Office Building

Washington, DC

Nick Szakelyhidi

Structural Option

Presentation Outline

- Existing Building
  - Design Features
  - Floor System
  - Lateral System
- Proposal
  - Goals
  - Concerns
- Alternative Structure
  - Overview
  - Floor System
  - Lateral System
- Comparison
  - Cost
  - Other considerations
  - Conclusion
- Acknowledgements

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Existing Building

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Project Team

Owner: Louis Dreyfus Property Group

Architect: Kevin Roche John Dinkeloo and Associates

Structure: Tadjer Cohen Edelson Associates

MEP: Tolk Engineering Inc

CM: Centex Construction

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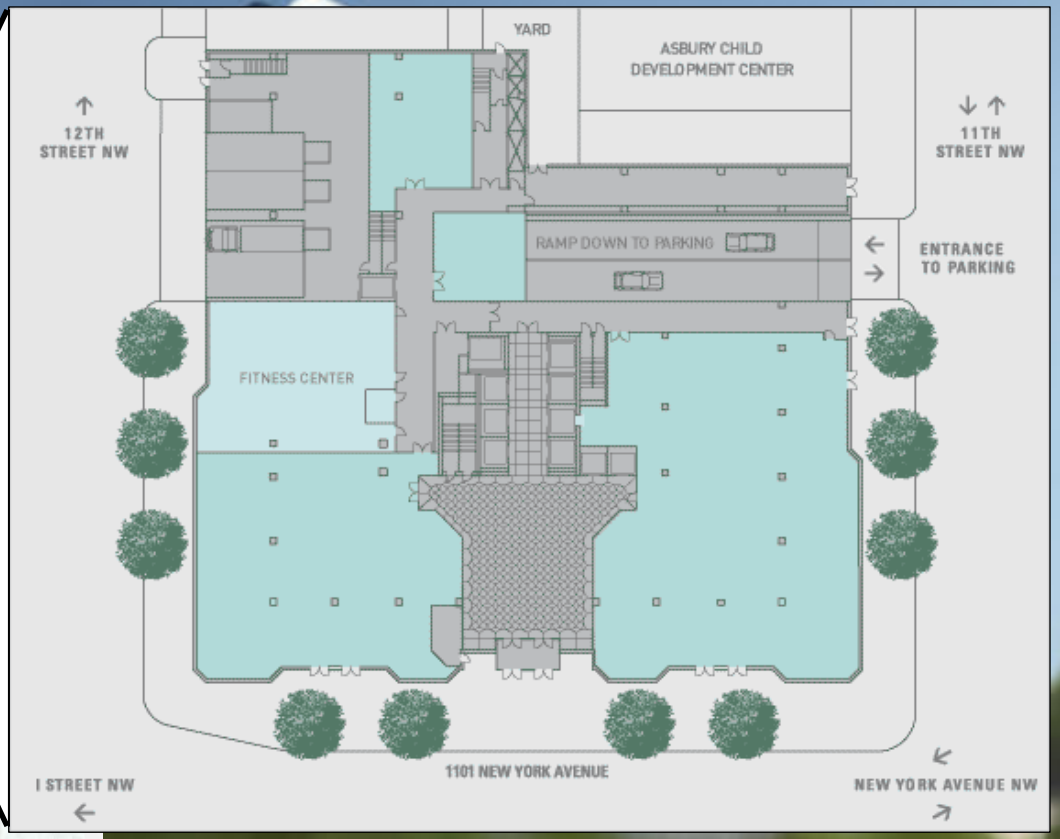
Building Site

- Existing Building
- Design Features



½ City Block

Urban Redevelopment

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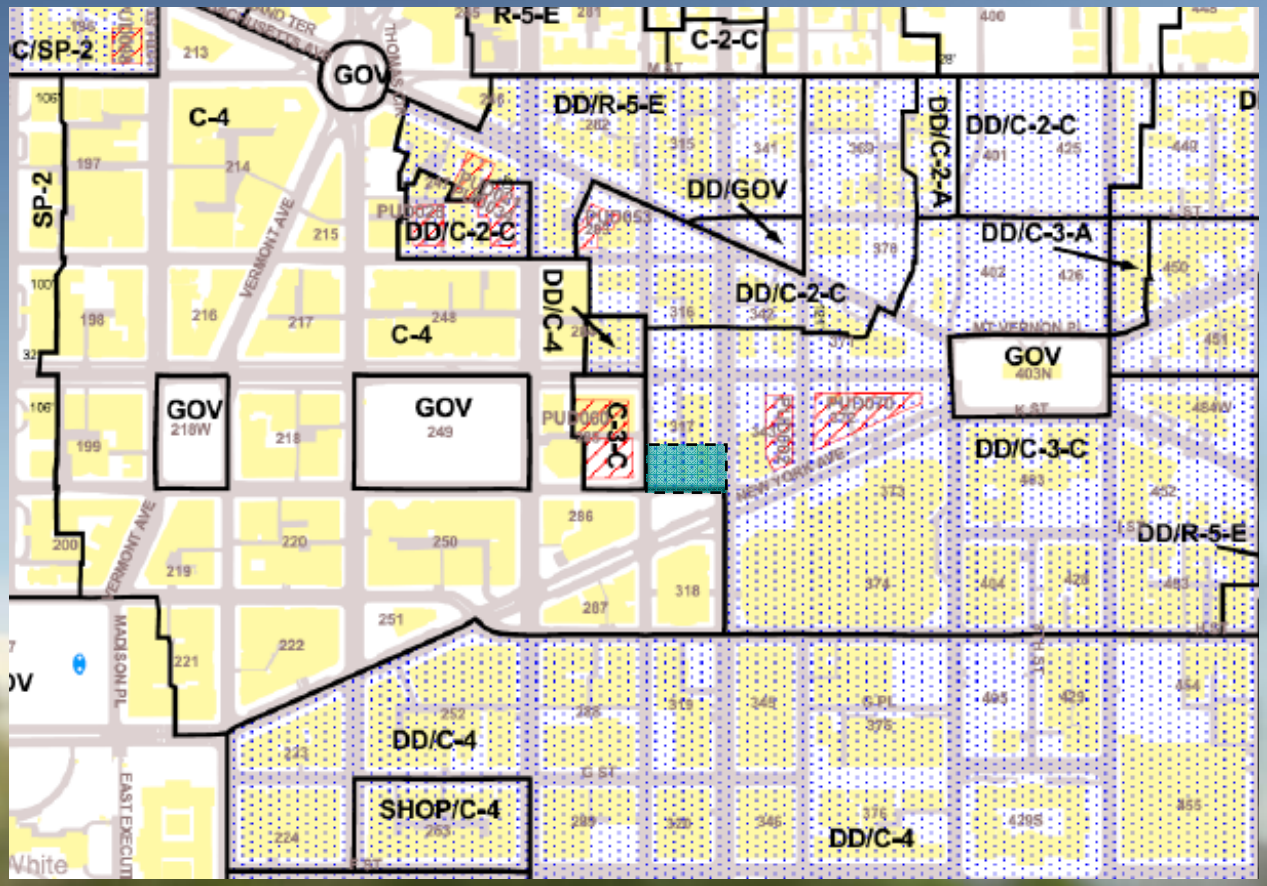
Zoning

- Existing Building
- Design Features



DD/C-3-C Zone

Height Restriction

Mixed-Use Office

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Building Features

- Existing Building
  - Design Features
  - Floor System

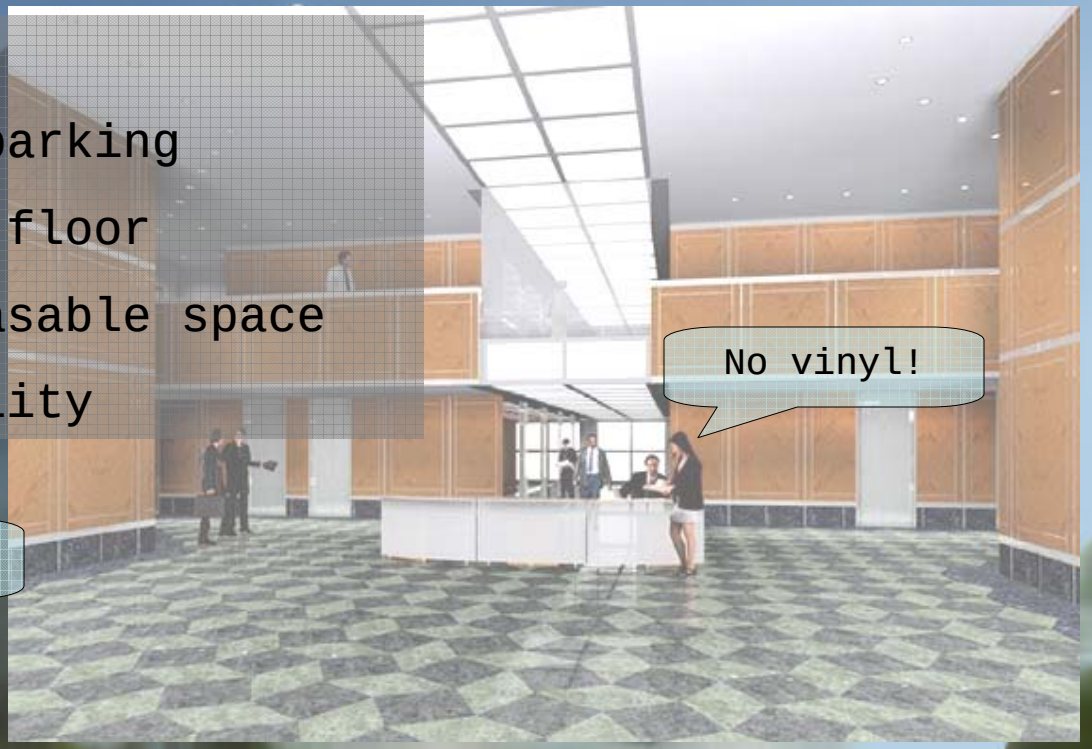
12 Stories above grade

3 stories below grade parking

31,115 square feet per floor

393,000 square feet leasable space

Mixed Use Class A facility



Colorless glass façade

20’ Cantilever on 3 sides creates column-free exterior

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Building Features

- Existing Building
  - Design Features
  - Floor System

LEED Rated Silver

Green roof

Roof patio

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Floor System

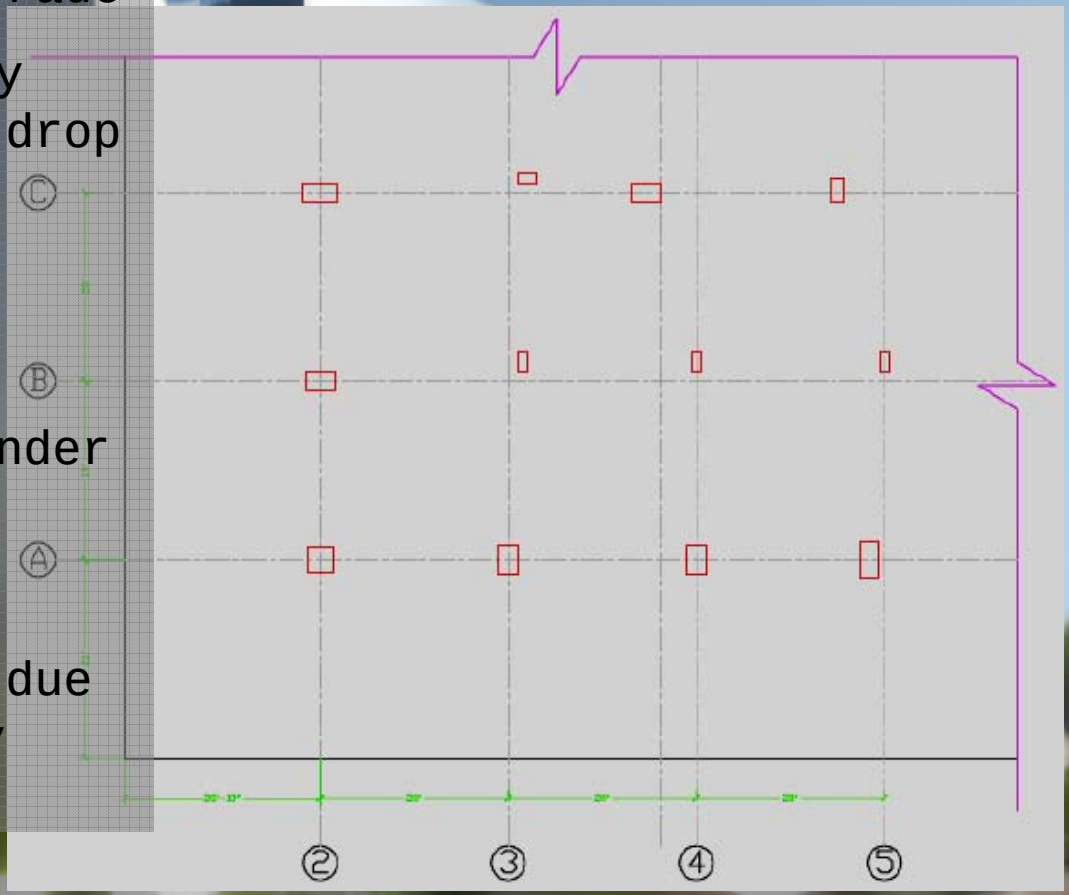
- Existing Building
  - Floor System
  - Lateral System

Ground floor and Below Grade

Reinforced two-way concrete flat slab with drop panels.

Foundation

Spread footings under gravity columns. Strip footing under basement retaining walls. Strip footing has cropped toe due to proximity to property line.



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Floor System

- Existing Building
  - Floor System
  - Lateral System

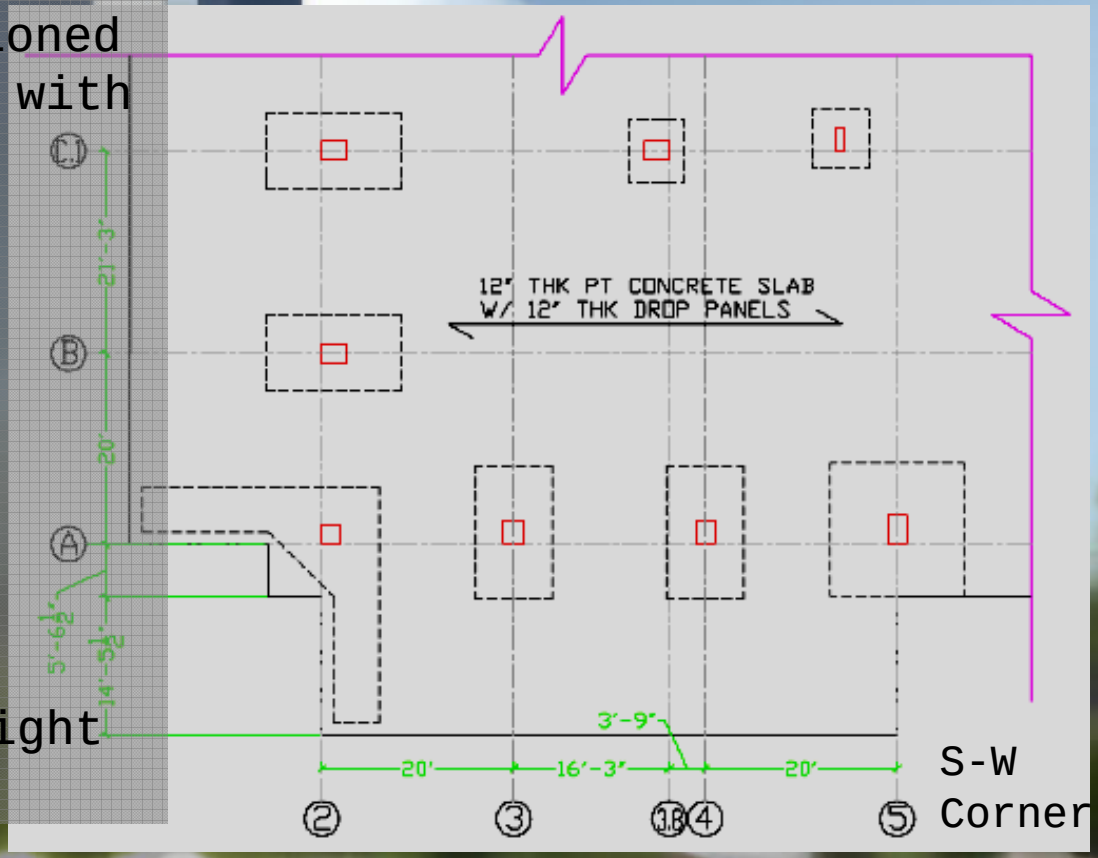
Above ground floor

Two-way post-tensioned flat plate concrete slab with drop panels at columns.

12″ thick with 12″ drops

5000 psi normal weight concrete in slabs

4000-12000 psi normal weight concrete in columns



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Lateral System

- Existing Building
  - Lateral System
- Proposal

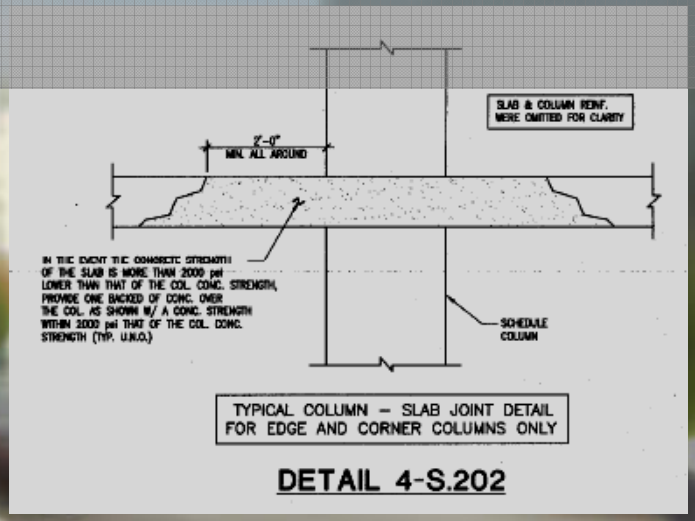
No exterior walls

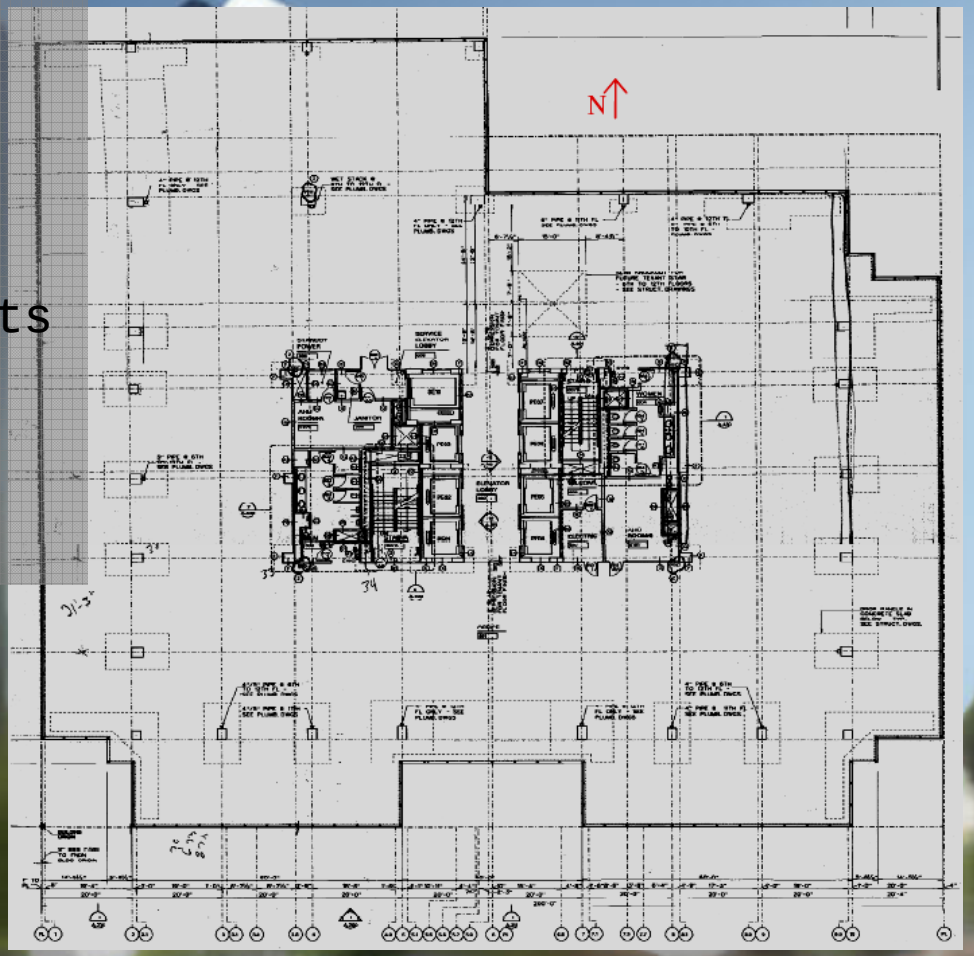
No shear walls in core

Monolitically cast concrete structure

Reinforced column-slab joints

Moment frames at exterior column line





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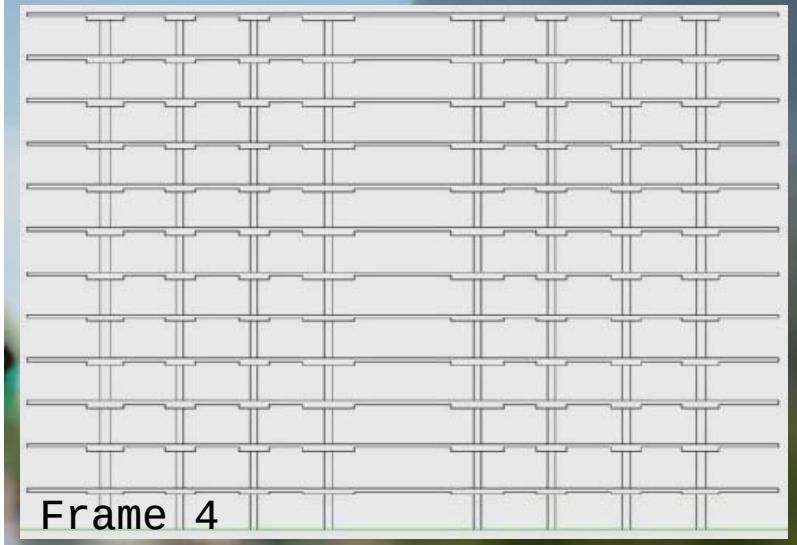
Lateral System

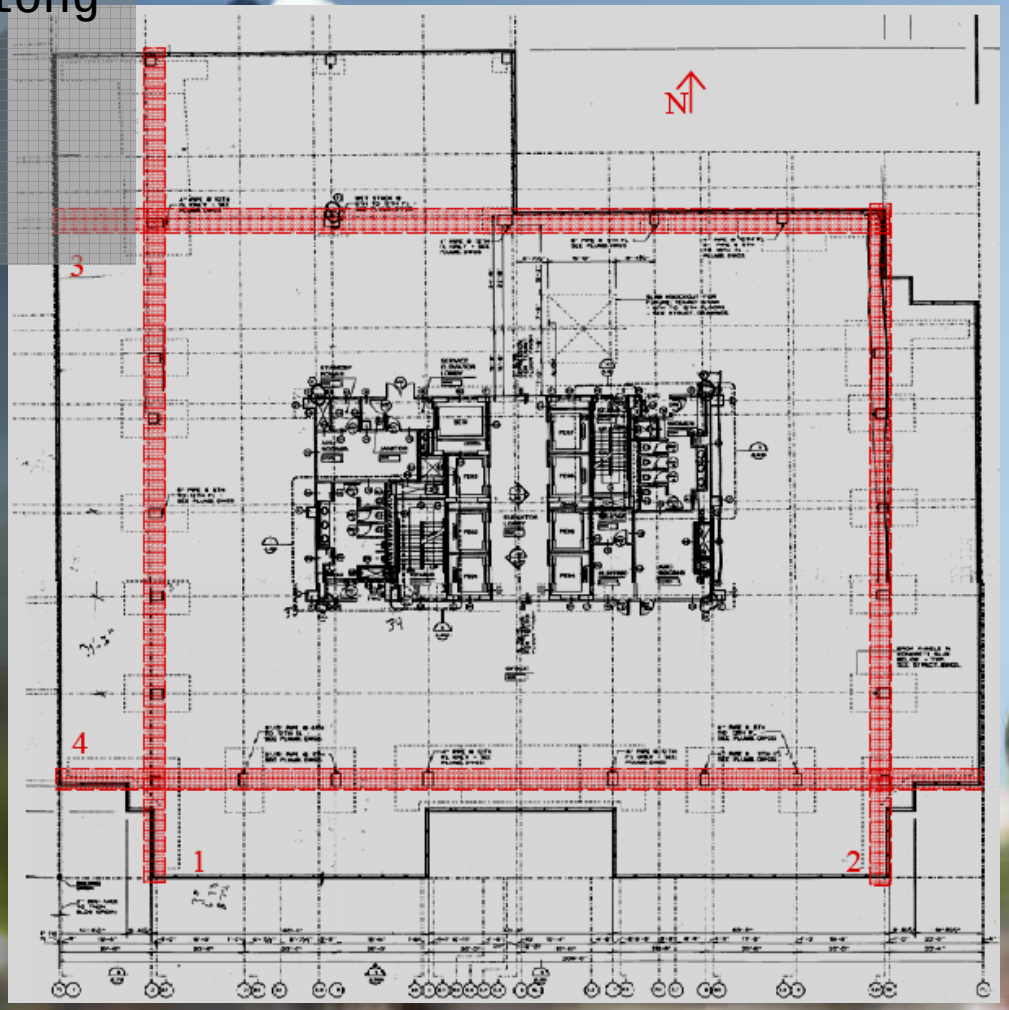
- Existing Building
  - Lateral System
- Proposal

4 Primary moment frames along exterior column lines

Two act E-W, two act N-S



Frame 4



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Thesis Proposal

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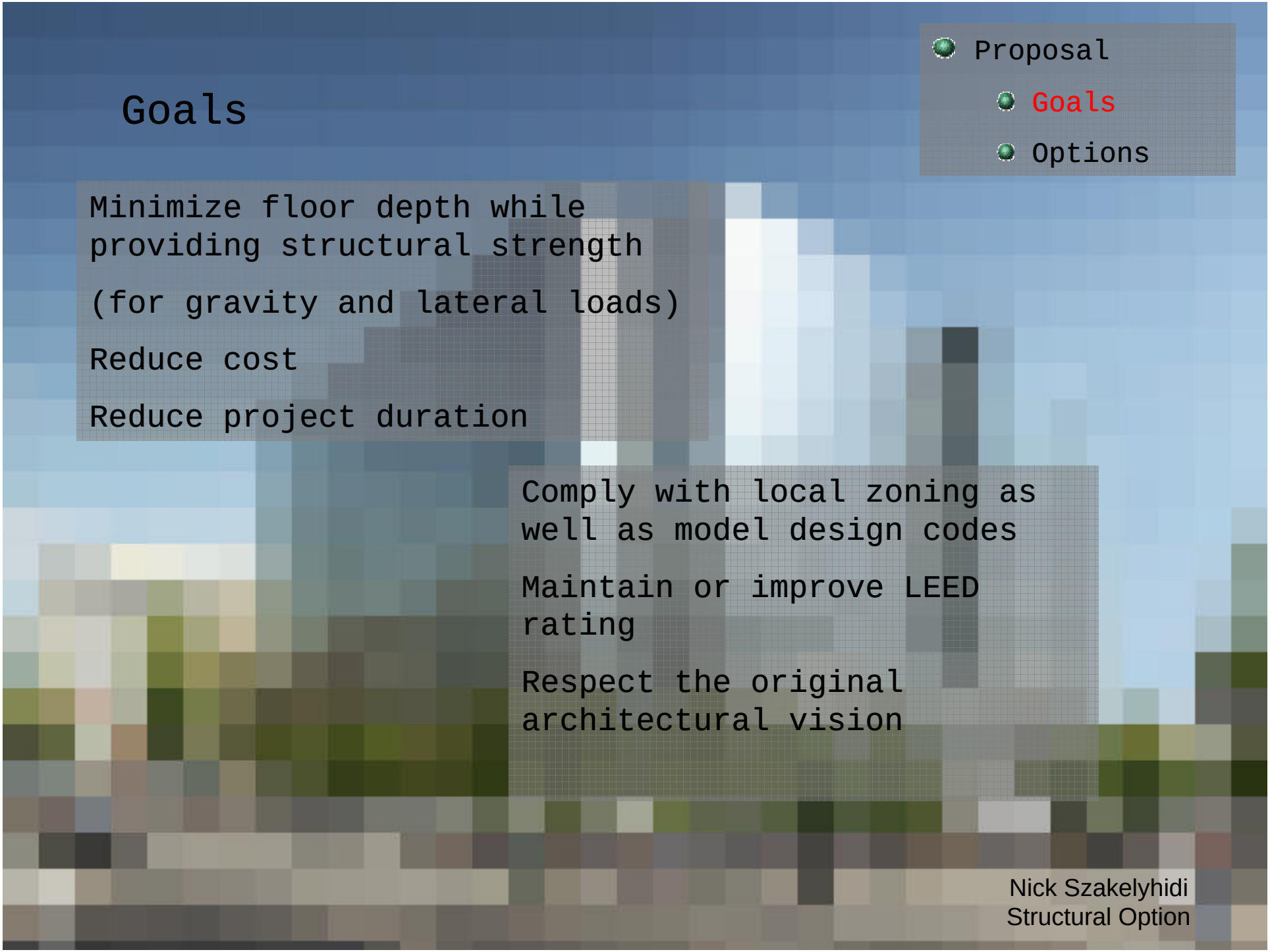

- Proposal
  - Goals
  - Options

Goals

Minimize floor depth while providing structural strength

(for gravity and lateral loads)

Reduce cost

Reduce project duration

Comply with local zoning as well as model design codes

Maintain or improve LEED rating

Respect the original architectural vision

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- Proposal
  - Options
- Alternative Structure

Options

Initial considerations:

Two-way concrete flat slab without post tensioning

One-way concrete skip joist system

Filigree slab system

Precast concrete tee beams with inverted tee girders

Two-way waffle slab

Alternative design decision:

Composite steel beams and girders with composite decking

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Alternative Structure

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- Alternative
  - Overview
  - Floor system

Overview

Alternative design will utilize a common structural system.

Composite steel decking used to maximize span without shoring.

Column layout remains essentially the same as the original system.

Gravity system designed using RAM Structural System

Lateral load resisting system designed using SAP2000

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- Alternative
  - Floor System
  - Lateral System

Floor System

Design Loads

Office live load = 80 psf

Superimposed dead load = 25 psf

Linear curtain wall load = 500 plf

1.2 Dead + 1.6 Live combination

Codes

ASCE-7 02 and IBC 2003 for loading

AISC LRDF for design

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- Alternative
  - Floor System
  - Lateral System

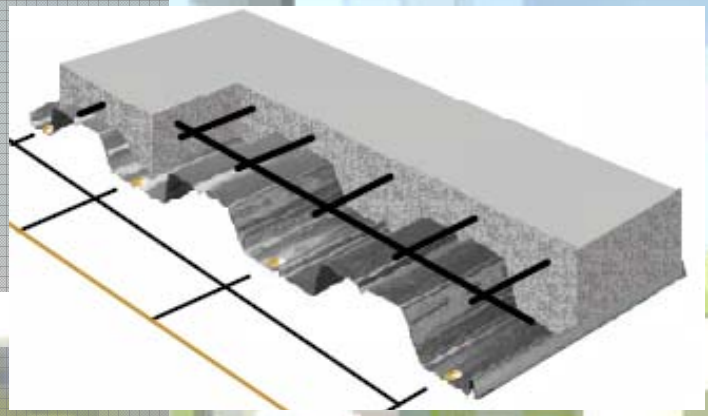
Floor System

Typical floor

- 20′ and 40′ column to column spans
- Cantilever bay at exterior

Decking

- 2″ composite W2 FormLok® Deck
- 20 gauge material
- 10′ span (typ.)
- 2 ½″ concrete slab, 4 ½″ total



Concrete

- 115 pcf lightweight concrete
- 4000 psi compressive strength

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- Alternative
  - Floor System
  - Lateral System

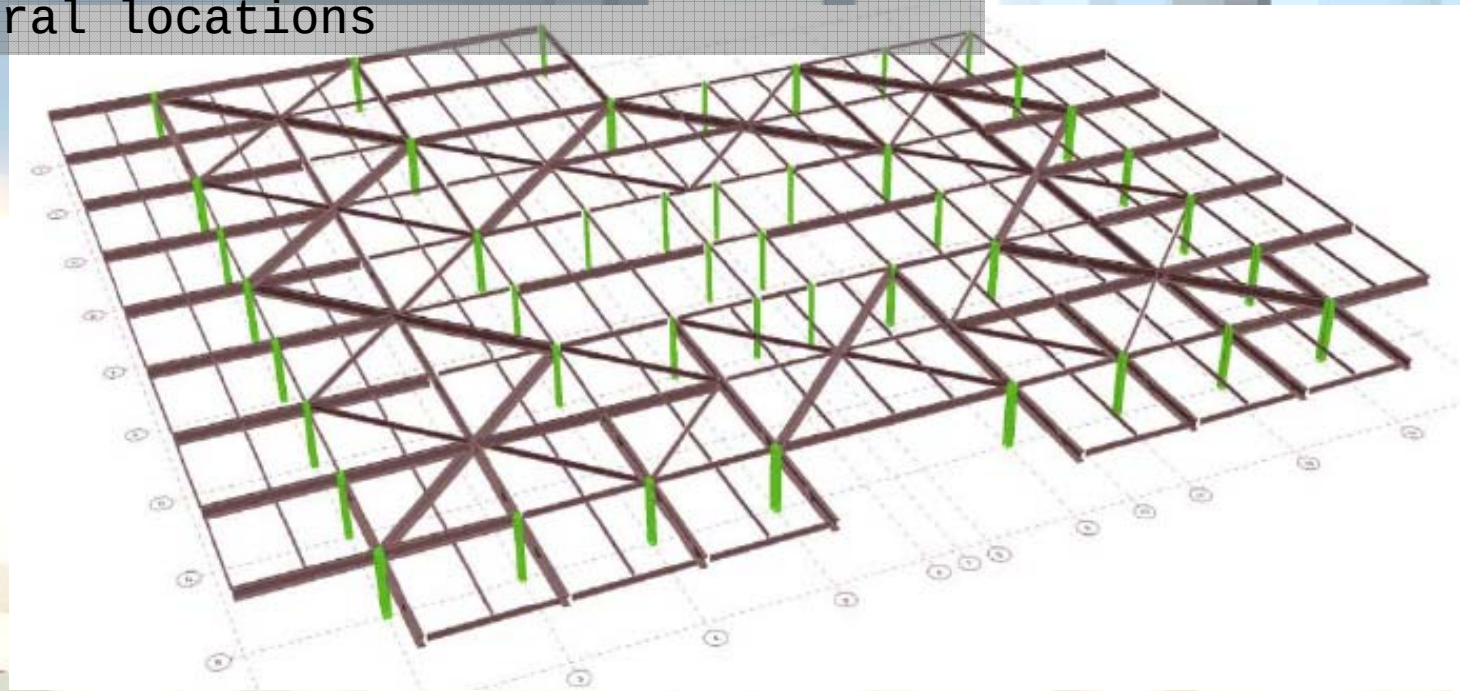
Floor System

Tried limiting to W18 maximum

Cantilever members were critical

Design had to be revised to decrease spans

Ended up still needing W21 shapes in several locations



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  - Floor System
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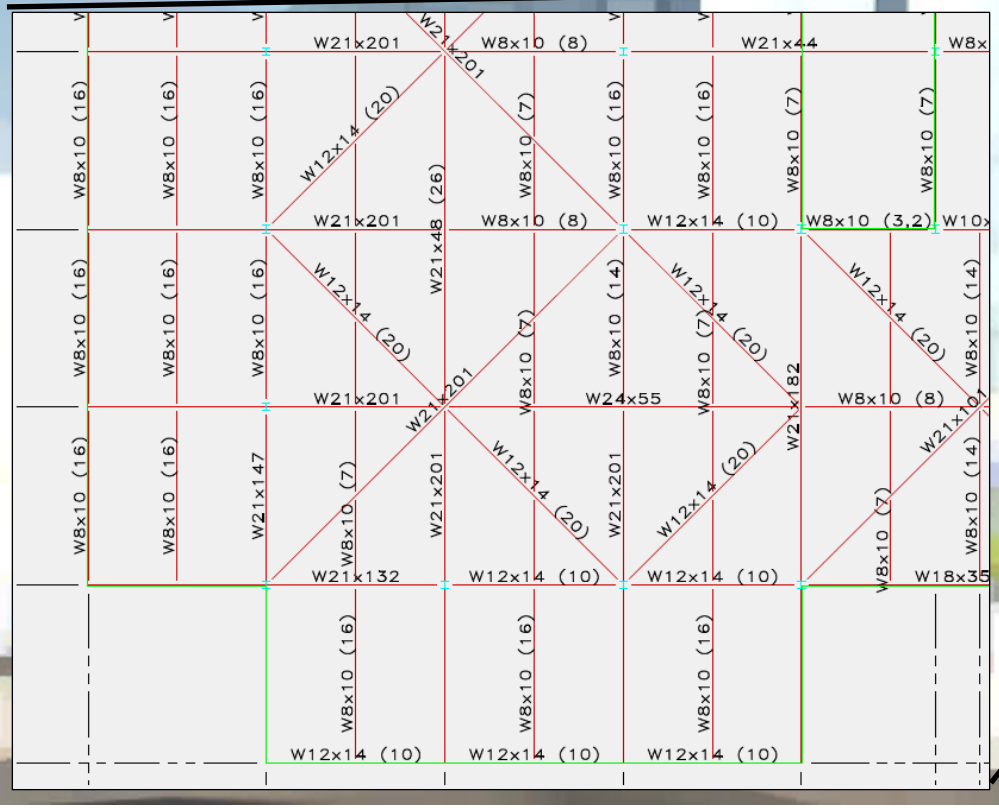
Floor System

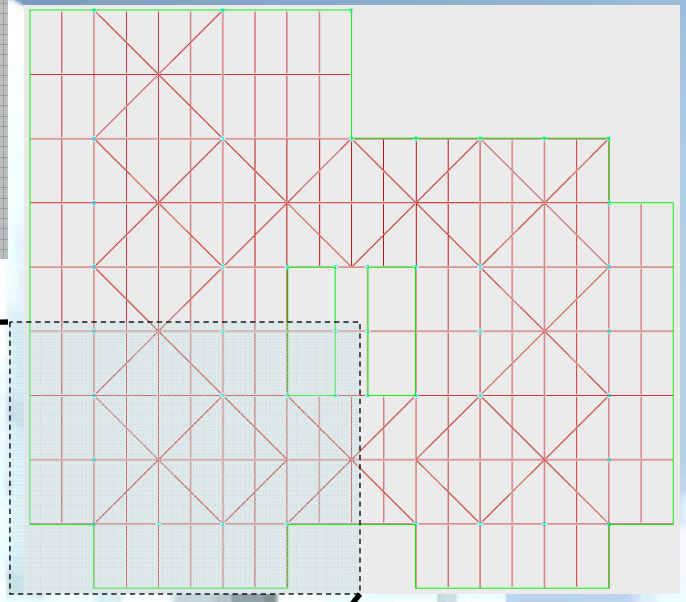
Full composite action utilized

Resulting member sizes shown

Minimal framing

Large girder members





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- Alternative
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- Comparison

Lateral System

Wind loads based on ASCE 7-02

Seismic loads based on ASCE 7-02 and IBC 2003

Load Combinations by ASCE 7-02

Steel system no longer has built in moment resisting capacity that existing concrete system utilized

Will require shear walls, braced frames, or frames with moment connections

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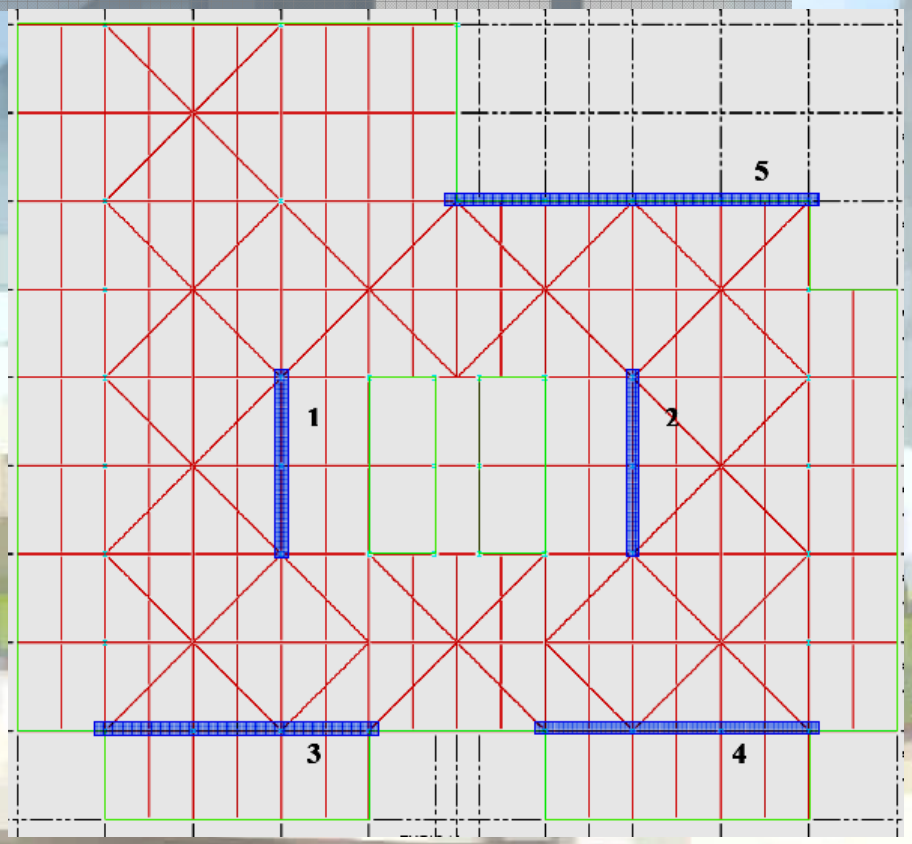
Lateral System

Moment frames are expensive

Utilize braced frames in N-S direction

Must use moment frames in E-W direction

Locations as shown



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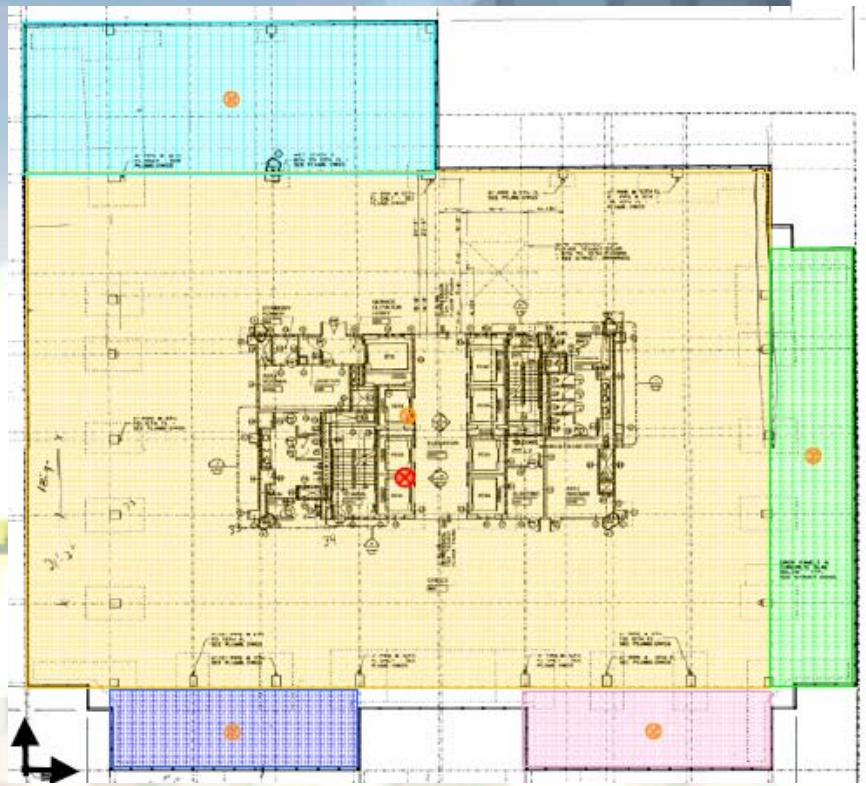
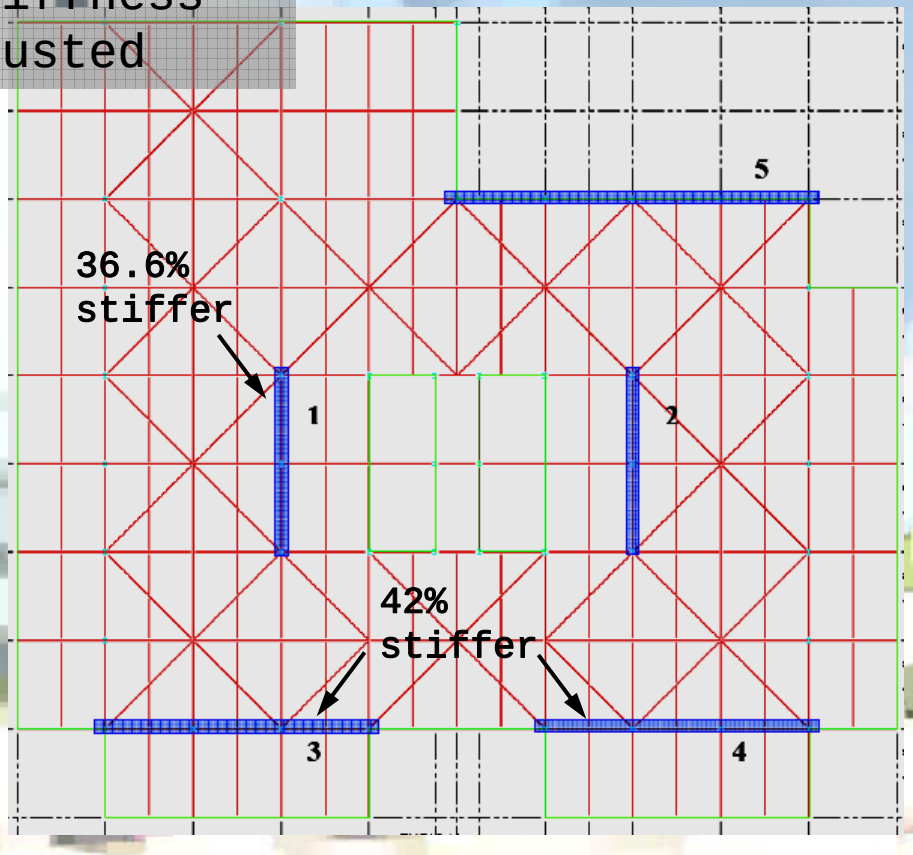
Torsion

To reduce the effects of torsion, center of rigidity was aligned with center of mass

To move center of rigidity, stiffness of frames would need to be adjusted





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- Alternative
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Lateral loads

Reduced structure weight

Highly reduced seismic forces

Less stiff overall compared to concrete

Storey	Shear				Storey Force			
	E-W		N-S		E-W		N-S	
	Wind	Seismic	Wind	Seismic	Wind	Seismic	Wind	Seismic
Roof					21.51	34.00	21.73	37.27
12	21.51	34.00	21.73	37.27	42.26	47.44	42.78	53.49
11	63.77	81.44	64.51	90.77	41.45	41.20	42.05	47.91
10	105.22	122.64	106.56	138.67	40.63	35.25	41.32	42.41
9	145.85	157.88	147.87	181.08	39.76	29.61	40.54	37.00
8	185.62	187.49	188.41	218.08	38.79	24.29	39.66	31.70
7	224.40	211.78	228.07	249.78	37.59	19.34	38.59	26.52
6	261.99	231.12	266.66	276.30	36.29	14.76	37.42	21.47
5	298.28	245.88	304.08	297.77	34.93	10.61	36.20	16.59
4	333.21	256.49	340.28	314.36	33.19	6.93	34.64	11.89
3	366.41	263.42	374.92	326.25	30.91	3.80	32.60	7.43
2	397.32	267.22	407.52	333.68	28.69	1.36	30.60	3.33
Base	426.01	268.58	438.12	337.02				

Base Moment			
E-W		N-S	
Wind	Seismic	Wind	Seismic
33955.15	27213.48	34664.82	32744.16

*all values in k and Ft-k

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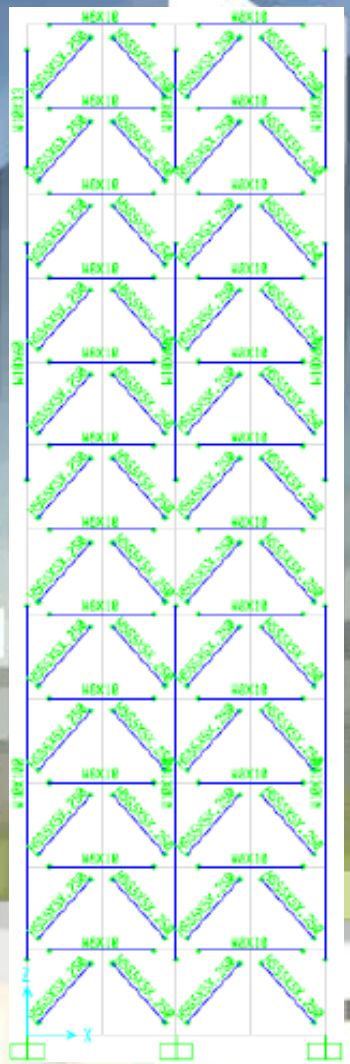
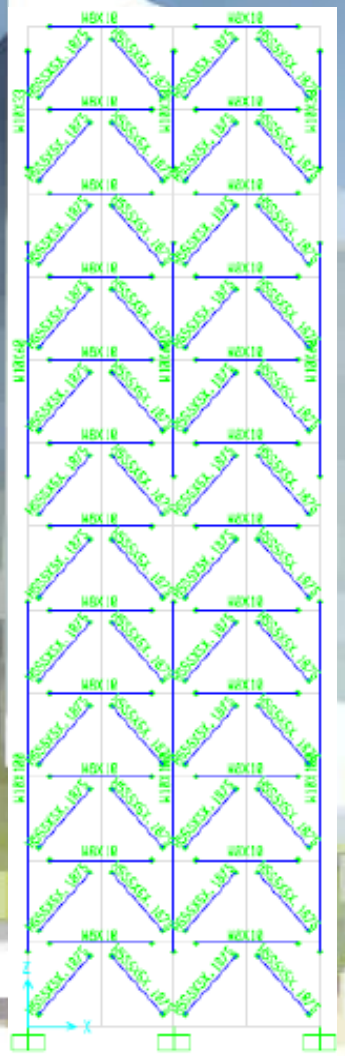
Braced Frames

Diagonal chevron bracing provided most stiffness using least material

5″ OD HSS shapes were used for bracing members



Frame 1



Frame 2

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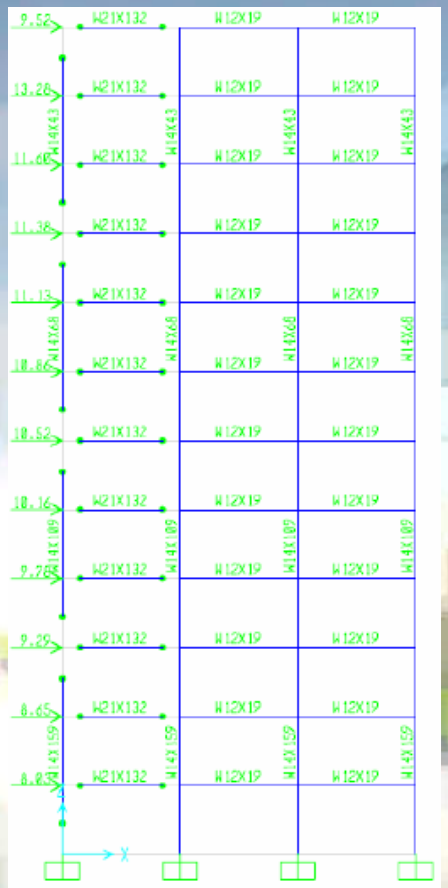
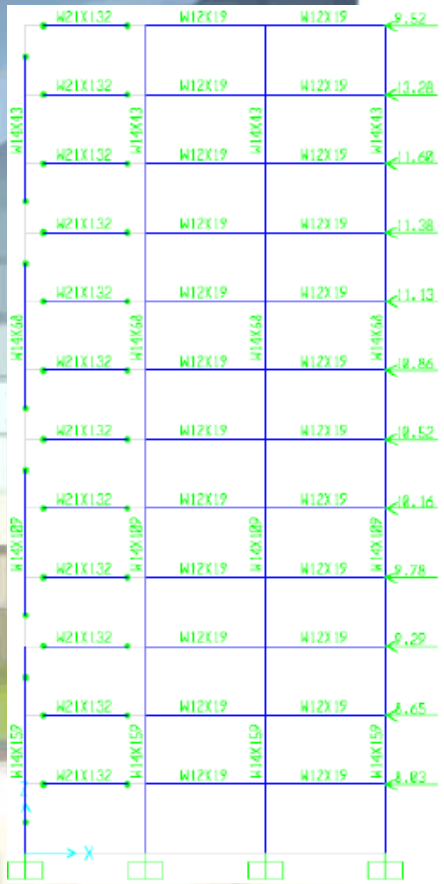
  - Lateral System
- Comparison

Moment Frames

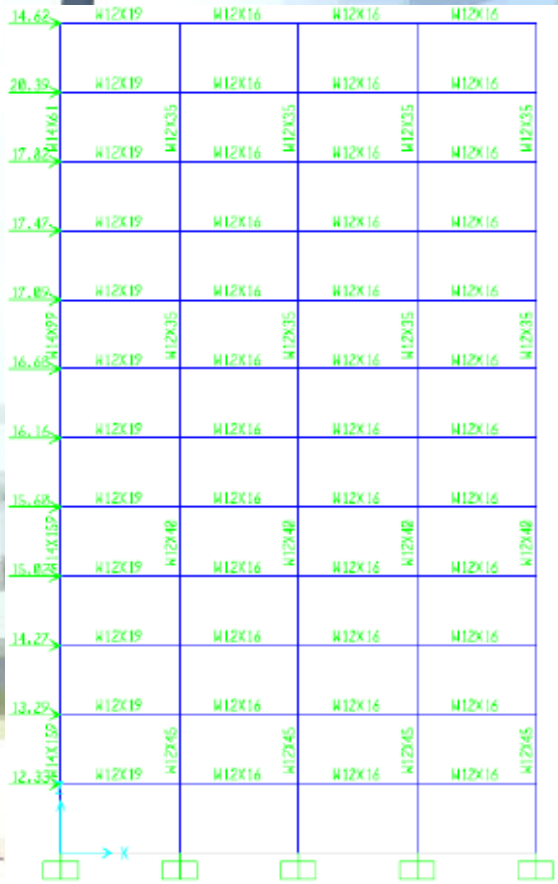
In the E-W direction moment frames were used because braced frames would interfere with office areas



Frame 3



Frame 4



Frame 5

Only 2 of 3 bays in frames 3 and 4 were used as moment frames

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- Alternative
  - Lateral System
- Comparison

Drift

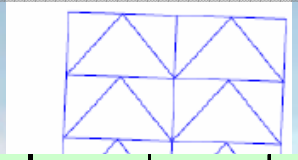
Drift was limited to H/400 total

Limited flexibility in glass façade

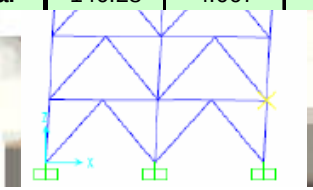
Plaster veneer ceiling

Frames 3 and 4 essentially identical

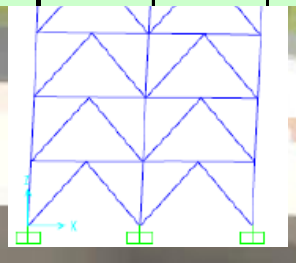
All frames < H/300 inter-story

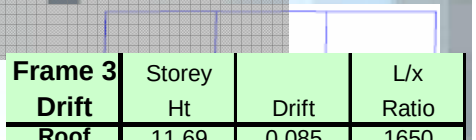


Frame 1 Drift	Storey Ht	Drift	L/x Ratio
Roof	11.69	0.251	559
12	11.69	0.280	501
11	11.69	0.310	453
10	11.69	0.334	420
9	11.69	0.351	400
8	11.69	0.361	389
7	11.69	0.374	375
6	11.69	0.380	369
5	11.69	0.380	369
4	11.69	0.372	377
3	11.69	0.352	399
2	11.69	0.322	435
Total	140.28	4.067	414

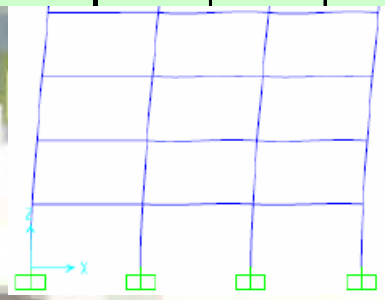


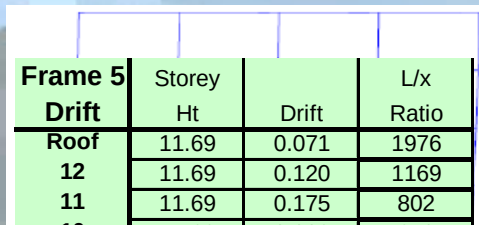
Frame 2 Drift	Storey Ht	Drift	L/x Ratio
Roof	11.69	0.187	750
12	11.69	0.213	659
11	11.69	0.241	582
10	11.69	0.262	535
9	11.69	0.280	501
8	11.69	0.291	482
7	11.69	0.305	460
6	11.69	0.313	448
5	11.69	0.318	441
4	11.69	0.316	444
3	11.69	0.306	458
2	11.69	0.287	489
Total	140.28	3.319	507



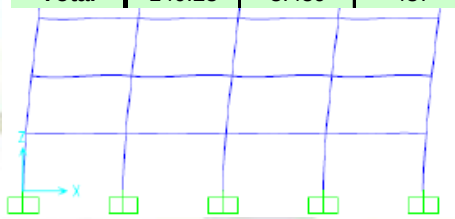


Frame 3 Drift	Storey Ht	Drift	L/x Ratio
Roof	11.69	0.085	1650
12	11.69	0.132	1063
11	11.69	0.189	742
10	11.69	0.238	589
9	11.69	0.282	497
8	11.69	0.326	430
7	11.69	0.352	399
6	11.69	0.369	380
5	11.69	0.364	385
4	11.69	0.323	434
3	11.69	0.260	540
2	11.69	0.122	1153
Total	140.28	3.042	553





Frame 5 Drift	Storey Ht	Drift	L/x Ratio
Roof	11.69	0.071	1976
12	11.69	0.120	1169
11	11.69	0.175	802
10	11.69	0.229	613
9	11.69	0.281	499
8	11.69	0.333	421
7	11.69	0.376	373
6	11.69	0.414	339
5	11.69	0.442	317
4	11.69	0.439	320
3	11.69	0.384	365
2	11.69	0.195	720
Total	140.28	3.459	487



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Comparison
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- Comparison
  - Cost
  - Other Considerations

Cost

Cost ended up being very similar to the cost of the equivalent portion of the original structure

Estimate	Existing Concrete Structure		Alternate Steel Structure	
	Item	Cost	Item	Cost
	Crane	$351,120.00	Crane	$351,120.00
	Formwork	$2,811,062.25	Steel	$4,968,106.38
	Concrete	$2,010,426.00	Decking	$660,096.00
	Reinforcing	$1,438,959.00	Shear Studs	$54,180.00
	Post-tensioning	$1,378,769.00	WWF	$126,835.20
			Concrete	$571,369.20
			Fireproofing	$425,088.00
			Connections	$880,354.00
Total		**$7,990,336.25**		**$8,037,148.78**

Too close to call…

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- Comparison
  - Other Considerations
  - Conclusion

Other Considerations

Steel construction resulted in a shorter schedule with a few assumptions

Schedule	Existing Concrete Structure		Alternate Steel Structure	
	Assumption	Duration	Assumption	Duration
	Without curing or reshoring	188 days	2 deck/concrete crews, 8 wk lead	270 days
	With removal of reshoring	265 days	3 deck/concrete crews, 8 wk lead	224 days
			3 deck/concrete crews, 6 wk lead	218 days

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Other Considerations

LEED rating can be maintained when switching the structure to composite steel

- Comparison
  - Other Considerations
  - Conclusion

LEED™ Scorecard

Y	?	N			
40	3	26	**Total Project Score**	Possible Points	69

Certified 26 to 32 points Silver 33 to 38 points Gold 39 to 51 points Platinum 52 or more points

Y	?	N	Sustainable Sites	Possible Points	14
12	0	2			
Y			Erosion & Sedimentation Control		0
1			Site Selection		1
1			Development Density & Community Connectivity		1
1			Brownfield Redevelopment		1
1			Alternative Transportation, Public Transportation Access		1
1			Alternative Transportation, Bicycle Storage & Changing Rooms		1
1			Alternative Transportation, Alternative Fuel Refueling Stations		1
1			Alternative Transportation, Parking Capacity		1
		1	Reduced Site Disturbance, Protect or Restore Open Space		1
		1	Reduced Site Disturbance, Development Footprint		1
1			Stormwater Management, Rate and Quantity		1
1			Stormwater Management, Treatment		1
1			Landscape & Exterior Design to Reduce Heat Islands, Non-Roof		1
1			Landscape & Exterior Design to Reduce Heat Islands, Roof		1
1			Light Pollution Reduction		1

Y	?	N	Materials & Resources	Possible Points	13
5	0	8			
Y			Storage & Collection of Recyclables		0
		1	Building Reuse, Maintain 75% of Existing Shell		1
		1	Building Reuse, Maintain 100% of Existing Shell		1
		1	Building Reuse, Maintain 100% Shell & 50% Non-Shell		1
1			Construction Waste Management, Divert 50%		1
		1	Construction Waste Management, Divert 75%		1
		1	Resource Reuse, Specify 5%		1
		1	Resource Reuse, Specify 10%		1
1			Recycled Content, Specify 25%		1
1			Recycled Content, Specify 50%		1
1			Local/Regional Materials, 20% Manufactured Locally		1
1			Local/Regional Materials, of 20% Above, 50% Harvested Locally		1
		1	Rapidly Renewable Materials		1
		1	Certified Wood		1

Y	?	N	Water Efficiency	Possible Points	5
5	0	0			
1			Water Efficient Landscaping, Reduce by 50%		1
1			Water Efficient Landscaping, No Potable Use or No Irrigation		1
1			Innovative Wastewater Technologies		1
1			Water Use Reduction, 20% Reduction		1
1			Water Use Reduction, 30% Reduction		1

Y	?	N	Energy & Atmosphere	Possible Points	17
6	1	10			
Y			Fundamental Building Systems Commissioning		0
Y			Minimum Energy Performance		0
Y			CFC Reduction in HVAC&R Equipment		0
2			Optimize Energy Performance, 20% New / 10% Existing		2
2			Optimize Energy Performance, 30% New / 20% Existing		2
		2	Optimize Energy Performance, 40% New / 30% Existing		2
		2	Optimize Energy Performance, 50% New / 40% Existing		2
		2	Optimize Energy Performance, 60% New / 50% Existing		2
		1	Renewable Energy, 5%		1
		1	Renewable Energy, 10%		1
		1	Renewable Energy, 20%		1
1			Additional Commissioning		1
		1	Ozone Depletion		1
1			Measurement & Verification		1
	1		Green Power		1

Y	?	N	Indoor Environmental Quality	Possible Points	15
9	0	6			
Y			Minimum IAQ Performance		0
Y			Environmental Tobacco Smoke (ETS) Control		0
1			Carbon Dioxide (CO_2) Monitoring		1
		1	Increase Ventilation Effectiveness		1
1			Construction IAQ Management Plan, During Construction		1
1			Construction IAQ Management Plan, Before Occupancy		1
1			Low-Emitting Materials, Adhesives & Sealants		1
1			Low-Emitting Materials, Paints		1
1			Low-Emitting Materials, Carpet		1
1			Low-Emitting Materials, Composite Wood		1
1			Indoor Chemical & Pollutant Source Control		1
		1	Controllability of Systems, Perimeter		1
		1	Controllability of Systems, Non-Perimeter		1
1			Thermal Comfort, Comply with ASHRAE 55-1992		1
		1	Thermal Comfort, Permanent Monitoring System		1
		1	Daylight & Views, Daylight 75% of Spaces		1
		1	Daylight & Views, Views for 90% of Spaces		1

Y	?	N	Innovation & Design Process	Possible Points	5
3	2	0			
	1		Innovation in Design: 41% water savings		1
1			Innovation in Design: Green housekeeping		1
	1		Innovation in Design: Exceed MR 3.1		1
1			Innovation in Design: SS 7.1 100% underground parking		1
1			LEED™ Accredited Professional		1

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- Comparison
  - Conclusion
- Acknowledgements

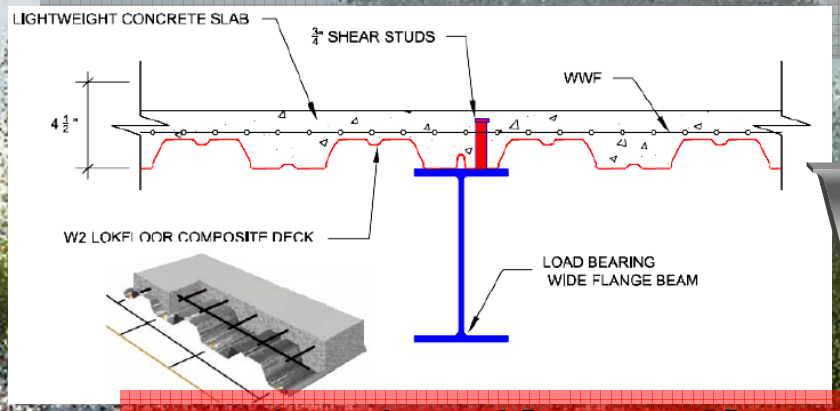
Conclusion

Cost comparison did not favor either system significantly

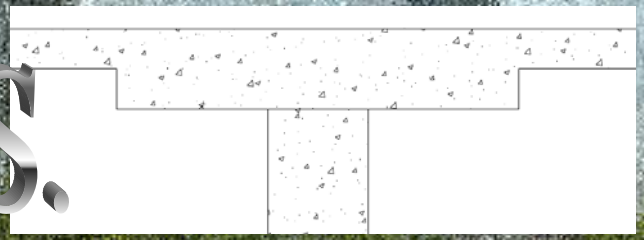
Steel construction had possible advantage in schedule

Neither structure prevents LEED rating

Post-tension concrete slab is thinner than composite steel system



VS.



Based primarily on floor thickness concerns, Choose original post-tensioned system as ideal building structural system

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Acknowledgements

I would like to thank the following:

Sean Cahill at Louis Dreyfus

Mike Deer at Truland Systems

Kevin Roche John Dinkeloo Associates

Centex Construction

All of the Penn State AE faculty that have taught me so much over the last 5 years

All of my AE friends and the thesis lab!

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