

Point Pleasant Apartments ***Point Pleasant, NJ***

Ryan P. Flynn
Structural Option

AE Senior Thesis – Spring 2008

Location, New Jersey Shore



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Structural Option

Point Pleasant Apts.

Site Layout



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Building Information

- **Height**
 - 4 Stories Over 1 Story Parking Garage
 - 65 ft. Above Grade
- **Square Footage**
 - 64,000 sq. ft. Total
 - (4) 2,500 sq. ft. apts. per floor
- **Occupancy**
 - Residential
- **Construction**
 - Aug. 2006 – Fall 2007



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Project Goals: Structural Depth

- **Structural Redesign**

- Design Wood Structural System to Meet Gravity Load, Vibration, and Deflection Criteria
- Recalculate Lateral Loads and Design Shear Walls
- Check Effects on Foundation
- Design More Efficient First Floor
- Maintain Architectural Integrity

Project Goals: Breadth Topics

- **Construction Management**

- Save Money
- Reduce Construction Time

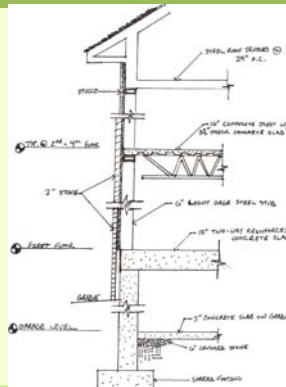
- **Acoustics Considerations**

- Maintain Adequate Sound Barrier from Floor to Floor and Between Common Walls
- Minimize Additional Cost for Sound Barrier

Existing Structural System

- **Roof**
 - Metal Roof Trusses @ 48" o.c.
- **Floors 2-4**
 - Open-Web Steel Joists @ 48" o.c.
 - 1 5/16" Metal Form Deck
 - 3.5" Total Depth Concrete
- **1st Floor**
 - 12" Thick Two-Way Slab w/ Drop Panels
- **Foundation**
 - 12" Thick Reinforced Concrete Foundation Walls
 - 2'-6" or 3'-0" x 12" Deep Spread Footings
 - 5" Slab On Grade

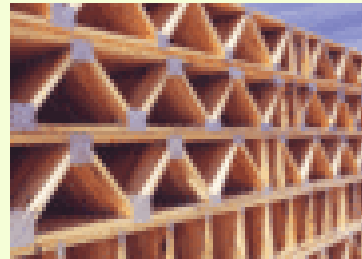
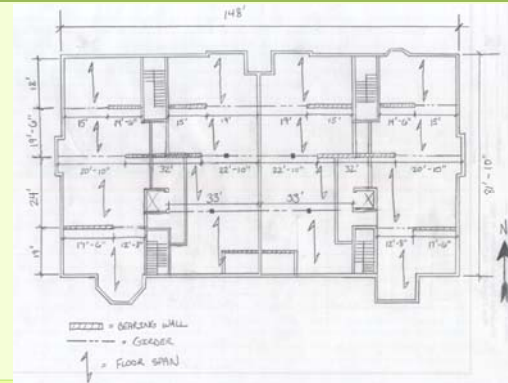
Typical Wall Section



Typical Floor Plan (Floors 2-4)

Proposed Wood Truss Floor System

- Wood Floor Trusses by ALPINE



4x2 Lumber

Center Spacing	Deflection Limit	Truss Depth				
		12"	14"	16"	18"	20"
40 PSF Live Load 55 PSF Total Load						
16" o.c.	L/900	22"	24 1/2"	26 1/2"	28"	29 1/2"
	L/480	20"	22"	24 1/2"	27"	29 1/2"
18.2" o.c.	L/900	20"	22 1/2"	24 1/2"	27"	29"
	L/480	18 1/2"	21"	23"	25"	28"
24" o.c.	L/900	18"	20 1/2"	22 1/2"	24 1/2"	26"
	L/480	17 1/2"	19 1/2"	21 1/2"	23 1/2"	25"
60 PSF Live Load 75 PSF Total Load						
16" o.c.	L/900	18 1/2"	21 1/2"	23 1/2"	26"	27 1/2"
	L/480	17 1/2"	19 1/2"	21 1/2"	23 1/2"	25 1/2"
18.2" o.c.	L/900	17"	19 1/2"	21 1/2"	23 1/2"	26 1/2"
	L/480	16 1/2"	18 1/2"	20 1/2"	22 1/2"	24 1/2"
24" o.c.	L/900	15 1/2"	17 1/2"	19 1/2"	21 1/2"	23 1/2"
	L/480	15 1/4"	17 1/4"	19 1/4"	21 1/4"	23 1/4"
85 PSF Live Load 100 PSF Total Load						
16" o.c.	L/900	16 1/2"	18 1/2"	19 1/2"	21 1/2"	23 1/2"
	L/480	15 1/2"	17 1/2"	19 1/2"	21 1/2"	23 1/2"
18.2" o.c.	L/900	15 1/4"	16 1/2"	18 1/2"	20 1/2"	21 1/2"
	L/480	14 1/2"	16 1/4"	18 1/4"	20 1/4"	21 1/4"
24" o.c.	L/900	13 1/2"	14 1/2"	16 1/2"	17 1/2"	19 1/2"
	L/480	13 1/4"	14 1/4"	16 1/4"	17 1/4"	19 1/4"

Existing Building Loads

- Existing Gravity Loads

- Dead Loads

- Steel Joist, Metal Deck, Concrete Slab = 40 PSF

- Superimposed Dead Load

- Mechanical, Electrical, Plumbing = 5 PSF
- Ceiling Finishes = 3 PSF
- Floor Finishes = 5 PSF

- Live Loads

- Floors 2-4, Res. Units and Corridors = 40 PSF
- Partition Allowance = 20 PSF

• Total Dead Load = 53 PSF Total Live Load = 60 PSF

New Building Loads

- New Gravity Loads

- Dead Loads

- Self Weight of Floor Trusses (@ 16" o.c.) = 3 PSF
- Plywood Sheathing (3/4" Thick) = 3 PSF
- Gyp-Crete Topping (3/4" Thick) = 6.25 PSF

- Superimposed Dead Load

- Mechanical, Electrical, Plumbing = 5 PSF
- Ceiling Finishes = 3 PSF
- Floor Finishes = 5 PSF

- Live Loads

- Floors 2-4, Res. Units and Corridors = 40 PSF
- Partition Allowance = 20 PSF

• Total Dead Load = 26.25 PSF Total Live Load = 60 PSF

PSL Beam Designs

Built-Up Headers

Beam Design for Floors 2-4									
Beam	Length (ft)	Trib (ft)	Live Load (klf)	Total Load (klf)	Moment (ft-k)	I for L/480 (in ⁴)	I for TU/360 (in ⁴)	Design	End Reactions (k)
1	15.25	11	0.66	0.95	27.58	1,053.3	1,135.6	3 1/2" x 16" PSL	7.23
2	19	14	0.84	1.21	54.49	2,592.7	2,795.3	7" x 18" PSL	11.47
3	13.167	15.5	0.93	1.34	28.97	955.3	1,030.0	3 1/2" x 16" PSL	8.80
4	8	15.7	0.942	1.35	10.83	217.0	234.0	3 1/2" x 9 1/2" PSL	5.42
5	9	15.7	0.942	1.35	13.71	309.0	333.2	3 1/2" x 11 7/8" PSL	6.09
6	17.5	15.67	0.9402	1.35	51.74	2,267.5	2,444.6	5 1/4" x 18 PSL	11.83
7	9.25	19.9	1.194	1.72	18.36	425.2	458.5	3 1/2" x 11 7/8" PSL	7.94
8	13.5	19.9	1.194	1.72	39.10	1,322.0	1,425.2	3 1/2" x 18" PSL	11.59
9	9.5	15.6	0.936	1.35	15.18	361.1	389.3	3 1/2" x 11 7/8" PSL	6.39
10	9.5	15.6	0.936	1.35	15.18	361.1	389.3	3 1/2" x 11 7/8" PSL	6.39
11	13.75	9.25	0.555	0.80	18.85	649.3	700.0	3 1/2" x 14" PSL	5.48

Headers													
Floor 2-4		W 12x12		W 12x12		W 12x12		W 12x12		W 12x12		W 12x12	
Length (ft)	Trib (ft)	Live Load (klf)	Total Load (klf)	Moment (ft-k)	I for L/480 (in ⁴)	I for TU/360 (in ⁴)	Design	End Reaction	Design	End Reaction	Design	End Reaction	
9.5	9.25	0.56	0.84	740.5	675	1680.09	1132.84	408,236,812.50	531,977,743.65	265.99	3.79	ppx12	
9.5	9.33	0.56	0.84	740.5	675	1691.65	1142.68	431,962,672.50	536,578,632.25	268.29	3.82	ppx12	
6.5	25.7	0.46	0.79	740.5	675	653.34	441.69	113,794,182.50	141,291,691.70	70.65	2.15	ppx10	
9	5.675	0.34	0.51	740.5	675	918.68	671.81	227,431,750.00	275,862,236.33	137.53	2.18	ppx12	
3	18.67	0.54	0.89	740.5	675	195.61	138.89	15,596,800.00	19,324,537.85	9.56	1.28	ppx10	
3	12.89	0.73	1.19	740.5	675	239.38	148.31	17,627,200.00	21,896,312.34	10.95	1.56	ppx10	
3	19.88	1.34	2.09	740.5	675	346.21	234.85	37,838,640.00	34,555,968.88	17.28	2.47	ppx10	
9	9.25	0.56	0.84	740.5	675	1518.58	1071.22	384,135,540.00	452,324,566.41	226.16	3.59	ppx12	
9.5	6.25	0.38	0.56	740.5	675	1132.22	768.81	289,364,062.50	359,444,671.39	179.22	2.56	ppx12	
6.5	1.75	0.23	0.38	740.5	675	319.43	215.95	16,671,542.50	69,879,987.29	34.54	1.85	ppx10	
9	5.75	0.35	0.55	740.5	675	939.01	634.81	226,154,540.00	281,274,238.17	148.59	2.23	ppx10	
3	15	0.59	0.89	740.5	675	272.18	184.00	21,870,000.00	27,266,648.53	13.58	1.96	ppx10	
3	19	1.34	2.09	740.5	675	344.74	233.87	37,732,000.00	34,411,878.13	17.21	2.46	ppx10	
3	12	0.72	1.19	740.5	675	217.74	142.28	17,476,000.00	21,733,312.50	10.87	1.56	ppx10	
3	12	0.72	1.19	740.5	675	217.74	142.28	17,476,000.00	21,733,312.50	10.87	1.56	ppx10	
3	36.4	0.864	1.35	740.5	675	262.29	176.64	28,976,200.00	26,879,975.00	13.84	1.86	ppx10	
3	36.4	0.864	1.35	740.5	675	262.29	176.64	28,976,200.00	26,879,975.00	13.84	1.86	ppx10	
3	39.1	1.146	1.50	740.5	675	346.57	234.30	37,847,800.00	34,592,189.86	17.30	2.47	ppx10	
3	39.1	1.146	1.50	740.5	675	346.57	234.30	37,847,800.00	34,592,189.86	17.30	2.47	ppx10	
5	11	0.66	0.99	740.5	675	554.44	374.82	24,250,000.00	92,232,621.88	46.12	2.37	ppx10	
3	11.8	0.788	1.21	740.5	675	234.11	144.75	17,234,400.00	21,371,898.63	10.69	1.53	ppx10	
3	11.8	0.788	1.21	740.5	675	234.11	144.75	17,234,400.00	21,371,898.63	10.69	1.53	ppx10	
3	25.9	0.954	1.42	740.5	675	288.51	195.04	23,182,000.00	28,796,639.86	14.40	2.06	ppx10	
3	6.75	0.41	0.63	740.5	675	122.48	82.80	9,841,540.00	12,274,988.28	6.11	0.87	ppx10	
3		2.88	4.35	740.5	675	886.75	544.22	65,124,000.00	88,281,125.00	48.14	5.25	ppx10	
Headers													
Roof		W 12x12		W 12x12		W 12x12		W 12x12		W 12x12		W 12x12	
Length (ft)	Trib (ft)	Live Load (klf)	Total Load (klf)	Moment (ft-k)	I for L/480 (in ⁴)	I for TU/360 (in ⁴)	Design	End Reaction	Design	End Reaction	Design	End Reaction	
9.5	24	0.5	0.88	853.88	776.25	2067.44	1397.68	285,838,750.00	706,948,312.50	353.82	4.66	3 1/2" x 11 1/4" PSL	
9	28	0.42	0.84	853.88	776.25	1592.59	1049.62	275,560,000.00	581,916,500.00	254.96	3.69	ppx12	
9	12.375	0.26	0.25	853.88	776.25	962.64	652.81	178,586,000.00	312,467,625.00	156.23	2.30	ppx10	
9.5	16	0.336	0.32	853.88	776.25	1380.92	925.59	259,270,000.00	472,242,150.00	236.12	3.12	ppx12	
4	13.75	0.29	0.25	853.88	776.25	425.44	321.43	16,174,000.00	180,424,500.00	51.21	1.49	ppx10	
3	21.25	0.45	0.405	853.88	776.25	190.88	124.45	18,976,000.00	19,819,687.50	9.91	1.38	ppx10	

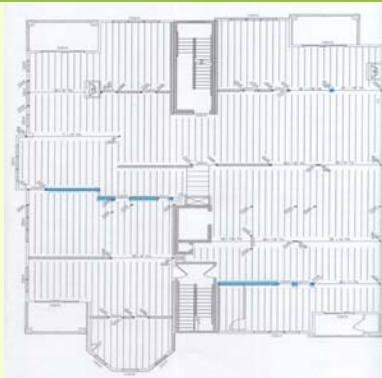
Bearing Walls and Posts

New Floor Layout for Floors 2-4

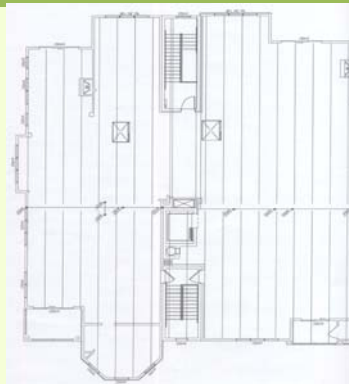
- **Bearing Walls**
 - 2x6 Spruce-Pine-Fir, Stud Grade
 - All Spaced at 16" o.c. Except for Several on First Floor
- **Posts**

Post Capacity	
Built Up Post Size	Load Range (k)
(2)2x6	3.3 - 6.5
(3)2x6	6.6 - 9.8
(4)2x6	9.9 - 13.1
(5)2x6	13.2 - 16.4

Post Capacity	
PSL Post Size	Load Range (k)
5 1/4" x 5 1/4"	Up to 26.655
5 1/4" x 7"	Up to 35.5



Loads Carried to First Floor, Roof Posts

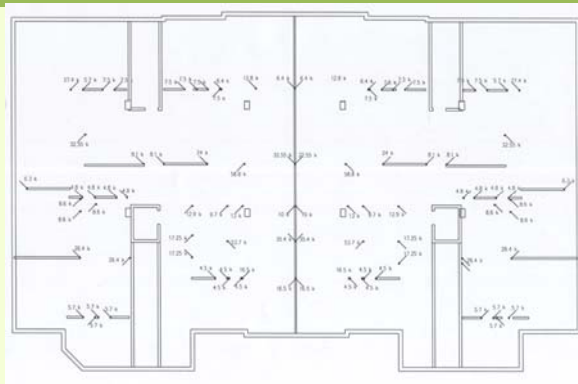


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Point Pleasant Apts.

Loads Carried to First Floor



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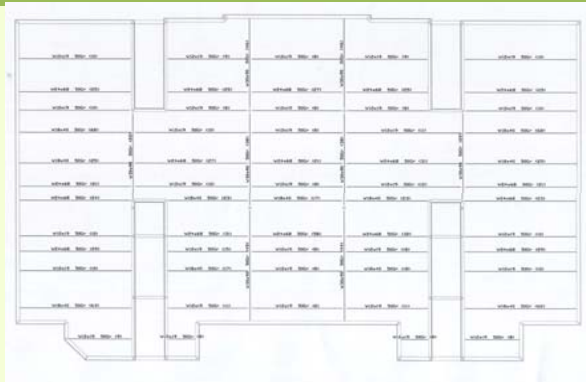
Structural Option

Point Pleasant Apts.

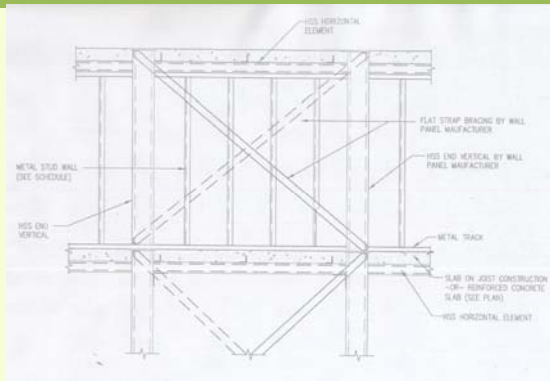
First Floor Redesign

RAM Model / First Floor Plan

- Composite Steel Beams and Girders
 - W12x19
 - W18x40
 - W24x68
 - W30x90
- Vulcraft 1.5VLR21 Metal Deck
- 4.5" Concrete Slab (Total Depth)



Existing Lateral System



Seismic Analysis

- **Building Weight**
 - Existing Structure = 5000 k
 - Proposed Structure = 2567 k
- **Controlling Base Shear**
 - Existing Structure = 148 k
 - Proposed Structure = 140 k

Wind Loads (E-W Direction)

Wind Loads (N-S Direction)

	Wind from E-W				
Level	Height (ft.)	Total PSF	Story Force (k)	Total Shear (k)	OT Moment (ft-k)
Parking	0	0.0	0.0	174.2	6058.0
1	11	30.6	31.7	174.2	349.2
2	21.33	32.0	33.1	142.4	706.4
3	32.67	33.8	34.7	109.3	1133.2
4	43.5	35.1	34.5	74.6	1499.6
Attic	53.5	36.1	28.5	40.1	1523.0
Roof	72.5	12.8	11.7	11.7	846.6

	Wind from N-S				
Level	Height (ft.)	Total PSF	Story Force (k)	Total Shear (k)	OT Moment (ft-k)
Parking	0	0.0	0.0	308.1	10541.6
1	11	34.0	57.6	308.1	634.0
2	21.33	35.4	59.8	250.5	1275.7
3	32.67	37.1	62.3	190.7	2036.5
4	43.5	38.4	61.7	128.3	2685.8
Attic	53.5	39.4	48.3	66.6	2584.3
Roof	72.5	12.6	18.3	18.3	1325.2

Shear Wall Design

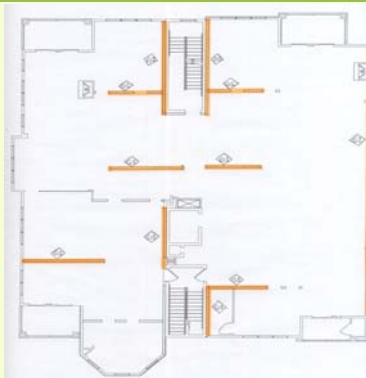
Typical Shear Wall Layout

- **Interior Shear Walls**

- 5/8" Gypsum Wallboard, Fastened w/ 6d Cooler Nails
- Maximum Fastener Spacing is 7" at Edges and 12" in the Field
- 2x Horizontal Blocking Provided at Edges
- Maximum Unit Shear = 290 plf

- **Exterior Walls**

- Sheathed w/ 7/16" OSB Fastened w/ 8d Nails
- Fastener Spacing is 6" at Edges and 12" in the Field
- 2x Horizontal Blocking Provided at Edges
- Maximum Unit Shear = 405 plf



Wall Cost Comparison

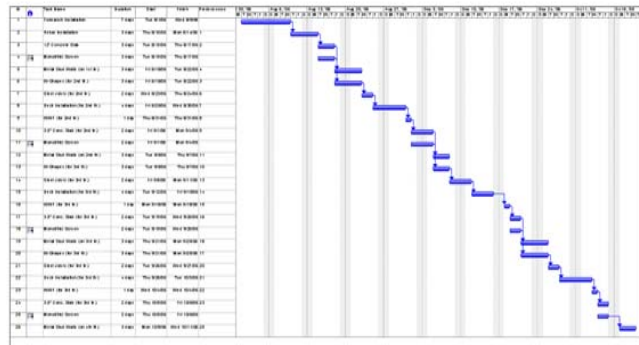
Summary of Total Savings

Metal Stud Walls							
Material	Unit	Material	Labor	Equip.	Total	City Adj. Factor	Adj. Total
2x6	L.F.	\$ 11.90	\$ 8.35		\$ 20.25	94.30%	\$ 72,563.85
2x4	L.F.	\$ 9.35	\$ 8.25		\$ 17.60	94.30%	\$ 66,387.20
Bracing	Ea.	\$ 22.50	\$ 34.00		\$ 56.50	94.30%	\$ 5,114.83
						TOTAL	\$ 144,065.88

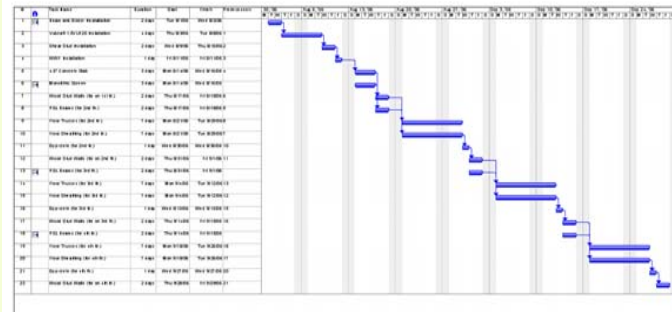
Wood Stud Walls							
Material	Unit	Material	Labor	Equip.	Total	City Adj. Factor	Adj. Total
2x6	L.F.	\$ 5.45	\$ 5.65		\$ 11.10	113.10%	\$ 50,216.40
2x4	L.F.	\$ 3.48	\$ 5.10		\$ 9.58	113.10%	\$ 43,339.92
						TOTAL	\$ 93,556.32

Final Cost Comparison	
First Floor	
Existing Structure	Proposed Structure
\$ 228,823.57	\$ 145,463.48
TOTAL SAVINGS	\$ 83,360.10
PERCENT SAVED	36%
Floors 2-4 and Walls	
Existing Structure	Proposed Structure
\$ 412,833.46	\$ 263,099.59
TOTAL SAVINGS	\$ 149,733.87
PERCENT SAVED	36%

Existing Construction Schedule

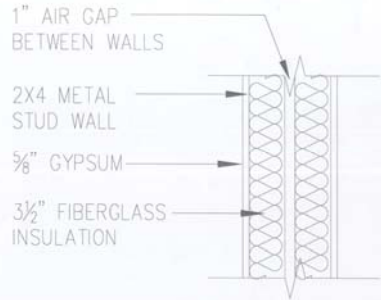


Proposed Construction Schedule



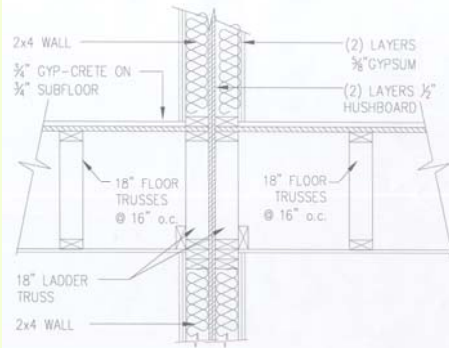
Existing Wall Assembly

- **STC = 56**



Proposed Wall Assembly

- **STC = 60+**

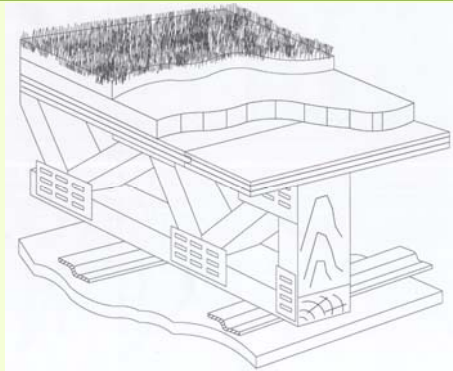


Existing Floor Assembly

- 3.5" Concrete Slab
- 1 5/16" Metal Form Deck
- 16" Open-Web Steel Joists
- Batt Insulation
- 5/8" Gypsum Hung on Resilient Channels

Proposed Floor Assembly

- FSTC = 59
- FIIC = 83



Were Project Goals Met?

- Wood Structural System Viable Alternative
- Design Shear Walls to Replace Braced Frames
- **Foundation Still Adequately Designed**
- More Efficient First Floor
- **Maintain Architectural Integrity**
- Save Money
- Reduce Construction Schedule
- Maintain Effective Sound Barriers

Recommendations

- Wood Truss Floor System to Replace Steel Joist and Concrete Slab
- Composite Beam and Concrete Slab to Replace 12" Thick Two-Way Slab at First Floor
- Wood Stud Walls and Shear Walls to Replace Metal Stud Walls and Braced Frames

Other Possible Considerations

- Roof Structure
- Balconies
- Analysis and Redesign of Foundation
- Study of Parking Grid
- Architecture Study
- Possibly Concrete Floors Throughout Building

Acknowledgments

- Mulhern and Kulp Structural Engineering, Inc. for Providing Plans
- Chris Scharff and Glenn Haydu for Their Help in the Building Selection Process
- The Staff of Mulhern and Kulp
- Dr. Hanagan and the Entire AE Faculty
- Family and Friends



Questions



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