

Washingtonian Center

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Presentation Outline

Background Information

Project Goals

Structural Depth

- Existing Steel System
- Redesigned Concrete System

Construction Management Breadth

- Steel Structural Estimate
- Concrete Structural Estimate

System Comparisons

Final Recommendation

Project Information

General Statistics

- Name: Washingtonian Center
- Location: Gaithersburg Maryland
- Size: 199,164 S.F.
- Function: Office Space
- Levels: Eight Floors

Project Team

- Owner: Washington Property Company
- Architect: Wisniewski Blair and Associates LTD
- Structural: Echelon Engineering
- MEP: GHT Limited

Site

- Located in Gaithersburg Maryland
- Previously Undeveloped Site
- 8 Acre Lot
- Planned Development Includes Two Office Buildings and a Parking Structure



Thesis Goal

“Determine the Best Structural Design For the Washingtonian Center”

Goal Achieved By:

1. Redesigning the Structure Using Concrete

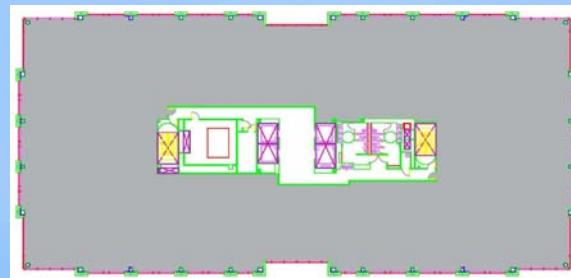
- Increase Leasable Space By Reducing Floor-to-Floor Heights So That An Additional Floor Can Be Added Beneath The 125' Height Restriction

2. Comparing the Redesign to the Original Steel Design

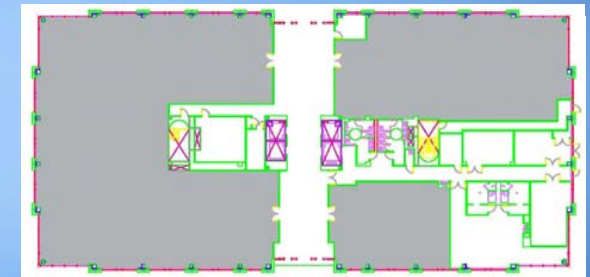
- Structural Costs
- Leasing Revenue
- Construction Time
- Architectural Considerations

Structural Depth: Existing System

- Core and Envelope Design
- Leasable Space Shown in Grey



Typical Architectural Floor Plan: Floors 3-8



First Floor Architectural Plan

Structural Depth: Existing System

Frame:

- Structural Steel Members
- Outer Bays: Typically W21x44 Spanning 45'- Spaced 10'
- Inner Bays: Typically W14x22 Spanning 20'- Spaced 10'

Floor System:

- 20 Gage Composite Steel Deck: 3" Deep, 3.25" LW Topping

Columns:

- Spliced at the 4th and 7th Levels
- Gravity Columns Range From W10x49-W12x96



Structural Depth: Existing System

Lateral Frame:

- 4 Identical Concentric Braced Chevron Frames
- Located Around the Elevator Core

Lateral Columns:

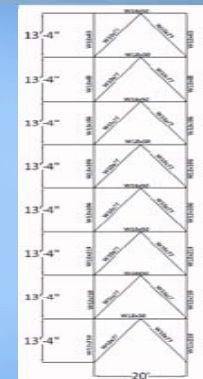
- Spliced at the 4th and 7th Levels
- W12x210 at Base, W12x106 in Middle, W12x65 at Top

Braces:

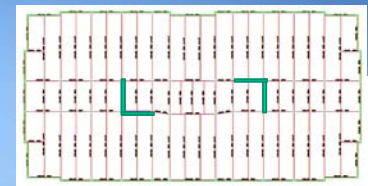
- W10x77 at all Levels

Beams:

- W18x50 at all Levels



Braced Frame Elevation



Braced Frame Locations

Structural Depth: PT-Floor

Design Procedure

- Ram Concept was used for design
- Initial Tendon numbers/spacing based on 150 psi pre-compression
- Balance 75% of dead load
- Add stud rails at locations of punching shear failures
- Jacking Stress= $0.8f_{pu}$
- Total Losses at service loading= 19%

PT System

1/2" Un-bonded Seven Wire Strand

$$A_{ps} = 0.153 \text{ in}^2$$

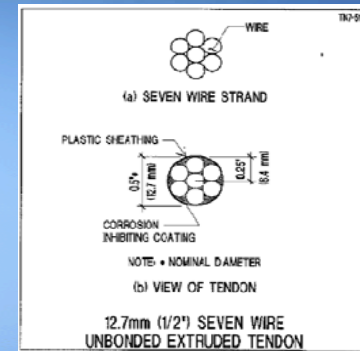
$$E_{ps} = 28000 \text{ ksi}$$

$$f_{cu} = 175 \text{ ksi}$$

$$f_{py} = 243 \text{ ksi}$$

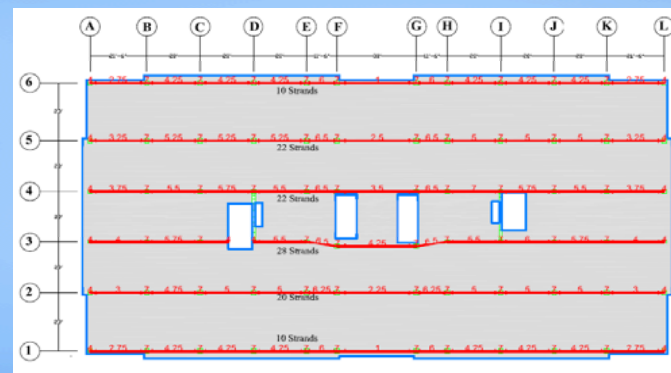
$$f_{pu} = 270 \text{ ksi}$$

$$f_j = 216 \text{ ksi}$$



Structural Depth: PT-Floor

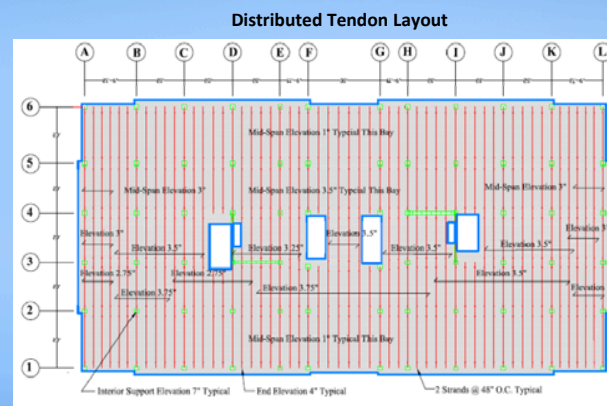
Banded Tendon Layout



Banded Tendons:

- Initial Number Based 150 psi Pre-Compression in Band Strip
- Profile Height Initially 7" Over Columns
- Profile Height Initially 1" at Mid-span
- Number/Profiles Altered at Mid-Span to Balance 75% of Dead Load
- Additional Tendons Added at Locations of Tensile Failures

Structural Depth: PT-Floor

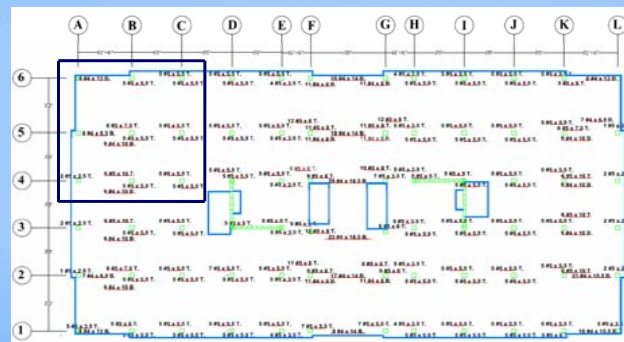


Distributed Tendons:

- Initial Number and Spacing Based 150 psi Pre-Compression
- Profile Height Initially 7" Over Columns
- Profile Height Initially 1" at Mid-span
- Profile Heights Altered at Mid-Span to Balance 75% of Dead Load
- Additional Tendons Added at Locations of Tensile Failures

Structural Depth: PT-Floor

Latitude Mild Steel Reinforcement



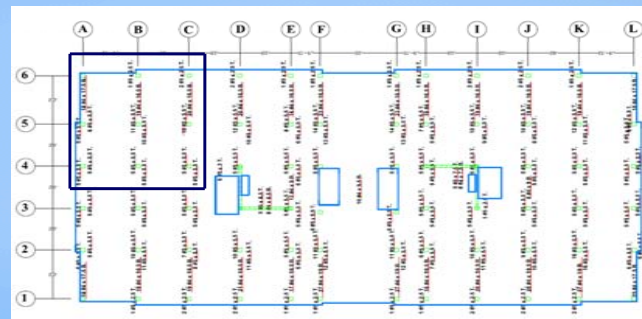
Mild Steel Reinforcement

- Added by requirements of ACI 318-08
- Top Bars: Typically #5 bars over supports extending at least $1/6^{\text{th}}$ span in each direction, distributed over design strip
- Bottom Bars: Typically #4 bars at mid-span extending at least $1/3^{\text{rd}}$ the span, distributed over design strip



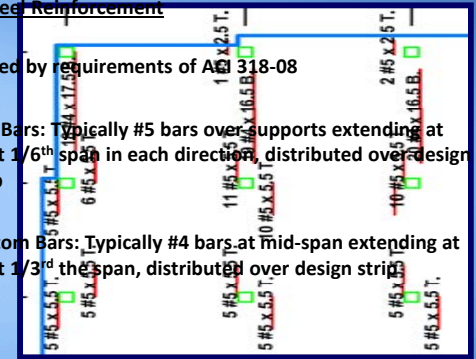
Structural Depth: PT-Floor

Longitude Mild Steel Reinforcement



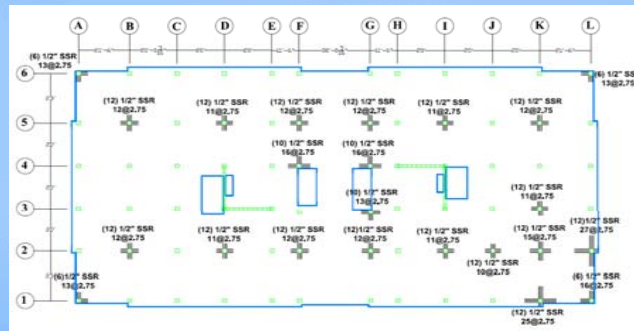
Mild Steel Reinforcement

- Added by requirements of ACI 318-08
- Top Bars: Typically #5 bars over supports extending at least $1/6^{\text{th}}$ span in each direction, distributed over design strip
- Bottom Bars: Typically #4 bars at mid-span extending at least $1/3^{\text{rd}}$ the span, distributed over design strip



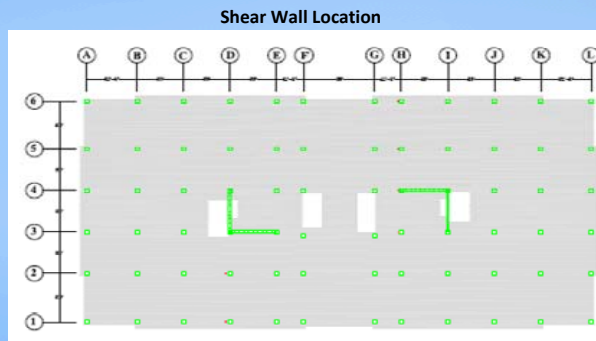
Structural Depth: PT-Floor

Supplemental Shear Reinforcement



Stud Rail Detail

Structural Depth: Shear Walls

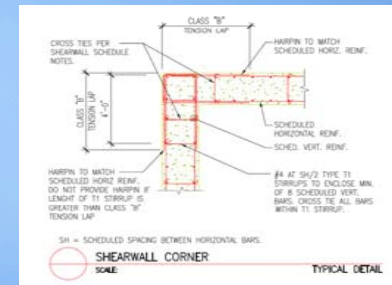


Designed in Etabs

- **Service Model Sized Walls**
 - Cracking Factors Initially Set to 1.0
 - Cracked Sections Changed to 0.5
- **Strength Model Designed Reinforcement**
 - Cracking Factors Initially Set to 0.7
 - Cracked Sections Changed to 0.35 (ACI 318-08 Section 10.10.4.1)
- **5000 psi concrete**

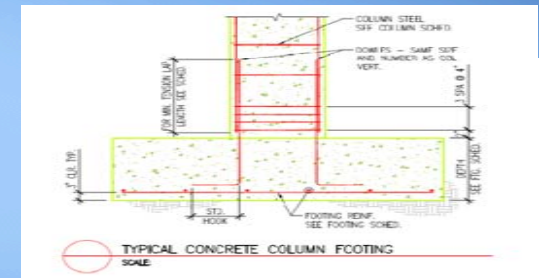
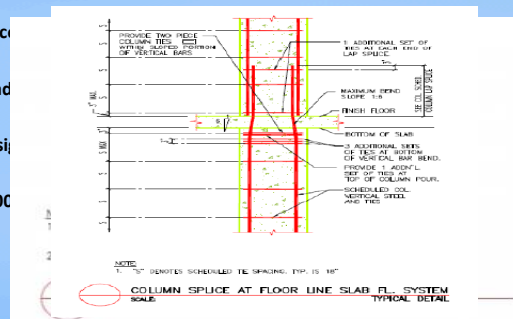
Structural Depth: Shear Walls

Shear Wall Schedule		
Level	Vert. Bars Each Face	Hor. Bars Each Face
Roof	#5 @ 12" o.c.	#4 @ 12" o.c.
9th	#5 @ 12" o.c.	#4 @ 12" o.c.
8th	#5 @ 12" o.c.	#4 @ 12" o.c.
7th	#5 @ 12" o.c.	#4 @ 12" o.c.
6th	#5 @ 12" o.c.	#4 @ 12" o.c.
5th	#7 @ 12" o.c.	#4 @ 12" o.c.
4th	#7 @ 12" o.c.	#4 @ 12" o.c.
3rd	#7 @ 12" o.c.	#4 @ 12" o.c.
2nd	#7 @ 12" o.c.	#4 @ 12" o.c.
Base	#7 @ 12" o.c.	#4 @ 12" o.c.



Structural Depth: Columns

- All c
- Load
- Desig
- 5000



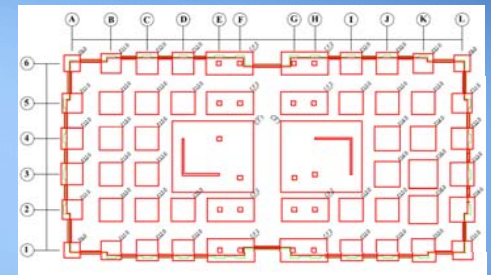


Structural Depth: Foundations

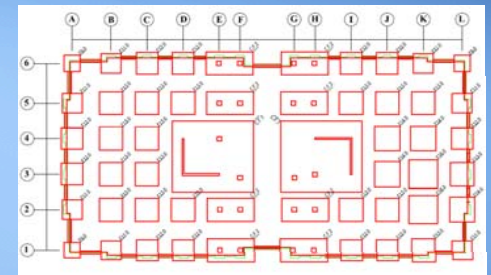
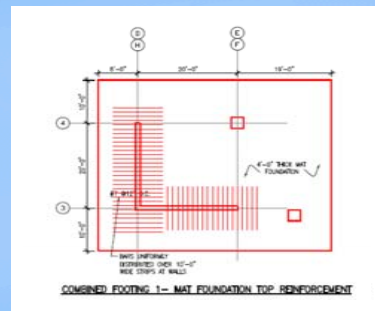
Design Procedure

Designation	Size	Depth	Bot. Reinforcing
F 9.0	9' x 9'	24"	11-#6 E.W.
F 10.0	10' x 10'	24"	9-#7 E.W.
F 11.0	11' x 11'	30"	12-#7 E.W.
F 12.0	12' x 12'	30"	13-#7 E.W.
F 13.0	13' x 13'	36"	17-#7 E.W.
F 14.0	14' x 14'	36"	11-#9 E.W.
F 15.0	15' x 15'	42"	23-#7 E.W.
F 16.0	16' x 16'	42"	23-#7 E.W.

Gravity Column Footing Schedule



Structural Depth: Foundations



Structural Depth: Analysis

Drifts

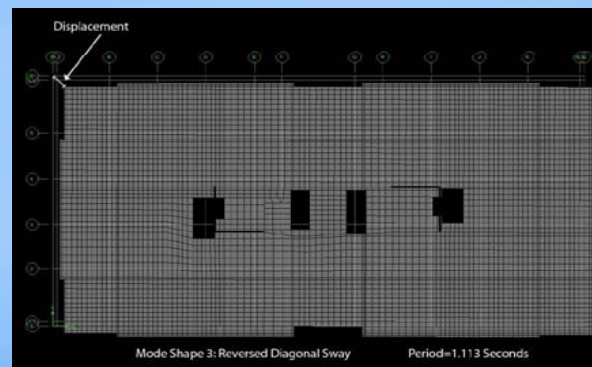
- Seismic-Allowable Story Drifts 0.02h
- Wind-Allowable Building Drift $h/400$

Drift Due to Seismic Forces					
Story	Drift Due to Wind				(in)
	Story	Height (ft)	Drift (in)	Allowable Drift (in)	
PHF	PHF	117.9	0.8	3.537	2.28
PHF	PHF	108.4	0.76	3.252	888
Root	PHFloor	104.7	0.72	3.141	784
9th	ROOF	93.1	0.62	2.793	808
8th	8	81.4	0.53	2.442	784
7th	7	69.8	0.43	2.094	784
6th	6	58.2	0.33	1.746	808
5th	5	46.5	0.24	1.395	784
4th	4	34.9	0.16	1.047	784
3rd	3	23.3	0.08	0.699	784
2nd	2	11.6	0.03	0.348	808
2nd		11.0	0.01	0.00	2.784



Structural Depth: Analysis

Building Modes and Fundamental Periods



Construction Management Breadth

Cost Analysis

- Done Using Material Take-Off and RS Means for Material, Labor and Equipment Costs

Cost Breakdown Summary

System	Base Costs	Adjustment Percentage	Adjusted Costs	
Beams/Girders		18%	\$528,298.32	
Columns		28%	\$579,445.03	
Foundations	Post-Tensioned Floors	\$1,990,469.09	0	\$149,208.34
Floor Deck	Shear Walls	\$153,083.30	0	\$389,400.00
Roof Deck	Columns	\$684,926.10	0	\$35,880.00
Shear Studs	Foundations	\$327,344.29	0	\$2,287.30
Concrete Topping	Total	\$3,155,822.74	0	\$425,702.20
Welded Wire Fabric			0	\$55,456.50
Fire Proofing			0	\$276,582.49
Total Structure Cost:				\$2,442,260.18

Construction Management Breadth

Revenue From Leasing Office Space

- Estimate was based on rental rate of \$5/ Sq. Ft. Annually

Cost Comparison Summary								
Concrete		Expense/Income	Steel	Concrete	Difference	Steel Design		
Floor	Leasable	Structure	\$2,442,260.18	\$3,155,822.74	-\$713,562.56	Leasable Footage	Revenue	
9th	19900	Leasing Revenue/Year	\$778,325.00	\$877,825.00	\$99,500.00	8th	19900	\$99,500.00
8th	19900					7th	19900	\$99,500.00
7th	19900					6th	19988	\$99,940.00
6th	19988					5th	19988	\$99,940.00
5th	19988					4th	19988	\$99,940.00
4th	19988					3rd	19988	\$99,940.00
3rd	19988					2nd	19988	\$99,940.00
2nd	19988					1st	15925	\$79,625.00
1st	15925					Total Revenue= \$778,325.00		
Total Revenue=			\$877,825.00					

Construction Management Breadth

Steel Construction Schedule: Total Time= 7 Weeks

Construction Scheduling

- Estimated 11 using RC Means and Professional Consultants

Forming Footings	2 days
Placing Rebar in Footings	2 days
1st Floor Concrete	5 days
1st Floor Steel	2 days
2nd Floor Steel	5 days
2nd Floor Concrete	2 days
3rd Floor Steel	5 days
3rd Floor Concrete	2 days
4th Floor Steel	5 days
4th Floor Concrete	2 days
5th Floor Steel	5 days
5th Floor Concrete	2 days
6th Floor Steel	5 days
6th Floor Concrete	2 days
7th Floor Steel	5 days
7th Floor Concrete	2 days
8th Floor Steel	5 days
8th Floor Concrete	2 days
Penthouse Steel	2 days
Penthouse Concrete	1 day

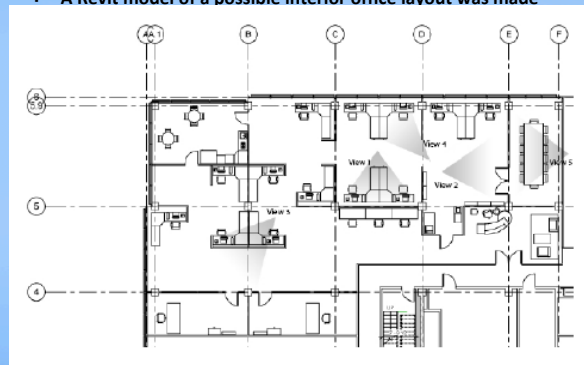
Concrete Construction Schedule: Total Time= 20 Weeks

Activity	Duration
Placing Rebar in Footings	2 days
Placing Concrete	2 days
1st Floor Columns	2 days
1st Floor Shear Walls	1 day
1st Floor PT Floor	7 days
1st Floor Columns	2 days
2nd Floor Shear Walls	1 day
2nd Floor PT Floor	7 days
2nd Floor Columns	2 days
3rd Floor Shear Walls	1 day
3rd Floor PT Floor	7 days
4th Floor Columns	2 days
4th Floor Shear Walls	1 day
4th Floor PT Floor	7 days
5th Floor Columns	2 days
5th Floor Shear Walls	1 day
5th Floor PT Floor	7 days
6th Floor Columns	2 days
6th Floor Shear Walls	1 day
6th Floor PT Floor	7 days
7th Floor Columns	2 days
7th Floor Shear Walls	1 day
7th Floor PT Floor	7 days
8th Floor Columns	2 days
8th Floor Shear Walls	1 day
8th Floor PT Floor	7 days
9th Floor Columns	2 days
9th Floor Shear Walls	1 day
9th Floor PT Floor	7 days
Penthouse Floor	1 day
Penthouse Roof	1 day



Architectural Breadth

- A Revit model of a possible interior office layout was made



View 4: Typical Workstations by the Windows



System Comparison

Characteristic	Steel Design	Concrete Design
Structural Cost	✓	
Leasing Revenue		✓
Scheduling Time	✓	
Open Floor Plan	✓	

Final Recommendation

Although the concrete design would provide additionally leasable space, the best solution for the Washingtonian Center is the original steel design.

Questions?