The New York City Bus Depot

Kaitlyn Triebl
Structural Option
Senior Thesis Presentation 2012
The Pennsylvania State University

Outline

- Existing Conditions
- Problem Statement
- Proposed Solution
- Structural Depth
- Construction Breadth
- Conclusions
- Questions

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BUILDING STATISTICS

EXISTING CONDITIONS
- ◊ BUILDING STATISTICS
- ◊ SITE AND LOCATION
- ◊ STRUCTURAL SYSTEM

PROBLEM STATEMENT

PROPOSED SOLUTION

STRUCTURAL DEPTH

CONSTRUCTION BREADTH

CONCLUSIONS

QUESTIONS

FUNCTION: Bus Depot, Service Garage, MTA Offices

SIZE: 390,000 SF

HEIGHT: 80'

STORIES: 3 (4 in office area)

PROJECT TEAM:

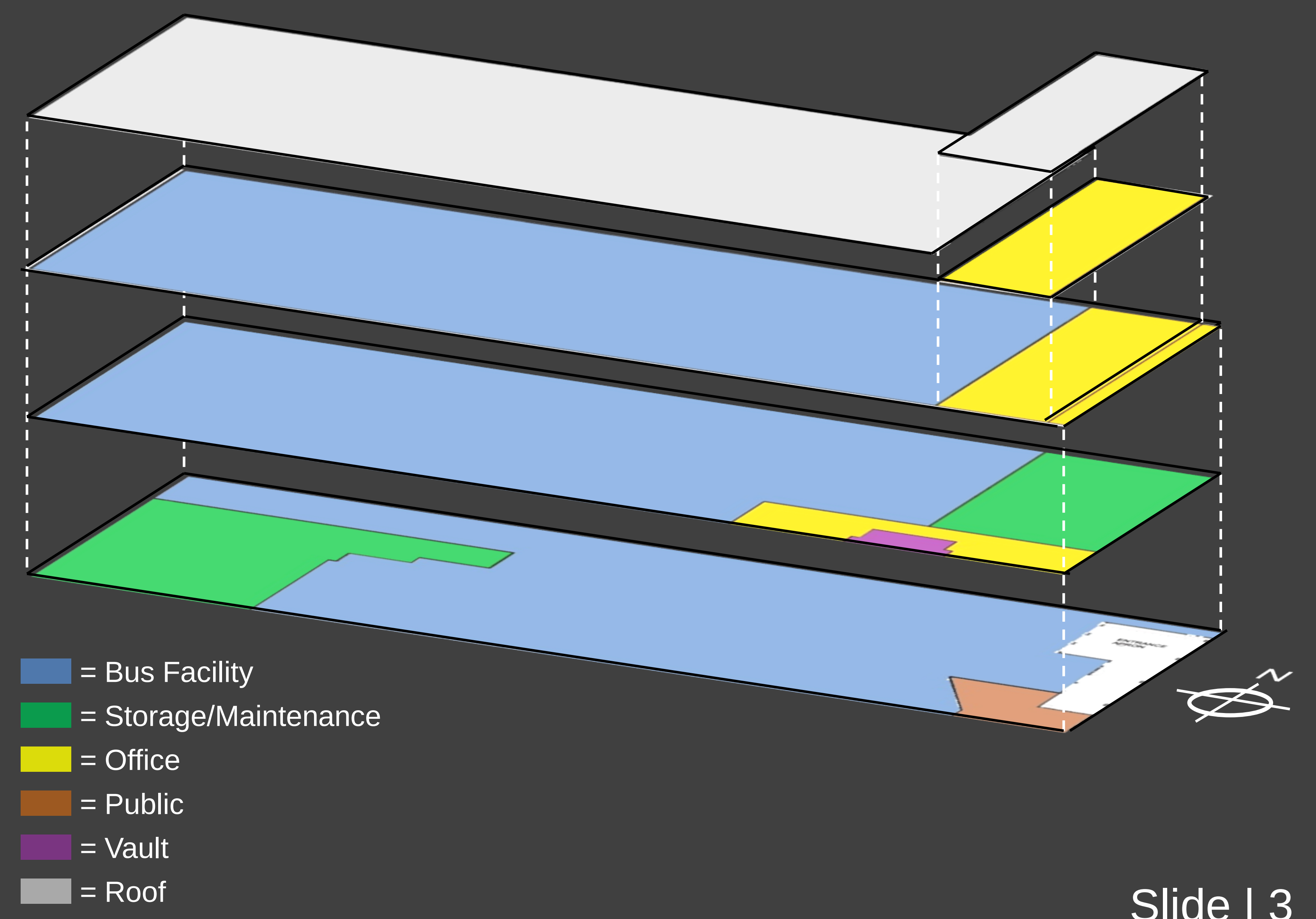
ENGINEER/ARCHITECT: STV, Incorporated

CONSTRUCTION MANAGER: Silverite Construction Co.

OWNER/ OCCUPANT: New York City Transit Authority

DATES OF CONSTRUCTION: Summer 2011 – Summer 2013

DELIVERY METHOD: Design Build



SITE AND LOCATION

EXACT LOCATION:
Undisclosed by Owner

SITE REUSE:
Former Trolley Barn

SITE ZONING:
Commercial - Heavy Automotive

SURROUNDINGS:
Moderate to High Density Residential Districts

SOILS:
Site Class E – Liquefiable Soil

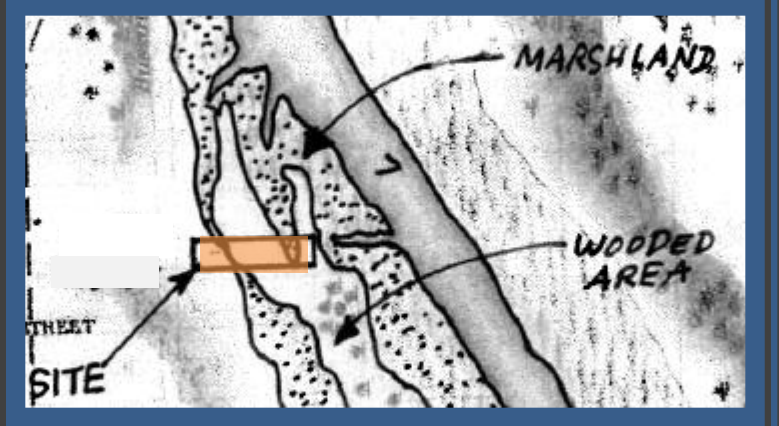
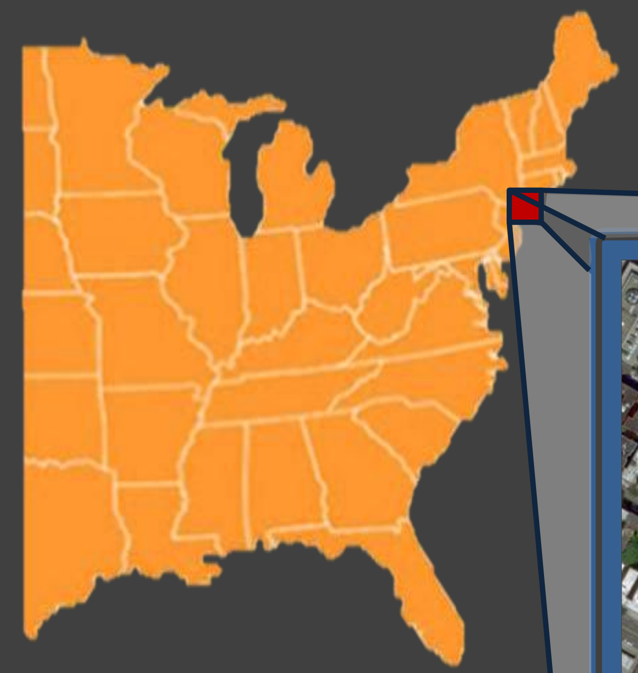


Image: Colton's Topographic Map of the City and County of New York (1835)



Safekids.org

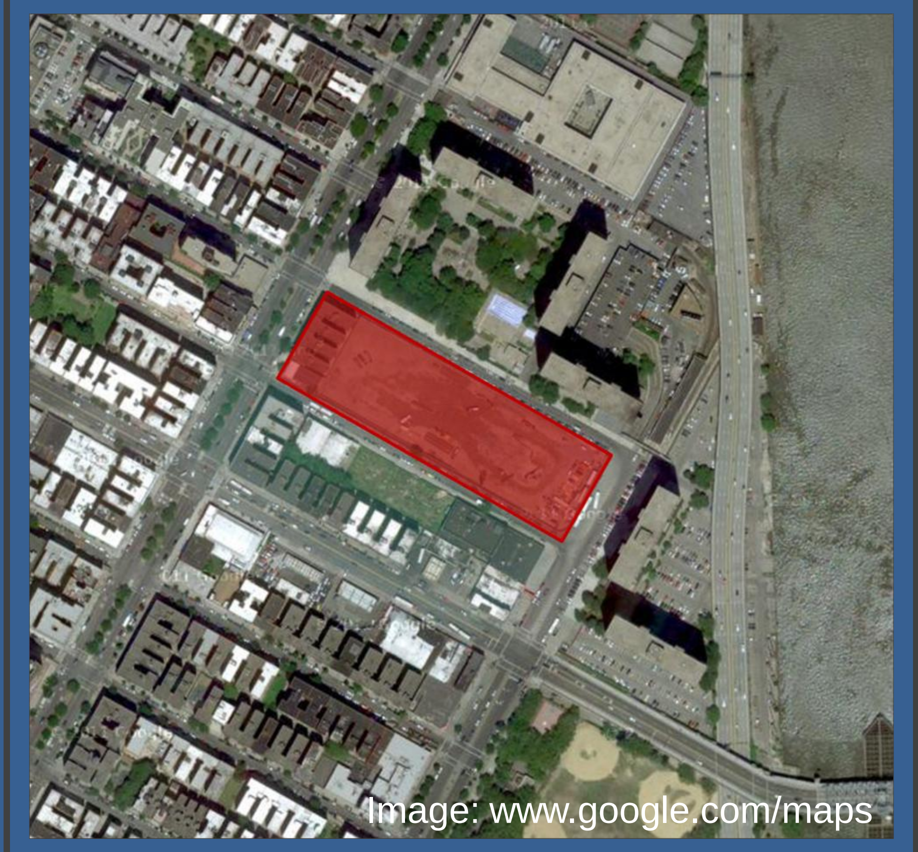


Image: www.google.com/maps

EXISTING STRUCTURAL SYSTEM

FOUNDATION:

Pile Foundation (as deep as 150')

BASE:

14" – 18" Reinforced Concrete Slab

FLOOR SYSTEM:

6" Reinforced Concrete Slab

2" 18 gage sacrificial metal deck

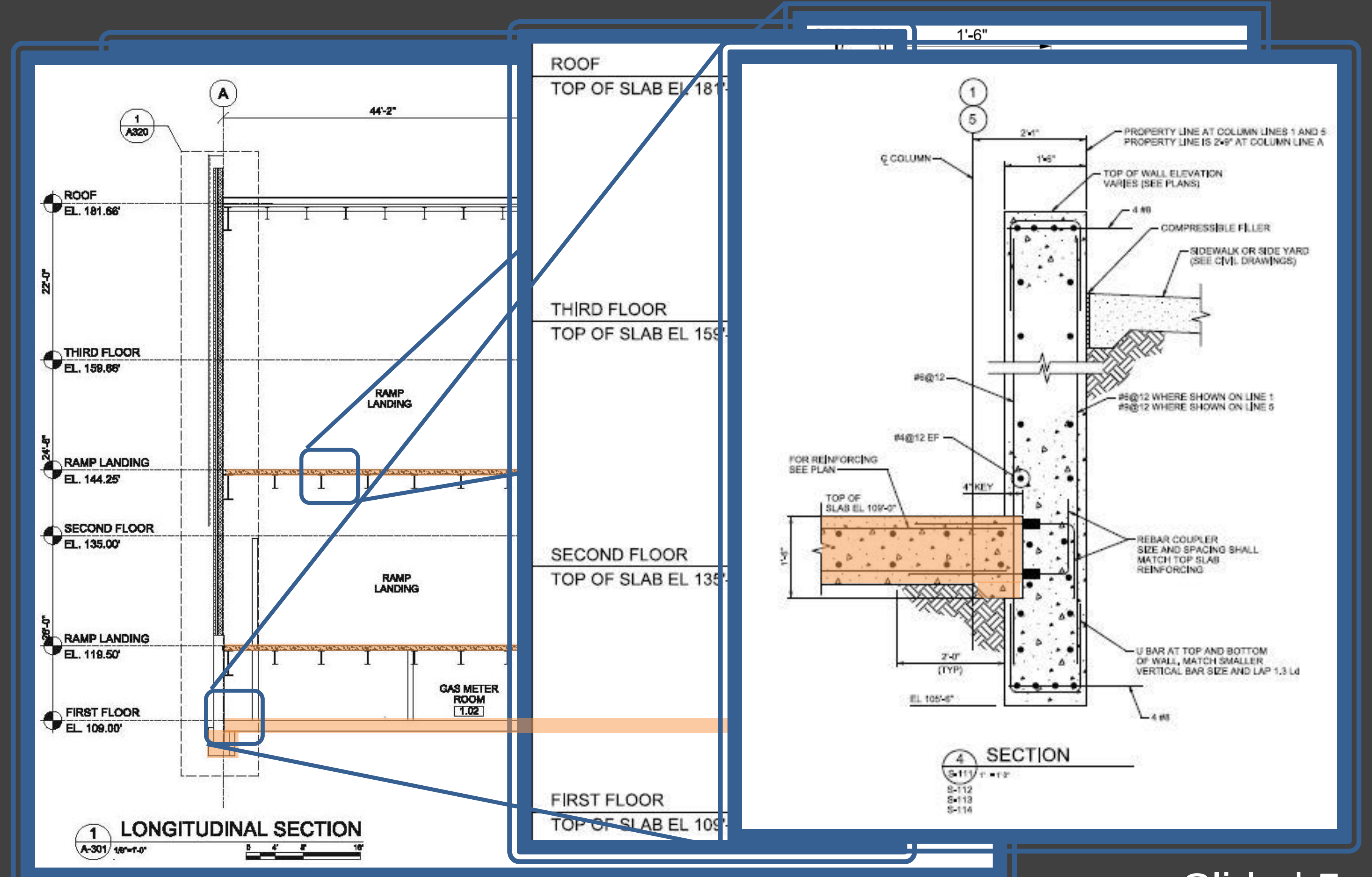
COLUMNS:

Steel Wide Flange W14x's

LATERAL SYSTEM:

E-W: Ordinary Steel Braced Frames

N-S: Ordinary Steel Moment Frames

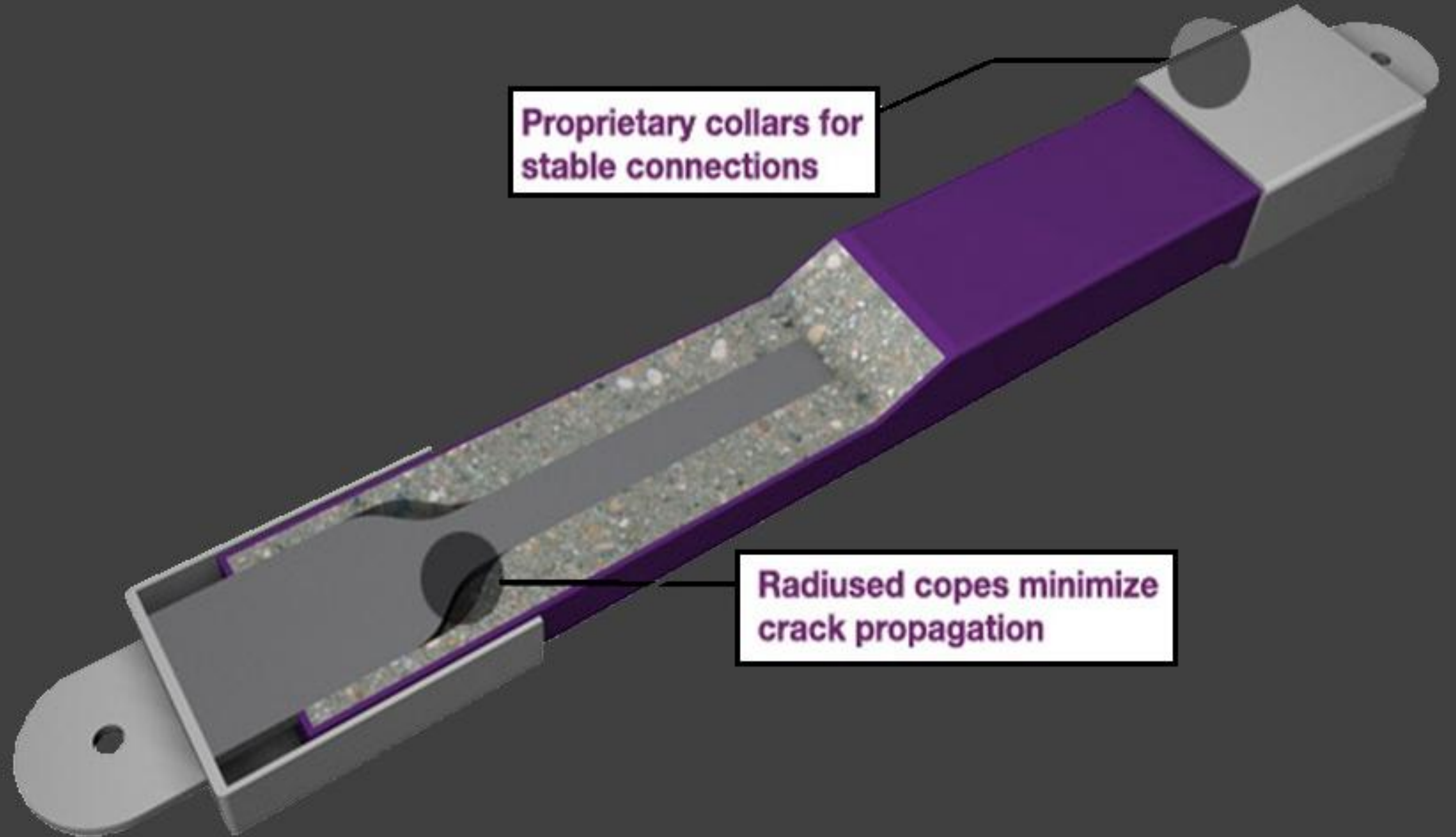


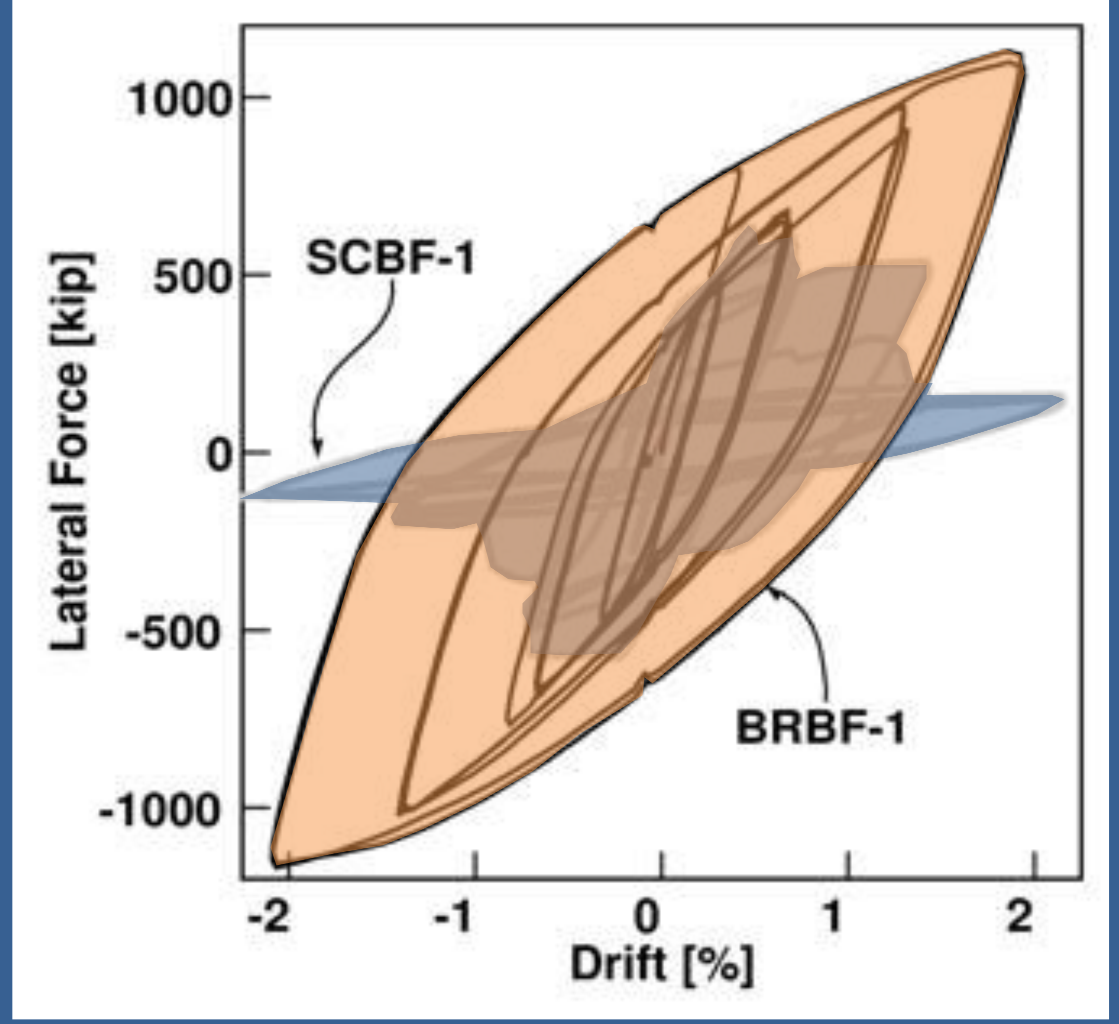
PROJECT GOALS

- ◊ Replace Moment Frame Scheme with Braced Frames
- ◊ Maintain Bus Flow
- ◊ Lower Seismic Reactions
- ◊ Control drift of the 3rd Floor Mezzanine and High Roof
- ◊ Decrease the Construction Time per Frame
- ◊ Decrease the Cost of Lateral System Erection
- ◊ Decrease the Skilled Laborers Necessary on Site

Buckling Restrained Braced Frames

STAR SEISMIC POWERCAT





Coffman Engineers

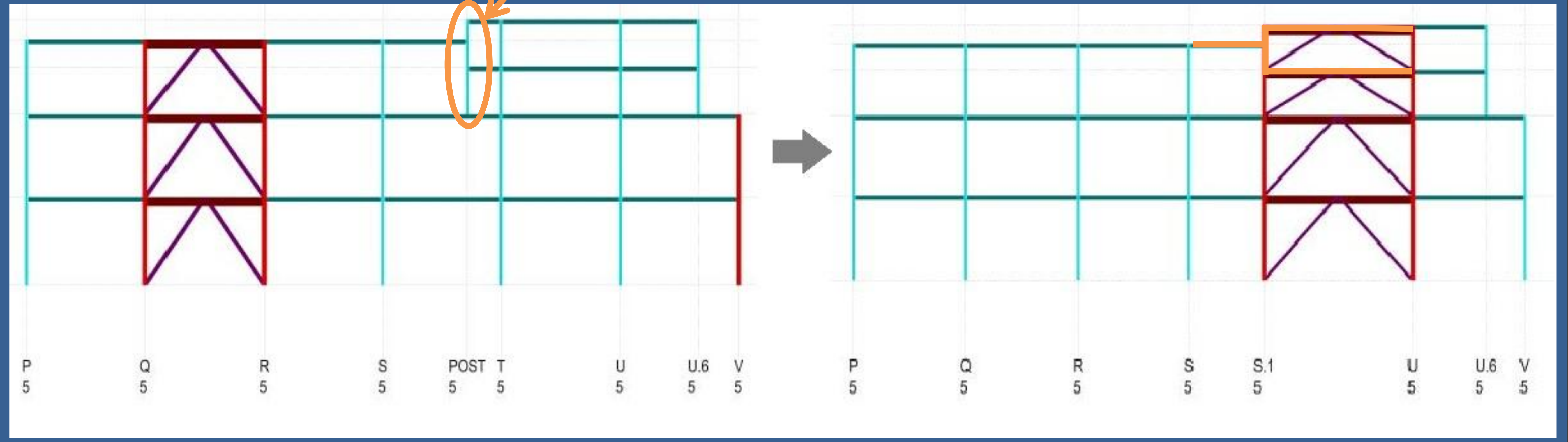
Benefits of Buckling Restrained Braces

- ◊ Beneficial for Poor Soils
- ◊ Simple Connections
- ◊ Predictable Behavior
- ◊ Yields in Tension and Compression
- ◊ Fewer Braces than Typical Braced Frame

Images: Nordstrom Topanga Mall (Coffman Engineers)

BRACE RELOCATION

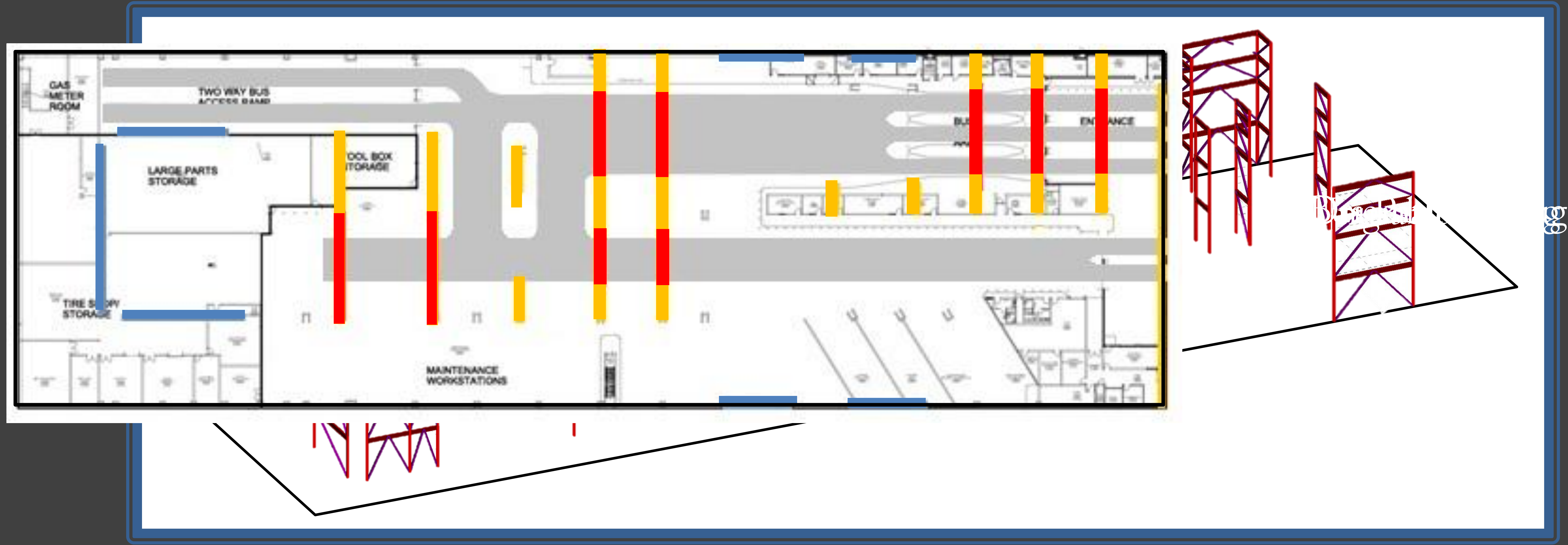
Posts



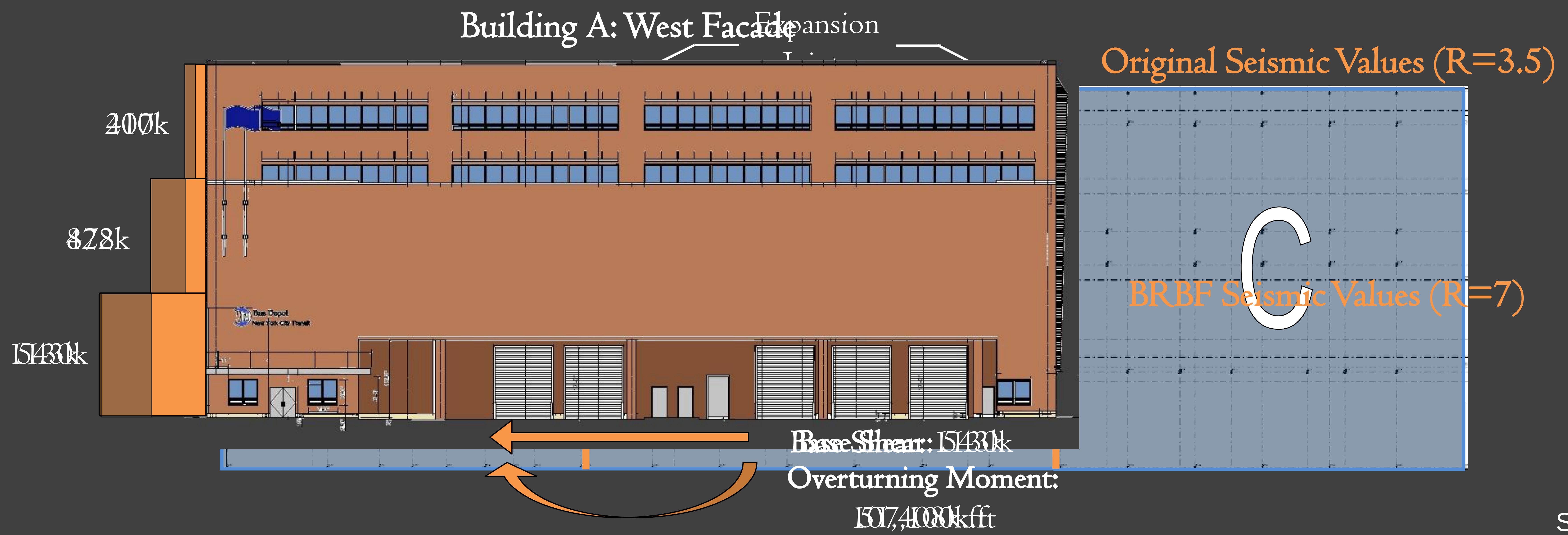
Large Deflections under Original Design

Proposed Design Alteration

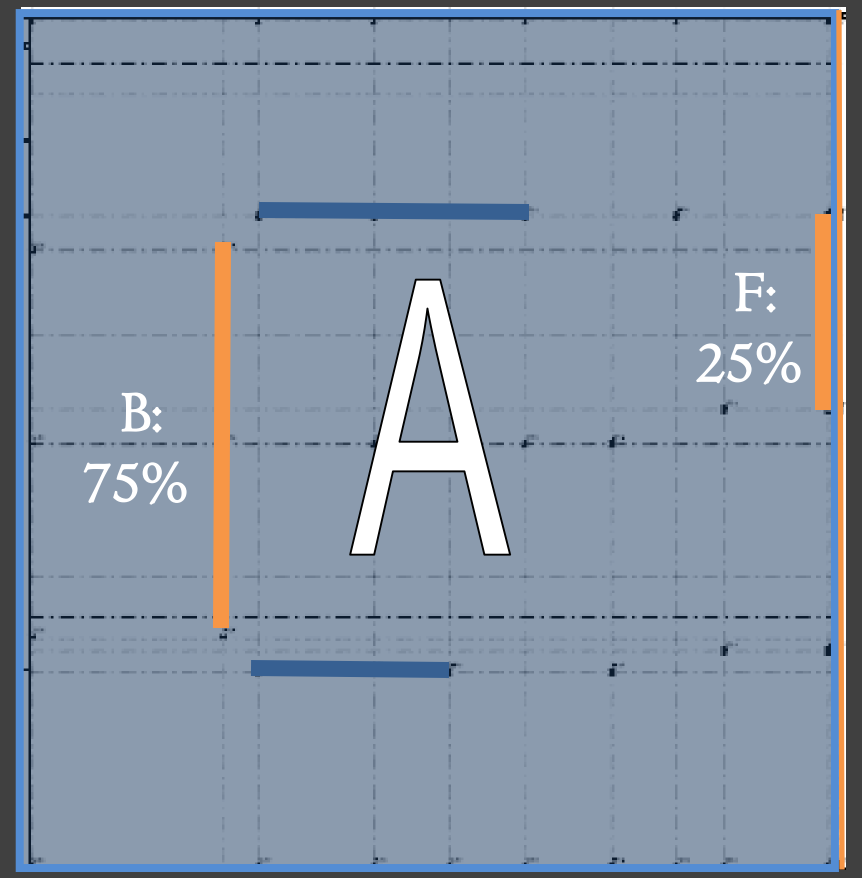
BAY ELIMINATION



Lateral Loads and Distributions



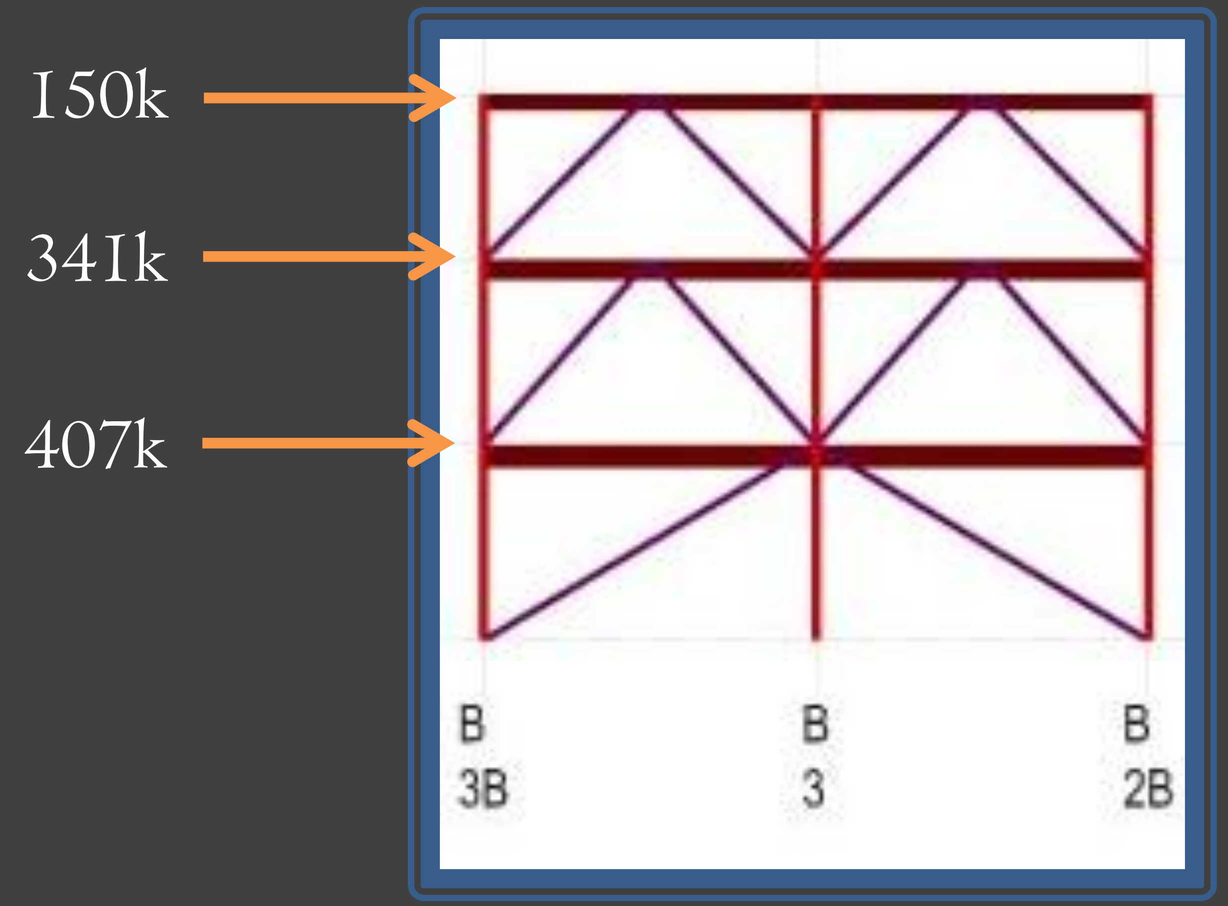
LATERAL LOADS AND DISTRIBUTIONS



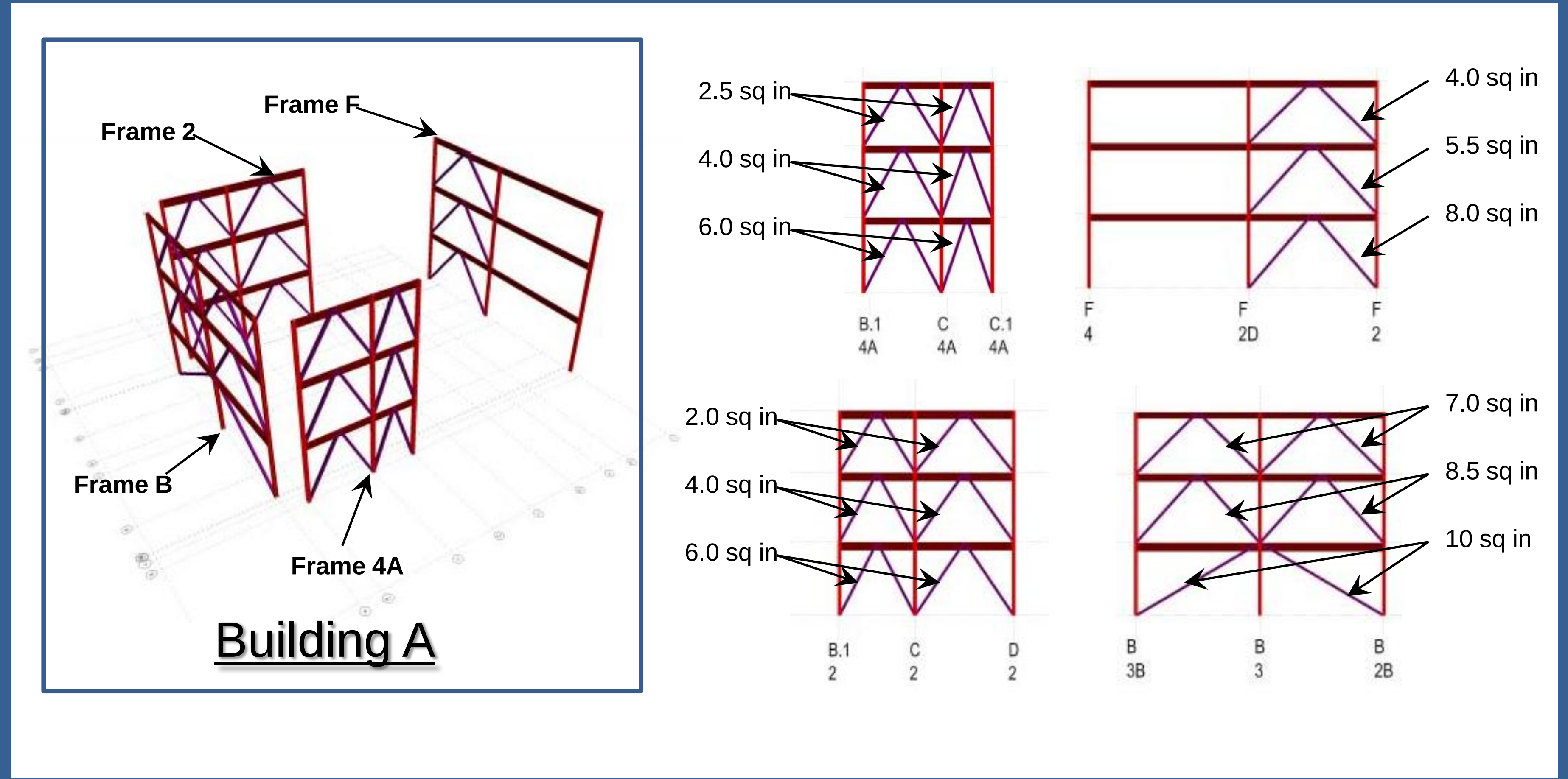
Level 1:
B: 407 k
F: 136 k

Level 2:
B: 341 k
F: 114 k

Level 3:
B: 150 k
F: 50 k



BRACE DESIGN

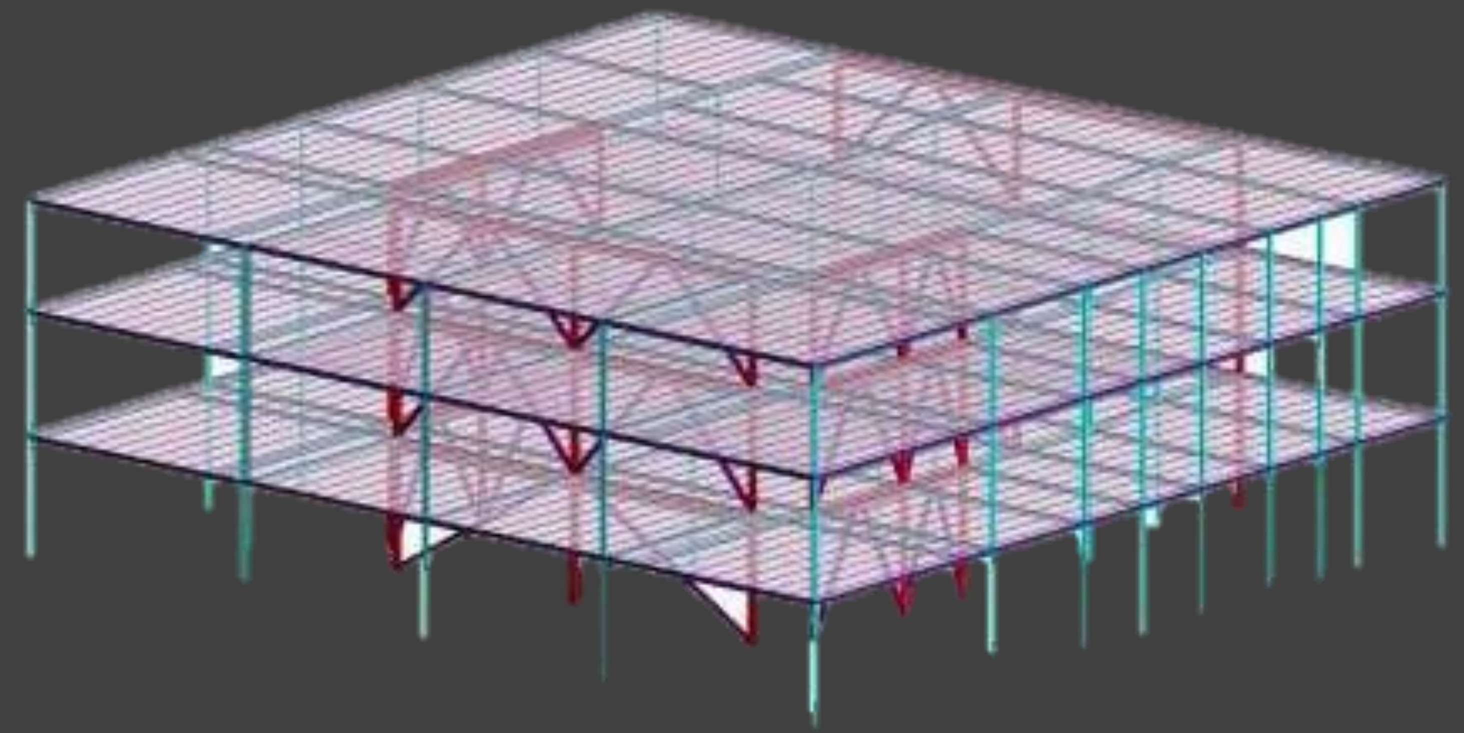


Coffman Engineers

RAM MODELS

Model Assumptions:

◊ All diaphragms rigid
◊ All connections pinned (except base)
◊ Axial Stiffness Modifier applied to Braces
◊ Rigid End Offsets applied to Braces
◊ PΔ Effects Included



COST ANALYSIS

$1,400 Study

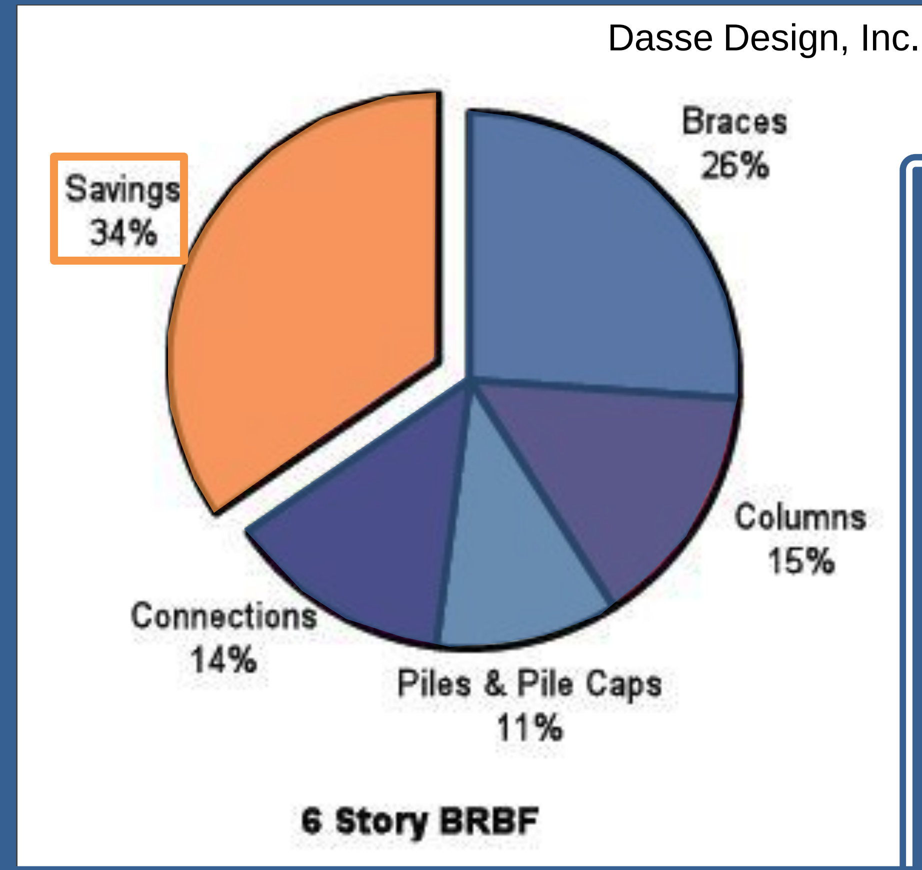
Pricing Connections			
Unit	BRB	Weld	Bolt
per connection	$200.50	$672.76	$1,164.08
per project	$2,995,548.31	$3,346,611.66	

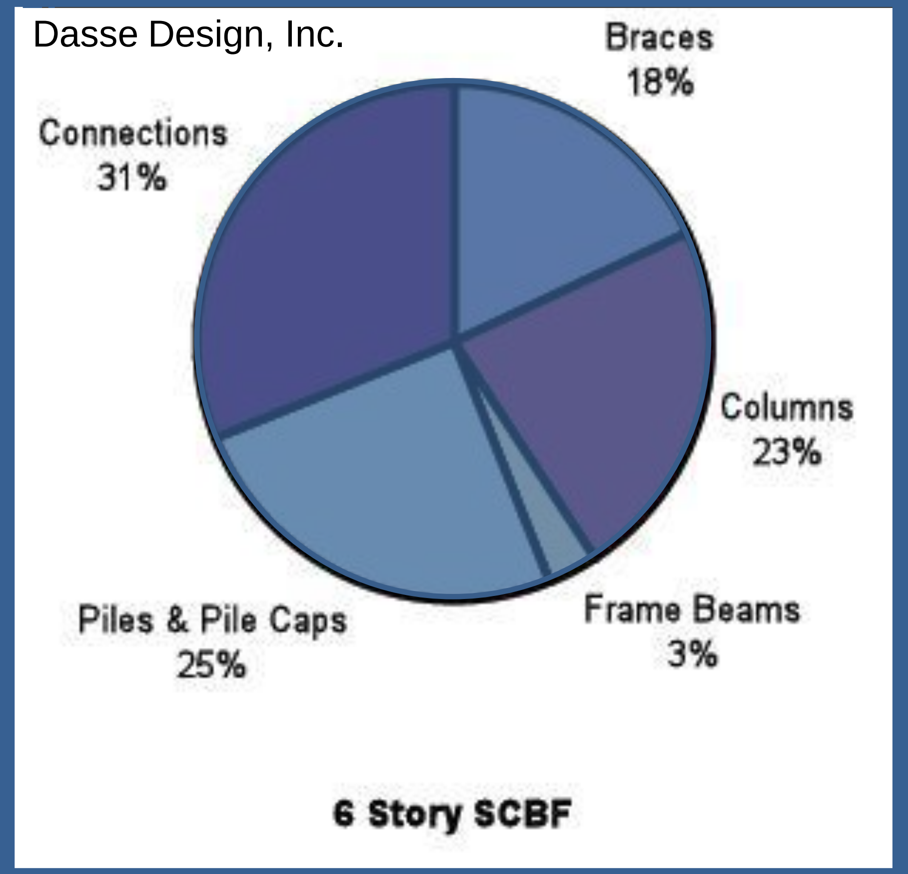
* Note : per project costs include braces, connections, columns, and beams

Dasse Design, Inc.

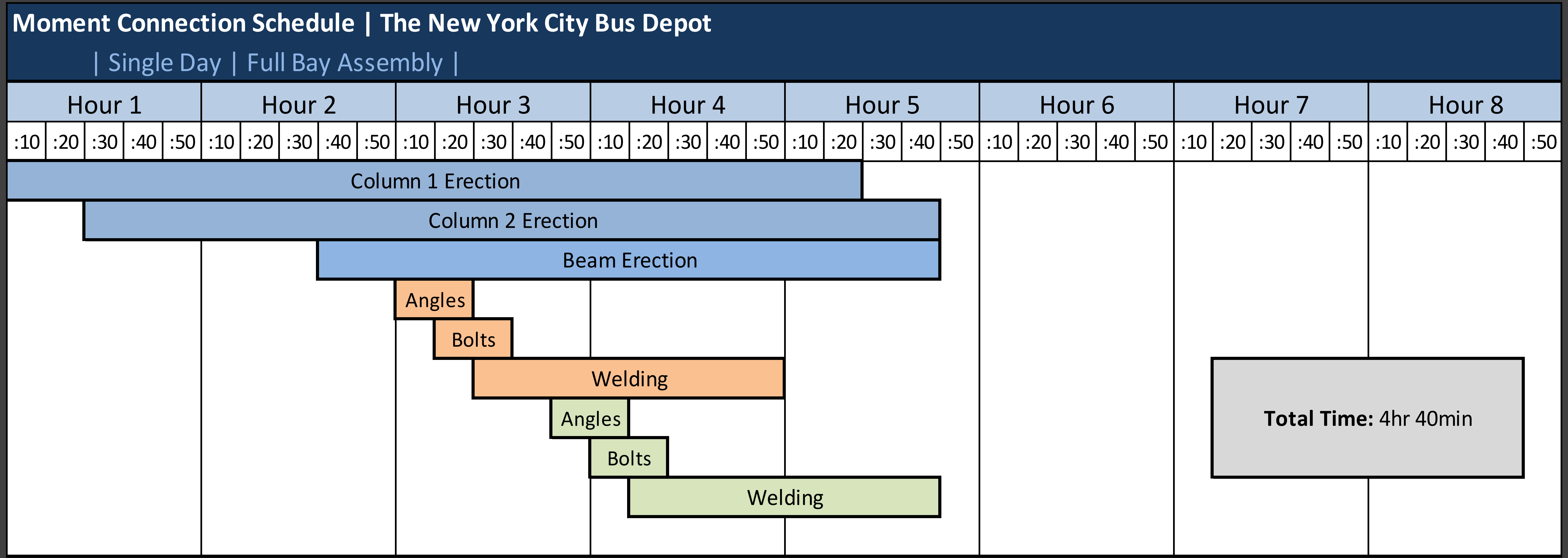
8% Savings

Cost Relative to Building Height



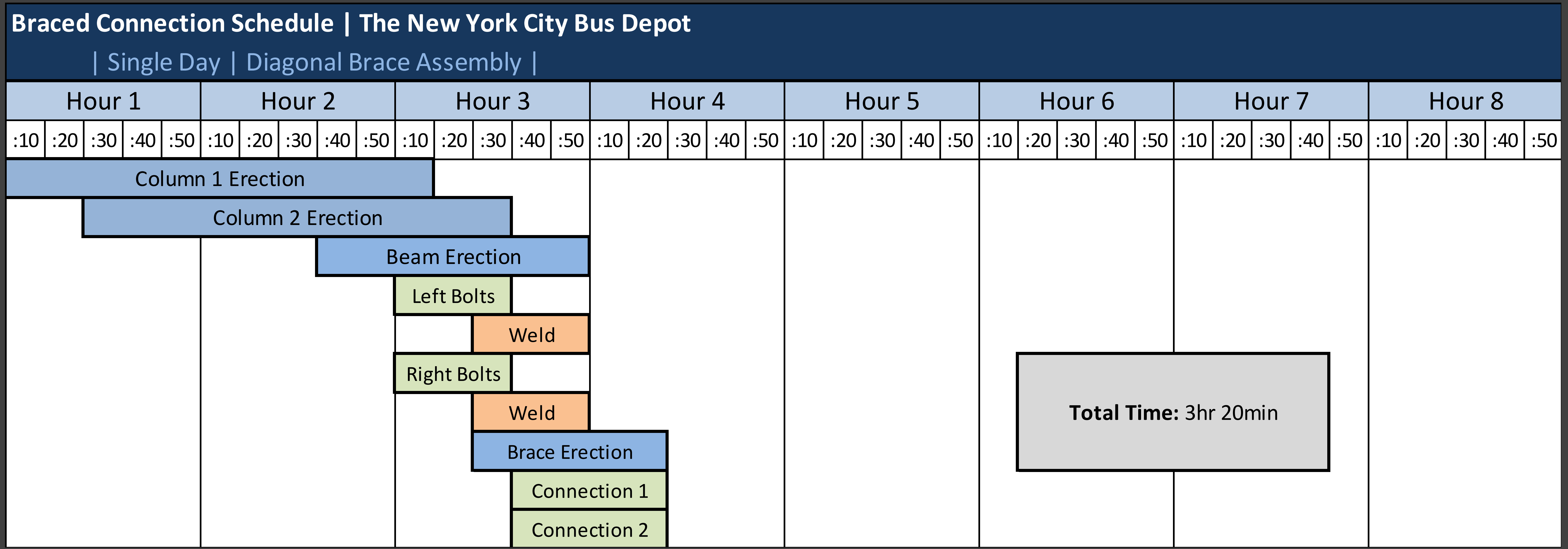


SCHEDULE ANALYSIS



SCHEDULE ANALYSIS

EXISTING CONDITIONS
PROBLEM STATEMENT
PROPOSED SOLUTION
STRUCTURAL DEPTH
CONSTRUCTION BREADTH
◊ COST ANALYSIS
◊ SCHEDULE ANALYSIS
◊ CONSTRUCTION SEQUENCE
CONCLUSIONS
QUESTIONS



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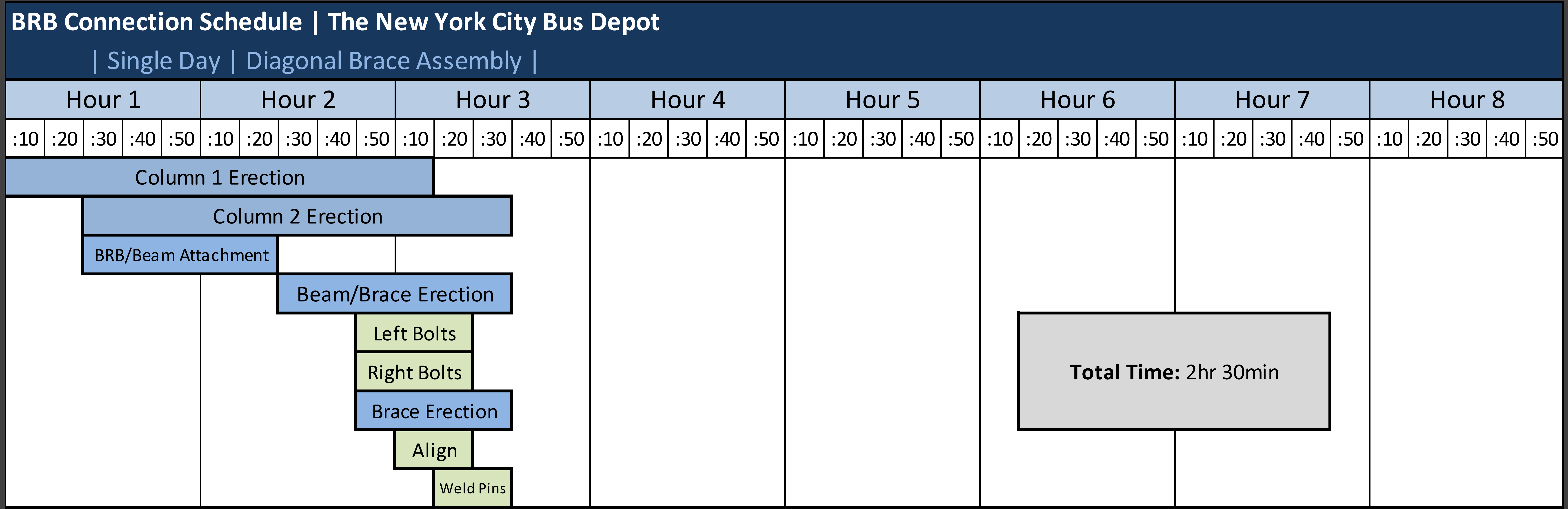
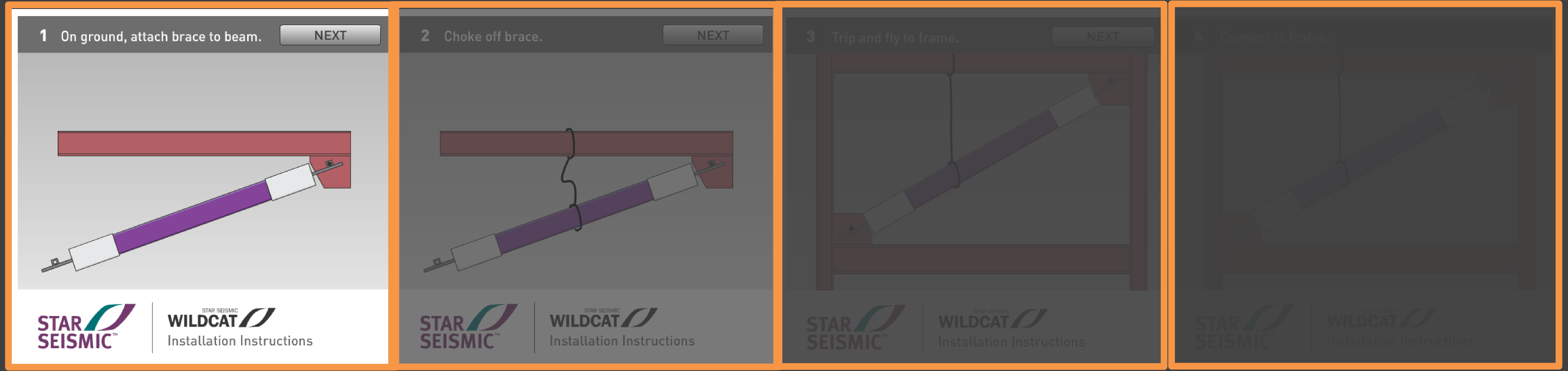


Construction Sequence



REEVALUATION OF GOALS

- Replace Moment Frame Scheme with Braced Frames
- Maintain Bus Flow
- Lower Seismic Reactions
- Control drift of the 3rd Floor Mezzanine and High Roof
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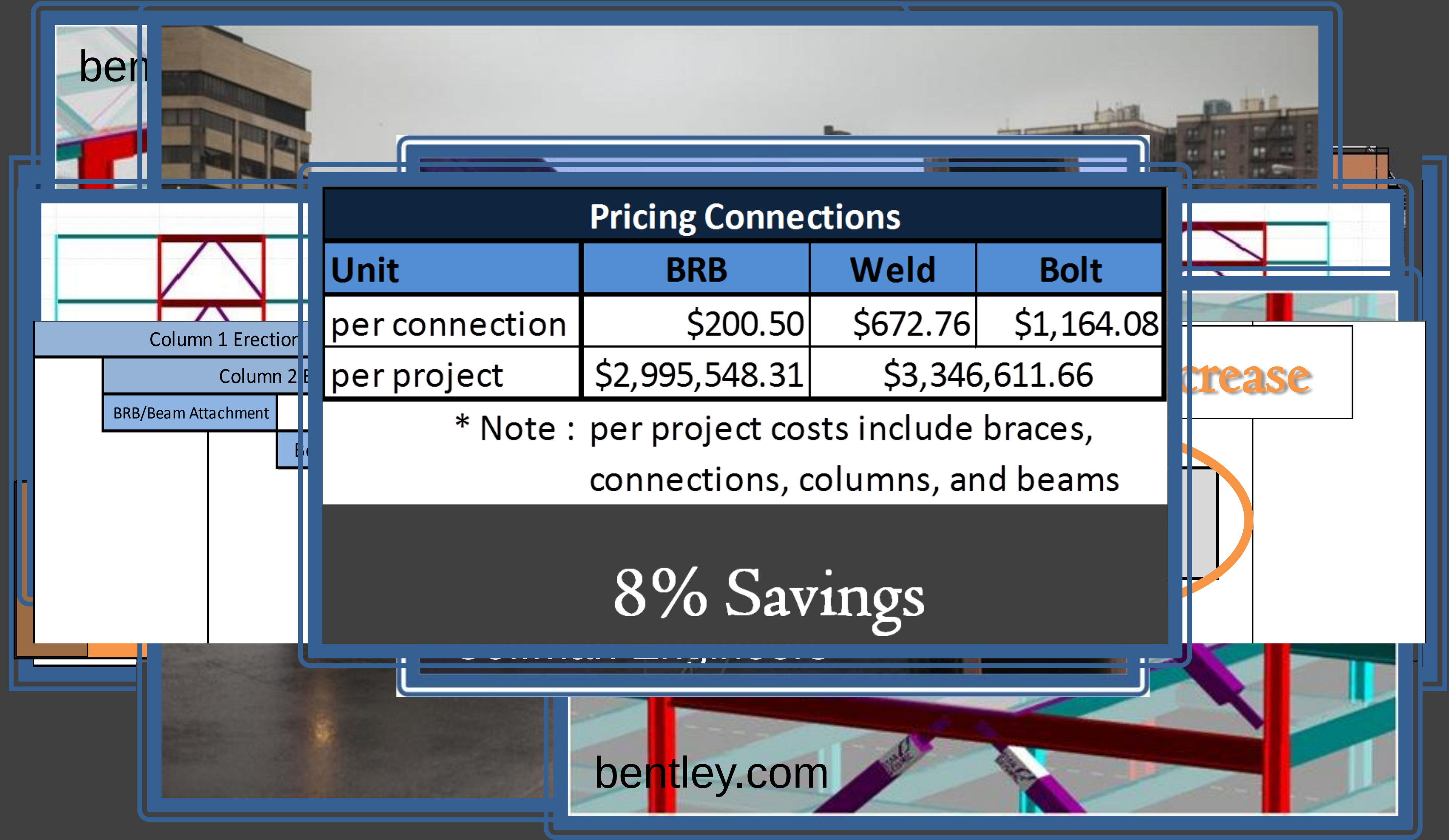

Pricing Connections			
Unit	BRB	Weld	Bolt
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per project	$2,995,548.31	$3,346,611.66	

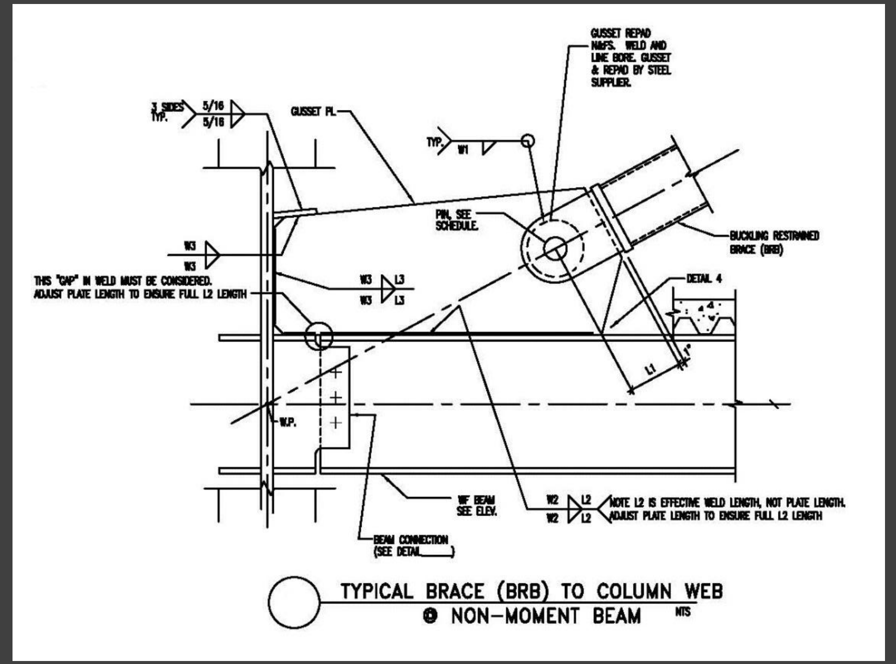
* Note : per project costs include braces, connections, columns, and beams

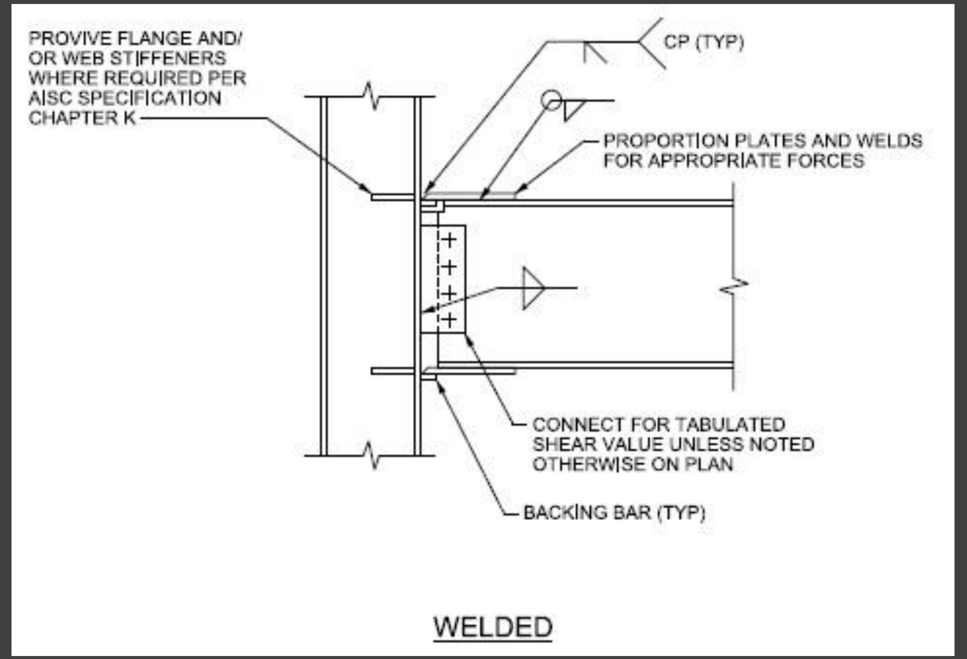
8% Savings

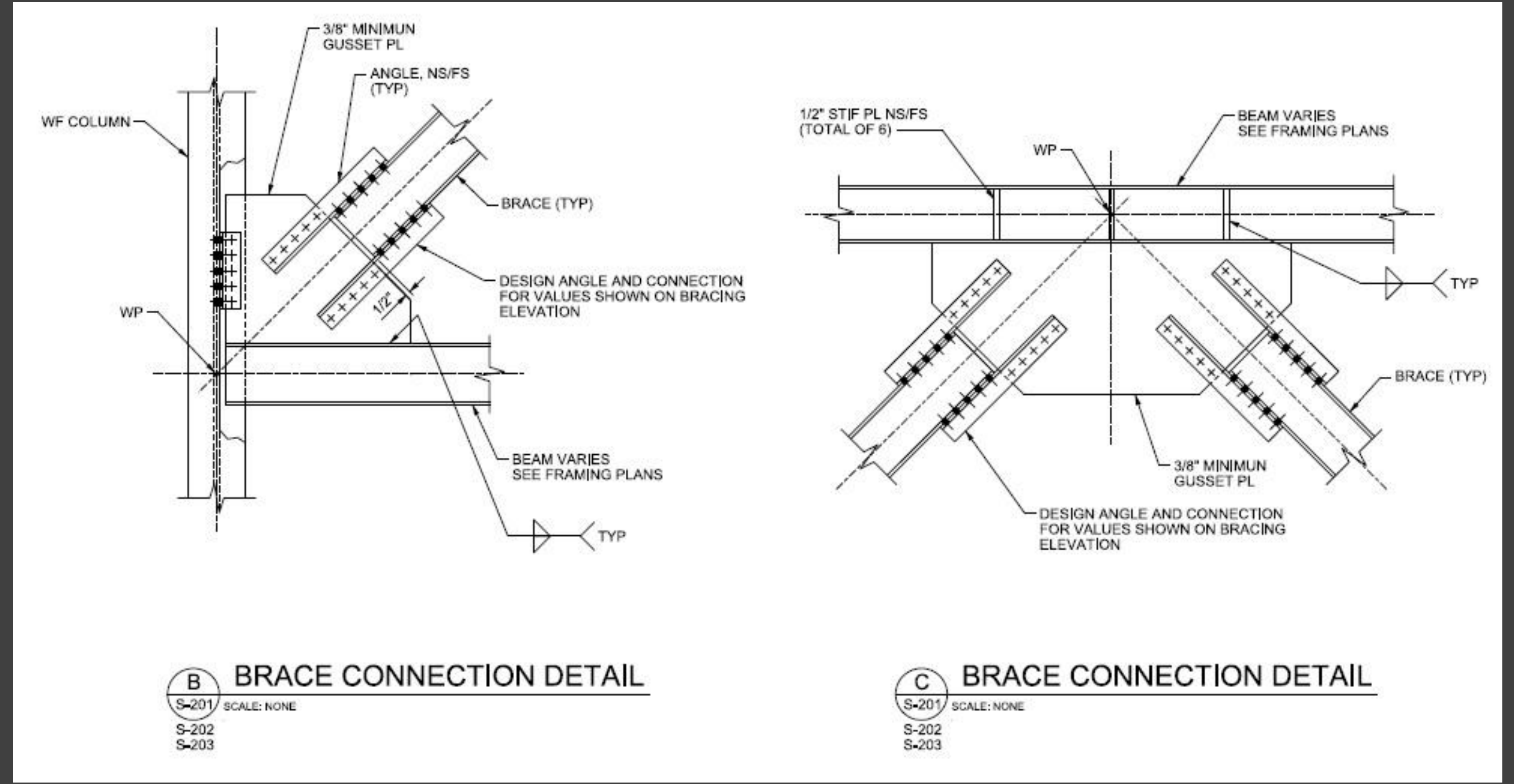
QUESTIONS

Architectural Engineering Faculty and Staff:
Professor Parfitt: Advisor
STV Incorporated:
A. Christopher Cerino
Christopher Papa
Robert Weimar
Andrew Nolt
Star Seismic™:
Kimberly Robinson
New York City Mass Transit Authority:
Mahesh Patel
Friends and Family

CONNECTIONS







CONNECTIONS

AXIAL STIFFNESS MODIFIERS

Connection Strength = $P_{\text{yielding core}} * \beta\ \omega$
β= Compression Max : Tension Max
ω= Tension Max : Yield Strength*Steel Area

$$Modifier = \frac{E_{brace} A_{yield\ core} / L_{yield\ core}}{E_{total\ brace} A_{yield\ core} / L_{total\ brace}}$$

BUILDING A ECONOMIZATION

Stiffness and Overstrength Factor Analysis

F_{ymin} = 39 ksi | F_{ymax} = 46 ksi | Cd (5, R=8, 5.5, R=7) 5.00 | ρ= 1.00 | I= 1.00 | A (A=Area Based,) | Gusset, paddle, Lyz, core, radius | (in)= 10 inside tube straight section | 3.75 No shim+Gap&plates

1.41 Use βω

Maxima: 1.177% 1.35 -1.30

NYC Bus Depot Building A

Wildcat™ Brace Information / Wildcat Brace Capacity Analysis / Wildcat Brace Stiffness Analysis

Brace #	Frame	Floor	P_u/ϕ	Design A_{sc} (in^2)	$P_{ysc-min}$	$P_{ysc-max}$	P_u/ϕ / $P_{ysc-min}$ Unity Ratio	L_{wp-wp} (in)	$L_{Guss-Guss}$ (in) (at sugg)	L_{ysc} (in)	L_{paddle} (in)	K_{core} (k/in)	K_{paddle} (k/in)	K_{eff} (k/in)
1	184.17ft-128.08ft to F-2D	3-Roof	130.7	4.00	156	184	0.84	376.9	311.0	272.2	19.38	426	11,222	396
2	184.17ft-128.08ft to F-2	3-Roof	121.3	4.00	156	184	0.78	376.9	311.0	272.2	19.38	426	11,222	396
3	184.17ft-128.08ft to F-2D	40942	190.6	5.50	215	253	0.89	400.0	331.0	292.6	19.18	545	15,120	508
4	184.17ft-128.08ft to F-2	40942	183.4	5.50	215	253	0.86	400.0	331.0	292.6	19.18	545	15,120	508
5	184.17ft-128.08ft to F-2D	G-2	252.8	8.00	312	368	0.81	412.0	342.0	303.2	19.38	765	22,445	716
6	184.17ft-128.08ft to F-2	G-2	253.2	8.00	312	368	0.81	412.0	342.0	303.2	19.38	765	22,445	716
7	65.79ft-150.50ft to B.1-2	G-2	198.2	6.00	234	276	0.85	350.9	271.0	233.8	18.58	744	15,611	679
8	65.79ft-150.50ft to C-2	G-2	195.7	6.00	234	276	0.84	350.9	271.0	233.8	18.58	744	15,611	679
9	65.79ft-45.00ft to B.1-4A	3-Roof	77.6	2.50	98	115	0.80	309.0	252.0	219.1	16.47	331	8,366	307
10	65.79ft-45.00ft to C-4A	3-Roof	50.9	2.50	98	115	0.52	309.0	252.0	219.1	16.47	331	8,366	307
11	87.92ft-45.00ft to C-4A	3-Roof	37.5	2.50	98	115	0.38	284.1	222.0	189.1	16.47	383	8,366	351
12	87.92ft-45.00ft to C.1-4A	3-Roof	94.8	2.50	98	115	0.97	284.1	222.0	189.1	16.47	383	8,366	351
13	65.79ft-45.00ft to B.1-4A	40942	129.6	4.00	156	184	0.83	336.7	272.0	233.2	19.38	497	11,222	457
14	65.79ft-45.00ft to C-4A	40942	108.8	4.00	156	184	0.70	336.7	272.0	233.2	19.38	497	11,222	457
15	87.92ft-45.00ft to C-4A	40942	88.7	4.00	156	184	0.57	314.1	239.0	200.2	19.38	579	11,222	525
16	87.92ft-45.00ft to C.1-4A	40942	137.5	4.00	156	184	0.88	314.1	239.0	200.2	19.38	579	11,222	525
17	65.79ft-45.00ft to B.1-4A	G-2	193.3	6.00	234	276	0.83	350.9	280.0	242.8	18.58	717	15,611	656
18	65.79ft-45.00ft to C-4A	G-2	193.0	6.00	234	276	0.82	350.9	280.0	242.8	18.58	717	15,611	656
19	87.92ft-45.00ft to C-4A	G-2	174.0	6.00	234	276	0.74	329.2	247.0	209.8	18.58	829	15,611	750
20	87.92ft-45.00ft to C.1-4A	G-2	176.8	6.00	234	276	0.76	329.2	247.0	209.8	18.58	829	15,611	750
21	44.17ft-75.50ft to B-3B	3-Roof	188.3	7.00	273	322	0.69	375.5	288.0	247.6	20.19	820	21,550	762
22	44.17ft-75.50ft to B-3	3-Roof	248.9	7.00	273	322	0.91	375.5	288.0	247.6	20.19	820	21,550	762
23	44.17ft-120.00ft to B-3	3-Roof	244.5	7.00	273	322	0.90	375.5	288.0	247.6	20.19	820	21,550	762
24	44.17ft-120.00ft to B-2B	3-Roof	192.0	7.00	273	322	0.70	375.5	288.0	247.6	20.19	820	21,550	762
25	44.17ft-75.50ft to B-3B	40942	258.9	8.50	332	391	0.78	398.6	309.0	271.0	18.98	909	22,920	843
26	44.17ft-75.50ft to B-3	40942	312.7	8.50	332	391	0.94	398.6	309.0	271.0	18.98	909	22,920	843
27	44.17ft-120.00ft to B-3	40942	308.0	8.50	332	391	0.93	398.6	309.0	271.0	18.98	909	22,920	843
28	44.17ft-120.00ft to B-2B	40942	262.5	8.50	332	391	0.79	398.6	309.0	271.0	18.98	909	22,920	843
29	B-3 to B-3B	G-2	268.6	10.00	390	460	0.69	618.5	522.0	482.4	19.78	601	29,318	577
30	B-3 to B-2B	G-2	268.6	10.00	390	460	0.69	618.5	522.0	482.4	19.78	601	29,318	577
31	65.79ft-150.50ft to B.1-2	3-Roof	69.3	2.00	78	92	0.89	309.0	241.0	208.5	16.26	278	6,352	256
32	65.79ft-150.50ft to C-2	3-Roof	50.3	2.00	78	92	0.64	309.0	241.0	208.5	16.26	278	6,352	256
33	C.1-2 to C-2	3-Roof	60.3	2.00	78	92	0.77	337.3	265.0	232.5	16.26	249	6,352	231
34	C.1-2 to D-2	3-Roof	64.5	2.00	78	92	0.83	337.3	265.0	232.5	16.26	249	6,352	231
35	65.79ft-150.50ft to B.1-2	40942	135.8	4.00	156	184	0.87	336.7	263.0	224.2	19.38	517	11,222	474
36	65.79ft-150.50ft to C-2	40942	117.0	4.00	156	184	0.75	336.7	263.0	224.2	19.38	517	11,222	474
37	C.1-2 to C-2	40942	130.1	4.00	156	184	0.83	362.9	284.0	245.2	19.38	473	11,222	436
38	C.1-2 to D-2	40942	135.7	4.00	156	184	0.87	362.9	284.0	245.2	19.38	473	11,222	436
39	C.1-2 to C-2	G-2	201.1	6.00	234	276	0.86	376.1	301.0	263.8	18.58	659	15,611	608
40	C.1-2 to D-2	G-2	203.3	6.00	234	276	0.87	376.1	301.0	263.8	18.58	659	15,611	608

Wildcat Overstrength Factor Analysis / Engineering Tools

Brace #	$P_{elongation}$ (service level - no ρ, φ, or I)	P/Kcore Method Δ_{bs} (in)	$\Delta_{bm} = C_d\Delta_{bx}$(in) (Used)	$2\Delta_{bm}$ (in)	ε_{bm}	ω	Recommend use ω	βω	Recommend use βω	β (Must be ≥ 1)	T_{MAX} (kip)	C_{MAX} (kip)	R_u = 1.1(CorT)$_{MAX}$	$F_{ysc-min}$	$F_{ysc-max}$	K_{model} (k/in)	Ratio K_{eff}/K_{model}	Recommended Stiffness Modificaiton Factor (KF)	Ratio K_{eff}/K_{wp-wp}/KF (Using Design A_{sc})
1	117.6	0.28	1.38	2.76	1.01%	1.31	**1.29**	-1.23	**-1.41**	1.09	240	259	285	39.0	46.0	399	0.99	**1.3**	0.99
2	109.2	0.26	1.28	2.56	0.94%	1.29	**1.29**	-1.19	**-1.41**	1.09	237	259	285	39.0	46.0	399	0.99	**1.3**	0.99
3	171.6	0.31	1.57	3.15	1.08%	1.32	**1.29**	-1.26	**-1.41**	1.09	334	356	391	39.0	46.0	512	0.99	**1.25**	1.02
4	165.1	0.30	1.51	3.03	1.04%	1.31	**1.29**	-1.24	**-1.41**	1.09	332	356	391	39.0	46.0	512	0.99	**1.25**	1.02
5	227.5	0.30	1.49	2.97	0.98%	1.30	**1.29**	-1.21	**-1.41**	1.09	477	517	569	39.0	46.0	721	0.99	**1.25**	1.02
6	227.8	0.30	1.49	2.98	0.98%	1.30	**1.29**	-1.21	**-1.41**	1.09	477	517	569	39.0	46.0	721	0.99	**1.25**	1.02
7	178.4	0.24	1.20	2.40	1.03%	1.31	**1.29**	-1.23	**-1.41**	1.09	361	388	427	39.0	46.0	691	0.98	**1.35**	1.01
8	176.2	0.24	1.18	2.37	1.01%	1.30	**1.29**	-1.23	**-1.41**	1.09	360	388	427	39.0	46.0	691	0.98	**1.35**	1.01
9	69.8	0.21	1.05	2.11	0.96%	1.29	**1.29**	-1.20	**-1.41**	1.09	149	162	178	39.0	46.0	312	0.98	**1.3**	1.01
10	45.8	0.14	0.69	1.39	0.63%	1.20	**1.29**	-1.05	**-1.41**	1.09	138	162	178	39.0	46.0	312	0.98	**1.3**	1.01
11	33.7	0.09	0.44	0.88	0.47%	1.16	**1.29**	-0.98	**-1.41**	1.09	133	162	178	39.0	46.0	364	0.96	**1.4**	0.98
12	85.3	0.22	1.11	2.22	1.18%	1.35	**1.29**	-1.30	**-1.41**	1.09	155	162	178	39.0	46.0	364	0.96	**1.4**	0.98
13	116.6	0.23	1.17	2.34	1.01%	1.30	**1.29**	-1.22	**-1.41**	1.09	240	259	285	39.0	46.0	461	0.99	**1.35**	0.98
14	97.9	0.20	0.98	1.97	0.84%	1.26	**1.29**	-1.15	**-1.41**	1.09	232	259	285	39.0	46.0	461	0.99	**1.35**	0.98
15	79.8	0.14	0.69	1.38	0.69%	1.22	**1.29**	-1.08	**-1.41**	1.09	224	259	285	39.0	46.0	530	0.99	**1.4**	1.02
16	123.8	0.21	1.07	2.14	1.07%	1.32	**1.29**	-1.25	**-1.41**	1.09	243	259	285	39.0	46.0	530	0.99	**1.4**	1.02
17	174.0	0.24	1.21	2.43	1.00%	1.30	**1.29**	-1.22	**-1.41**	1.09	359	388	427	39.0	46.0	667	0.98	**1.3**	1.02
18	173.7	0.24	1.21	2.42	1.00%	1.30	**1.29**	-1.22	**-1.41**	1.09	359	388	427	39.0	46.0	667	0.98	**1.3**	1.02
19	156.6	0.19	0.94	1.89	0.90%	1.27	**1.29**	-1.18	**-1.41**	1.09	352	388	427	39.0	46.0	763	0.98	**1.4**	1.01
20	159.2	0.19	0.96	1.92	0.91%	1.28	**1.29**	-1.18	**-1.41**	1.09	353	388	427	39.0	46.0	763	0.98	**1.4**	1.01
21	169.5	0.21	1.03	2.07	0.83%	1.26	**1.29**	-1.15	**-1.41**	1.09	405	453	498	39.0	46.0	762	1.00	**1.4**	1.01
22	224.0	0.27	1.37	2.73	1.10%	1.33	**1.29**	-1.27	**-1.41**	1.09	428	453	498	39.0	46.0	762	1.00	**1.4**	1.01
23	220.0	0.27	1.34	2.68	1.08%	1.32	**1.29**	-1.26	**-1.41**	1.09	426	453	498	39.0	46.0	762	1.00	**1.4**	1.01
24	172.8	0.21	1.05	2.11	0.85%	1.26	**1.29**	-1.15	**-1.41**	1.09	406	453	498	39.0	46.0	762	1.00	**1.4**	1.01
25	233.1	0.26	1.28	2.56	0.95%	1.29	**1.29**	-1.20	**-1.41**	1.09	503	550	605	39.0	46.0	855	0.99	**1.35**	1.01
26	281.4	0.31	1.55	3.09	1.14%	1.34	**1.29**	-1.28	**-1.41**	1.09	524	550	605	39.0	46.0	855	0.99	**1.35**	1.01
27	277.2	0.30	1.52	3.05	1.12%	1.33	**1.29**	-1.28	**-1.41**	1.09	522	550	605	39.0	46.0	855	0.99	**1.35**	1.01
28	236.3	0.26	1.30	2.60	0.96%	1.29	**1.29**	-1.20	**-1.41**	1.09	504	550	605	39.0	46.0	855	0.99	**1.35**	1.01
29	241.7	0.40	2.01	4.02	0.83%	1.26	**1.29**	-1.15	**-1.41**	1.09	578	647	711	39.0	46.0	582	0.99	**1.25**	0.99
30	241.8	0.40	2.01	4.02	0.83%	1.26	**1.29**	-1.15	**-1.41**	1.09	578	647	711	39.0	46.0	582	0.99	**1.25**	0.99
31	62.4	0.22	1.12	2.24	1.08%	1.32	**1.29**	-1.26	**-1.41**	1.09	122	129	142	39.0	46.0	259	0.99	**1.35**	1.01
32	45.3	0.16	0.81	1.63	0.78%	1.24	**1.29**	-1.12	**-1.41**	1.09	114	129	142	39.0	46.0	259	0.99	**1.35**	1.01
33	54.3	0.22	1.09	2.18	0.94%	1.28	**1.29**	-1.19	**-1.41**	1.09	118	129	142	39.0	46.0	234	0.99	**1.35**	1.00
34	58.1	0.23	1.16	2.33	1.00%	1.30	**1.29**	-1.22	**-1.41**	1.09	120	129	142	39.0	46.0	234	0.99	**1.35**	1.00
35	122.2	0.24	1.18	2.36	1.05%	1.32	**1.29**	-1.25	**-1.41**	1.09	242	259	285	39.0	46.0	478	0.99	**1.35**	1.02
36	105.3	0.20	1.02	2.04	0.91%	1.28	**1.29**	-1.18	**-1.41**	1.09	235	259	285	39.0	46.0	478	0.99	**1.35**	1.02
37	117.1	0.25	1.24	2.48	1.01%	1.30	**1.29**	-1.23	**-1.41**	1.09	240	259	285	39.0	46.0	440	0.99	**1.35**	1.01
38	122.1	0.26	1.29	2.58	1.05%	1.32	**1.29**	-1.24	**-1.41**	1.09	242	259	285	39.0	46.0	440	0.99	**1.35**	1.01
39	181.0	0.27	1.37	2.75	1.04%	1.31	**1.29**	-1.24	**-1.41**	1.09	362	388	427	39.0	46.0	617	0.99	**1.3**	1.01
40	182.9	0.28	1.39	2.77	1.05%	1.32	**1.29**	-1.24	**-1.41**	1.09	363	388	427	39.0	46.0	624	0.97	**1.3**	1.01

TORSION: BUILDING A

Building A: Frame Torsional Shear

Level	Frame	V_{tot} (k)	R_i	e_x (ft)	d_i (ft)	$R_i d_i^2$	Torsional Shear (k)
Roof	B	200.02	0.75	11.18	45.83	1575.29	20.28
	F	200.02	0.25	11.18	94.12	2214.64	13.88
	2	215.22	0.61	21.45	41.00	1030.45	42.05
	4a	215.22	0.39	21.45	66.83	1728.44	43.27
Third	B	421.58	0.75	16.42	40.83	1250.32	57.19
	F	421.58	0.25	16.42	99.12	2456.19	46.28
	2	435.75	0.61	20.78	42.00	1081.33	84.49
	4a	435.75	0.39	20.78	65.83	1677.10	83.61
Second	B	542.56	0.75	20.67	36.83	1017.34	84.28
	F	542.56	0.25	20.67	103.12	2658.43	78.65
	2	542.56	0.61	20.48	42.00	1081.33	103.69
	4a	542.56	0.39	20.48	65.83	1677.10	102.60

Building A : Mass and Rigidity

Level	Centers of Rigidity		Centers of Mass		Eccentricity(+5%)	
	Xr (ft)	Yr (ft)	Xm (ft)	Ym (ft)	X (ft)	Y (ft)
Roof	90	110	92	98	11	21
3rd Floor	85	109	92	98	16	21
2nd Floor	81	109	92	98	21	20

Building B : Mass and Rigidity

Level	Centers of Rigidity		Centers of Mass		Eccentricity(+5%)	
	Xr (ft)	Yr (ft)	Xm (ft)	Ym (ft)	X (ft)	Y (ft)
Roof	125	89	123	98	13	19
3rd Floor	125	95	123	98	13	13
2nd Floor	125	99	123	98	13	11

Building C : Mass and Rigidity

Level	Centers of Rigidity		Centers of Mass		Eccentricity(+5%)	
	Xr (ft)	Yr (ft)	Xm (ft)	Ym (ft)	X (ft)	Y (ft)
High Roof	124	103	163	100	42	13
Roof	111	114	65	98	54	25
3rd Mezz	123	101	164	99	44	12
3rd Floor	120	99	106	99	25	10
2nd Floor	121	99	106	98	25	11

SEISMIC

- EXISTING CONDITIONS
- PROBLEM STATEMENT
- PROPOSED SOLUTION
- STRUCTURAL DEPTH
- CONSTRUCTION BREADTH
- CONCLUSIONS
- APPENDICES

BRBF Seismic Calc

BASE SHEAR (R=7, not 3.5 as for moment frames)

$V_B = C_s W$

$$C_s = \min \begin{cases} S_{DS}/(R/I) = .448/(7/1) = 0.064 \\ S_{D1}/[T_o\, R/I] = 0.14/[(.806)(7/1)] = 0.024 \quad \text{CONTROLS (also > .01)} \\ S_{D1} T_L/[T_o^2(R/I)] = 0.14(6)/[(.806^2)(7/1)] = 0.18 \end{cases}$$

SEISMIC

$$\frac{H}{400}\ (Wind\ per\ Code)$$

$$0.020h_{sx}\ (Seismic\ per\ Code)$$

$$\frac{H}{240}\ (Seismic\ for\ Nonstructural)$$

Structure	Load	Max (in)	Permitted (in)	Ratio
A	EQ	0.50053	3.634	0.14
	W	0.20579	2.180	0.09
B	EQ	1.45441	3.634	0.40
	W	0.62195	2.180	0.29
C	EQ	4.53502	3.934	1.15
	W	0.86859	2.557	0.34

Structure	Load	Max (in)	Permitted (in)	Ratio
A	EQ	1.28	3.634	0.35
	W	0.312	2.180	0.14
B	EQ	0.520	3.634	0.14
	W	0.315	2.180	0.14
C	EQ	0.724	3.934	0.18
	W	0.386	2.557	0.15