Fordham Place

Bronx, NY

Aric Heffelfinger
Structural Option
Spring 2006

Presentation Outline

- **Building Introduction**
- Existing Structure
- Proposal / Goals
- Structural Redesign
- Breadth Work
- Conclusion / Recommendations

Building Introduction

- ***Owner***

  Acadia Realty
- ***Construction Manager***

  Acadia Realty
- ***Architect***

  Greenburg Farrow
- ***Structural Engineer***

  M.G. McLaren
- ***Mechanical Engineer***

  Greenburg Farrow

Building Introduction

- *Size*
  - 15 Stories
  - 174,000 SF
- *Cost*
  - $34.8 Million
- *Retail*

  Ground – 2nd floor
- *Community*

  3rd – 9th floor
- *Office*

  10th – 15th floor

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Existing Structure

- ❖ *Design Codes*

  Building Code of

  New York City

- ❖ *Floor System*
  - Composite Concrete Slab & Steel beams
    - 6 ¼″ Lightweight Slab (115 pcf)
    - A992 Grade 50 Steel
    - 3″ Composite Galvanized Metal Deck

Existing Structure

- ***Columns***
  - Grade 50 W14 Shapes
  - Splice every 3rd Floor
  - 13.5 ft typical unbraced length
- ***Lateral System***
  - Eccentrically braced Chevron Frames
    - 12 x 12 x ½ HSS bracing members
    - A500 Grade B Steel
      - $F_y = 46$ksi
      - $F_u = 58$ksi

Existing Structure

- ***Foundations***
  - 150 ton Group piles (4-13)
  - 45 – 50 ft Deep
  - A992 Grade 50 Steel W shapes
- ***Enclosure***
  - Brick Façade up to 6th floor
  - Glass Façade 6th – 15th floors

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Proposal / Goals

- ❖ *Viable Structural Systems*
- ❖ *Effects the new floor system had on other building systems*
  - Lateral System
  - Columns
  - Foundations
- ❖ *Compare Constructability & Cost*
- ❖ *Examine pros / cons of each systems*
- ❖ *Determine which floor system is more efficient in NY area*

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Structural Redesign

- ***Design Codes***
  - ASCE 7 – 02
  - ACI 318 – 02
- ***Floor System***
  - Two Way Slab with Drop Panels
    - Normal Weight Concrete
    - f'c = 4ksi
    - Designed using ADOSS

Structural Redesign

- ***Design Process***
  - Column size estimate
  - ACI to get minimum floor slab thickness, drop depth, and width
  - Determine column strips
  - Input into ADOSS
  - Make Adjustments as necessary
  - Determine reduced gravity loads and moments on columns
  - Input Into PCA Column

Structural Redesign

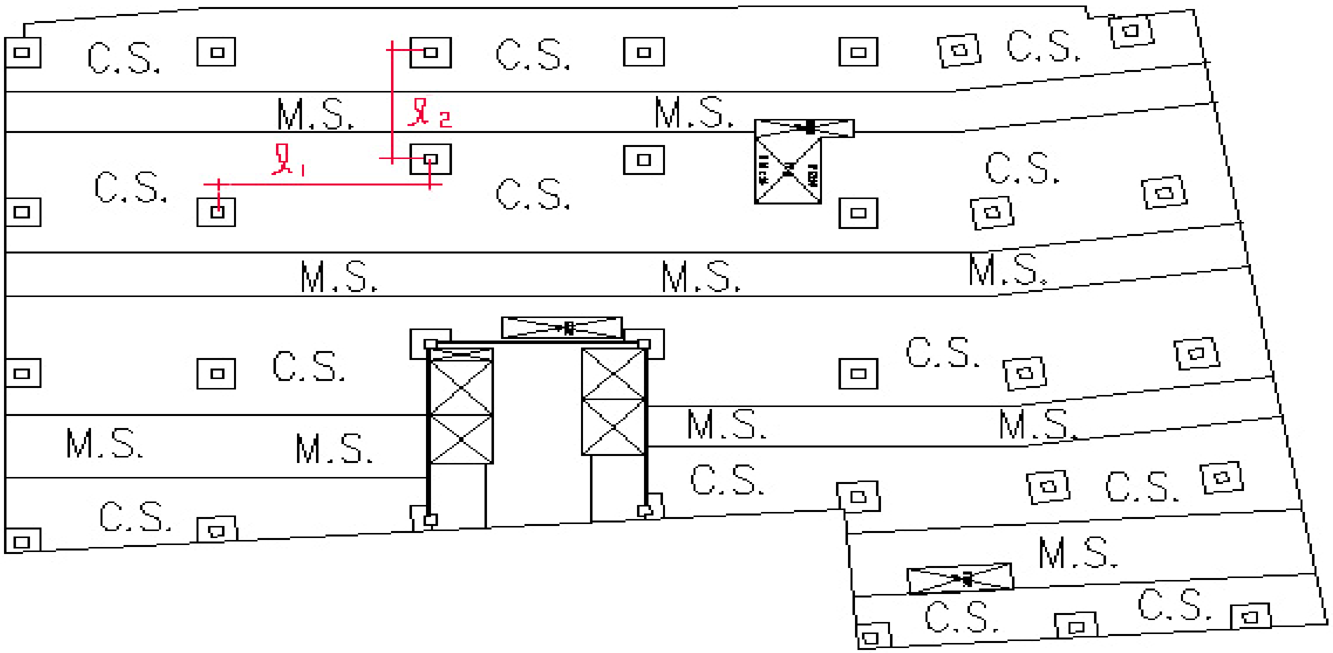
- *Design Process*
  - Check column size assumption
  - Select slab and column Reinforcement
  - Determine critical lateral load
  - Design shear walls
  - Select shear wall Reinforcement
  - Consider special areas throughout building

Structural Redesign

- ***Column size estimate***
  - 24″ x 24″
  - Clear span = 28′ – 2′ = 26′
- ***Floor slab depth***
  - $\ell n/36 = 26/36 = 8.67''$ → use 9″
- ***Drop panel***
  - Projection = ¼ t_{slab} = 2.25″ → try 3.5″
  - Width = $^1/_6$ span = $^1/_6$ (28′) = 4′-8″

Structural Redesign

- ***Column strip width***
  - Width = least of 0.25 ℓ_1 or ℓ_2



Structural Redesign

- ***Input into ADOSS***
  - NW concrete (150 pcf)
  - f'c = 4ksi
  - Reinforcing steel fy = 60ksi
  - Minimum rebar spacing = 6in
  - Minimum rebar size = #4
  - Loads
    - Dead = 30psf
    - Live = 80psf
  - Geometric properties as determined in previous slides

Structural Redesign

- ***Adjustments***
  - Drop projection
    - Increase to 5.5″
    - High shear stresses at columns
    - Excessive reinforcement at columns
- ***Reduced Live loads***
  - $L = L_o [0.25 + (15/\sqrt{(K_{LL} A_T)}]$
    - L_o = 80psf
    - A_T = Tributary Area
    - K_{LL} = Live load element factor

Structural Redesign

- *Input into PCA Column*
  - f'c = 4ksi
  - Biaxial Column
  - steel reinforcement fy = 60ksi
  - 24" x 24" with increment of 2"
  - Equal reinforcement
  - Cover = 0.75" to ties
  - Min / Max bar size = 8 / 11
  - Column Heights = varies
  - Moments from ADOSS
  - Reduced axial loads

Structural Redesign

- ***Check Column Size Assumption***
  - Actual Size = 26″ x 26″
    - Conservative compared to 24″ x 24″
- ***Selection of Slab Reinforcement***
  - Column Strip
    - Positive Reinforcement
      - As ≅ 0.3 in^2/ft ∴ ϱ = 0.028
      - #5′s @ 12″
    - Negative Reinforcement
      - As ≅ 0.55 in^2/ft ∴ ϱ = 0.0032
      - 50% long, 50% short
      - #6′s @ 12″

Structural Redesign

- ***Selection of Slab Reinforcement***
  - Middle Strip
    - Positive Reinforcement
      - As ≅ 0.2 in^2/ft ∴ $\rho = \rho_{min} = 0.0018$
      - 50% long, 50% short
      - #4's @ 12"
    - Negative Reinforcement
      - As ≅ 0.3 in^2/ft ∴ $\rho = 0.0028$
      - #5's @ 12"

Structural Redesign

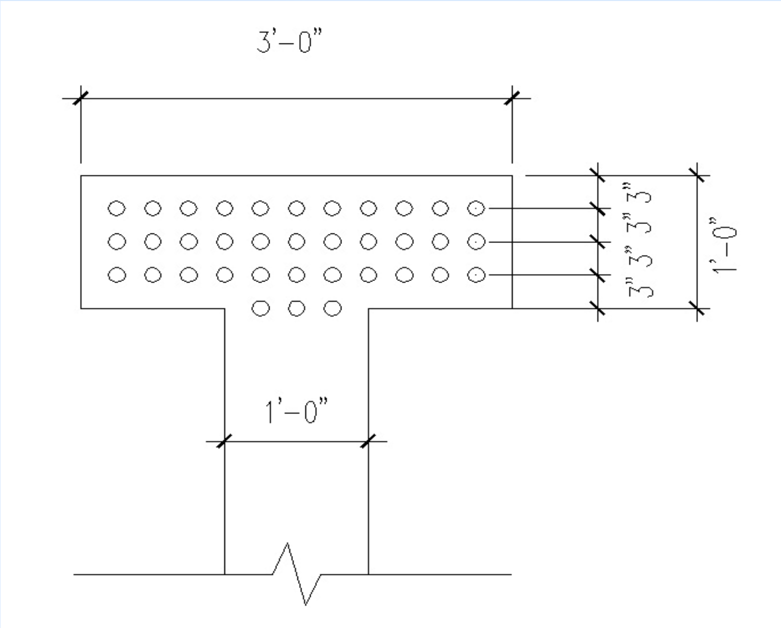
- ***Selection of Column Reinforcement***
  - Longitudinal
    - Maximum = 20 - #11
      - As = 29.7 in^2 ∴ $\varrho = 0.044$
    - Minimum = 12 - #8
      - As = 9.48 in^2 ∴ $\varrho = 0.014 > \varrho_{min} = 0.01$
  - Transverse
    - Spacing = least of the following:
      - 16 x $d_{longitudinal}$ bar = 16(1″) = 16″
      - 48 x d_{tie} bar = 48(.375″) = 18″
      - 0.5 x column dimension = 0.5(26) = 13″ → **use 12″**
    - #3's @ 12″ with #8 longitudinal bars
    - #4's @ 12″ with #11 longitudinal bars

Structural Redesign

- ***Determine Critical Lateral Loads***
  - Seismic now controlled over wind
  - $1.2D + 1.0E + L + 0.2S$
- ***Design Shear Walls***
  - Treated as a huge cantilevered beam
  - 12″ thick based on drift limits
  - Shear Design
    - Reinforcement
      - #5's @ 12″ for first third of building height
      - #5's @ 24″ for second third
      - No reinforcement required for last third

Structural Redesign

- *Design Shear Walls*
  - Flexural Design
    - Reinforcement
      - $A_s = 53.7 in^2$
    - Flanged shear walls
    - 1ft flanges on each end to help fit steel
    - 36 - #11's
    - $A_s = 56.2 in^2$

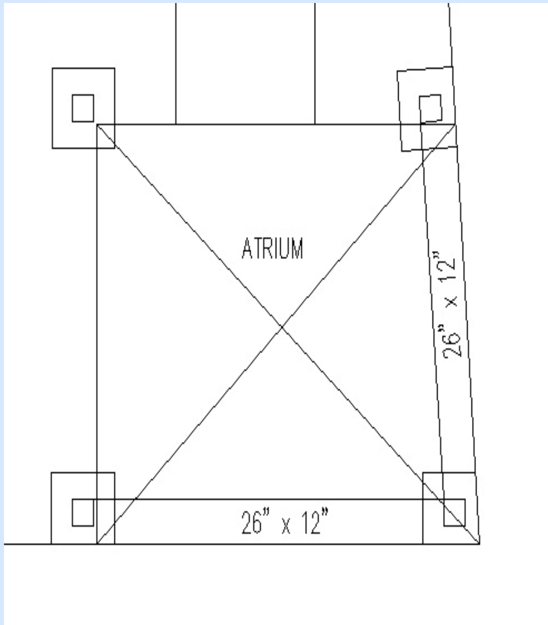


Structural Redesign

- ***Design Shear walls***
  - Drift Limit
    - Most severely loaded shear wall
    - $\Delta_{Limit} = h/400 = 6.07in$
    - $\Delta_{Actual} = Pb^2((3L - b) / (6EI) = 5.32in$
      - Where P = Force on wall
      - b = Distance from base to force
      - L = Height of wall
      - E = Modulus of elasticity of concrete
      - I = Moment of Inertia of cross section
    - Used method of superposition

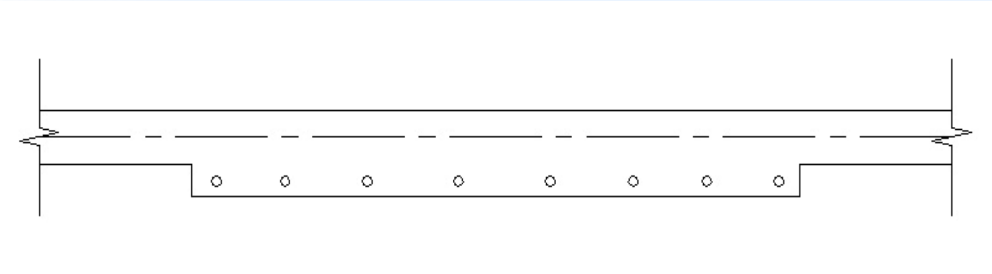
Structural Redesign

- ***Special Cases***
  - Floor Opening
    - Atrium space below
    - Mezzanine floor below
    - Large unbraced length
    - 26″ x 12″ beams to support columns
      - minimum reinforcement in beams
    - f′c = 8ksi
    - 20 - #11′s

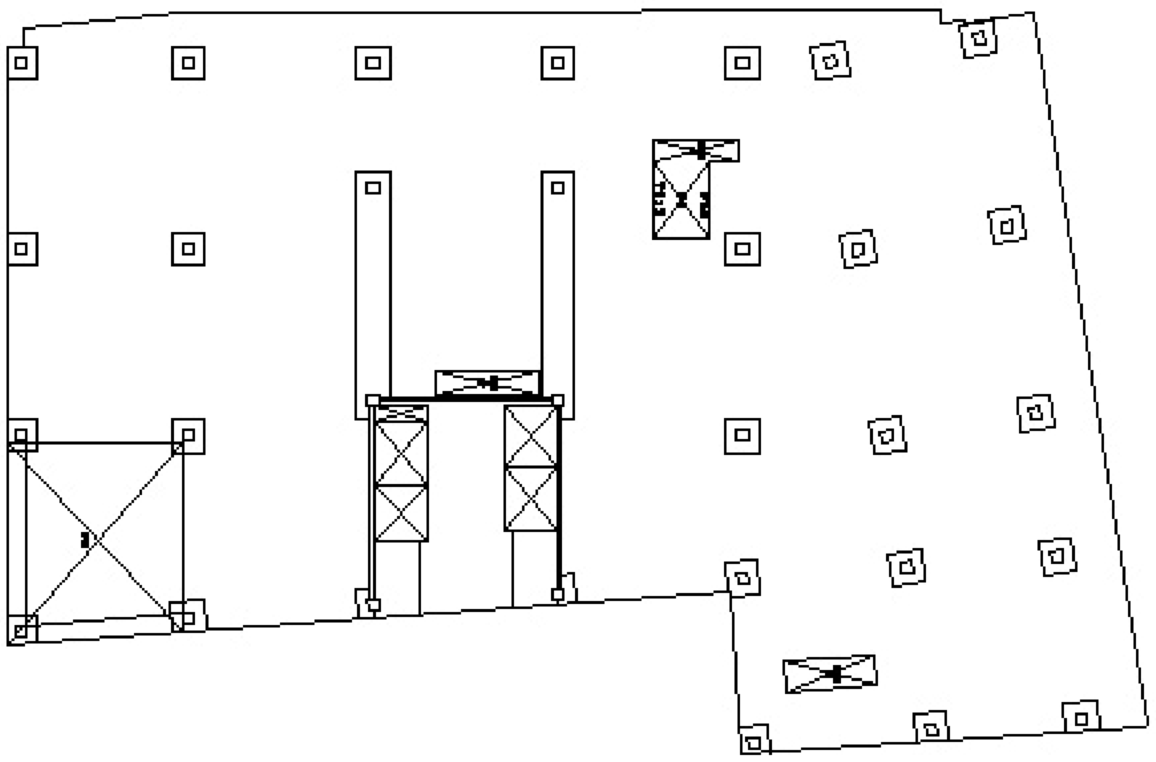


Structural Redesign

- ***Special Cases***
  - Slab
    - Large clear span = 30′-0″
    - $\ell_n/36 = 30/36 = 10'' > 9''$
    - Only two locations per floor
    - Continuous drops
    - Middle strip positive reinforcement depth
    - Designed normally but with 14.5″ slab



Structural Redesign



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CM Breadth

- ***Cost of Superstructure***
  - Composite steel
    - $1.74 Million
  - All Concrete
    - $2.42 Million
    - 140% Composite steel
  - Difference
    - $2.42 – $1.74 = $680,000

CM Breadth

- ***Durations***
  - Composite steel
    - 40.2 calendar weeks
  - All Concrete
    - 78.3 calendar weeks
      - Primarily formwork
    - 195% Composite steel
  - Difference
    - 78.3 – 40.2 = 38.1 weeks

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Conclusions / Recommendations

❖ Comparison of each system

	Composite steel	All Concrete
Cost	5	4
Duration	5	2
Vibration Issues	5	5
Constructibility	4	3
Floor depth	2	5
Area of country	4	1
Lateral Drift	5	5
OVERALL	4.29	3.57

❖ Composite Steel is a better floor system

Acknowledgements

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  - Penn State AE Faculty
  - M.G. McLaren
  - Acadia Realty
  - AE Class of 2006
  - Family

QUESTIONS?

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Structural Redesign

- *Edge Beam*
  - 26″ x 12″
  - Tu = 133 k-ft
  - Torsion Threshold
    - Tu = 4.93 k-ft
  - Reduced Torsion
    - Tu = 4 x 4.93 = 19.7 k-ft
  - $\Phi Tn \geq Tu$
  - $Tn = 2(A_o)(A_t)(f_{yv})\cos(\theta)/s$
  - Use #4 bars, $A_t = 0.2$
  - s = 12.3in

Structural Redesign

- *Edge Beam*
  - Extra Longitudinal Reinforcement
    - $Al = (At)(pn)(fvy)\cot^2(\theta)/(s)(fyl) = 1.01in^2$
    - Use 4 - #5's