Structural Steel Solution and Optimization

House of Sweden

Georgetown, Washington, D.C.

Kimberlee McKitish
Structural Option

AE Senior Thesis

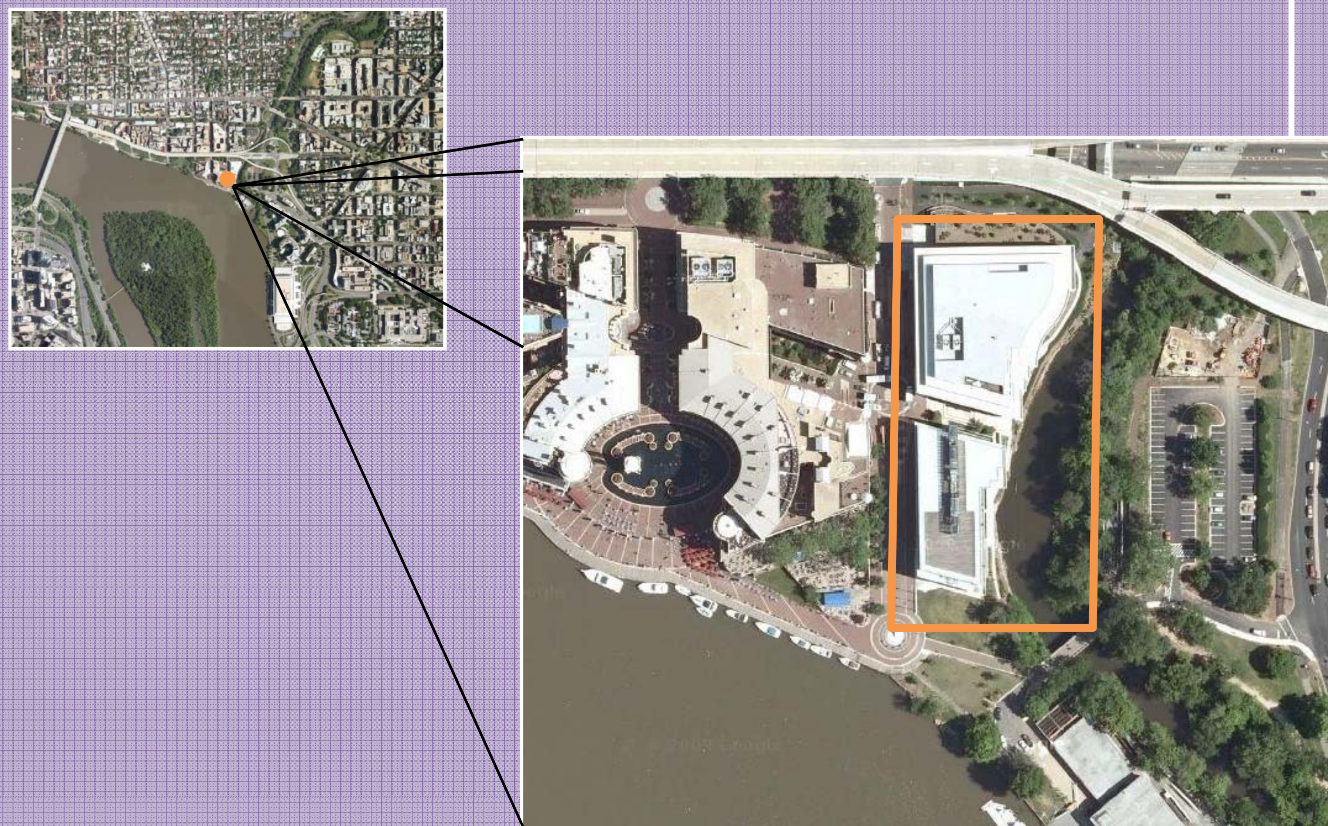
April 14, 2008
Penn State University

Site Location

- Background
- Existing Conditions
- Proposal & Goals
- Structural Redesign
- Design Implications
- Mechanical Move
- Cost Analysis
- Schedule Analysis
- Evaluation
- Conclusions
- Questions

The House of Sweden is located in

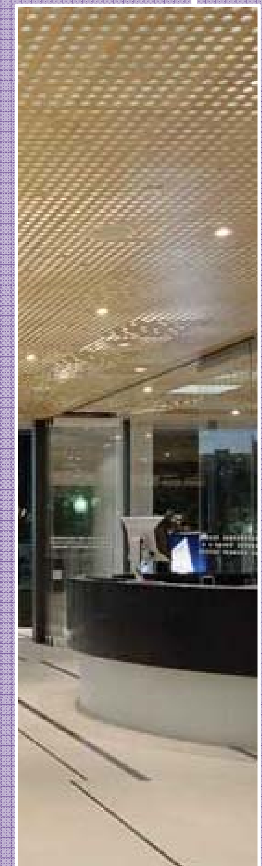
Georgetown, Washington, D.C.



Building Statistics

House of Sweden

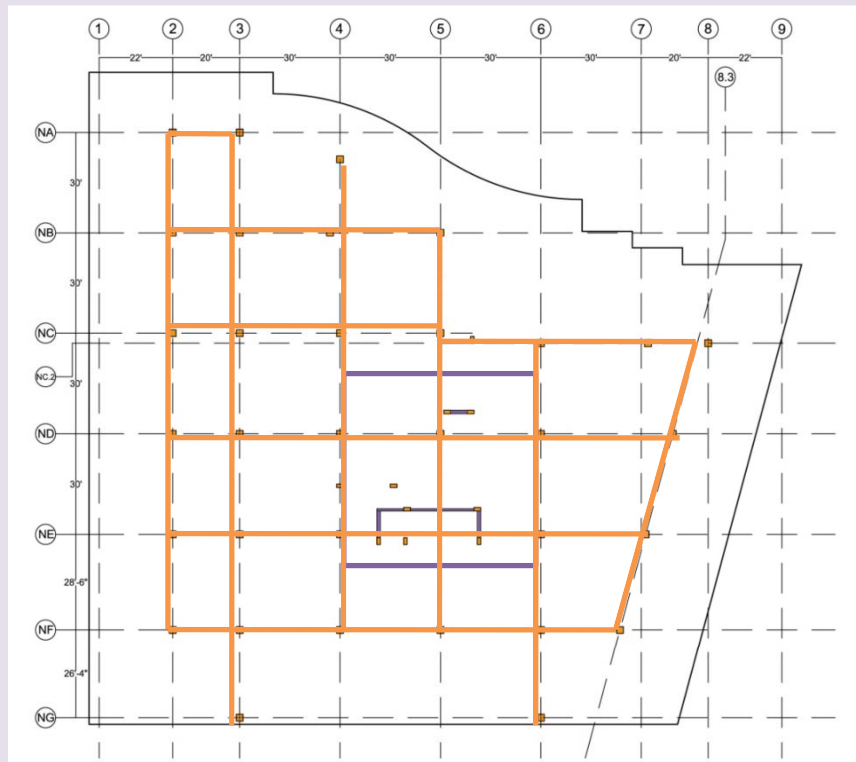
▪ Function:	Embassy, Residential, Commercial
▪ Project Size:	North Building – 170,000 SF
	South Building – 69,150 SF
	Parking – 41,555 SF
▪ Stories:	North Building – 7 stories above grade
	South Building – 5 stories above grade
	1 parking level below grade
▪ Total Cost:	North Building – \$22.1 million
	South Building – \$19.7 million
▪ Construction:	August 2004 – May 2006



Existing Floor Framing & Foundation

Typical Framing Plan (North Building)

- Post-Tensioned flat slab
- NWC moment frames and shear walls
- Typical floor height is 10'-10" with a 12'-0" penthouse
- Foundation: mat slab



Existing Floor Framing and Foundation

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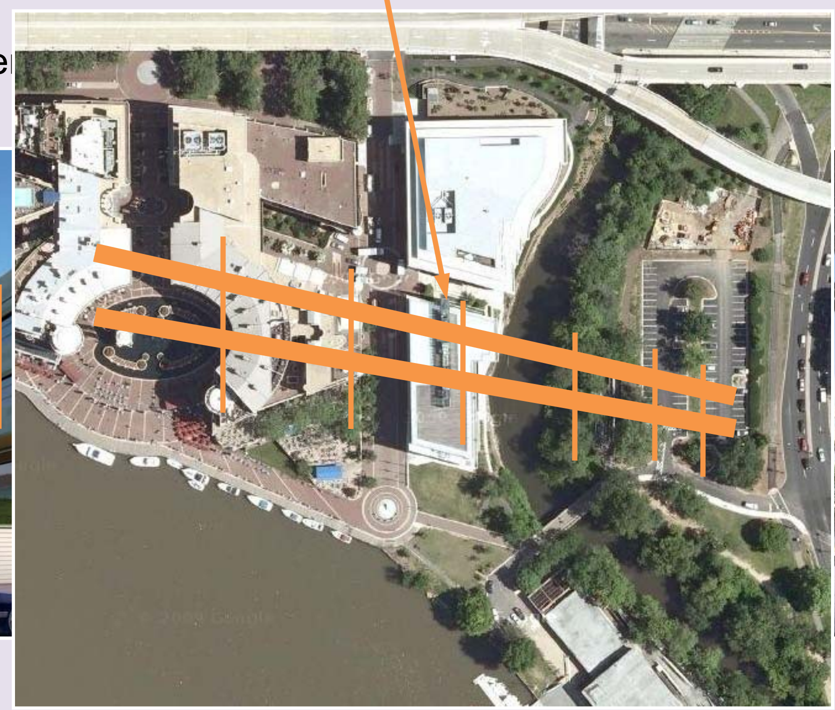
Two Towers

- Shared Parking and Plaza

Transfer Level

- Steel Posts
- Post-Te



Proposal and Goals

Existing Problem

Schedule

- Original Overall Schedule:
  - February 2005-February 2006
  - 12 months total
- Structural Schedule:
  - February 2005-October 2005
  - 8 months total (67% of schedule)

Cost

- Original Overall Cost:
  - $22,084,233
- Structural Cost:
  - $6,751,194 (31% of budget)

Proposal and Goals

Overall Goal

Design and Optimize a steel building solution for the North Building.

This will be accomplished by…

Proposal

- Redesigning the existing gravity system in steel and the lateral system as a moment or braced frame steel system without impacting the architecture.
- Reducing the overall building cost and erection schedule.
- Research progressive collapse mitigation techniques.
- Generating more revenue by moving the mechanical system and creating more residential space.

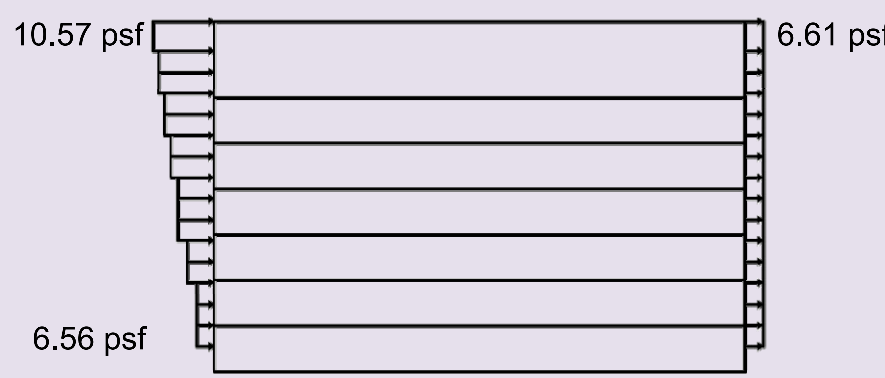
Depth Study

Lateral Loads

- Wind Loads
  - Shear = 1.6*325 K = 520 K
  - Moment = 1.6*10,069 K-ft = 16,110 K-ft
- Seismic Loads (R=3)
  - Shear = 1.0*216 K = 216 K
  - Moment = 1.0*12,972 K-ft = 12,972 K-ft
- Governing Lateral Loads:

V_{wind} = 520 K > $V_{Seismic}$ = 216K

M_{wind} = 16,110 K-ft > $M_{Seismic}$ = 12,972 K-ft



Depth Study

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- **Structural Redesign**
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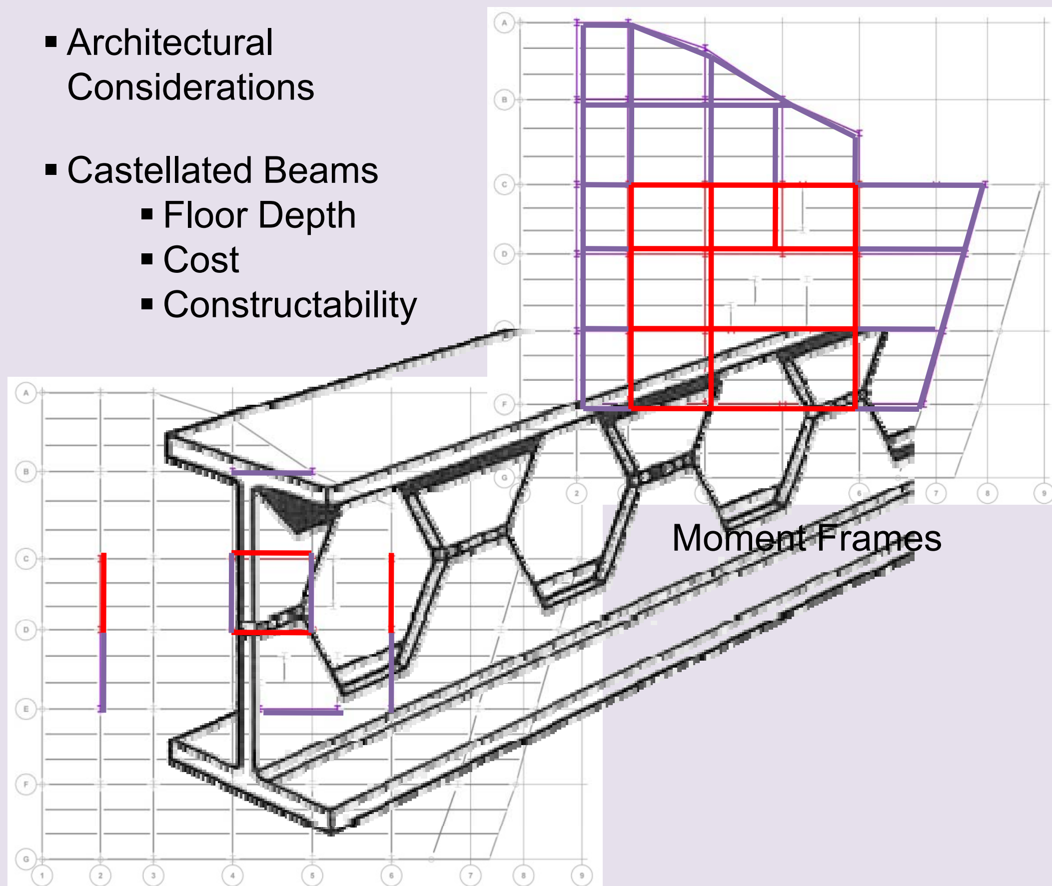
Evolution of Design

- Architectural Considerations
- Castellated Beams
  - Floor Depth
  - Cost
  - Constructability



Braced Frames

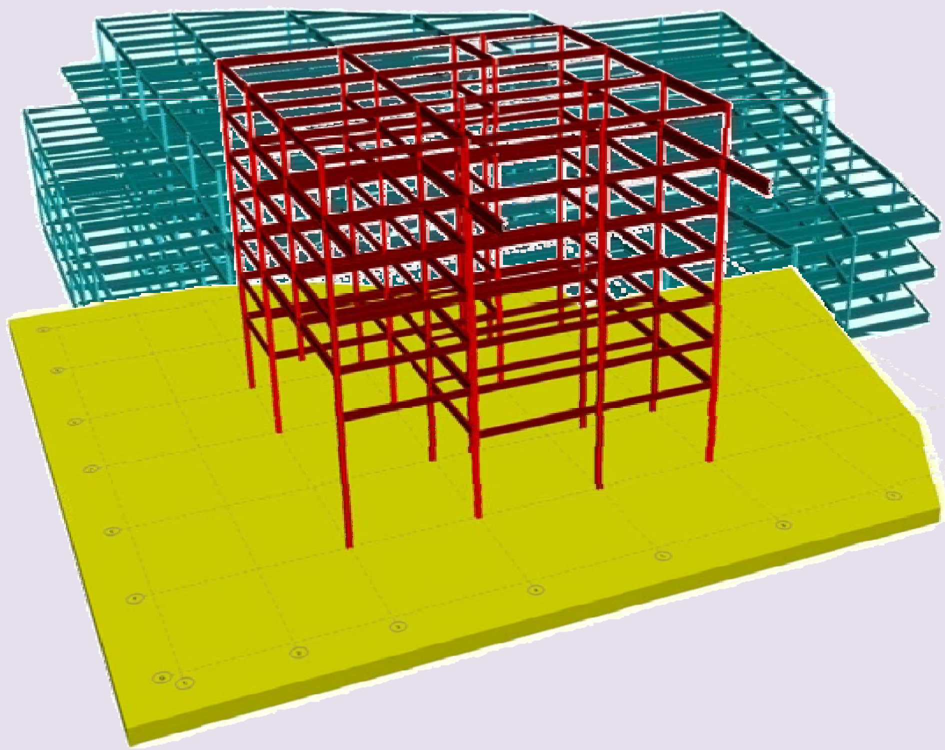
Depth Study

RAM Computer Model

- Both gravity and lateral members modeled
- Castellated beams were modeled as user-defined members
- Assumed rigid diaphragms except first floor shared plaza
- Seismic forces were applied at the center of mass and inherent and accidental torsion effects were considered
- Wind forces were applied at the center of pressure and each of the 4 load cases outlined in ASCE7-05 were considered
- Braces were assumed pinned at both ends
- Lateral beams were assumed fixed at both ends
- Base was modeled as fixed due to mat foundation
- Modeling of all beam and column elements took panel zone, shear, and axial deformations into account
- P-delta effects was considered and a dynamic analysis was performed to find periods of vibrations for the model
- Wind drift was determined based on ASCE7-05 Commentary to Appendix C using load combination of: D+0.5L+0.7W

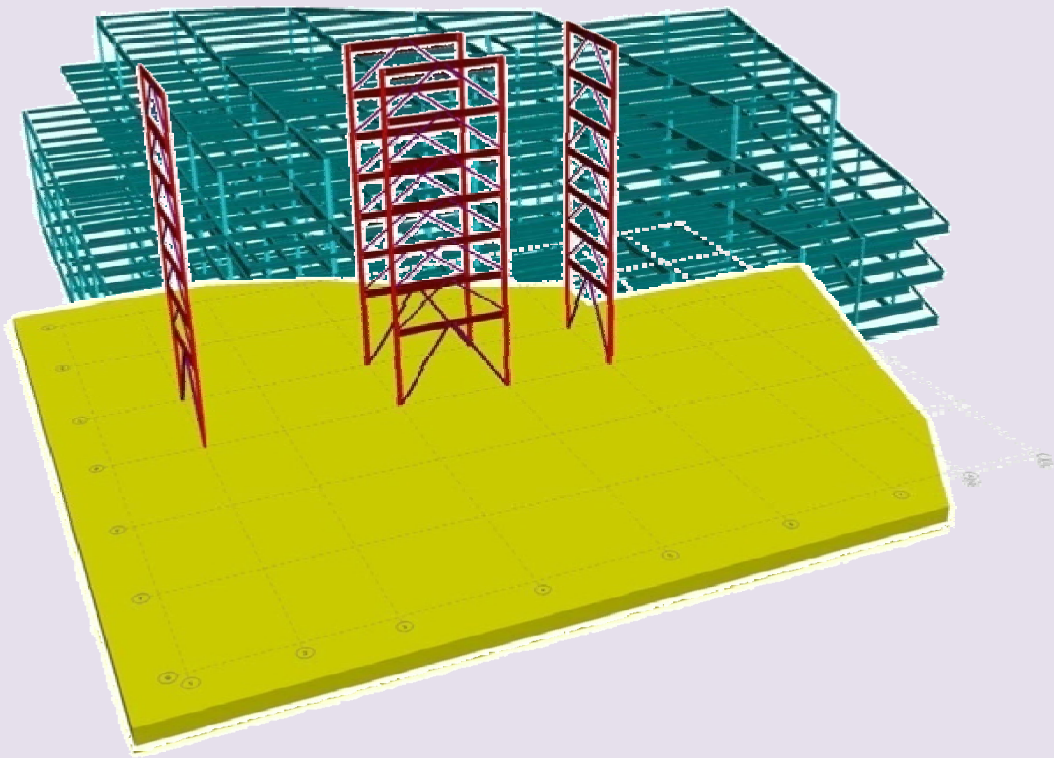
Depth Study

Moment Frame Cases



Depth Study

Braced Frame Cases



Depth Study

NWC Braced Frame Checks

Check	Comment	Observation
Story Drifts	Allowable story drifts for each level are met in each of the two orthogonal directions. Although the computed story drifts is at most 38% of the allowable, H/400, this design was driven more by member strength instead of serviceability.	OK
Torsion	Accidental Torsion = 5%. Inherent torsion is assumed by applying loads at the center of mass and being resisted by the center of rigidity of the structure.	OK
Redundancy	There are only two frames in each direction so one resists at least 50% of the total story shear, however, in SDC=B, ρ is still equal to 1.0.	OK
Modal Period	ASCE7-05 Approximate Period, CuTa=1.63 sec RAM modal period X Direction: 1.49 sec RAM modal period Y Direction: 1.71 sec Sine the X direction RAM model period is less than the period approximation, this period was then used to update the seismic loads in the model.	OK
Member Spot Checks	Columns and beams are approximately 32% to 96% of their total design strength based off their interaction equations. This occurs due to member updates for size uniformity.	Some System Overdesign

Depth Study

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Structural Redesign

Design Implications

Mechanical Move

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Schedule Analysis

Evaluation

Conclusions

Questions

Material Takeoff

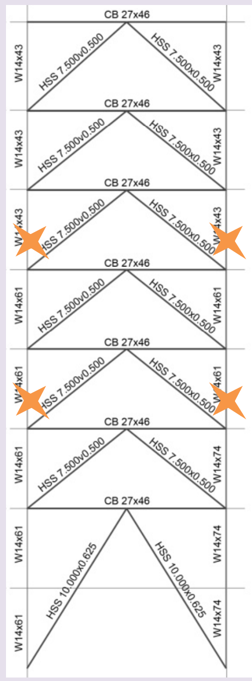
- Steel tonnage takeoffs from RAM models
- $1.50/lb of steel estimated cost for materials

Structural Frame Type	Steel Weight (lb)	Cost
NWC Braced Frame	1229639	$1,844,459
LWC Braced Frame	1206033	$1,809,050
NWC Moment Frame	1343073	$2,014,610
LWC Moment Frame	1302411	$1,953,617

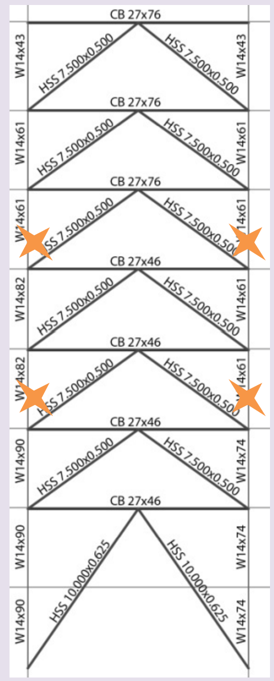
- LWC Premium – 30%
  - Total Deck Area: 185,147 SF
  - NWC 7.5" deep: 3,143 CY*$85/CY = $267,155
  - LWC 6.5" deep: 2,571 CY*120/CY = $308,520
  - $41,365 premium for LWC
- LWC Braced Frame vs. NWC Braced Frame
  - $35,409 savings using LWC Braced Frames
- Total Difference – $5,956 more to use LWC Braced Frames

Depth Study

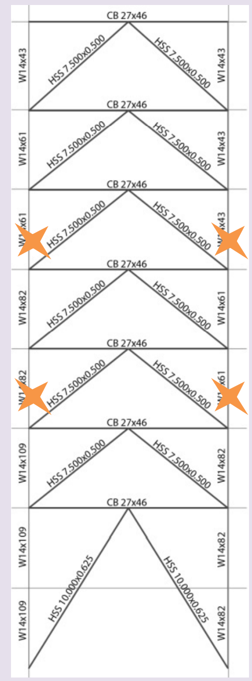
Normal Weight Concrete Braced Frames



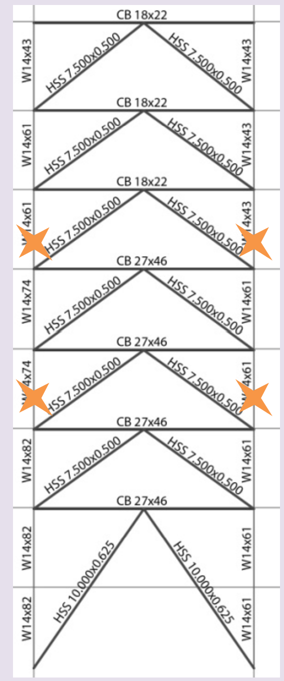
X-Direction



X-Direction



Y-Direction

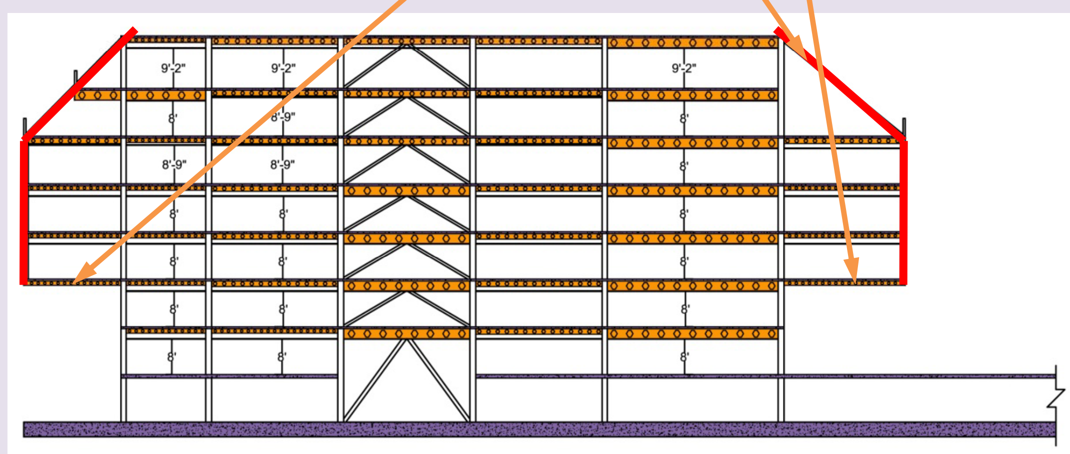


Y-Direction

Depth Study

Cantilever Solution

- Long cantilevers involved in this design
- Designed a steel hanger system
- Governing size: HSS 7.000x0.500



Design Implications

Garage Column and Progressive Collapse

- Composite Columns with spiral ties in garage
- Catenary Cables mitigate progressive collapse

Foundati

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- Original T
- New mat
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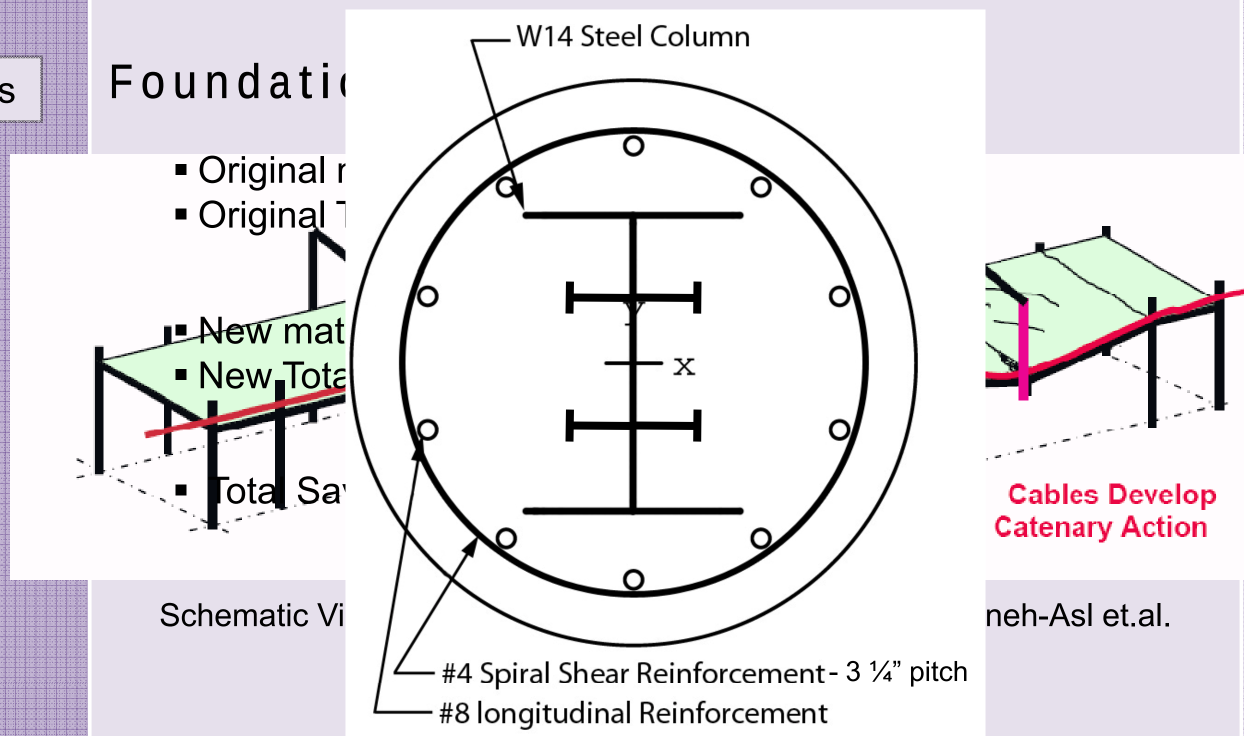


Schematic Vi … neh-Asl et.al.

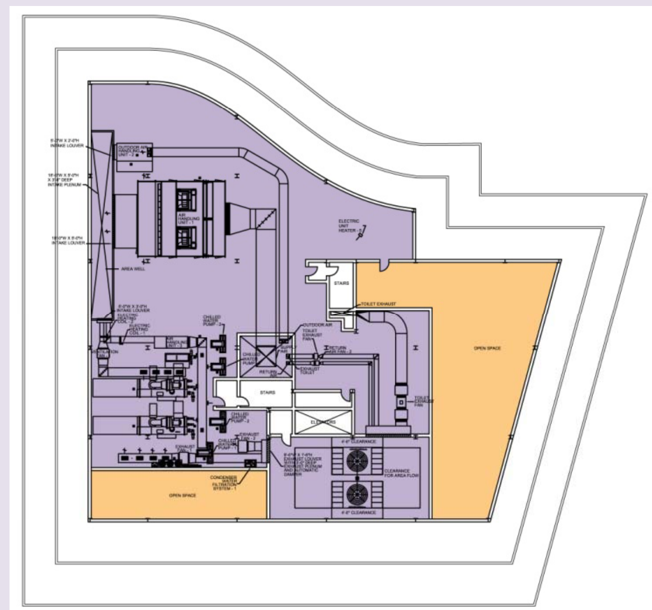
Breadth Study 1

Problem Statement:

Entire Penthouse space is taken up by mechanical equipment

Goals:

- Move the mechanical room to the basement parking garage without losing the required number of parking spaces.
- Create apartments in the new penthouse space so more revenue can be generated for the owner by charging a premium for these units.
- Look at the impacts of this move on the cost and schedule and architecture of the project.



Breadth Study 1

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Parking Study

Breadth Study 1

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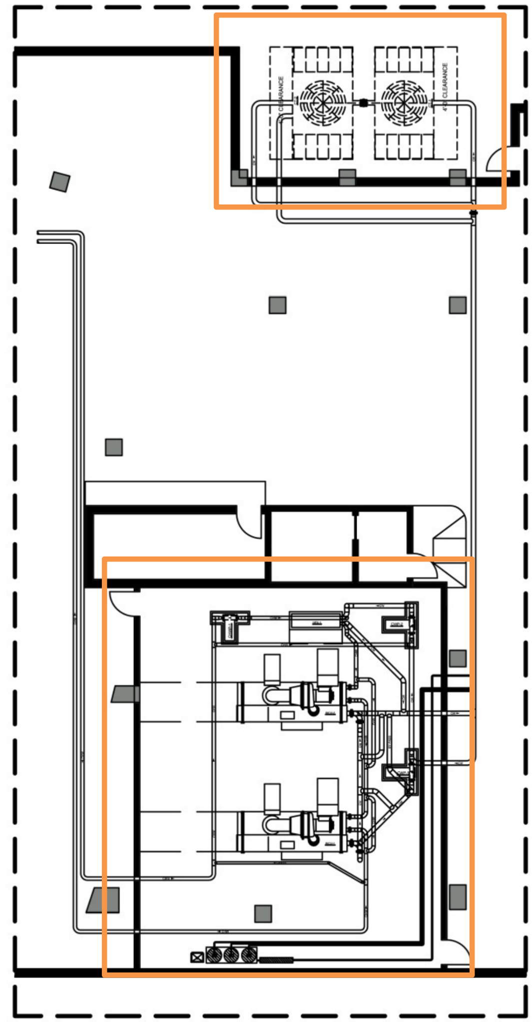
Mechanical Move

- Redesigned the parking level
- Created space for the chillers
- Placed the cooling towers outside next to Rock Creek so air can be drawn
- Impact to “scenic walkway”



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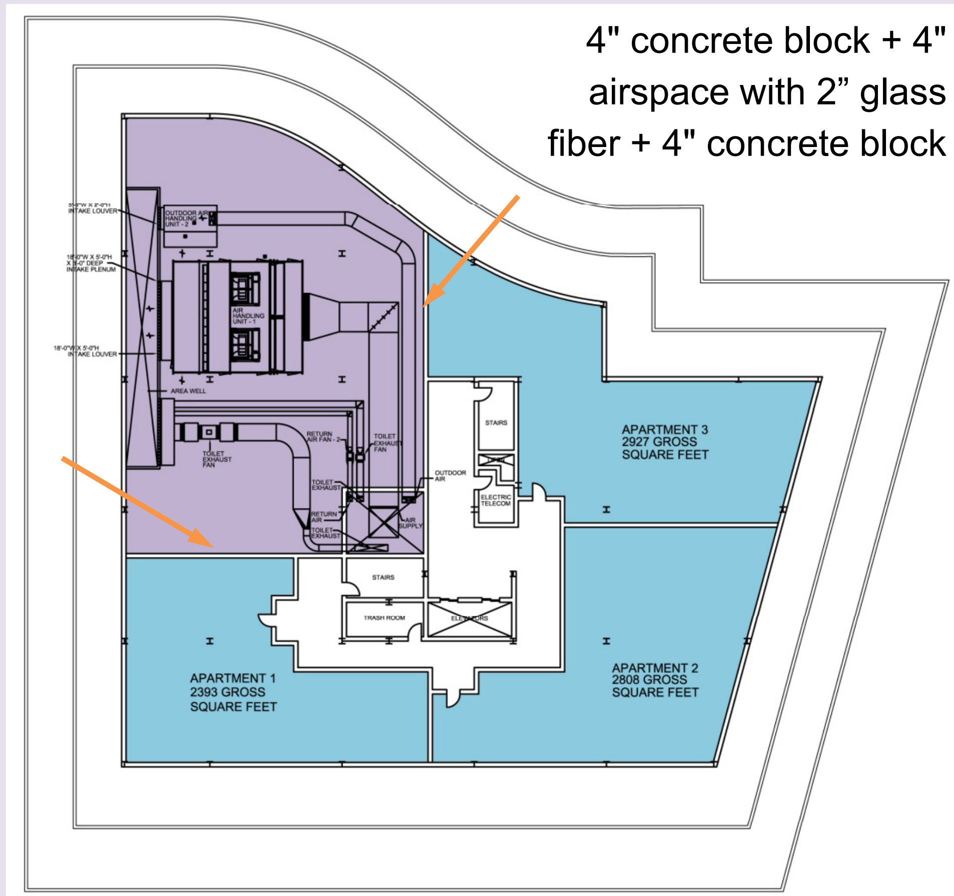
Penthouse Redesign



Breadth Study 2

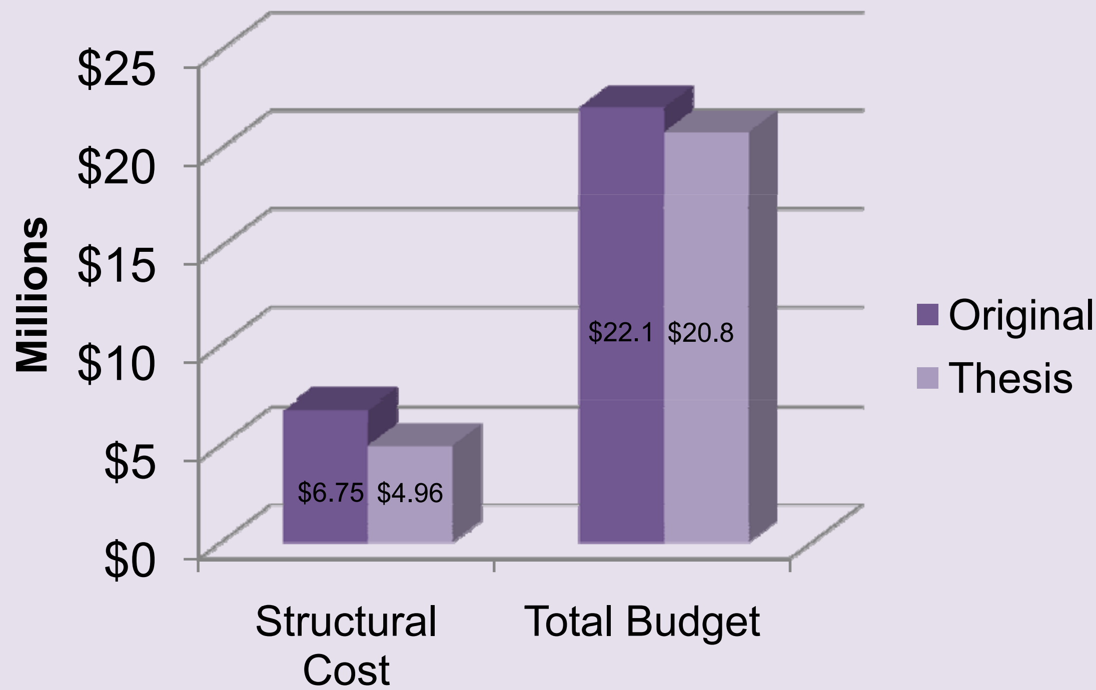
Cost Analysis

Structural Cost Analysis

Item	Amount	Units	Material Unit Cost	Material Cost	Labor Unit Cost	Labor Cost	Total Cost
Columns	134.3	Ton	$838	$112,530	$370	$49,691	$162,221
Beams	480.5	Ton	$1,461	$701,770	$370	$177,785	$879,555
Braces	41.8	Ton	$2,899	$121,178	$370	$15,466	$136,644
Brace Connections	84	EACH	$0	$0	$200	$16,800	$16,800
Shear Connections	1880	EACH	$0	$0	$100	$188,000	$188,000
Shear Studs	11865	EACH	$0	$3,441	$1	$7,712	$11,153
Metal Deck	185147	SF	$4	$740,588	$1	$185,147	$925,735
Concrete (4000 psi)	3143	CY	$85	$267,155	$79	$248,297	$515,452
Welded Wire Fabric	1851.47	CSF	$18	$34,160	$22	$39,807	$73,966
Concrete (5000 psi)	1506	CY	$92	$138,552	$79	$118,974	$257,526
Rebar	54.3	Ton	$230	$12,489	$600	$32,580	$45,069
Fireproofing	50374	SF	$2	$100,748	$2	$100,748	$201,496
New Foundation	Previously Calculated						$901,855
						Subtotal	$4,315,473
						O&P	15%
						Total	$4,962,794

Breadth Study 2

Cost Analysis



- Penthouse Apartment Cost: $548,235 (2.5%)
- Structural Savings: -$1,788,401 (-26%)
- Overall Savings: -$1,240,166 (-6%)

Breadth Study 2

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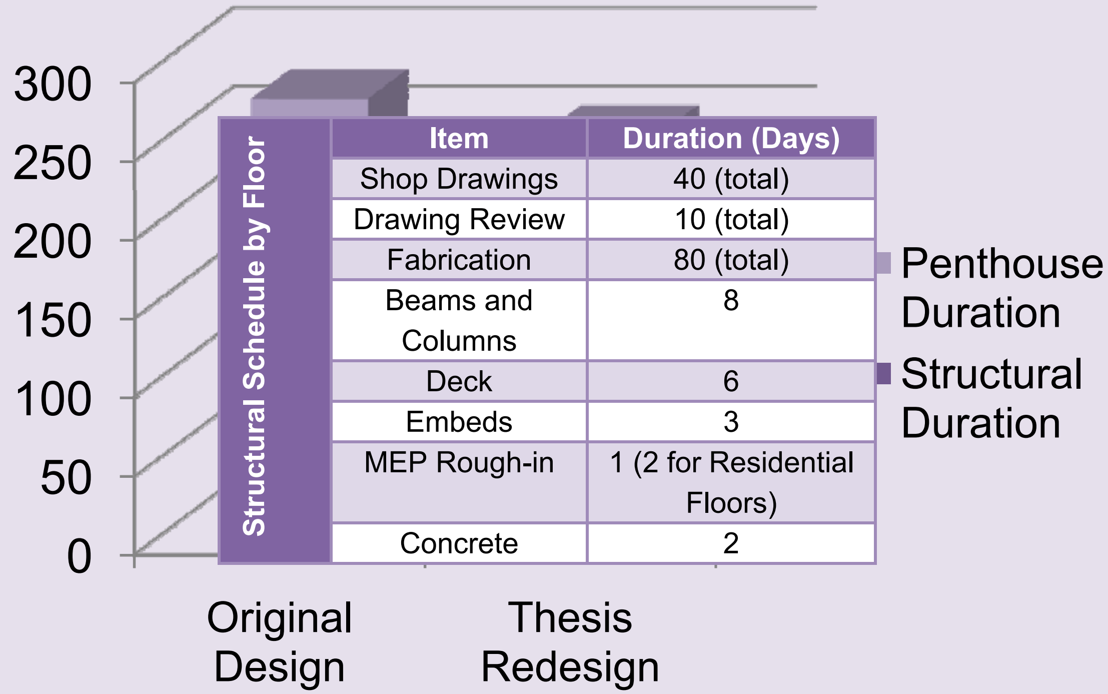
Schedule Analysis



Structural Schedule by Floor

Item	Duration (Days)
Shop Drawings	40 (total)
Drawing Review	10 (total)
Fabrication	80 (total)
Beams and Columns	8
Deck	6
Embeds	3
MEP Rough-in	1 (2 for Residential Floors)
Concrete	2

- Structural Duration: Decrease critical path by 15 days
- Penthouse Duration: Decrease critical path by 8 days
- Overall: Decrease critical path by 23 days (-13%)

Evaluation of Redesign

Evaluation

Structural Redesign in Steel	Completed
Reduce Cost	✓
Retain Original Architecture	✓
Reduce Erection Schedule	✓
Design for Progressive Collapse	✓
Penthouse Redesign	
Move Equipment Without Losing Required Parking	✓
Generate More Revenue by Creating Apartment Space	✓
Cost and Schedule Analysis	
Decrease Overall Structural Cost	✓
Decrease Overall Structural Schedule	✓

Final Conclusions

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Conclusions

- The overall cost decreases significantly, lending more merit to the steel solution.
- The overall schedule decreases and the critical path decreases by 23 days also lending merit to this solution.
- The savings on the foundation is possibly significant enough to offset the extra cost of the progressive collapse mitigating catenary cables and this area warrants further investigation.
- The penthouse redesign potentially generates more revenue for the owner with little impact on the budget and no impact on the schedule.

Structural Steel Solution and Optimization

Questions?

Acknowledgements

Oncore Construction – Armada Hoffler – Tadjer Cohen Edelson – VOA – CMC

Dr. Andres LePage – M. Kevin Parfitt – Robert Holland – Dr. Linda Hanagan

A special thanks to family, friends, and classmates for their much needed support

Reference Slide

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Gravity Loads

Floor Dead Loads		
	Design Load	Reference
Normal Weight Concrete	150 pcf	ACI 318-08
Roof Pavers	25 psf	Structural Drawings
Ballast, Insulation, and waterproofing	8 psf	AISC 13th Edition
Glass Curtain Wall	6.4 psf	Glass Association of North America
Studs and Batt Insulation	4 psf	AISC 13th Edition
Superimposed MEP	12 psf	

Roof Live Loads		
	Design Load	Reference
Public Terrace	100 psf	ASCE7-05
Snow Load	30 psf	ASCE7-05

Floor Live Loads		
Occupancy	Design Load	Reference
Penthouse Machine Room	150 psf	Structural Drawings
Residential	80 psf + 20 psf for partitions	Structural Drawings
Stairways	100 psf	ASCE7-05
Corridors	100 psf	ASCE7-05
Commercial and Plaza Area	100 psf	Structural Drawings

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Lateral Loads

Wind Pressures (North Building N-S)						
Height (ft)	K_z	q_z (psf)	Windward Wall (psf)	Leeward Walls (psf)	Total (psf)	Length in E-W Direction (ft)
77	0.918	16.18	10.54	-3.95	14.49	160
59	0.846	14.91	9.71	-3.95	13.66	190
48.17	0.801	14.12	9.19	-3.95	13.14	206
37.33	0.746	13.15	8.56	-3.95	12.51	206
26.5	0.672	11.84	7.71	-3.95	11.66	206
15.67	0.587	10.35	6.74	-3.95	10.69	206
4.83	0.57	10.05	6.54	-3.95	10.49	162

North Building N-S				
Story	Height (ft)	Force (K)	Shear (K)	Moment (ft-K)
PH	77'-0"	14	0.0	1071
MR	59'-0"	31	14	1805
6	48'-2"	30	44	1442
5	37'-4"	29	74	1069
4	26'-6"	81	103	2143
3	15'-8"	75	184	1178
2	4'-10"	18	259	85
1	-6'-0"	0	277	0
			V = 277	**ΣM = 8792**

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Wind Loads

Wind Pressures (North Building E-W)						
Height (ft)	K_z	q_z (psf)	Windward Wall (psf)	Leeward Walls (psf)	Total (psf)	Length in E-W Direction (ft)
77	0.918	16.18	10.57	-6.61	17.18	135
59	0.846	14.91	9.74	-6.61	16.35	176
48.17	0.801	14.12	9.22	-6.61	15.83	192
37.33	0.746	13.15	8.59	-6.61	15.20	192
26.5	0.672	11.84	7.74	-6.61	14.35	192
15.67	0.587	10.35	6.76	-6.61	13.37	163
4.83	0.57	10.05	6.56	-6.61	13.17	163

North Building E-W				
Story	Height (ft)	Force (K)	Shear (K)	Moment (ft-K)
PH	77'-0"	14	0.0	1075
MR	59'-0"	34	14	1996
6	48'-2"	33	44	1613
5	37'-4"	35	74	1293
4	26'-6"	97	103	2579
3	15'-8"	90	184	1404
2	4'-10"	22	259	107
1	-6'-0"	0	277	0
			V = 325	**ΣM = 10069**

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Seismic Loads (NWC)

Vertical Distribution of Seismic Forces (Moment Frame)					
Level	Height h_x (ft)	Story Weight w_x (K)	Lateral Force Fx (K)	Story Shear Vx (K)	Moment at Floor (ft-K)
P	83'-0"	1533	58	58	4775
MR	65'-0"	1613	41	99	2679
6	54'-2"	1982	38	137	2061
5	43'-4"	1995	27	164	1169
4	32'-6"	1782	15	179	498
3	21'-8"	1109	5	184	109
2	10'-10"	1098	5	186	18
$\Sigma w_i h_i^k$ =	5,103,746	**ΣF_x = V =**	186 K	**ΣM =**	11,330 ft-k

Vertical Distribution of Seismic Forces (Braced Frame)					
Level	Height h_x (ft)	Story Weight w_x (K)	Lateral Force Fx (K)	Story Shear Vx (K)	Moment at Floor (ft-K)
P	83'-0"	1524	64	64	5308
MR	65'-0"	1604	47	111	3069
6	54'-2"	1972	45	156	2414
5	43'-4"	1968	32	188	1394
4	32'-6"	1769	19	207	619
3	21'-8"	1098	7	214	142
2	10'-10"	1076	2	216	26
$\Sigma w_i h_i^k$ =	3,119,645	**ΣF_x = V =**	216 K	**ΣM =**	12,972 ft-k

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Seismic Loads (LWC)

Vertical Distribution of Seismic Forces (Moment Frame)					
Level	Height h_x (ft)	Story Weight w_x (K)	Lateral Force Fx (K)	Story Shear Vx (K)	Moment at Floor (ft-K)
P	83'-0"	1014	38	38	3280
MR	65'-0"	1094	28	67	1831
6	54'-2"	1336	26	93	1399
5	43'-4"	1328	18	111	784
4	32'-6"	1202	10	121	339
3	21'-8"	778	4	125	77
2	10'-10"	747	1	126	12
$\Sigma w_i h_i^k$ =	3,423,048	**$\Sigma F_x = V =$**	126 K	**$\Sigma M =$**	7,623 ft-k

Vertical Distribution of Seismic Forces (Braced Frame)					
Level	Height h_x (ft)	Story Weight w_x (K)	Lateral Force Fx (K)	Story Shear Vx (K)	Moment at Floor (ft-K)
P	83'-0"	1524	47	47	3936
MR	65'-0"	1604	36	83	2334
6	54'-2"	1972	33	117	1807
5	43'-4"	1968	24	141	1044
4	32'-6"	1769	14	155	466
3	21'-8"	1098	5	160	111
2	10'-10"	1076	2	162	19
$\Sigma w_i h_i^k$ =	2,084,780	**$\Sigma F_x = V =$**	162 K	**$\Sigma M =$**	9,718 ft-k

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RAM Computer Model

Wide-Flange	Equivalent Castellated Beam
W12x14	CB12x15
W14x22	CB15x19
W16x26	CB18x22
W21x48	CB27x46
W24x76	CB27x60
W27x84	CB27x76
W30x90	CB27x97
W30x108	CB27x119
W40x167	CB36x162
W40x324	CB50x201
W40x372	CB50x221

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NWC Moment Frame Checks

Check	Comment	Observation
Story Drifts	Allowable story drifts for each level are met in each of the two orthogonal directions. The computed story drifts is at most 81% of the allowable.	OK
Torsion	Accidental Torsion = 5%. Inherent torsion is assumed by applying loads at the center of mass and being resisted by the center of rigidity of the structure.	OK
Redundancy	There are only three frames in each direction so each frame had to be designed to resist more than 25% of the total story shear, however, in SDC=B, ρ is still equal to 1.0.	OK
Modal Period	ASCE7-05 Approximate Period, CuTa: 1.63 sec RAM modal period X Direction: 2.22 sec RAM modal period Y-Direction: 2.29 sec The RAM model period is more than the conservative period approximation of the ASCE7-05 code.	OK
Member Spot Checks	Columns and beams are approximately 30% to 98% of their total design strength based off their interaction equations. This occurs due to member updates for size uniformity and drift improvement.	Some System Overdesign

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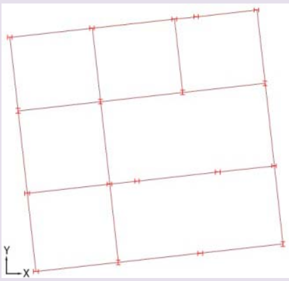
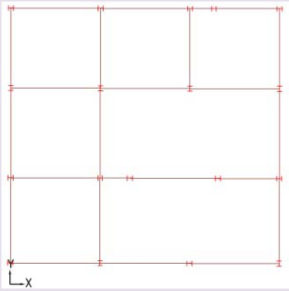
NWC Moment Frame Checks

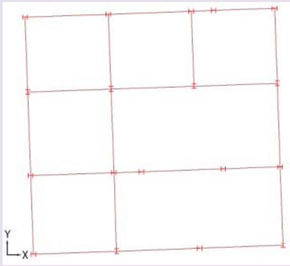
- Wind Drift:
  - Overall Deflection — H/400 Limit
  - N-S: 1.37” < 2.31”
  - E-W: 1.20” < 2.31”
  - Interstory Deflection — H/400 Limit
  - N-S: 0.29” < 0.32”
  - E-W: 0.26” < 0.32”
- Seismic Drift:
  - Interstory Drift — $0.02h_{sx}$ Limit
  - N-S: 1.47” < 2.60”
  - E-W: 1.35” < 2.60”



Tz = 3.27 seconds



T_y = 2.29 seconds



T_x = 2.22 seconds

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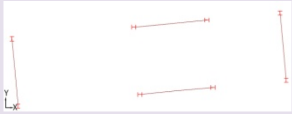
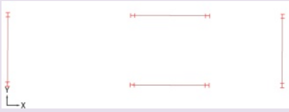
NWC Braced Frame Checks

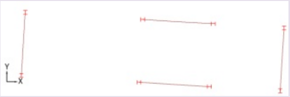
- Wind Drift:
  - <u>Overall Deflection H/400 Limit</u>
  - N-S: 0.64” < 2.31”
  - E-W: 0.75” < 2.31”
  - <u>Interstory Deflection H/400 Limit</u>
  - N-S: 0.10 < 0.32”
  - E-W: 0.13” < 0.32”
- Seismic Drift:
  - <u>Interstory Drift $0.02h_{sx}$ Limit</u>
  - N-S: 0.60” < 2.60”
  - E-W: 0.63” < 2.60”
- Modal Period:



Tz = 2.18 seconds



T_y = 1.71 seconds



T_x = 1.49 seconds

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Cantilever Solution

Hanger	Gravity Load	P_u (K)	Shape	Rupture ΦP_n (K)
A1	125.02	146.37	HSS 7.0x0.250	161
B1	237.93	278.56	HSS7.0x0.500	311
C1	227.81	266.71	HSS7.0x0.500	311
D1	217.48	254.62	HSS7.0x0.500	311
E1	222.61	260.63	HSS7.0x0.500	311
F1	193.71	226.79	HSS7.0x0.375	238
G1	93.5	109.47	HSS7.0x0.188	122
G2	160.64	188.07	HSS7.0x0.312	200
147	384.09	301.02	HSS7.0x0.500	311
179, 28.33	143.9	168.47	HSS7.0x0.312	200
186.67, 56.83	223.32	261.46	HSS7.0x0.500	311
195.33, 86.83	217.28	254.39	HSS7.0x0.500	311
203, 113.83	112.32	131.50	HSS 7.0x0.250	161

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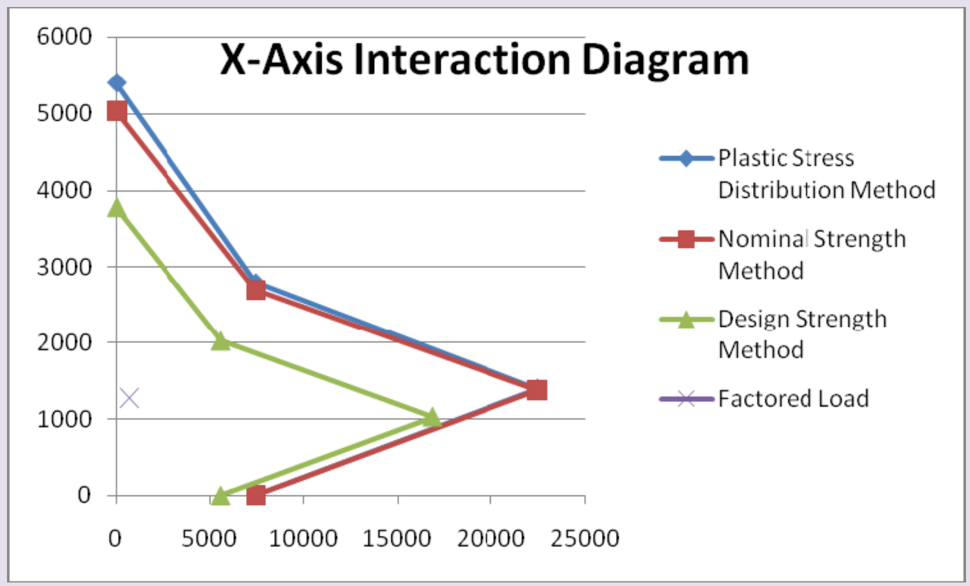
Column Interaction Diagram

X-Axis	Plastic Stress Distribution Method		Nominal Strength Method		Design Strength Method	
Point	P (K)	M (in-K)	P (K)	M (in-K)	P (K)	M (in-K)
A	5397	0	5036	0	3777	0
C	2788	7448	2690	7448	2018	5586
D	1394	16389	1369	16389	1027	12292
B	0	7448	0	7448	0	5586



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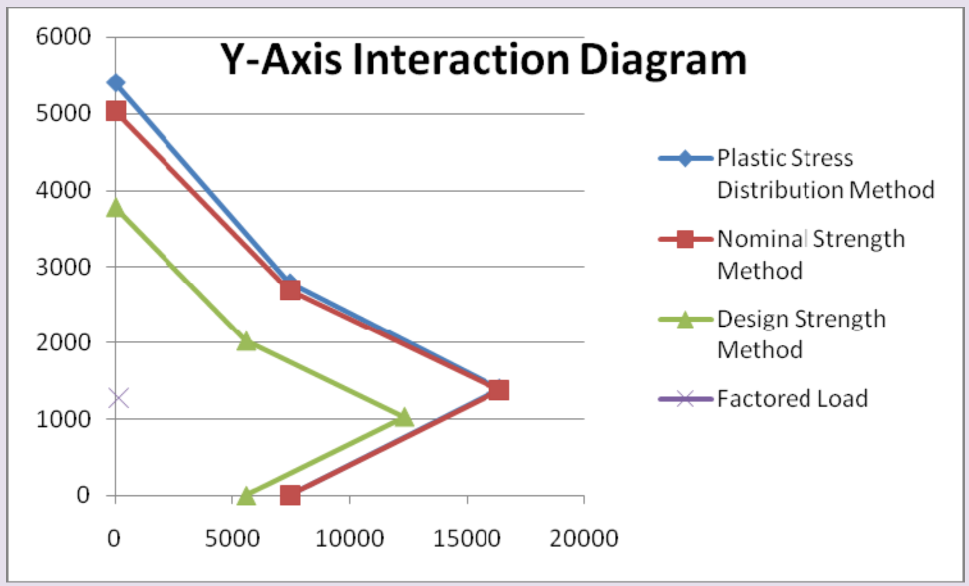
Column Interaction Diagram

X-Axis	Plastic Stress Distribution Method		Nominal Strength Method		Design Strength Method	
Point	P (K)	M (in-K)	P (K)	M (in-K)	P (K)	M (in-K)
A	5397	0	5036	0	3777	0
C	2788	7448	2690	7448	2018	5586
D	1394	22470	1369	22470	1027	16852
B	0	7448	0	7448	0	5586



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Garage Column and Progressive Collapse

Foundation Cost Estimate			
Steel Rebar:			
Cost: $830/ton	Total Original Tonnage	358.63	$297,663
Contractor Cost	Total New Tonnage	304.84	$253,013
		Total Steel Savings:	-$44,650 (-15%)
4000 psi NW Concrete:			
Cost: $115/CY	Total Original Volume (CY)	6,156	$707,974
Contractor Cost	Total New Volume (CY)	5,387	$619,477
		Total Concrete Savings:	-$88,497 (-13%)
460 HP Dozer, 150' Haul, Clay Soil Excavation:			
Cost: $3.18/CY	Total Original Volume (CY)	10,006	$31,820
RS Means Cost	Total New Volume (CY)	9,234	$29,365
		Total Excavation Savings:	-$2,455 (-7.7%)
		Total Original Cost:	$1,037,457
		Total New Cost:	$901,855
		Total Savings:	-$135,602 (-13%)

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Parking Study

Original Parking Count			
Building Use	Requirements	Parking Required	Parking Provided
General Office 122,520 SF	One space per 1,800 SF over 2,000 SF	67 Spaces	67 Spaces
Residential 23 Units	One space per 3 residential units	8 Spaces	8 Spaces
	Total Spaces Required	75 spaces	75 Spaces
	Handicapped Spaces Required	3 Spaces	4 Spaces
	Allowable Compact Spaces (40% of Total)	30 Spaces Max.	30 Spaces

New Parking Count			
Building Use	Requirements	Parking Required	Parking Provided
General Office 122,520 SF	One space per 1,800 SF over 2,000 SF	67 Spaces	67 Spaces
Residential 26 Units	One space per 3 residential units	9 Spaces	9 Spaces
	Total Spaces Required	76 spaces	76 Spaces
	Handicapped Spaces Required	4 Spaces	4 Spaces
	Allowable Compact Spaces (40% of Total)	30 Spaces Max.	30 Spaces

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Acoustics Study

Transmission Loss (dB)						
Construction	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
8" painted concrete block wall	34	40	44	49	59	64
4" Airspace Improvement in TL	10	12	24	30	35	35
4" concrete block + 4" airspace + 4" concrete block with 2" glass fiber in airspace	44	52	68	79	94	99

Sound Pressure Level (dB)						
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Sound in Source Room	83	85	86	84	83	81
Background Noise Level (RC-25)	40	35	30	25	20	15
Required Noise Reduction	43	50	56	59	63	66
Provided Noise Reduction	44	52	68	79	94	99
Acceptable	Yes	Yes	Yes	Yes	Yes	Yes

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Zoning Impacts

Zoning: W-2			
FAR	Allowed Square Footage	Original Provided Square Footage	Thesis Provided Square Footage
Total: 4.0	245,040	167,298	185,426
Office: 2.0	122,520	122,520	122,520
Residential: 2.0	122,520	54,778	62,906

- More residential space is allowed by code

Waterproofing

- Parking level is below the water table
- Needed to prevent water from infiltrating
- Provided a way for water to exit
- Redesigned waterproofing details to reflect current job
- Generated a set of Good Practice guidelines for waterproofing

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Waterproofing Checklist

1. **Hire a building envelop consultant to review the waterproofing details.** On most projects, architects normally deal with waterproofing details, but there is no one in the field checking the work. Most waterproofing details in construction documents are just standard details that have not been tailored for specific jobs. A consultant can perform a document review of the details and point out problem areas and this service normally only costs around $5,000. This may seem costly, but it can save time and money later in the project when waterproofing details either need to be clarified, or are installed incorrectly and need to be taken out and reinstalled.

2. **Hire a consultant to oversee correct installation of the waterproofing during the construction of the building.** This is an expansive endeavor, but it is cheaper than hiring the consultant a few years after the final fit-out of the building when leaks start to occur and all the waterproofing has to be ripped out and reinstalled.

3. **Hire experienced construction firms.** There is an organization called the National Organization of Waterproofing and Structural Repair Contractors. This organization is a professional trade association whose members are required to uphold a strict standard of practice and cannon of ethics. These documents can be reviewed on their website http://nawsrc.org. It is also possible to locate members and suppliers in the area of the construction project who are required to do the best possible job of waterproofing the construction job.

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Waterproofing Checklist

4. **Ensure that the waterproofing is continuous around the entire building.** This is one of the most important details. Even a small tear in the waterproofing can allow enough water to penetrate to the interior of the building that an identifiable leak can be found. Ideally, there should be no penetrations in the waterproofing, but this is impossible as windows and doors are a necessary part of design. Unnecessary penetrations as part of installation should be avoided. These include nail holes, tears in the waterproofing sheets, or outlet penetrations to name a few. If these occur, a new sheet of waterproofing should be installed, or at the very least, they should be repaired with mastic.

5. **Create a mock-up of the system and/or perform tests during construction.** It is possible to hire testing firms to come in and test curtain walls, brick panels, and other water sensitive areas to find trouble areas before the fit-out of the building when they will become harder and more costly to repair. These tests can cost approximately $10,000/day, but they will again be cheaper than trying to fix the problem areas later during the lifetime of the building when leaks occur.

6. **Perform regular building maintenance.** Replacing all the sealant on a building every 5 years is cheaper than removing all the curtain walls, ripping out the steel that is now corroded because of water infiltration, and then replacing all the steel and the curtain walls every 10 years.

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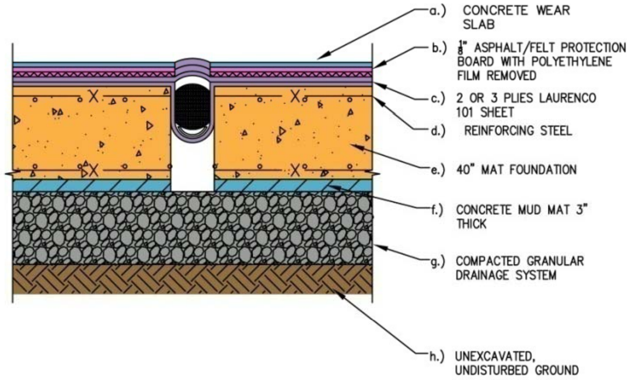
Waterproofing Detail

JOINT INSTALLATION:

1. COAT BOTH SIDES OF CONSTRUCTION JOINT WITH ADHESIVE
2. LOOP IN 1 PLY OF WATERPROOFING SHEET INTO JOINT
3. COAT WITH ADHESIVE
4. INSERT NEOPRENE RUBBER ROD 1½ TIMES THE SIZE OF THE JOINT, SQUEEZE TO INSERT AND USE WET ADHESIVE
5. COAT WITH ADHESIVE
6. INSTALL FLASHING OVER JOINT
7. COAT WITH ADHESIVE
8. APPLY CONTINUOUS SHEETS OF WATERPROOFING OVER JOINT
9. INSTALL SEALANT OVER WATERPROOFING TO PROVIDE WEARING SURFACE



General Notes:

1. Install all materials and details in accordance with manufacturer recommendations and details.
2. Submit product data and perform adhesion tests on actual substrates prior to wide scale installation of work.
3. Notify owner, general contractor, and consultant (if one is retained) before using a substitute product than the one specified.
4. All dimensions to be field verified and coordinated with owner, general contractor, and consultant (if one is retained).

Notes: Component Functions

a. Completes aesthetic affect.
b. Protects membrane
c. Prevents moisture entry
d. Provides structural support to wear surface
e. Provides structural support to wear surface
f. Provides uniform slab base
g. Promotes water flow to subdrain pipes or sumps
h. Slab system foundation material

BELOW GRADE MAT - WATERPROOF SYSTEM

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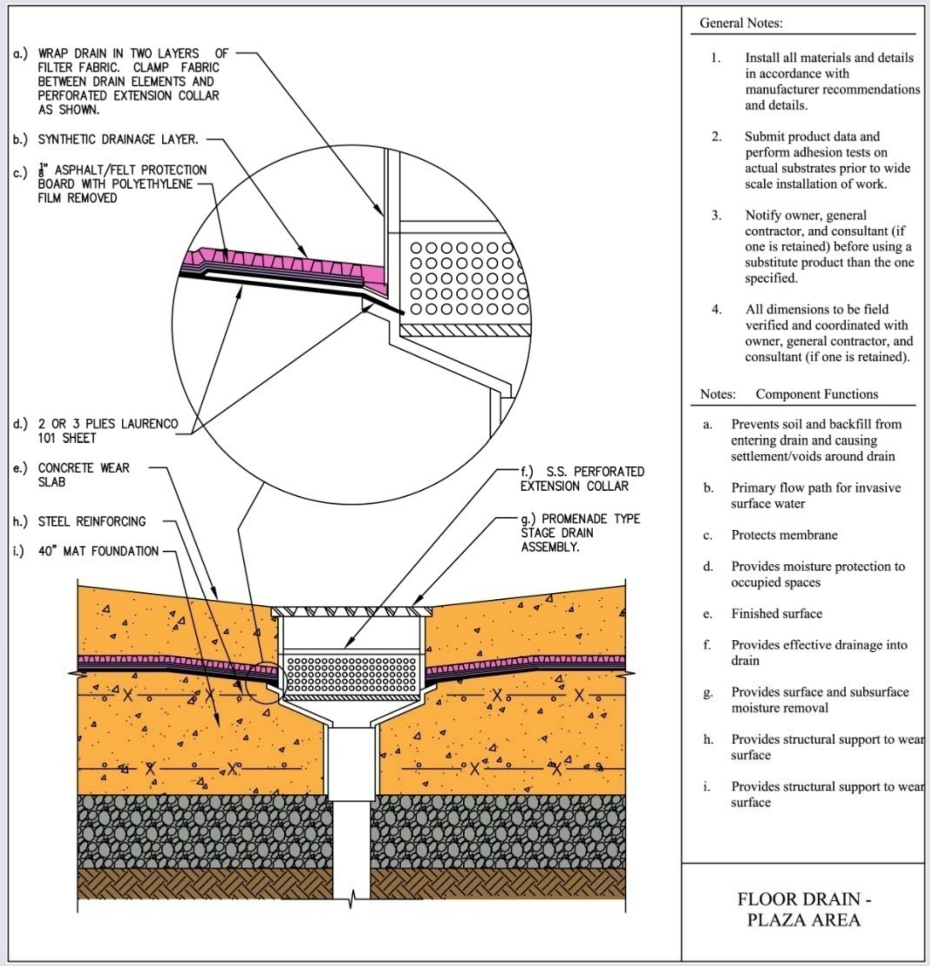
Waterproofing Detail



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Structural Cost Information

Column Takeoff

Column	Length (ft)	Cost/ft	Cost
W14x43	1800.50	$29.90	$53,834.95
W14x61	715.00	$40.83	$29,193.45
W14x74	335.90	$47.52	$15,961.97
W14x82	216.60	$52.25	$11,317.35
W14x90	260.00	$58.58	$15,230.80
W14x109	162.50	$71.06	$11,547.25
W14x120	65.00	$77.76	$5,054.40
W14x132	65.00	$85.04	$5,527.60
W14x145	32.50	$112.75	$3,664.38
		Total Cost:	$151,332.14
		Adjusted Cost:	$112,529.03

Beam Takeoff

Beam	Length (ft)	Cost/ft	Cost
CB12x15	6863.50	$32.77	$224,916.90
CB15x19	5383.45	$24.57	$132,271.37
CB18x26	2592.00	$26.00	$67,392.00
CB27x46	6671.07	$42.23	$281,719.29
CB27x60	2070.14	$51.03	$105,639.24
CB27x76	877.00	$65.83	$57,732.91
CB27x97	379.59	$81.97	$31,114.99
CB27x119	160.55	$98.35	$15,790.09
CB36x162	139.50	$125.81	$17,550.50
CB50x221	50.00	$193.45	$9,672.50
		Total Cost:	$943,799.78
		Adjusted Cost:	$701,799.84

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Brace Takeoff

Brace	Length (ft)	Cost/ft	Cost
HSS7.5x0.5	865.30	$75.46	$65,295.54
HSS10.0x0.625	207.50	$114.30	$23,717.25
		Total Cost:	$89,012.79
		Adjusted Cost:	$66,189.00

Steel Deck Takeoff

Floor	Area (ft^2)	Cost/ft^2	Cost
Roof	16269	$1.10	$17,895.90
Penthouse	25914	$1.10	$28,505.40
Sixth	32427	$1.10	$35,669.70
Fifth	32427	$1.10	$35,669.70
Fourth	32427	$1.10	$35,669.70
Third	28646	$1.10	$31,510.60
Second	17037	$1.10	$18,740.70
		Total Cost:	$185,765.80
		Adjusted Cost:	$138,133.54

Concrete Takeoff

Floor	Area (ft^2)	Thickness (ft)	Volume (yd^3)	Cost/yd^3	Cost
Roof	16269	0.46	276	$85.00	$23,474.56
Penthouse	25914	0.46	440	$85.00	$37,391.34
Sixth	32427	0.46	550	$85.00	$46,788.96
Fifth	32427	0.46	550	$85.00	$46,788.96
Fourth	32427	0.46	550	$85.00	$46,788.96
Third	28646	0.46	486	$85.00	$41,333.35
Second	17037	0.46	289	$85.00	$24,582.71
				Total Cost:	$267,148.83

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Penthouse Cost Analysis

- Penthouse Redesign Costs and Potential Profit

Interior Cost	Number of Units	3
	Average size	2709 SF
	Size Modifier	0.93
	Cost Per Unit	$196,500
	Modified Cost Per Unit	$182,745
	Total Cost	$548,235

- 2.5% increase to original budget

Potential Profit From Added Units	# of Units Added	3
	Average Cost of Unit	$1,500,000.00
	Total Possible Profit	$4,500,000.00

- $4,500,000 potential gross profit

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Penthouse Schedule Analysis

	Item	Duration (Days)
Interior Schedule	Layout	2
	Mechanical Ducts/Shafts	2
	Vertical Plumbing Risers	2
	Vertical Fire Protection Risers	3
	Plumbing Rough-In	5
	Sprinkler Rough-In	5
	Duct Rough-in	15
	Electrical Rough-In	7
	CMU Walls	9
	Mechanical Controls Rough-In	3
	Set Mechanical Equipment	20
	Mechanical and Plumbing Insulation	5
	Metal Stud Framing	2
	Shaftwall Fireproofing	2
	In-Wall Electrical Rough-In	3
	Inspections	1
	Hang Drywall	2
	Finish Drywall	1
	Prime Paint	2
	Point Up	1
	Hang Doors	1
	Set Light Fixtures	5
	Finish Hardware	2
	Mechanical Trim-Out	1
	Electrical Trim-Out	1
	Punch Out	5

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Typical Framing Plan (South Building)

- Post-Tensioned flat slab
- NWC moment frames
- Embassy located on first floor with a floor height of 13’-0”
- Typical floor height is 10’-6” with a 12’-0” penthouse
- Foundation: mat slab