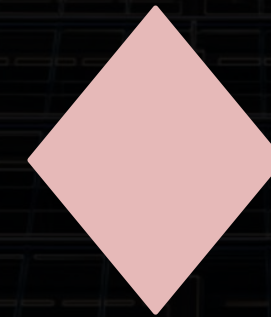




440 FIRST STREET, NW

WASHINGTON, DC



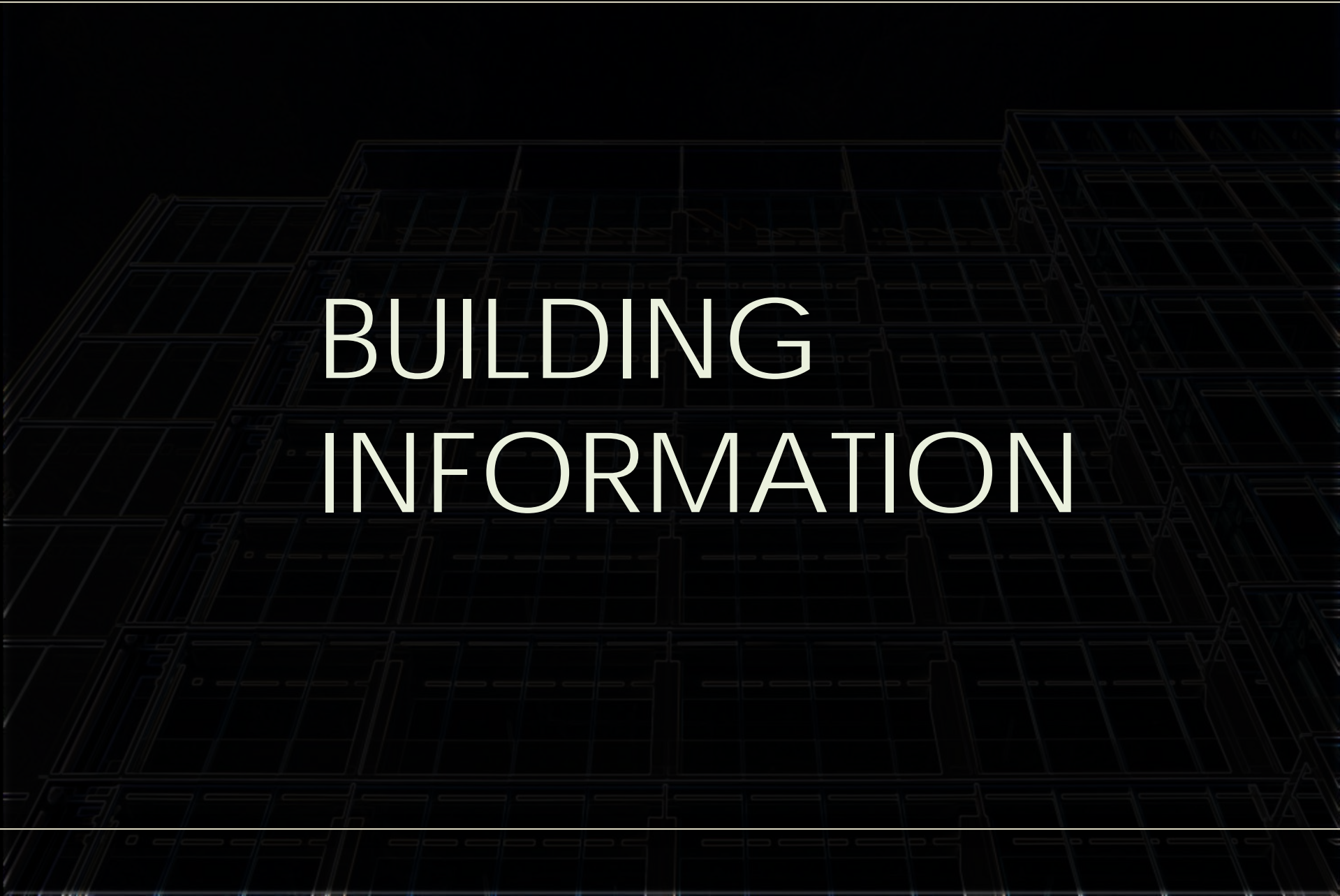
YEMI OSITELU | STRUCTURAL OPTION
ADVISER | DR. ALY SAID





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◆ 440 FIRST STREET, NW

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- ❖ MIXED-USE BUILDING (OFFICE + RETAIL)
 - ROOFTOP TERRACE, FITNESS FACILITY, CONFERENCE ROOM
- ❖ 10 STORIES + 2 BELOW-GRADE PARKING LEVELS+ A MECHANICAL PENTHOUSE [(FLOOR TO FLOOR HEIGHTS – 10.33 FEET (TYP.))]
- ❖ 142,000 GSF
- ❖ ORIGINAL CONSTRUCTION – COMPLETED 1982 (7 STORIES)
 - ❖ RENOVATION – COMPLETED IN 2013
 - ❖ RENOVATION COST - \$20,000,000



IMAGE COURTESY OF FOX ARCHITECTS

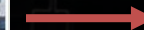


IMAGE COURTESY OF FOX ARCHITECTS

SITE LOCATION

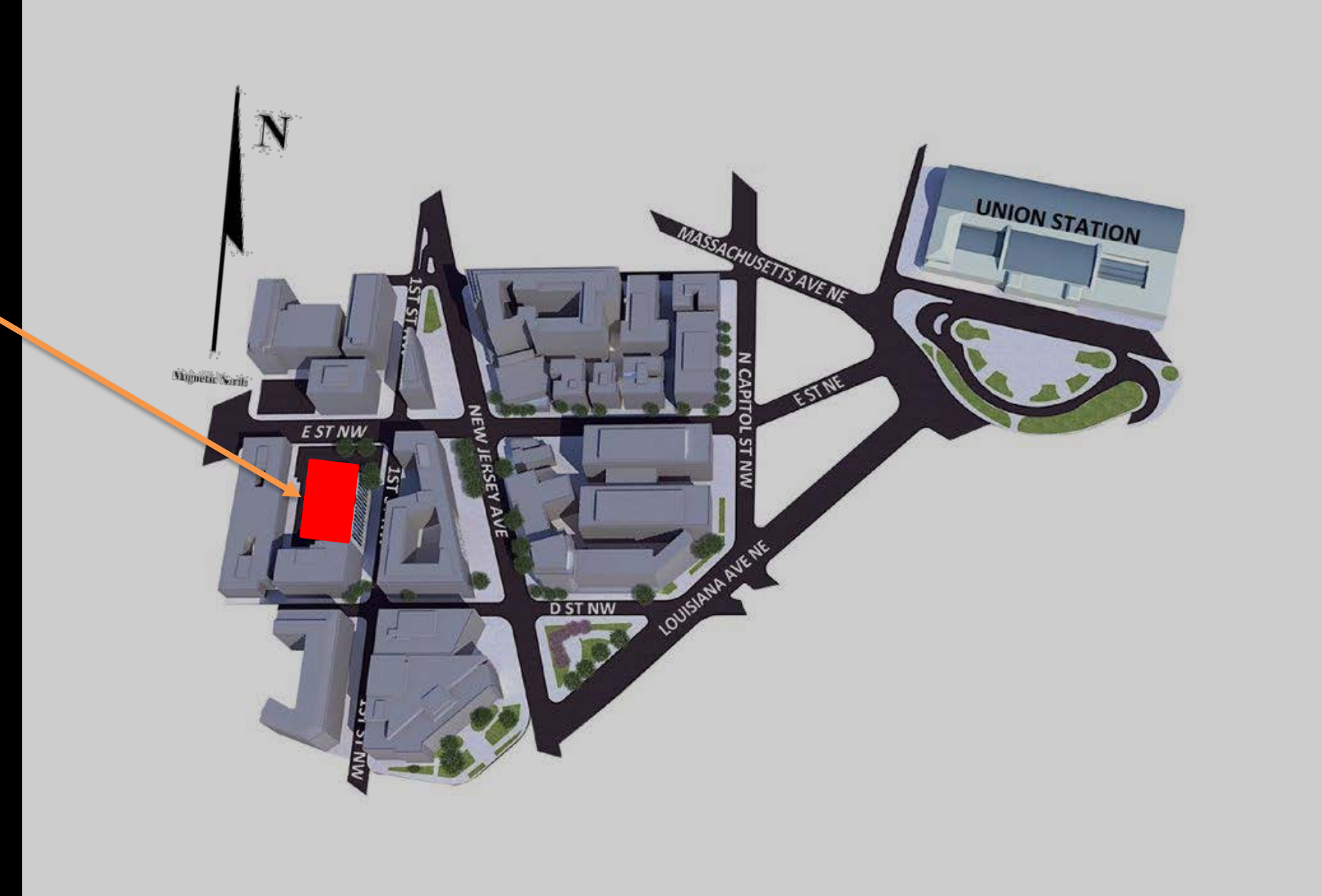


IMAGE COURTESY OF FOX ARCHITECTS

SITE PLAN

◆ 440 FIRST STREET, NW

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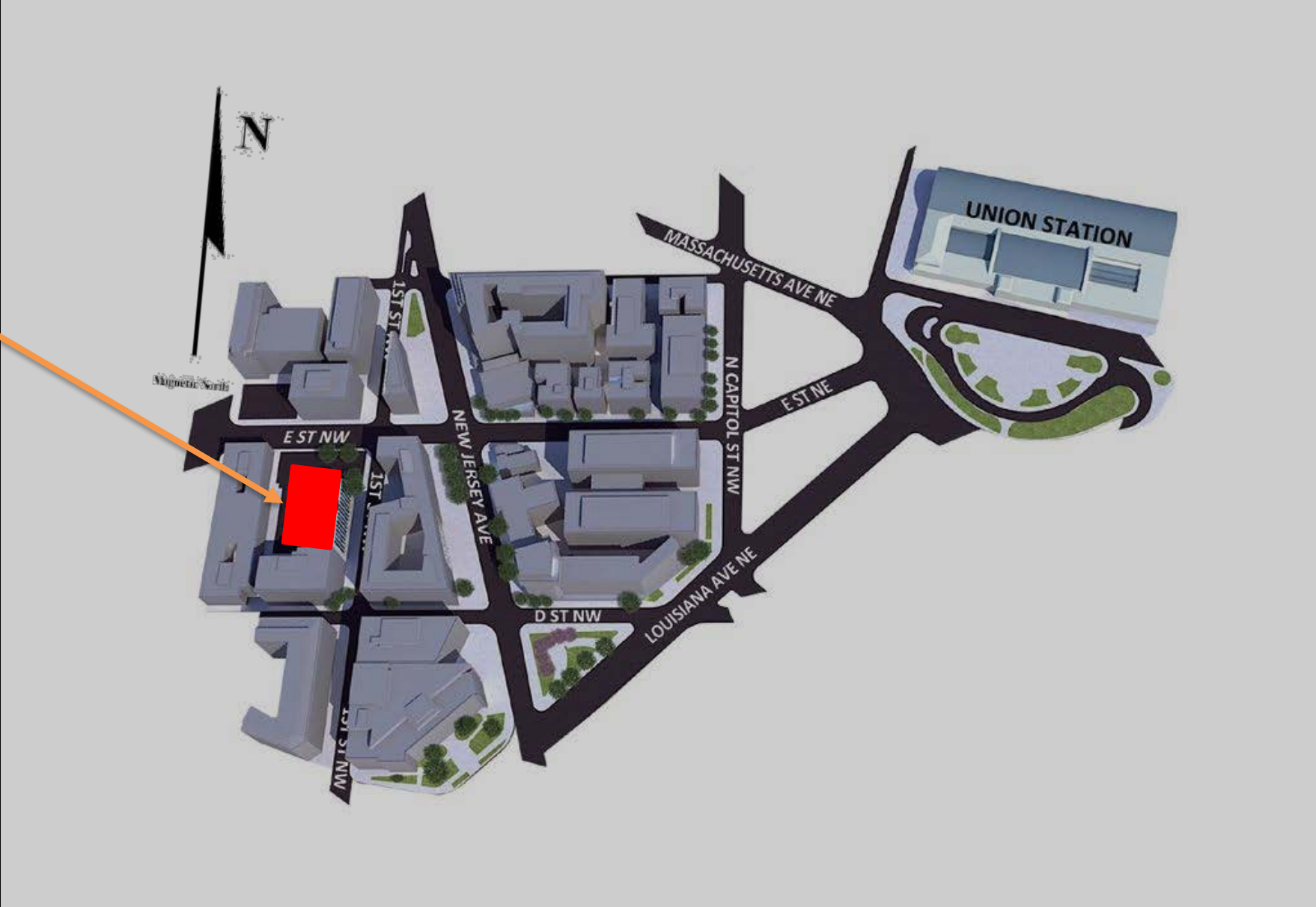
EVALUATION

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- ❖ ARCHITECTURE – FOX ARCHITECTS
- ❖ STRUCTURAL ENGINEER – RATHGEBER/GOSS ASSOCIATES
- ❖ CM – SIGAL CONSTRUCTION

SITE LOCATION



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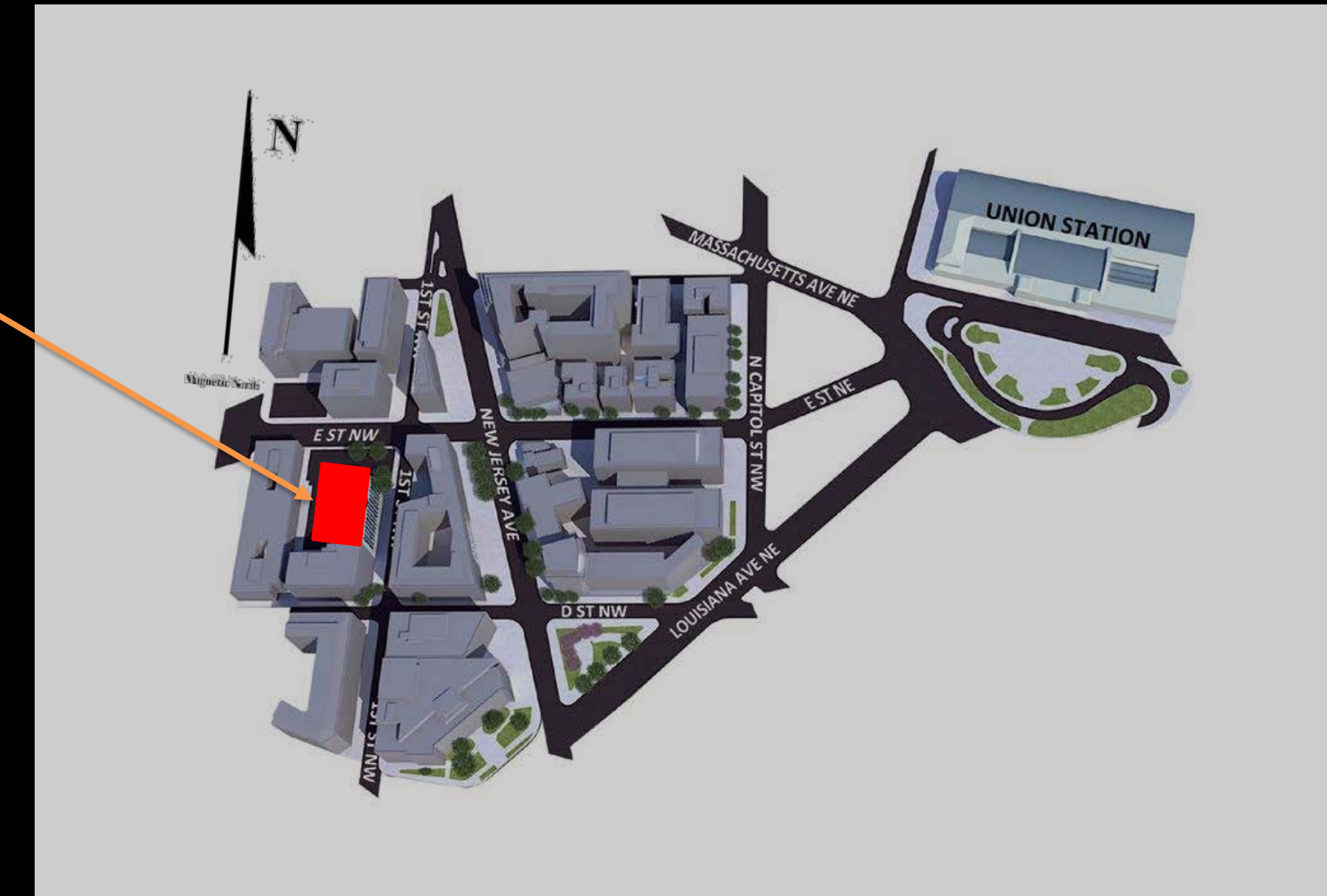
IMAGE COURTESY OF FOX ARCHITECTS



ROOFTOP TERRACE

- ❖ GREEN ROOF
- ❖ DEDICATED OUTDDOR AIR SYSTEM (DOAS)
- ❖ SUSTAINABLE CONSTRUCTION
- ❖ CONVENIENT TO PUBLIC TRANSPORTATION
- ❖ TARGETING LEED PLATINUM CERTIFICATION

SITE LOCATION



SITE PLAN



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- ❖ STEEL-REINFORCED, POURED-IN- PLACE CONCRETE FLOORS (1-8) W/ EDGE BEAMS

- ❖ SLAB THICKNESS – 7.25 INCHES (TYPICAL)
- ❖ EDGE BEAMS – 12 INCHES X 16 INCHES

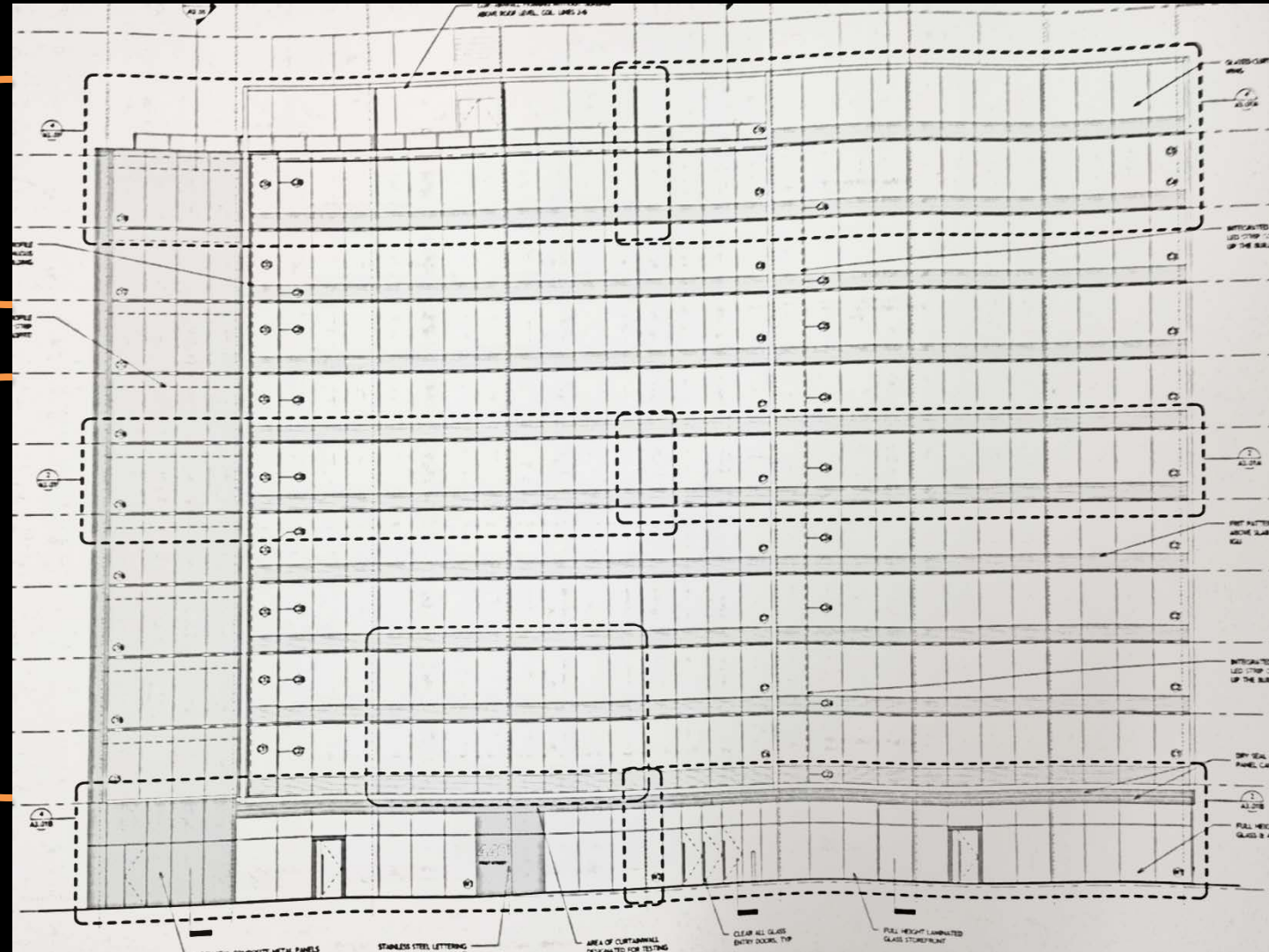
- ❖ COMPOSITE STEEL FLOOR (9 AND ABOVE)

- ❖ 2 INCH DEEP X 18 GAGE COMPOSITE METAL DECK
- ❖ 3 ¼" LIGHTWEIGHT CONCRETE (TOTAL – 5.25 INCHES)
- ❖ ¾ INCH DIA. X 4 INCH SHEAR CONNECTORS
- ❖ 6X6 – W2.0X2.0 WWF

COMPRESSIVE STRENGTH – 3000 PSI (FOR CONCRETE TOPPINGS)
4000 PSI (SLABS)

STEEL FLOORS

CONCRETE FLOORS



◆ 440 FIRST STREET, NW

EXISTING GRAVITY SYSTEM

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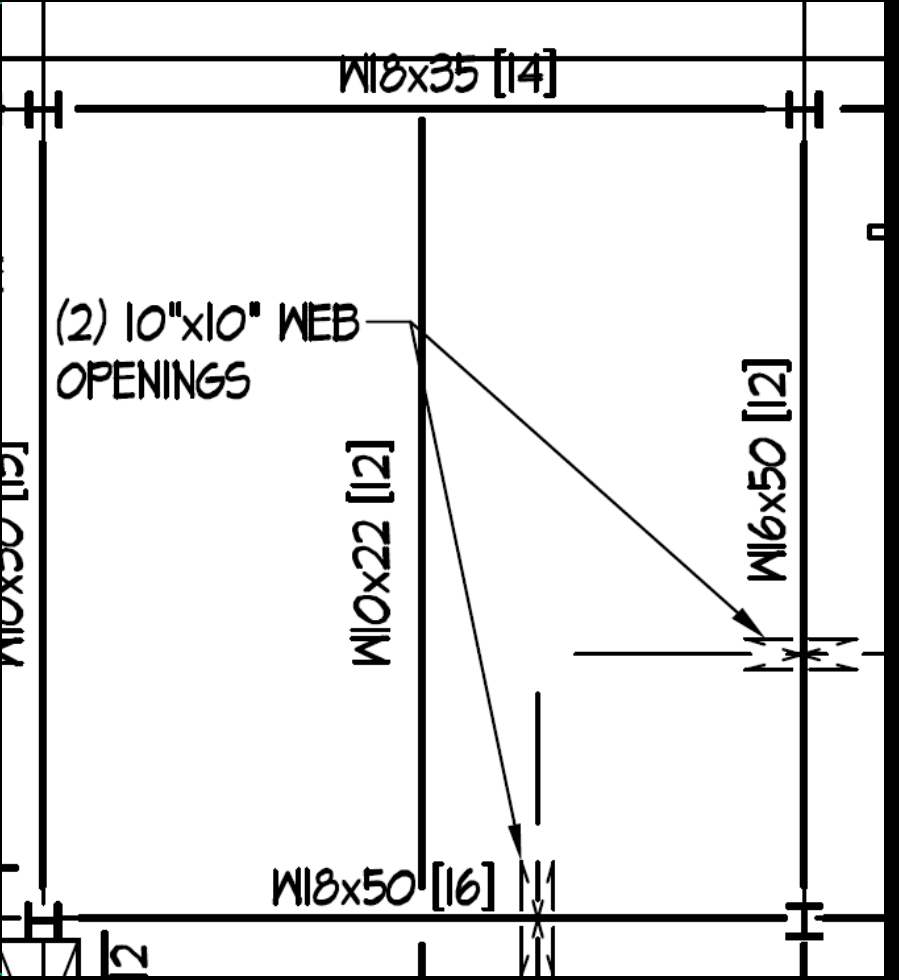
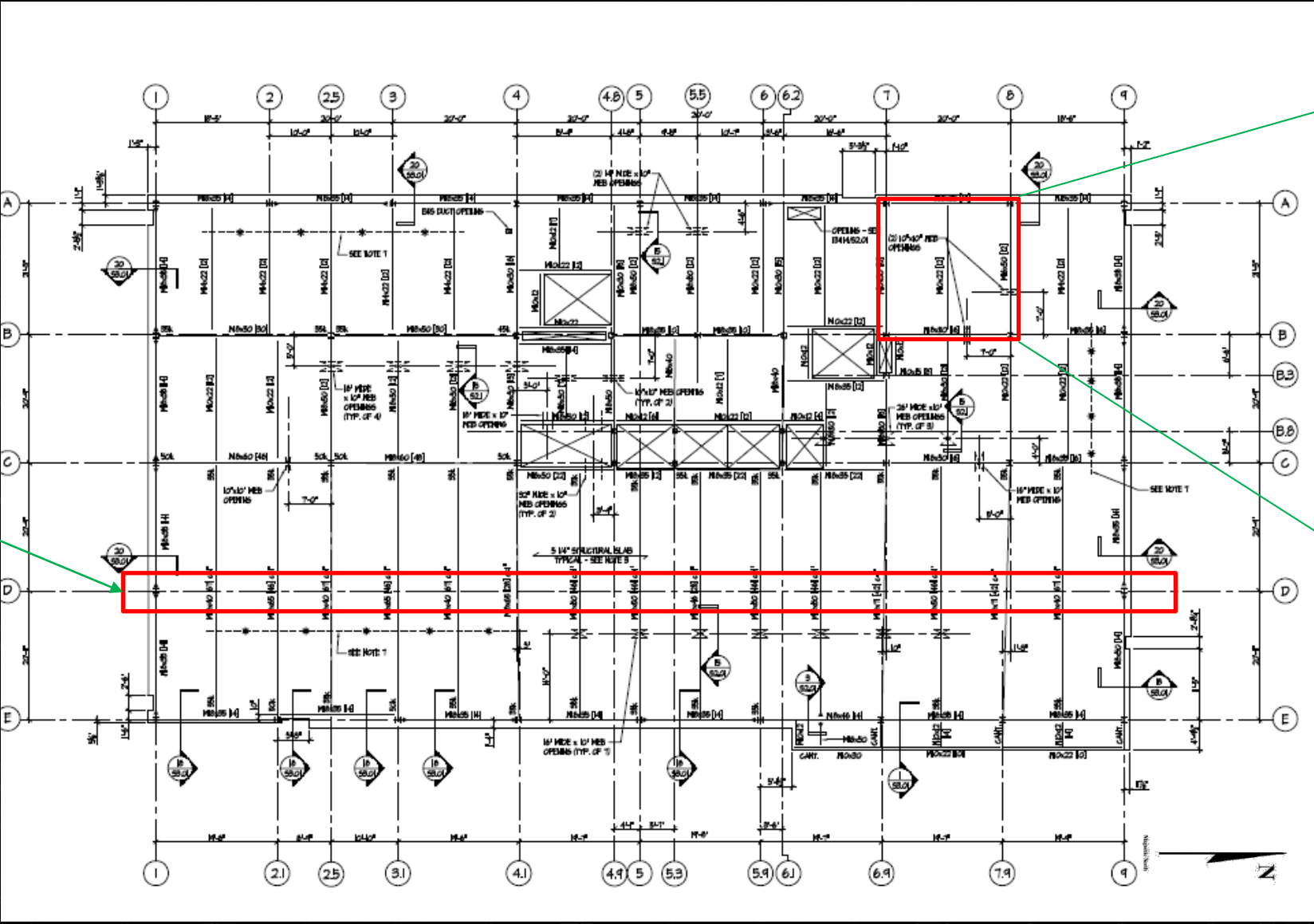
EVALUATION

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COLUMNS ALONG
GRIDLINE REMOVED

IMAGE COURTESY OF FOX ARCHITECTS



BEAMS – W10X33 (12)
GIRDERS – W18X35(12)
COLUMNS –W12X96
(TYP.)

TYPICAL BAY (STEEL)

YEMI A. OSITELU

STRUCTURAL OPTION

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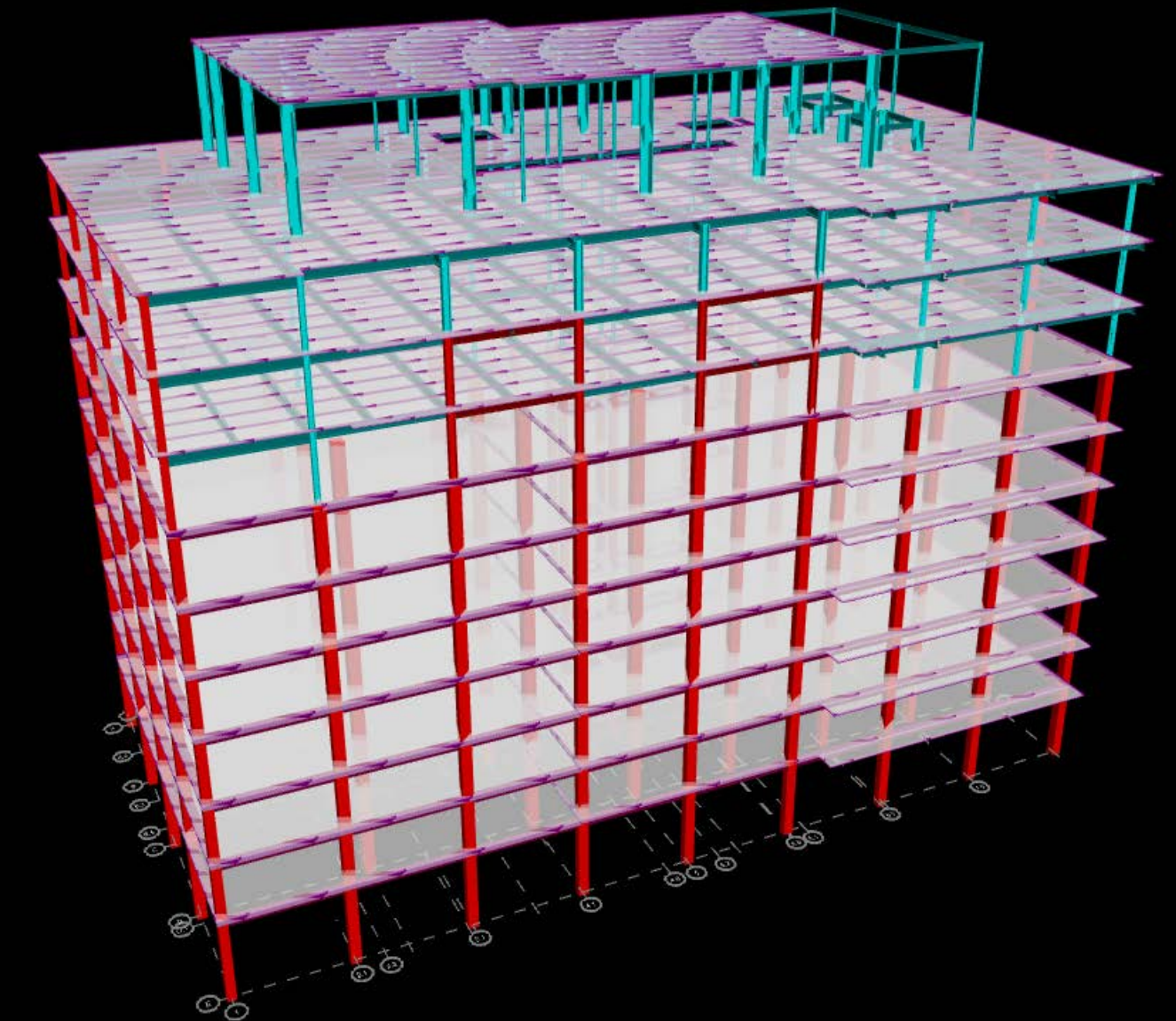
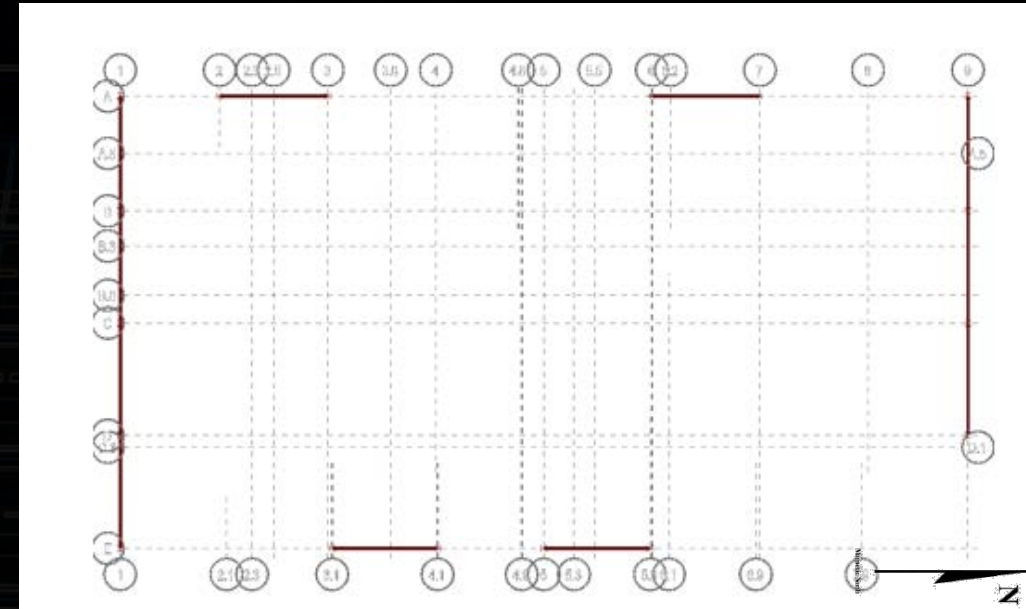
MECHANICAL BREADTH

EVALUATION

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- ❖ SLAB – COLUMN FRAMES (EXISTING FLOORS)
- ❖ STEEL MOMENT FRAMES, 2 IN EACH DIRECTION
- ❖ MINOR IMPACT ON THE ARCHITECTURAL LAYOUT
- ❖ COR AND COM RELATIVELY CLOSE





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THESES PROPOSAL & GOALS

<div> <div>◆ 440 FIRST STREET, NW</div> </div>	<div> <div>PROBLEM STATEMENT</div> </div>	<div> <div>THESIS PROPOSAL</div> </div>
<div> <div>BUILDING INFORMATION</div> <div>EXISTING CONDITIONS</div> <div>THESIS PROPOSAL & GOALS</div> <div>--PROBLEM STATEMENT & THESIS PROPOSAL</div> <div>--DESIGN GOALS & CRITERIA</div> <div>STRUCTURAL REDESIGN</div> <div>MECHANICAL BREADTH</div> <div>EVALUATION</div> <div>CONCLUSIONS</div> <div>QUESTIONS</div> </div>	<div> <div>❖ BUILDING HAS NO EVIDENT PROBLEMS</div> <div>❖ REDESIGN BUILDING IN STEEL</div> <div>❖ CONSIDER IMPACTS ON <div>❖ ARCHITECTURE</div> <div>❖ OVERALL COST</div> </div> </div>	<div> <div>❖ KEEP BAY SIZES UNIFORM ACROSS ALL LEVELS</div> <div>❖ DESIGN OFFICE/RETAIL LEVELS USING COMPOSITE STEEL JOISTS</div> <div>❖ COMPARE OVERALL COST OF PROJECT</div> </div>
		<div> <div>YEMI A. OSITELU</div> <div>STRUCTURAL OPTION</div> </div>

<div> <div>◆ 440 FIRST STREET, NW</div> <div></div> </div>	DESIGN GOALS	DESIGN CRITERIA
<div> <div> <div>BUILDING INFORMATION</div> <div>EXISTING CONDITIONS</div> <div> <div> <div>THESES PROPOSAL & GOALS</div> <div>--PROBLEM STATEMENT & THESIS PROPOSAL</div> <div>--DESIGN GOALS & CRITERIA</div> </div> </div> <div>STRUCTURAL REDESIGN</div> <div>MECHANICAL BREADTH</div> <div>EVALUATION</div> <div>CONCLUSIONS</div> <div>QUESTIONS</div> </div> </div>	<div> <div> <div>❖ DESIGN AN ALTERNATIVE USING LIGHTWEIGHT STRUCTURAL STEEL</div> <div>❖ PROVIDE A SOLUTION THAT DOES NOT INTERFERE WITH THE EXISTING ARCHITECTURAL LAYOUT</div> <div>❖ EVALUATE THE SYSTEM BASED ON ITS COST</div> </div> </div>	<div> <div> <div>❖ NONE OF THE STEEL MOMENT FRAMES WERE SEISMICALLY DETAILED (R = 3) TO REDUCE COST</div> <div>❖ ALL WIND LOAD CASES ARE TAKEN INTO ACCOUNT FOR THE DESIGN</div> <div>❖ THERE ARE NO HORIZONTAL OR VERTICAL IRREGULARITIES</div> <div>❖ THE LATERAL RESISTING SYSTEM HAS A REDUNDANCY FACTOR GREATER THAN 1, WHICH IS APPROPRIATE FOR BUILDING STRUCTURES OF SDC = A</div> </div> </div>
		<div> <div>YEMI A. OSITELU</div> <div>STRUCTURAL OPTION</div> </div>



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STRUCTURAL REDESIGN

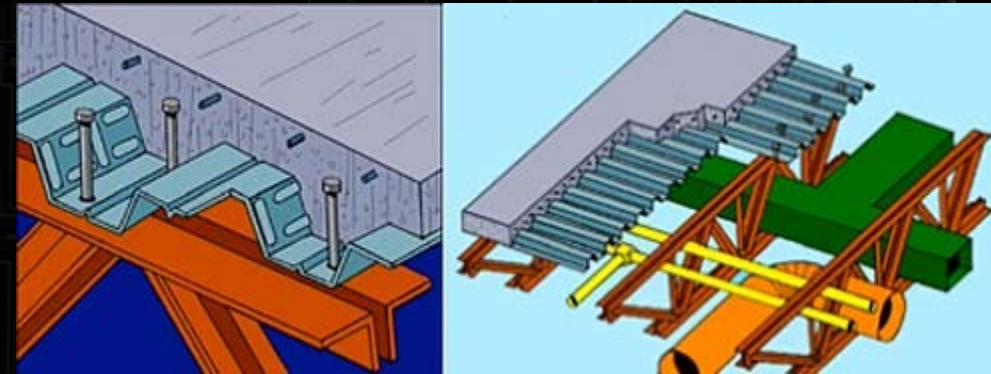
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DESIGN EVOLUTION – GRAVITY SYSTEM

- ❖ COMPOSITE STEEL JOIST FRAME
 - ❖ 12 INCH JOISTS (TYP.), 18 INCHES IN LONGER SPAN AREAS
 - ❖ SPACED AT 4 FEET O.C. (TYP.)
- ❖ 2VLI20 VULCRAFT DECK
 - ❖ CONCRETE SLAB – 2.5 INCHES THICK
 - ❖ TOTAL SLAB THICKENESS – 4.5 INCHES
 - ❖ REINFORCED WITH 6X6 – W2.0X2.0 WWF

ADVANTAGES

- COST-EFFECTIVE
- LIGHTWEIGHT
- EASY & FAST INSTALLATION
- ENVIRONMENTALLY FRIENDLY



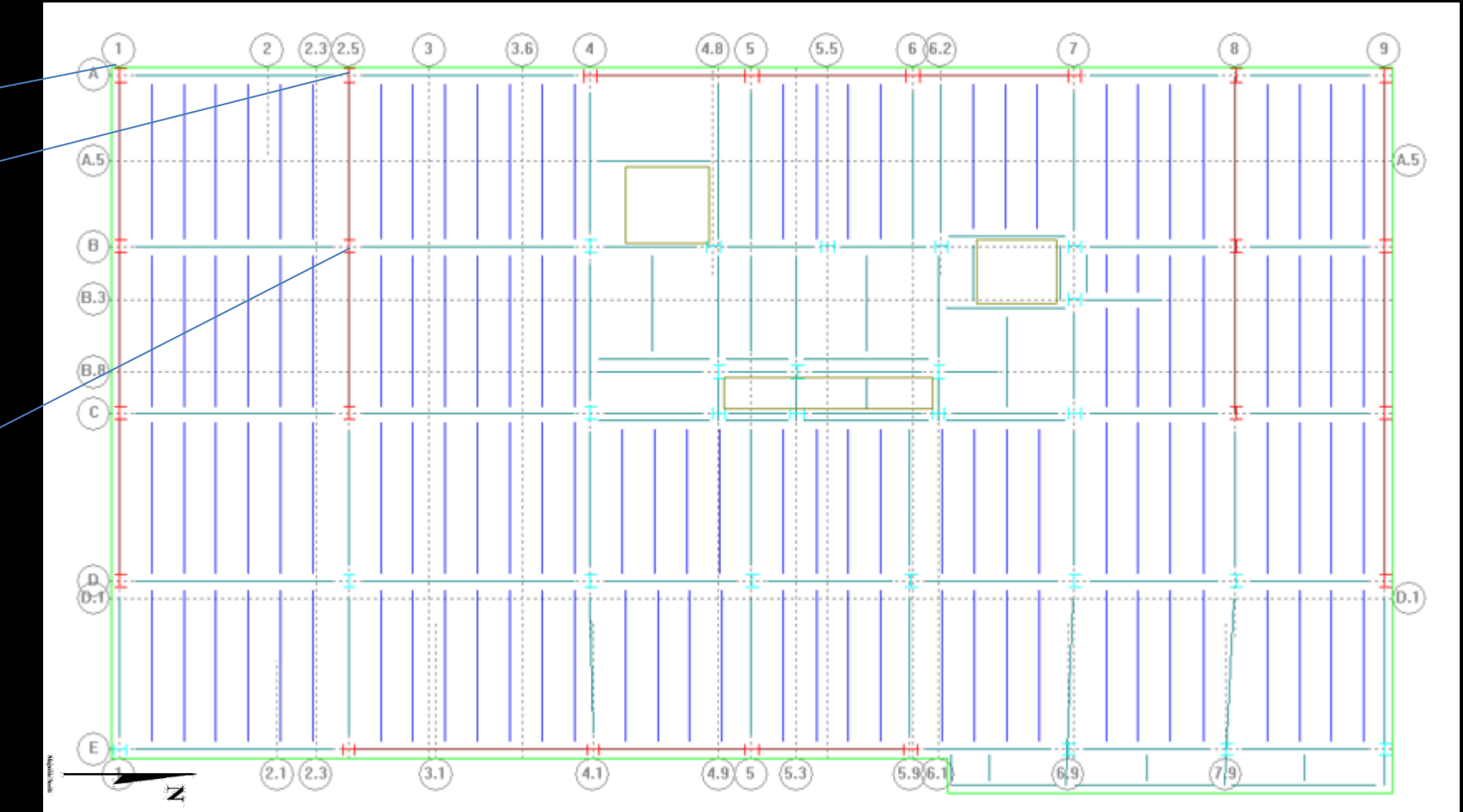
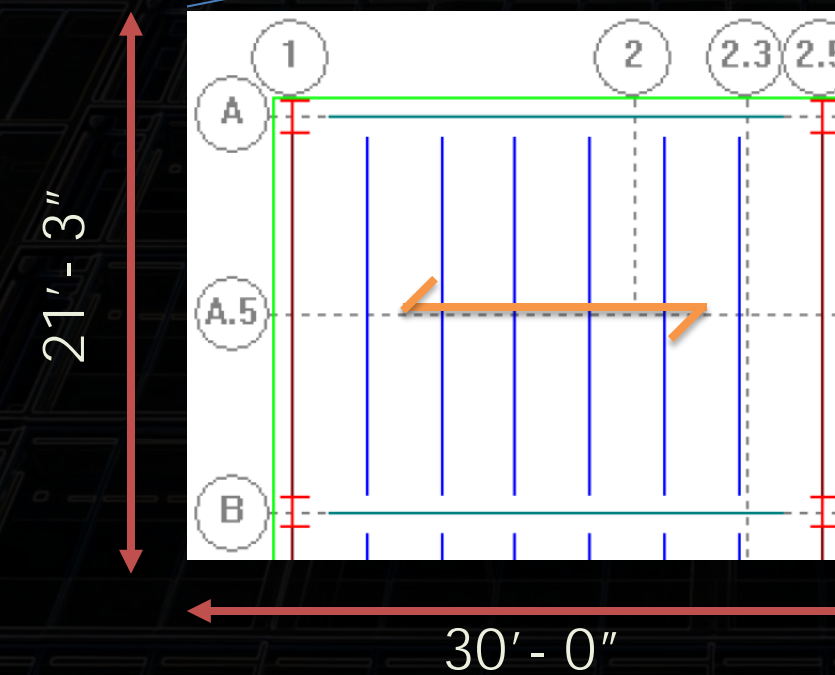
TYPICAL LOADING	RESIDENTIAL	COMMERCIAL
	Total load = 112 psf Live Load = 55 psf NC Dead Load = 42 psf Comp Dead Load = 15 psf	Total load = 152 psf Live Load = 95 psf NC Dead Load = 42 psf Comp Dead Load = 15 psf
Depth	Length	Length
10"	25'-0"	25'-0"
12"	30'-0"	30'-0"
14"	35'-0"	32'-8"
16"	40'-0"	37'-4"
18"	45'-0"	39'-0"
20"	46'-8"	43'-4"
Notes: 1. E-series joists are typically spaced at 4'-0" on center. 2. Shaded areas may require special chord or web members. 3. Tables assume 2 1/2" concrete above deck with 3000 psi concrete strength.		

DEFLECTION CRITERIA

L/360 – LIVE LOAD (UNFACTORED)
L/240 – TOTAL LOAD (UNFACTORED)

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- ❖ NON – COMPOSITE BEAMS AND GIRDERS
 - ❖ USED ON COLUMN LINES TO ADD STIFFNESS
 - ❖ TYPICALLY W12X26 AND W14X30

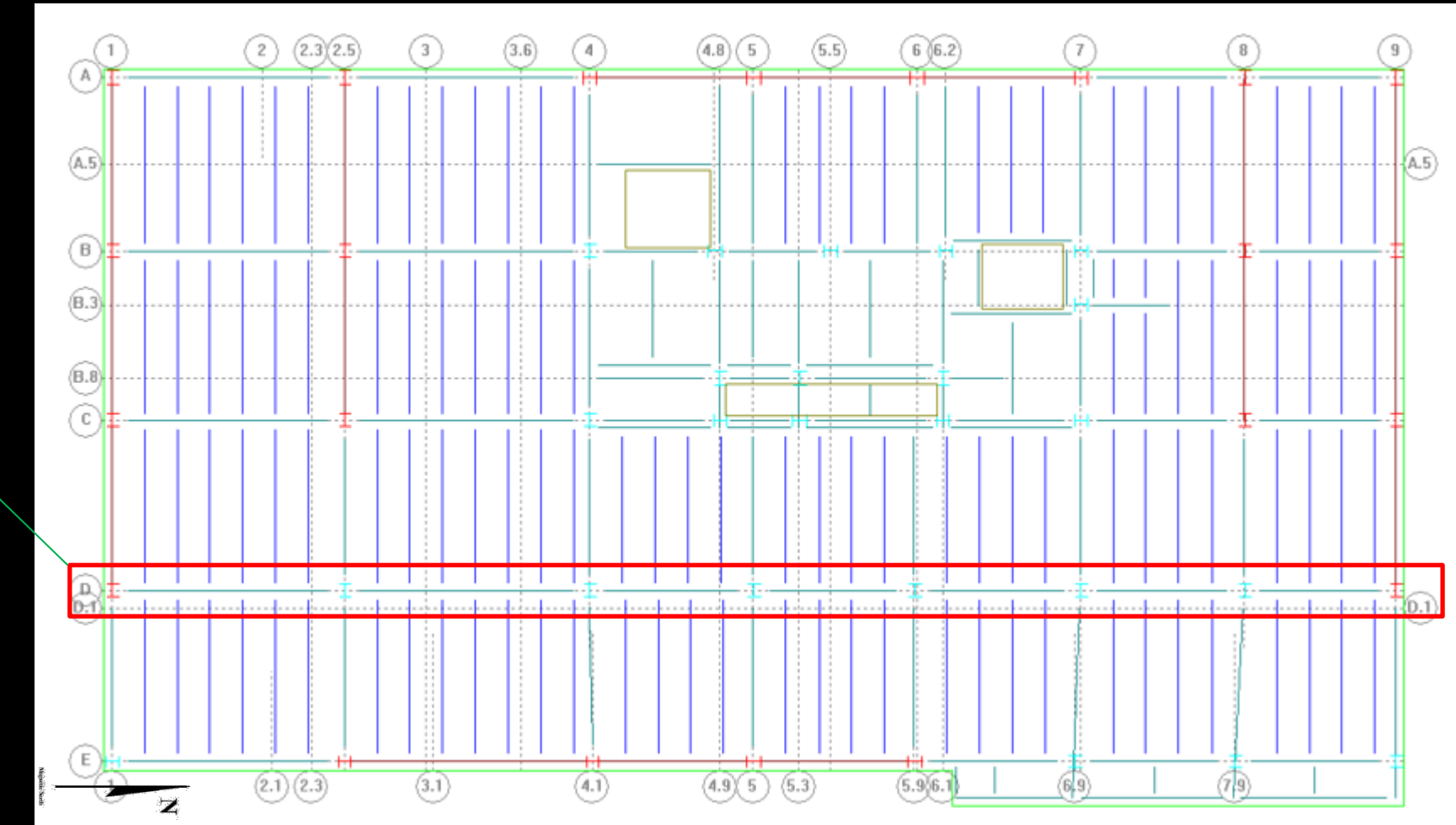


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COLUMN DESIGN

- ❖ W10X33 (INT.) , W21X93 (EXT.)
- ❖ SIZES VARY FOR LATERAL SYSTEM (W21's)
- ❖ COLUMNS SPLICED EVERY 2 FLOORS

COLUMNS
REMOVED ALONG
GRIDLINE
FOR FLOORS 9 AND
ABOVE

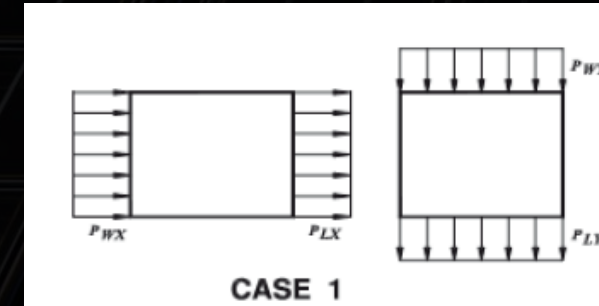


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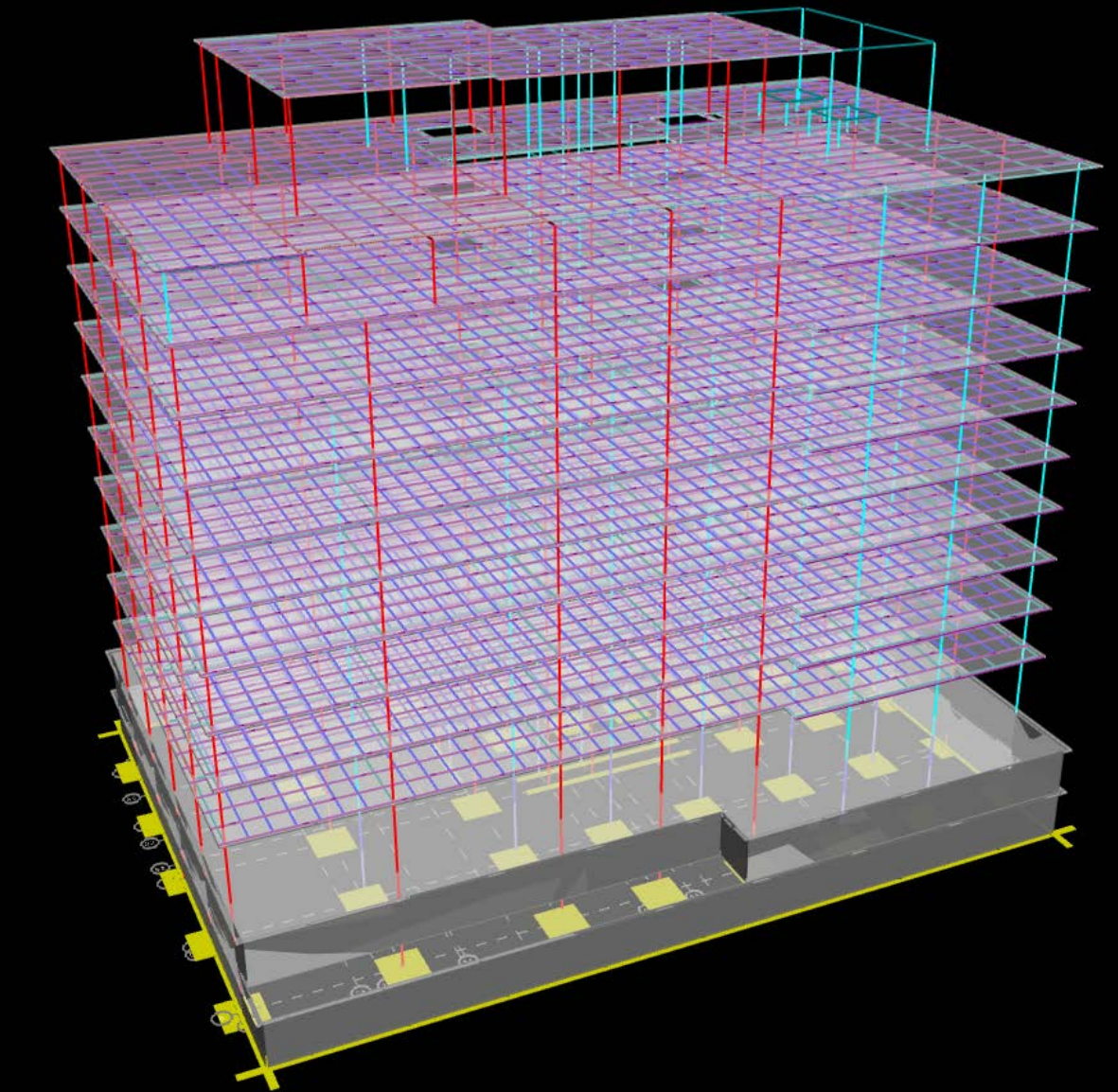
❖ SHEAR WALLS CONSIDERED, HOWEVER INEFFECTIVE

❖ STEEL MOMENT FRAMES

❖ WIND CONTROLS (CASE 1), WIND SPEED – 115MPH



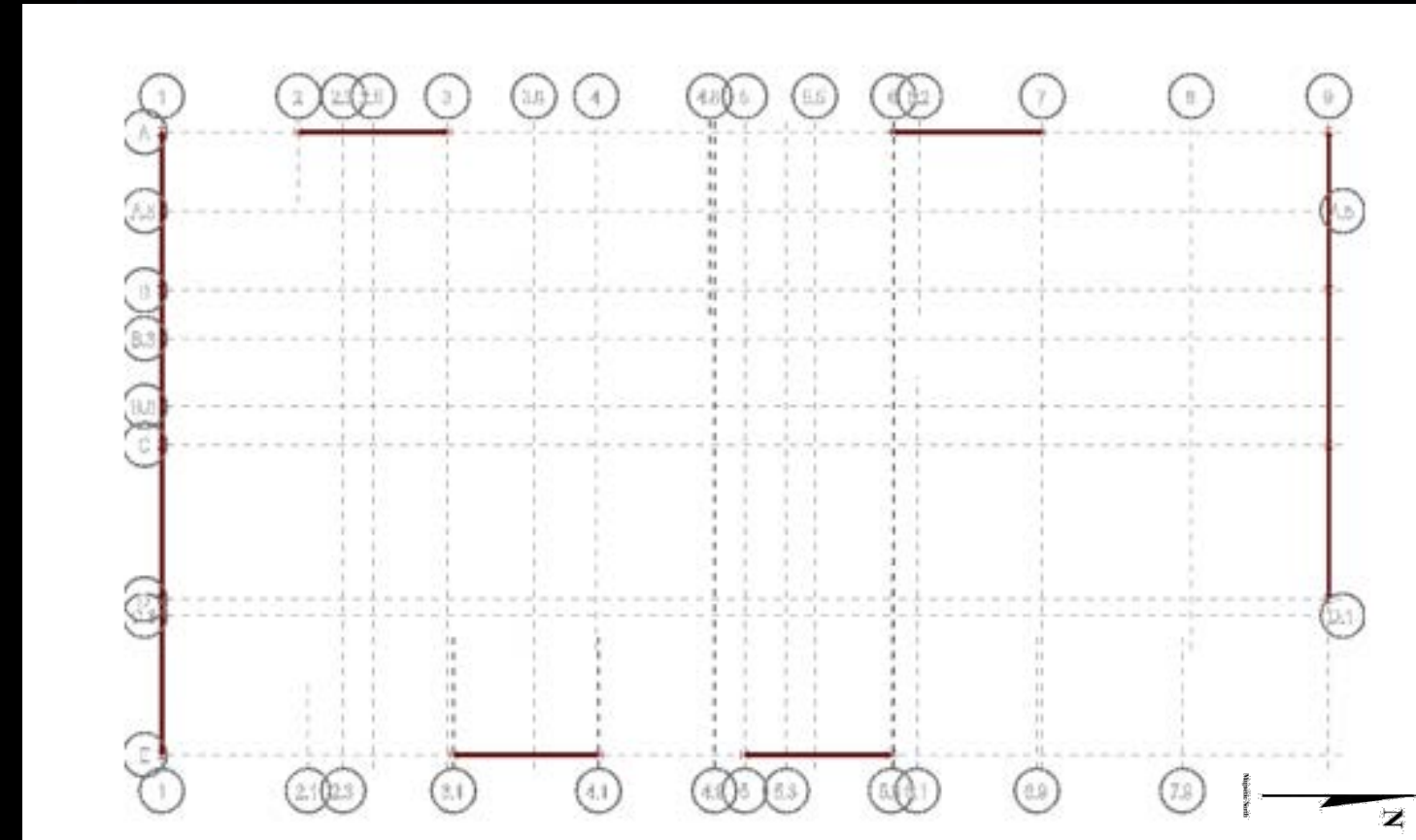
❖ NO ARCHITECTURAL CONFLICTS



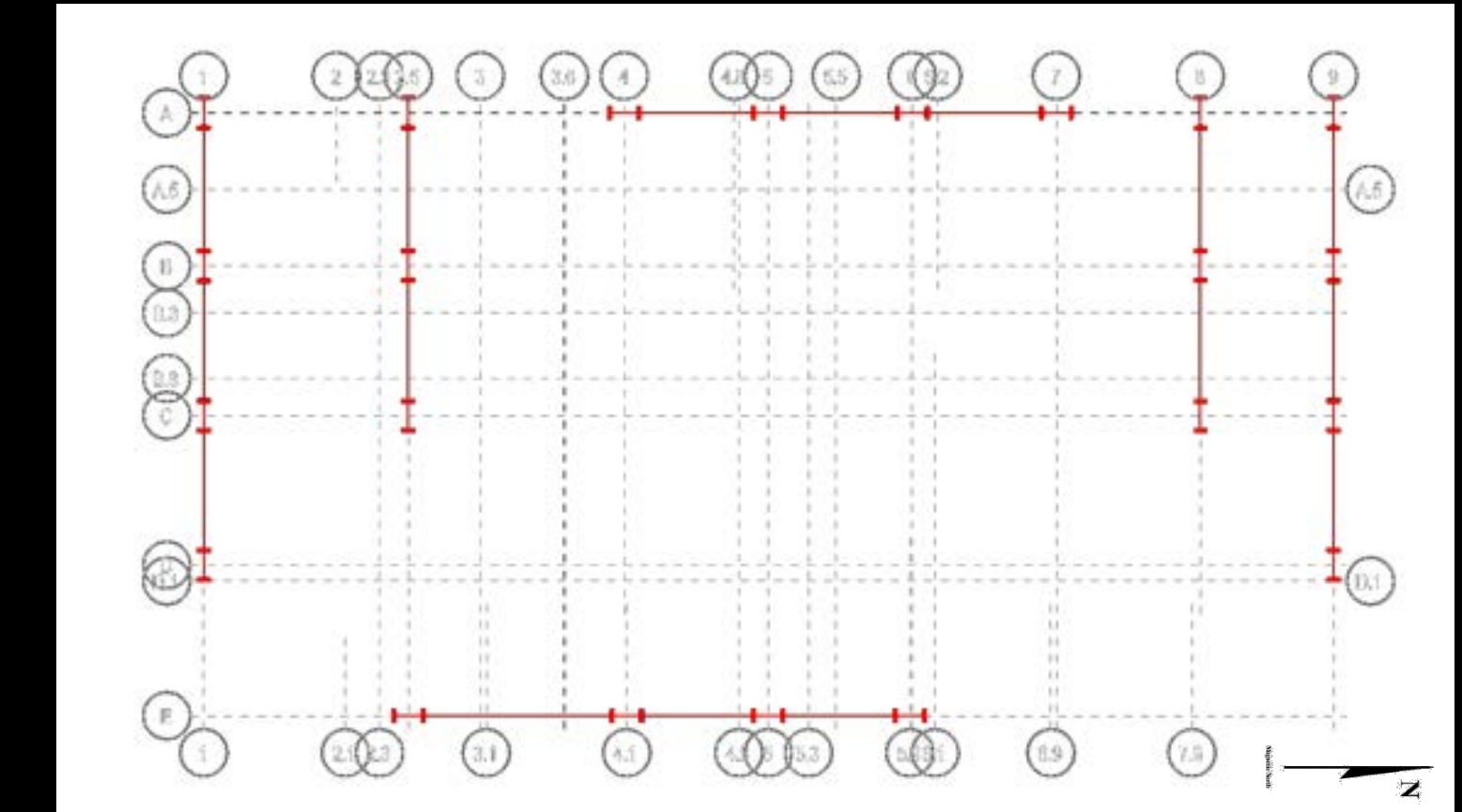
◆ 440 FIRST STREET, NW

DESIGN EVOLUTION – LATERAL SYSTEM

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ORIGINAL LFRS LAYOUT



REDESIGN LFRS LAYOUT

◆ 440 FIRST STREET, NW

DESIGN EVOLUTION – LATERAL SYSTEM

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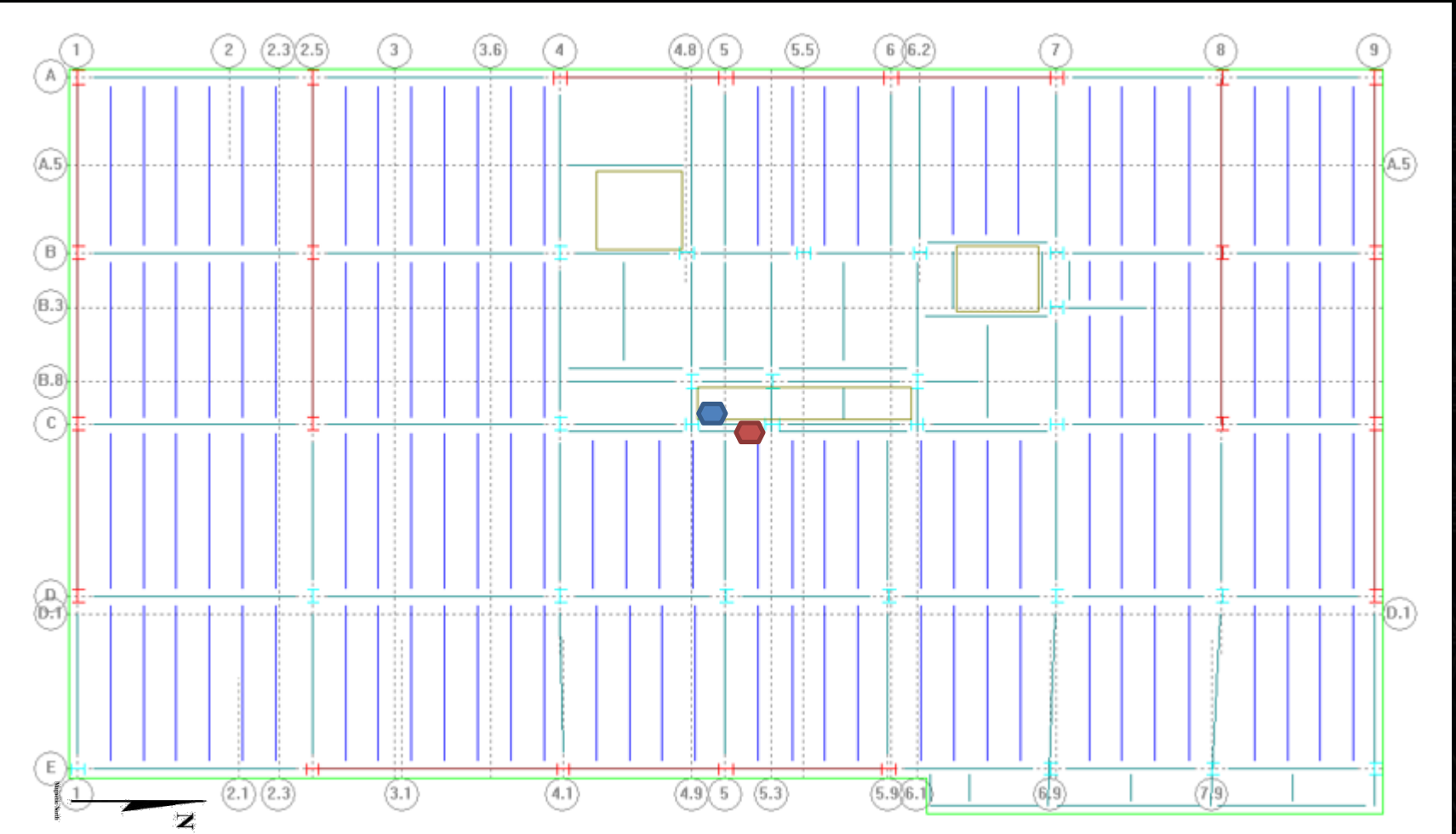
EVALUATION

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● CENTER OF RIGIDITY

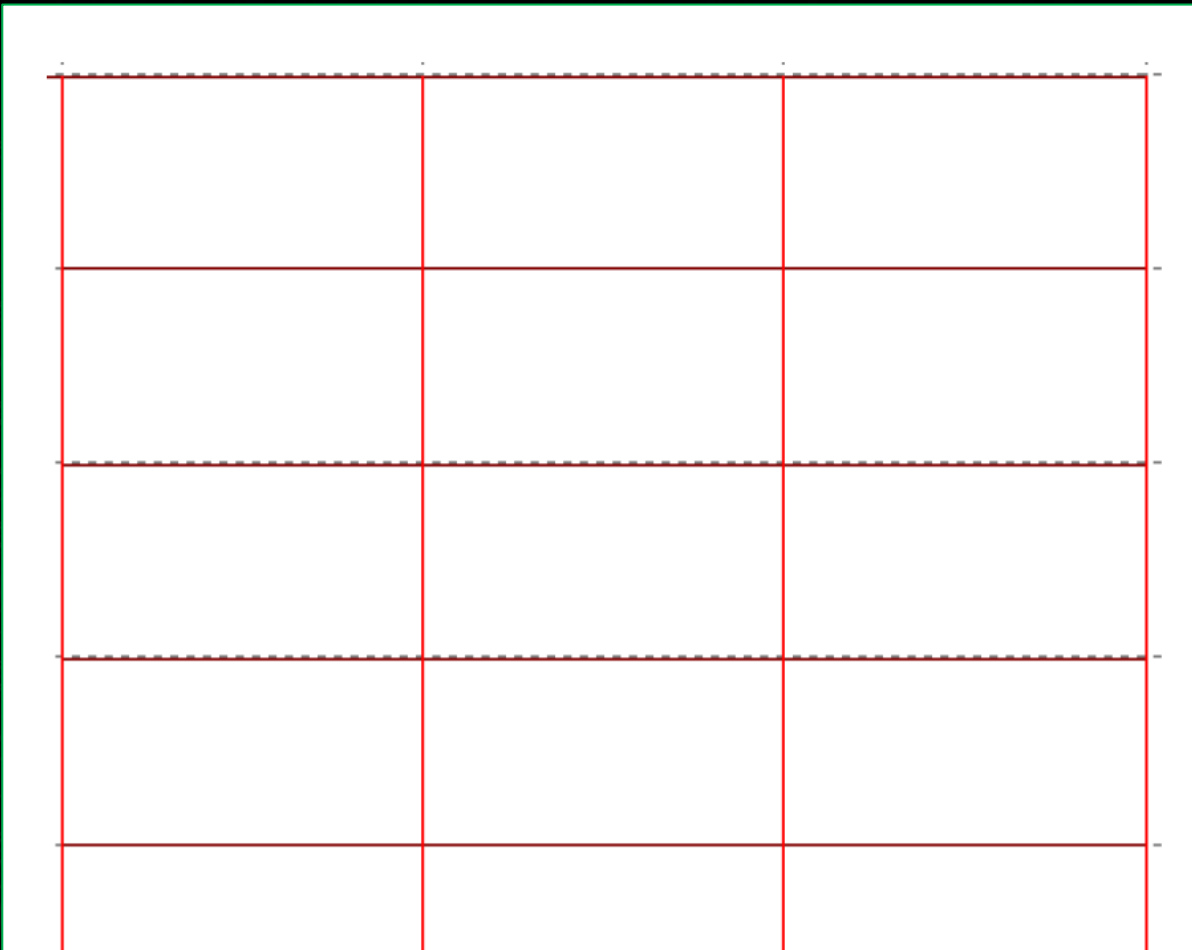
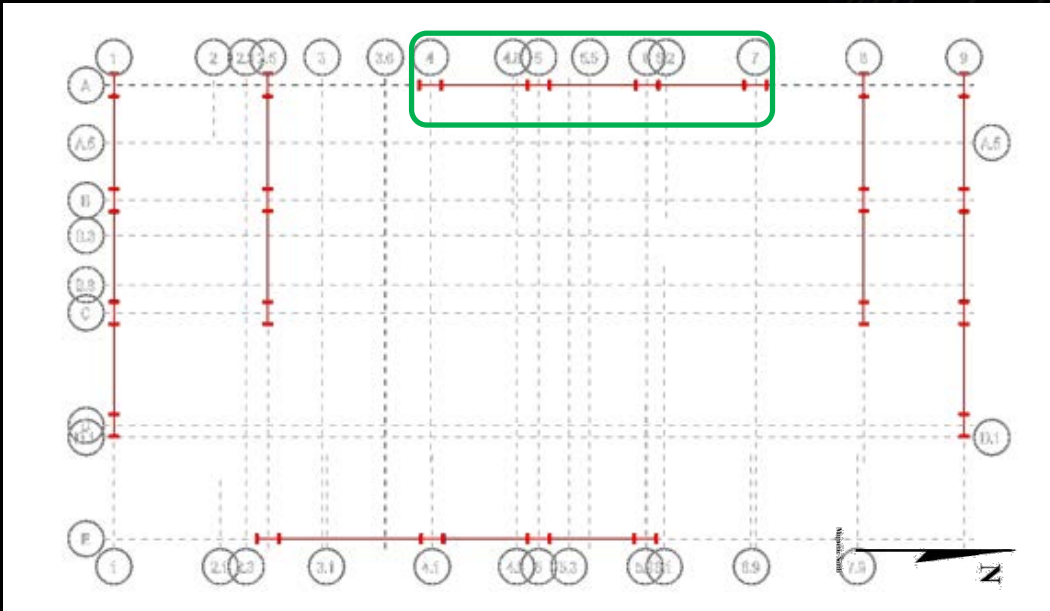
● CENTER OF MASS



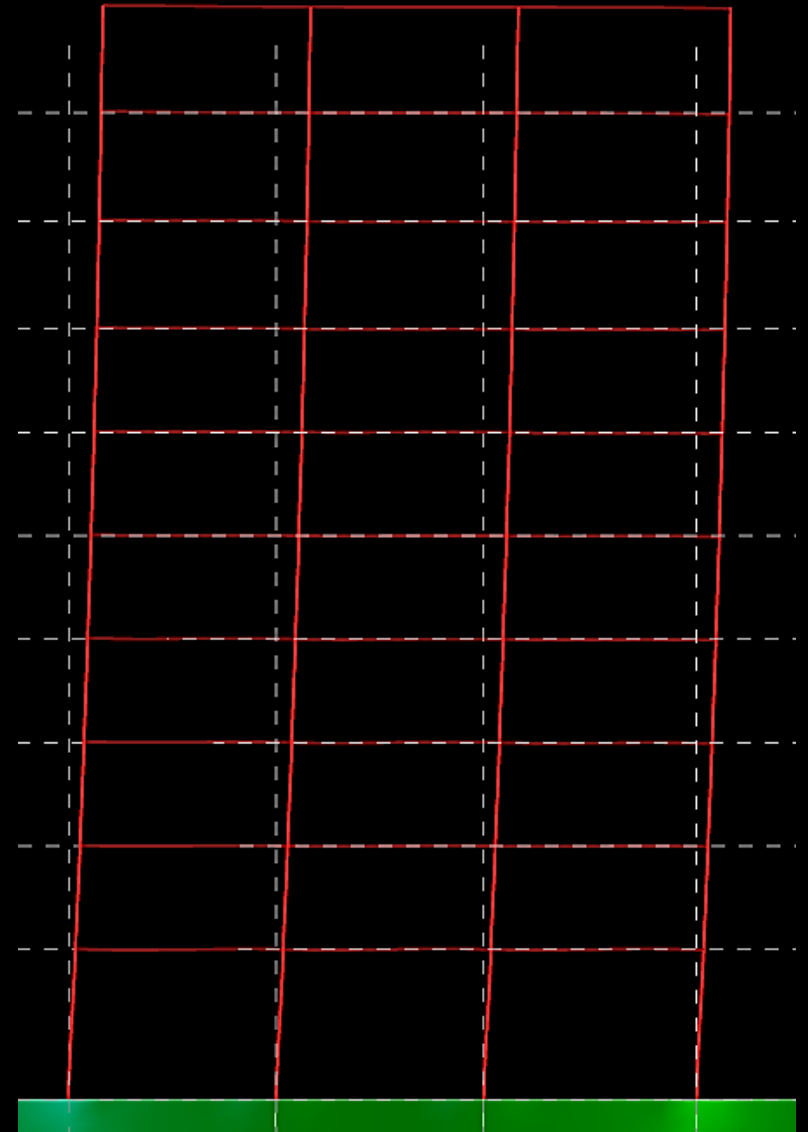
N - S DIRECTION (STEEL MOMENT FRAMES) - H/240 LIMIT				
STORY	hx (ft)	STORY DRIFT	ALLOWABLE DRIFT	CHECK
P.H. ROOF	18.5	0.79	0.93	OK
MAIN ROOF	10.75	0.24	0.54	OK
TENTH FLOOR	10.84	0.23	0.54	OK
NINTH FLOOR	10.75	0.27	0.54	OK
EIGHTH FLOOR	10.33	0.3	0.52	OK
SEVENTH FLOOR	10.33	0.34	0.52	OK
SIXTH FLOOR	10.33	0.38	0.52	OK
FIFTH FLOOR	10.33	0.39	0.52	OK
FOURTH FLOOR	10.33	0.43	0.52	OK
THIRD FLOOR	10.33	0.48	0.52	OK
SECOND FLOOR	15	0.68	0.75	OK

E - W DIRECTION (STEEL MOMENT FRAMES) - H/240 LIMIT				
STORY	hx (ft)	STORY DRIFT	ALLOWABLE DRIFT	CHECK
P.H. ROOF	18.5	0.85	0.93	OK
MAIN ROOF	10.75	0.19	0.54	OK
TENTH FLOOR	10.84	0.25	0.54	OK
NINTH FLOOR	10.75	0.31	0.54	OK
EIGHTH FLOOR	10.33	0.34	0.52	OK
SEVENTH FLOOR	10.33	0.38	0.52	OK
SIXTH FLOOR	10.33	0.43	0.52	OK
FIFTH FLOOR	10.33	0.44	0.52	OK
FOURTH FLOOR	10.33	0.46	0.52	OK
THIRD FLOOR	10.33	0.47	0.52	OK
SECOND FLOOR	15	0.64	0.75	OK

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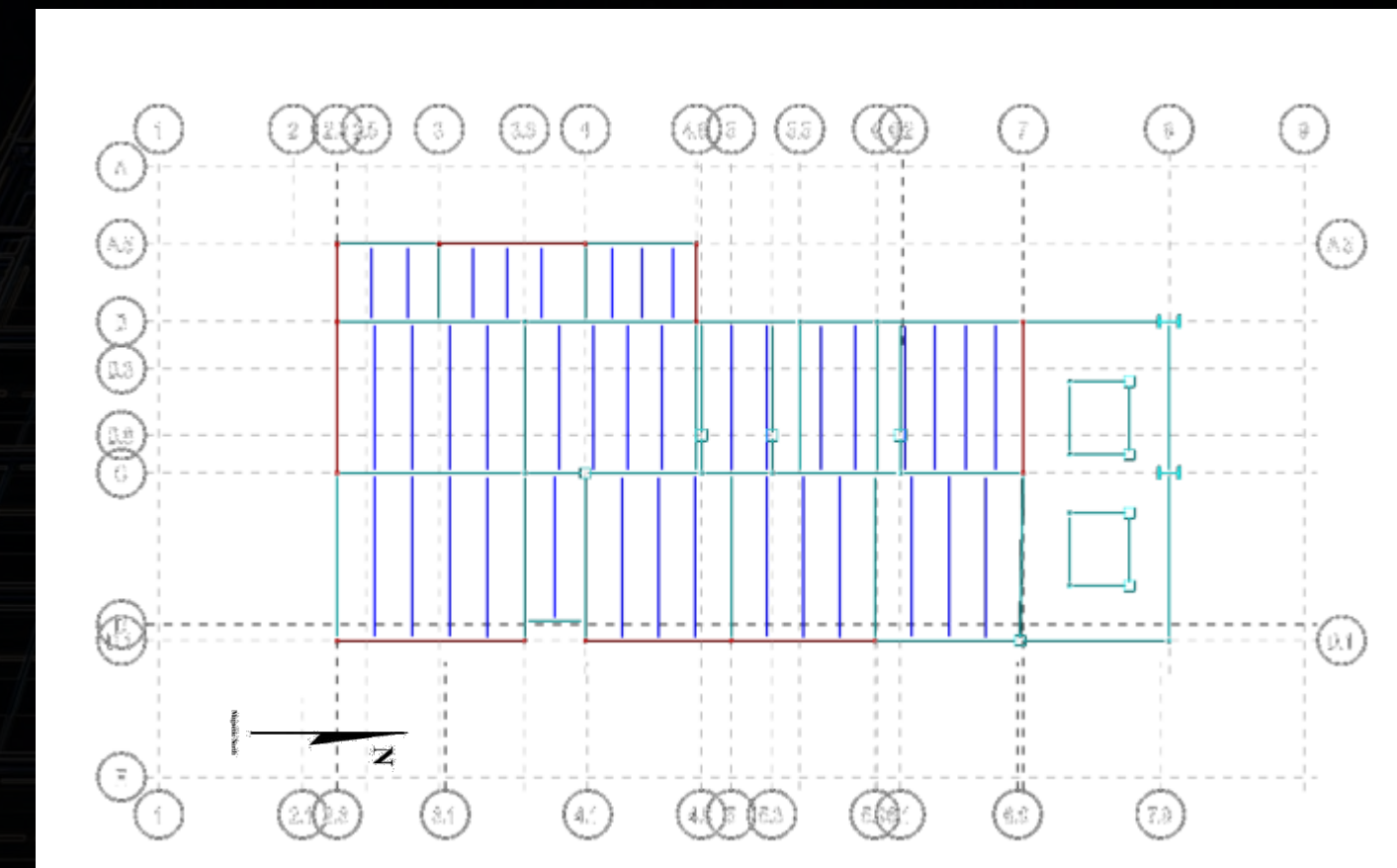
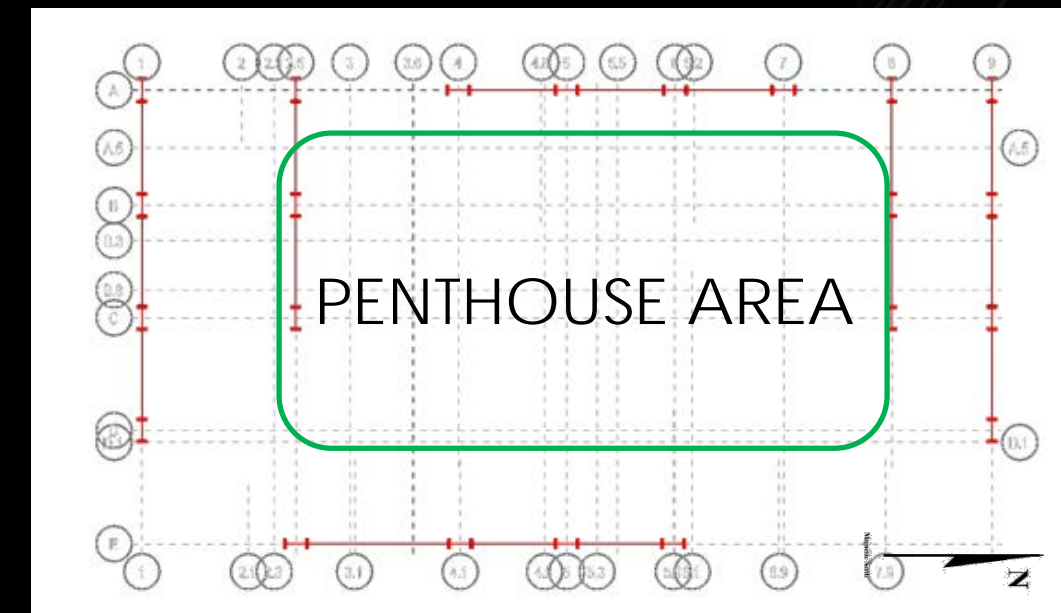


COLUMNS – W24X94
BEAMS – W21X93

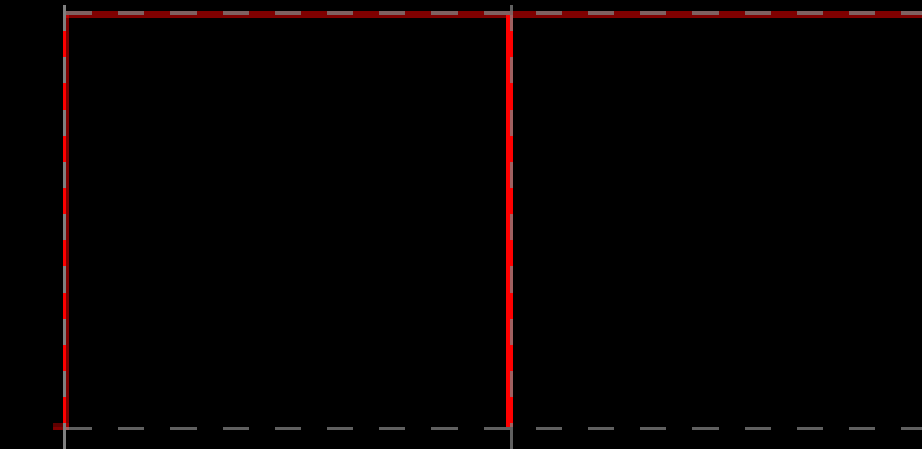


DEFLECTED SHAPE

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MOMENT FRAME LAYOUT

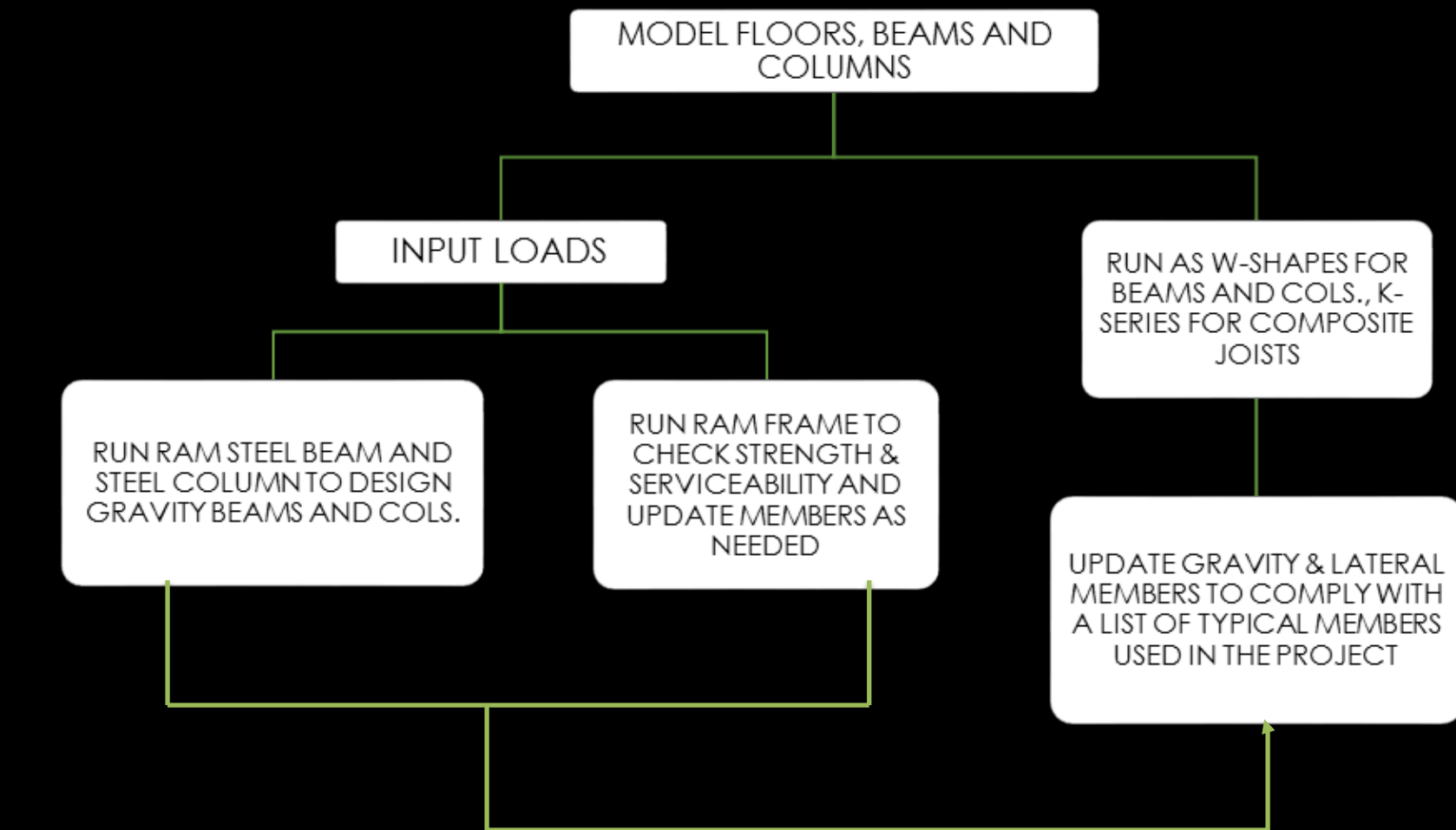


COLUMNS – HSS6X6X1/2
BEAMS – 14X22

- ❖ PENTHOUSE COLUMNS DON'T ALIGN
- ❖ BASES PINNED TO TAKE SHEAR AND NOT MOMENT

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- I. COMPOSITE STEEL JOISTS WERE MODELED AS NON-COMPOSITE STEEL JOISTS, DUE TO THE INABILITY OF THE SOFTWARE TO ACCOUNT FOR THE COMPOSITE ACTION OF A JOIST. THE EQUIVALENT JOISTS WERE SELECTED BASED ON DEPTH.
- II. A RIGID DIAPHRAGM WAS ASSUMED ON EVERY LEVEL.
- III. ACCIDENTAL AND INHERENT TORSION WERE ACCOUNTED FOR.
- IV. ALL LATERAL MEMBERS WERE FIXED AT BOTH ENDS
- V. P-DELTA EFFECTS WERE TAKEN INTO ACCOUNT.
- VI. LOAD COMBINATIONS WERE GENERATED USING IBC 2012/ASCE 7 -10





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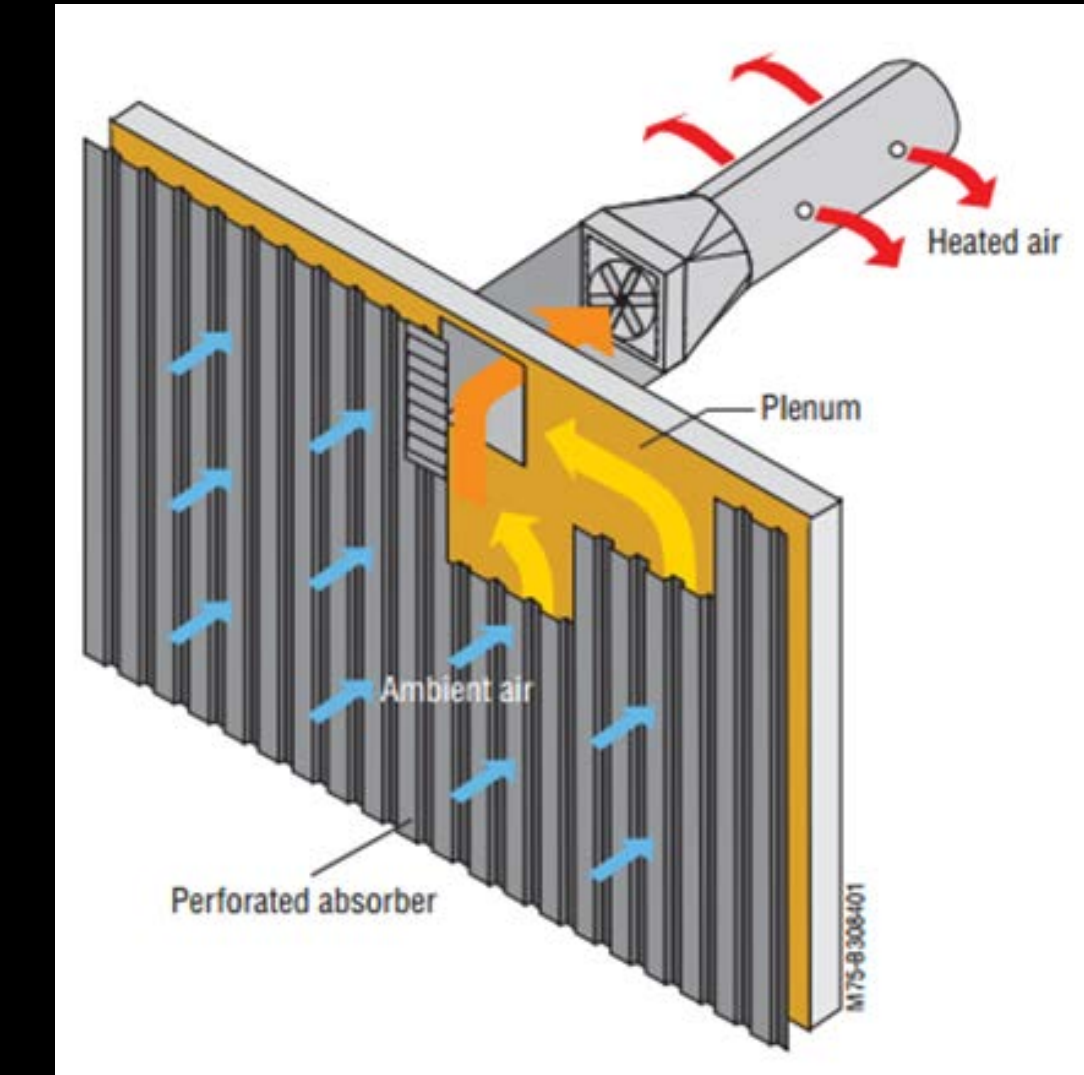
MECHANICAL BREADTH

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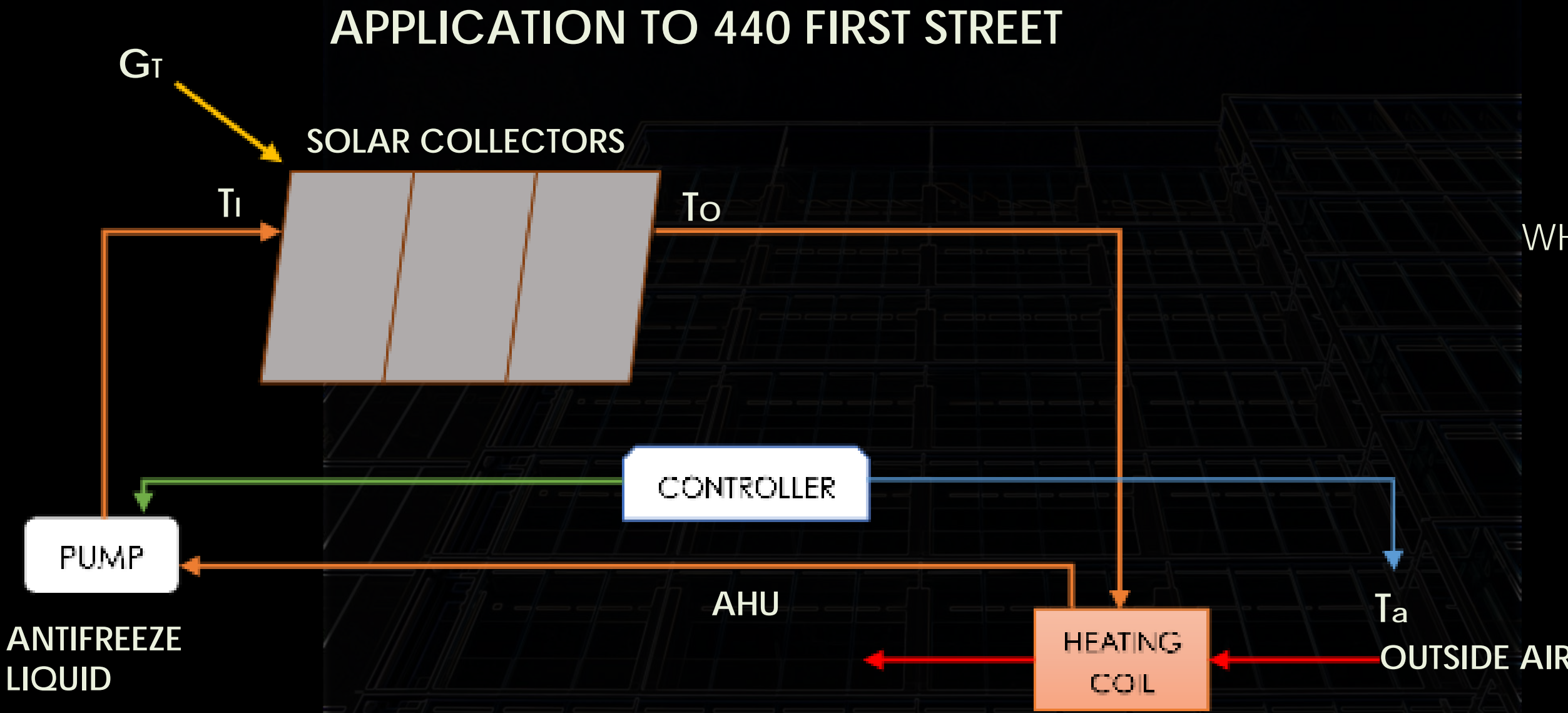
USING SOLAR THERMAL ENERGY TO PREHEAT VENTILATION AIR

DESIGN GOALS

- ❖ CREATE A LINK THAT ALLOWS INTAKE AIR TO BE COLLECTED BY THE SOLAR COLLECTORS AND TRANSFERRED INTO THE BUILDING.
- ❖ DESIGN THE TRANSPIRED COLLECTORS TO BE MOUNTED ON THE ROOF.
- ❖ CHECK FEASIBILITY OF REDUCING ENERGY REQUIREMENTS OF THE BUILDING



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CALCULATIONS

$$Q_U = A_C [G_T \cdot F_R(tr) - F_R U_L (T_i - T_a)]$$

WHERE G_T – SOLAR IRRDIANCE (w/m^2)
 T_f – INLET FLUID TEMP. TO THE COLLECTORS
 T_o – OUTLERT FLUID TEMP. FROM COLLECTORS

$$F_R U_L = 0.83 \quad F_R(tr) = 6.3 \text{ w/m}^2 \cdot \text{C}$$

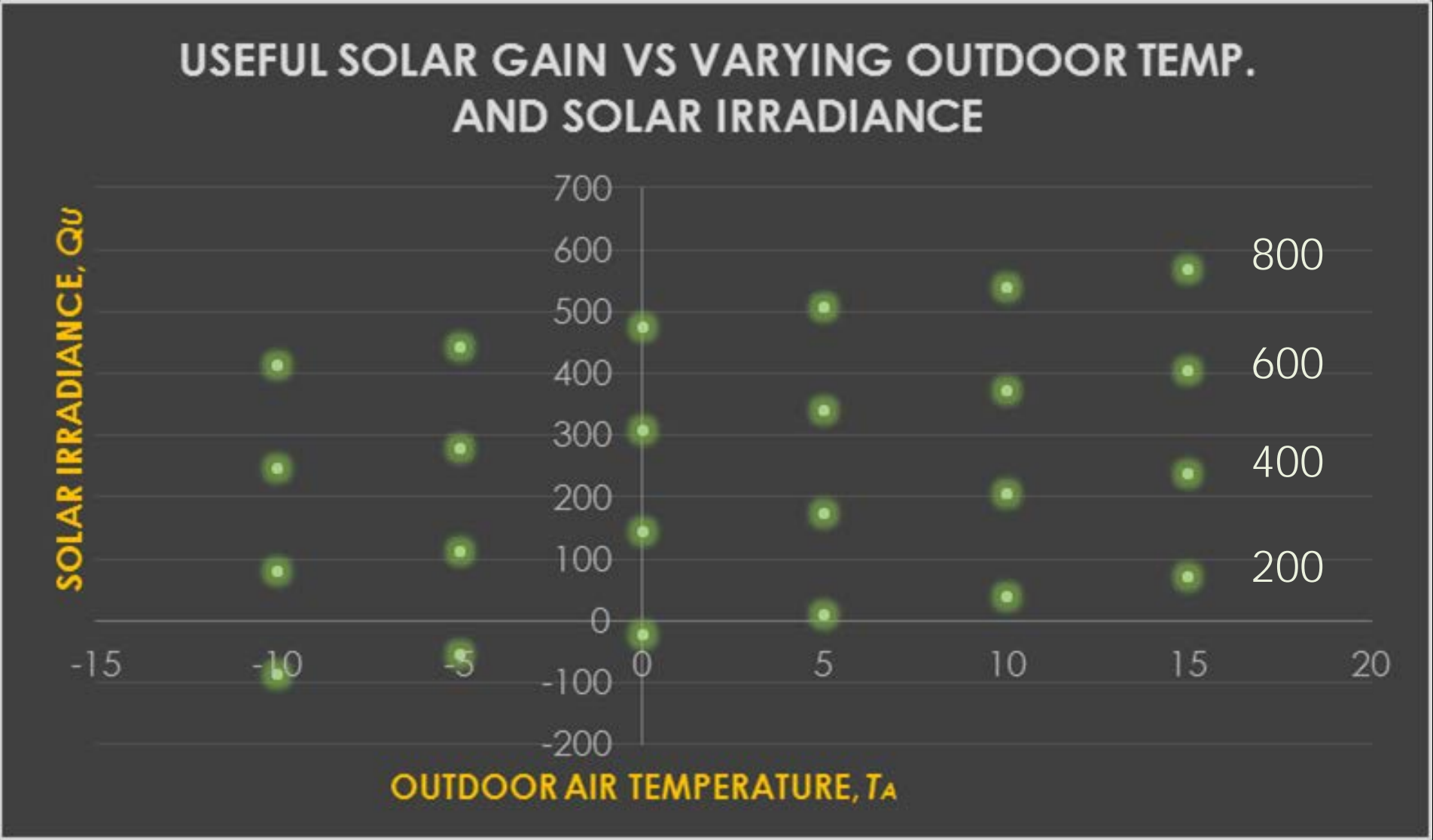
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TABLE 7: SOLAR IRRADIANCE X OUTDOOR AIR TEMP. X USEFUL SOLAR GAIN

SOLAR IRRADIANCE	OUTDOOR AIR TEMP.	USEFUL SOLAR GAIN
200	-10	-86
200	-5	-54.5
200	0	-23
200	5	8.5
200	10	40
200	15	71.5
400	-10	80
400	-5	111.5
400	0	143
400	5	174.5
400	10	206
400	15	237.5
600	-10	246
600	-5	277.5
600	0	309
600	5	340.5
600	10	372
600	15	403.5
800	-10	412
800	-5	443.5
800	0	475
800	5	506.5
800	10	538
800	15	569.5

$$Q_U = A_C [G_T \cdot F_R(tr) - F_R U_L (T_i - T_a)]$$

GT – (200, 400, 600, 800)
Ta - (-10, -5, 0, 5, 10, 15)



BUILDING INFORMATION
EXISTING CONDITIONS
THESIS PROPOSAL & GOALS
STRUCTURAL REDESIGN
MECHANICAL BREADTH
EVALUATION & CONCLUSIONS
QUESTIONS

REDESIGN EVALUATION

STRUCTRUAL REDESIGN	CHECK
PROVIDE A LIGHTWEIGHT SOLUTION	✓
REDUCE COST	✓
RETAIN ARCHITECTURAL LAYOUT	✓
MECHANICAL BREADTH	✓
MECHANICAL BREADTH	
CREATE SCHEMATIC OF THE SYSTEM	✓
DESIGN THE TRANSPIRED COLLECTORS	✓
COST ANALYSIS	
REDUCE OVERALL COST	✓

CONCLUSION

- ❖ LESS EXPENSIVE
 - ❖ ORIGINAL - \$20,000,000
 - ❖ REDESIGN - \$18,593,874 (6% SAVINGS)
- ❖ LIGHTWEIGHT STRUCTURE
 - ❖ ORINGINAL – 11500 KIPS
 - ❖ REDESIGN - 6500 KIPS

DESIGN FEASIBLE



ACKNOWLEDGEMENTS

SPECIAL THANKS TO:

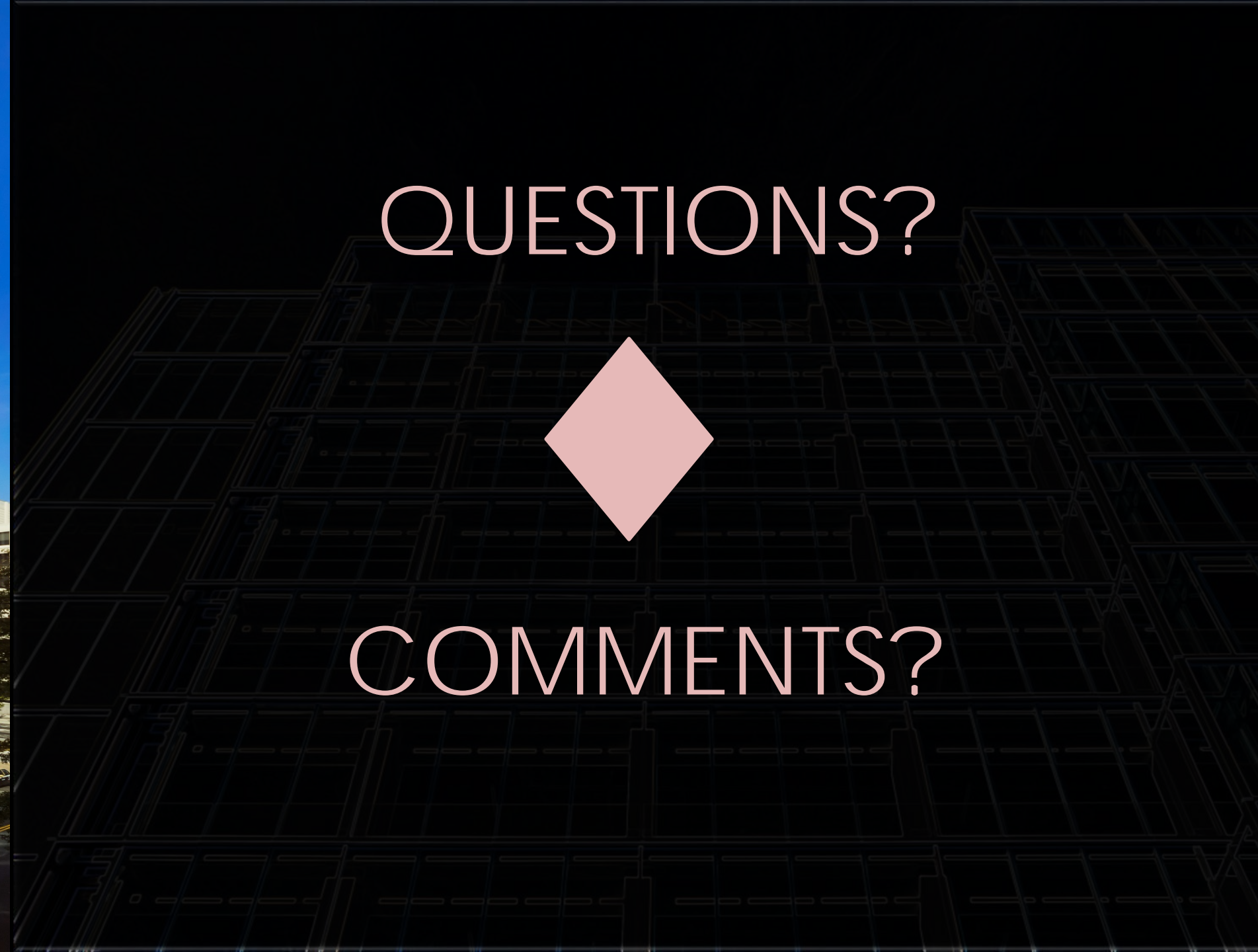
JUSTIN DOMIRE, MICHEAL GOSS | RGA

JP SPICKLER | FOX ARCHITECTS

ENTIRE AE FACULTY

MY FAMILY, FRIENDS & CLASSMATES







APPENDIXES

WIND PRESSURES & FORCES IN NORTH – SOUTH DIRECTION

WIND PRESSURES (N - S)					
HEIGHT (FT.)	Kz	qz	WINDWARD WALL (PSF)	LEEWARD WALL (PSF)	TOTAL (PSF)
127.25	1.06	30.50	20.74	-8.43	29.17
109.25	1.01	29.07	19.7	-8.43	28.13
98.5	0.99	28.49	19.4	-8.43	27.83
87.75	0.95	27.34	18.6	-8.43	27.03
77	0.92	26.48	18	-8.43	26.43
66.67	0.88	25.32	17.2	-8.43	25.63
56.33	0.84	24.17	16.4	-8.43	24.83
46	0.79	22.73	15.4	-8.43	23.83
35.67	0.73	21.01	14.2	-8.43	22.63
25.33	0.66	18.99	12.9	-8.43	21.33
15	0.57	16.40	11.2	-8.43	19.63

SUMMARY (N - S)				
STORY	HEIGHT (FT.)	FORCE (K)	SHEAR (K)	MOMENT (FT-K)
PHR	127.25	45.68	0	5812.78
MR	109.25	25.28	45.96	2761.84
10	98.5	25.01	71.24	2463.49
9	87.75	24.29	96.25	2131.45
8	77	23.75	120.54	1828.75
7	66.67	23.03	144.29	1535.41
6	56.33	22.31	167.32	1256.72
5	46	21.42	189.63	985.32
4	35.67	20.34	211.05	725.53
3	25.33	19.17	231.39	485.58
2	15	25.58	250.56	383.70
			276.14	20370.56

WIND PRESSURES & FORCES IN EAST-WEST DIRECTION

WIND PRESSURES (E - W)					
HEIGHT (FT.)	Kz	qz	WINDWARD WALL (PSF)	LEEWARD WALL (PSF)	TOTAL (PSF)
127.25	1.06	30.50	20.7	-12.9	33.6
109.25	1.01	29.07	19.7	-12.9	32.6
98.5	0.99	28.49	19.4	-12.9	32.3
87.75	0.95	27.34	18.6	-12.9	31.5
77	0.92	26.48	18	-12.9	30.9
66.67	0.88	25.32	17.2	-12.9	30.1
56.33	0.84	24.17	16.4	-12.9	29.3
46	0.79	22.73	15.4	-12.9	28.3
35.67	0.73	21.01	14.2	-12.9	27.1
25.33	0.66	18.99	12.9	-12.9	25.8
15	0.57	16.40	11.2	-12.9	24.1

SUMMARY (E - W)				
STORY	HEIGHT (FT.)	FORCE (K)	SHEAR (K)	MOMENT (FT-K)
PHR	127.25	96.92	0	12333.07
MR	109.25	53.9	96.92	5888.58
10	98.5	53.4	150.82	5259.90
9	87.75	52.1	204.22	4571.78
8	77	51.2	256.32	3942.40
7	66.67	49.83	307.52	3322.17
6	56.33	48.5	357.35	2732.01
5	46	46.85	405.85	2155.10
4	35.67	44.86	452.7	1600.16
3	25.33	42.71	497.56	1081.84
2	15	57.93	540.27	868.95
			598.2	43755.94

APPENDIXES

STRUCTURAL COST INFORMATION

ECOSPAN COMPOSITE JOISTS TAKEOFF				
SIZE	FLOOR	FLOOR AREA	COST/SF	COST
12" EJ	PHR	4567	1.2	5480.4
	MR	6171	1.2	7405.2
	10	6171	1.2	7405.2
	9	6171	1.2	7405.2
	8	12765	1.2	15318
	7	12765	1.2	15318
	6	12765	1.2	15318
	5	12765	1.2	15318
	4	12765	1.2	15318
	3	12765	1.2	15318
	2	12765	1.2	15318
				134922
18	MR	6594	1.2	7912.8
	10	6594	1.2	7912.8
	9	6594	1.2	7912.8
				23738.4

BEAM TAKEOFF			
SIZE	LENGTH (FT.)	COST/FT.	COST
W8X10	1272	9.17	11664.24
W12x26	7057	21.45	151372.65
W10x30	1075	26.4	28380
W14X30	1570	31.35	49219.5
W14X43	756	37.84	28607.04
W14X74	529	72.8	38511.2
W24X94	157	86.7	13611.9
			321366.53

COLUMN TAKEOFF			
SIZE	LENGTH (FT.)	COST/FT.	COST
W10X33	2210.4	19.67	43478.568
W21X93	2512.75	68.9	173128.475
HSS6X6X1/2	647.5	29.1	18842.25
			235449.293

CONCRETE TAKEOFF					
FLOOR	AREA	THICKNESS	VOLUME	COST/YD3.	COST
MAIN ROOF	14253	0.208	109.80	90	9882.08
10TH	14253	0.208	109.80	90	9882.08
9TH	14253	0.208	109.80	90	9882.08
8TH	14253	0.208	109.80	90	9882.08
7TH	14253	0.208	109.80	90	9882.08
6TH	14253	0.208	109.80	90	9882.08
5TH	14253	0.208	109.80	90	9882.08
4TH	14253	0.208	109.80	90	9882.08
3RD	14253	0.208	109.80	90	9882.08
2ND	14253	0.208	109.80	90	9882.08
					98820.8

STEEL DECK TAKEOFF			
FLOOR	AREA	COST/SF.	COST
P.ROOF	4567	1.15	5252.05
MAIN ROOF	14253	2.5	35632.5
10TH	14253	2.5	35632.5
9TH	14253	2.5	35632.5
8TH	14253	2.5	35632.5
7TH	14253	2.5	35632.5
6TH	14253	2.5	35632.5
5TH	14253	2.5	35632.5
4TH	14253	2.5	35632.5
3RD	14253	2.5	35632.5
2ND	14253	2.5	35632.5
			361577.05