Wisconsin Place Residential

Chevy Chase, Maryland

Kurt Krasavage ● Structural Option

Presentation Outline

- Building Overview
- Thesis Objective
- Architectural Breadth Study
- Structural Depth Study
- Construction Breadth Study
- Summary and Conclusions
- Acknowledgements
- Questions

Building Overview

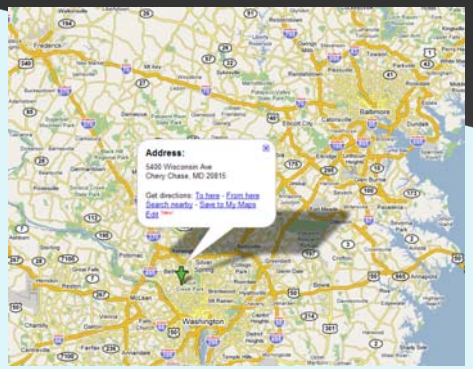
15 - Story, U-shaped residential tower consisting of 432 units within a world-class urban development.

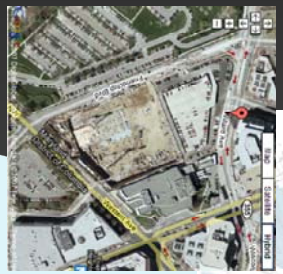
2 - levels of underground parking

1,000 S.F. pool located on the 13th floor.

Size: 479,000 S.F.
Cost: $94 Million
Dates of Construction:
May 2006 – February 2009

Features
Location
Project Team
Structural System



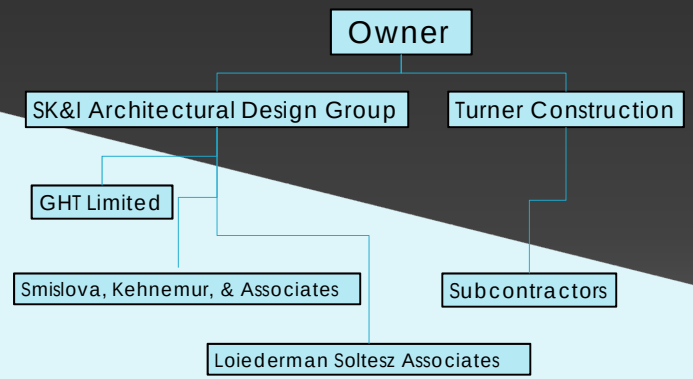


Building Overview

Features
Location
Project Team
Structural System

Building Overview

Owner/Developer:
Archstone-Smith
Architect:
SK&I Architectural Design Group
Landscape Architect:
Carol R. Johnson Associates
Structural Engineer:
Smislova, Kehnemur, & Associates
MEP Engineer:
GHT Limited
Civil Engineer:
Loiederman Soltesz Associates
Interior Designers:
Handel Architects
General Contractor:
Turner Construction



Foundations

The foundations consist of spread and combined footings. These footings are typically 12' X 12' by 24" thick.

Columns

Reinforced concrete columns that are typically 16"x28" and 16"x32". The typical reinforcement is 8 #7 or 8 #8 bars, but varies throughout typical levels.

Typical Floors

Flat plate 7 ½" thick unbounded post-tension slabs, with two-way bottom reinforcement of #4@24" continuous bars each way.

Normal weight concrete at 5000 psi.

The post-tension cables consist of uniform tendons being pulled in the S-N direction and the banded tendons are in the pulled in the W-E direction of the building

Building Overview

Features
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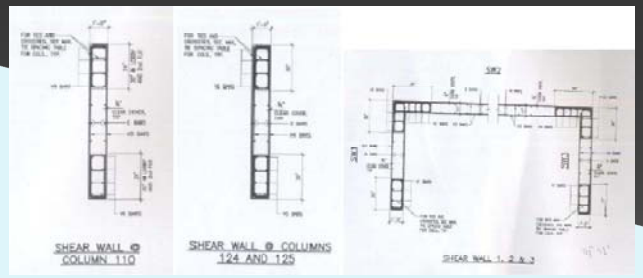
Lateral System

•Concrete shear walls around the two elevator cores.

•Three other shear walls spread out on the west wing side of the building.

•Typical thickness of each shear wall is approximately 12”

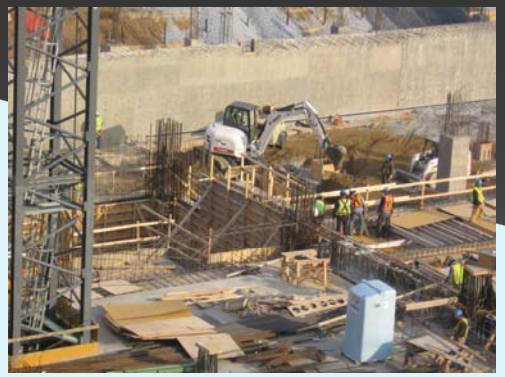


Architectural Goals

Construction Goals

- Integrate a new column
- Accelerate the speed of construction and save the owner as much money as possible
- and overall quality

Structural Goals



Thesis Objective

Architectural Breadth
Structural Depth
Construction Breadth

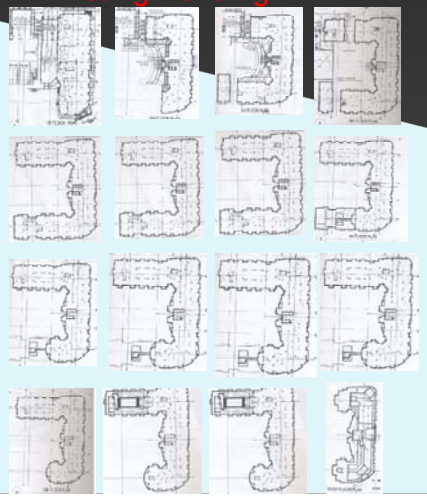
Thesis Assumption

Assume that the two levels of underground parking will be capable of being integrating within the proposed column layout

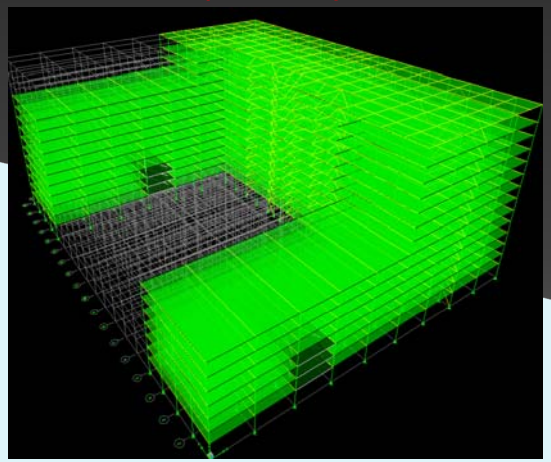
Architectural Breadth

Proposed Layout
Building Dimensions
Square Footage
Location of Lateral Resisting Elements
Functionalism
Inclusive Floor Plan
Enlarged View of Typical Apartments

Existing Building



Proposed Layout



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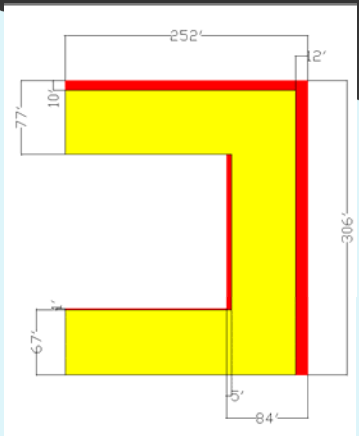
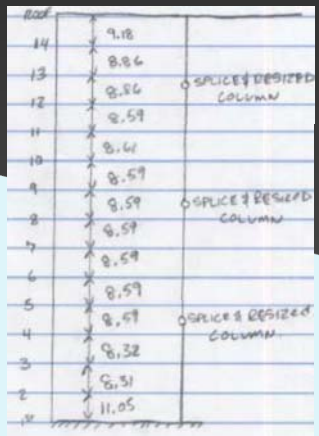
Building Dimensions



Floor-to-Floor Heights



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Floors	Existing Total Floor Area	Estimated Total Area for Proposed Tower	Difference
1	19,103	25,064	5,961
2	22,988	28,708	5,720
3	30,510	34,368	3,858
4	30,507	34,380	3,873
5	40,789	47,518	6,729
6	40,789	47,518	6,729
7	40,789	47,518	6,729
8	40,970	47,699	6,729
9	32,974	38,179	5,205
10	32,980	38,185	5,205
11	32,980	38,185	5,205
12	32,980	38,185	5,205
13	33,158	28,843	-4,315
14	25,373	28,843	3,470
15	25,373	28,843	3,470
Roof	25,373	0	-25,373
Sum	507,636	552,036	44,400

Architectural Breadth

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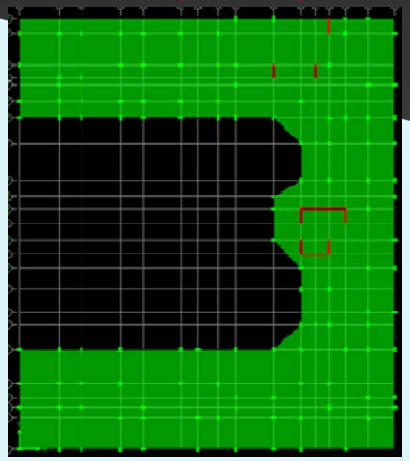
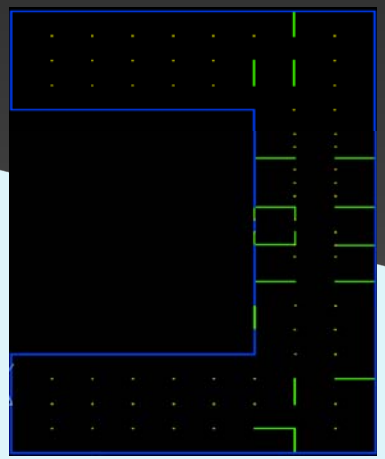
Existing Building



Proposed Building



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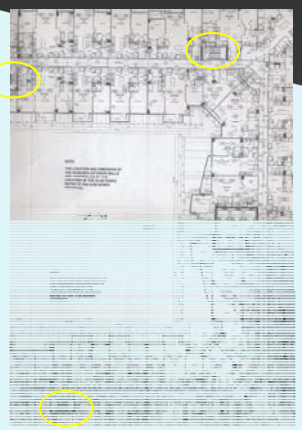
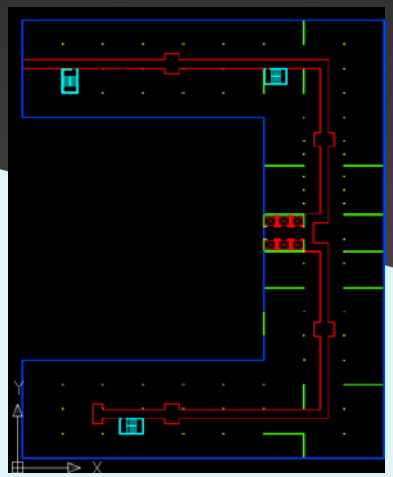


Proposed Building



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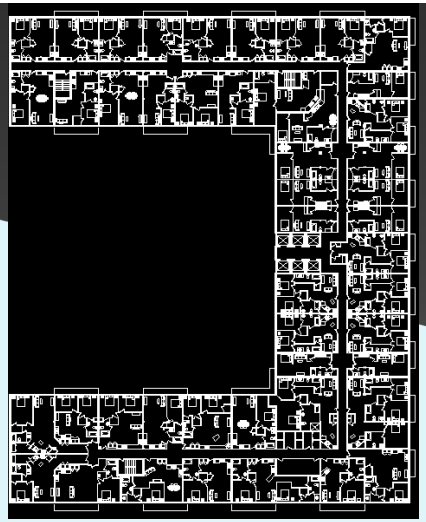

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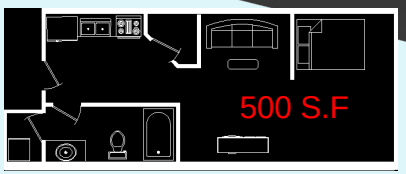
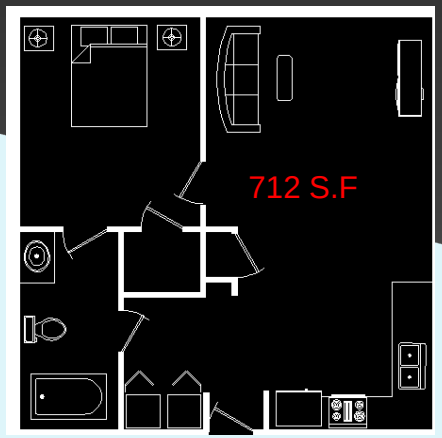
Studio



1- Bedroom



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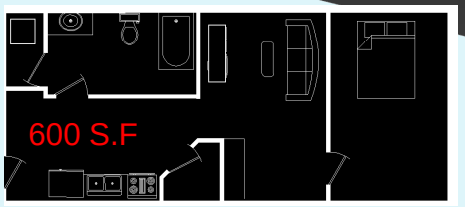

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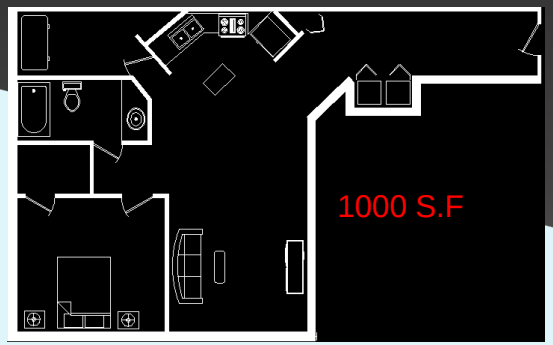

Architectural Breadth

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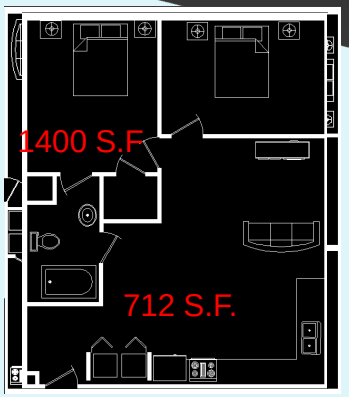
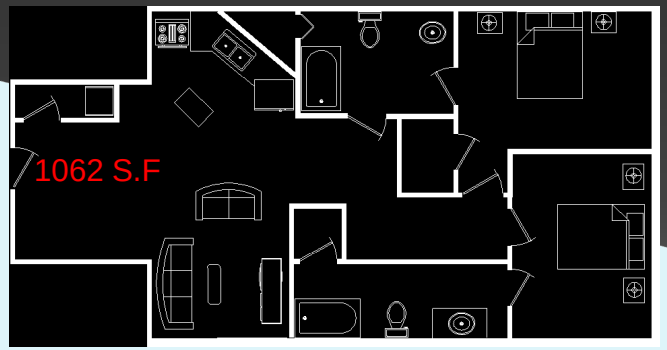
3 2- Bedroom



2- Bedroom



Architectural Breadth

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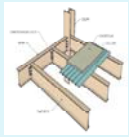
Post-Tensioned

Composite Deck w/ Non-Composite Steel Framing



Two-way Flat Plate

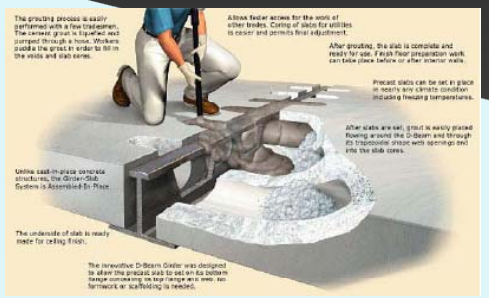
Girder-Slab

System	Two-Way Post-Tensioned Flat Plate w/ Normal Weight Concrete (EXISTING)	Two-Way Post-Tensioned Flat Plate w/ Lightweight Concrete	Precast Girder-Slab	Two-Way Flat Plate w/ Normal Weight Concrete	Two-Way Flat Plate w/ Lightweight Concrete	Composite Deck with Non-Composite Steel Framing
Weight (psf)	94	74	74	128	101	45
Slab Depth (in)	7.5	8	6	11	11	3.5
Largest Depth	7.5	8	8	11	11	17.5
Construction Difficulty	Hard	Hard	Easy	Easy	Easy	Easy
Lead Time	Short	Short	Long	Short	Short	Long
Formwork	Yes	Yes	Little	Little	Little	Little
Additional Fireproofing	No	No	Yes	No	No	Yes
Lateral System Effects	N/A	Medium	Medium	High	Medium	High
Relative Vibration	Low	Low	Medium	Low	Low	High
Foundation Impact	N/A	Medium	Medium	High	Medium	High
Cost/SF						
Materials	$10.62	$10.75	$10.72	$7.64	$7.77	$16.61
Labor	$8.01	$8.01	$8.15	$8.10	$8.10	$7.73
Total ($)	$18.63	$18.76	$13.87	$15.74	$15.87	$24.34

Structural Depth

Alternate Systems
Overview of Girder-Slab
Floor Framing
Wind Distribution
Seismic Distribution
Braced Frames
Drift

Girder-Slab



Advantages

- Low floor-to-floor heights
- Super-fast structure and building completion
- Reduced building structure weight
- Limited weather impact
- Limited on-site labor
- Reduced on-site overhead costs

Structural Depth

Alternate Systems
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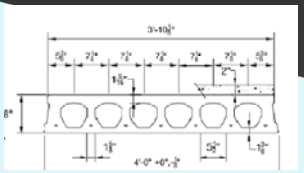
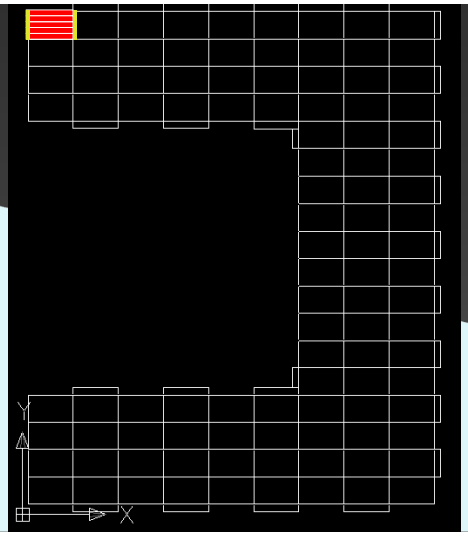
Precast Hollow Core Planks



Supporting D-Beams



Structural Depth

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Structural Depth

Main Roof Framing

Girders

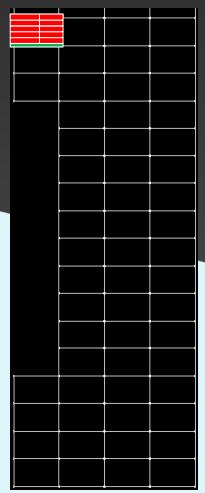
W24X68

Beams

W16X31

Columns

W12X40 through W12X120



Existing Building Wind Distribution

Load (kips)		Shear (kips)		Moment (ft-k)	
N/S	E/W	N/S	E/W	N/S	E/W
32	25	0	0	4,536	3,548
62	48	32	25	8,096	6,327
60	47	94	73	7,364	5,755
58	45	154	120	6,512	5,083
56	44	212	165	5,799	4,527
55	43	268	209	5,131	4,001
54	42	323	252	4,546	3,542
54	42	376	294	4,052	3,158
53	41	430	335	3,494	2,721
51	40	483	376	2,936	2,284
50	39	534	416	2,401	1,866
49	38	584	455	1,890	1,467
47	37	633	493	1,393	1,080
43	33	680	530	892	689
47	36	[illegible]	[illegible]	[illegible]	[illegible]
770	599	770	599	59,587	46,464

Proposed Building Wind Distribution

Load (kips)		Shear (kips)		Moment (ft-k)	
N/S	E/W	N/S	E/W	N/S	E/W
37	13	0	0	5,033	1,799
66	24	36	13	8,290	2,964
58	21	103	37	6,636	2,370
57	46	160	57	5,990	4,813
54	44	217	103	5,230	4,197
53	43	272	146	4,632	3,715
53	43	325	189	4,124	3,308
52	42	378	232	3,555	2,849
51	41	431	274	2,986	2,390
50	40	482	315	2,441	1,952
48	39	532	355	1,920	1,534
46	37	580	394	1,393	1,111
42	34	626	430	891	708
45	36	669	464	539	427
714	500	714	500	53,661	34,136

Structural Depth

Alternate Systems
Overview of Girder-Slab Floor Framing
Wind Distribution
Seismic Distribution
Braced Frames
Drift

Existing Building Seismic Distribution

Level	w_x	FL-FL Height	h_x	$w_x h_x^k$	C_{vx}	Load F_x	Shear V_x	Moment M_x
	(kips)	(ft)	(ft)			(kips)	(kips)	(ft-kips)
Roof	3,737	9.85	141.23	2,110,715	0.122	82	0	11,639
15	3,641	9.48	131.38	1,874,727	0.108	73	82	9,617
14	3,639	9.48	121.9	1,702,420	0.098	66	156	8,103
13	3,936	9.21	112.42	1,660,102	0.096	65	222	7,287
12	4,691	9.21	103.21	1,773,492	0.102	69	287	7,147
11	4,691	9.21	94	1,573,508	0.091	61	356	5,775
10	4,691	9.21	84.79	1,378,944	0.079	54	418	4,565
9	4,690	9.21	75.58	1,189,964	0.069	46	471	3,512
8	4,733	9.21	66.37	1,016,858	0.059	40	518	2,635
7	5,777	9.21	57.16	1,025,133	0.059	40	558	2,288
6	5,777	9.21	47.95	818,675	0.047	32	598	1,533
5	5,777	9.21	38.74	623,084	0.036	24	630	942
4	4,347	8.93	29.53	331,228	0.019	13	654	382
3	4,346	8.93	20.6	208,853	0.012	8	667	168
2	3,317	11.67	11.67	77,019	0.004	3	675	35
Totals				17,364,724	1.00	678	**678**	**65,627**

Proposed Building Seismic Distribution

Level	w_x	FL-FL Height	h_x	$w_x h_x^k$	C_{vx}	Load F_x	Shear V_x	Moment M_x
	(kips)	(ft)	(ft)			(kips)	(kips)	(ft-kips)
Roof	2,717	12.01	136.98	1,153,926	0.091	63	0	8,691
14	3,632	9.70	124.97	1,377,898	0.109	76	63	9,468
13	3,632	9.70	115.27	1,247,547	0.099	69	139	7,907
12	4,715	9.43	105.57	1,453,572	0.115	80	208	8,437
11	4,768	9.44	96.14	1,310,112	0.104	72	288	6,925
10	4,768	9.42	86.70	1,153,718	0.091	63	360	5,500
9	4,767	9.42	77.28	1,001,308	0.079	55	423	4,255
8	5,946	9.42	67.86	1,064,412	0.084	59	478	3,972
7	5,938	9.42	58.44	884,492	0.070	49	537	2,842
6	5,938	9.42	49.02	712,524	0.056	39	585	1,920
5	5,938	9.42	39.60	548,031	0.043	30	625	1,193
4	5,517	9.15	30.18	364,550	0.029	20	655	605
3	5,516	9.15	21.03	233,731	0.019	13	675	270
2	5,535	11.88	11.88	116,183	0.009	6	688	76
Totals				12,622,004	1.00	694	**694**	**62,061**

Structural Depth

Alternate Systems
Overview of Girder-Slab
Floor Framing
Wind Distribution
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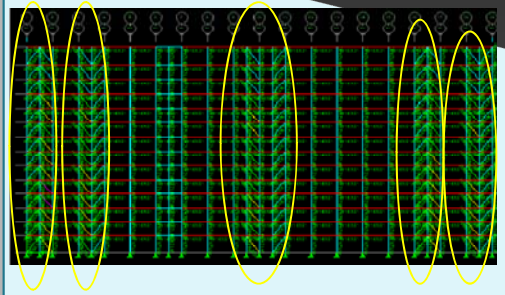
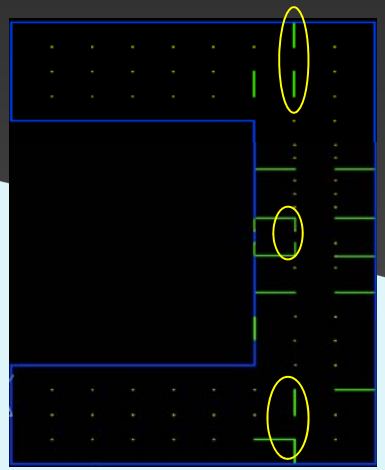
Braced Frames
Drift

Braced Frames
East – West Direction





Structural Depth

Alternate Systems
Overview of Girder-Slab
Floor Framing
Wind Distribution
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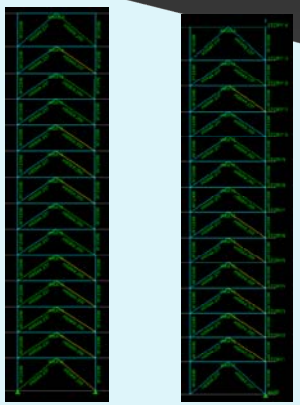
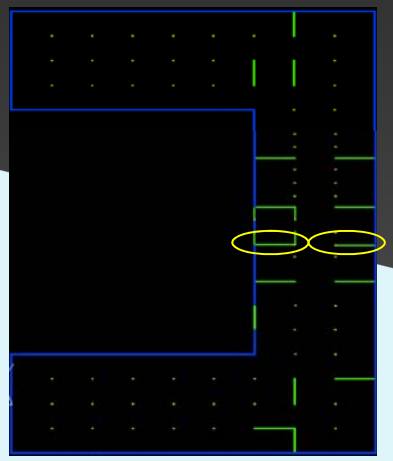
Braced Frames
North - South Direction





Structural Depth

Drift due to Wind
North - South Direction

H/400	Wind Displacement N S	Drift (in)	Check
0.3603	2.85	0.27	OK
0.291	2.58	0.25	OK
0.291	2.33	0.25	OK
0.2829	2.08	0.25	OK
0.2832	1.83	0.25	OK
0.2826	1.58	0.23	OK
0.2826	1.35	0.22	OK
0.2826	1.13	0.21	OK
0.2826	0.92	0.2	OK
0.2826	0.72	0.18	OK
0.2826	0.54	0.16	OK
0.2745	0.38	0.12	OK
0.2745	0.26	0.12	OK
0.3564	0.14	0.14	OK

Drift due to Wind
East – West Direction

Wind Displacement E-W	Drift (in)	Check
3.37	0.360	OK
3.01	0.190	OK
2.82	0.210	OK
2.61	0.210	OK
2.4	0.280	OK
2.12	0.280	OK
1.84	0.280	OK
1.56	0.280	OK
1.28	0.270	OK
1.01	0.259	OK
0.751	0.230	OK
0.521	0.197	OK
0.324	0.165	OK
0.159	0.159	OK

Structural Depth

Alternate Systems
Overview of Girder-Slab
Floor Framing
Wind Distribution
Seismic Distribution
Braced Frames
Drift

Drift due to Seismic North - South Direction

0.015H	ETABS Displacement N-S	Actual Displacement (N-S)	Drift (in)	Check
2.1618	4.2	21	2.00	OK
1.746	3.8	19	1.50	OK
1.746	3.5	17.5	1.50	OK
1.6974	3.2	16	1.50	OK
1.6992	2.9	14.5	1.50	OK
1.6956	2.6	13	1.50	OK
1.6956	2.3	11.5	1.00	OK
1.6956	2.1	10.5	1.50	OK
1.6956	1.8	9	1.50	OK
1.6956	1.5	7.5	1.50	OK
1.6956	1.2	6	1.50	OK
1.647	0.9	4.5	1.05	OK
1.647	0.69	3.45	1.45	OK
2.1384	0.4	2	0.00	OK

Drift due to Seismic East – West Direction

ETABS Displacements E-W	Actual Displacements (E-W)	Drift (in)	Check	Cd
4.3	21.5	2.00	OK	5
3.9	19.5	1.50	OK	5
3.6	18	1.00	OK	5
3.4	17	1.50	OK	5
3.1	15.5	1.50	OK	5
2.8	14	0.75	OK	5
2.65	13.25	1.25	OK	5
2.4	12	1.50	OK	5
2.1	10.5	1.50	OK	5
1.8	9	1.50	OK	5
1.5	7.5	1.50	OK	5
1.2	6	1.50	OK	5
0.9	4.5	1.50	OK	5
0.6	3	0.00	OK	5

Structural Depth

Alternate Systems
Overview of Girder-Slab
Floor Framing
Wind Distribution
Seismic Distribution
Braced Frames
Drift

Existing Building Cost

Description	Crew	Daily Output	Lab Hrs	Unit	Mat	Lab	EQ	Total /Unit	Adjustment	Total	Adjusted Total
Column Forms	C1	215	0.136	SFCA	0.73	4.58	0	5.19	0.786	[illegible]	[illegible]
Slab Forms	C2	500	[illegible]	S.F.	1.4	[illegible]	0	4.36	0.786	[illegible]	[illegible]
Shear Wall Forms	C2	395	[illegible]	SFCA	0.7	4.2	0	4.9	0.786	[illegible]	[illegible]
Column Reinforcement	[illegible]	5400	[illegible]	lbs	0.44	[illegible]	0	0.67	[illegible]	[illegible]	[illegible]
Slab Reinforcement	[illegible]	5000	[illegible]	lbs	0.47	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
PT Strands	[illegible]	[illegible]	[illegible]	lbs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shear Wall Reinforcement	[illegible]	6000	[illegible]	lbs	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Spread Footings F.W. Concrete, Reinforcing	C-14C	38.07	[illegible]	C.Y.	175	99.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Concrete for Columns	0	0	0	C.Y.	100	11.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Concrete for Slab	0	0	0	C.Y.	100	11.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Concrete for Shear Walls	0	0	0	C.Y.	100	11.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Machine Trowel Finishing	[illegible]	550	[illegible]	S.F.	0	0.5	0	0.5	[illegible]	[illegible]	[illegible]
Shoring/Reshoring	[illegible]	1400	[illegible]	S.F.	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]
Concrete Placement for Columns	C20	92	[illegible]	C.Y.	0	20.5	[illegible]	28.6	[illegible]	[illegible]	[illegible]
Concrete Placement for Slabs	C20	160	[illegible]	C.Y.	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Concrete Placement for Shear Walls	C20	100	[illegible]	C.Y.	0	17.25	[illegible]	24	[illegible]	[illegible]	[illegible]
TOTAL											[illegible]
										Cost/S.F.	[illegible]

Formwork %	[illegible]
Concrete %	[illegible]
Rebar %	[illegible]
Placement and Finishes %	[illegible]
Shoring and Reshoring	[illegible]
Total Footing %	[illegible]
Totals	[illegible]

Proposed Building Cost

Description	Crew	Daily Output	Lab Hrs	Unit	Mat	Lab	EQ	Total /Unit	Adjustment	Total	Adjusted Total
Formwork for Edge of Topping	C1	500.0	0.064	L.F.	0.190	2.140	0.000	2.330	0.786	40,001.0	31,441
Hollowcore 8" Planks	C11	3,200.0	0.023	S.F.	5.750	0.880	0.480	7.110	0.903	3,923,689.0	3,543,091
Finishing of the Topping	1Cefi	900.0	0.009	S.F.	0.000	0.310	0.000	0.310	0.908	171,075.0	155,336
Concrete Topping	0.0	0.0	0.000	C.Y.	100.000	11.550	4.320	115.870	0.908	395,502.0	359,116
Averaged W-Shapes for Columns	E-2	972.0	0.058	L.F.	91.000	2.210	1.450	94.660	1.005	1,033,650.0	1,038,818
D-Beams	0.0	0.0	0.000	lbs	1.250	0.000	0.000	1.250	1.005	1,533,490.0	1,541,157
D-Beam Erection	E-2	972.0	0.058	L.F.	0.000	2.250	1.470	3.720	1.005	101,035.0	101,540
W-Shapes for Girders and Beams	E-2	984.0	0.057	L.F.	77.500	2.210	1.450	81.160	1.005	348,176.0	349,917
Braces in Frames	E-2	1,080.0	0.052	L.F.	32.500	2.020	1.320	35.840	1.005	368,794.0	370,638
Fireproofing for Roof Beams	G-2	1,500.0	0.016	S.F.	0.430	0.470	0.080	0.980	0.904	28,267.0	25,553
Spread Footings F.W. Concrete, Reinforcing	C-14C	38.1	2.942	C.Y.	175.000	99.500	0.560	275.060	0.903	399,020.0	[illegible]
TOTAL											7,876,923
										Cost/S.F.	14.27

Floor Assembly (Plank, Toping)	49.5
Steel Framing D-Beam, Girders, Beams	41.9
Erection and Finishing Costs	3.3
Total Foundation %	4.6
Formwork & Fire Proofing	0.7
Totals	100.0

Proposed building is approximately 25% more expensive to construct

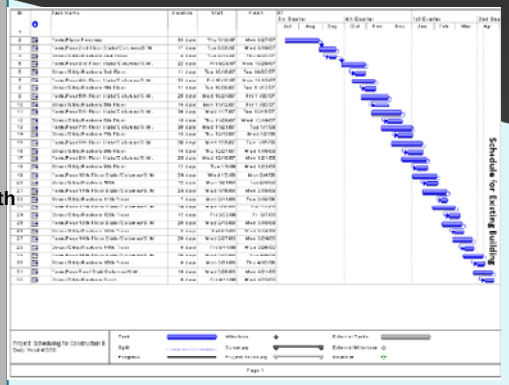
Construction Breadth

Cost Analysis

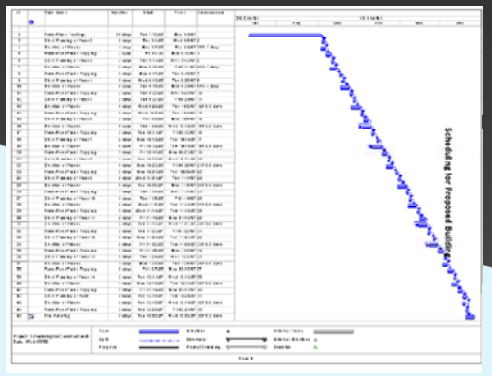
Scheduling Impacts

Estimated Revenue

Existing Building Schedule



Proposed Building Schedule



Construction Breadth

Cost Analysis
Scheduling Impacts
Estimated Revenue

Existing Building
Rent Generated per Month

Existing Building	# of Apartments	Total S.F.	Cost/S.F.	Total Rent
Floor				
15	22	25,373	1.50	38059.5
14	22	25,373	1.50	38059.5
13	22	25,373	1.50	38059.5
12	32	32,980	1.50	49470
11	32	32,980	1.50	49470
10	32	32,980	1.50	49470
9	32	32,974	1.50	49461
8	32	40,789	1.50	61183.5
7	40	40,789	1.50	61183.5
6	40	40,789	1.50	61183.5
5	40	40,789	1.50	61183.5
4	30	30,507	1.50	45760.5
3	30	30,510	1.50	45765
2	21	22,988	1.50	34482
1	5	19,103	1.50	28654.5
Total	432	474,297	1.50	711,446

Proposed Building
Rent Generated per Month

New Building	# of Apartments	Total S.F.	Cost/S.F.	Total Rent
Floor				
14	29	28,843	1.40	40380.2
13	29	28,843	1.40	40380.2
12	29	38,185	1.40	53459
11	38	38,185	1.40	53459
10	38	38,185	1.40	53459
9	38	38,179	1.40	53450.6
8	38	47,518	1.40	66525.2
7	47	47,518	1.40	66525.2
6	47	47,518	1.40	66525.2
5	47	47,518	1.40	66525.2
4	39	34,380	1.40	48132
3	39	34,368	1.40	48115.2
2	39	28,708	1.40	40191.2
1	5	25,064	1.40	35089.6
Total	502	523,012	1.40	732,217

Construction Breadth

Cost Analysis
Scheduling Impacts
Estimated Revenue

Construction Breadth

Cost Analysis
Scheduling Impacts
Estimated Revenue

Revenue generated by Rent

Approximate Revenue from Rent	
At $1.40/S.F.	
4 months early	2,928,867

Proposed Building Rent Generated per Month

Early Income for Faster Construction		
7,928,217	Total Expected Cost of New Structure	Total Expected Cost of Existing Building
	7,928,217	5,740,237
At $1.40/S.F.		Saving
4 months early	4,999,350	740,887

Architectural Goals

- Integrate a new column layout that coincides with existing building architecture
- Improve overall quality of floor plans
- Design apartments that meet square footage requirements while maintaining style, shape, and overall quality

Summary

- 17' X 28' bays with braced frames
- Gained an additional 45,000 S.F. which resulted in 70 more apartments
- Corridors were shortened and opened up to prevent the feeling of walking through a tunnel
- An additional elevator was integrated with proposed system
- Architecture not only complied with square footages, but provided more variety, i.e. non-typical apartments, option of a 3-bedroom and also used the concept of mirroring apartments to save money on construction costs.

Conclusion and Summary

Architectural Breadth
Structural Depth
Construction Breadth
Overall Conclusion

Structural Goals

• Design floor system and supporting elements to resist gravity loading for the proposed building

•Design a lateral system that will resist wind and seismic forces due to strength and servicability for the proposed structure

Summary

• Foundations will not significantly change due to the loading on columns and weight of the building

• Rolled W12 shapes were spliced and redesigned every 4- floors

•8" x 4'0" Hollow core planks with a 2" topping spanned 28', while DB9 X46 beams spanned 17'. Typical grout; 6ksi

• Lateral system consisted of 20 specially concentric braced frames that resisted strength and met servicability requirements for drift due to seismic and wind loads

Conclusion and Summary

Architectural Breadth
Structural Depth
Construction Breadth
Overall Conclusion

Construction Goals

Accelerate the speed of construction and save the owner as much money as possible

Summary

- Proposed building system was found to be approximately 25% more expensive to construct upfront
- Proposed system was estimated to cost $7,876,923.00
- Highly probable that the proposed building will be completed at least 4- months earlier than existing building
- The addition apartments will generate enough revenue to offset the cost of construction and additionally save the owner $750,000,000
- Additional revenue for the 70 additional apartments will generate income throughout the life of the building

Conclusion and Summary

Architectural Breadth
Structural Depth
Construction Breadth
Overall Conclusion

Thesis Assumptions

•Assume that the two levels of underground parking will be capable of being integrated within the proposed column layout

Overall Conclusion and Recommendation

Changing the current structural system of a two-way flat plate post-tensioned slab with shear walls to a precast girder-slab floor utilizing braced frames would save the owner approximately $750,000 and improve the overall floor plan. This number does not include the future revenue generated by the 70 additional apartment throughout the life of the building

Conclusion and Summary

Architectural Breadth
Structural Depth
Construction Breadth
Overall Conclusion

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Questions