Park Potomac Office Building "E"

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AE Senior Thesis l Spring 2010
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Presentation Overview

- Project Information
- Existing Structural System
- Problem Statement and Solution
- Structural Depth Study
- Cost and Schedule Analysis
- Additional Topics
- Conclusions
- Acknowledgements
- Questions and Comments

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Project Information

- Located off I-270 in Potomac, MD
- Part of Park Potomac Place
- Townhomes, Office Space, Retail, Dining
- Prominent location within Community
  - Focal point from Cadbury Ave.
  - Face of community from I-270

View from Cadbury Ave

www.parkpotomacplace.com

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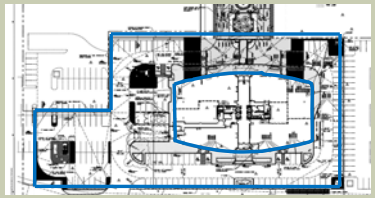
Project Information

- Two levels mostly underground parking
  - 100,000+ SF each
- Seven levels of mostly office space
  - Approx. 25,000 SF each



Building Footprint

North Entrance to Parking Levels

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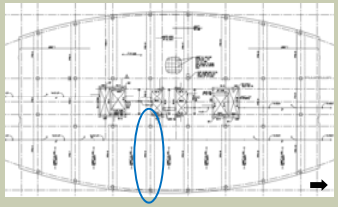
Existing Structural System

- Underground Parking all Cast-in-place concrete
- 7” Thick slab post-tensioned in N-S direction
- 72” x 20” D Beams post-tensioned in E-W direction
- Concrete Moment Frames in both directions
- Long Spans accomplished
  - Flexibility for Tenant
- 12’ Cantilever at N, S ends



Existing Structural System

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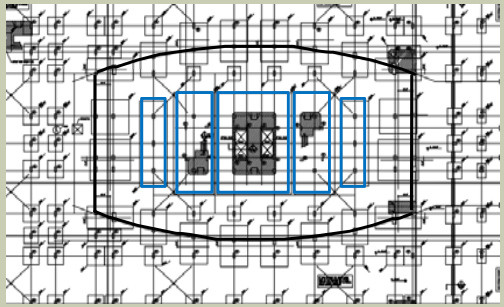
Problem Statement

- Concrete structure results in large building self weight
  - Larger gravity members result
  - Large mat foundations at soil level
  - Central Foundation 52’ x 64’ x 60” Deep
- Longer schedule duration from concrete construction

- End Result: Negative Cost and Schedule Implications



Existing Foundation Plan

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Problem Solution

- Reduce building self weight by utilizing a steel structure
- Composite Beams and lightweight concrete used
- To maintain integrity of existing design:
  - Maintain current column layout
  - Maintain current ceiling heights in Tenant Spaces
  - Maintain current MEP Spaces
- Braced Frames used to resist lateral forces
- Steel construction likely to reduce construction schedule
- Parking levels will remain unchanged

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Project Goals

- Reduce building self weight
- Maintain integrity of tenant spaces
- Reduce overall cost
- Reduce schedule duration

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Design Loads

- Design Loads
  - ASCE 7-05
- Superimposed Dead Loads
  - 5 psf Floor
  - 10 psf Roof
- Flat Roof Snow Load
  - 21 psf

Floor Live Loads		
Area	**Design Load (psf)**	**ASCE 7-05 Load (psf)**
Assembly Areas	100	100
Corridors	100	100
Corridors Above First Floor	80	80
Lobbies	100	100
Marquees & Canopies	75	75
Mechanical Rooms	150	125
Offices	80 + 20 psf Partitions	50 + 20 psf Partitions
Parking Garages	50	40
Plaza, Top Floor Parking	Fire Truck Load or 250 psf	250
Retail- First Floor	100	100
Stairs and Exitways	100	100
Storage (Light)	125	125

Live Load Values

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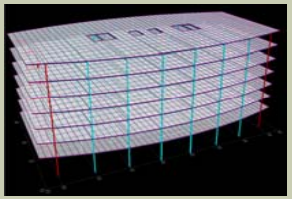
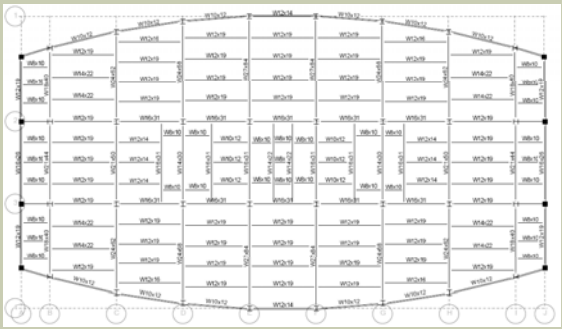
Gravity System Design

- 5 ½" Thick Slab on 2", 18 Gage Metal Decking
  - Provides adequate 2 hour fire rating between floors
- Beams spacing does not exceed 10'
  - Unshored
  - Minimize number of beams required
- Columns spliced every other floor



RAM Model



Typical Floor Layout

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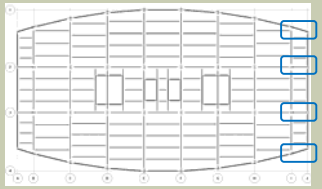
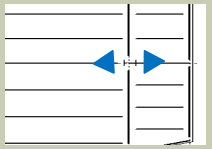
Cantilevered Ends

- 12’ Cantilever on North and South Ends
- Unobstructed glass around building corners



- Four beams used to transfer load back to columns
- Beam required:
  - W18x55



- Moment connection at interior to balance moment at column

- Moment from cantilever: 575 ft-k
- Moment from interior: 376 ft-k
- Moment to column: 199 ft-k
- Design for moment and axial due to gravity load
- Final Design shown at right

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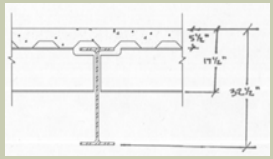
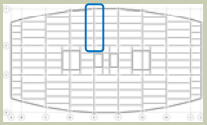
Floor Depth Comparison

- Existing post-tensioned system
  - 20” depth at beams



- Steel Design
  - Deepest Beam: W27x84



- Floor Depth Approx. 32”

- Maintain ceiling heights and MEP Spaces

- Increase overall building height
  - No code restrictions
  - Increase by 12” per floor
  - Overall height increase by 7’
  - Recalculate lateral loads

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Lateral Loads

- Wind: Method 2 of ASCE 7-05 Chapter 6
  - Assume wind negligible beneath plaza level
- Seismic: ELFP of ASCE 7-05 Chapter 11
  - Seismic Design Category B
  - Seismic Base Level taken at plaza level
- Wind controlled for strength and serviceability

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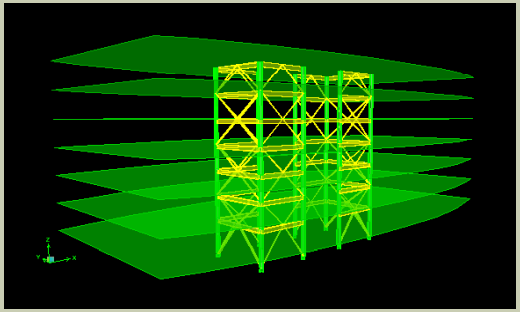
ETABS Model

- 7 Load combinations, 4 wind cases, accidental torsion (5% ecc.) due to seismic all manually included
- Floors modeled as rigid diaphragms
  - Loads distributed based on relative stiffnesses of frames
- Only lateral system modeled
- Gravity loads applied using additional area mass to diaphragm



ETABS Model

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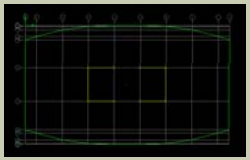
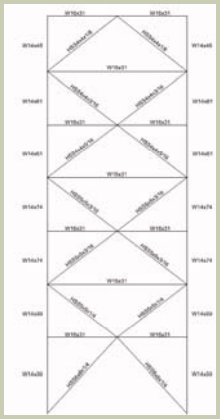
Braced Frame Design

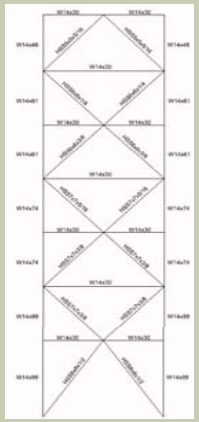


- Symmetry in Geometry and Stiffness
- Loads distributed evenly to each frame

- SAP used to calculate forces in braces for critical load combination
- Critical load combination used to design columns
- Final Brace Frame Design shown at right
- E-W Frames larger than N-S Frames



N-S Braced Frame



E-W Braced Frame

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Lateral Analysis

- Primary controlling load case was 0.9D+1.6W
- Controlling wind case was Wind Case 1
- Center of mass and rigidity both at geometric center
- Overall building torsion was negligible
- Wind drift within L/400
- Seismic drift found to be well within limitations

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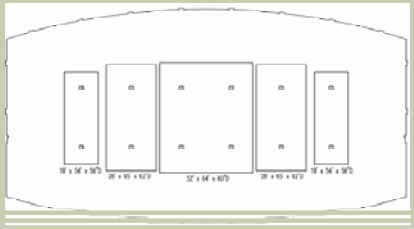
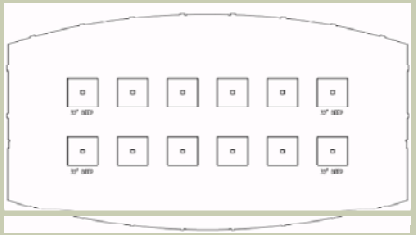
Foundation Design



• Existing foundations



• Steel Structure Foundations

•17’ x 17’ x 34” Deep (U.N.O.)

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Cost/ Schedule

- Detailed takeoffs completed for both systems
- Foundations cost reduced 78%
- Total Structure cost reduced by 25%

- Schedule predicted to be decreased by approx. 10 months
  - General conditions savings not factored into cost results

Original Structure					
	Mat'l	Labor	Equipment	Total	COST/SF
Foundations	$272,327	$59,403	$250	$331,980	$1.90
Superstructure	$2,532,939	$1,594,087	$48,370	$4,175,396	$23.86
Total Incl. Additional Costs					**$27.83**

Steel Redesign					
	Mat'l	Labor	Equipment	Total	COST/SF
Foundations	$54,082	$17,076	$1,874	$73,033	$0.42
Superstructure	$2,669,627	$290,079	$114,563	$3,074,269	$17.57
Total Incl. Additional Costs					**$19.43**

- Assuming $50 per SF of building enclosure
  - $224,000 additional
  - Final Steel cost of **$20.69 per SF**

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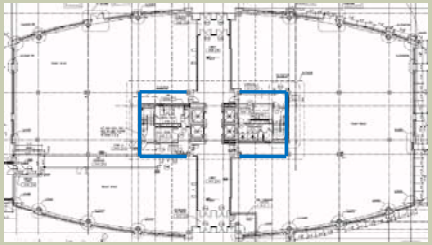
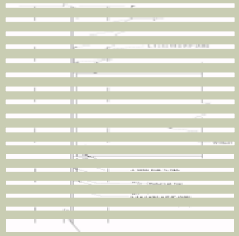
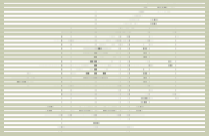
Additional Topics

- Architectural Study



- Design of Connections





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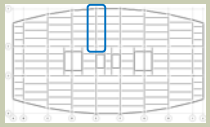
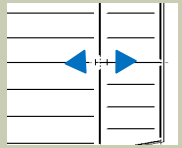
Further Improvements

- Potential to reduce floor depth
  - From Earlier:
  - Deepest Beam: W27x84



  - Use W21 x 93 instead
  - Constrain 10 beams on each floor
  - Floor depth required: 32” ➔ 26”
  - Overall height increase by 3.5’, not 7’

- Potential to balance additional moment
  - Unbalanced moment: 199 ft-k



  - Decreasing cantilever distance or increase moment on interior
  - Much smaller columns will result

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Conclusions

- Reduce building self weight ☑
- Maintain integrity of tenant spaces ☑
- Reduce overall cost ☑
- Reduce schedule duration ☑

- Steel could have been a viable and beneficial alternative.

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Acknowledgements

A special thanks to:

CAGLEY & ASSOCIATES
CONSULTING STRUCTURAL ENGINEERS

- Frank Malits
- Daniel Camp

FOULGER-PRATT
We Build to Last

- Karl Alt

PSU Architectural Engineering Faculty

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Questions/Comments