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

Paul Kuehnel

Stephen Pfund

Stephen Kijak
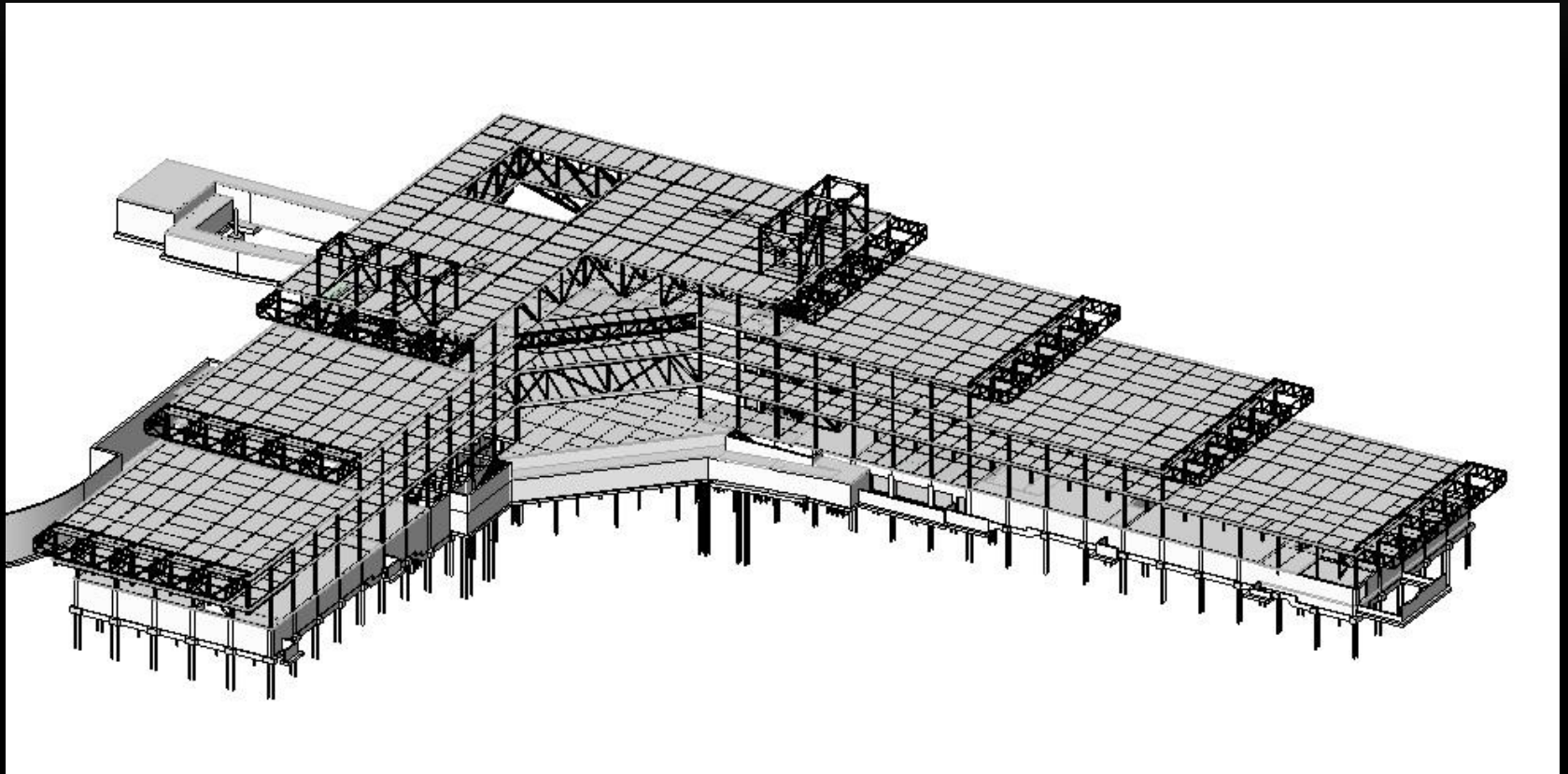
SUMMARY

- Introduction

- Structural System Overview

  - Floor Plans

  - Frame Elevations

- Lateral System

- Specialty Systems

- Lateral Loads

- Spot Checks

- IPD/BIM
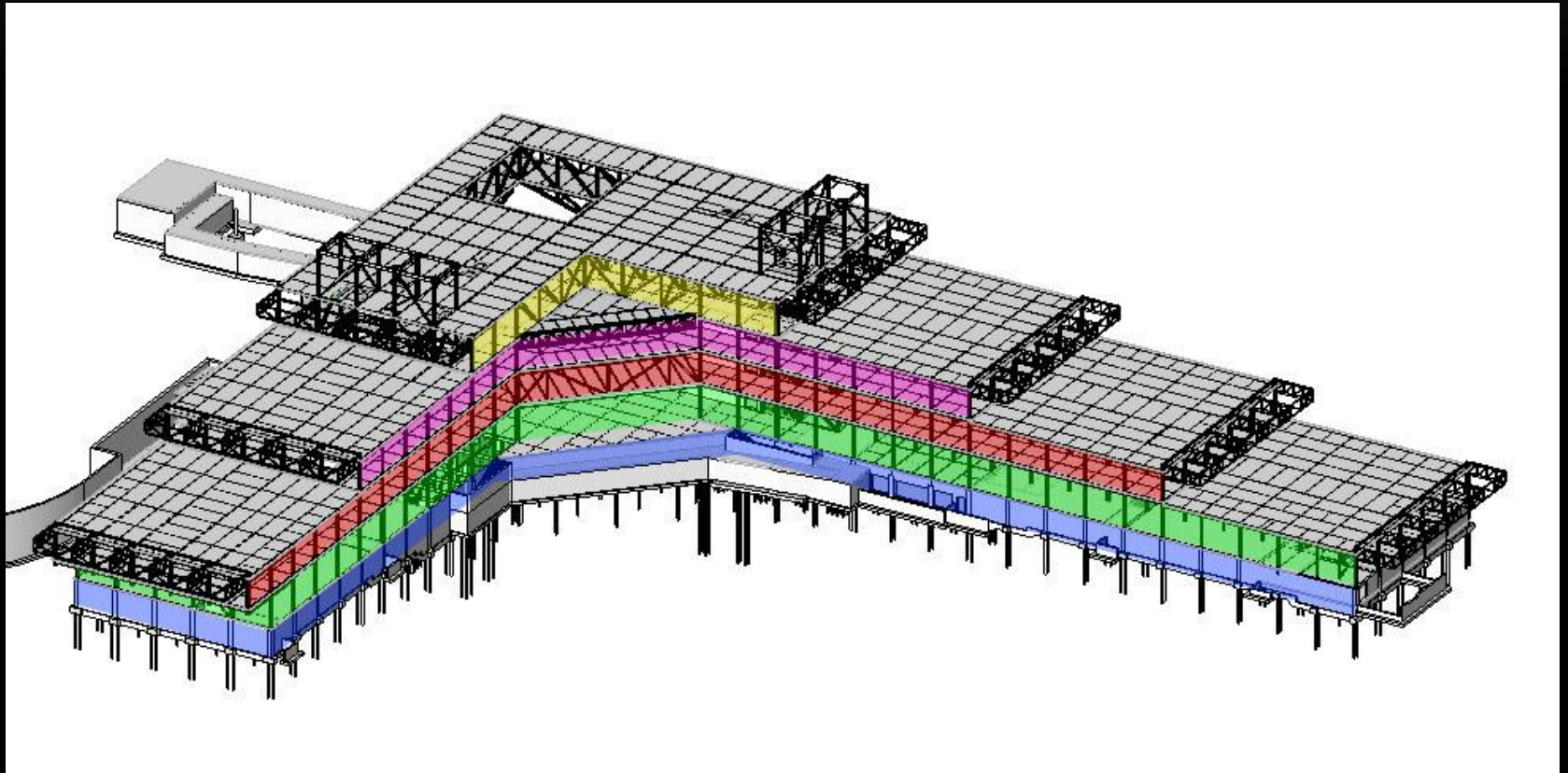
- Tech II

CANTILEVER RENDERING

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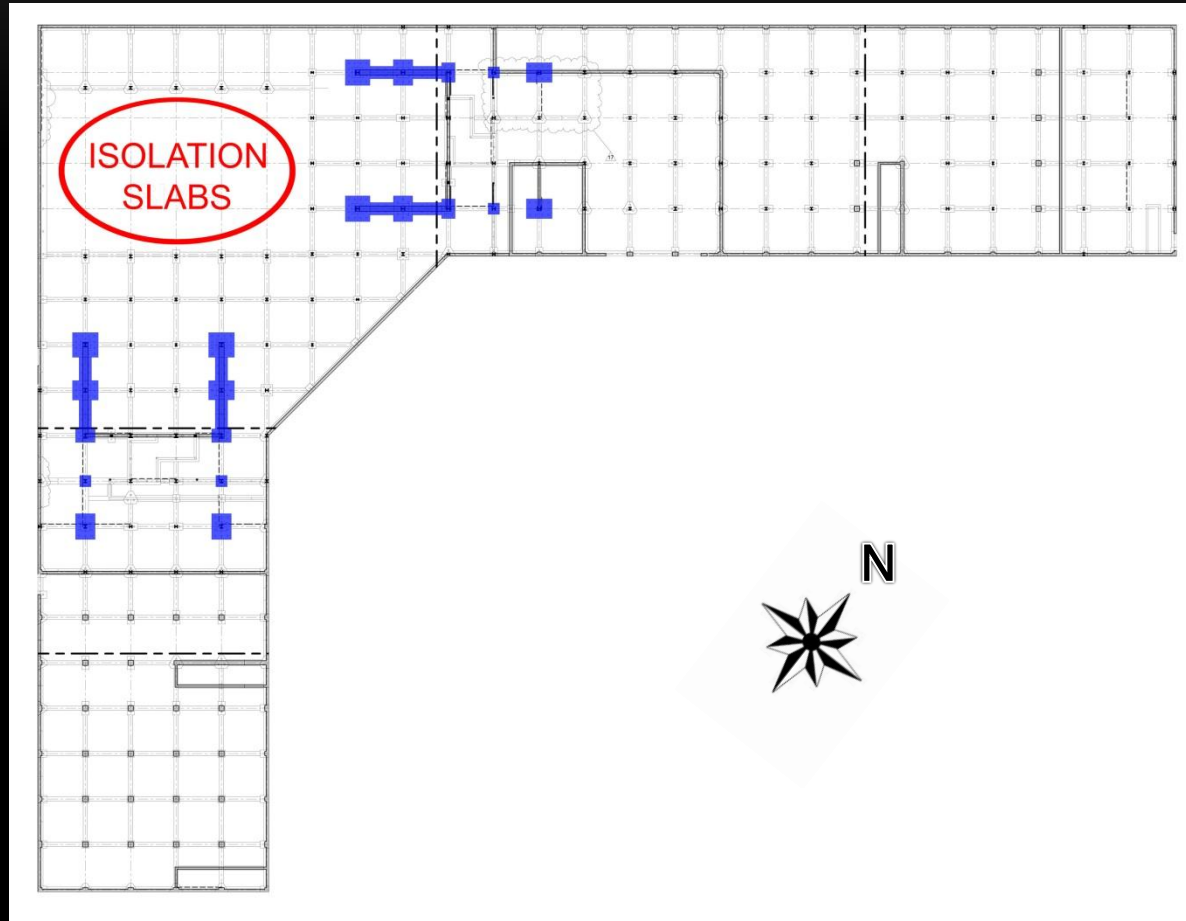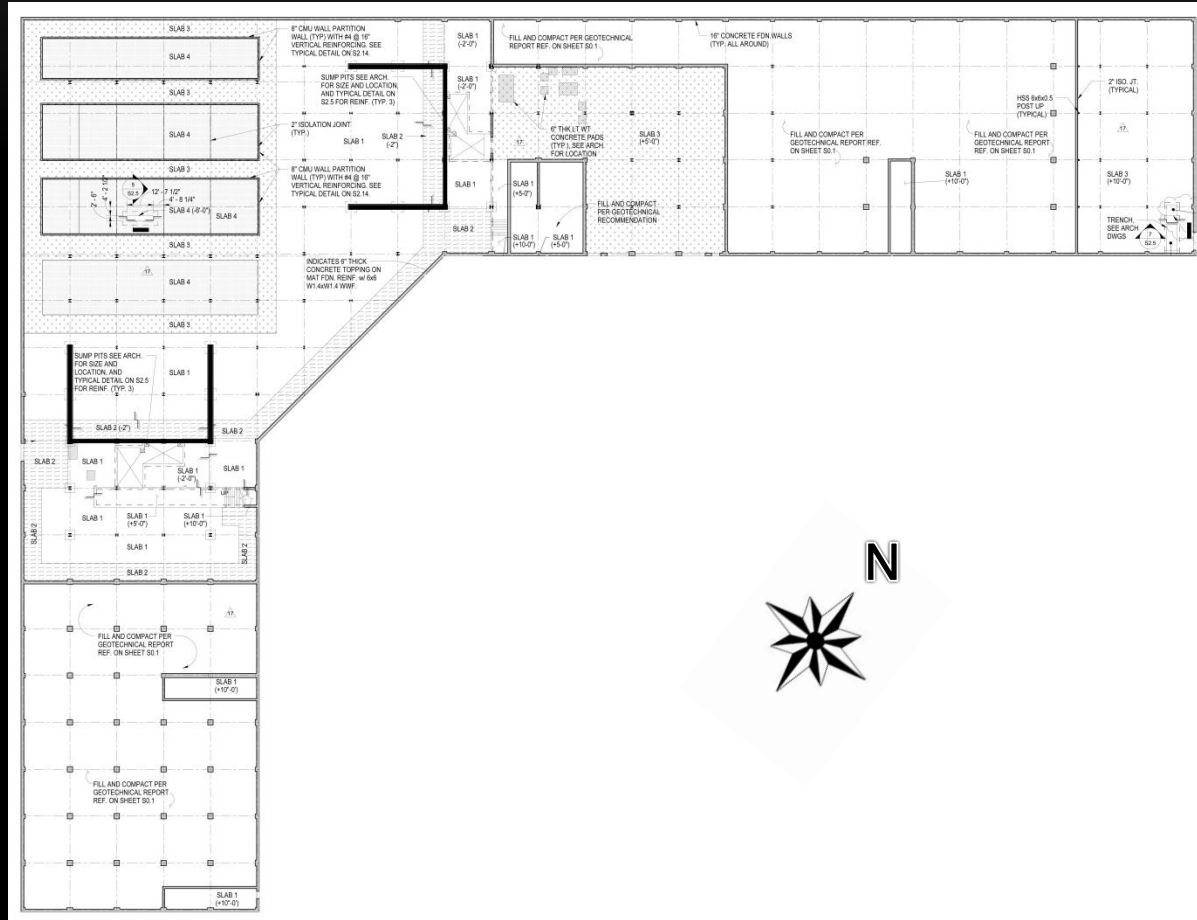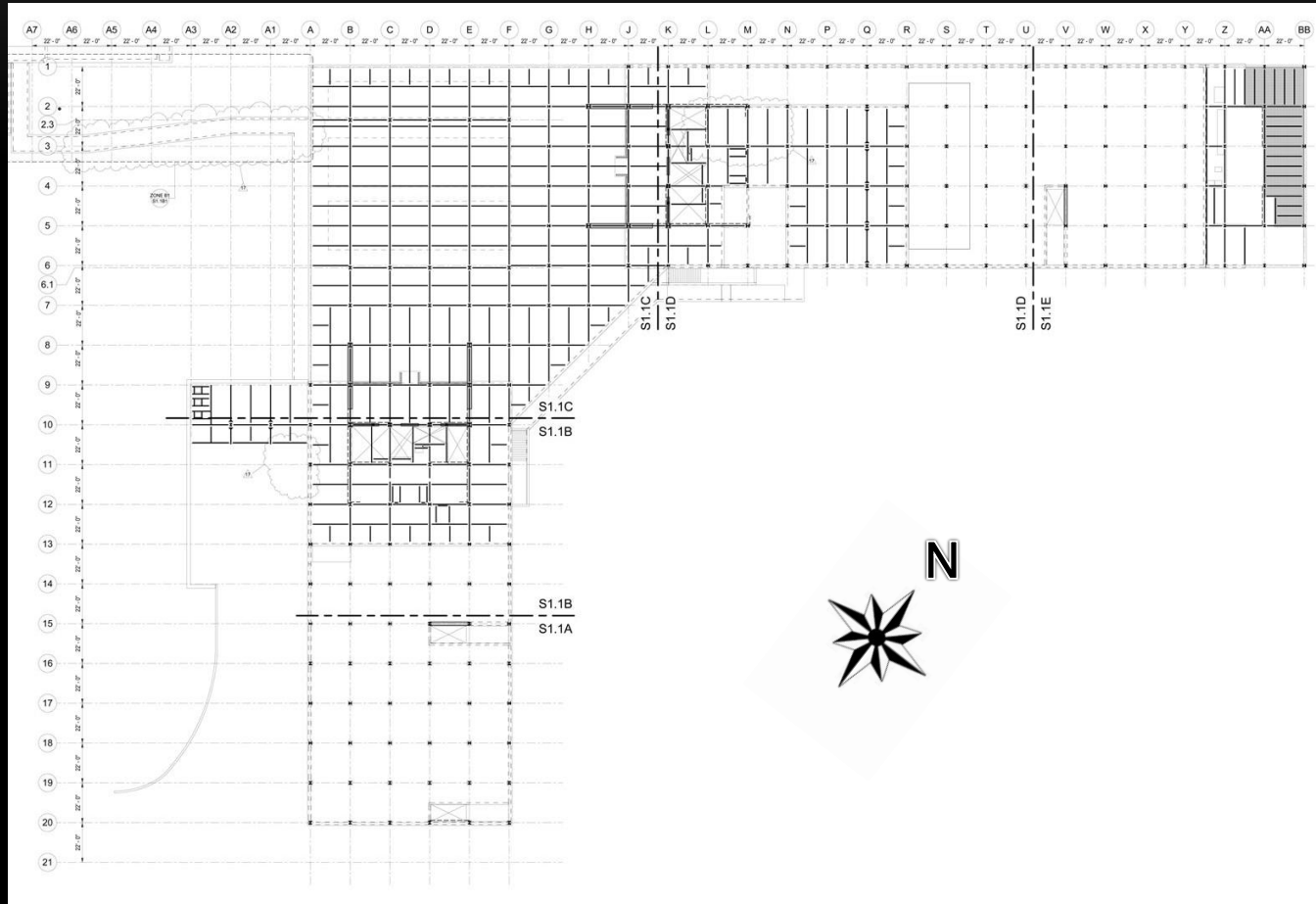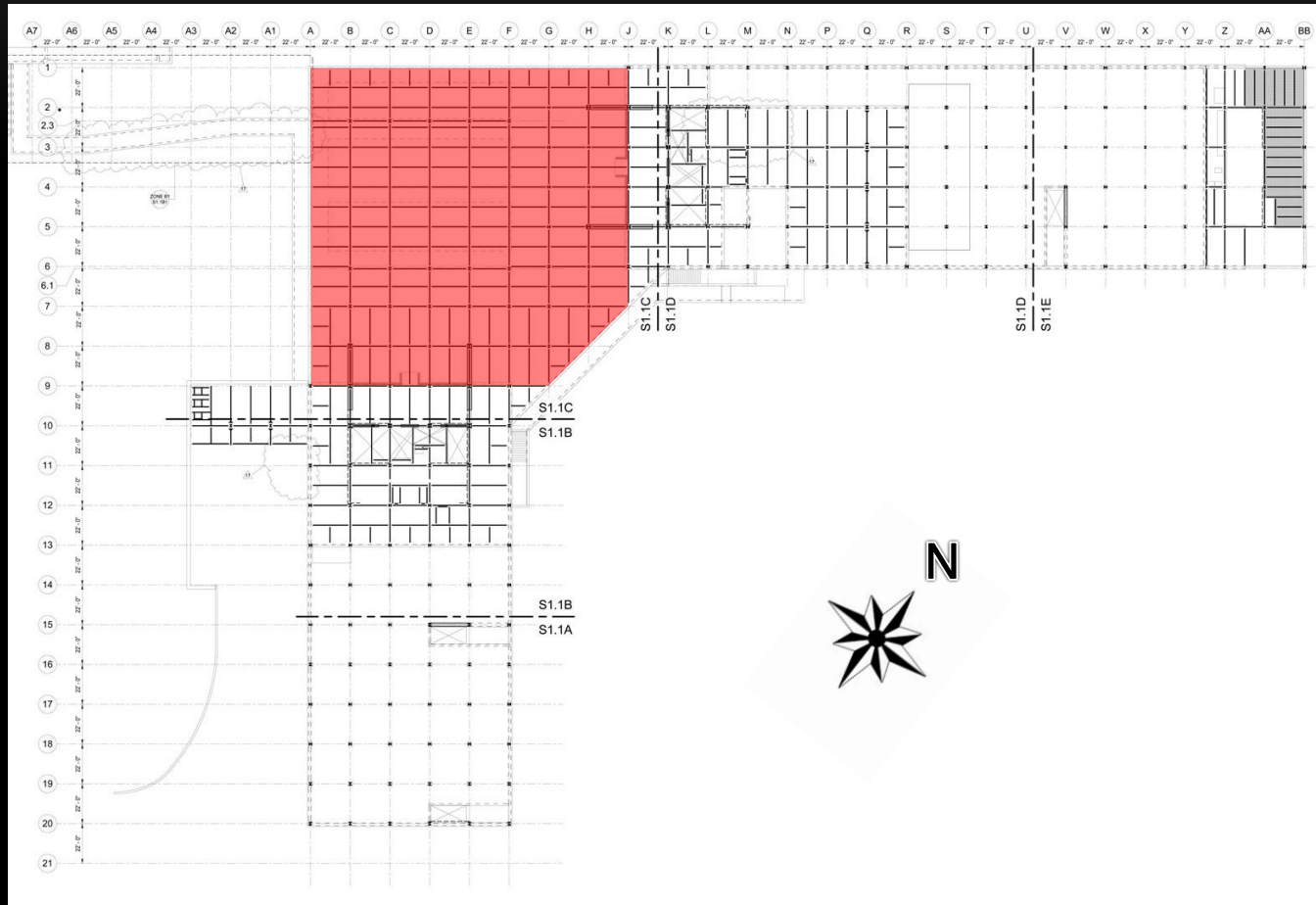
SOUTH EAST PERSPECTIVE

BUILDING LEVELS
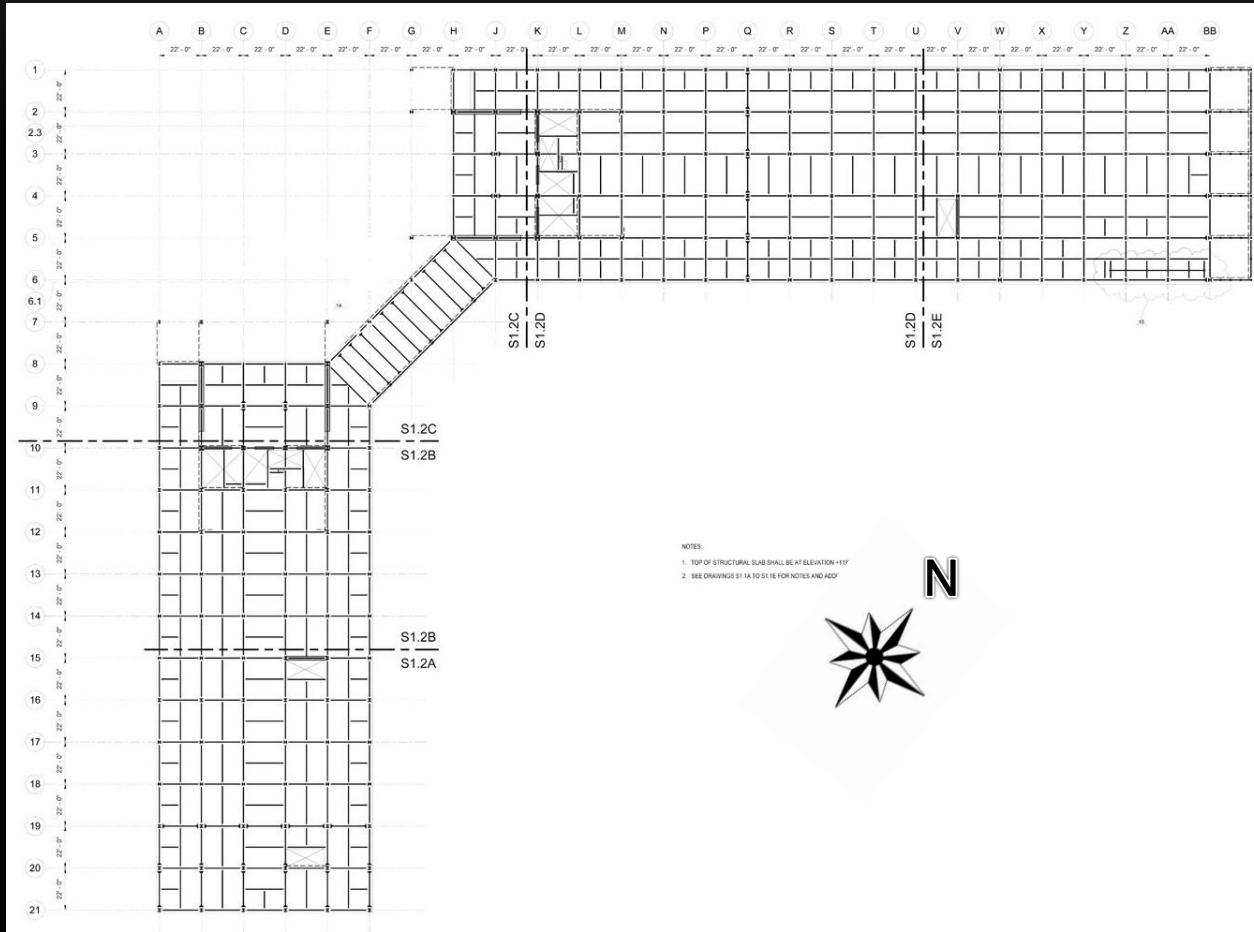
FOUNDATION

BASEMENT

BASEMENT

FIRST FLOOR

FIRST FLOOR

SECOND FLOOR

COMPOSITE DECKS
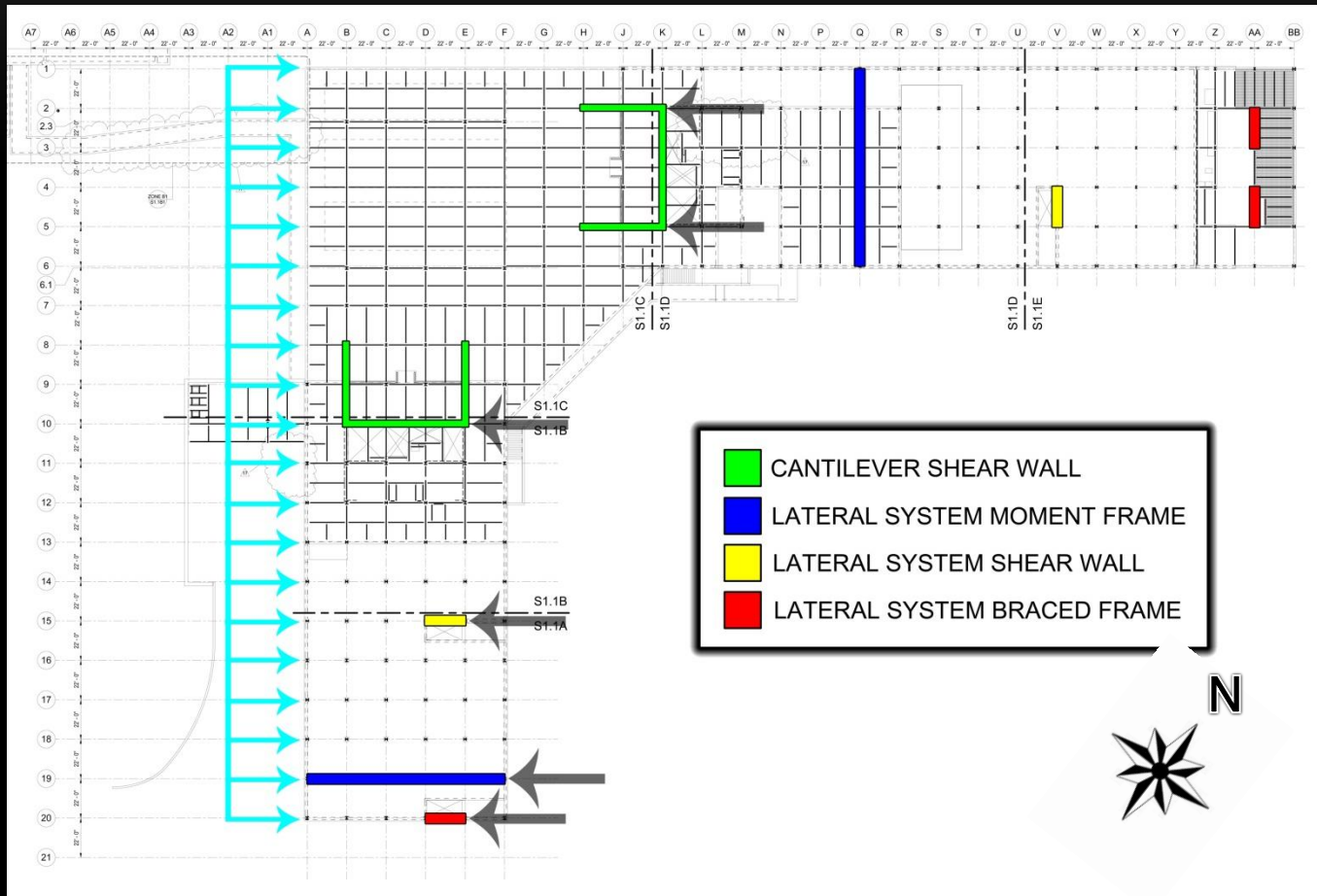

6.25" LWT CONC. DECKING

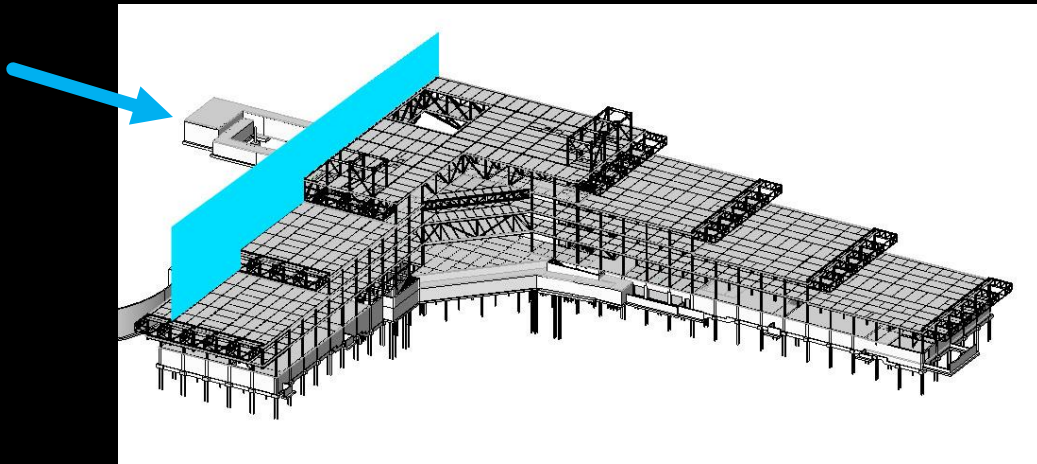7.5" NWT CONC. DECKING
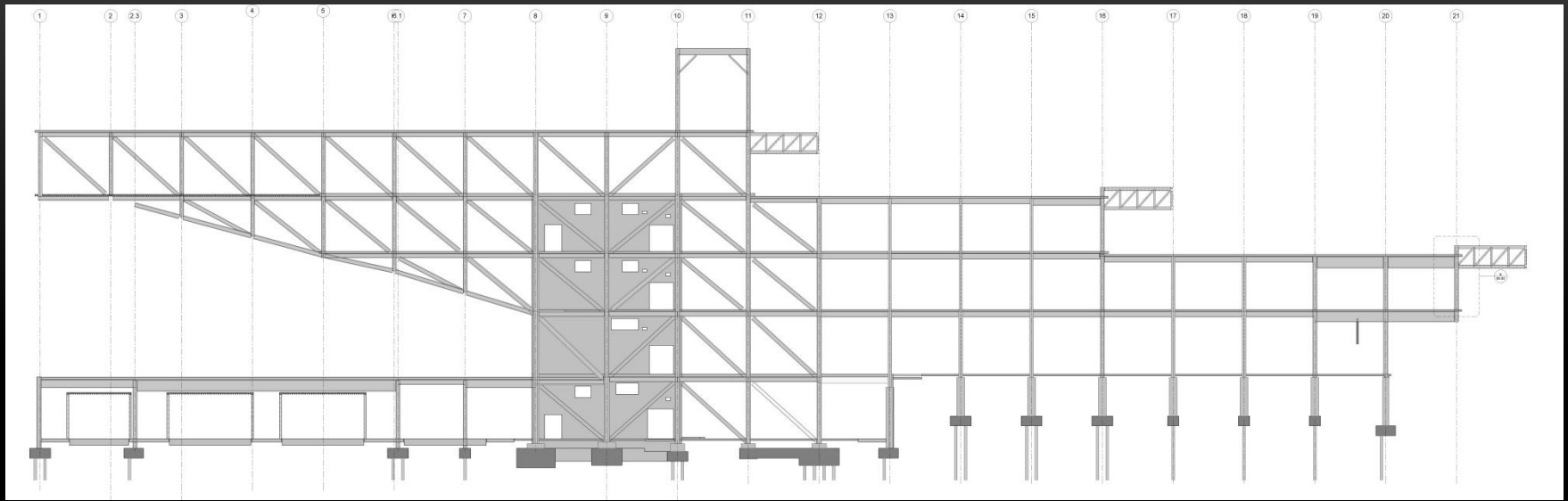
FOOTPRINT OF CANTILEVER

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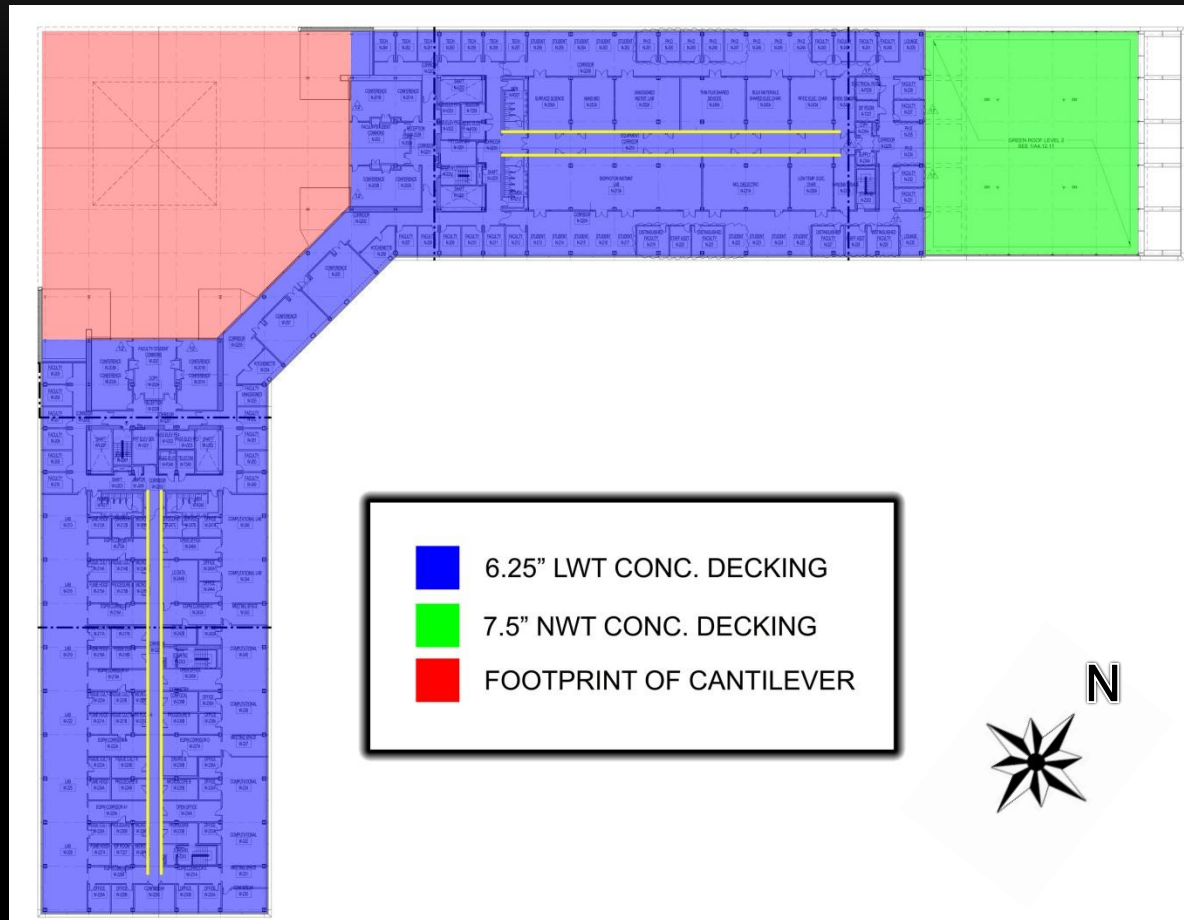
THIRD FLOOR

MECHANICAL PENTHOUSE

ROOF
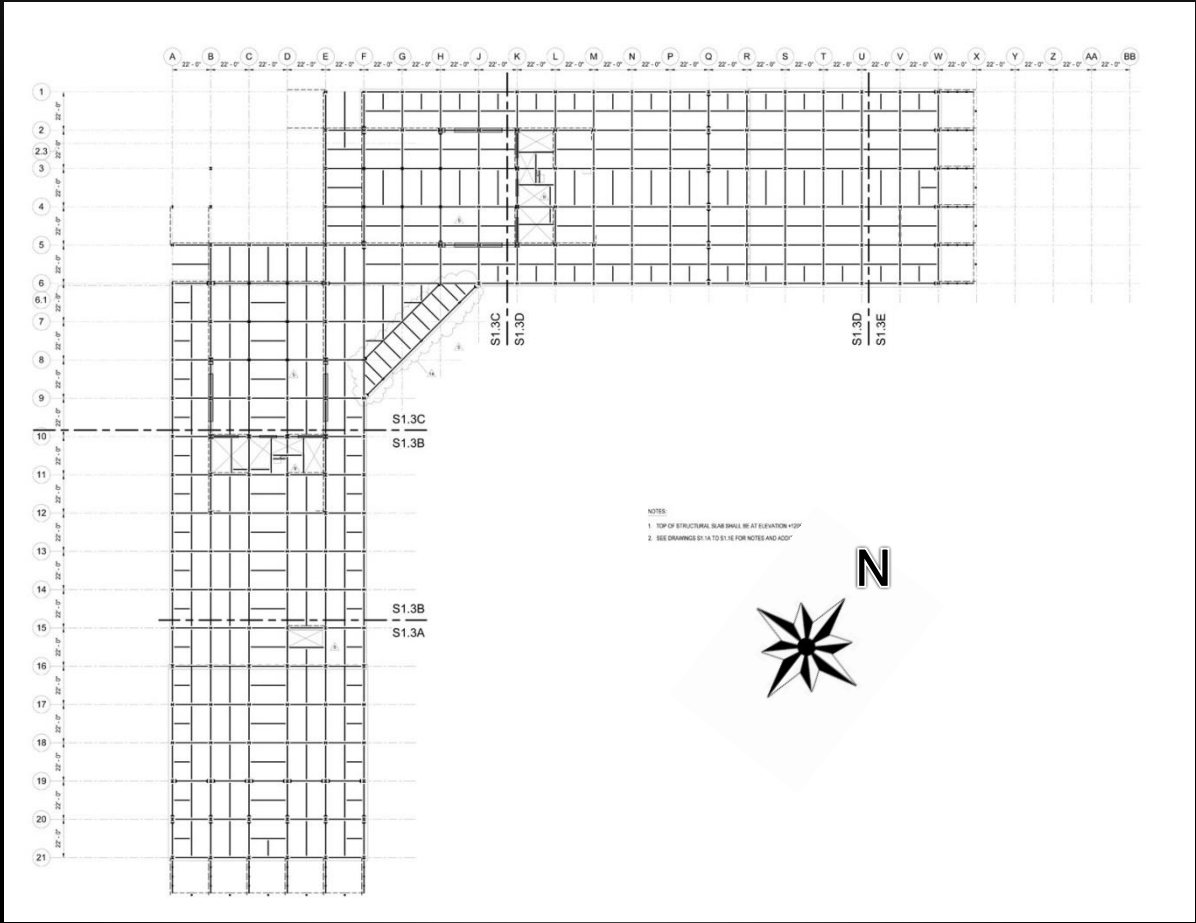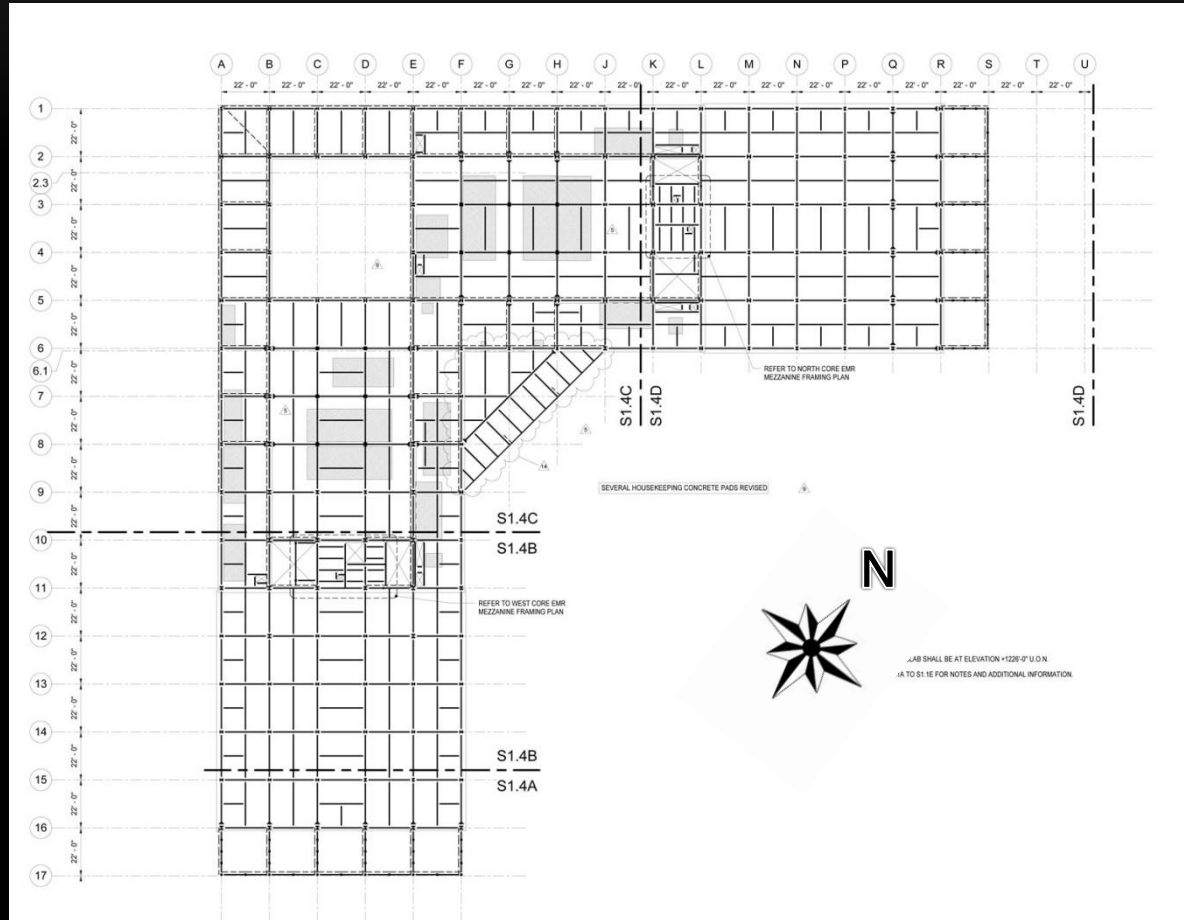
LATERAL SYSTEM & SPECIAL SYSTEMS

CANTILEVER SHEAR WALL

LATERAL SYSTEM MOMENT FRAME
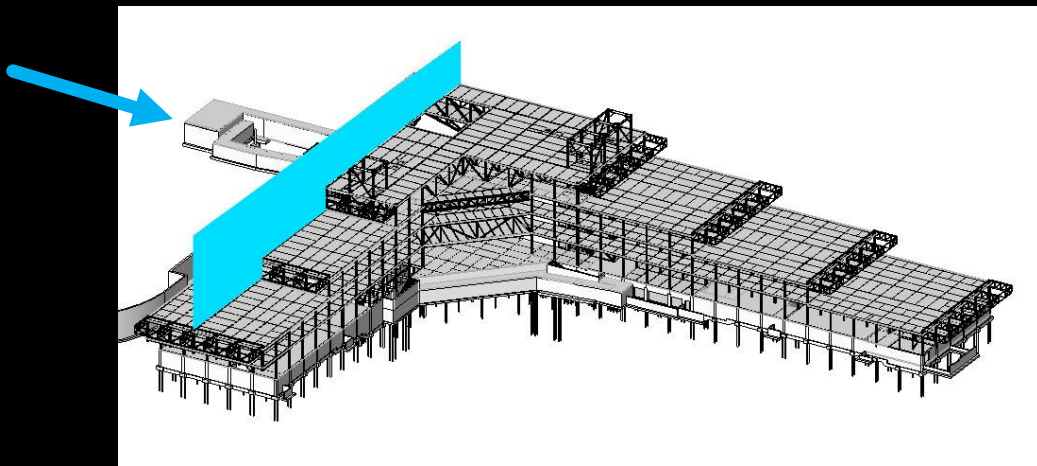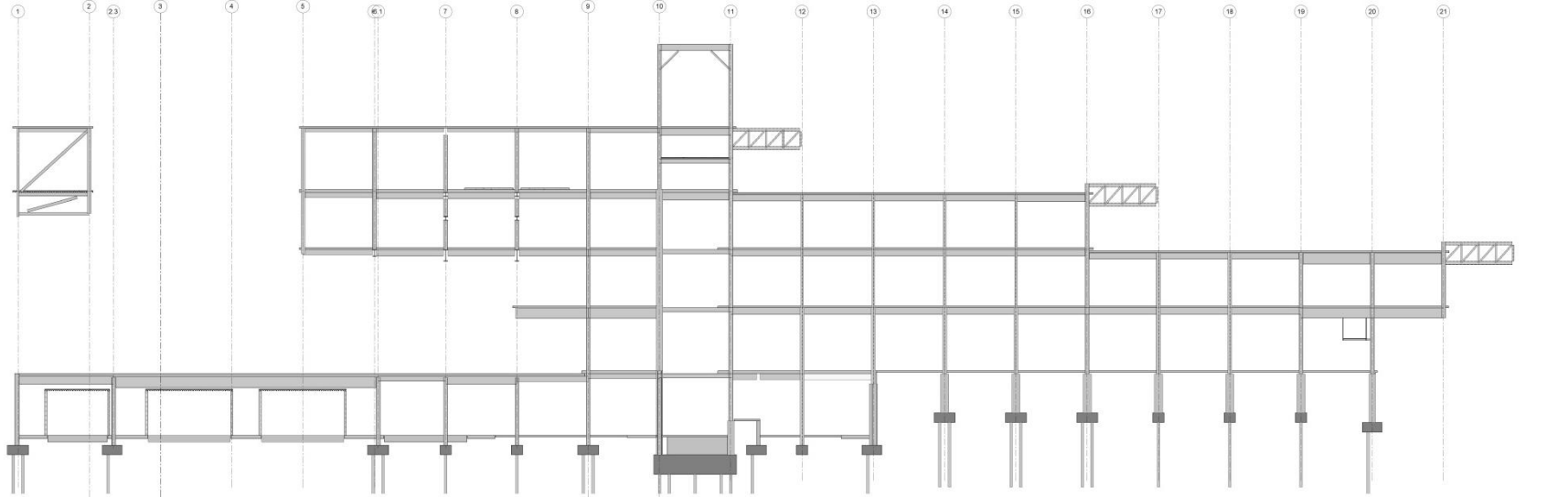
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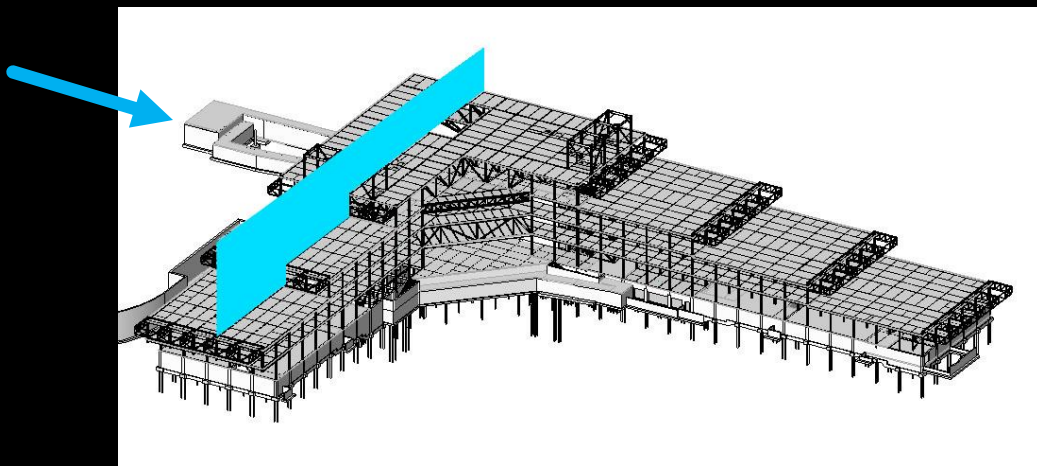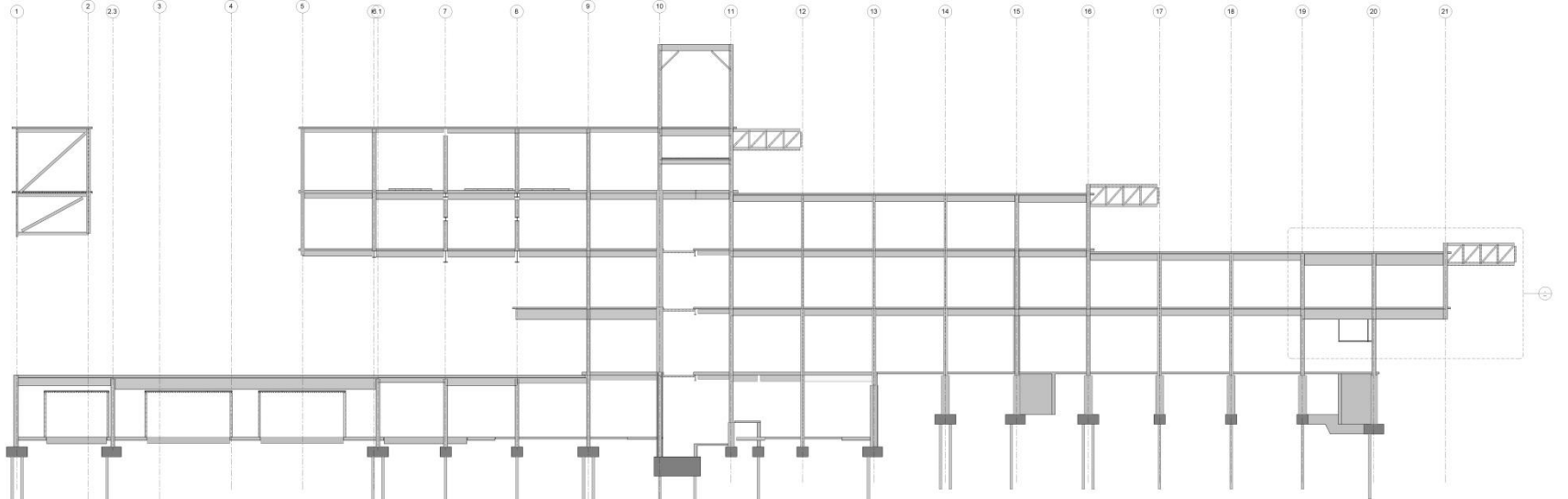
LATERAL SYSTEM BRACED FRAME
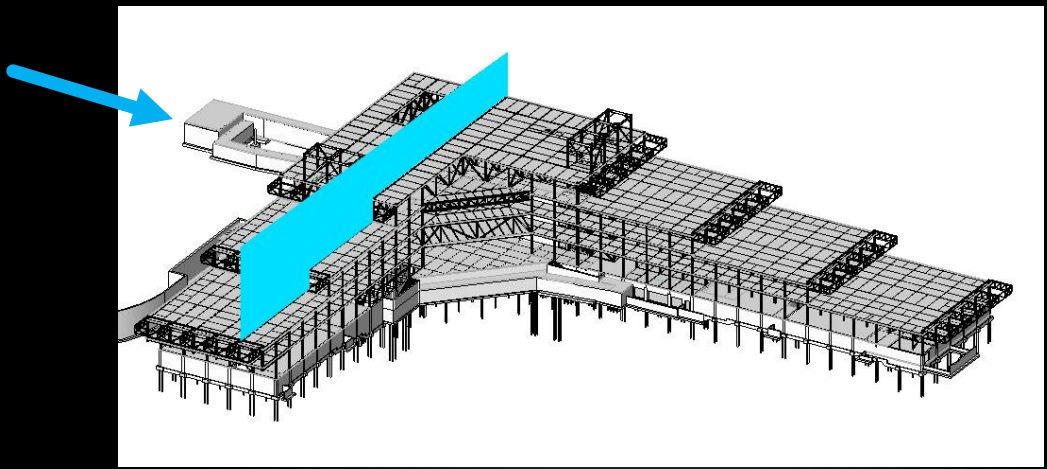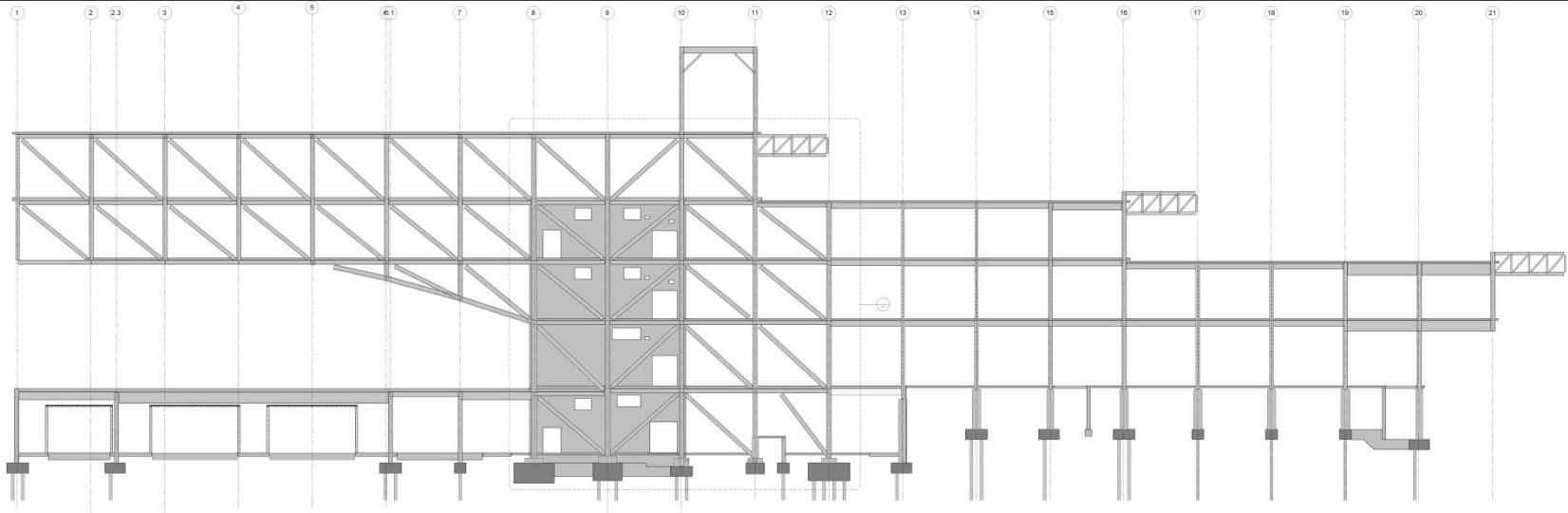
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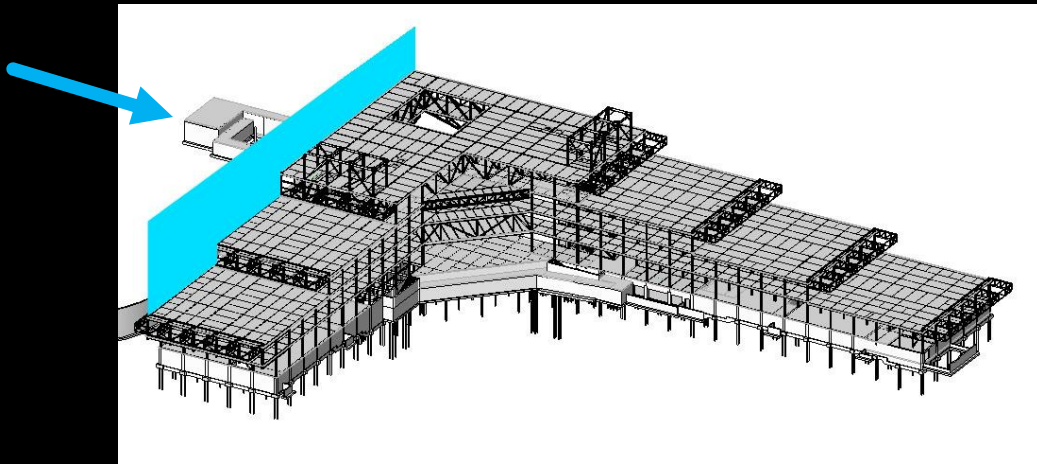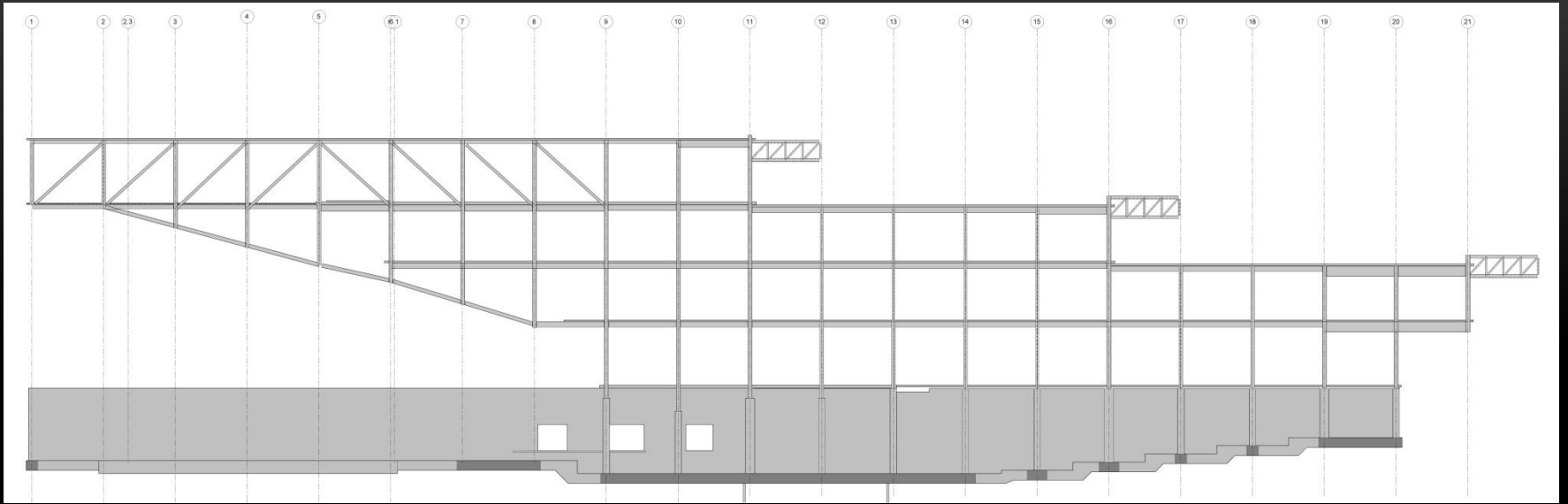
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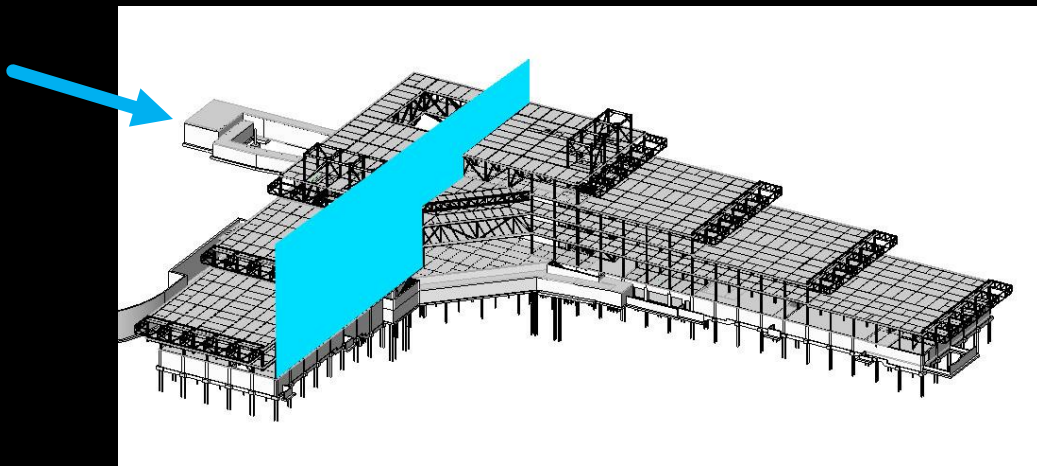
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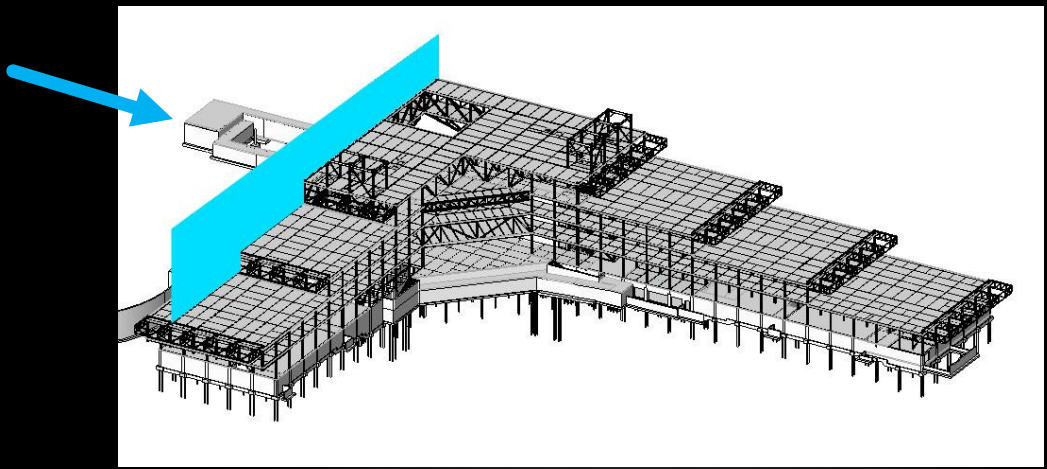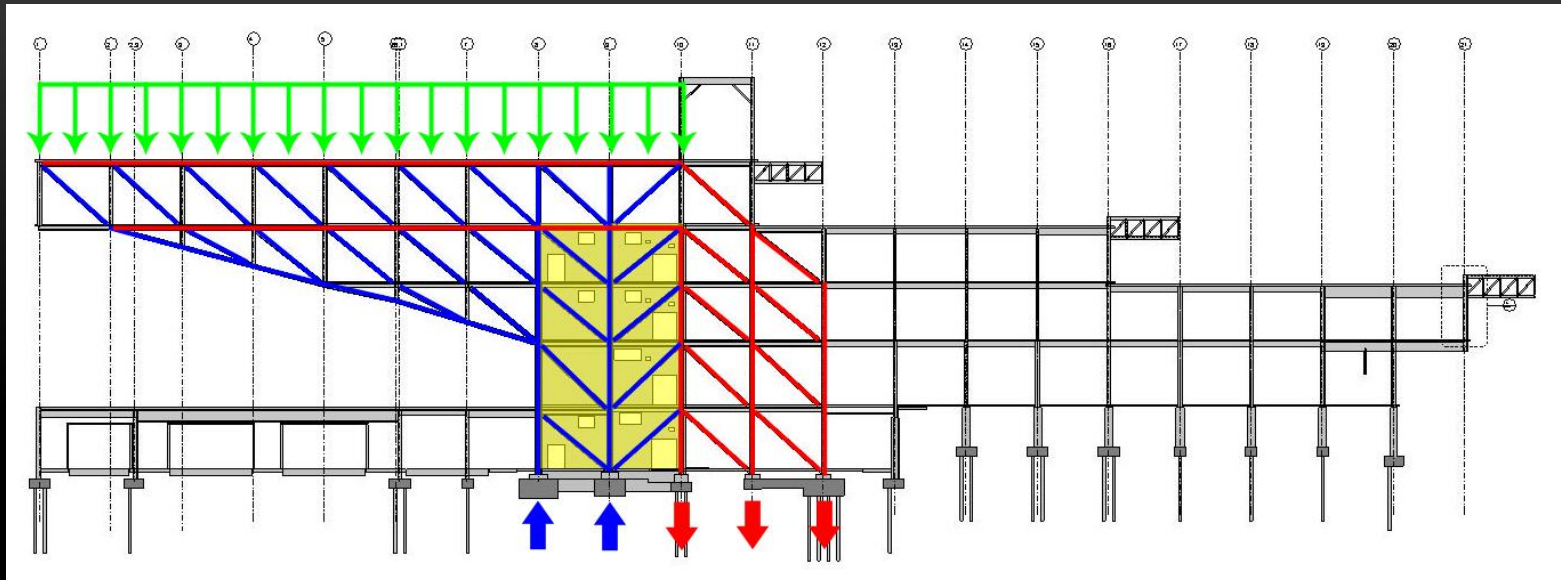
Frame – B (Looking East)

Frame – C (Looking East)

Frame – D (Looking East)

Frame – E (Looking East)
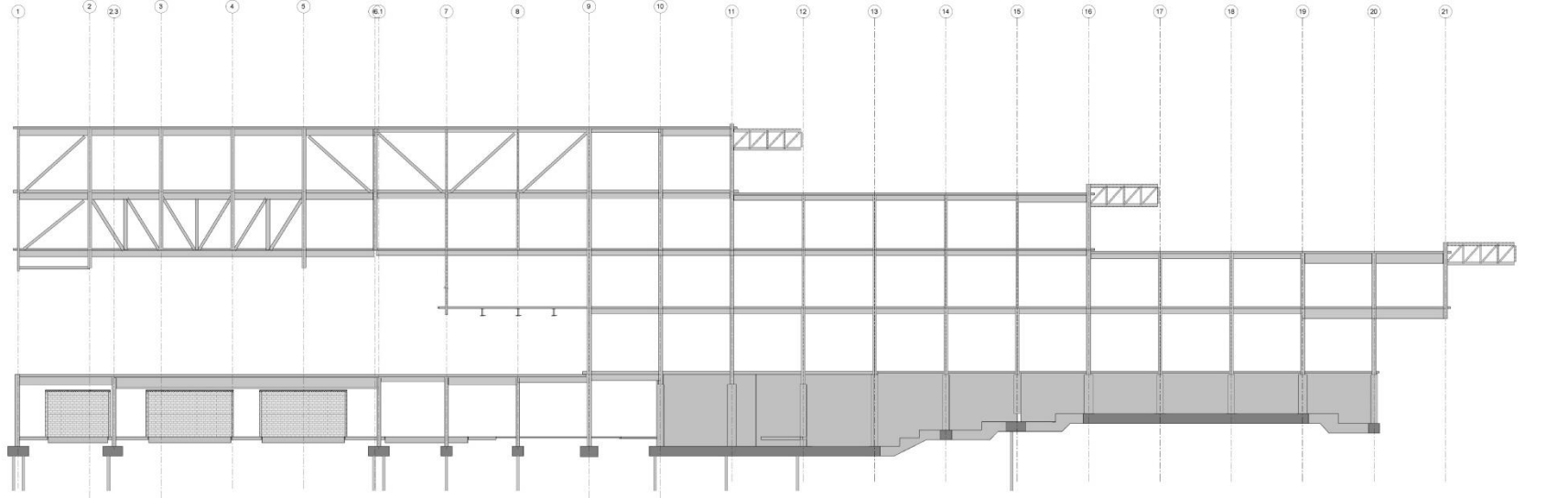
Frame – F (Looking East)

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 g (0.147 g, USGS)
    - S_{ds} = 0.096 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
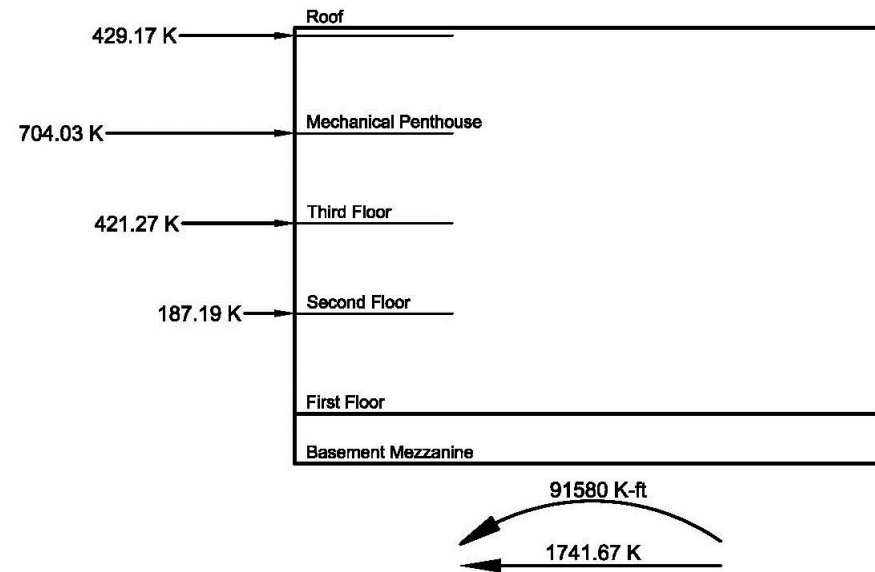
Seismic Loads

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
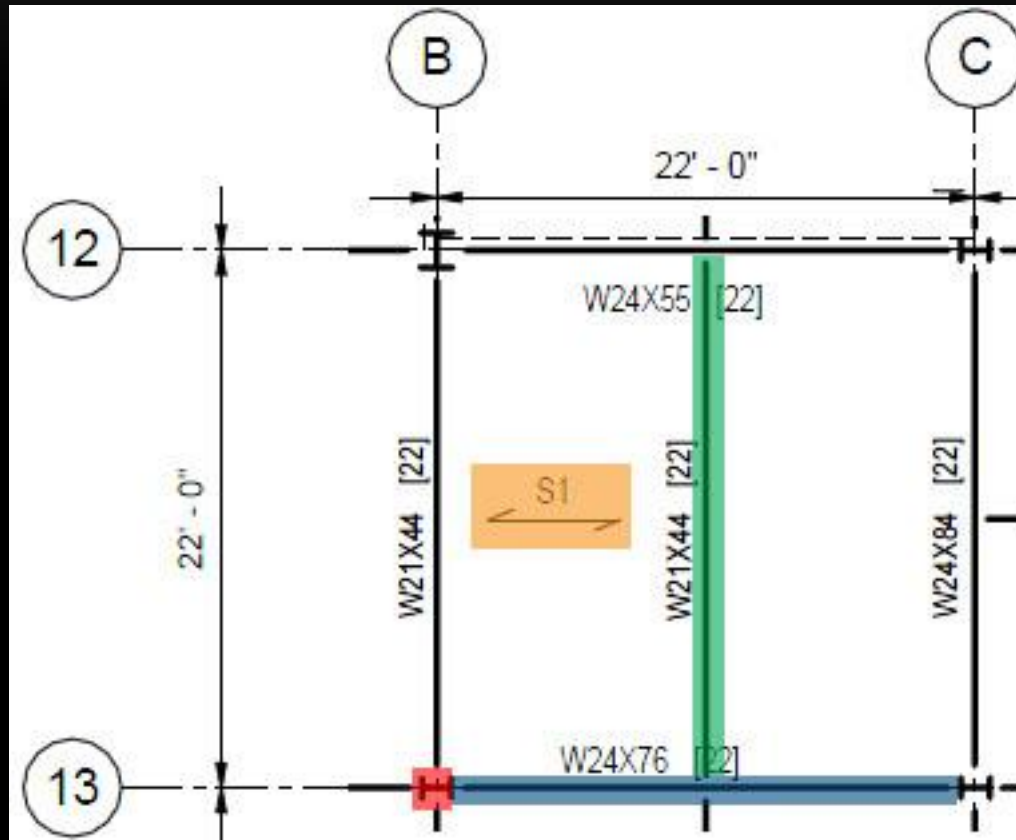
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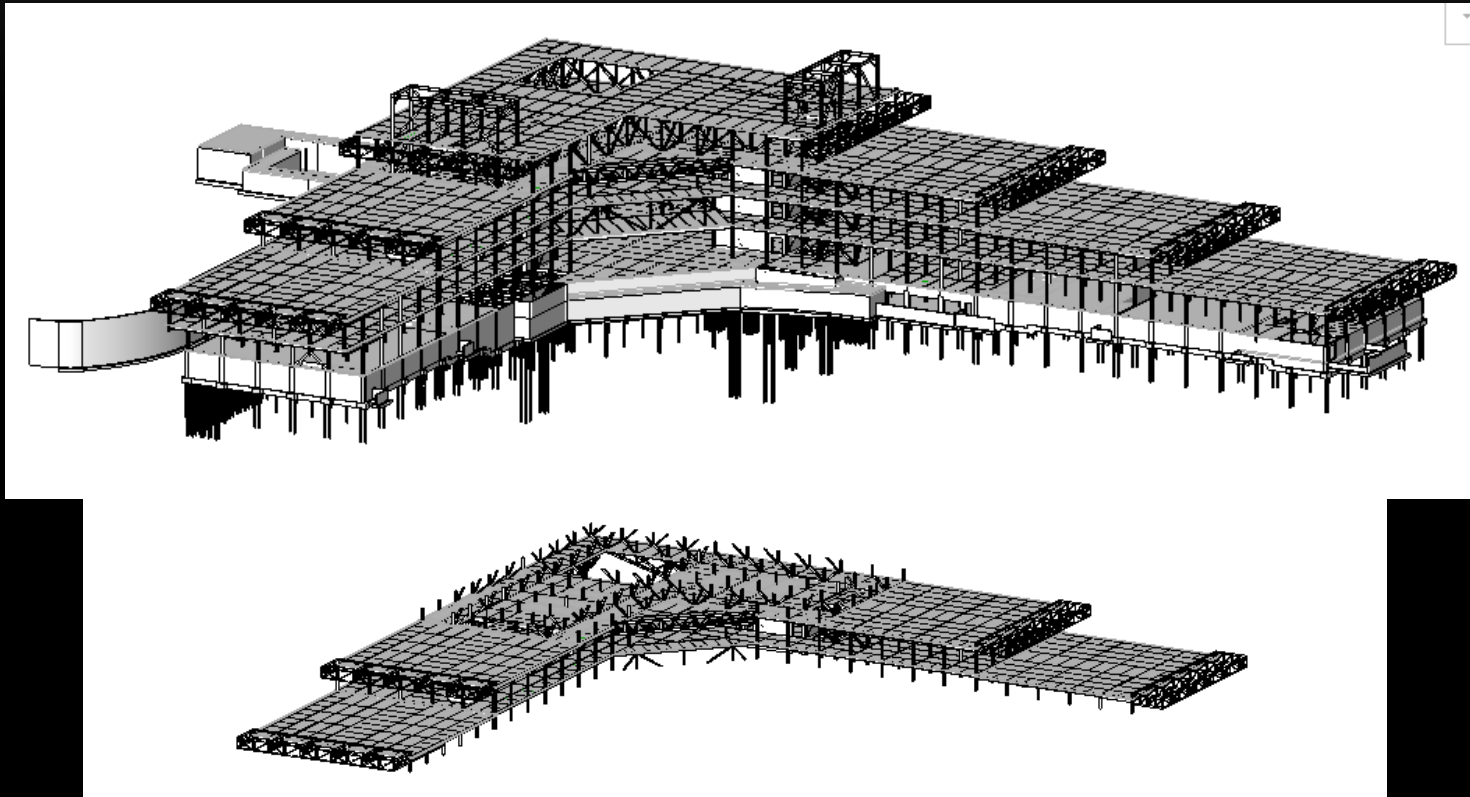
EXISTING MODEL

- Connection Issues

IPD/BIM STRUCTURAL PROCESS

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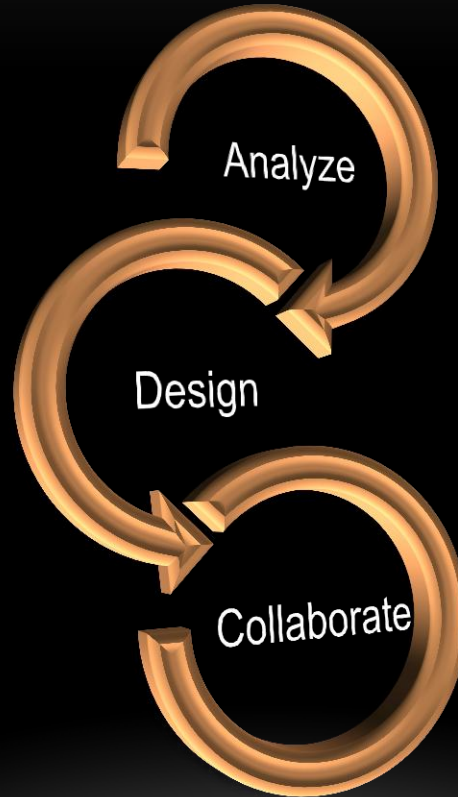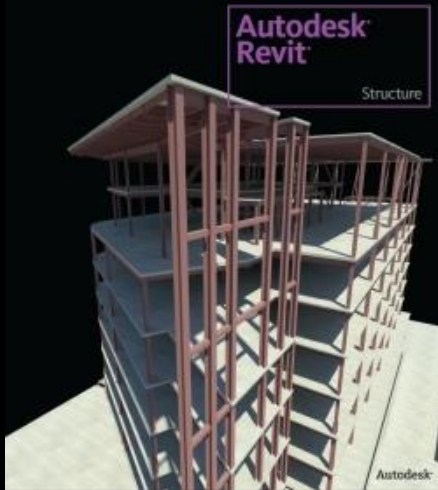
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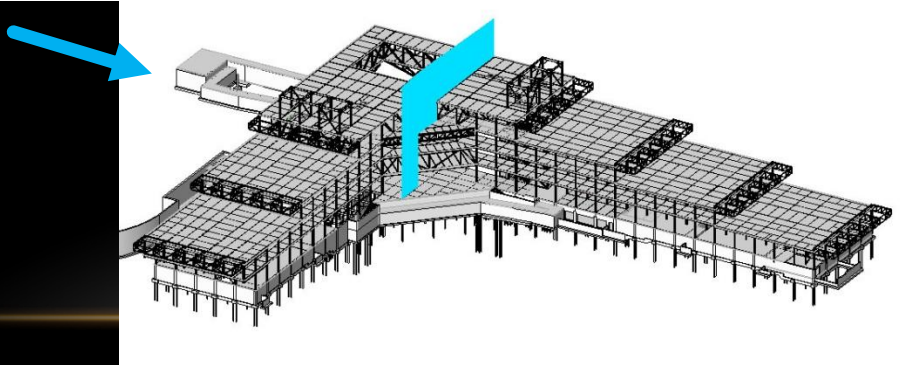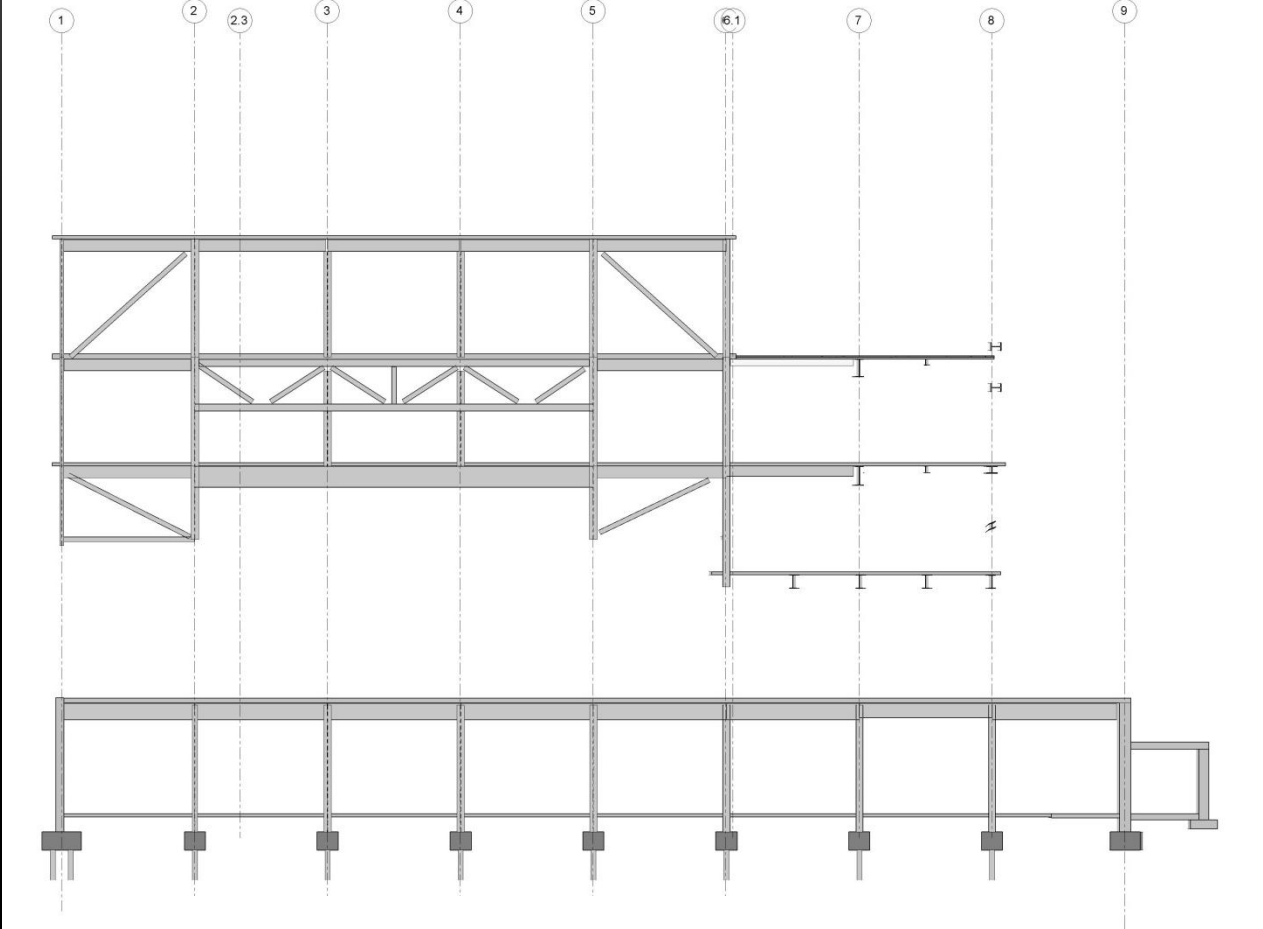
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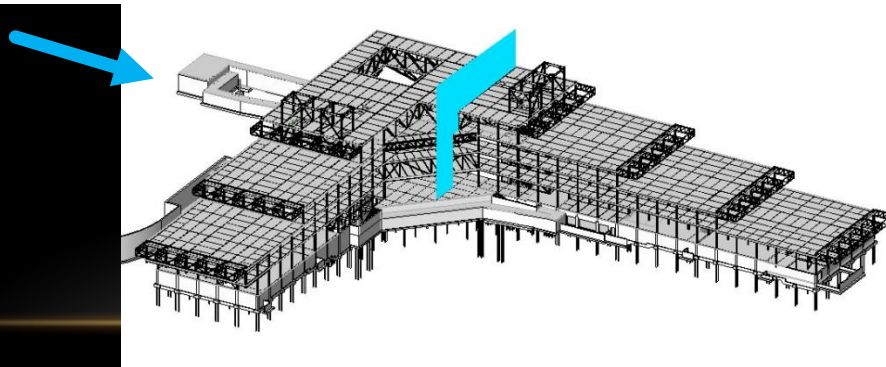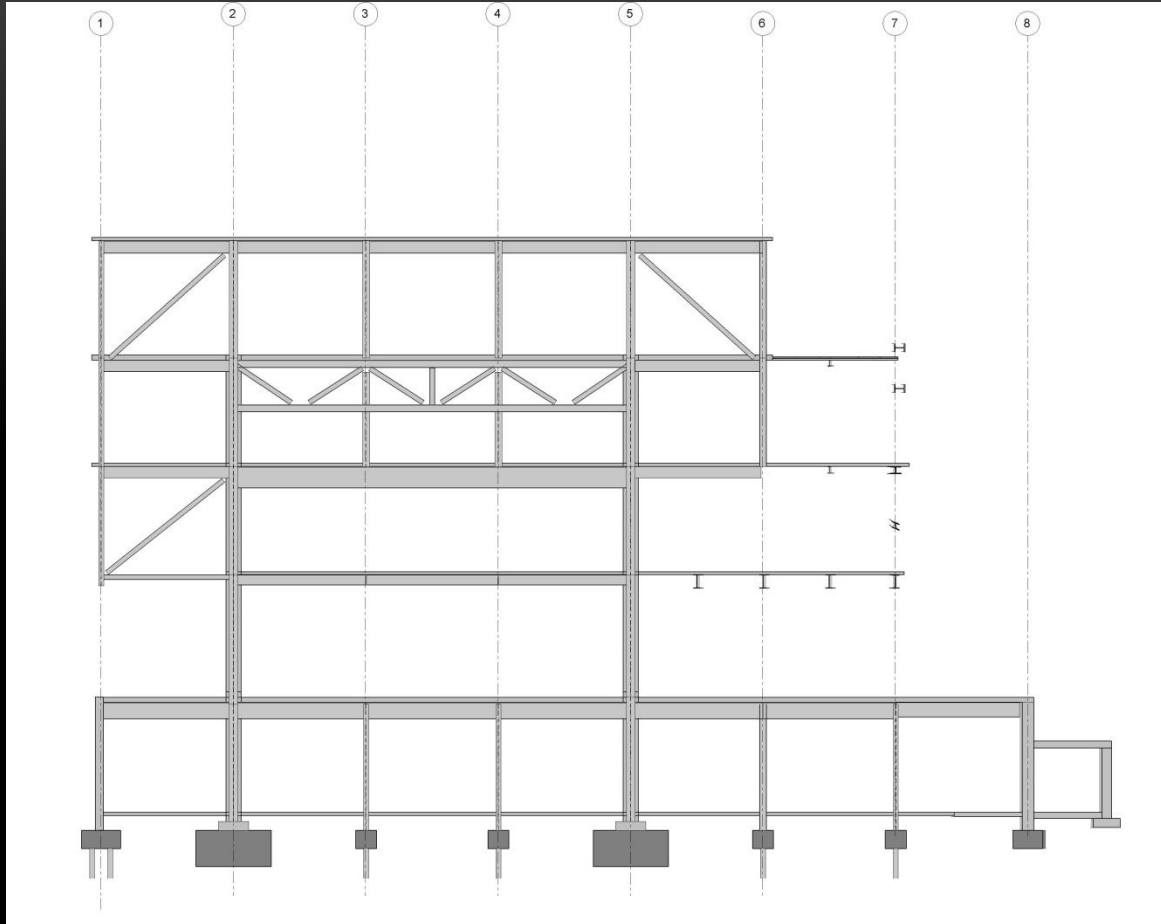
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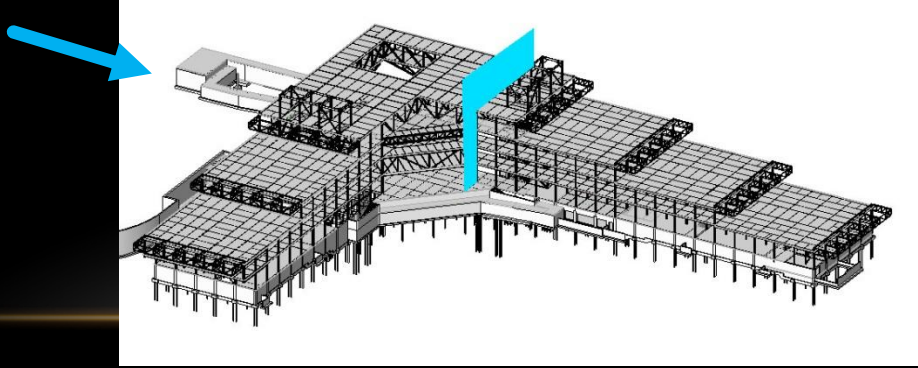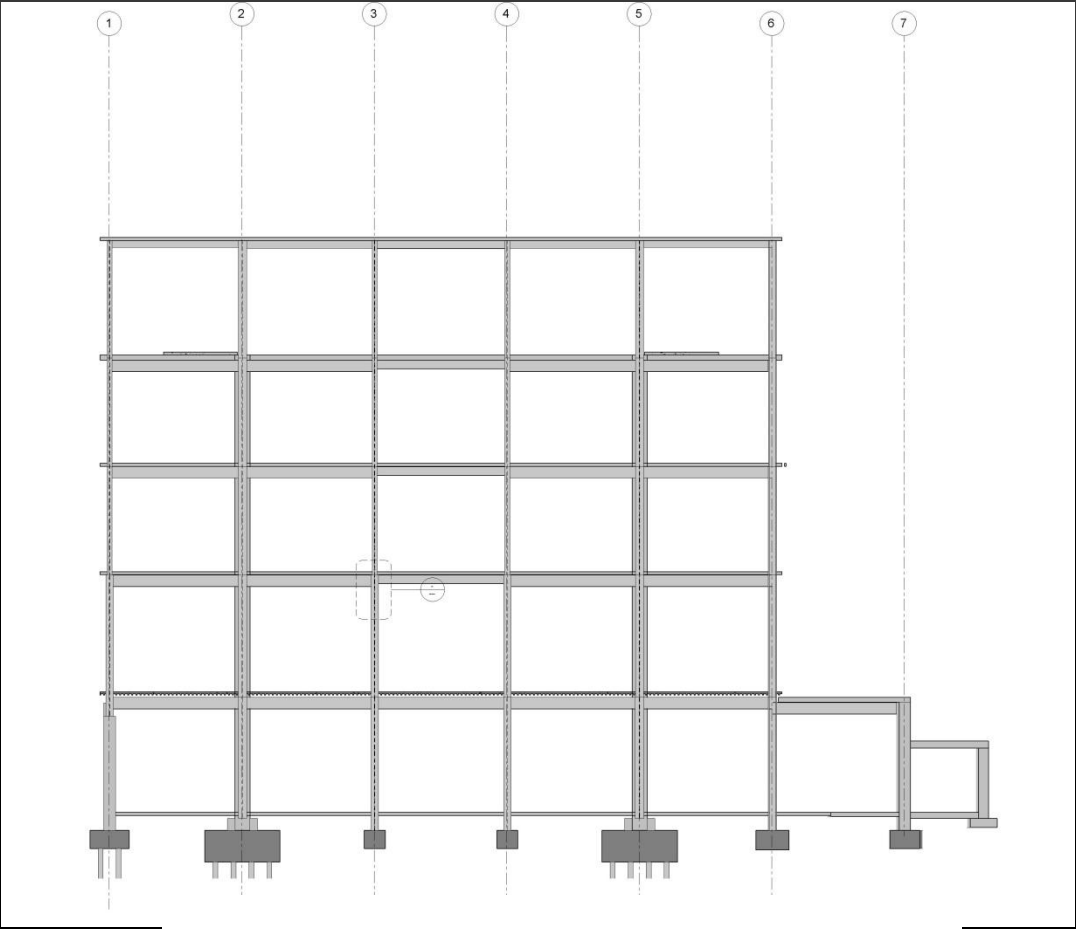
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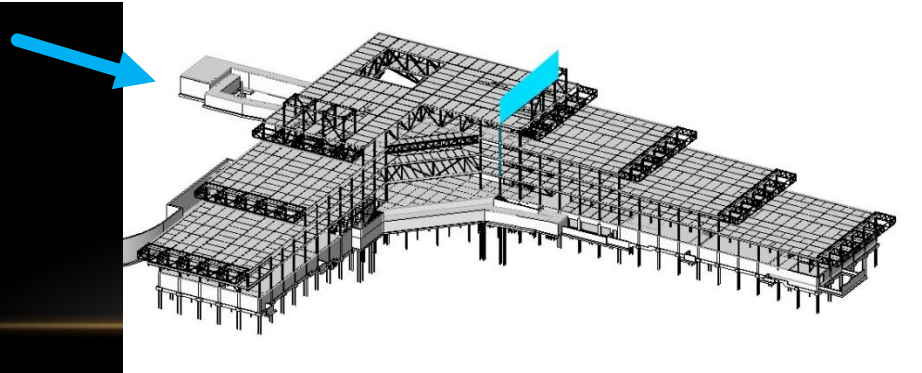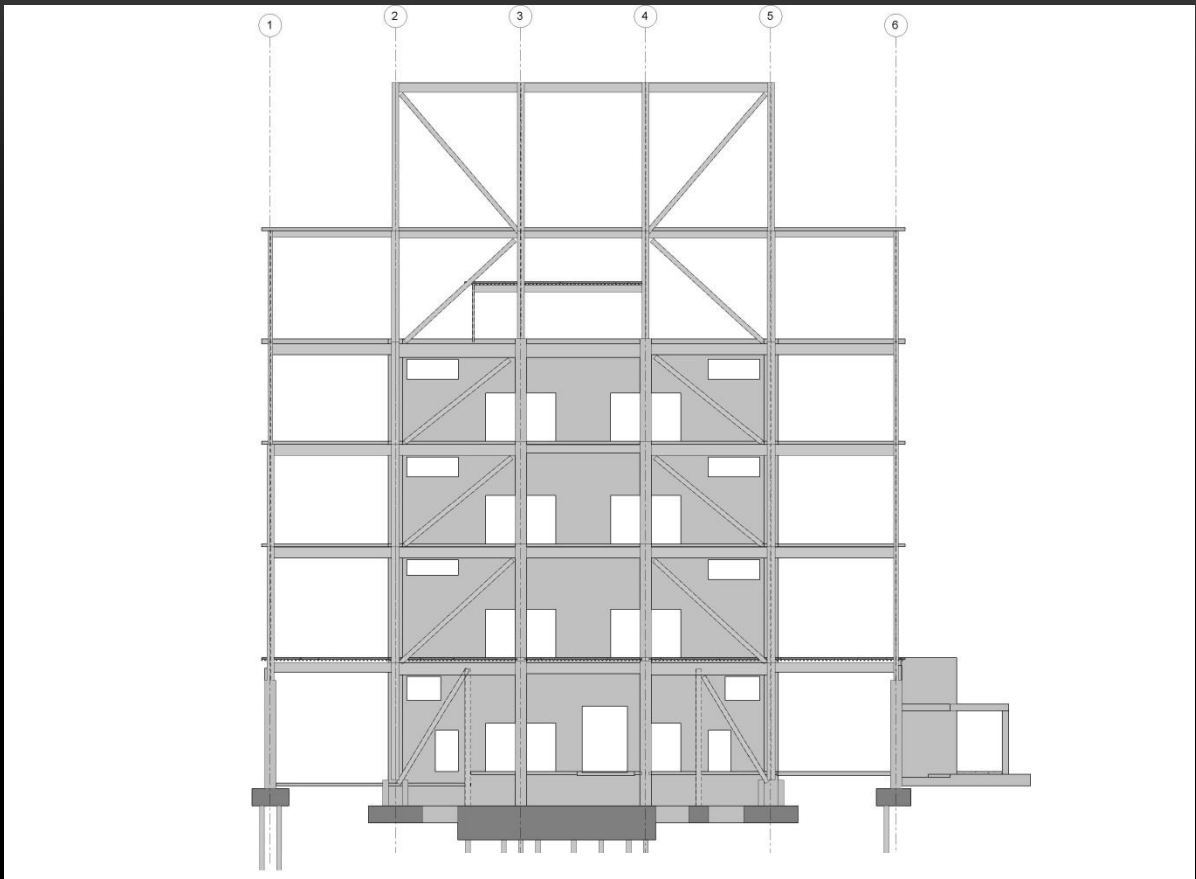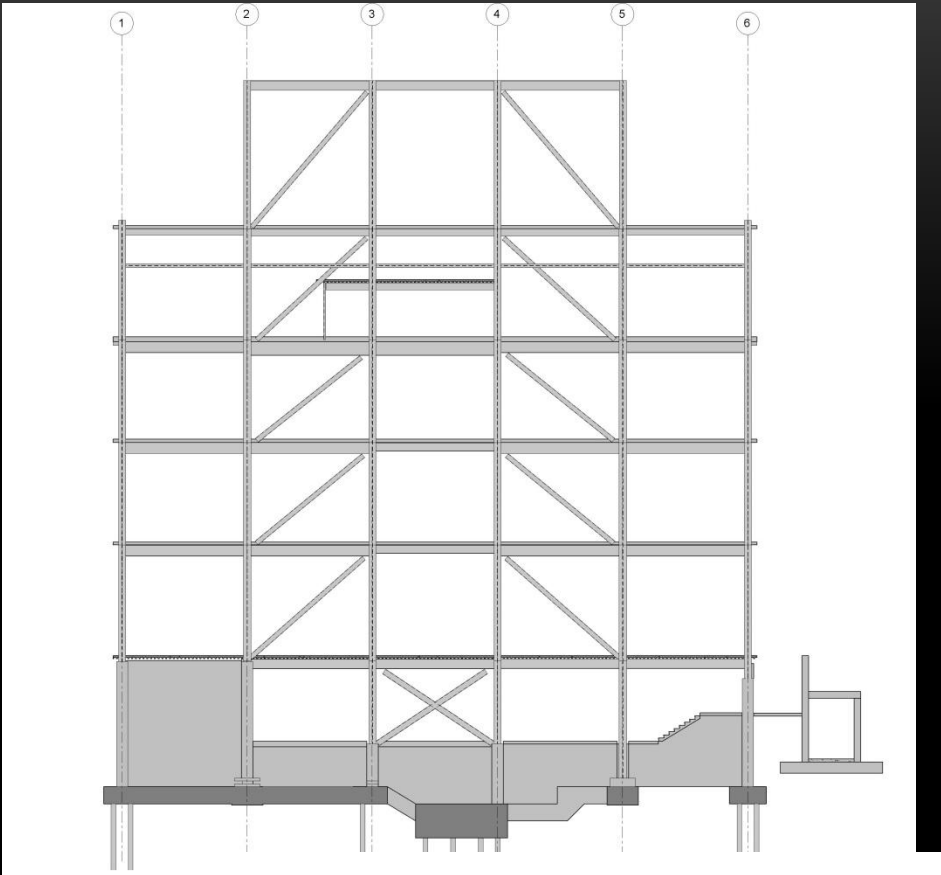
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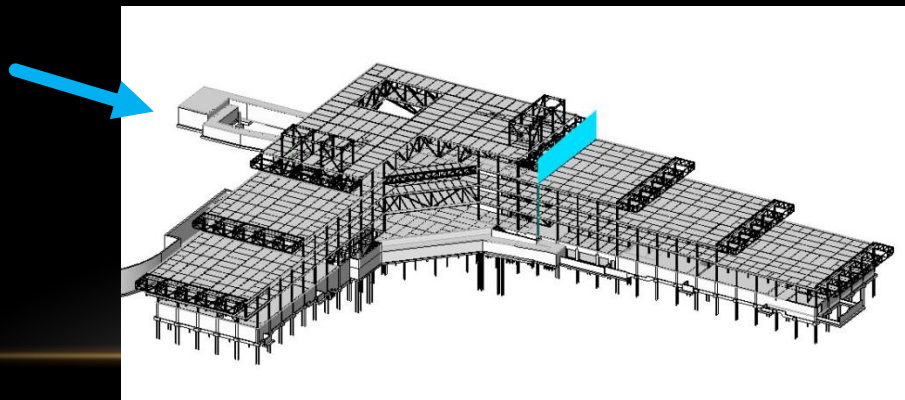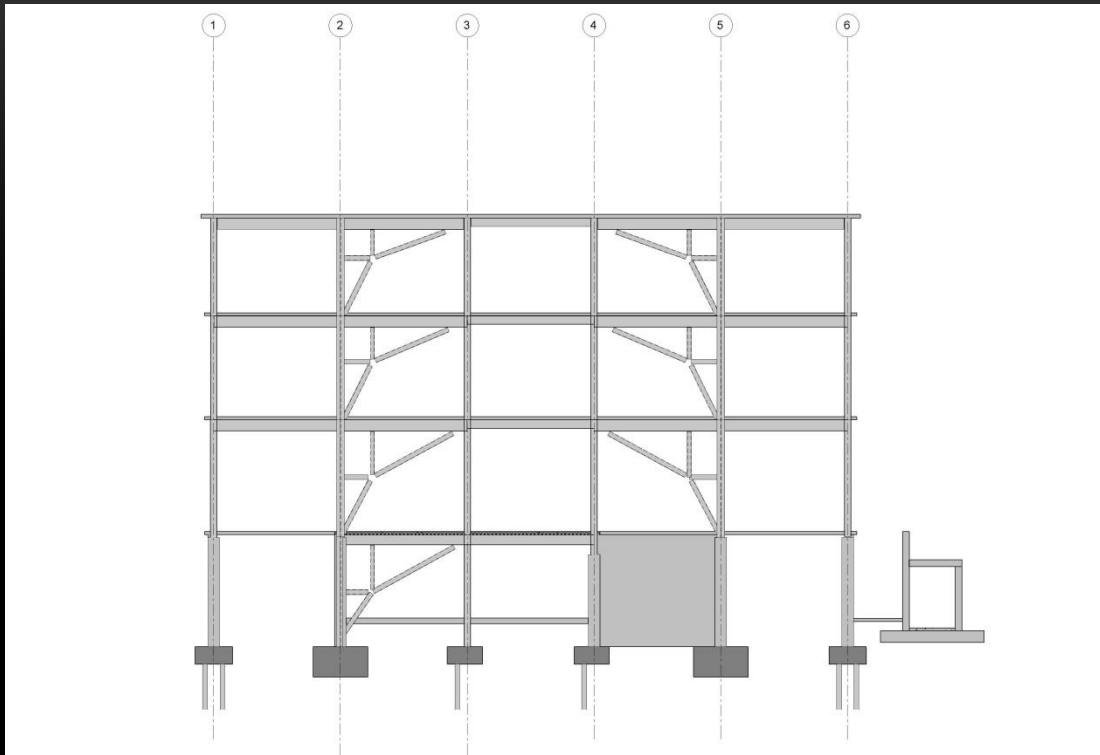
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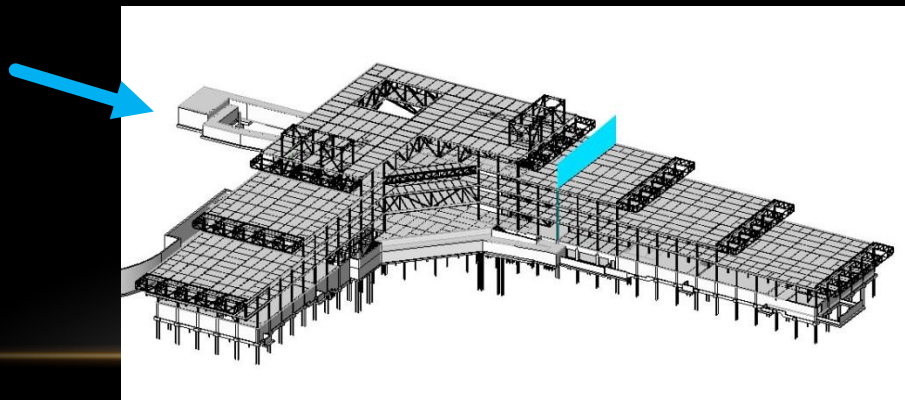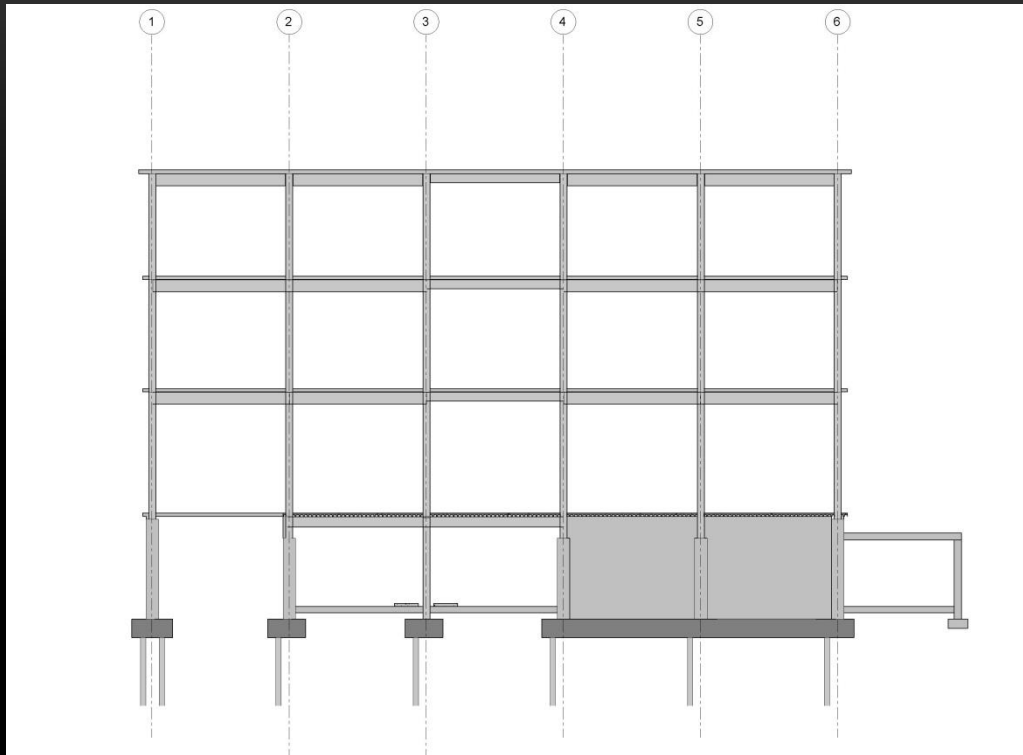
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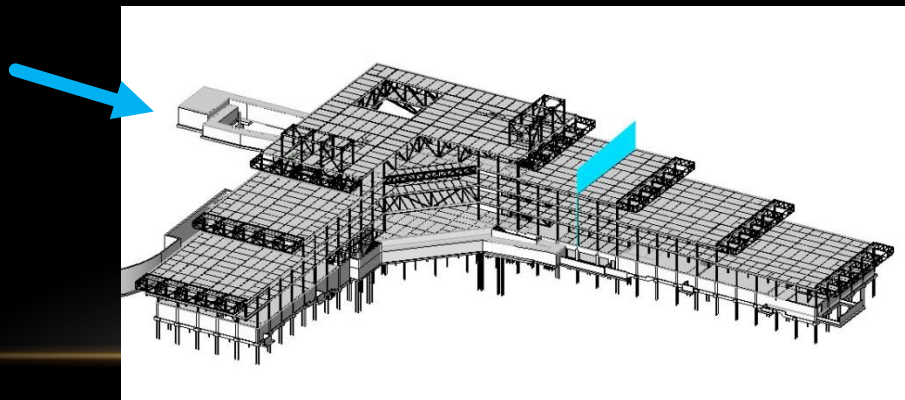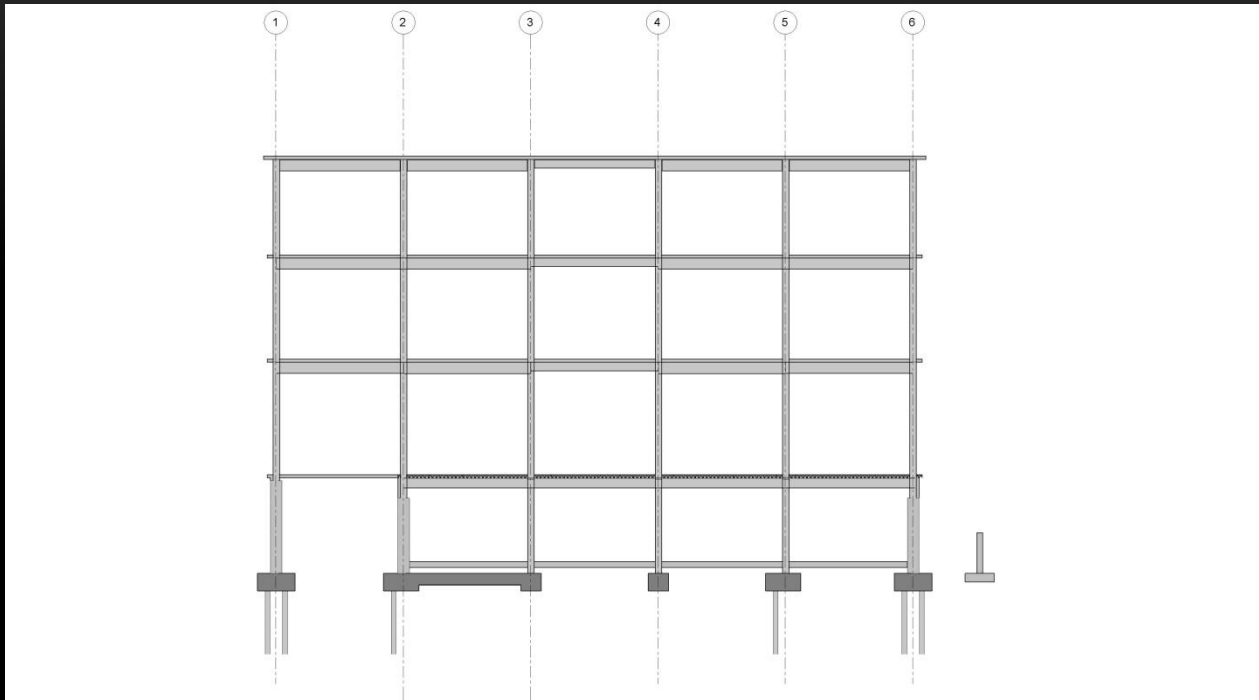
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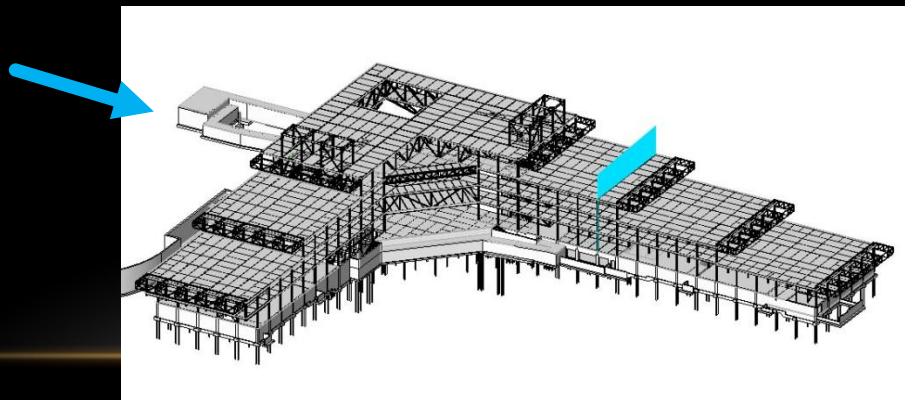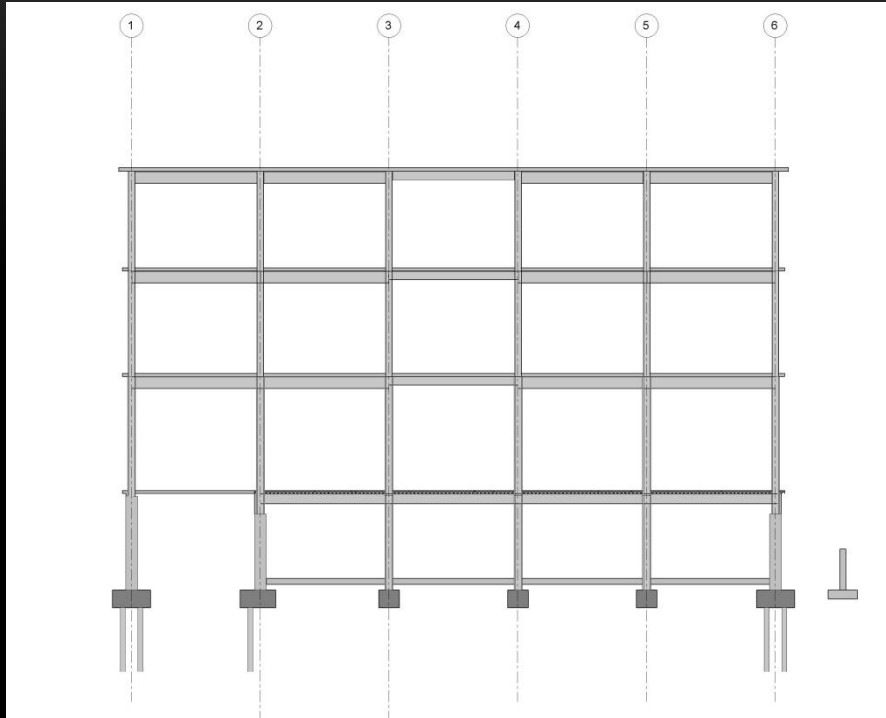
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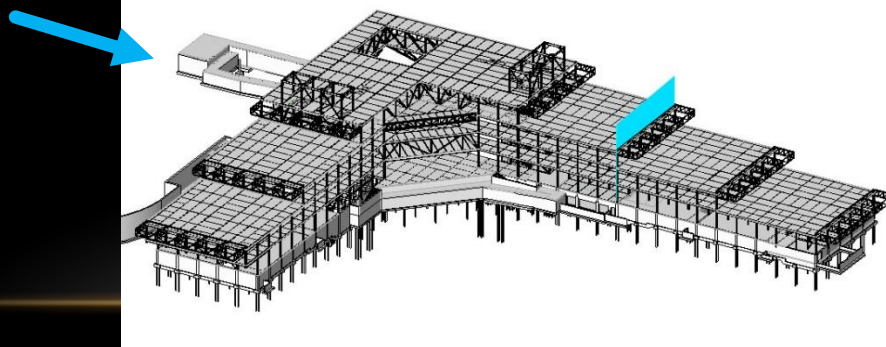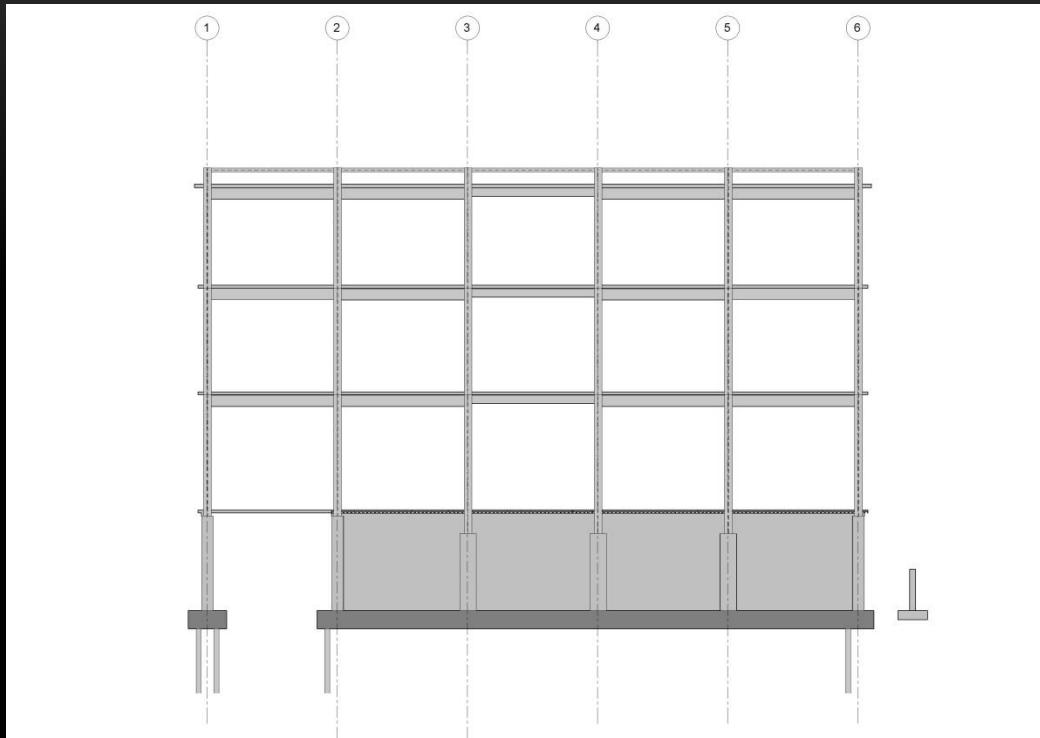
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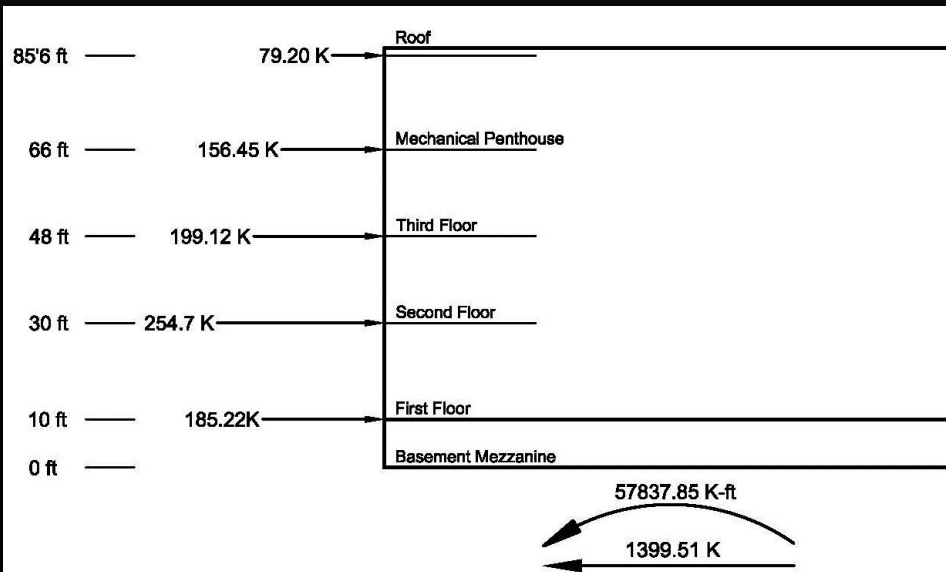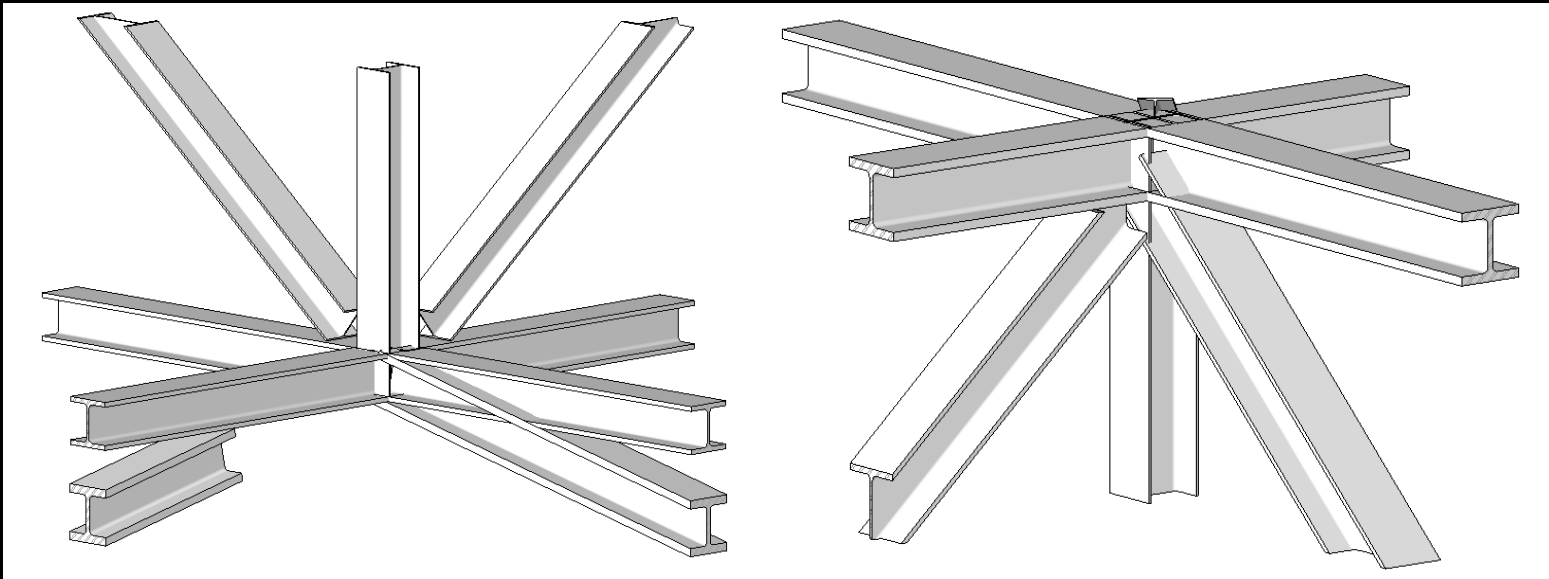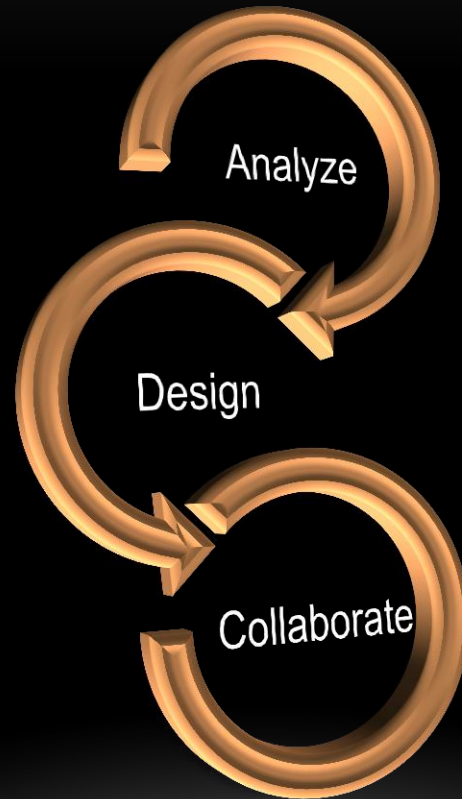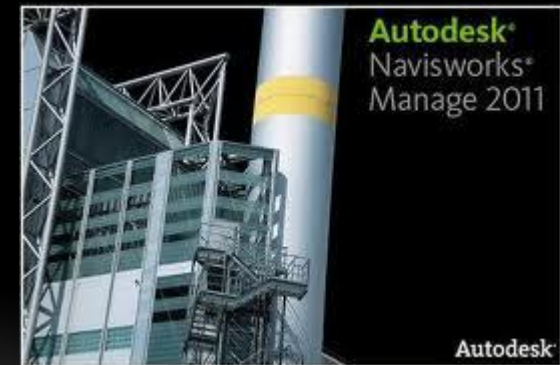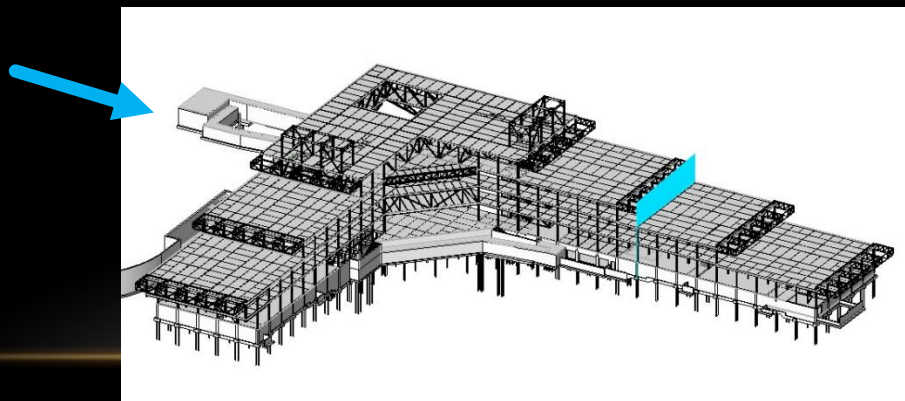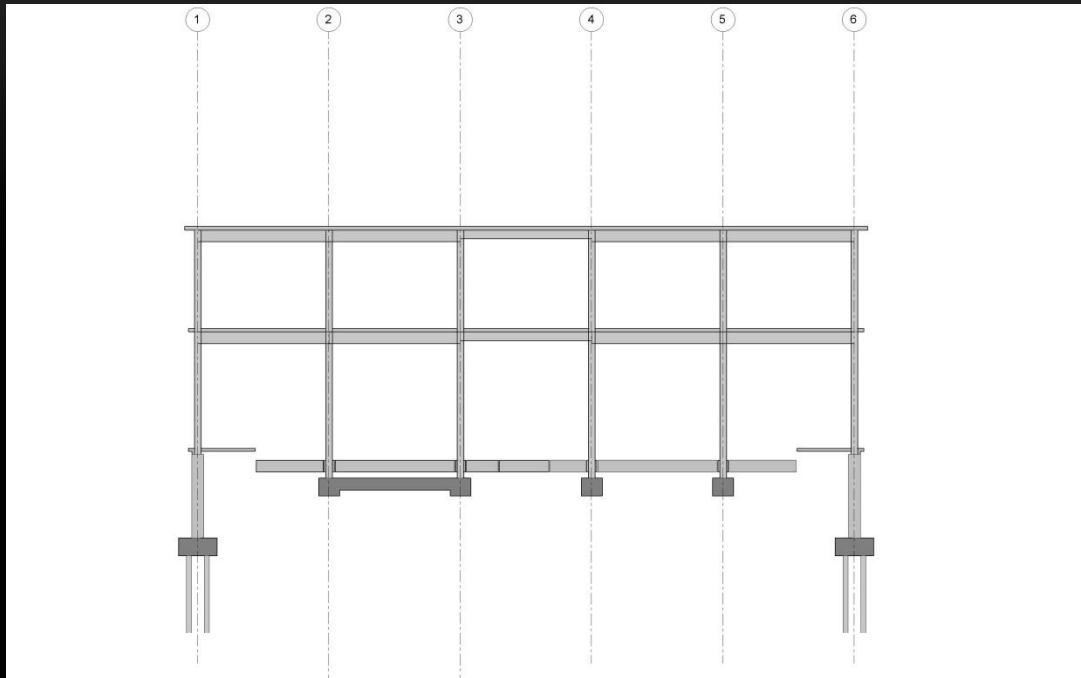
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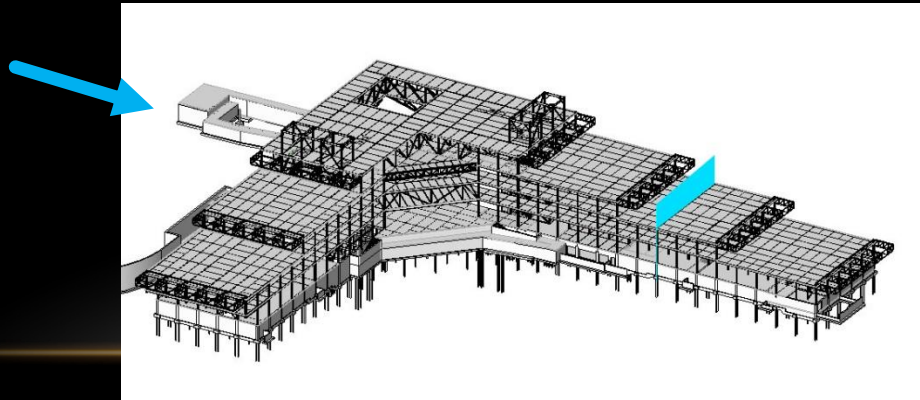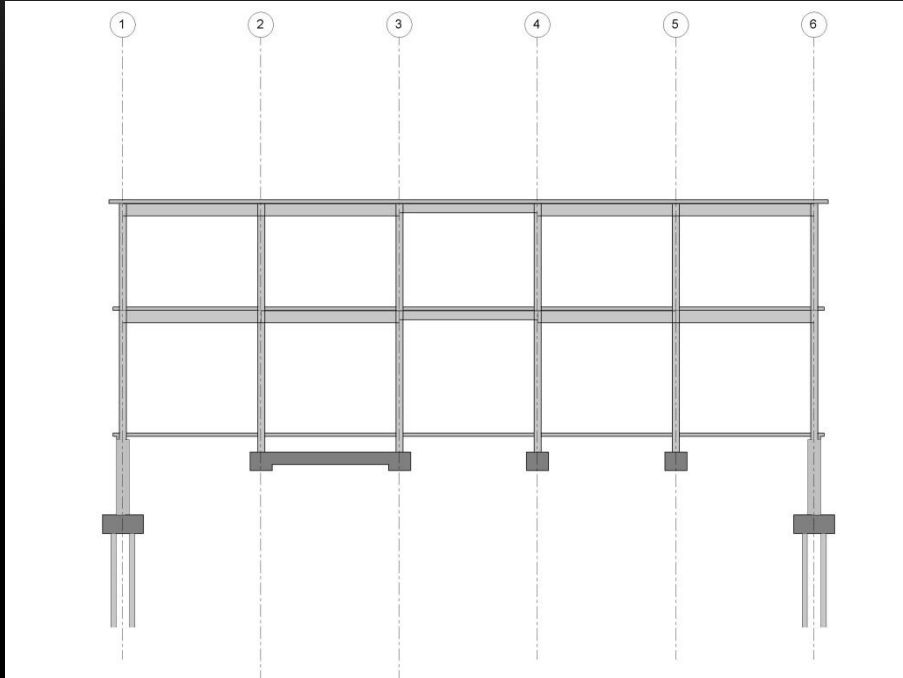
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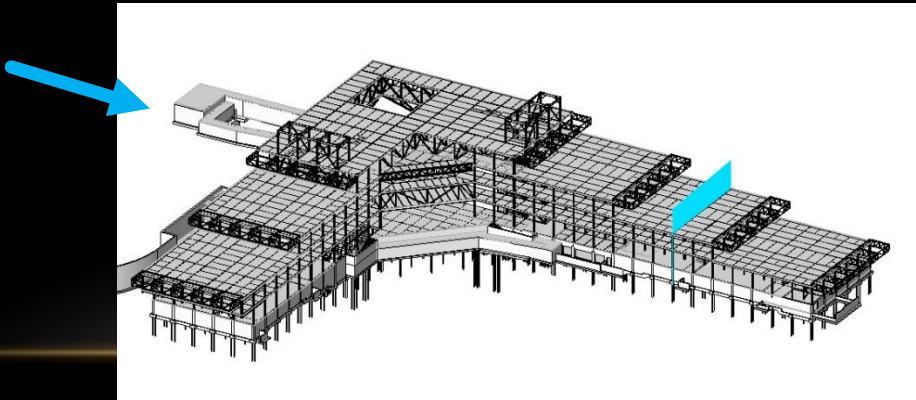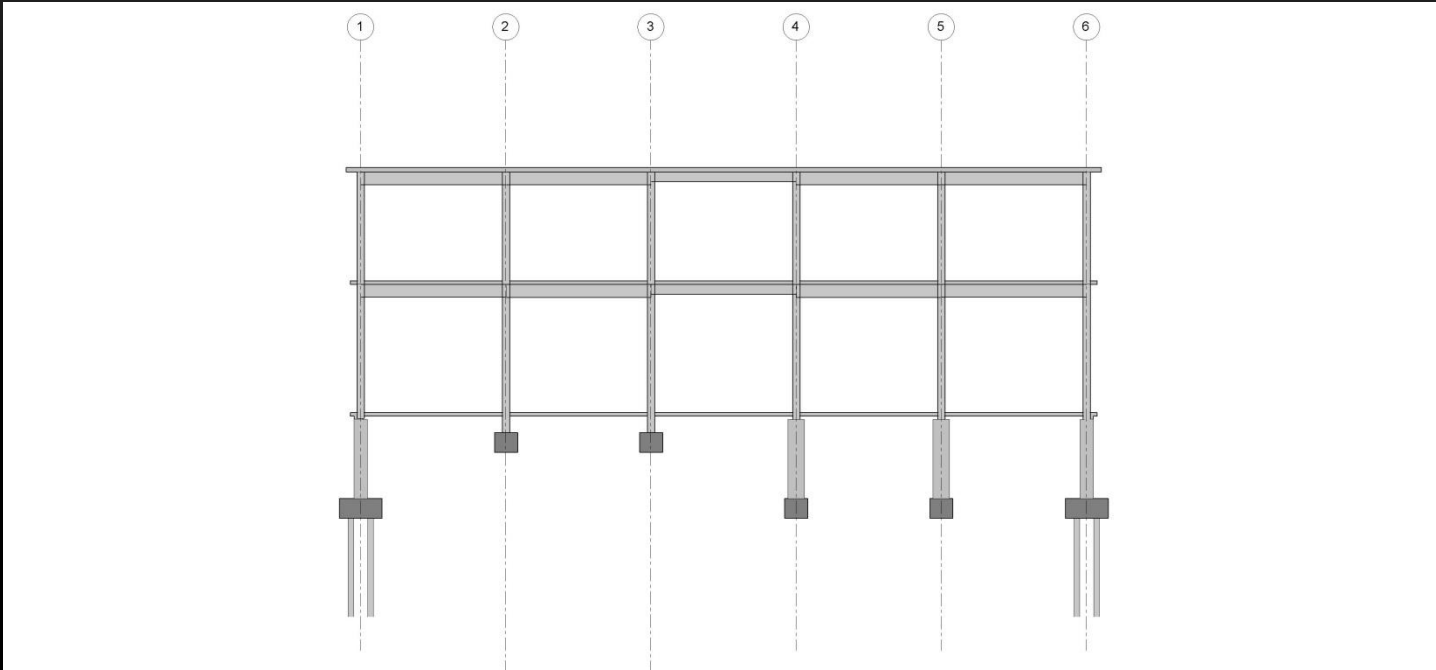
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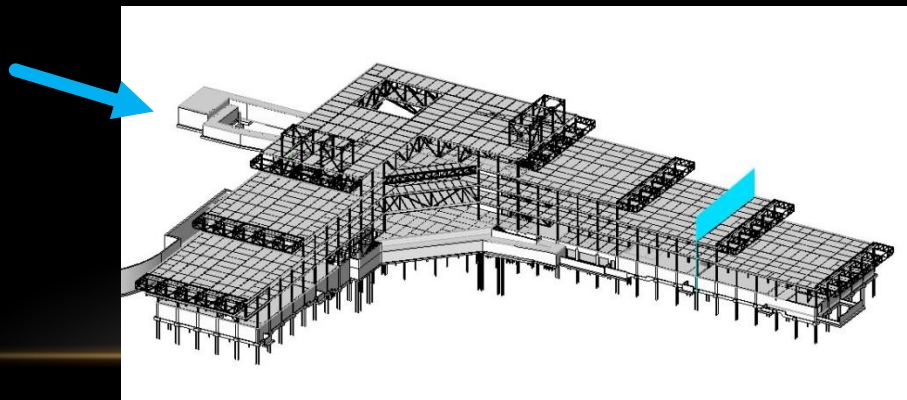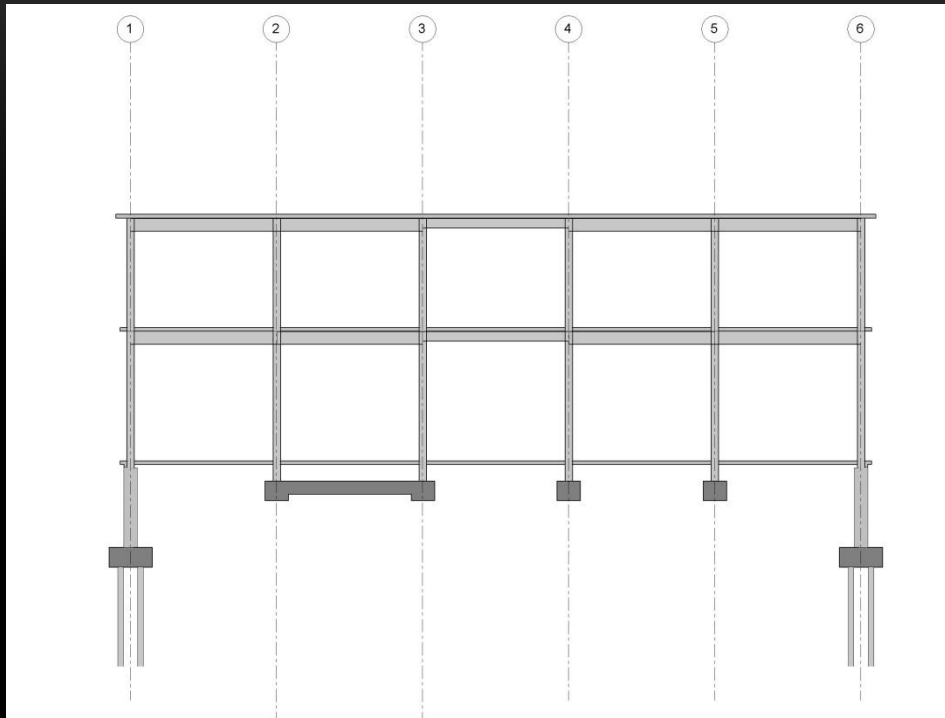
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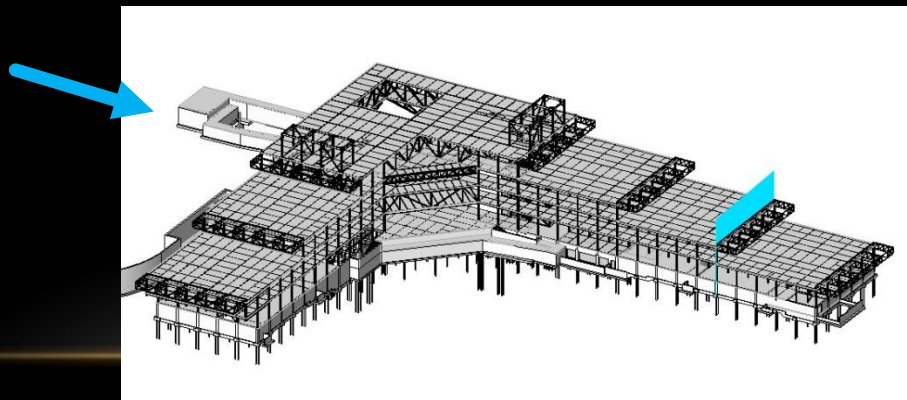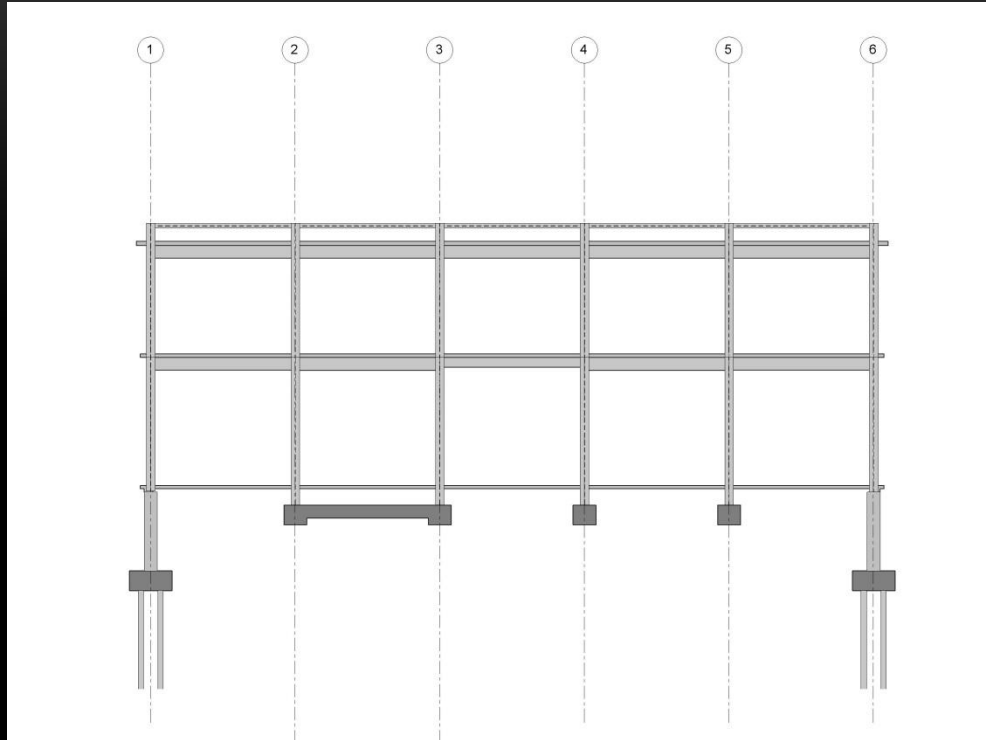
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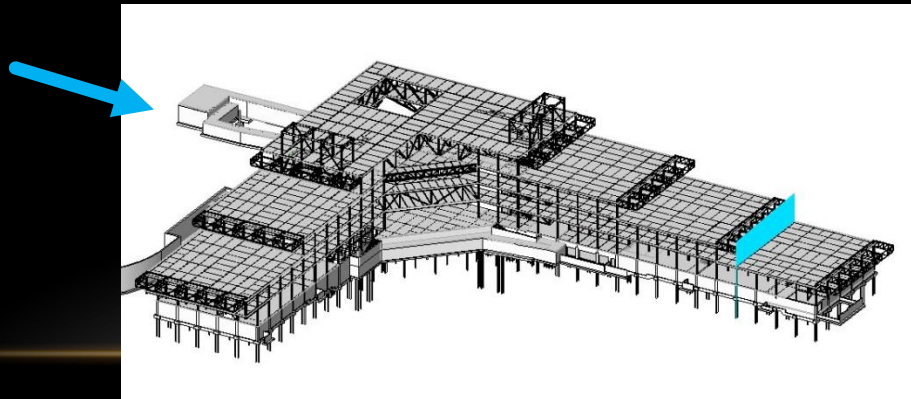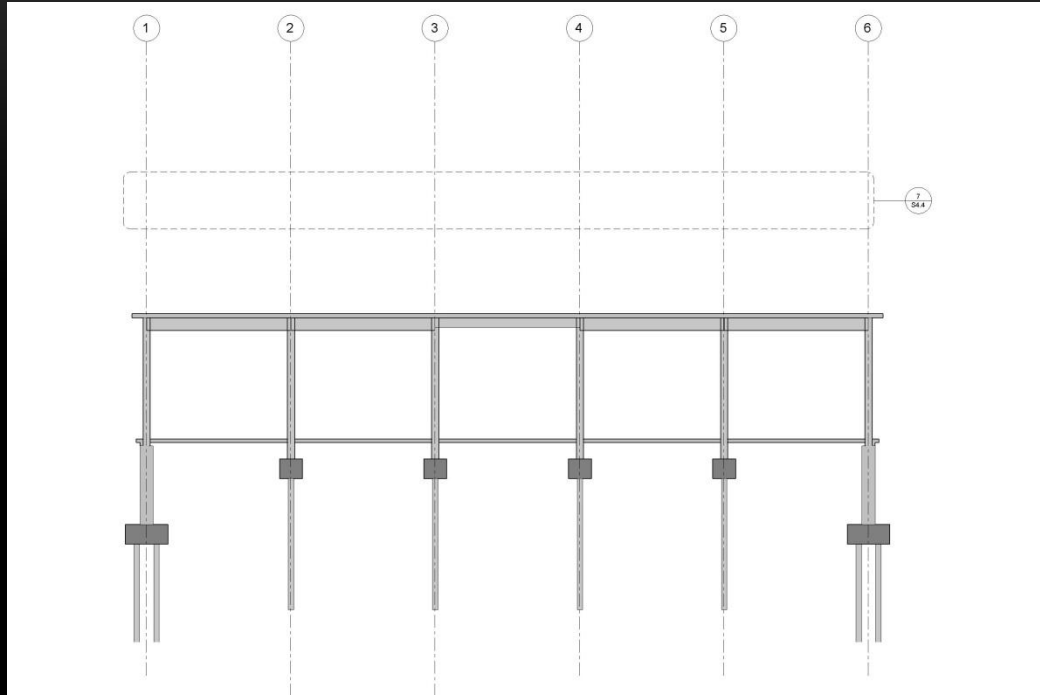
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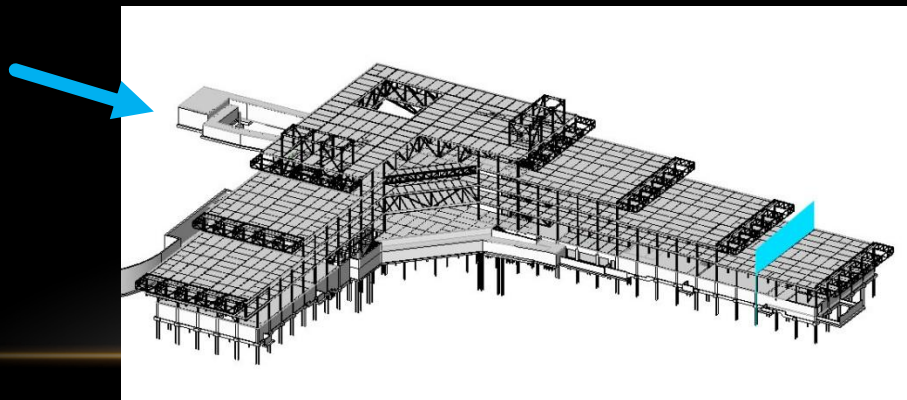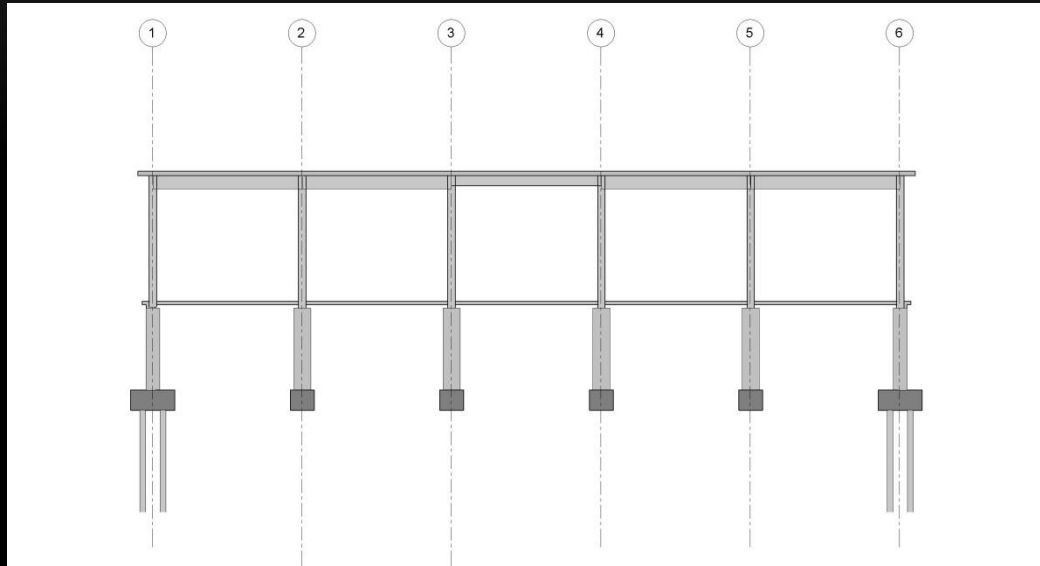
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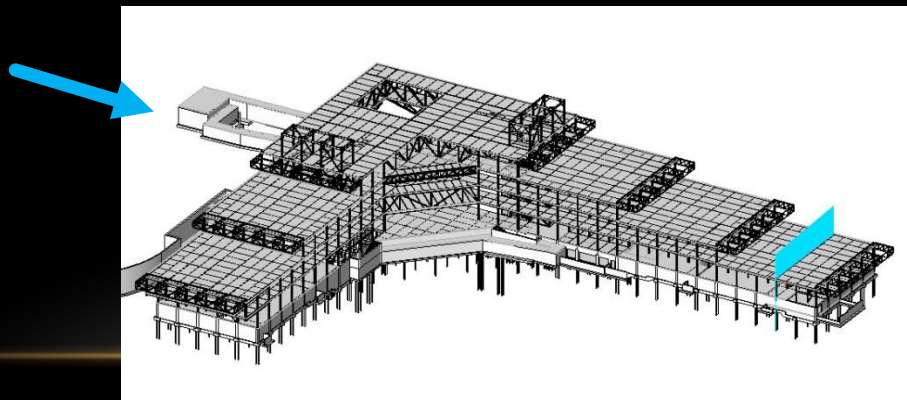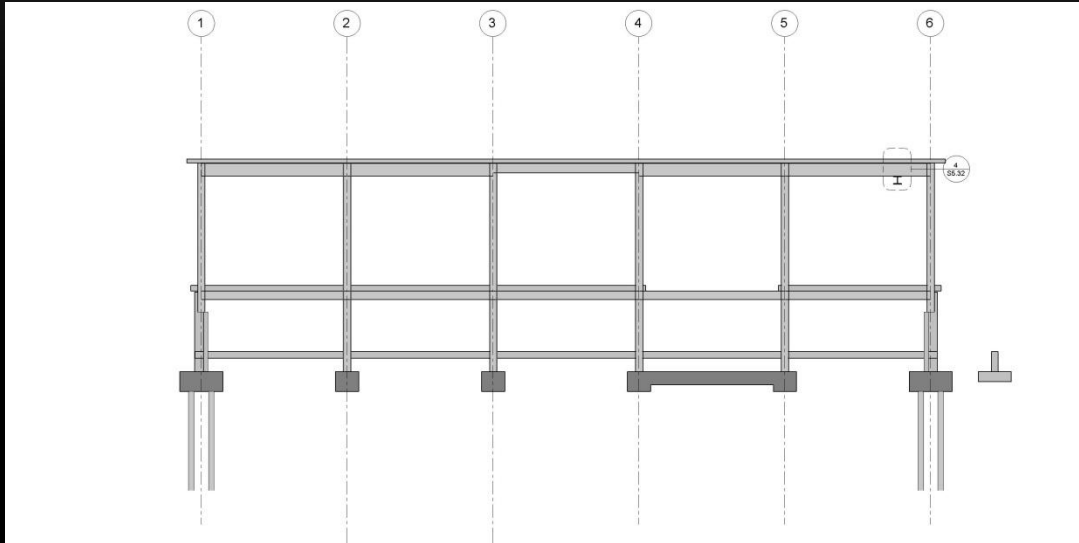
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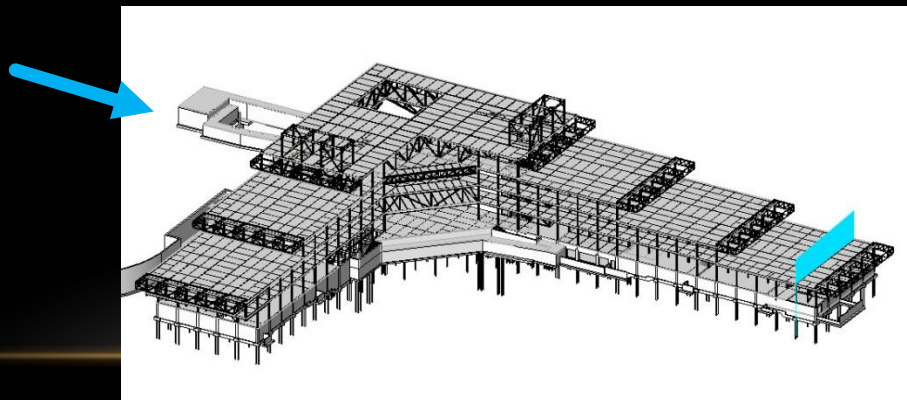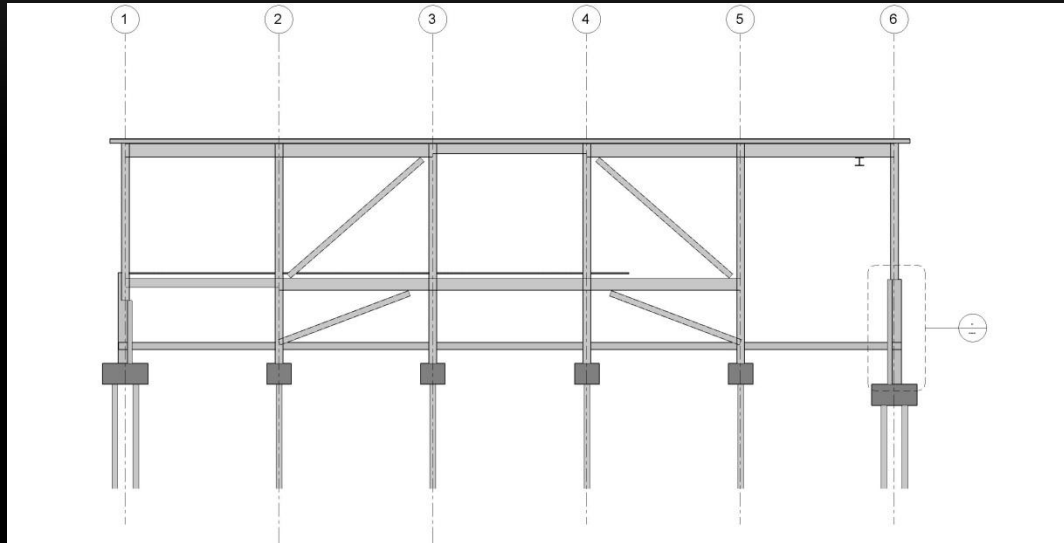
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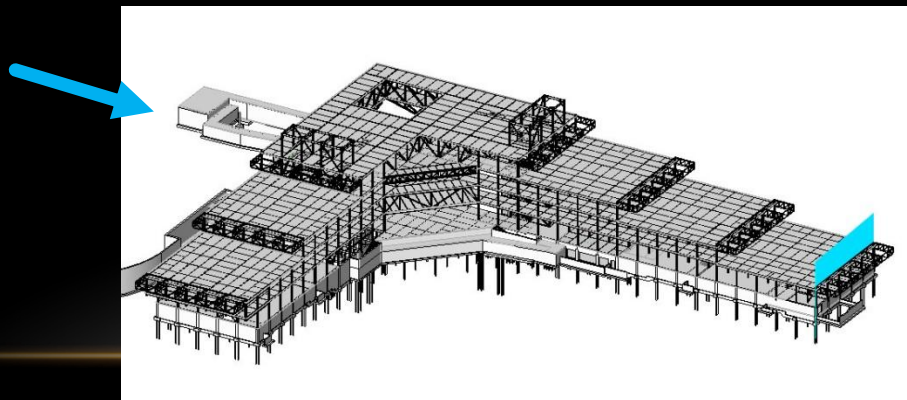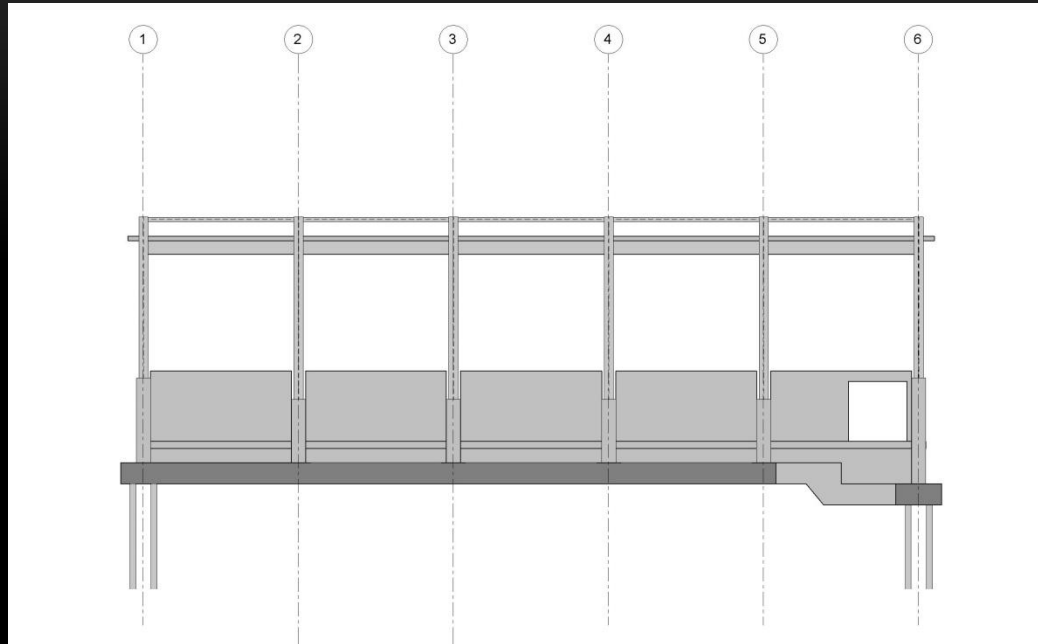
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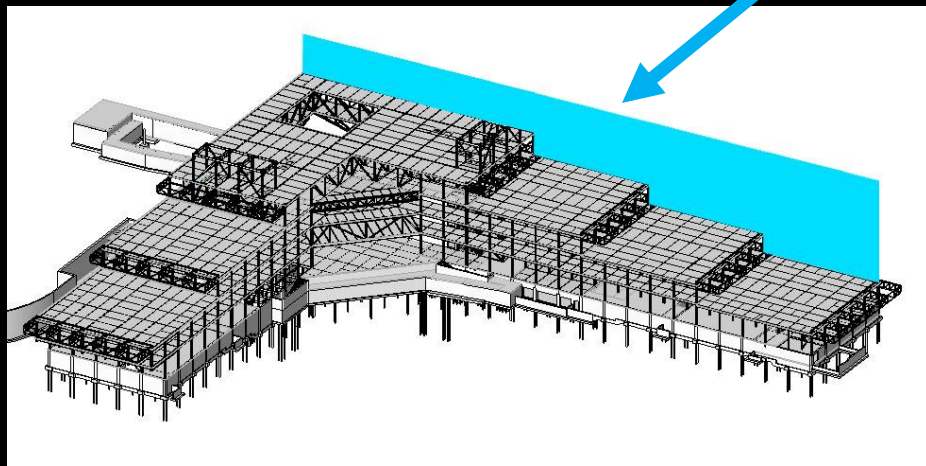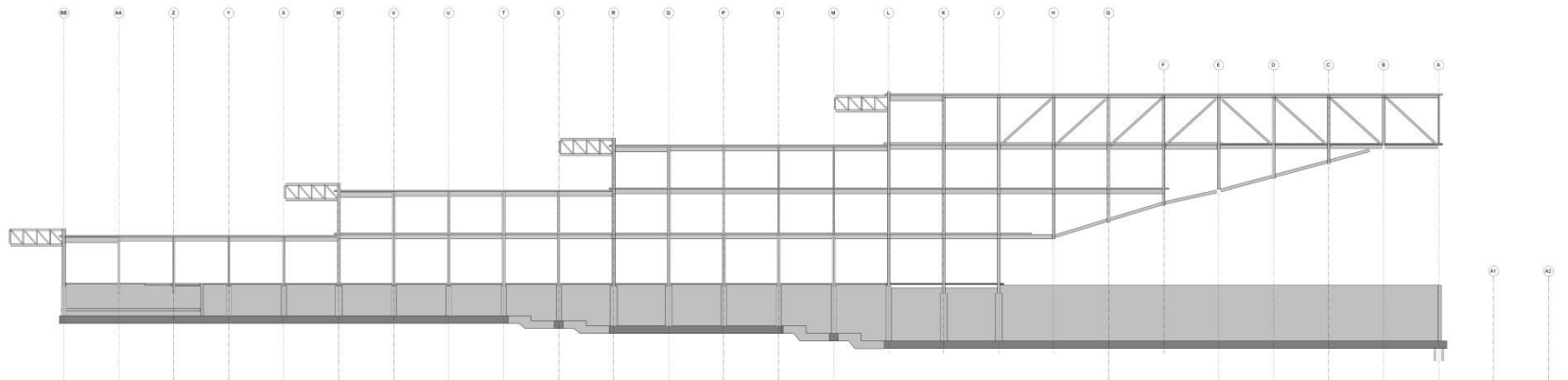
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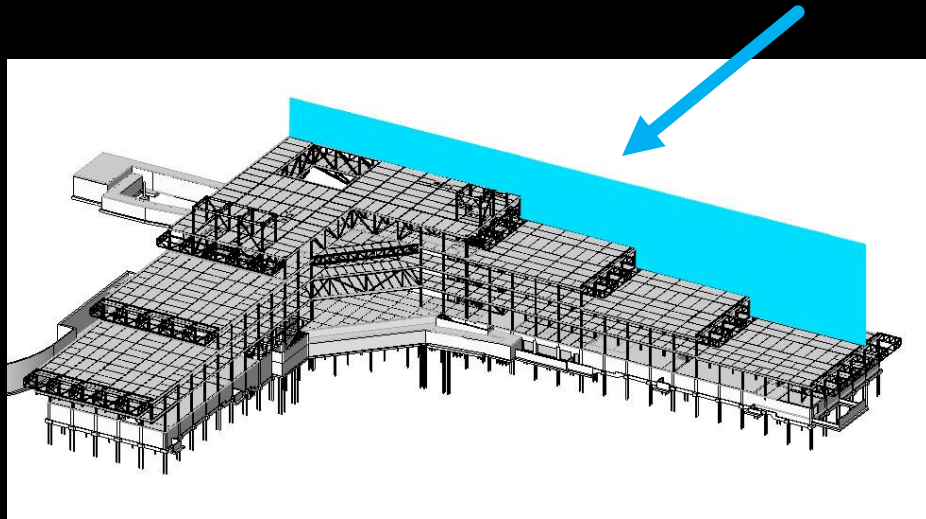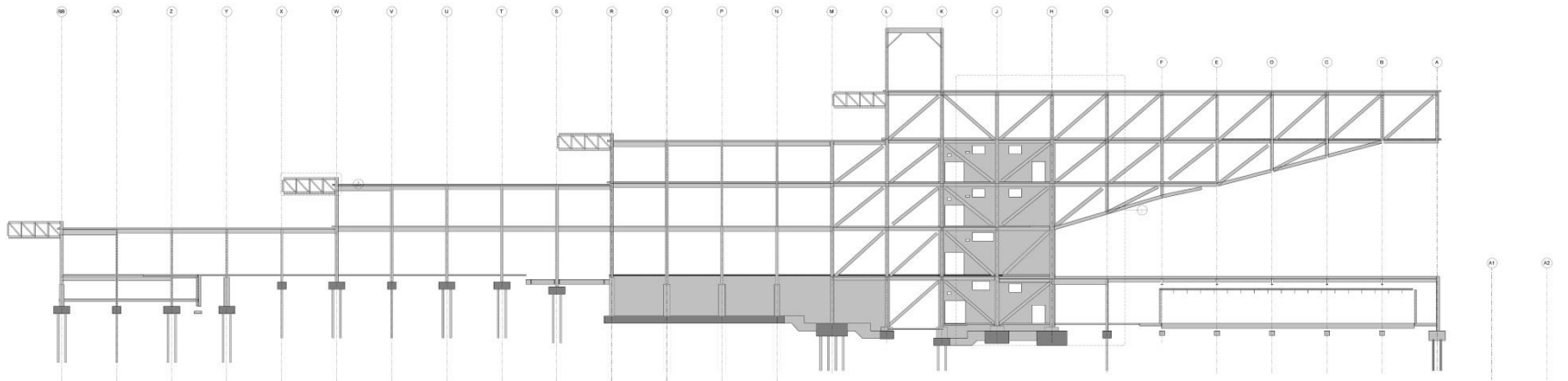
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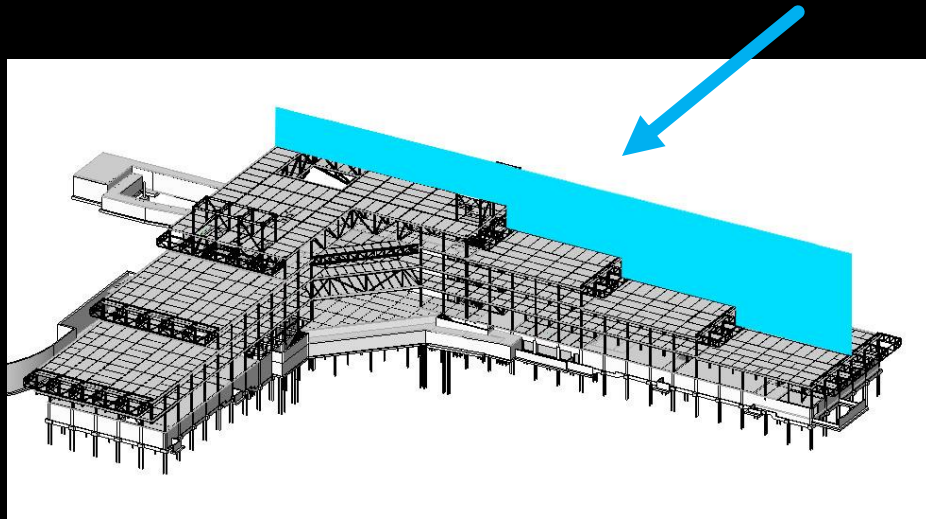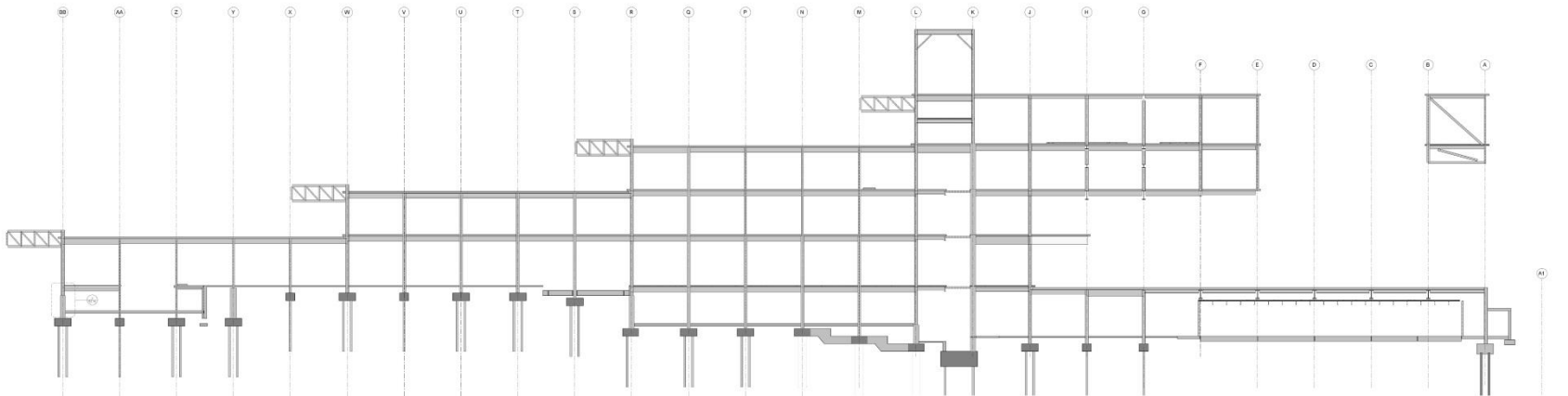
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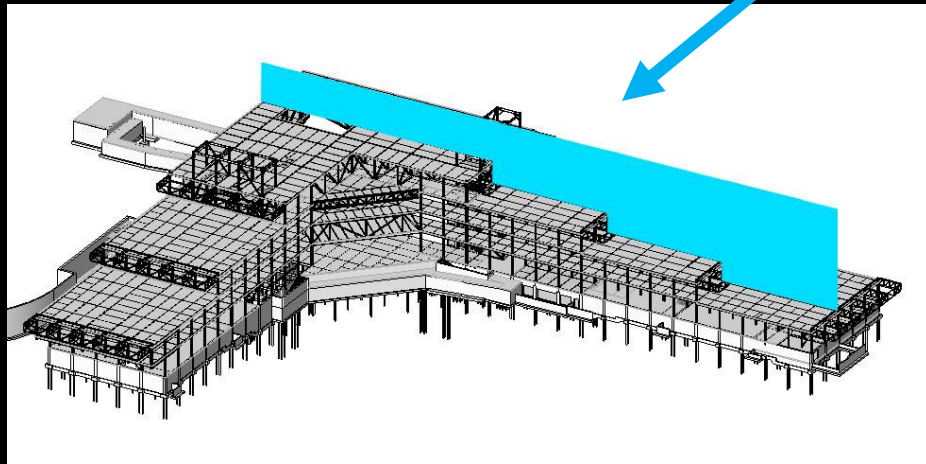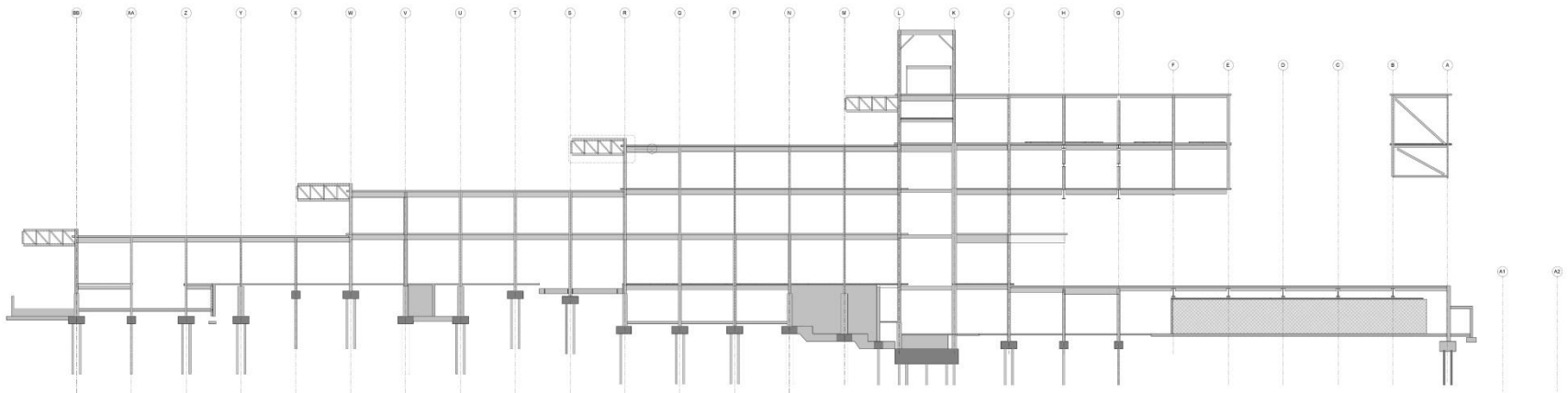
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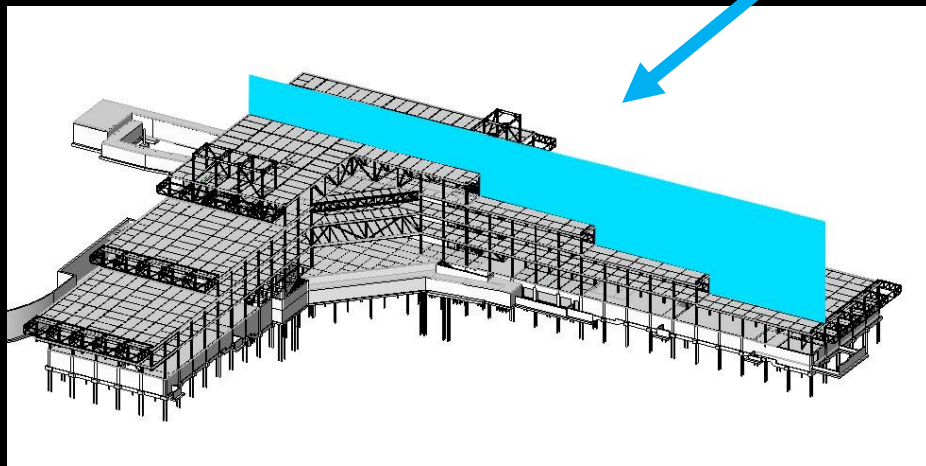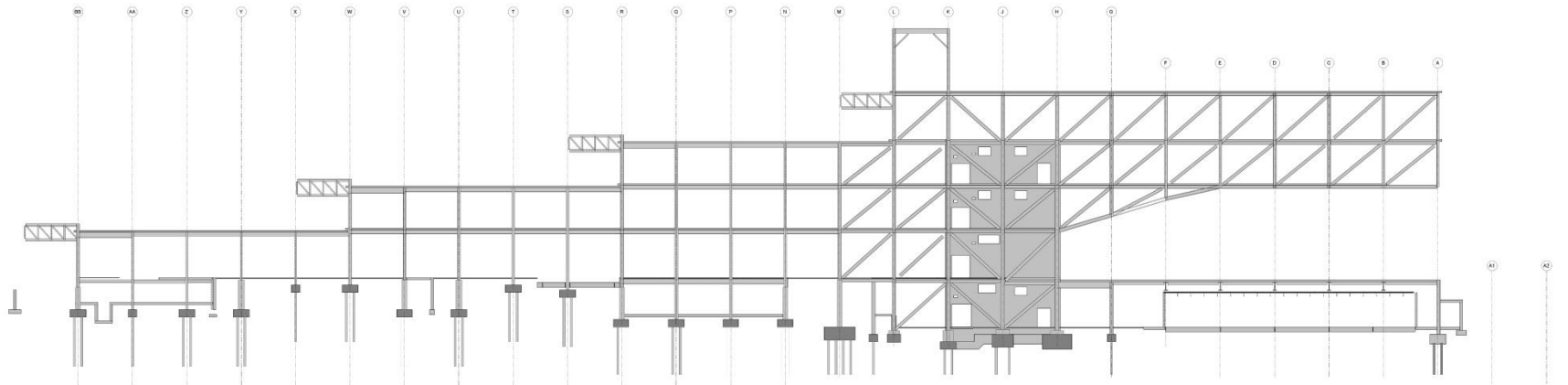
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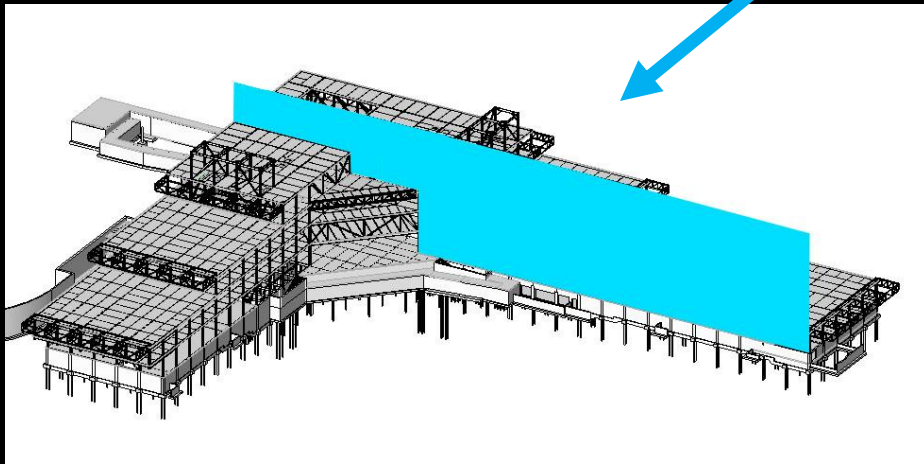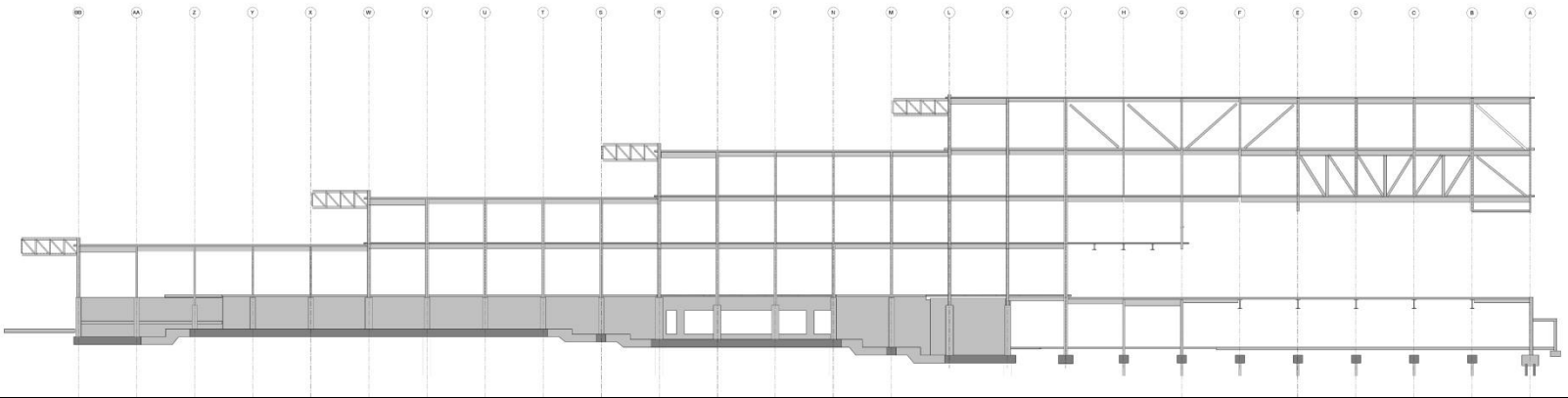
Frame – 6 (Looking South)
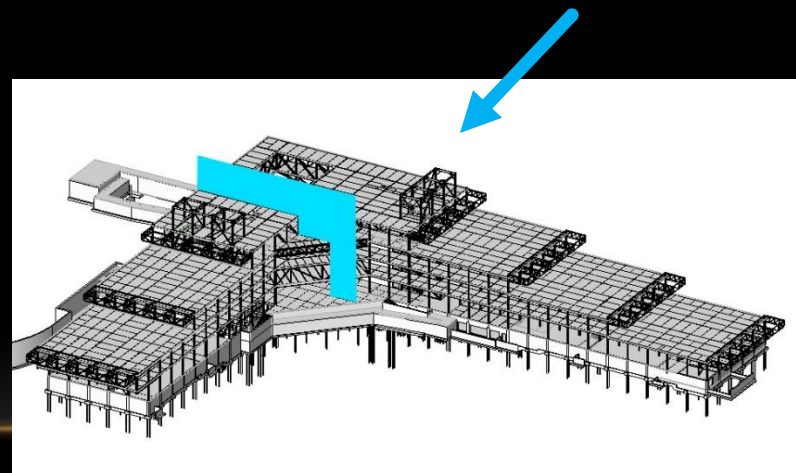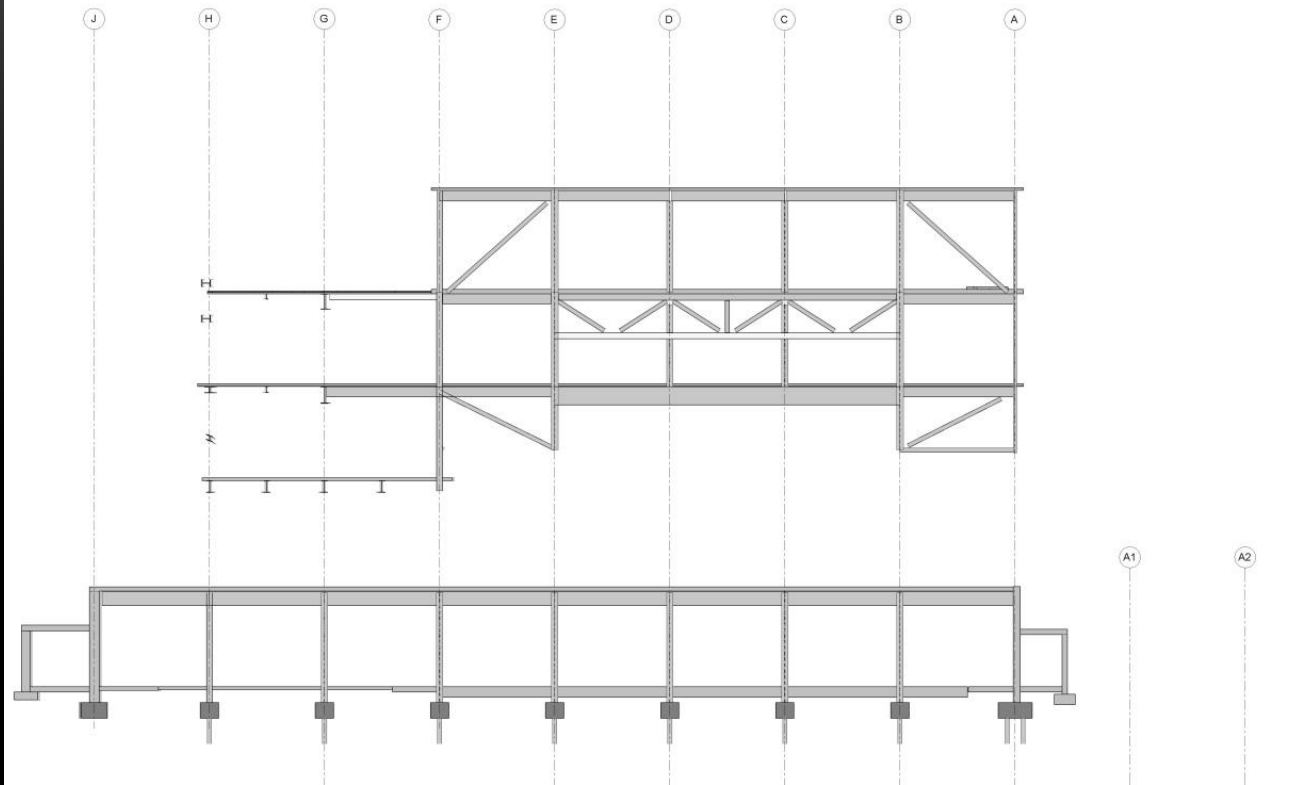
Frame – 7 (Looking South)
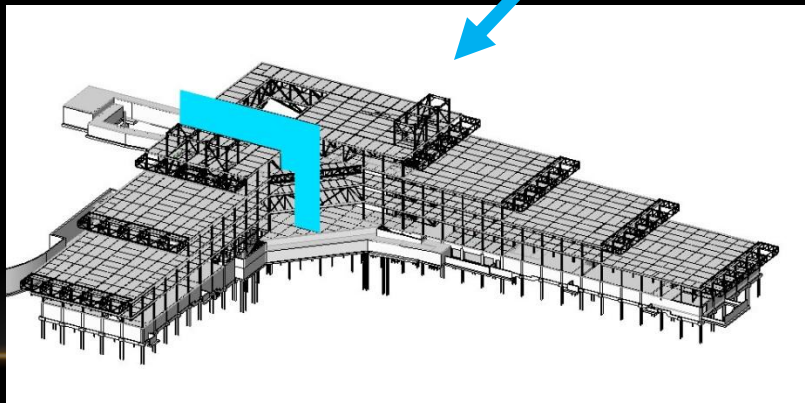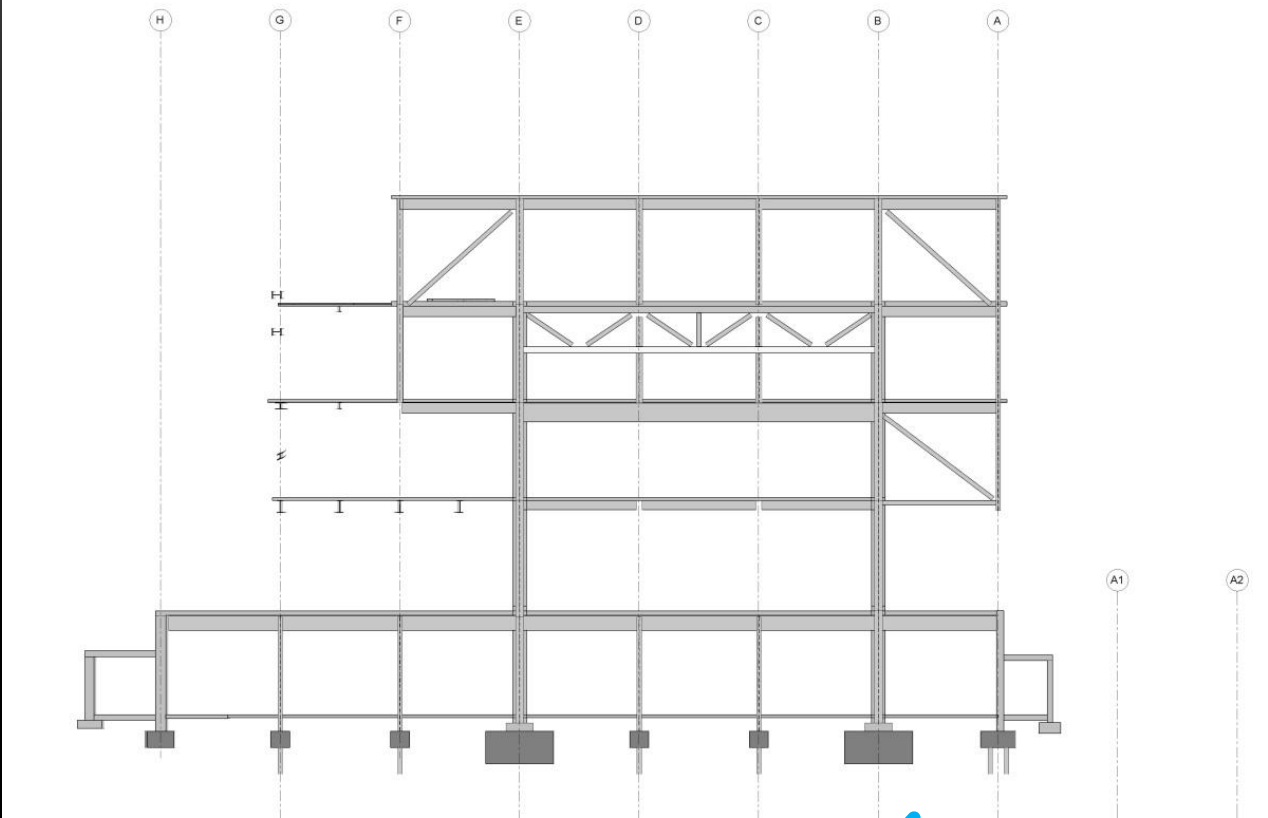
Frame – 8 (Looking South)
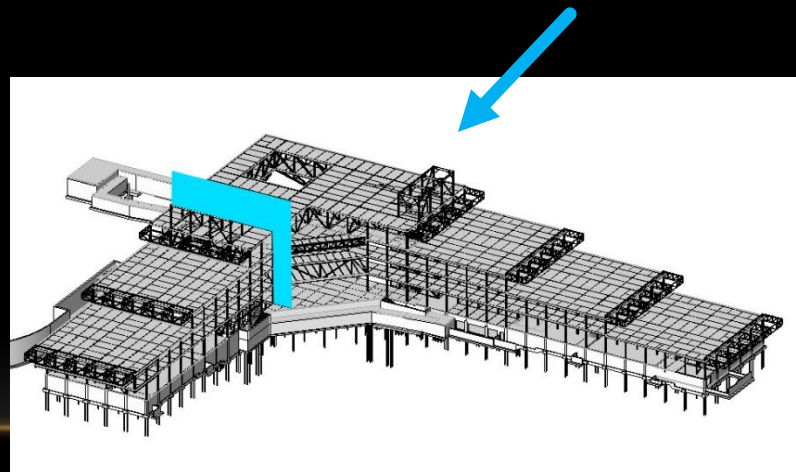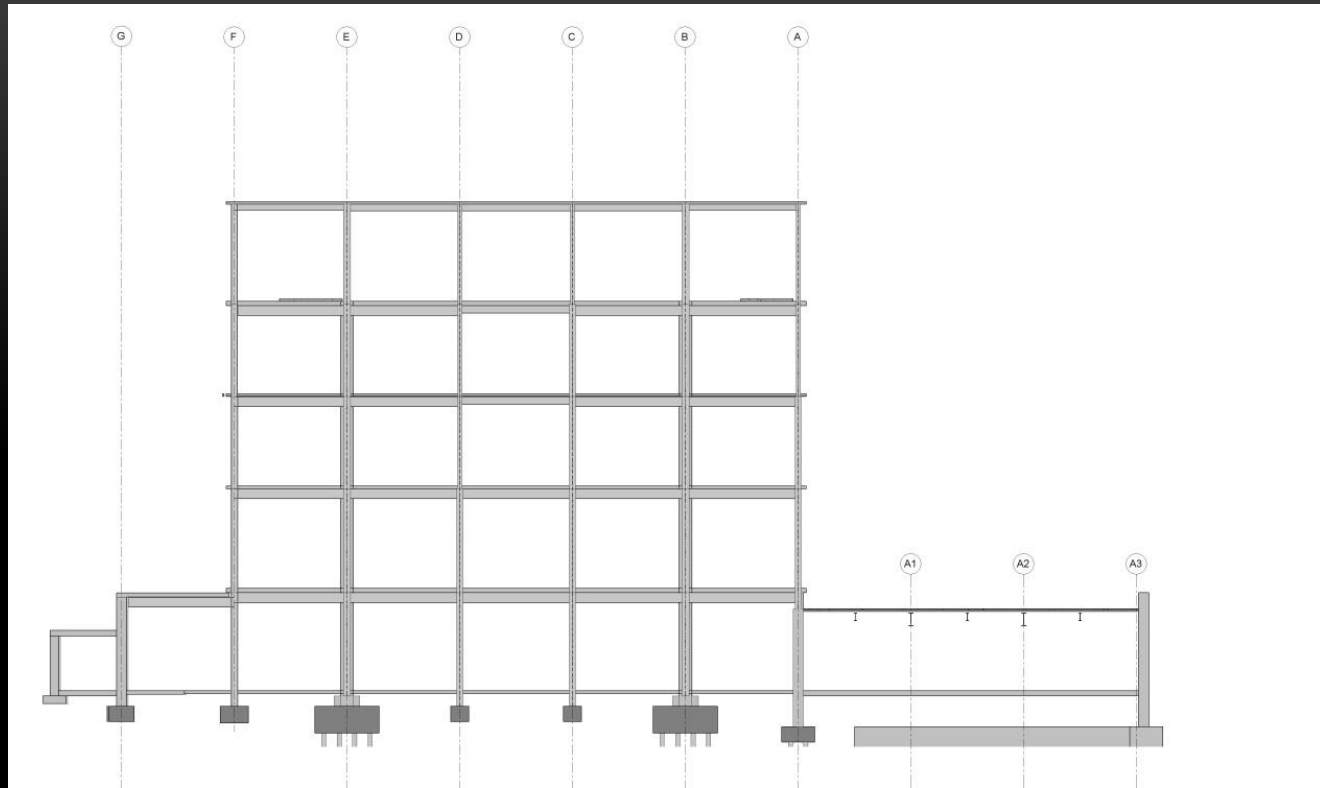
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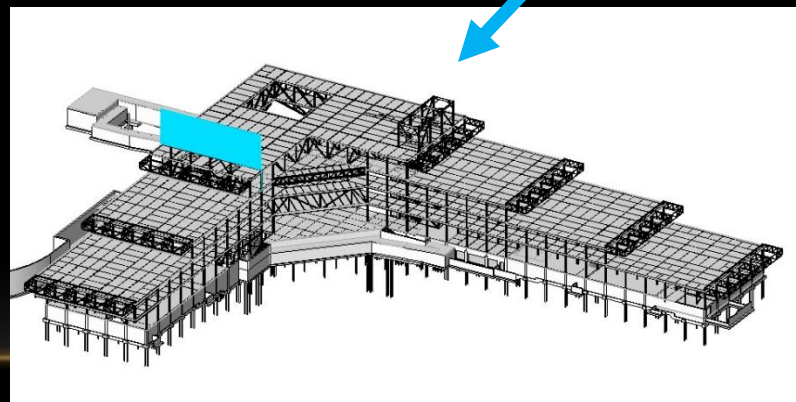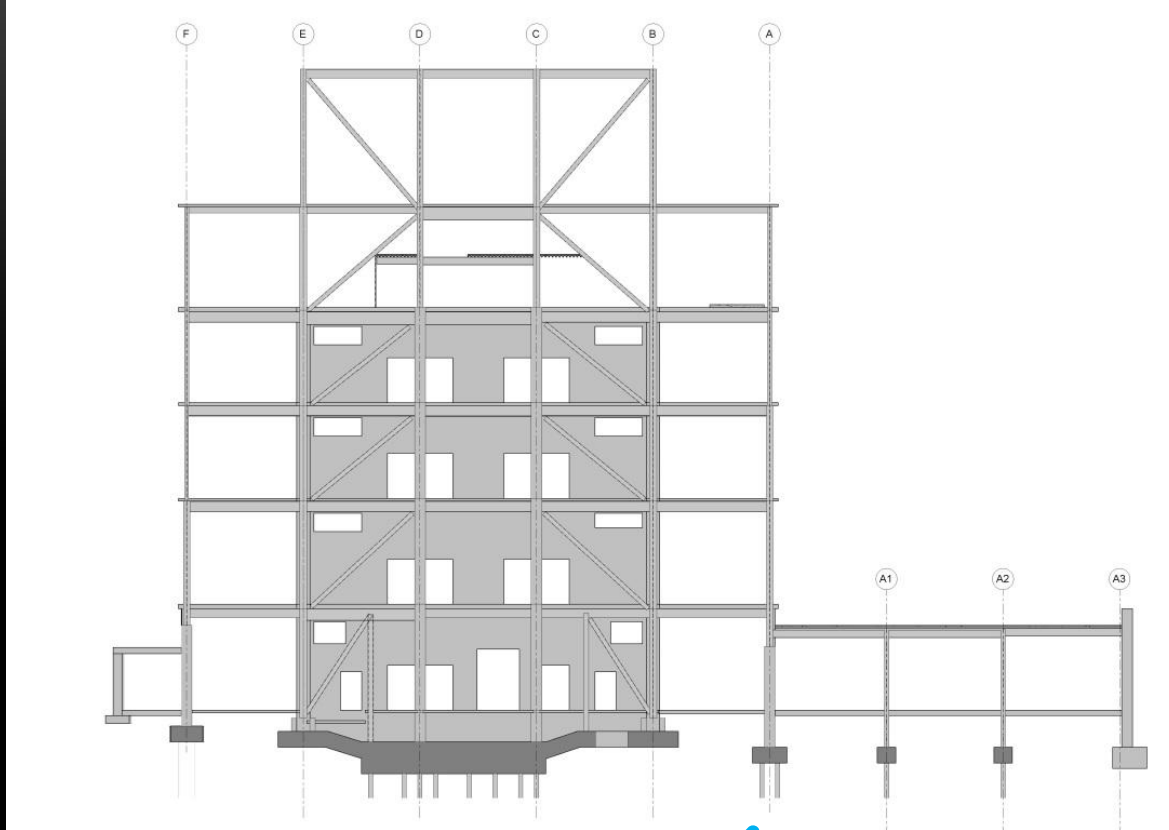
Frame – 10 (Looking South)
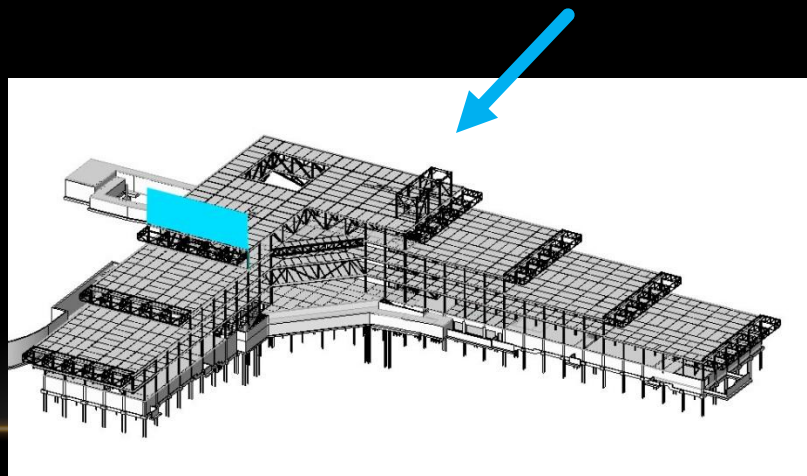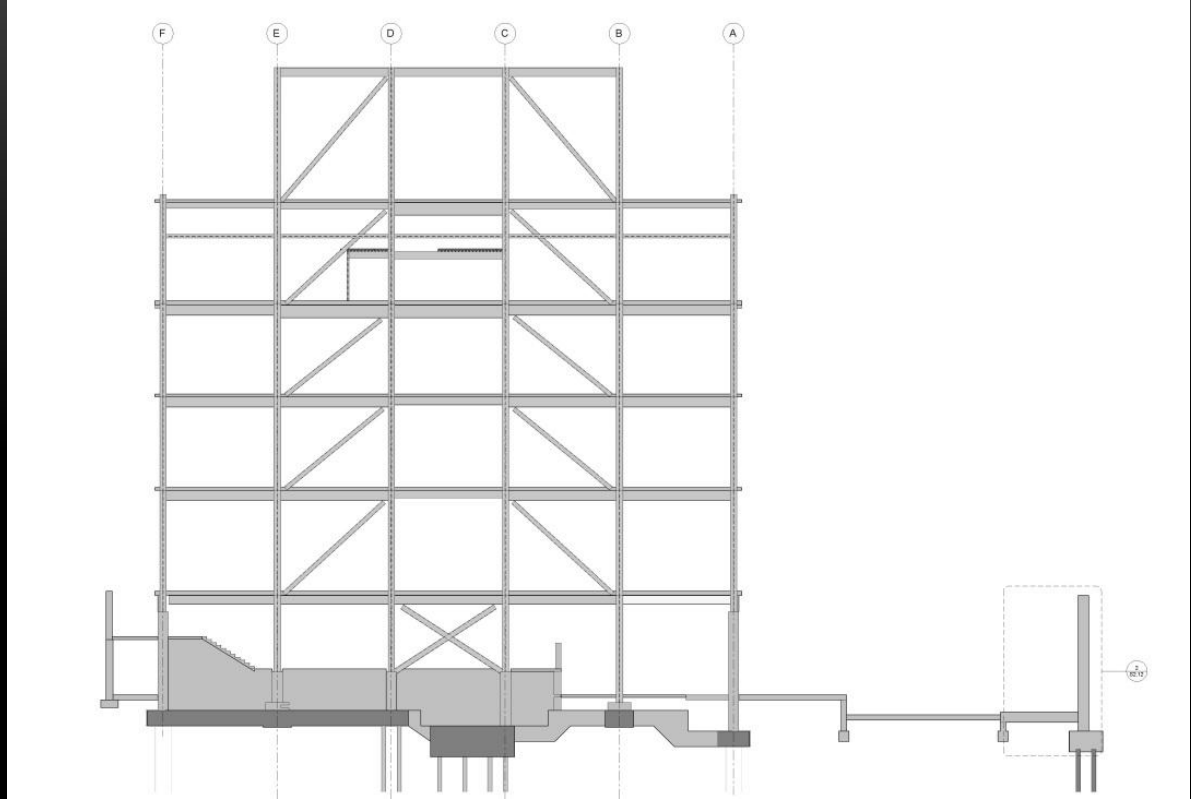
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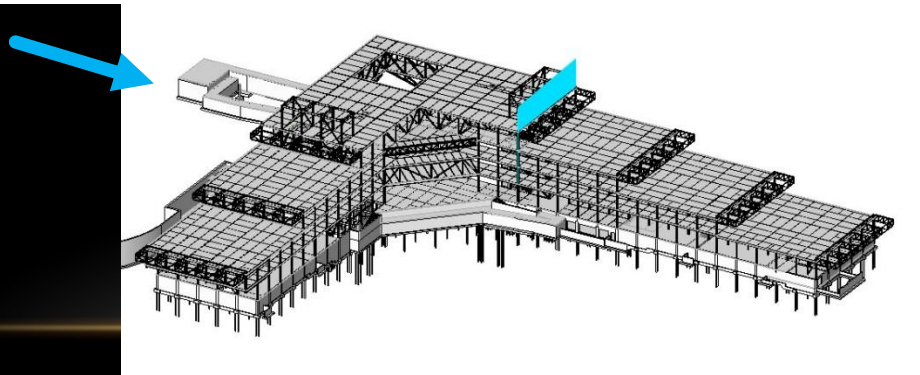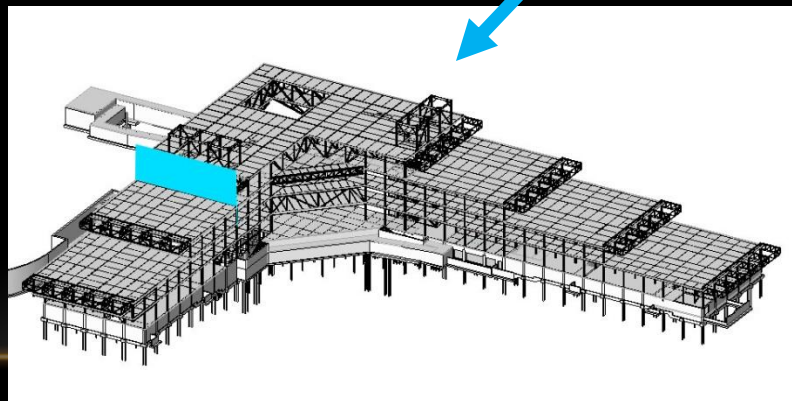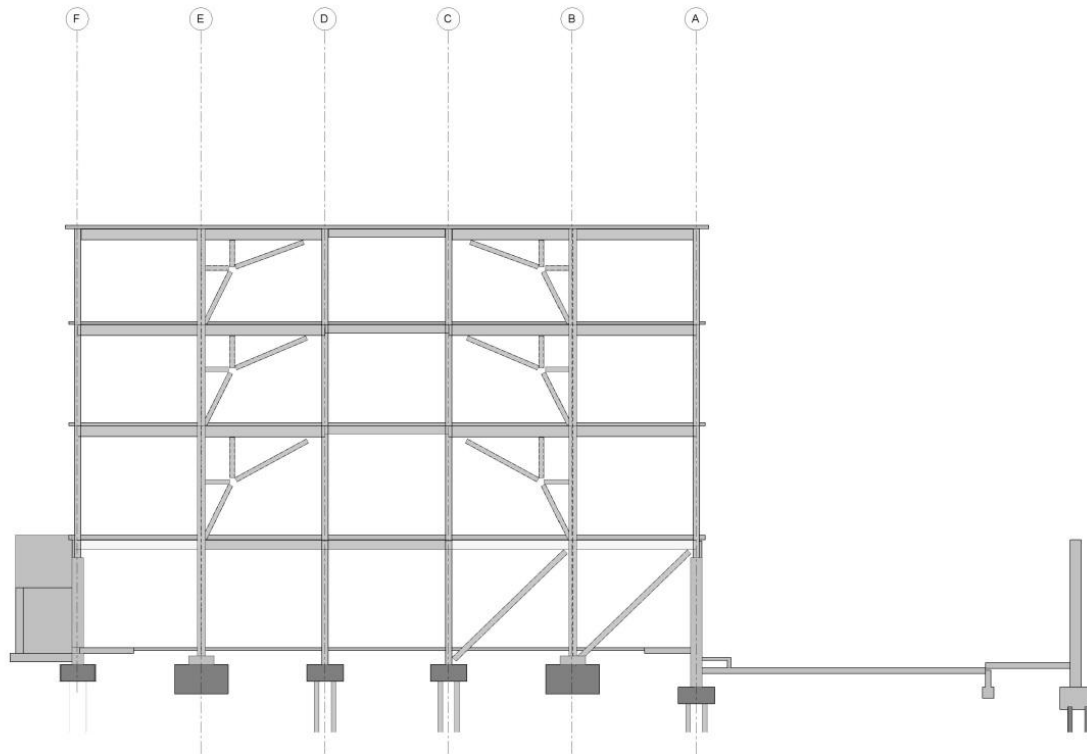
Frame – 12 (Looking South)
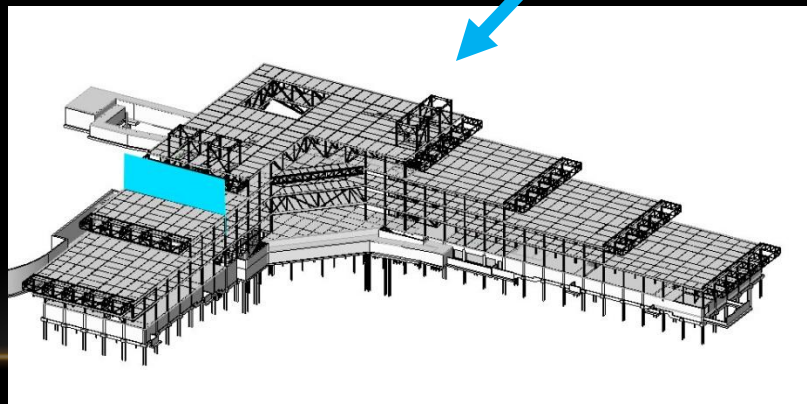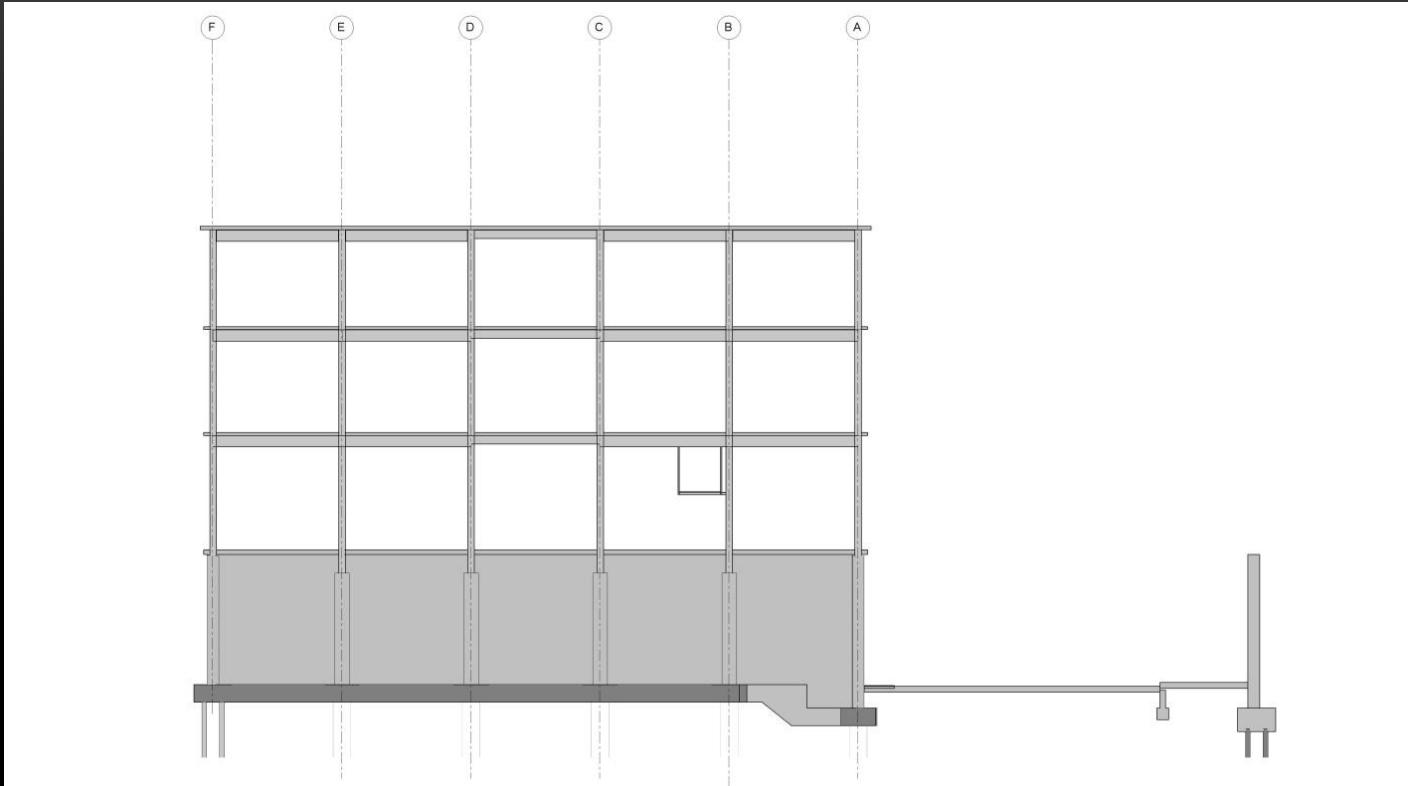
Frame – 13 (Looking South)
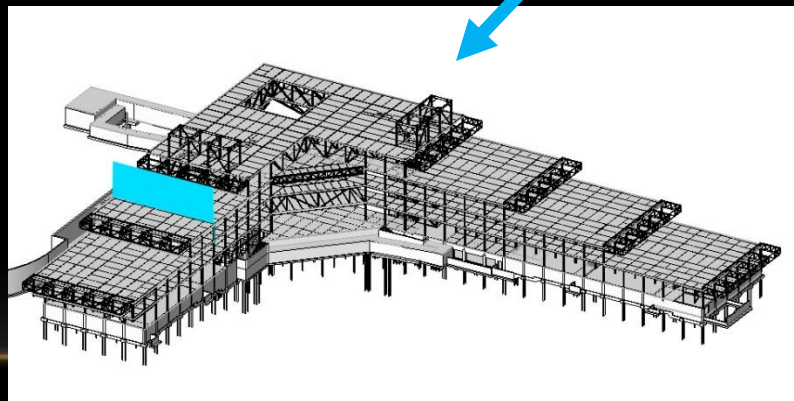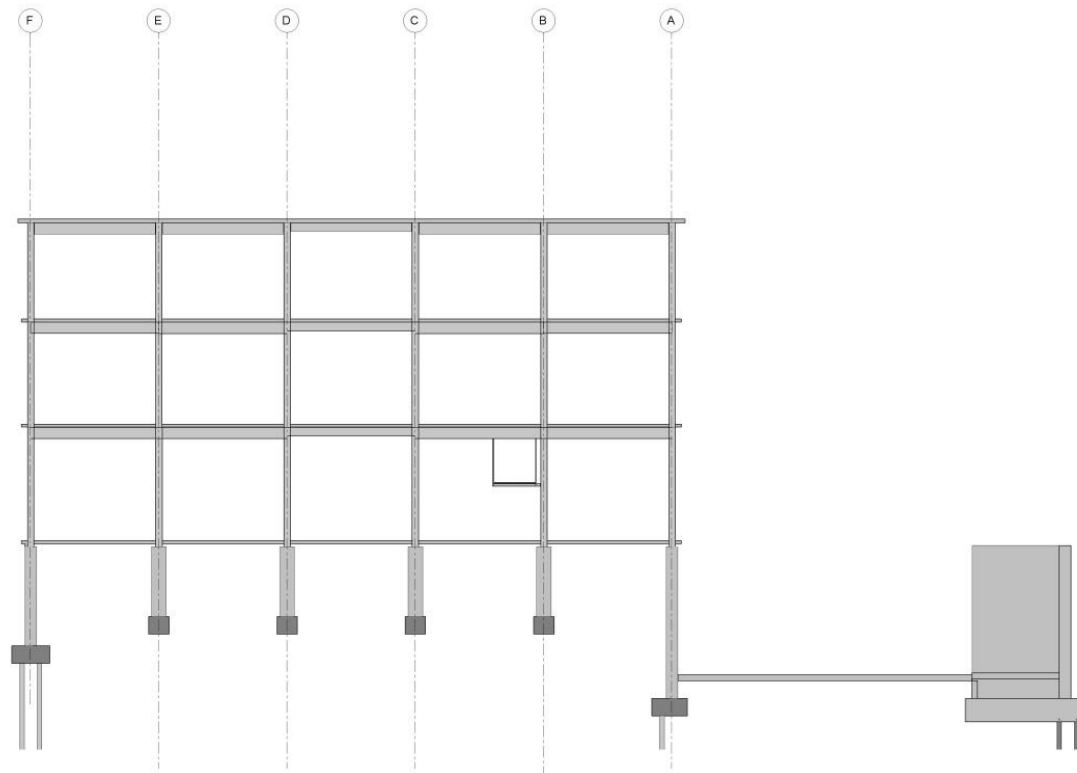
Frame – 14 (Looking South)
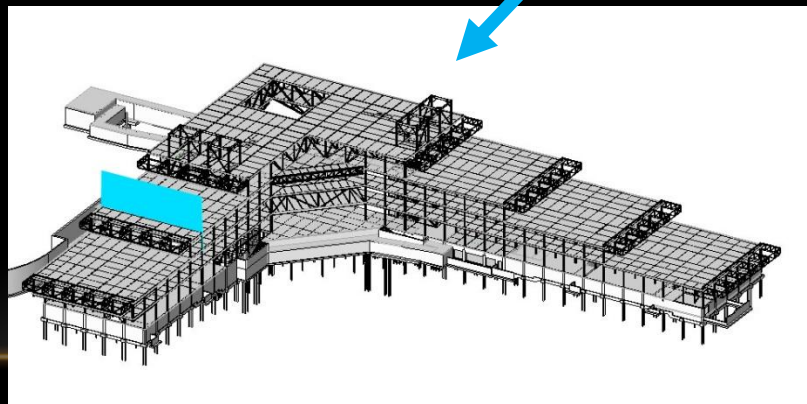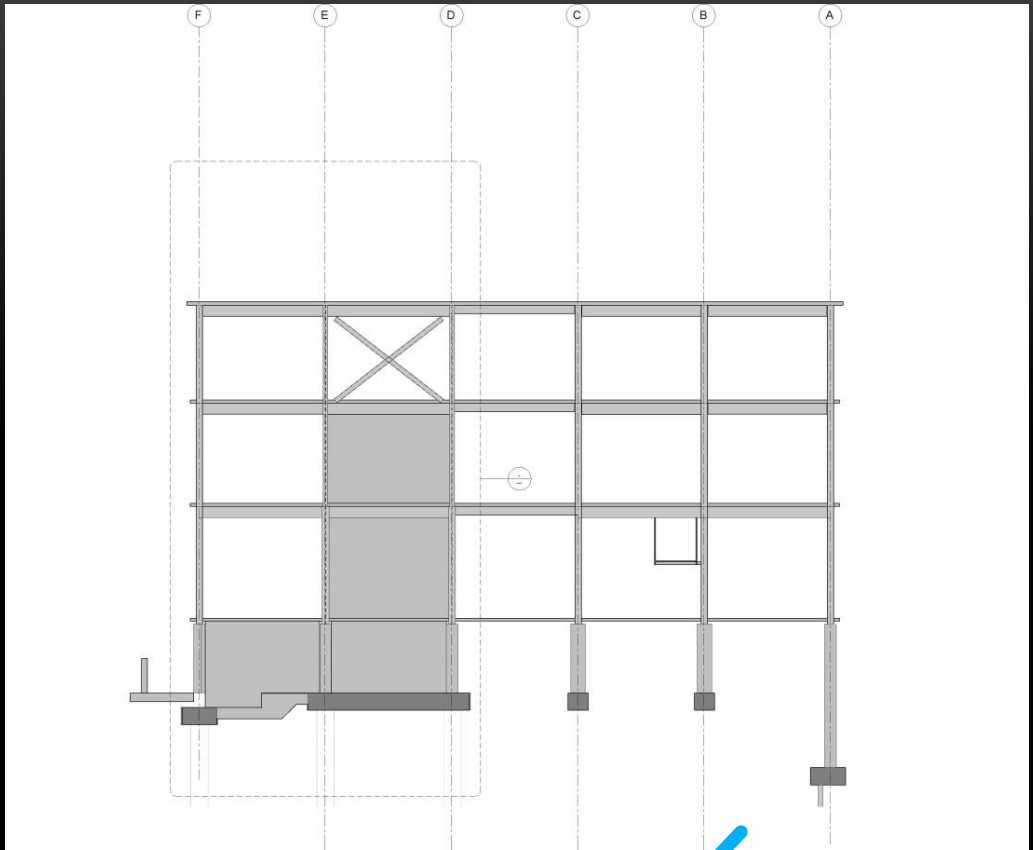
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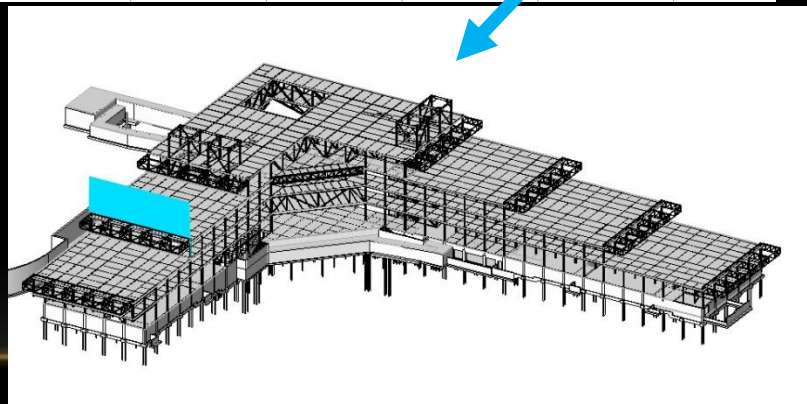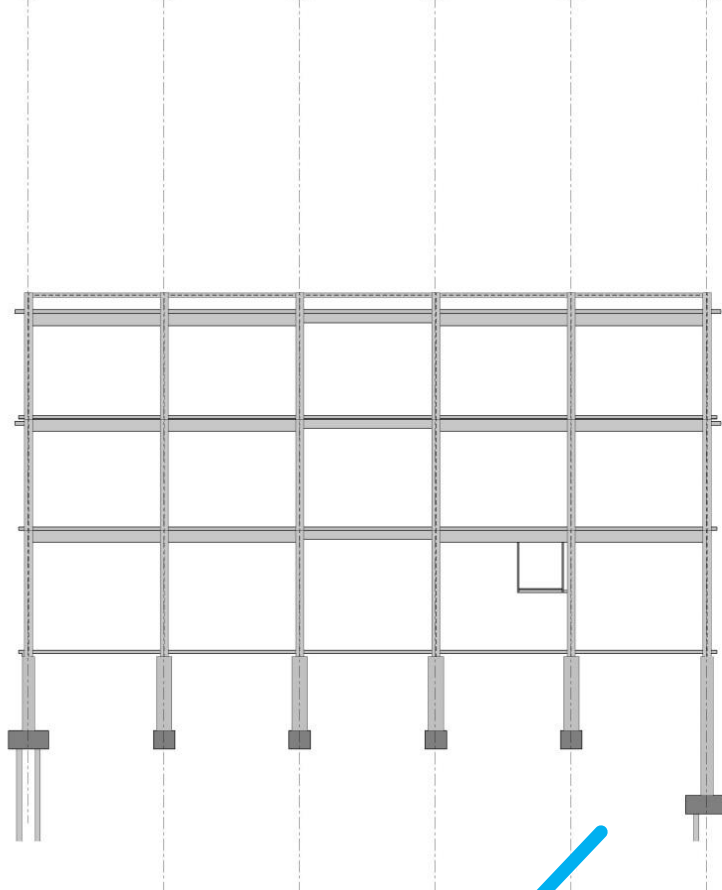
Frame – 16 (Looking South)
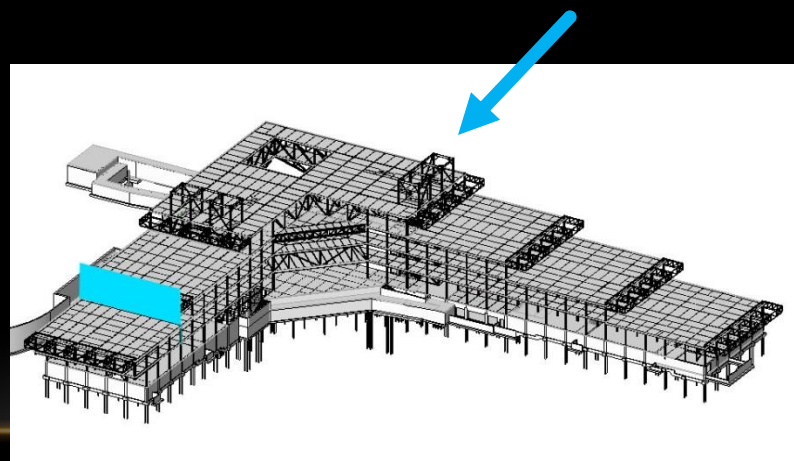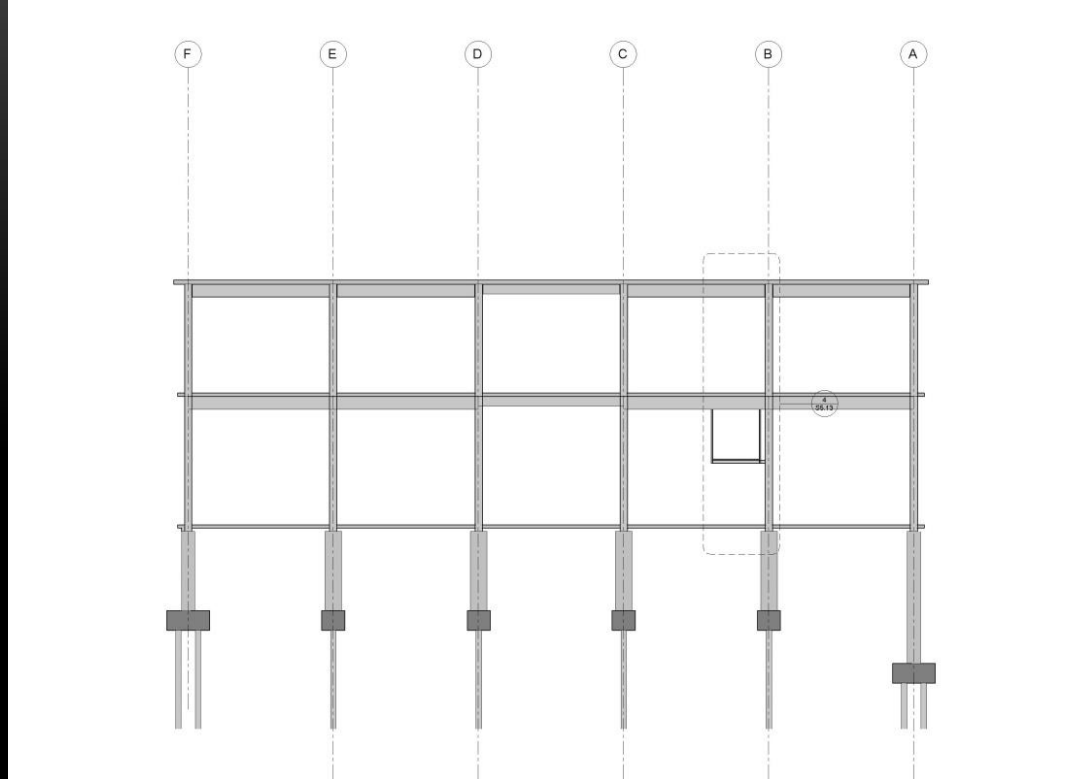
Frame – 17 (Looking South)
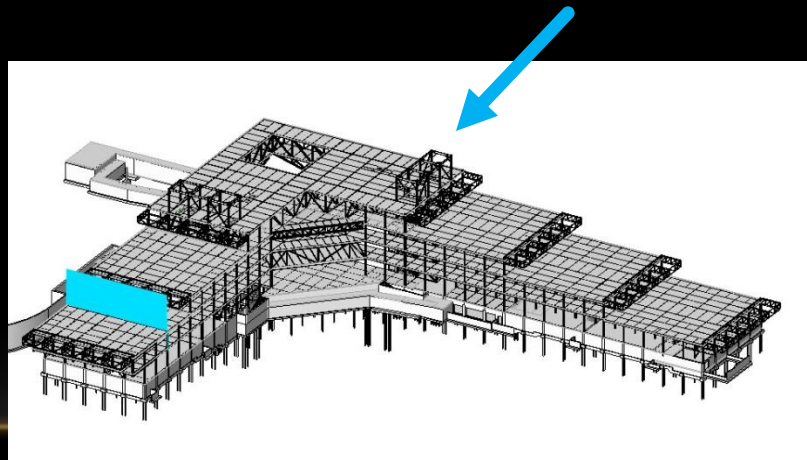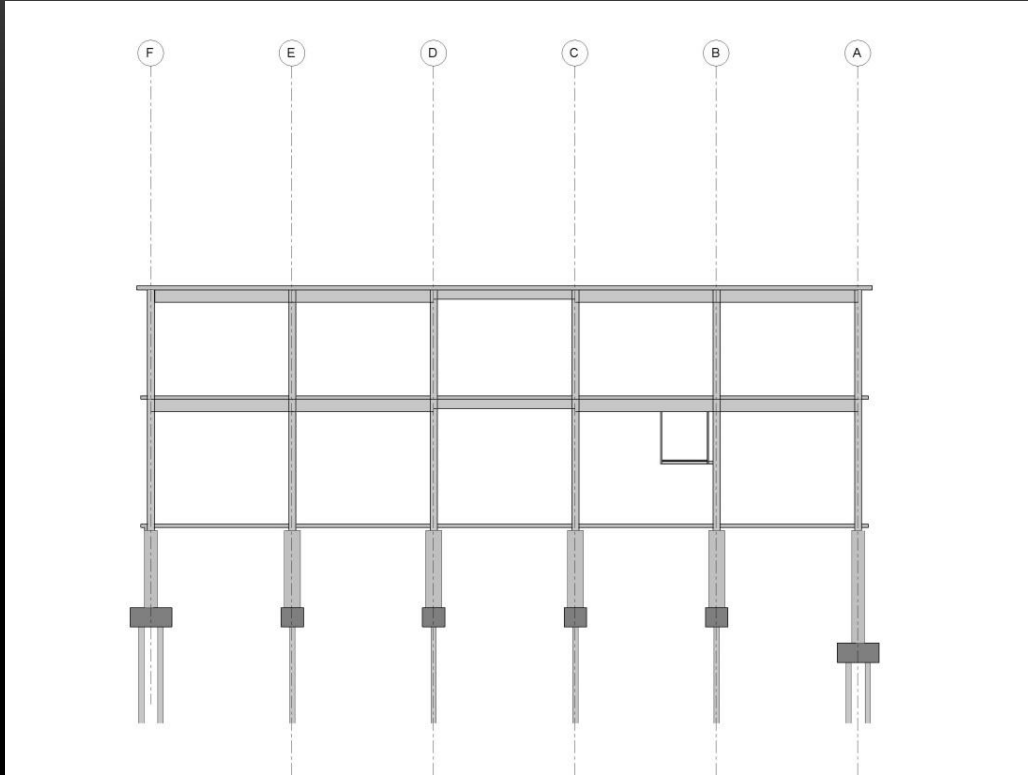
Frame – 18 (Looking South)
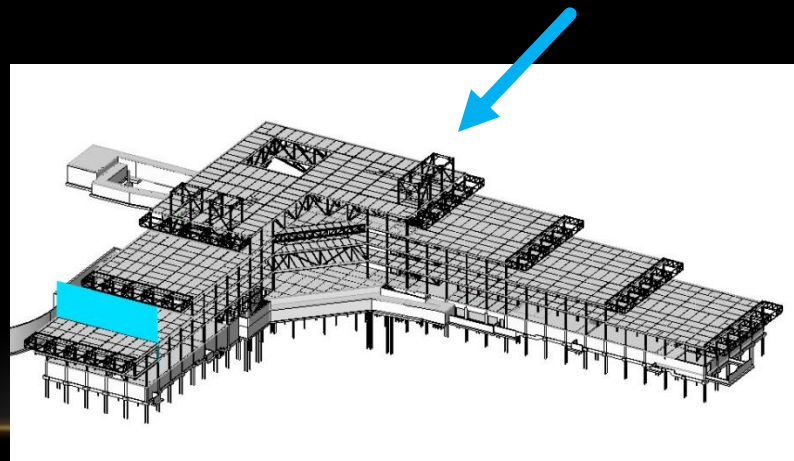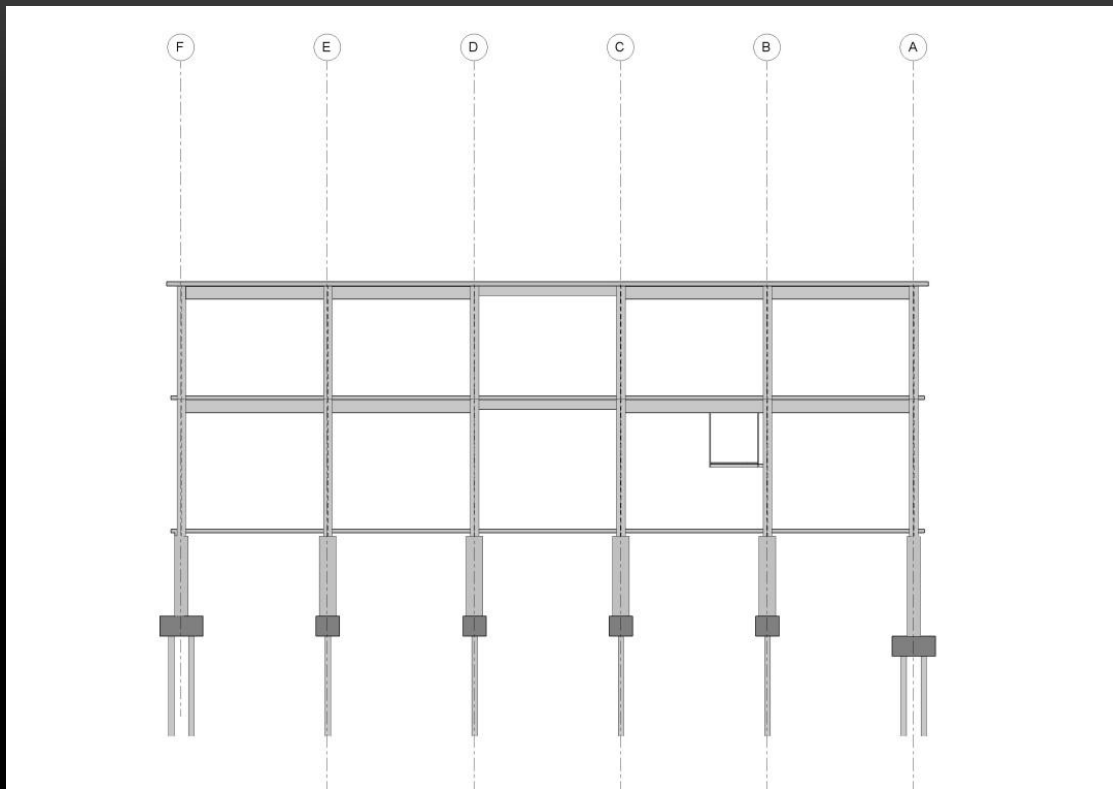
Frame – 19 (Looking South)
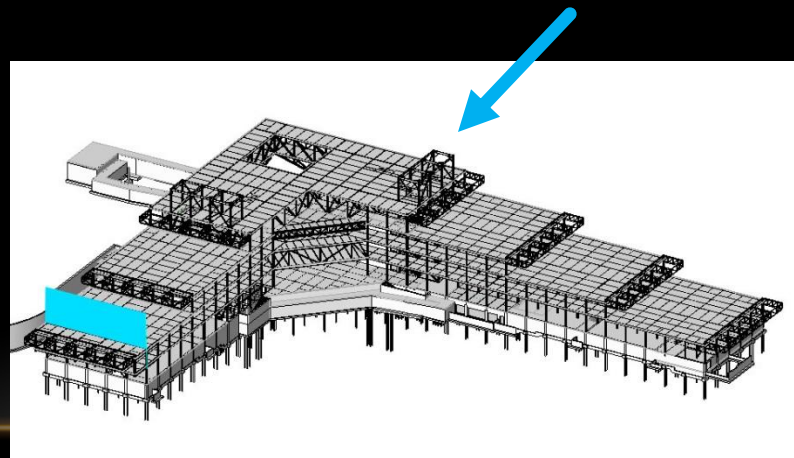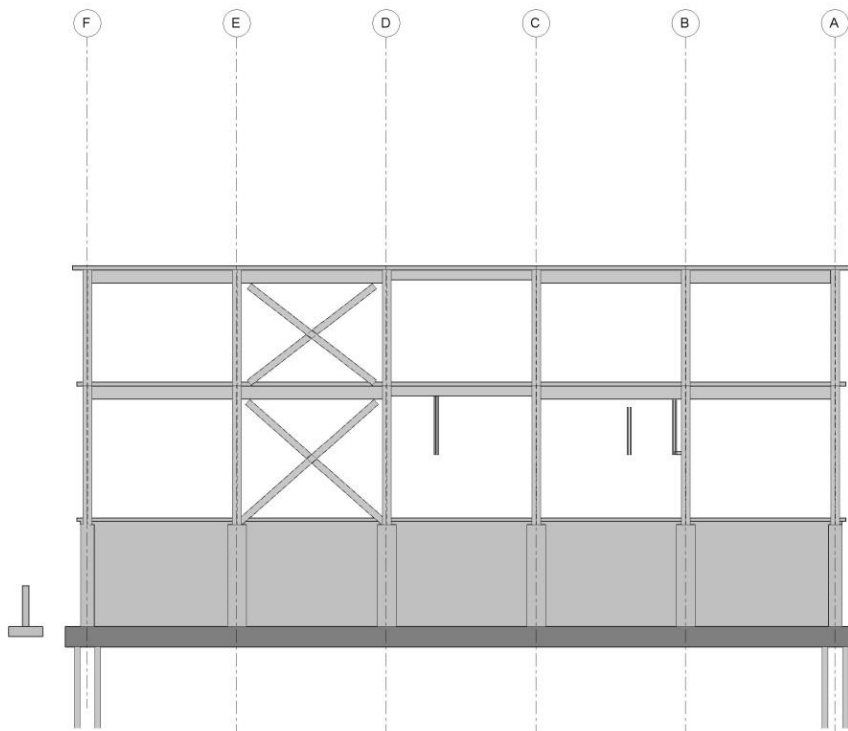
Frame – 20 (Looking South)

GRAVITY LOADS

Floor Loading Schedule							Confirmed Loads	
				Loads				
Floor	Elevation (ft-in.)	Occupancy	Slab Type	Slab (PSF)	SDL (PSF)	LL (PSF)	ASCE7-05 LL	USD* - DL
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	$p_f = 0.7 C_e C_t I p_g$	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	qp	GCpn	Pp= qpGCpn	
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						
	Load		Shear		Moment	
Floor Level	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)			
$S_1 =$	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)		
Tl=	6 s (Fig. 22-15)		
Ta=	0.512 s		
Cu=	1.7		
Cu*Ta=	0.871 s		
Cs=	Min	0.0603	
		0.0346	
		0.2386	

V=	CS*W	
Cs=	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)	Mi (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