PRESENTATION OUTLINE

OVERVIEW

1. BUILDING INTRODUCTION
2. Existing Structural System
3. Proposal Overview
4. Gravity System Re-Design
5. Lateral System Re-Design
6. Construction Management Breadth
7. Summary
8. Acknowledgements
9. Questions/Comments
BUILDING INTRODUCTION

- Commercial office building with fitness center, retail, and parking garages
- Located at 1701 K Street, NW at Connecticut Ave, in Washington, DC
- 555,000 SF (370,000 SF above grade and 185,000 SF below grade)
- Height: 130 ft. above grade
- 12 stories above and 4 stories below grade (underground parking)
- Construction Dates: September 2009 - February 2012
- Construction Cost: $60 million
- LEED Gold
1000 CONNECTICUT AVENUE

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PROJECT TEAM

- Owner Representative: MJ Tyler and Associates
- Architect-of-Record: WDG Architecture
- Design Architect: Pei Cobb Freed and Partners
- MEP: Girard Engineering
- Structural: SK&A Structural Engineers
- Civil Engineer: VIKA, Inc.
- General Contractor: Clark Construction Group
ARCHITECTURAL FEATURES

- Curtain wall glass façade
  - Blends both traditional and modern materials to compliment surrounding institutions
  - Consists of glass, stainless steel, and stone panels
- Two-story intricate lobby space
  - Carrera marble
  - Chelmsford flooring
  - Aluminium spline panels integrated with glass fiber reinforced gypsum ceiling tiles
  - European white oak wood screens
- Integrated green roof and roof-top terrace
EXISTING STRUCTURAL SYSTEM

- Foundation
  - Spread footings
  - Typical sizes include 4’x4’, 5’x5’, and 4’x8’
  - Strap beams
  - 5” thick, 5000 psi SOG
  - The foundation walls consists of CMUs

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2. Existing Structural System

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  - Strap beams
    - 5” thick, 5000 psi SOG
  - The foundation walls consists of CMUs
EXISTING STRUCTURAL SYSTEM

- Gravity Floor System
  - Comprised of 8" thick two-way flat slab with 8" thick drop panels
  - Has a specified strength of $f_c=5000$ psi
EXISTING STUCTURAL SYSTEM

- **Framing System**
  - Composed of reinforced concrete columns with 6” thick column capitals
  - Typical column sizes are 24”x24”, 16”x48”, 24”x30”
  - 30’x30’ average column-to-column spacing
  - Specified column strength of f’c= 8000 psi for levels B4-B1, f’c= 6000 psi for levels 4-7, f’c=5000 psi levels 8 though mech. PH
- Columns frame at the concrete floor
EXISTING STRUCTURAL SYSTEM

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Lateral System
- Reinforced concrete moment frame
- The two-way flat slab and concrete columns forms the moment frame
Interest in steel design
Steel structural system will increase floor structural depth
Maintain minimum floor-to-ceiling height of 8'-6"
To use new steel structural system, number of stories must reduce to stay within Washington D.C.’s restricted height limit of 130 ft and to maintain 8'-6" floor-to-ceiling height
Using existing non-uniform column layout with new steel system will result in large number of skewed members
New steel system is more flexible
PROPOSAL OVERVIEW

- Building relocated to Arlington, VA
  - New location does not have a height limitation
- Create new structural system layout with wider bays
- Create uniform column layout to reduce number of required skewed members
- Increase floor-to-floor height to create higher floor-to-ceiling heights
- Use composite beam/girder system with composite deck for gravity floor system
- Use braced frames and moment frames for the lateral system

GOALS

- Increase the bay sizes to open the floor plan layout
- Increase floor-to-floor height to increase the openness of the space
- Reduce the construction schedule
- Reduce the structural system cost
- Increase the annual revenue by increasing the rental value of the space and increasing the amount of rentable space
Composite beams/girders used for gravity system
Designed manually using AISC 14th edition
LRFD
1.2D + 1.6L + 0.5Lr controlled design
To increase the rental value of the building, wider bays and higher floor-to-ceiling heights were created
Certain existing column lines that were in the existing structural layout were removed to increase the bay sizes
Columns were re-located to create a uniform framing layout to reduce the number of required skewed connections
3VL120 composite deck was chosen for the floor system
1.2D+1.6L+0.5Lr controlled design

To increase the rental value of the building, wider bays and higher floor-to-ceiling heights were created.

Certain existing column lines that were in the existing structural layout were removed to increase the bay sizes.

Columns were re-located to create a uniform framing layout to reduce the number of required skewed connections.

3VLI20 composite deck was chosen for the floor system.
Gravity System Re-Design

- Composite beams/girders used for gravity system
- Designed manually using AISC 14th edition
- LRFD
  - $1.2D + 1.6L + 0.5L_r$ controlled design
- To increase the rental value of the building, wider bays and higher floor-to-ceiling heights were created
- Certain existing column lines that were in the existing structural layout were removed to increase the bay sizes
- Columns were re-located to create a uniform framing layout to reduce the number of required skewed connections
- 3VLI20 composite deck was chosen for the floor system
To maintain high floor-to-ceiling heights while taking into account the increase in structural depth due to the gravity members, floor-to-floor height increased from 10'-7" to 15'-0"

Columns designed as two-tiers

Gravity columns designed manually using AISC 14th edition
Typical orthogonal and skewed shear connections were designed manually using AISC 14th edition and material learned in Steel Connection Design Course (AE 534).
5 moment frames were chosen to resist the lateral loads in the E-W direction.
2 moment frame and 4 brace frames chosen to resist lateral loads in N-S direction.
Moment frames were used to maintain an open floor plan without any obstructions.
To keep the floor layout open, the brace frames were located around the elevator shafts and stairwell cores.
Wind loads were determined using the Main Wind Force Resisting System (MWFRS) procedure (method 2) in conformance to Chapters 26 and 27 outlined in ASCE 7-10.

Due to the building’s complex geometry, a rectangular building shape was assumed to simplify the wind load analysis.
Wind loads were determined using the Main Wind Force Resisting System (MWFRS) procedure (method 2) in conformance to Chapters 26 and 27 outlined in ASCE 7-10.

Due to the building’s complex geometry, a rectangular building shape was assumed to simplify the wind load analysis.

Seismic loads were determined using the Equivalent Lateral Force Procedure outlined in Chapters 11 and 12 in ASCE 7-10.
The lateral force resisting beams that connect the columns were designed as non-composite. The member sizes were estimated by manually designing the beams, girders, and columns for gravity loads only using AISC 14th edition. Lateral system with estimated member sizes was modeled in ETABS using concepts learned in Computer Modeling (AE 597A). ETABS model used to determine controlling wind load case and controlling load combination for strength design.
To determine the controlling wind load case and controlling load combination, shear forces acting in each frame on story 6 were used. The wind load case that resulted in the highest shear forces in the frames was concluded to control the design. Wind load case 1 was found to control.
LATERAL SYSTEM RE-DESIGN

- To determine the controlling wind load case and controlling load combination, shear forces acting in each frame on story 6 were used.
- The load combination that resulted in the highest shear forces in the frames was concluded to control the strength of the design.
- Load combination 1.2D+1.0L+1.0W was found to control strength of design.
The steel frame design check in ETABS was used to design the lateral system.
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**LATERAL SYSTEM RE-DESIGN**

- The steel frame design check in ETABS was used to design the lateral
- Inter-story drift limited to
  - W/400 for un-factored wind load case 1 and
  - 0.02H for un-factored seismic loads

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The steel frame design check in ETABS was used to design the lateral Inter-story drift limited to H/400 for un-factored wind load case 1 and 0.02H for un-factored seismic loads.
The steel frame design check in ETABS was used to design the lateral inter-story drift.

- Limited to L/400 for unfactored wind loads.
- Limited to 0.02H for unfactored seismic loads.

Typical moment connection designed in accordance to AISC 14th edition and material learned in Steel Connections Design (AE 534).
The Lateral system was checked for building torsion due to eccentric wind.
The Lateral system was checked for:
- Building torsion due to eccentric wind
- Relative stiffness
  - Moment frame B will resist the largest portion of the lateral load in the E-W direction
  - Brace frame 3 will resist the largest portion of the lateral load in the N-S direction
The lateral system was checked for overturning and stability.

- Controlling load combination for checking overturning is 0.9D + 1.0W
- Resisting Moment ≥ Overturning moment in both N-S and E-W directions, therefore the structure is adequate to resist the overturning moment.
LATERAL SYSTEM RE-DESIGN

- Foundation design beyond scope of re-design, but foundation checked for uplift forces
- The brace frames will subject the foundation to uplift
- 0.9D+1.0W load combination controlled uplift force
- Uplift force ≥ 0.9DL, therefore foundation will be subjected to uplift
LATERAL SYSTEM RE-DESIGN

- Foundation design beyond scope of re-design, but foundation checked for uplift forces
- The brace frames will subject the foundation to uplift
- 0.9D + 1.0W load combination controlled uplift force
- Uplift force ≥ 0.9DL, therefore foundation will be subjected to uplift
- 3 alternative foundation options for controlling uplift
  - Grade beam
  - Combined footing
  - Mat foundation
CONSTRUCTION MANAGEMENT BREADTH

- New System Cost
  - $5,994,630 increase in system cost

- Construction schedule
  - Erection of superstructure with new steel system will be completed 18 days earlier than the existing superstructure
CONSTRUCTION MANAGEMENT BREADTH

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  - $5,994,630 increase in system cost
- Construction schedule
  - Erection of superstructure with new steel system will be completed 18 days earlier than the existing superstructure
- Site Logistics
  - Site logistics study was conducted to determine how concrete and steel will have to be managed differently on the same site.
  - The existing project used Ox Blue, a web camera, to track the on-site progress of the project
CONSTRUCTION MANAGEMENT BREADTH

- New System Cost
  - $5,994,630 increase in system cost

- Construction schedule
  - Erection of superstructure with new steel system will be completed 18 days earlier than the existing superstructure

- Site Logistics
  - Site logistics study was conducted to determine how the existing site will have to be managed differently for steel vs. concrete
  - The existing project used Ox Blue, a web camera used to track the on-site progress of the project
    - Conn. Ave and public alley ways used for egress
    - Trailers located along Conn. Ave, which provides good viewing location for project managers and engineers
    - Crane and bucket used to pour and place concrete
CONSTRUCTION MANAGEMENT BREADTH

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  - $5,994,630 increase in system cost

- **Construction schedule**
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- **Site Logistics**
  - Site logistics study was conducted to determine how the existing site will have to be managed differently for steel vs. concrete
  - The existing project used Ox Blue, a web camera used to track the on-site progress of the project
    - Conn. Ave and public alley ways were used for egress
    - Trailers located alongside Conn. Ave, which provides good viewing location for project managers and engineers
    - Crane and bucket used to pour and place concrete
  - New System
    - Site logistics will be similar to that of the existing system
    - Lay down areas adjacent to crane and on the North-facing side of the building

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LEED Certification Check

- Building will remain LEED Gold certified with new steel system

Revenue

- Current asking price: $55.00 per sq. ft.
- Additional amenities of higher floor-to-ceiling heights and wider bays will increase the asking cost to an additional $10 to 20 per sq. ft.
- New system will increase building annual revenue an additional $3,705,450
1000 Connecticut Avenue

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SUMMARY

GOALS

- Increase the bay sizes to open the floor plan layout
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- Reduce the construction schedule
- Reduce the structural system cost
- Increase the annual revenue by increasing the rental value of the space and increasing the amount of rentable space

RESULTS

- Increased average bay size from 30' to 35'
- Increased floor-to-floor height from 10'-7" to 15'-0"
- Increased floor-to-ceiling height from 8'-6" to 10'-6"
- Reduced the construction schedule by 18 days
- Structural system cost increased $6,000,000
- Increased rental value of space, therefore resulting in an increased annual revenue of $3,705,450

After the design and analysis, I can conclude that the proposed steel system is a viable alternative system to use in Arlington, VA since the new system has many additional benefits compared to the existing structural system.
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ACKNOWLEDGEMENTS

I would like to thank:

- SK&A Structural Engineers
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- WDG Architecture
- Girard Engineering
- All AE Faculty and Staff
  - Dr. Linda Hanagan
- Family and friends for their support
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