

IPD/BIM THESIS
TECH I:
STRUCTURAL
10/06/2010

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Stephen Pfund

Stephen Kijak

SUMMARY

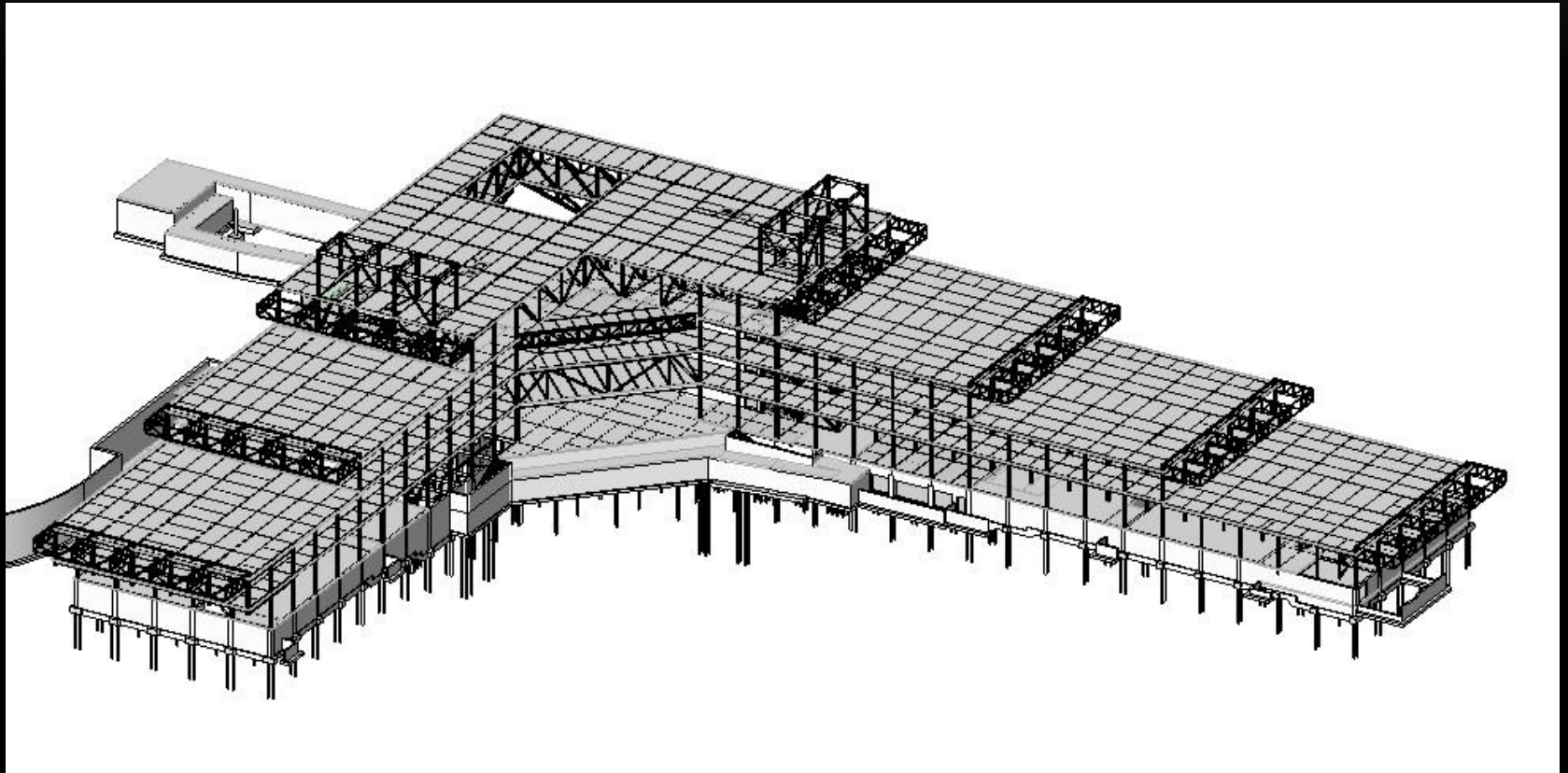
- Introduction
 - Structural System Overview
 - Floor Plans
 - Frame Elevations
 - Lateral System
 - Specialty Systems
 - Lateral Loads
 - Spot Checks
 - IPD/BIM
 - Tech II
-

CANTILEVER RENDERING

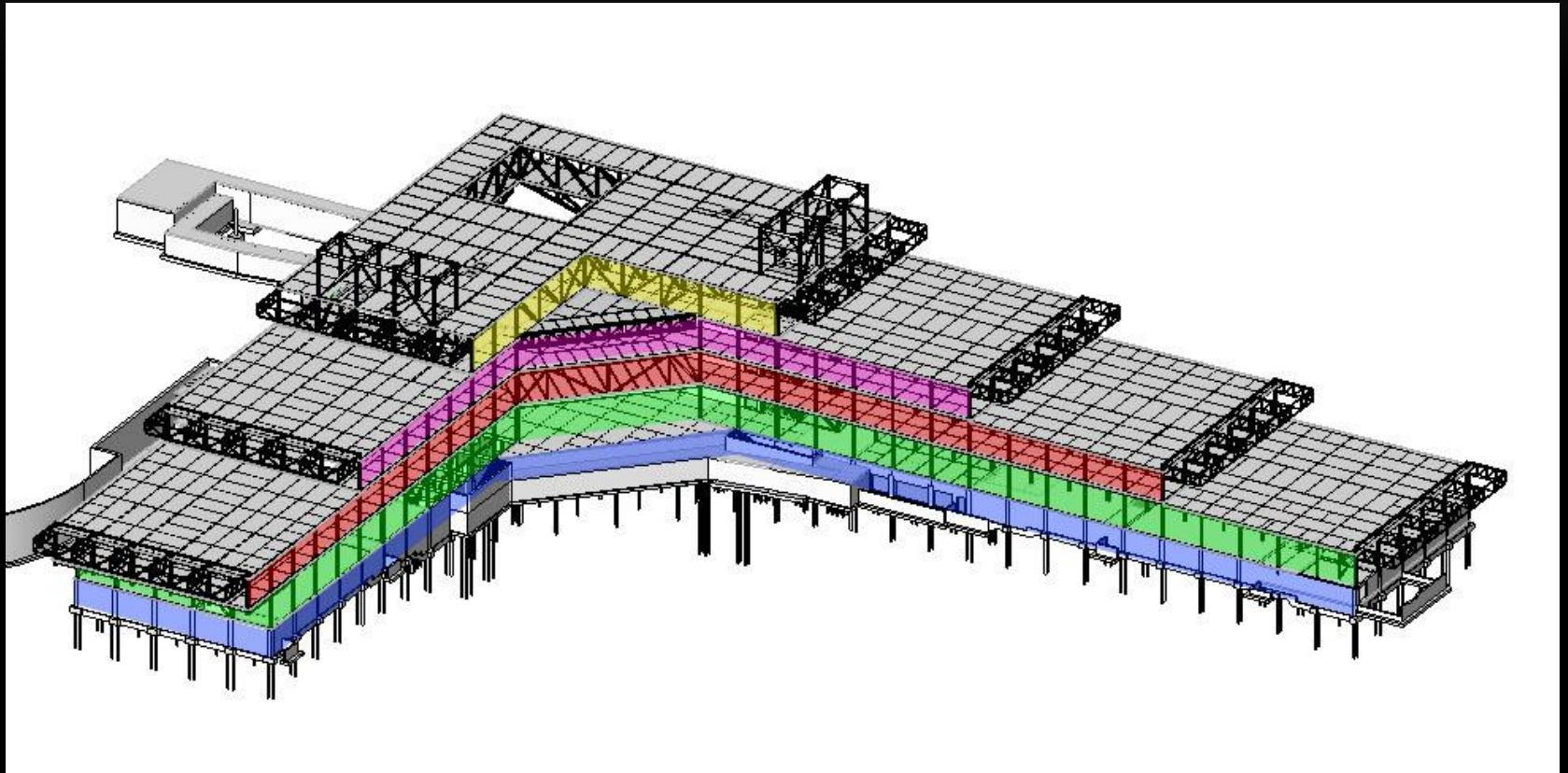


Image taken from OPP website: http://www.opp.psu.edu/planning-construction/projects/Millennium_Science_Complex

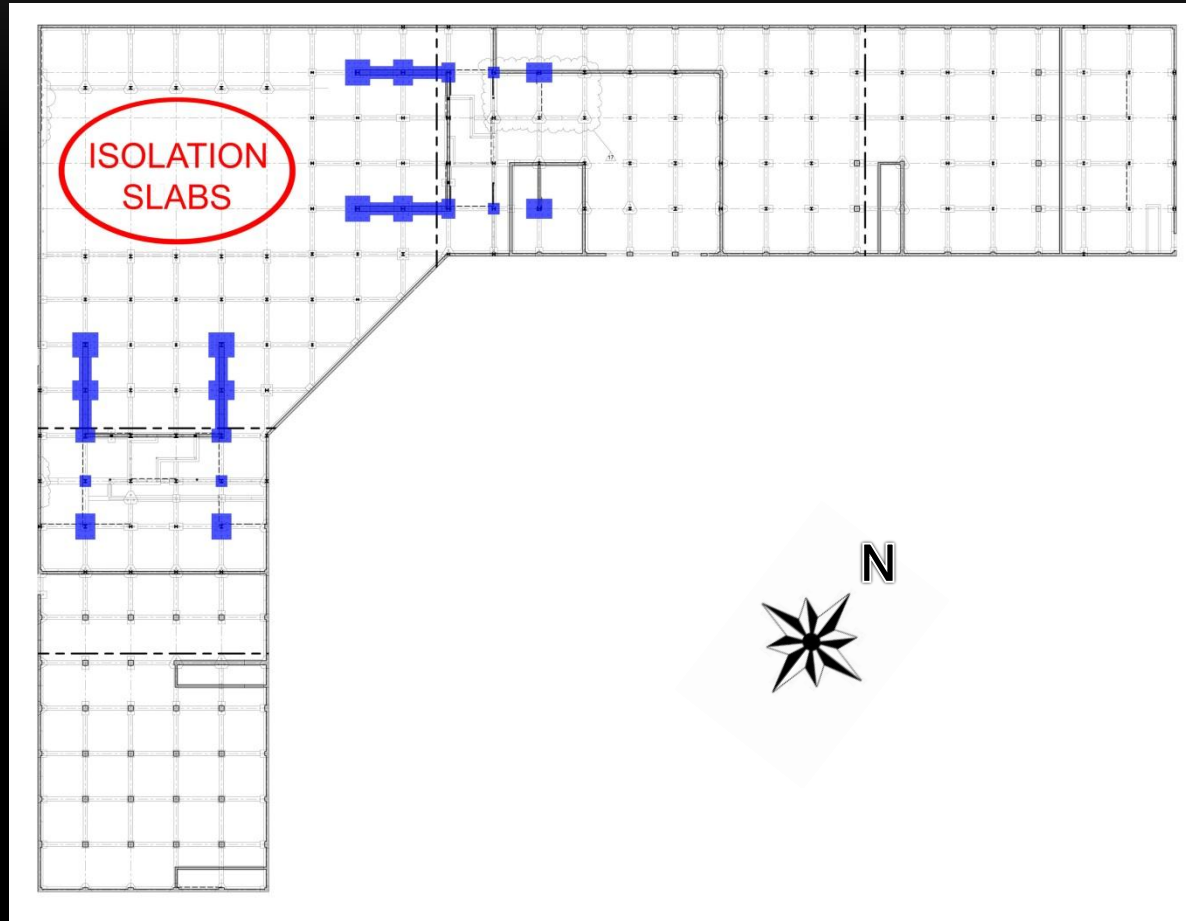
SOUTH EAST PERSPECTIVE



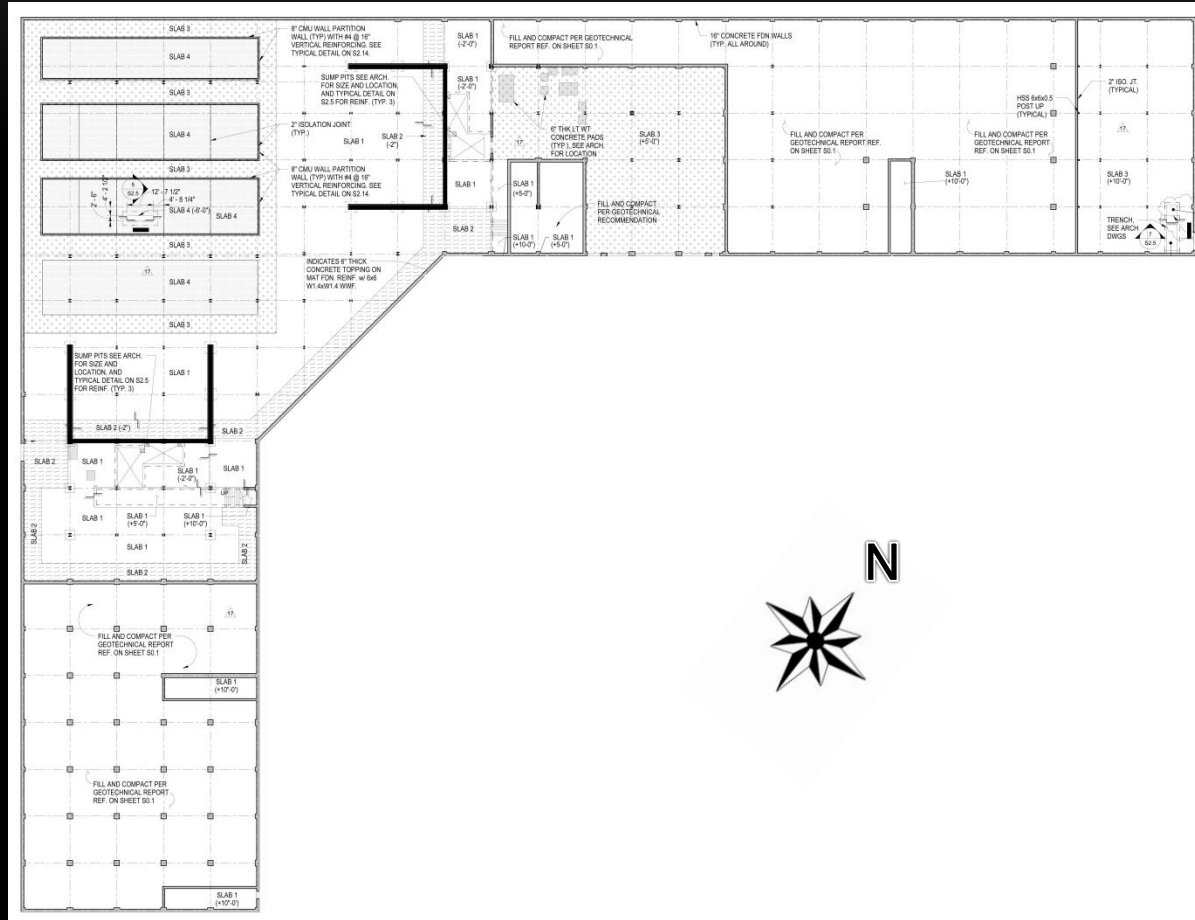
BUILDING LEVELS



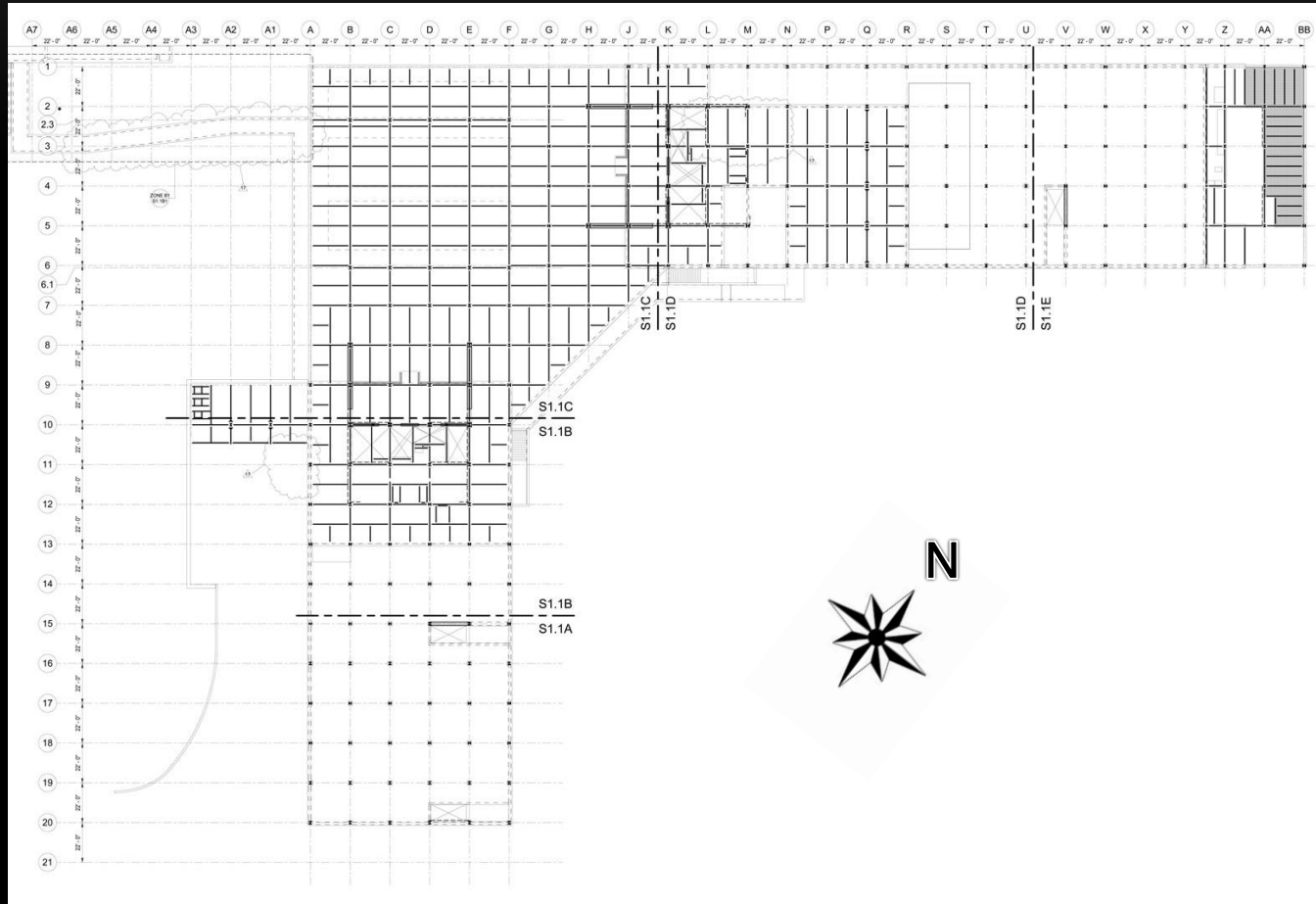
FOUNDATION



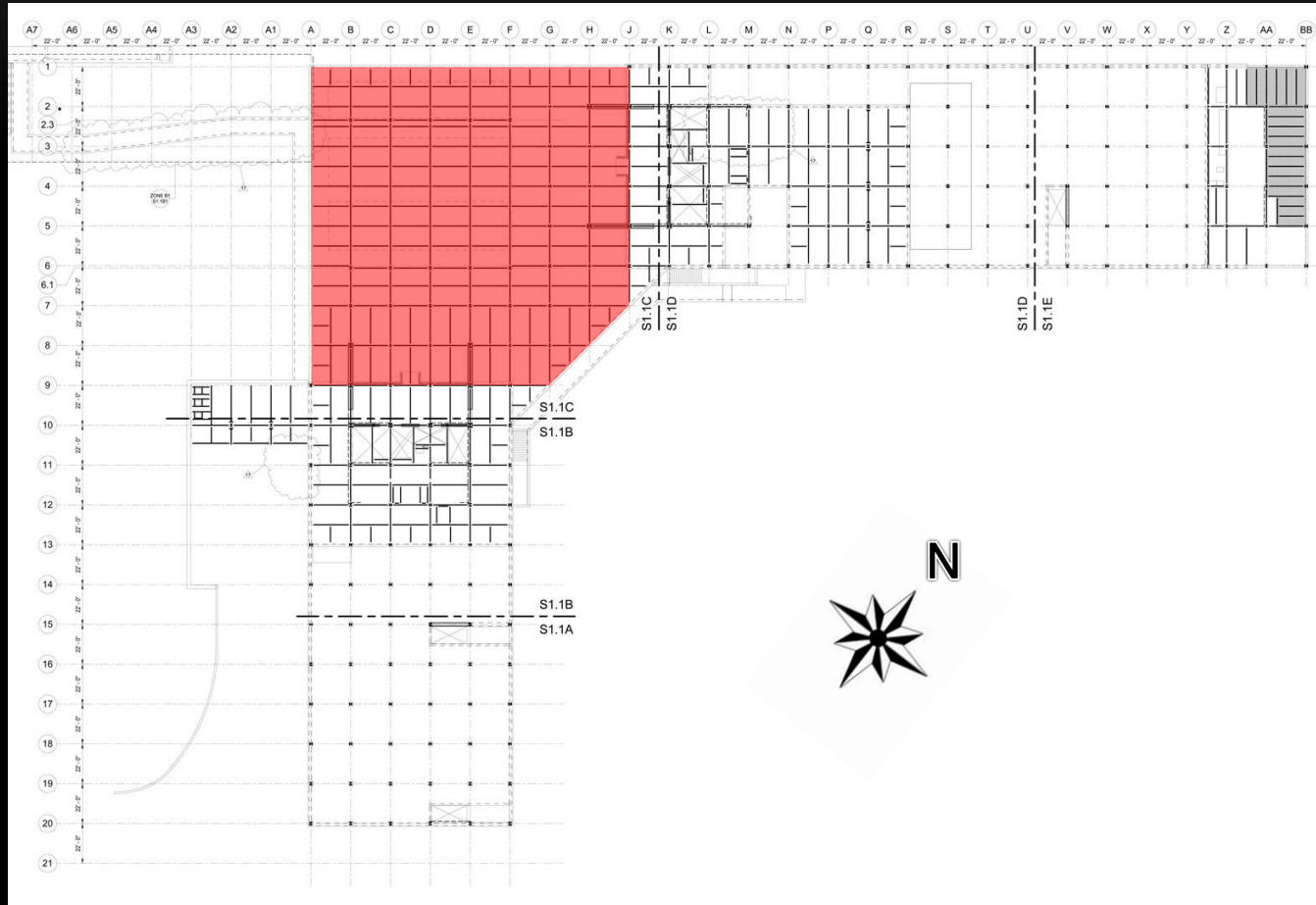
BASEMENT



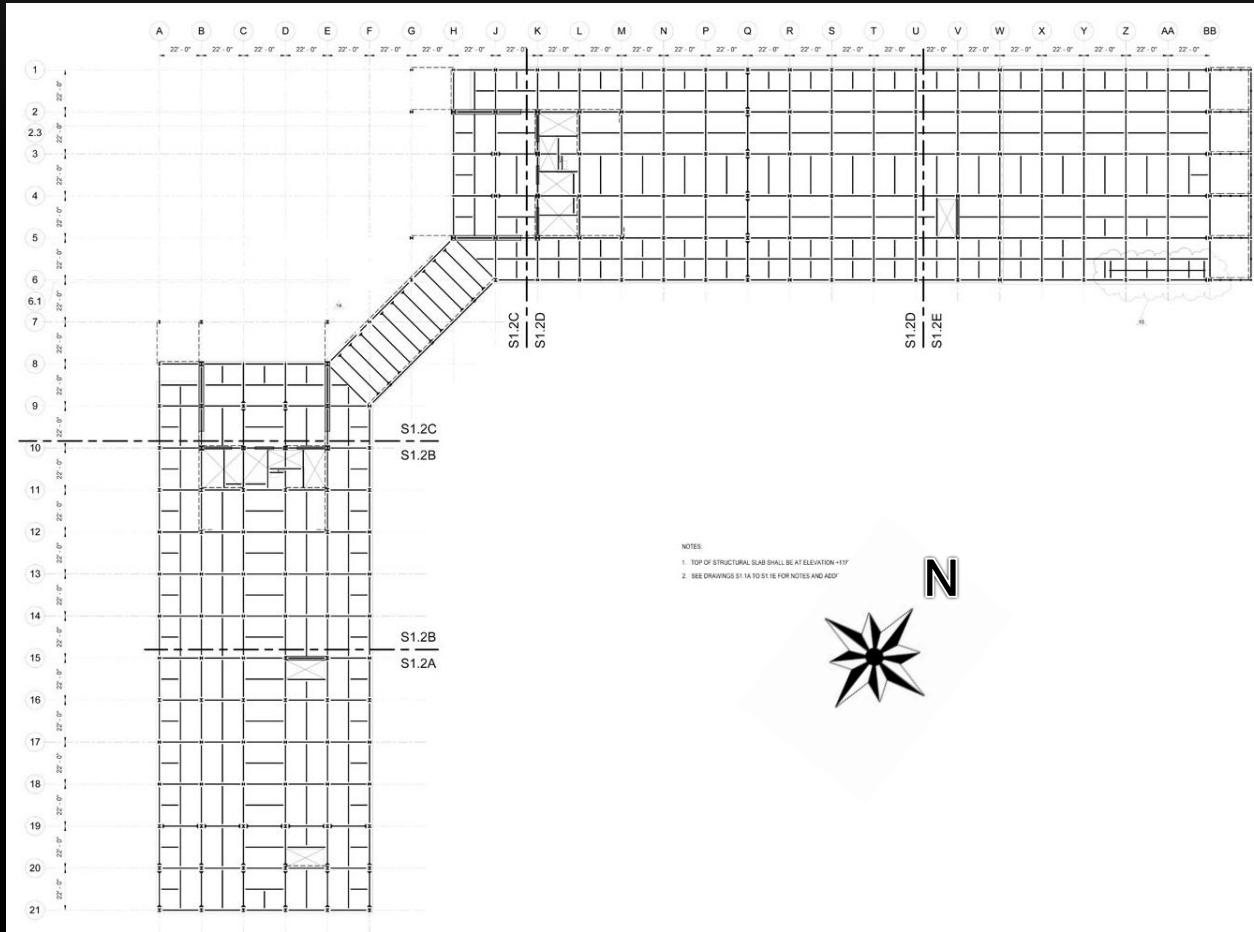
FIRST FLOOR



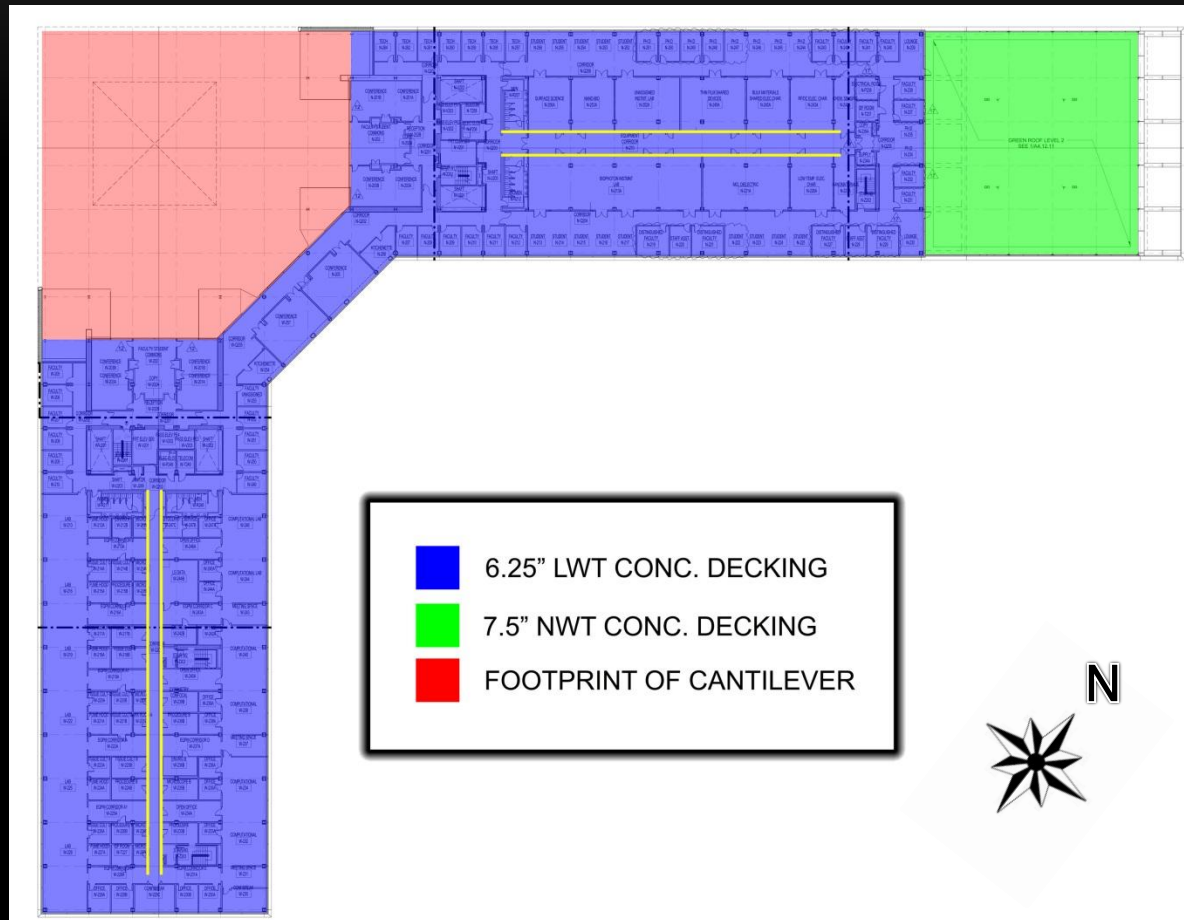
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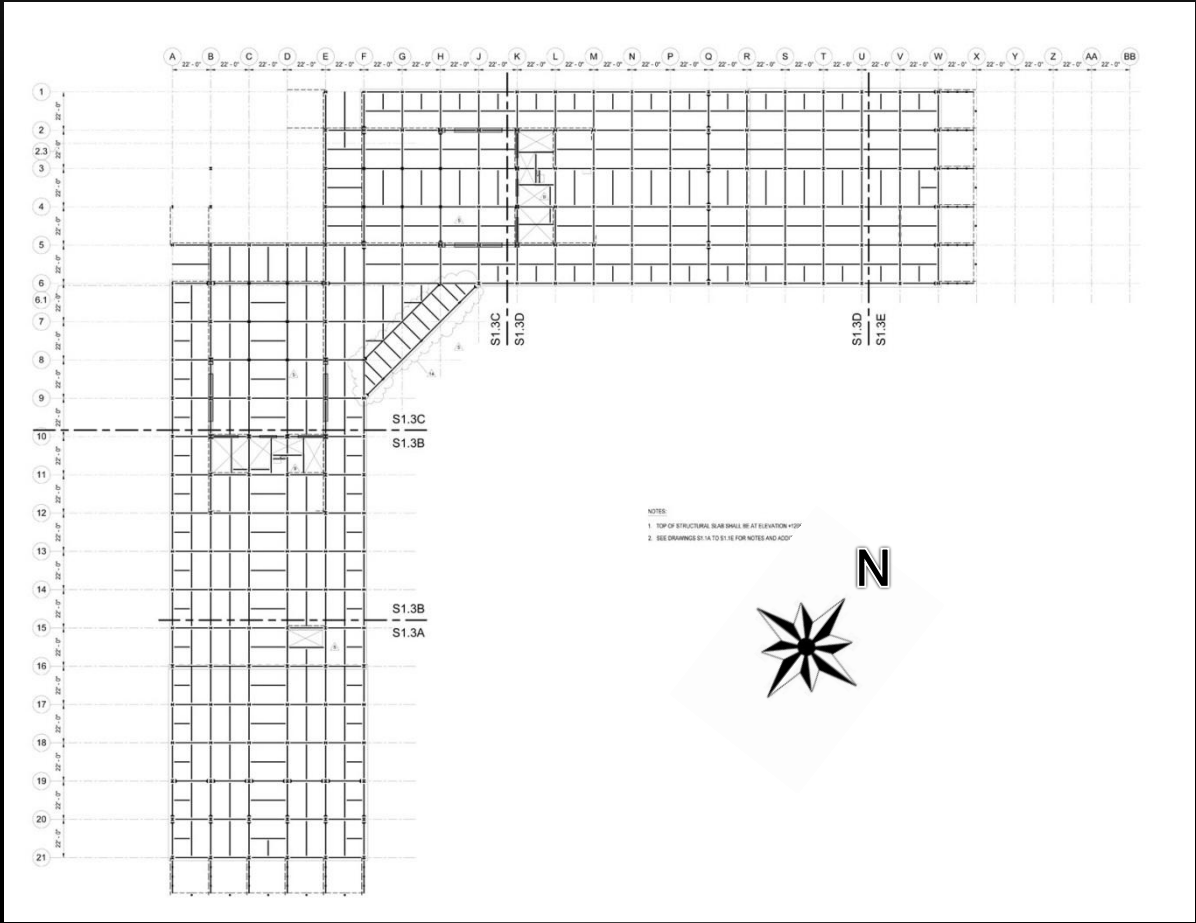
SECOND FLOOR



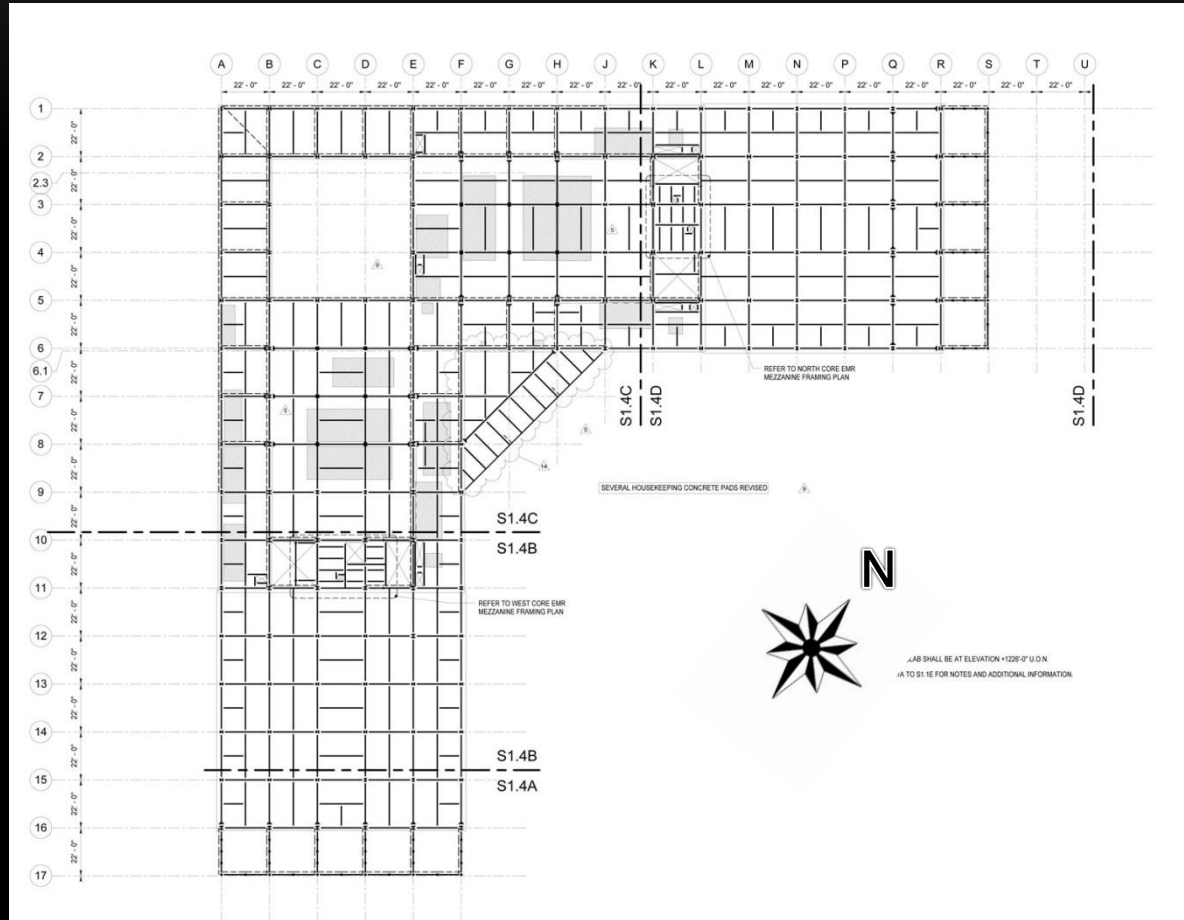
COMPOSITE DECKS



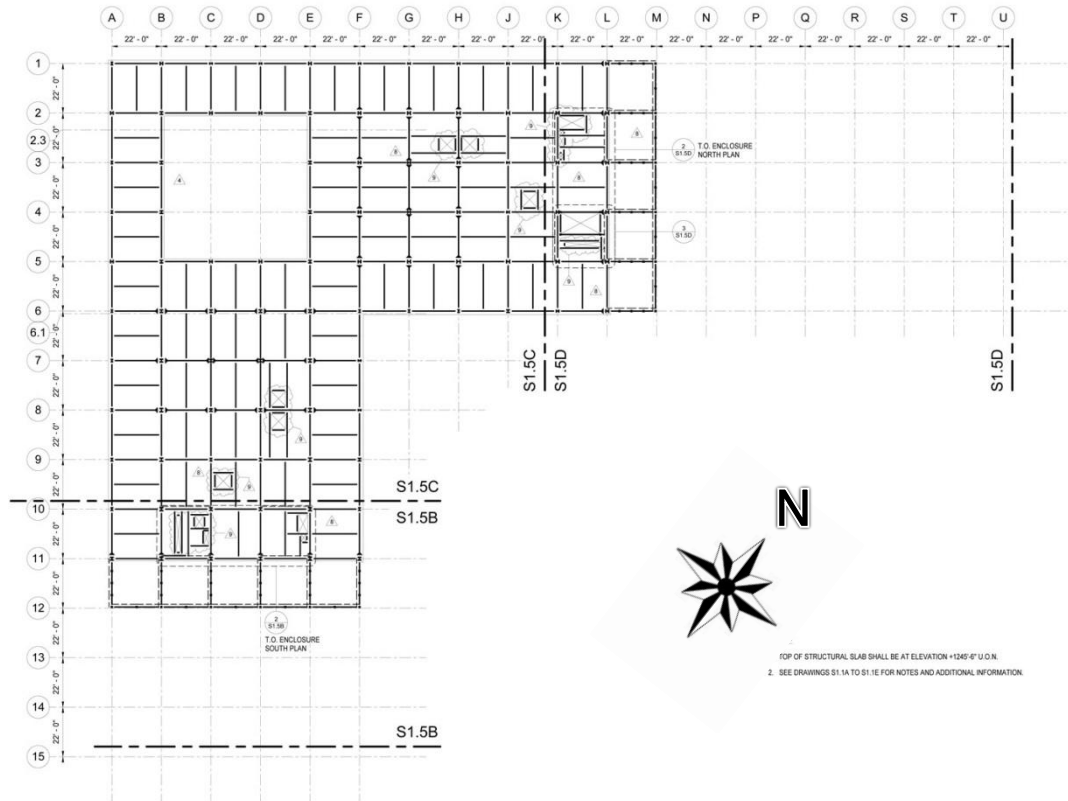
THIRD FLOOR



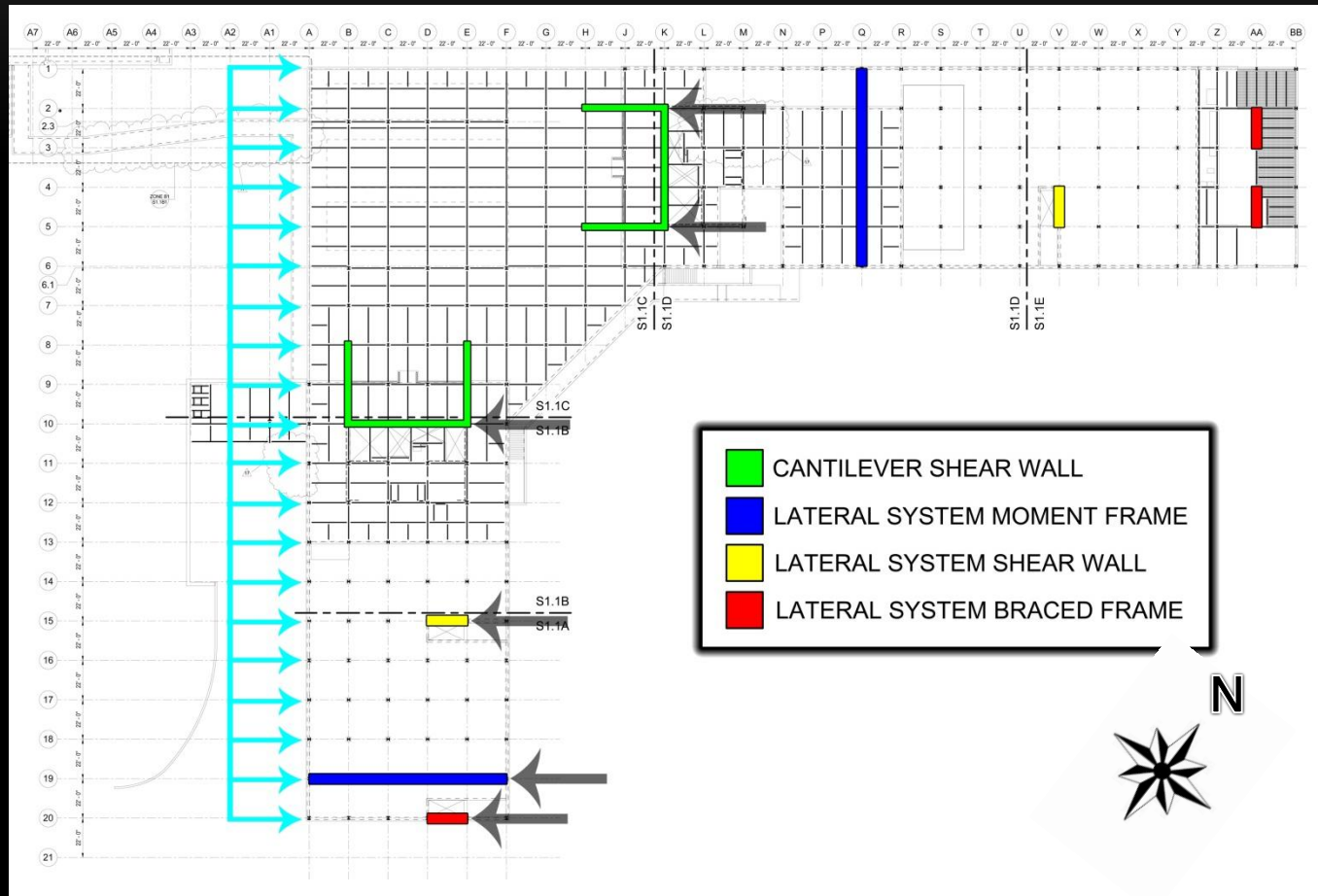
MECHANICAL PENTHOUSE

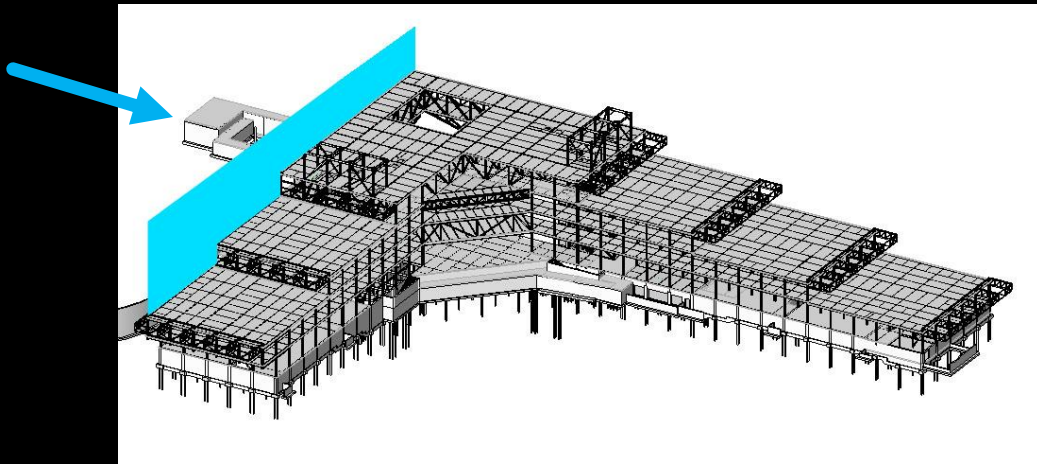
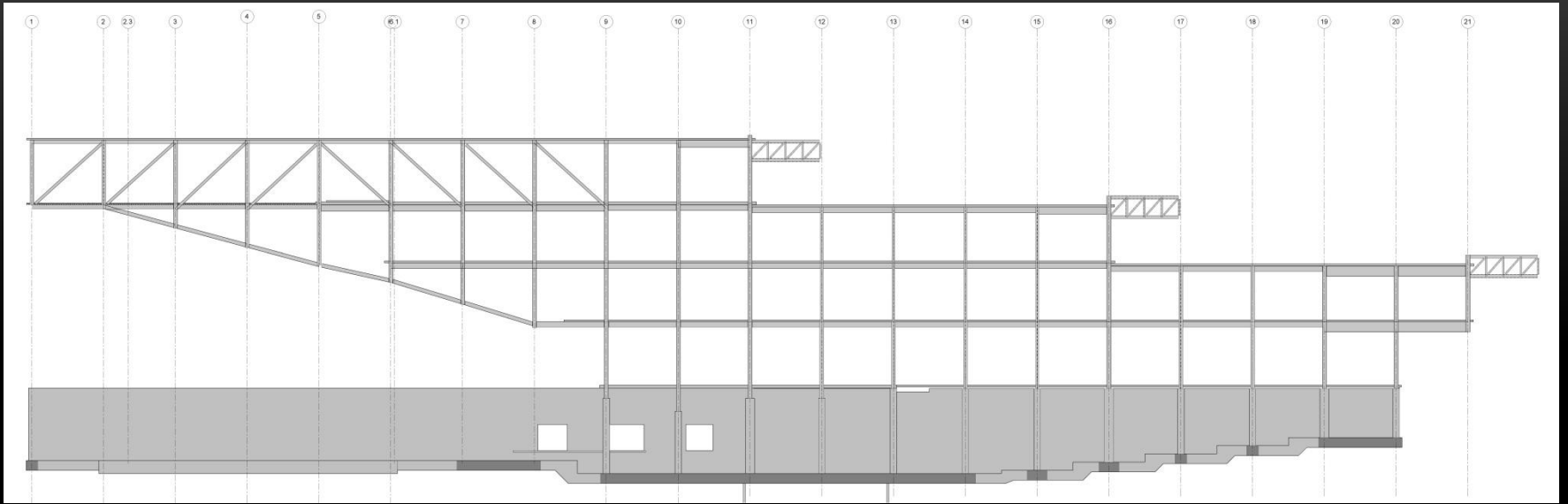


ROOF

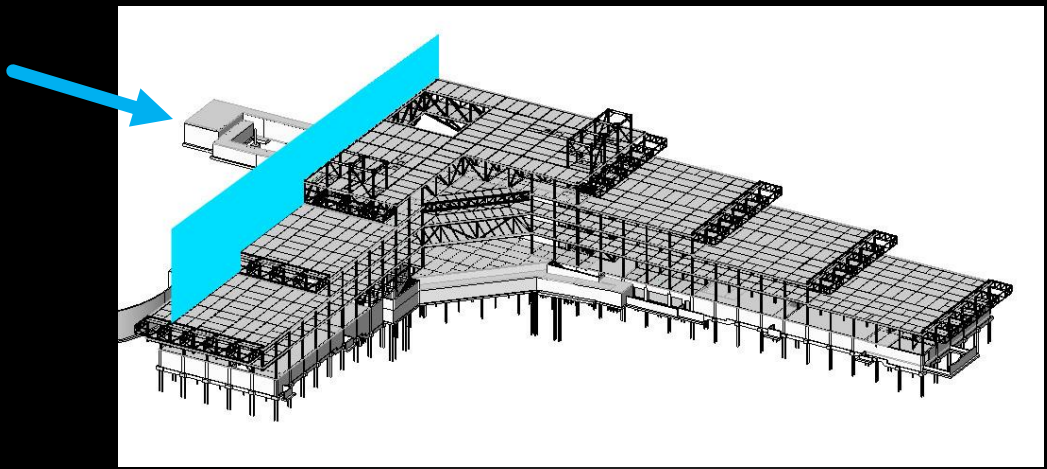
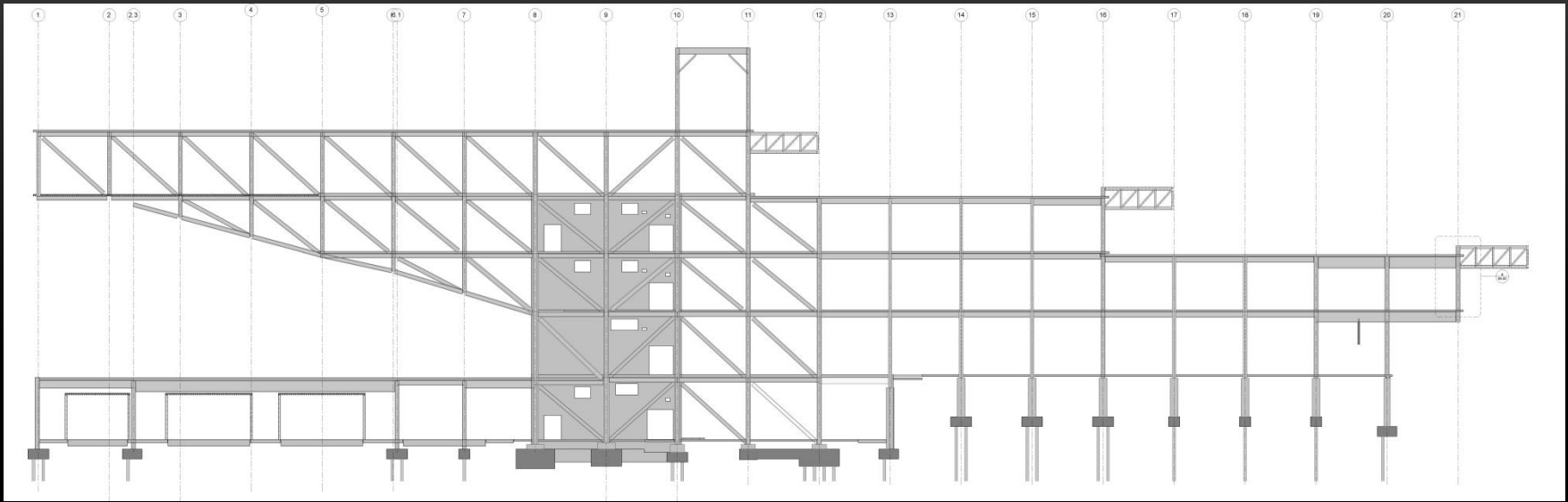


LATERAL SYSTEM & SPECIAL SYSTEMS

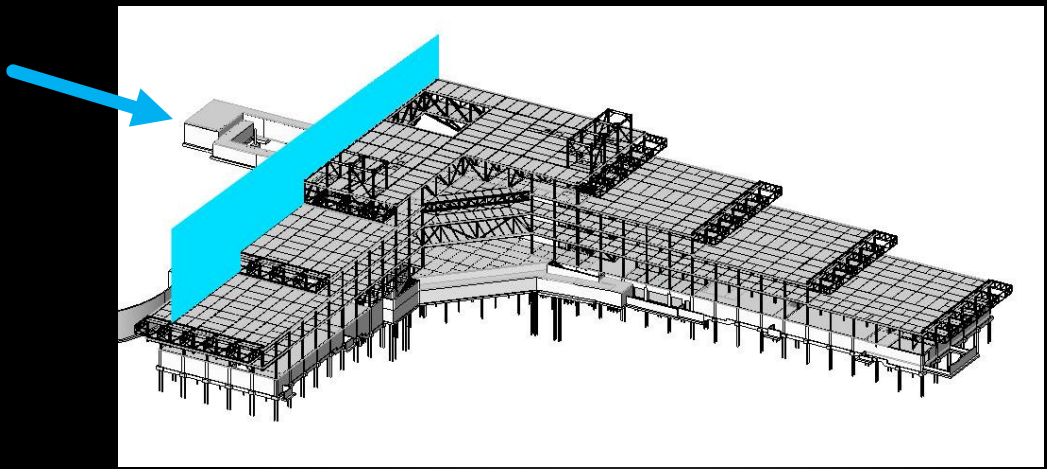
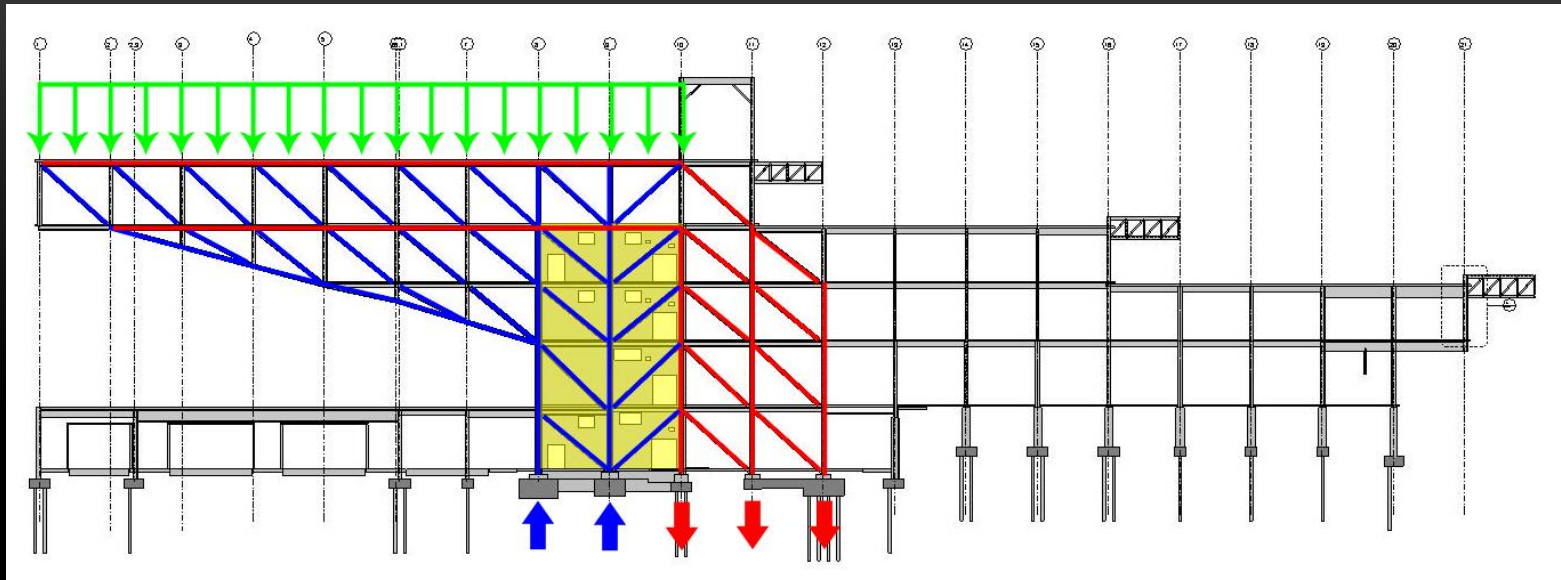




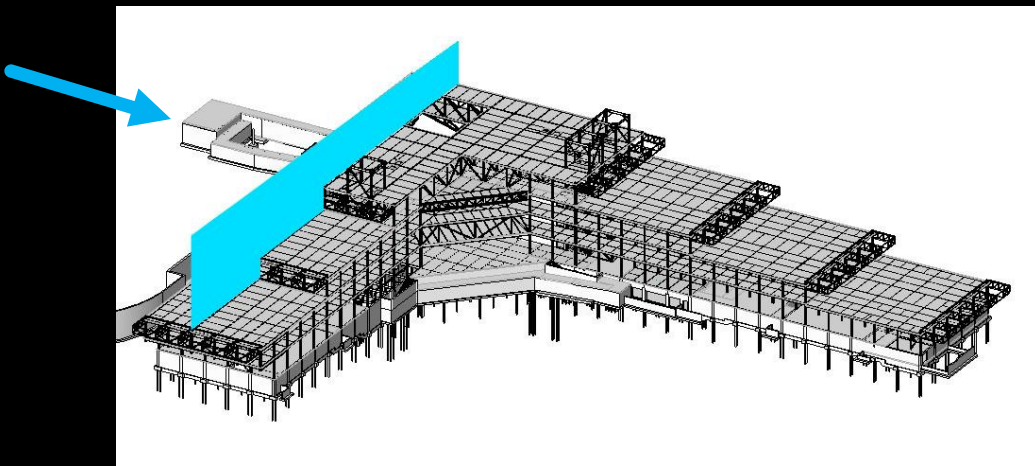
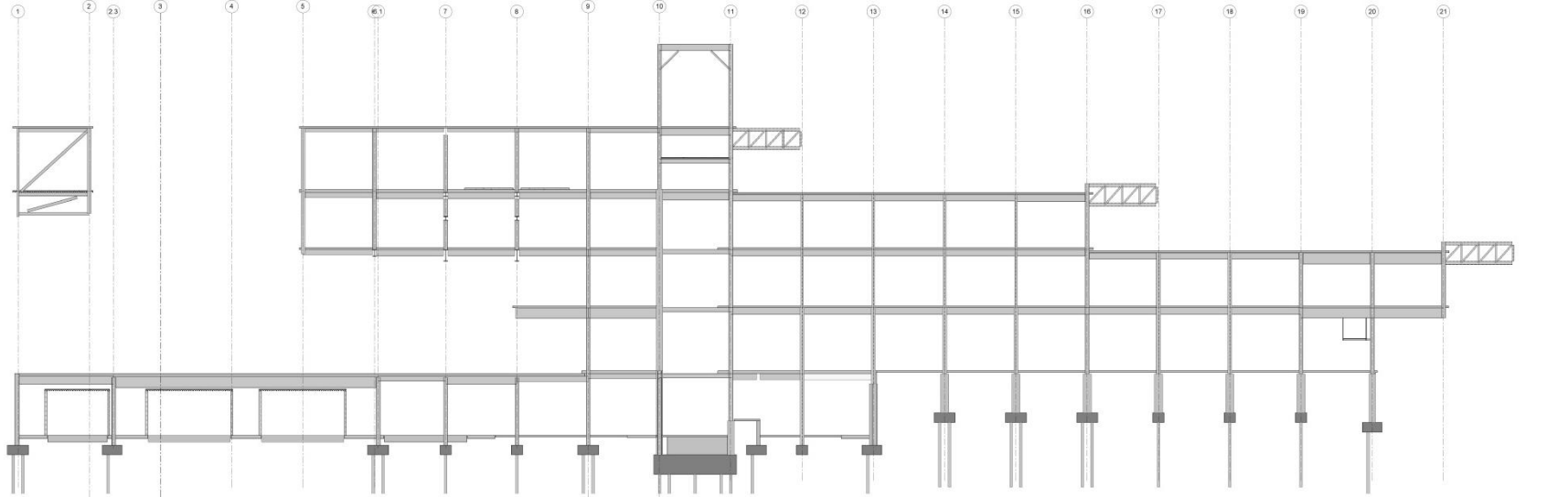
Frame – A (Looking East)



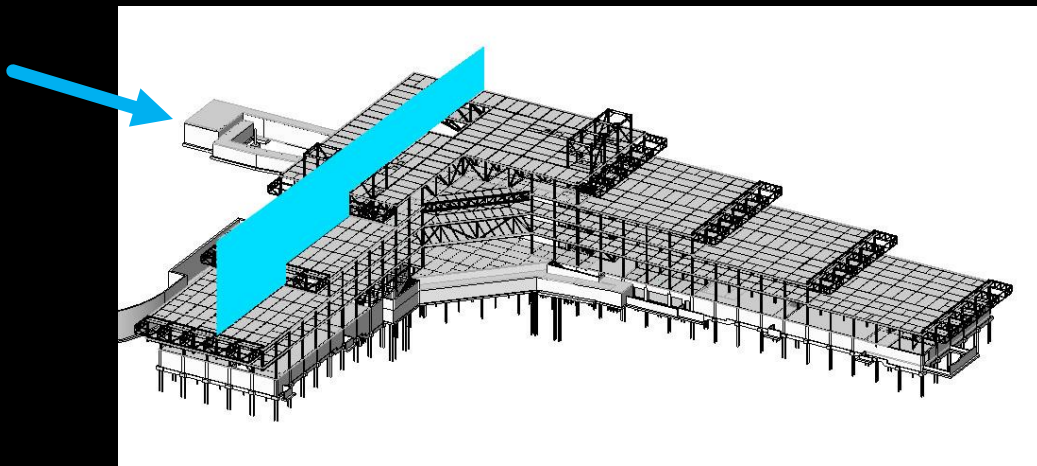
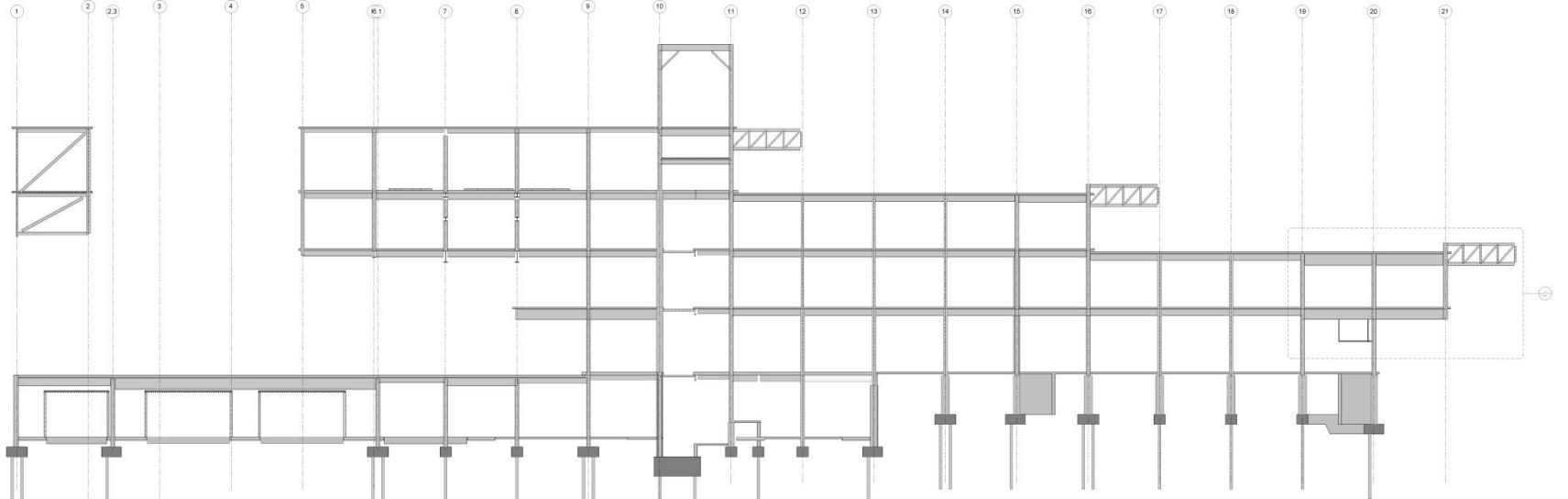
Frame – B (Looking East)



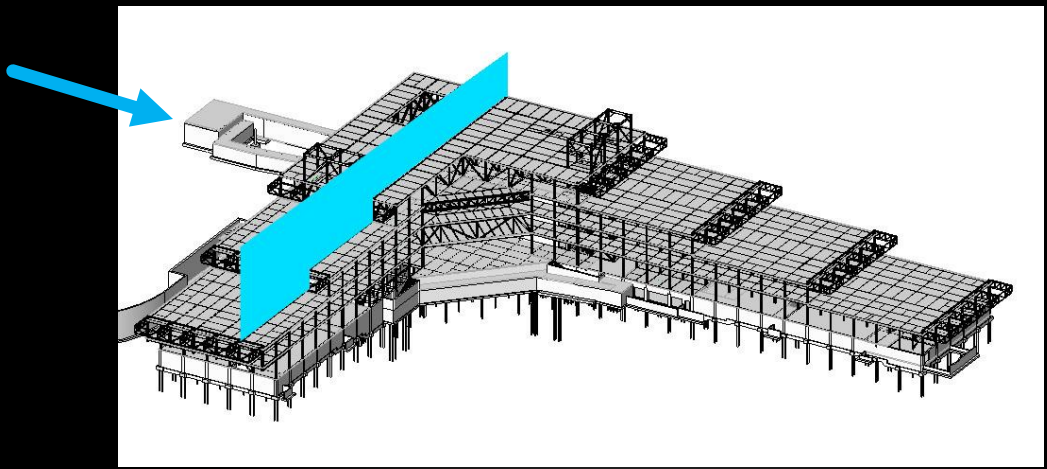
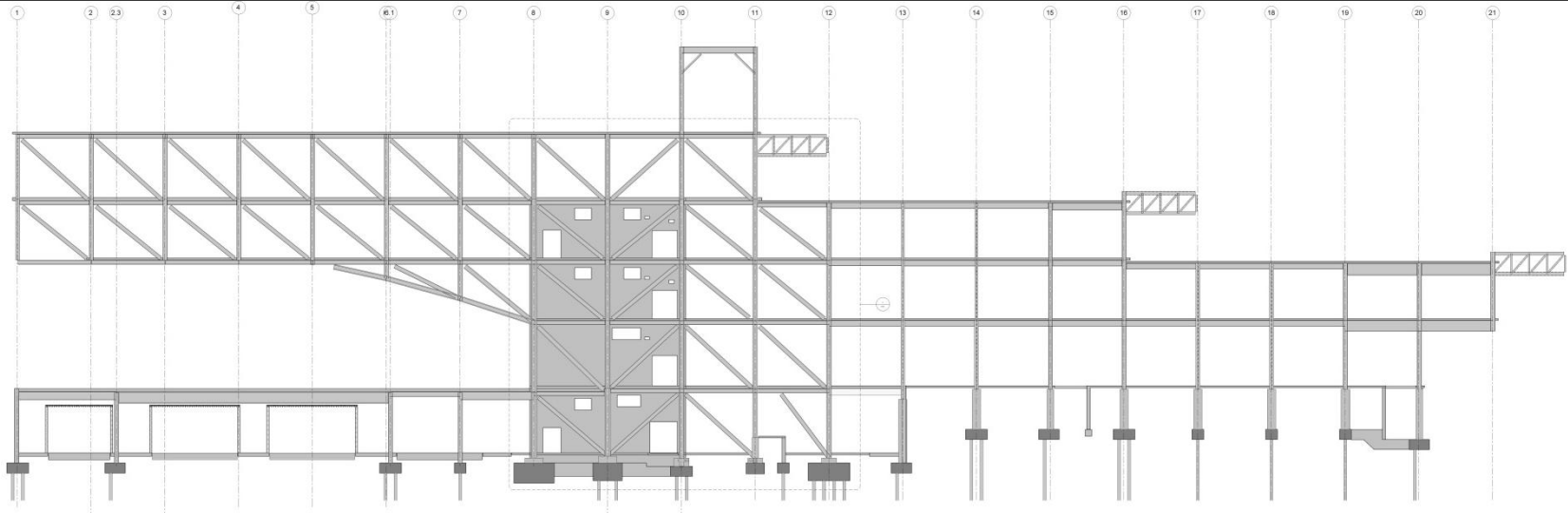
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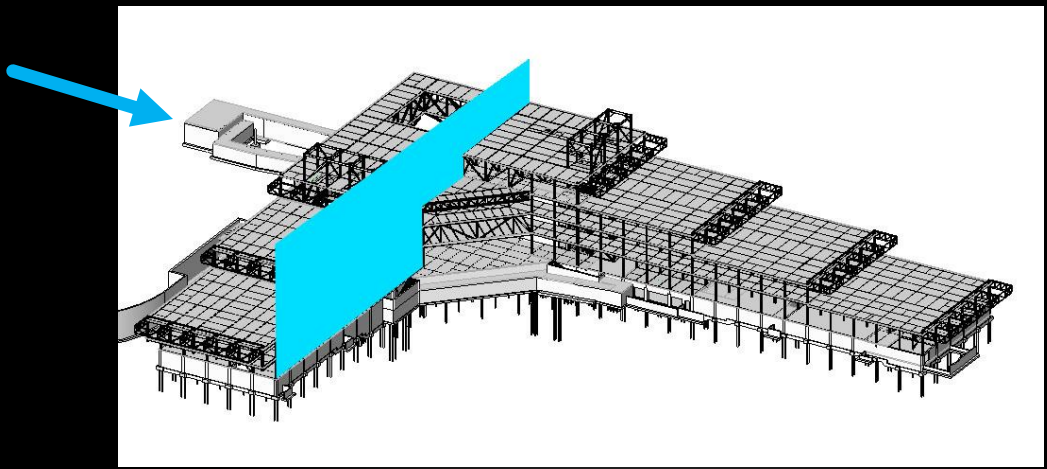
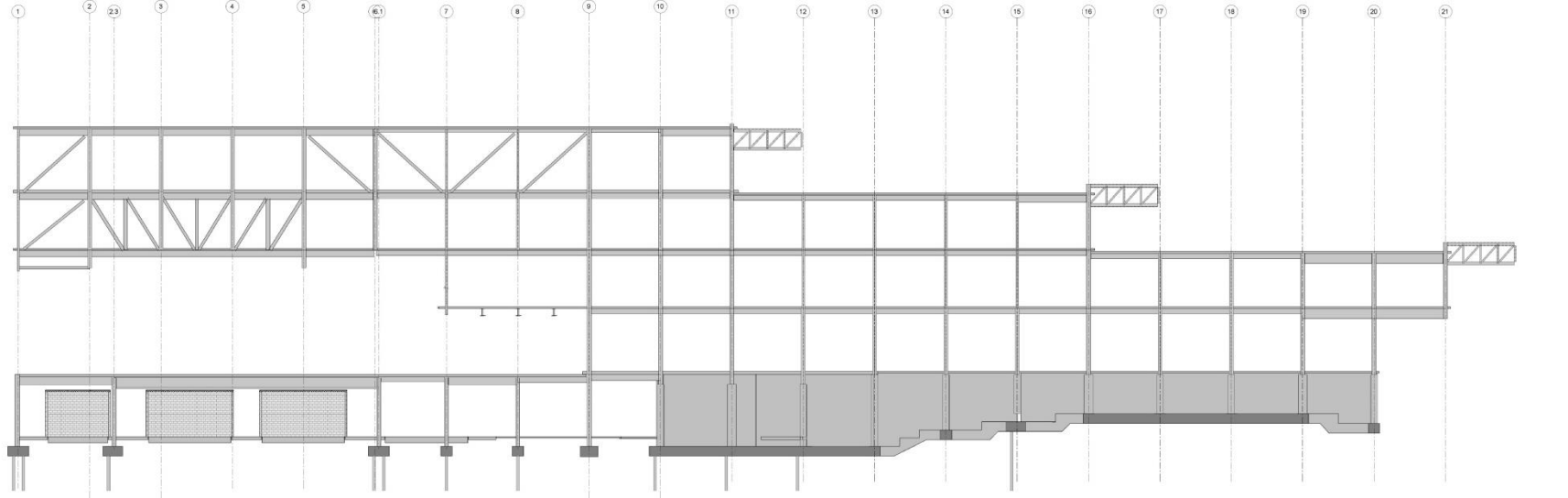
Frame – C (Looking East)



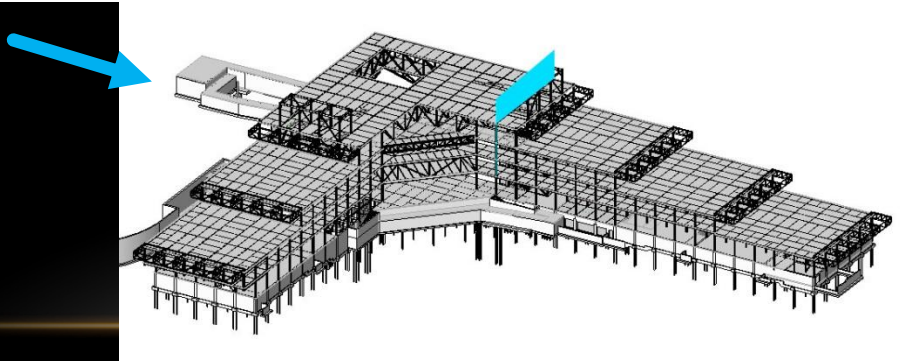
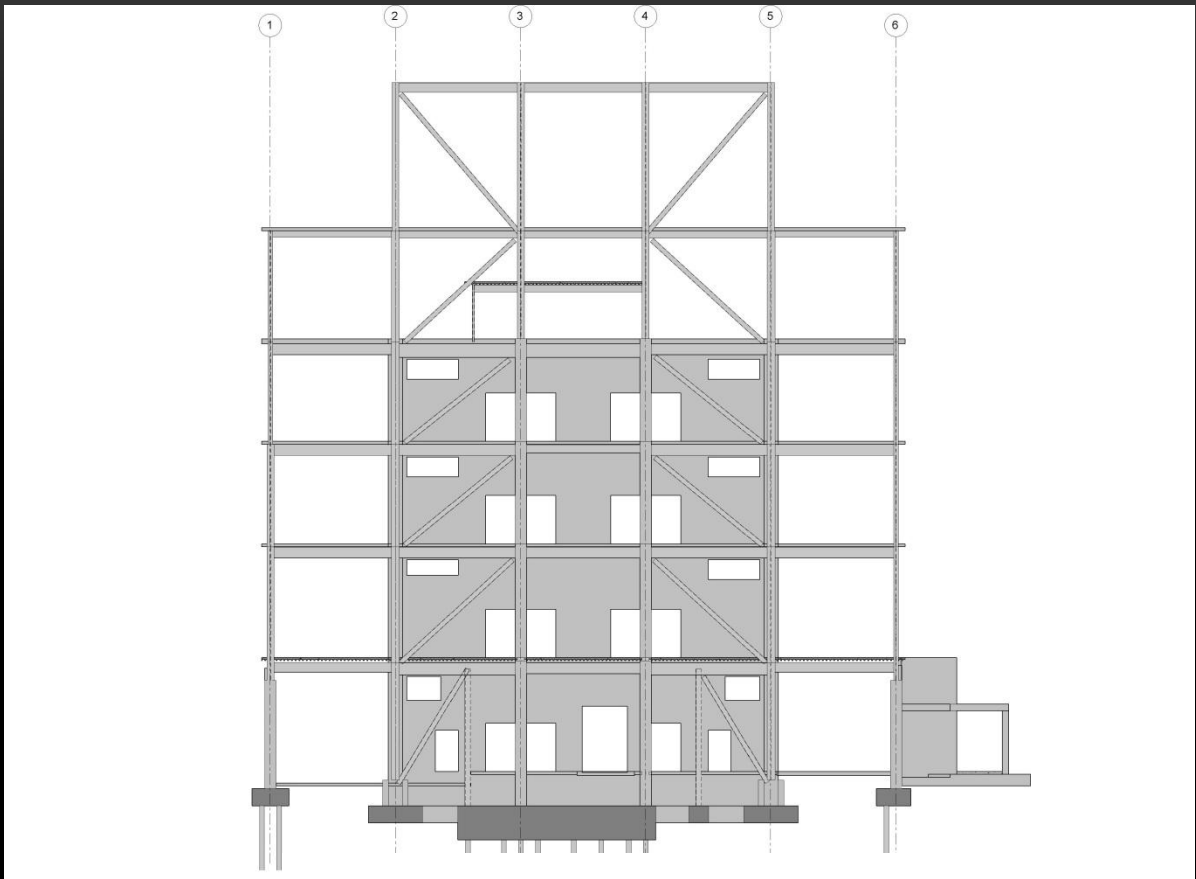
Frame – D (Looking East)



Frame – E (Looking East)



Frame – F (Looking East)



Frame – K (Looking East)

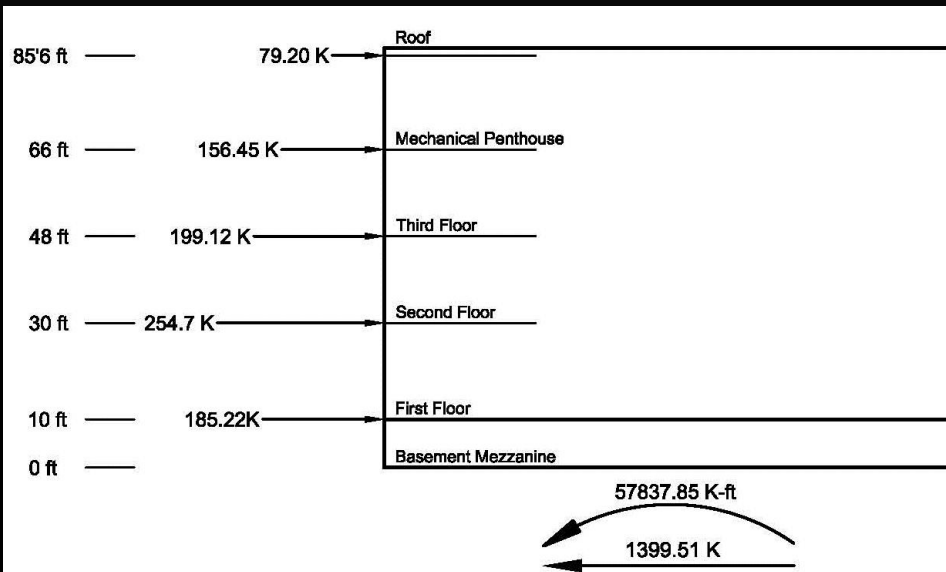
WIND/SEISMIC NOTES

- Reported From Structural Drawings
- Wind:
 - Exposure Category: B
 - Basic Wind Speed: 90mph
 - Importance Factor: 1.15
- Seismic:
 - Importance Factor: 1.25
 - Mapped Spectral Response Accelerations (different than USGS)
 - $S_s = 0.181 \text{ g}$ (0.147 g, USGS)
 - $S_{ds} = 0.096 \text{ g}$ (0.049 g, USGS)
 - Design Category: B
 - LFRS: Ordinary Concentric Braced Frame
 - $R = 3.25$
 - Analysis: Equivalent Lateral Force Analysis

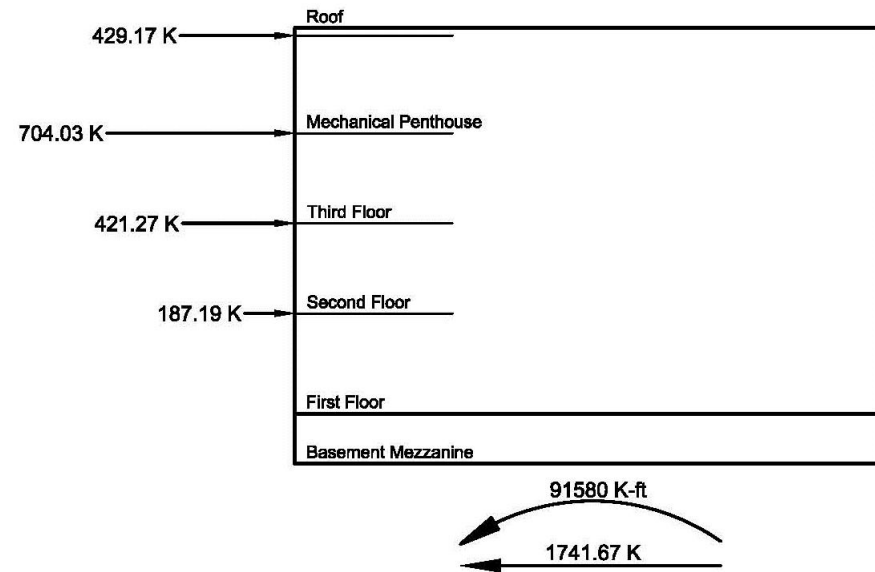
WIND/SEISMIC LOAD DISTRIBUTION

Wind Loads

Seismic Loads



North Wing Section- N/S Loads

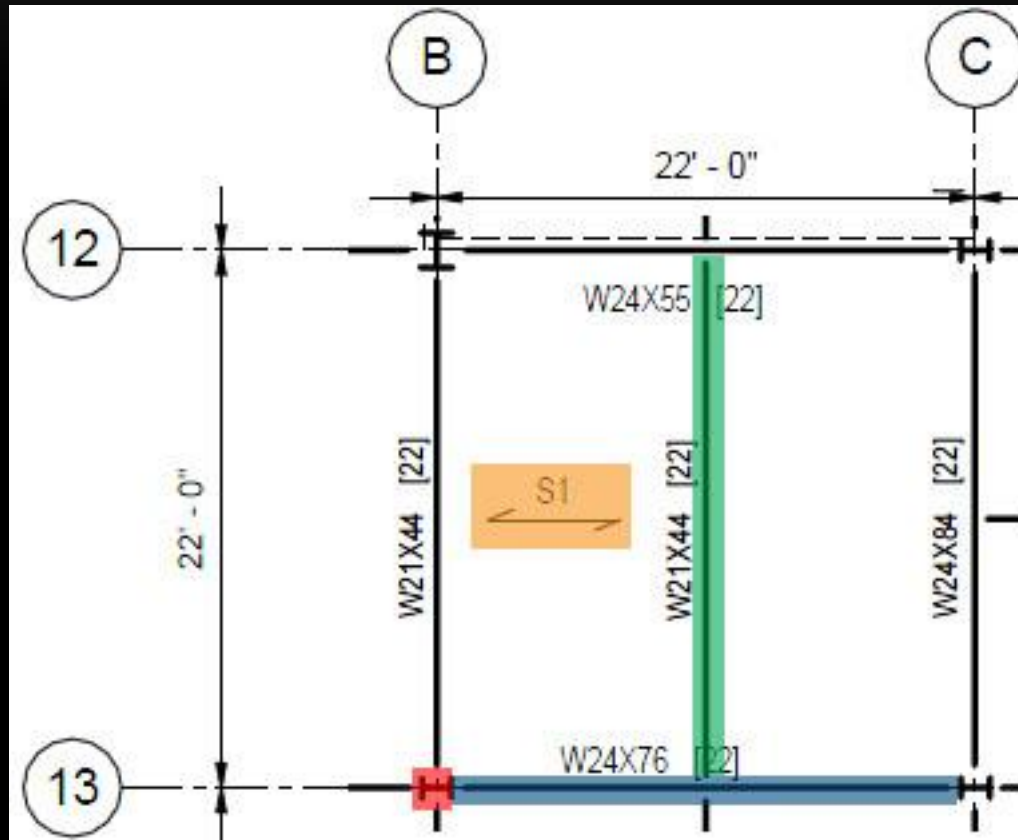


North Wing Section- N/S Loads

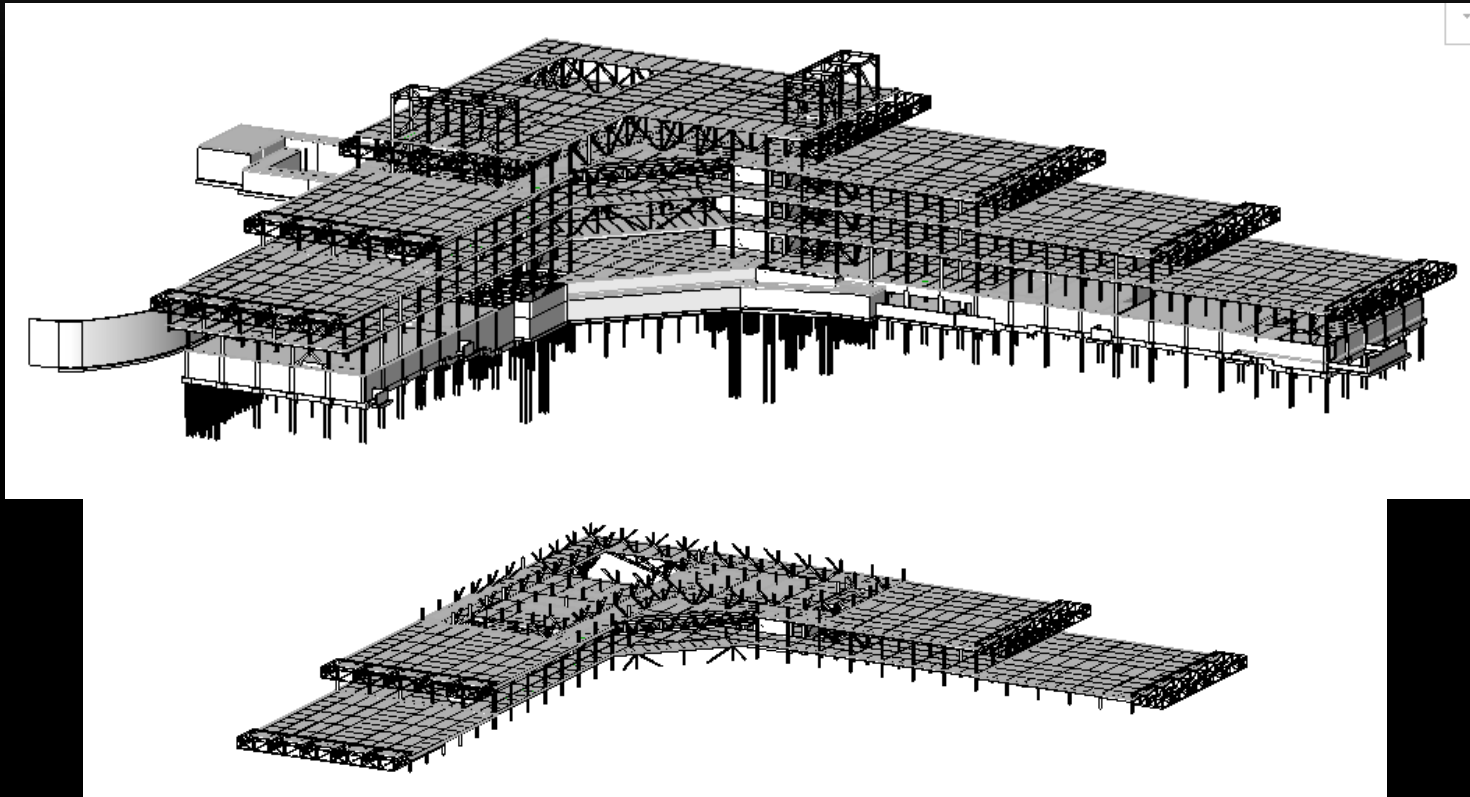
GRAVITY LOADS

- Design loads used by Thornton Tomasetti checked against the following sources:
 - ASCE7-05
 - IBC 2006
 - United Steel Deck design guide
- All loads used found to be correct or conservative
- Ground Snow Load and Snow Importance Factor
 - Pending confirmation from UCC and roof R values

SPOT CHECKS

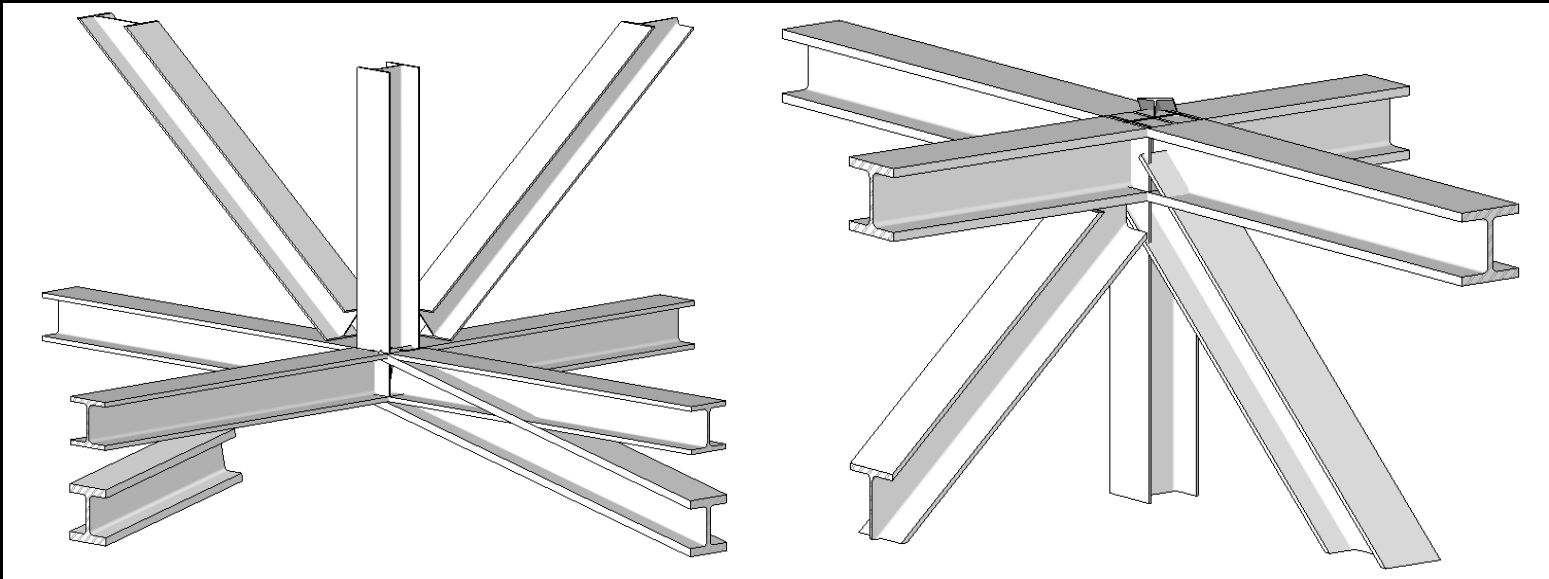


EXISTING MODEL

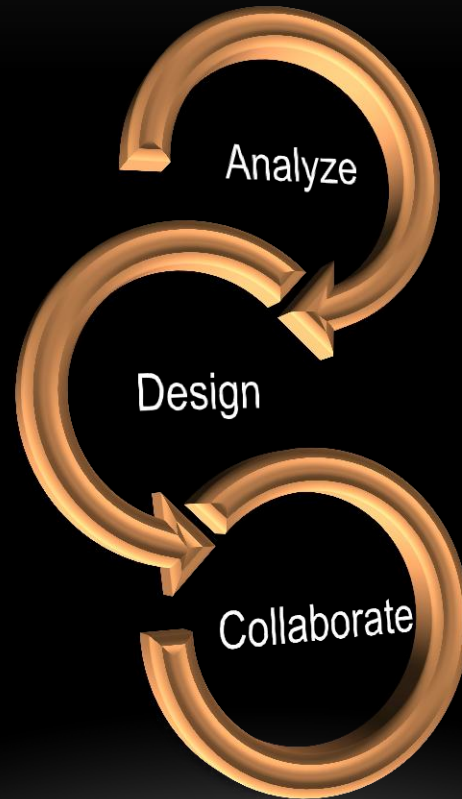


EXISTING MODEL

- Connection Issues

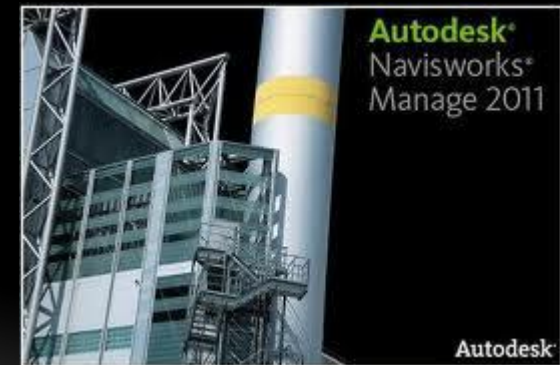
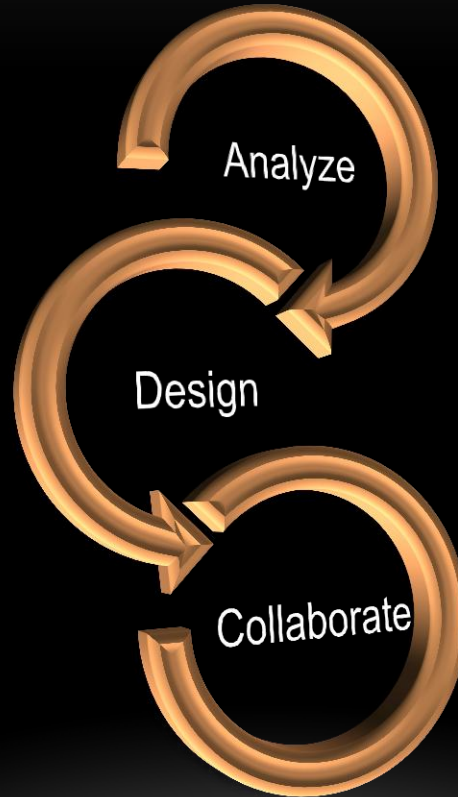
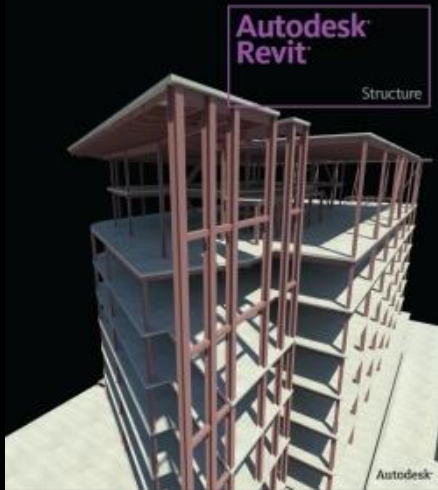


IPD/BIM STRUCTURAL PROCESS



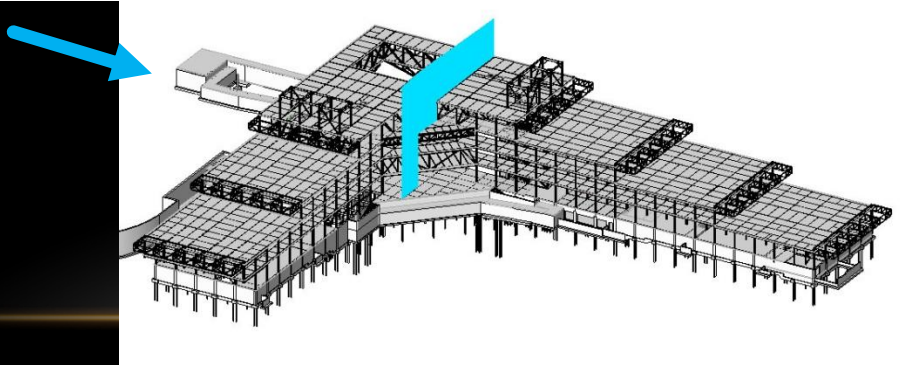
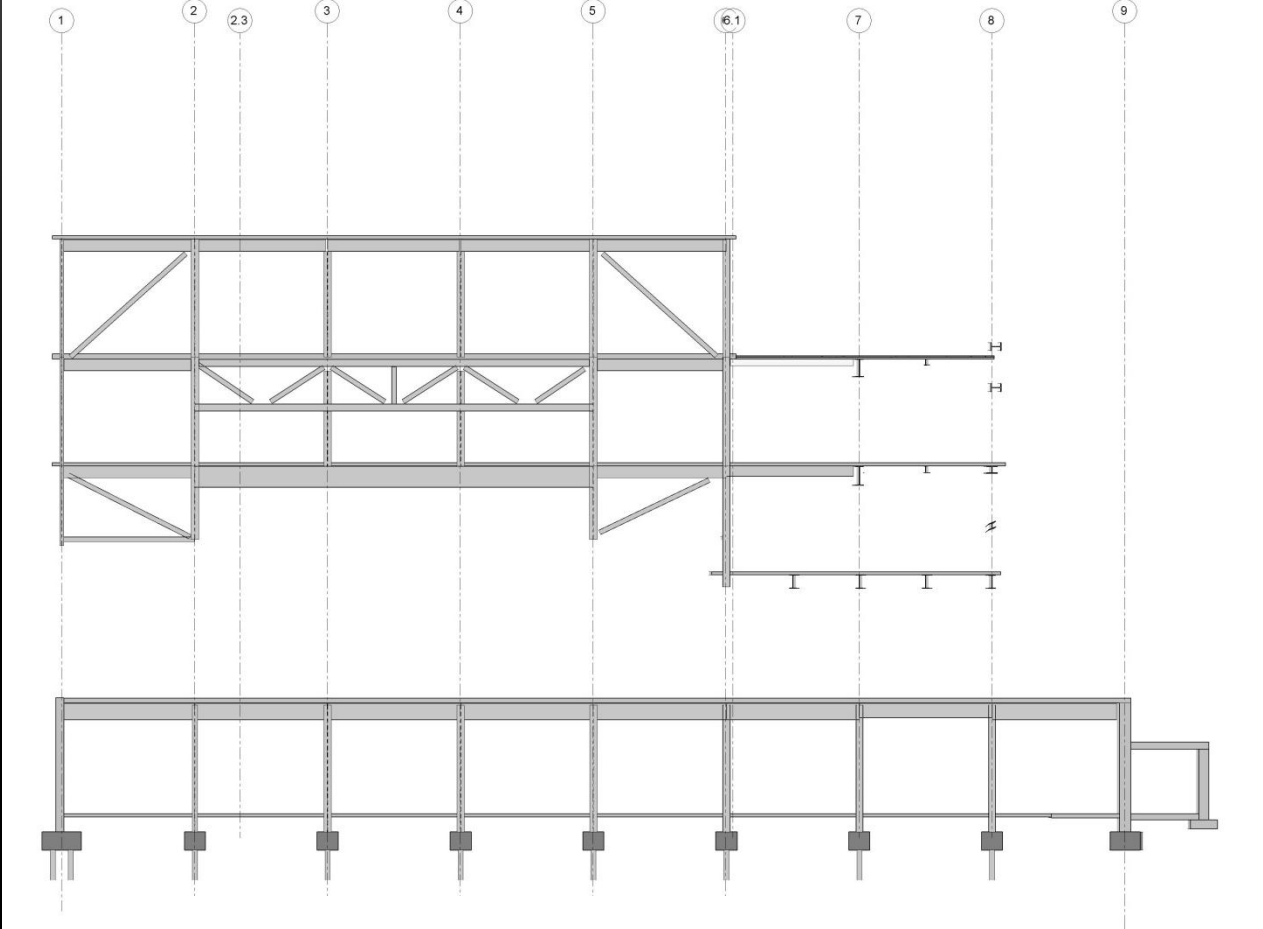
IPD/BIM STRUCTURAL PROCESS

The power of BIM
for structural engineering.

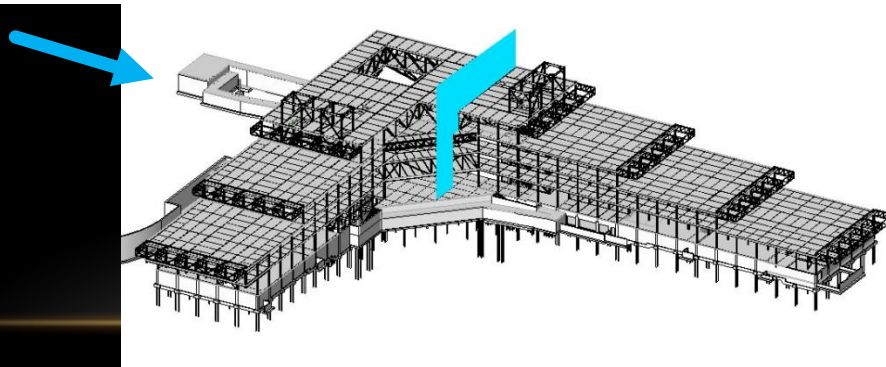
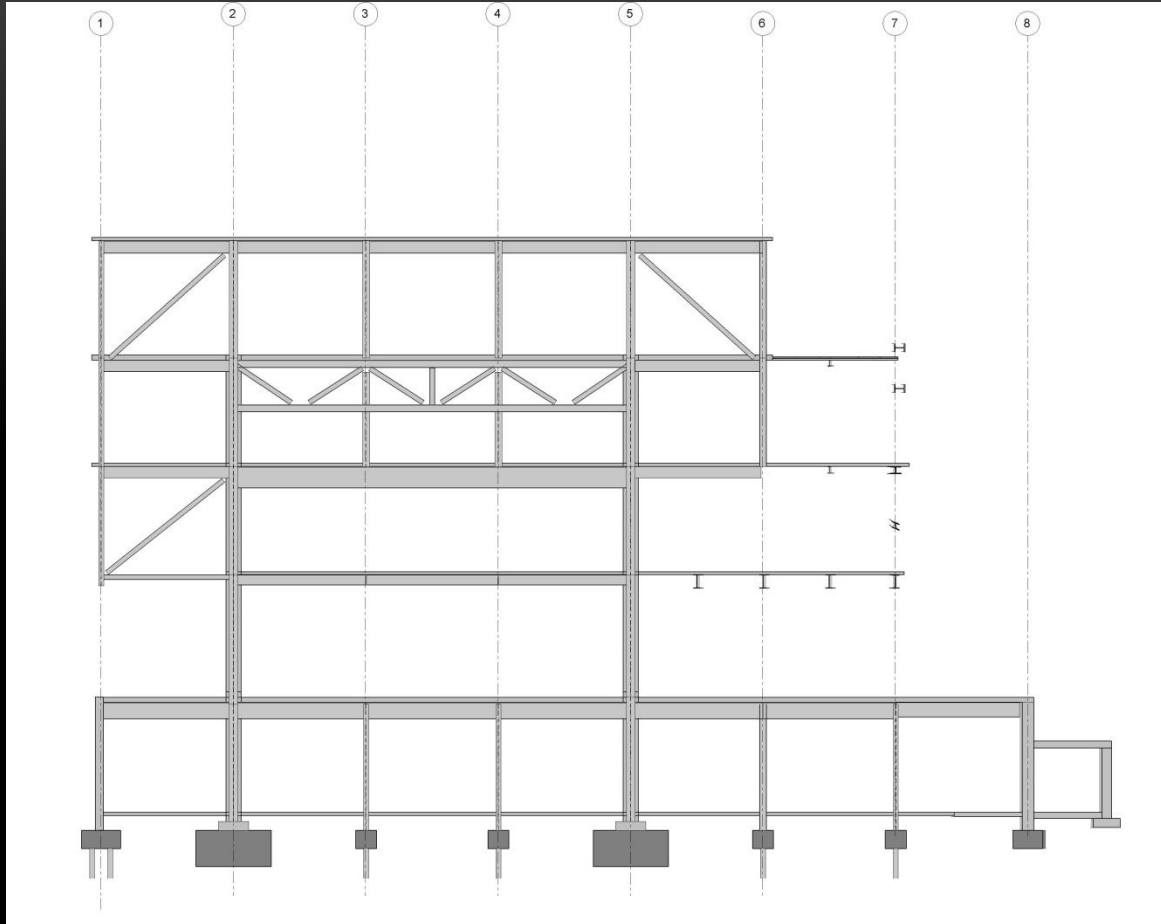


QUESTIONS?

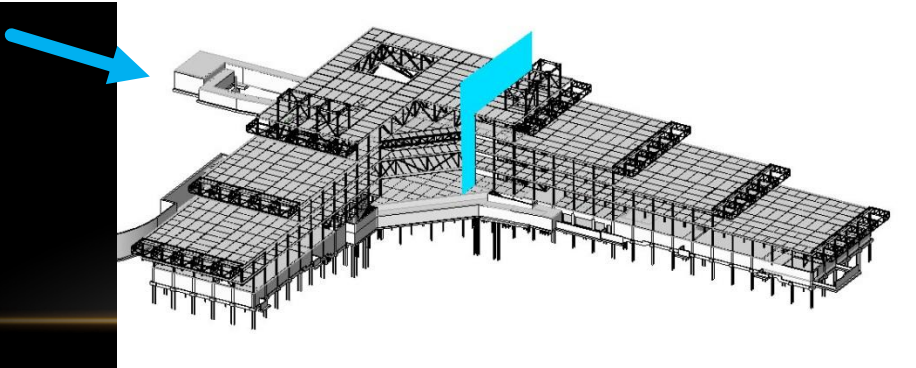
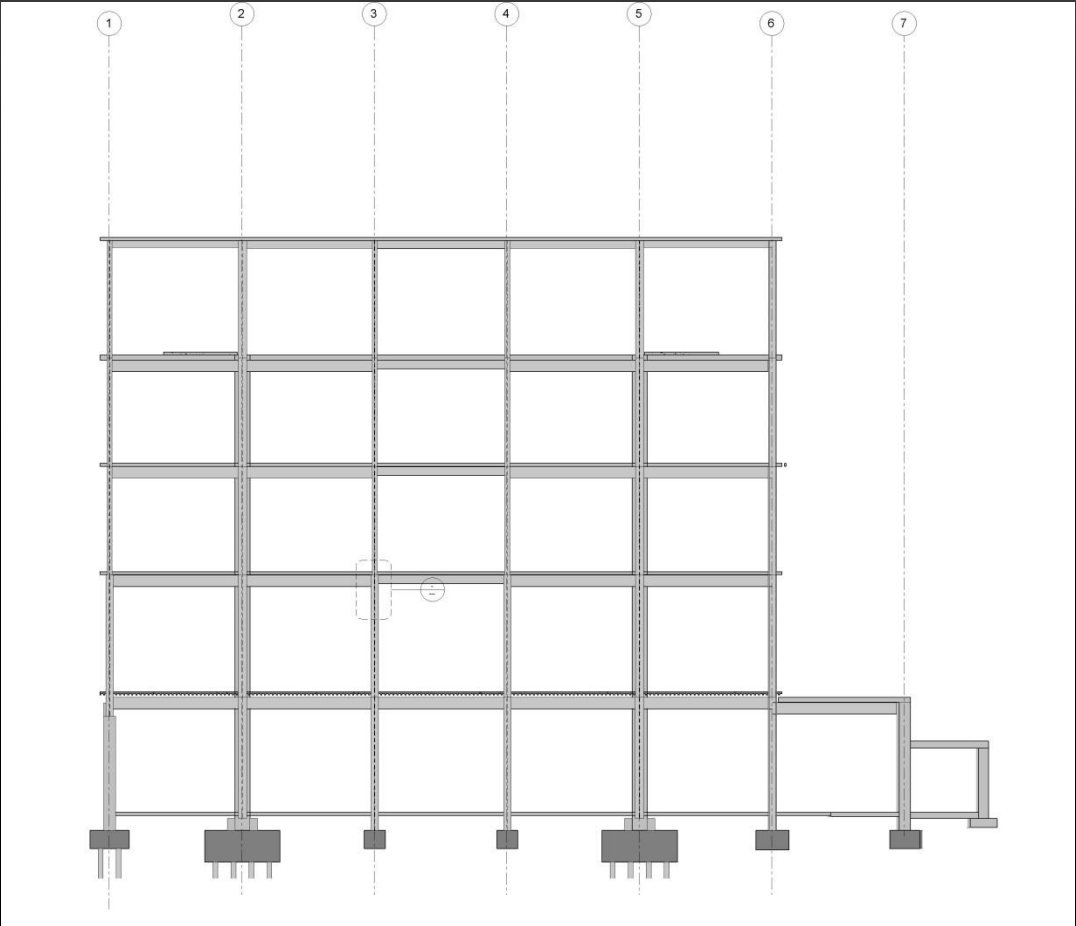




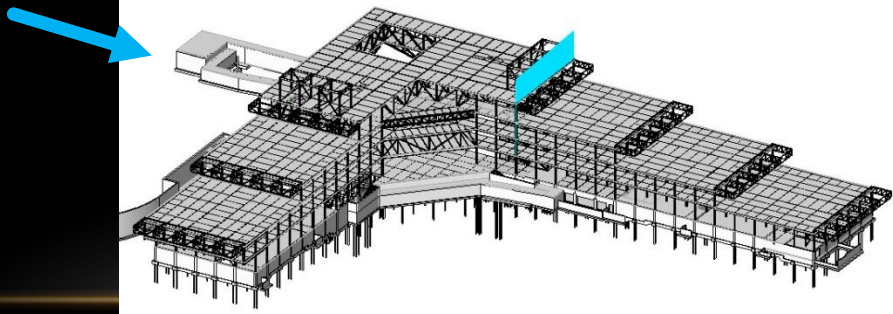
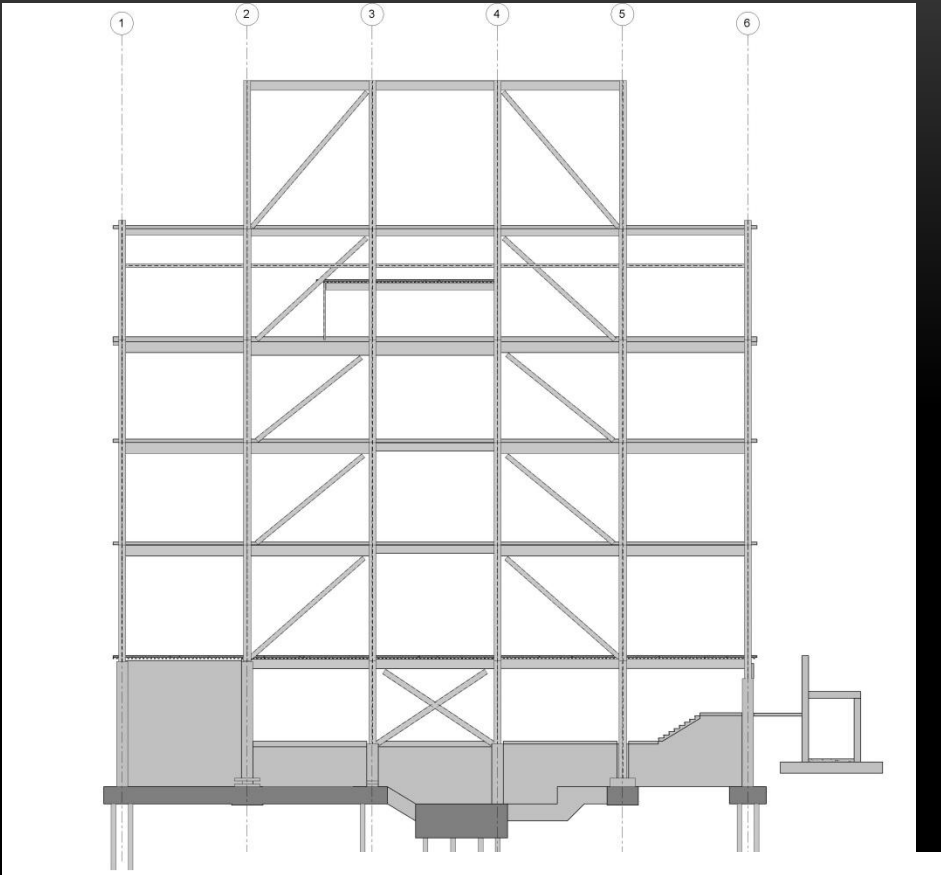
Frame – G (Looking East)



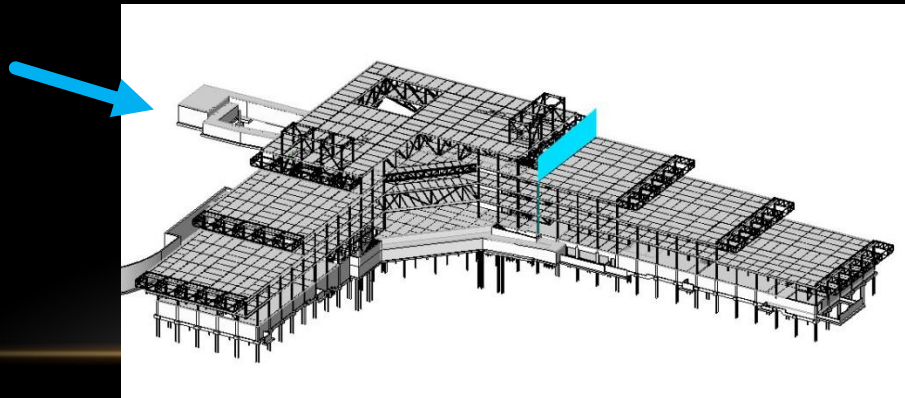
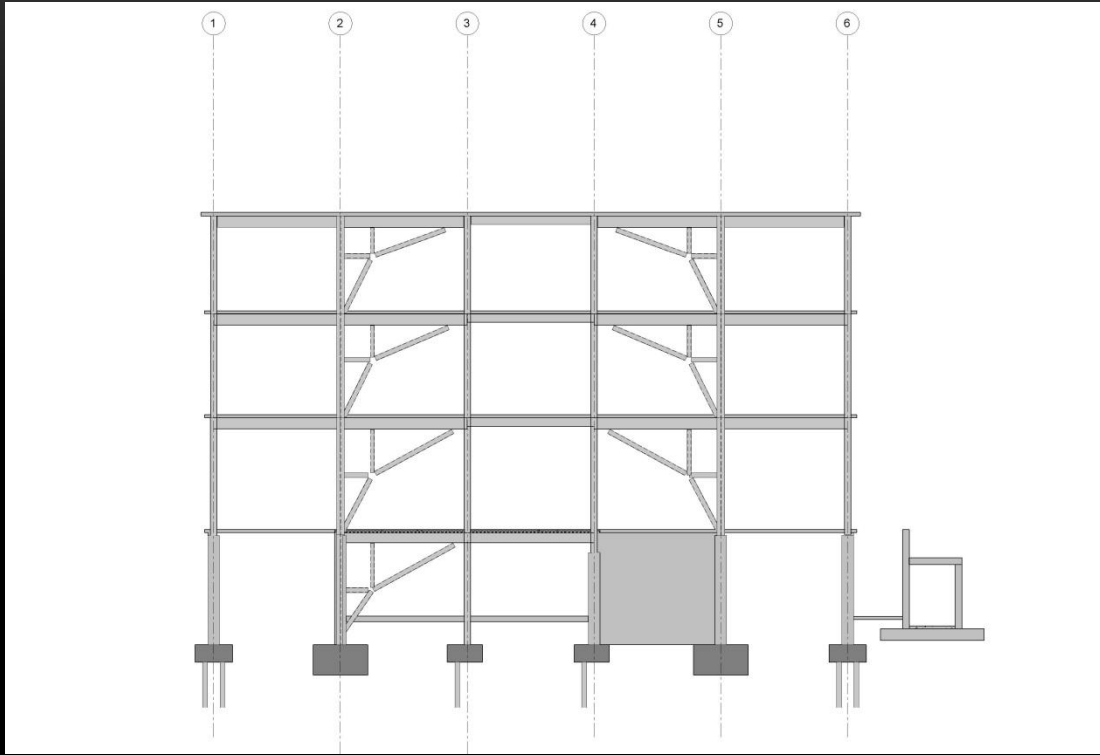
Frame – H (Looking East)



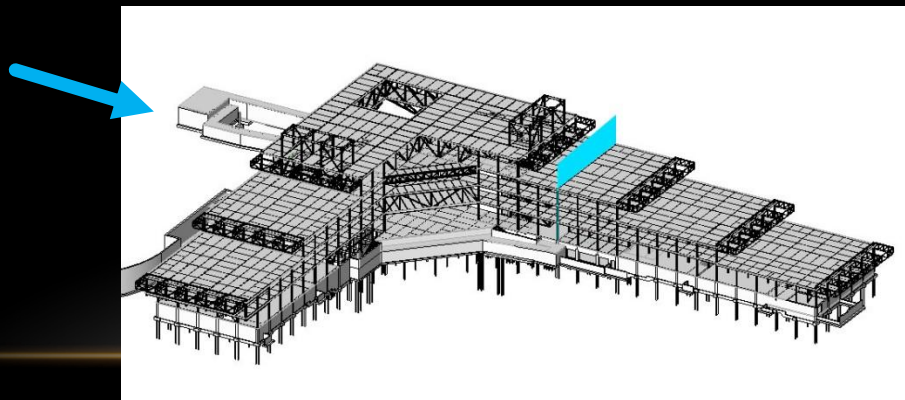
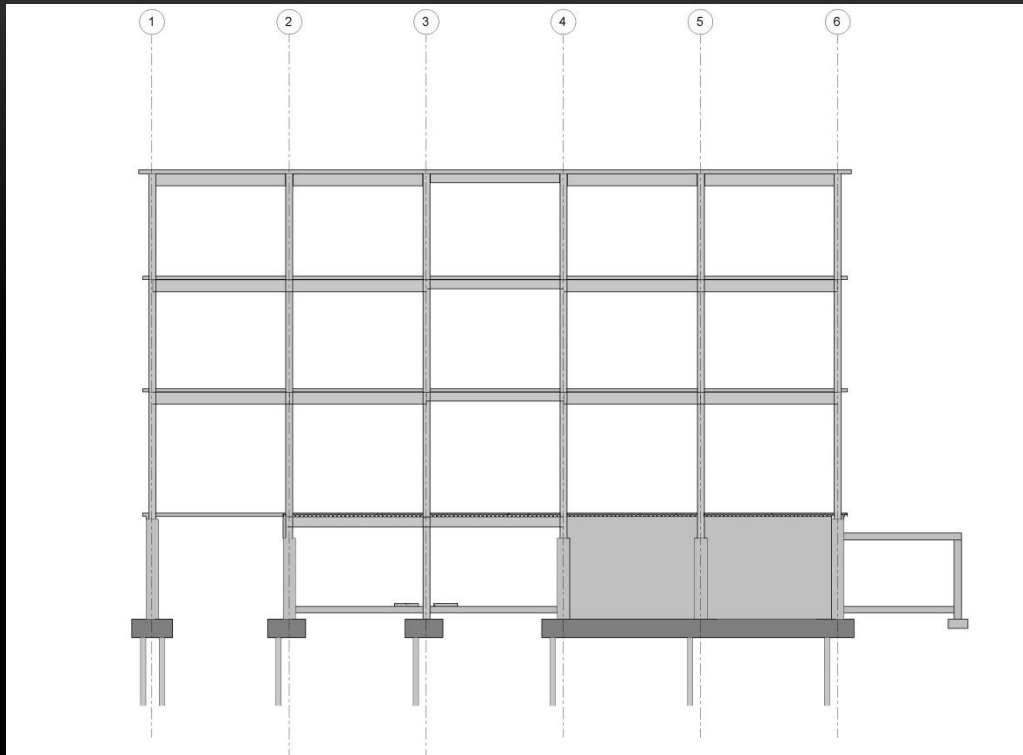
Frame – J (Looking East)



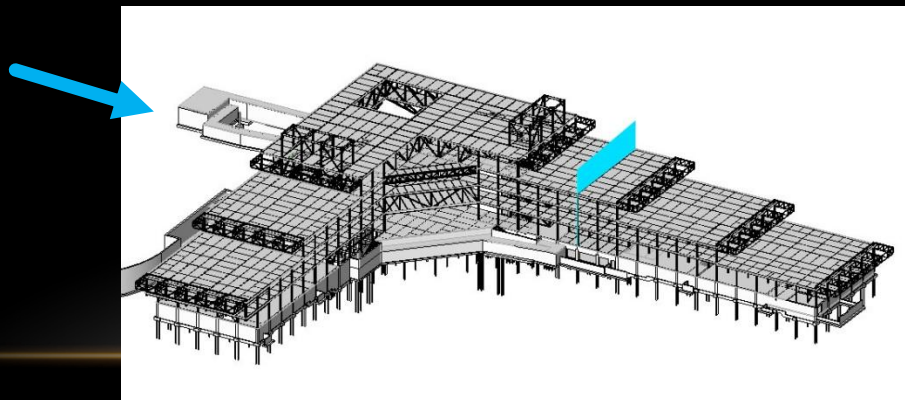
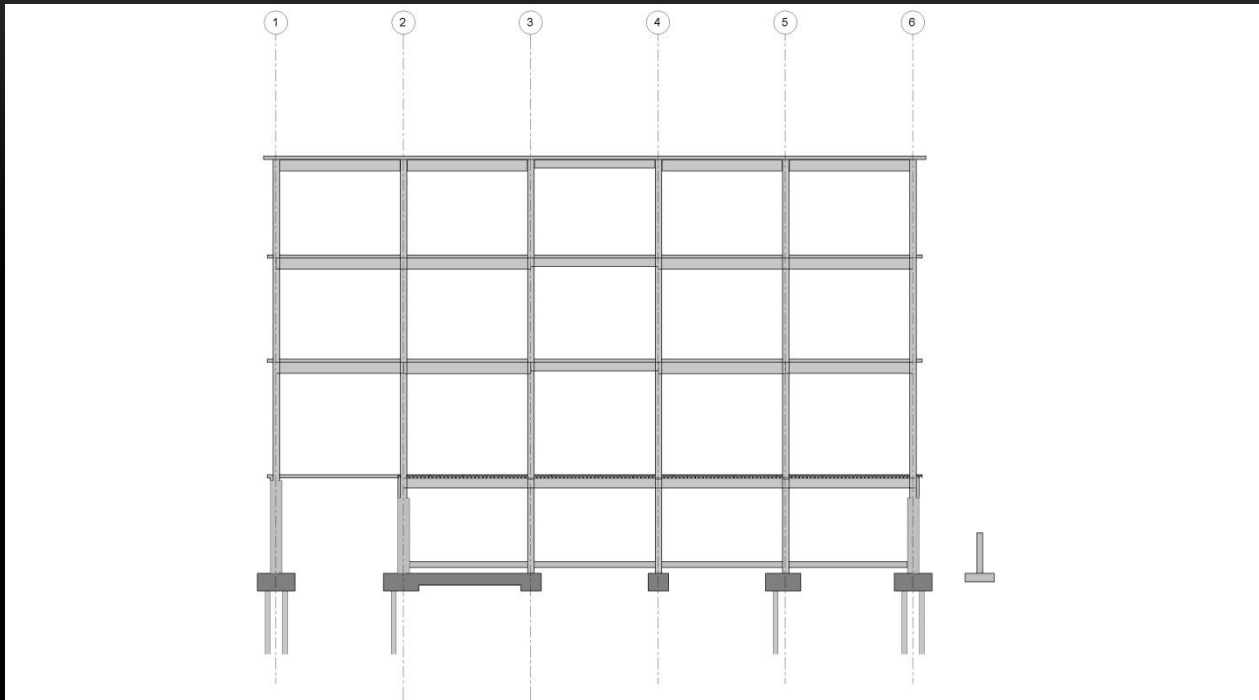
Frame – L (Looking East)



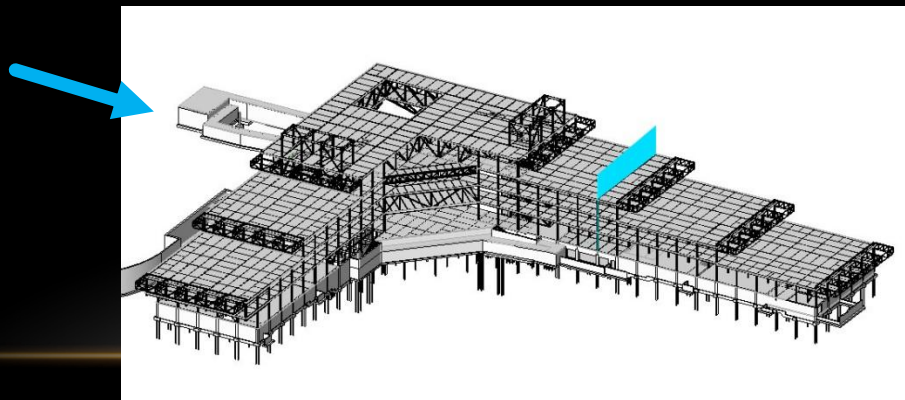
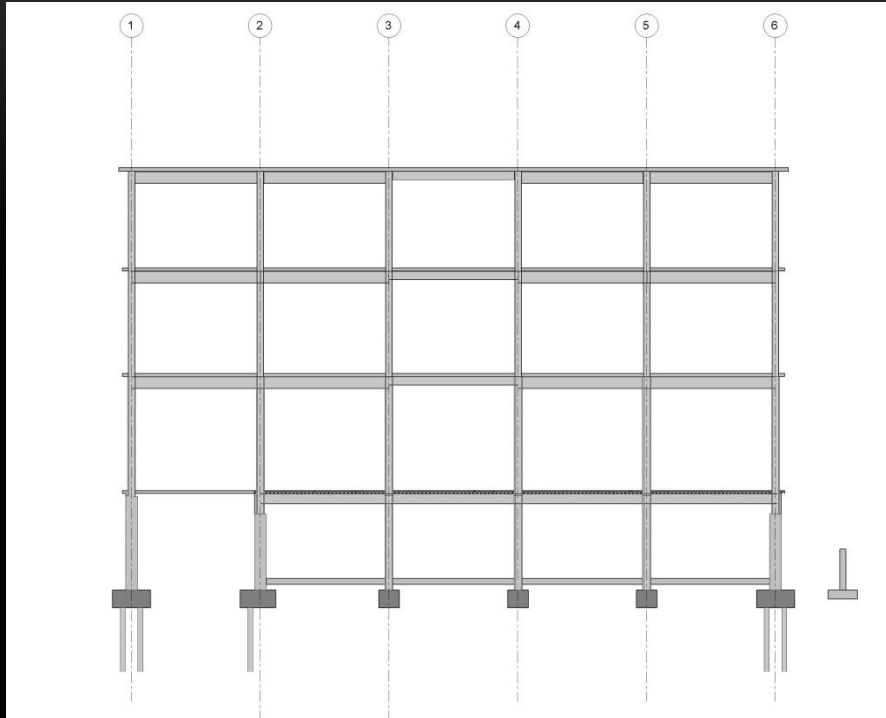
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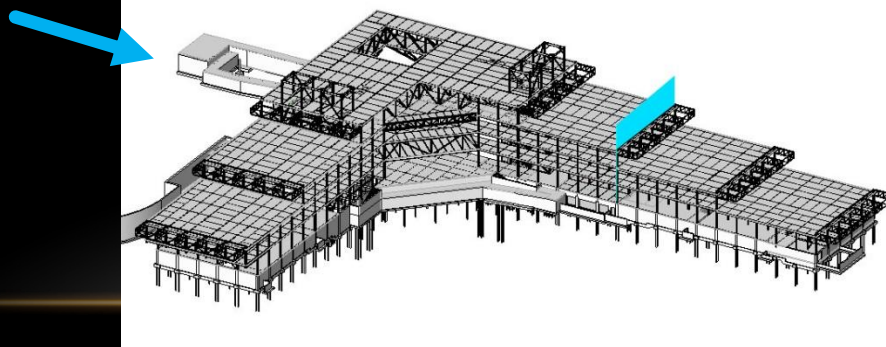
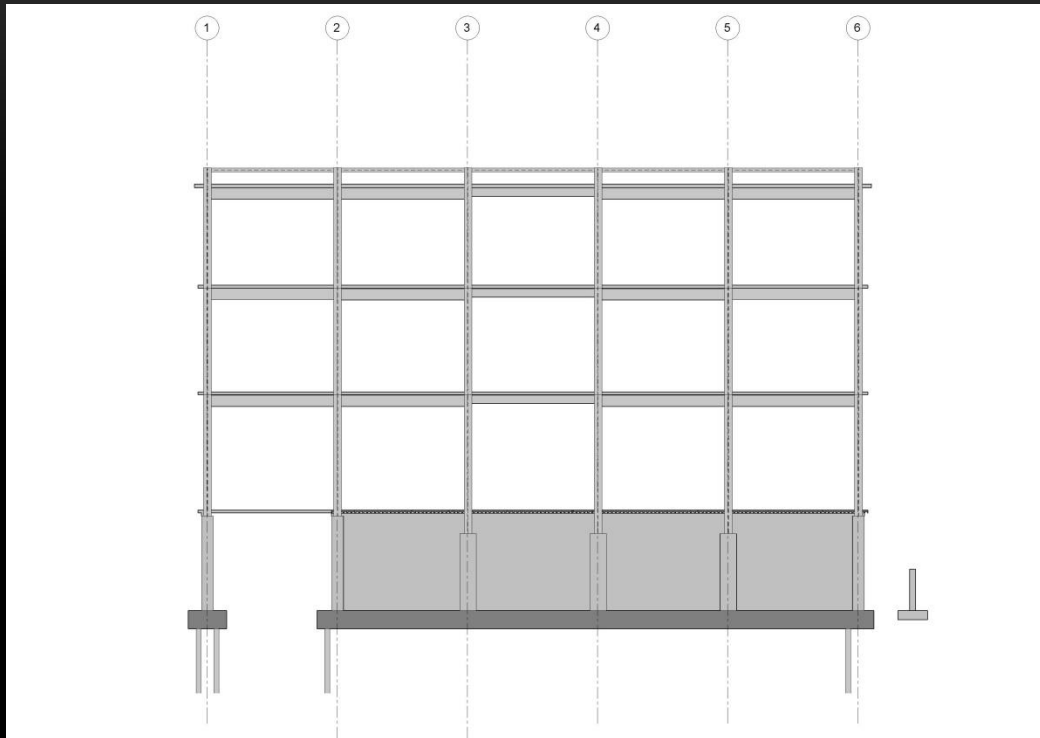
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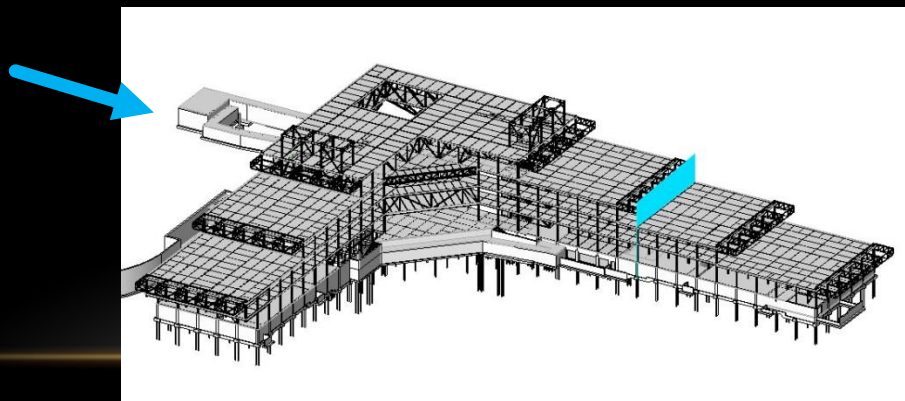
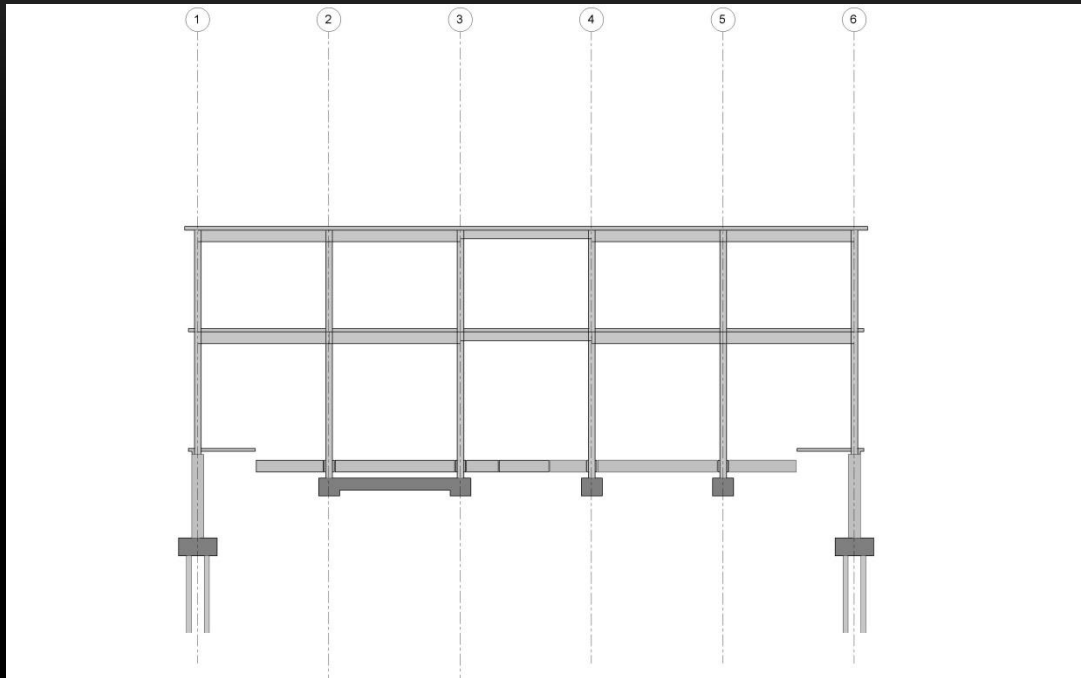
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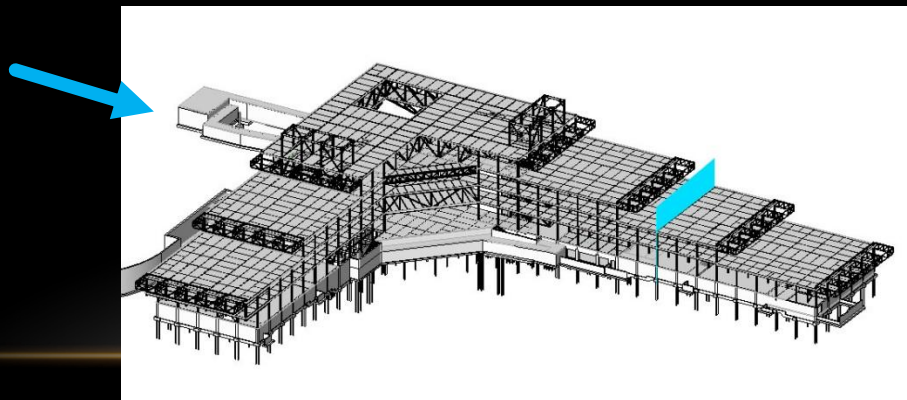
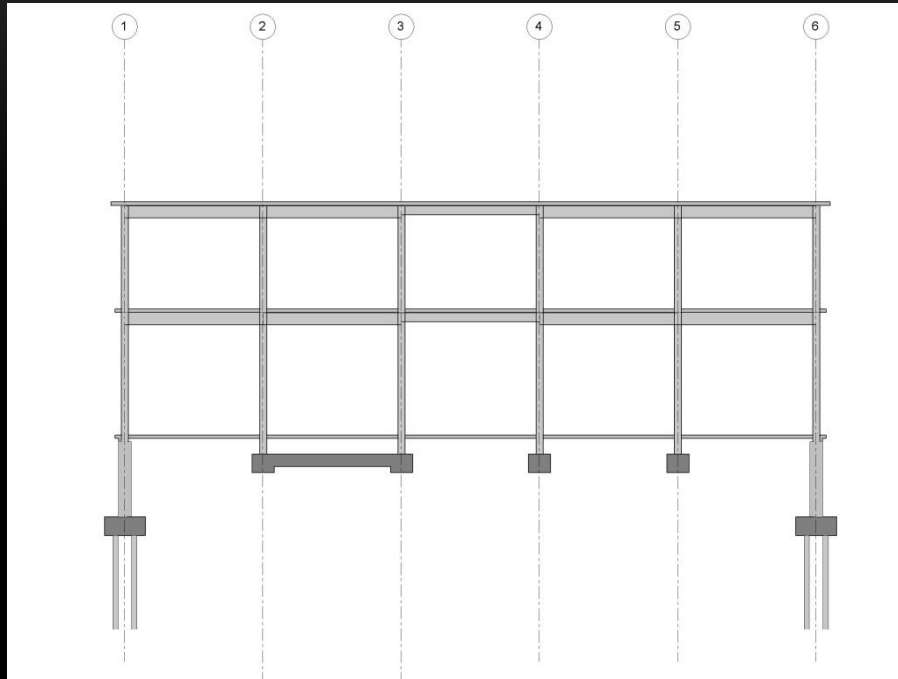
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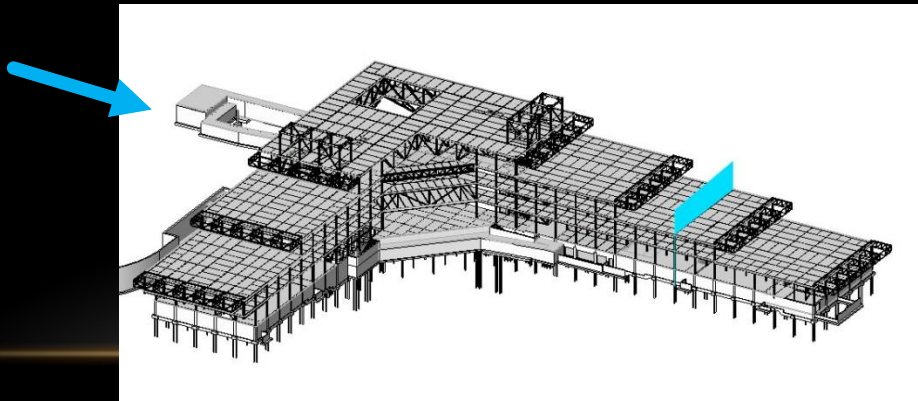
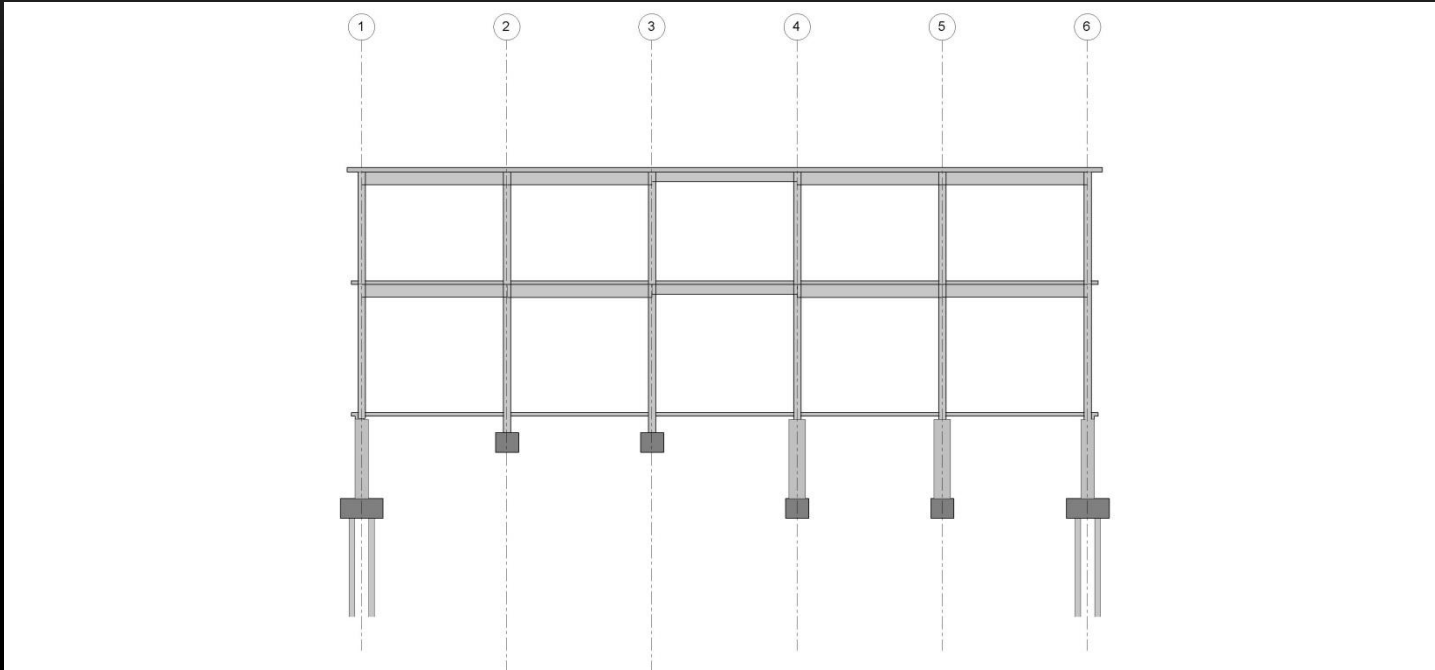
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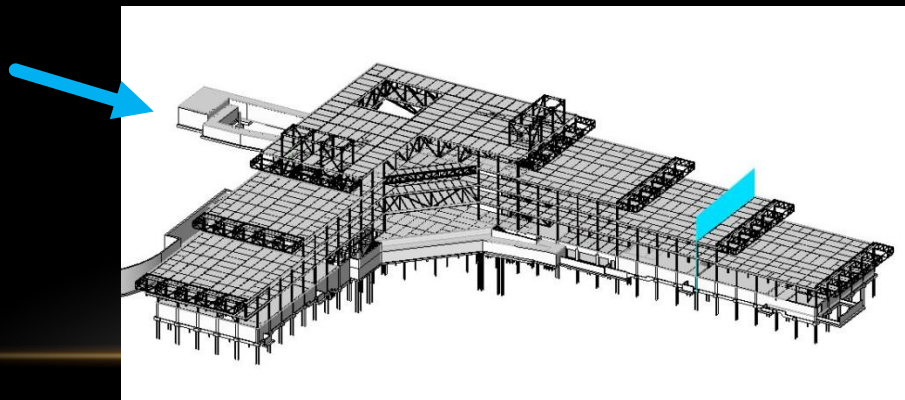
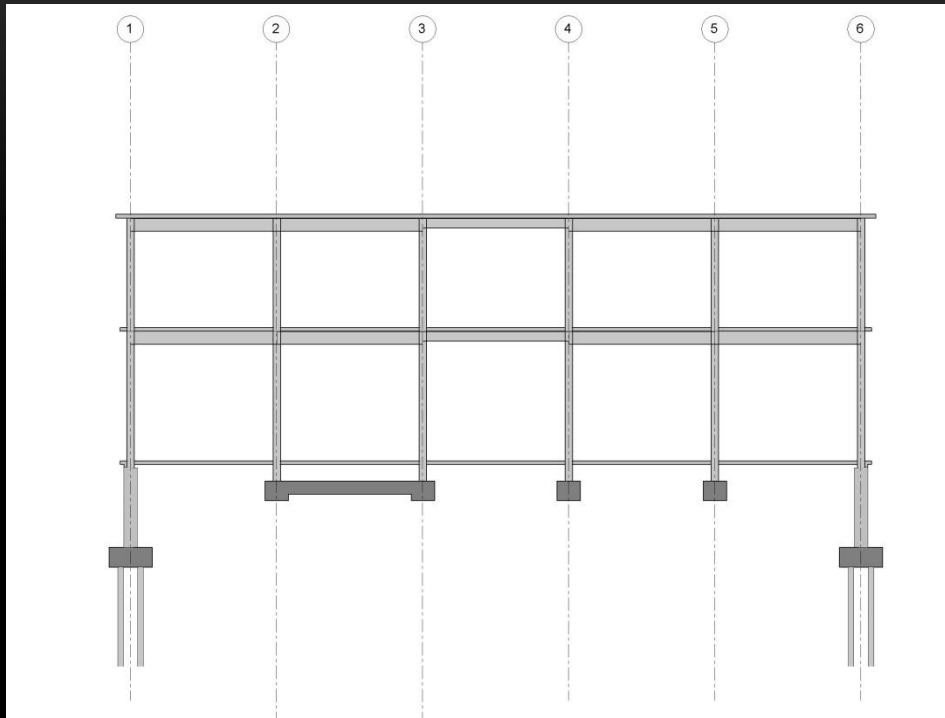
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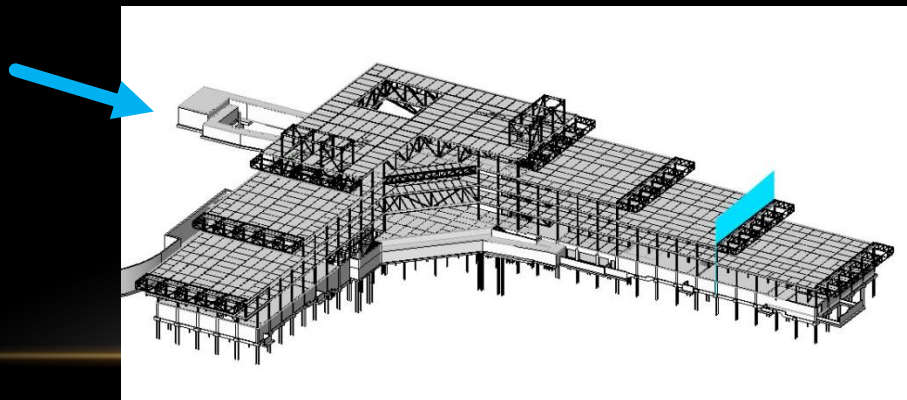
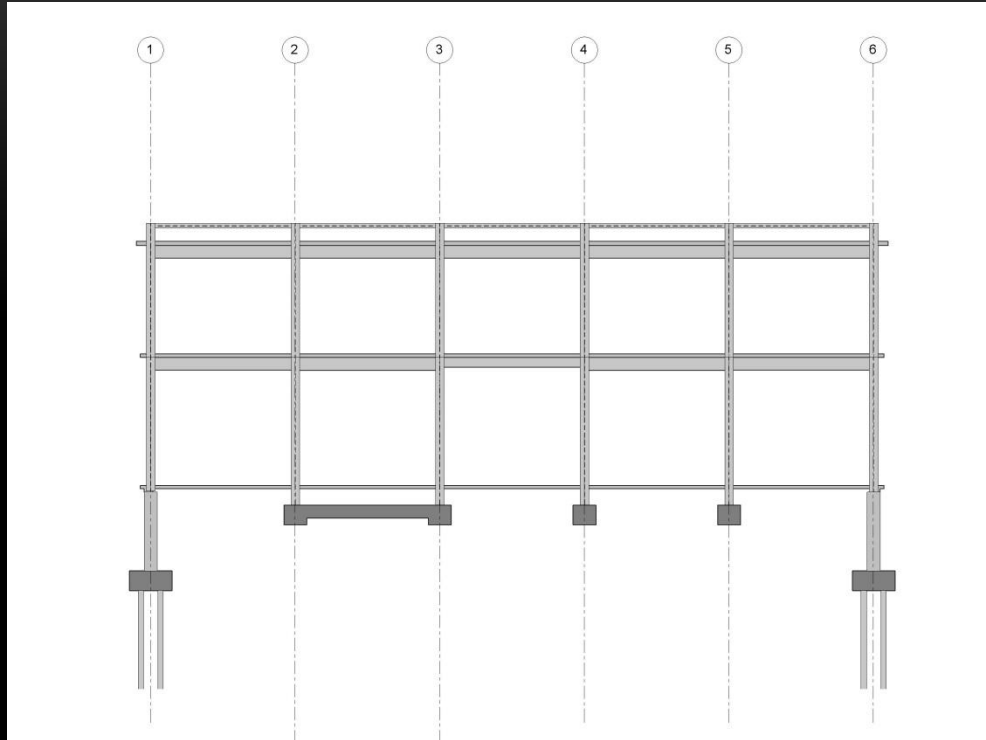
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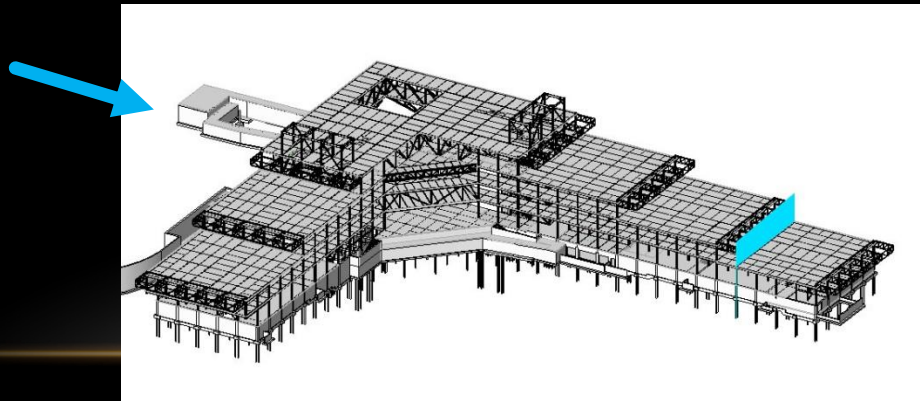
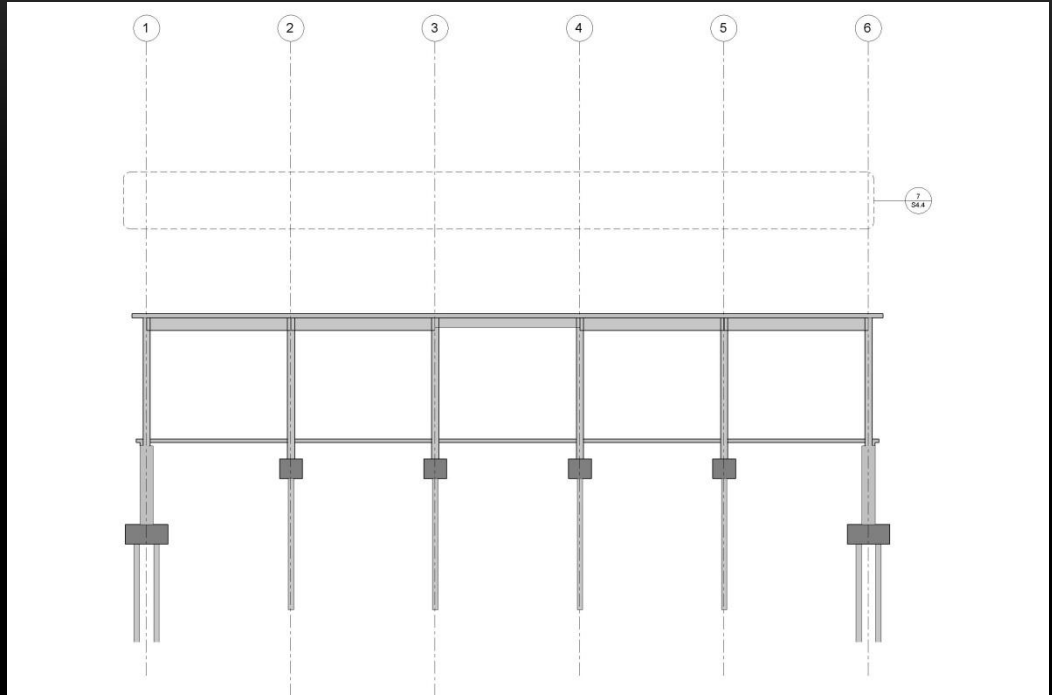
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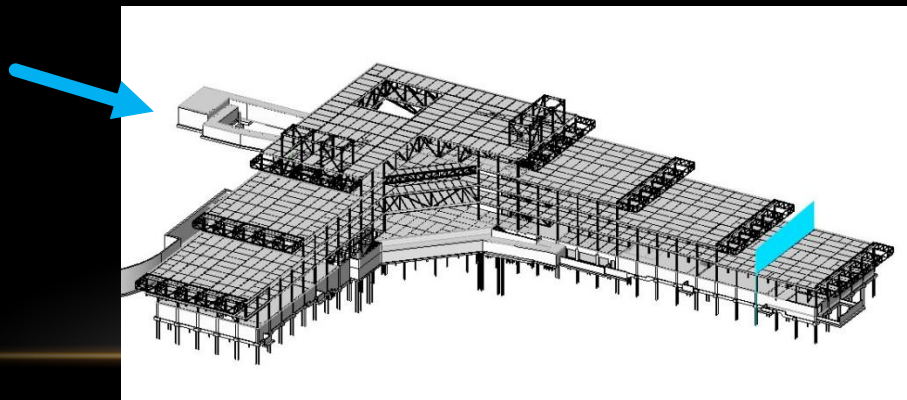
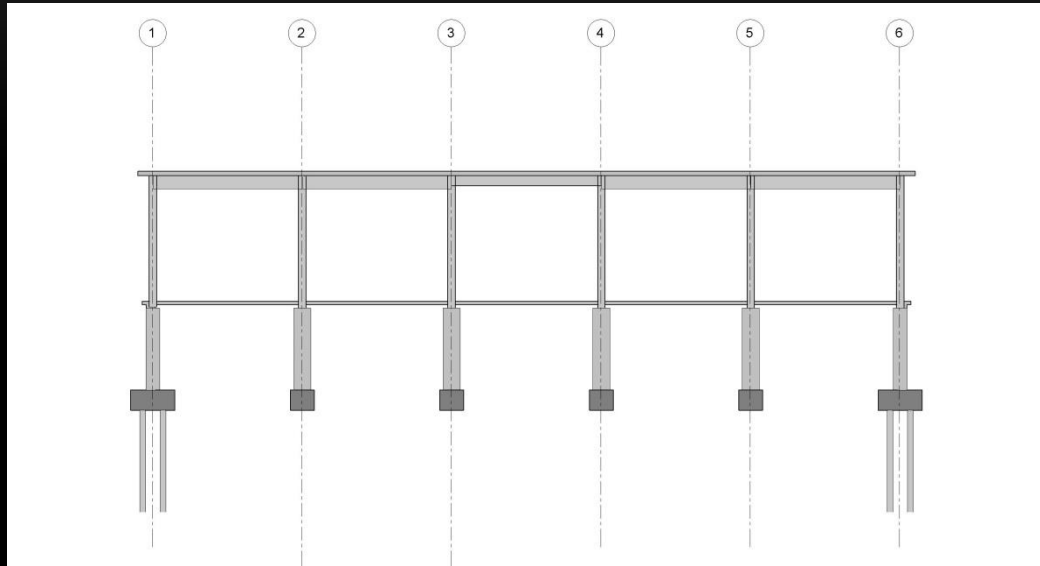
Frame – V (Looking East)



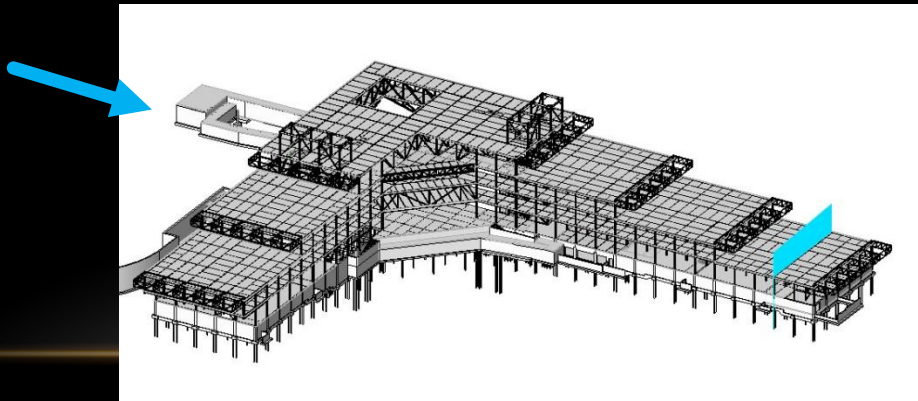
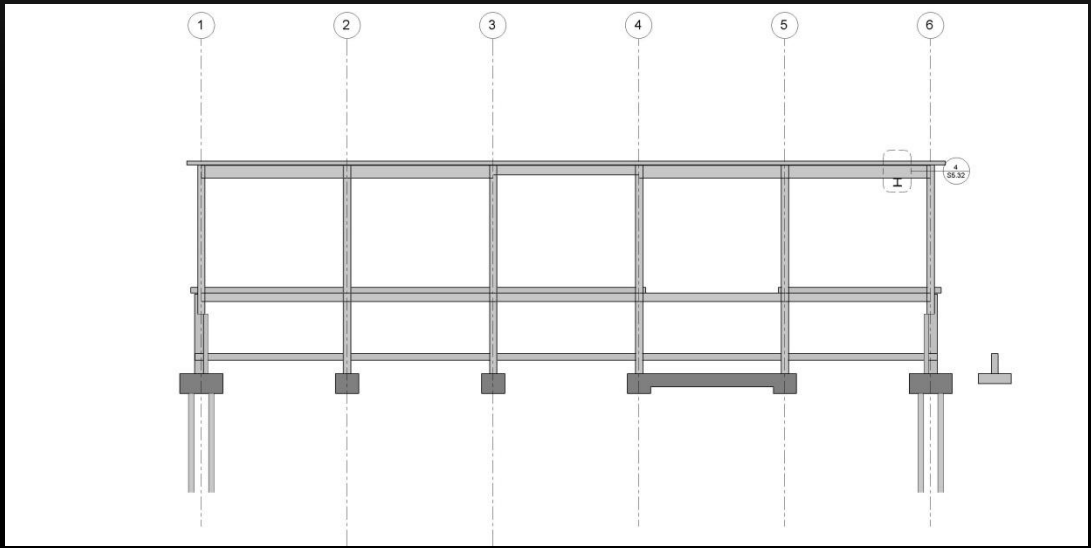
Frame – W (Looking East)



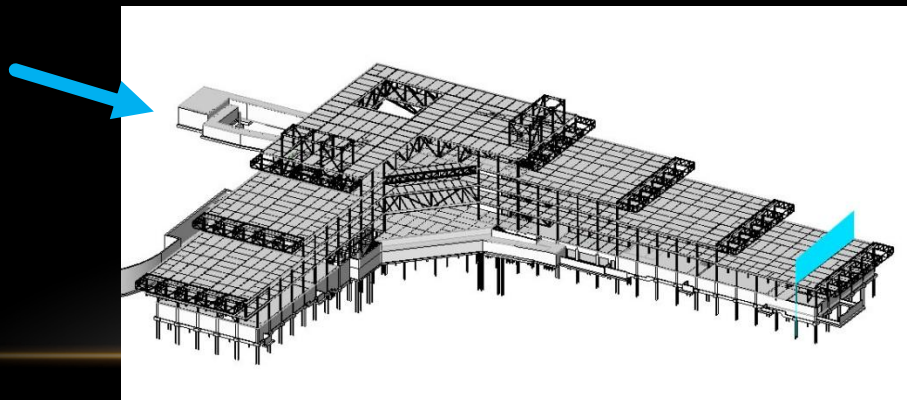
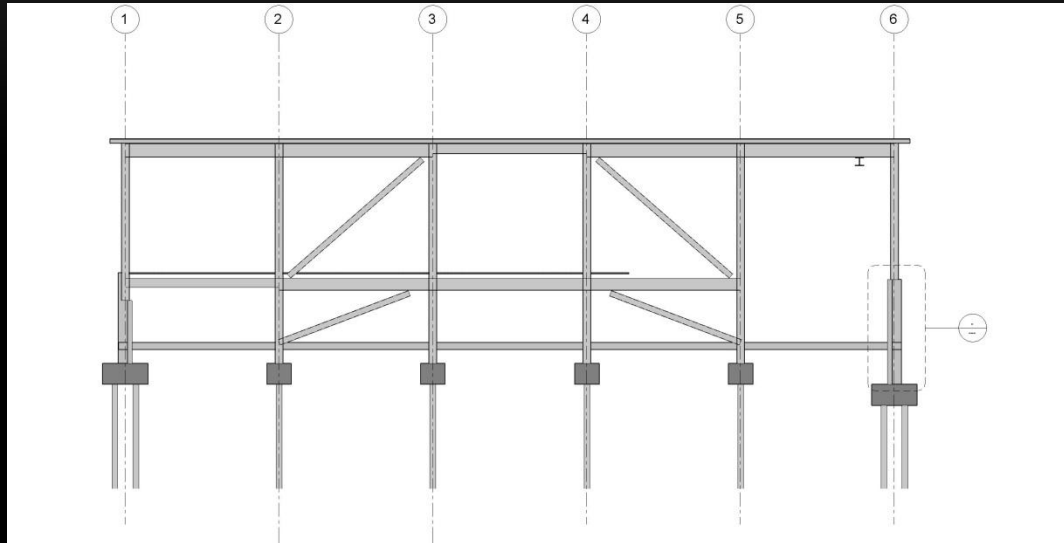
Frame – X (Looking East)



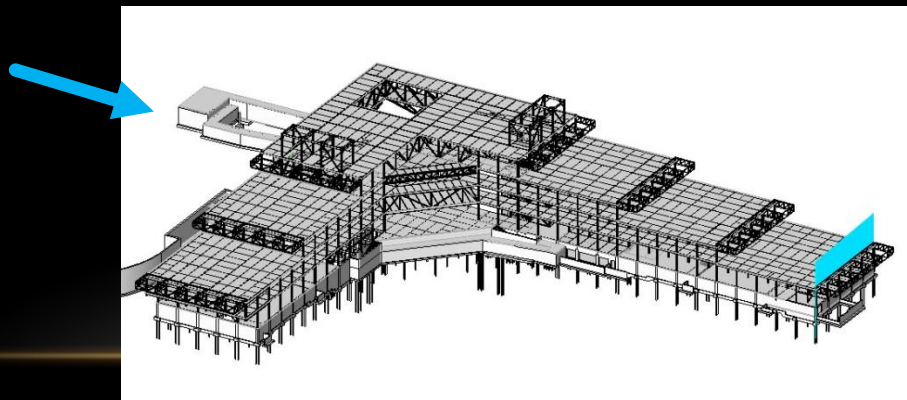
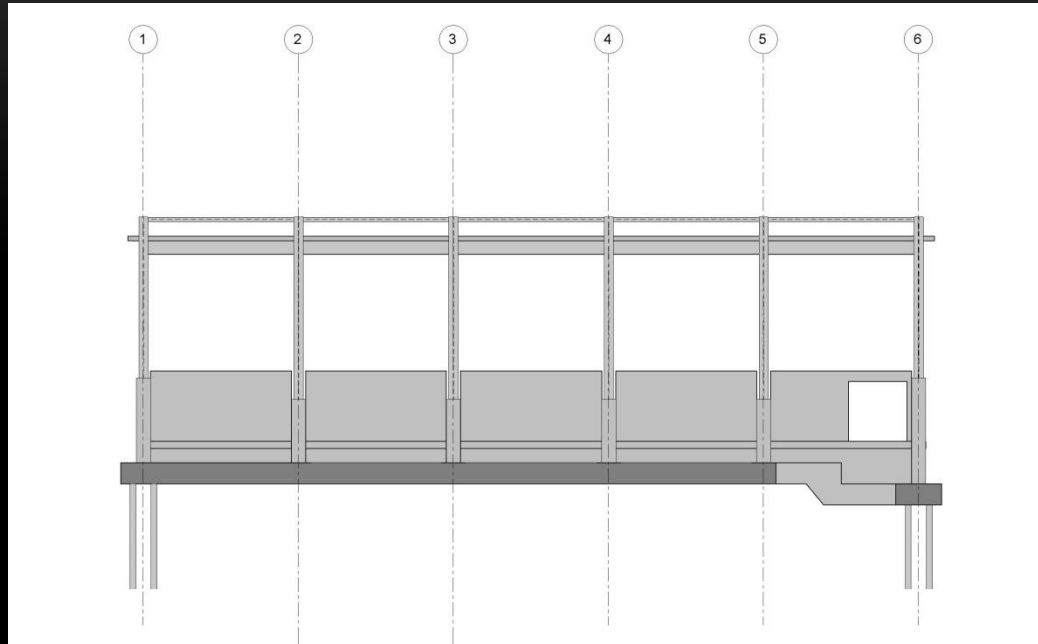
Frame – Y (Looking East)



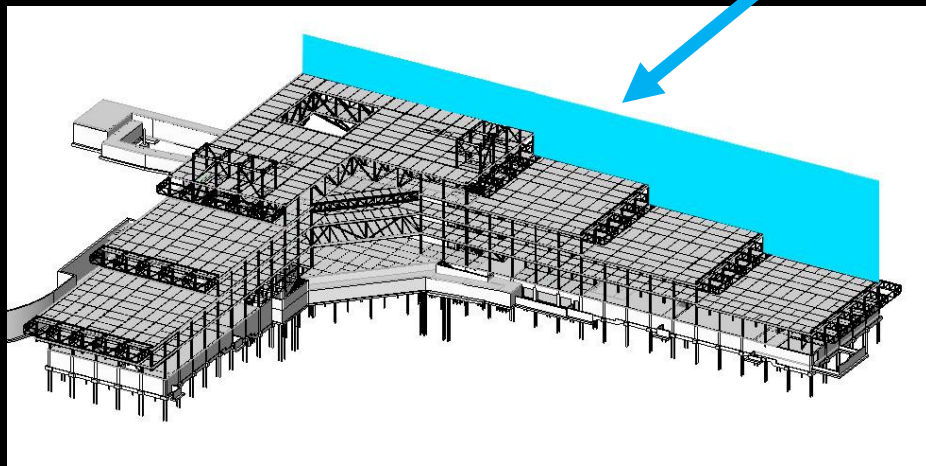
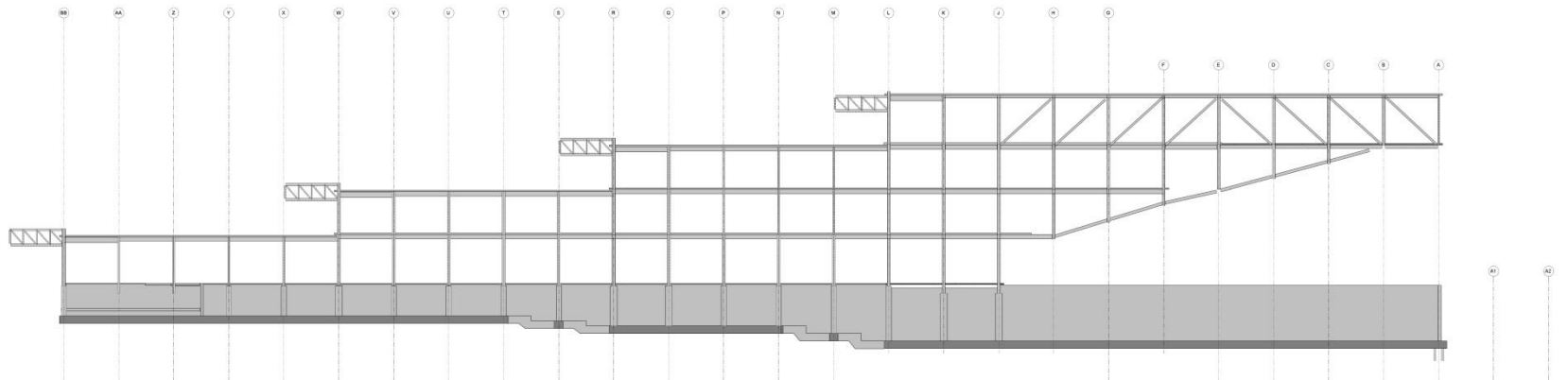
Frame – Z (Looking East)



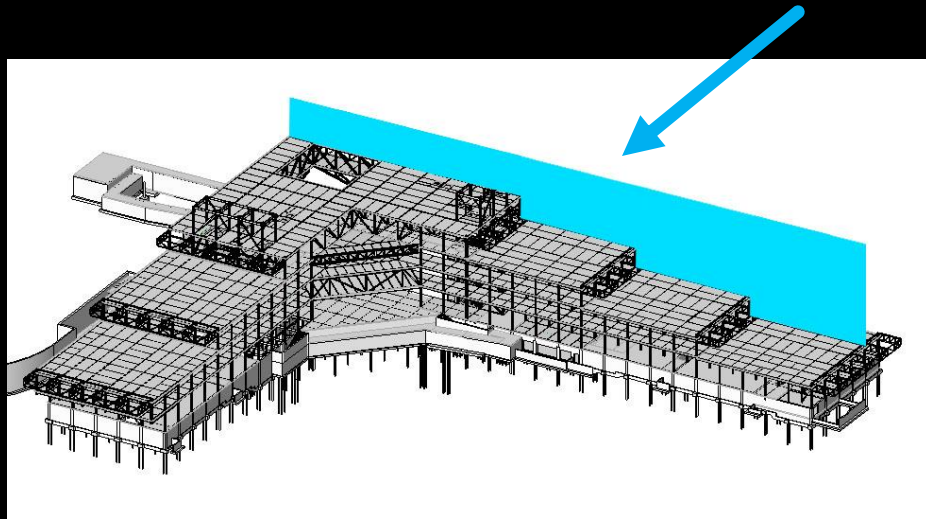
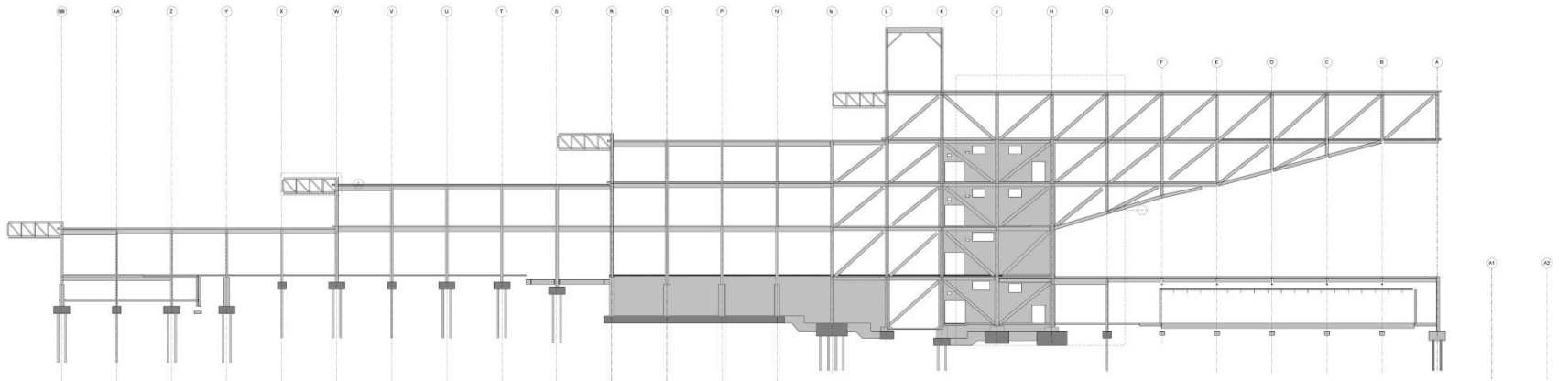
Frame – Z (Looking East)



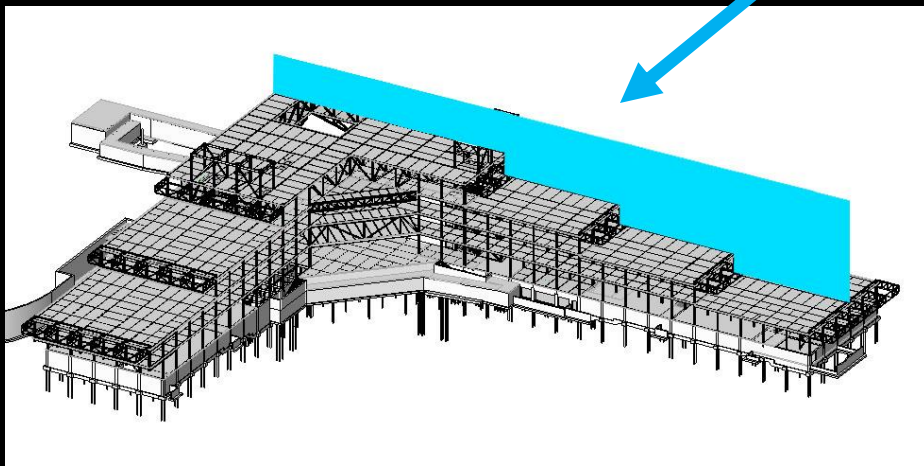
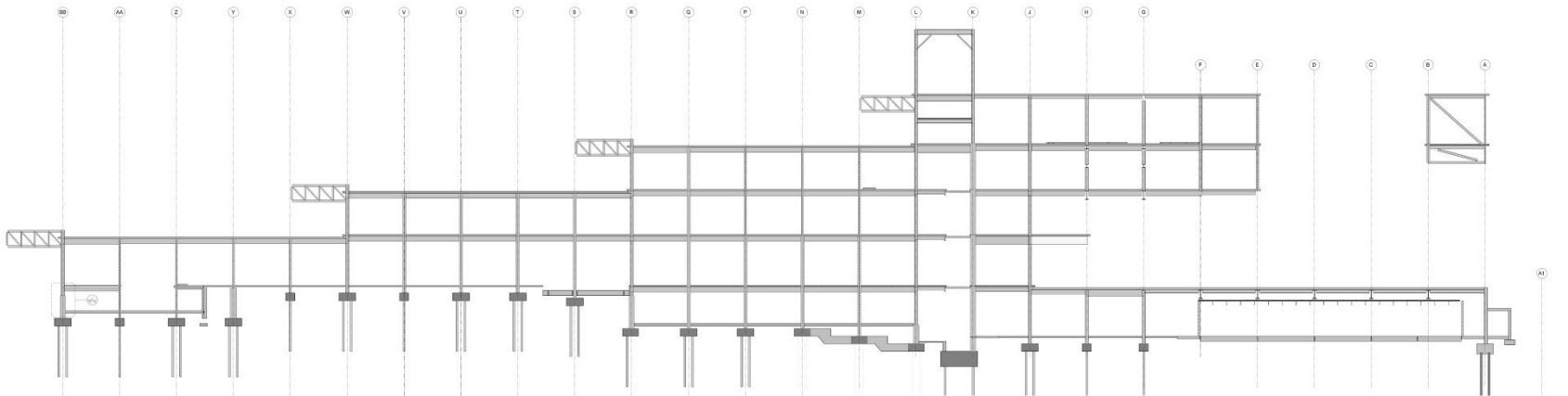
Frame – Z (Looking East)



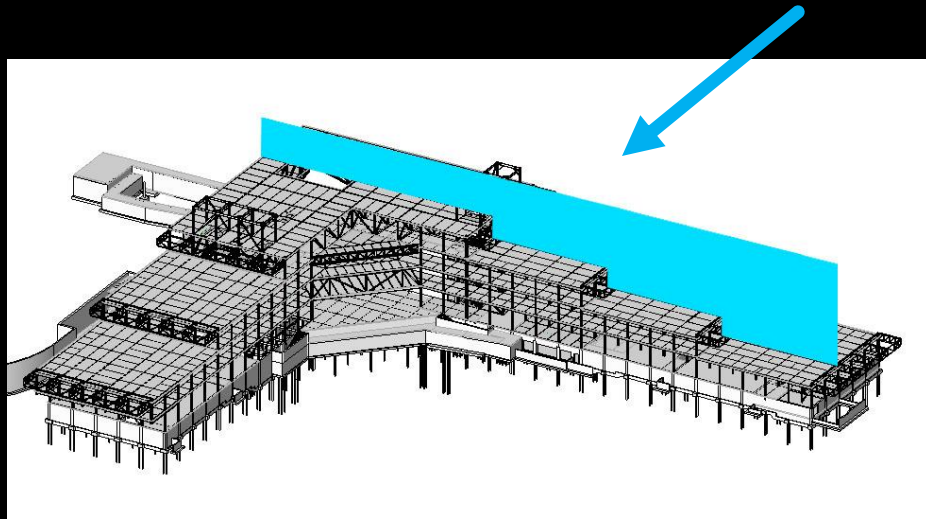
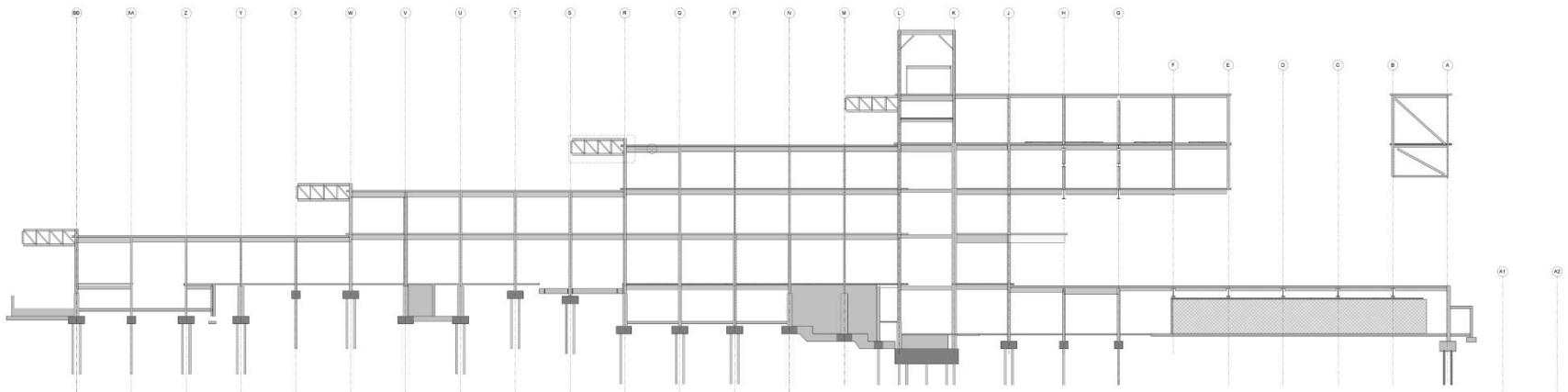
Frame – 1 (Looking South)



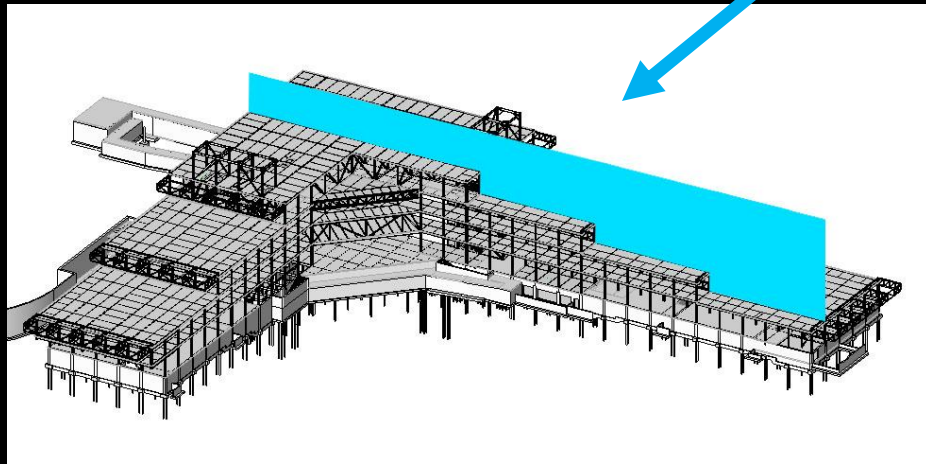
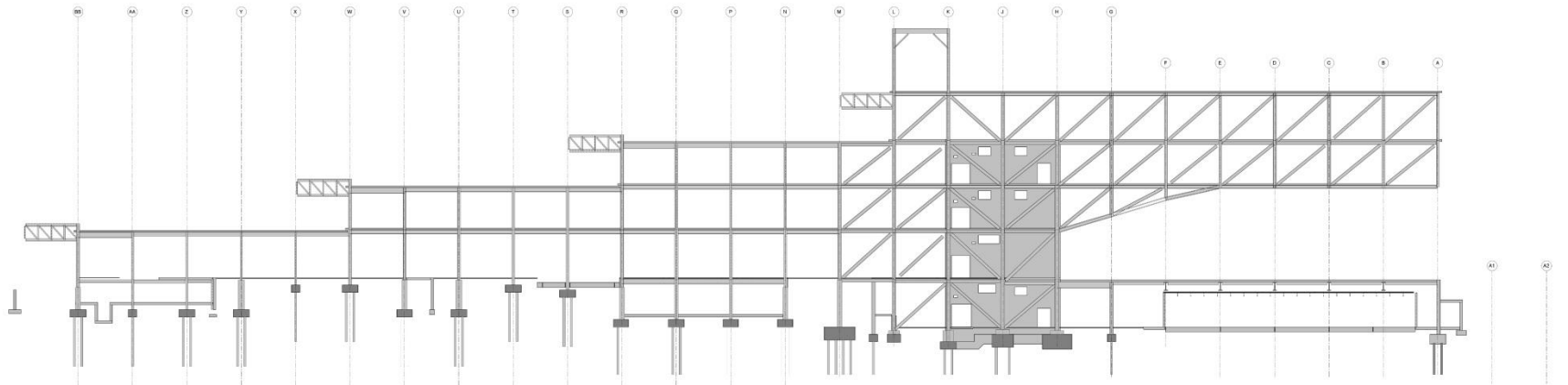
Frame – 2 (Looking South)



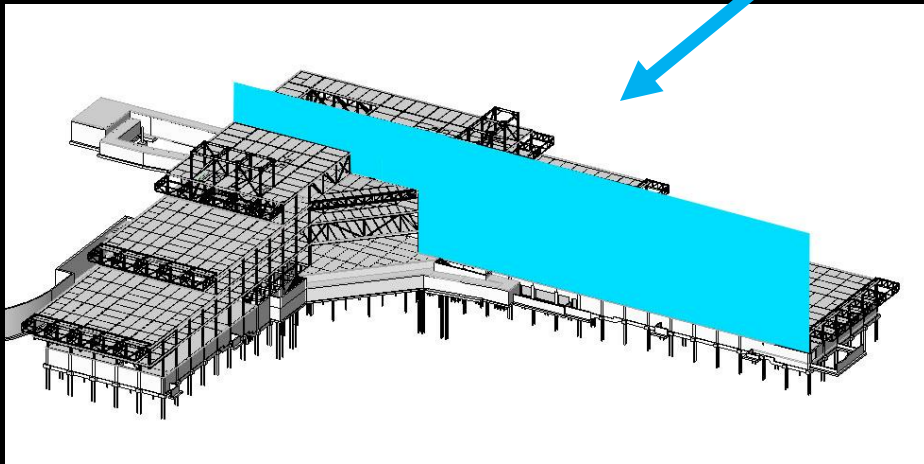
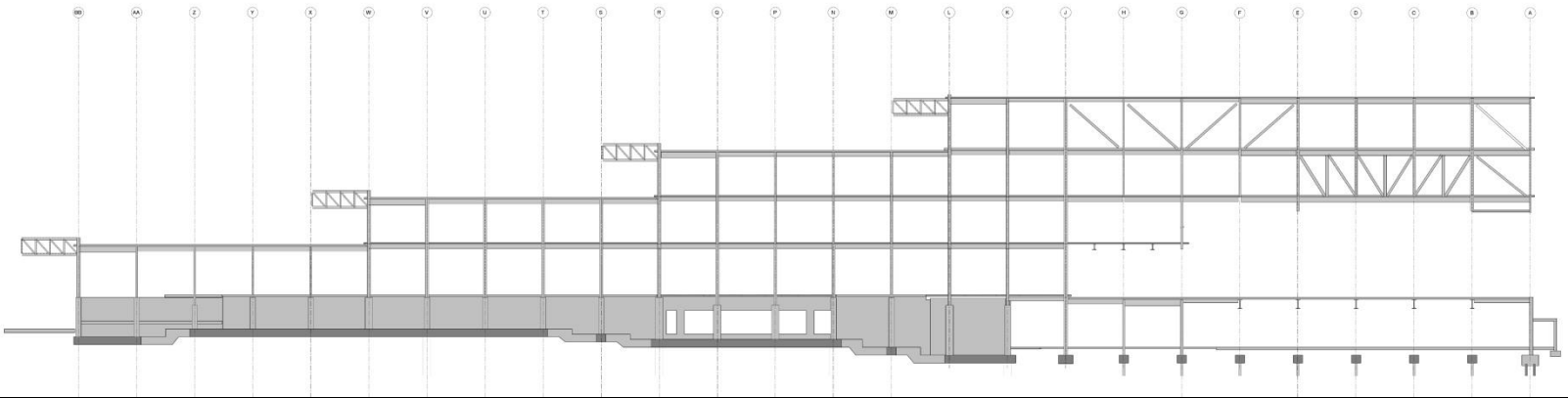
Frame – 3 (Looking South)



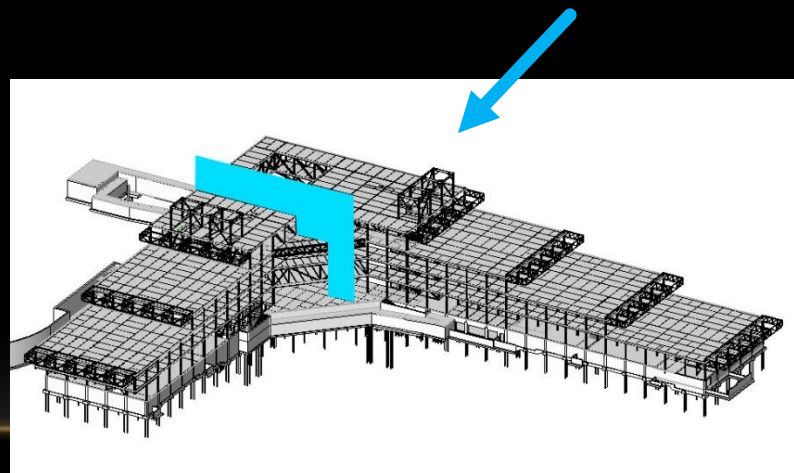
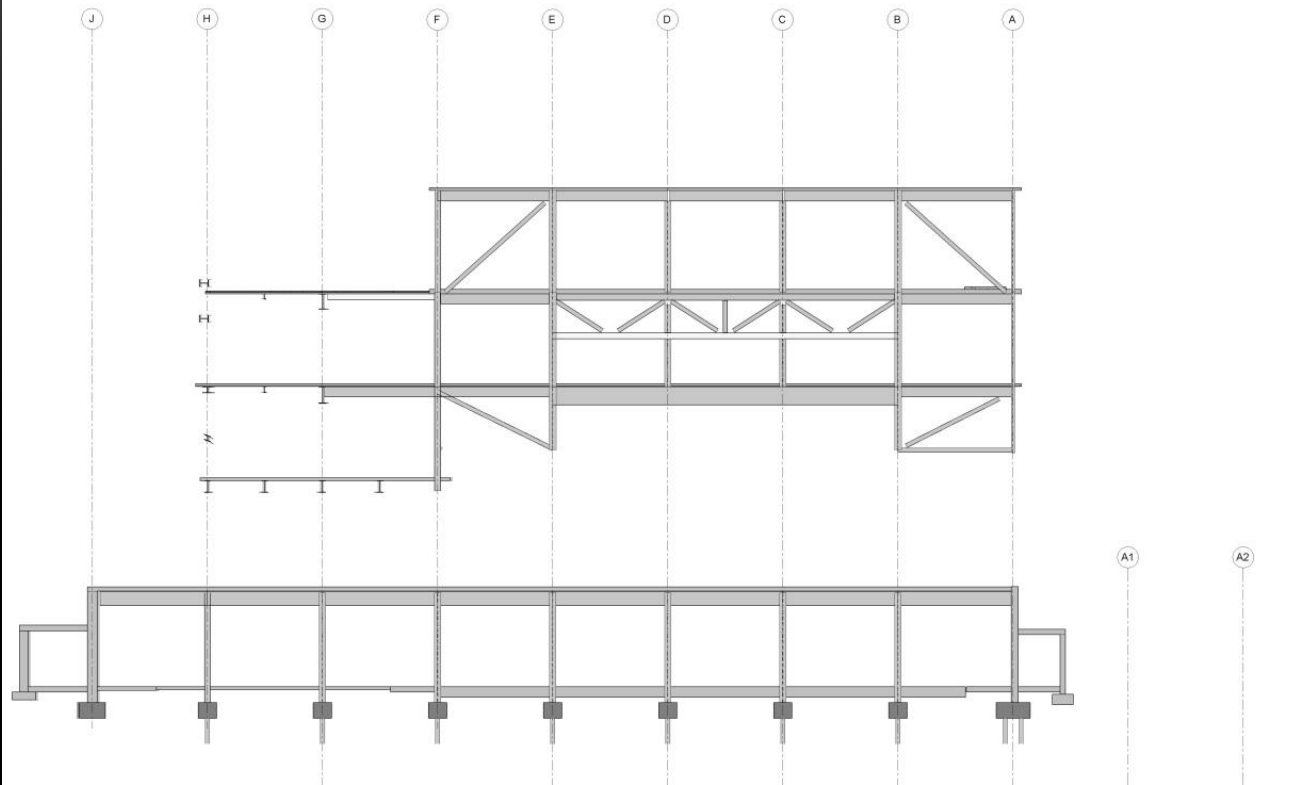
Frame – 4 (Looking South)



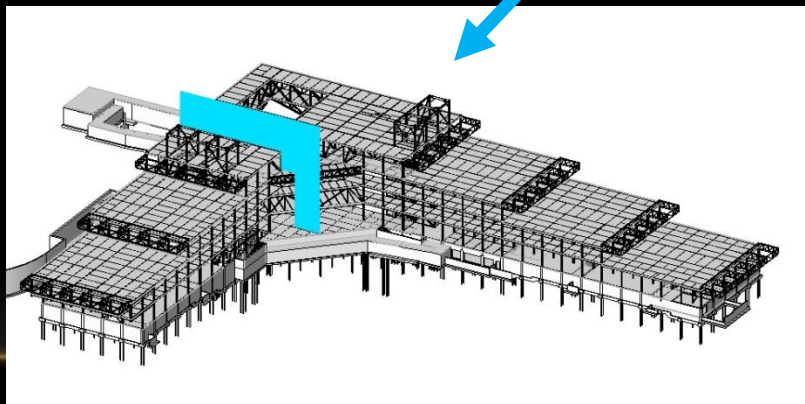
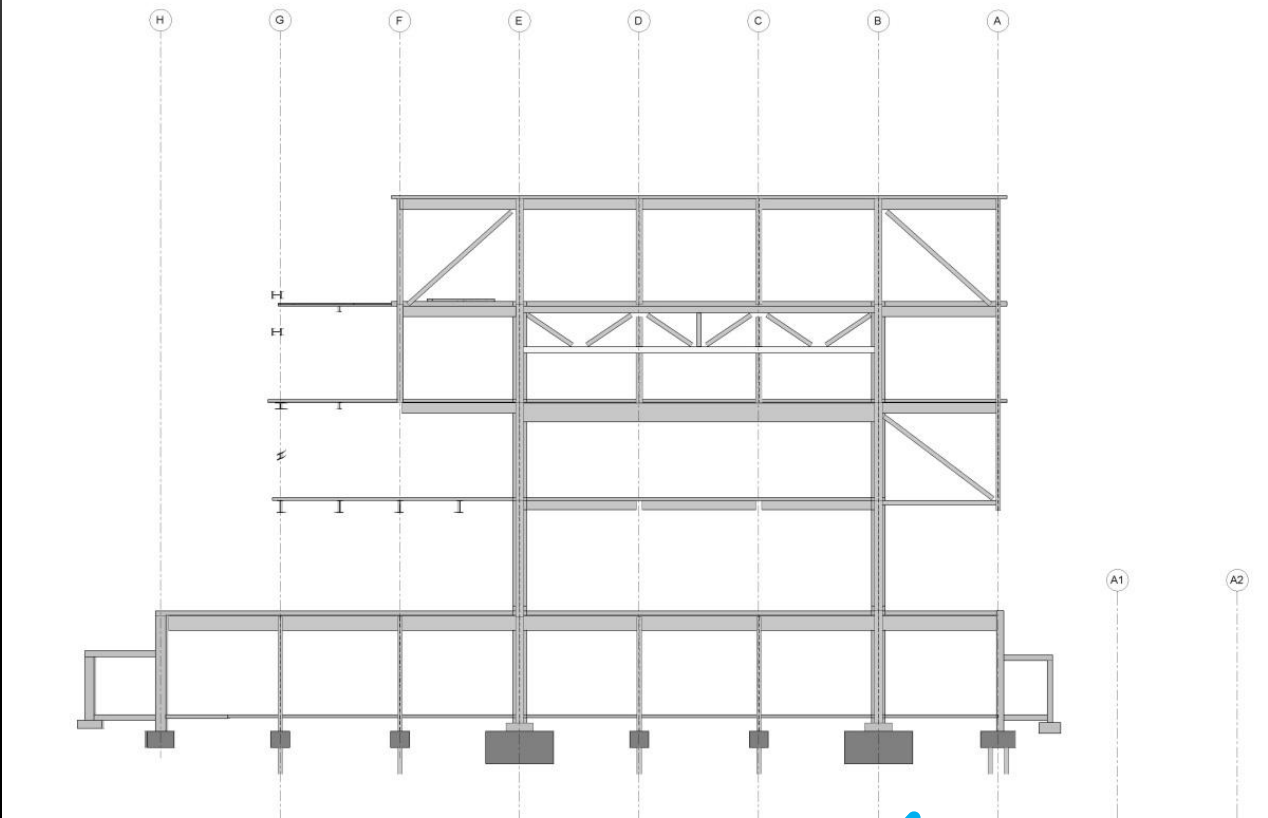
Frame – 5 (Looking South)



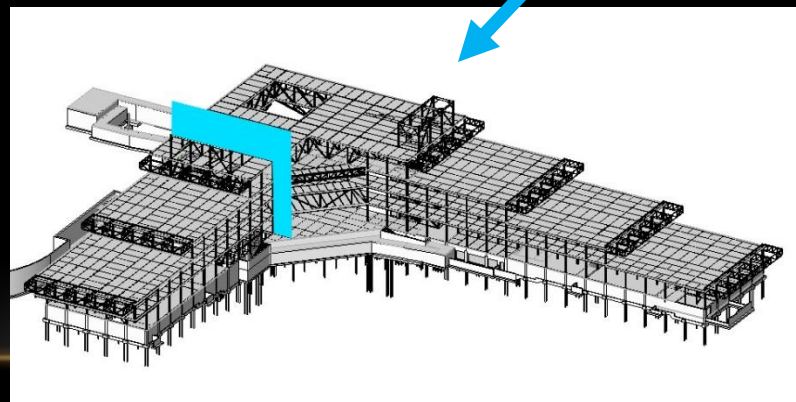
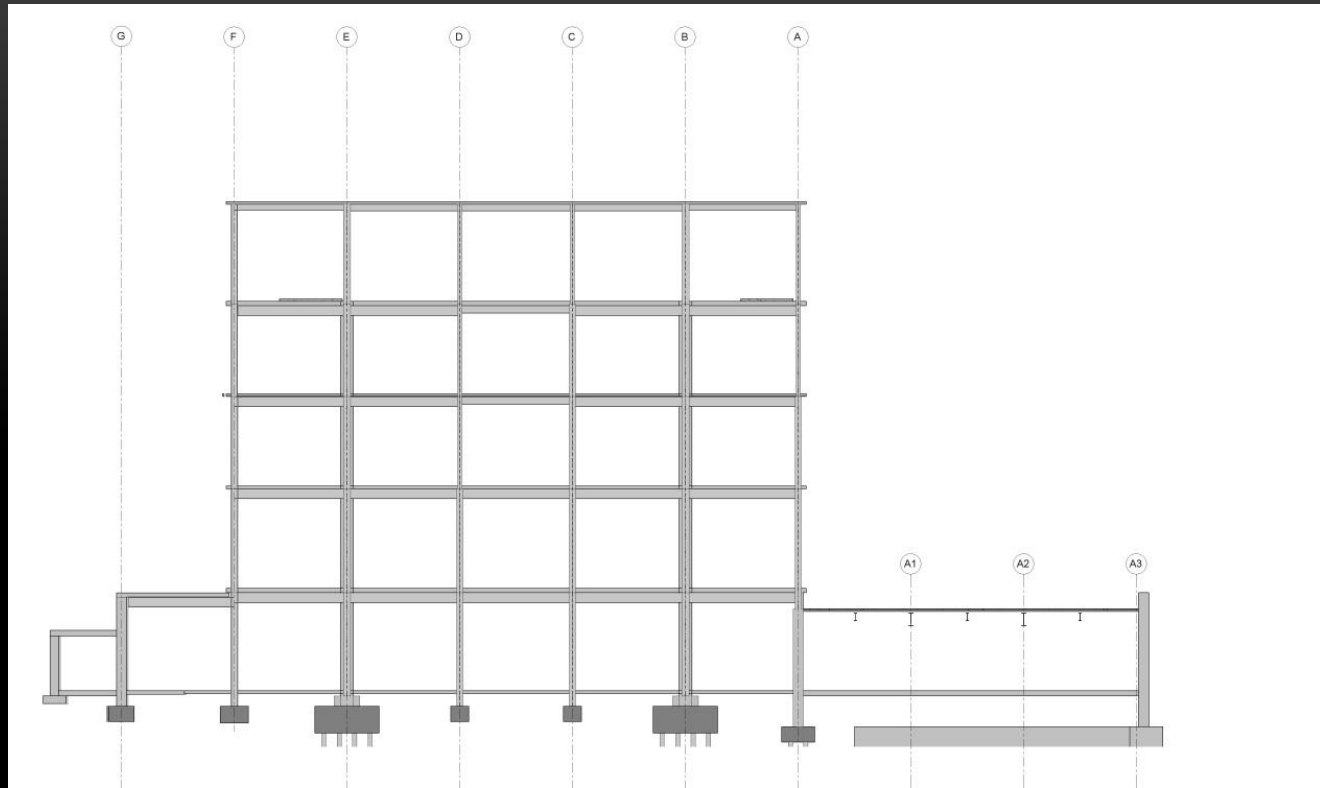
Frame – 6 (Looking South)



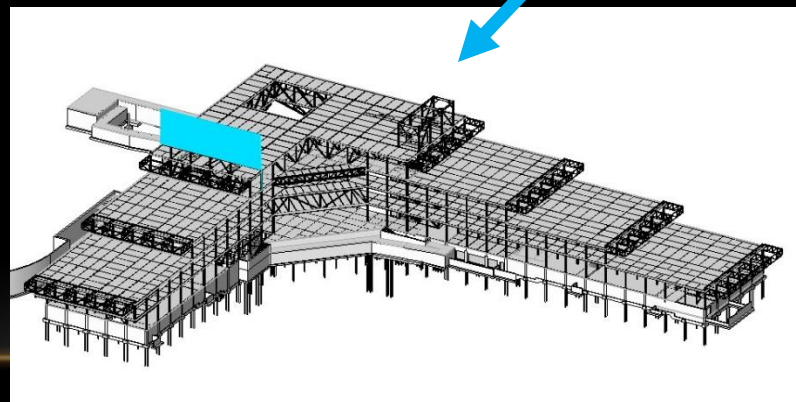
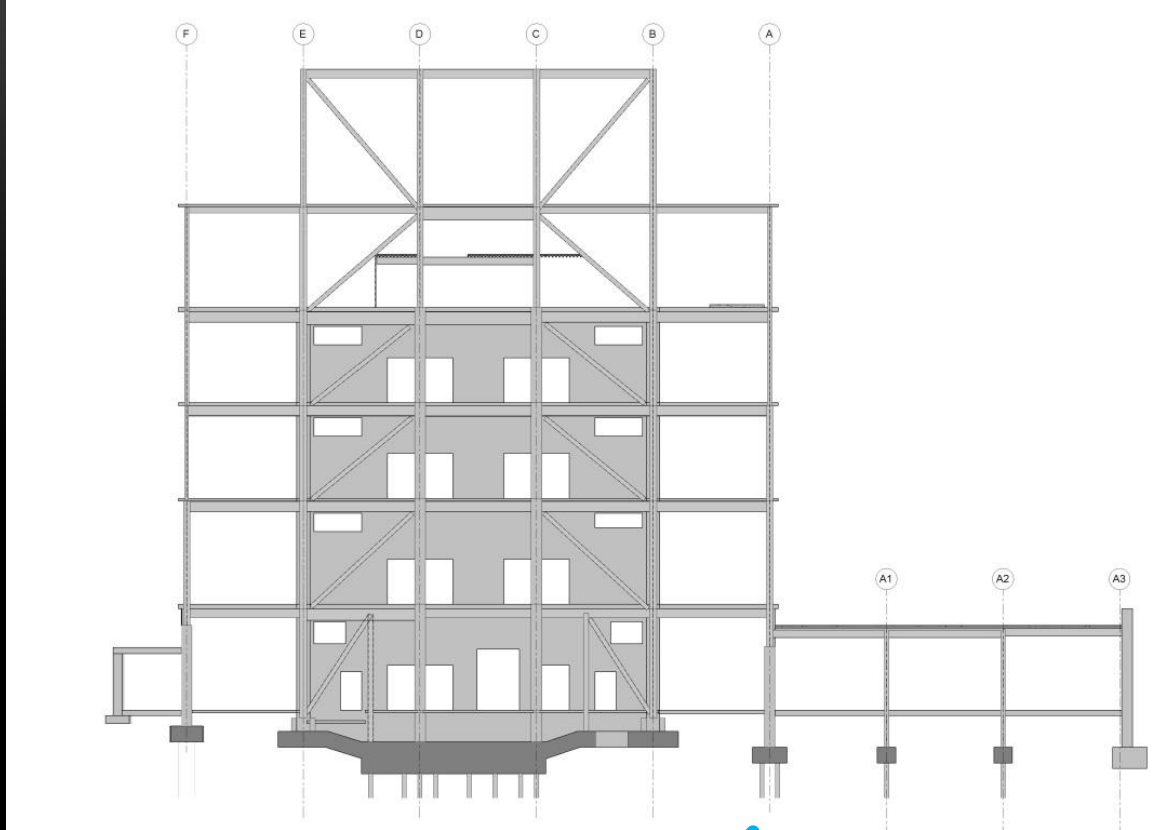
Frame – 7 (Looking South)



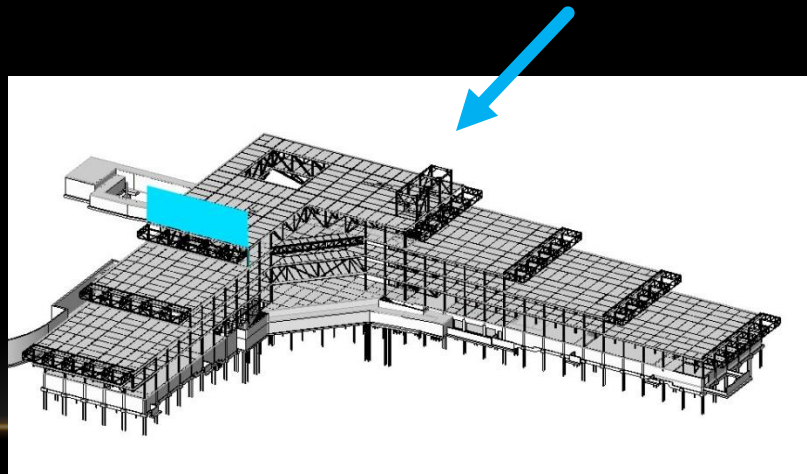
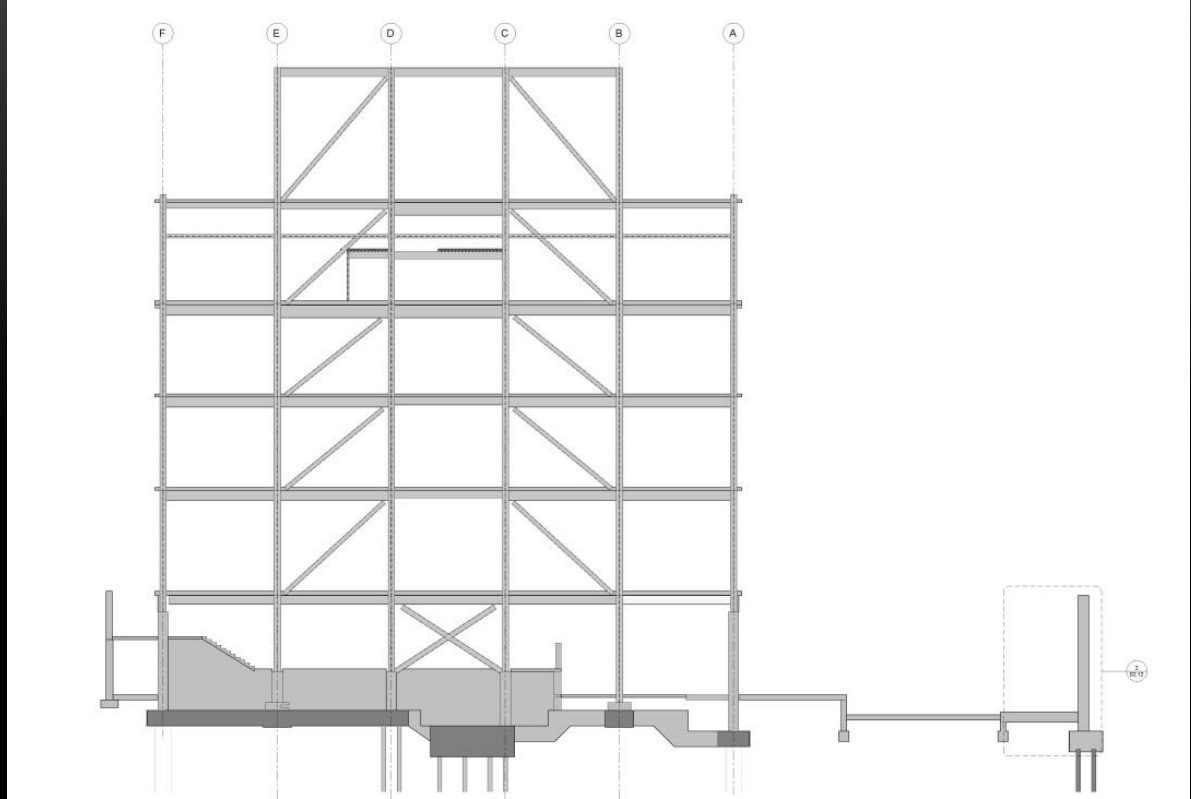
Frame – 8 (Looking South)



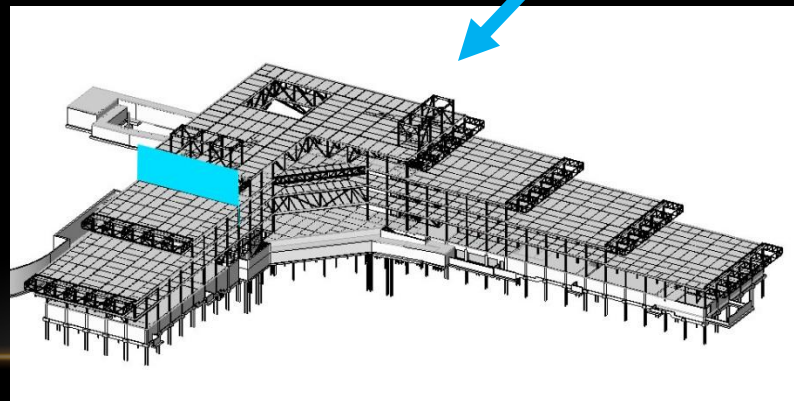
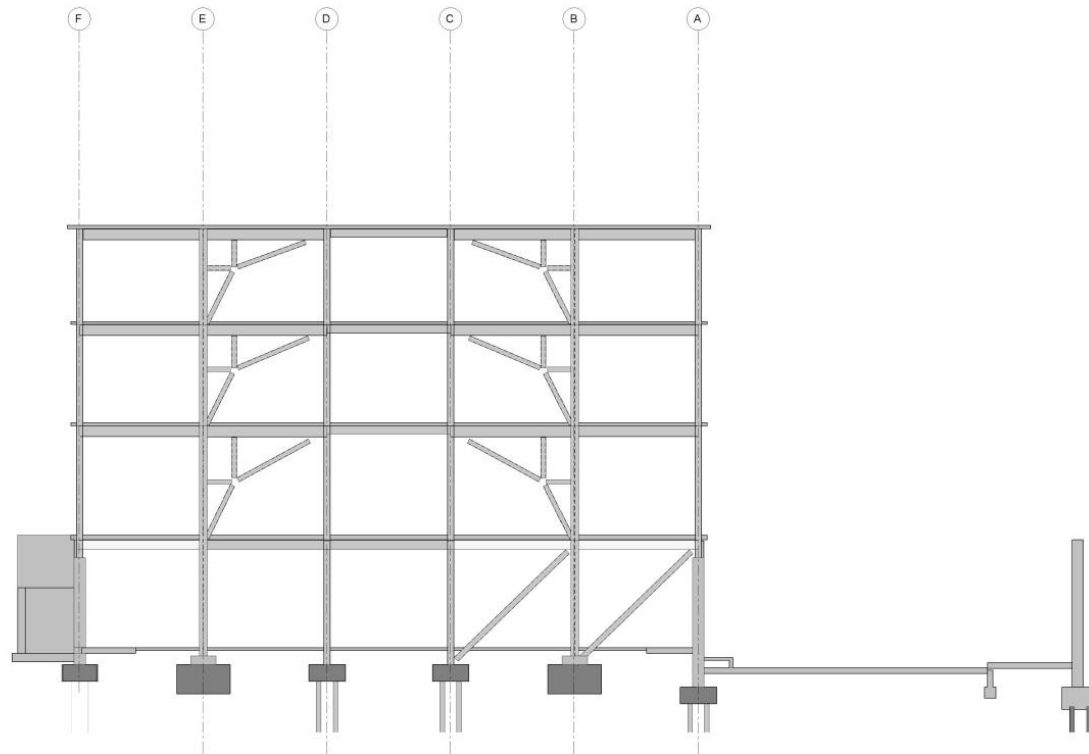
Frame – 9 (Looking South)



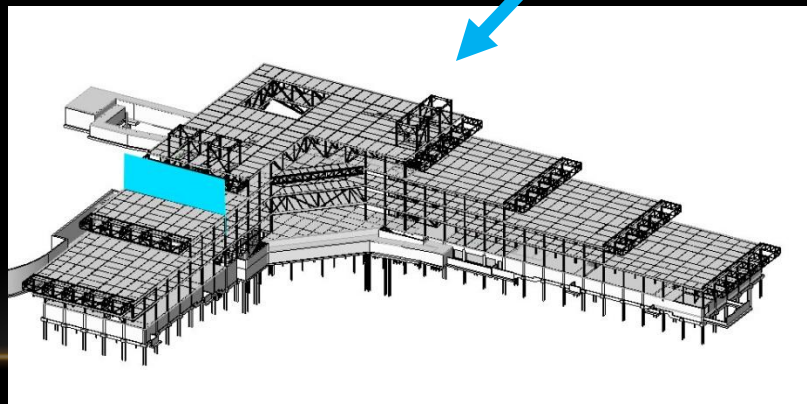
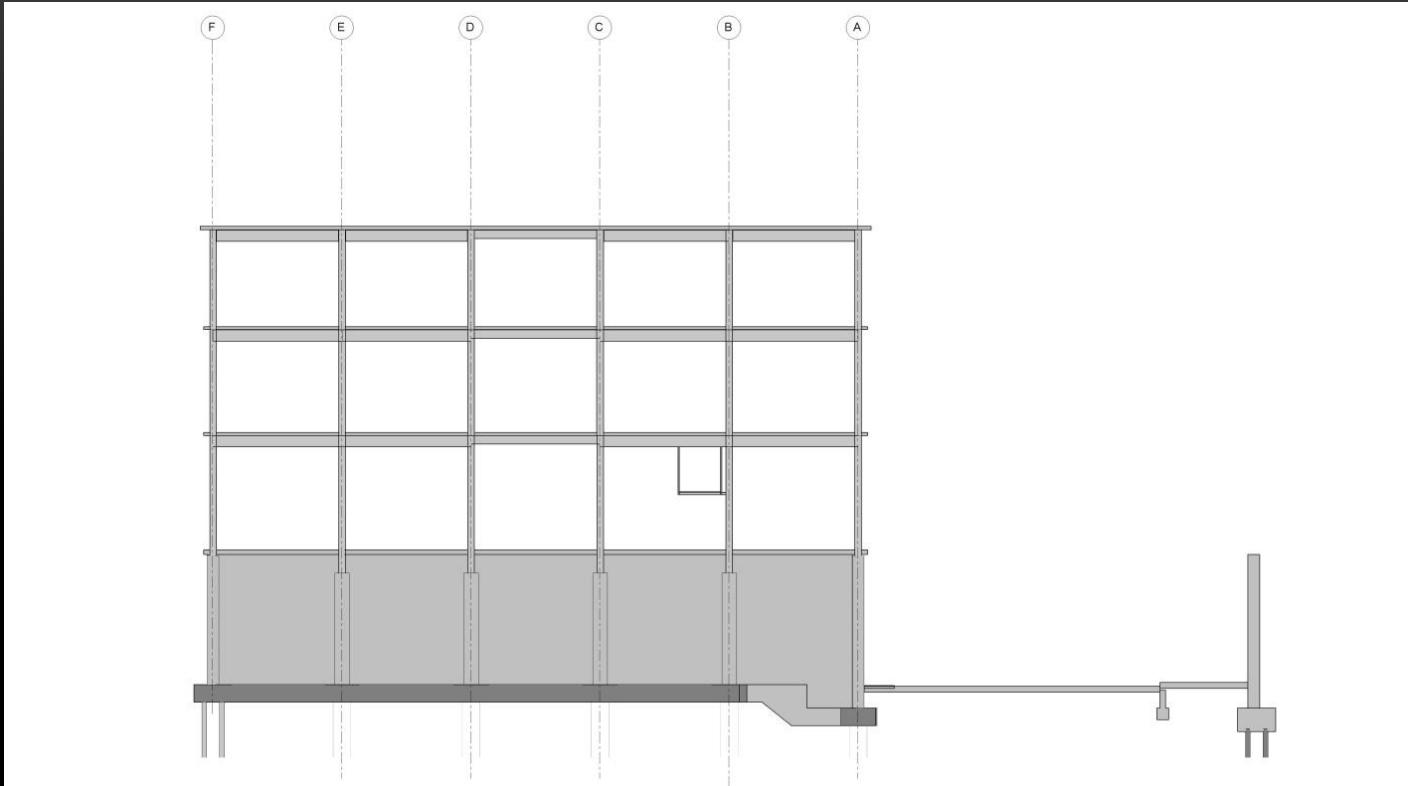
Frame – 10 (Looking South)



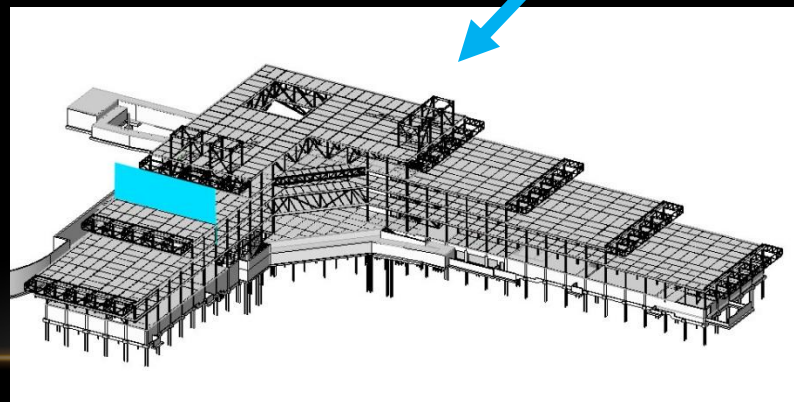
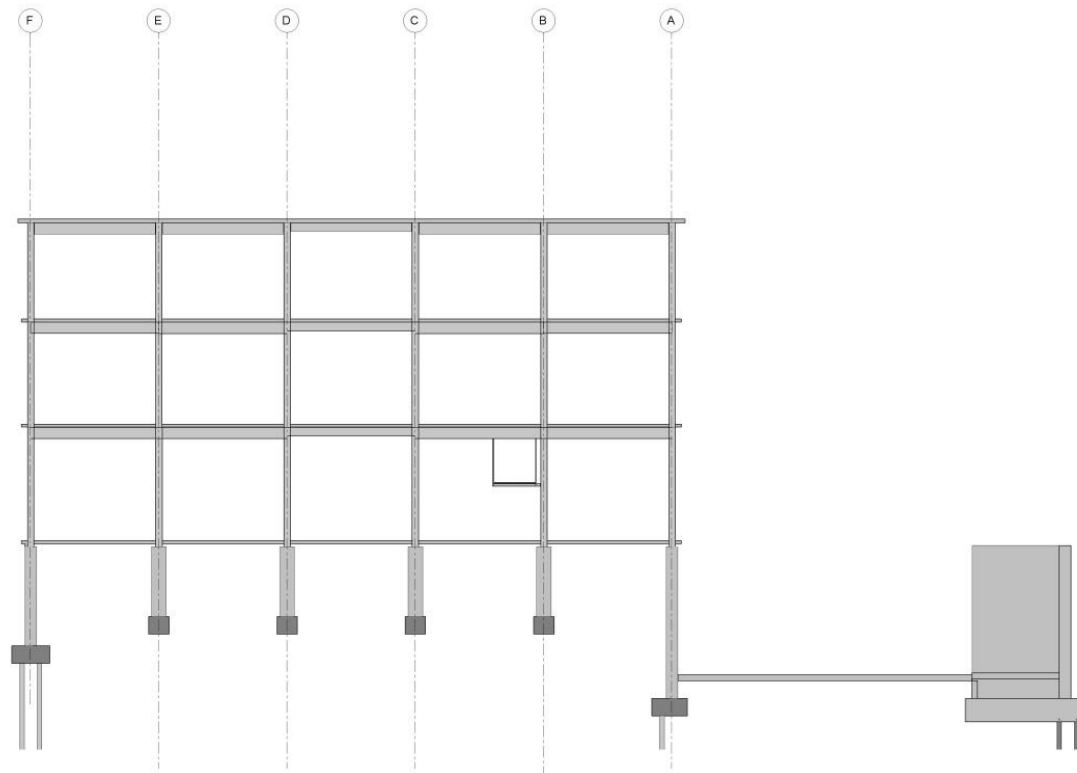
Frame – 11 (Looking South)



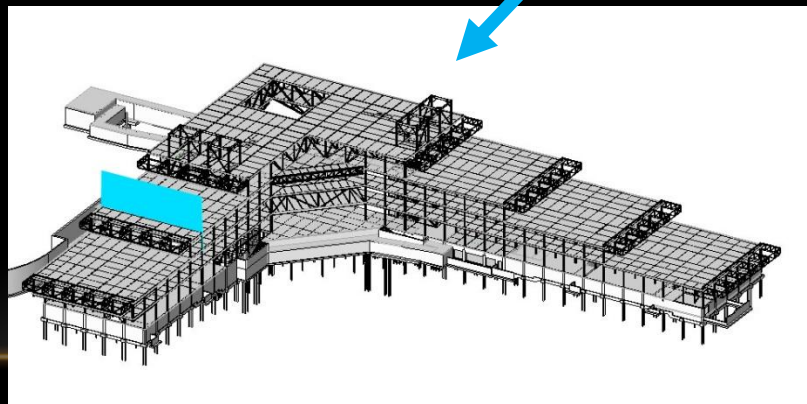
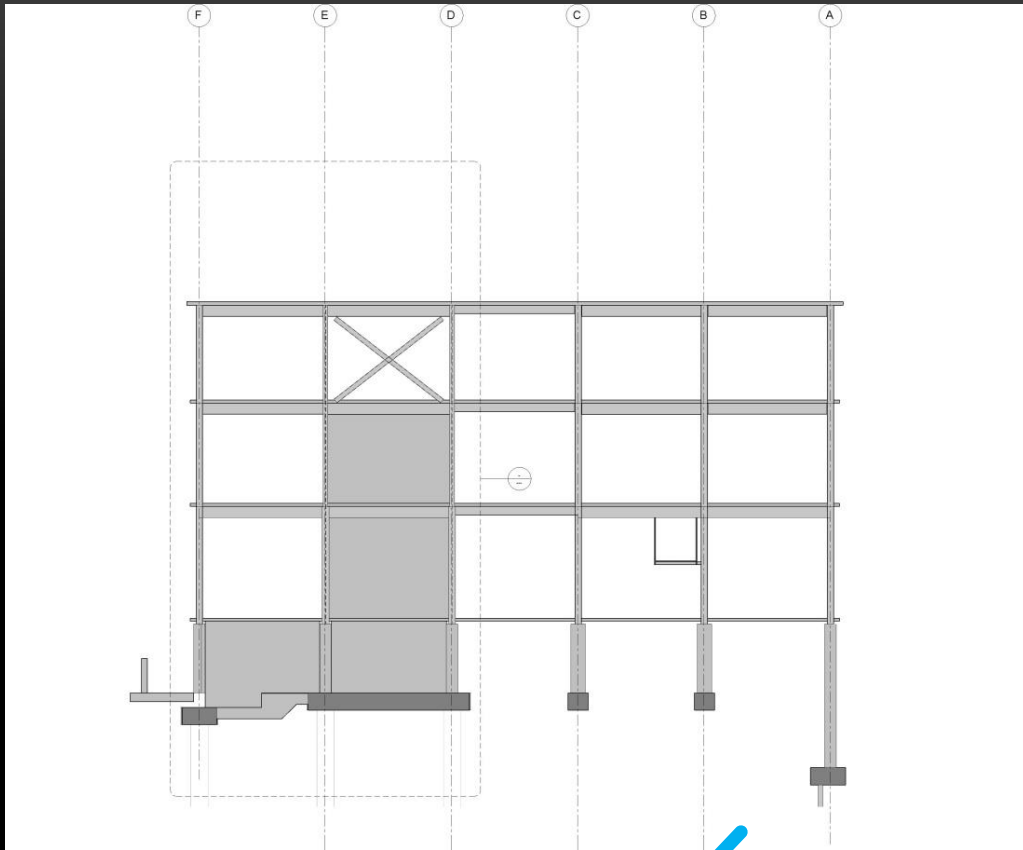
Frame – 12 (Looking South)



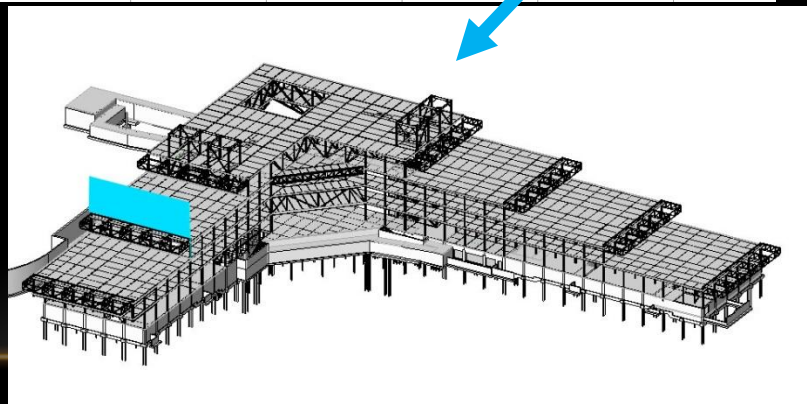
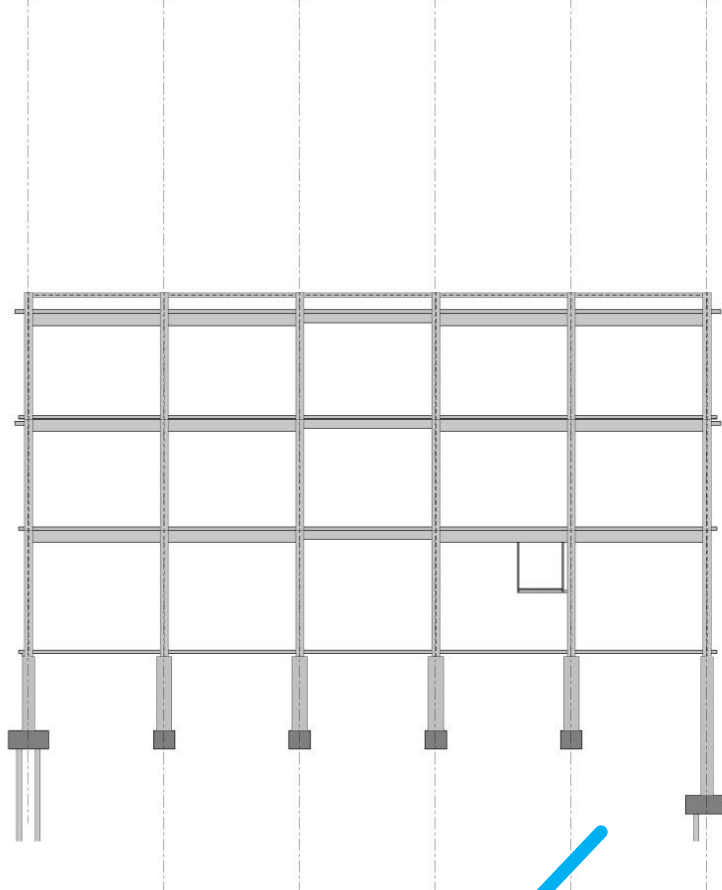
Frame – 13 (Looking South)



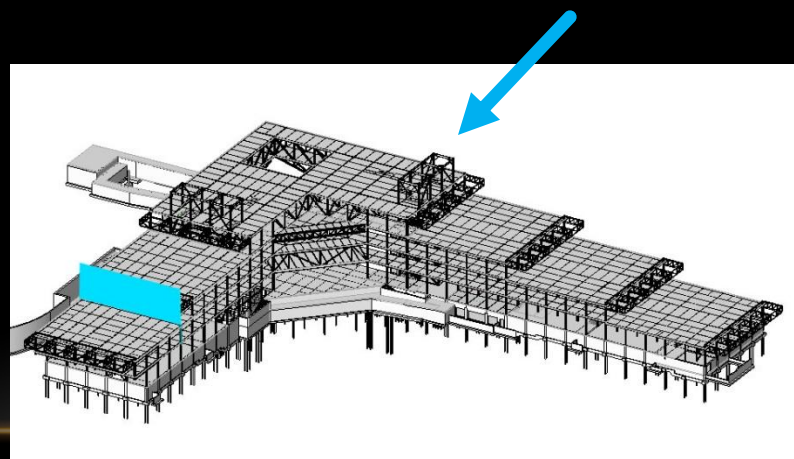
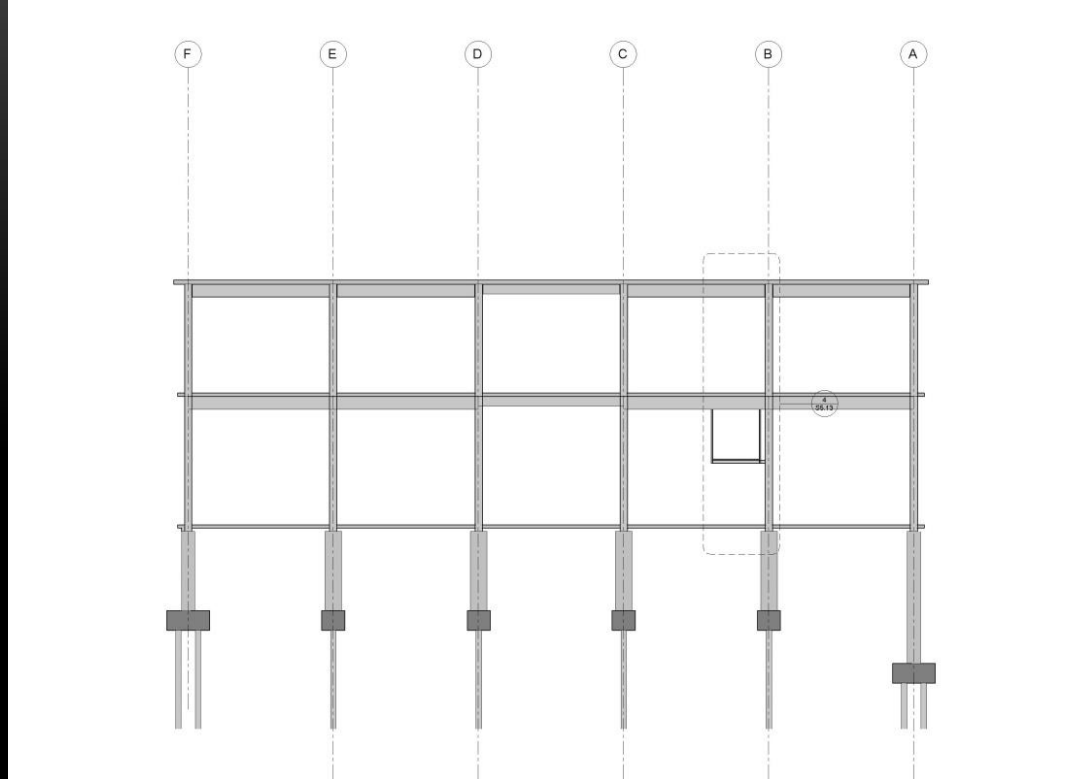
Frame – 14 (Looking South)



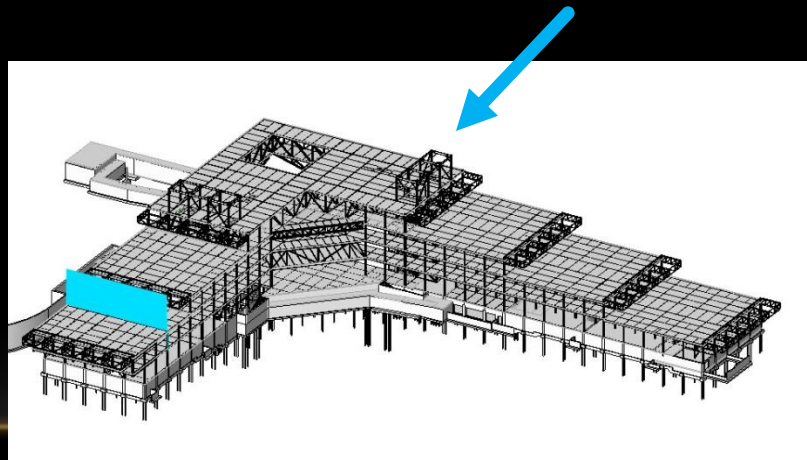
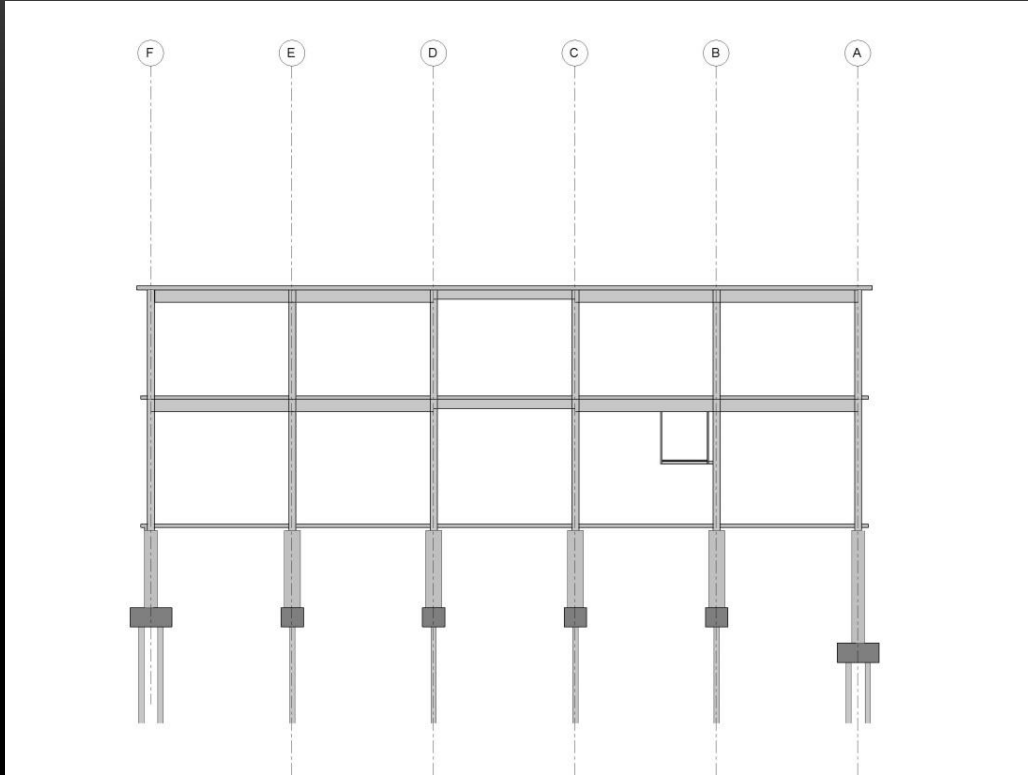
Frame – 15 (Looking South)



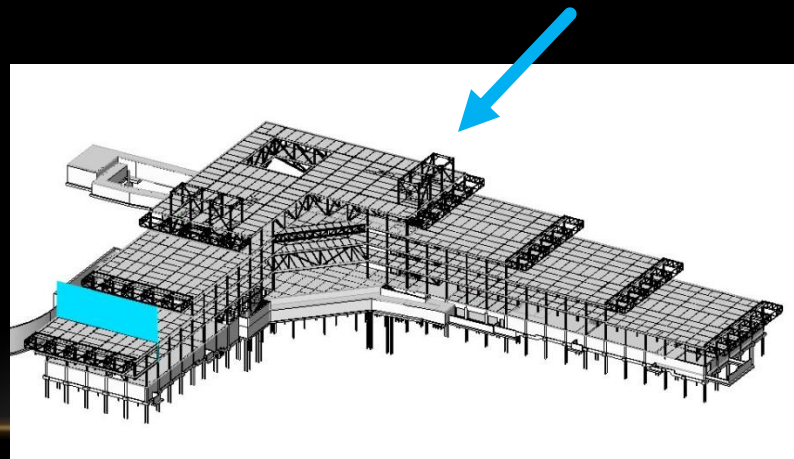
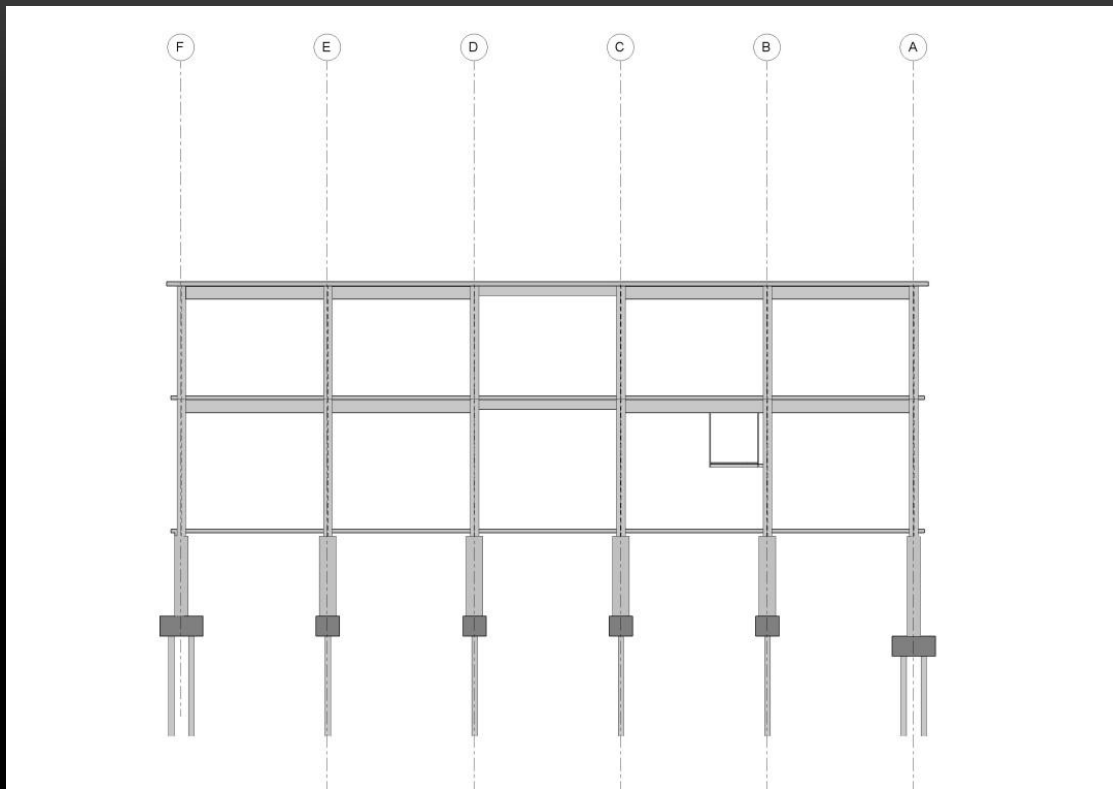
Frame – 16 (Looking South)



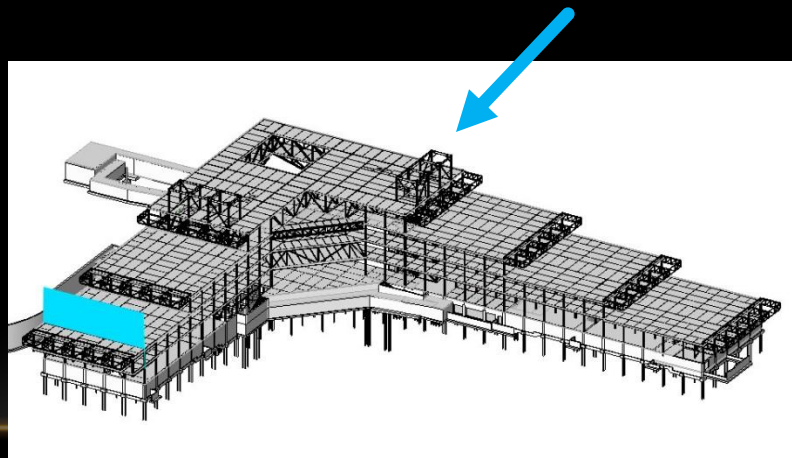
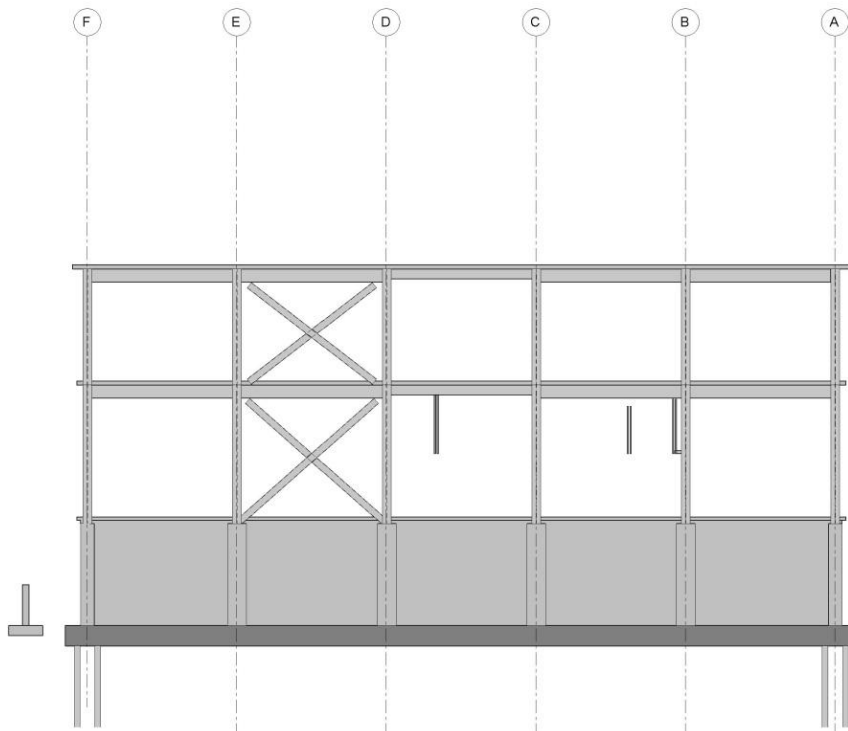
Frame – 17 (Looking South)



Frame – 18 (Looking South)



Frame – 19 (Looking South)



Frame – 20 (Looking South)

GRAVITY LOADS

Floor Loading Schedule							Confirmed Loads	
Floor	Elevation (ft-in.)	Occupancy	Slab Type	Loads			ASCE7-05 LL	USD* - DL
				Slab (PSF)	SDL (PSF)	LL (PSF)		
Level Roof	1245'-6"	Roof	S1	50	25	30	30	48.8
Mechanical Penthouse	1226'-0"	Mechanical	S2	110	25	150	--	106
Third Floor	1208'-0"	Green Roof	S3	76	120	30	--	75.8
		Office	S1	50	30	50	50	48.8
		Material Science Labs	S1	50	30	150	--	48.8
		Life Science Labs	S1	50	30	150	--	48.8
		Corridors	S1	50	30	Area Served	Area Served	48.8
		Elevator Lobbies	S1	50	30	100	100	48.8
Second Floor	1190'-0"	Green Roof	S3	76	120	30	--	75.8
		Office	S1	50	30	50	50	48.8
		Material Science Labs	S1	50	30	150	--	48.8
		Life Science Labs	S1	50	30	100	--	48.8
		Corridors	S1	50	30	Area Served	Area Served	48.8
		Elevator Lobbies	S1	50	30	100	100	48.8
First Floor	1170'-0"	Plaza Landscape	S2	110	300	100	100	106
		Office	S1	50	30	50	50	48.8
		Material Science Labs	S1	50	30	150	--	48.8
		Life Science Labs	S1	50	30	100	--	48.8
		Corridors	S1	50	30	100	100	48.8
		Mechanical Mezzanine	Grating	10	10	150	--	--
		Elevator Lobbies	S1	50	30	100	100	48.8
Basement Mezzanine	1160'-0"	Retail	S1	50	30	50	--	48.8

SNOW LOADS

Snow Loads				Loading Check		Applicable Standard	
Ground Snow Load	p_g	40	psf	30	pending confirmation	ASCE7-05	Fig 7-1
Snow Exposure Factor	C_e	0.9		0.9	Exp. B	ASCE7-05	6.5.6.2
Snow Importance Factor	I	1.1		1.1	pending confirmation	ASCE7-05	Table 7-4
Thermal Factor	C_t	1		1		ASCE7-05	Table 7-3
Flat Roof Snow Load	$p_f = 0.7C_eC_tI p_g$	28	psf	20.8			
Snow Drifts	Based on Sect. 1608.7 as applicable						

WIND LOADS

Windward Wall Pressures		
	$P = qGCp + qi(Gcpi)$	$P = qGCp - qi(Gcpi)$
Height	Pressure 1 (psf)	Pressure 2 (psf)
z= 15ft	11.39	4.46
z= 20ft	12.07	5.14
z= 39ft	13.87	6.94
z= 57ft	15.06	8.14
z= 75.75ft	16.05	9.12
z= 87ft	16.55	9.62

Parapets(Windward)			
Heights	q_p	GC_{pn}	$P_p = q_p GC_{pn}$
z= 33ft	13.87	1.5	20.81
z= 51ft	15.06	1.5	22.60
z= 69ft	16.05	1.5	24.07
z= 87ft	16.55	1.5	24.83

Leeward Walls		
	Pressure 1 (psf)	Pressure 2 (psf)
Wind- short side	0.19	-6.74
Wind-Long Side	-4.72	-11.65

Final Story Forces						
Floor Level	Load		Shear		Moment	
	E/W(K)	N/S(K)	E/W(K)	N/S(K)	E/W(K-ft)	N/S(K-ft)
First Floor	140.24	185.22	763.68	874.70	1402.381	1852.21
Second Floor	204.54	254.70	623.44	689.47	6136.109	7640.975
Third Floor	194.15	199.12	418.90	434.77	9319.04	9557.669
Mech. Pent.	151.16	156.45	224.76	235.66	9976.463	10325.96
Roof	73.60	79.20	73.60	79.20	6292.719	6771.838
Totals*(1.6)			1221.887	1399.512	53002.74	57837.85

SEISMIC LOADS

Design Seismic Base Shear- MSC Complex, University Park, PA

Latitude: 40.802 Site Class: D
 Longitude: -77.86 Occ. Cat: III

S_s = 0.147 g (Site Class B)
 S₁ = 0.049 g (Site Class B)

F_a = 1.6
 F_v = 2.4

S_{MS} = 0.2352 g S_{DS} = 0.1568 g
 S_{M1} = 0.1176 g S_{D1} = 0.0784 g

Lateral Force Resisting System: Ordinary Steel Concentrically Braced Frames

R = 3.25

I = 1.25

SDC: B (No Limitations)

TI = 6 s (Fig. 22-15)

T_a = 0.512 s

C_u = 1.7

C_u*T_a = 0.871 s

C_s = Min 0.0603

0.0346

0.2386

$$V = C_s * W$$

C_s = 0.0346

W = 50120.12 K

V = 1735.46 K

SEISMIC LOAD DISTRIBUTION

i (Level)	Story Height h_i (ft)	Effective Height h (ft)	Story Weight w (K)	w^*h^k	C_{vx}	Lateral Force f_i (K)	Story Shear V_i (K)	M_i (K-ft)
Roof	19.5	75.5	4165.67	701200	0.246	429.17	429	32402.14
Mech.	18.0	56.0	9738.01	1150294	0.404	704.03	1133	39425.91
3	18.0	38.0	9227.25	688304	0.242	421.27	1554	16008.44
2	20.0	20.0	8774.75	305846	0.107	187.19	1742	3743.844
Totals	75.5	75.5	31905.68	2845644	1.000	1741.67	1742	91580