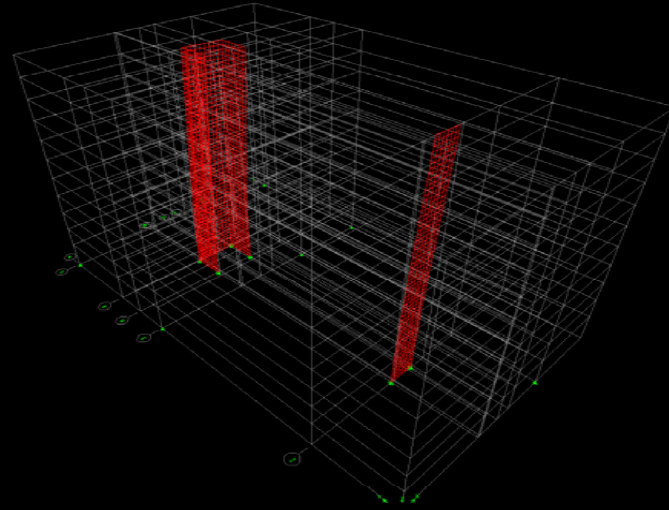




City Vista | Building 2

460 L Street Washington D.C.

Sr. Thesis Presentation
April 14, 2008



Gravity System Optimization

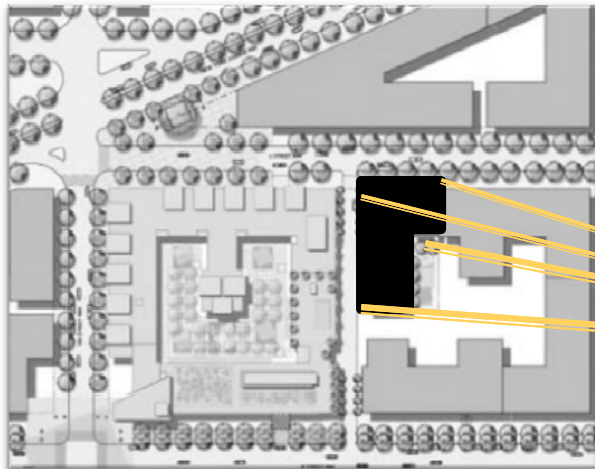
Julie Davis | Structural Option
Penn State University



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City Vista | Building 2

Building Stats

| **Building Stats** | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



City Vista | Building 2 | 460 L Street Washington D.C 2001



Location: Building 2: 3 building mixed use complex
5th and K, Washington D.C

Size: 11 stories
324,000 sqft

Height: 110'-6"
128'-5" [including mechanical penthouse]

Use: Residential [149 condos]

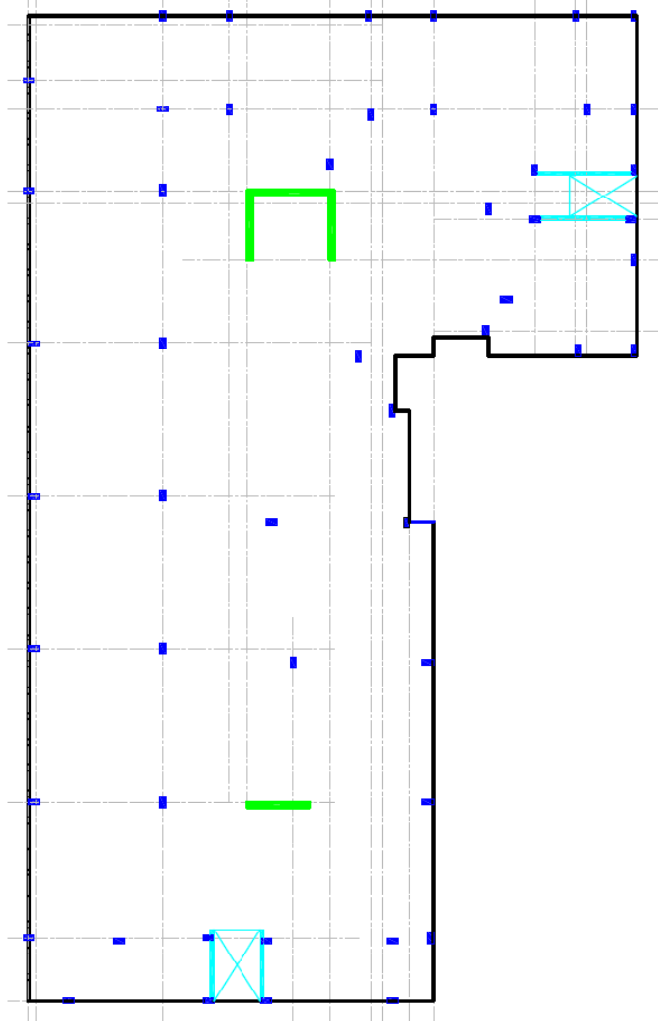
Constructed Start: December 2005
Finish: December 2007



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Building System : Foundation

| **Building Stats** | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Foundation System

Slab On Grade:

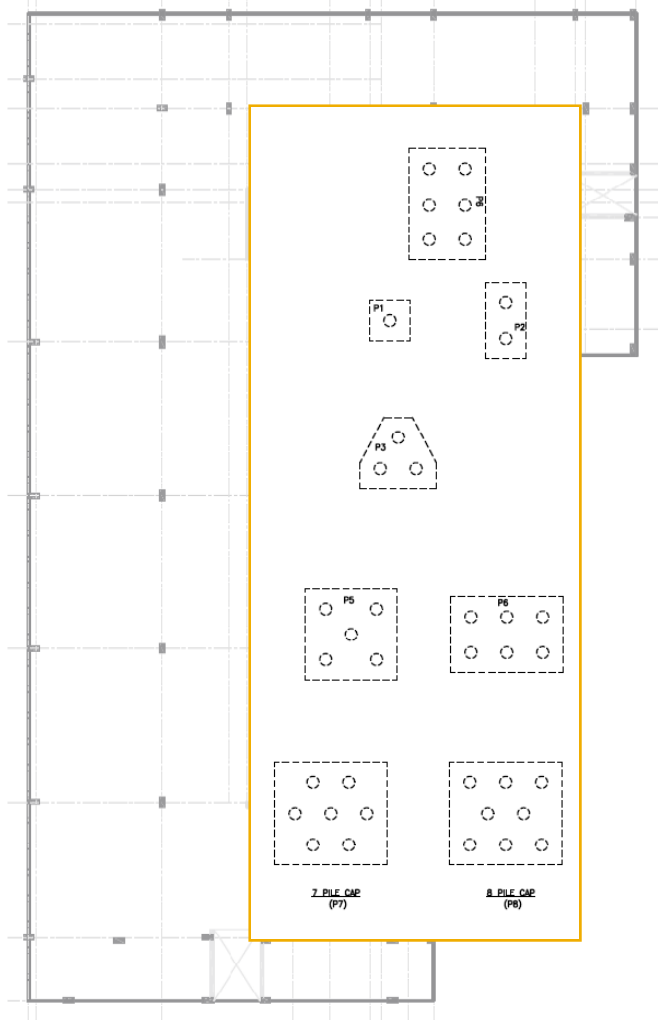
- Depth: 4"
- $f'c = 4000$ psi
- Reinforcing: Conventional Reinforcing



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City Vista | Building 2

Building System : Foundation

| **Building Stats** | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Foundation System

Slab On Grade:

- Depth: 4"
- $f'c = 4000$ psi
- Reinforcing: Conventional Reinforcing

Deep Foundation system:

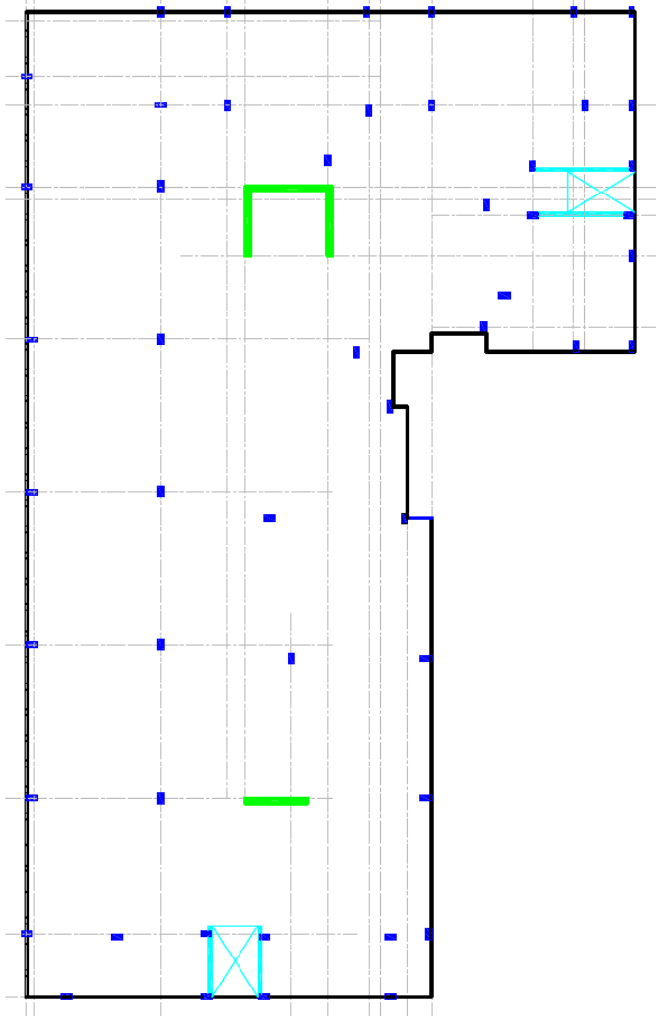
- Augured cast in place piles
- Quantity: 250 piles
- Size: 16" Diam.
- Depth: 60-65 ft



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City Vista | Building 2

Building System : Gravity

| **Building Stats** | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Gravity System

Slab

- 2-way flat plate
- 7 1/2" Thick
- $f'_c = 6000$ psi

Reinforcing: Post tension tendons
Banded: North - South
Uniform: East - West

Columns

- (52)- cast in place
- Typical Size : 16" x 28"
- $f'_c = 5000$ psi

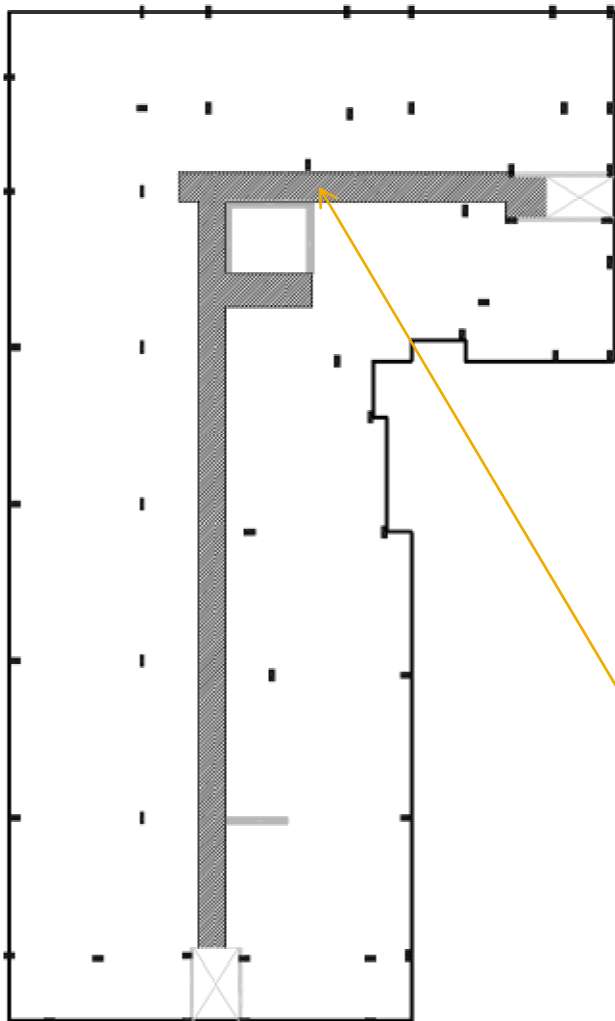
Reinforcing: Conventional Reinforcing
Typical : (12)-#9 Base
(8) - #9 Top



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Building System : Gravity

| **Building Stats** | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Gravity System

Slab

- 2-way flat plate
- 7 1/2" Thick
- $f'c = 6000$ psi

Reinforcing: Post tension tendons

Banded: North - South

Uniform: East - West

Columns

- (52)- cast in place
- Size : 16" x 28"
- $f'c = 5000$ psi

Reinforcing:

Loading

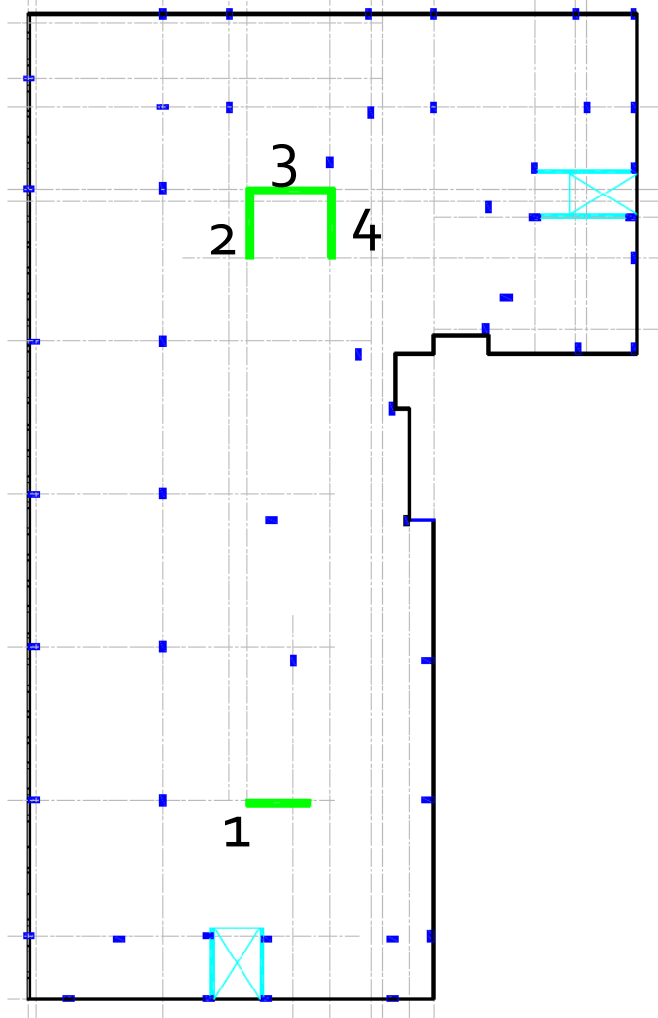
- Pattern : 100 psf corridor
- White : 40 psf residential



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Building System : Lateral

| **Building Stats** | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Lateral System

Shear Walls

- (4) Shear Walls
- Cast in place
- $f'_c = 5000$ psi

Wall 1 : 1ft x 11 ft

Wall 2 : 1 ft x 13 ft

Wall 3 : 1 ft x 18 ft

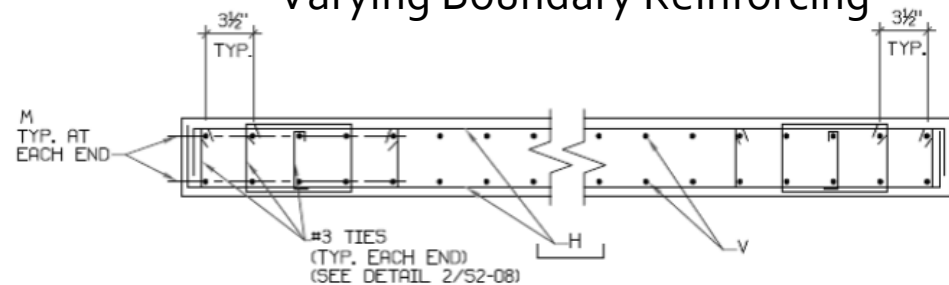
Wall 4 : 1 ft x 13 ft

-Reinforcing:

Flexural : #5 @ 12" O.C

Shear : # 4 @ 12" O.C

Varying Boundary Reinforcing

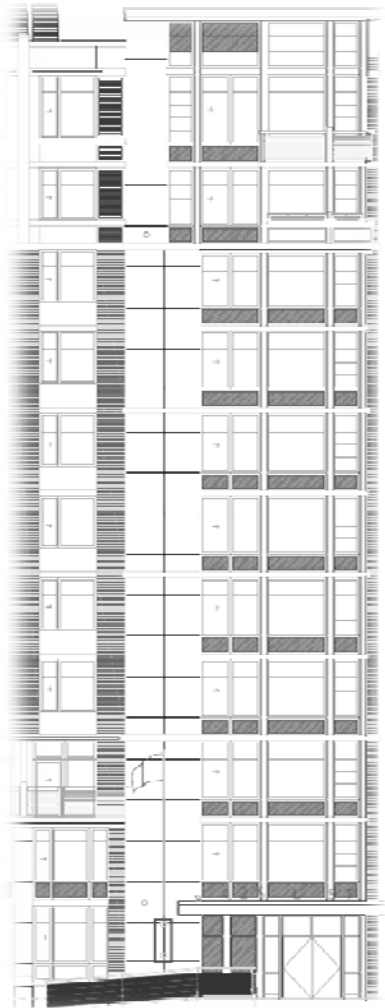




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Proposal: Objectives

| Building Stats | **Proposal** | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



OBJECTIVES

1. Redesign Gravity System

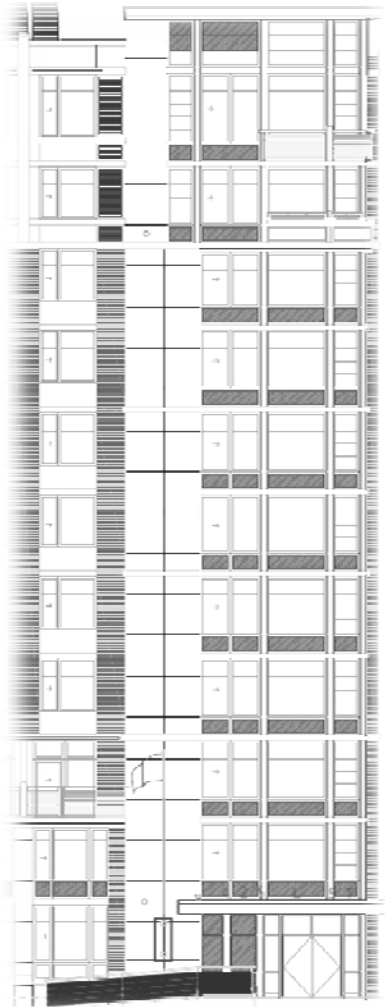
—————> Developer Options



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Proposal: Post Tension System

| Building Stats | **Proposal** | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Post Tension System

Advantages

1. Floor to Floor Height = 9'-4"
2. Slab thickness = 7 1/2"
3. Irregular Column Grid → Long Clear Spans
Open Plan Condos
4. Finished Ceiling
5. Lightweight

Disadvantages

1. Shortening: Tension cracks around perimeter
2. Remodeling: Very Limited due to tendons
3. On site erection time



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Proposal: Pre-Cast System

| Building Stats | **Proposal** | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



Pre-Cast System

1. Finished Ceiling
2. Similar floor to ceiling height
3. Thin Slab : min thickness 6"
4. Lightweight

Advantages

1. Structural Integrity: Cast in monitored environment
2. LEED Possibility
3. Faster Erection Time : Less field labor



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Structural Option
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Proposal: Objectives

| Building Stats | **Proposal** | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |



OBEJECTIVES

1. Redesign Gravity System
 - Optimize: Pre-Cast Gravity System
—————> Developer Options
2. Check Existing Lateral System
 - New Building Weight
 - E-Tabs
 - Serviceability / Strength
3. Constructability :
 - Cost
 - Schedule
 - Architecture Impacts



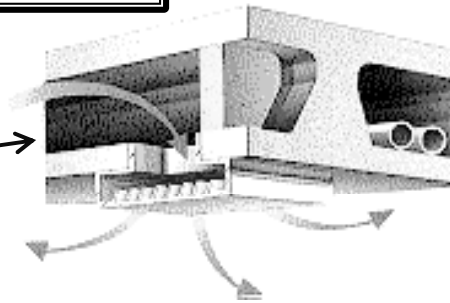
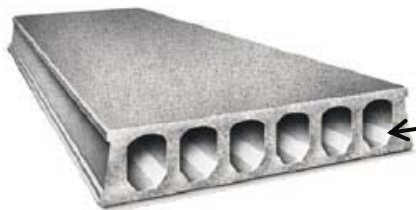
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Preliminary Design : Decisions

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

System Comparison

1. Hollow core vs. Solid slab
2. Composite topping vs. $\frac{3}{4}$ " leveling topping
3. Ridged diaphragm vs. flexible



- longer spans
- Sound absorption
- Fast erection
- Finished ceiling
- Voids used to run electrical and mechanical equipment



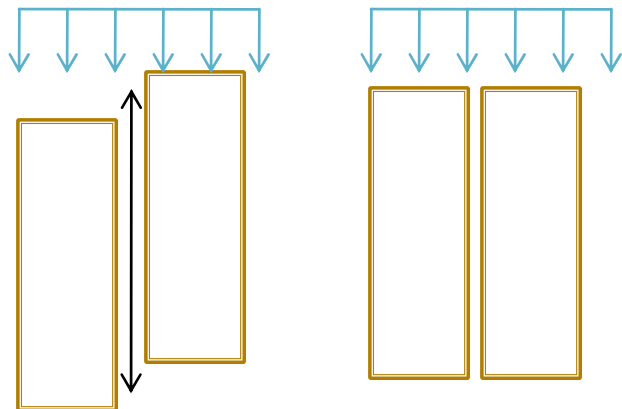
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Preliminary Design : Decisions

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

System Comparison

1. Hollow core vs. Solid slab
2. Composite topping vs. $\frac{3}{4}$ " leveling topping
3. Ridged diaphragm vs. flexible



Transfer forces

- Member to member connections
 - Added Stiffness
 - Distributes loads
 - Potentially: Eliminate need to keyhole and grout planks.
 - Fire Proofing
- Horizontal Shear < 80 psi**



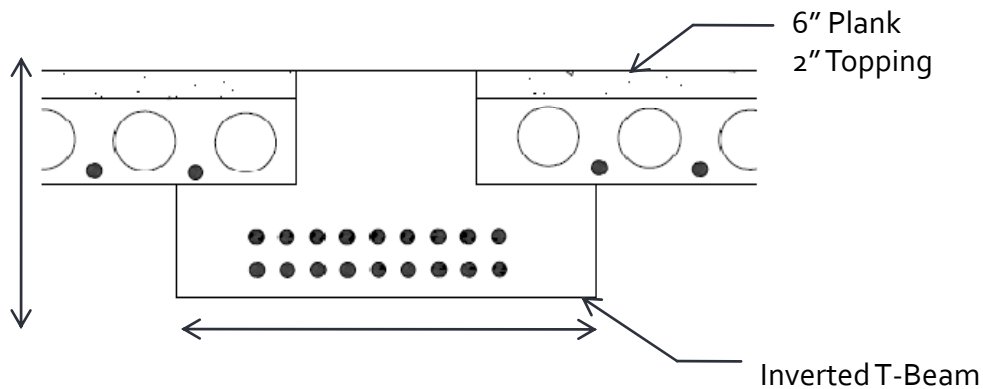
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Structural Option
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Preliminary Design : Considerations

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

1. Floor Composition
2. Architecture





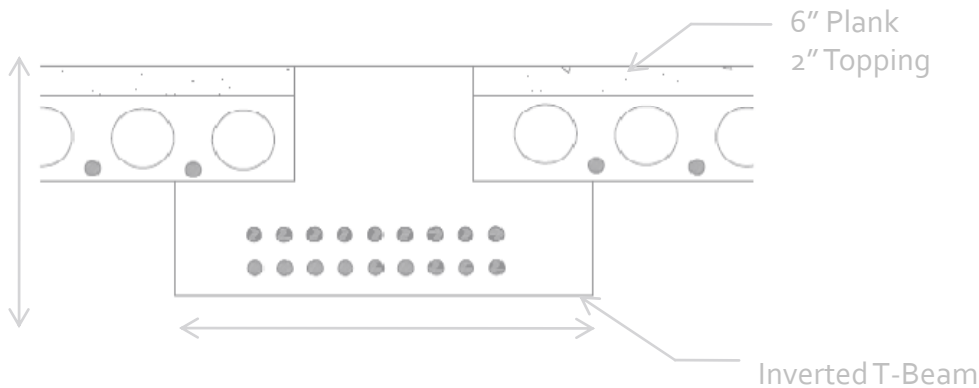
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Preliminary Design : Considerations

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

1. Floor Composition
2. Architecture
3. Manufacturing
4. Erection / Transportation





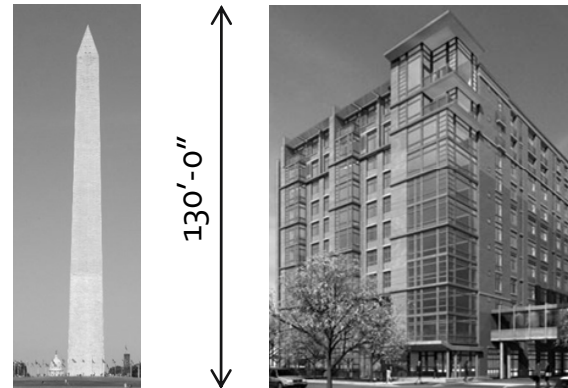
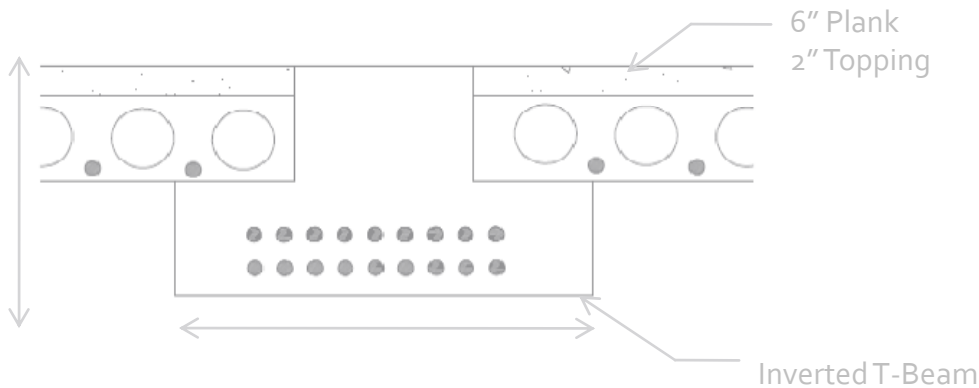
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Preliminary Design : Considerations

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

1. Floor Composition
2. Architecture
3. Manufacturing
4. Erection / Transportation
5. Height Restriction



CONTROLLING FACTOR



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Preliminary Design : Considerations Cont.

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

1. Floor Composition
2. Architecture
3. Manufacturing
4. Erection / Transportation
5. Height Restriction
6. Fireproofing



- Type II
- Floors: 2 hr fire rating
- 6" plank → 1" Topping



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Preliminary Design : Considerations Cont.

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

1. Floor Composition
2. Architecture
3. Manufacturing
4. Erection / Transportation
5. Height Restriction
6. Fireproofing
7. Span / Depth Ratio
8. Cost



Type II
Floors: 2 hr fir rating
6" plank \longrightarrow 1" Topping

Span / Depth Ratio

Hollow Core Floor Slabs 30-40

Hollow Core Roof Slabs 40-50

Beams 10-20



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City Vista | Building 2

Preliminary Design : Considerations Cont.

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

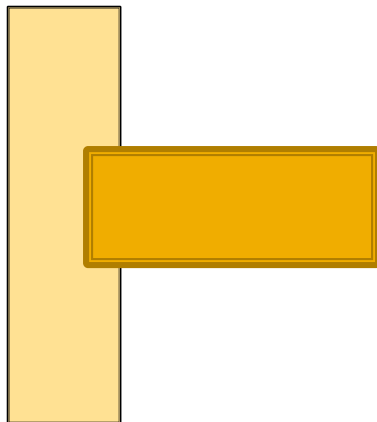
1. Floor Composition
2. Architecture
3. Manufacturing
4. Erection / Transportation
5. Height Restriction
6. Fireproofing
7. Span / Depth Ratio
8. Cost
9. Connections



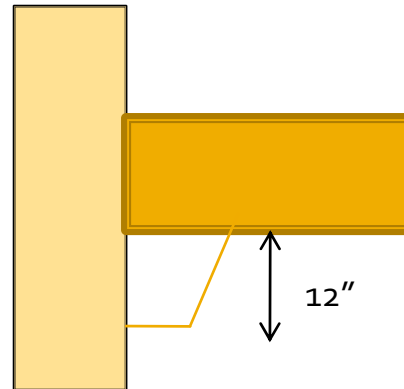
Type II
Floors: 2 hr fir rating
6" plank → 1" Topping

Span / Depth Ratio

Hollow Core Floor Slabs	30-40
Hollow Core Roof Slabs	40-50
Beams	10-20



Hanger
-Prone to manufacturing error
-Reduce floor to ceiling height



Corbel
-Easy Erection
-Require a lot of Space



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Structural Option
City Vista | Building 2

Preliminary Design : Considerations Cont.

| Building Stats | Proposal | **Preliminary Design** | Gravity System | Lateral System | Constructability | Conclusion |

Optimization of System

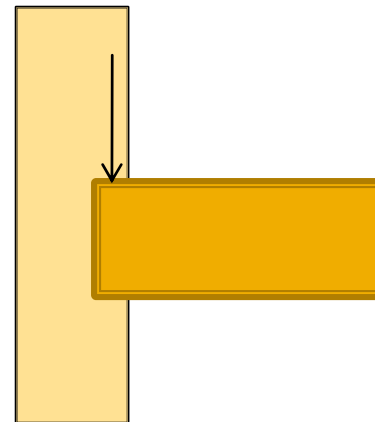
1. Floor Composition
2. Architecture
3. Manufacturing
4. Erection / Transportation
5. Height Restriction
6. Fireproofing
7. Span / Depth Ratio
8. Cost
9. Connections
10. Eccentric moment



Type II
Floors: 2 hr fir rating
6" plank \longrightarrow 1" Topping

Span / Depth Ratio

Hollow Core Floor Slabs	30-40
Hollow Core Roof Slabs	40-50
Beams	10-20

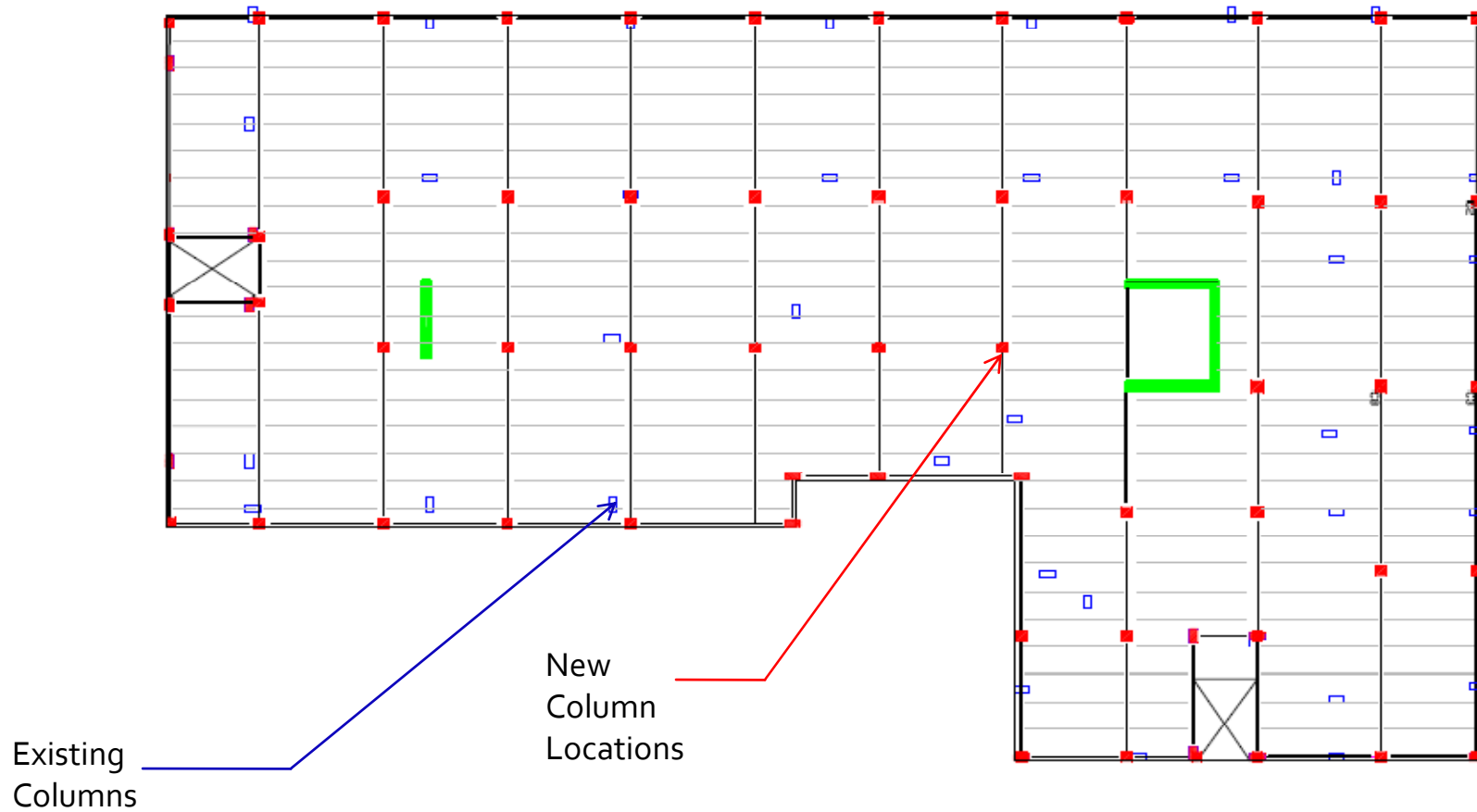




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Structural Option
City Vista | Building 2

Gravity System : Column Grid

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

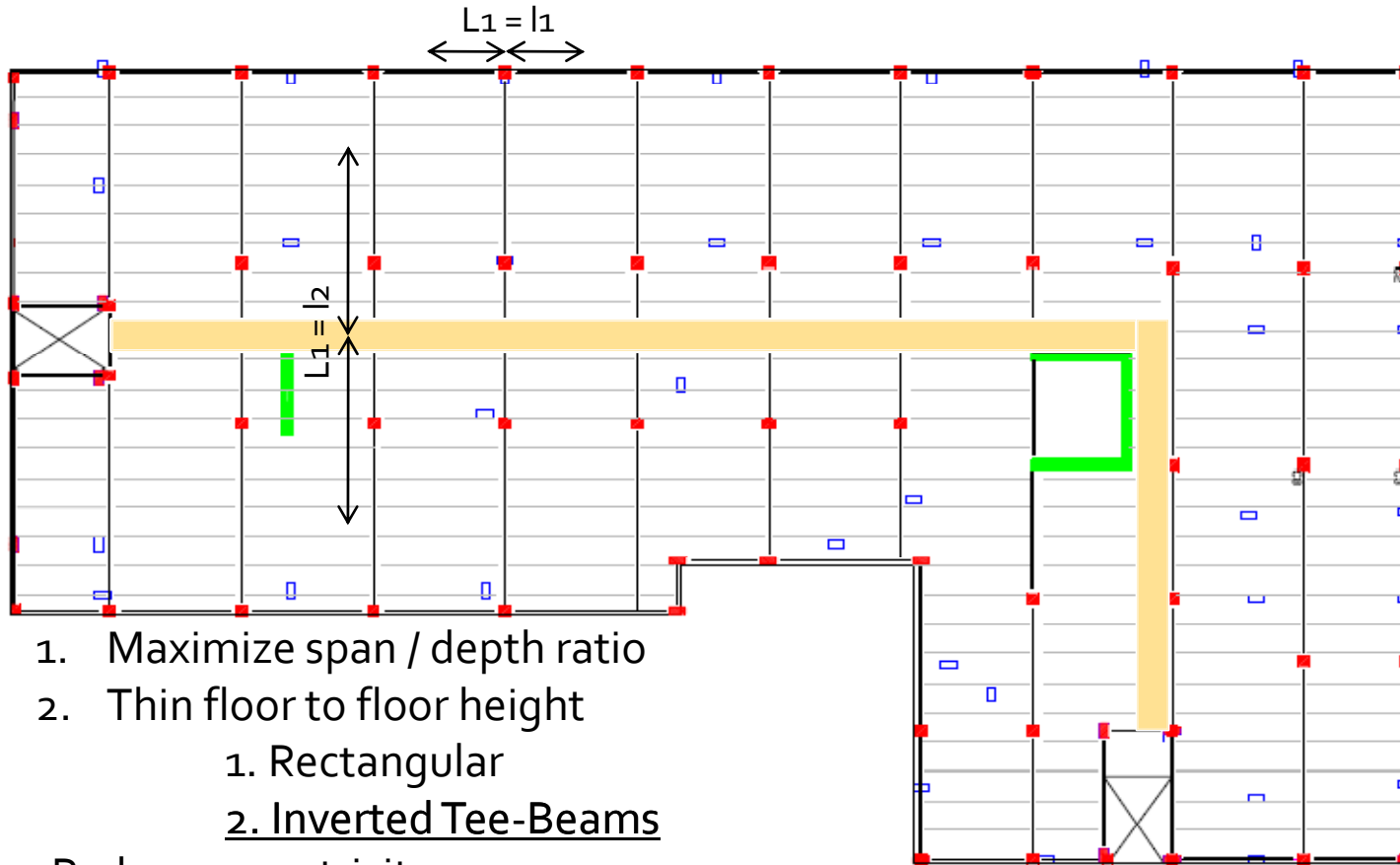




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Structural Option
City Vista | Building 2

Gravity System : Column Grid

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



1. Maximize span / depth ratio
 2. Thin floor to floor height
 1. Rectangular
 2. Inverted Tee-Beams
- Reduce eccentricity
 - Column location
 - Not In corridors



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City Vista | Building 2

Gravity System : Member Selection

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

Prestressed Concrete
6"x4'-0" Hollow Core Plank
2 Hour Fire Resistance Rating With 2" Topping

PHYSICAL PROPERTIES
Composite Section

6"x4'-0" Hollow core Plank
2" Composite Topping

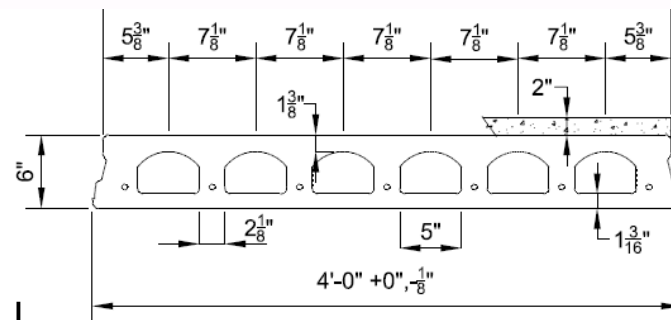
7-1/2" Diam. Strands
Ac = 253 in²
Ic = 1519 in⁴
Wt = 196 plf
Topping Wt = 48.75 plf

Strand Pattern	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	
4 - 1/2"ø LOAD (PSF)	227	187	300	308	268	229	194	165	141	120	102	86	73	61	50					
7 - 1/2"ø LOAD (PSF)	387	305	495	455	418	387	340	312	275	243	215	189	167	147	130	114	97	83	70	

N.A. WAREHOUSE CONCRETE PRODUCTS
2855 Molly Pitcher Hwy, South, Box N
Chambersburg, PA 17201-0813
717-267-4505 Fax 717-267-4518

This table is for simple spans and uniform loads. Design data for any of these span-load conditions is available on request. Individual designs may be furnished to satisfy unusual conditions of heavy loads, concentrated loads, cantilevers, barge or stem openings and narrow walls. The allowable loads shown in this table reflect a 2 Hour & 0 Minute fire resistance rating.

05/14/07 **6F2.0T**





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Structural Option
City Vista | Building 2

Gravity System : Member Selection

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

Normal Weight Concrete

L-BEAMS									
Normal Weight Concrete									
Designation	h	h ₁	A	I	y _c	S _x	S _y	wt	plf
	in	in	in ²	in ⁴	in	in ³	in ³	plf	
20LB20	20	12/8	304	10,160	8.74	1,163	922	317	
20LB24	24	12/12	384	17,568	10.50	1,073	1,301	400	
20LB20	20	16/12	432	27,603	12.22	2,292	1,767	450	
20LB32	32	20/12	620	41,900	14.00	2,971	2,311	590	
20LB36	36	24/12	628	59,119	15.82	3,737	2,900	550	
20LB40	40	24/16	608	81,252	17.47	4,000	3,908	633	
20LB44	44	28/16	660	108,107	19.27	6,016	4,370	683	
20LB48	48	32/16	704	140,133	21.09	6,646	5,208	733	
20LB52	52	36/16	752	177,752	22.94	7,749	6,117	783	
20LB56	56	40/16	800	221,384	24.80	8,824	7,054	833	

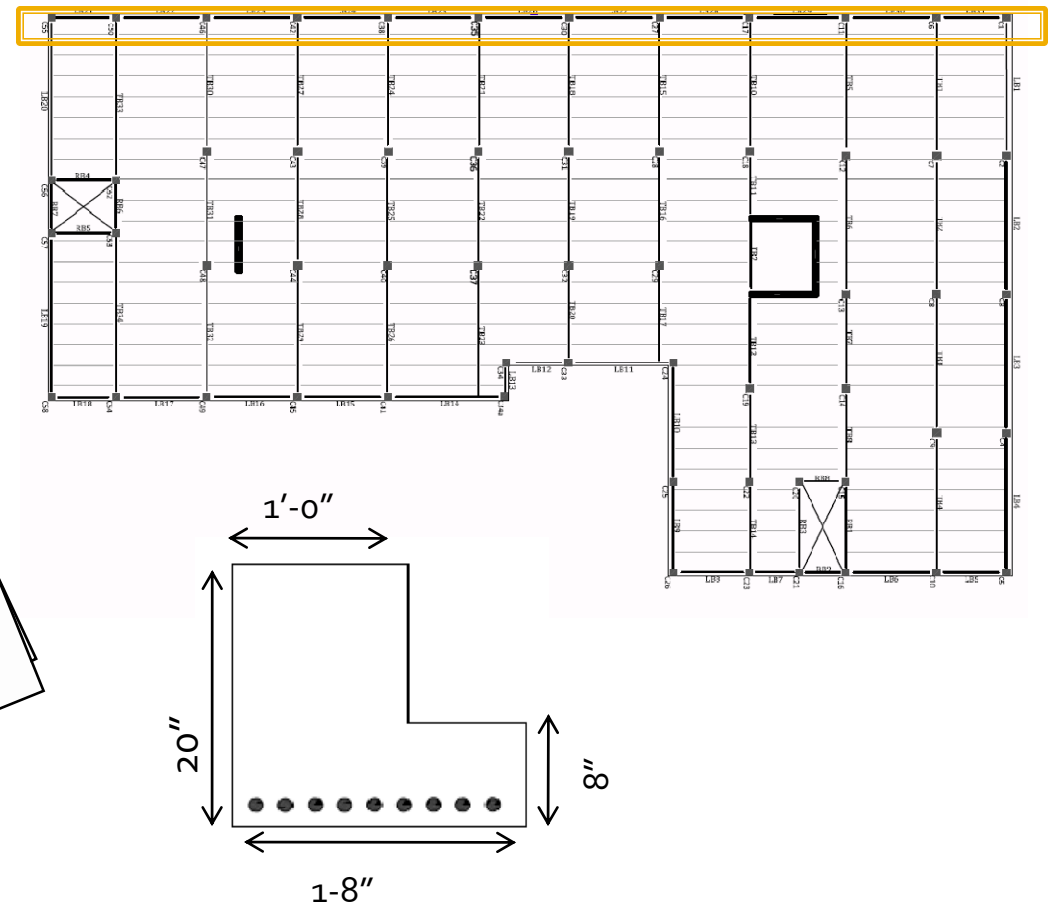
20LB20 L-Beam

9-1/2" Diam. Strands
F_{pu}=270 ksi
H= 20"
A_c= 304 in²
F'_c= 5000 psi
Wt = 317 plf

20LB52	238-S	6.17	0.024	0.521	7.578	0.714	0.022	0.462	4.659	4.004
		6.17	0.0	0.0	0.1	0.0	0.0	0.0	1.0	1.0
			0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
20LB56	258-S	6.64	0.024	0.589	7.927	7.924	0.427	0.620	5.237	4.916
		6.64	0.0	0.0	0.1	0.0	0.0	0.0	1.0	1.0
			0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
20LB60	278-S	7.33	0.024	0.619	8.173	7.380	0.658	0.630	5.544	5.146
		7.33	0.0	0.0	0.1	0.0	0.0	0.0	1.0	1.0
			0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

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Structural Option
City Vista | Building 2

Gravity System : Member Selection

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

Normal Weight Concrete

L-BEAMS									
Normal Weight Concrete									
Designation	h	h ₁	A	I _x	y _c	S _x	S _x	wt	
	in	in	in ²	in ⁴	in	in ³	in ³	plf	
20LB20	20	12/8	304	10,160	8.74	1,163	922	317	
20LB24	24	12/12	384	17,569	10.50	1,073	1,301	400	
20LB20	20	16/12	432	27,603	12.22	2,292	1,767	450	
20LB32	32	20/12	624	41,900	14.00	2,971	2,311	590	
20LB36	36	24/12	624	59,119	16.82	3,737	2,900	550	
20LB40	40	24/16	608	81,252	17.47	4,055	3,909	635	
20LB44	44	28/16	664	108,107	19.27	6,016	4,370	683	
20LB48	48	32/16	704	140,133	21.09	6,646	5,208	733	
20LB52	52	36/16	752	177,752	22.94	7,749	6,117	753	
20LB56	56	40/16	800	221,384	24.80	8,724	7,054	829	

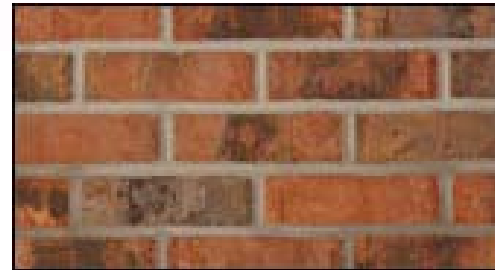
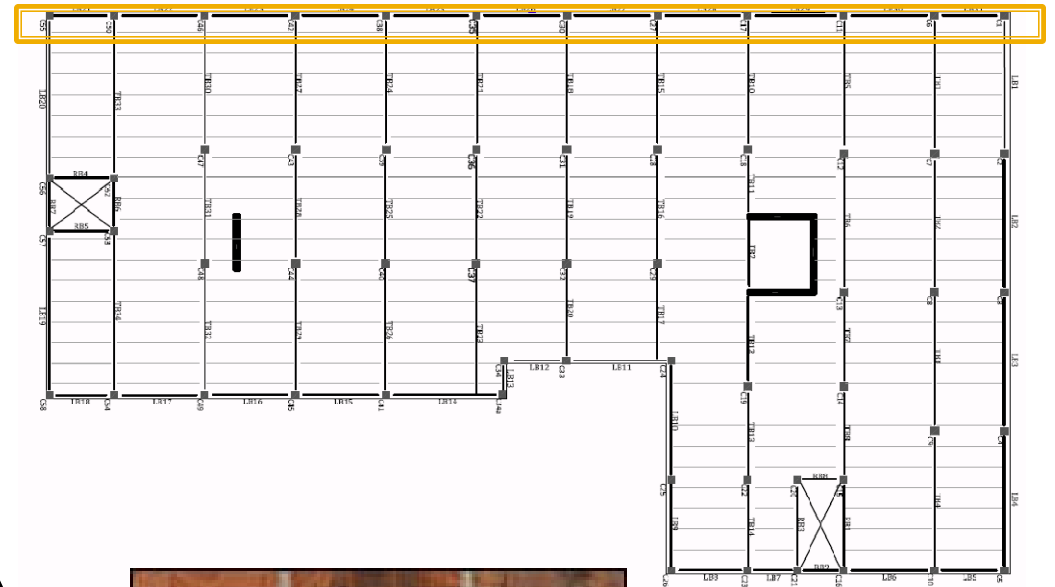
20LB20 L-Beam

9-1/2" Diam. Strands
F_{pu}=270 ksi
H= 20"
A_c= 304 in²
F'_c= 5000 psi
Wt = 317 plf

20LB52	238-S	6.17	6.17	0.624	0.521	0.718	0.714	0.692	0.462	0.469	0.404
		6.17		0.6	0.6	0.7	0.7	0.6	0.5	0.5	0.4
				0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3
20LB56	258-S	6.64	6.64	0.664	0.569	0.727	0.724	0.627	0.520	0.527	0.416
		6.64		0.6	0.7	0.7	0.8	0.6	0.6	0.6	0.4
				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
20LB60	278-S	7.33	7.33	0.608	0.573	0.780	0.780	0.658	0.630	0.564	
				0.7	0.7	0.8	0.8	0.6	0.6	0.6	0.6
				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

PC Design Handbook Edition
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Structural Option
City Vista | Building 2

Gravity System : Member Selection

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

RECTANGULAR BEAMS
Normal Weight Concrete

Designation	b in.	h in.	A in. ²	I in. ⁴	J _c in. ³	S in. ³	wt plf
12RB15	12	15	182	4,090	8.00	512	200
12RB20	12	20	240	8,000	10.00	800	250
12RB24	12	24	288	13,824	12.00	1152	300
12RB28	12	28	336	21,952	14.00	1568	350
12RB32	12	32	384	32,768	16.00	2048	400
12RB36	12	36	432	46,656	18.00	2592	450
12RB40	12	40	480	63,840	20.00	3200	500
12RB44	12	44	528	84,384	22.00	3872	550
12RB48	12	48	576	108,288	24.00	4608	600
12RB52	12	52	624	135,456	26.00	5408	650
12RB56	12	56	672	165,888	28.00	6272	700
12RB60	12	60	720	199,680	30.00	7200	750

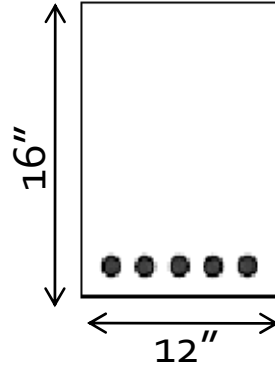
$f'_c = 5,000 \text{ psi}$
 $f_{pu} = 270,000 \text{ psi}$

12RB16 R-Beam

8-1/2" Diam. Strands
F_{pu}=270 ksi
H=16"
A_c=192 in²
F'_c=5000 psi
Wt = 200 plf

Designation	Wt plf	h in.	A in. ²	I in. ⁴	J _c in. ³	S in. ³
16RB32 188-S	4.67	32	840	7891	6741	5813
16RB32 188-S	4.67	32	5094	4425	3697	3851
16RB36 208-S	5.40	36	900	8070	7142	2485
16RB36 208-S	5.40	36	2210	1962	1600	1319
16RB40 228-S	6.00	40	1260	1192	1010	1010
16RB40 228-S	6.00	40	2943	6391	5603	4942
		40	4363	3605	3494	3138
		40	2827	2555	2314	1918
		40	117	9.6	0.8	0.8
		40	1.4	0.4	0.4	0.4
		40	0.5	0.5	0.5	0.5
		40	0.6	0.6	0.6	0.6
		40	0.8	0.8	0.8	0.8
		40	1.0	1.0	1.0	1.0
		40	1.2	1.2	1.2	1.2
		40	1.4	1.4	1.4	1.4
		40	1.6	1.6	1.6	1.6
		40	1.8	1.8	1.8	1.8
		40	2.0	2.0	2.0	2.0
		40	2.2	2.2	2.2	2.2
		40	2.4	2.4	2.4	2.4
		40	2.6	2.6	2.6	2.6
		40	2.8	2.8	2.8	2.8
		40	3.0	3.0	3.0	3.0
		40	3.2	3.2	3.2	3.2
		40	3.4	3.4	3.4	3.4
		40	3.6	3.6	3.6	3.6
		40	3.8	3.8	3.8	3.8
		40	4.0	4.0	4.0	4.0
		40	4.2	4.2	4.2	4.2
		40	4.4	4.4	4.4	4.4
		40	4.6	4.6	4.6	4.6
		40	4.8	4.8	4.8	4.8
		40	5.0	5.0	5.0	5.0
		40	5.2	5.2	5.2	5.2
		40	5.4	5.4	5.4	5.4
		40	5.6	5.6	5.6	5.6
		40	5.8	5.8	5.8	5.8
		40	6.0	6.0	6.0	6.0

2-42
PC Design Handbook (10th Edition)
First Printing 2004 (10th Edition)





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Structural Option
City Vista | Building 2

Gravity System : Member Selection

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

INVERTED TEE BEAMS

Normal Weight Concrete

Designation	h in.	h/h ₂ in./in.	A _c in. ²	I _c in. ⁴	Y _c in.	S _x in. ³	S _y in. ³	wt plf
28IT20	20	2/8	368	11,688	7.91	1,478	697	383
28IT24	24	12/12	480	20,274	9.89	2,112	1,408	500
28IT28	28	16/12	608	32,076	11.03	2,922	1,827	650
28IT32	32	20/12	676	47,872	12.67	3,778	2,477	800
28IT36	36	24/12	824	68,101	14.31	4,760	3,140	950
28IT40	40	24/16	728	63,608	15.83	6,907	3,859	787
28IT44	44	28/16	784	124,437	17.43	7,139	4,683	817
28IT48	48	32/16	832	161,424	18.03	6,400	5,552	897

28IT24 – T-beams

(18) ½" Diam Strands

F_{pu} = 270 ksi

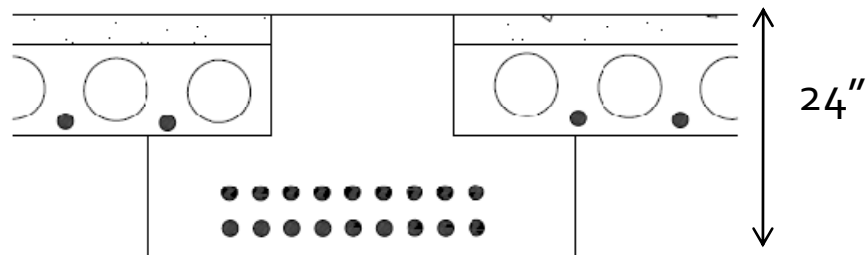
A = 480 in²

H = 24"

Wt 500 plf



28IT44	208-S	4.40	0.180	7.969	8.097	0.162	5.482	4.891	4.344	3.896	3.502	3.162	2.859
		4.40	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
28IT48	228-S	4.55	0.119	8.525	7.823	16.716	6.929	6.338	4.701	4.322	3.927	3.642	
		4.55	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
28IT52	248-S	5.17	0.687	8.823	7.838	6.696	6.274	5.647	4.100	4.619	4.198		
		5.17	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
28IT56	268-S	5.23	0.507	8.579	7.459	6.751	3.088	5.504	5.025				
		5.23	0.5	0.6	0.6	0.7	0.7	0.8	0.8				
			0.2	0.2	0.2	0.2	0.2	0.2	0.2				
28IT60	288-S	5.57	0.948	8.668	7.220	7.651	6.432	5.256					
		5.57	0.6	0.6	0.7	0.7	0.8	0.8					
			0.2	0.2	0.2	0.2	0.2	0.2					





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Structural Option
City Vista | Building 2

Gravity System : Member Selection

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

INVERTED TEE BEAMS

Normal Weight Concrete

Designation	h in.	h/h ₂ in./in.	A _c in. ²	I _c in. ⁴	Y _c in.	S _c in. ³	S _s in. ³	wt plf
28IT20	20	2/8	368	11,688	7.91	1,478	697	383
28IT24	24	12/12	480	20,274	9.89	2,112	1,408	500
28IT28	28	16/12	608	32,078	11.03	2,922	1,827	650
28IT32	32	20/12	676	47,872	12.67	3,778	2,477	800
28IT36	36	24/12	824	68,101	14.31	4,760	3,140	950
28IT40	40	24/16	728	63,603	15.83	6,907	3,859	787
28IT44	44	28/16	784	124,437	17.43	7,139	4,683	817
28IT48	48	32/16	832	161,424	18.03	6,400	5,552	897

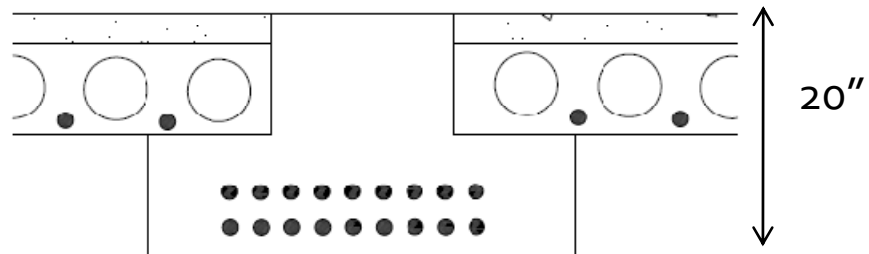
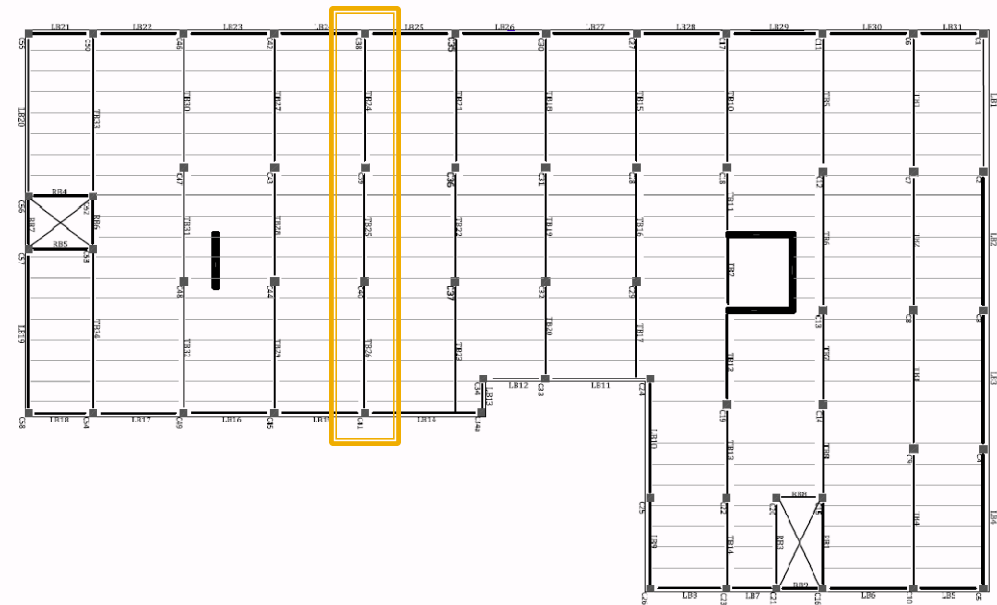
28IT20 T-beams

(9) 1/2" Diam Strands
F_{pu} = 270 ksi
A = 192 in²
H = 20"
Wt 200 plf

28IT44	208-S	4.40	0.180	7.989	8.097	0.162	5.482	4.891	4.344	3.896	3.502	3.162	2.859
		4.40	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
28IT48	228-S	4.55	0.170	8.525	7.823	16.716	5.929	5.338	4.701	4.320	3.927	3.542	
		4.55	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.8	
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
28IT52	248-S	5.17	0.687	8.823	7.838	6.096	6.274	5.647	4.100	4.619	4.198		
		5.17	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	
			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
28IT56	268-S	5.23	0.507	8.579	7.459	6.751	3.088	5.504	5.025				
		5.23	0.5	0.6	0.6	0.7	0.7	0.8	0.8				
			0.2	0.2	0.2	0.2	0.2	0.2	0.2				
28IT60	288-S	5.57	0.648	8.668	7.220	7.651	6.432	3.656					
		5.57	0.6	0.6	0.7	0.7	0.8	0.8					
			0.2	0.2	0.2	0.2	0.2	0.2					

PCI Design Handbook Edition
First Printing © 2012 Edition

2-45

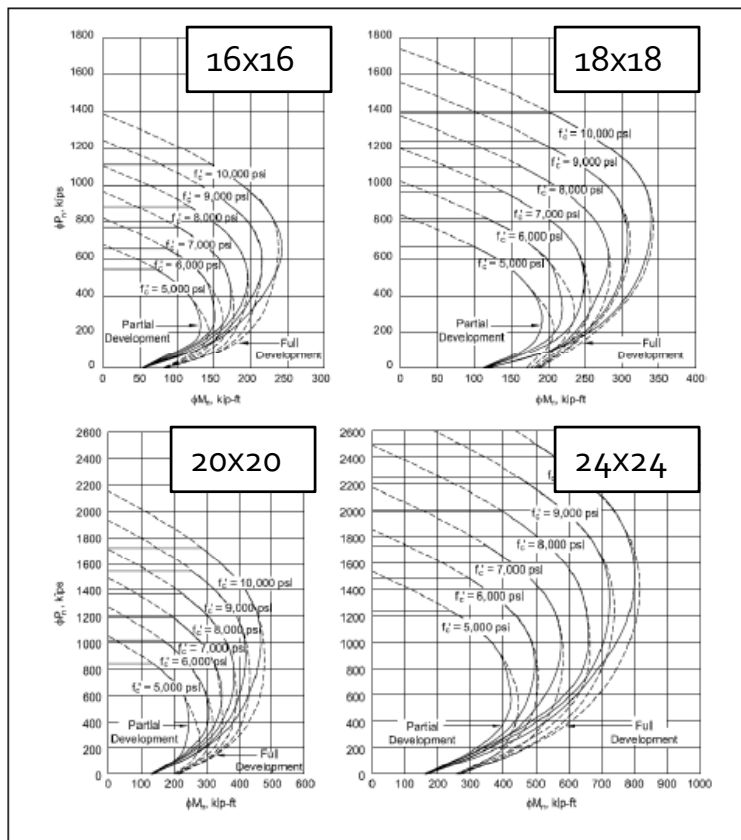




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Structural Option
City Vista | Building 2

Gravity System: Columns

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Columns

- Conventionally Reinforced
- Sized Every 4 stories
- Cast Double story height

Story 1-4: 24X24 (4-#11)
20X20, 18x18 (4 - #9)

Story 5-9: 18x18
16x16 (4- #8)

Story 10-11: 16x16

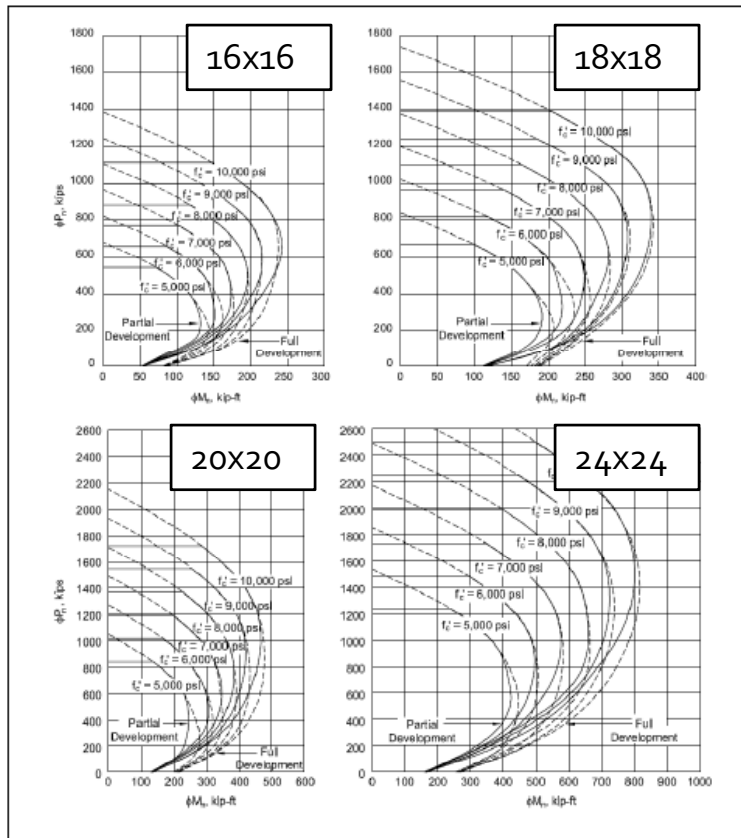
- $f'_c = 5000$ psi



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Gravity System: Columns

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Columns

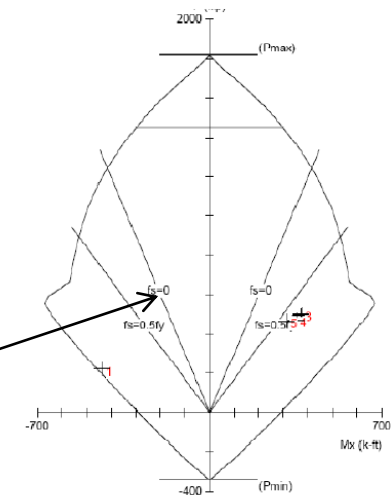
- Flexure Check:

24x24 column (base)

$P = 474$ kips

$M = 352$ kip-ft

Well within
the limit





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Gravity System: Connections

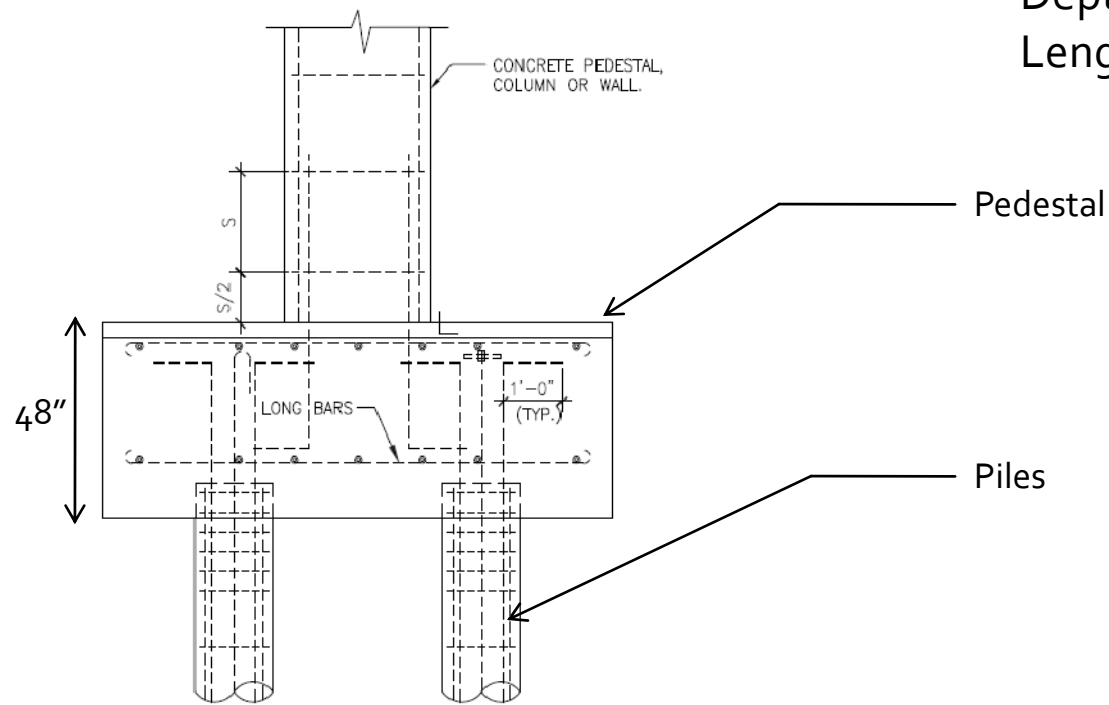
| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

Column Connection

-Existing System : Pedestal pile caps

Depth = 48 "

Length = Varies



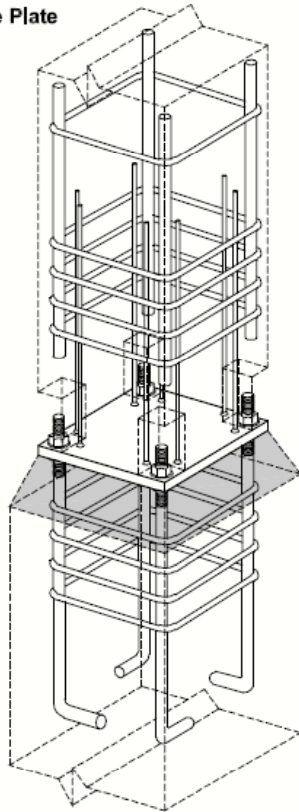


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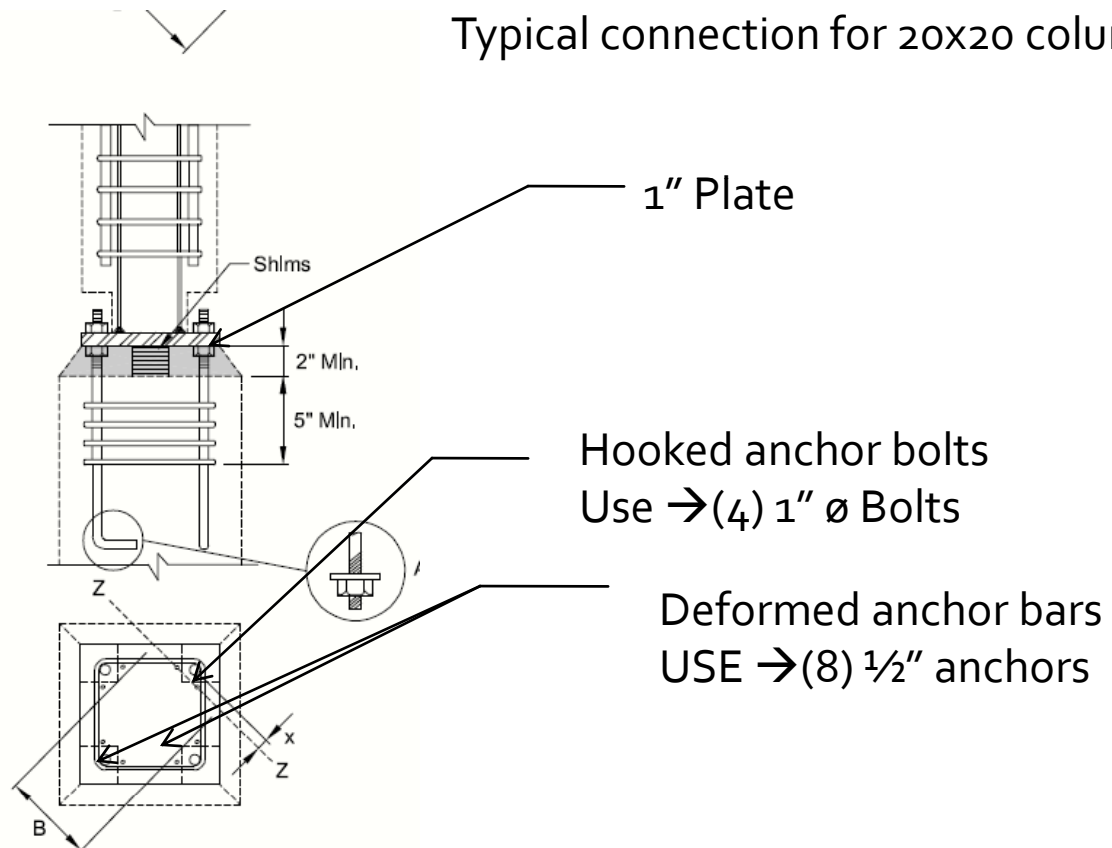
Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

Use Plate



Typical connection for 20x20 column

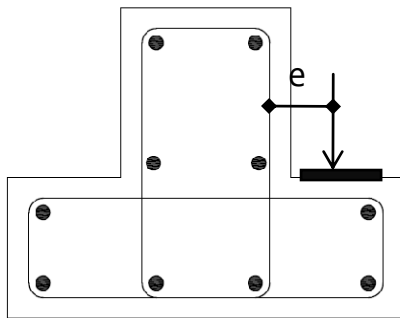




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Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Ledger Reinforcing

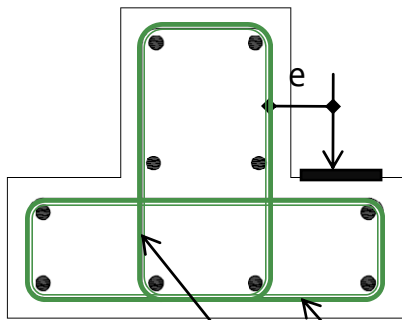
- Hollow core bearing on T & L Beams
- Torsion
- Shear
- Un-even loading
- Bearing Pad : 3" min bearing



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Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Ledger Reinforcing

- Hollow core bearing on T & L Beams
- Torsion
- Shear
- Un-even loading
- Shear Reinforcing

$A_s \#3 @ 12'' \text{ O.C}$

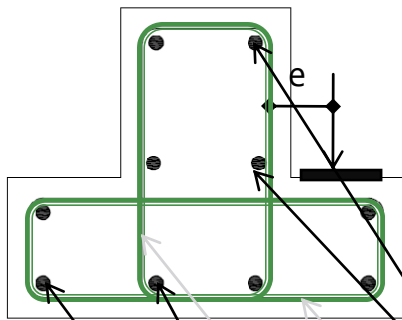
$A_{sh} \#3 @ 12'' \text{ O.C}$



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Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Ledger Reinforcing

- Hollow core bearing on T & L Beams
- Torsion
- Shear
- Bearing Pad
- Shear Reinforcing
- Longitudinal

A_{wv} #3 [Out of plane bending]

A_s #3 @ 12" O.C

A_{sh} #3 @ 12" O.C

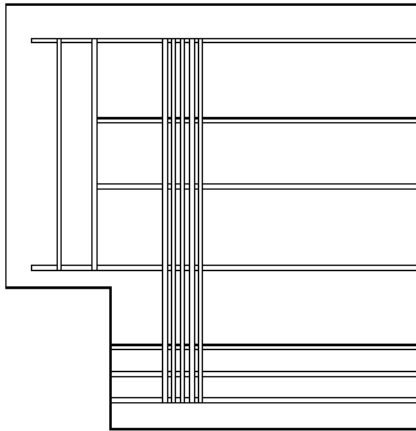
Pre-Stress Tendons



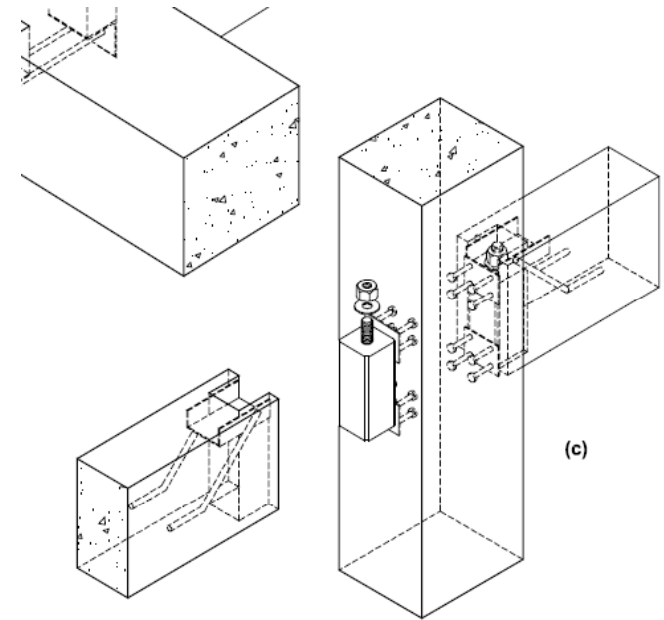
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Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Dapped End Reinforcing
-For Hanger connection to column

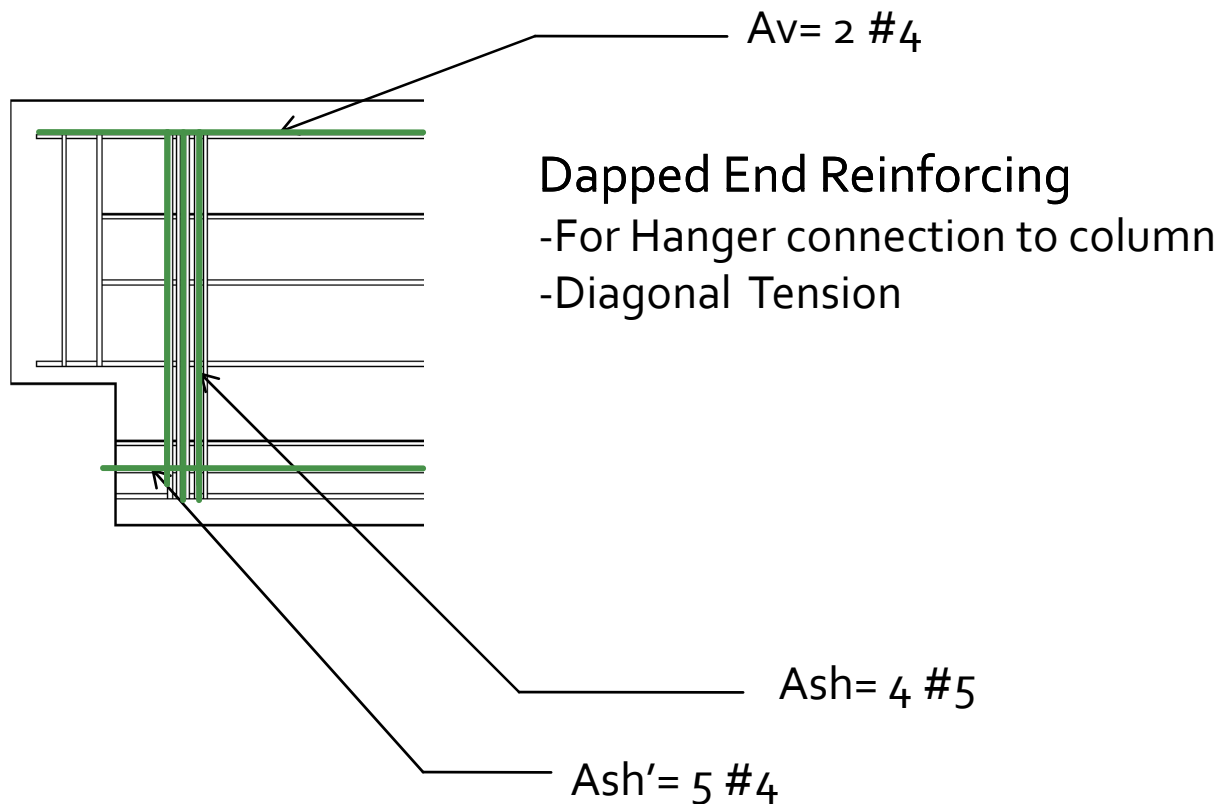




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Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



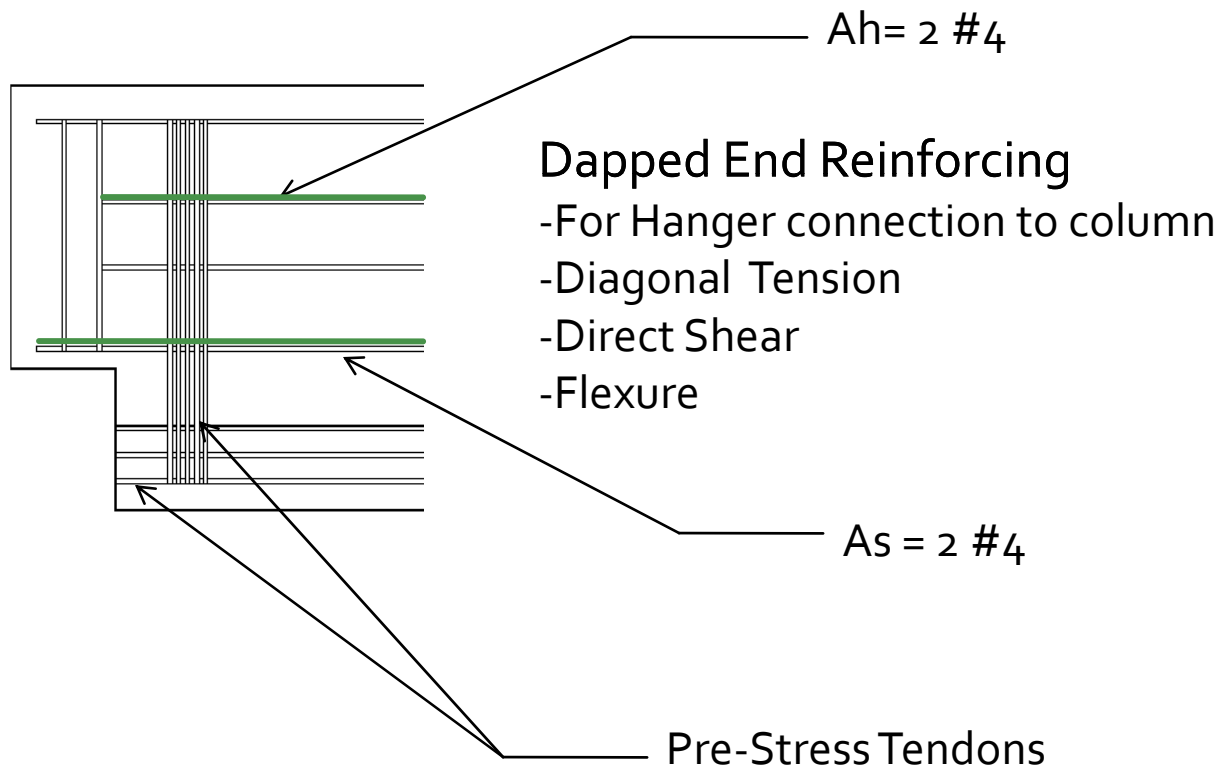
Development Length = 26.6"



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Gravity System: Connections

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Development Length = 26.6"



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Gravity System: Foundation

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

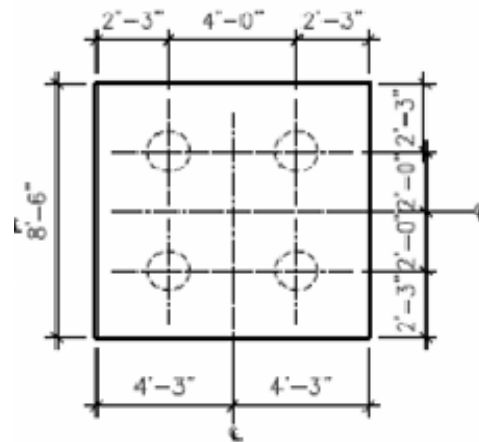
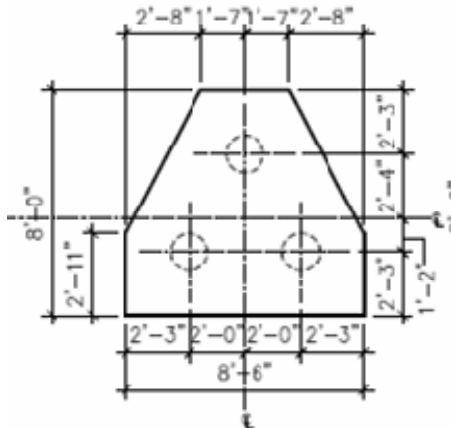
Foundation Capacity Numbers

1 Pile = 125 Tons
 1 Kips = 0.446 Tons
 [1 ton = 2.24 kips]

Foundation Alterations

- Existing piles : Adequate
- Reduction in column Size
- Reduction in column loading
- (5) additional column

Column load : 0-700 Kips



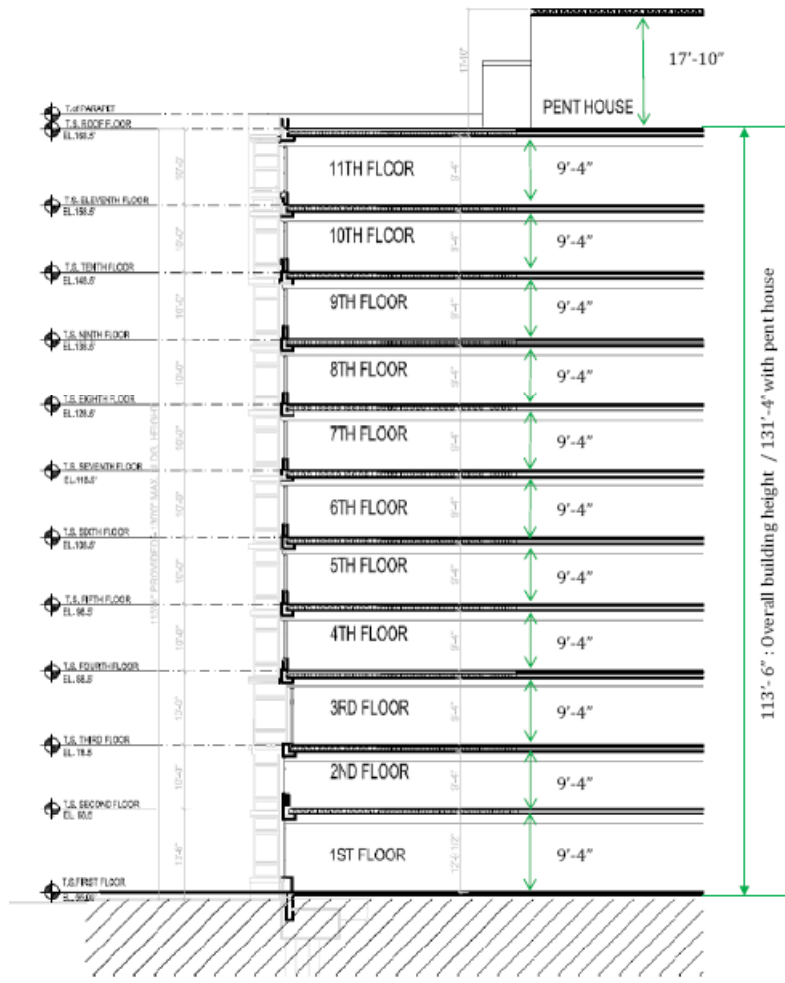
Column load: 700-999 Kips



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City Vista | Building 2

Gravity System: Outcome

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |



Gravity System Summary

- Height Increase : 3'-0"
 - 8" added to each floor
 - 9'-4" maintained
 - Reducing : 1st floor : 9'-4"
 - 11th floor : 9'-4"

Building Height : 113'- 6"

At pent house : 128'-6"

6" Over height limit

Solution: Reduction in pent house height
17'-10" : Not Considered



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Gravity System: Outcome

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

2. Finished Ceiling

- Exposed Beams
- ~~Finished Ceiling~~ (add additional height)





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Structural Option
City Vista | Building 2

Gravity System: Outcome

| Building Stats | Proposal | Preliminary Design | **Gravity System** | Lateral System | Constructability | Conclusion |

2. Finished Ceiling ✓

- Exposed Beams
- ~~- Finished Ceiling (add additional height)~~



3. Weight Increase ~ 3000 Kips [1.1 % weight increase]

- Result : Composite Topping (25psf)
Beams (275 kips / floor)



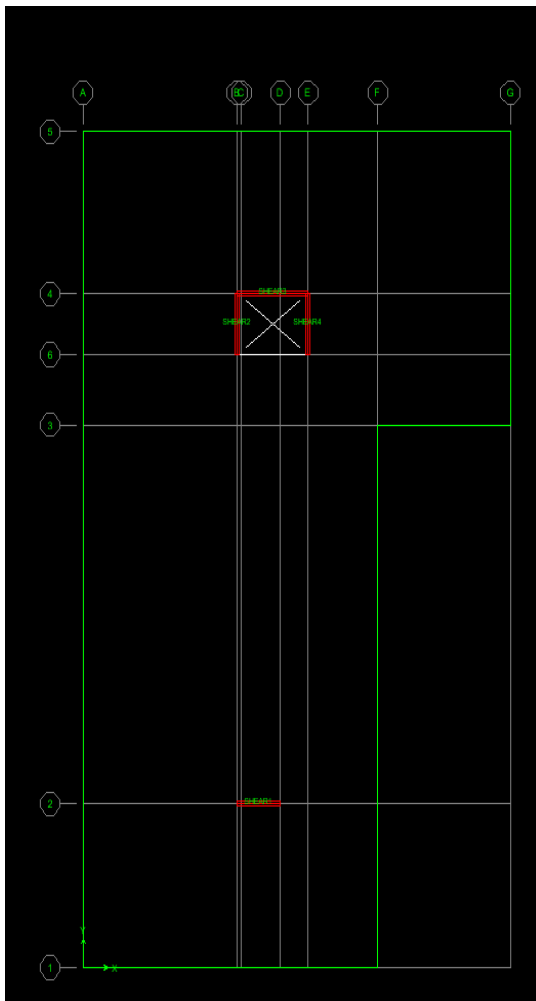
Still Lightweight Structure ✓



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Structural Option
City Vista | Building 2

Lateral System: Check

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |



Seismic Check

Height increase = 3'-0"

Weight increase = 3000 Kips

1.1 % increase

Seismic Base Shear = 915.27 Kips

Over-turning Moment = 73,601.43 Kip-Ft

Site Class : D

Design Category: B

Occupancy: I

$R = 5.0$

$\Omega = 2.5$

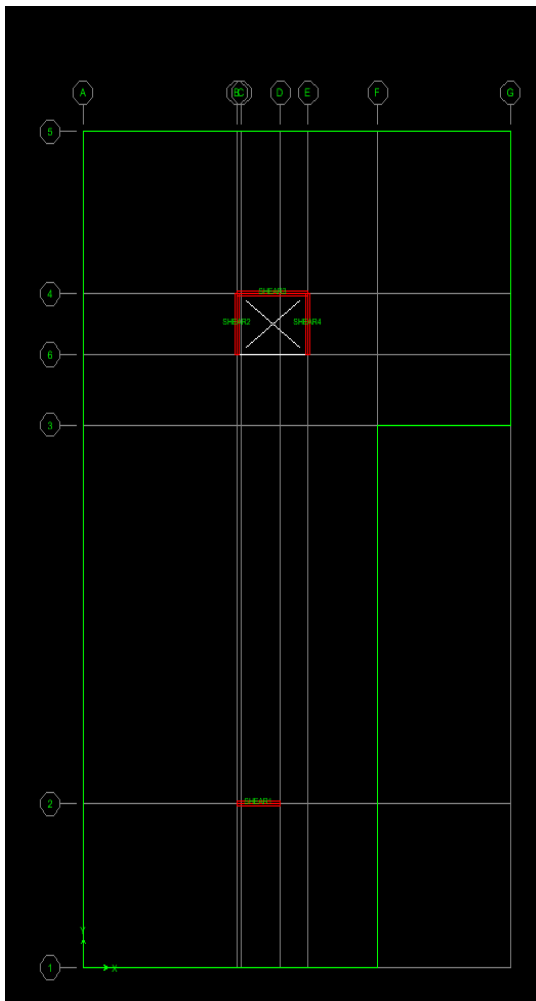
$C_d = 4.5$



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Structural Option
City Vista | Building 2

Lateral System: Check

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |



Seismic Check

Height increase = 3'-0"

Weight increase = 3000 Kips

1.1 % increase

Seismic Base Shear = 915.27 Kips

Over-turning Moment = 73,601.43 Kip-Ft

E-Tabs Analysis:

- Flexural reinforcement
- Shear reinforcement
- Story Drift



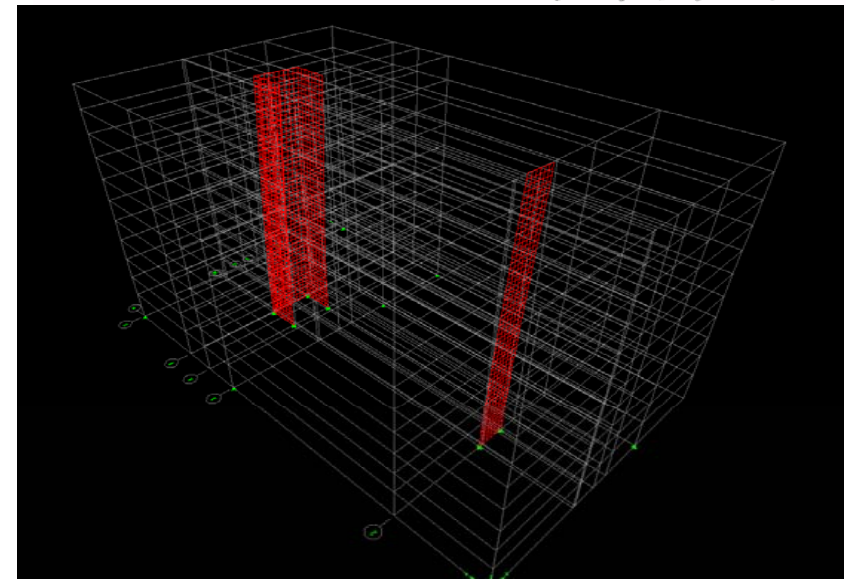
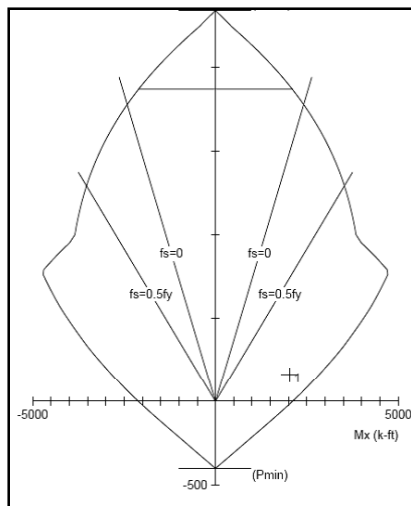
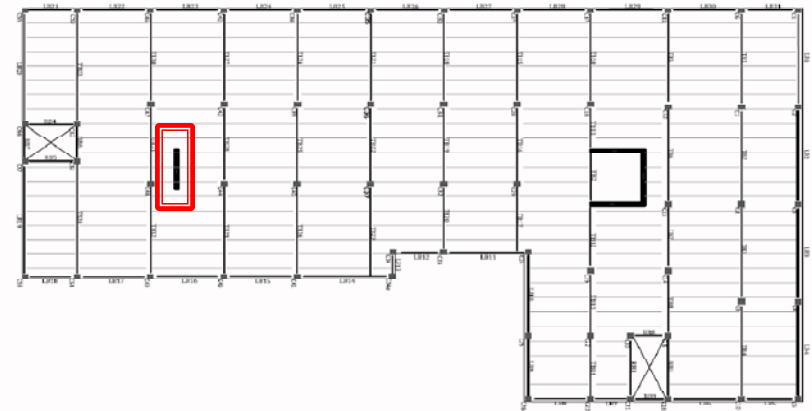
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Lateral System: Reinforcement

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |

Reinforcing:

Wall #1: Adequate [V: #5 @ 12" O.C]
[H: #4 @ 12" O.C]
B.E.: None Req'd





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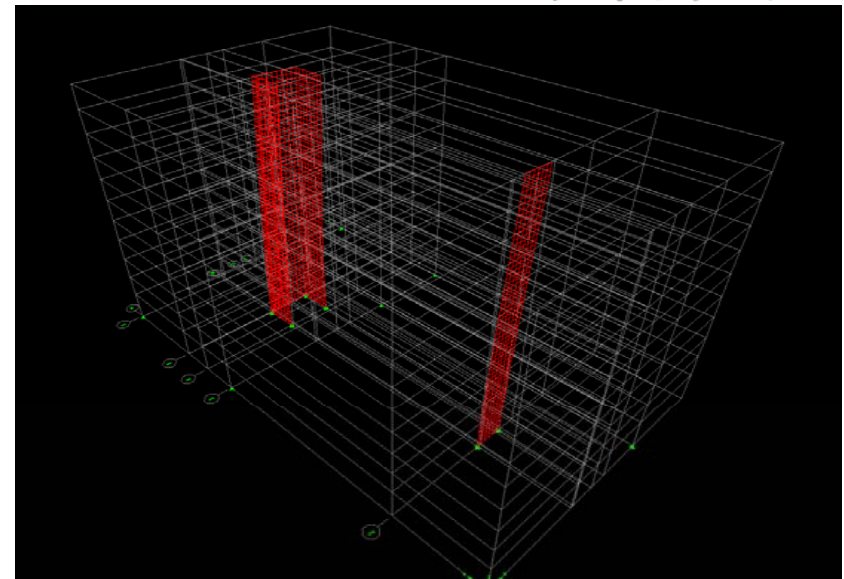
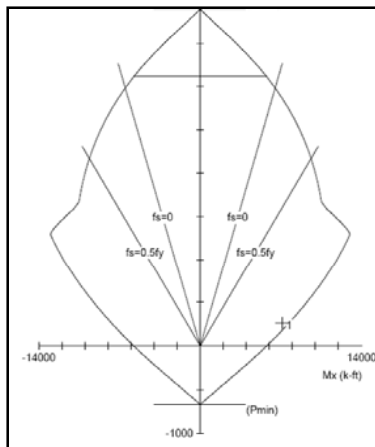
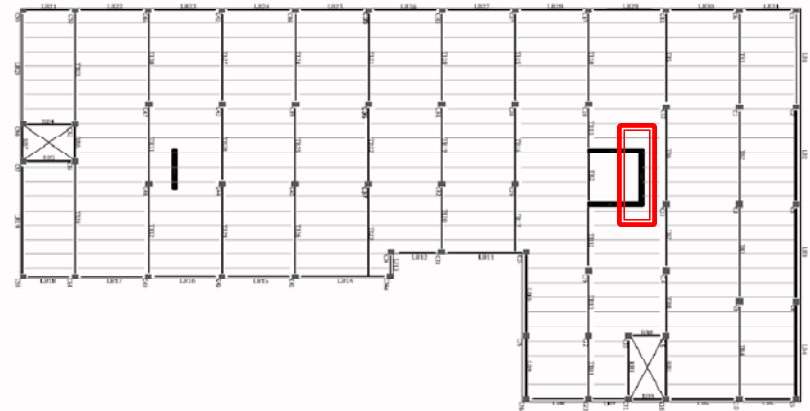
Lateral System: Reinforcement

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |

Reinforcing:

Wall #1: *Adequate* [V: #5 @ 12" O.C]
[H: #4 @ 12" O.C]
B.E.: None Req'd

Wall #3: *Adequate* [#5 @ 12" O.C]
[#4 @ 12" O.C]
B.E. : 4 ft





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Structural Option
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Lateral System: Reinforcement

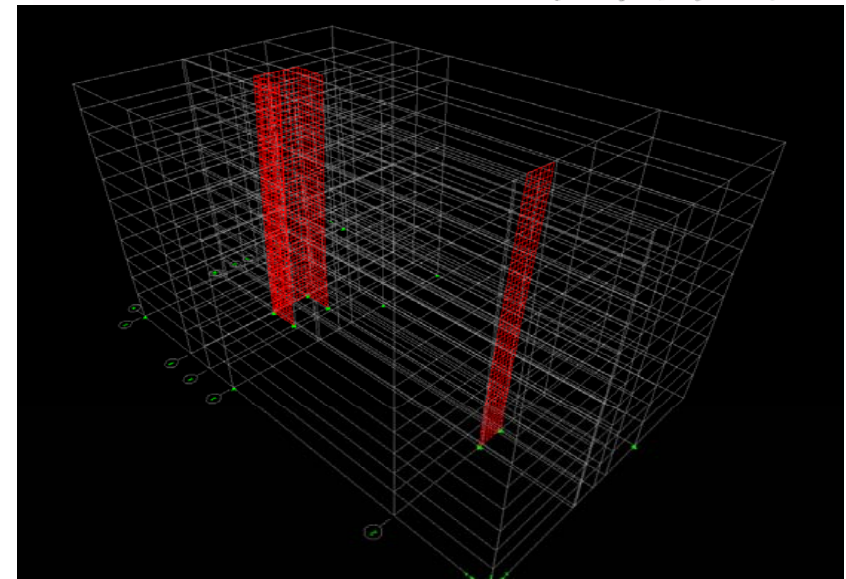
| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | Conclusion |

Reinforcing:

Wall #1: *Adequate* [V: #5 @ 12" O.C]
[H: #4 @ 12" O.C]
B.E.: None Req'd

Wall #2: *Inadequate*

Wall #4: *Inadequate*





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Structural Option
City Vista | Building 2

Lateral System: Reinforcement

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |

Reinforcing Alterations:

Wall #2: Adequate

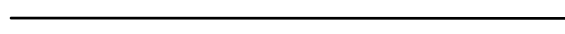


Thick : 16"

V: Story 1-2: #8 @ 12" O.C

H: Story 1 -2 #5 @ 12" O.C

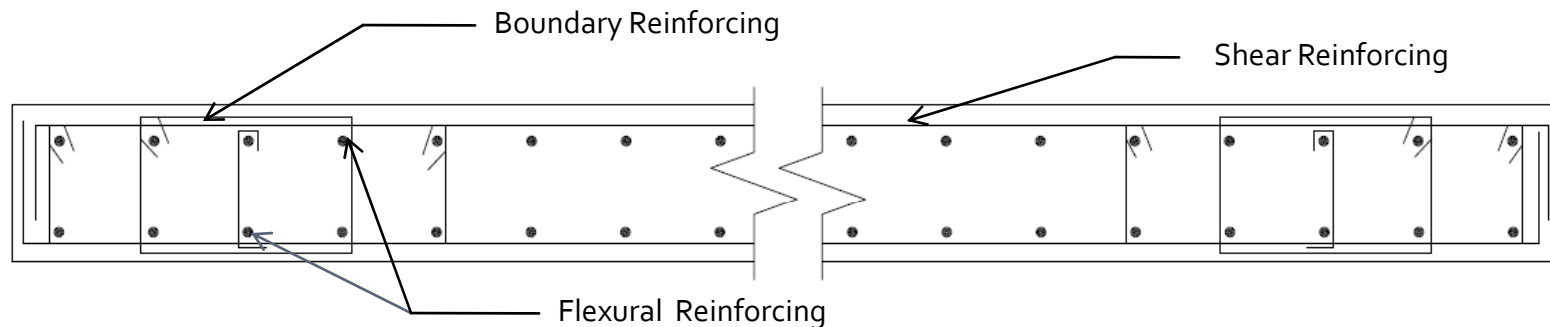
Wall #4: Adequate



Thick : 16"

V: Story 1-2: #8 @ 12" O.C

H : Story 1-2: #5 @ 12" O.C



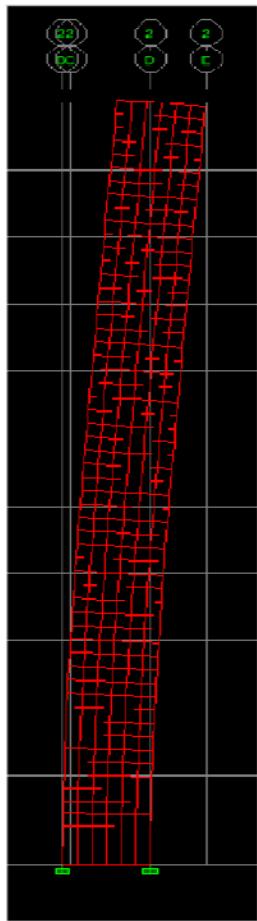
Typical Detail From existing drawings



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Lateral System: Drift

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |



Seismic Drift : [ASCE7-03]

- Amplified : $C_d \delta_{ei} / I_e$
- Drift Requirement = $0.020 h_{sk}$

$C_d = 4.5$ $h_{sk} = 10\text{ft}$ $I_e = 1.0$
--

North\South (x- dir): ADEQUATE

Wall #1 }
 Wall #3 } Total Drift 1.82" < 2.40"

Shear in East \ West : **INADEQUATE**

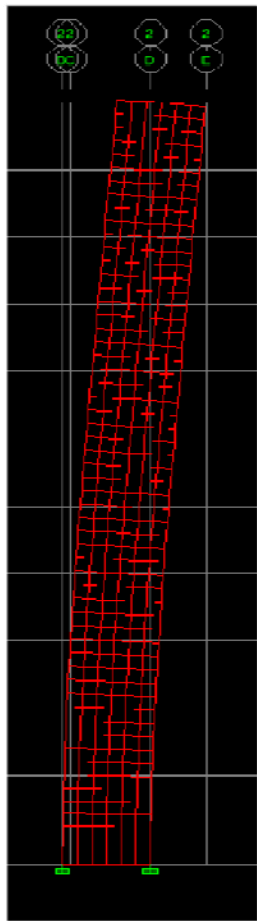
Wall #2 }
 Wall #4 } Total Drift 3.78" > 2.40"



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Structural Option
City Vista | Building 2

Lateral System: Summary

| Building Stats | Proposal | Preliminary Design | Gravity System | **Lateral System** | Constructability | Conclusion |



Seismic Summary

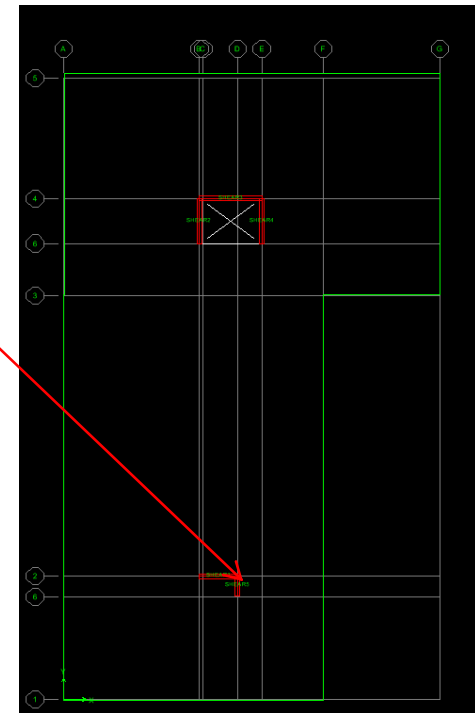
- Model assumption 100% lateral load taken by walls
- Original : Columns took a portion of lateral loads

Possible Solution:

- Added Shear wall in E-W Direction
- Wall #5: 6'x16"

Reinforcing: V: #5 @ 12" O.C
H: #4 @ 12" O.C
B.E: 1ft

Drift : Reducing Drift 2.38" < 2.40"

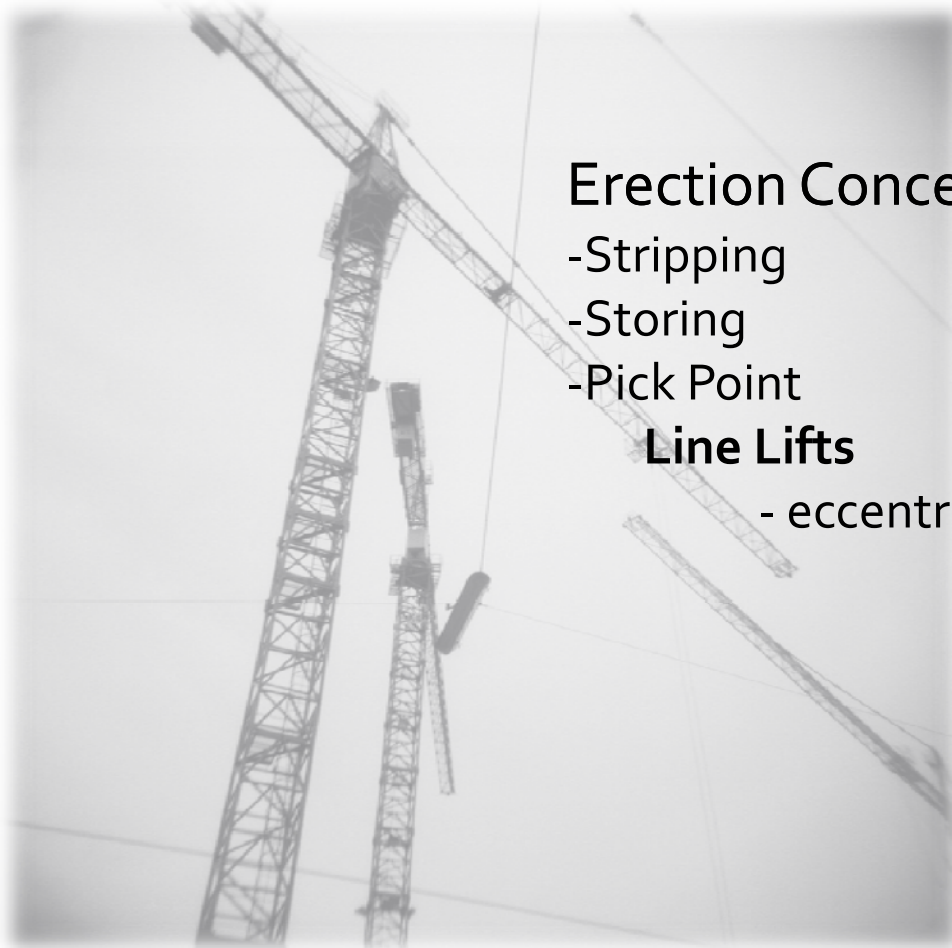




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City Vista | Building 2

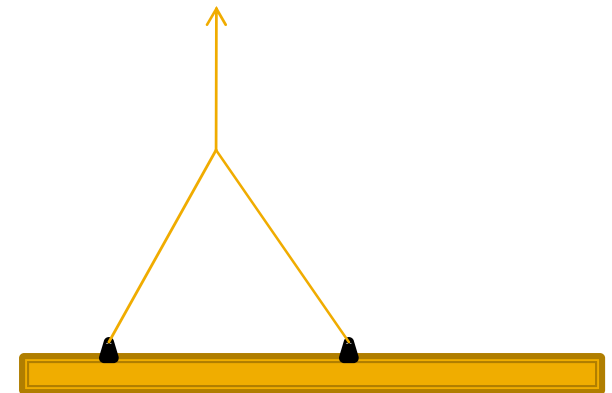
Constructability: Erection

| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | **Constructability** | Conclusion |



Erection Concerns

- Stripping
- Storing
- Pick Point
- **Line Lifts**
 - eccentric moment

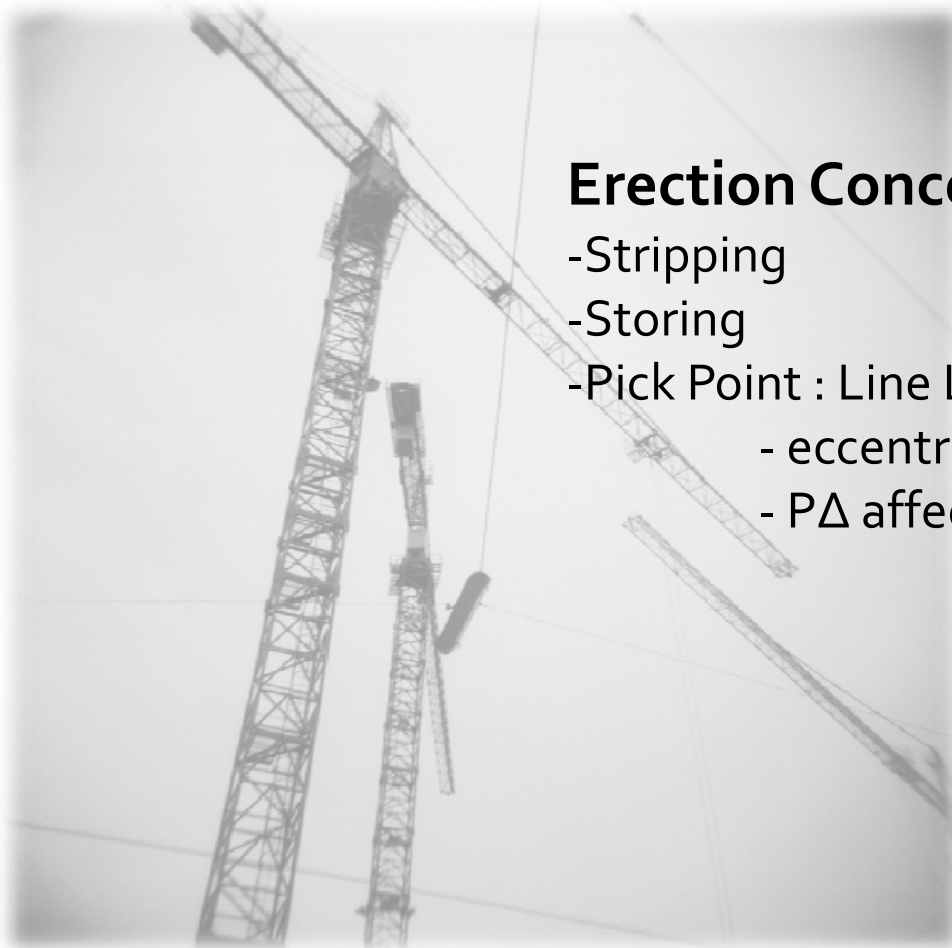




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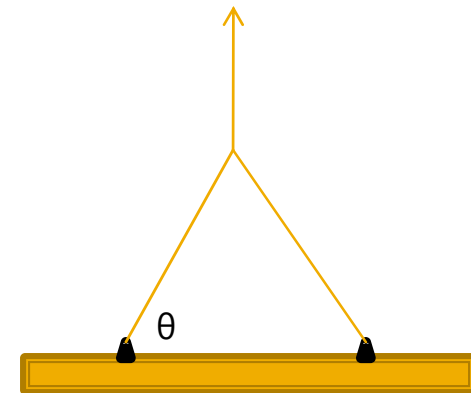
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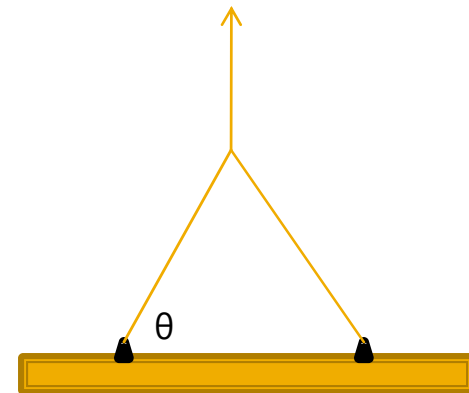
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Erection Concerns

- Stripping
- Storing
- Pick Point : Line Lifts
 - eccentric moment
 - $P\Delta$ affects

SAFETY FACTOR = 1.2

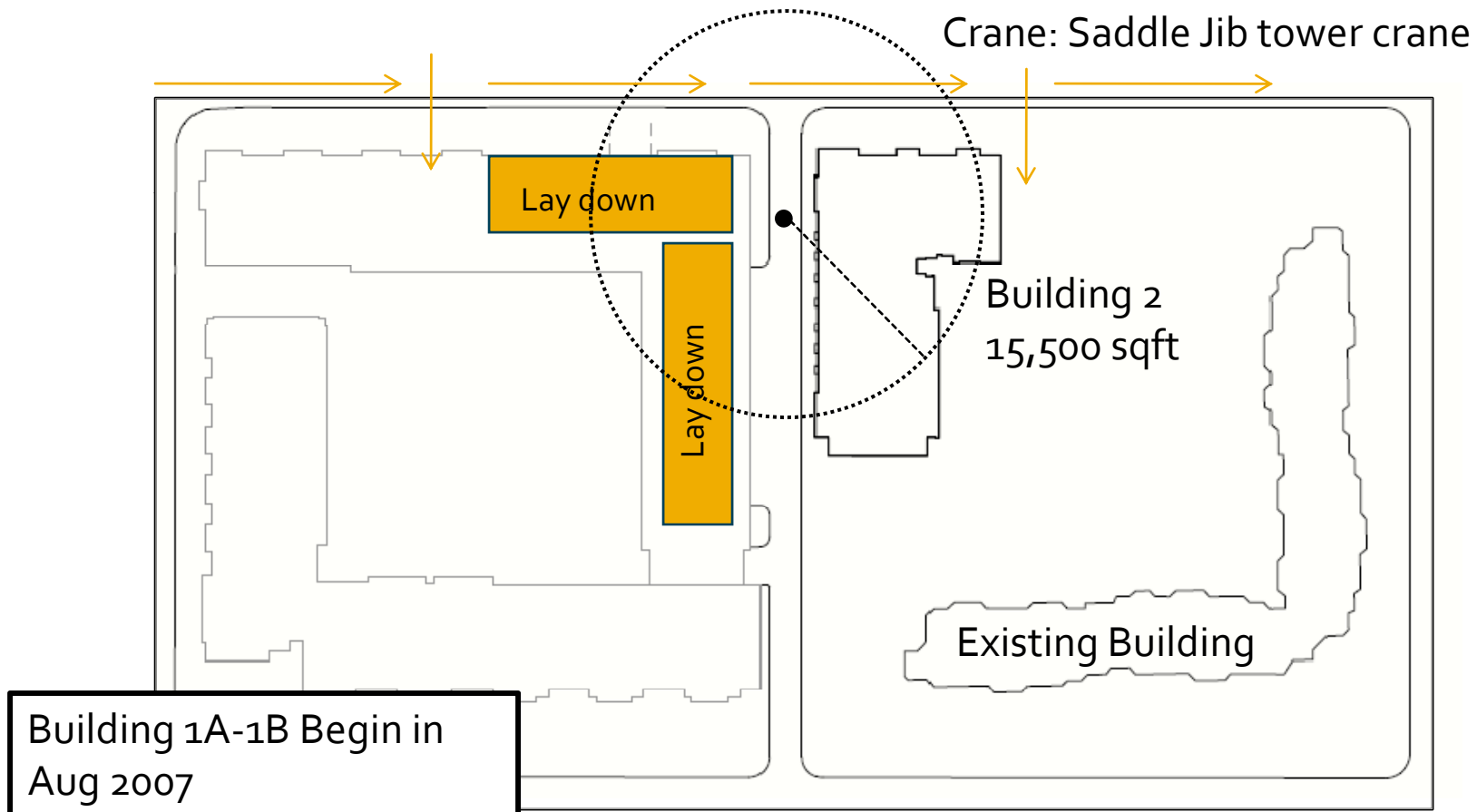




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Constructability: Erection

| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | **Constructability** | Conclusion |





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Constructability: LEEDS

| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | **Constructability** | Conclusion |



Material Recourses:

Reusable

Corrosion control → Maintenance

Production:

Material Waste : 2.5%

Water Reuse : 95%

Energy:

Possibility : passive solar system

Production: slag cement & silica fumes

Reuse:

Modular pieces



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 Structural Option
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Constructability: LEEDS

| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | **Constructability** | Conclusion |



Material Recourses:

Reusable

Corrosion control → Maintenance

Production:

Material Waste : 2.5%

Water Reuse : 5%

Energy:

Possibility : passive solar system

Production: slag cement & silica fumes

Reuse:

Modular pieces

23/27 : LEEDS CERTIFIED BUILDING

RE-USE



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Constructability: Cost & Schedule

| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | **Constructability** | Conclusion |

Cost Analysis : materials and labor

Pre-Cast System:

\$750,000.00 / Floor →

Post Tension System :

\$600,000.00 / Floor →

Pre-Cast : \$ 2,000,000.00

Pre-Cast System								Page 1 of 1
Quantity	Assembly Number	Description	Unit	Ext. Material O&P	Ext. Installation O&P	Extended Total O&P	Labor Type	
84.85	B10102132200	Concrete beam, precast, 12" x 16", 200 PLF, 15...	L.F.	\$ 4,072.80	\$ 1,654.58	\$ 5,727.38	Standard Union	
64.647	B10102132800	Concrete beam, precast, 12" x 16", 200 PLF, 20...	L.F.	\$ 5,387.78	\$ 1,092.83	\$ 6,480.61	Standard Union	
510	B10102144600	Concrete T beam, precast, 24" x 28", 260 PLF, ...	L.F.	\$ 111,180.00	\$ 8,445.60	\$ 119,625.60	Standard Union	
272.5	B10102145750	Concrete T beam, precast, 24" x 28", 865 PLF, ...	L.F.	\$ 60,495.00	\$ 5,014.00	\$ 65,509.00	Standard Union	
70.97	B10102152300	Concrete I beam, precast, 12" x 20", 300 PLF, 1...	L.F.	\$ 8,232.52	\$ 1,305.85	\$ 9,538.37	Standard Union	
224.58	B10102152900	Concrete I beam, precast, 12" x 20", 300 PLF, 2...	L.F.	\$ 26,051.28	\$ 3,096.96	\$ 29,148.24	Standard Union	
235.94	B10102154000	Concrete I beam, precast, 12" x 28", 435 PLF, 2...	L.F.	\$ 32,559.72	\$ 2,597.70	\$ 35,157.42	Standard Union	
29,481.64	B10102302900	Precast concrete plank, 2" topping, 8" total thic...	S.F.	\$ 240,275.37	\$ 135,910.36	\$ 376,185.73	Standard Union	
940	B10102071500	Precast concrete column, 20" sq, tied, eccentric...	V.L.F.	\$ 81,780.00	\$ 8,638.60	\$ 90,418.60	Standard Union	
200	B10102071380	Precast concrete column, 16" sq, tied, eccentric...	V.L.F.	\$ 13,900.00	\$ 1,656.00	\$ 15,556.00	Standard Union	
				\$ 583,934.47	\$ 169,412.48	\$ 753,346.95		

PF System								Page 1 of 1
Quantity	Assembly Number	Description	Unit	Ext. Material O&P	Ext. Installation O&P	Extended total O&P	Labor Type	
324,298	B10102234200	Flat plate, concrete, 7" slab, 16" column, 20"x20...	S.F.	\$ 1,637,704.90	\$ 2,390,076.26	\$ 4,027,781.16	Standard Union	
5,928	B10102034250	Cast-in-place concrete column, 24" square, tied...	V.L.F.	\$ 361,608.00	\$ 761,036.64	\$ 1,122,644.64	Standard Union	
				\$ 1,999,312.90	\$ 3,151,112.90	\$ 5,150,425.80		

After the Fact:

- Considering - Scaffolding
- Shoring
- Formwork

Cost would balance out



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Constructability: Cost & Schedule

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\$750,000.00 / Floor

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Schedule Analysis: Gravity
System and shear walls

Pre-Cast System:

62,000 in² /week

(2) Floor every 11 days

Post Tension:

(2) Floors every 12 days

Overall : 11 Day Saving

Member	Quantity	Total Area
Column #1 [20x20]	24	66.69 in ²
Column #2 [16x16]	10	17.68 in ²
Column #3 [24x24]	23	92 in ²
L-Beams	31	9424 in ²
T-Beams	34	16 320 in ²
R-Beams	9	1728 in ²
Planks	200	50,600 in ²
TOTAL		78,249 in²



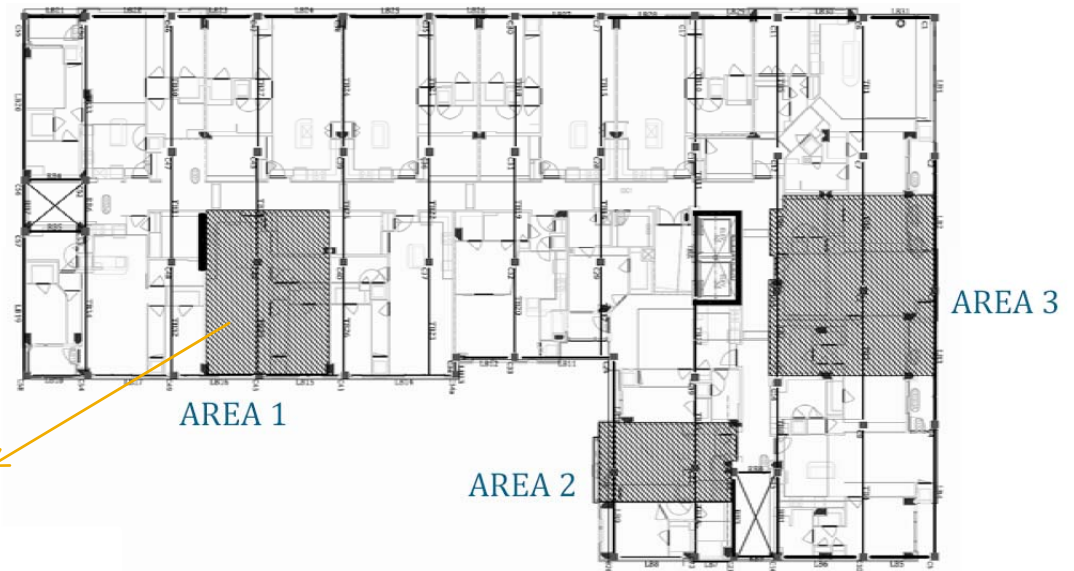
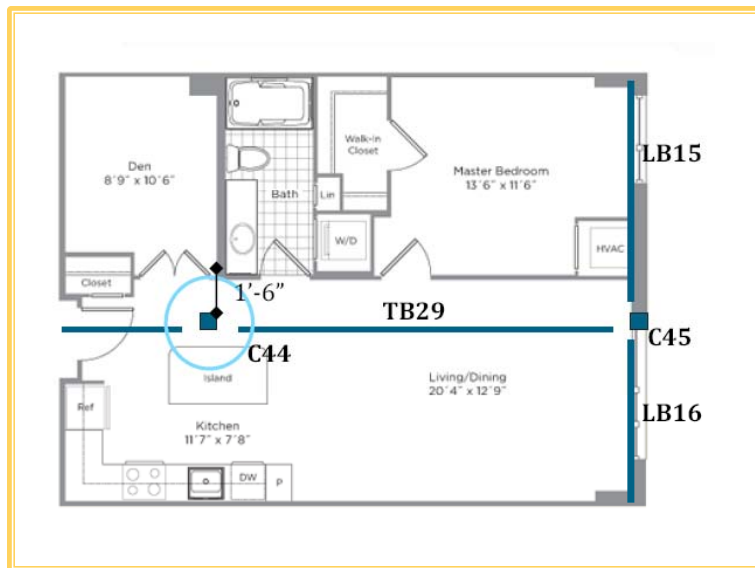
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Constructability: Architecturally

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Architectural Concerns

1. Additional Columns
 - Reducing rentable space
 - Reducing window





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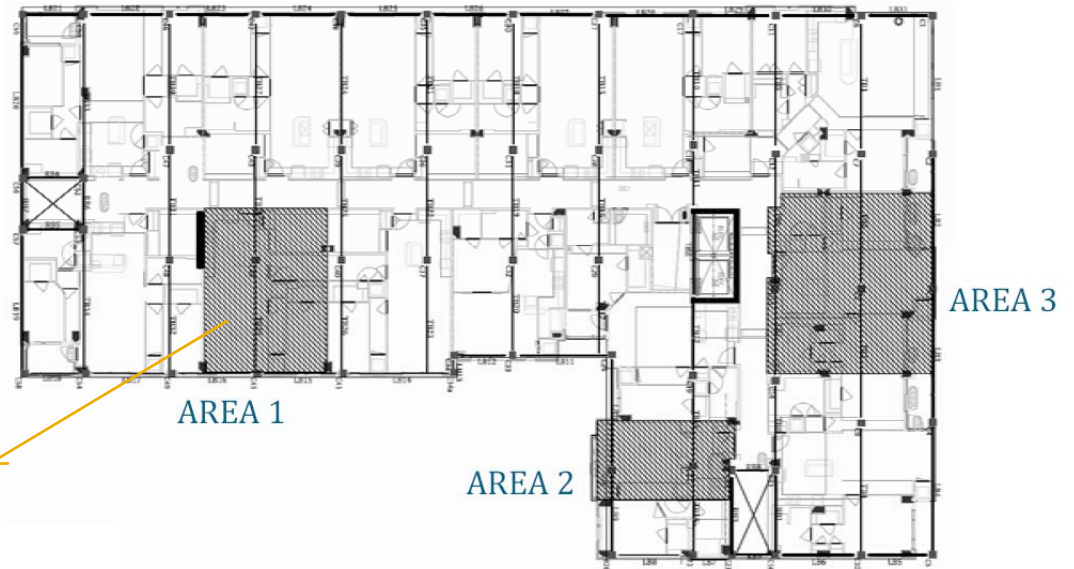
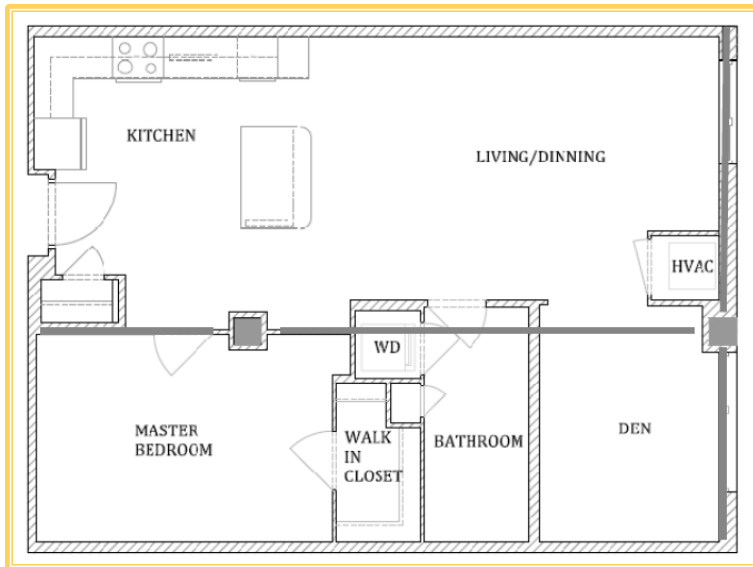
Constructability: Architecturally

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Architectural Concerns

1. Additional Columns
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 - Reducing window

Architectural Solution





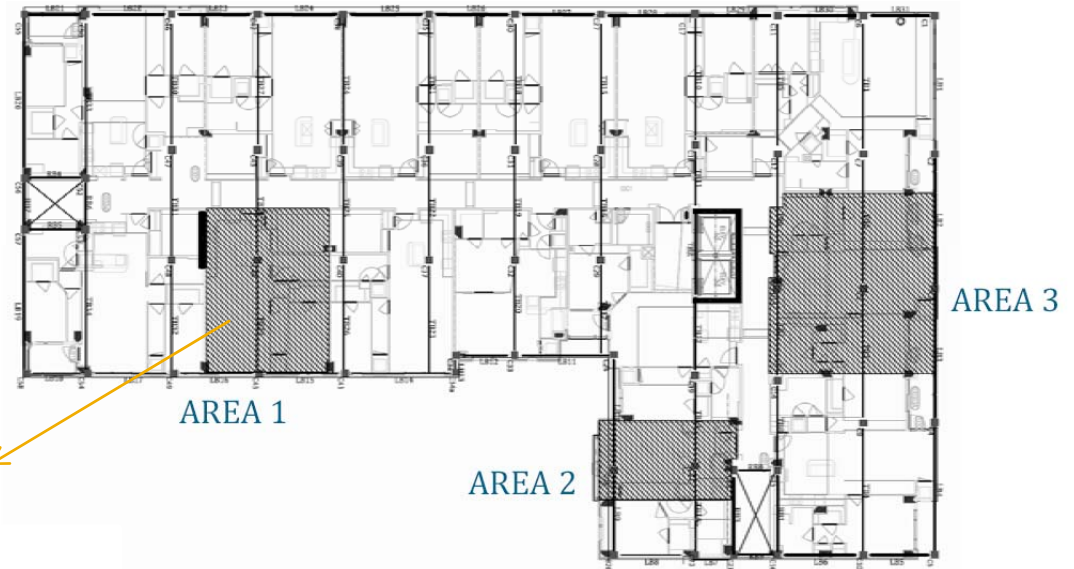
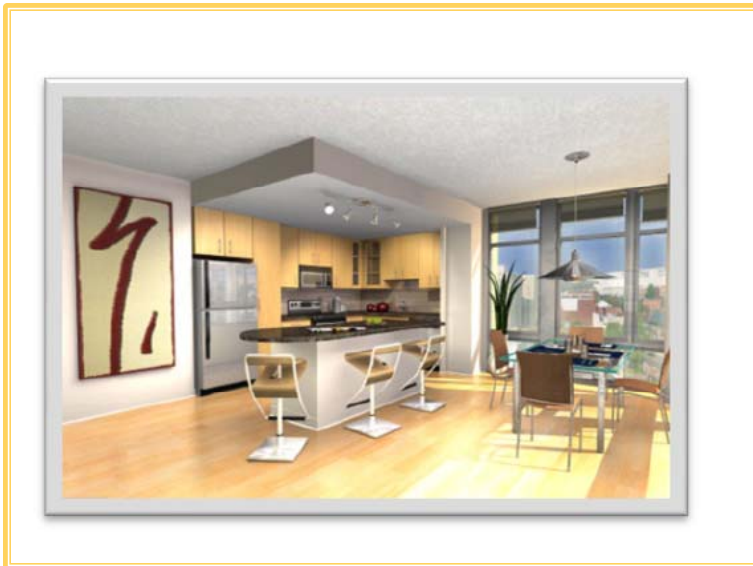
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Constructability: Architecturally

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Architectural Concerns

1. Additional Columns
 - Reducing rentable space
 - Reducing window
2. Exposed Ceiling Grid





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Conclusion

| Building Stats | Proposal | Preliminary Design | Gravity System | Lateral System | Constructability | **Conclusion** |



Pre-cast is NOT a better solution

Post Tension System:

1. Height: Not as restricting
2. Architecture: Irregular grid —————> Open plan condos
2. Economically: Post-tension less concrete ———> Cheaper



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Pre-cast is NOT a better solution

Post Tension System:

1. Height: Not as restricting
2. Architecture: Irregular grid —————> Open plan condos
2. Economically: Post-tension less concrete ———> Cheaper

Although If

Incorporation in preliminary design

1. Height Limit
2. Finished Ceiling
3. LEEDS possibility
4. Fast onsite erection

Acknowledgements

- SK& A Engineering
- Davis Construction
- Faculty
- Friends and Family

QUESTIONS ?