



Gateway Plaza Wilmington, DE

Elizabeth Hostutler
Structural Option

GATEWAY PLAZA

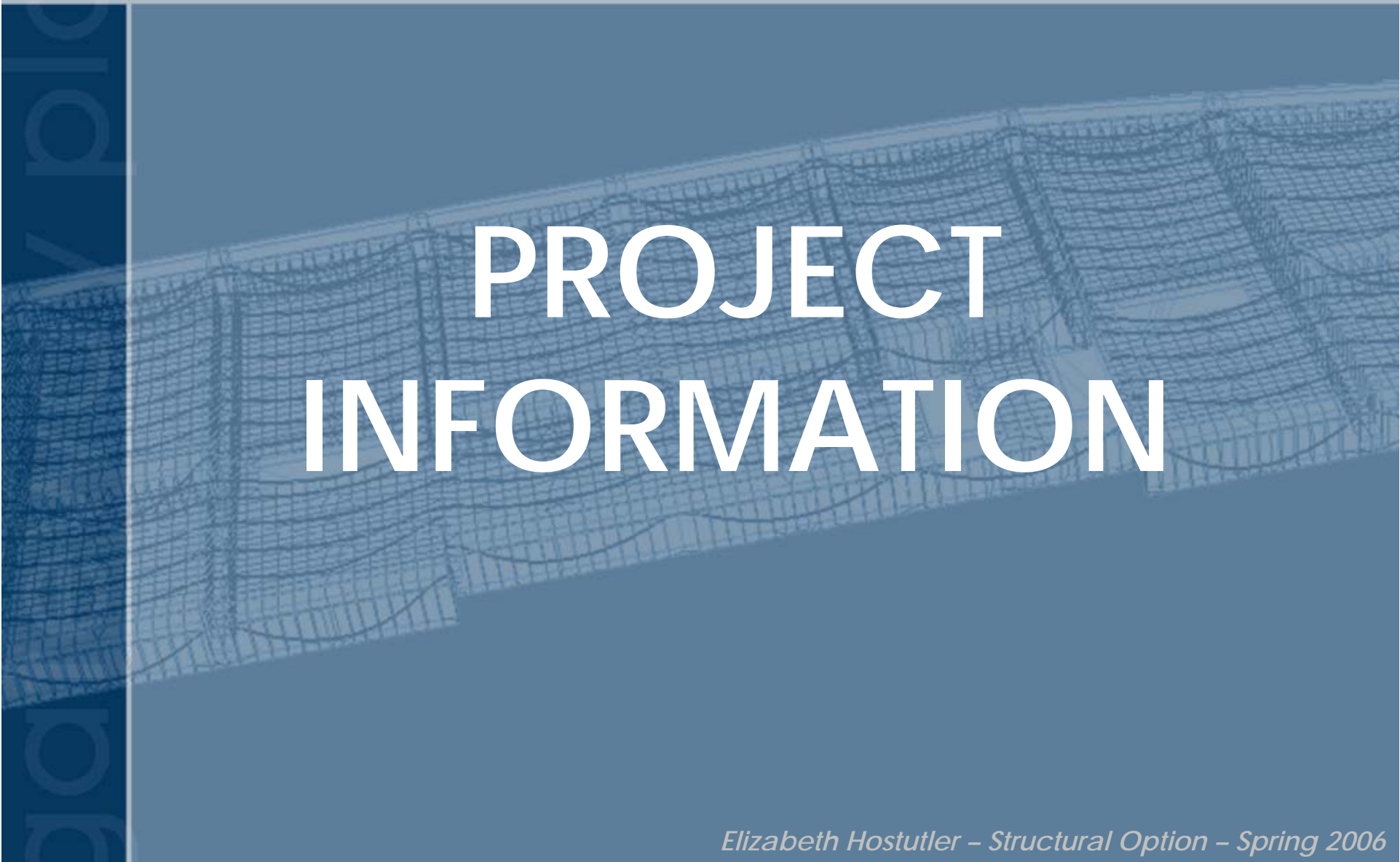
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Presentation Outline

- Project Overview
- Depth Study
- Breadth Studies
 - Mechanical: duct design
 - Construction Management: scheduling and cost estimates.
- Cost Analysis
- Conclusions



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PROJECT INFORMATION

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Project Information-Key Players

- Buccini/Pollin Group
- Gilbane
- Gensler
- Engineers
 - Landmark Engineering
 - Duffield Assoc., Inc.
 - BALA Consulting Engineers, Inc.
 - O'Donnell Naccarato & MacIntosh

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Project Information-Overview

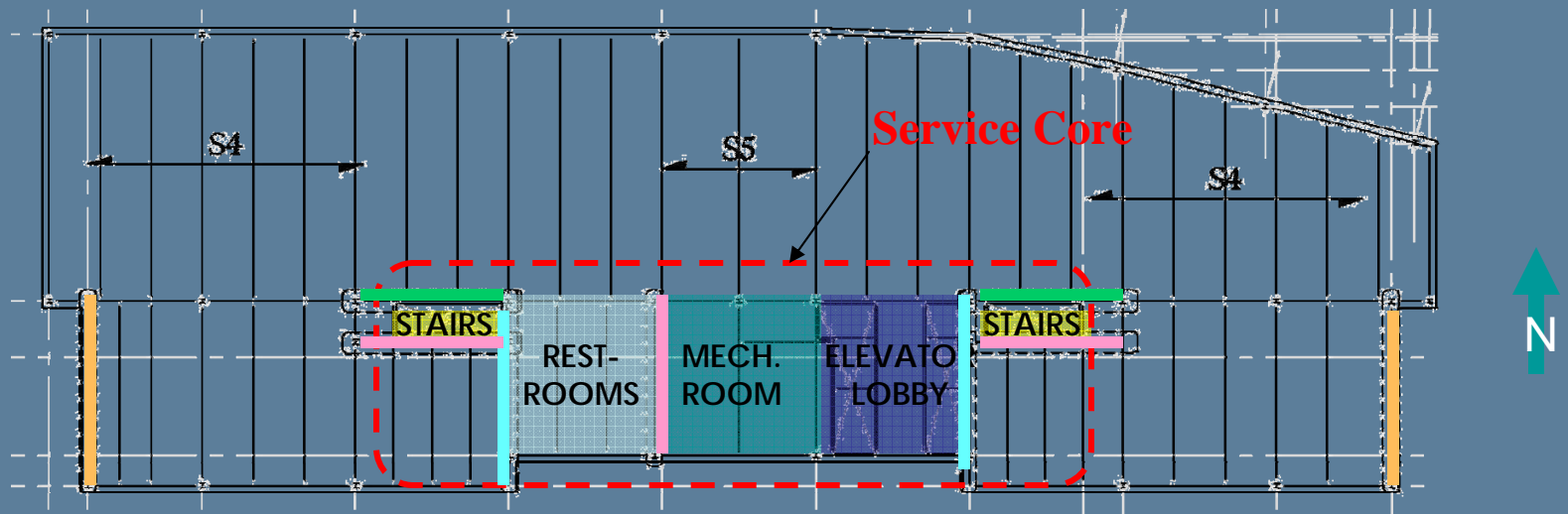
- Location: 500 Delaware Ave.
- 15 stories + mechanical penthouse (210'-6")
 - 1st level: retail space & lobby.
 - 14 floors office space for tenant fit-out.
- July 2005-December 2006
- \$52 million (17% structural system)
- 387,000 ft²
- 5-story parking garage in rear
- Tinted glass curtain wall façade



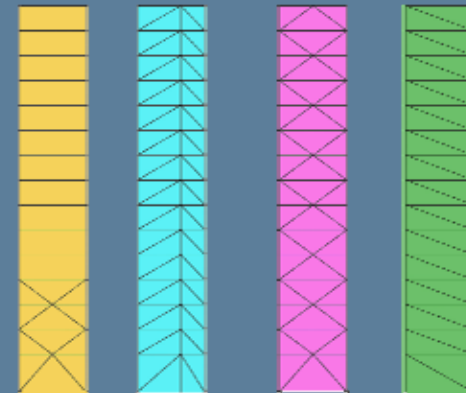
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Project Information: Existing Conditions



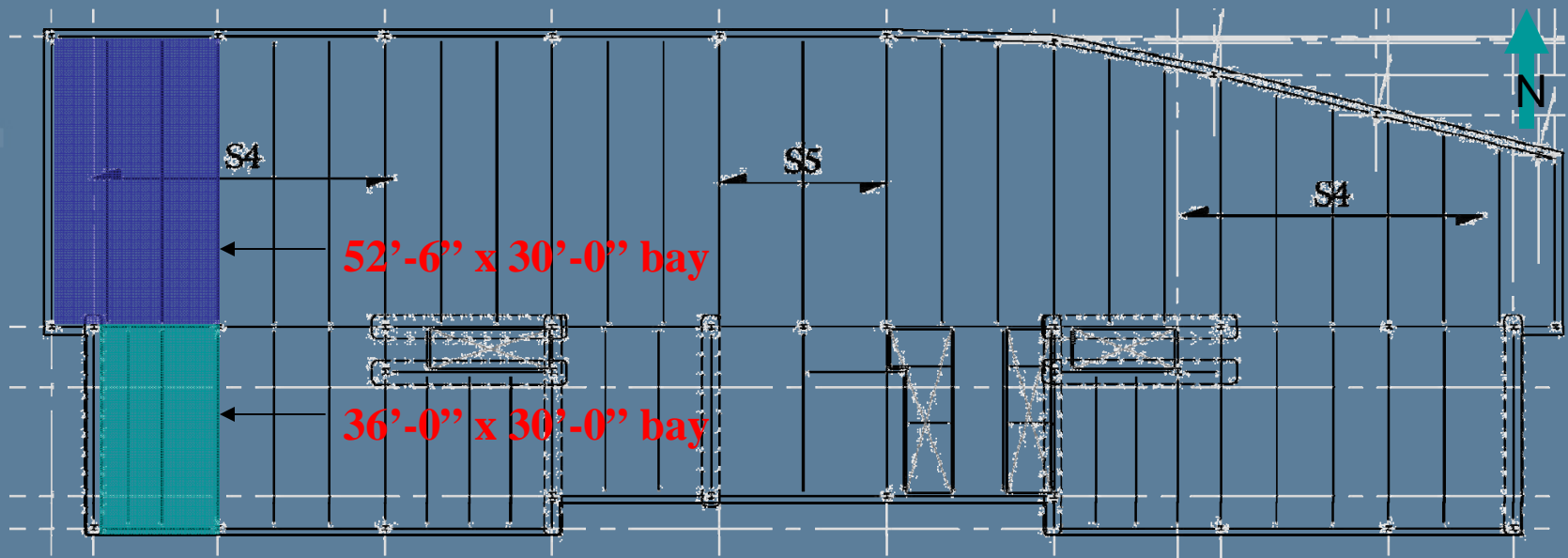
- Composite steel framing
- Concrete filled steel pile foundations with pile cap
- 6-1/4" slab on deck
- 30-1/4" floor depth.
- Concentrically braced frames.



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Project Information: Existing Conditions



52'-6"x30'-0" and 36'-0"x30'-0" typical bays.

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DEPTH STUDY

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Depth Study-Post-tensioned Concrete Floor

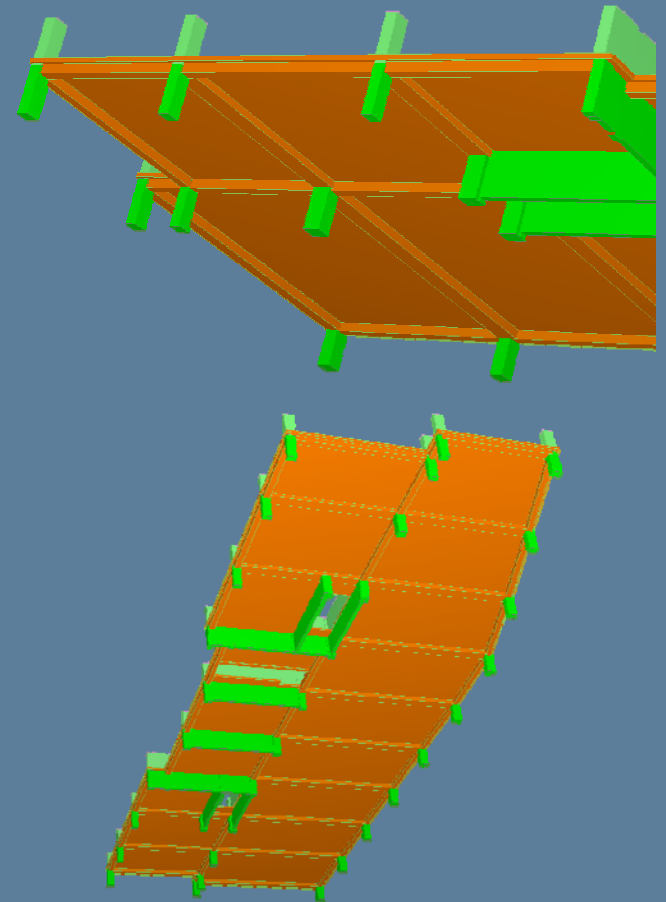
- Design Objectives:
 - Preserve long span bays.
 - Limit floor depth to 24”.
- Feasibility Factors:
 - Cost
 - Schedule
 - Impact on foundations

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Depth Study-Post-tensioned Concrete Floor

- Design: One-way post-tensioned concrete slab with post-tensioned beams framing along column lines.
- Criteria:
 - 6000 psi concrete
 - 8” thick slab
 - 52.5’ long beams: 24”x 36” beams

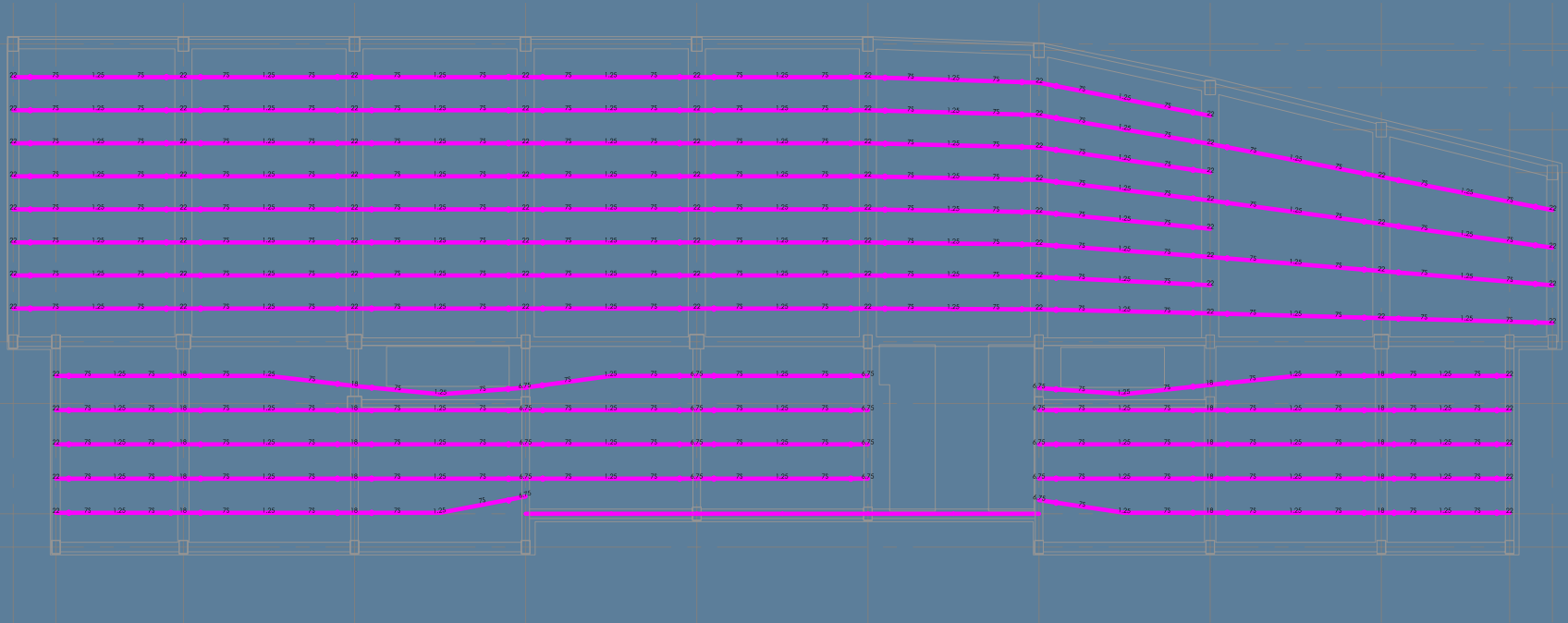


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Depth Study-Post-tensioned Concrete Floor

Tendon Layout

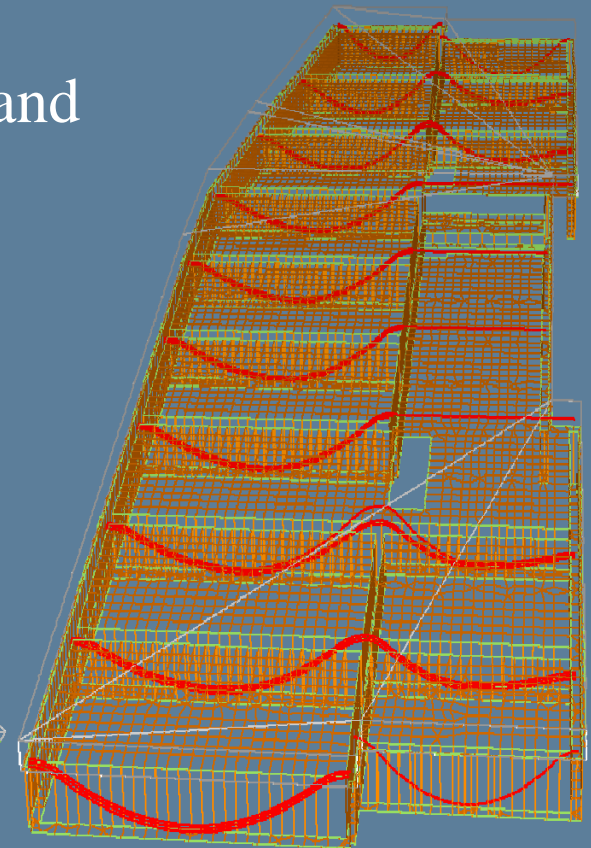
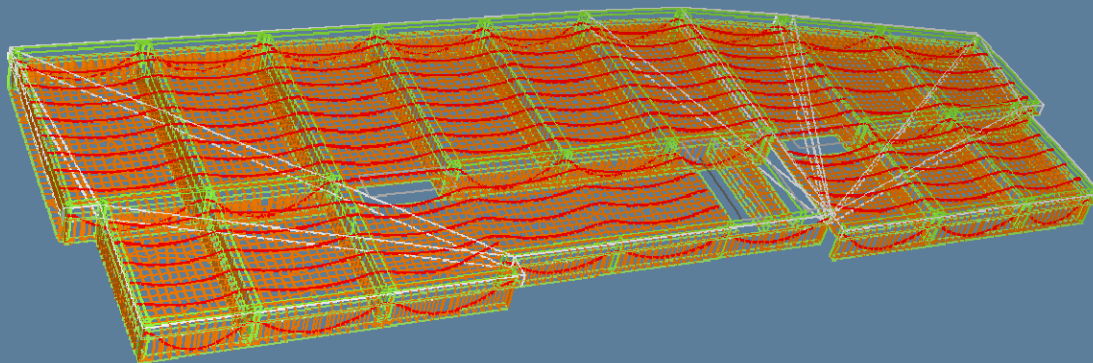


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Depth Study-Post-tensioned Concrete Floor

- Final Design:
 - Initial jacking force: 1303 k in slab and 1040 k in beams.
 - (6)-1/2" dia banded tendons in slab.
 - Tendons spaced 6' apart.
 - 39 tendons in longitude beams.
 - 20 tendons in latitude beams.

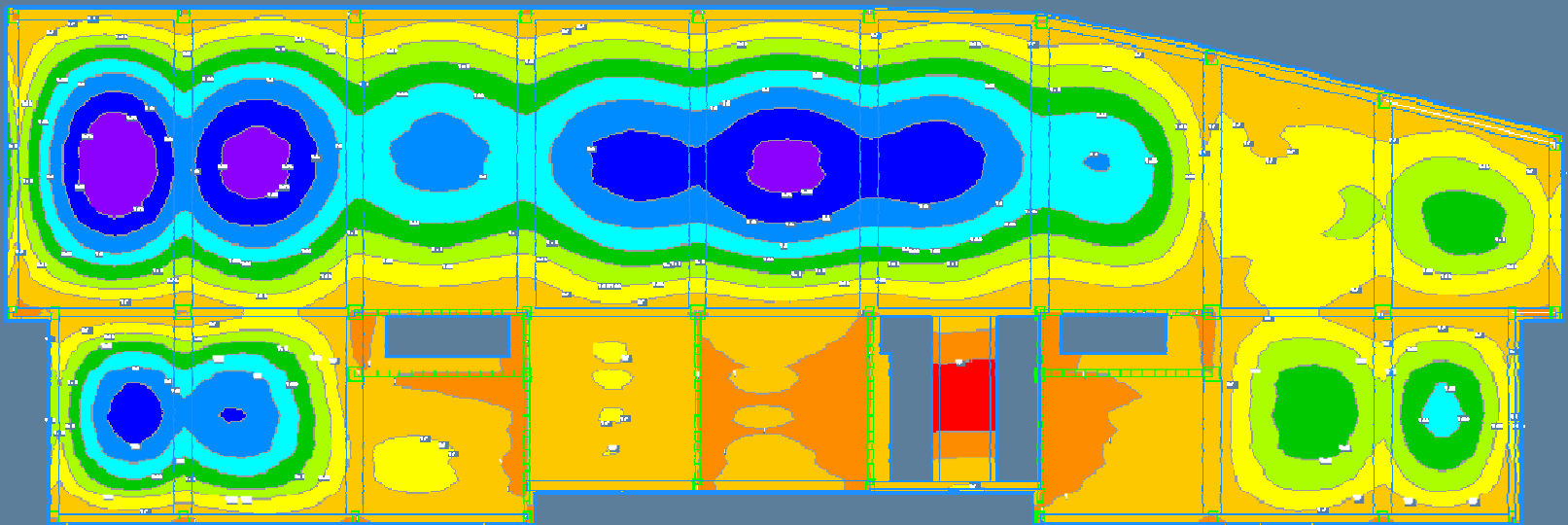


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Depth Study-Post-tensioned Concrete Floor

- Initial Service Loading



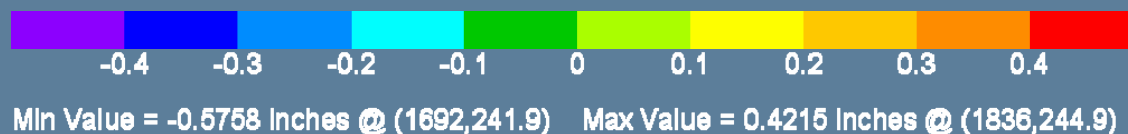
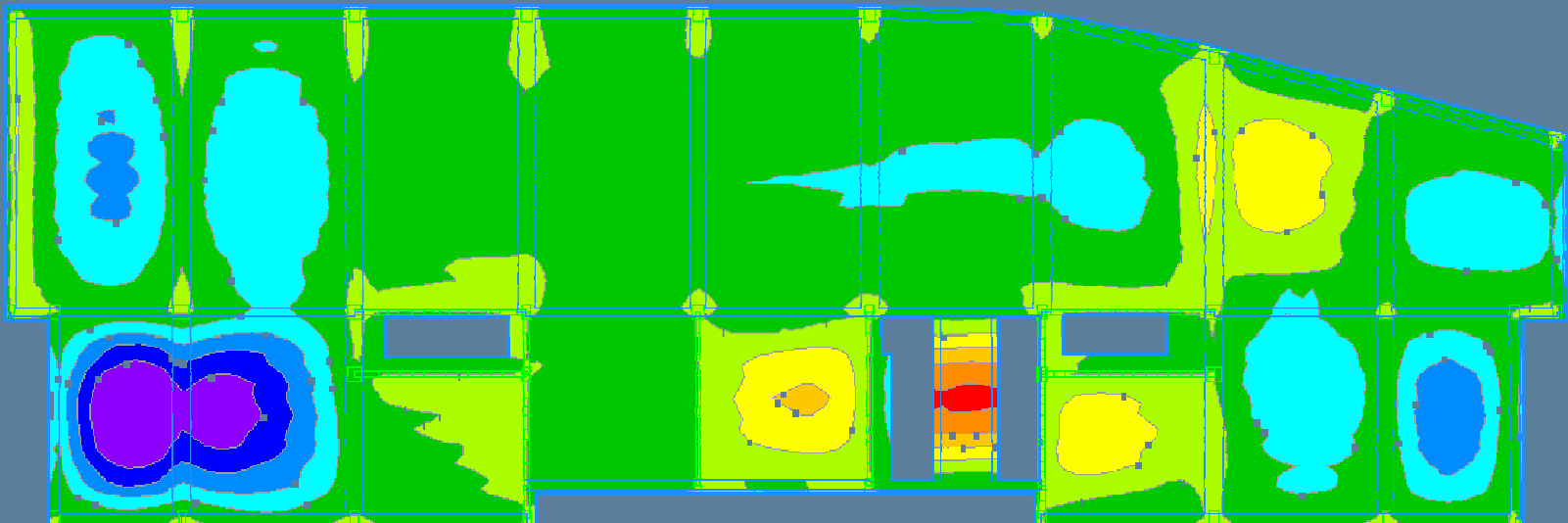
Min Value = -1.123 Inches @ (1687,284.2) Max Value = 0.2254 Inches @ (1842,244.8)

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Depth Study-Post-tensioned Concrete Floor

- Sustained Service Loading



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Depth Study-Lateral System

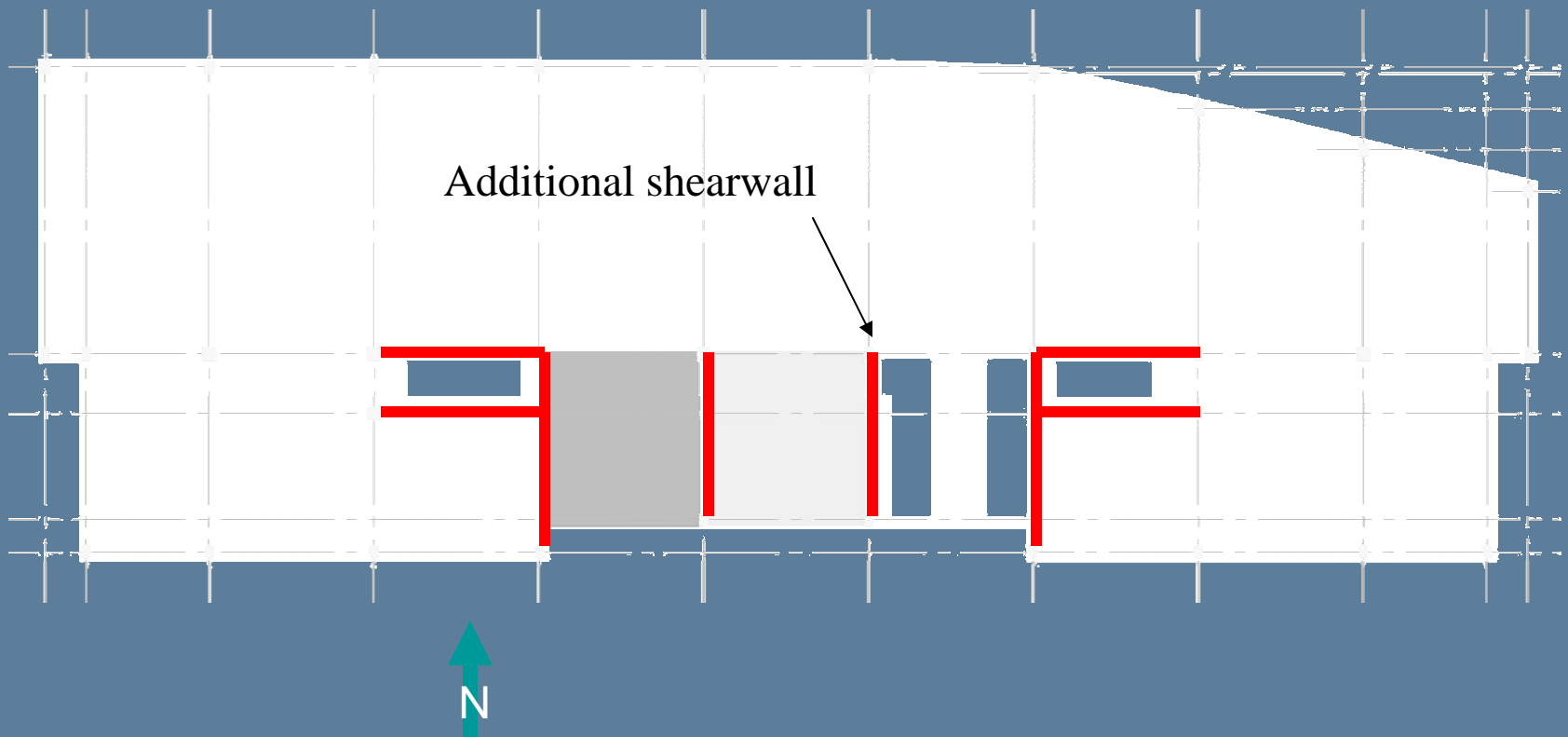
- Problems:
 - Increased weight impacted seismic.
 - Eccentricity created torsion.
 - Limiting drift to $H/600 = 4.21''$
- Solutions:
 - Added 1 shearwall between mechanical room and elevator lobby.
 - Considered concrete frames to resist lateral load.
 - Maximum drift was $3''$ ($H/840$).

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Depth Study-Lateral System

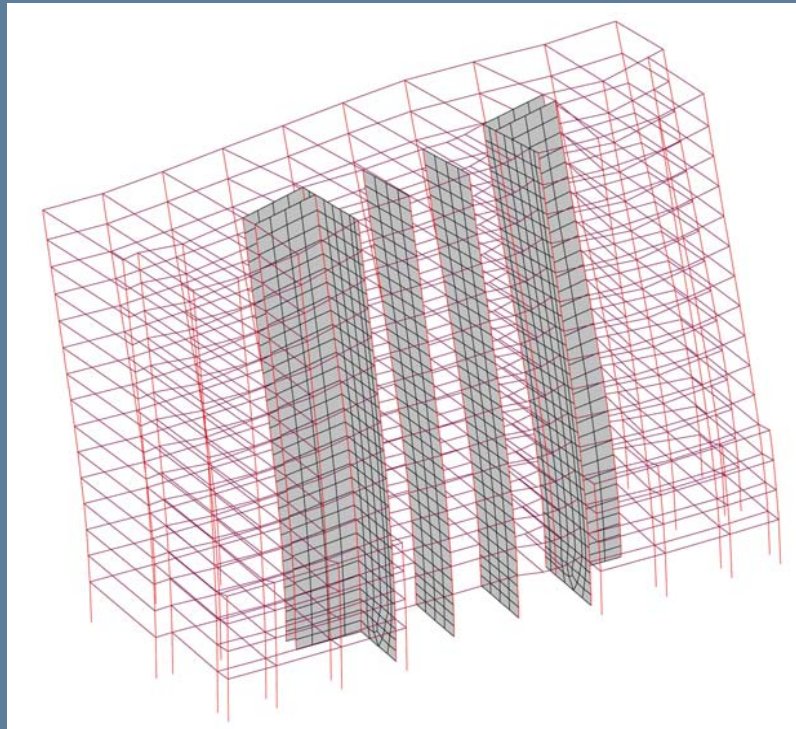
- Shearwalls: 12" thick 4000 psi with #6 @ 14" o.c.



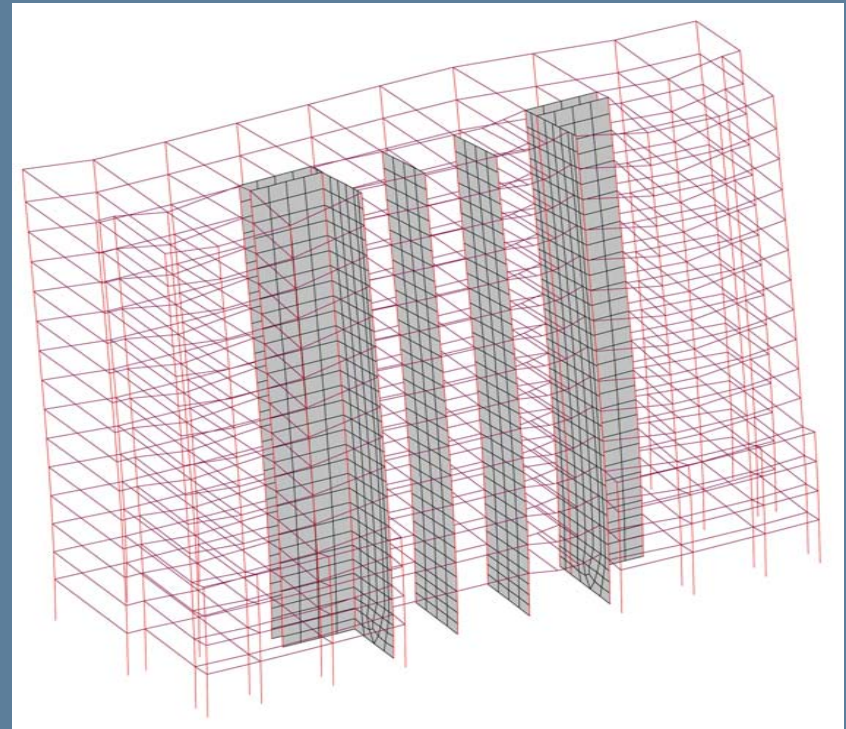
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Depth Study-Lateral System



Seismic Loads in east-west direction:
 $0.9D + 1.0 E$



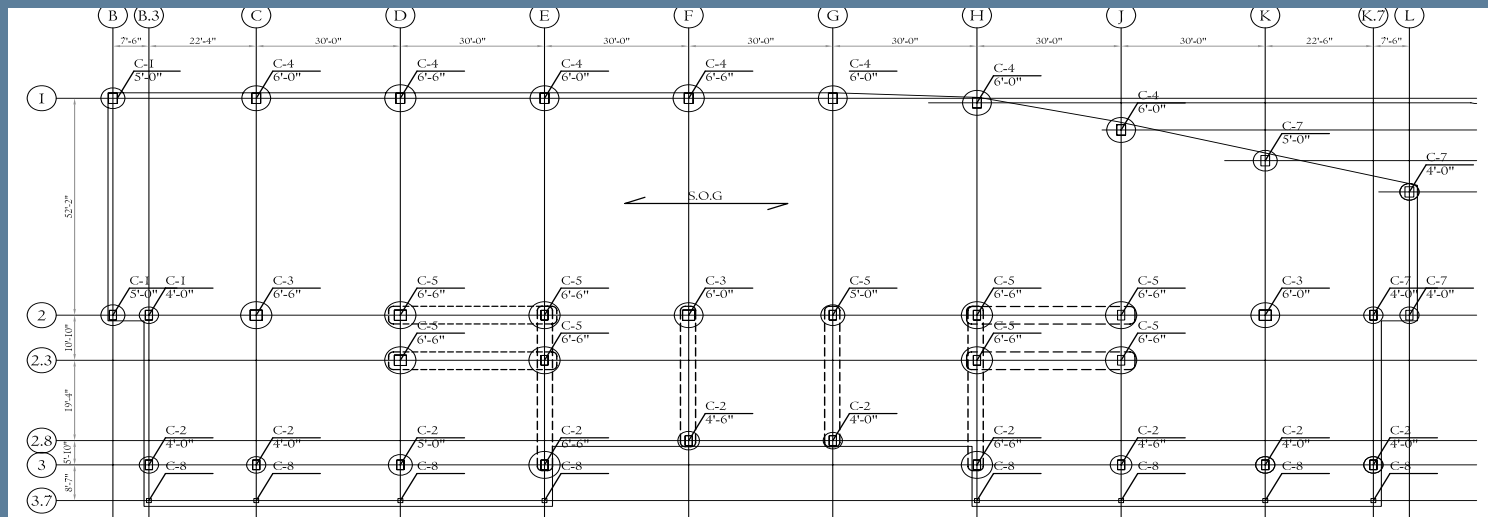
Wind Loads in north-south direction:
 $1.2D + 1.6W + L + 0.5 L_r$

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Depth Study-Impact on Foundation

- Increase foundation loads by an average 38%.
- Change foundations to end-bearing caissons.
 - Minimum size: 3.5' diameter
 - Maximum Size: 6.5' diameter

Location	Concrete	Steel
B 2	1107 k	307 k
1	1151 k	754 k
C 3.7	98 k	98 k
3	957 k	829 k
2	2434 k	1796 k
1	1597 k	1325 k
K 3.7	98 k	81 k
3	992 k	831 k
2	2069 k	1490 k
1.4	1203 k	943 k



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BREADTH STUDIES

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MECHANICAL STUDY

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Mechanical Study

- Check for proper indoor air quality.
- Design ductwork.

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Mechanical Study

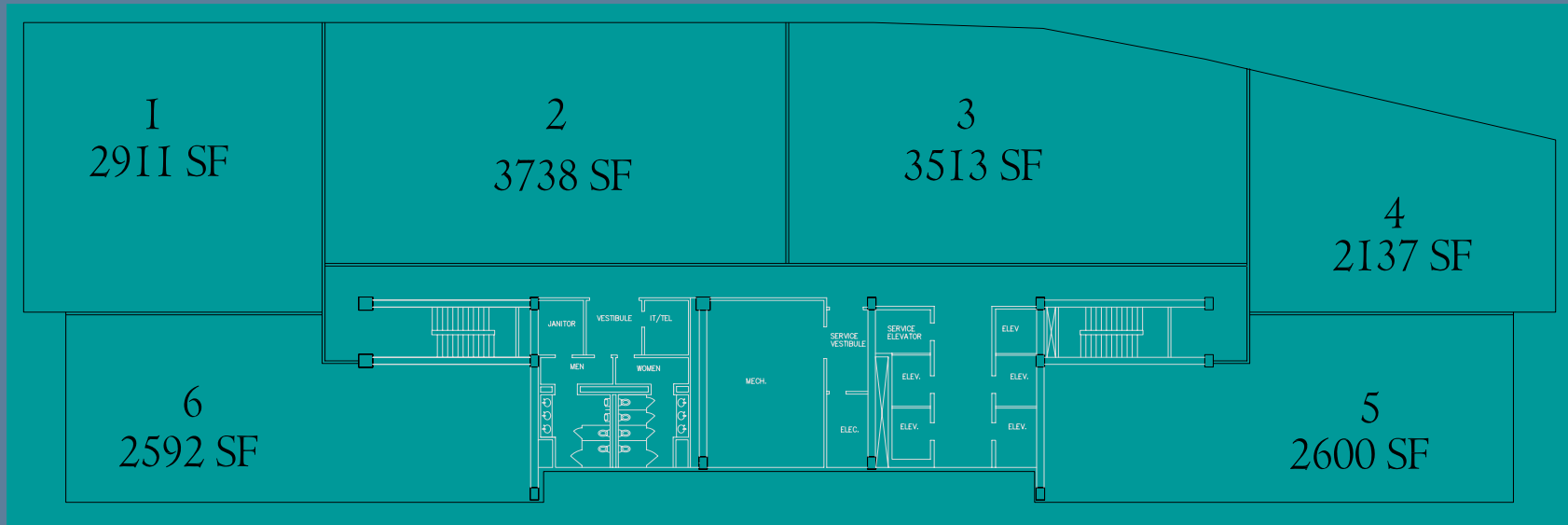
- Existing system:
 - Rooftop cooling tower.
 - Heat pump and air conditioning unit in each mechanical room.
 - 26”x96” main supply duct on each floor.
- 24”x24” supply and return diffusers.
- Ceiling plenum return.

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Mechanical Study

Typical open office floor plan for 6 tenants.

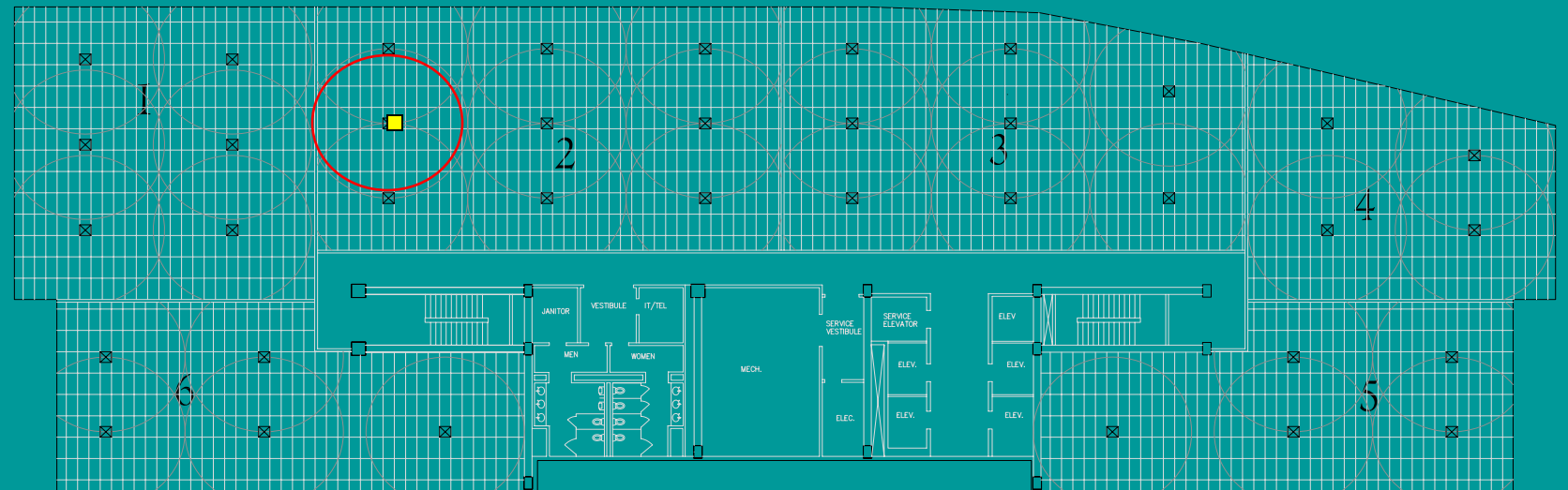


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Mechanical Study

- Supply diffuser layout with 16' air throws.
- 650 cfm per diffuser.

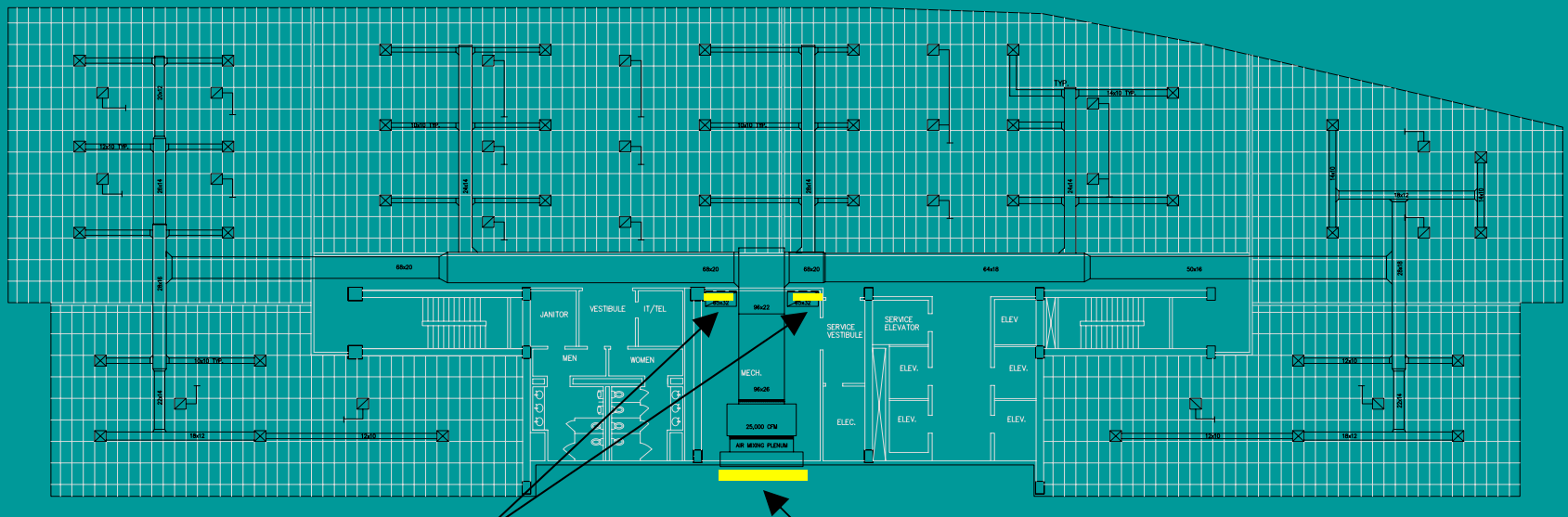


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Mechanical Study

- Supply ducts with return stub ducts.
 - Largest: 68"x20"
 - Smallest: 10"x10"



Return grill

Exhaust Louver

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CONSTRUCTION MANAGEMENT STUDY

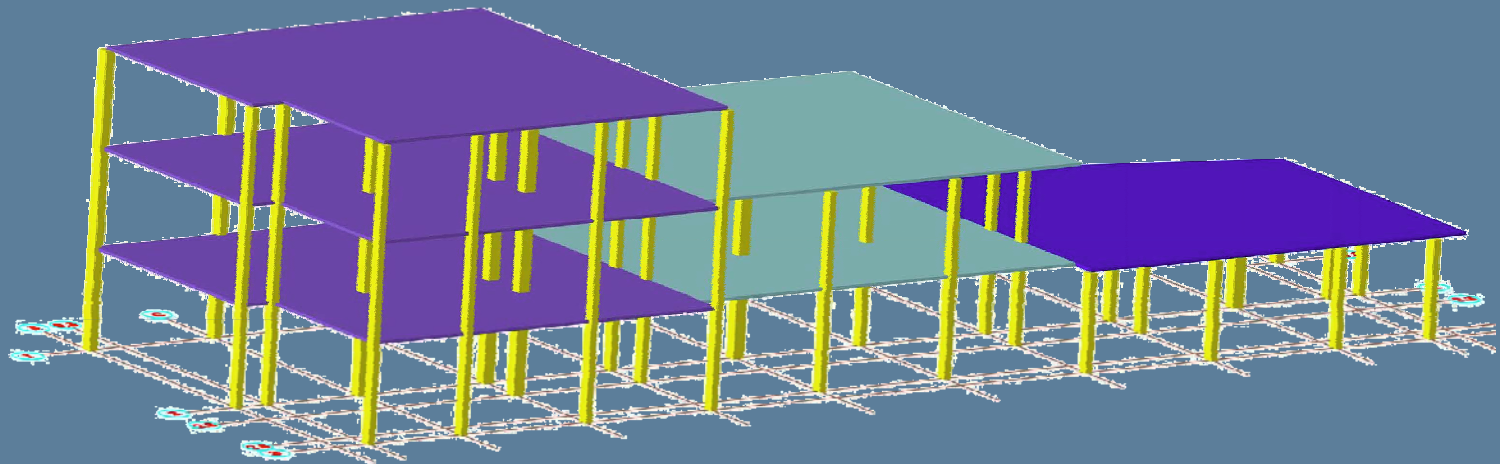
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Construction Management Study

- Schedule Comparison
- Cost Comparison
- Rough estimate of foundation costs and comparison.

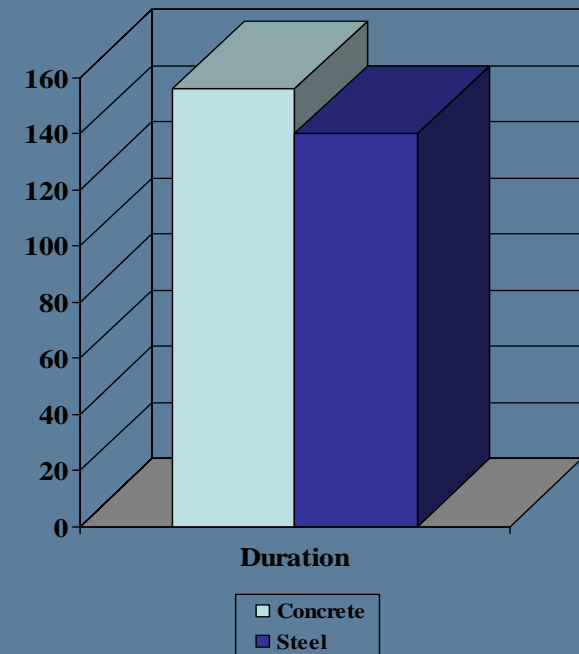


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Construction Management Study-Scheduling

- Duration: 156 days
 - Columns (F/R/P): 2 days
 - Forming
 - Tying Reinforcement
 - Pouring and curing
 - Construct/Erect shoring and formwork: 3 days
 - Tie reinforcement for slab and beams: 1 day
 - Rough-in for MEP: 1 day
 - Concrete (for each section):
 - Pour and finish: 1 day
 - Cure: 2 days
 - Strip formwork & reshore: 2 days
 - Jack the post-tensioning tendons: 1 day



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Construction Management Study-Estimates

Estimate of Post-tensioned Concrete Design for One Typical Floor						
Slabs System		Amount	Material	Labor	Equipment	Cost
03110-405	Beam formwork	7044 SFCA	0.91	4.05		\$63,466
03110-420	slab edge forms	479 SFCA	0.48	4.6		\$2,432
	slab formwork	21910 sf	1.3	2.86		\$216,471
03210-600	Slab Reinforcing	46.18 tons	800	380		\$72,041
032230-600	UngROUTed Post-tensioned strand	26350 lb	0.47	0.87	0.02	\$58,761
03300-220	6000 psi Concrete	687 CY	109			\$74,883
03310-700	Placing	687 CY	11.5	4.7		\$11,129
	Total					\$499,183
Columns						
03310-240	24"x24" average reinforcing including 4 use forms, concrete, placement, reinforcing	72 CY	370	400	41	\$58,392
	Total					\$58,392
Shearwalls						
B2010-101	12" thick, plain finish, 4000 psi wall including 4 use forms, reinforcing, concrete, placement	3402 sf	6.6	15.35	21.95	\$97,127
	Total					\$97,127
					Total Cost/sf	\$654,702
						\$28

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Construction Management Study-Estimates

Estimate of Composite Steel Design for One Typical Floor						
Slabs System		Amount	Material	Labor	Equipment	Total Cost
05310-300	20 ga. 3-1/4" Metal Deck	23403 SF	1.88	0.34	0.02	\$60,380
03210-200	6x6 W1.4xW1.4	234 CSF	19.35	17.35		\$12,649
03300-220	6000 psi concrete	253 CY	81			\$20,478
03310-700	Placing concrete	253 CY		13.1	5.35	\$4,664
05120-260	Curb Edging	718 LF	14	4.95	0.33	\$17,397
	Total					\$98,171
Structural Steel						
05120-680	Offices over 15-stories	107 TON	1900	345	109	\$251,878
05090-840	3/4" dia Shear Studs	27352	0.49	0.67	0.28	\$57,713
	Total					\$309,591
Frames						
05120-680	Columns, Beams, and Braces	50 TON	1900	345	109	\$117,700
Fireproofing						
07800-600	Decking	22000 SF	0.62	0.54	0.09	\$51,260
	Beams	17295 SF	0.41	0.45	0.07	\$31,650
	Columns	3506 SF	0.47	0.62	0.1	\$8,521
	Total					\$91,430
TOTAL						\$616,892
Cost/sf						\$26

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Construction Management Study-Estimates

Caissons						
		Amount	Material	Labor	Equipment	Cost
A1020-310	4'-0" dia. x 100'	20 Ea	4358	70459		\$1,496,329
	5'-0" dia. x 100'	6 Ea	8064	144990		\$918,324
	6'-0" dia. x 100'	10 Ea	11730	172277		\$1,840,069
					TOTAL	\$4,254,722
Concrete Filled, Drilled Piers						
		Amount	Material	Labor	Equipment	Cost
A1020-130	End Bearing Steel Piles					
2380	4 pile cluster	5	5625	3325		\$44,750
2460	6 pile cluster	8	8425	5025		\$107,600
2480	7 pile cluster	7	9825	5850		\$109,725
2500	8 pile cluster	5	12600	7525		\$100,625
2560	12 pile cluster	9	15400	9200		\$221,400
03310-240	Pile caps, incl. forms and reinf.	612	108	49	0.31	\$96,309
					TOTAL	\$680,409

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Construction Management Study

System Comparison					
	Total Cost	Cost/Floor	Cost/sf	Duration	Foundations
Concrete	\$ 10,475,227	\$ 654,702	\$27.98	156	\$4,254,722
Steel	\$ 9,870,274	\$ 616,892	\$ 26.36	140	\$680,409

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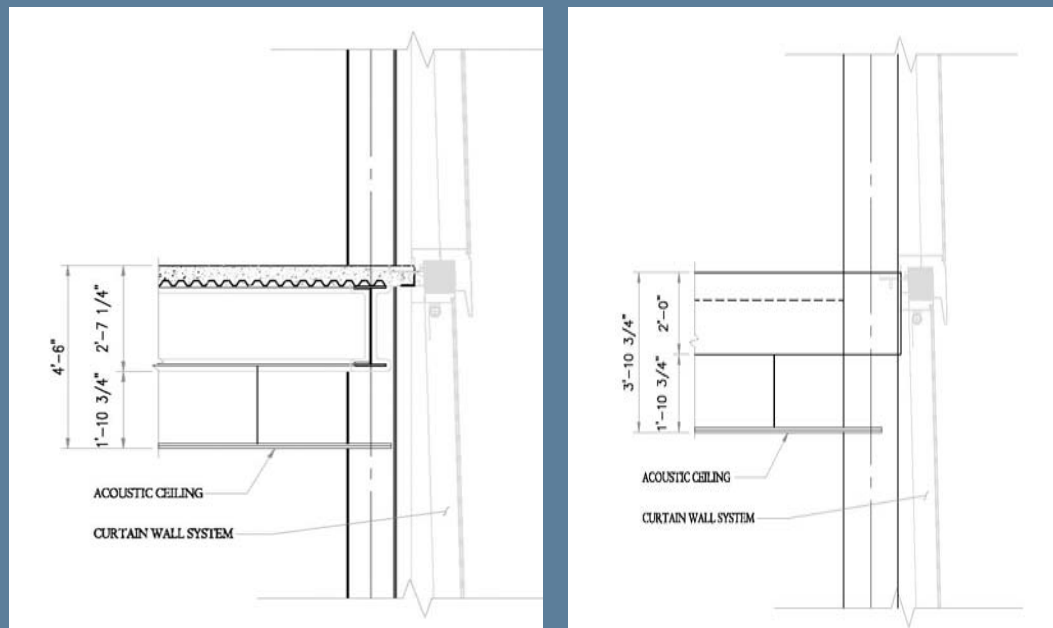
CONCLUSIONS

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Conclusions

- Post-tensioned system is viable based on cost and schedule, not on foundations.
- Achieved savings of 6.25”/floor=100” total.



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Acknowledgements

O'Donnell Naccarato & MacIntosh
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QUESTIONS?