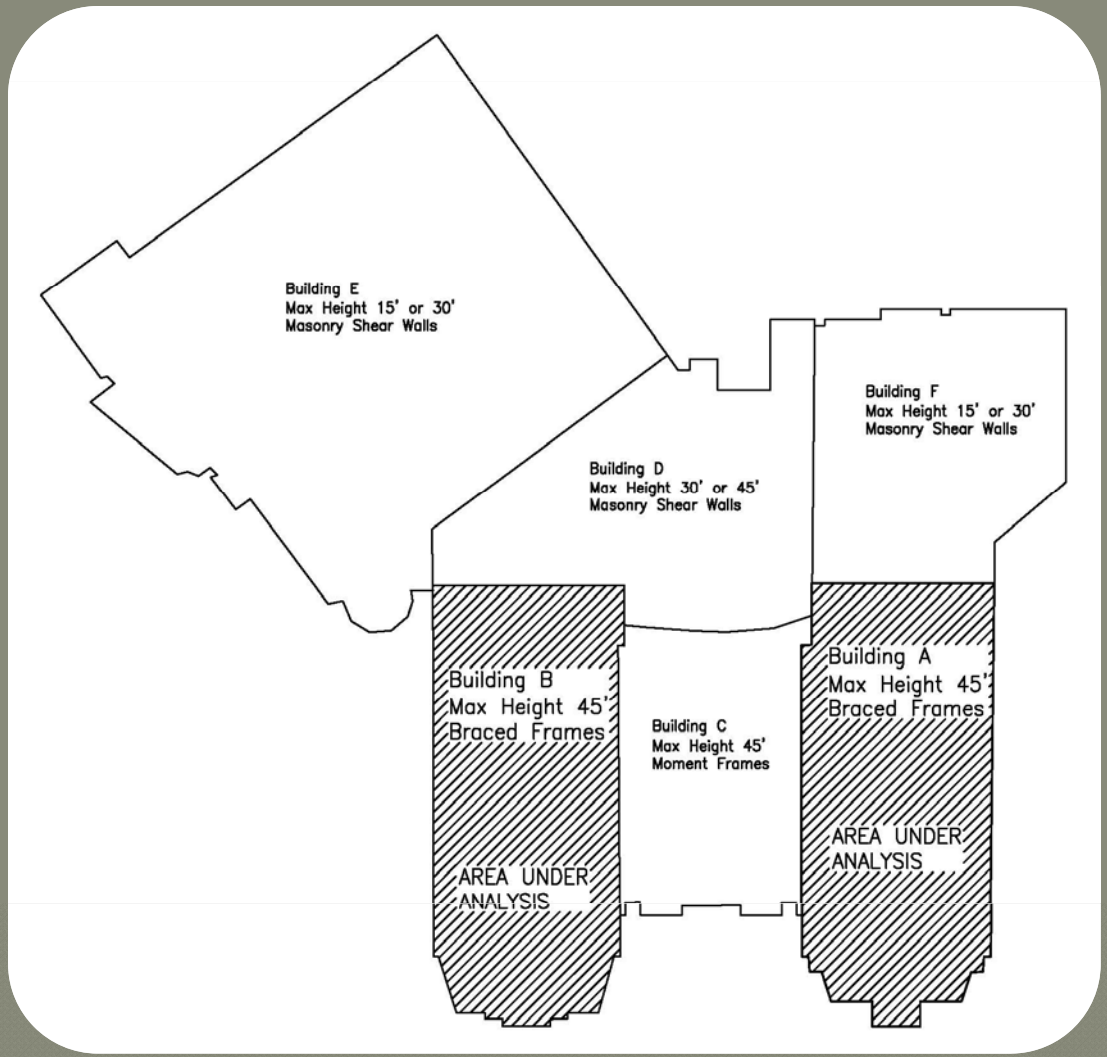
Building Summary

- LEED Silver Certification
  - 450,000 Gallon Cistern
  - Green Roof
- Owner: City of Alexandria
- Arch/Engineer: Moseley Architects
- Construction: Hensel Phelps

MOSELEYARCHITECTS

Hensel Phelps Construction Co

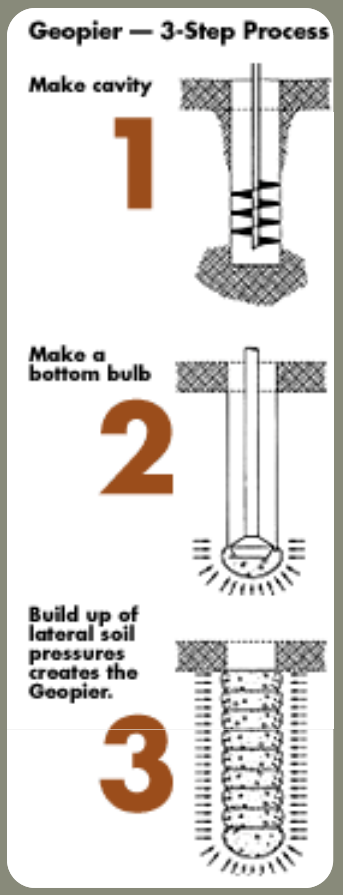
Building Summary



Soil Conditions

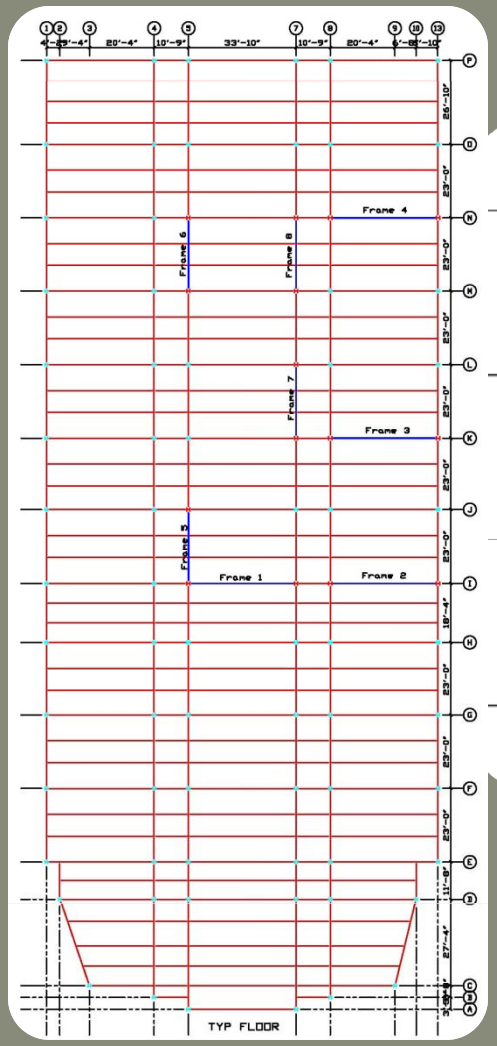
- Poor Soil Conditions
- Geopier 'Rammed Aggregate Pier' Soil Reinforcement
  - 1) Drill
  - 2) Place Aggregate
  - 3) Compact Aggregate

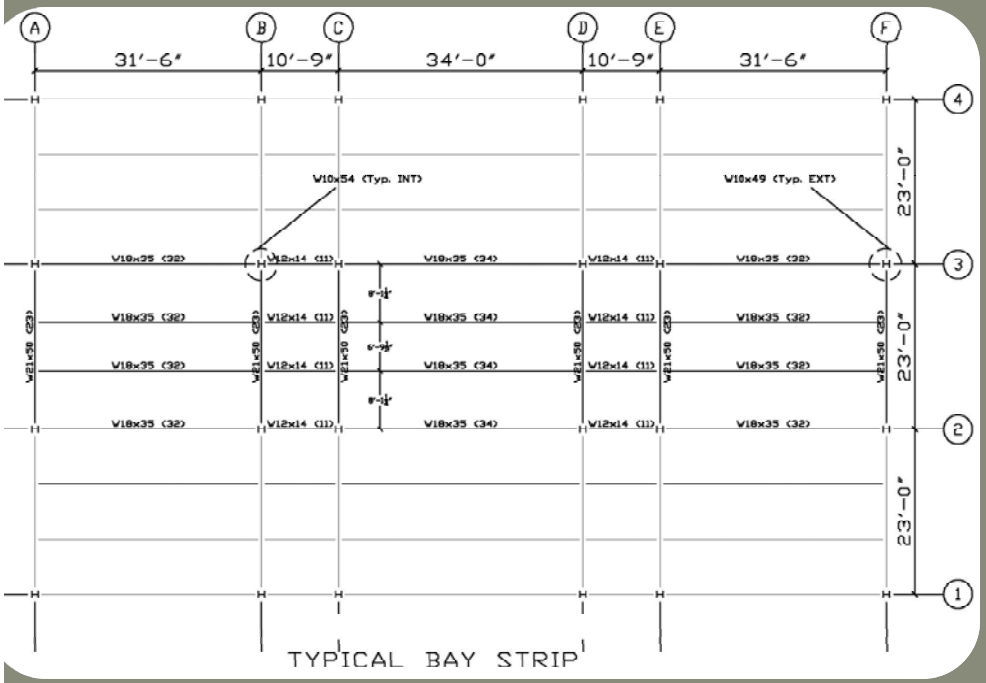
  - Pre-stresses Surrounding Soil
  - 6000 PSF Bearing Capacity



Typical Floor Plan

- Introduction
  - ~~Summary~~
  - Existing Conditions
    - Existing Structural Systems
    - Codes
- Architectural Breadth
- Structural Depth
- Construction Management Breadth
- Conclusions





Structural System

- Introduction
  - ~~Summary~~
  - ~~Existing Conditions~~
  - Existing Structural Systems
  - Codes
- Architectural Breadth
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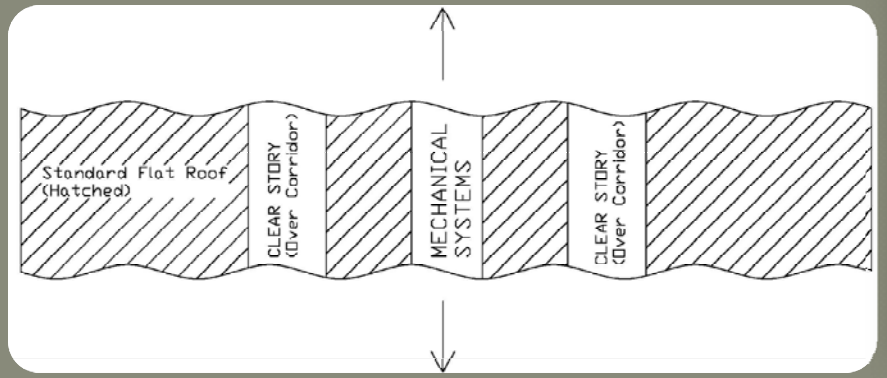
Roof System

- K-Series Steel Joists @ 5' O.C.
- KCS Steel Joists @ 3.5' O.C.
- Steel Roof Deck



Structural System

- Introduction
  - ~~Summary~~
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  - Existing Structural Systems
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- Architectural Breadth
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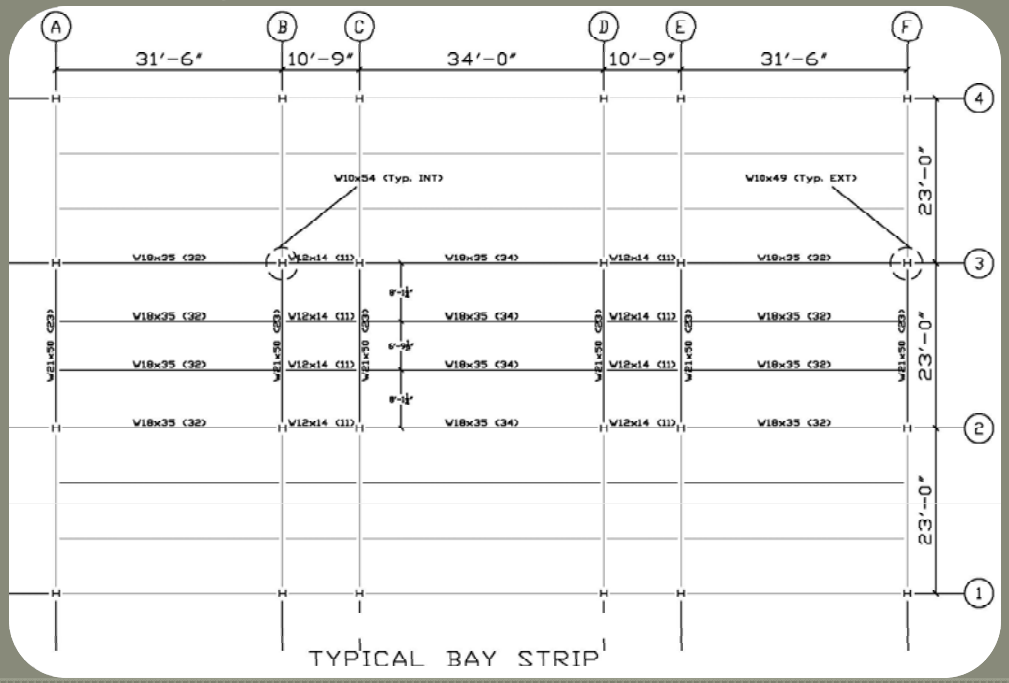
Floor System

- W18x35 Composite Beams @ 8' O.C.
- W21x50 Girders
- Shear Studs @ 12"
- 18 Gage Composite Deck



Structural System

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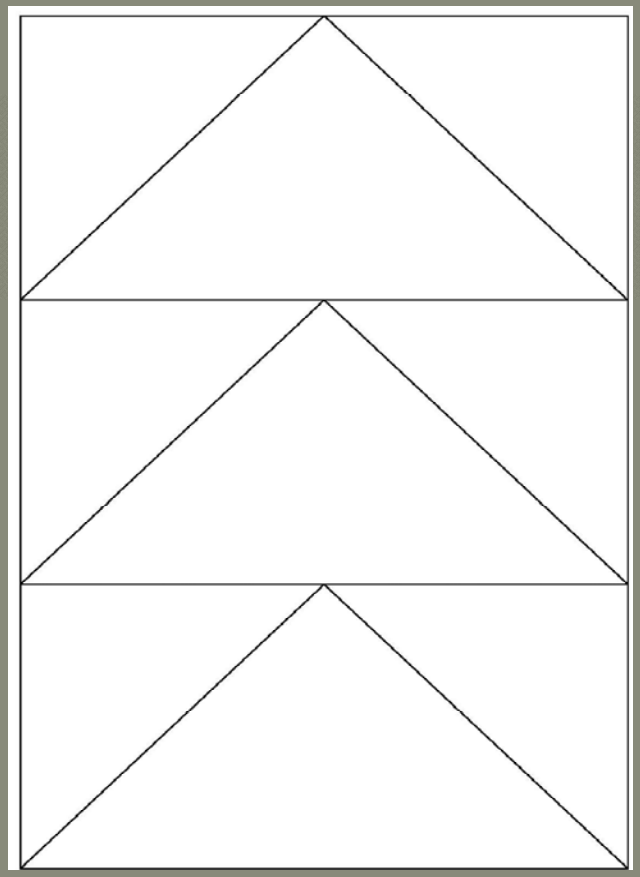
Lateral Force Resisting System

- 4 Braced Frames – Each Direction

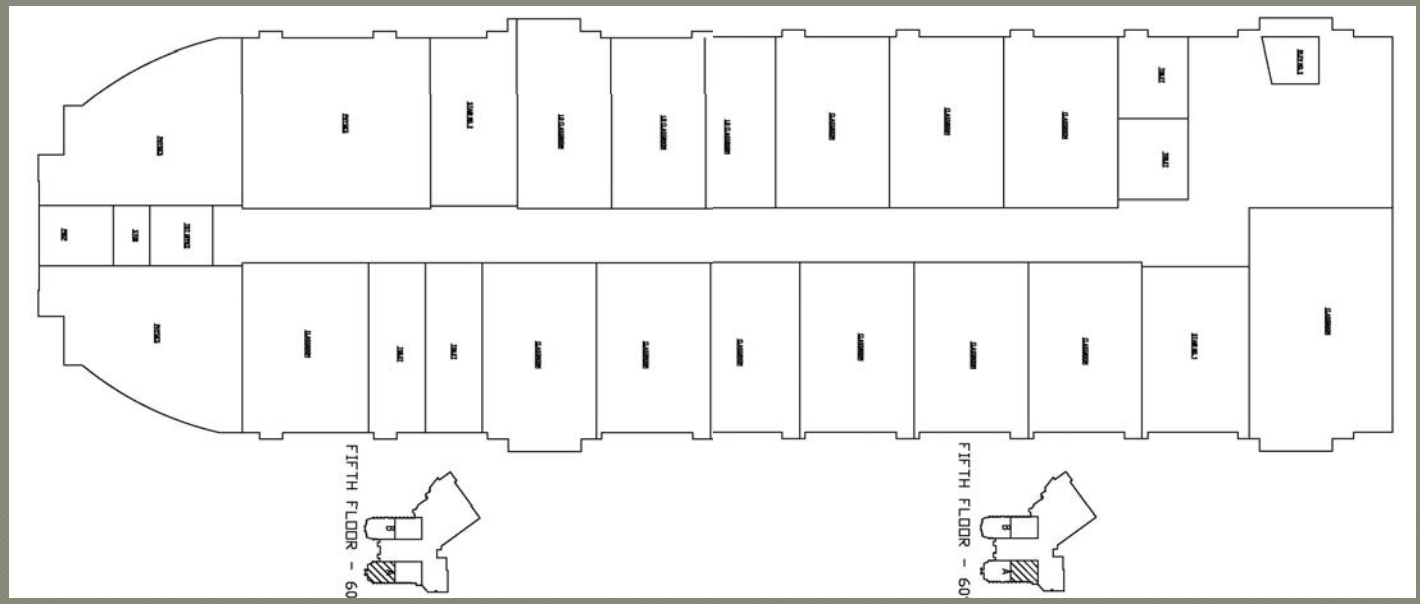


Codes

- Existing
  - ASCE 7-99
  - IBC 2000
  - ASD
- Redesign
  - ASCE 7-05
  - IBC 2006
  - LRFD
- Deflections
  - L / 360 - Live
  - L / 240 - Total
  - L / 600 – Live - Masonry Walls
  - H / 400 – Drift

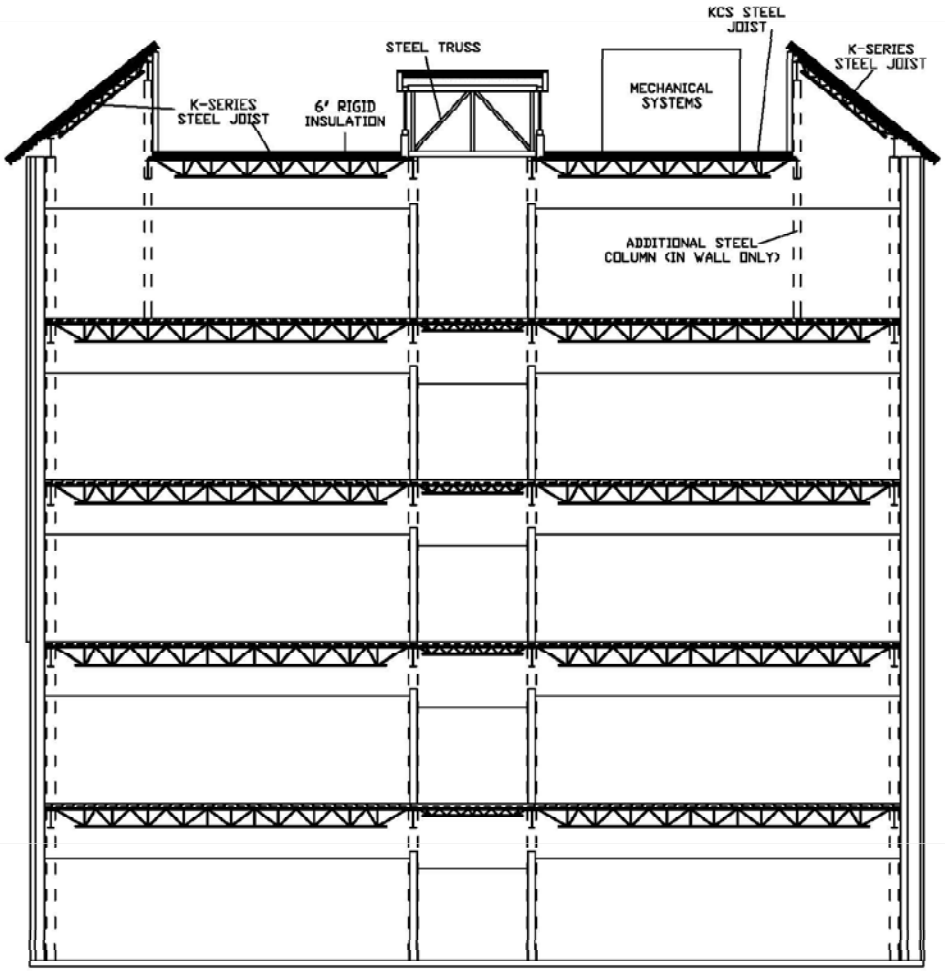
Typical Floor Plan

- ~~Introduction~~
- Architectural Breadth
  - Floor Plans
  - Roof Layout
- Structural Depth
- Construction Management Breadth
- Conclusions



Building Section

- ~~Introduction~~
- Architectural Breadth
  - ~~Floor Plans~~
  - Roof Layout
- Structural Depth
- Construction Management Breadth
- Conclusions



Roof Section

- ~~Introduction~~
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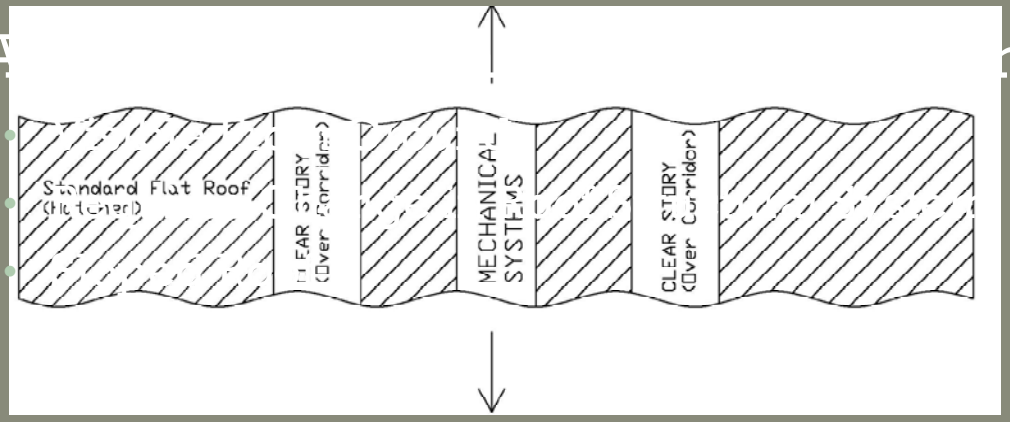
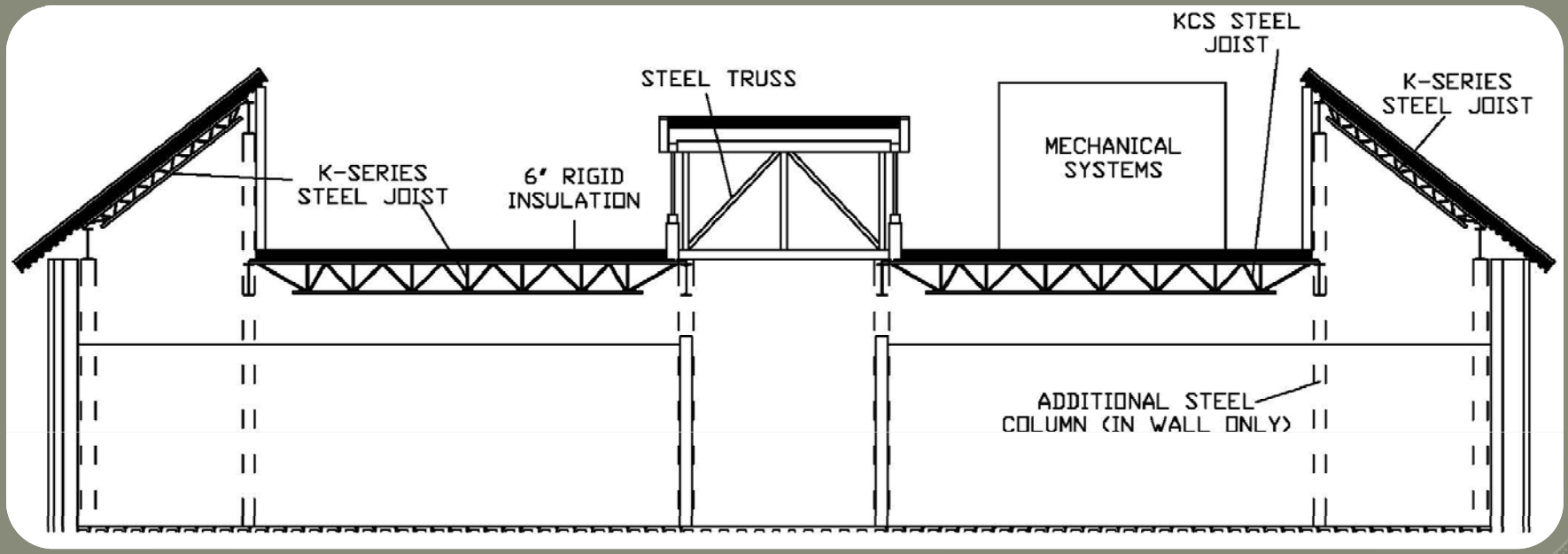
  - Roof Layout
- Structural Depth
- Construction Management Breadth
- Conclusions





Goals

- ~~Introduction~~
- ~~Architectural Breadth~~
- Structural Depth
  - Proposal
  - Roof System
  - Floor System
  - Columns
  - Shear Walls
  - Footings
  - Summary
- Construction Management Breadth
- Conclusions

- Reduce Building Costs
- Stay on Schedule
- Increase Number of Rooms Receiving Natural Light
- Decrease SF of Corridor Space

Proposal

- ~~Introduction~~
- ~~Architectural Breadth~~
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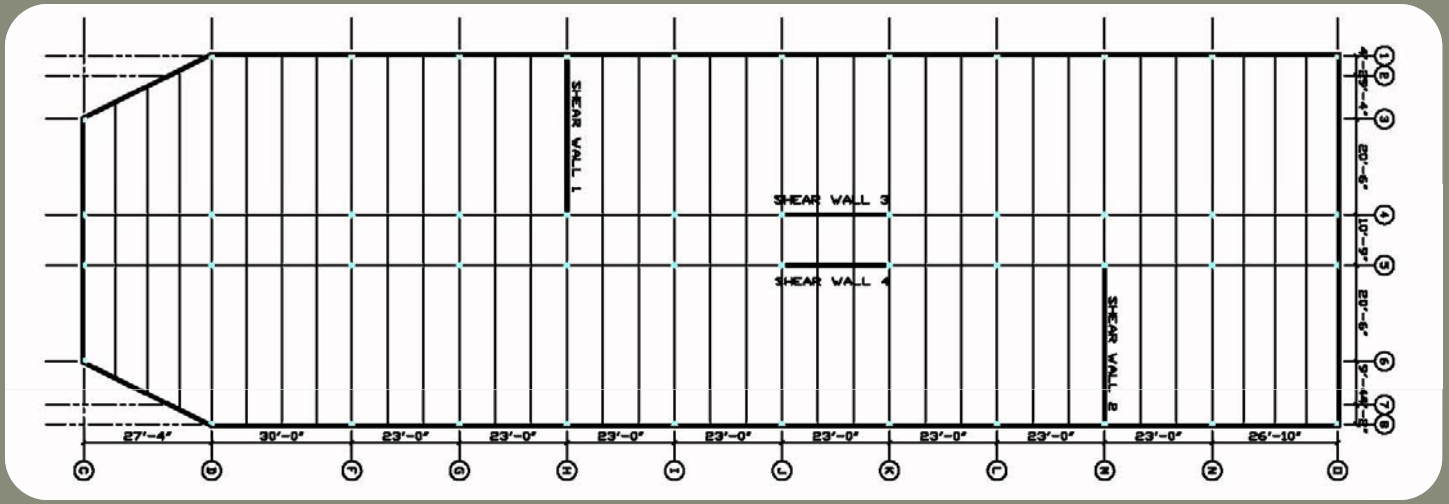
- Change Building Height
  - 3 Floors (45’)
  - 5 Floors (75’)
  - Constant Square Footage (108,000 SF)
    - Smaller Building Footprint
    - Less Geopiers



Proposal

- ~~Introduction~~
- ~~Architectural Breadth~~
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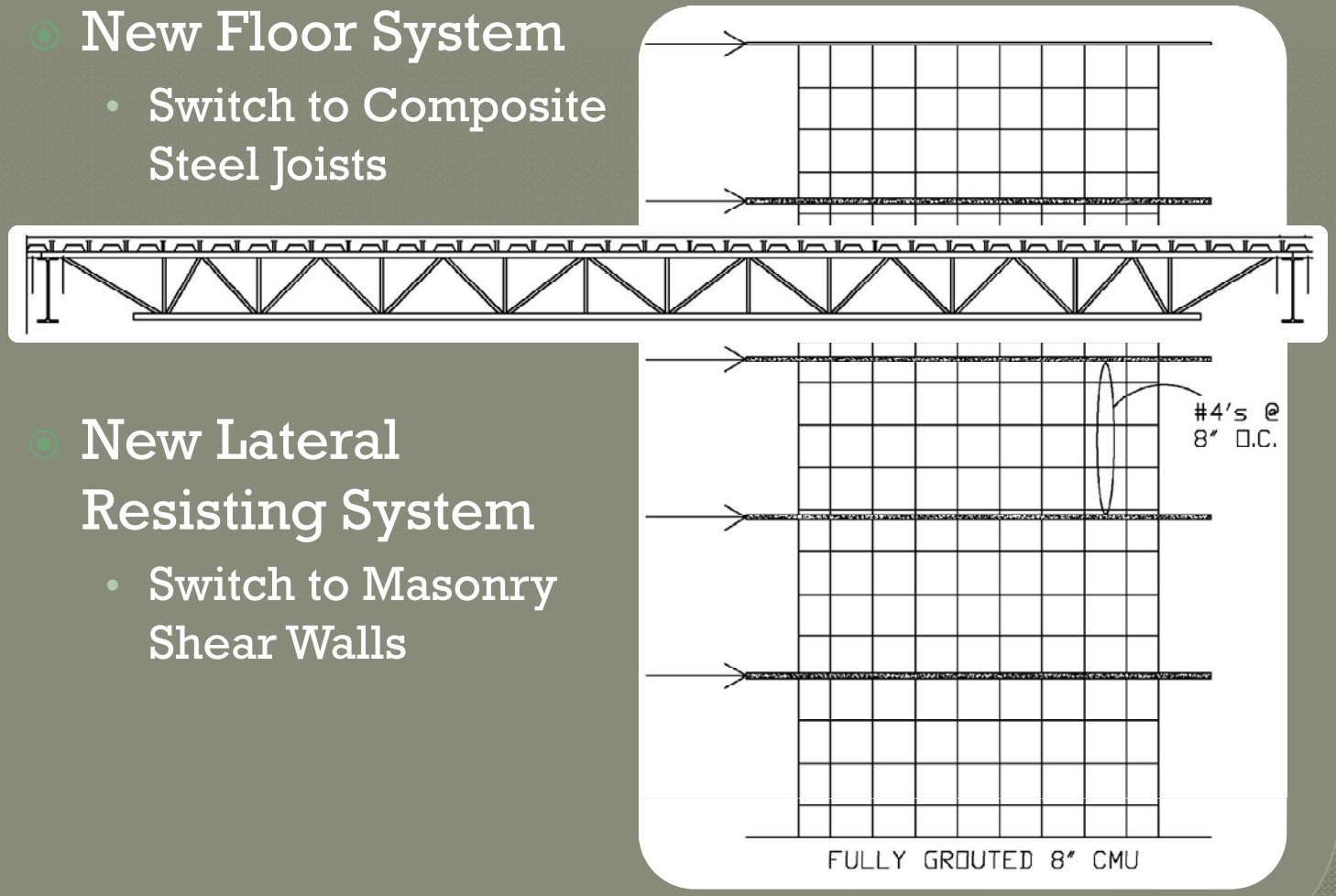
New Floor System

- Switch to Composite Steel Joists



New Lateral Resisting System

- Switch to Masonry Shear Walls

Proposal

- ~~Introduction~~
- ~~Architectural Breadth~~
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- Due to Change in Height :
  - Required Change in Roof System
  - Required Exterior Wall Redesign
  - Required Column Redesign
  - Required Change in Footing Sizes

Roof System Redesign

- ~~Introduction~~
- ~~Architectural Breadth~~
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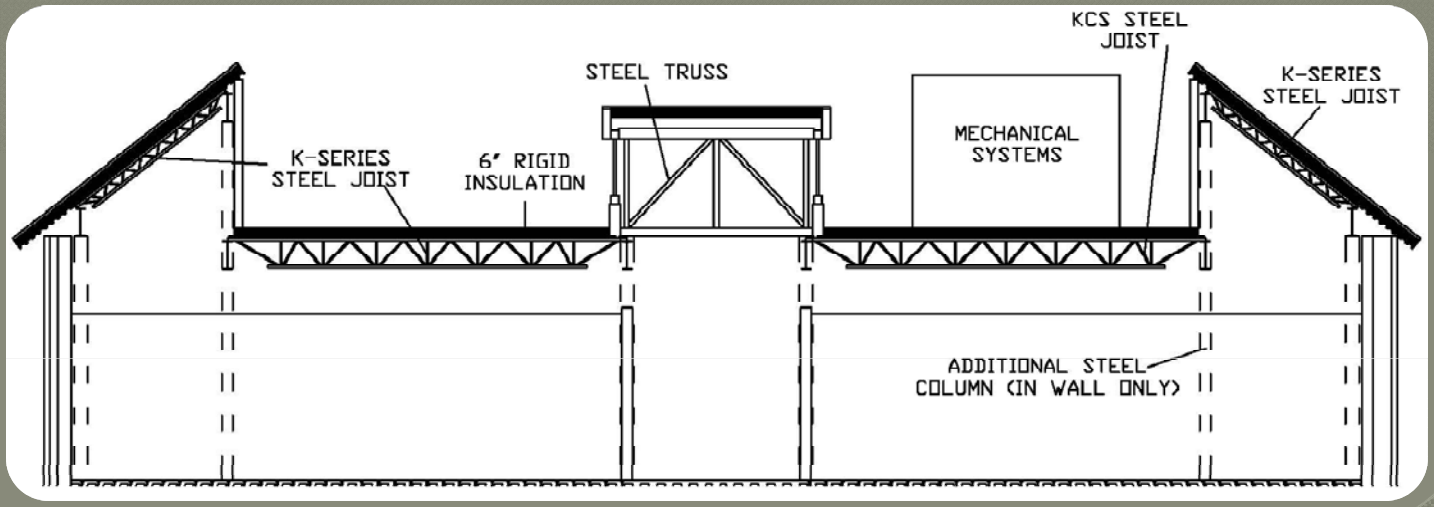
- 24KCS3 Joists (Span w/ Mechanical Systems)
- 18K3 Joists (Span w/o Mechanical Systems)
- 10K1 Joists (Sloped Roof)

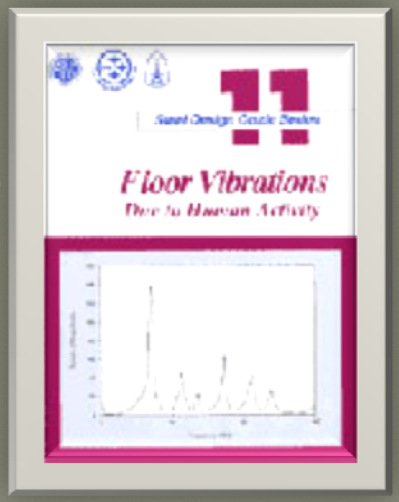


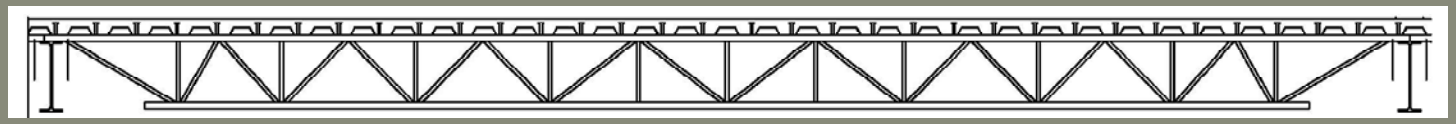
Floor System Redesign

- ~~Introduction~~
- ~~Architectural Breadth~~
- Structural Depth
  - ~~Proposal~~
  - ~~Roof System~~
  - Floor System
  - Columns
  - Shear Walls
  - Footings
  - Summary
- Construction Management Breadth
- Conclusions

Composite Steel Joists

- 22VC1600
- Cementious Spray-on Fireproofing
- Spaced 8' O.C.
- 34' Span
- 2" Deck w/ 2.5" Topping
- W21x50 Girders – 23' Span
- Paper Office Vibration Criteria
  - $\beta = 0.03$
  - $A_p / g < 0.5\%g$
  - $f_n = 4.9$ Hz





Columns

- ~~Introduction~~
- ~~Architectural Breadth~~
- Structural Depth
  - ~~Proposal~~
  - ~~Roof System~~
  - ~~Floor System~~
  - Columns
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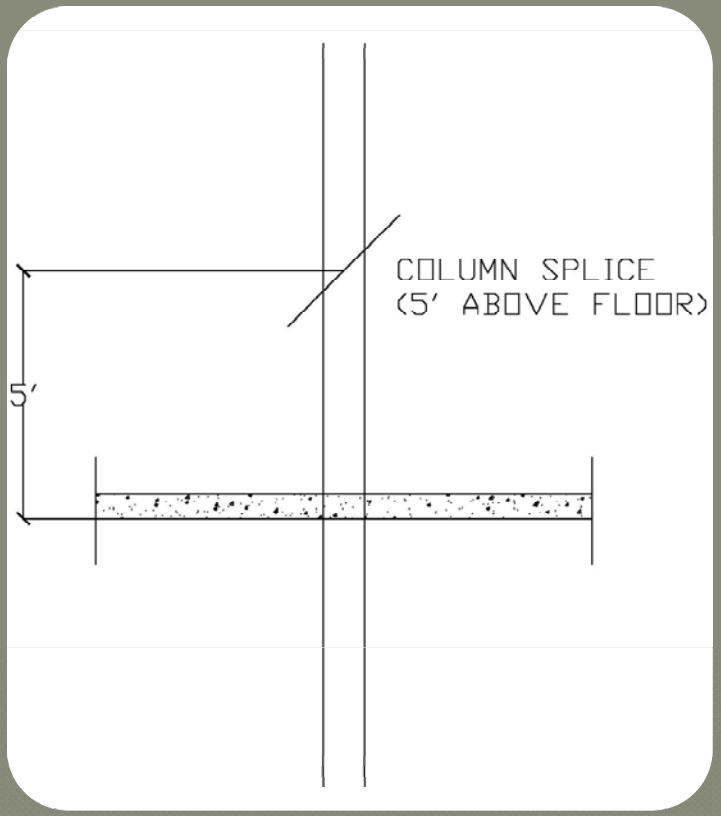
- Existing – Un-spliced
- Redesigned – Splice Required
  - Splice 5’ Above Third Floor



Lateral Force Resisting System Redesign

- ~~Introduction~~
- ~~Architectural Breadth~~
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  - ~~Columns~~
  - Shear Walls
  - Footings
  - Summary
- Construction Management Breadth
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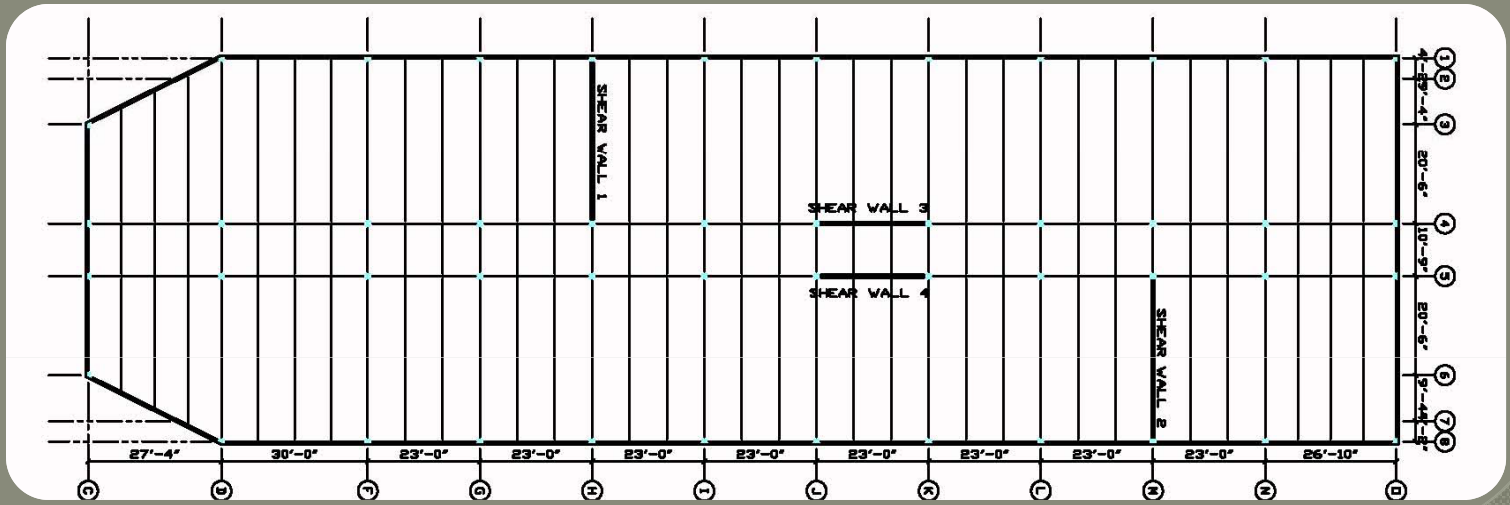
- Existing – Braced Frames
- Redesign – Masonry Shear Walls
  - Torsion
  - Shear
  - Overturning Moment
  - Drift



Lateral Force Resisting System Redesign

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  - Shear Walls
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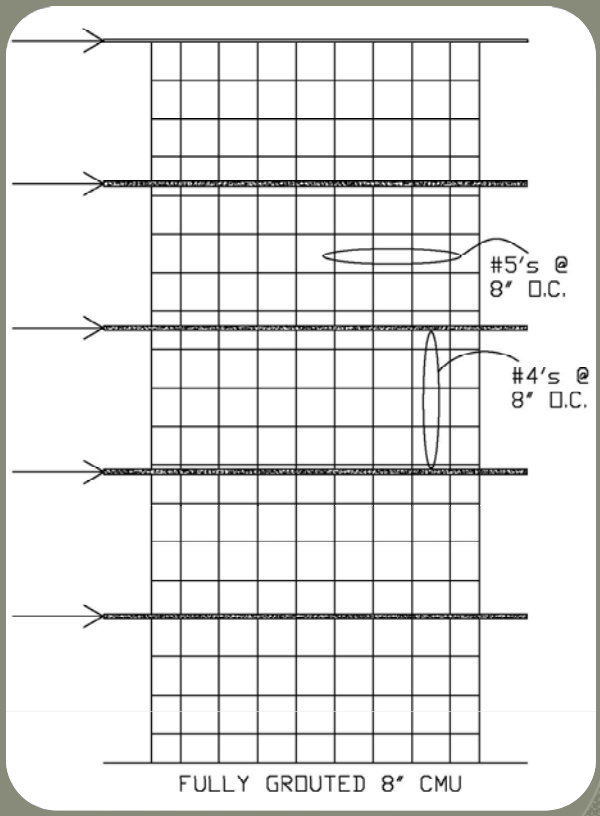
Wall Properties

- L = 34’ or 23’
- 8’’ Fully Grouted CMU

- Vert Reinf - #5’s @ 8’’ O.C.
- Horiz Reinf - #4’s @ 8’’ O.C.



Foundations

- ~~Introduction~~
- ~~Architectural Breadth~~
- Structural Depth
  - ~~Proposal~~
  - ~~Roof System~~
  - ~~Floor System~~
  - ~~Columns~~
  - ~~Shear Walls~~
  - Footings
  - Summary
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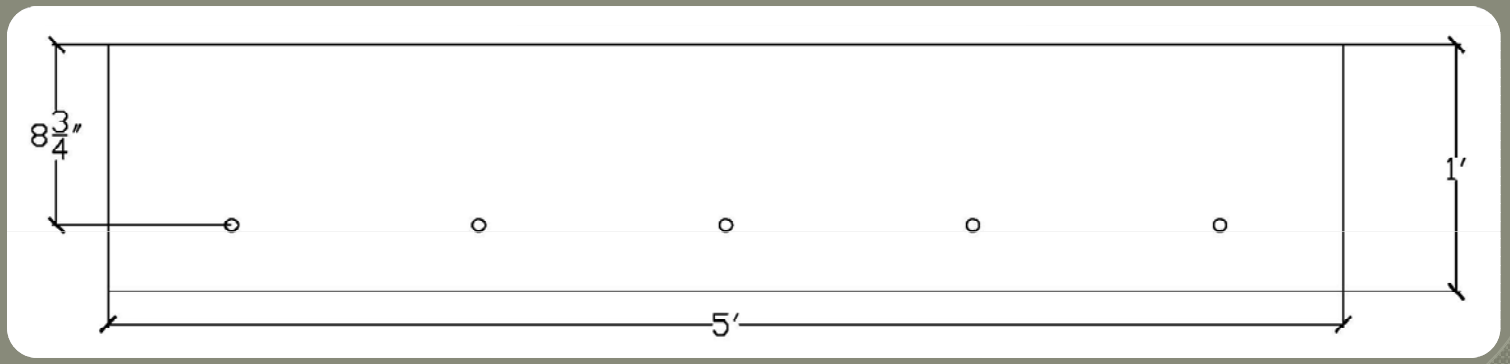
- Redesigned Footings – For Additional Loads
- Geopier System
- 6” Slab on Grade



Structural Summary

- ~~Introduction~~
- ~~Architectural Breadth~~
- Structural Depth
  - ~~Proposal~~
  - ~~Roof System~~
  - ~~Floor System~~
  - ~~Columns~~
  - ~~Shear Walls~~
  - ~~Footings~~
  - Summary
- Construction Management Breadth
- Conclusions

- Redesigned Floor System
  - Composite Steel Joist System
- Redesigned Lateral Force Resisting System
  - Reinforced Masonry Shear Walls
- Redesigned Structural Elements to Account for Change in Building Shape
  - Roof System
  - Exterior Curtain Walls
  - Columns
  - Strip and Spread Footings

Cost Analysis

- ~~Introduction~~
- ~~Architectural Breadth~~
- ~~Structural Depth~~
- Construction Management Breadth
  - Cost Analysis
  - Schedule Analysis
- Conclusions

Existing SF Costs

- Roof – $13.25
- Floor – $21.37
- Foundations – $12.57

Redesign SF Costs

- Roof – $14.50
- Floor – $16.72
- Foundations – $13.22

SF Costs

Roof : +$1.25

Floor: -$4.65

Found: +$0.65

Cost Analysis

- ~~Introduction~~
- ~~Architectural Breadth~~
- ~~Structural Depth~~
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Existing Costs

- Roof – $465,000
- Floor – $1,500,000
- Lateral Sys – $268,000
- Columns – $308,000
- Foundations – $484,000
- Curtain Wall – $1,040,000
- Partitions – $556,000

Existing
$4,616,000

Redesign Costs

- Roof – $313,000
- Floor – $1,445,000
- Lateral Sys – $140,000
- Columns – $329,000
- Foundations – $285,000
- Curtain Wall – $1,500,000
- Partitions – $556,000

Redesign
$4,606,000

Schedule Analysis

- ~~Introduction~~
- ~~Architectural Breadth~~
- ~~Structural Depth~~
- Construction Management Breadth
  - Cost Analysis
  - Schedule Analysis
- Conclusions

- Schedule Start Date: July 2, 2004
- Existing Structural End Date: Nov 8, 2005
- Redesign Structural Finish Date: Nov 25, 2005

+17 Days

+12 Working Days

Schedule Analysis

- ~~Introduction~~
- ~~Architectural Breadth~~
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- Conclusions

- What if … No Change of Lateral Resisting System?

- Existing Structural End Date: Nov 8, 2005
- Redesign Structural Finish Date: Sept 19, 2005

-50 Days

-36 Working Days

Conclusions

- ~~Introduction~~
- ~~Architectural Breadth~~
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- Savings of $20,000
- Increase of 24% of Rooms in Classroom Wing Receiving Natural Light
- Increase of 10,000 SF Usable Floor Area

Conclusions

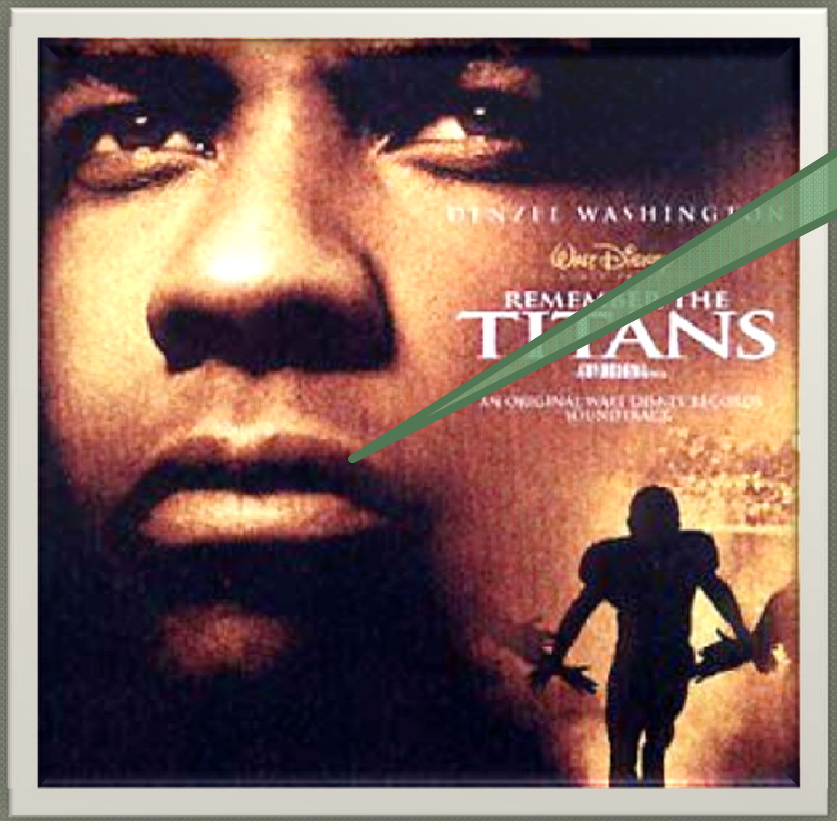
- ~~Introduction~~
- ~~Architectural Breadth~~
- ~~Structural Depth~~
- ~~Construction Management Breadth~~
- Conclusions

- Owner Option: Remove Extra 10,000 SF of Usable Area
  - $150 / SF for Classroom Wings

Total Savings:
$1.5 Million

T.C. Williams High School
Home of the Titans

Questions???



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