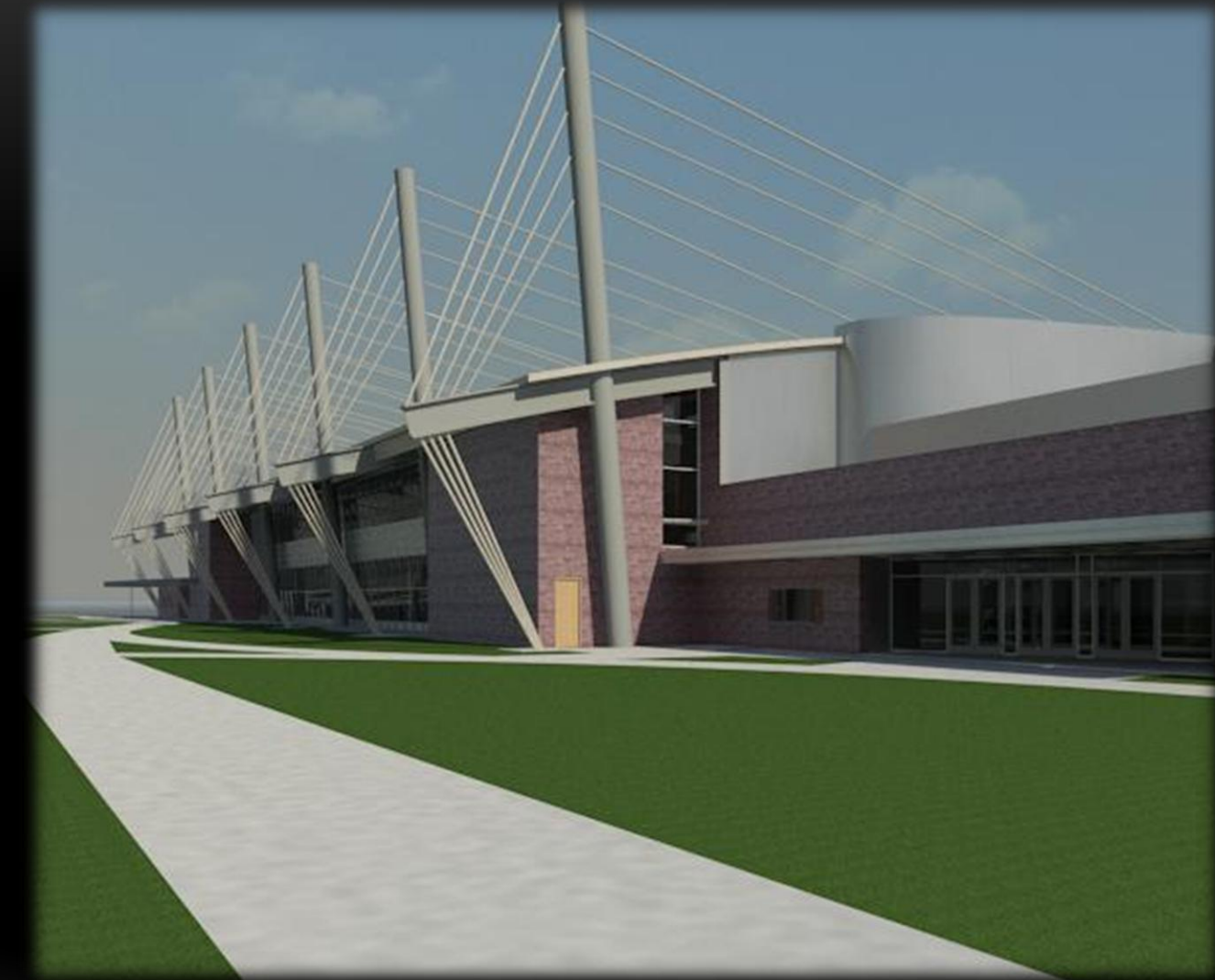
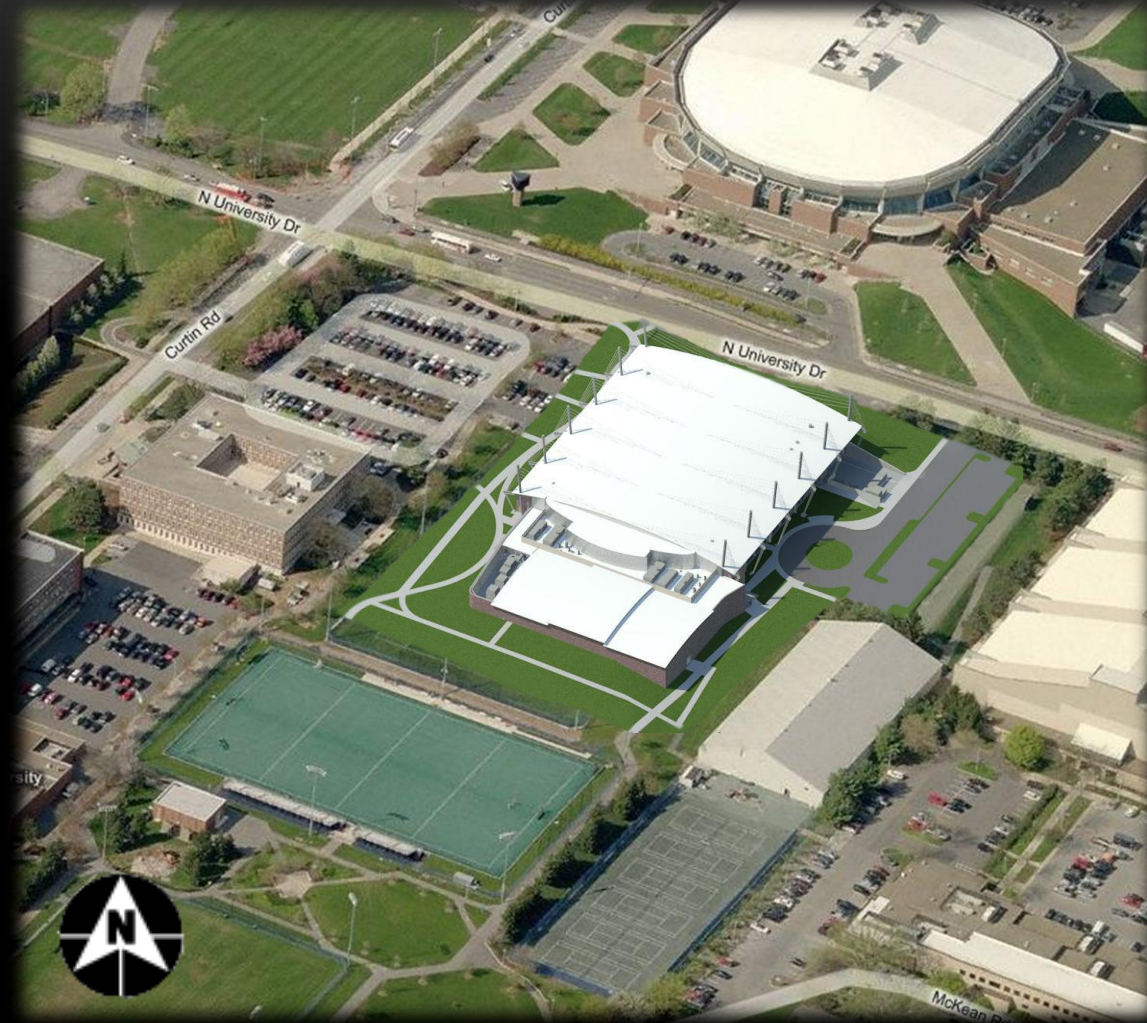


# lightsout DESIGN

Mission Statement:  
*To deliver innovative designs, with an integrated, streamlined approach to building systems and construction management*







## FINAL PRESENTATION AGENDA

Introduction

Roof Redesign

Façade Redesign

Mechanical Loft Design

Coordination

Conclusion





# PENN STATE ICE ARENA

## Building Stats:

Funded Solely Through Private Donations  
6,000 Seat Multi-Purpose Arena  
220,000 Square Feet  
2 Ice Rinks  
Home to Division 1 Men's and Women's Hockey  
Construction Began February 2012



# DESIGN TEAM

Architects:



**Bohlin Cywinski Jackson**  
Architecture Planning Interior Design

Structural Engr:



MEP Engr:



Construction Manager:



**Nate Babyak**



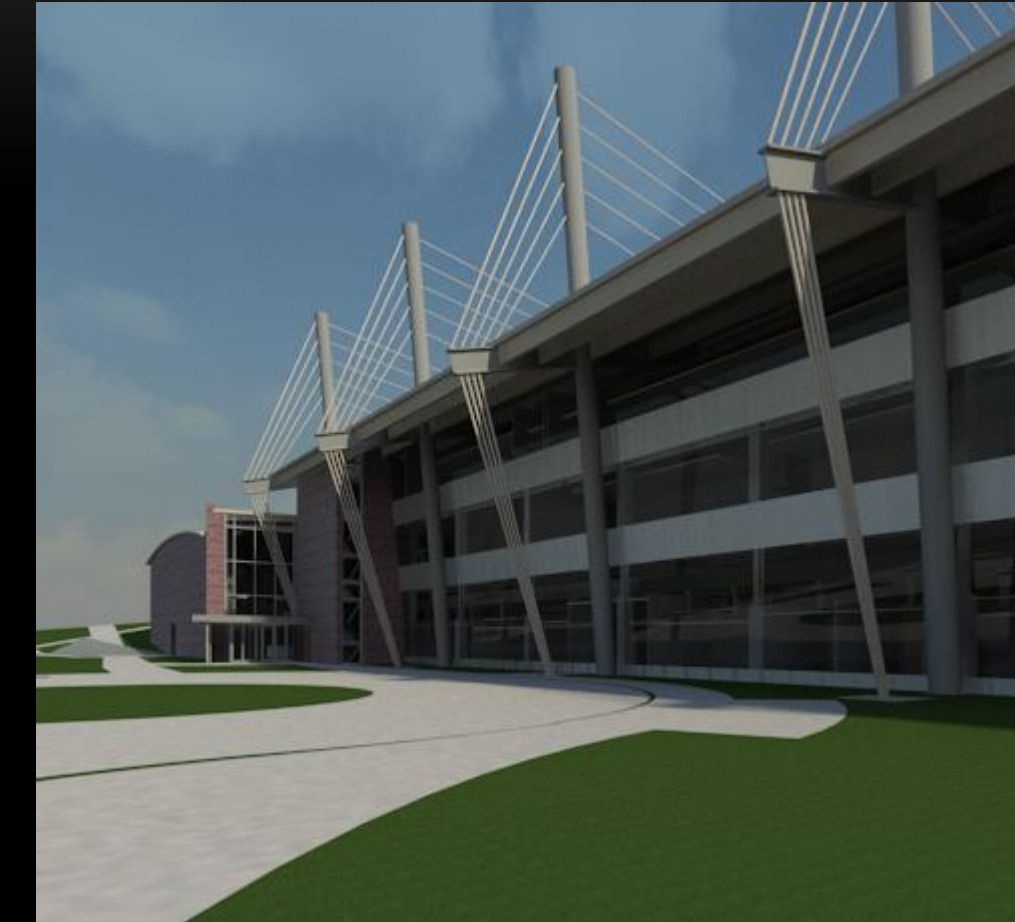
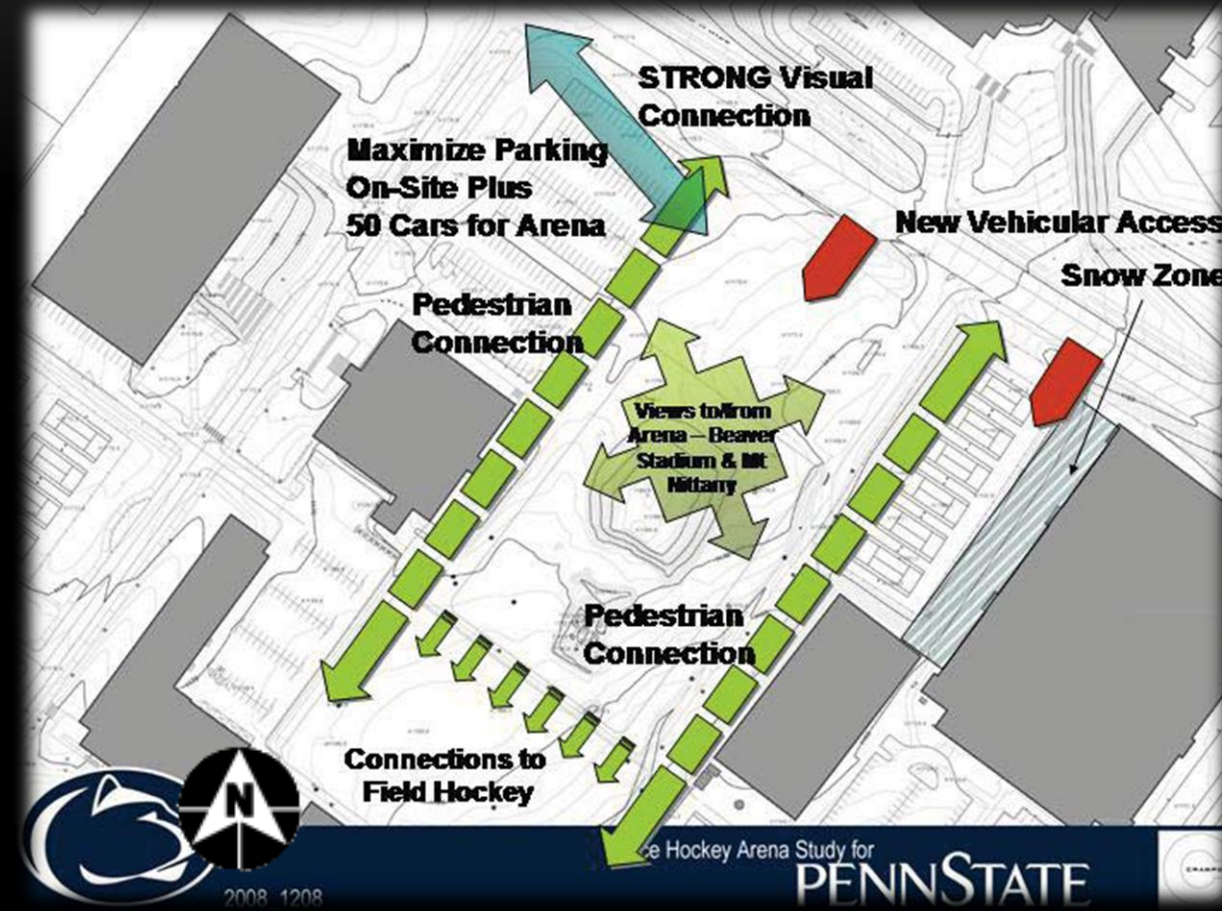
**Brian Sampson**



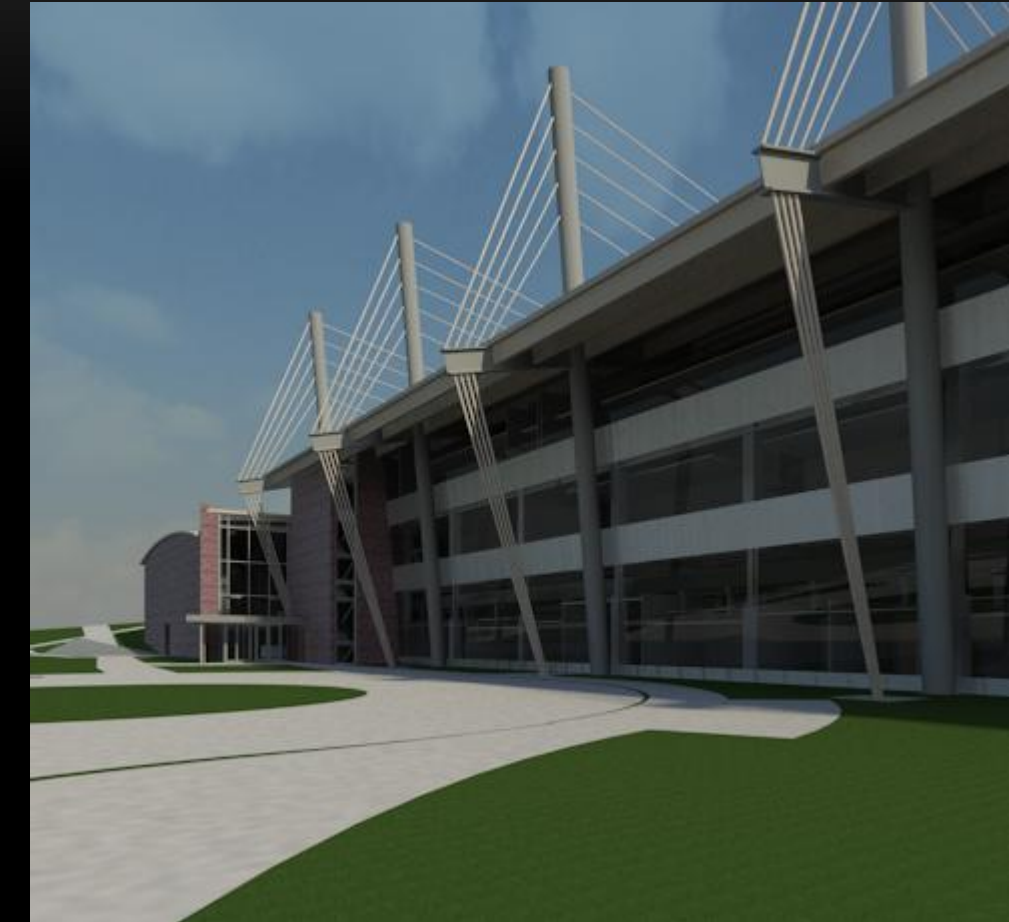
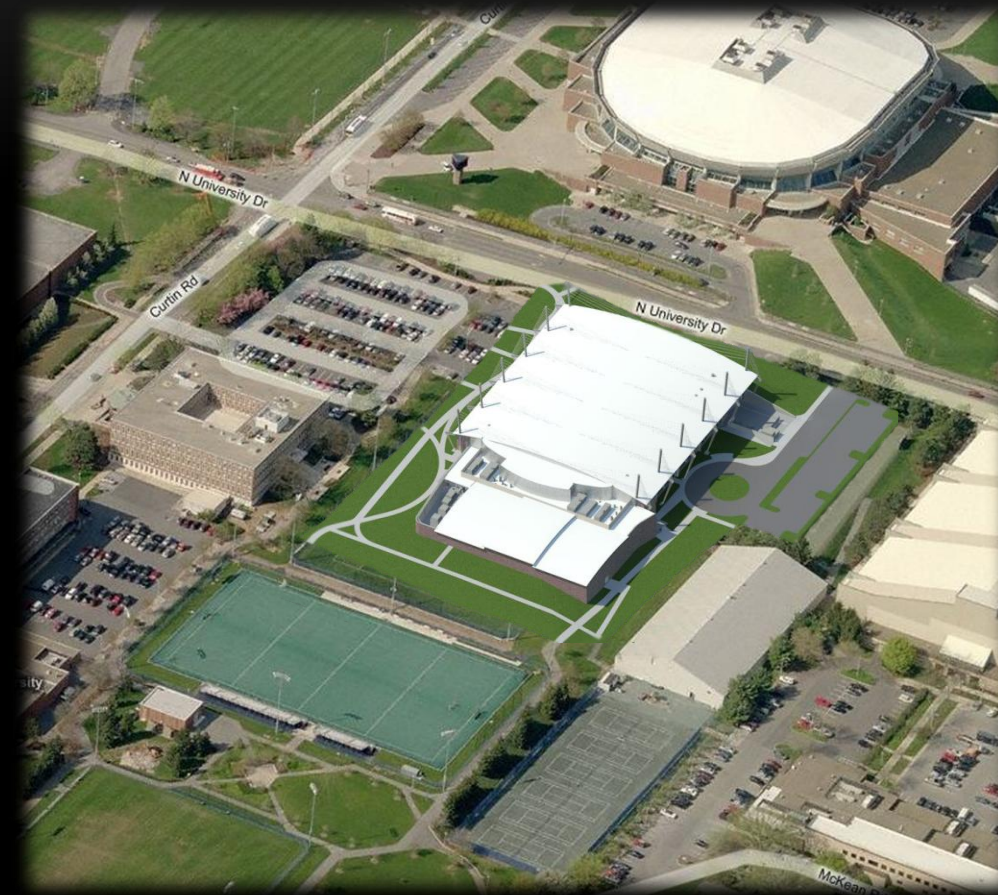
**Alex Schreffler**



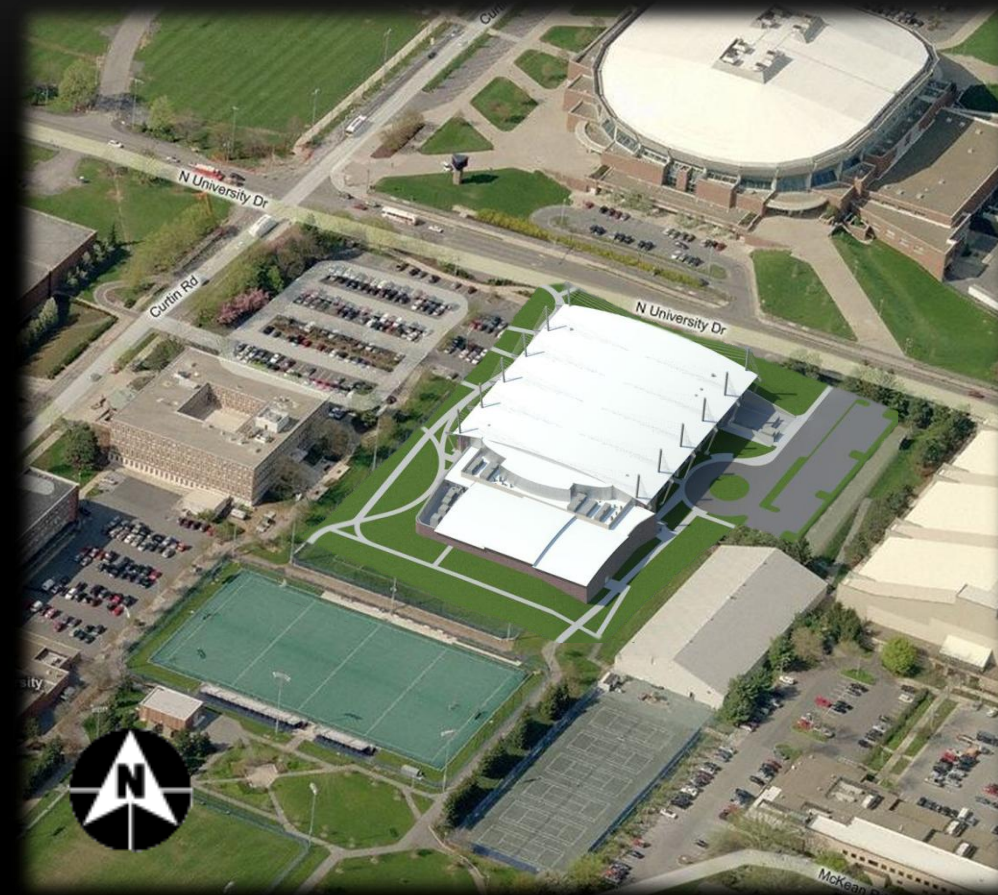








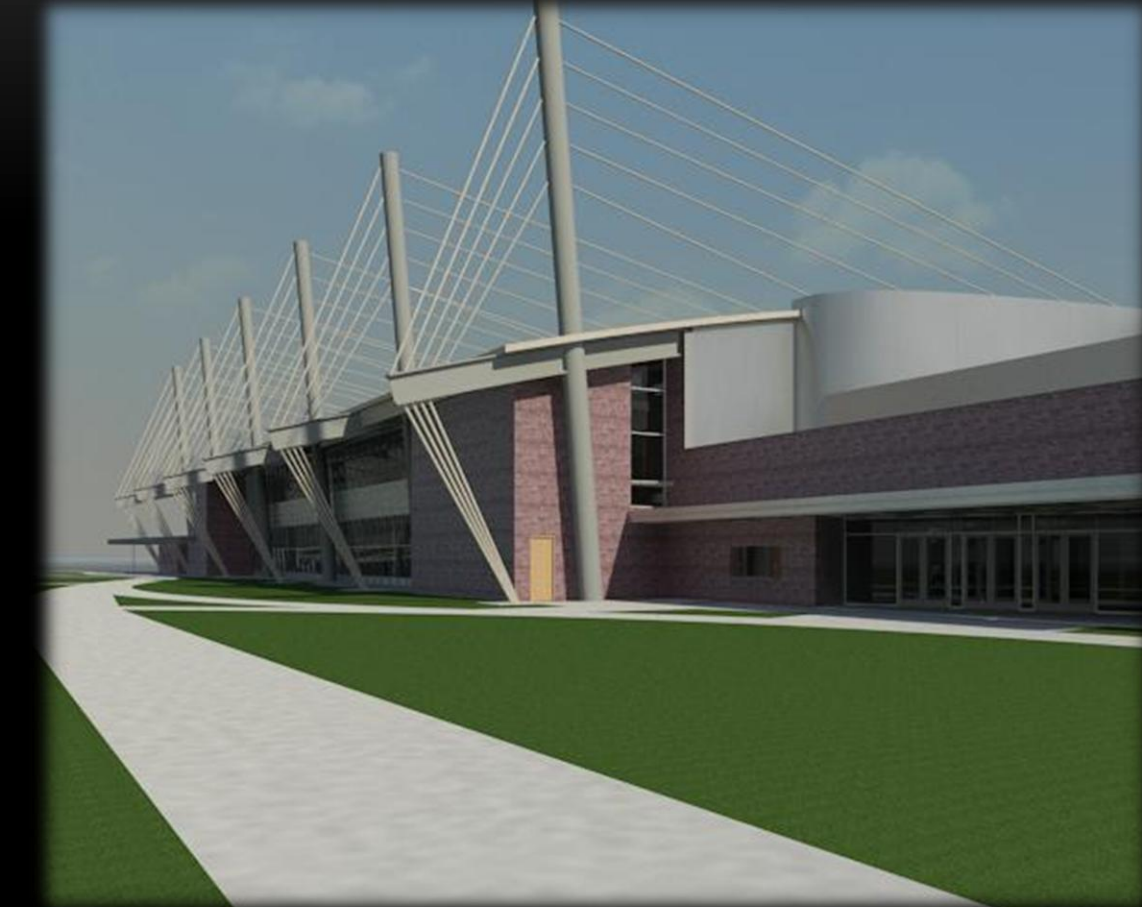
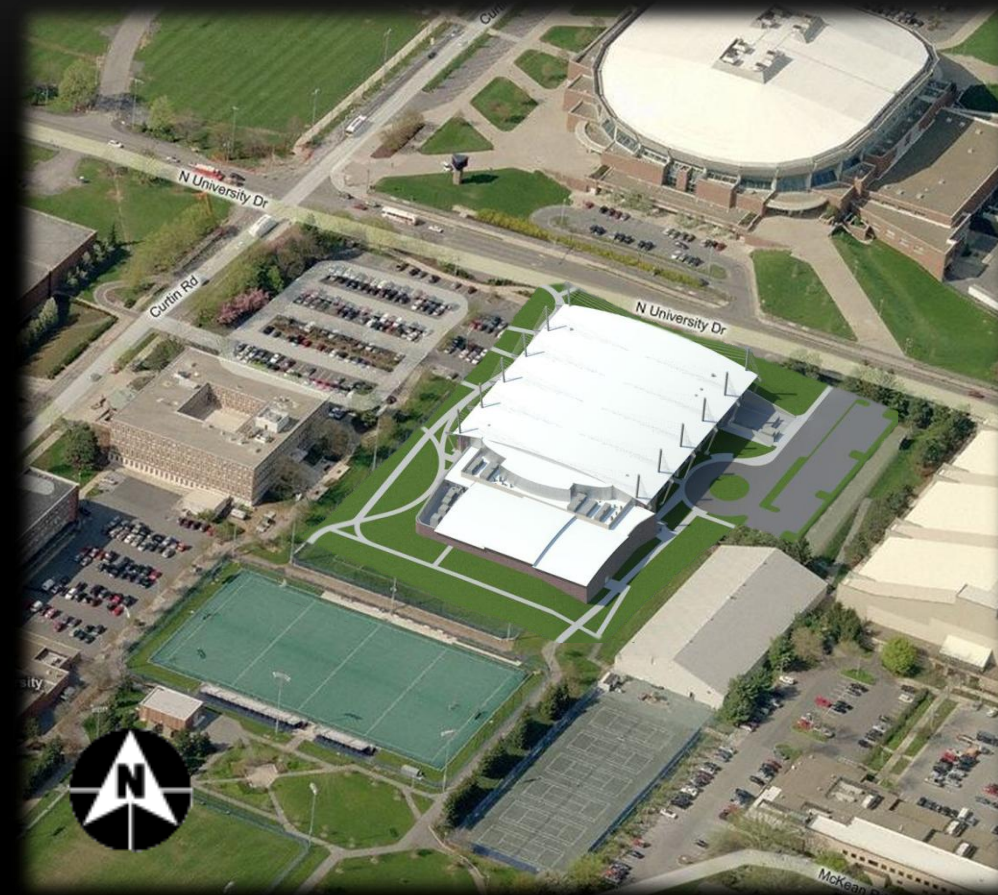




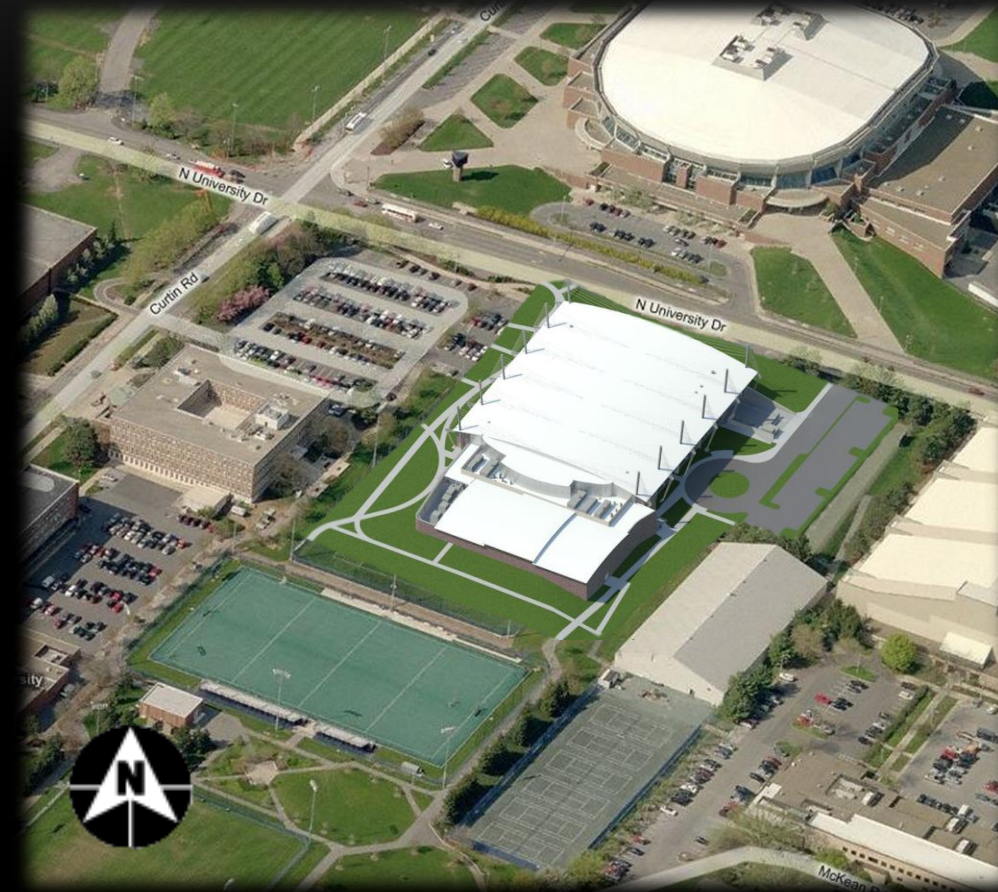
MAIN CONCOURSE LEVEL



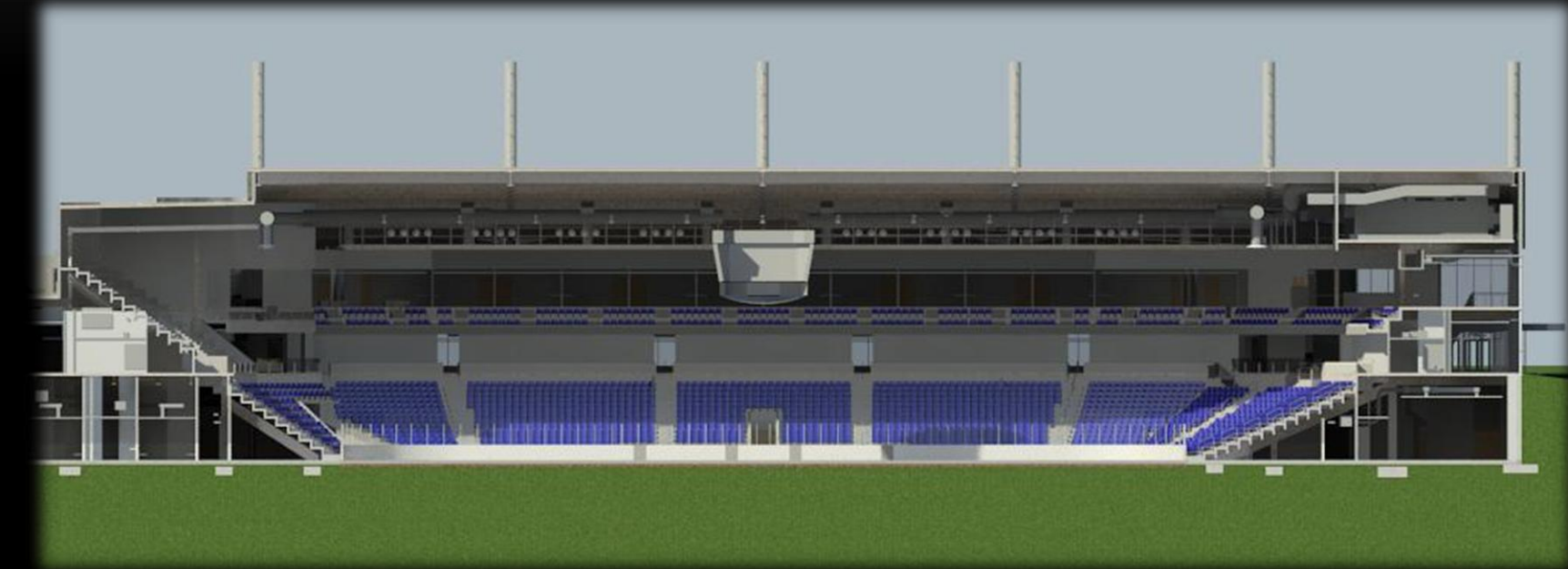




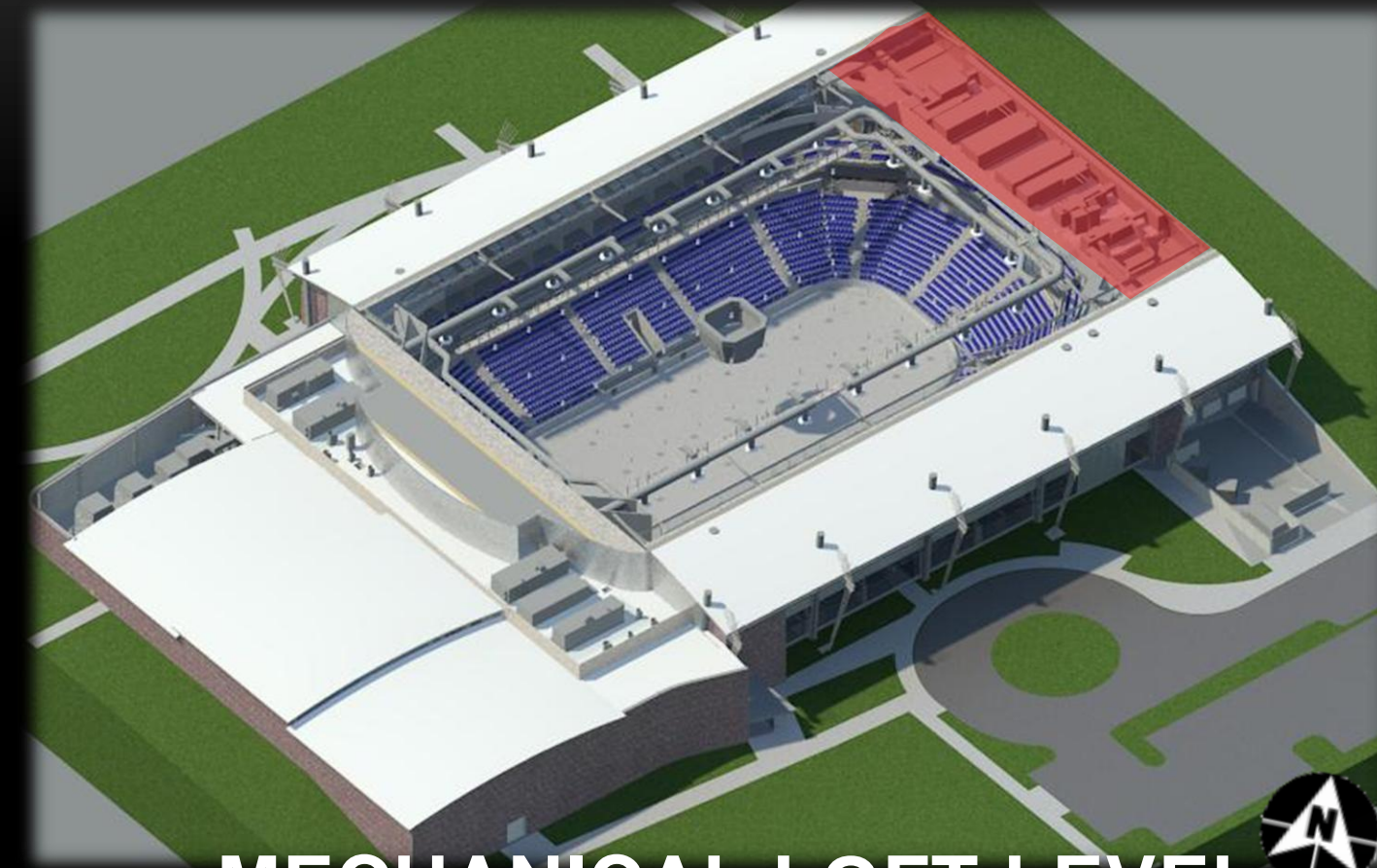
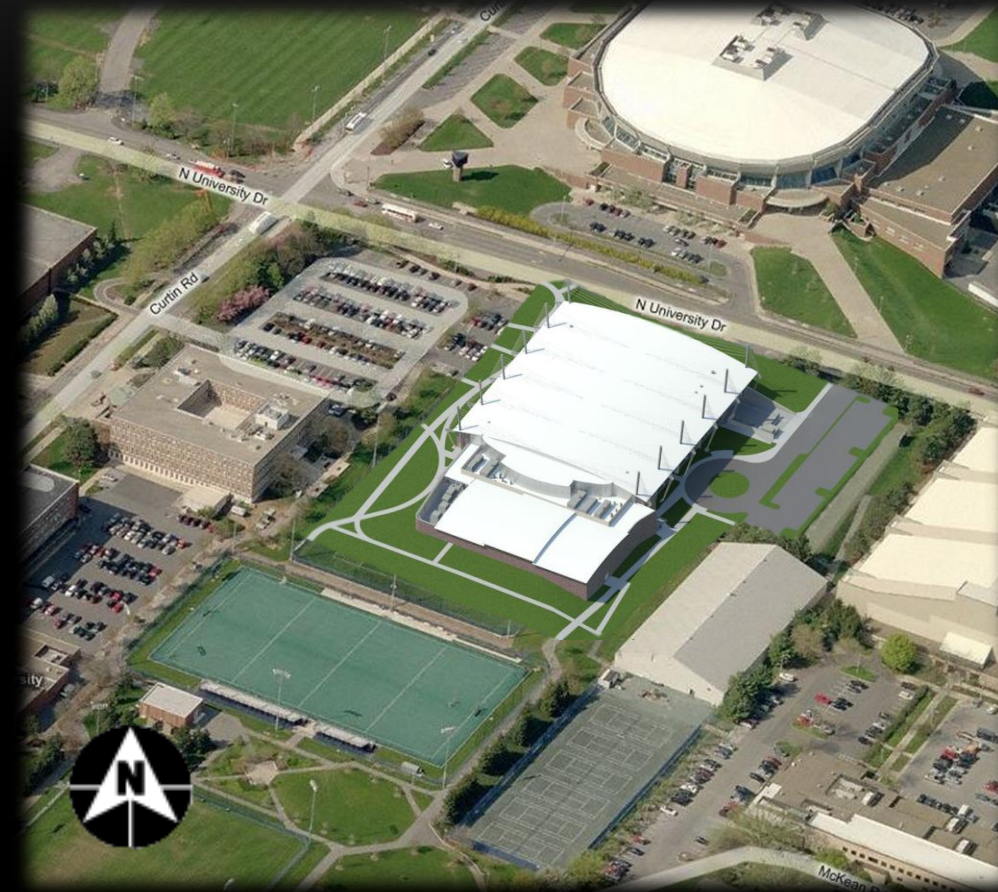




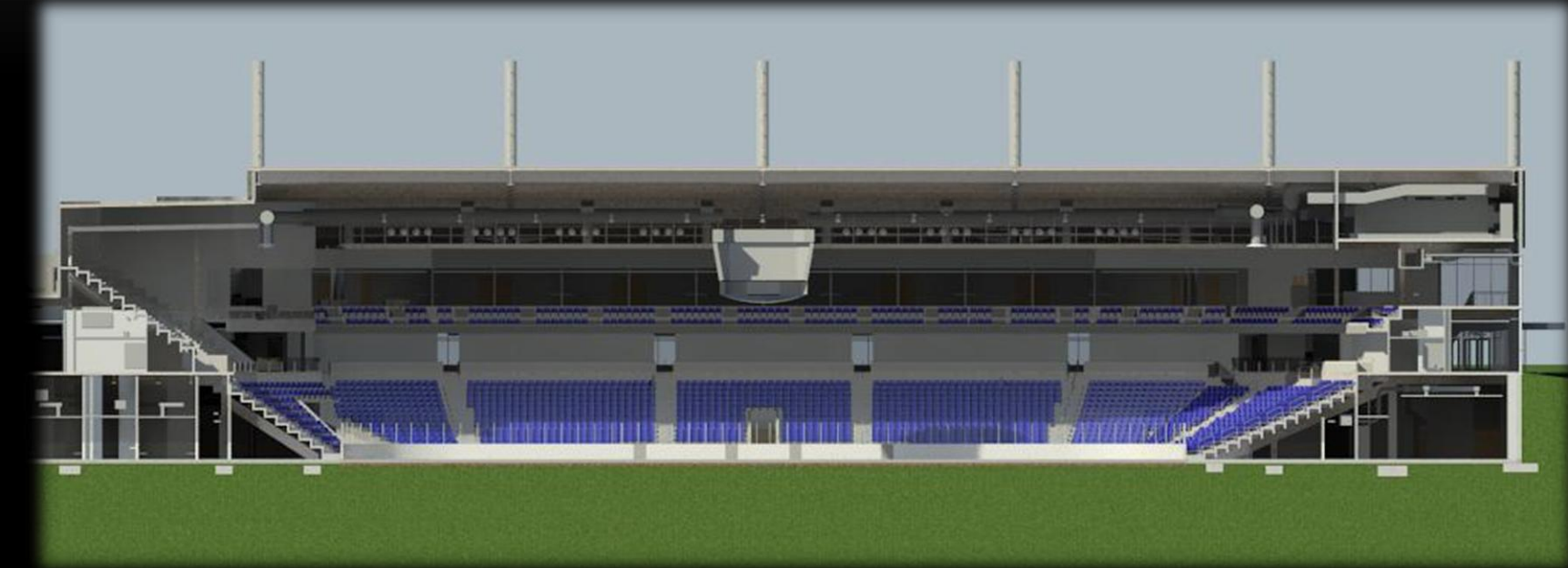
CLUB CONCOURSE LEVEL







MECHANICAL LOFT LEVEL

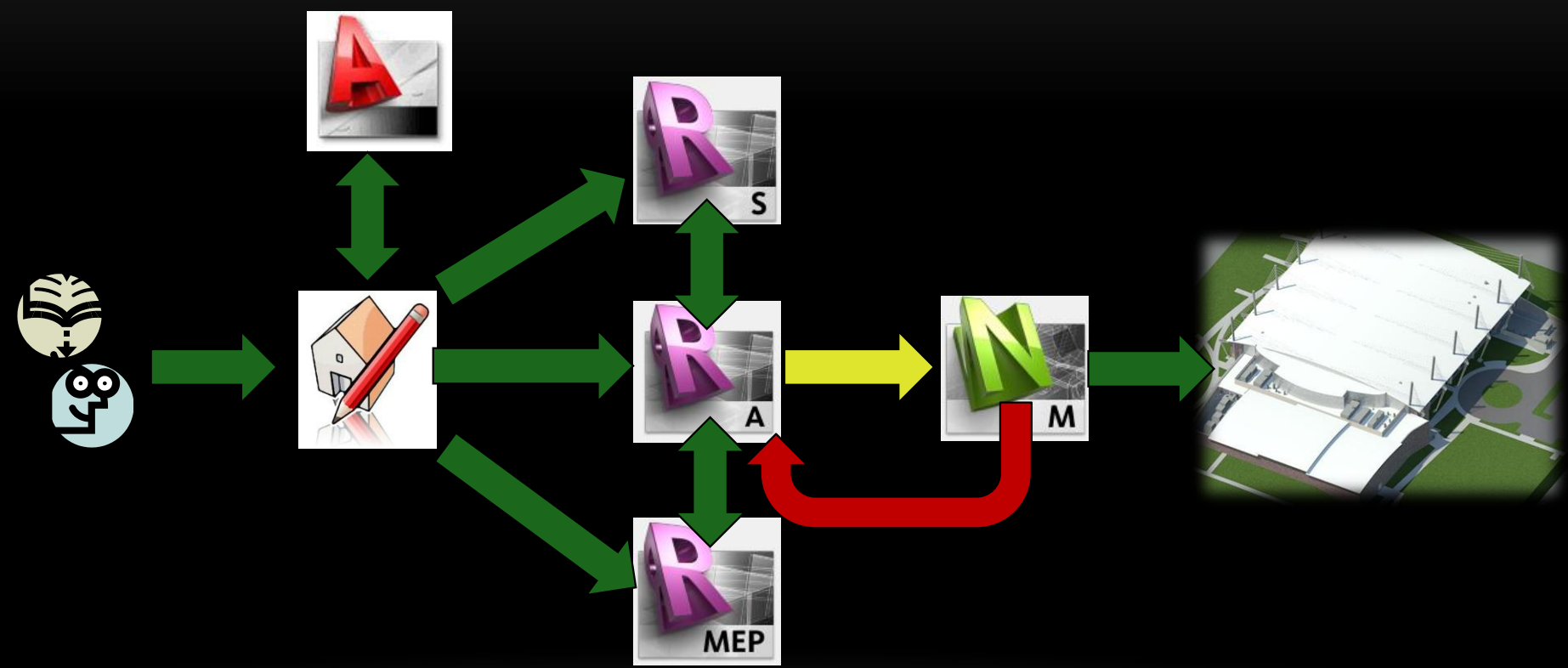




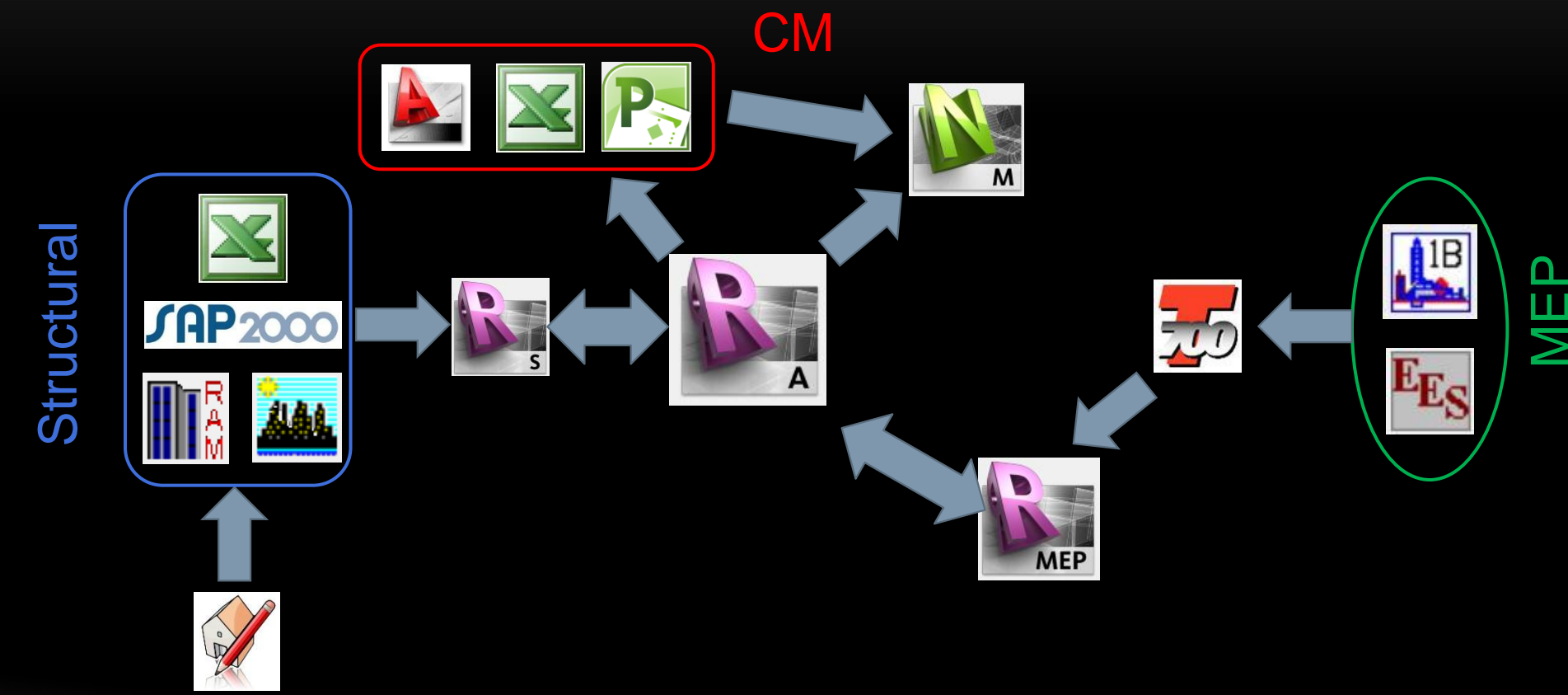
## BIM GOALS

Priority (1-3) 1-Most Important	Goal Description (Value Added Objectives)	Potential BIM Uses
1	Recognize Design Conflicts Before They Reach Construction	3D Coordination, Design Review, Design Authoring
1	Create an Energy Efficient Arena	Energy Analysis, Lighting Analysis, Building Systems Analysis, Site Analysis, Design Authoring, Sustainability, LEED Evaluation
2	Design with Constructability in Mind	3D Coordination, 4D Modeling, Cost Estimation, Design Authoring
1	Optimize Building Performance	Building Systems Analysis, Cost Estimation, Structural Analysis, Energy Analysis, Mechanical Analysis, Design Authoring, 3D Coordination, Construction Systems Design

## DESIGN PROCESS



## PROGRAM COORDINATION

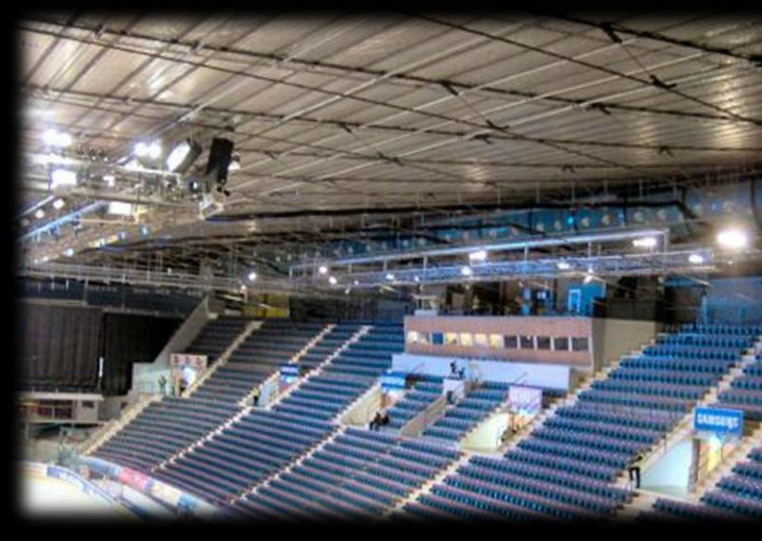




## ROOF DEVELOPMENT



Ingalls Rink- 1959  
Yale University



Hovet-1962  
(Johannesov Isstadion)  
Stockholm, Sweden



Oxford Ice Rink- 1984  
Oxford, England



Blyth Arena- 1959  
Squaw Valley, California

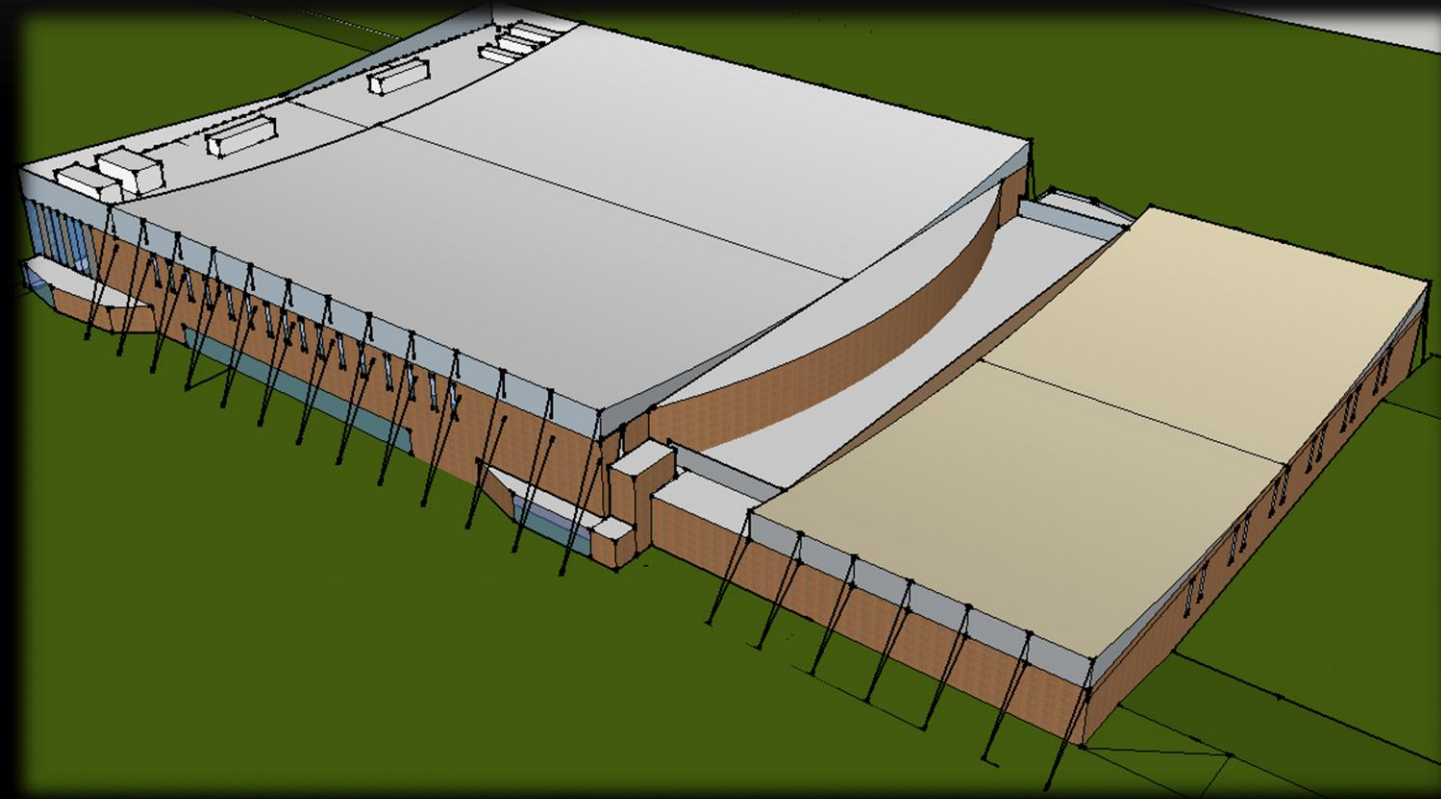


Ratner Center-2003 University of Chicago



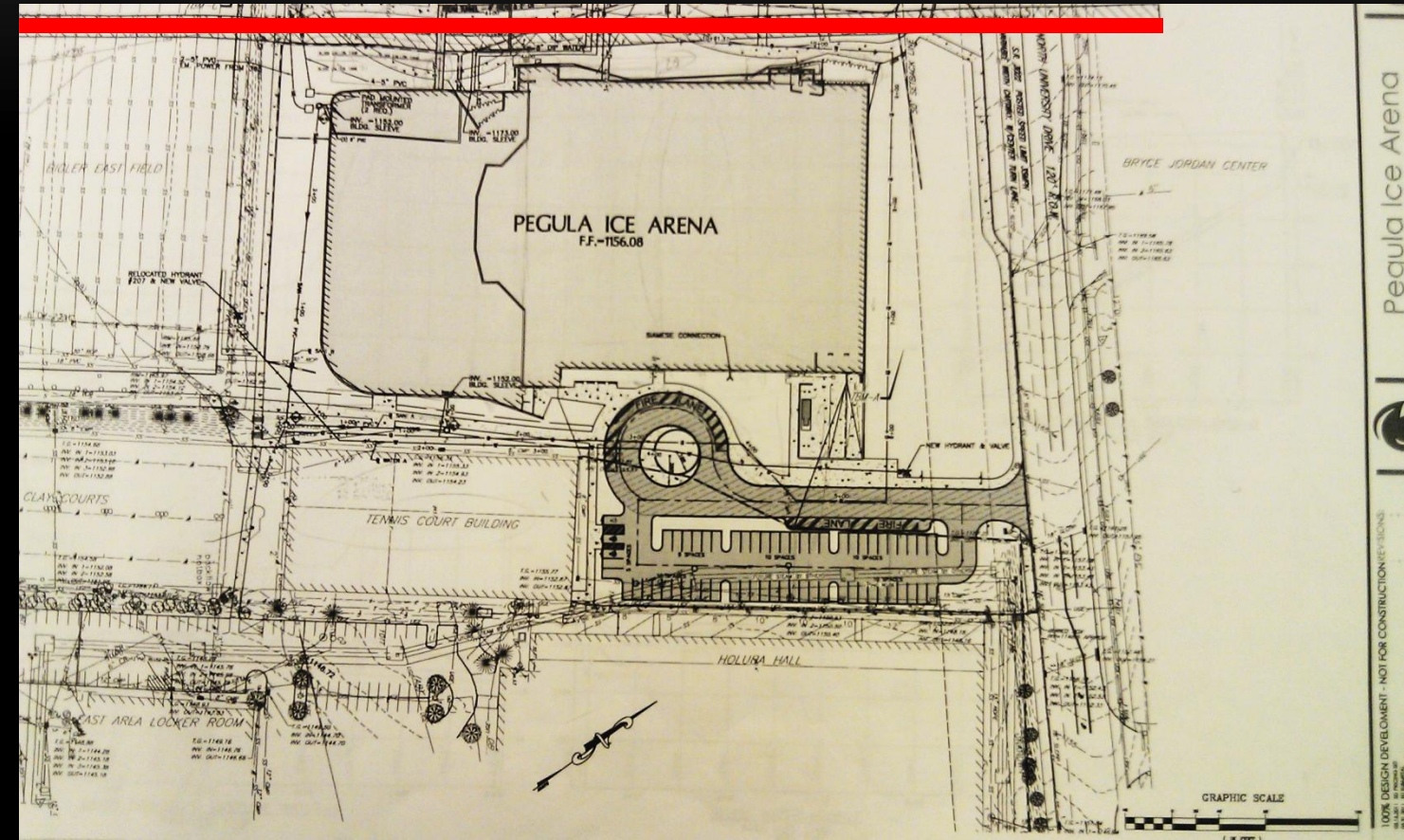


# ROOF DEVELOPMENT

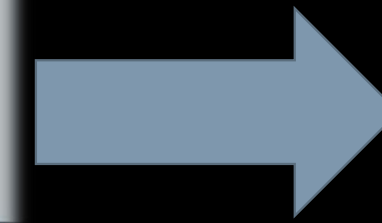
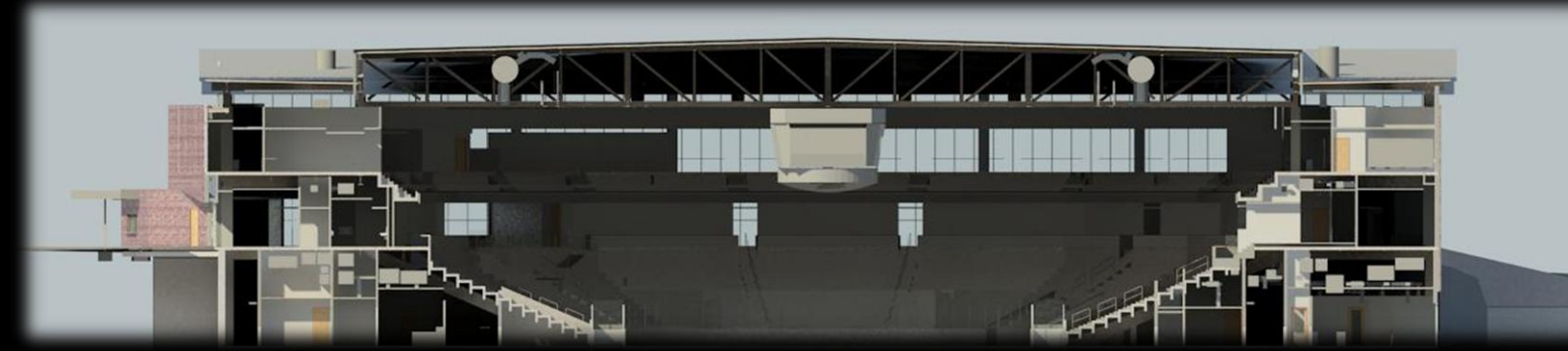




# SITE CONDITIONS



# ACTUAL DESIGN

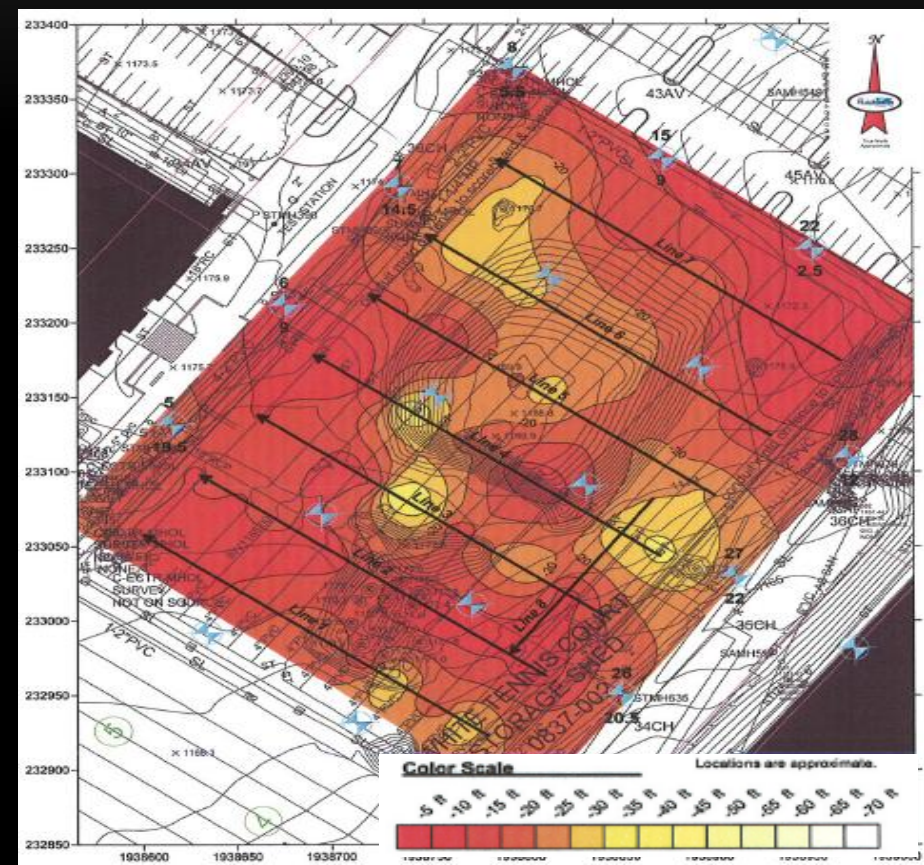


# OUR DESIGN

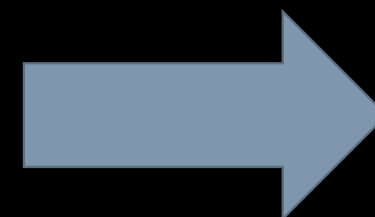
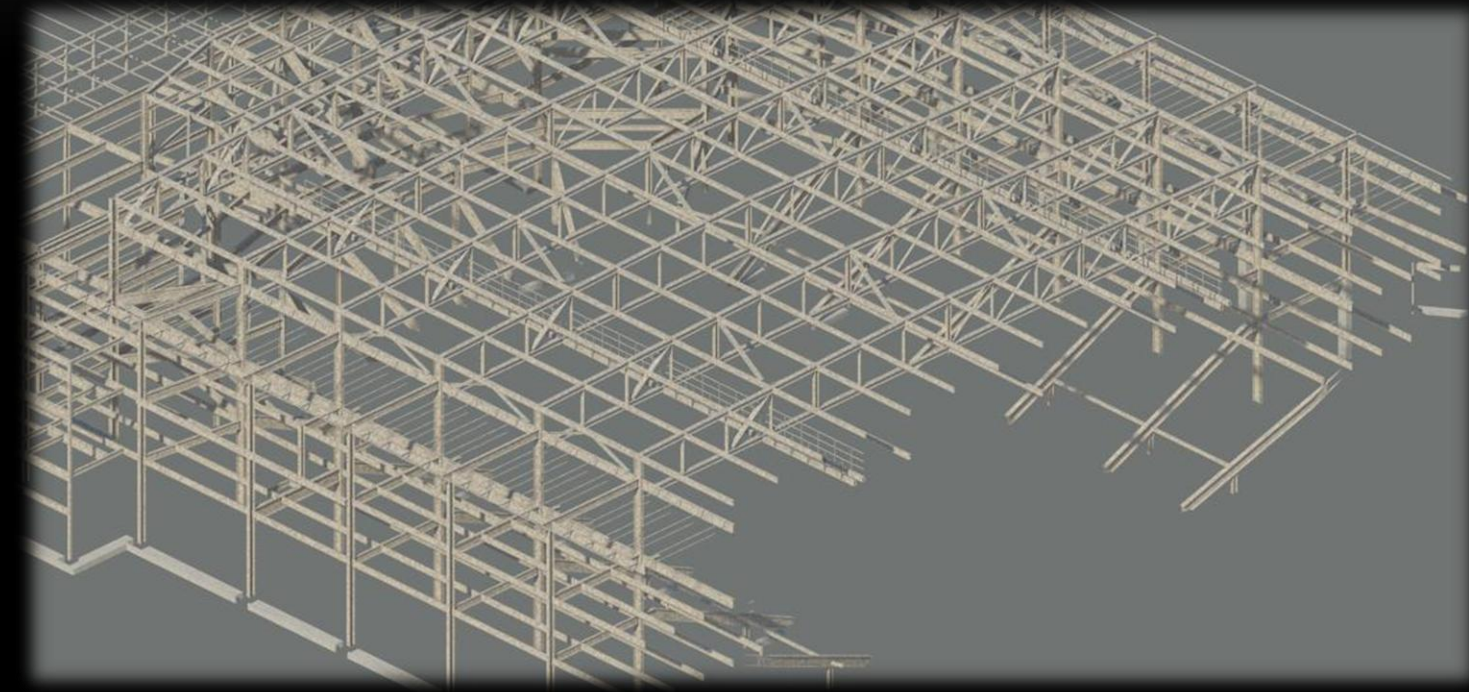




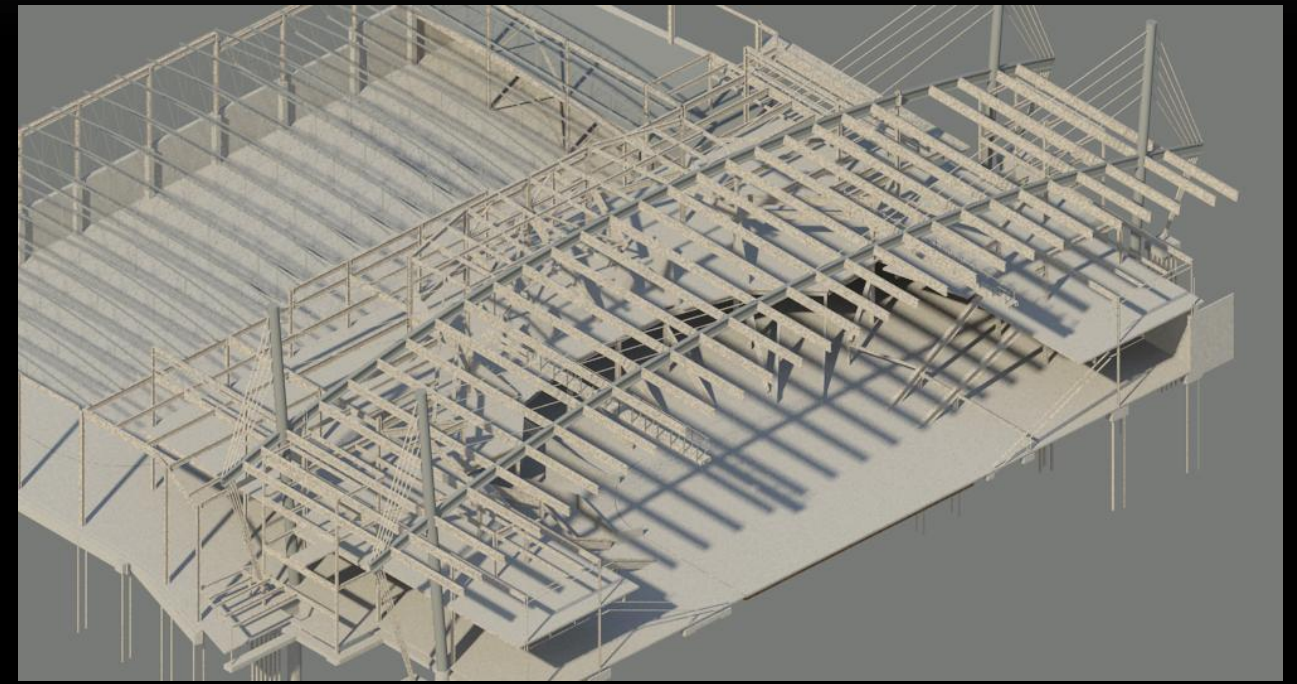
# SITE CONDITIONS



# ACTUAL DESIGN

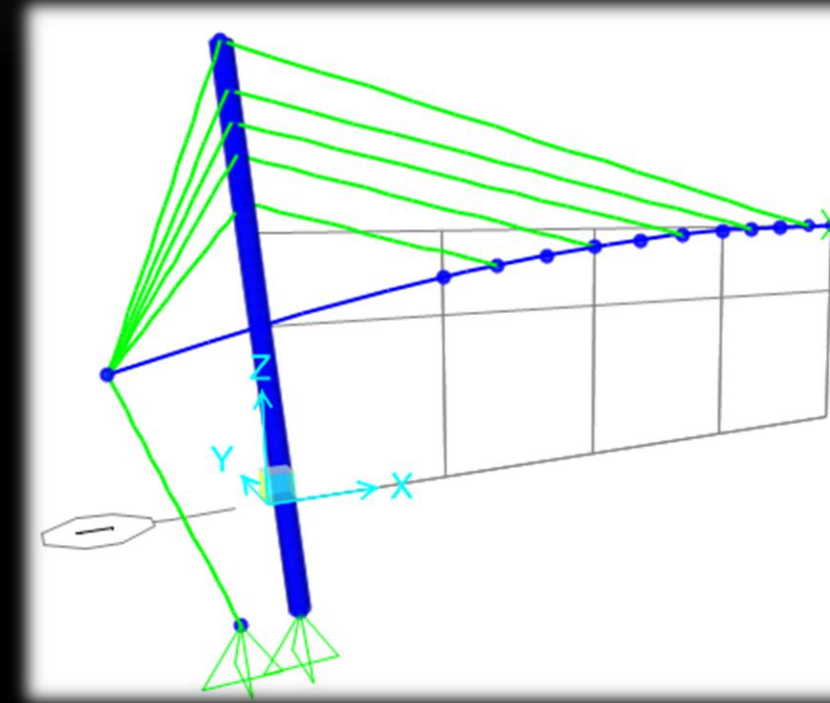
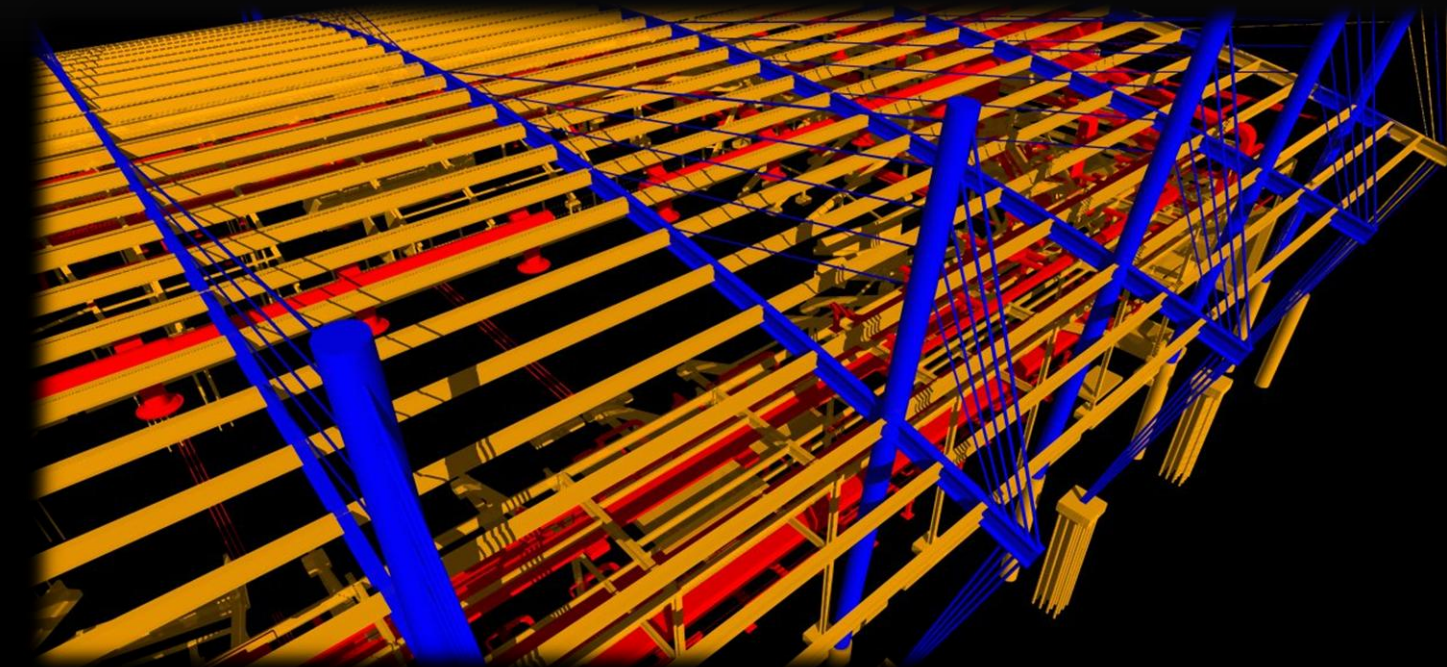


# OUR DESIGN





## ROOF DESIGN



First Attempt:

Deck: 3N18 14' Span

Roof Beams:

W30x90

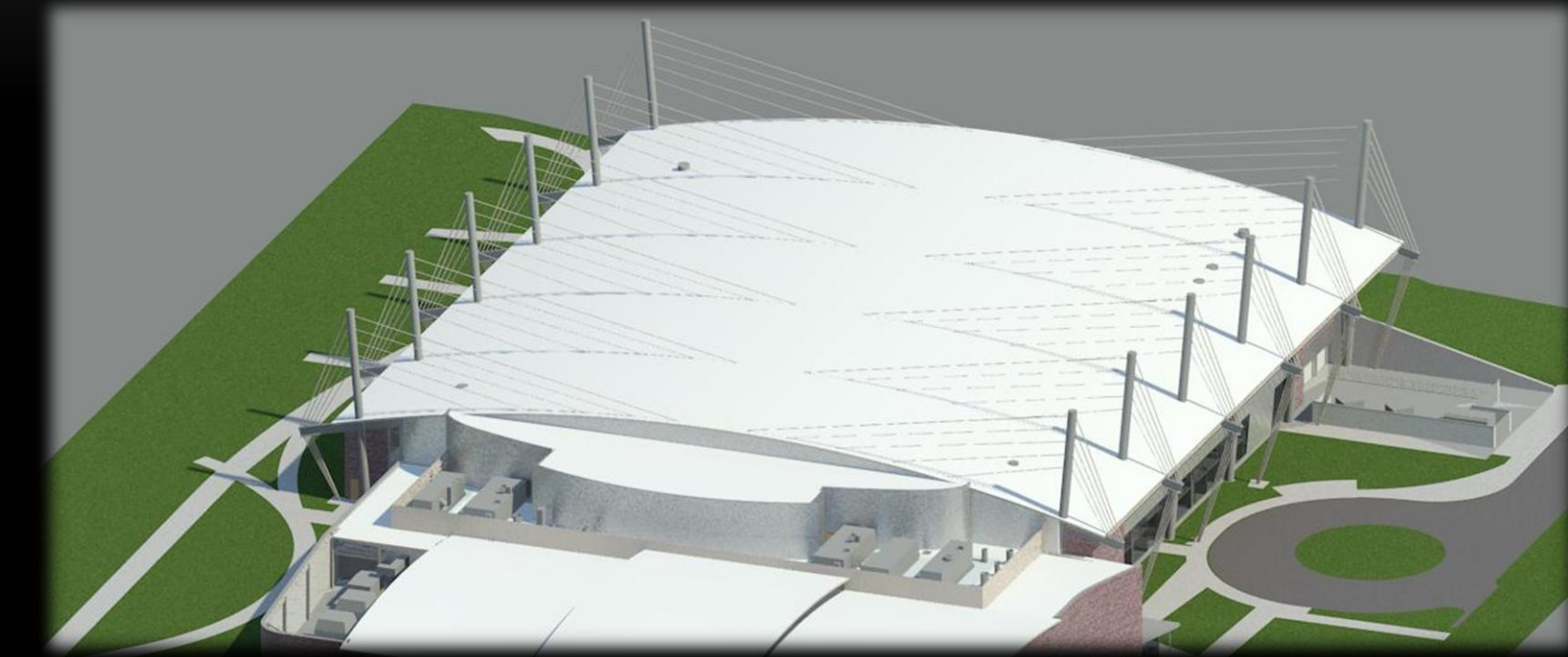
CB 36x55

Our Design:

Deck: 3C18 11' Span

Roof Beams:

W33x130





# ROOF DESIGN

Construction Templates - Project

Alternative: Alternative 1  
Description: WALL(W:0,E:100,S:10,Nc:80,Ns:25)

Construction... U-factor Btu/h ft<sup>2</sup> °F

Slab	6" HW Concrete	0.0714
Roof	Steel Sheet, 4" Ins	0.043178
Wall	Metal, 3" Ins	0.045455
Partition	0.75" Gyp Frame	0.387955

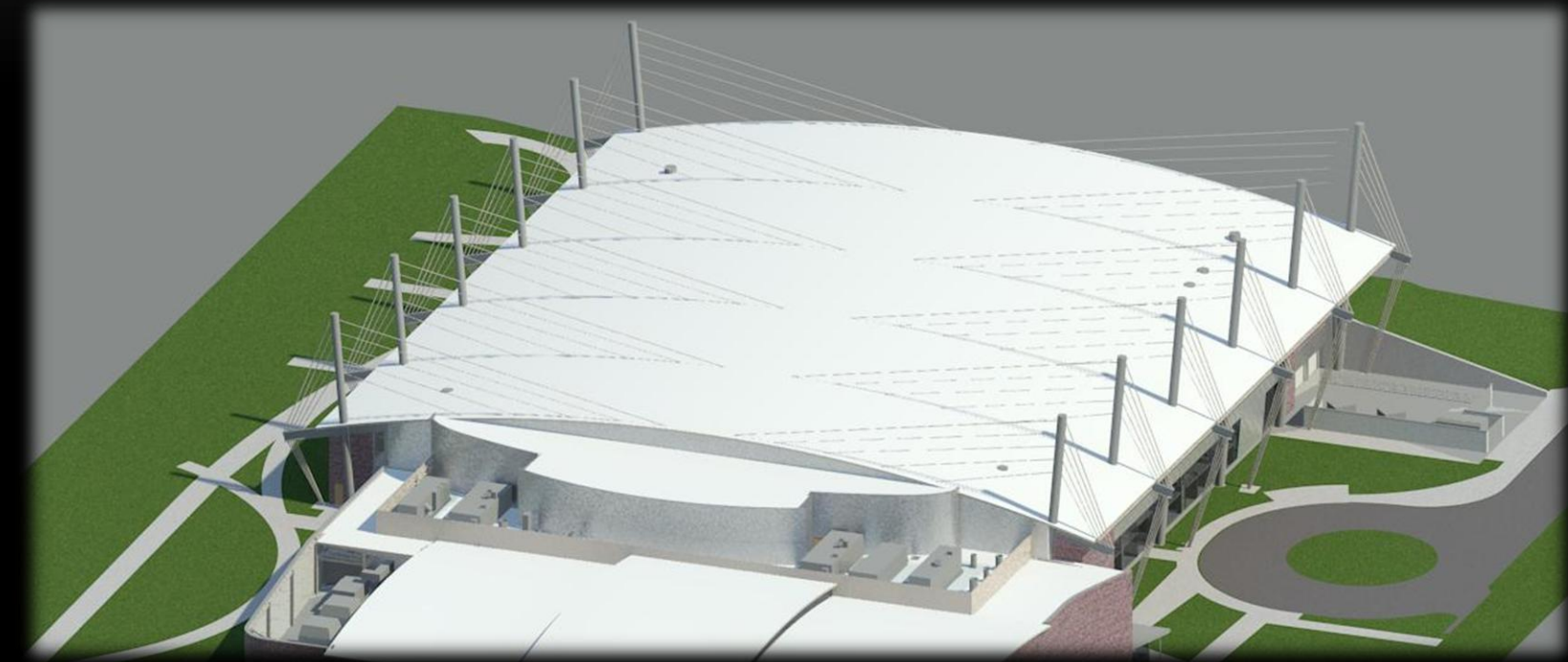
Glass type... U-factor Btu/h ft<sup>2</sup> °F Shading coeff

Window	3mm Dbl Low-E (e3=.1) Clr 13mm Argon	0.2857	0.75
Skylight	Triple Clear 1/4"	0.35	0.16
Door	90.1-07 Min Nonswinging Nonres Zone 5-8	0.5	0

Height... Pct wall area to underfloor plenum % Room type

Wall	20	ft		Conditioned
Flr to flr	20	ft		
Plenum	10	ft		

Internal Load Airflow Thermostat **Construction** Room



TOOL NO. 1  
R VALUE ANALYSIS

CLIMATE CONDITIONS

	Winter		Summer	
Temp(°F)	RH(%)	Temp(°F)	RH(%)	
Indoor	65 40	65 40		
Outdoor	9 59	91 64		

City: Harrisburg, PA

MATERIALS

Layer	Generic Material	Thick.	R Val.
1	air film (ext). 3/4 in.	0.75	0.17
2	coating (#1). (50mil)	0.05	0.12
3	membrane (#2). .080 in.	0.08	0.07
4	rigid ins. (extru.). 4 in.	4.00	20.55
5	plywood shtg.. 1/2 in.	0.50	0.64
6	concrete wall. 6 in.	6.02	0.87
7	steel clad (unvntd). 1-1/2 in.	1.50	0.12
8	air film (int). 3/4 in.	0.75	0.64
9			
10			
11			
12			
Total or (Layer 0)		12.15	23.16

WALL SECTION & TEMPERATURE GRADIENTS

Standard Wall Wider Wall

This software is licensed to: PENNSYLVANIA STATE UNIVERSITY



# ROOF DESIGN

Construction Templates - Project

Alternative: Alternative 1  
 Description: WALL(W:0,E:100,S:10,Nc:80,Ns:25)

Construction... U-factor Btu/h ft<sup>2</sup> °F

Slab	6" HW Concrete	0.0714
Roof	Steel Sheet, 4" Ins	0.043178
Wall	Metal, 3" Ins	0.045455
Partition	0.75" Gyp Frame	0.387955

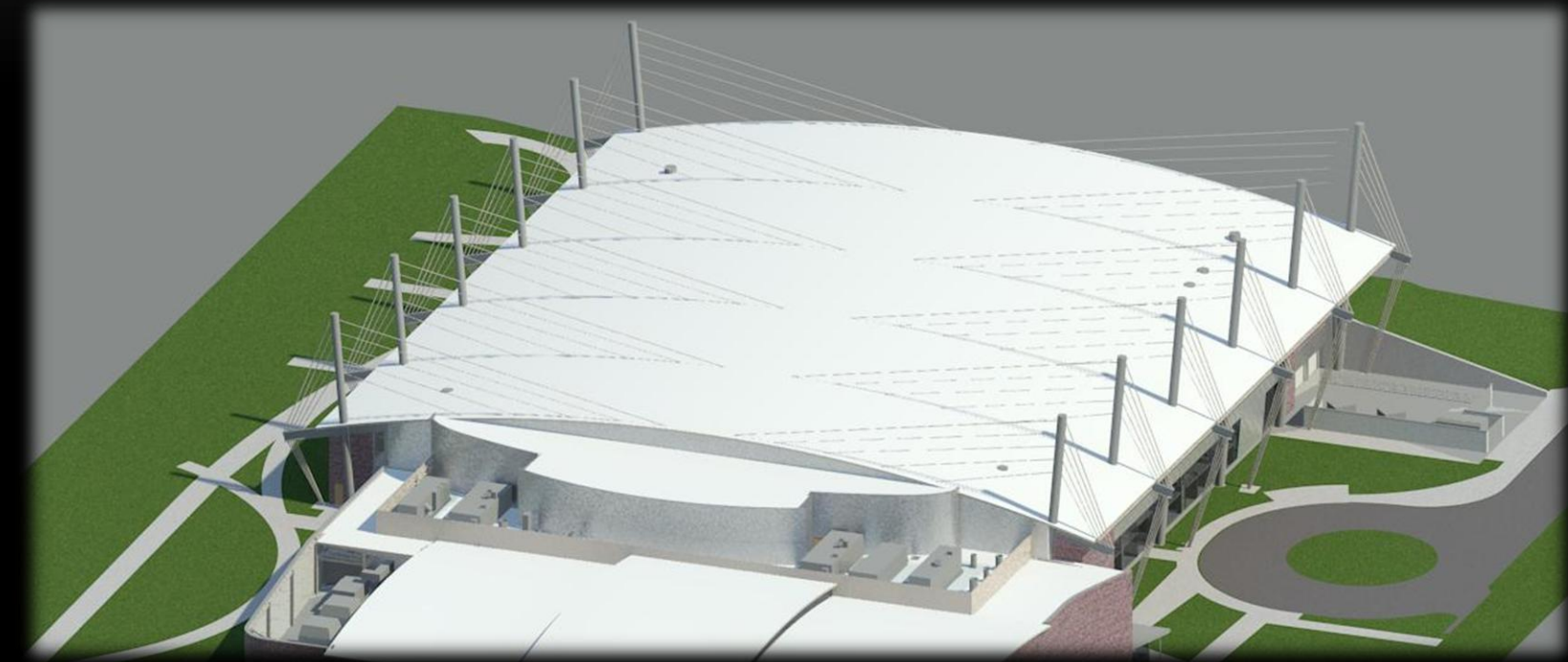
Glass type... U-factor Btu/h ft<sup>2</sup> °F Shading coeff

Window	3mm Dbl Low-E (e3=,1) Clr 13mm Argon	0.2857	0.75
Skylight	Triple Clear 1/4"	0.35	0.16
Door	90.1-07 Min Nonswinging Nonres Zone 5-8	0.5	0

Height... Pct wall area to underfloor plenum %

Wall	20	ft	
Fir to fir	20	ft	Room type: Conditioned
Plenum	10	ft	

Buttons: Internal Load, Airflow, Thermostat, **Construction**, Room



**TOOL NO. 2 CONDENSATION ANALYSIS**

CLIMATE CONDITIONS

	Winter		Summer	
	Tmp(°F)	RH(%)	Tmp(°F)	RH(%)
Indoor	65	40	65	40
Outdoor	9	59	91	64

City: Harrisburg, PA

MATERIALS

Layer	Description	RVap	V Drp	VpC
1	air film (ext), 3/4 in.	0.001	0	0
2	coating (#1), (50mil)	0.182	10	0
3	membrane (#2), .080 in.	21.190	1,160	0
4	rigid ins. (extru.), 4 in.	3.365	184	0
5	plywood shtg., 1/2 in.	1.054	58	0
6	concrete wall, 6 in.	1.635	89	0
7	steel clad (unvntd), 1-1/2 in.	11.443	626	0
8	air film (int), 3/4 in.	0.006	0	0
9				
10				
11				
12				
TOTAL or (Layer 0)		39.036	2,128	(0.3)

WALL SECTION & VAPOR PRESSURE GRADIENTS (in.Hg)

Standard Wall, Thicker Wall

This software is licensed to: PENNSYLVANIA STATE UNIVERSITY



# ASCE 19-10: STRUCTURAL APPLICATIONS OF STEEL CABLES FOR BUILDINGS

Load Combinations:

$$T_1 = D+P$$

$$T_2 = D+P+L+S$$

$$T_3 = D+P+W$$

$$T_4 = D+P+L+S+W$$

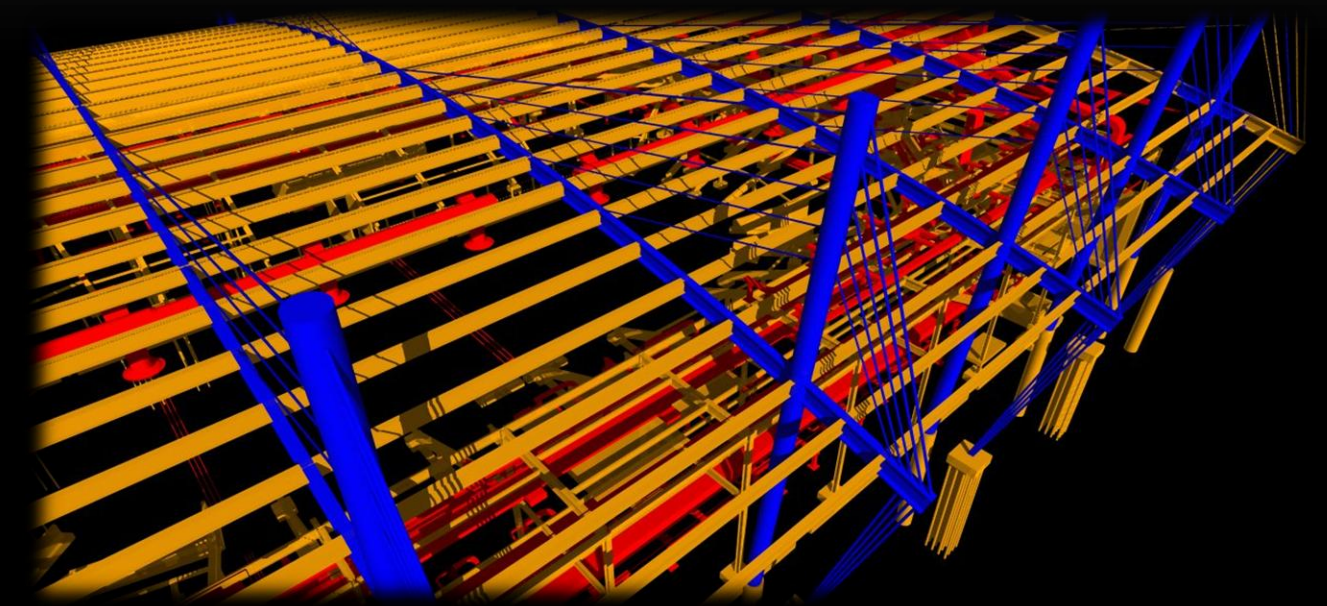
Design Strength:

$$2.2T_1$$

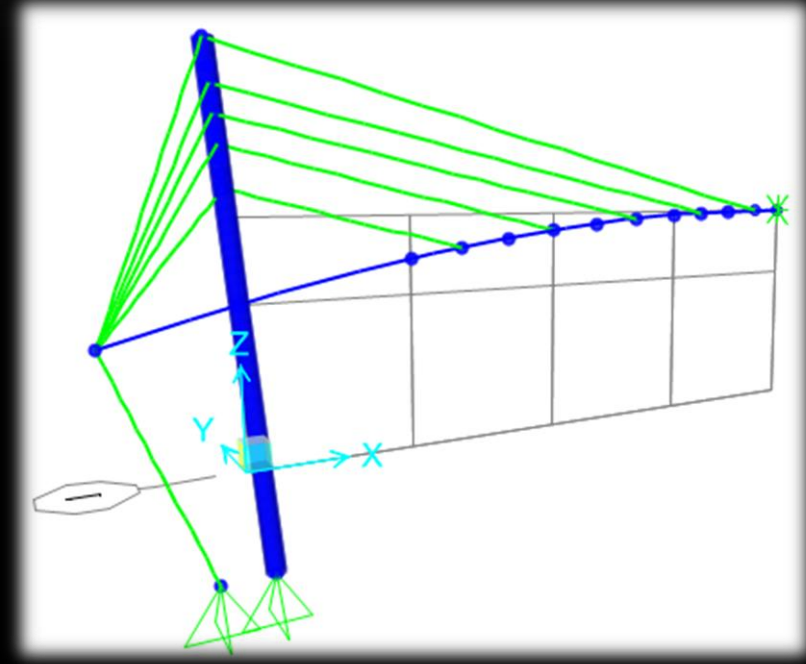
$$2.2T_2$$

$$2.0T_3$$

$$2.0T_4$$



## CABLE DESIGN



## CABLE MANUFACTURER





# CABLE DESIGN

## ASCE 19-10: STRUCTURAL APPLICATIONS OF STEEL CABLES FOR BUILDINGS

Load Combinations:

$$T_1 = D+P$$

$$T_2 = D+P+L+S$$

$$T_3 = D+P+W$$

$$T_4 = D+P+L+S+W$$

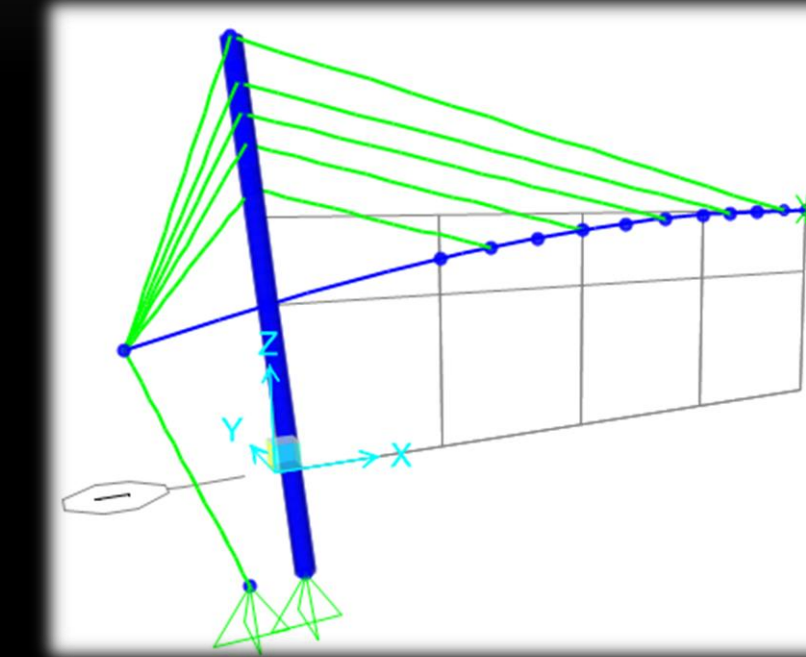
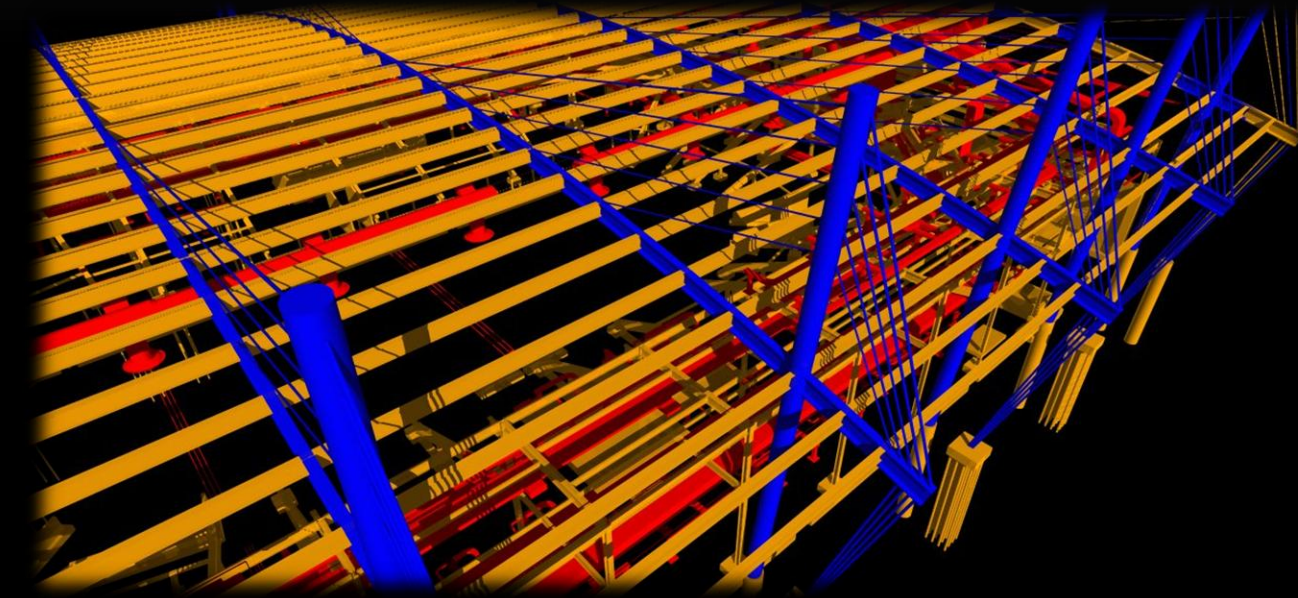
Design Strength:

$$2.2T_1$$

$$2.2T_2$$

$$2.0T_3$$

$$2.0T_4$$

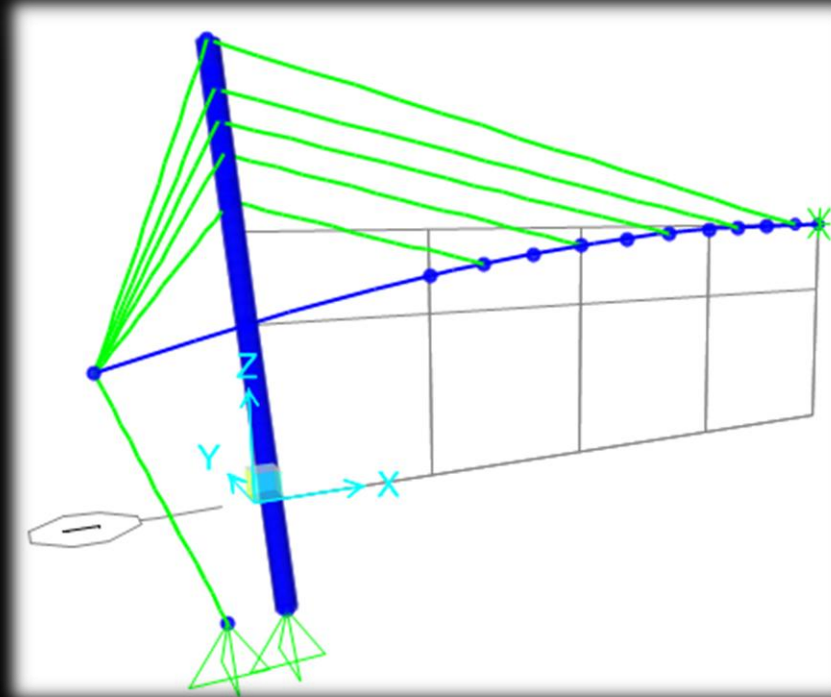


STRAND DIAMETER	APPROX. WEIGHT (lb./ft.)		NOMINAL STRENGTH (tons)				
	inches	mm.	SPIRAL STRAND	SPIRAL STRAND			SS-265
			SS-265	Class A	Class B*	Class C*	Class A
2-5/16	59.0	11.2	11.0	327	322	317	376
2-3/8	60.0	11.7	11.6	344	339	334	396
2-7/16	62.0	12.5	12.2	360	355	349	414
2-1/2	64.0	12.8	12.9	376	370	365	432
2-9/16	65.0	13.6	13.6	392	386	380	451
2-5/8	67.0	14.5	14.4	417	411	404	480
2-11/16	68.0	15.2	15.0	432	425	419	497
2-3/4	70.0	15.9	15.6	452	445	438	520
2-7/8	74.0	17.4	17.2	494	486	479	568
3	76.0	18.9	18.8	538	530	522	618
3-1/8	79.0	20.5	20.4	584	575	566	672
3-1/4	83.0	22.2	21.8	625	616	606	719
3-3/8	86.0	23.9	23.6	673	663	653	774
3-1/2	89.0	25.7	25.5	724	713	702	832
3-5/8	92.0	27.6	27.1	768	756	745	883
3-3/4	96.0	29.5	29.4	822	810	797	934
3-7/8	99.0	31.5	--	878	865	852	--
4	103.0	33.6	--	925	911	897	--
4-1/8	105.0	35.7	--	985	--	--	--
4-1/4	109.0	37.9	--	1,002	--	--	--
4-3/8	111.0	40.2	--	1,108	--	--	--
4-1/2	115.0	42.5	--	1,173	--	--	--
4-5/8	117.0	44.9	--	1,239	--	--	--
4-3/4	122.0	47.4	--	1,306	--	--	--
4-7/8	124.0	49.9	--	1,376	--	--	--
5	128.0	52.5	--	1,448	--	--	--
5-1/4	133.0	57.9	--	1,596	--	--	--
5-1/2	140.0	63.5	--	1,752	--	--	--

Strand Diameter (in)	Approx. Weight (lb/ft)	Nominal Strength (tons)
3.375	23.9	822
3.875	31.5	878
4.75	49.9	1306
5.25	63.5	1752



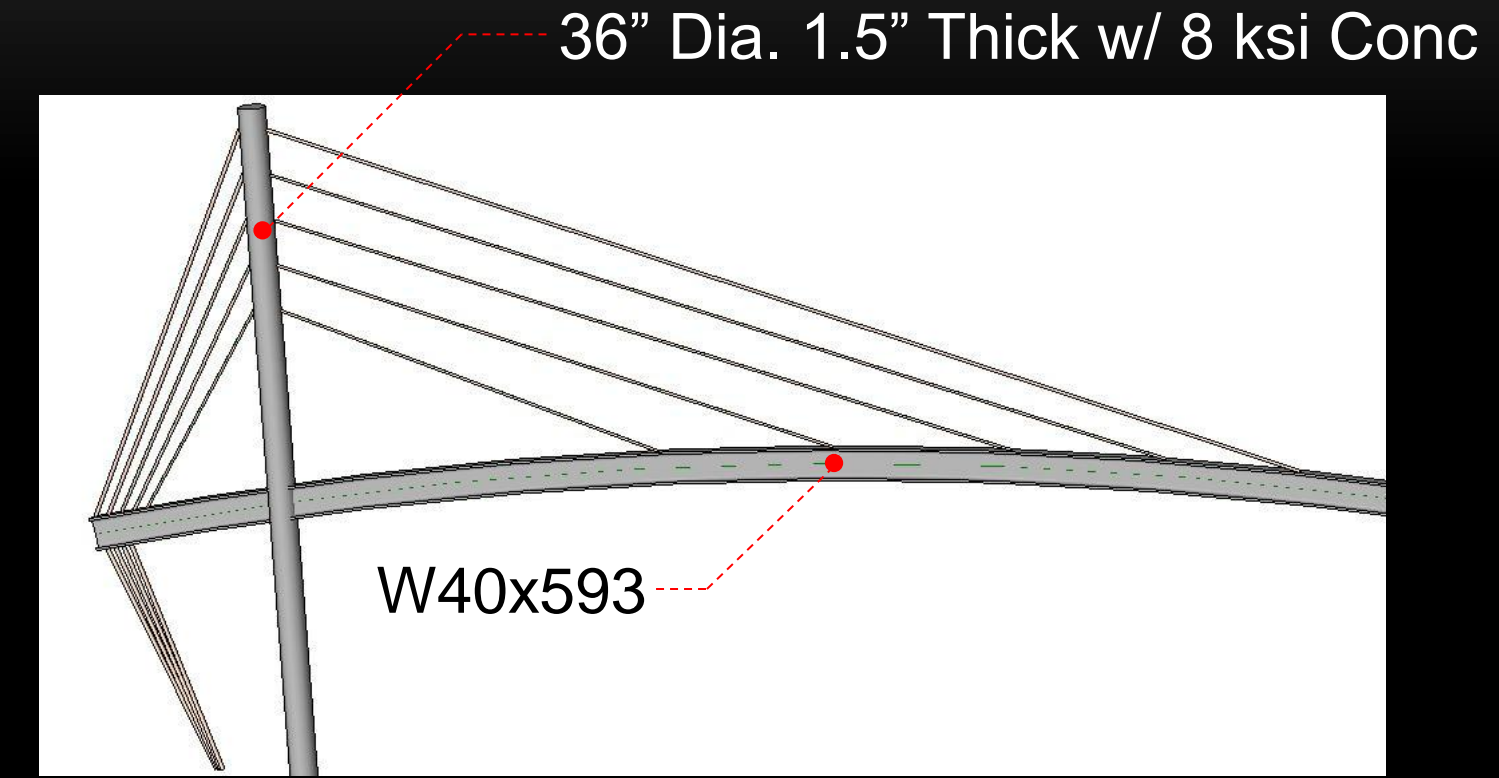
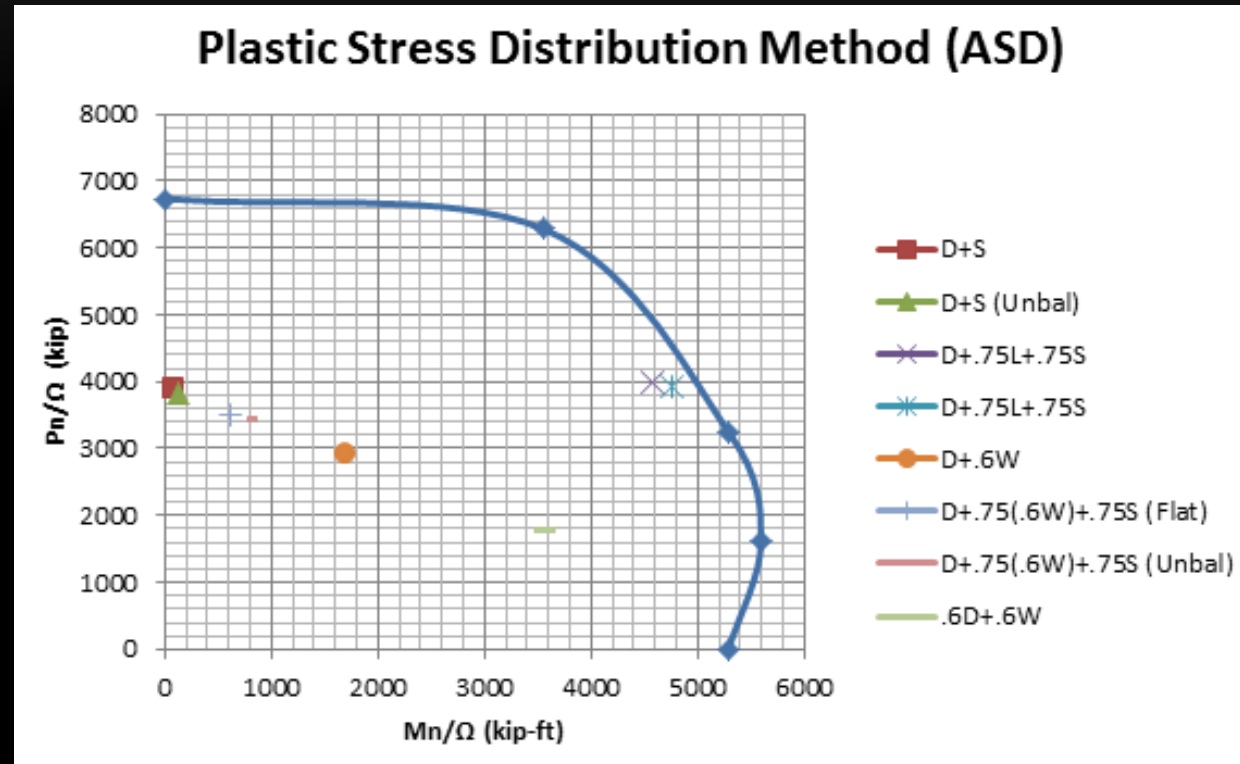
# MAST AND GIRDER DESIGN



**Table D. Plastic Capacities for Composite, Filled Round HSS Bent About Any Axis**

Section	Stress Distribution	Point	Defining Equations
(A)		A	$P_x = F_y A_c + 0.95 f'_c A_c^*$ $M_x = 0$ $A_c = \pi(d - t)^2$ $A_c^* = \frac{\pi d^2}{4}$
(E)		E	$P_x = P_c - k \left[ F_y (d^2 - h^2) + \chi (0.95 f'_c)^2 \right] (\theta_1 - \sin \theta_1)$ $M_x = P_x Z_{ca} + \chi (0.95 f'_c Z_{ca})$ $Z_{ca} = \frac{d^2 \sin^2 \left( \frac{\theta_1}{2} \right)}{6}$ $Z_{ca} = \frac{(d^2 - h^2)}{6} \sin \left( \frac{\theta_1}{2} \right)$ $h_x = \frac{d}{2} + \frac{h}{4}$ $\theta_1 = \pi - 2 \arcsin \left( \frac{2h_x}{d} \right)$
(C)		C	$P_x = 0.95 f'_c A_c$ $M_x = M_p$
(D)		D	$P_x = \frac{0.95 f'_c A_c}{2}$ $M_x = P_x Z_{ca} + \chi (0.95 f'_c Z_{ca})$ $Z_{ca} = \text{plastic section modulus of steel shape} - \frac{d^2}{6} - Z_c$ $Z_c = \frac{h^2}{6}$
(B)		B	$P_x = 0$ $M_x = P_x Z_{ca} + \chi (0.95 f'_c Z_{ca})$ $Z_{ca} = \frac{(d^2 - h^2)}{6} \sin \left( \frac{\theta}{2} \right)$ $Z_{ca} = \frac{h^2 \sin^2 \left( \frac{\theta}{2} \right)}{6}$ $\theta = \frac{0.0260 K_x - 2 K_y}{0.0848 K_x} + \sqrt{\frac{0.0260 K_x + 2 K_y}{0.0848 K_x} + \frac{0.857 K_x K_y}{0.0848 K_x}}$ (rad) $K_x = f_y h^2$ $K_y = P_x \left( \frac{d-1}{2} \right)$ (thin HSS wall assumed) $h_x = \frac{h}{2} \sin \left( \frac{\pi - \theta}{2} \right) = \frac{h}{2}$

\*0.95f'c may be used for concrete filled round HSS.





# MAST AND GIRDER DESIGN

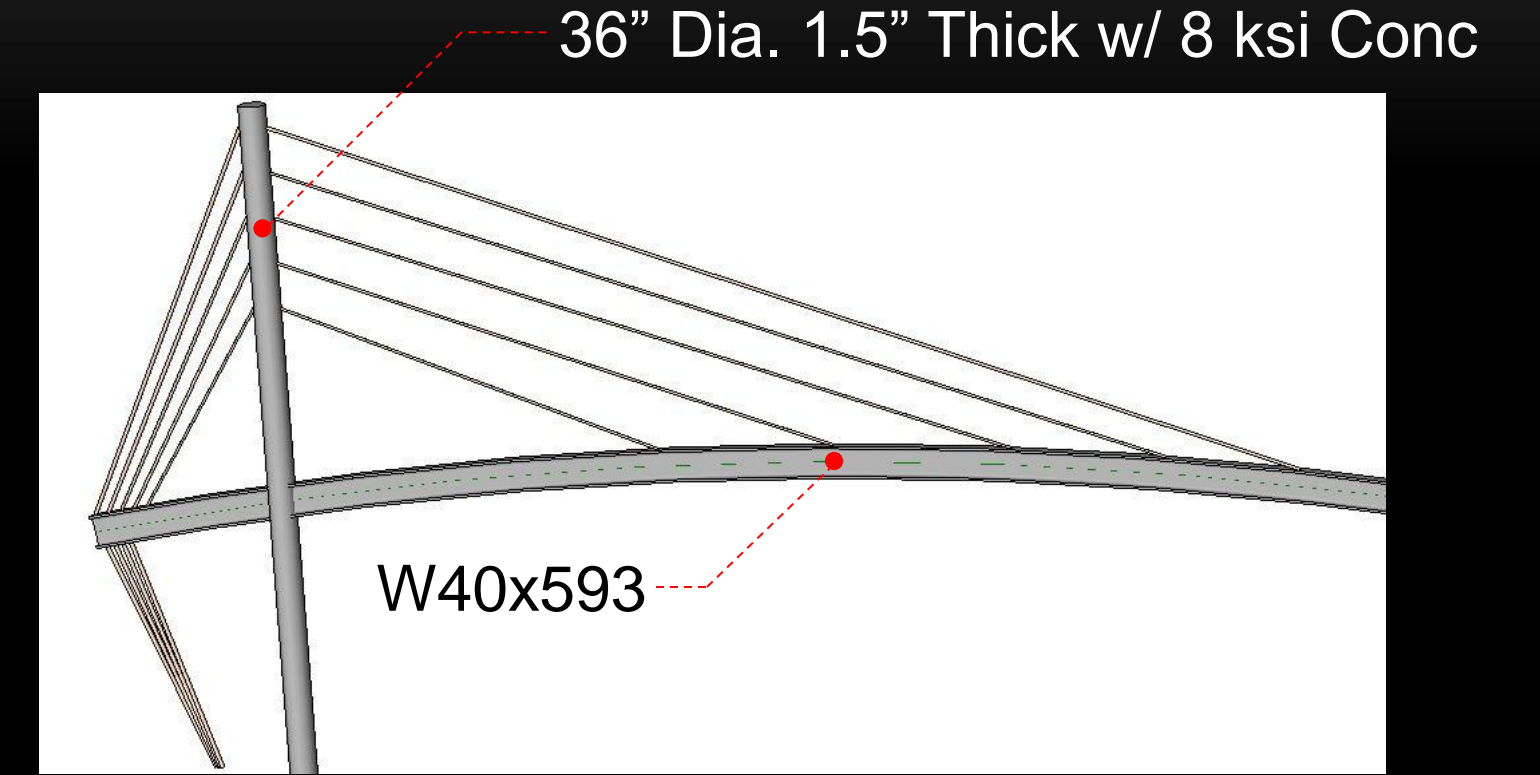
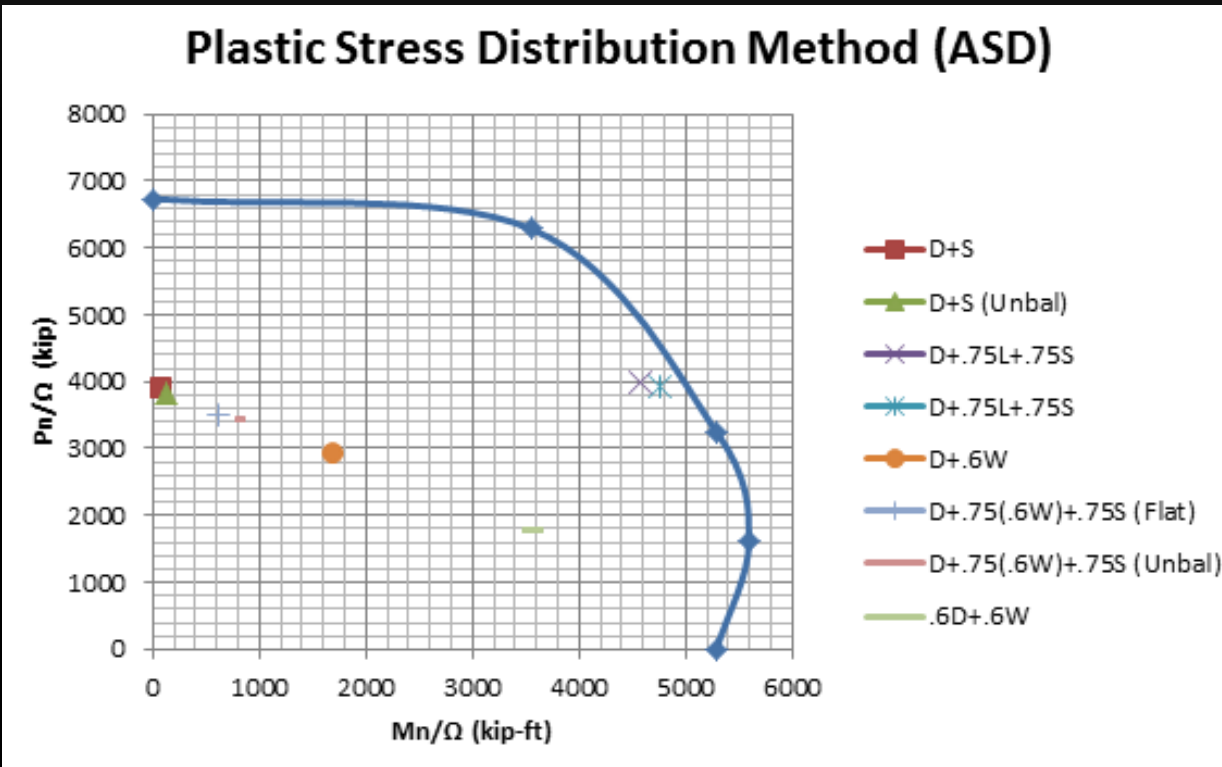
Interaction Surface (ACI 318-05/IBC 2003)

	P	M2	M3
1	-9525	0	0
2	-9525	0	1667.1521
3	-9525	0	2697.4977
4	-9525	0	3911.5518
5	-7560	0	5215.7632
6	-5957	0	6597.8205
7	-3922	0	8604.5708
8	-1757	0	9773.973
9	1029.0289	0	8904.7894
10	3983.9408	0	5864.4863
11	7886.0418	0	0
12			
13			
14			
15			
16			
17			
18			
19			
20			

**Table D.**  
Plastic Capacities for Composite, Filled Round HSS  
Bent About Any Axis

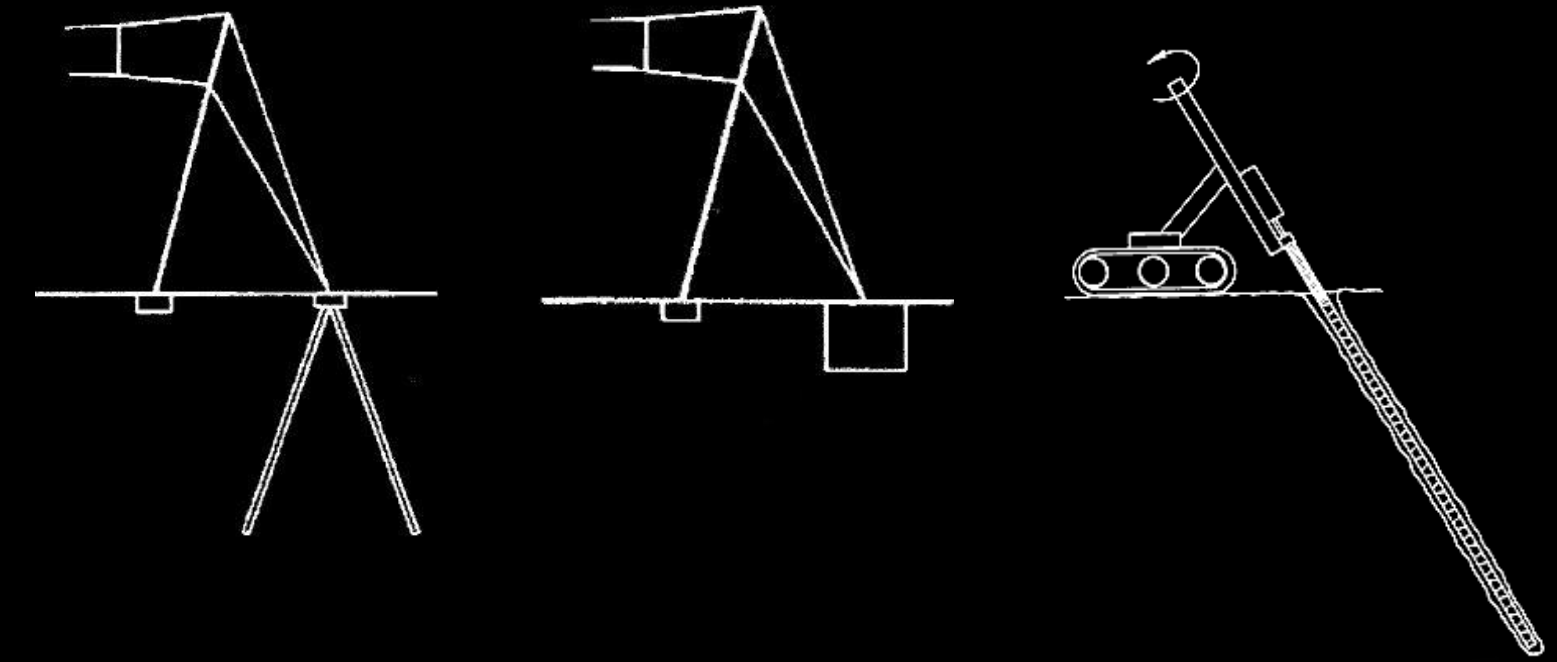
Section	Stress Distribution	Point	Defining Equations
(A)		A	$P_x = F_y A + 0.95 f'_c A_c$ $M_x = 0$ $A_c = \pi(d-t)^2$
(E)		E	$P_x = P_y - \lambda \left[ F_y (d-h)^2 + \lambda (0.95 f'_c)^2 \right] (\theta_x - \sin \theta_x)$ $M_x = P_y Z_x + \lambda (0.95 f'_c Z_x)$ $Z_x = \frac{d^2 \sin^2 \left( \frac{\theta_x}{2} \right)}{6}$ $Z_y = \frac{(d-h)^2 \sin \left( \frac{\theta_y}{2} \right)}{6}$ $\theta_x = \frac{h}{d} + \frac{h}{4}$ $\theta_y = \pi - 2 \arcsin \left( \frac{2h_y}{h} \right)$
(C)		C	$P_x = 0.95 f'_c A_c$ $M_x = M_y$
(D)		D	$P_y = \frac{0.95 f'_c A_c}{2}$ $M_y = P_y Z_y + \lambda (0.95 f'_c Z_y)$ $Z_x = \text{plastic section modulus of steel shape} = \frac{d^2}{6} - Z_y$ $Z_y = \frac{h^2}{6}$
(B)		B	$P_x = 0$ $M_x = P_y Z_x + \lambda (0.95 f'_c Z_x)$ $Z_x = \frac{(d-h)^2 \sin \left( \frac{\theta_x}{2} \right)}{6}$ $Z_y = \frac{h^2 \sin^2 \left( \frac{\theta_y}{2} \right)}{6}$ $\theta = \frac{0.0260 K_x - 2 K_y}{0.0848 K_x} + \sqrt{\frac{0.0260 K_x + 2 K_y}{0.0848 K_x} + \frac{0.857 K_x K_y}{0.0848 K_x}}$ (rad) $K_x = f_y h^2$ $K_y = F_y \left( \frac{d-t}{2} \right)$ (thin HSS wall assumed) $h_y = \frac{h}{2} \sin \left( \frac{\pi - \theta}{2} \right) = \frac{h}{2}$

\*0.95f'c may be used for concrete filled round HSS.

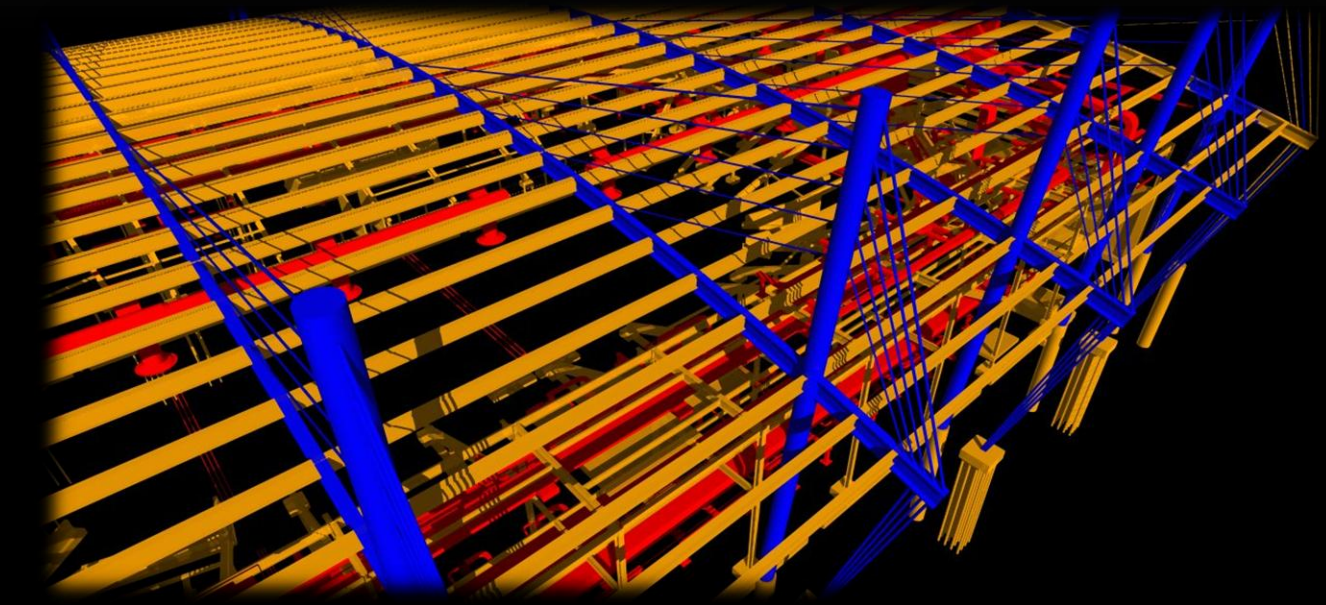
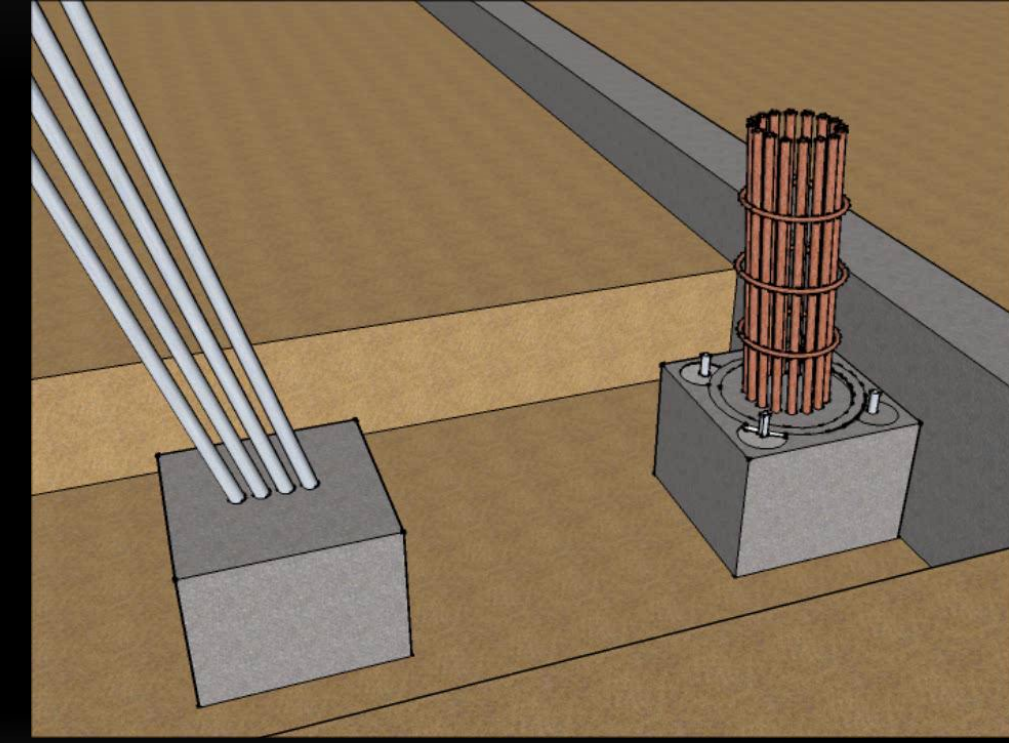




# FOUNDATION CONSIDERATIONS



# ERECTION SEQUENCE

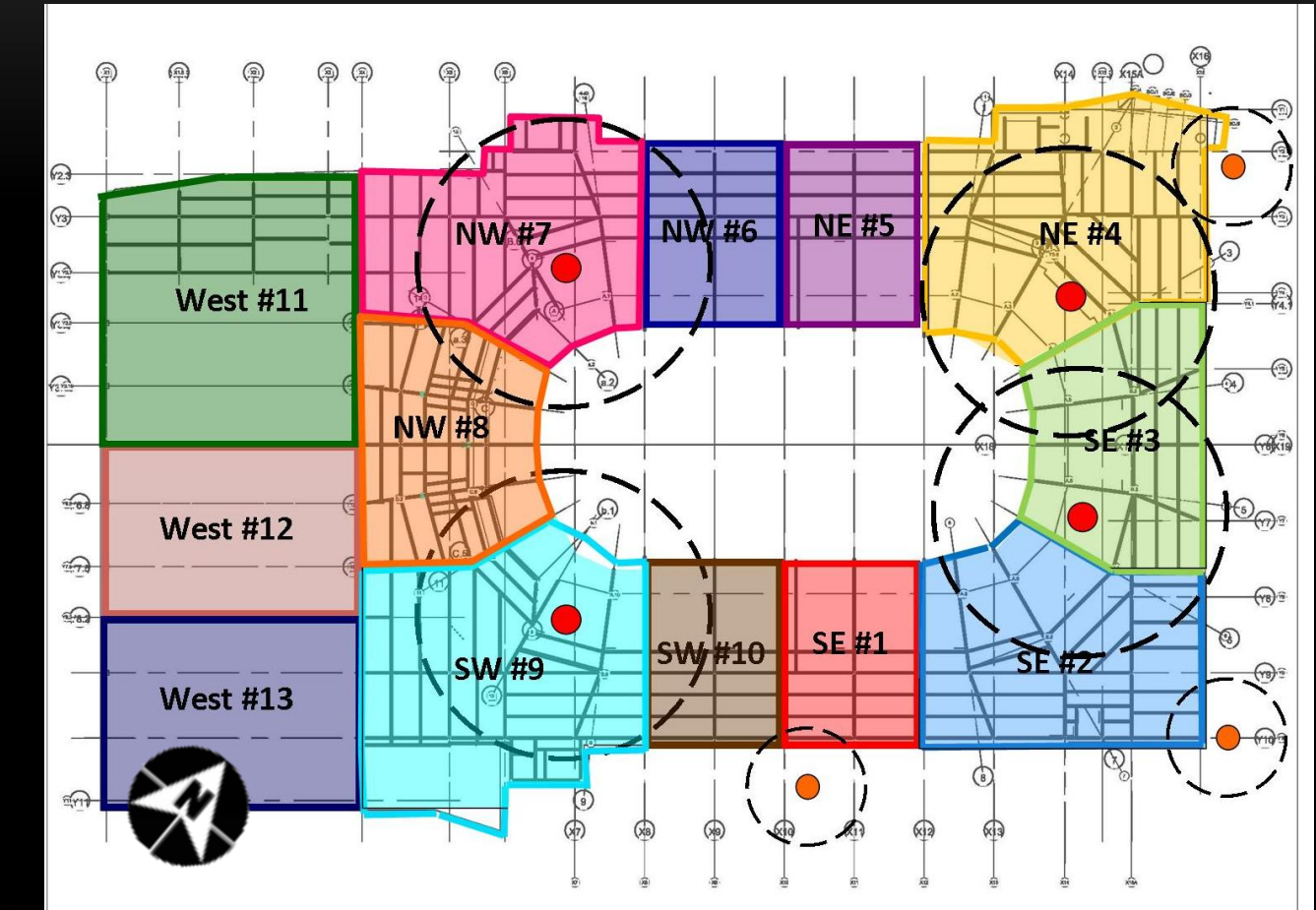




# CRANE SELECTION

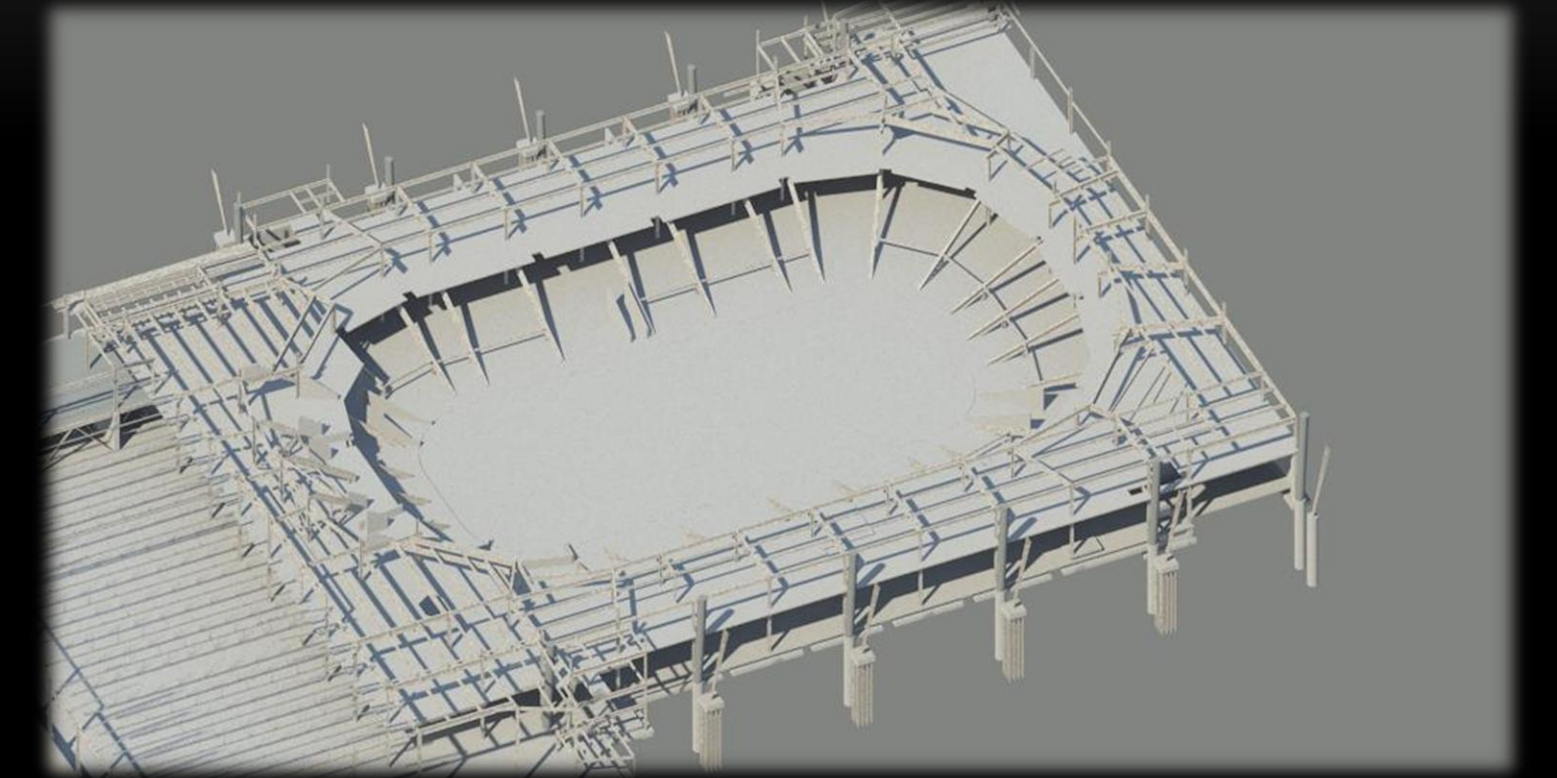
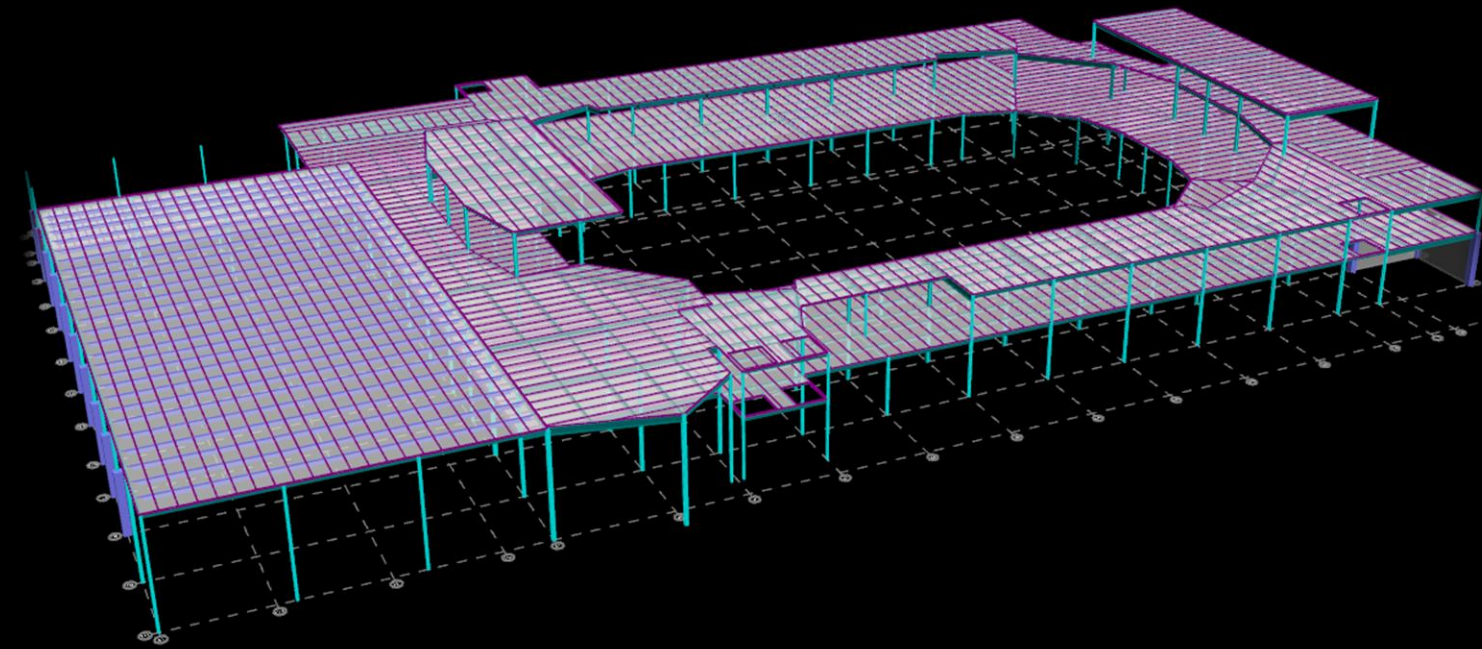


Crane Selection						
Model	Tonnage	Crane Type	Max. Radius For >25,000 lbs Lift (ft)	Rental Rate (\$/Hr)	Rental Rate (\$/day)	Transportation Fee
Grove TMS 475	50	Truck	25	\$ 150.00	\$ 1,200.00	\$ 1,200.00
<b>Grove RT 760</b>	<b>60</b>	<b>Rough Terrain</b>	<b>25</b>	<b>\$ 180.00</b>	<b>\$ 1,440.00</b>	<b>\$ 1,350.00</b>
P & H T750	75	Truck	40	\$ 200.00	\$ 1,600.00	\$ 1,500.00
Krupp GMT - AT70	80	Truck	45	\$ 205.00	\$ 1,640.00	\$ 1,500.00
<b>Grove TMS 900E</b>	<b>90</b>	<b>Truck</b>	<b>65</b>	<b>\$ 325.00</b>	<b>\$ 2,600.00</b>	<b>\$ 1,500.00</b>
Link-Belt HTC 3140	140	Truck	60	\$ 350.00	\$ 2,800.00	\$ 2,400.00
Liebherr 1150	170	Crawler	120	\$ 425.00	\$ 3,400.00	\$ 3,200.00



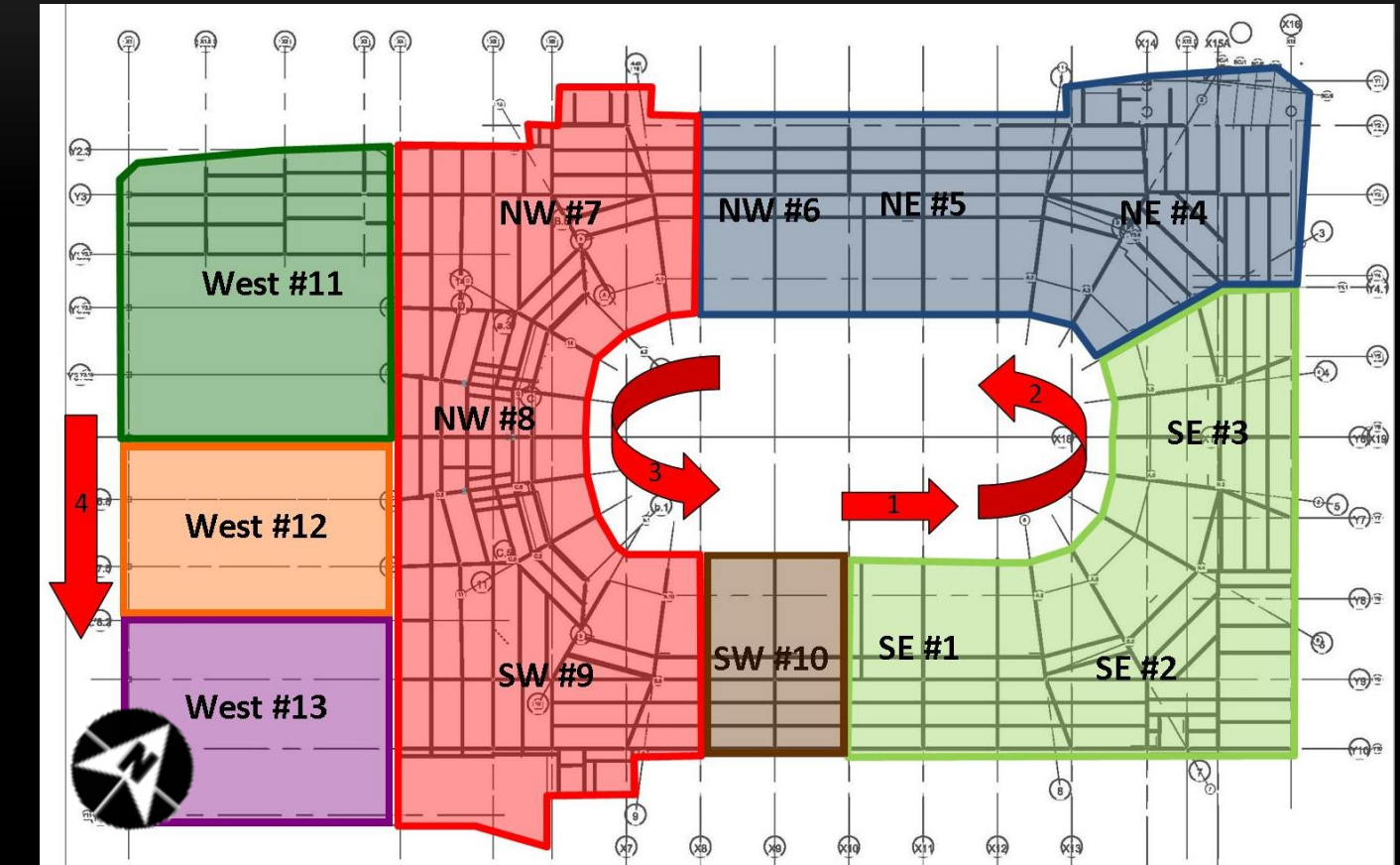
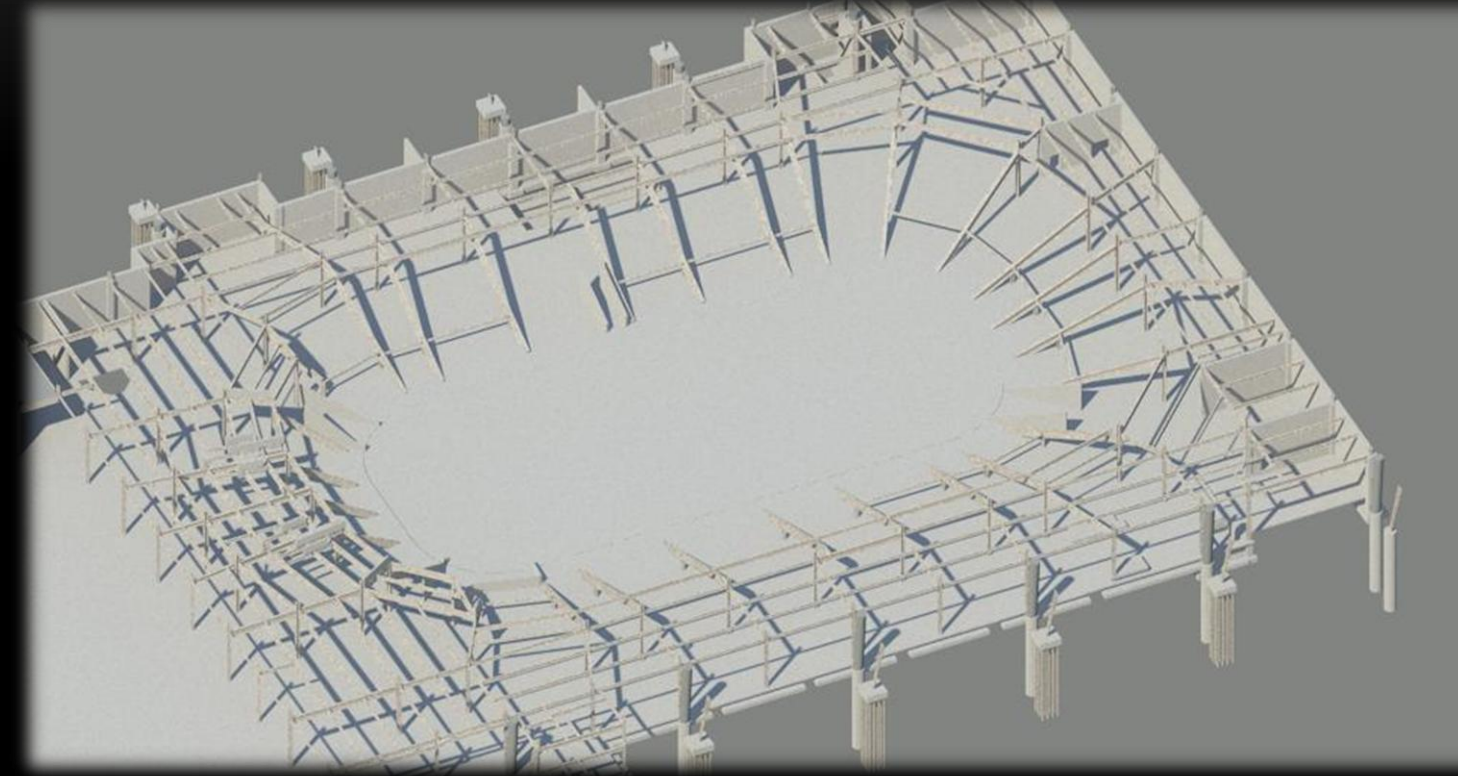
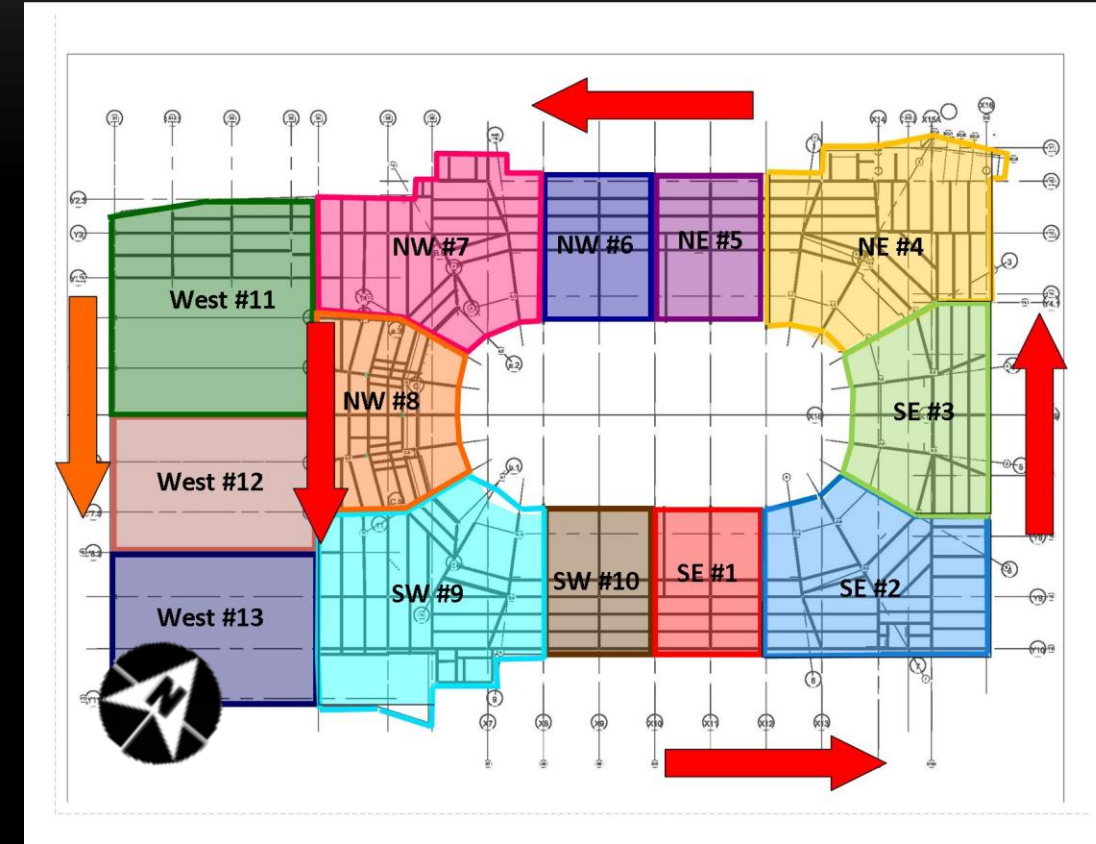


# STRUCTURAL IMPACTS



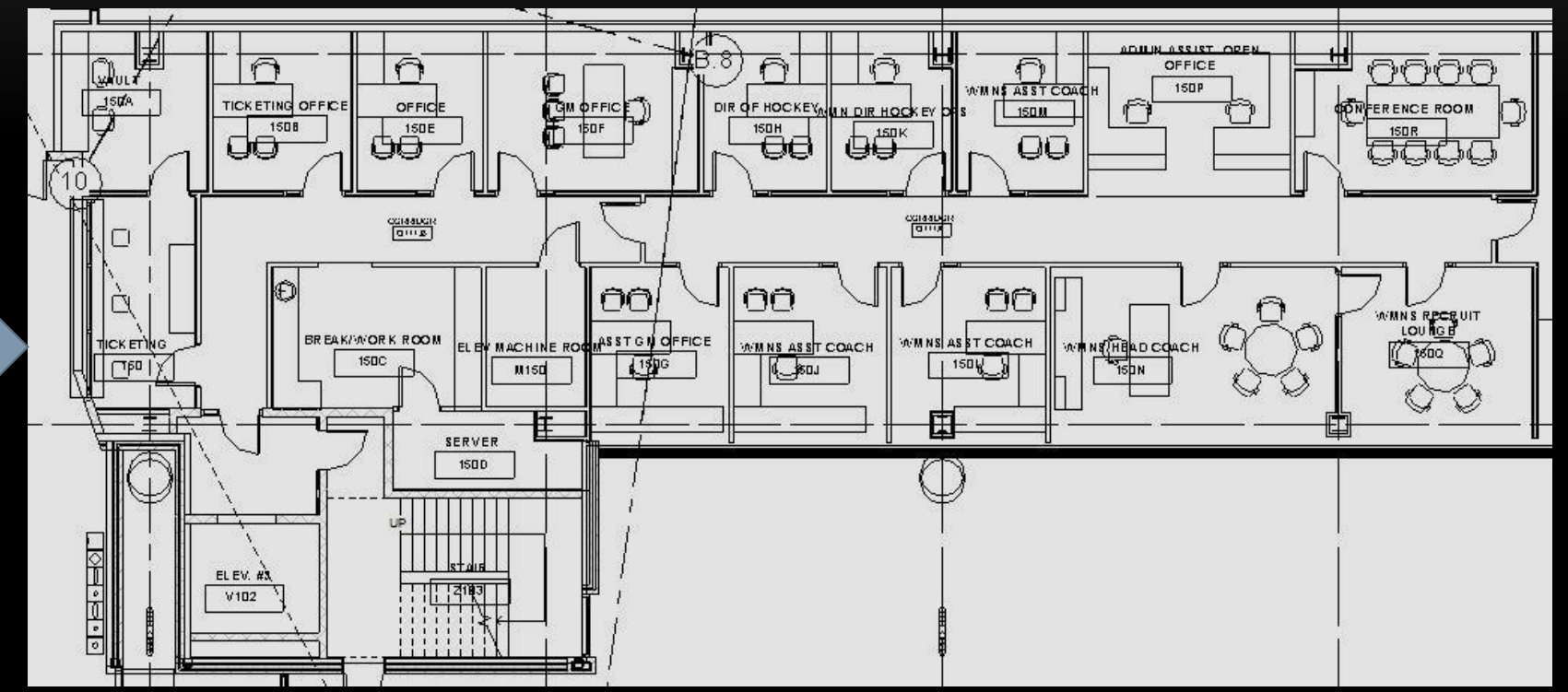
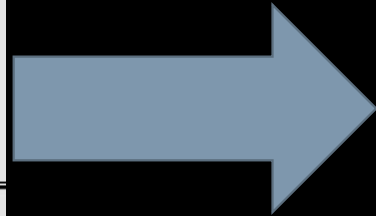
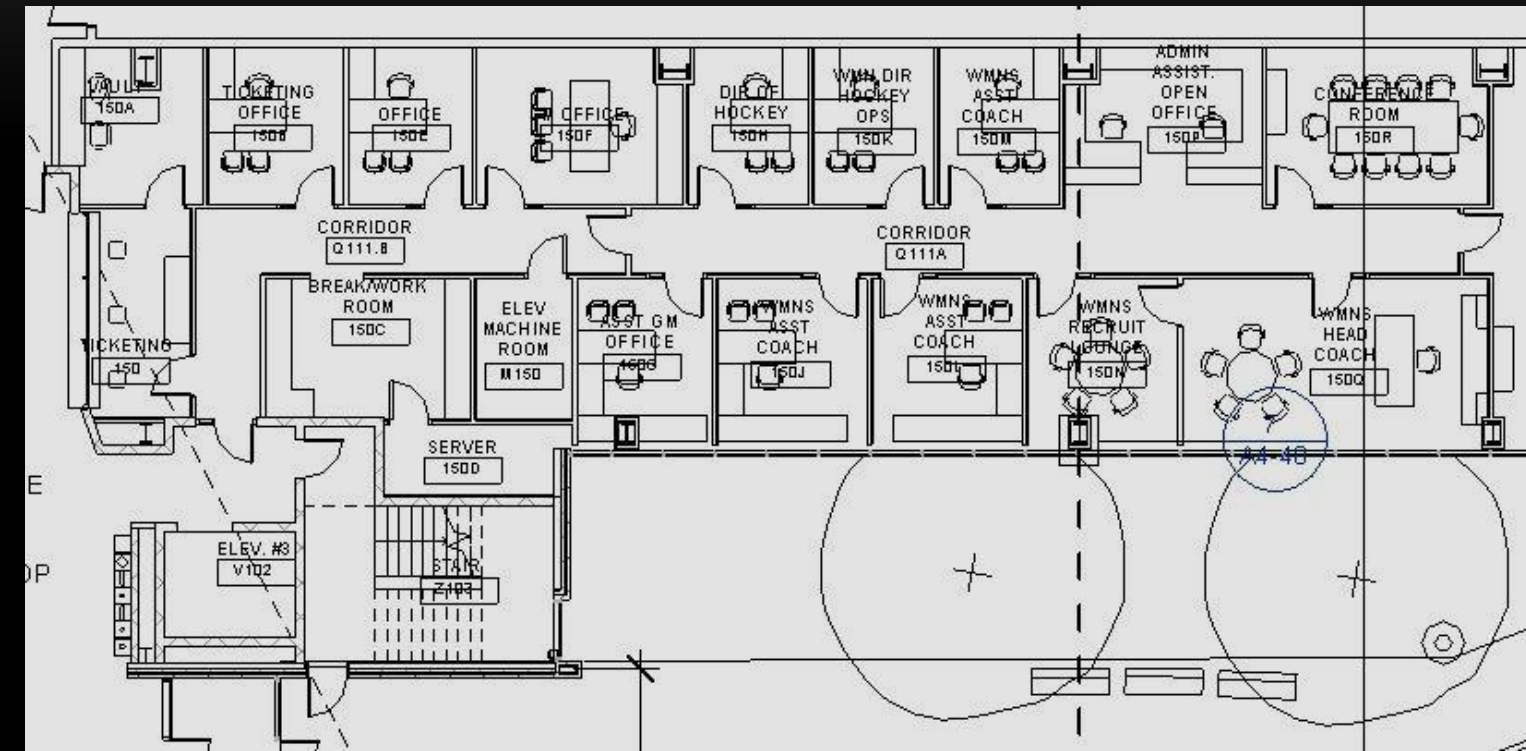


# CONSTRUCTION SEQUENCE



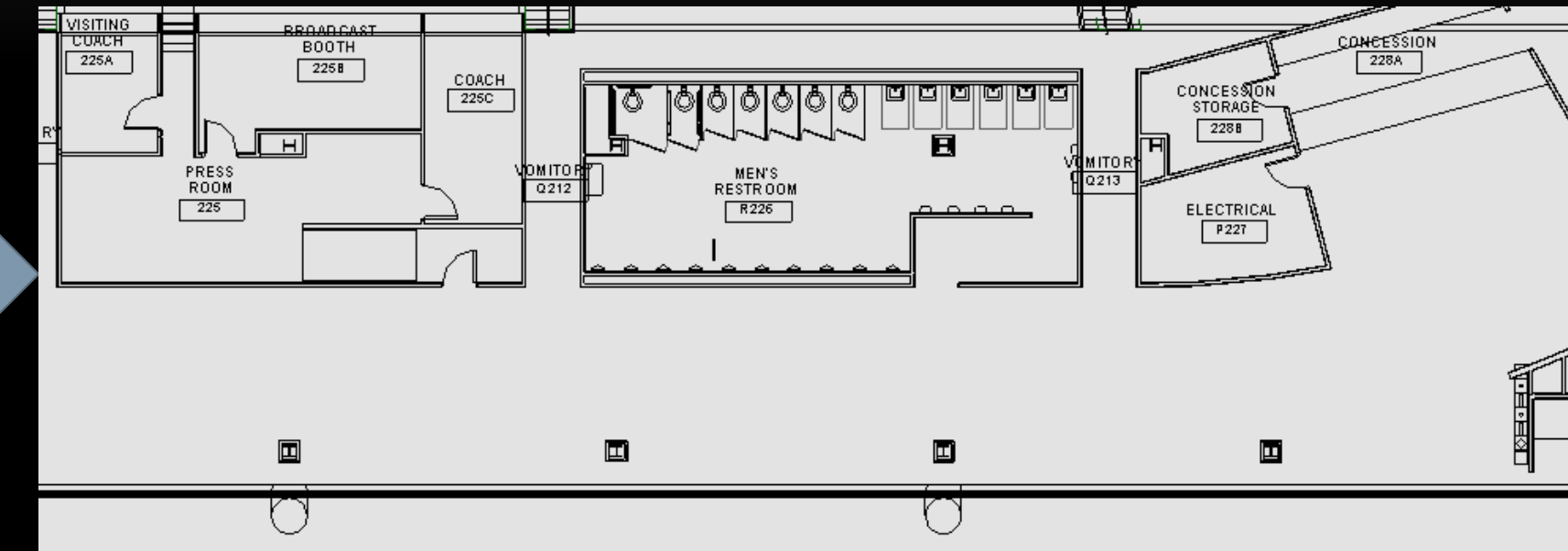
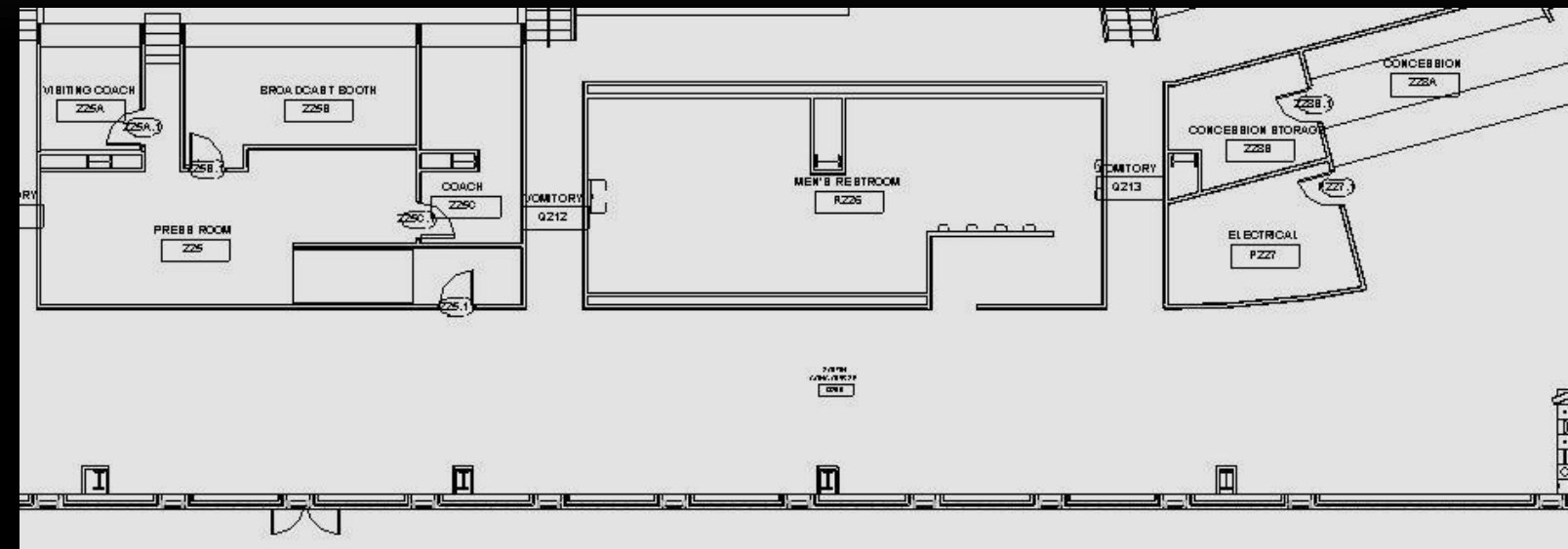


# ARCHITECTURAL IMPACTS



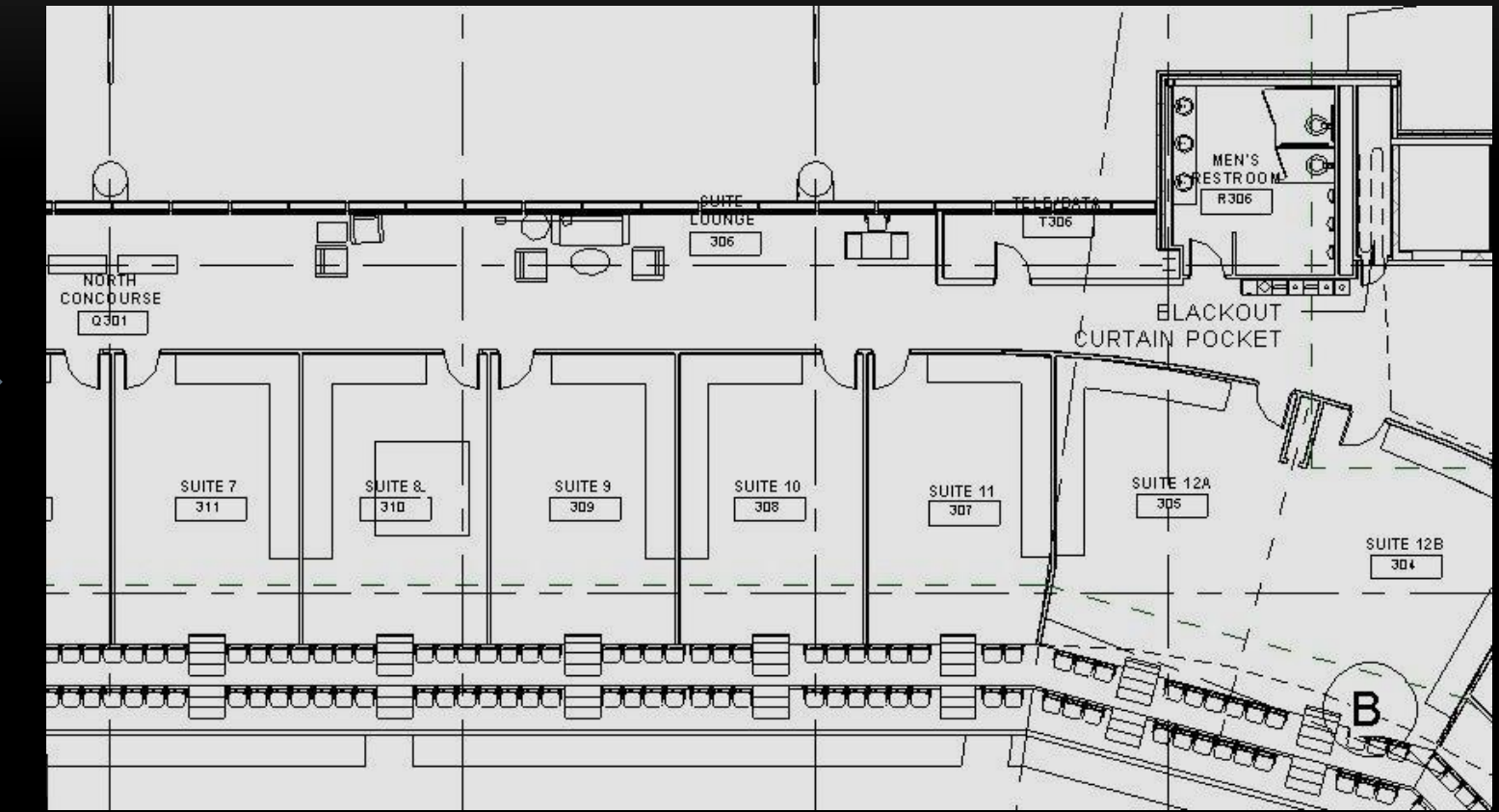
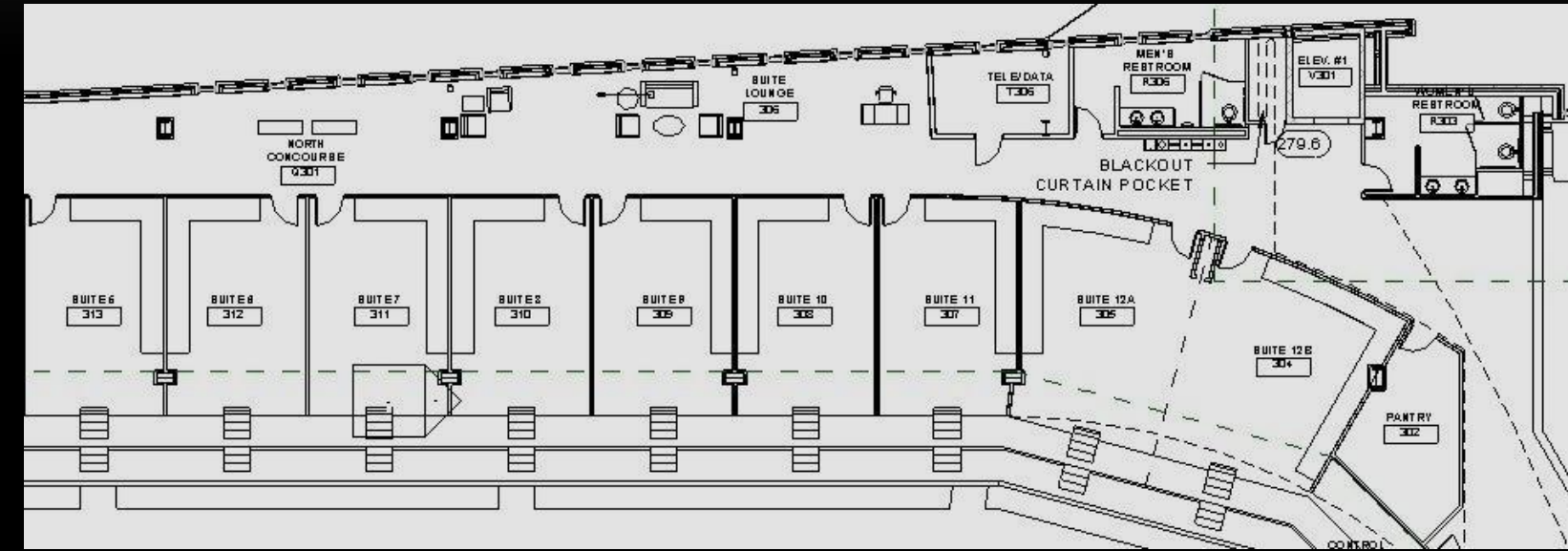


# ARCHITECTURAL IMPACTS





# ARCHITECTURAL IMPACTS



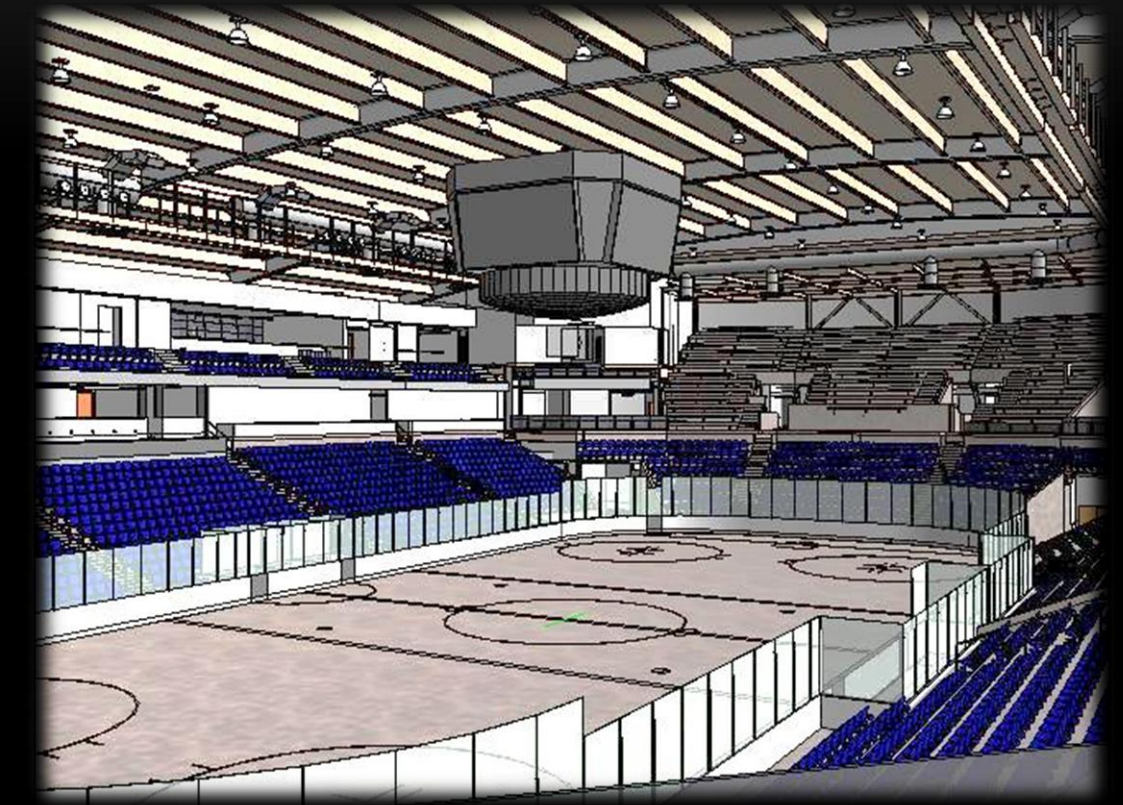
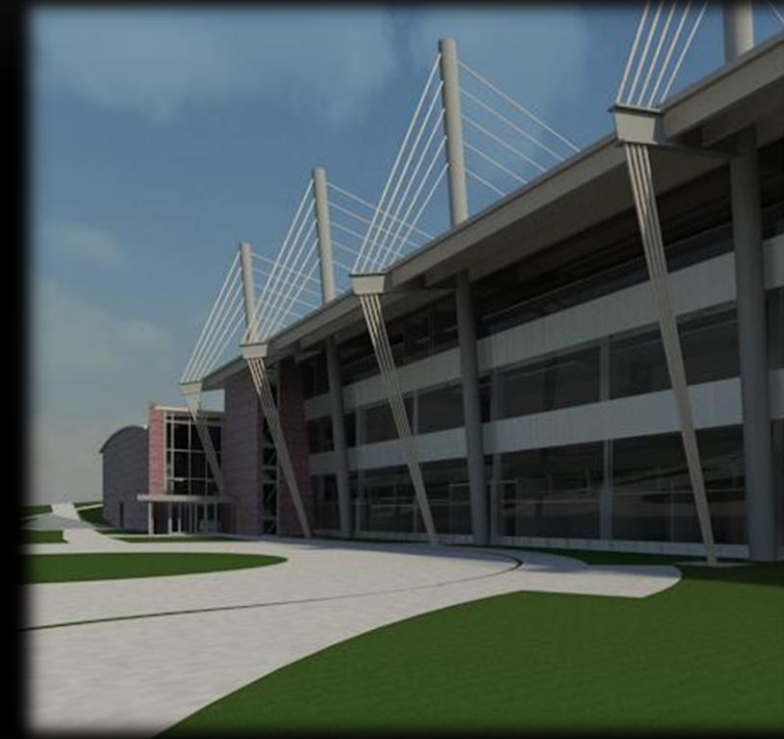


# ARCHITECTURAL IMPACTS



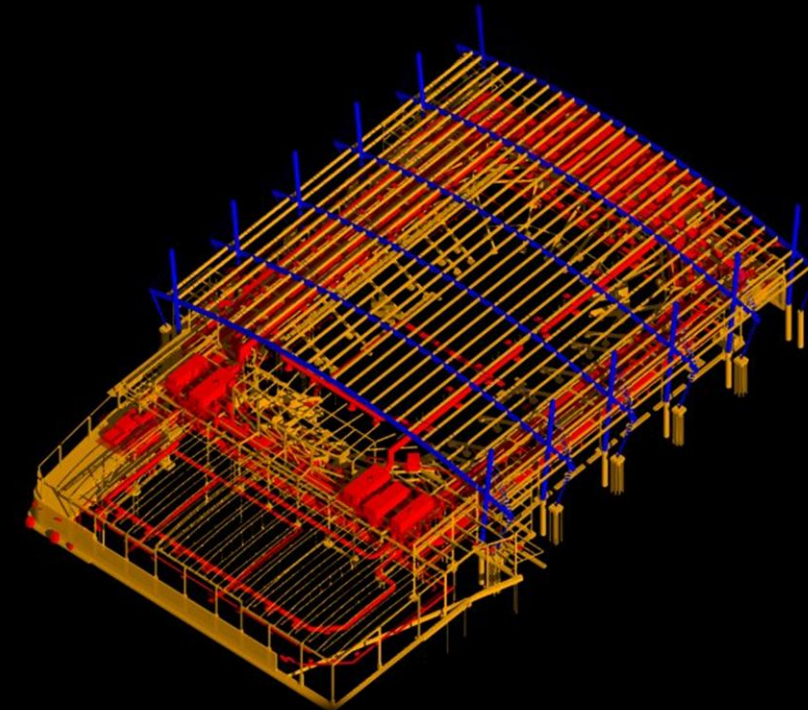


# ARCHITECTURAL IMPACTS





# COST AND SCHEDULE IMPACT



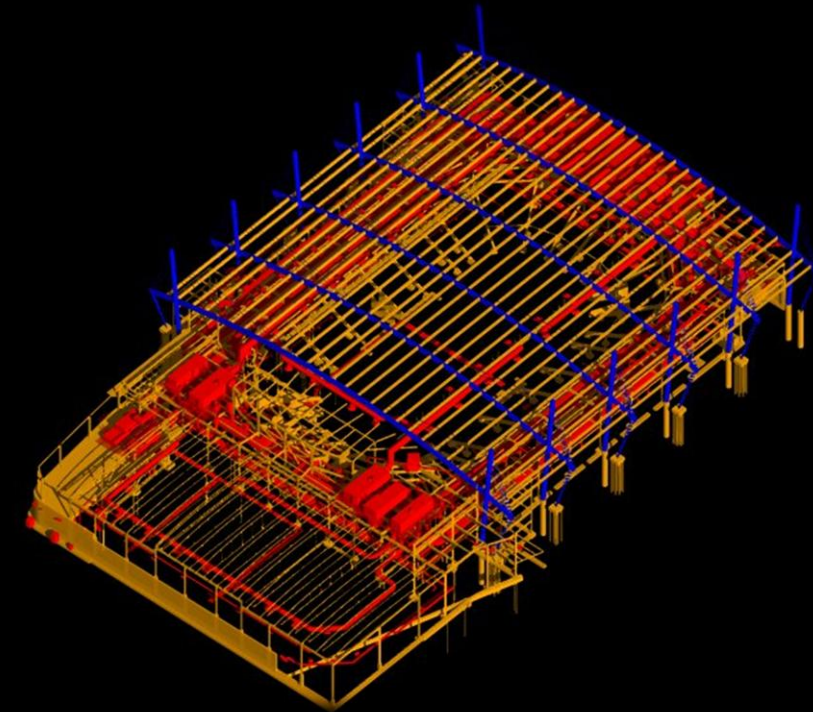
Existing Roof				
	Total	Unit	Price/Unit	Price
Trusses:	249.74	Ton	\$ 4,800.00	\$ 1,198,752.00
Joists:	107.70	Ton	\$ 2,900.00	\$ 312,330.00
Roof Skin:	88376.00	SF	\$ 12.00	\$ 1,060,512.00
Cranes:	194.00	Day	\$ 7,660.00	\$ 769,580.00
			Total	\$ 3,341,174.00

Redesigned Roof				
	Total	Unit	Price/Unit	Price
Beams:	559.25	Ton	\$ 2,900.00	\$ 1,621,825.00
Girders:	755.48	Ton	\$ 4,800.00	\$ 3,626,304.00
Masts:	282.54	Ton	\$ 2,900.00	\$ 819,366.00
Cables:	-	Feet	-	\$ 4,500,000.00
Roof Skin:	90800	SF	\$ 12.00	\$ 1,089,600.00
Cranes:				
60 Ton Crane	73	Day	\$ 1,440.00	\$ 107,820.00
90 Ton Crane	124	Day	\$ 2,600.00	\$ 325,400.00
Man Lift:	121	Day	\$ 80.00	\$ 77,840.00
			Total	\$ 12,168,155.00





# COST AND SCHEDULE IMPACT



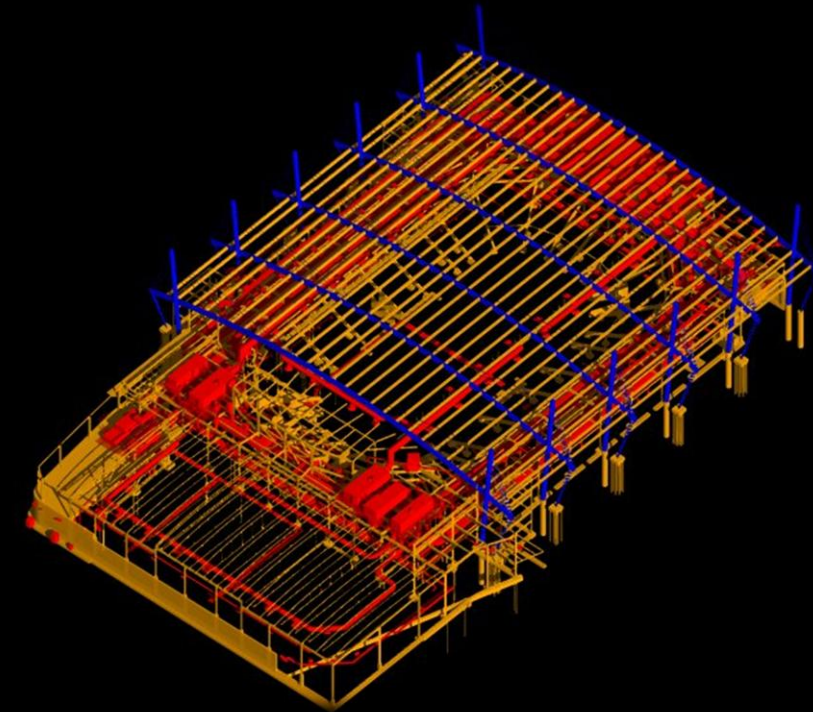
Existing Superstructure Steel		
Member Type	Total Type Weight (Tons)	Price (\$2,900/Ton)
Columns:	225.30	\$ 653,370.00
Framing:	640.61	\$ 1,857,769.00
<b>Total</b>	<b>865.91</b>	<b>\$ 2,511,139.00</b>

Redesigned Superstructure Steel		
Member Type	Total Type Weight (Tons)	Price (\$2,900/Ton)
Columns:	101.36	\$ 293,944.00
Framing:	484.07	\$ 1,403,803.00
<b>Total</b>	<b>585.43</b>	<b>\$ 1,697,747.00</b>





## COST AND SCHEDULE IMPACT



Total Roof System Cost	
Existing	\$ 5,852,313.00
Redesign	\$ 13,865,902.00
Difference	<b>\$ (8,013,589.00)</b>





# FAÇADE REDESIGN

# SMART-R WALL SOLUTION

Construction Templates - Project

Alternative: Alternative 1  
 Description: WALL(W:0.E:100.S:10.Nc:80.Ns:25)

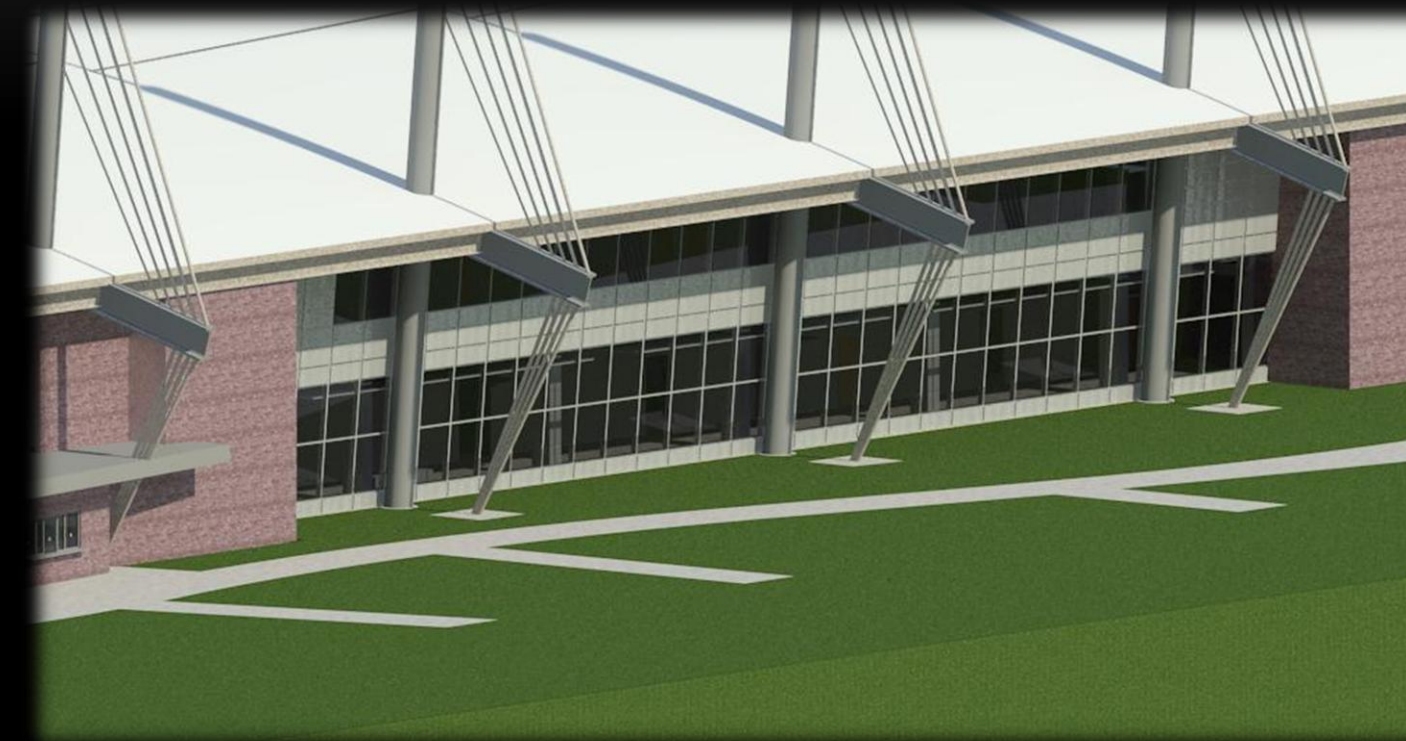
Construction...	U-factor Btu/h·ft <sup>2</sup> ·°F
Slab: 6" HW Concrete	0.0714
Roof: Steel Sheet, 4" Ins	0.043178
Wall: Metal, 3" Ins	0.045455
Partition: 0.75" Gyp Frame	0.387955

Glass type...	U-factor Btu/h·ft <sup>2</sup> ·°F	Shading coeff
Window: 3mm Dbl Low-E (e3=.1) Clr 13mm Argon	0.2857	0.75
Skylight: Triple Clear 1/4"	0.35	0.16
Door: 90.1-07 Min Nonswinging Nonres Zone 5-8	0.5	0

Height..  
 Wall: 20 ft  
 Flr to flr: 20 ft  
 Plenum: 10 ft

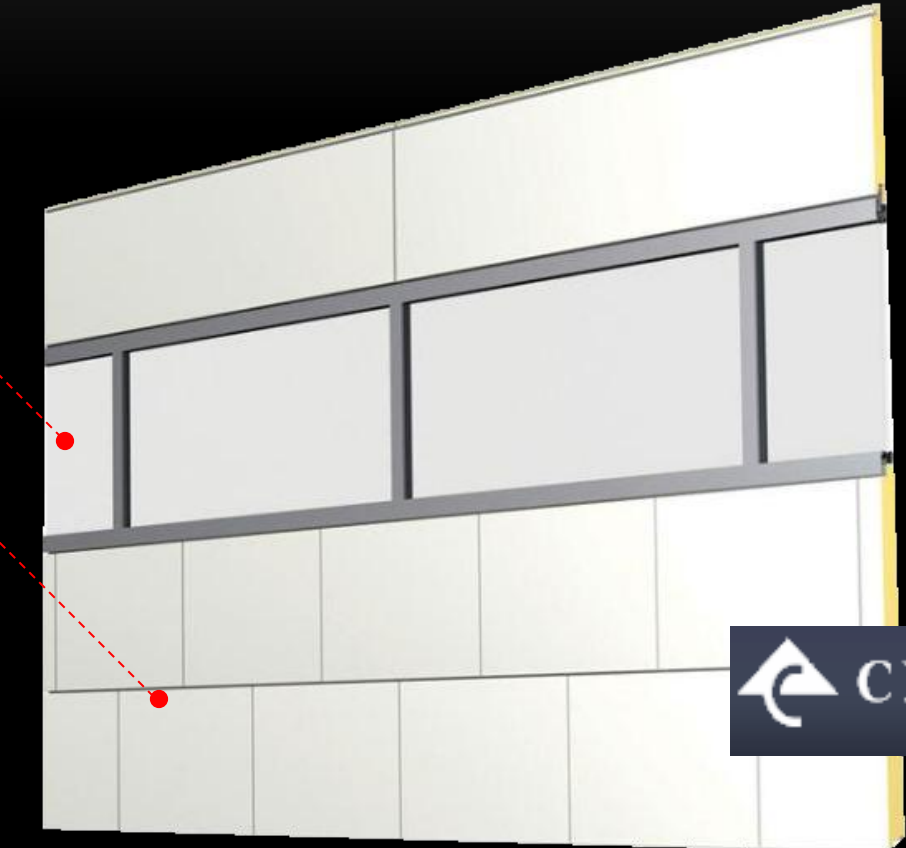
Pct wall area to underfloor plenum: %  
 Room type: Conditioned

Internal Load Airflow Thermostat **Construction** Room



R=3.5

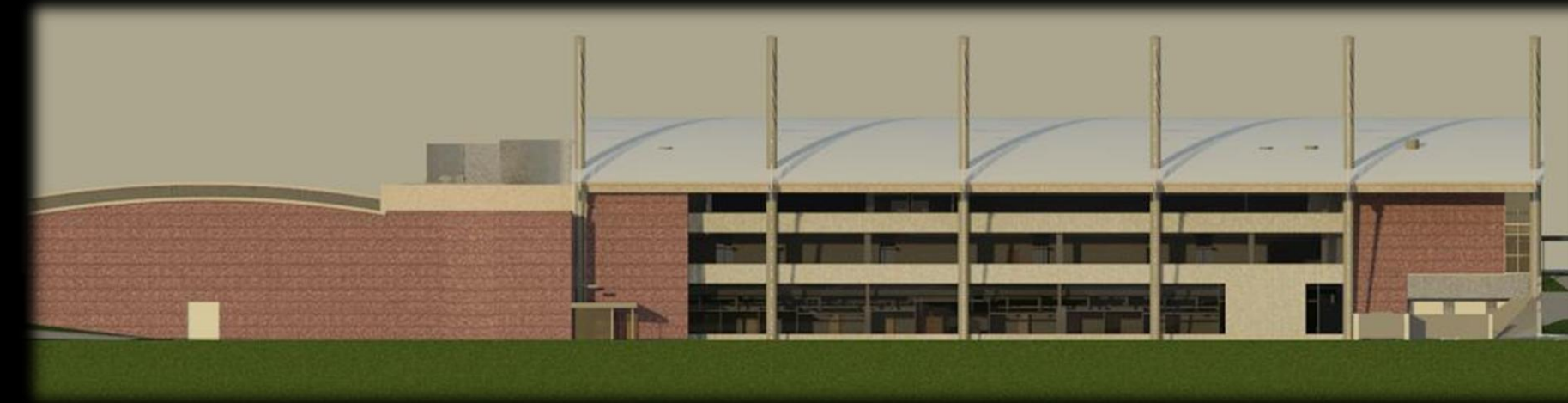
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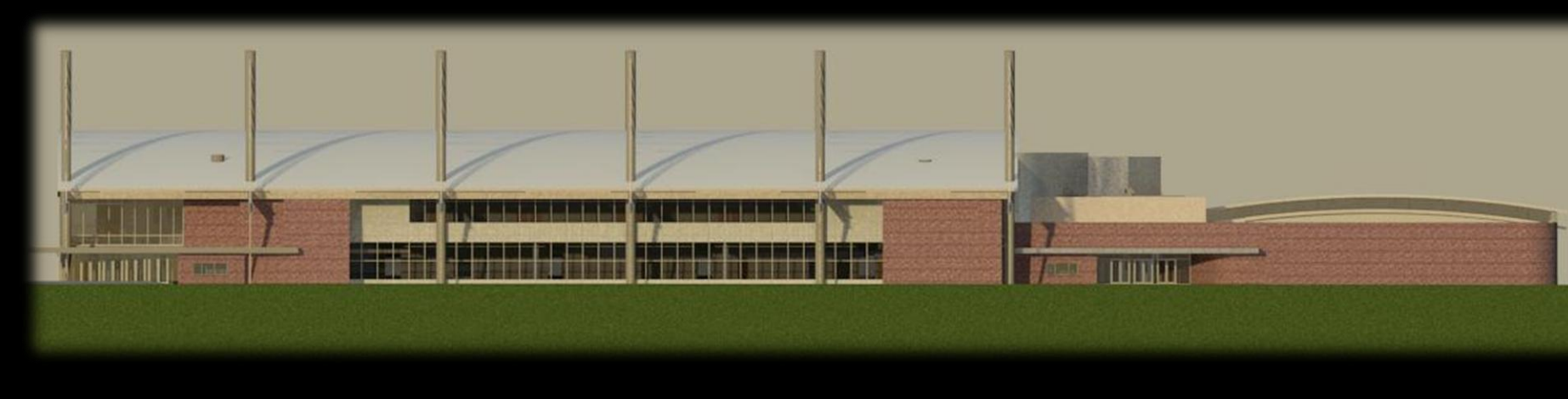


# LIFE-CYCLE COST ANALYSIS

Façade	Life-Cycle Cost
Schematic Brick	\$8,678,995
Schematic Metal Panels	\$8,682,912
90% Glass	\$8,825,755
80% Glass	\$8,793,717
70% Glass	\$8,764,696
60% Glass	\$8,737,283
50% Glass	\$8,717,036



**SOUTH ELEVATION**



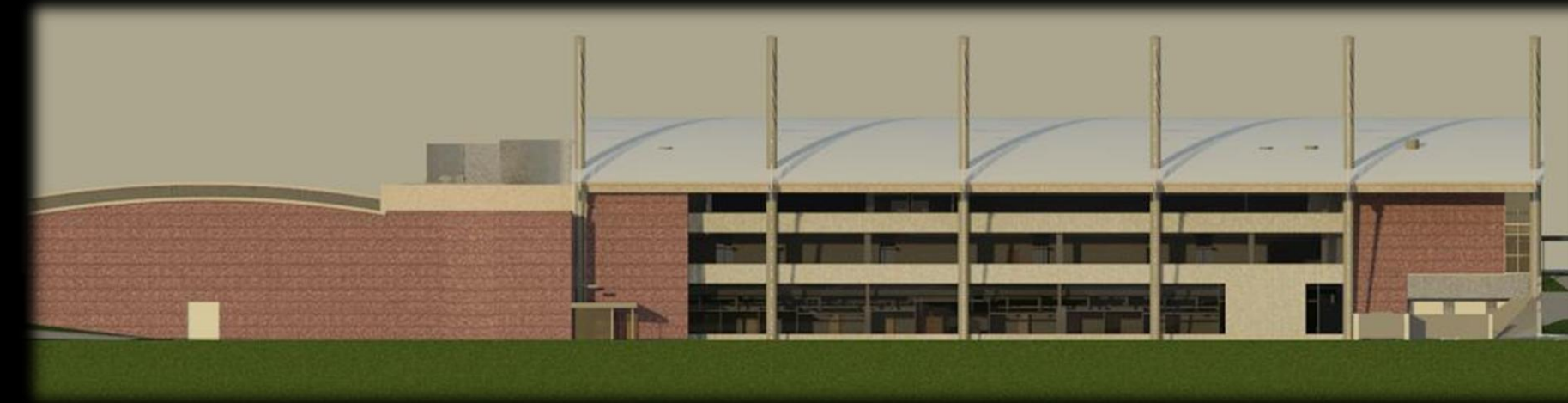
**NORTH ELEVATION**



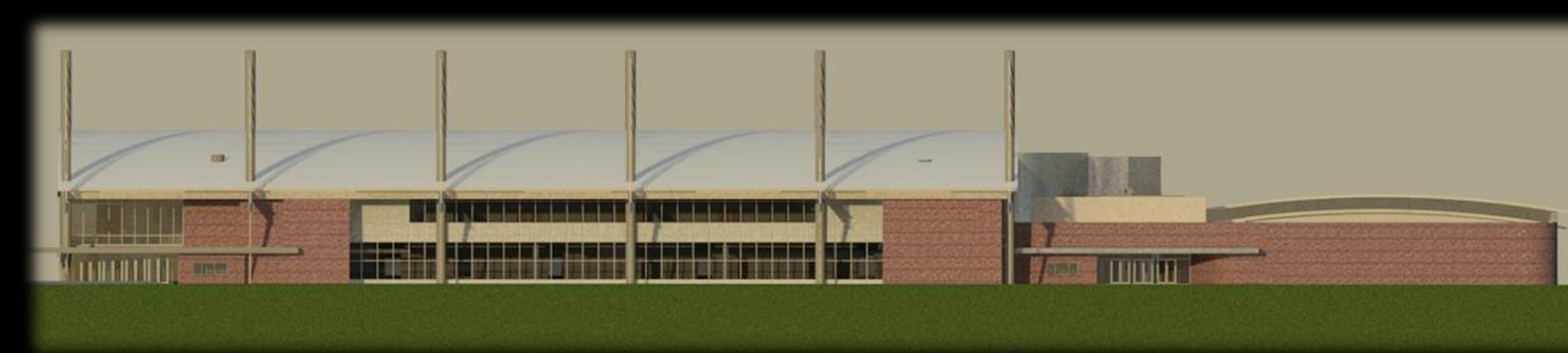


### Existing vs. Redesign Façade Cost and Duration

	Wall Type	Total SF	Daily Output (SF/Day)	Cost/SF	Total Duration (Days)	Total Price
Existing:	Curtain Wall	13760	375	\$ 60.00	37	\$ 825,600.00
	Exterior Brick	15570	80	\$ 37.00	195	\$ 576,090.00
	Metal Panel	5770	50	\$ 52.00	120	\$ 300,040.00
				Totals:	351	\$ 1,701,730.00
Redesign:	Curtain Wall	24065	375	\$ 60.00	64	\$ 1,443,900.00
	Exterior Brick	7547	80	\$ 37.00	94	\$ 279,239.00
	Metal Panel	4361	50	\$ 52.00	90	\$ 226,772.00
				Totals:	249	\$ 1,949,911.00
<b>Difference:</b>					<b>102</b>	<b>\$241,181.00</b>



**SOUTH ELEVATION**

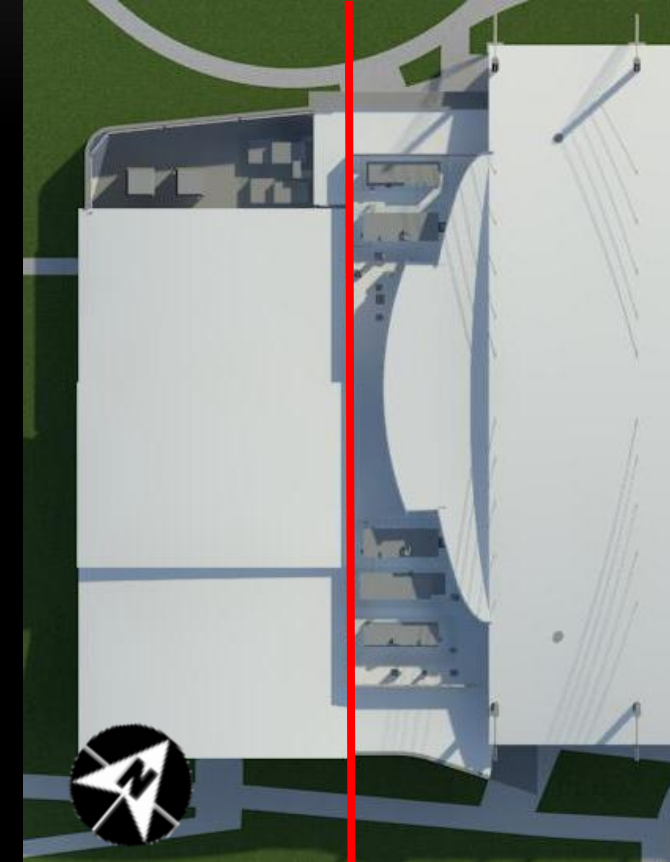
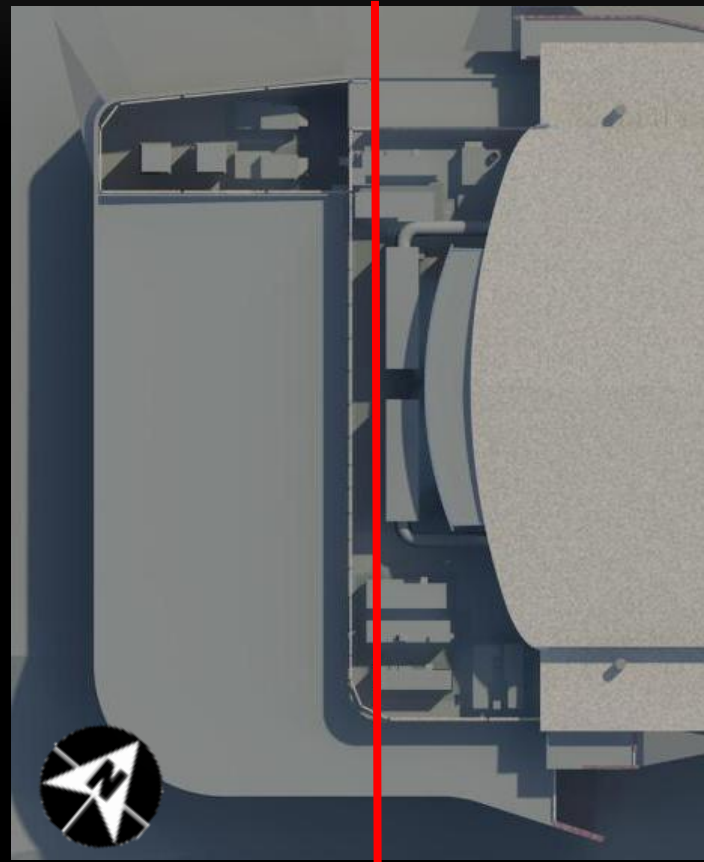


**NORTH ELEVATION**

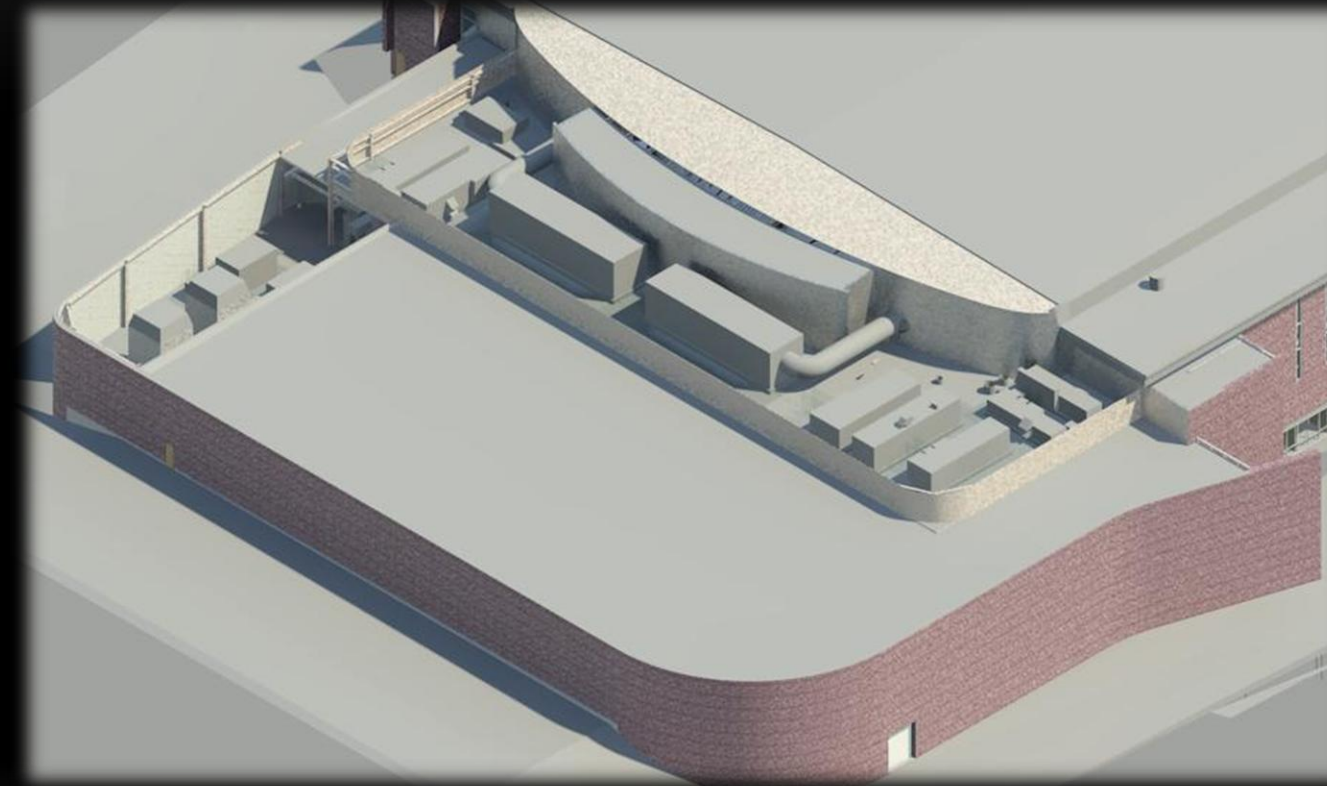




## COMMUNITY ROOF



## ACTUAL DESIGN

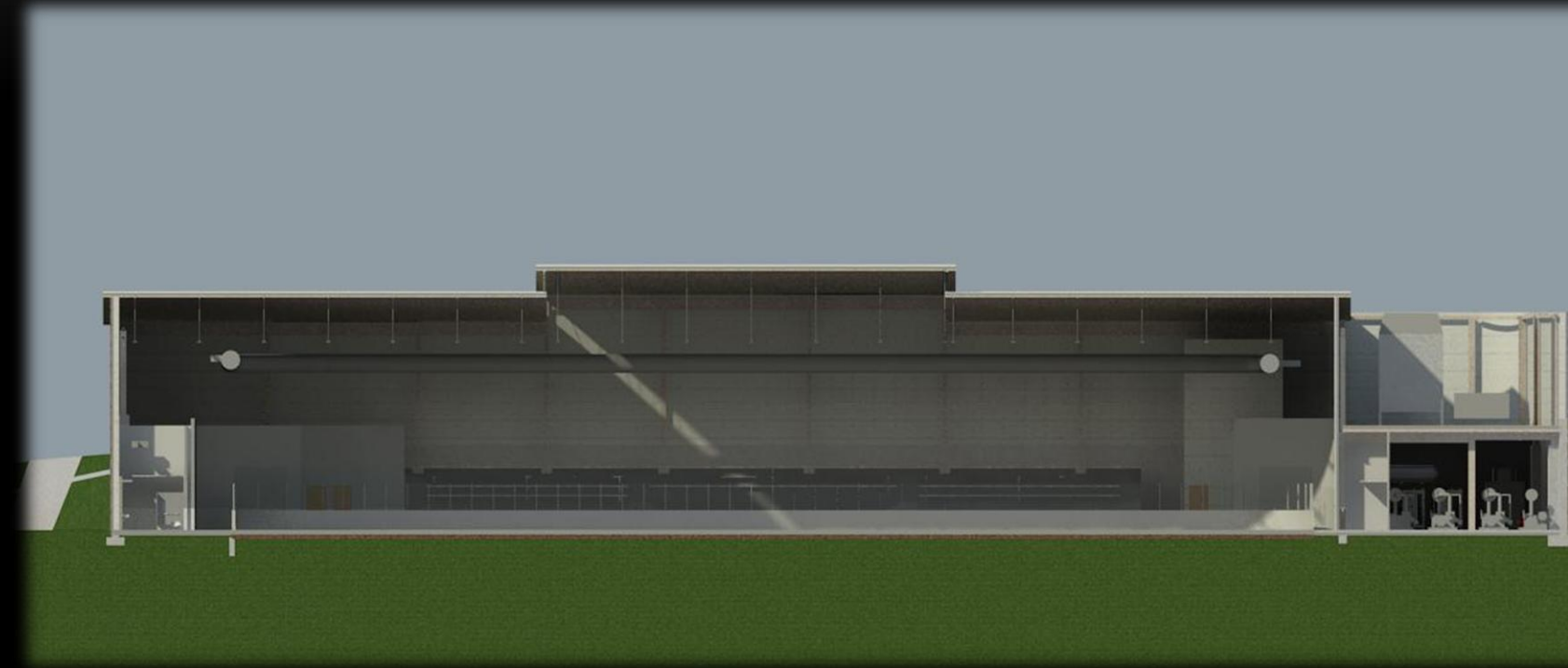
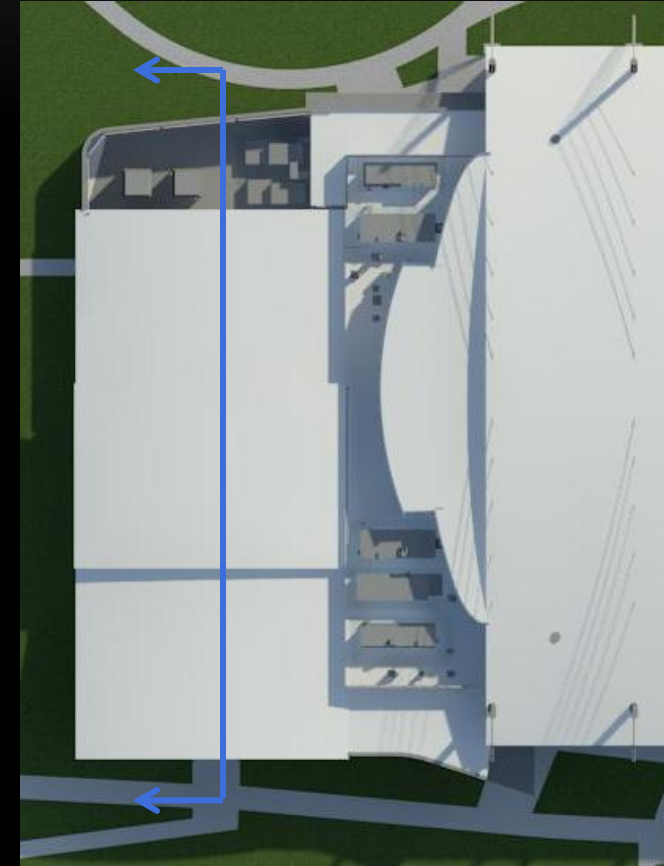


## OUR DESIGN



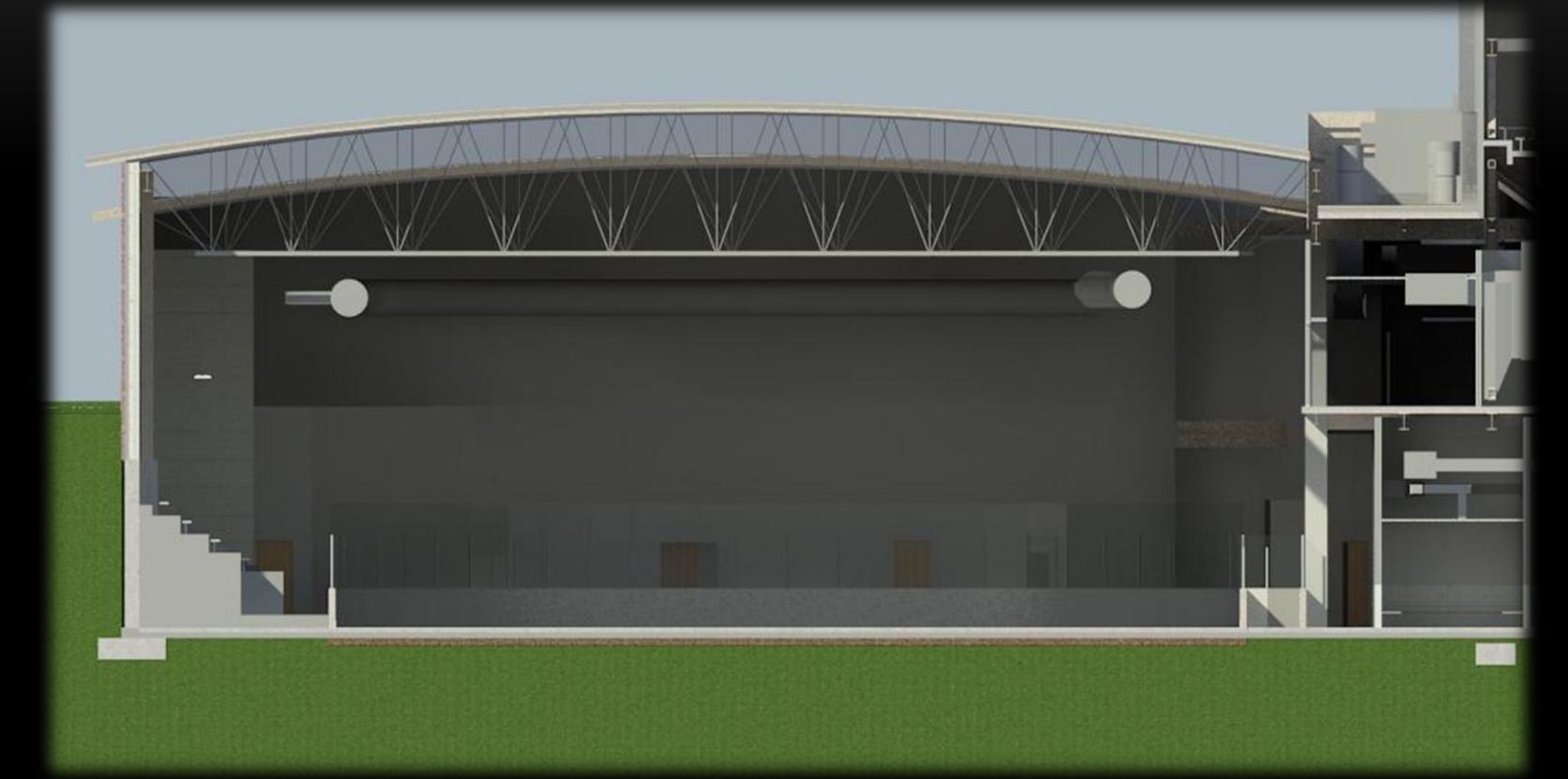
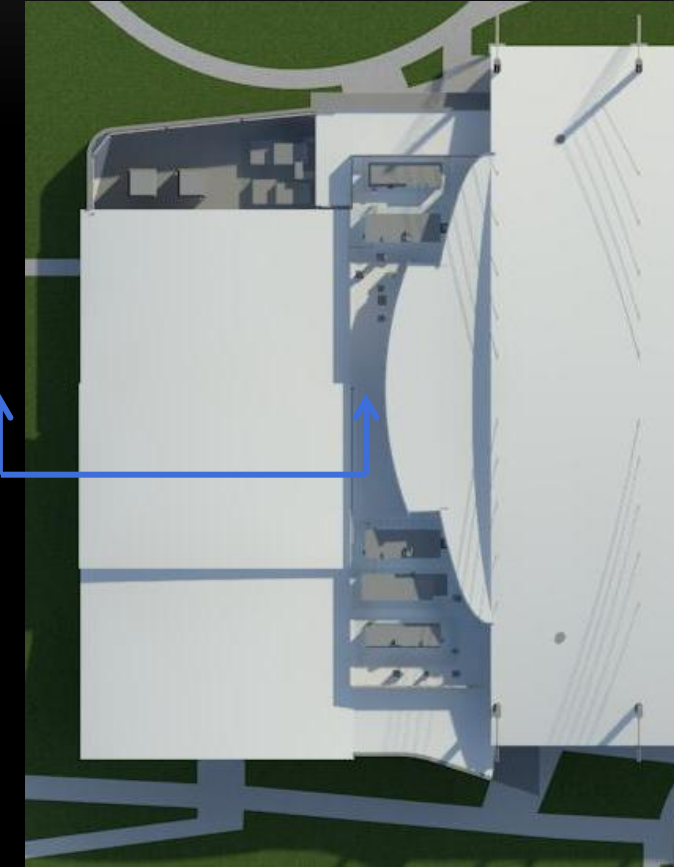


# COMMUNITY RINK REDESIGN



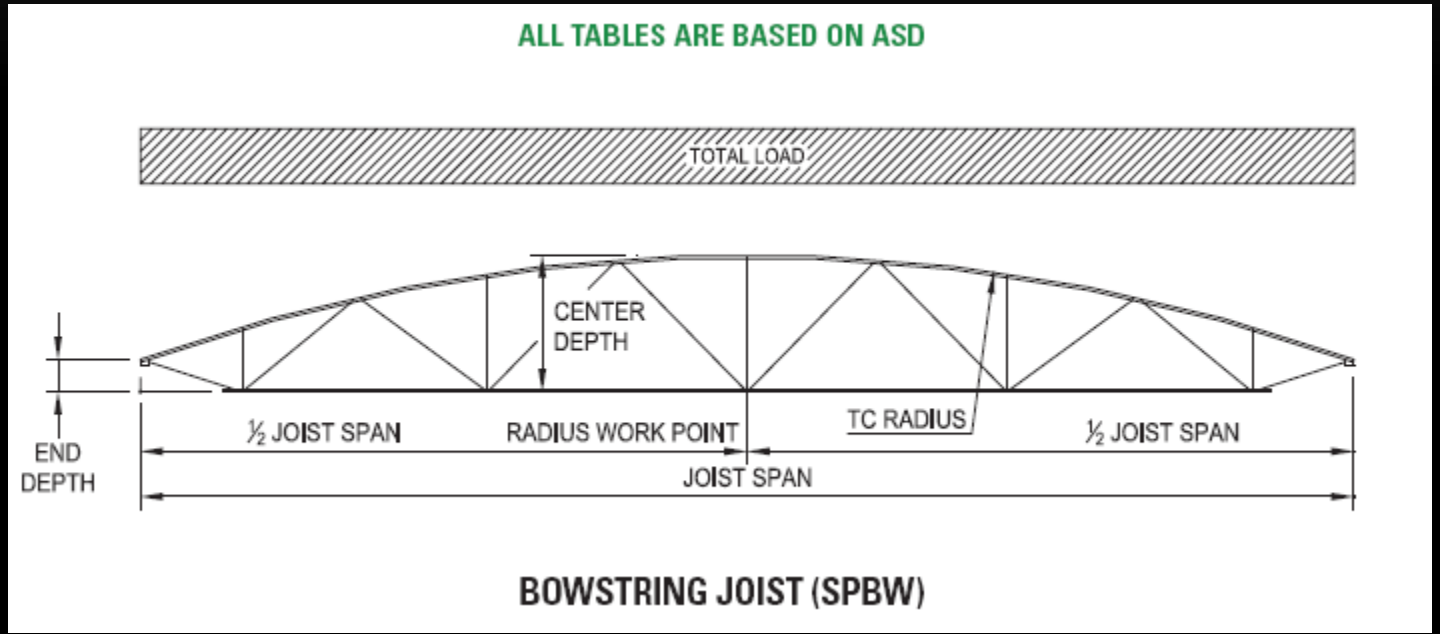
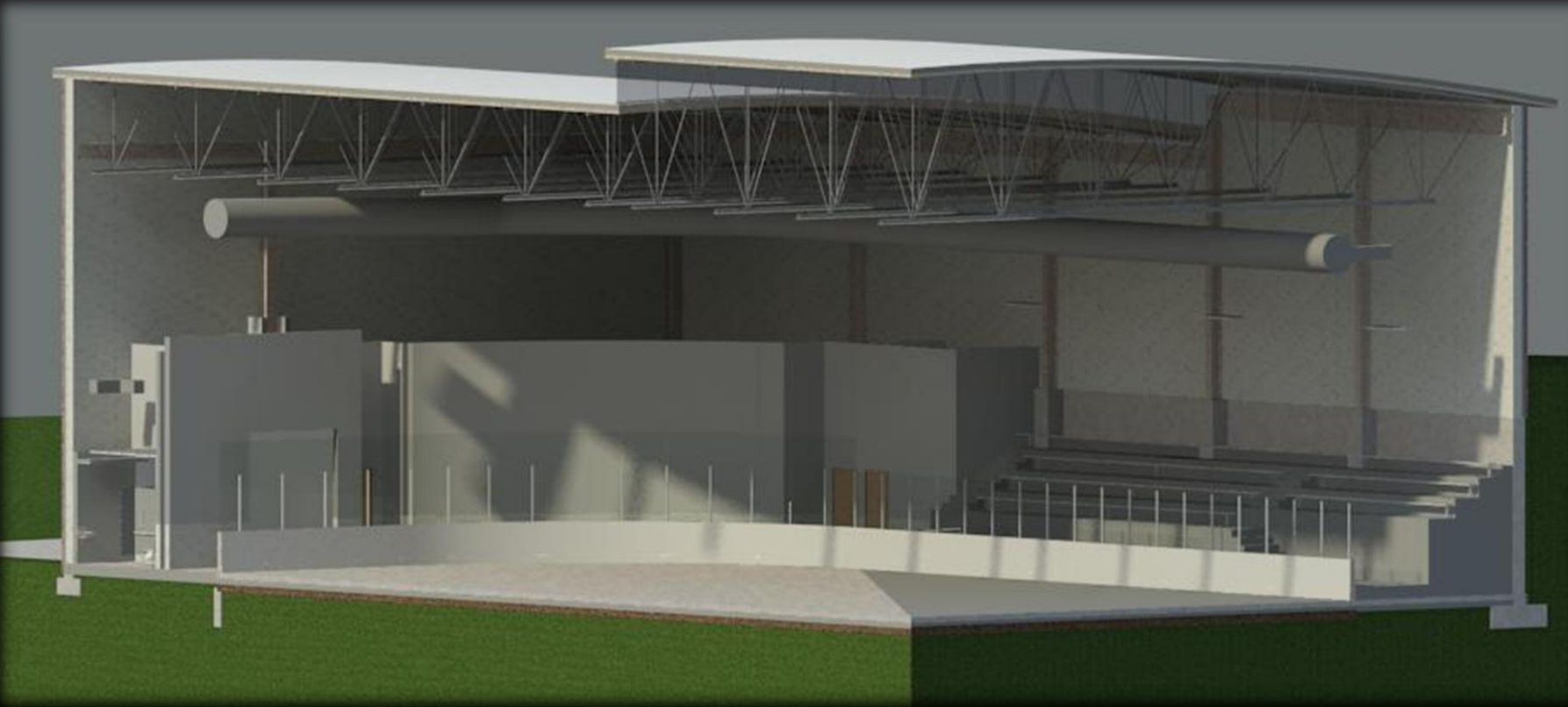


# COMMUNITY RINK REDESIGN





# BOWSTRING JOIST DESIGN



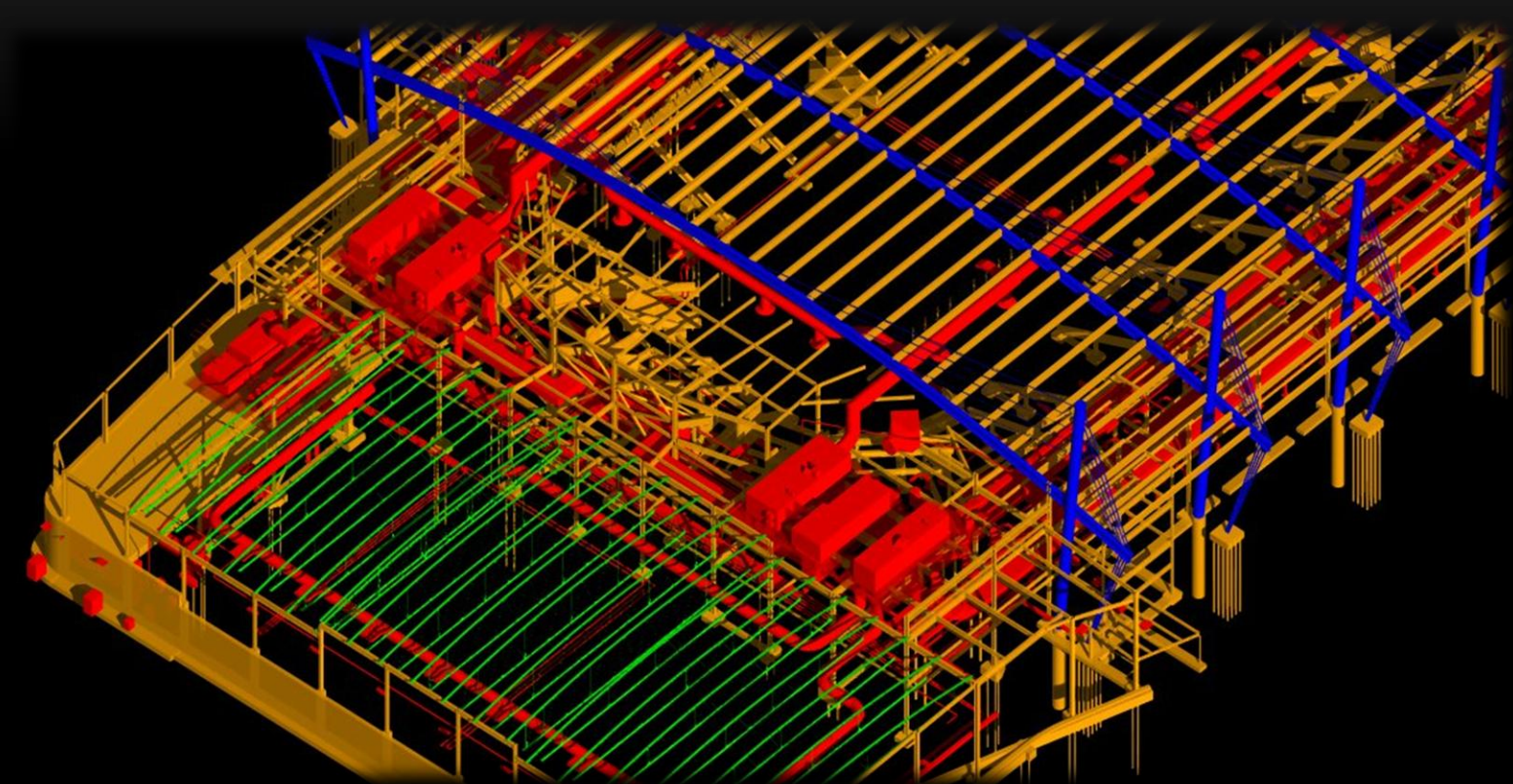
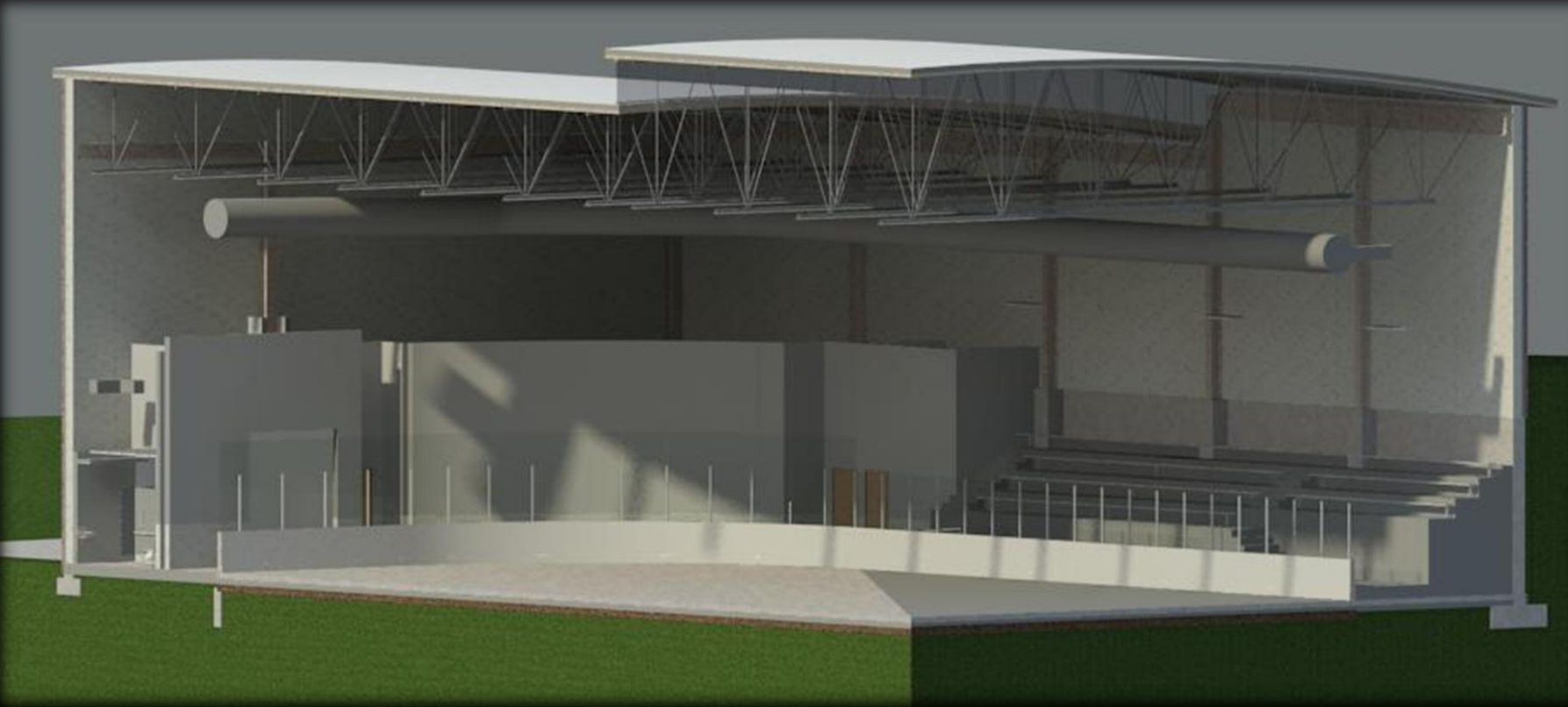
Span ft	End Depth in	Center Depth in	Top Chord Radius ft	Top Chord Uniform Load - Pounds per Linear Foot (plf) (ASD)										
				300	350	400	450	500	550	600	650	700	750	800
Joist Self-Weight - Pounds per Linear Foot (plf)														
110	70	104	535	30	32	33	35	39	41	44	49	51	53	58
110	63	104	444	31	31	33	35	39	41	43	49	51	53	58
110	56	104	380	31	31	33	35	38	40	43	49	51	53	58
110	49	104	332	31	33	33	34	40	40	43	49	51	52	58
110	35	104	266	31	32	34	36	39	42	43	48	50	52	60
110	22	104	225	32	32	34	37	41	41	42	52	54	56	59
110	123	164	444	46	46	48	49	52	53	56	59	60	62	66
110	116	164	380	46	47	49	51	51	51	55	57	59	64	64
110	109	164	332	46	46	47	48	51	51	52	57	59	63	64
110	95	164	266	44	46	46	49	49	51	51	53	59	60	61
110	82	164	225	43	44	46	48	48	50	51	56	59	59	60
110	54	164	170	42	43	44	47	47	49	49	53	55	56	58

**X - Bridging Requirements - Reference SP-Series Specification Section 904.5 BRIDGING on page 92**

1 row	2 rows	3 rows	4 rows	5 rows	6 rows	7 rows	8 rows	9 rows	10 rows
Bearing Seat Depth - Profiles to the right of a colored line have a seat depth as indicated in the chart below									
Minimum 5"		7½"		10"		Maximum 12½"			



# BOWSTRING JOIST DESIGN



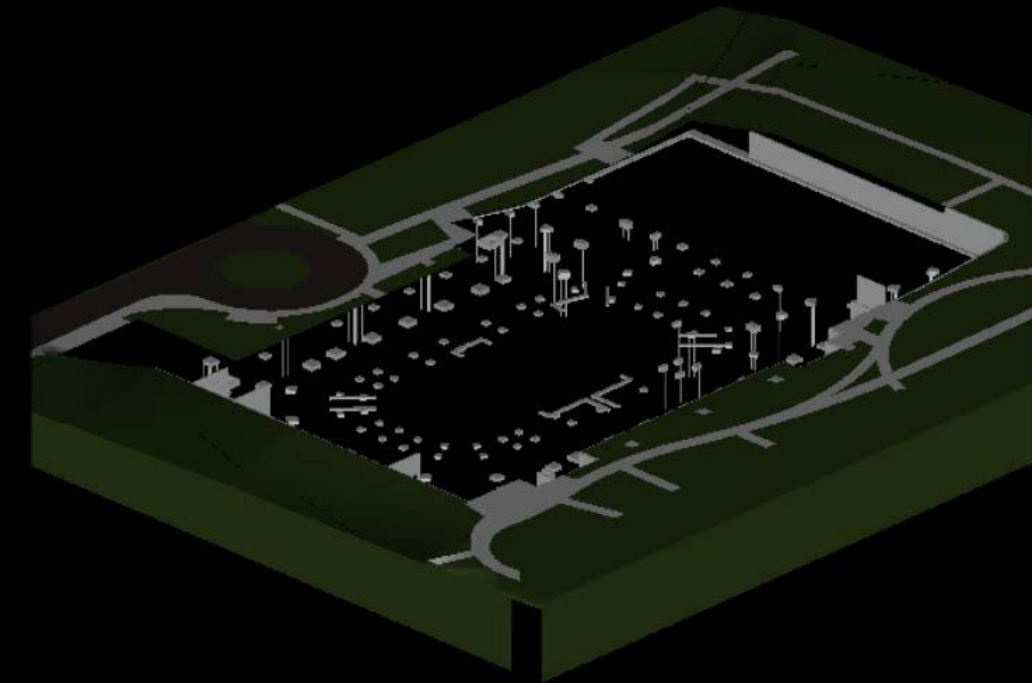
Span ft	End Depth in	Center Depth in	Top Chord Radius ft	Top Chord Uniform Load - Pounds per Linear Foot (plf) (ASD)																				
				300	350	400	450	500	550	600	650	700	750	800										
														Joist Self-Weight - Pounds per Linear Foot (plf)										
110	70	104	535	30	32	33	35	39	41	44	49	51	53	58										
110	63	104	444	31	31	33	35	39	41	43	49	51	53	58										
110	56	104	380	31	31	33	35	38	40	43	49	51	53	58										
110	49	104	332	31	33	33	34	40	40	43	49	51	52	58										
110	35	104	266	31	32	34	36	39	42	43	48	50	52	60										
110	22	104	225	32	32	34	37	41	41	42	52	54	56	59										
110	123	164	444	46	46	48	49	52	53	56	59	60	62	66										
110	116	164	380	46	47	49	51	51	51	55	57	59	64	64										
110	109	164	332	46	46	47	48	51	51	52	57	59	63	64										
110	95	164	266	44	46	46	49	49	51	51	53	59	60	61										
110	82	164	225	43	44	46	48	48	50	51	56	59	59	60										
110	54	164	170	42	43	44	47	47	49	49	53	55	56	58										

**X - Bridging Requirements** - Reference SP-Series Specification Section 904.5 BRIDGING on page 92

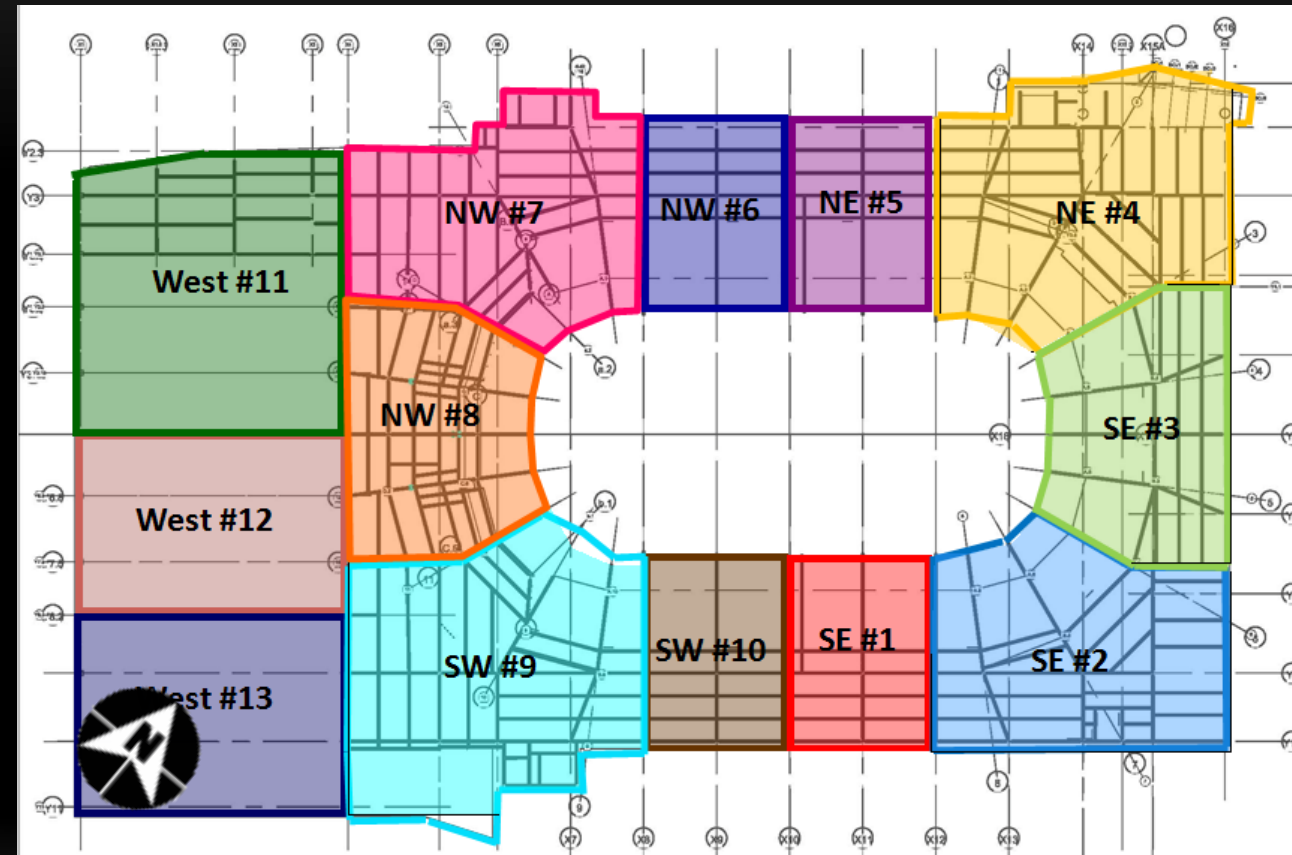
1 row	2 rows	3 rows	4 rows	5 rows	6 rows	7 rows	8 rows	9 rows	10 rows
Bearing Seat Depth - Profiles to the right of a colored line have a seat depth as indicated in the chart below									
Minimum 5"		7½"		10"		Maximum 12½"			



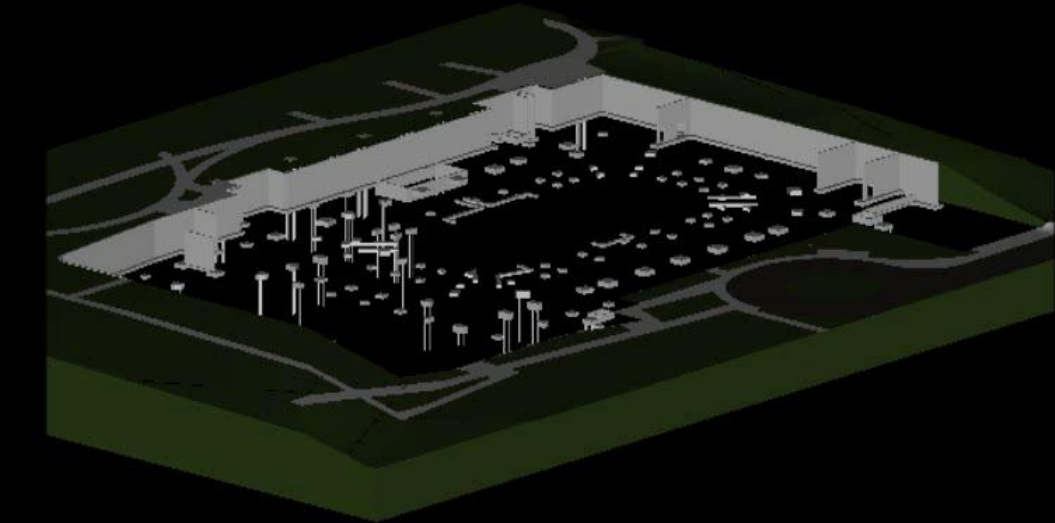
Monday 8:00:00 AM 5/28/2012 Day=1 Week=1



## 4D CONSTRUCTION SEQUENCE

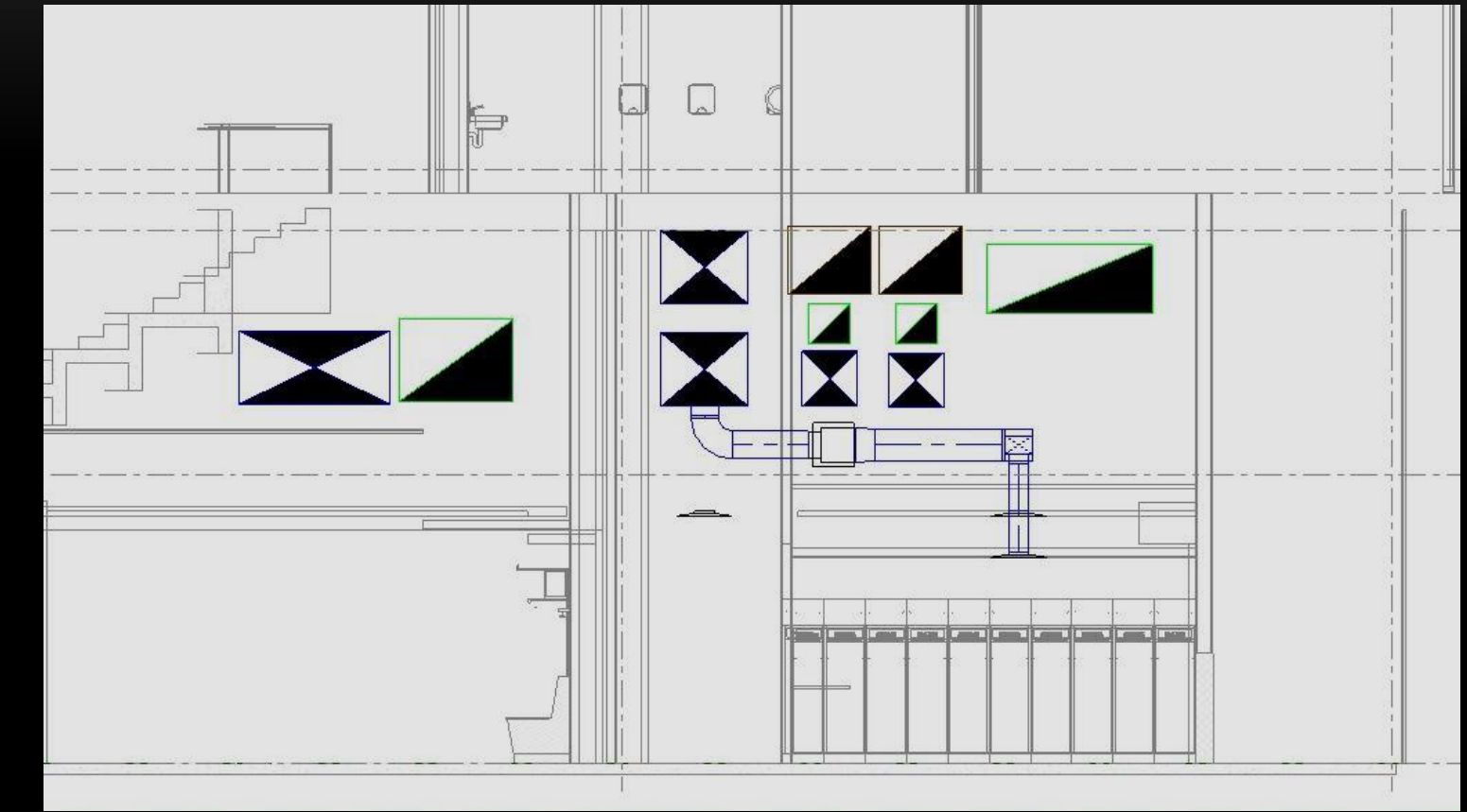
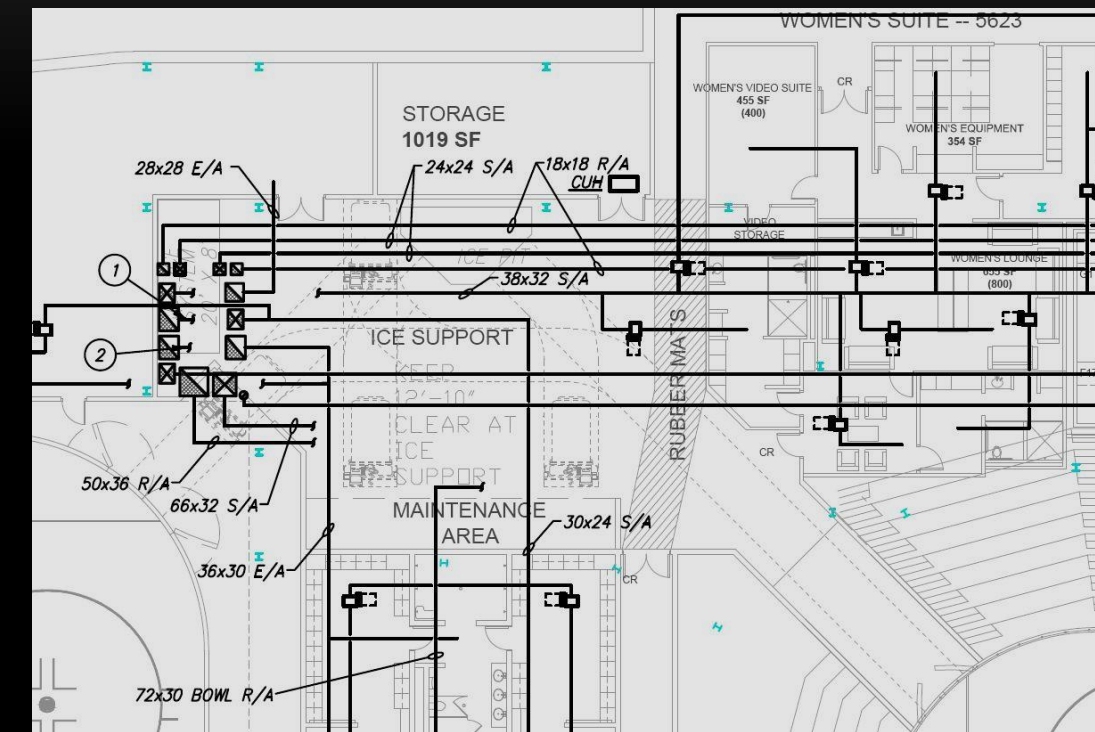


Monday 8:00:00 AM 5/28/2012 Day=1 Week=1



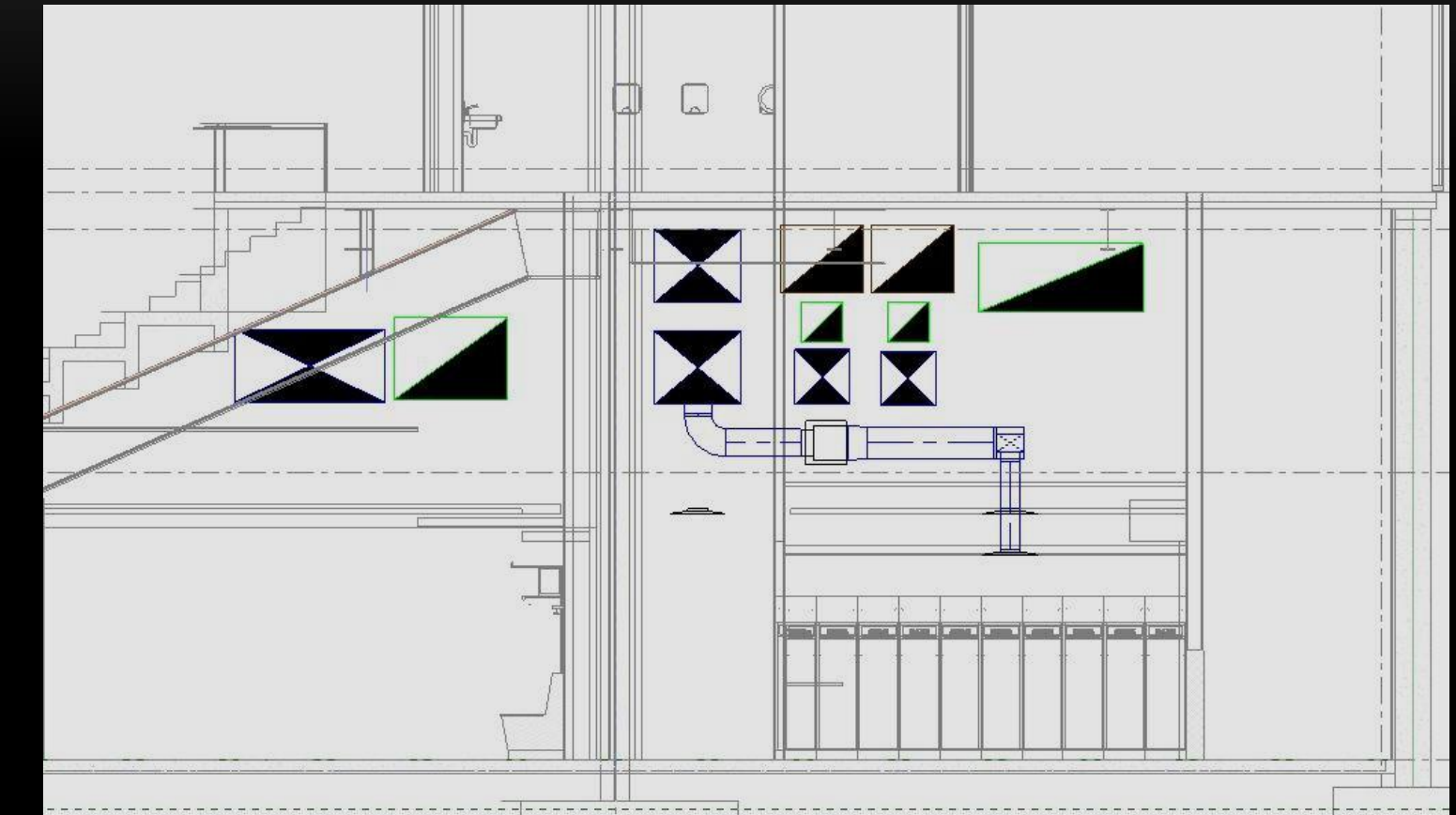
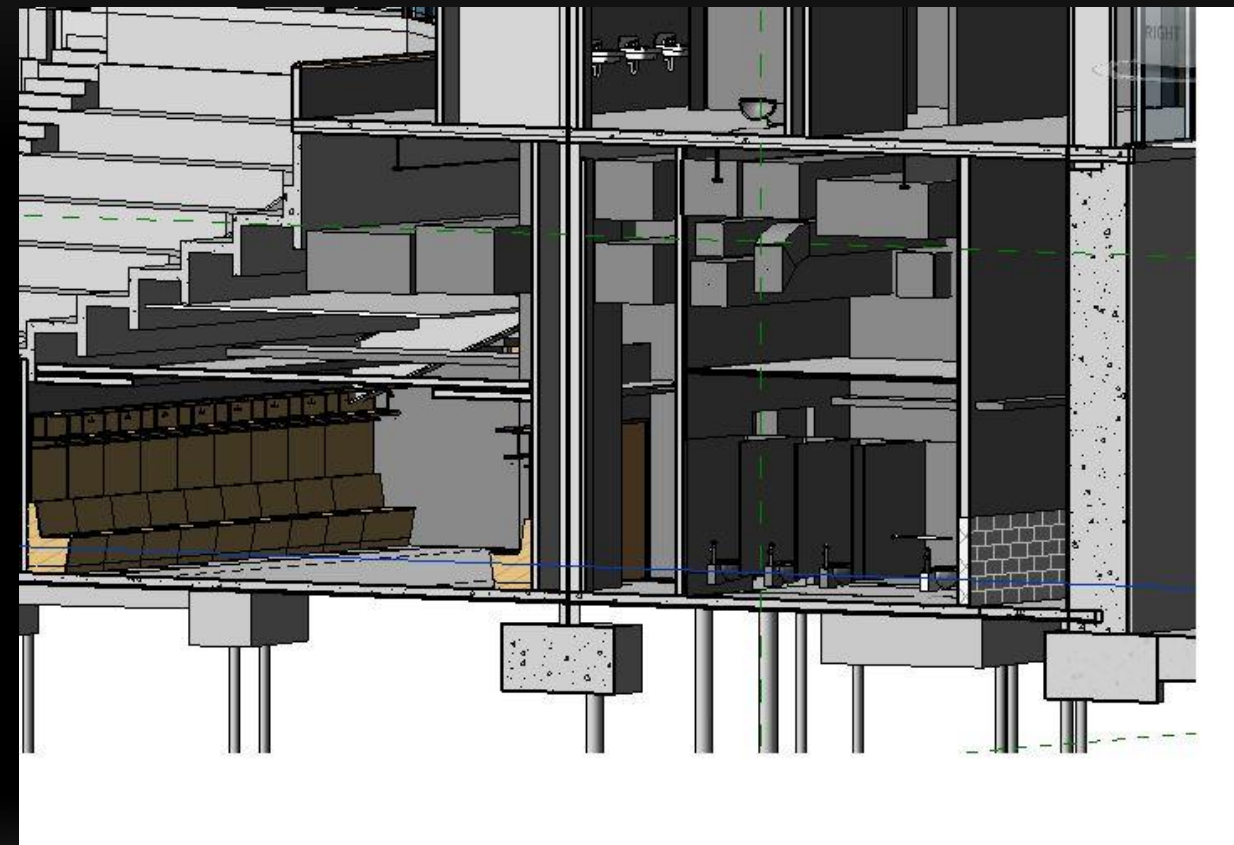
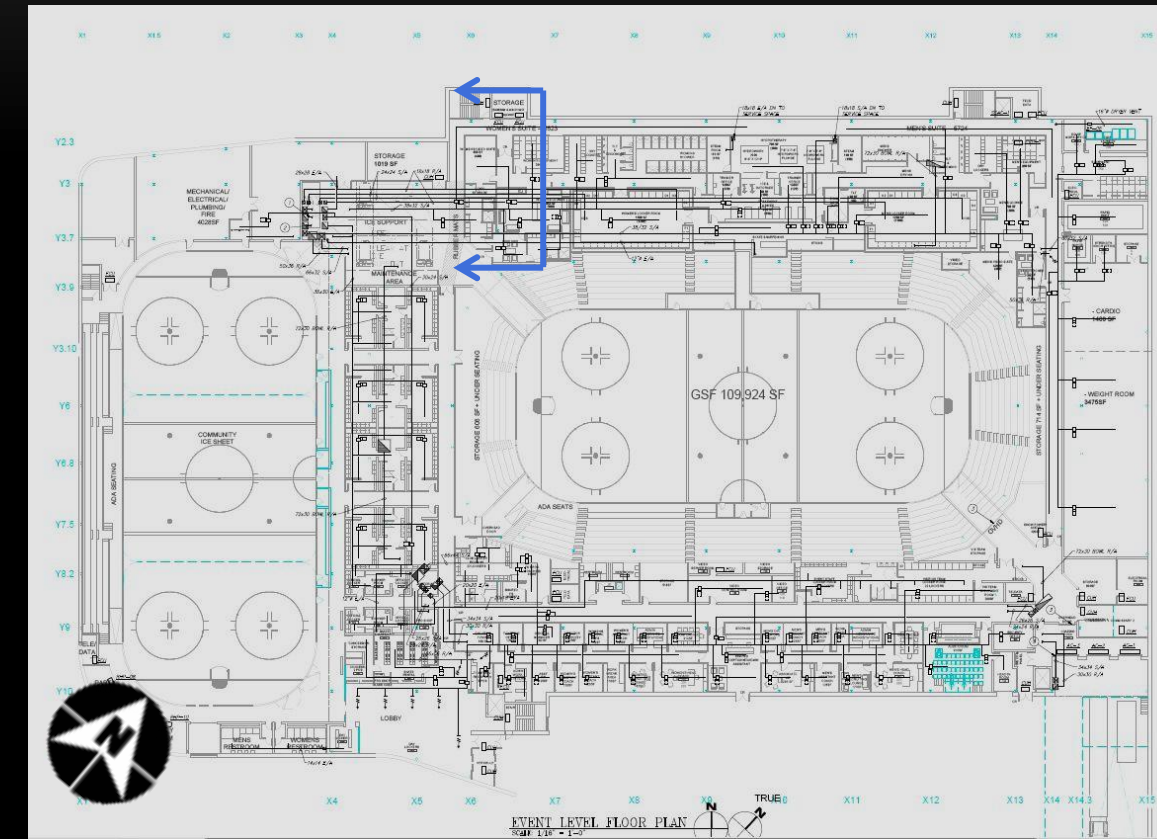


# EVENT LEVEL COORDINATION



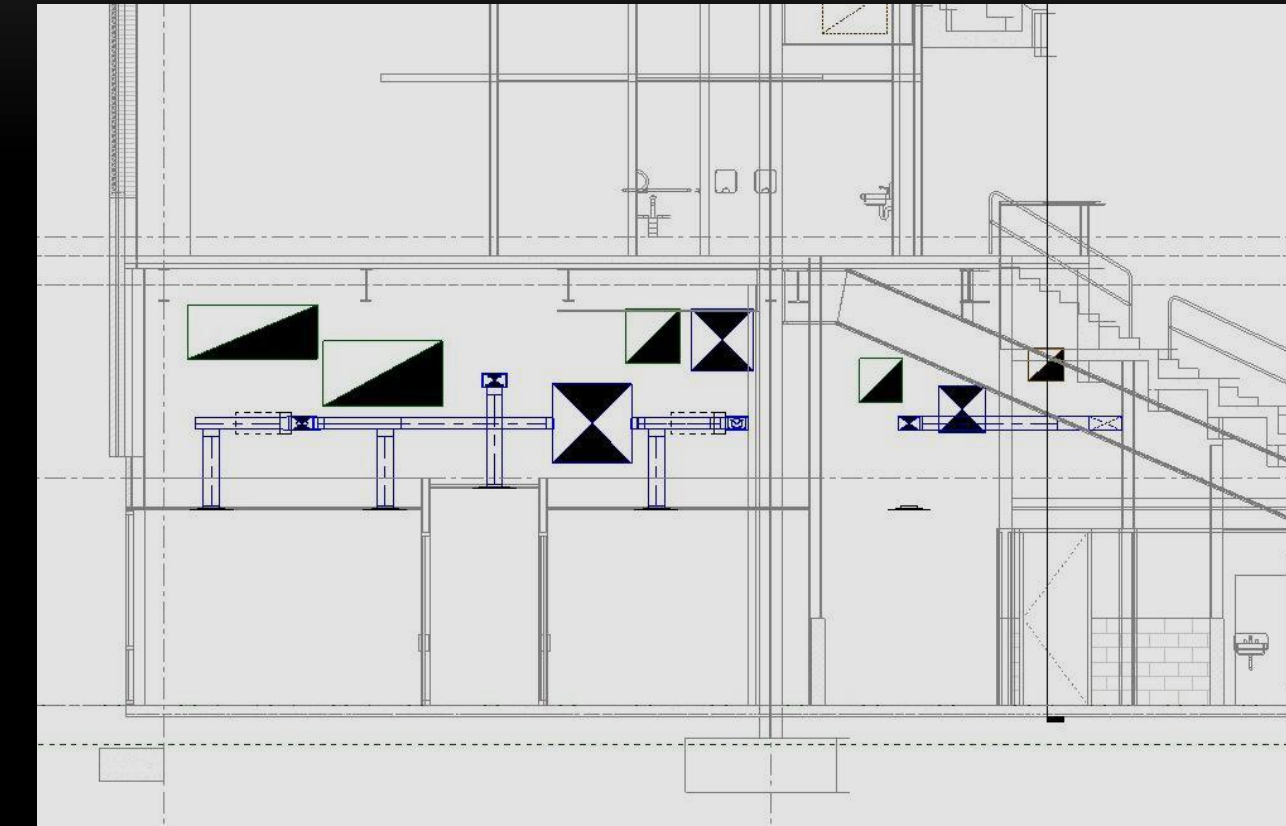
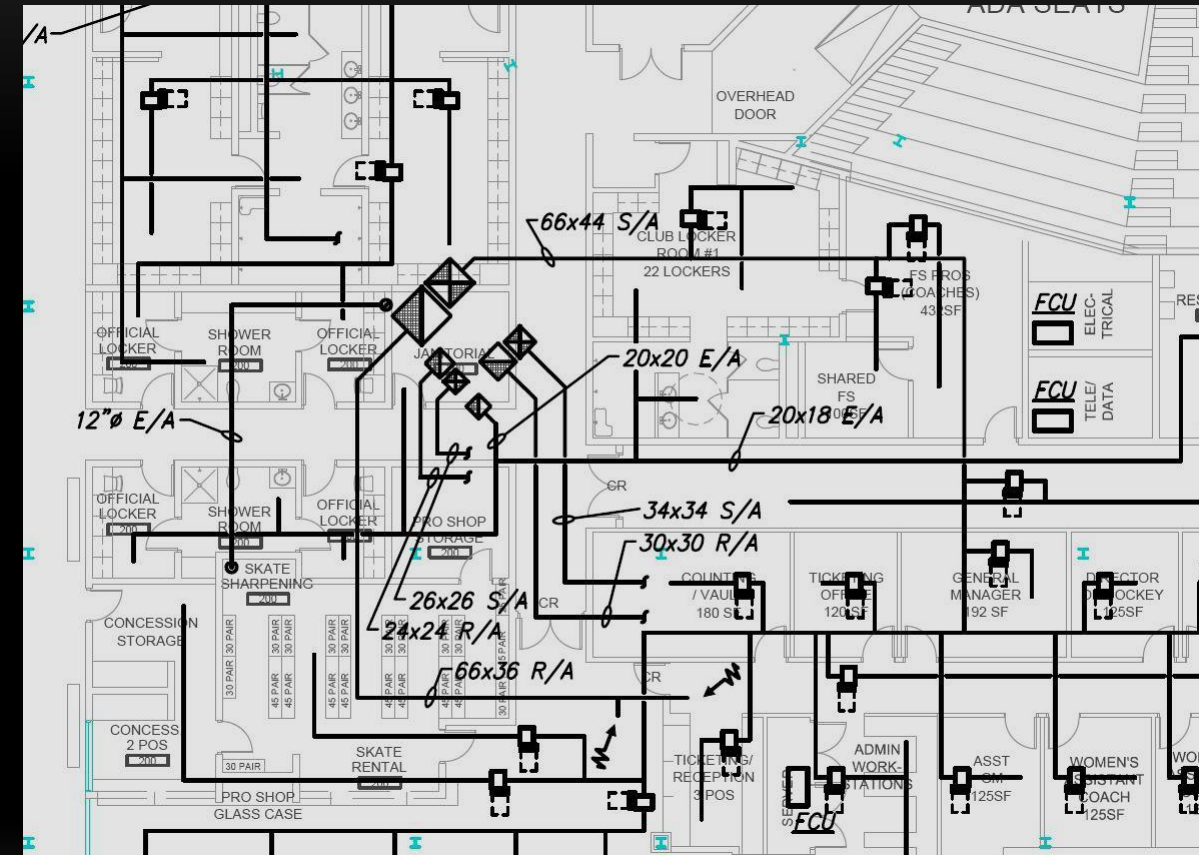


# EVENT LEVEL COORDINATION



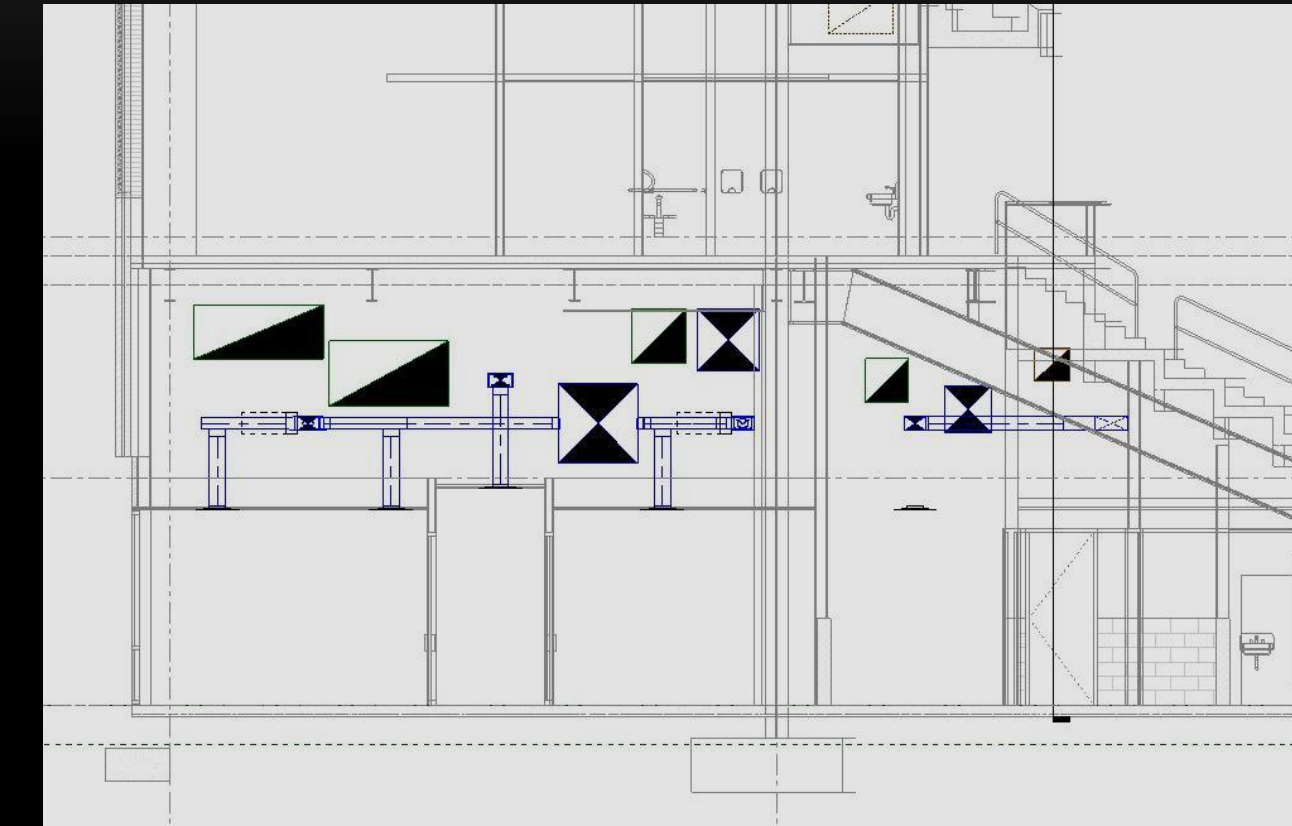
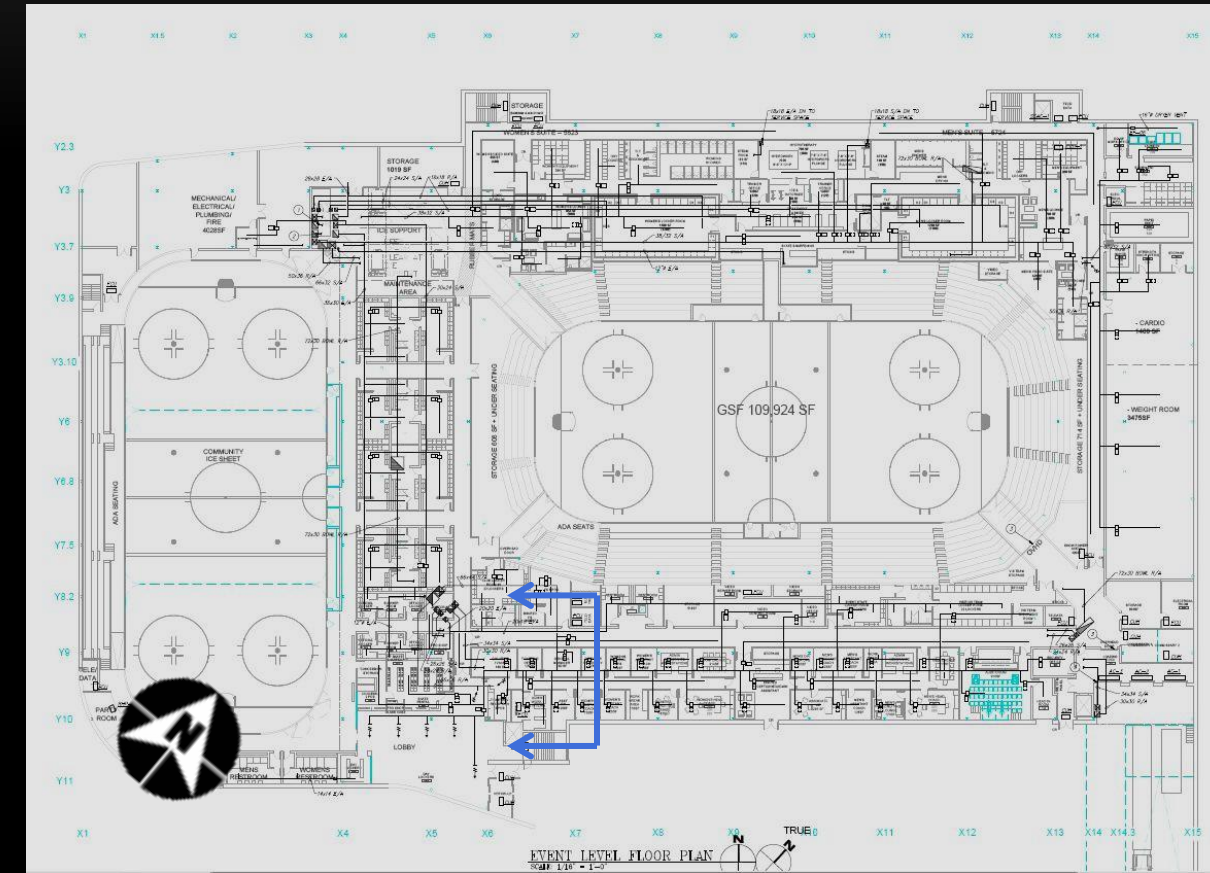


# EVENT LEVEL COORDINATION



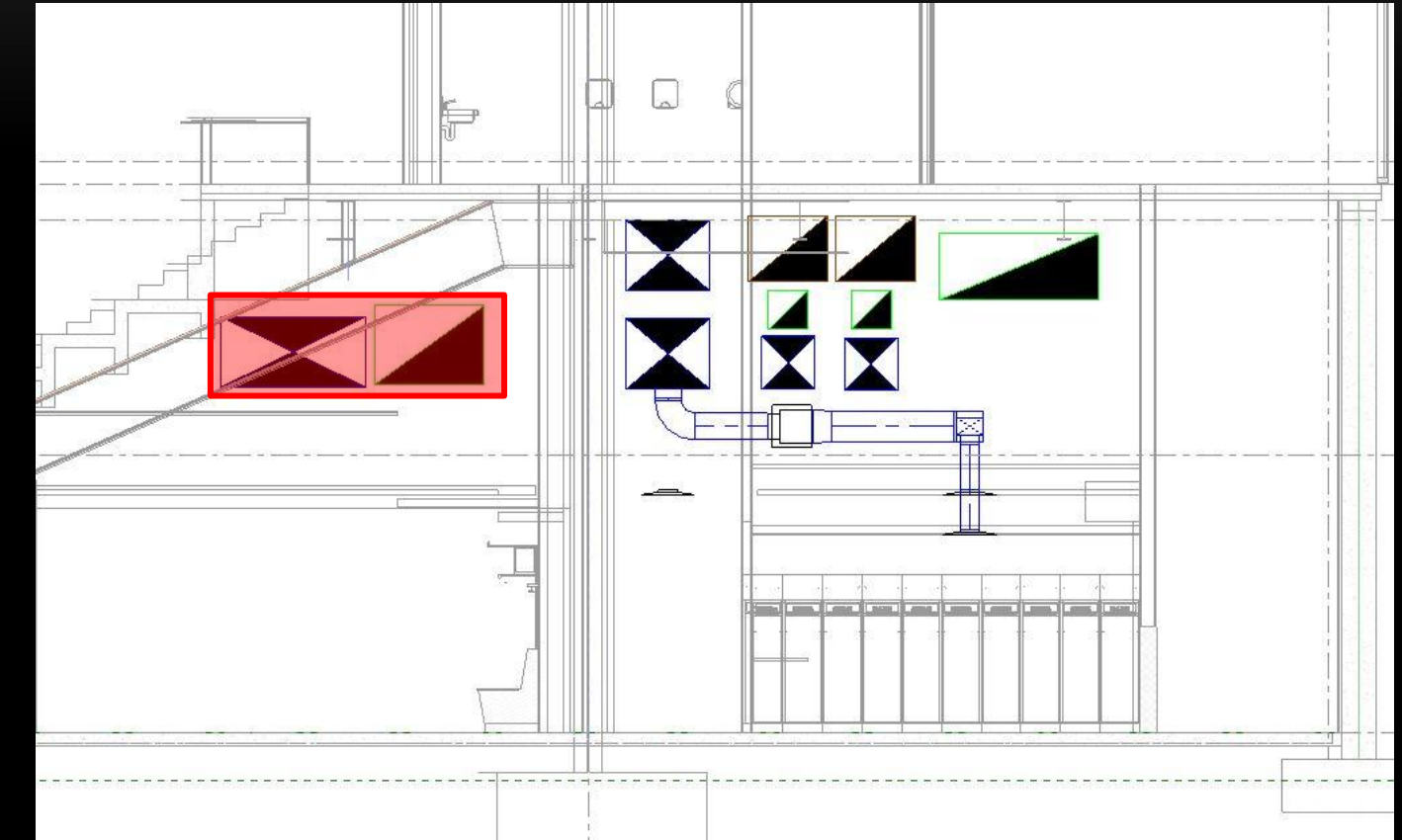
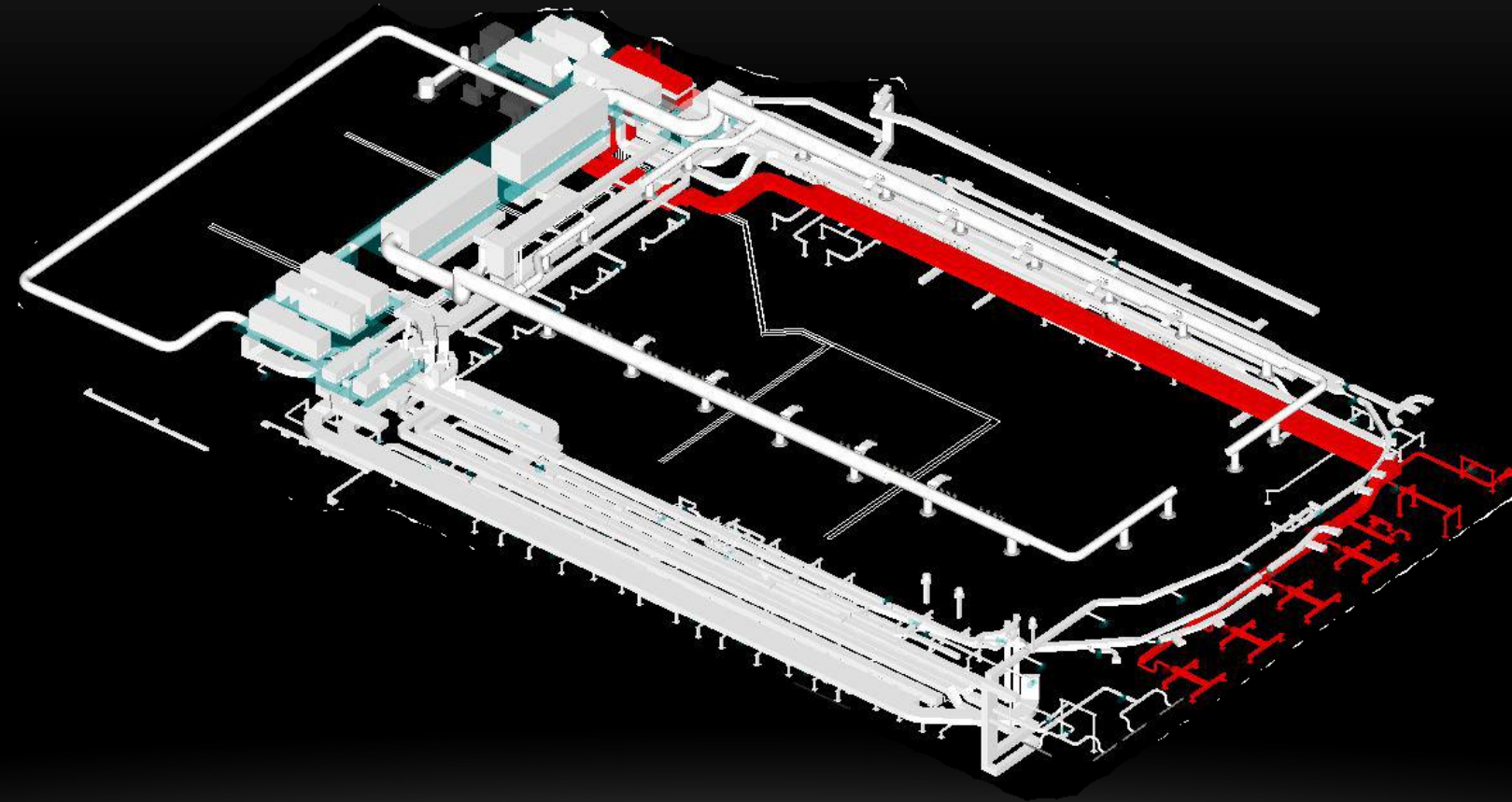
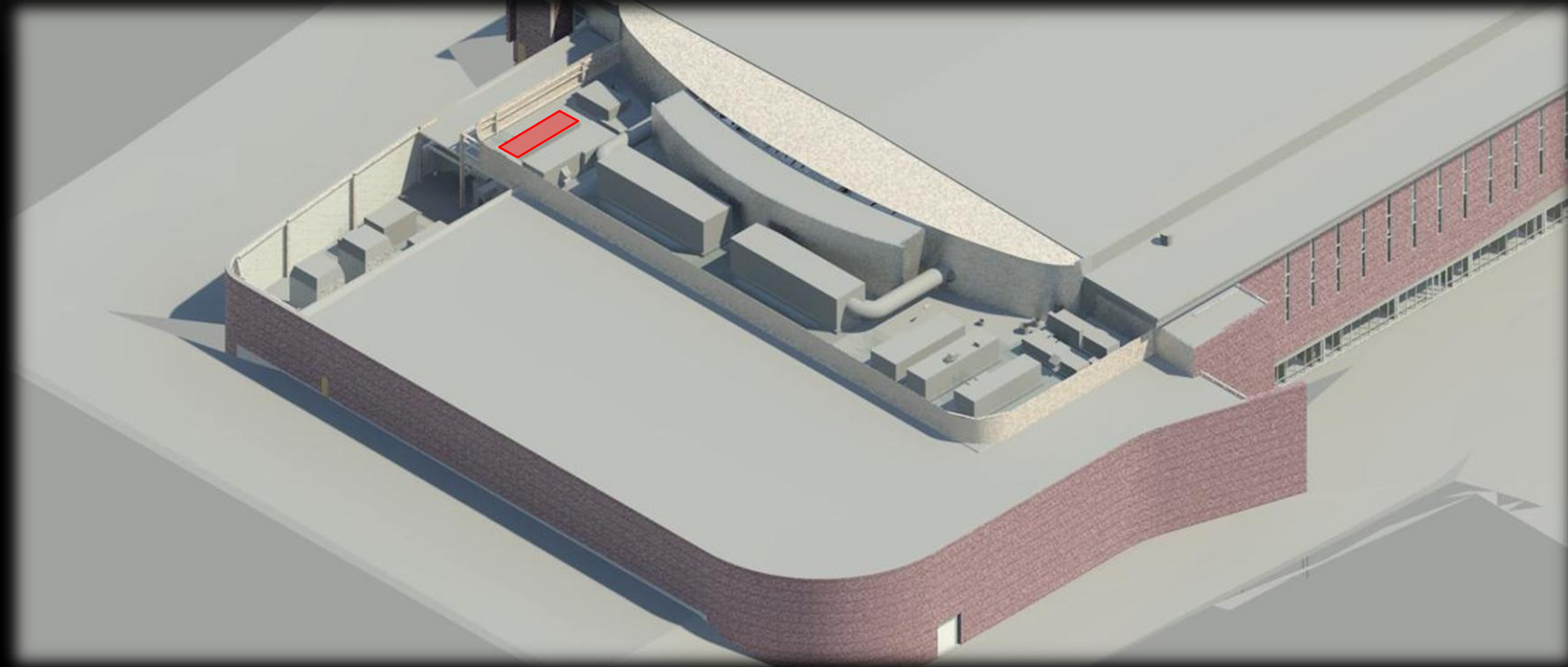


# EVENT LEVEL COORDINATION



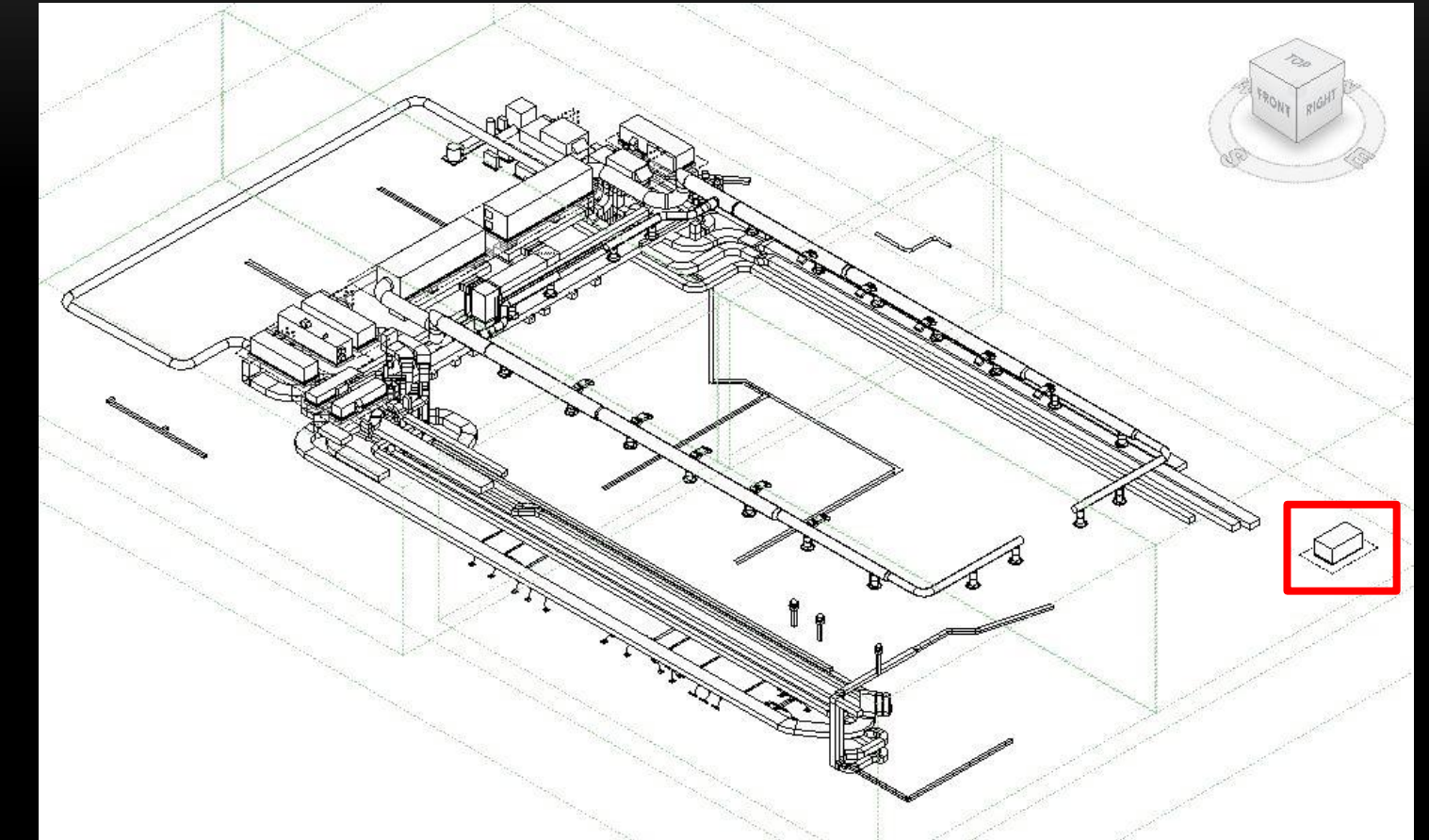
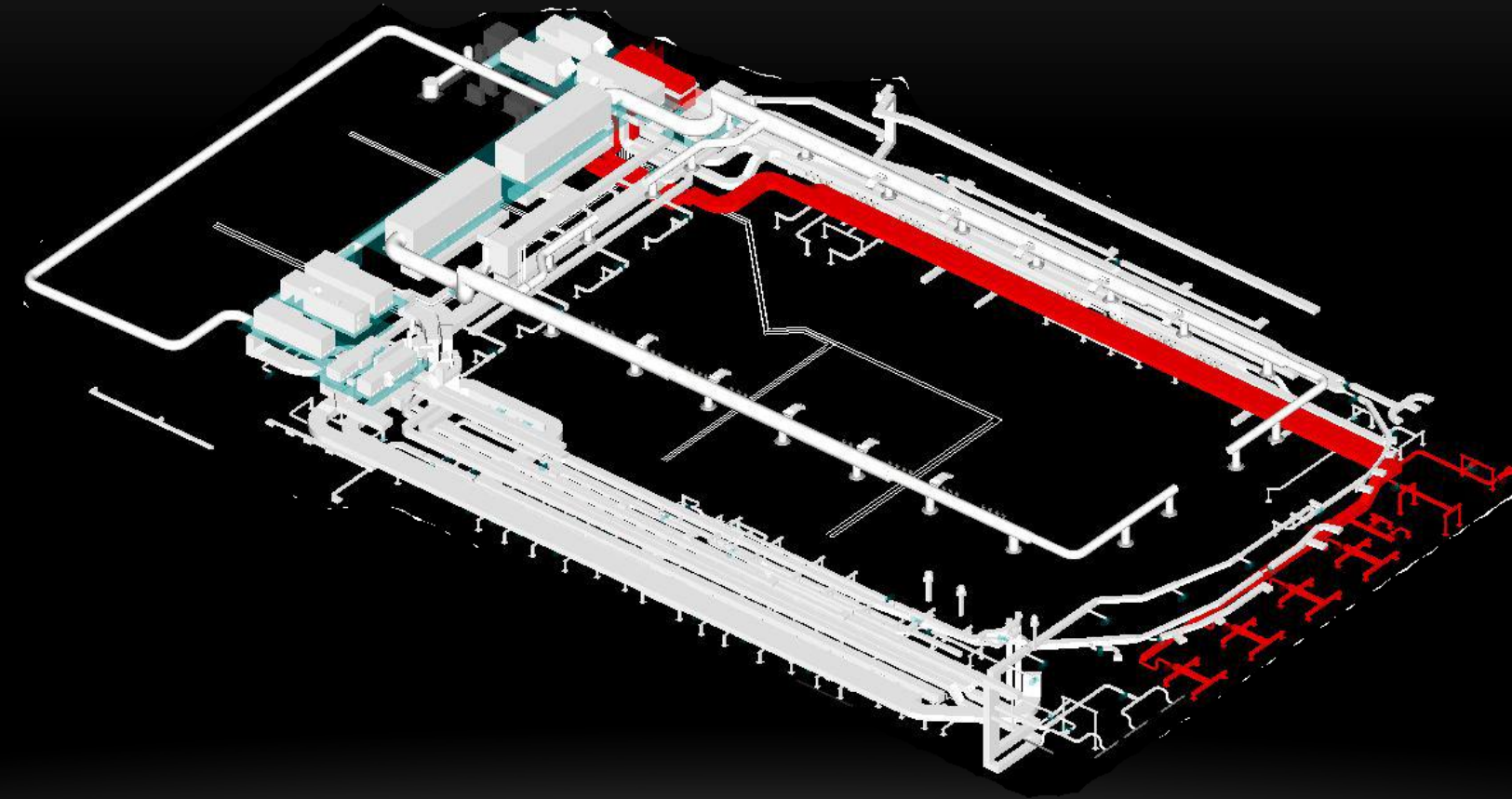
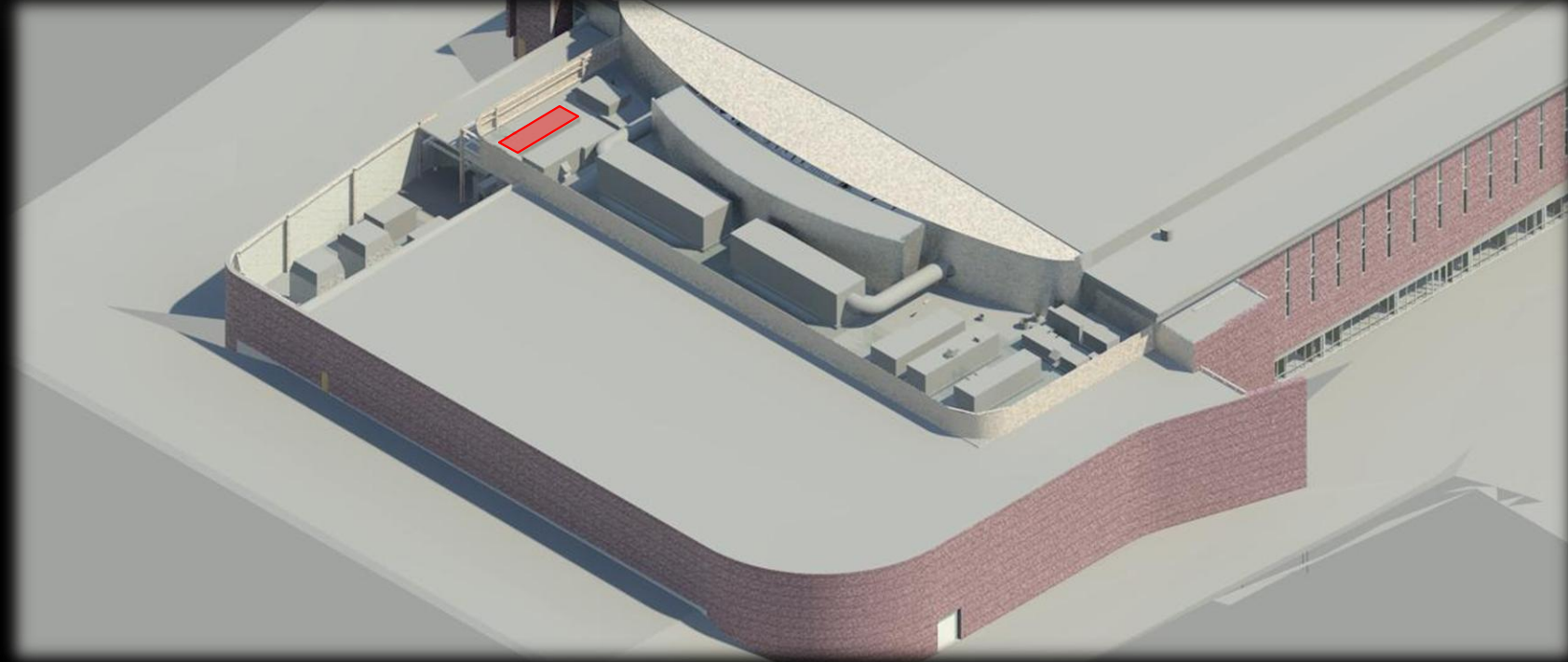


# AHU-6



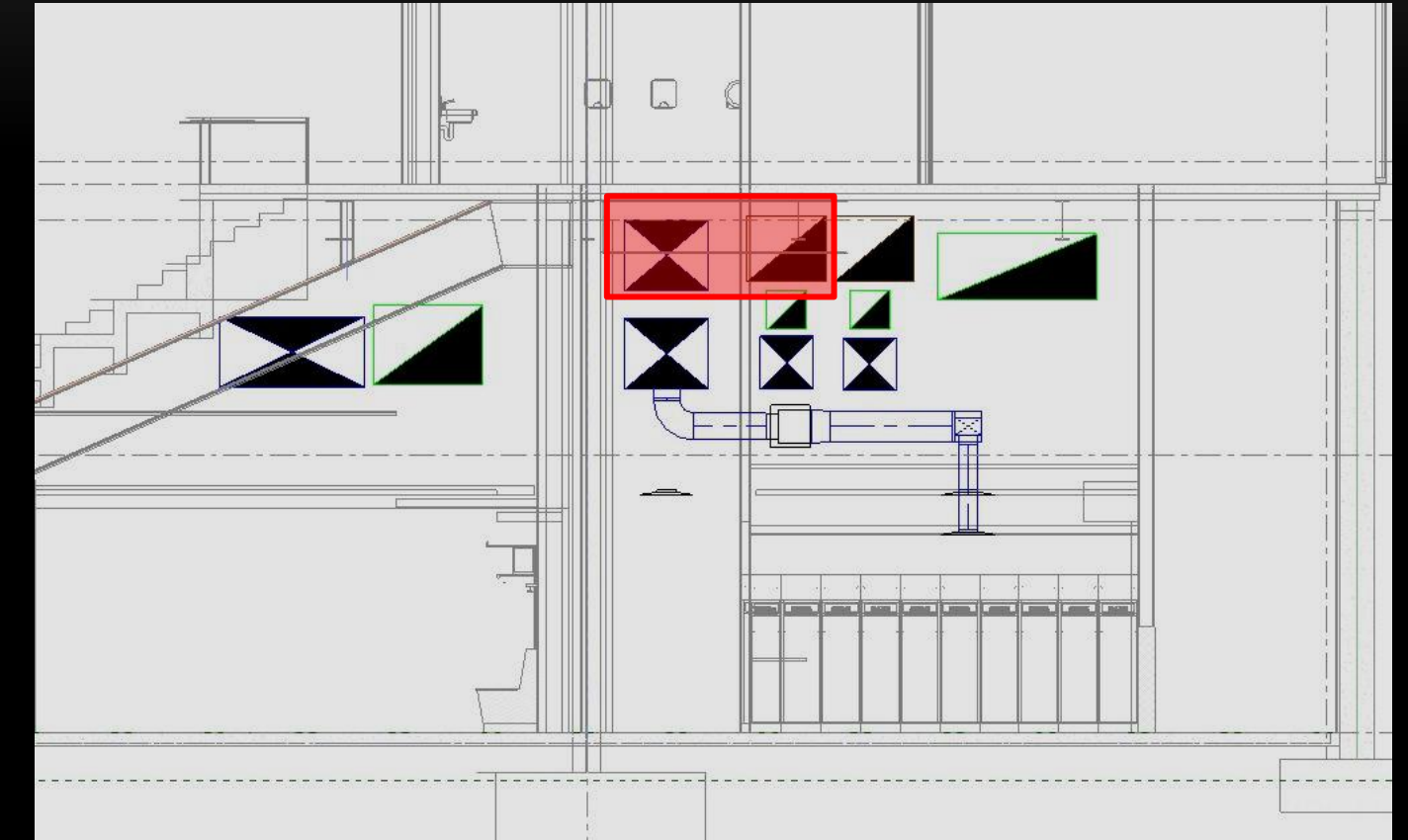
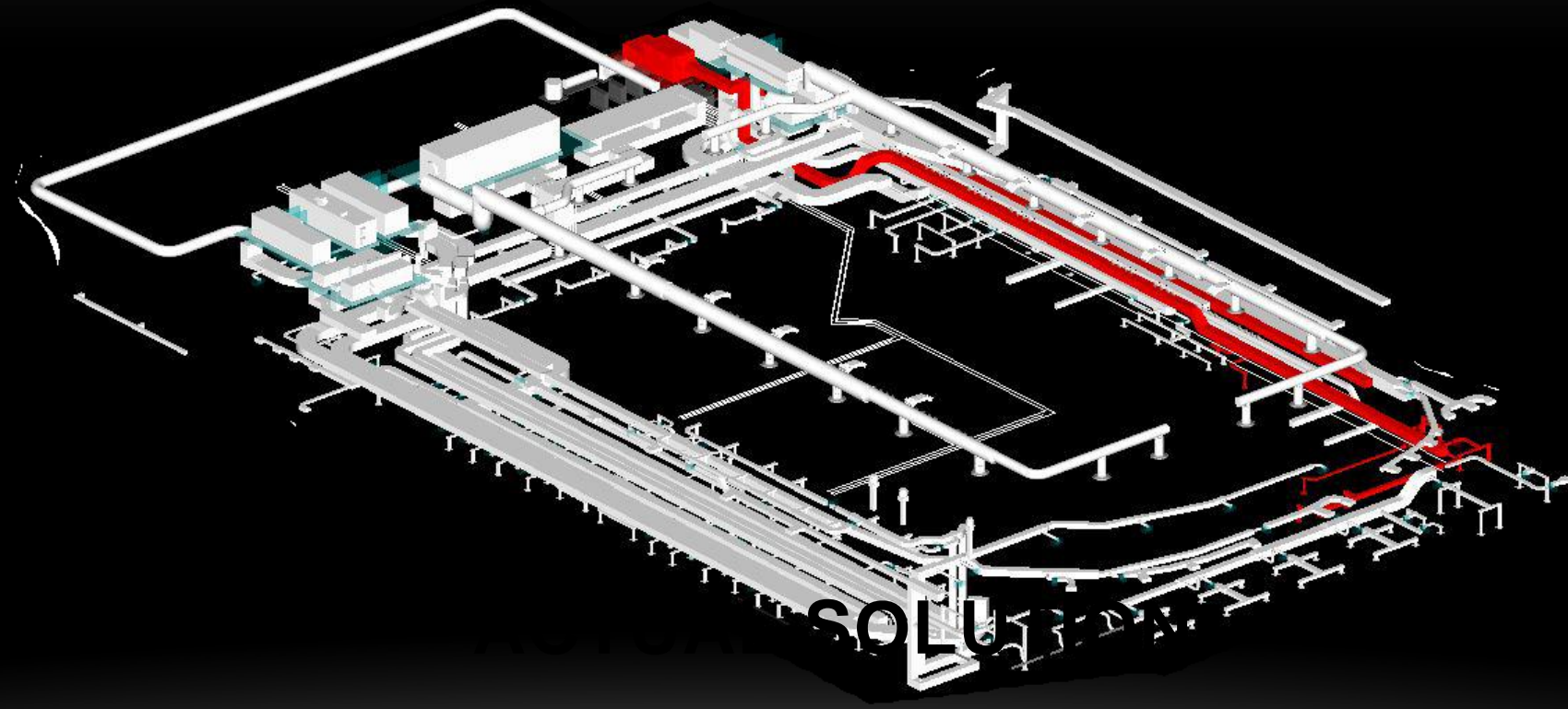


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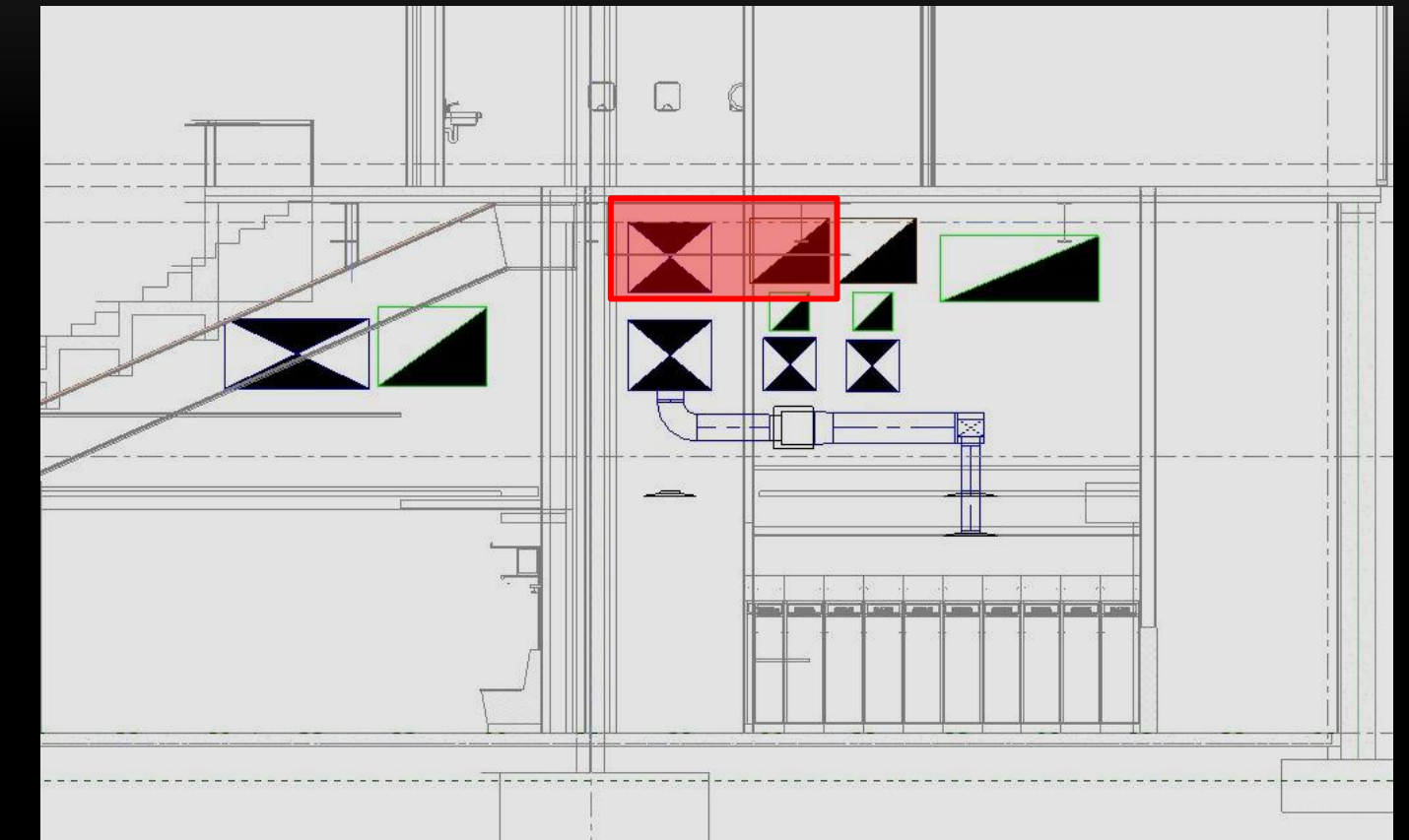
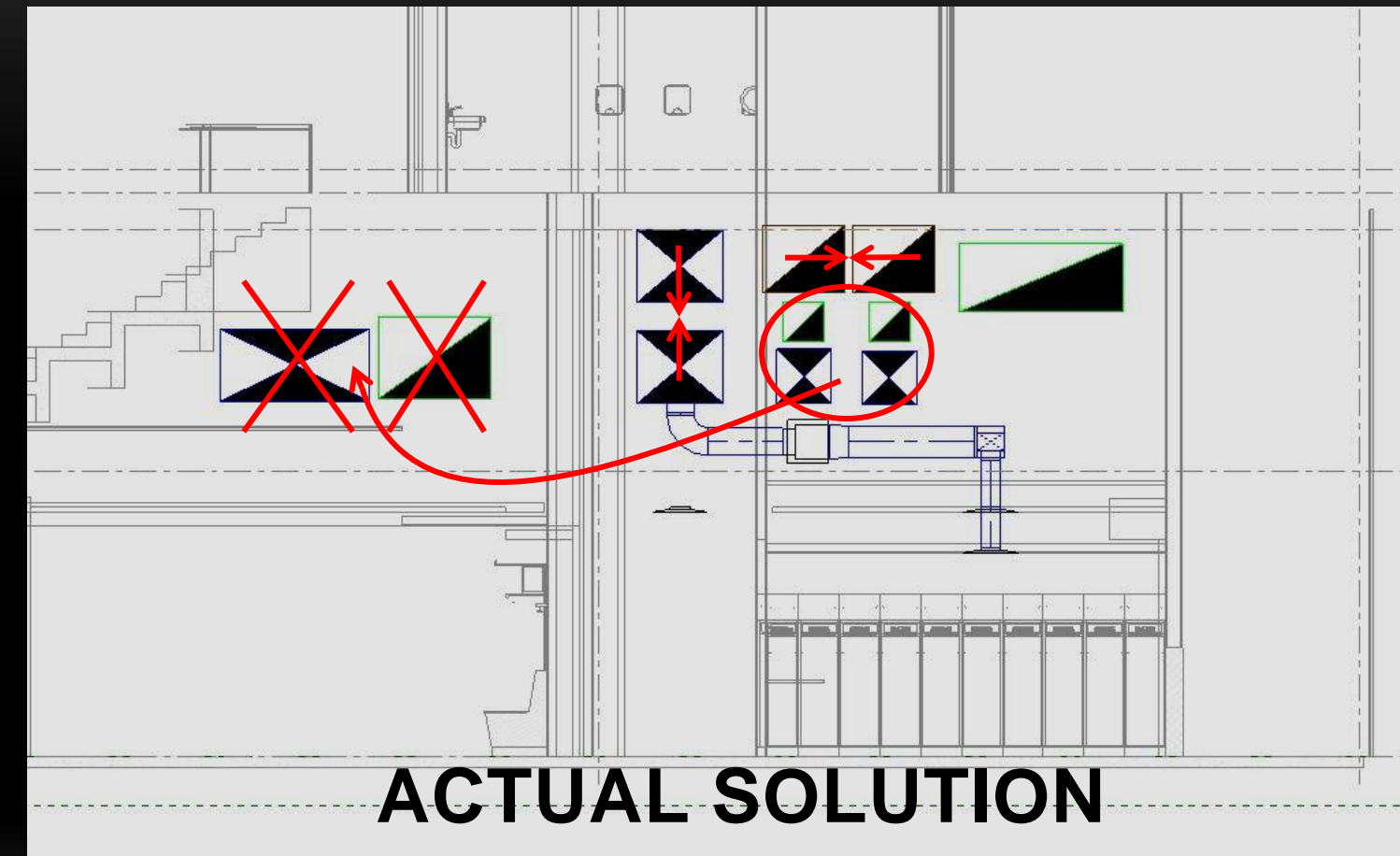
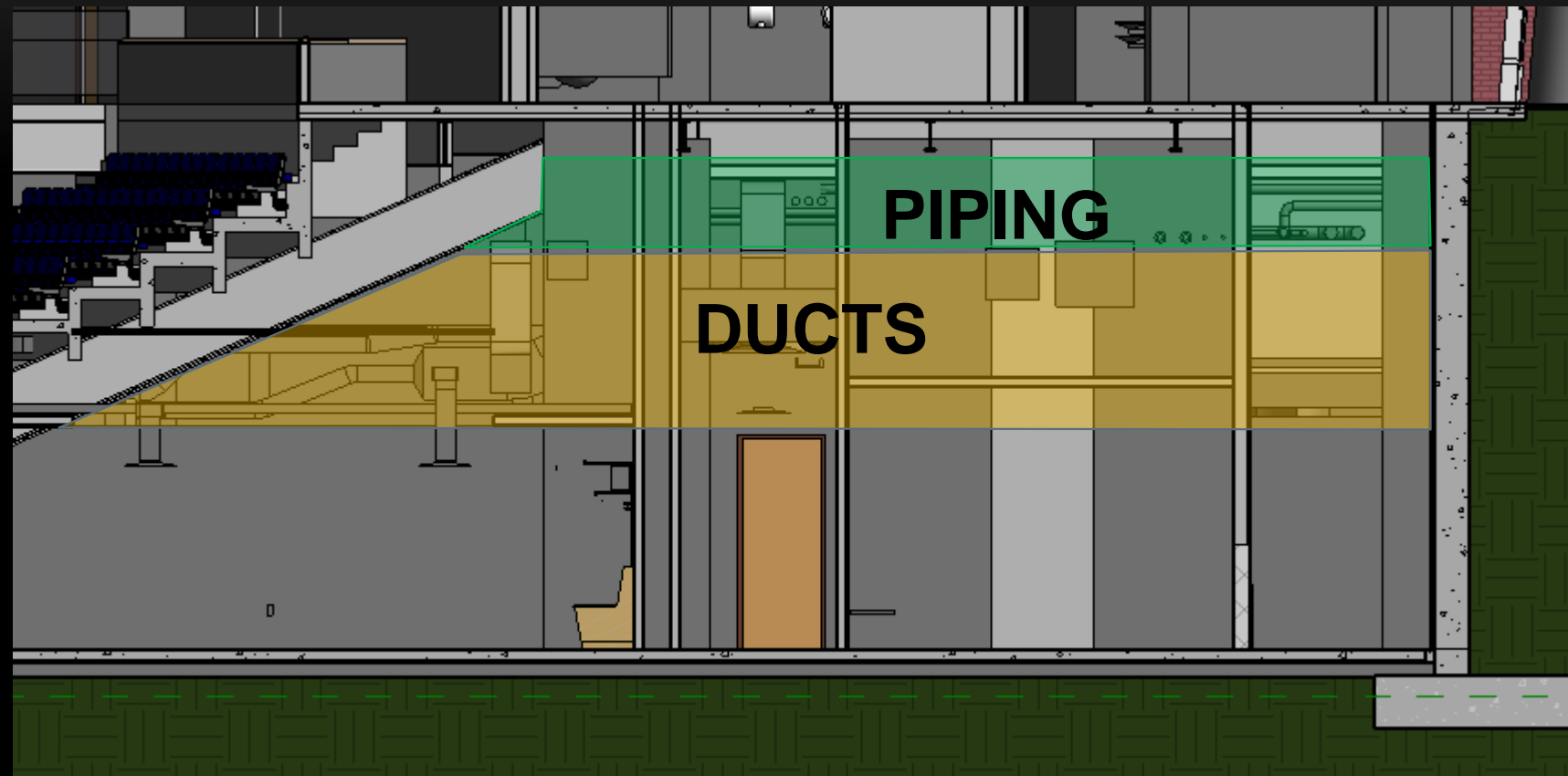




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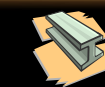
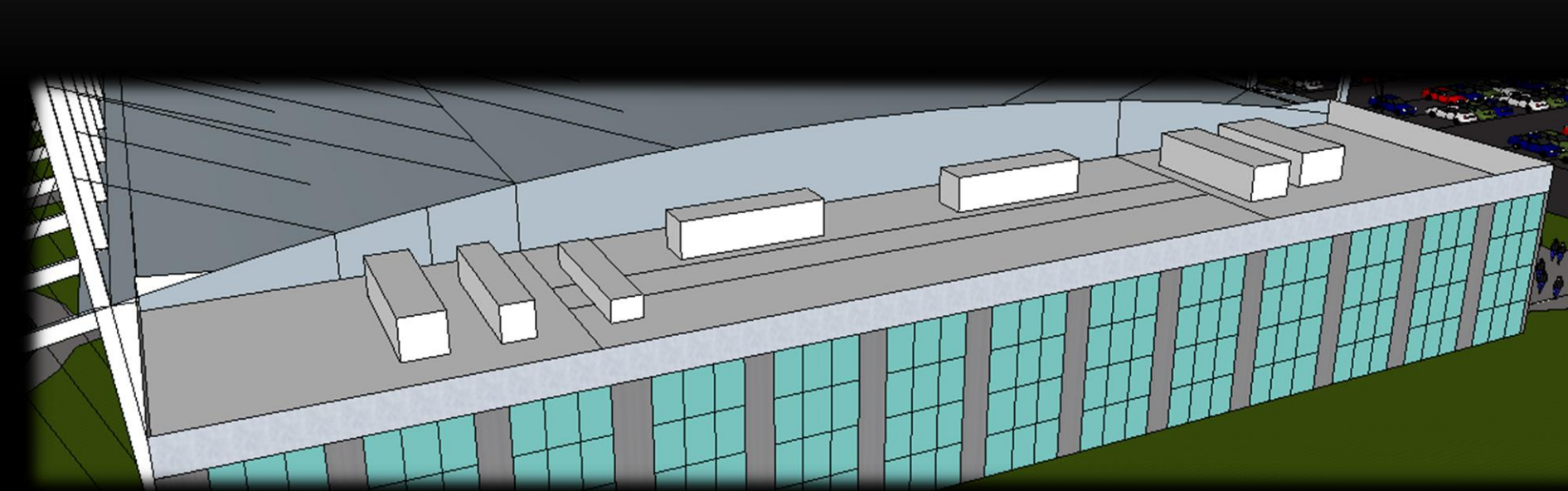
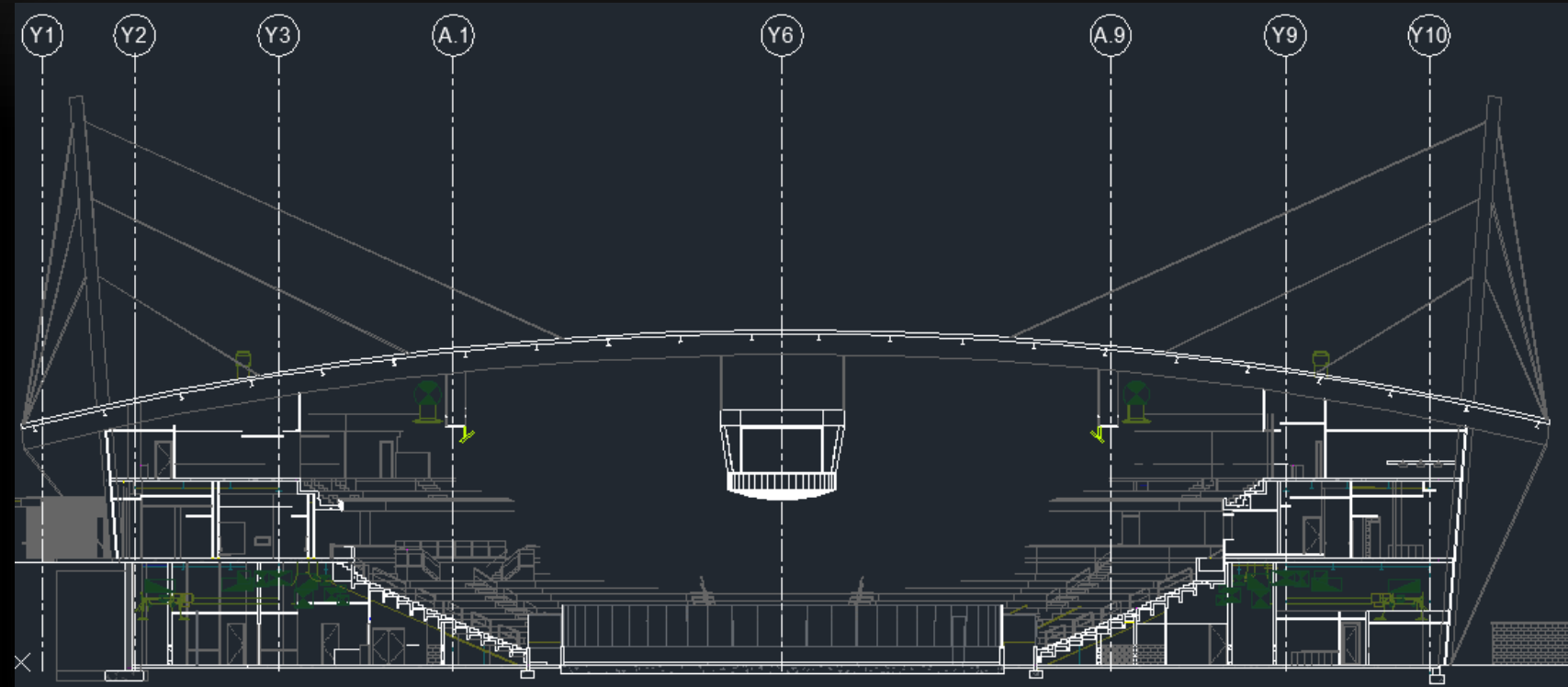






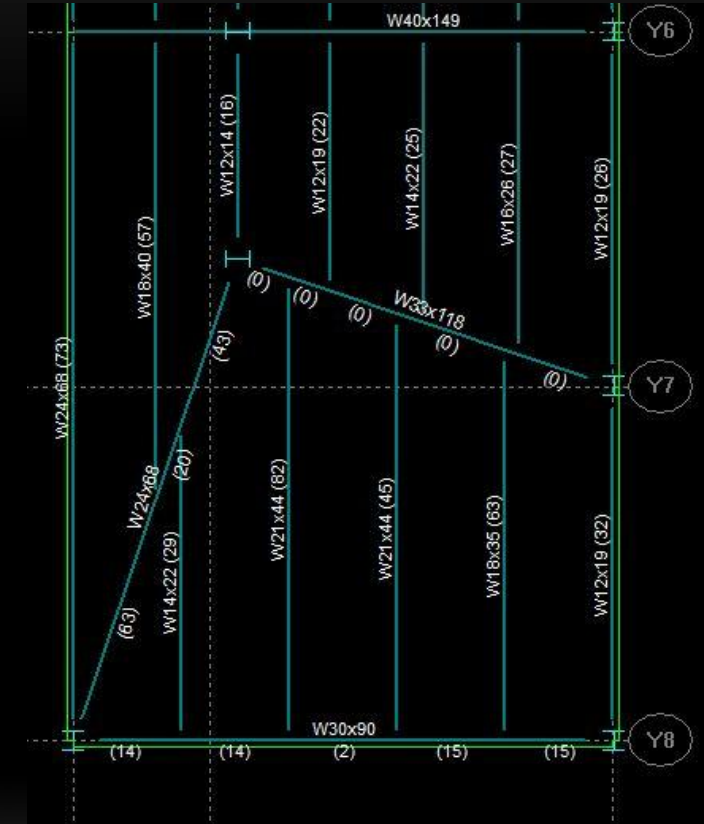
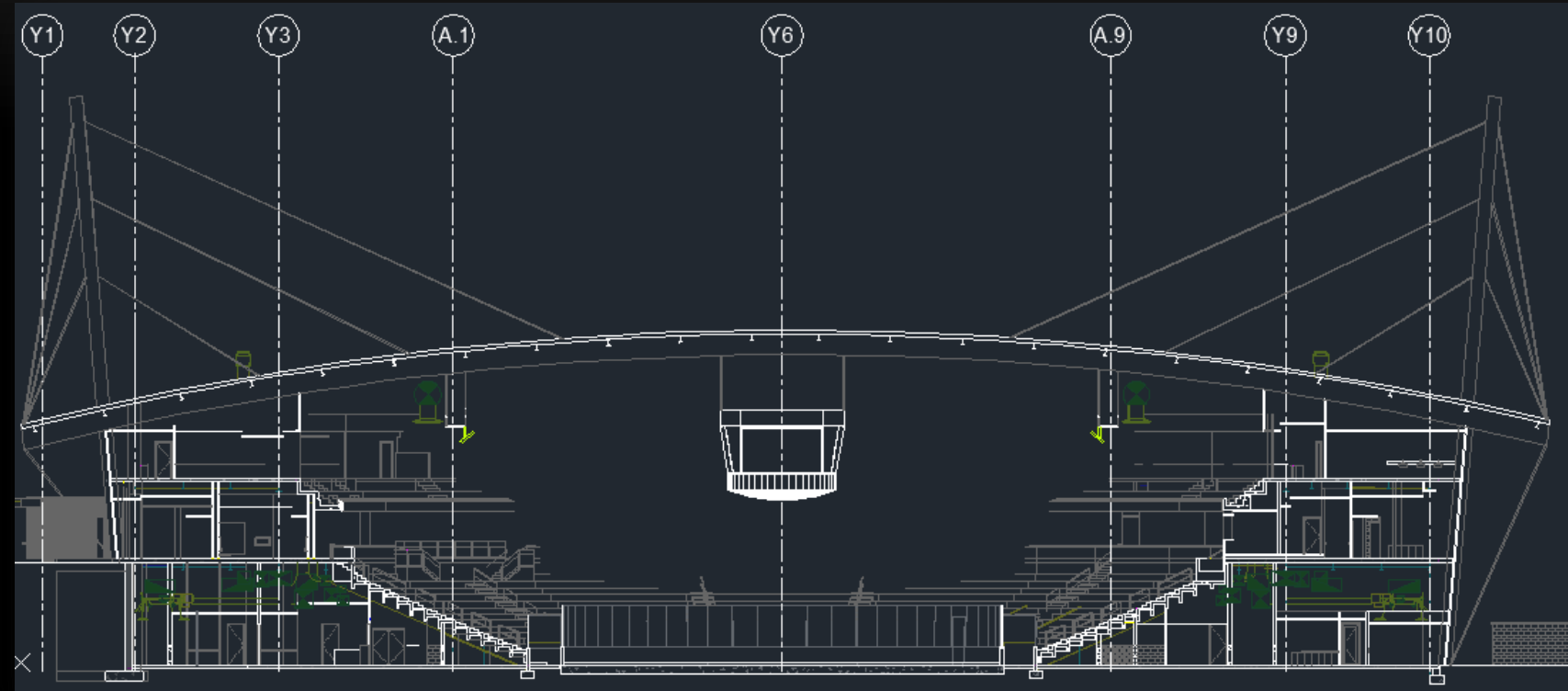


# MECHANICAL LOFT DESIGN



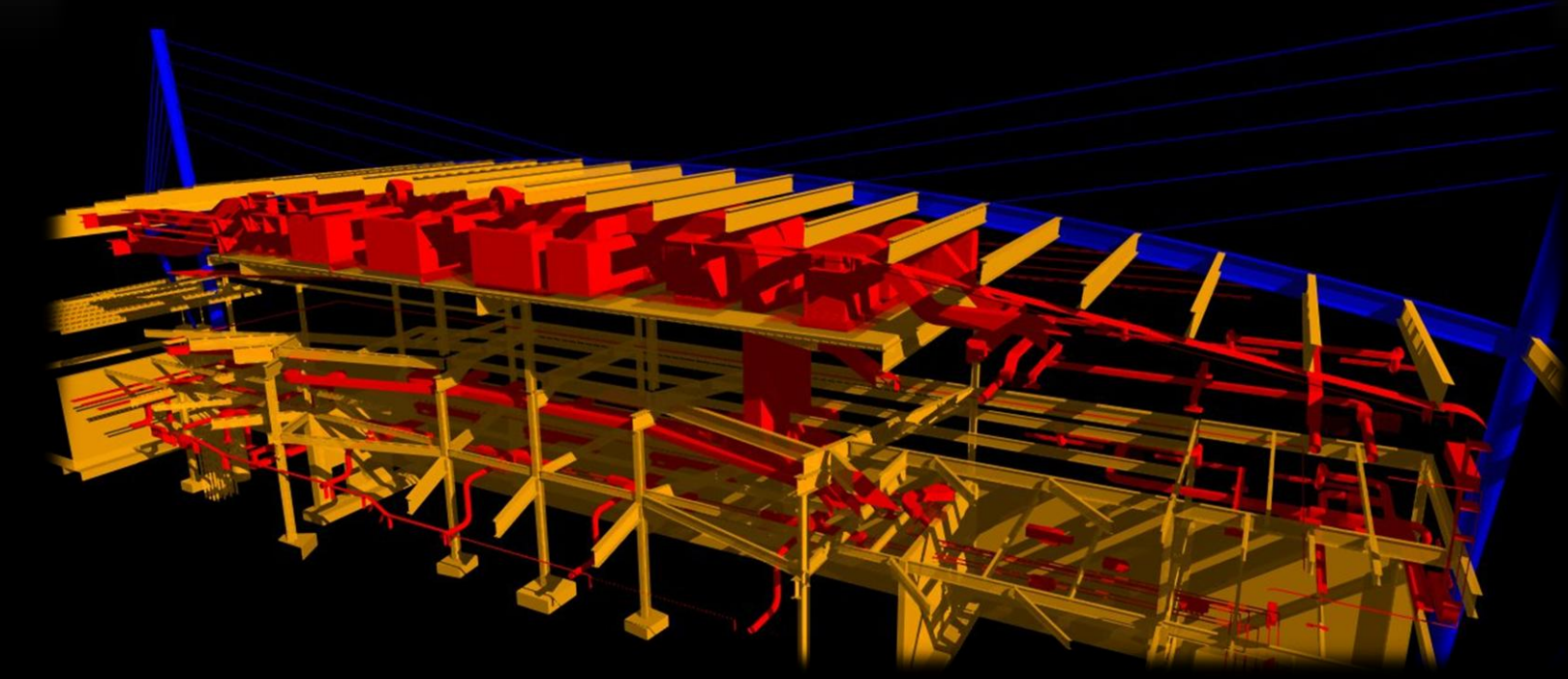
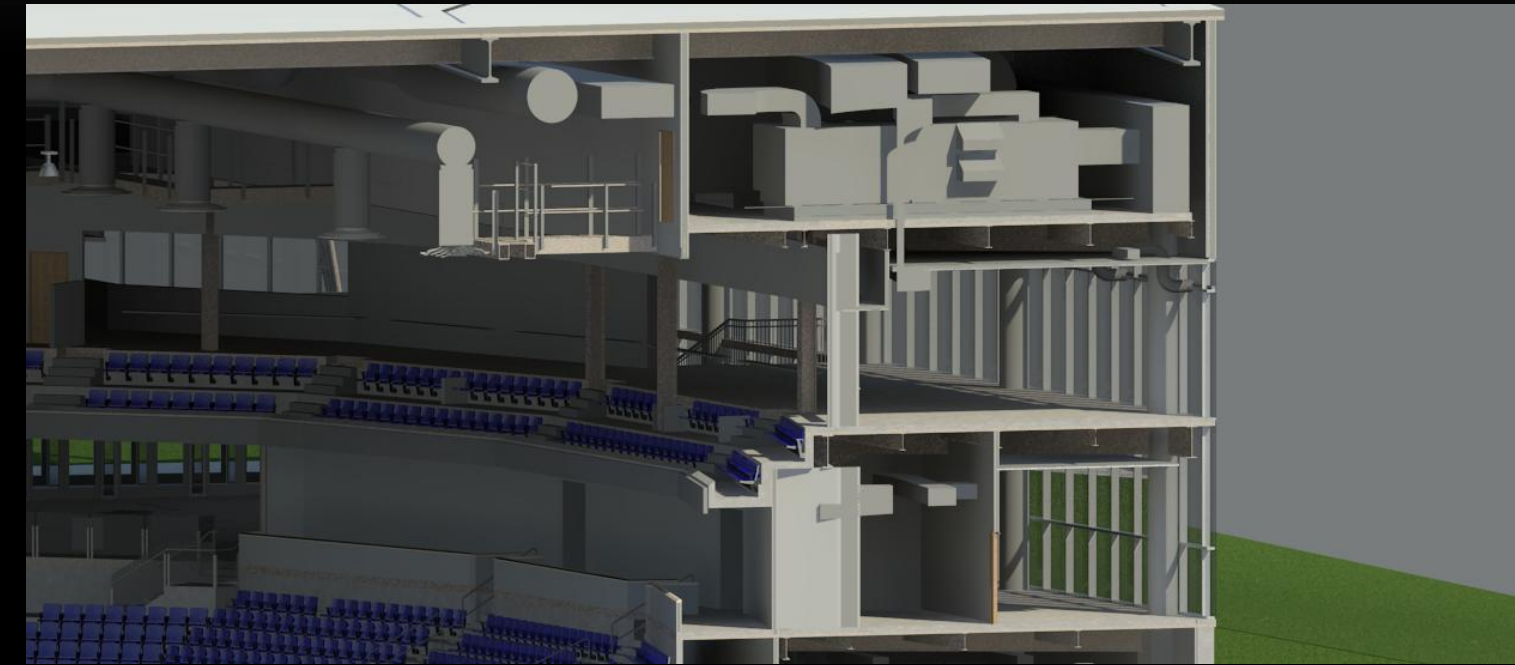
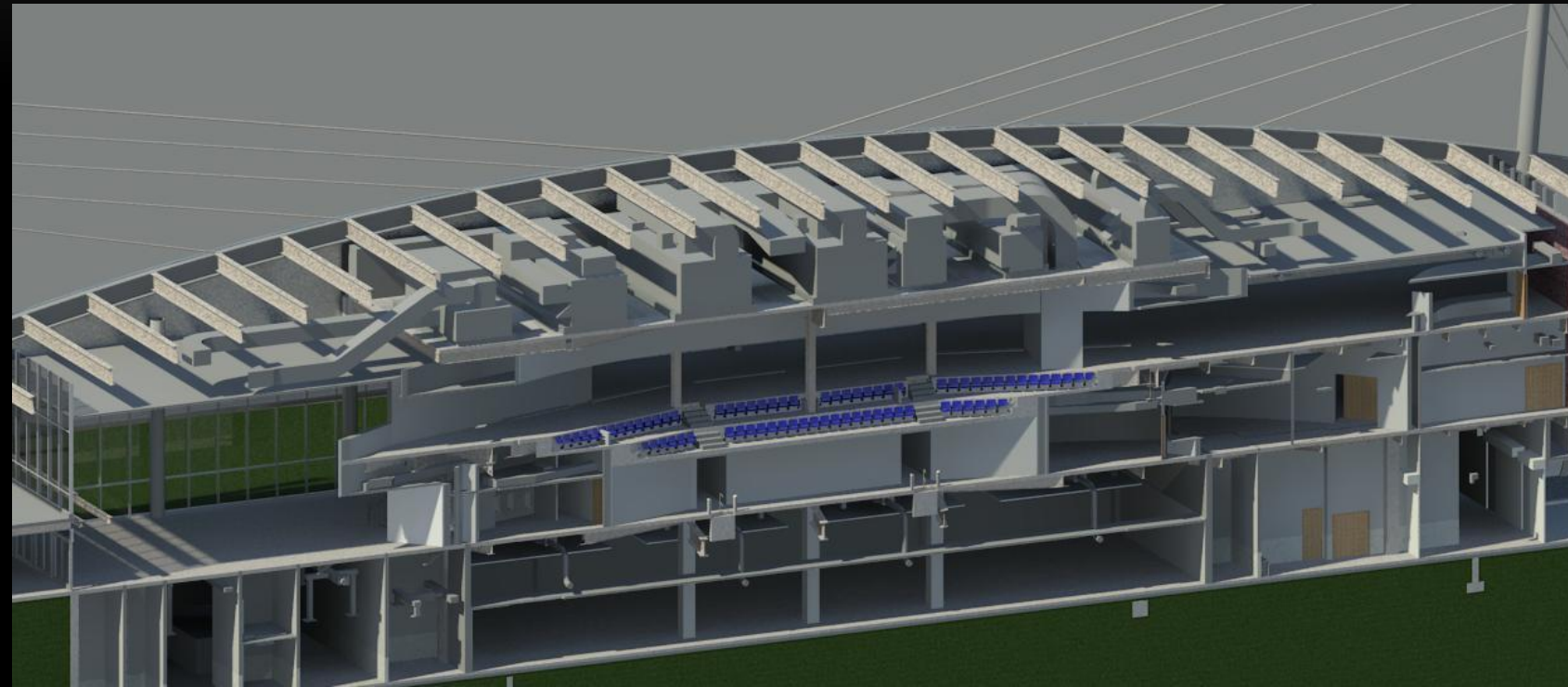


# MECHANICAL LOFT DESIGN



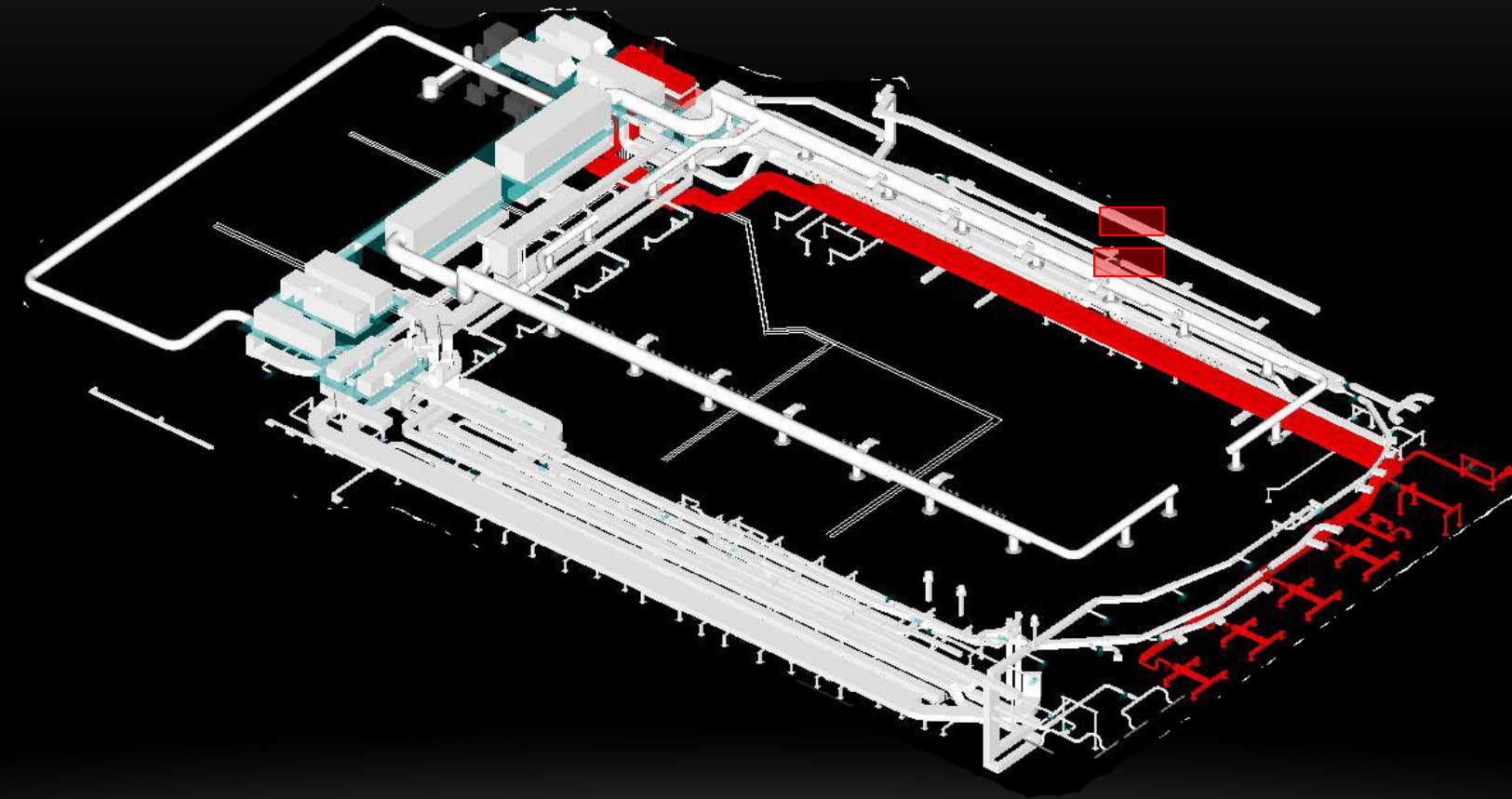
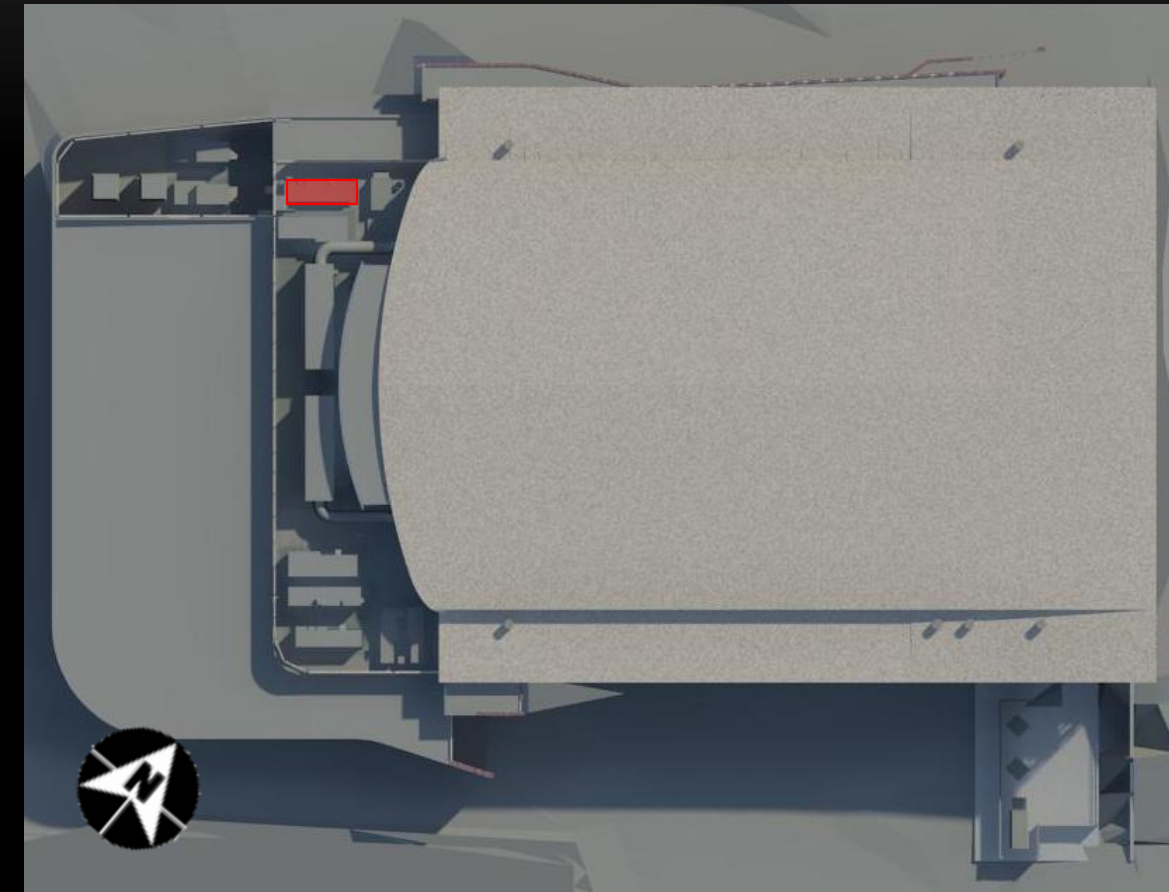


# MECHANICAL LOFT DESIGN



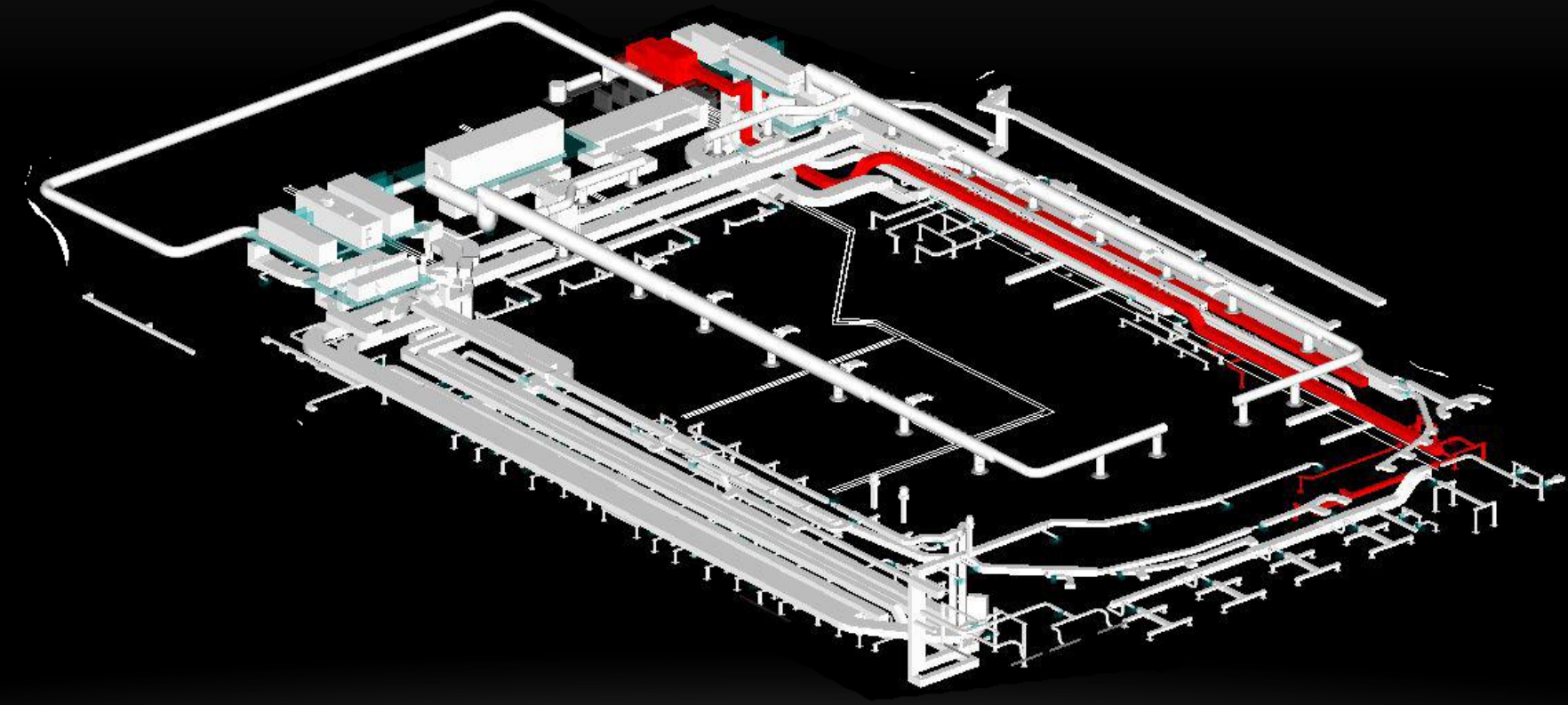
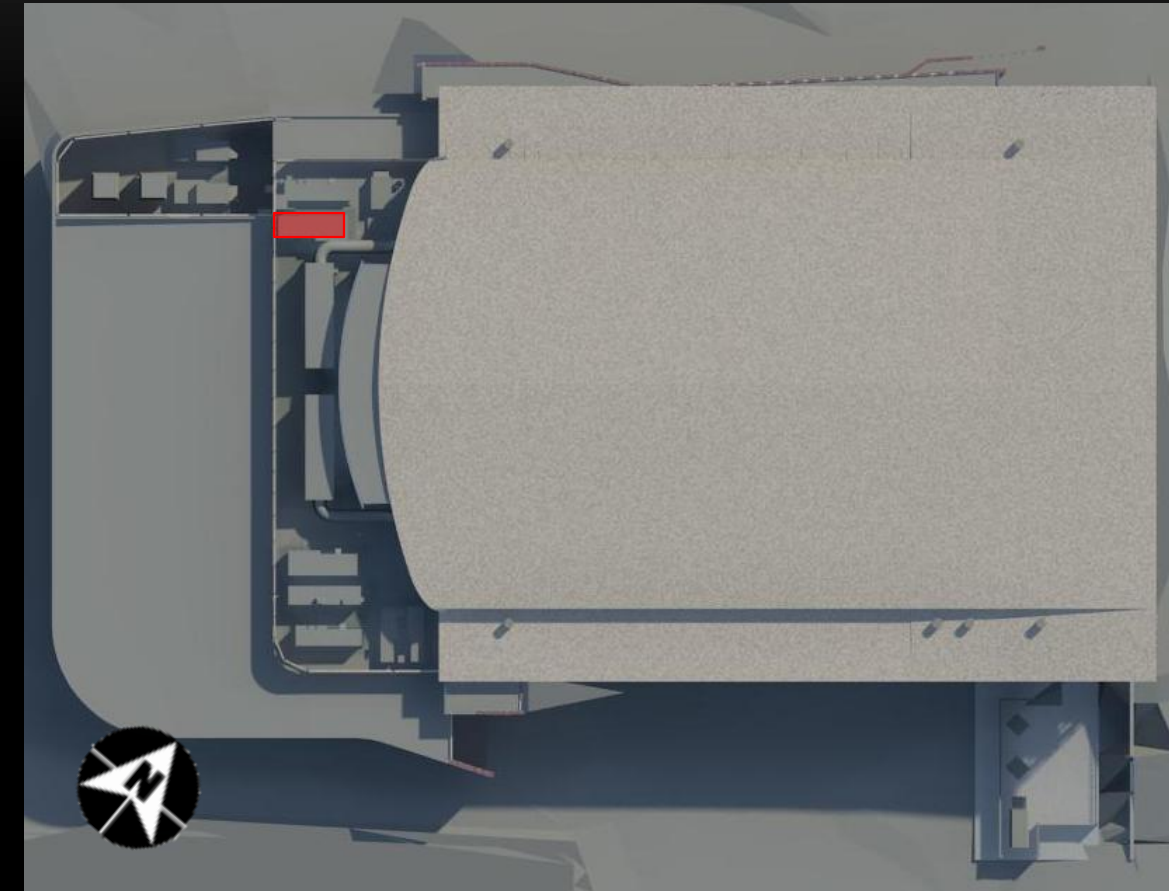


## AHU-6 AND AHU-7



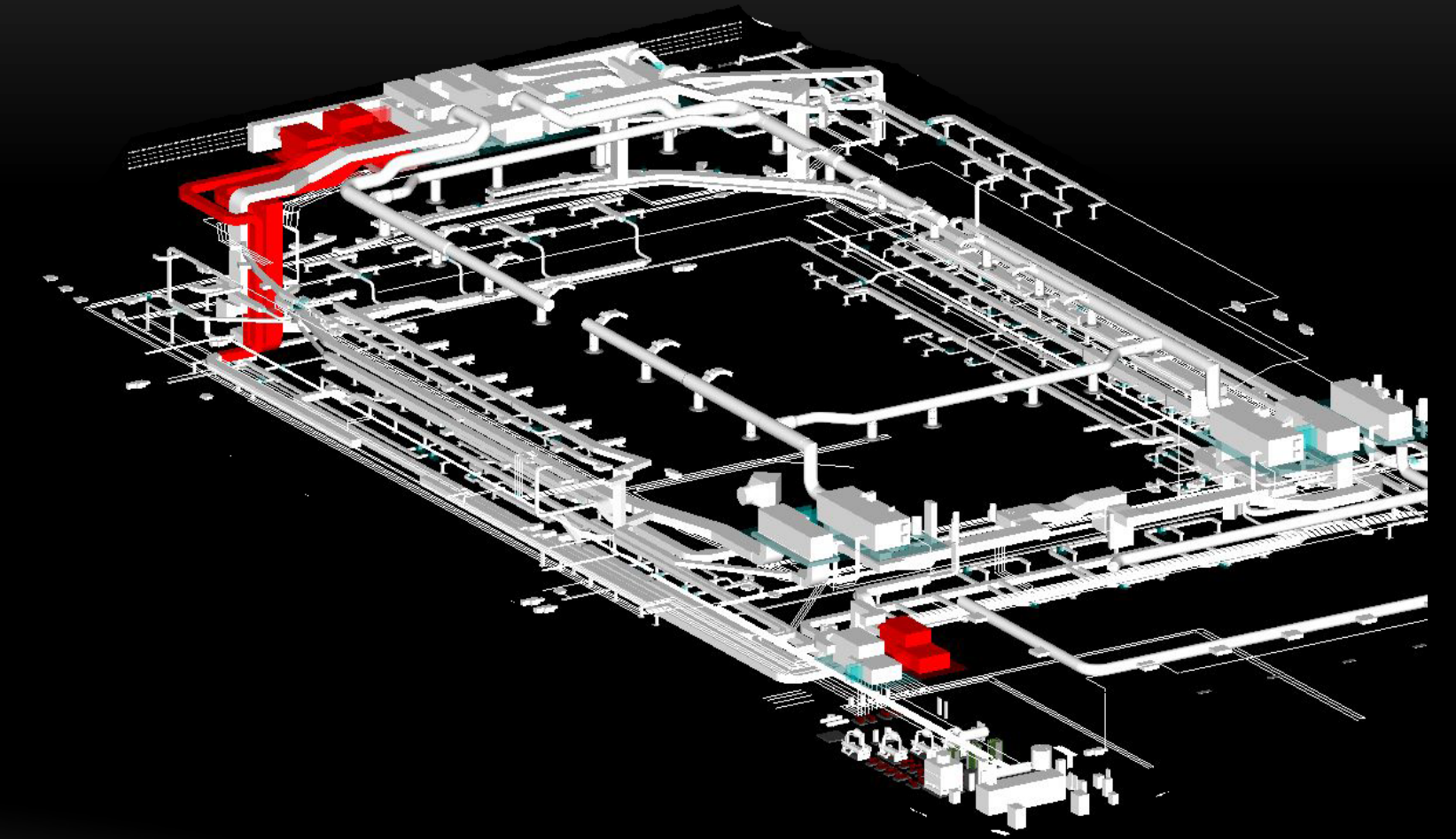
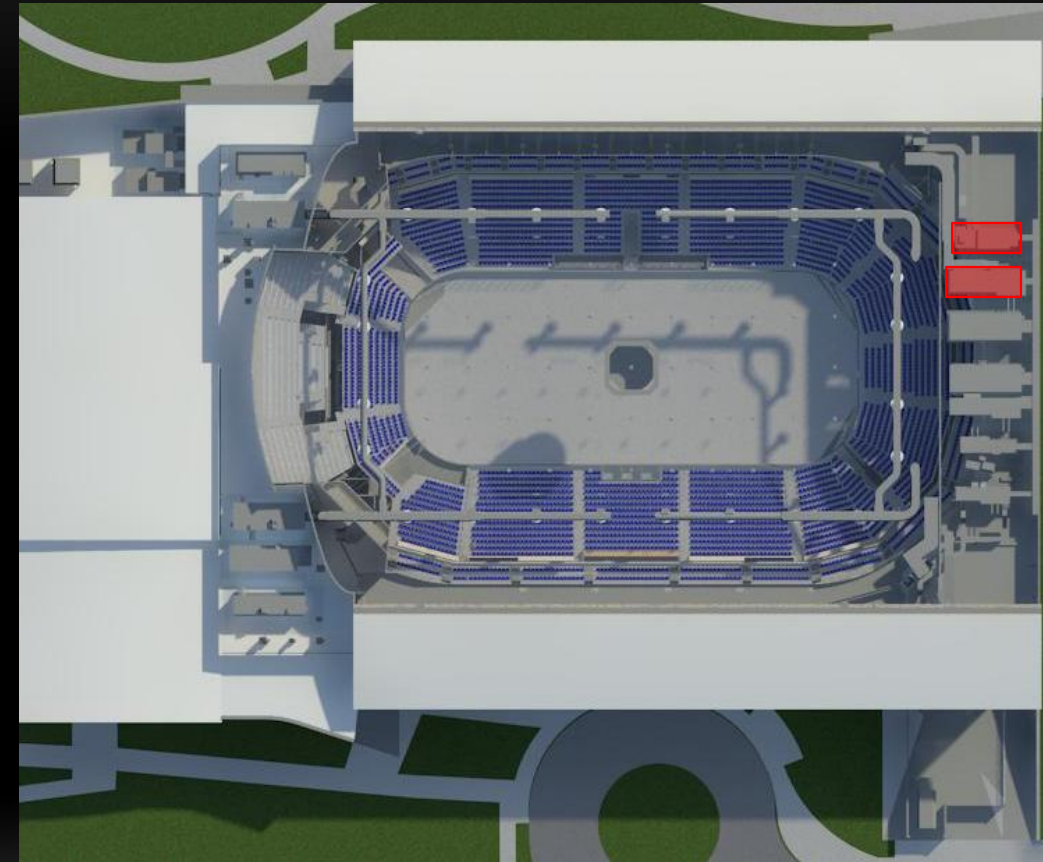
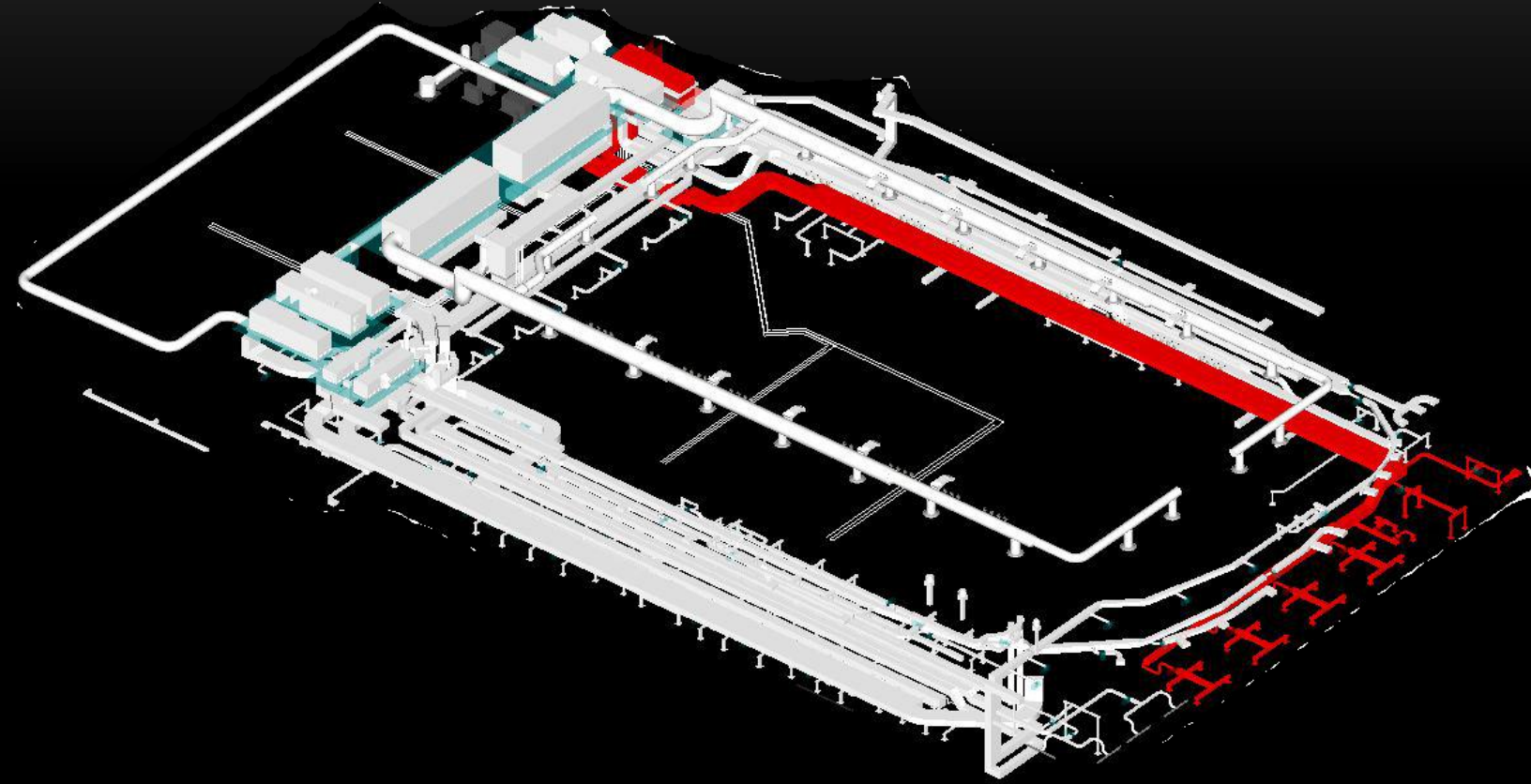


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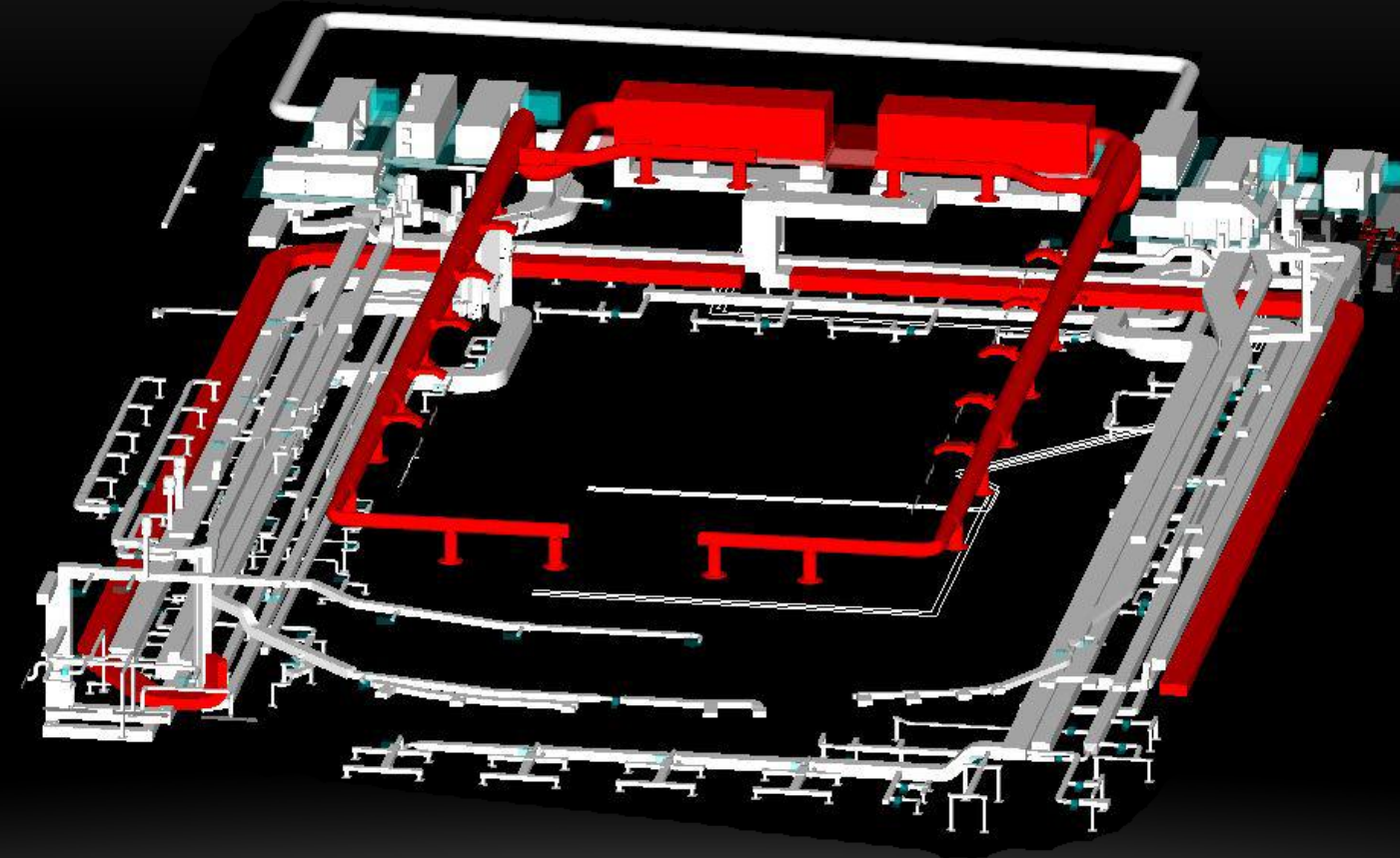
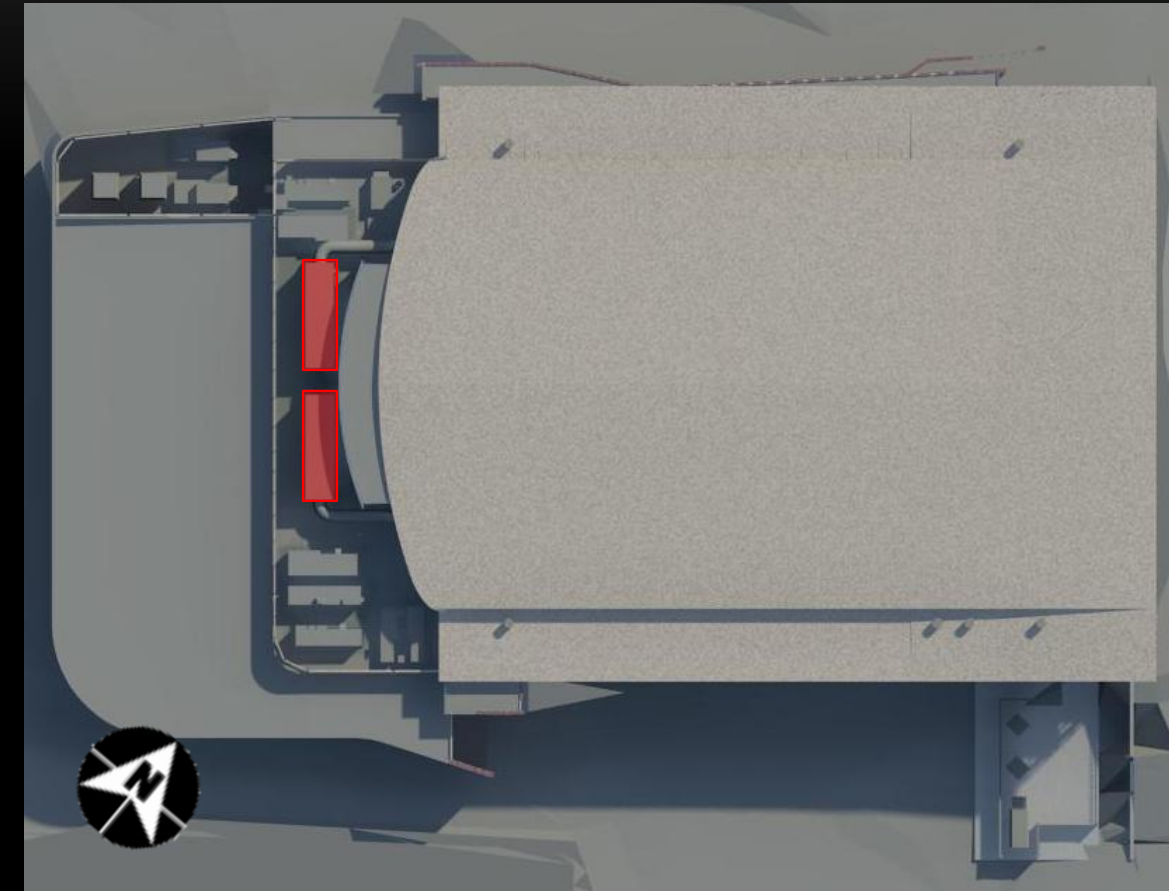


## AHU-6 AND AHU-7



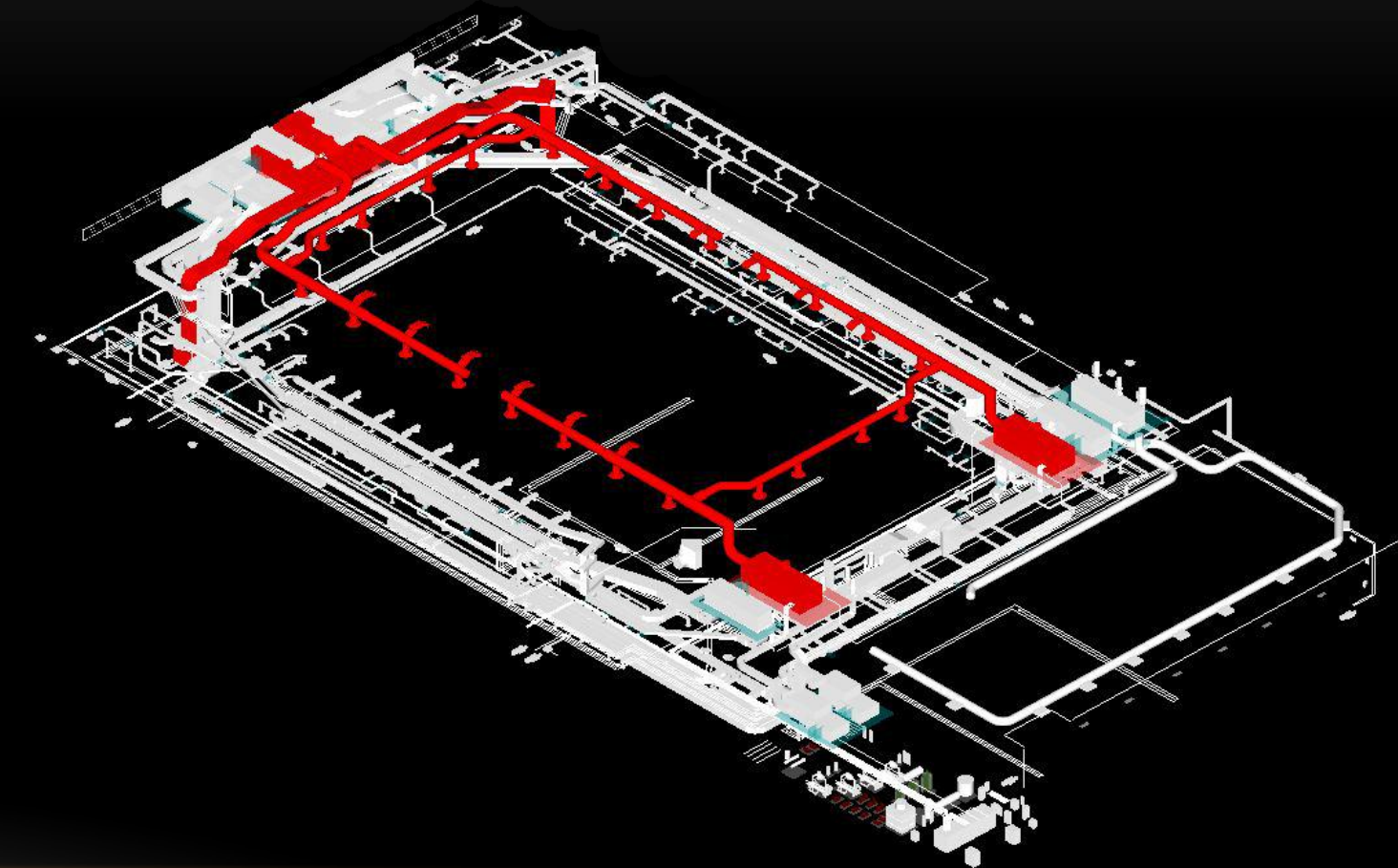
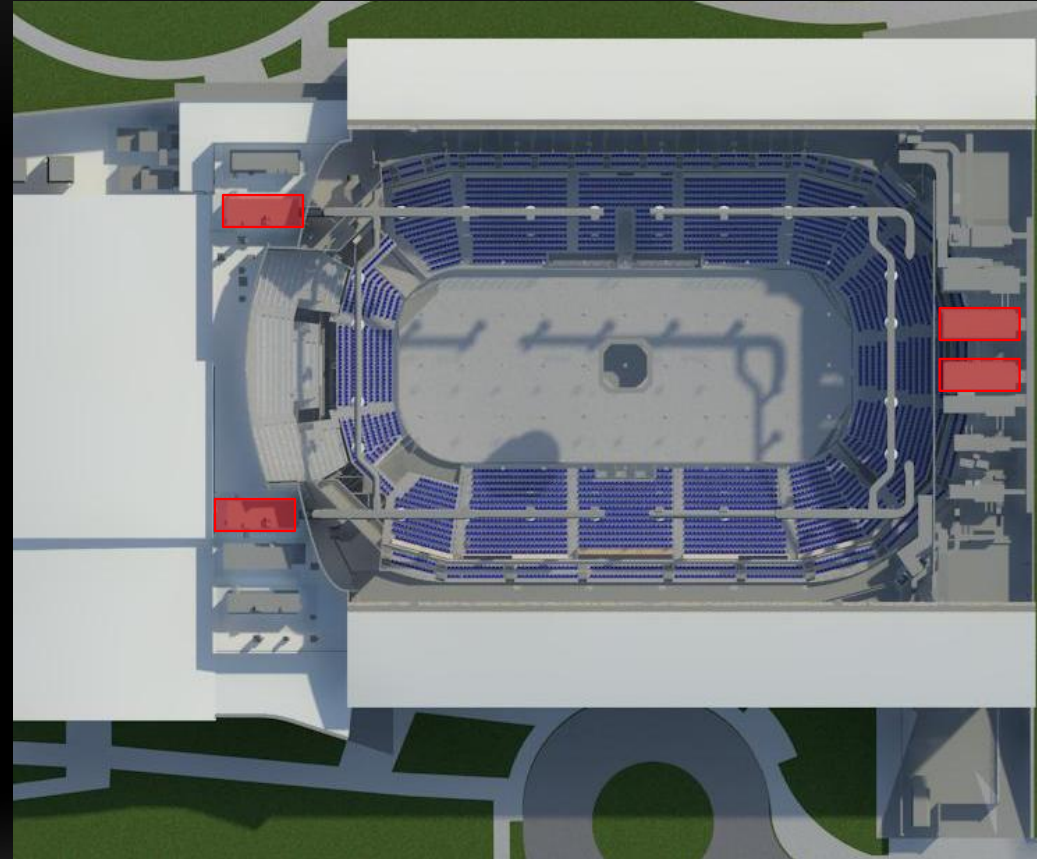
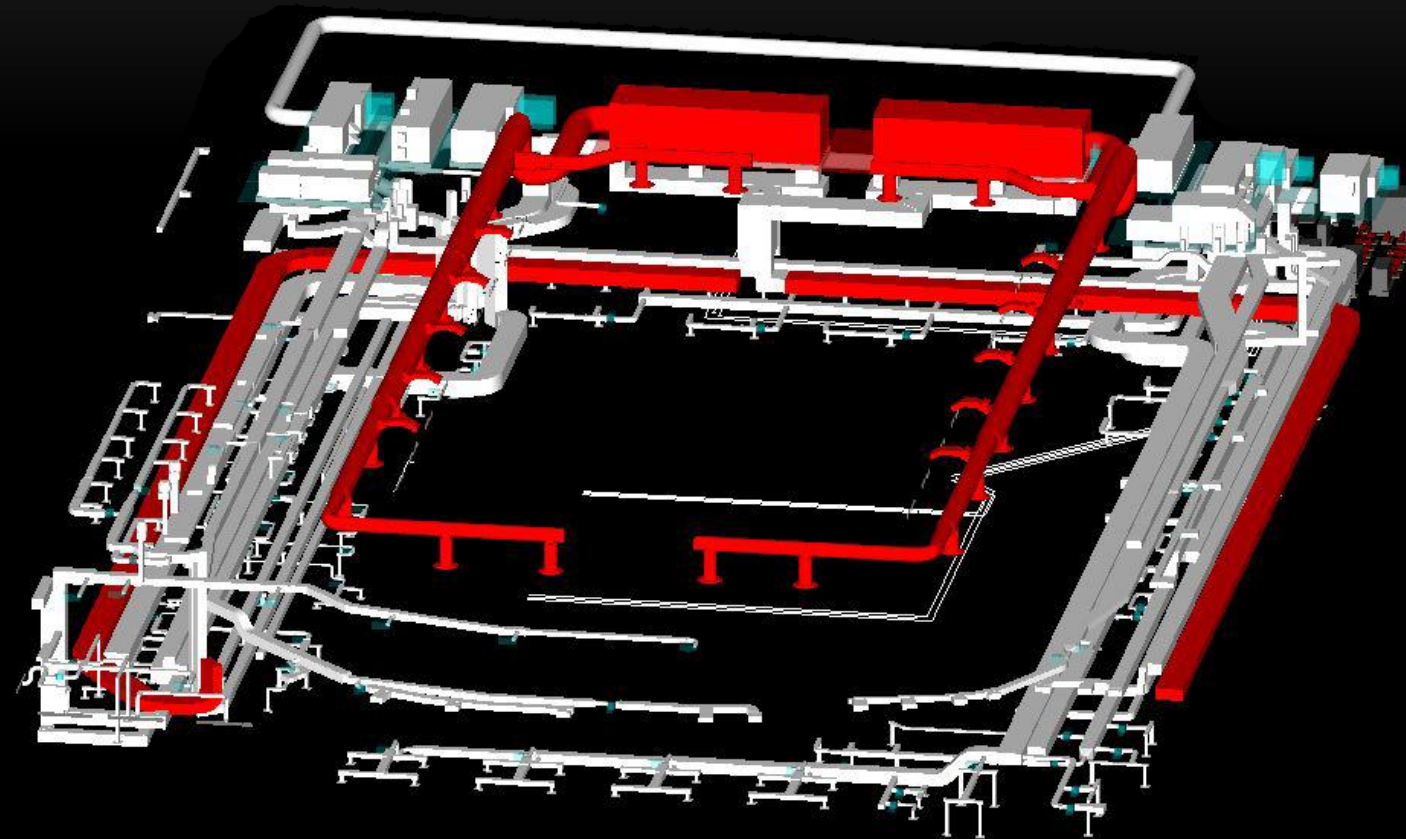


## AHU-MAIN BOWL



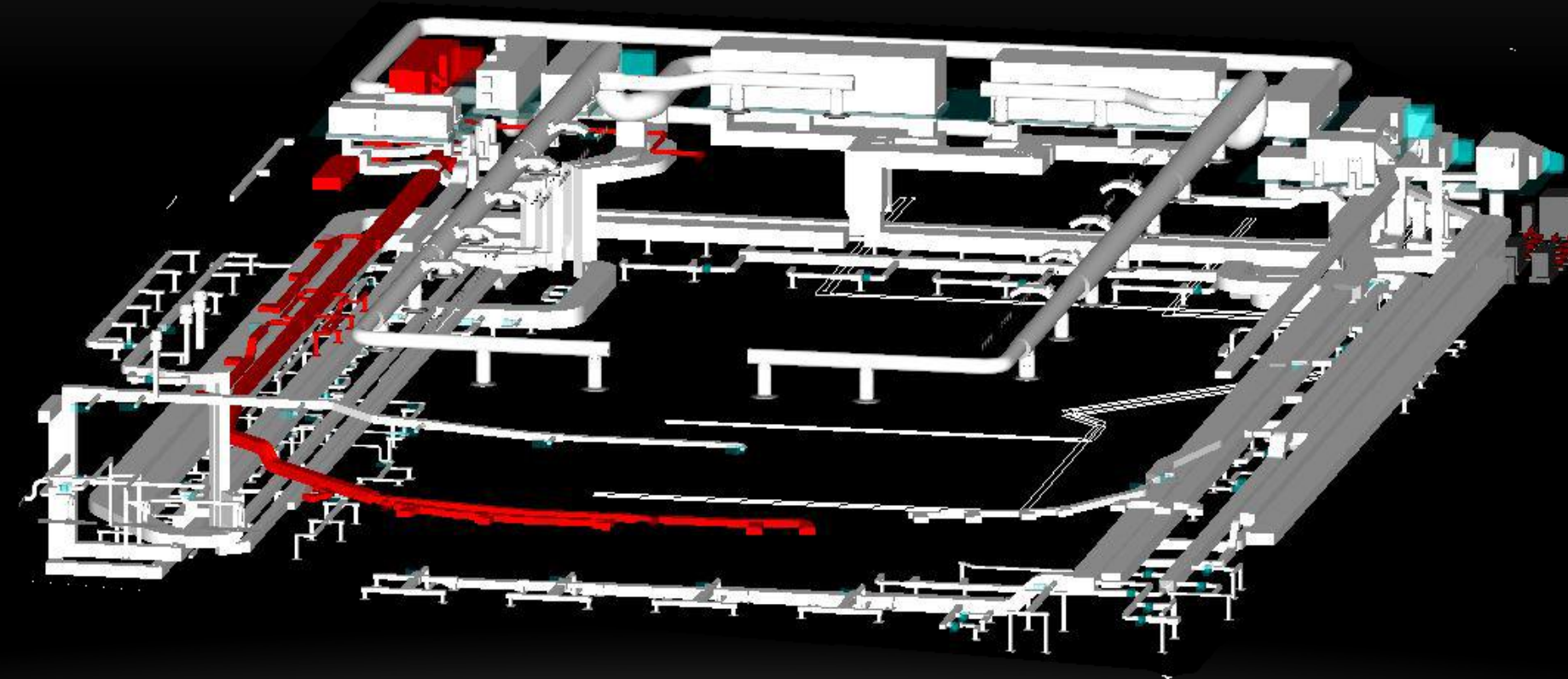


## AHU-MAIN BOWL



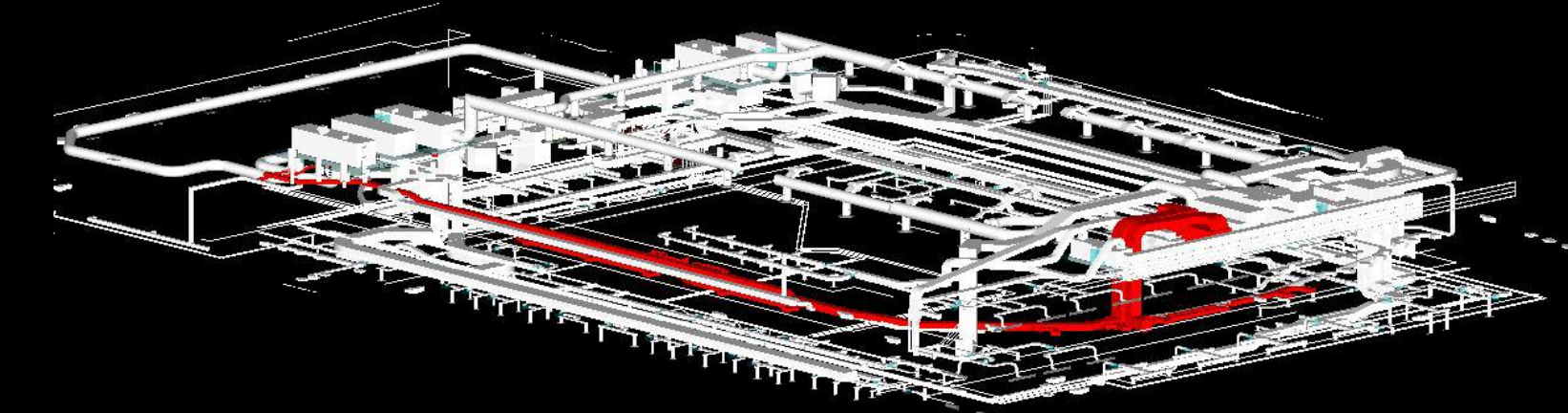
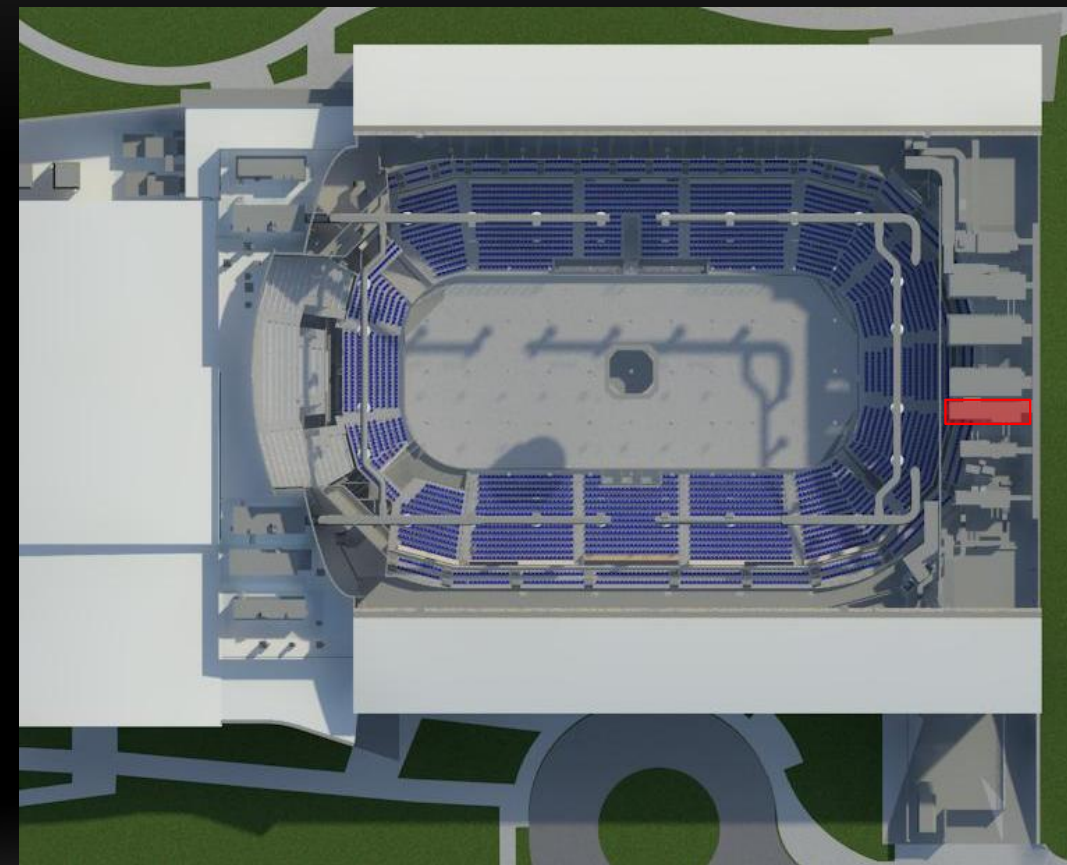
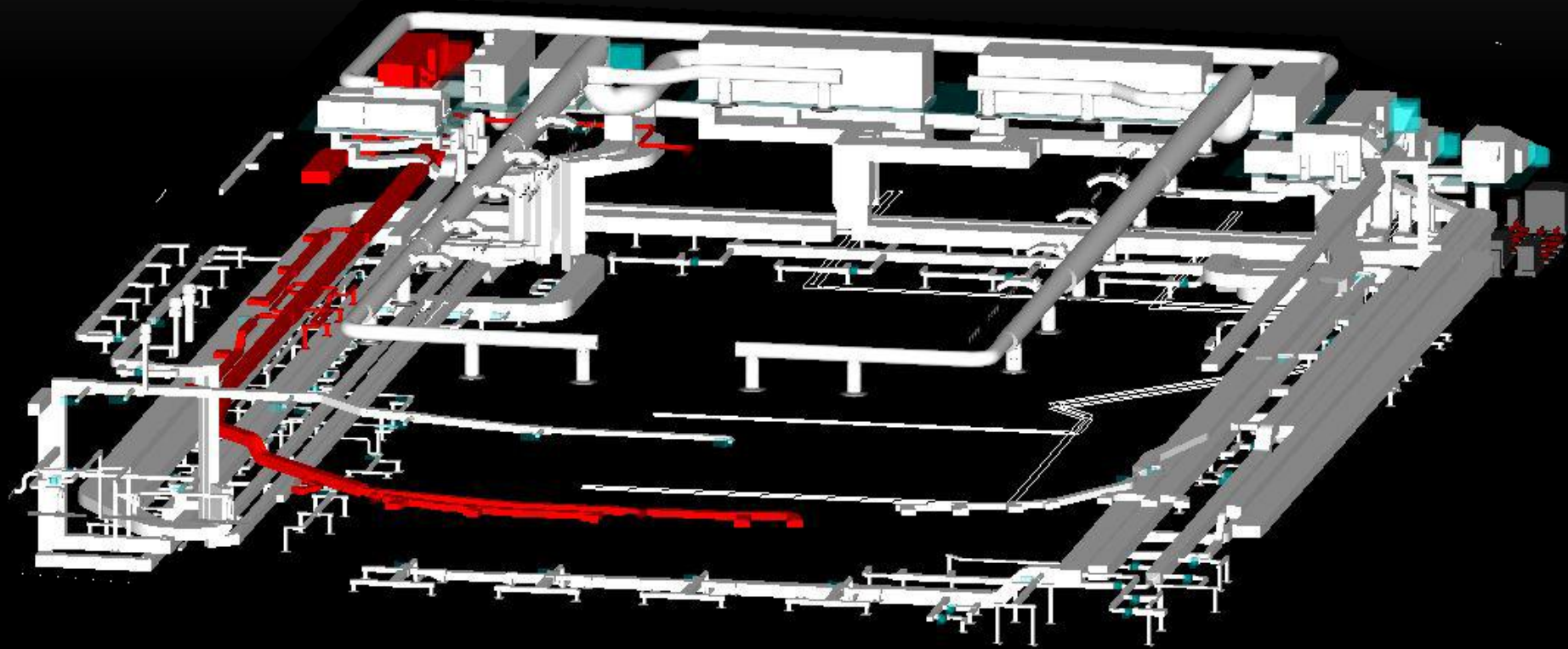


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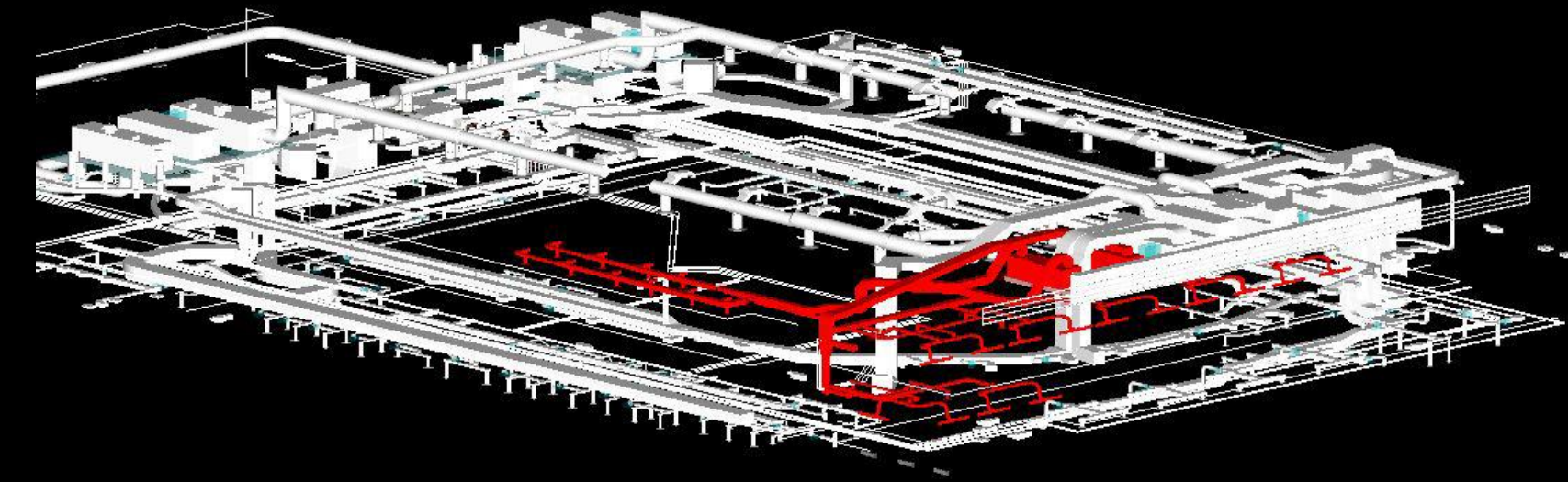
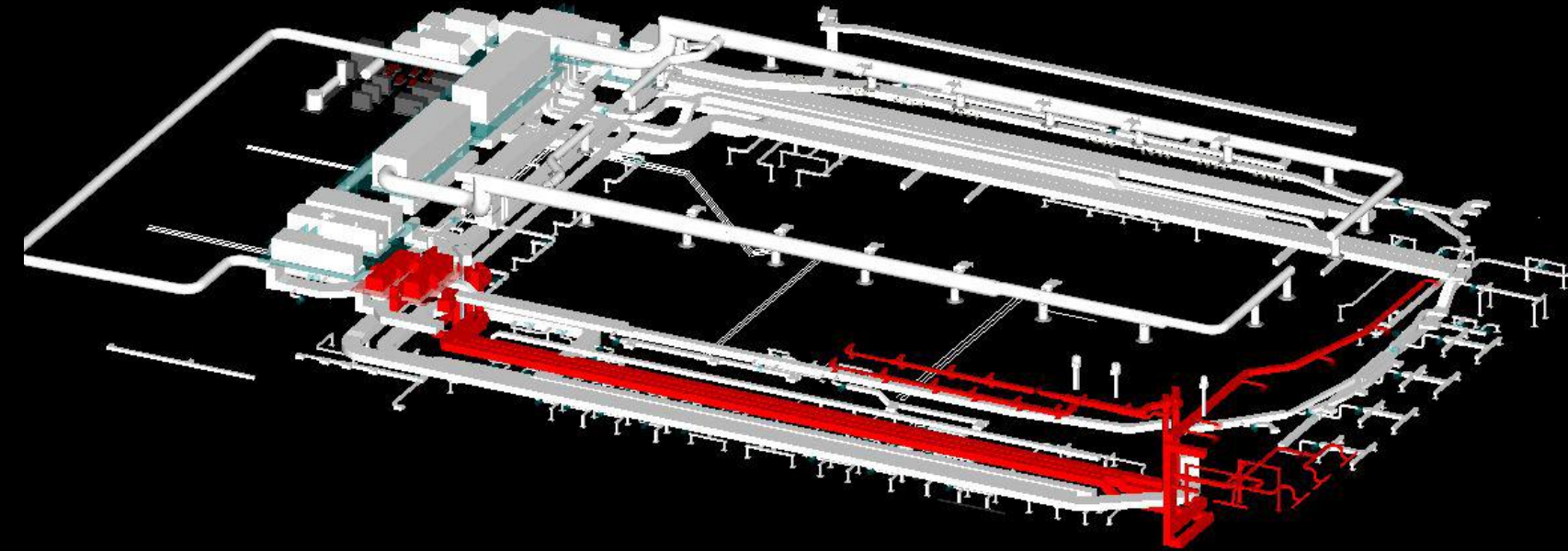


# AHU-4



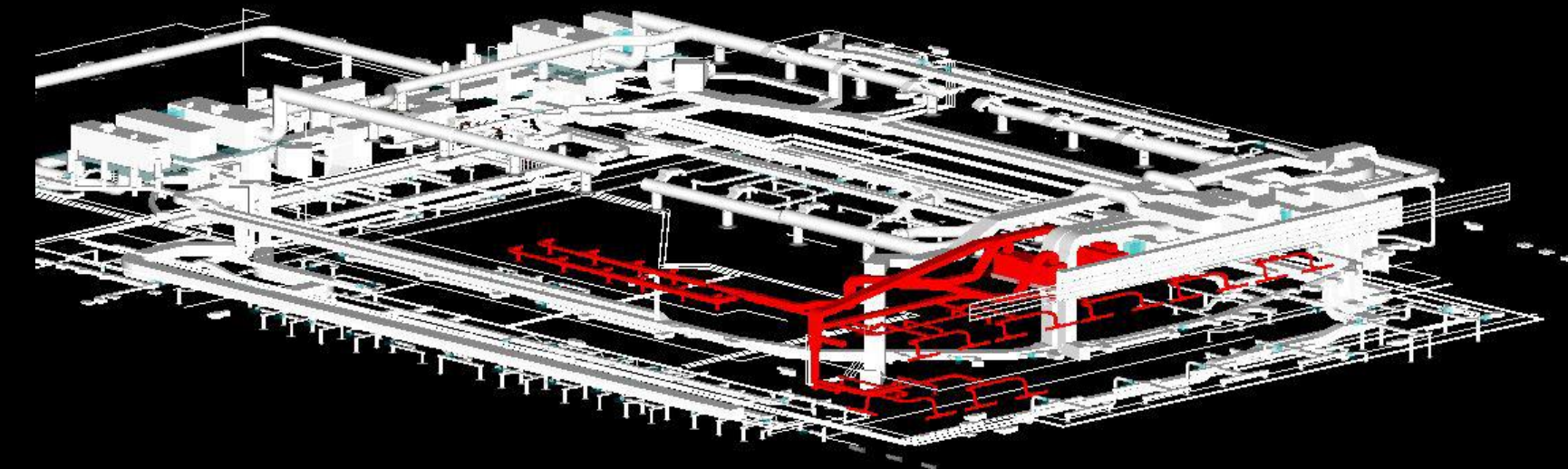
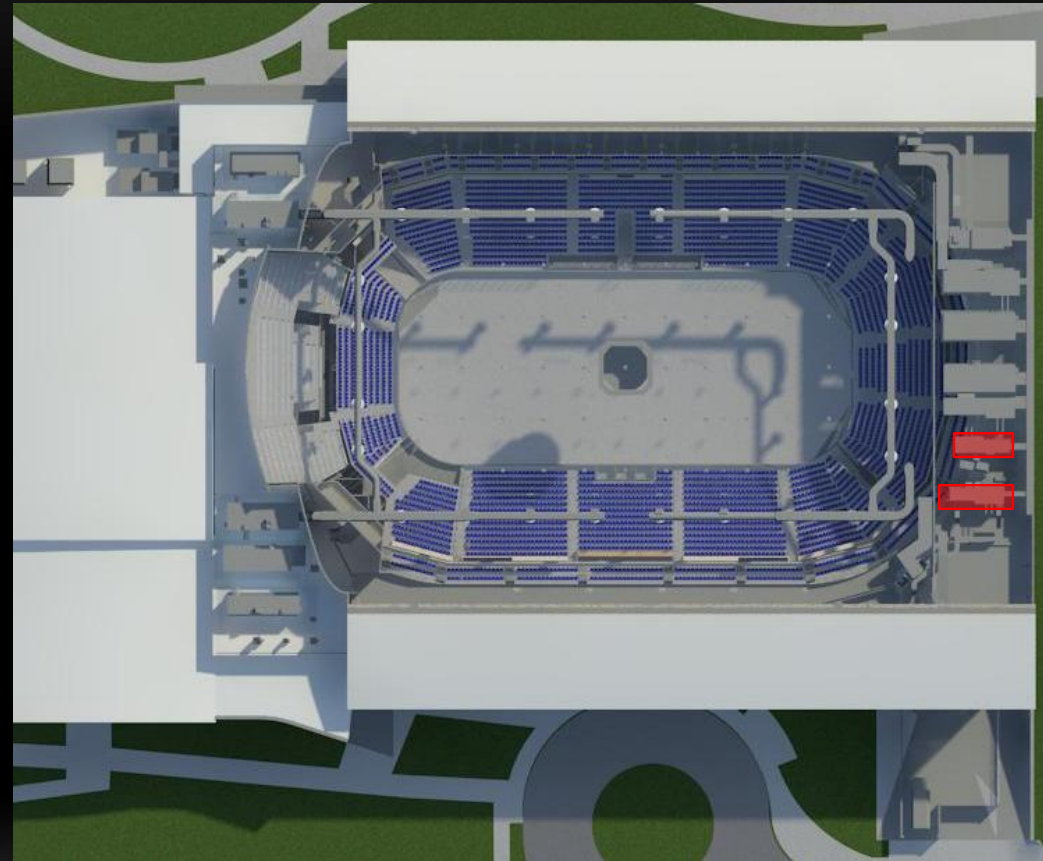
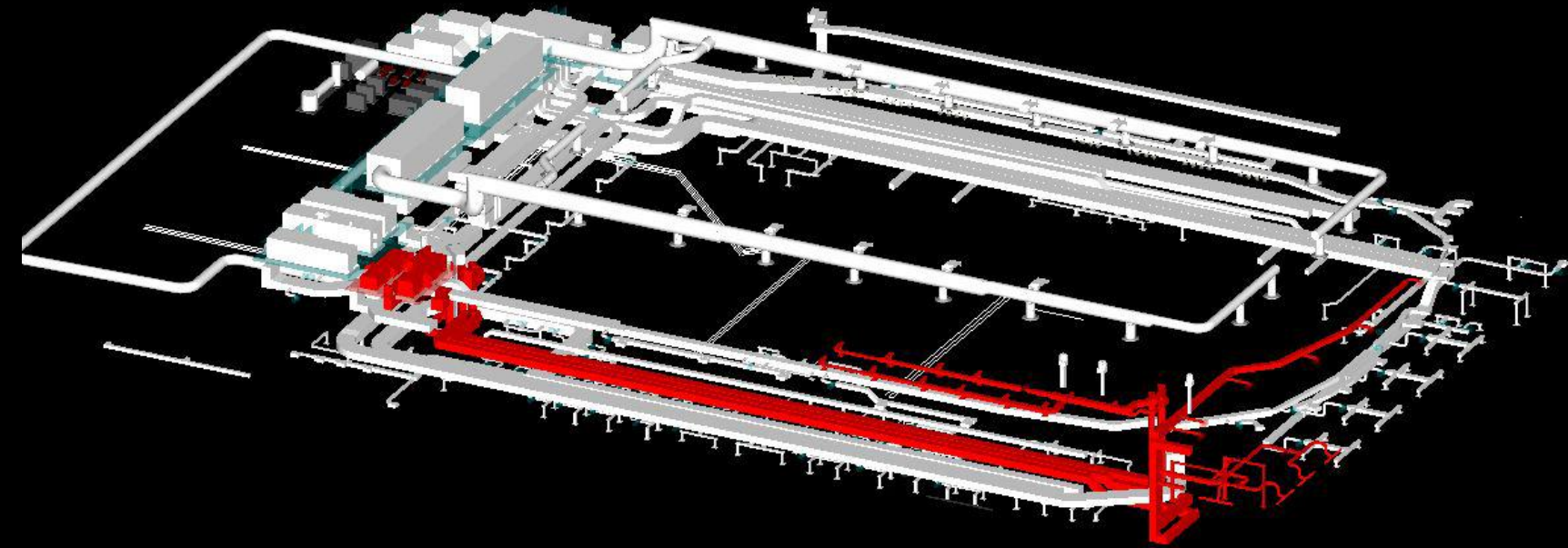


## AHU-1 AND AHU-2



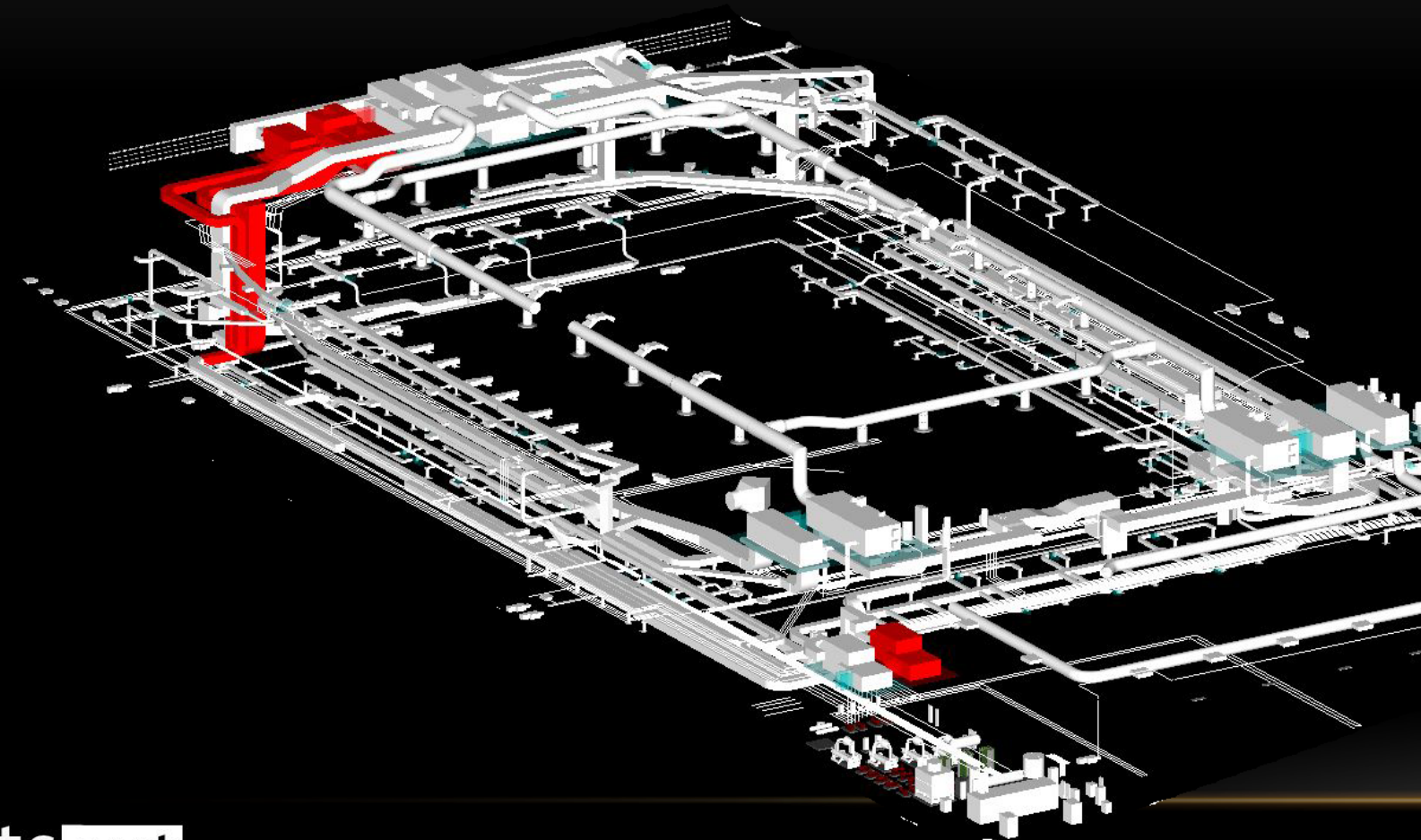


## AHU-1 AND AHU-2

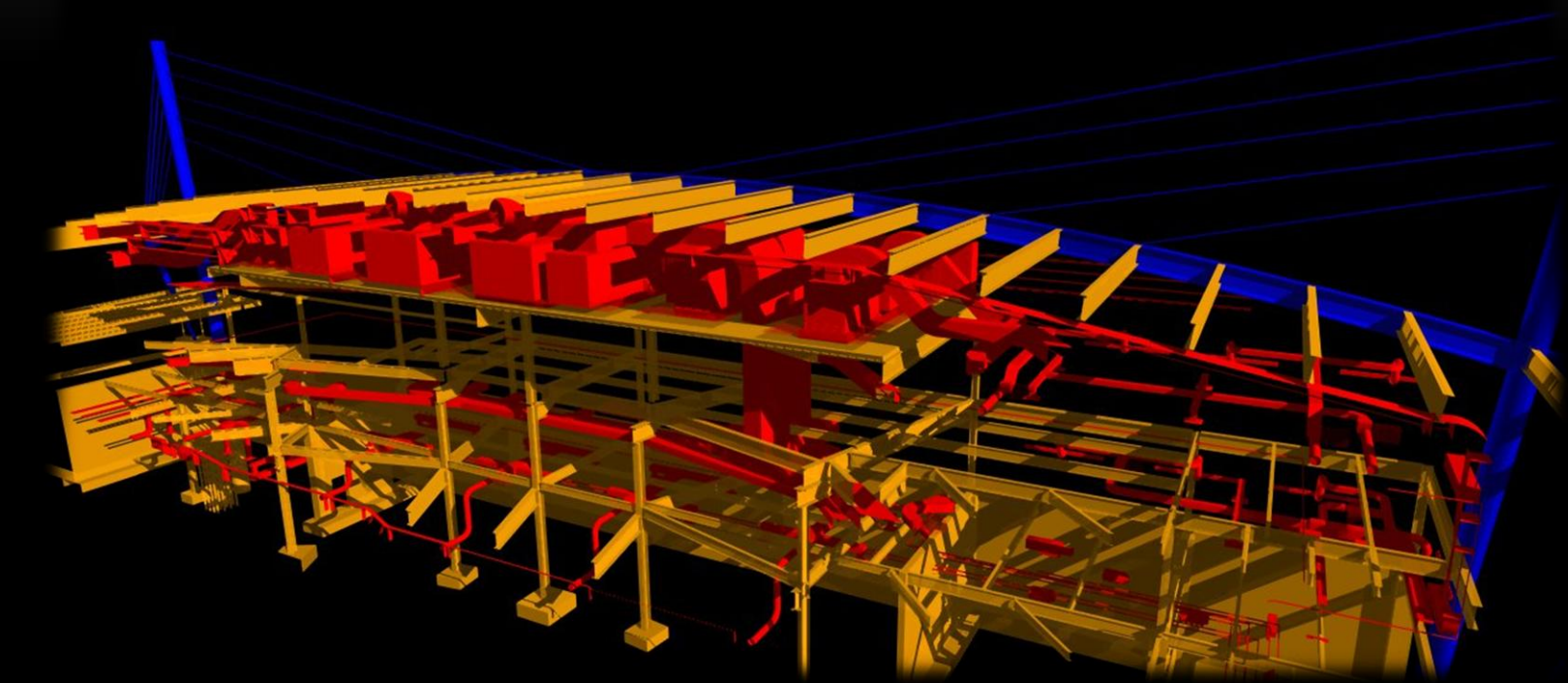




## DUCTWORK SAVINGS

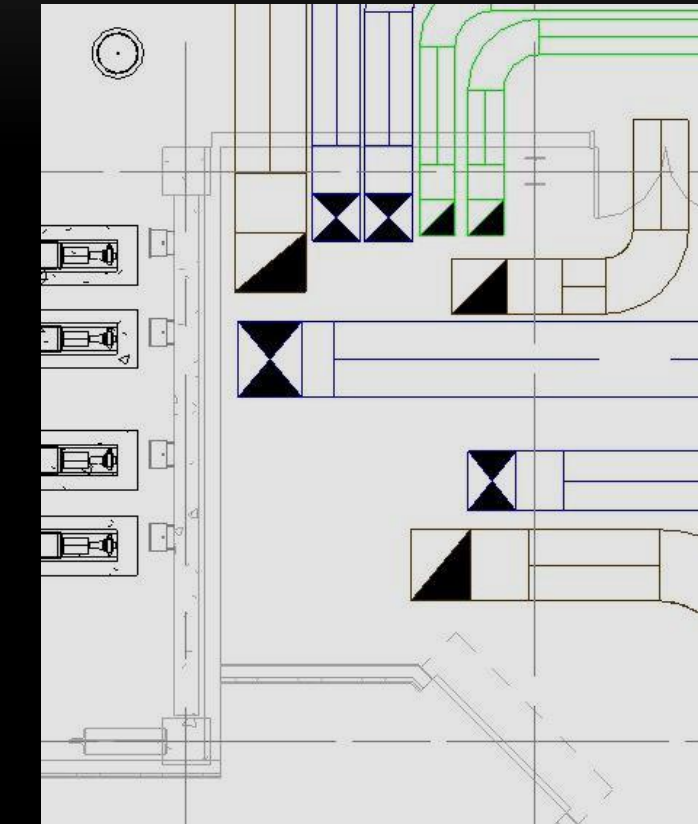
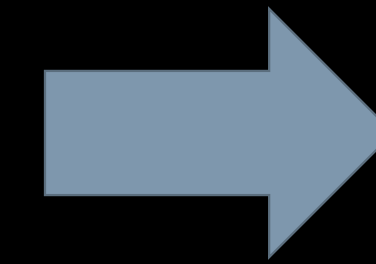
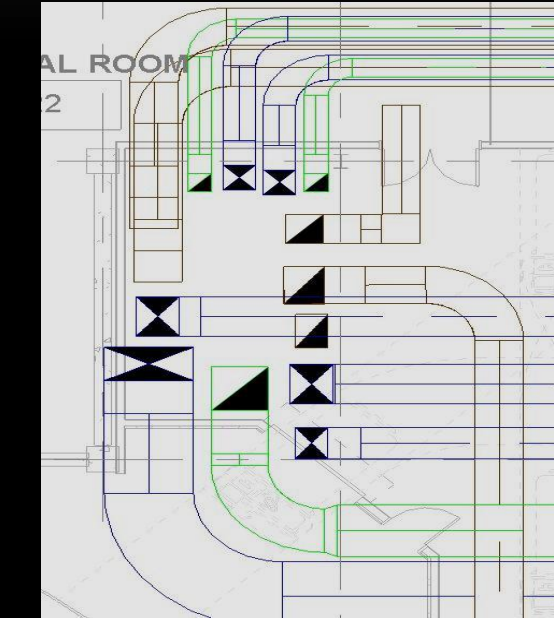
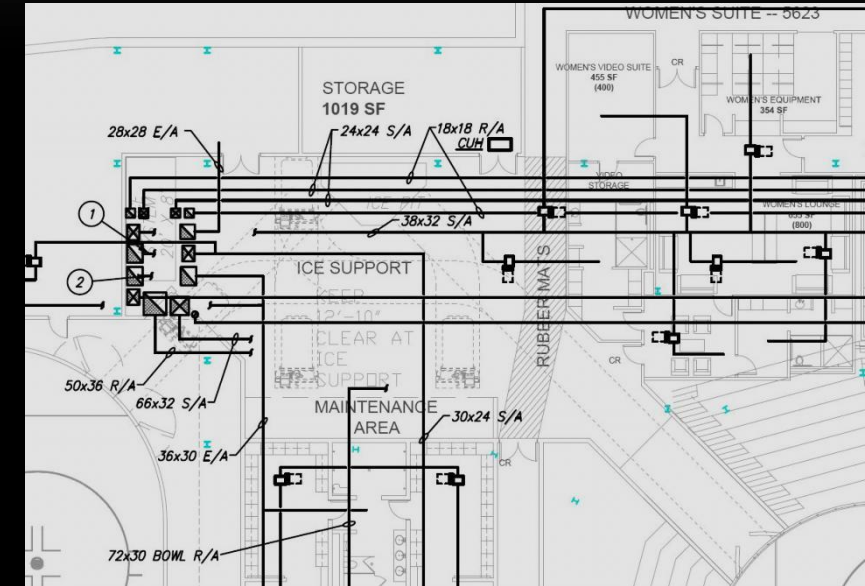


Existing vs Redesign Ductwork Totals		
	Length	Cost
Total Existing Ductwork:	3546.88	\$1,853,464.96
Total Redesign Ductwork:	1301.67	\$870,818.29
Cost Difference:		<b>\$982,646.67</b>



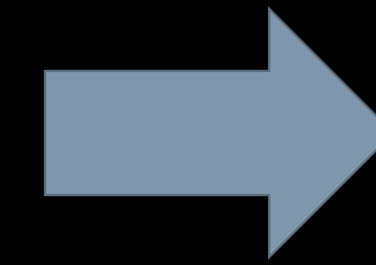
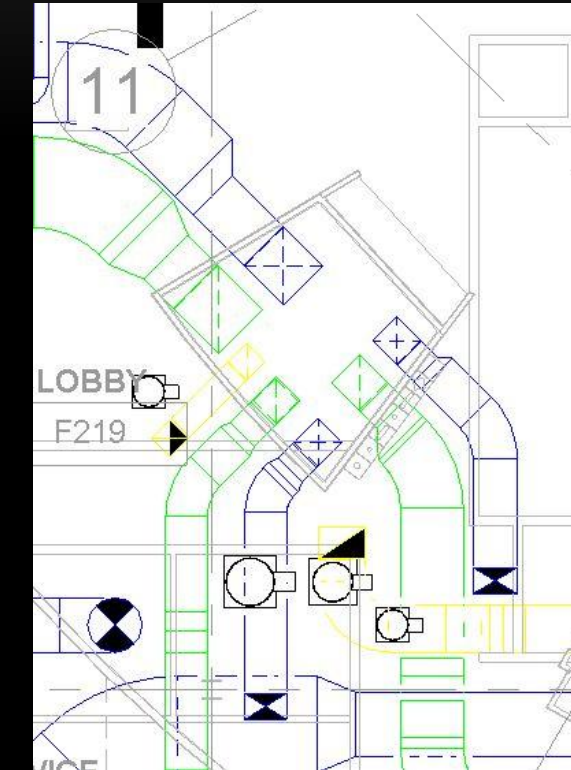
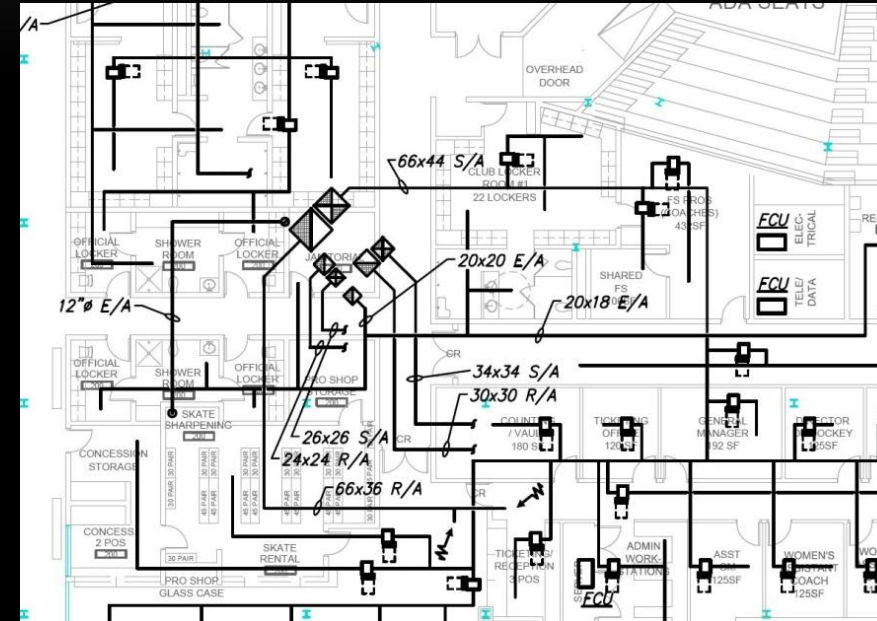


# SHAFT COORDINATION



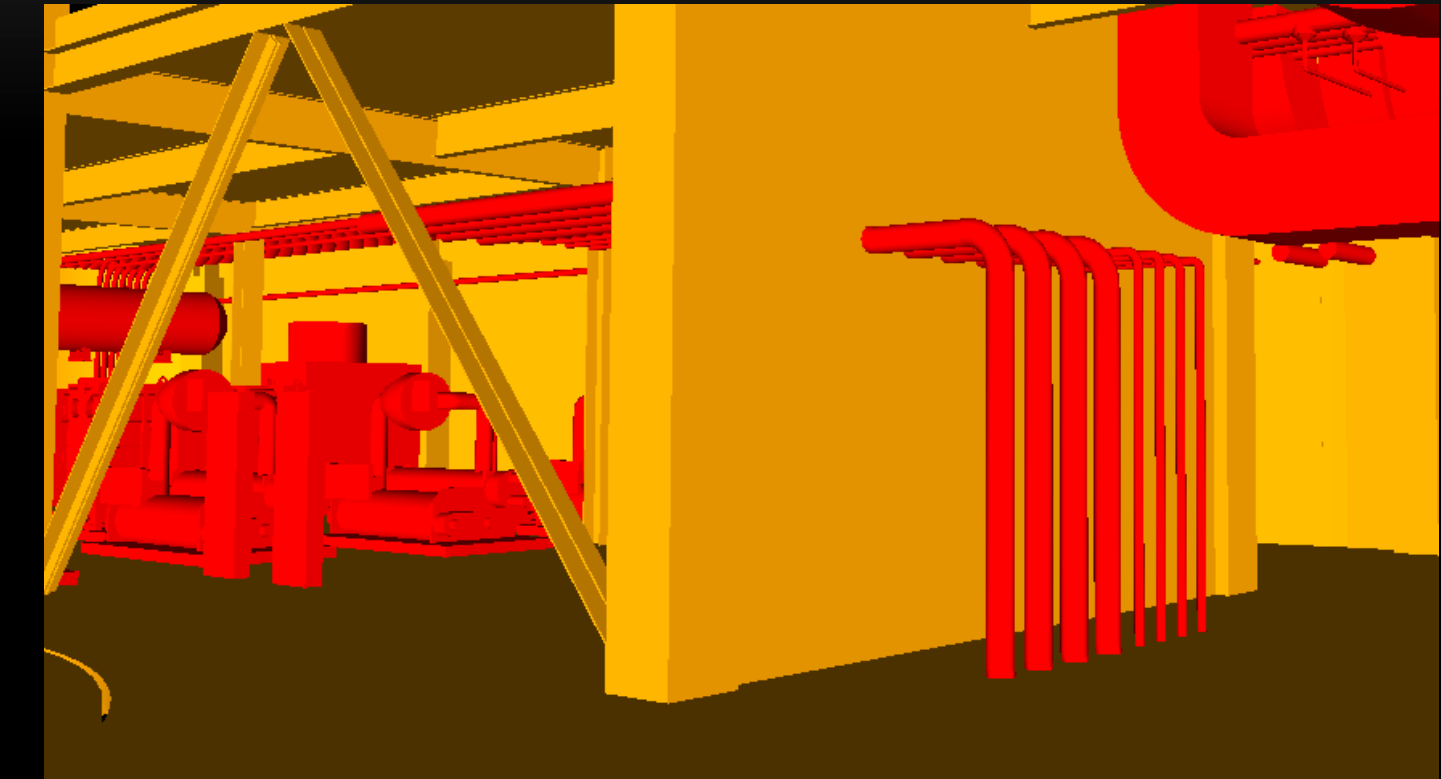
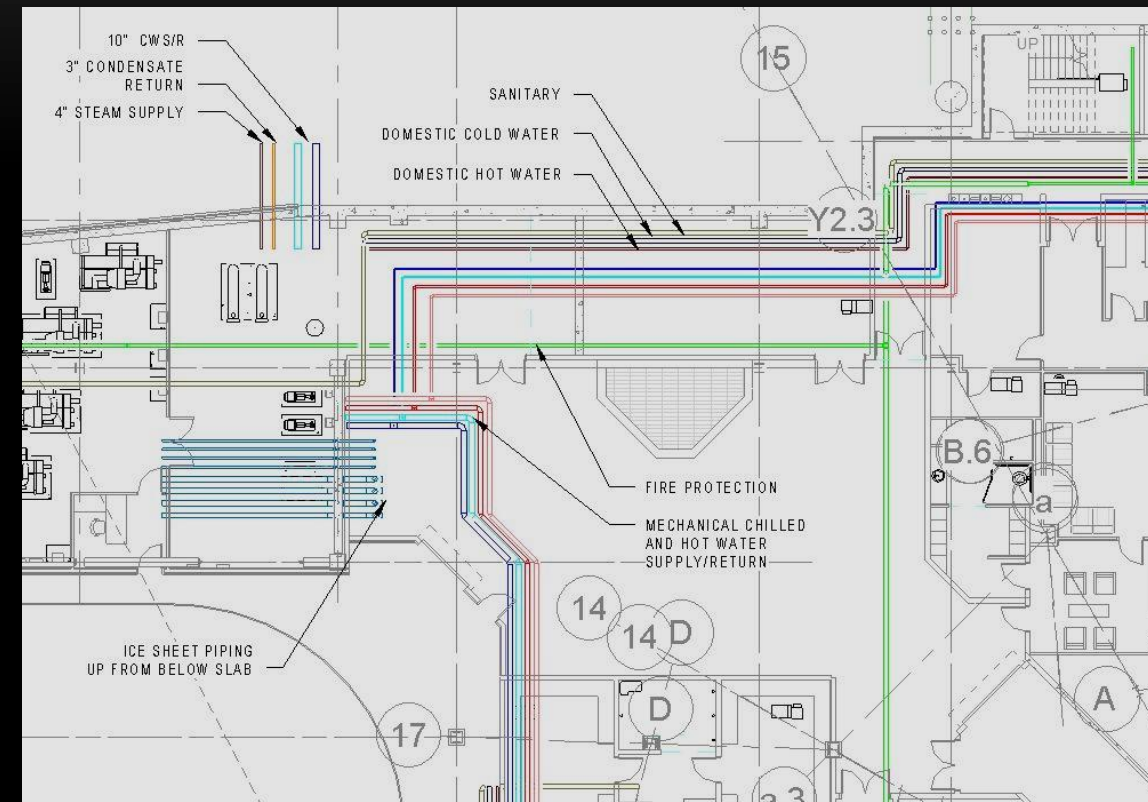
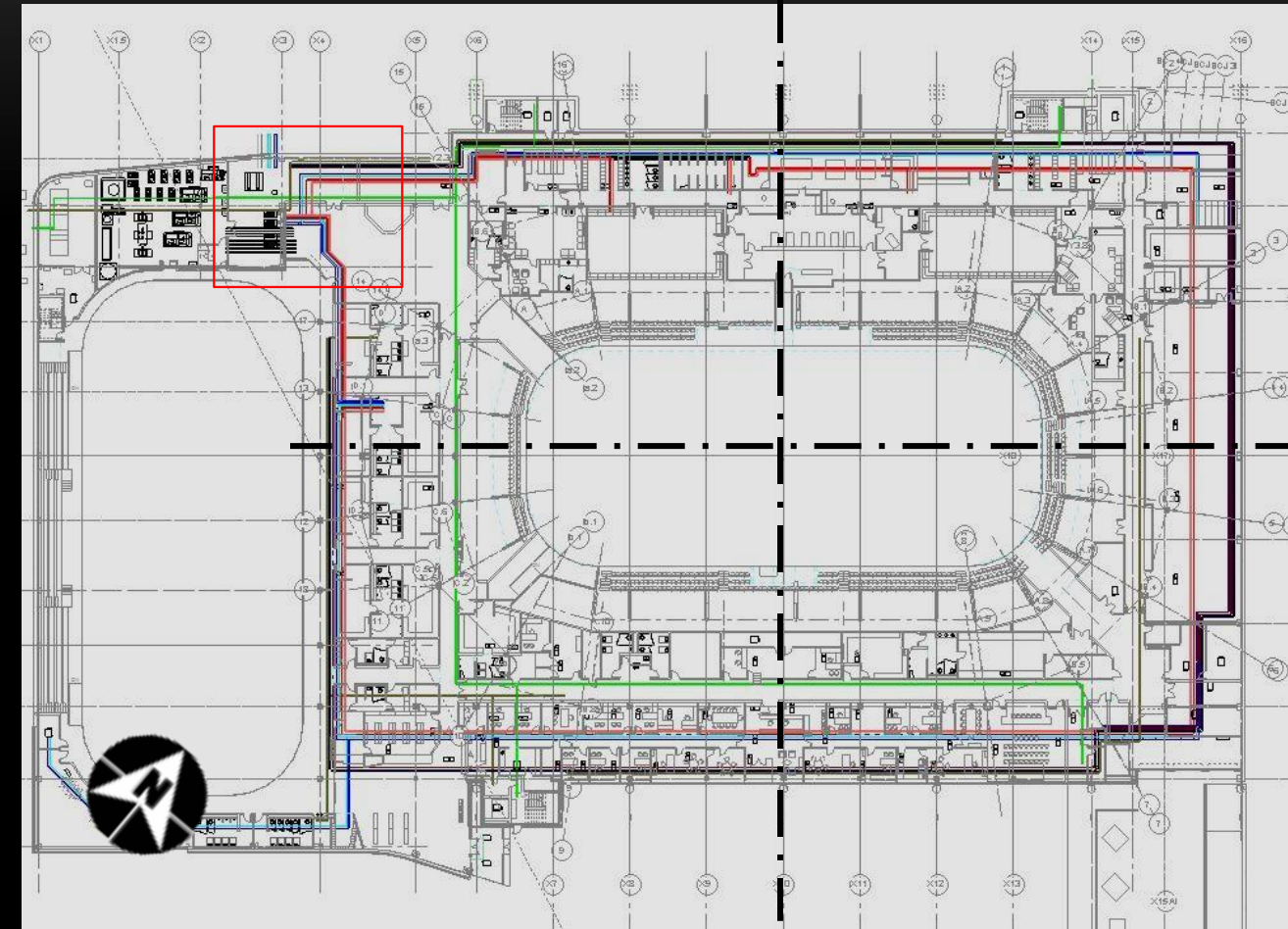


# SHAFT COORDINATION



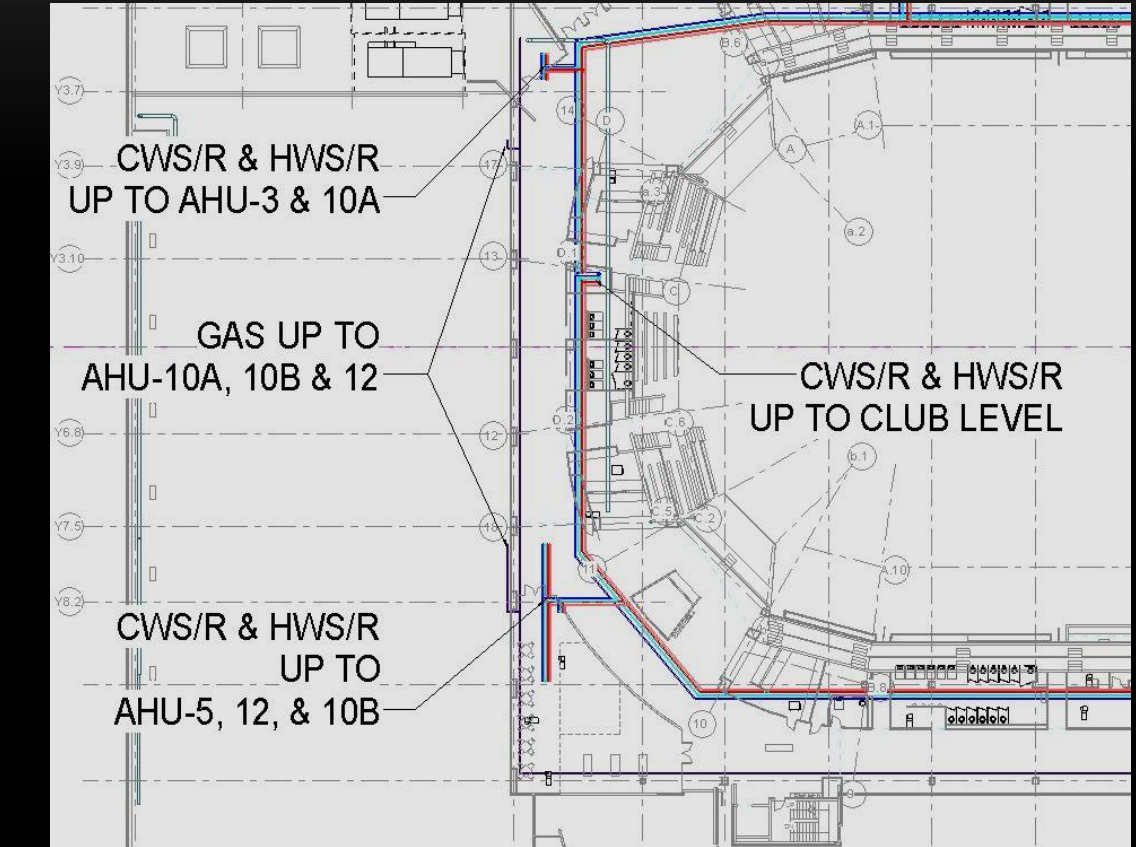
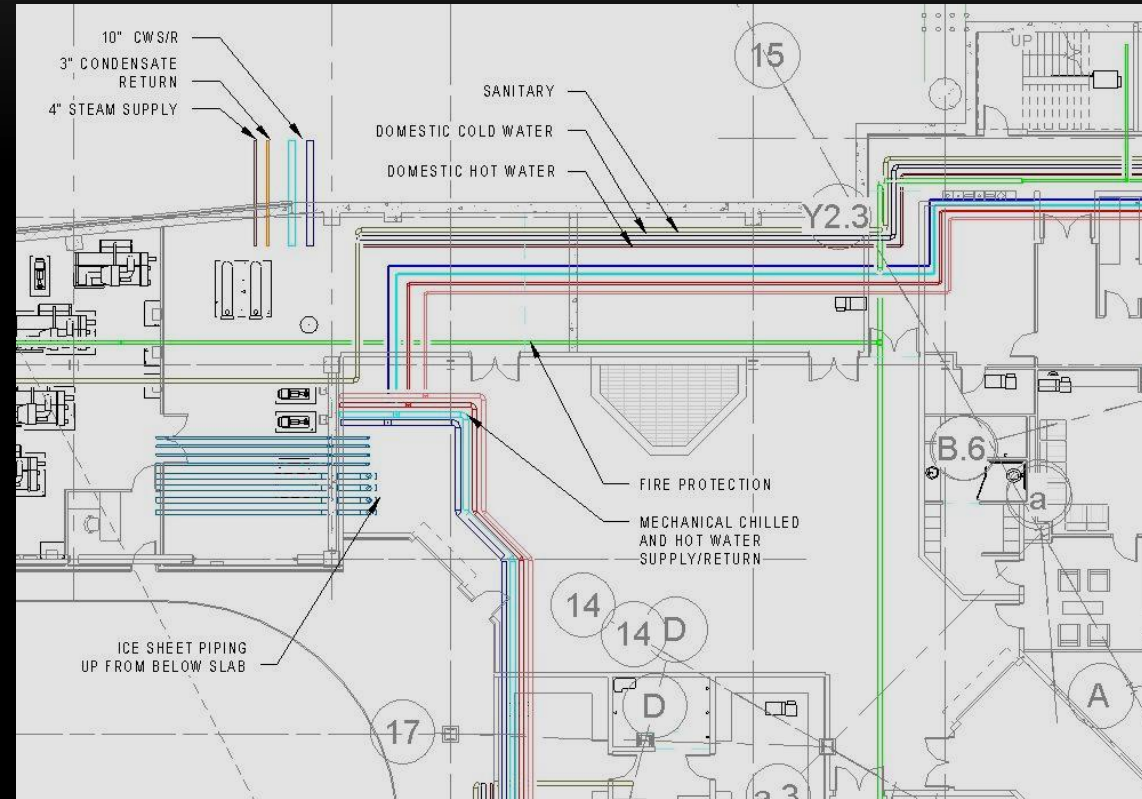
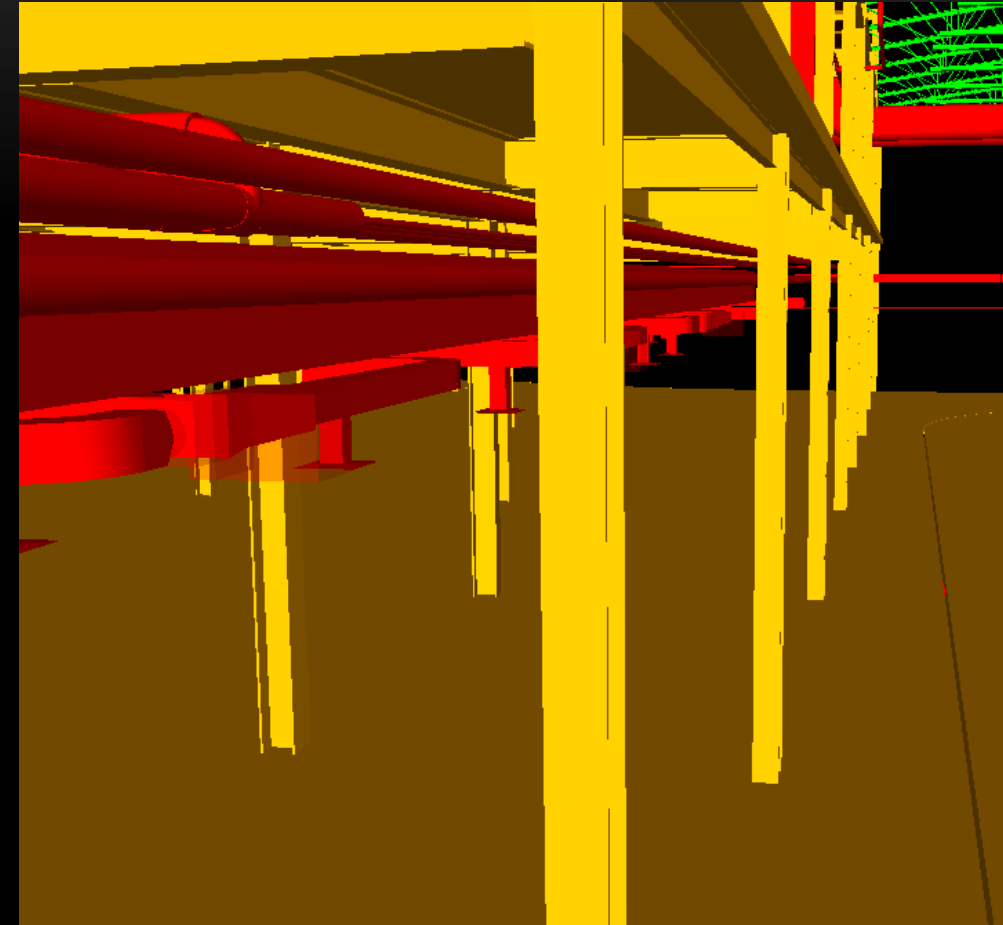


# MEP DESIGN



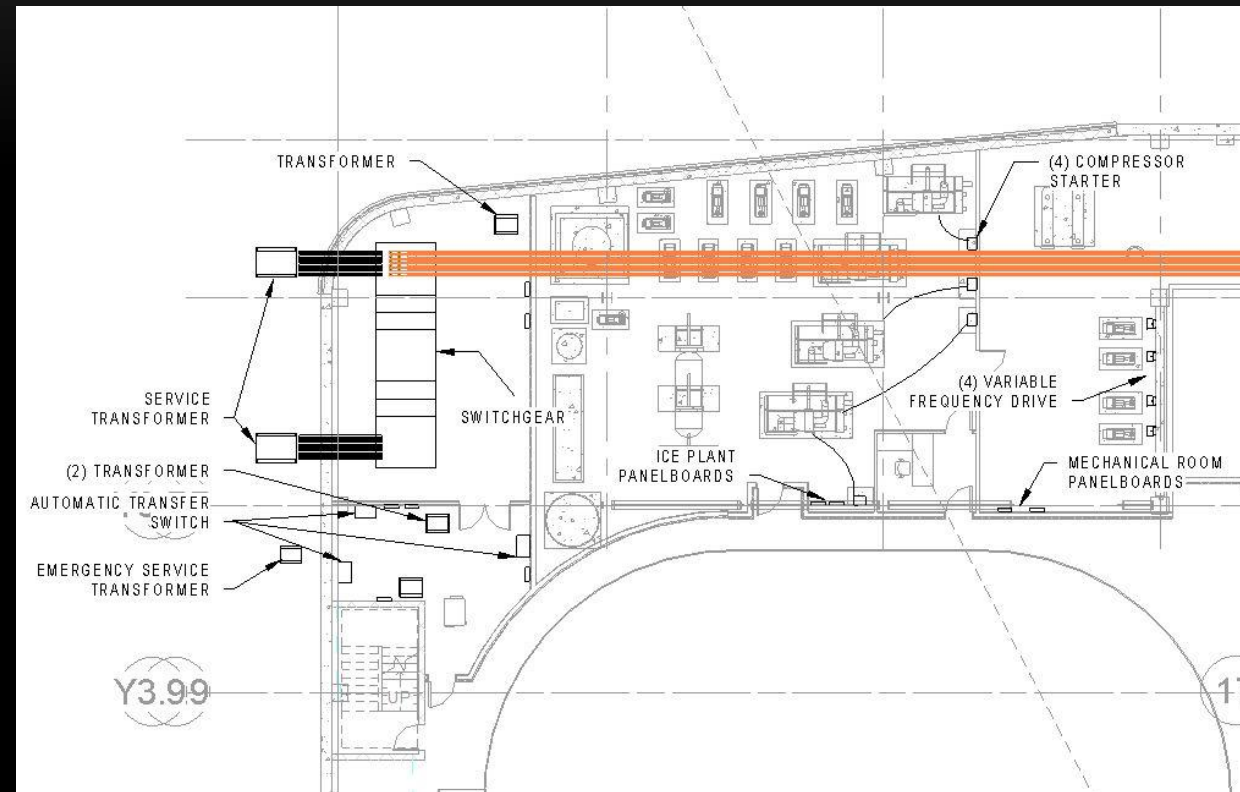


# MEP DESIGN



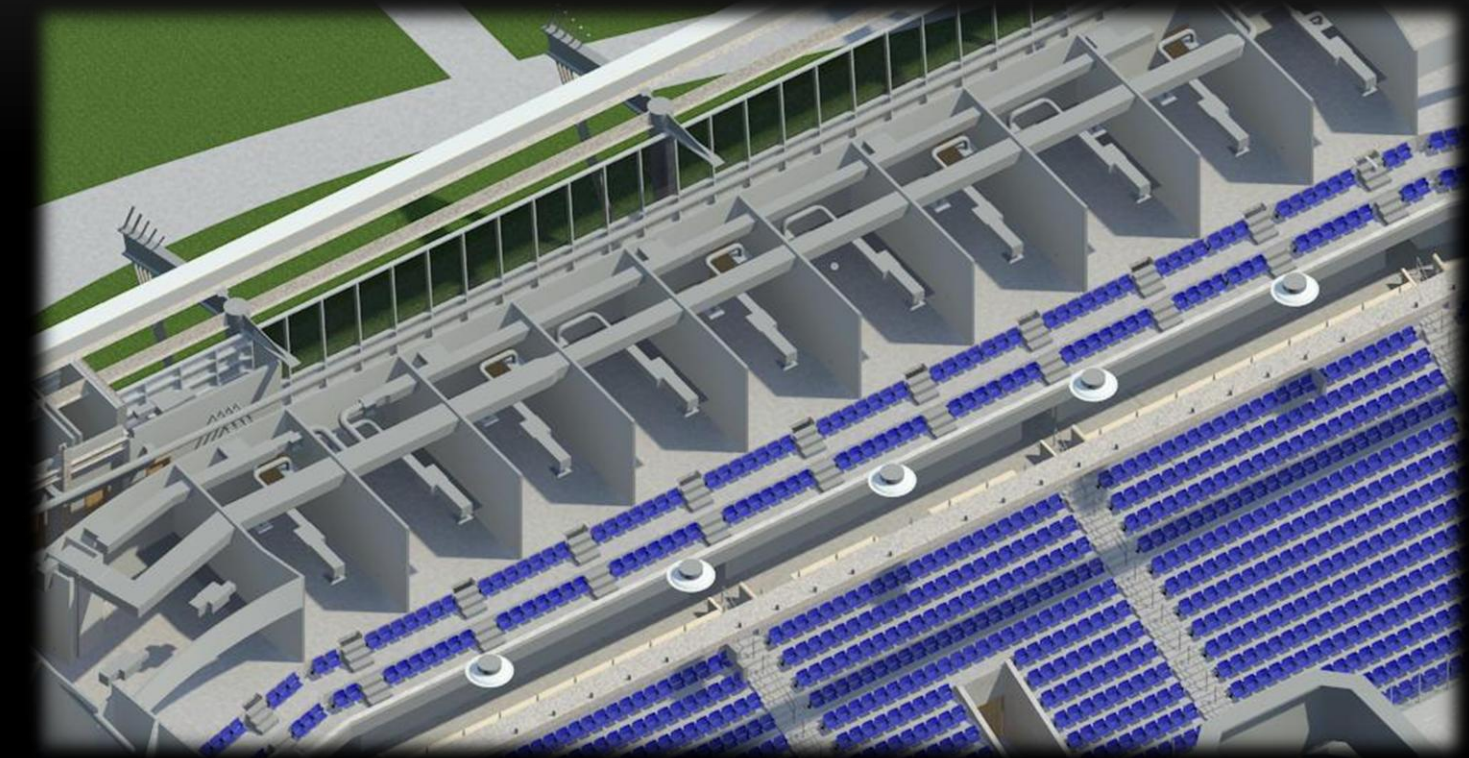
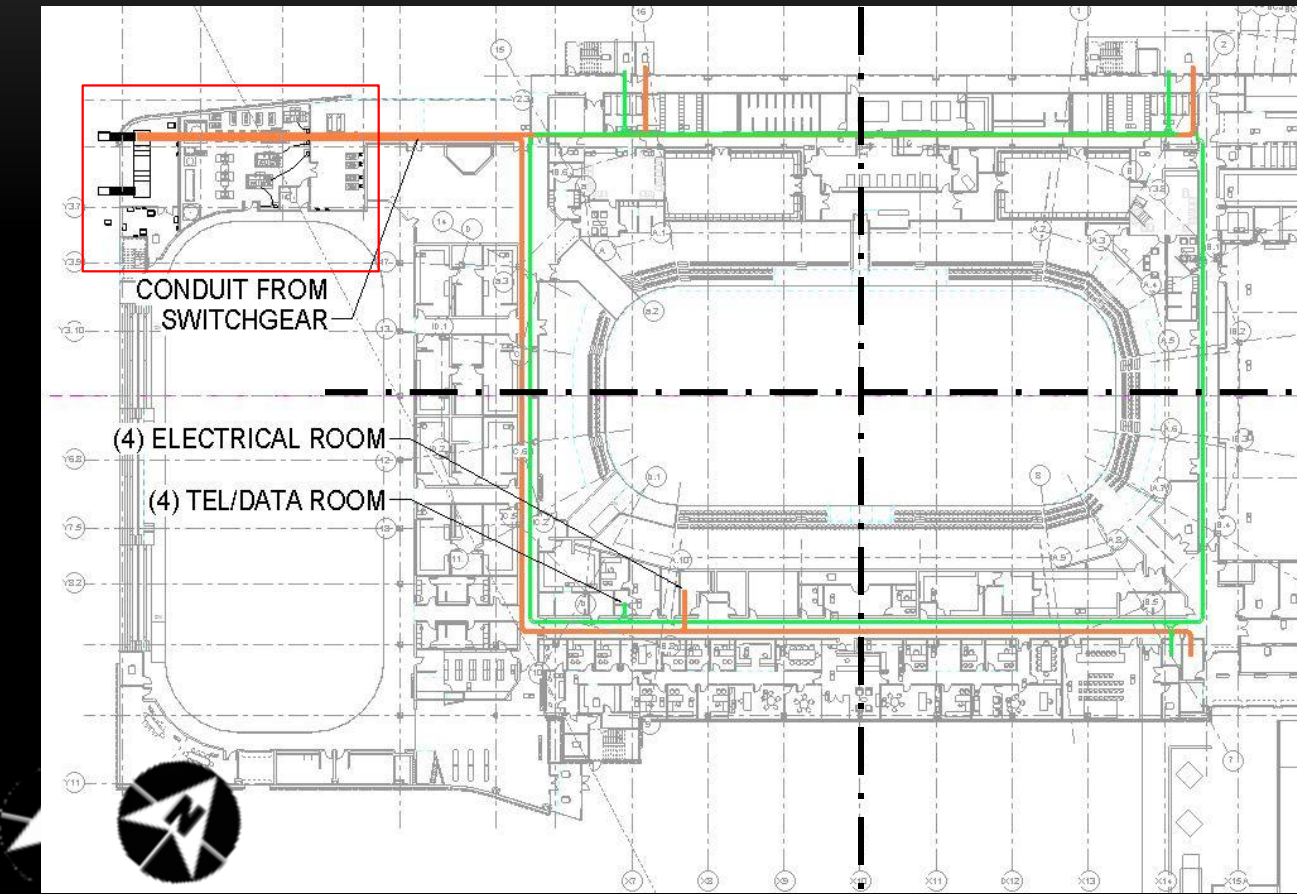


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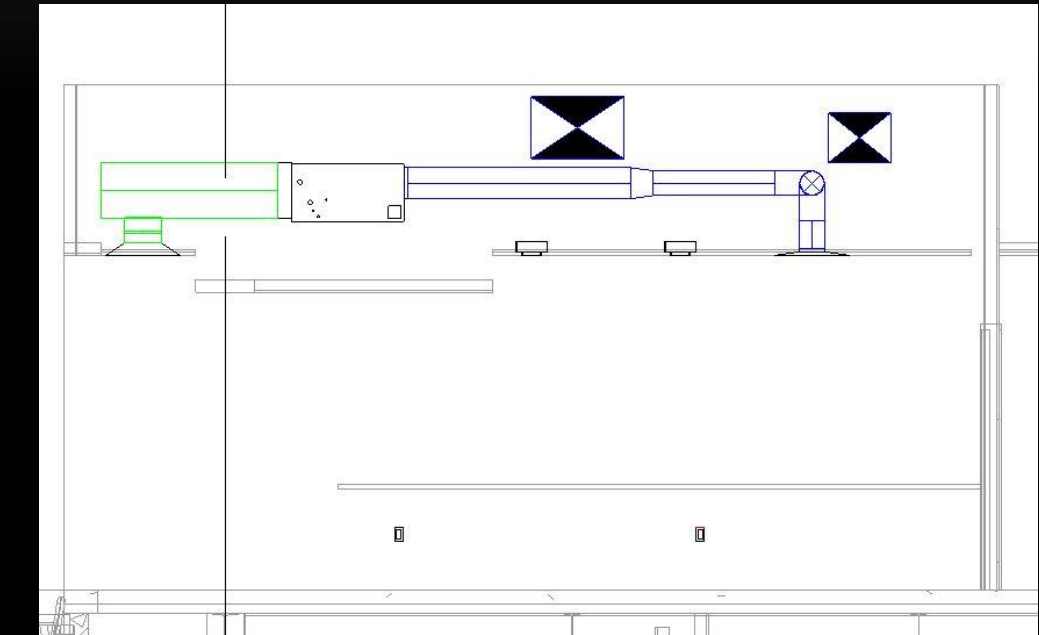
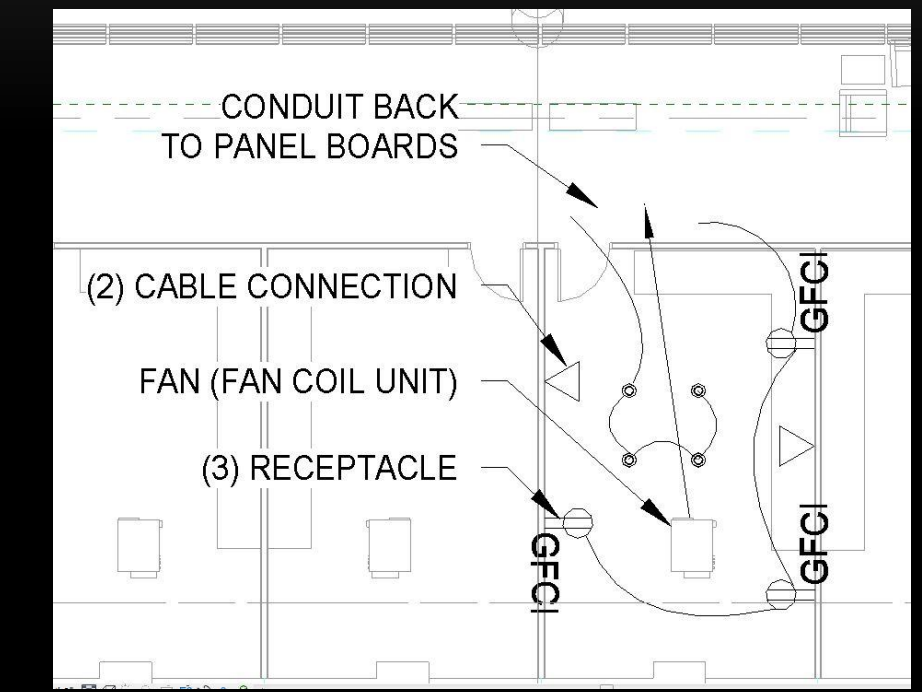




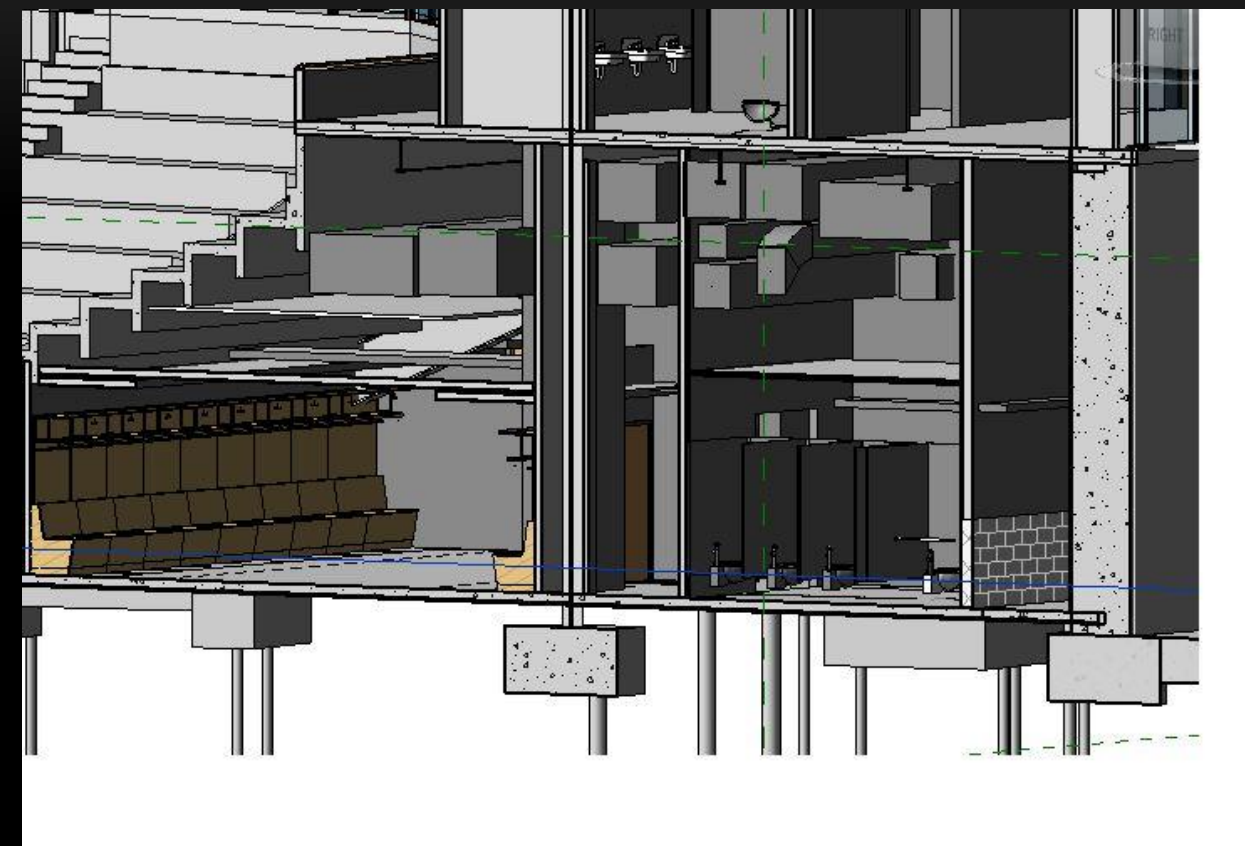
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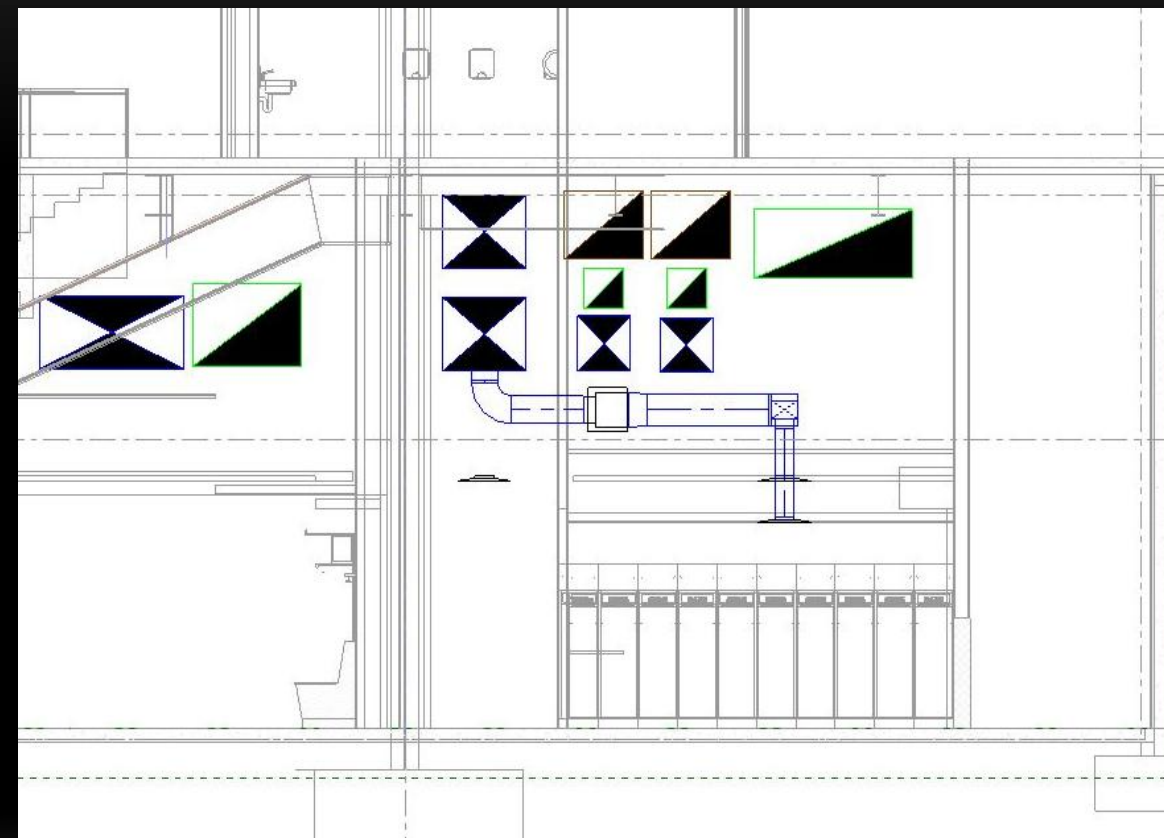
# SUITE COORDINATION



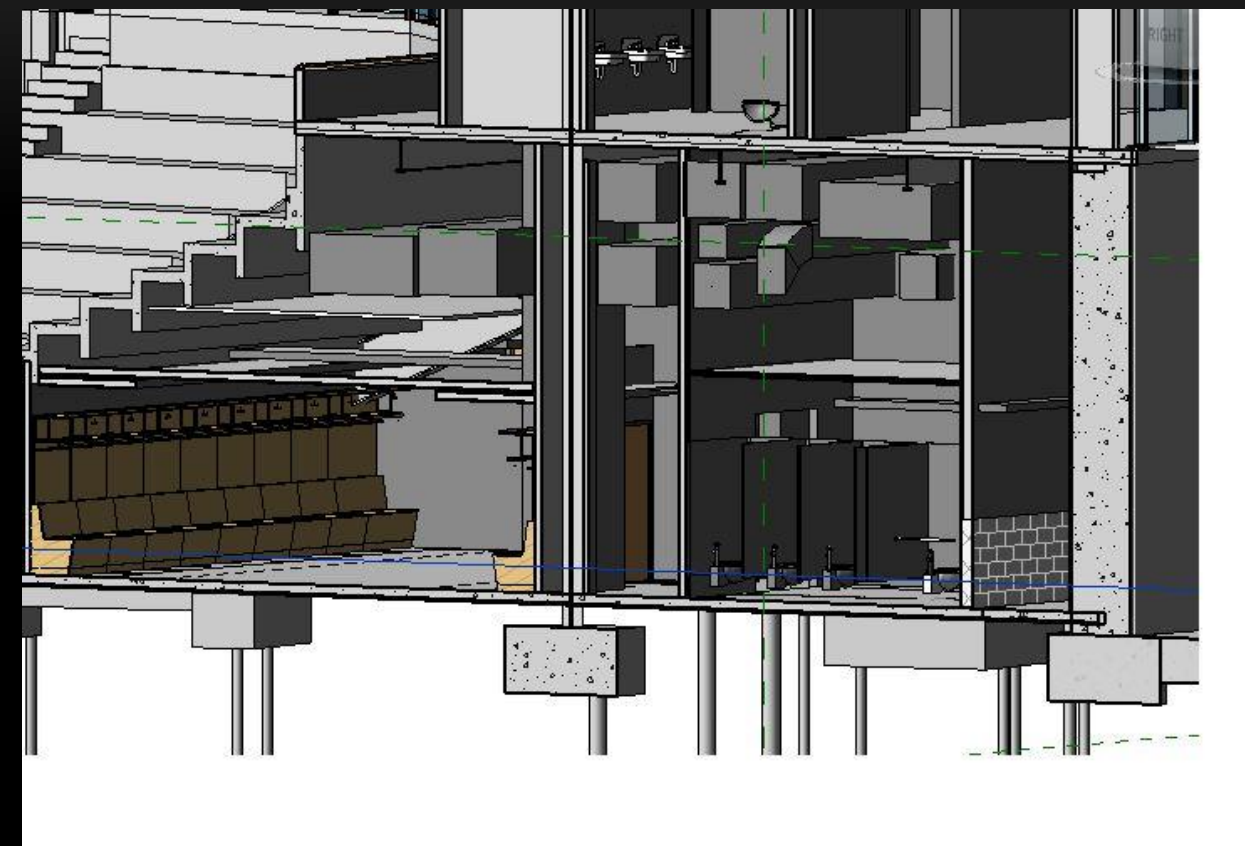




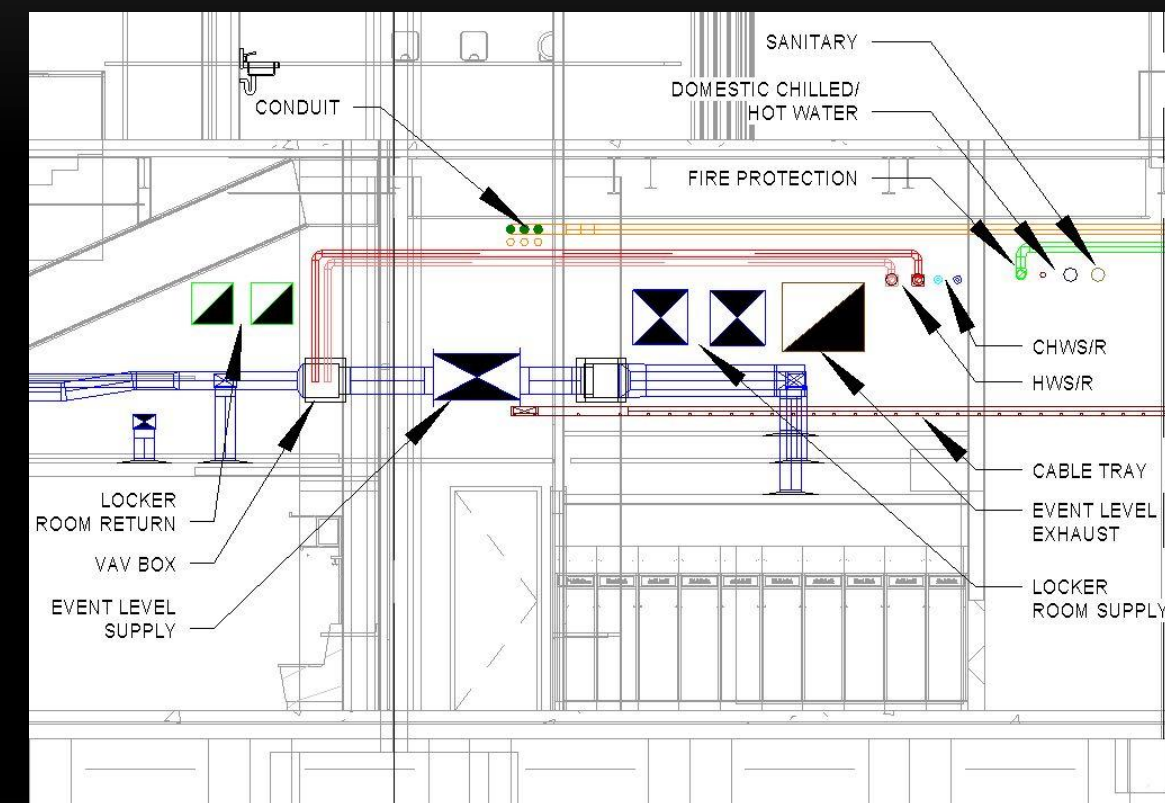
## EVENT LEVEL REDESIGN





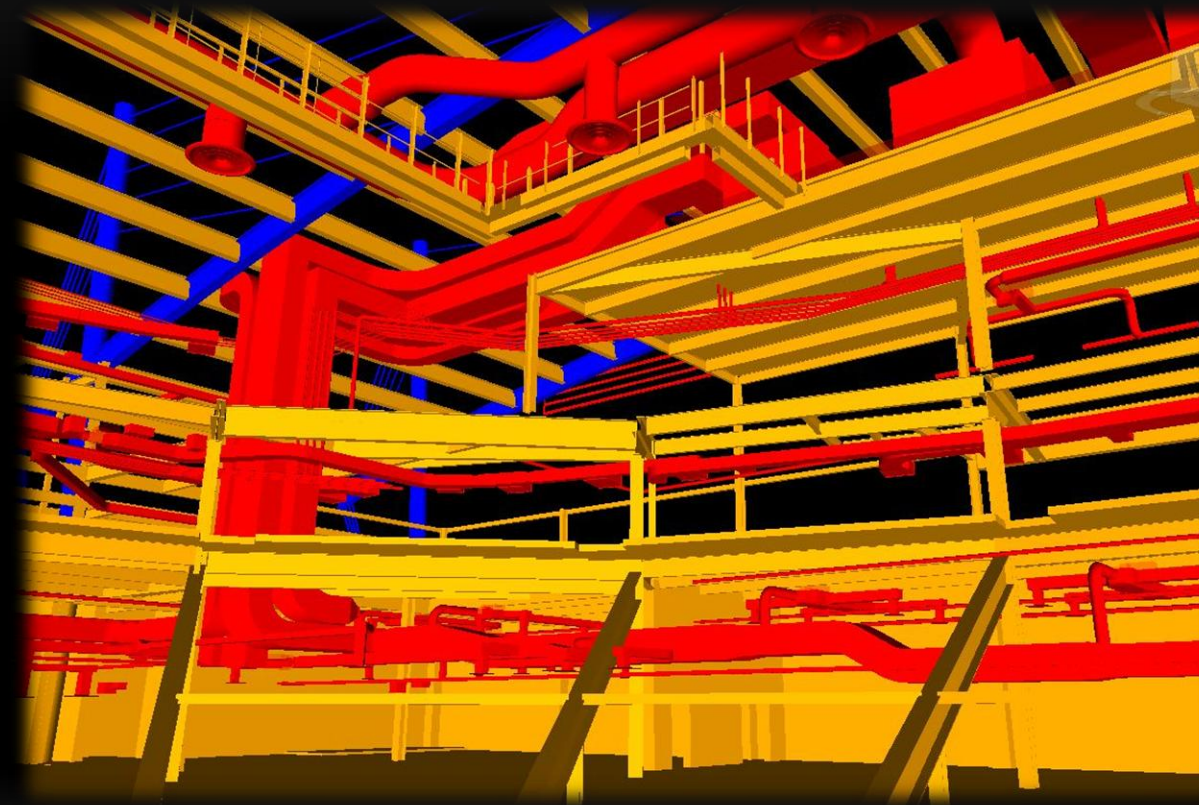
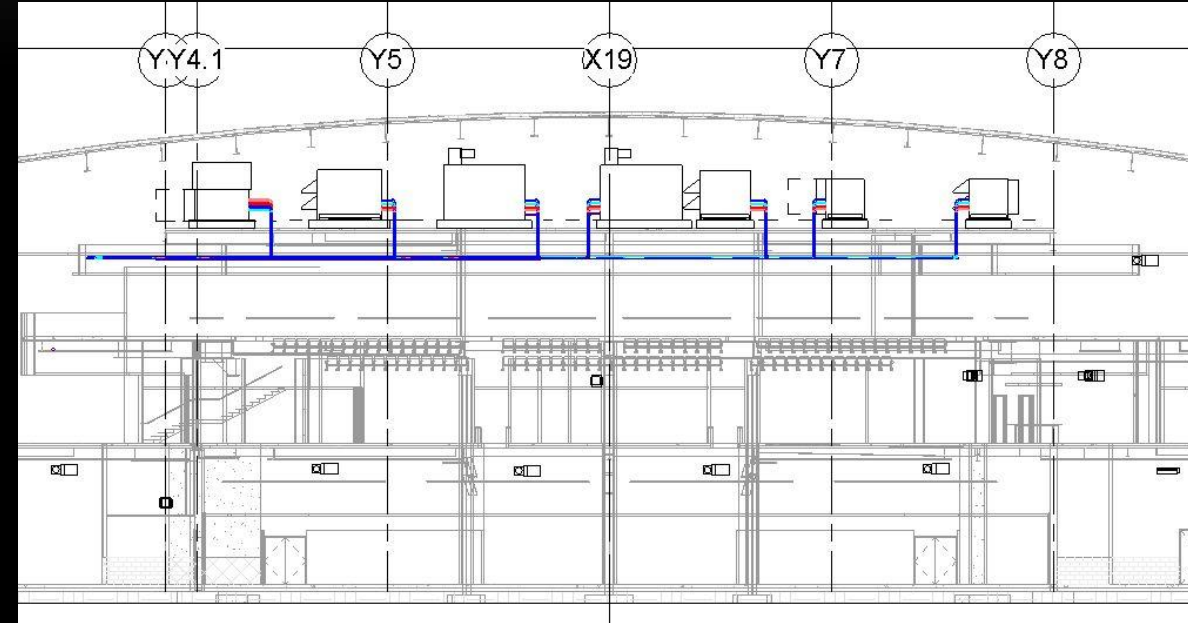
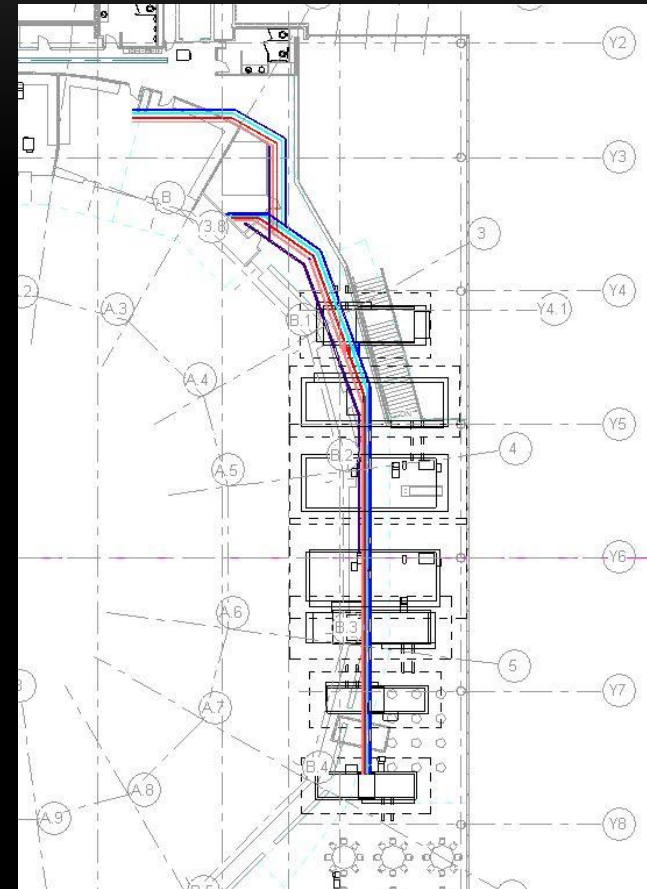


## EVENT LEVEL REDESIGN



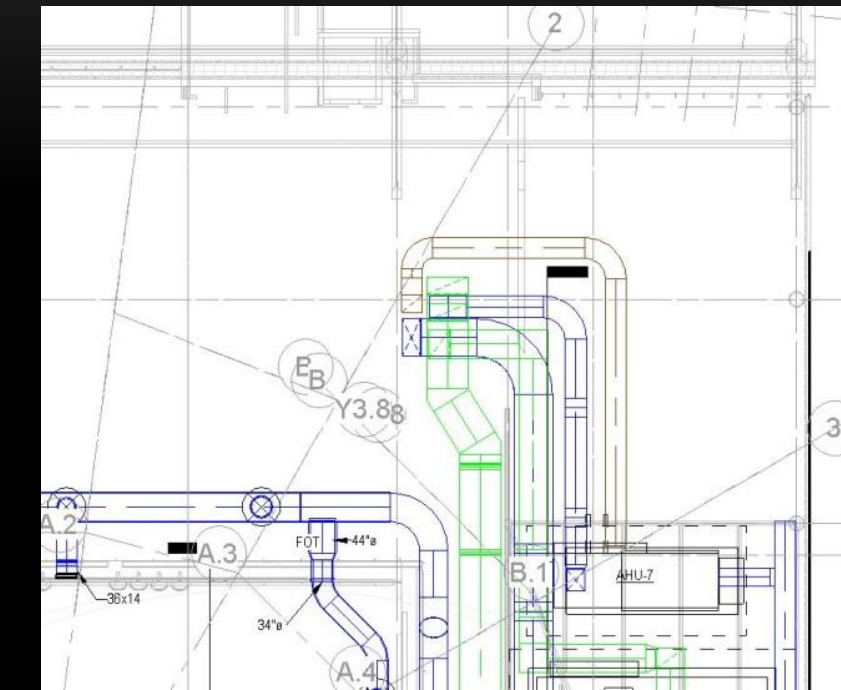
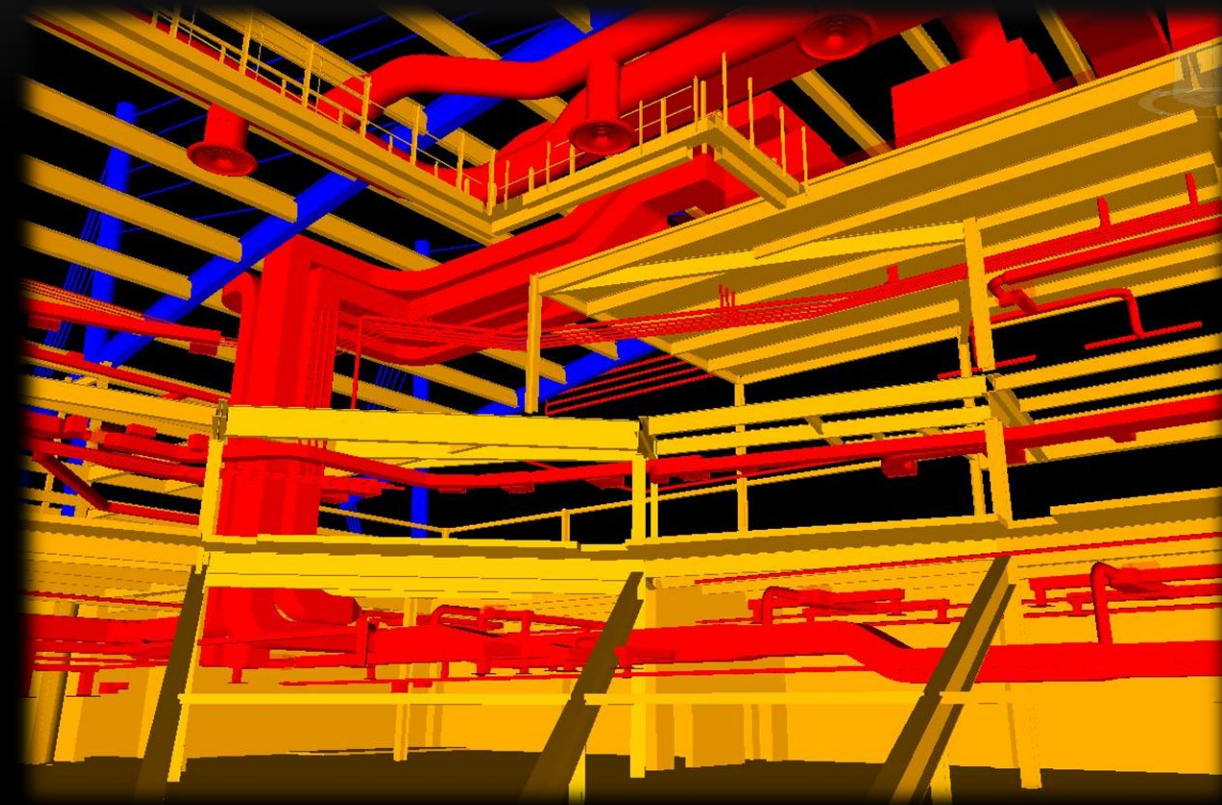


# DUCTWORK PIPING RISERS

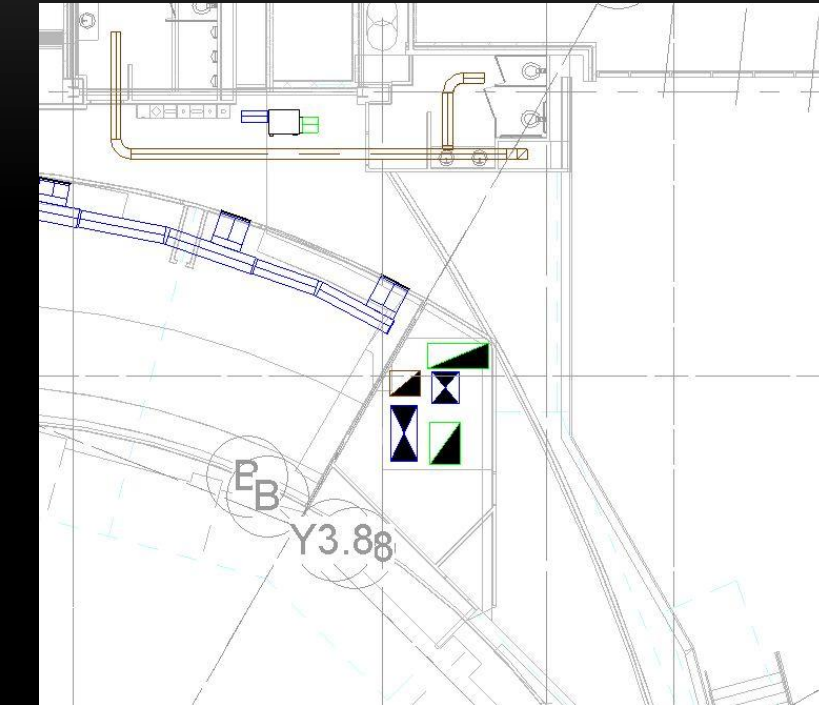




# DUCTWORK PIPING RISERS



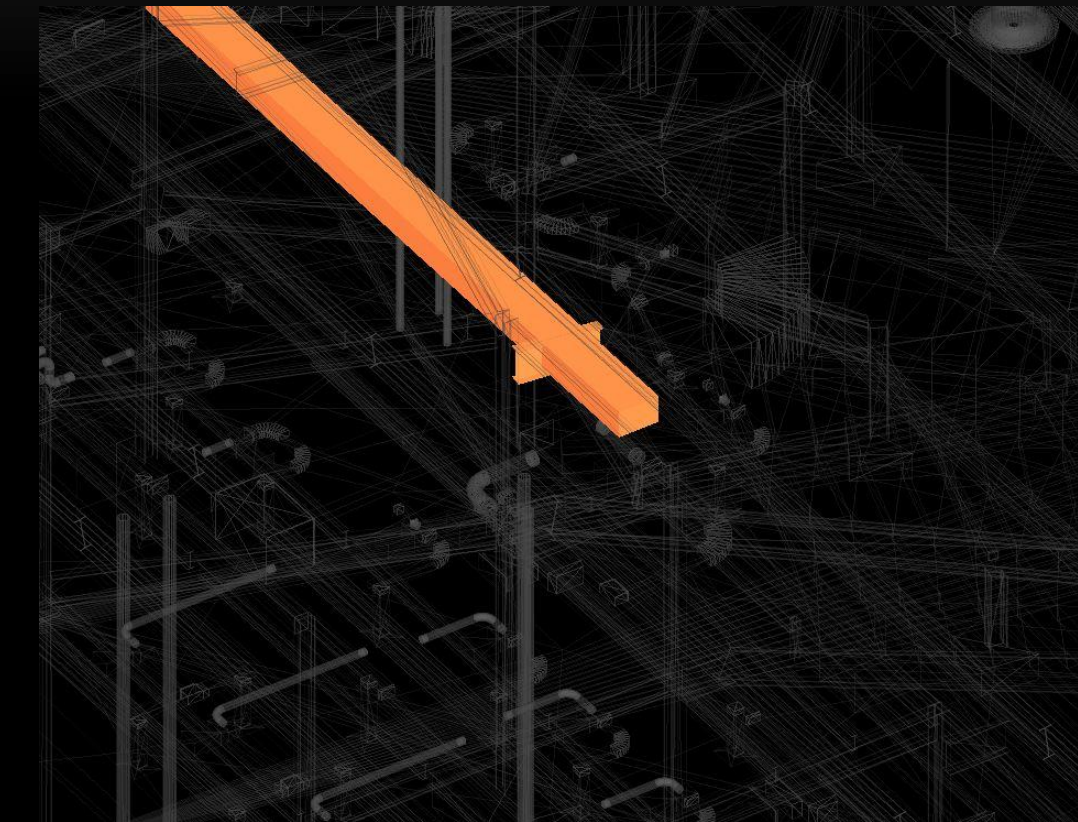
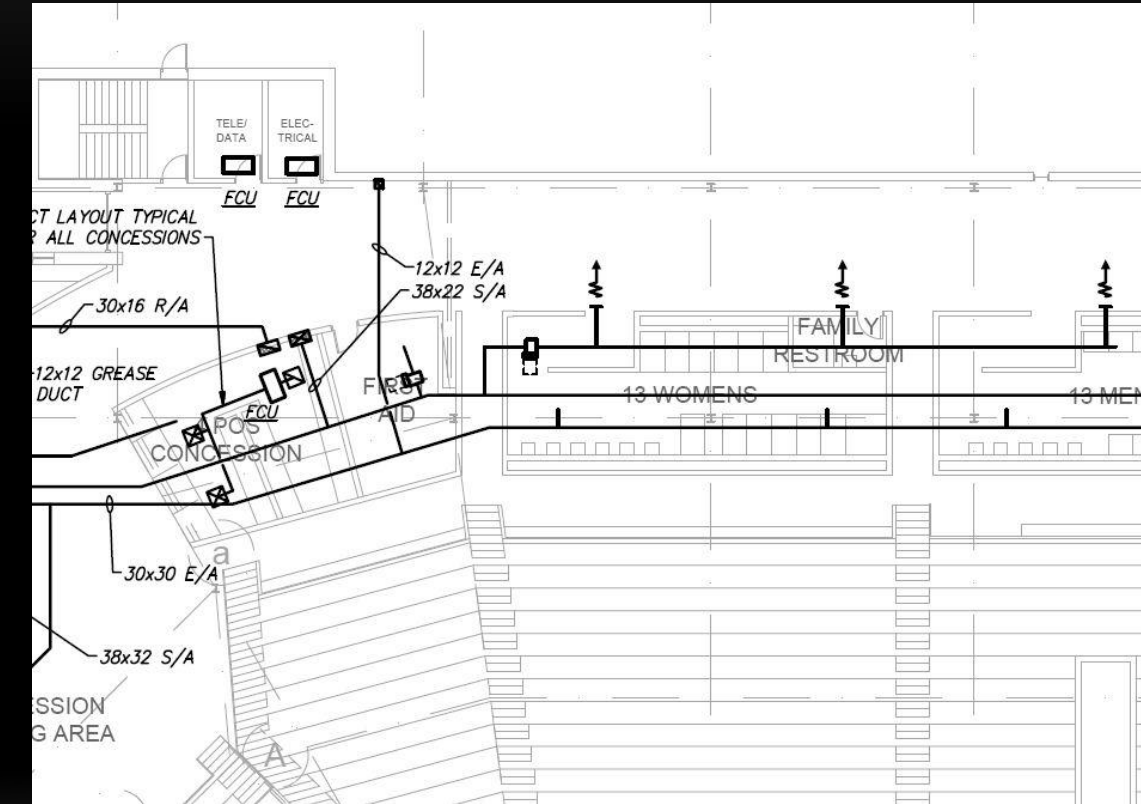
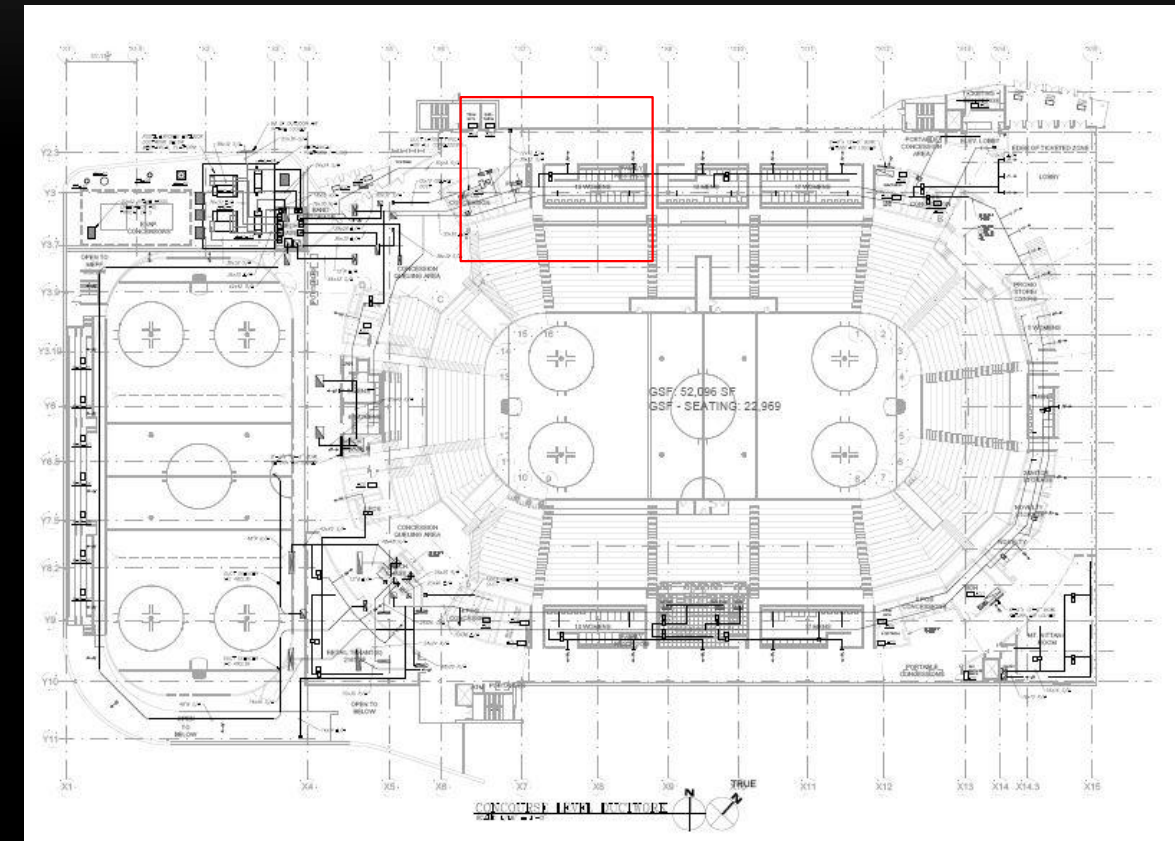
**CATWALK/CLUB**



**MAIN/CLUB**

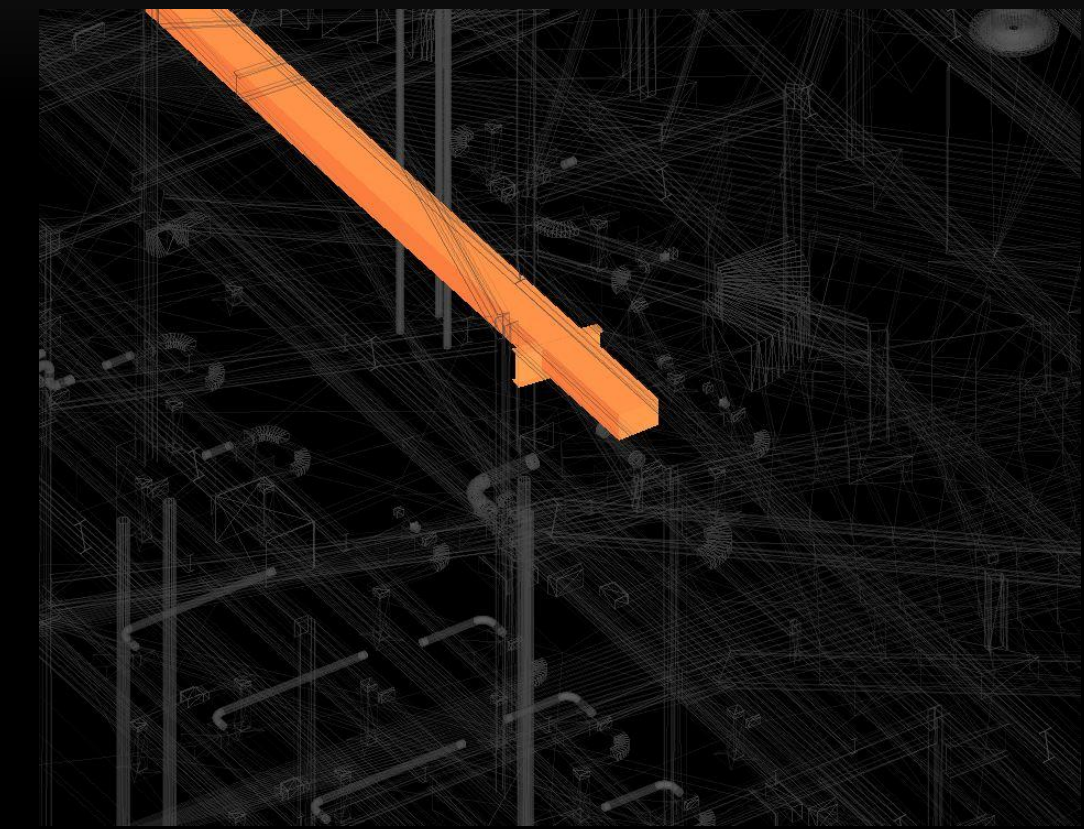
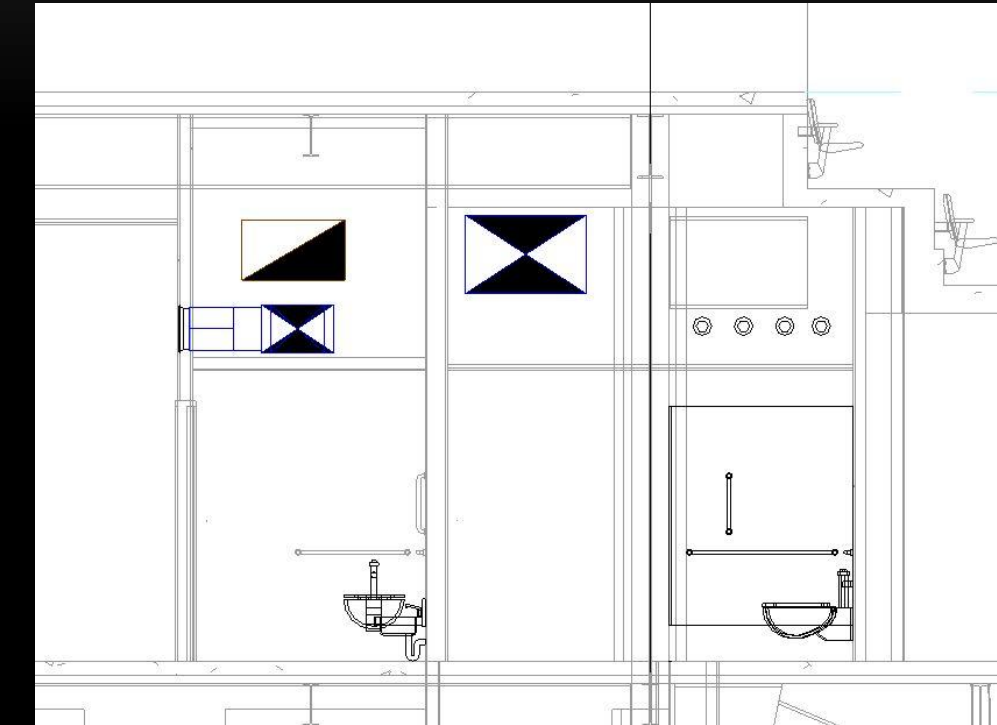
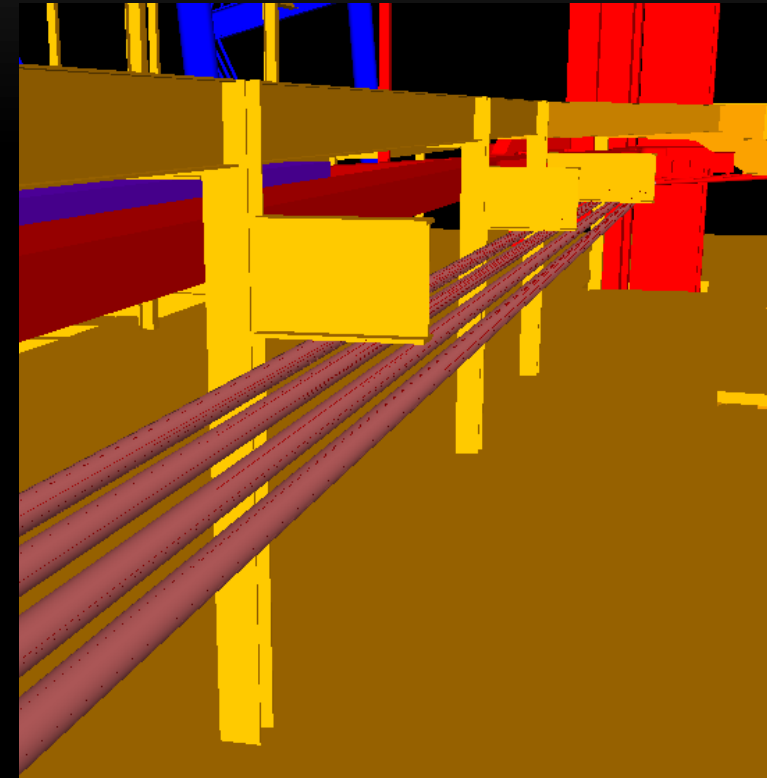


# MAIN CONCOURSE PLENUM COORDINATION



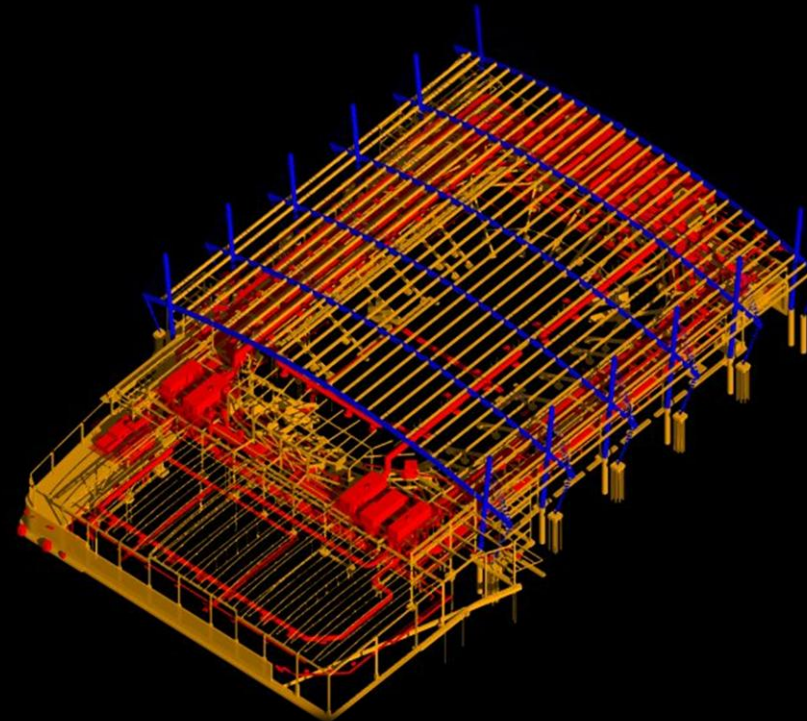
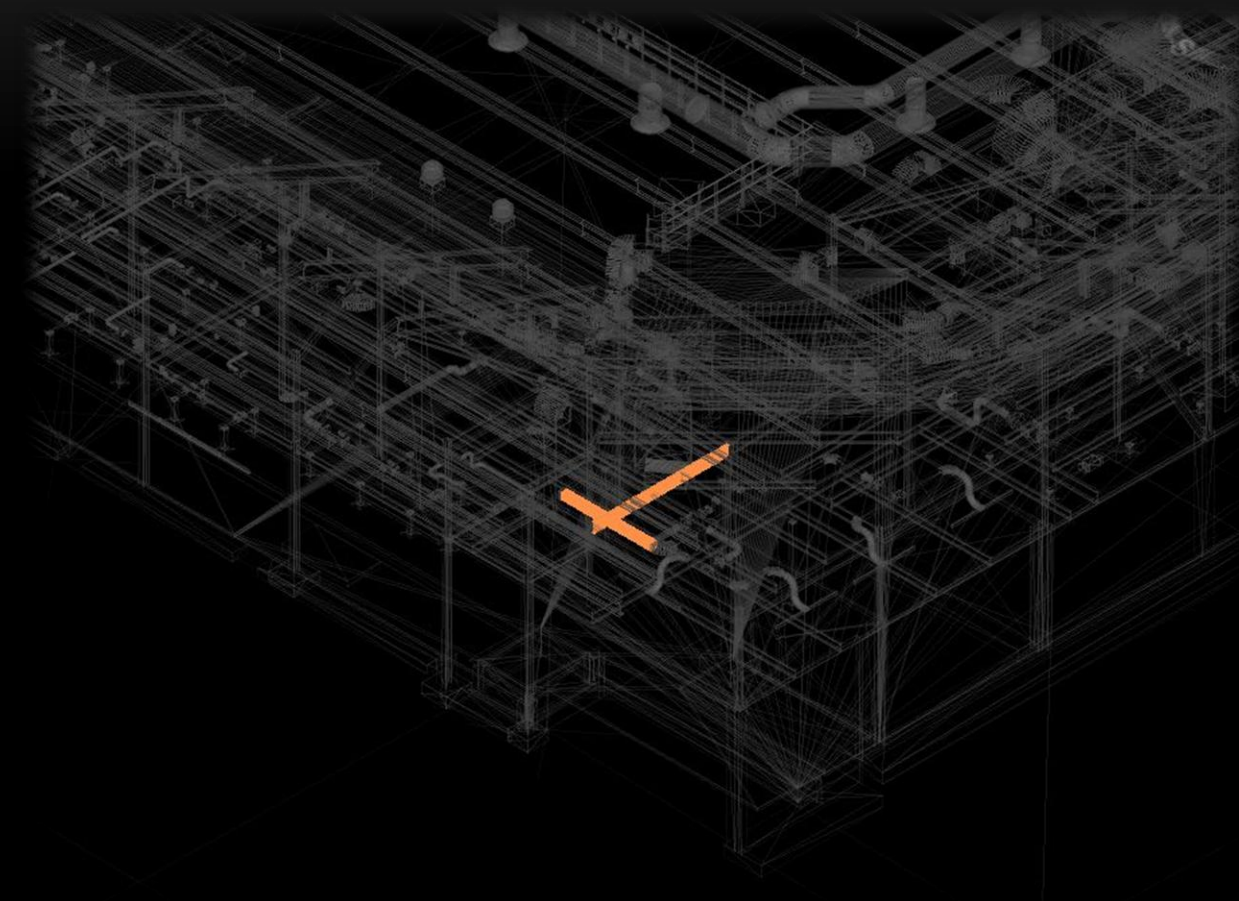


# MAIN CONCOURSE PLENUM COORDINATION

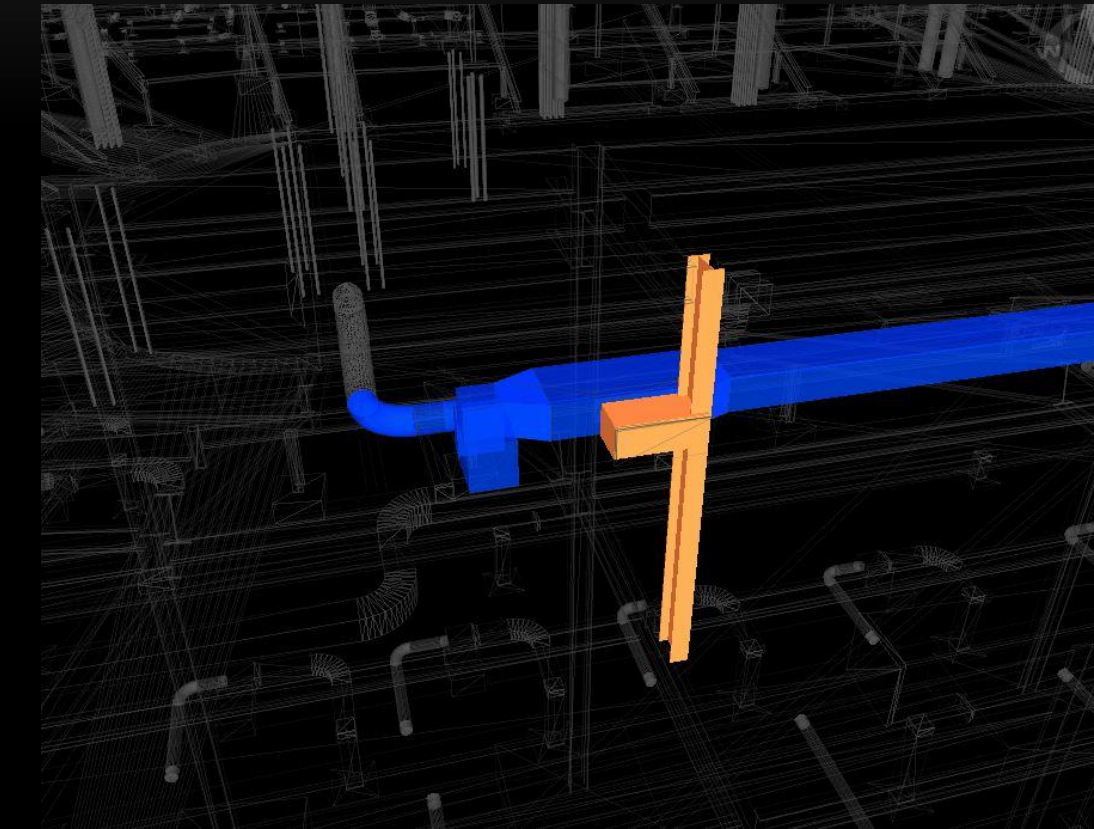




# ENGINEERING COORDINATION

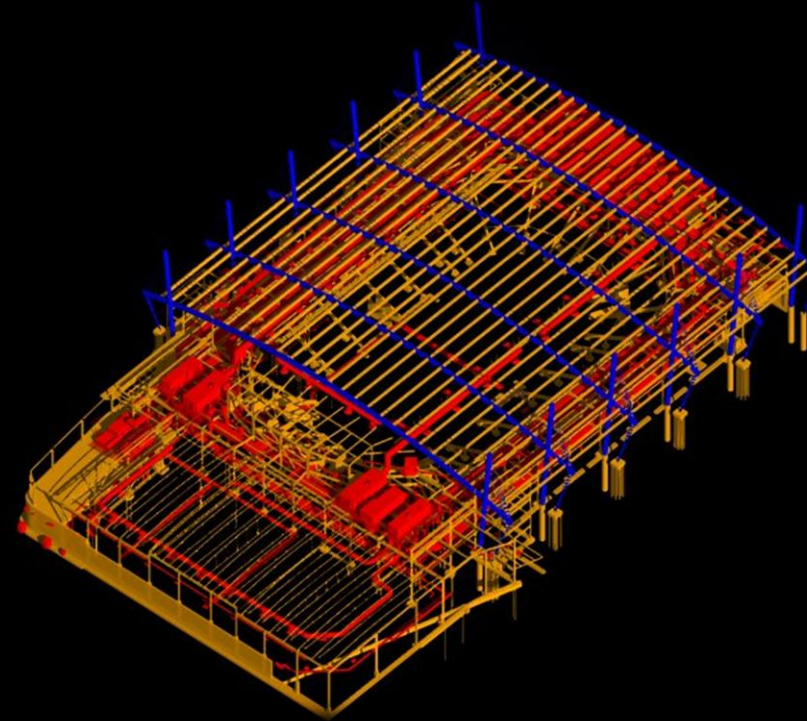
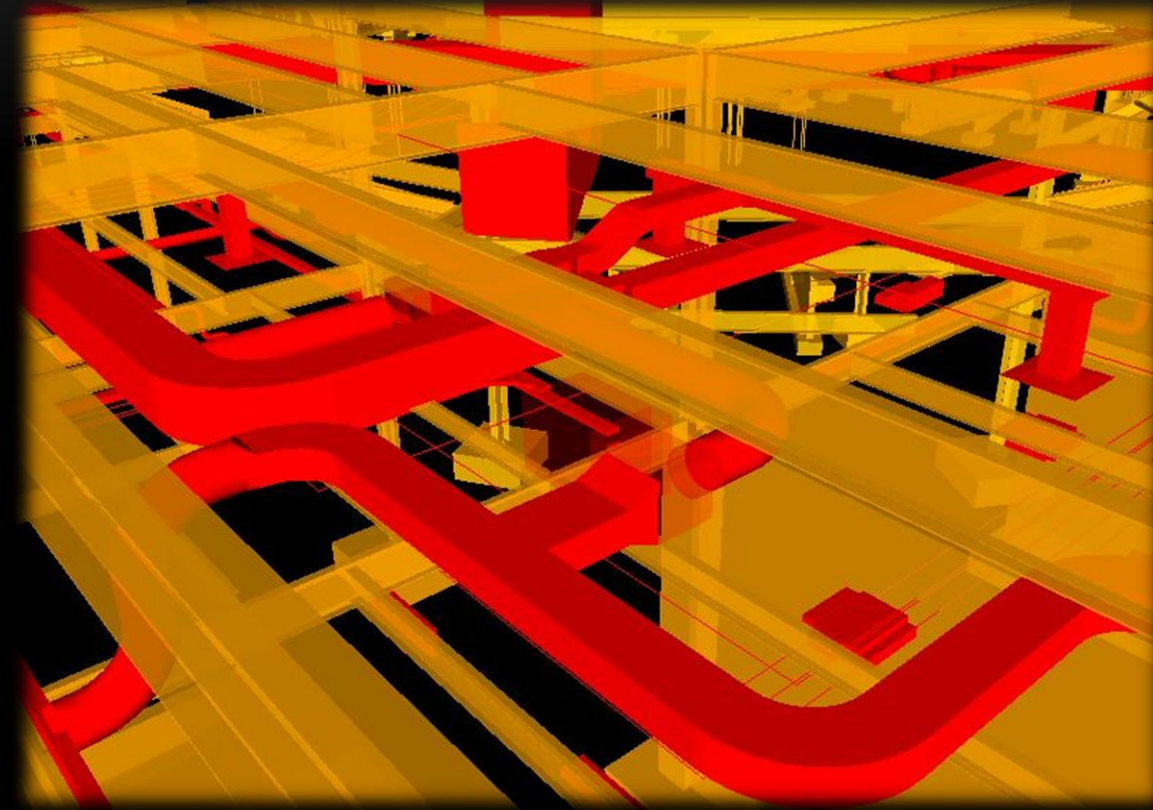


Clash Runs	# of Clashes
1	595
2	540
3	494
4	457
5	215
6	177
7	131
8	100
9	95

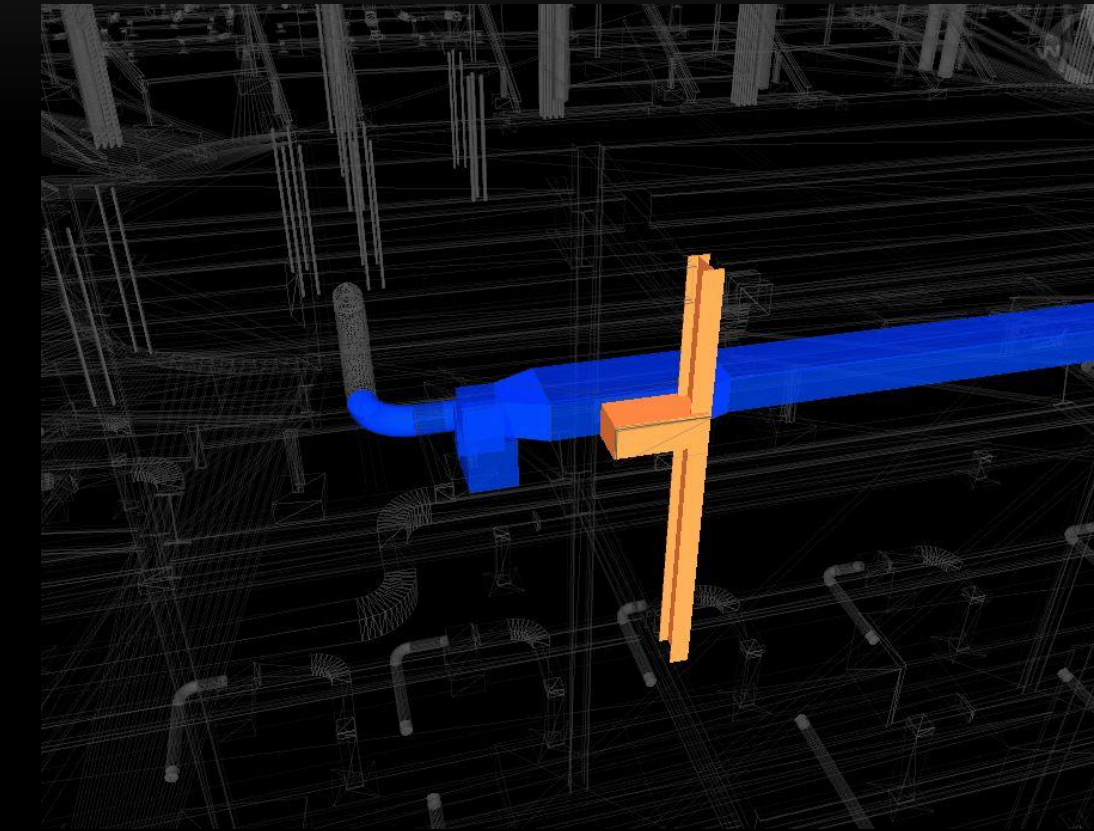




# ENGINEERING COORDINATION

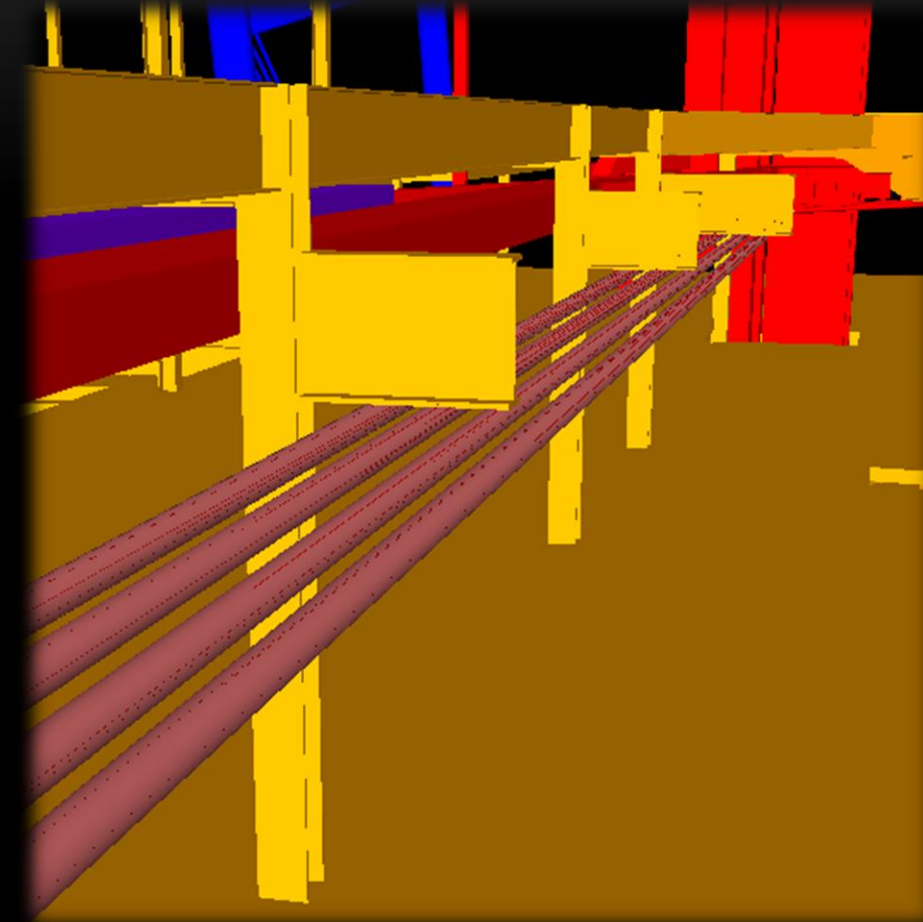
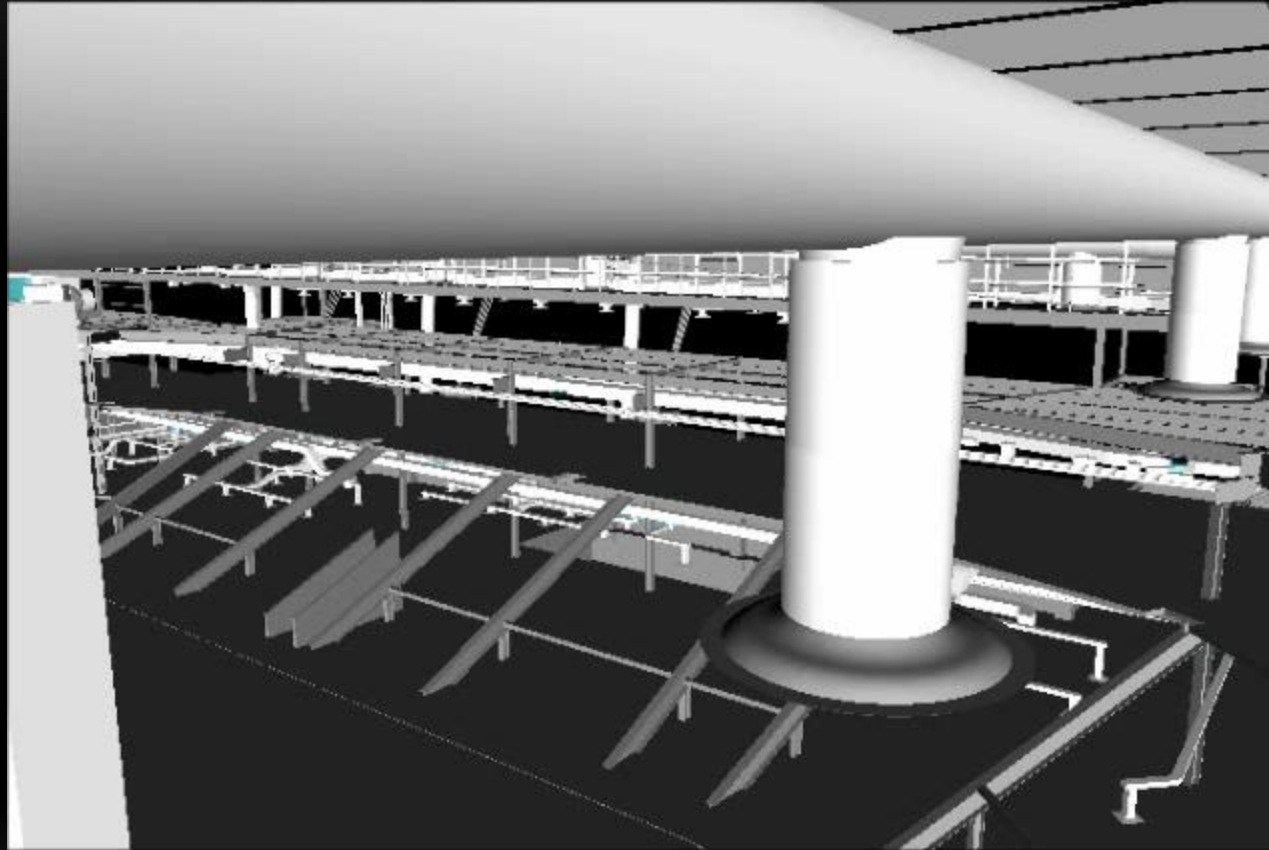
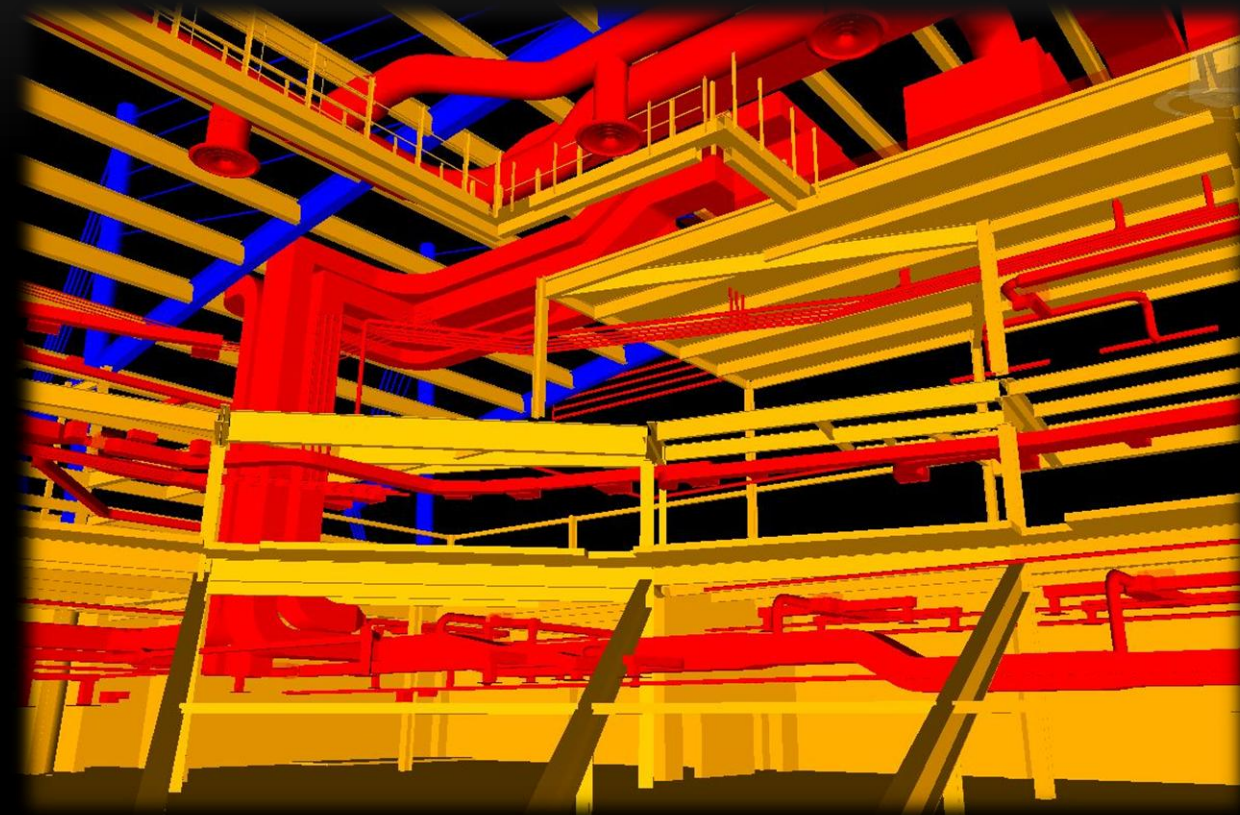


Clash Runs	# of Clashes
1	595
2	540
3	494
4	457
5	215
6	177
7	131
8	100
9	95





# ENGINEERING COORDINATION



Nate Babyak



Brian Sampson

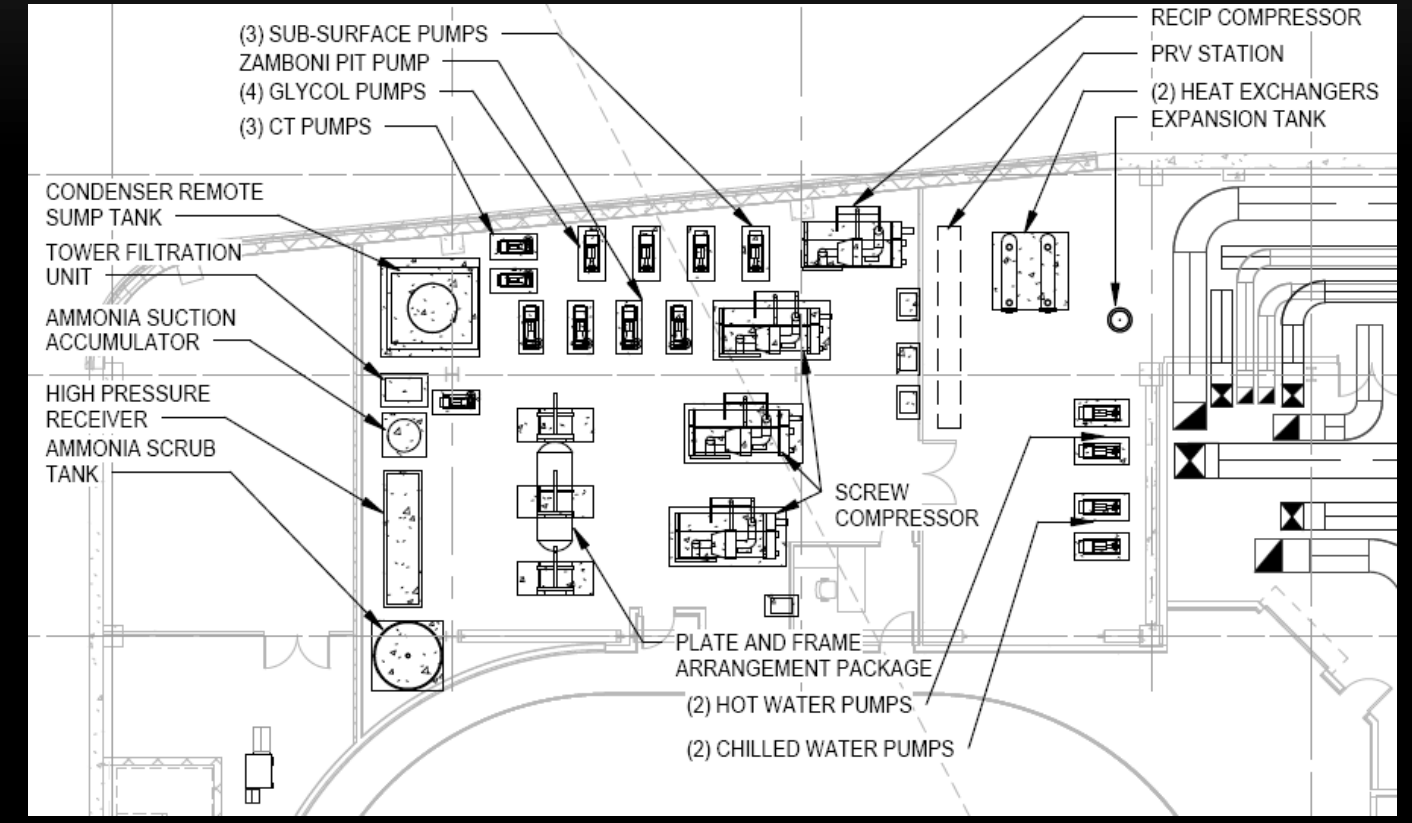
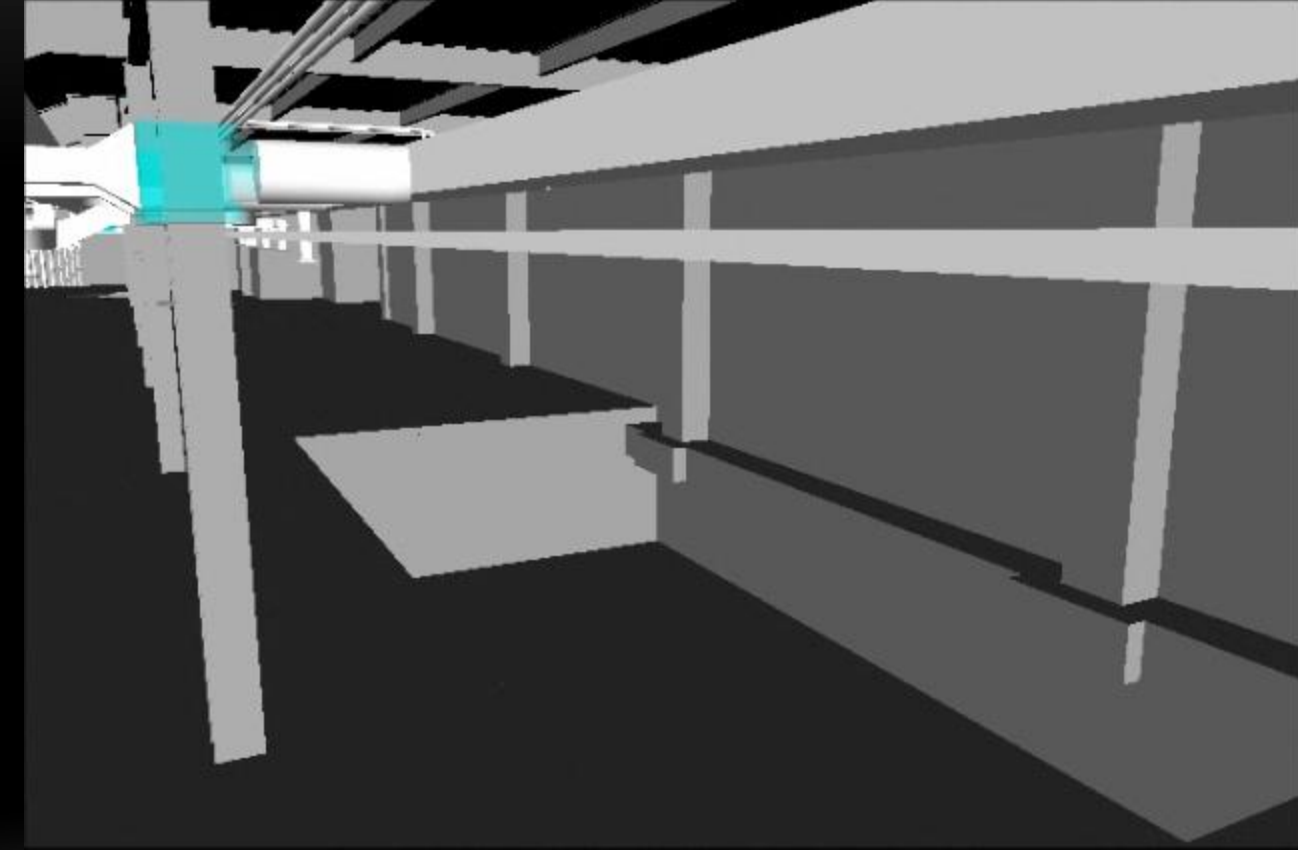
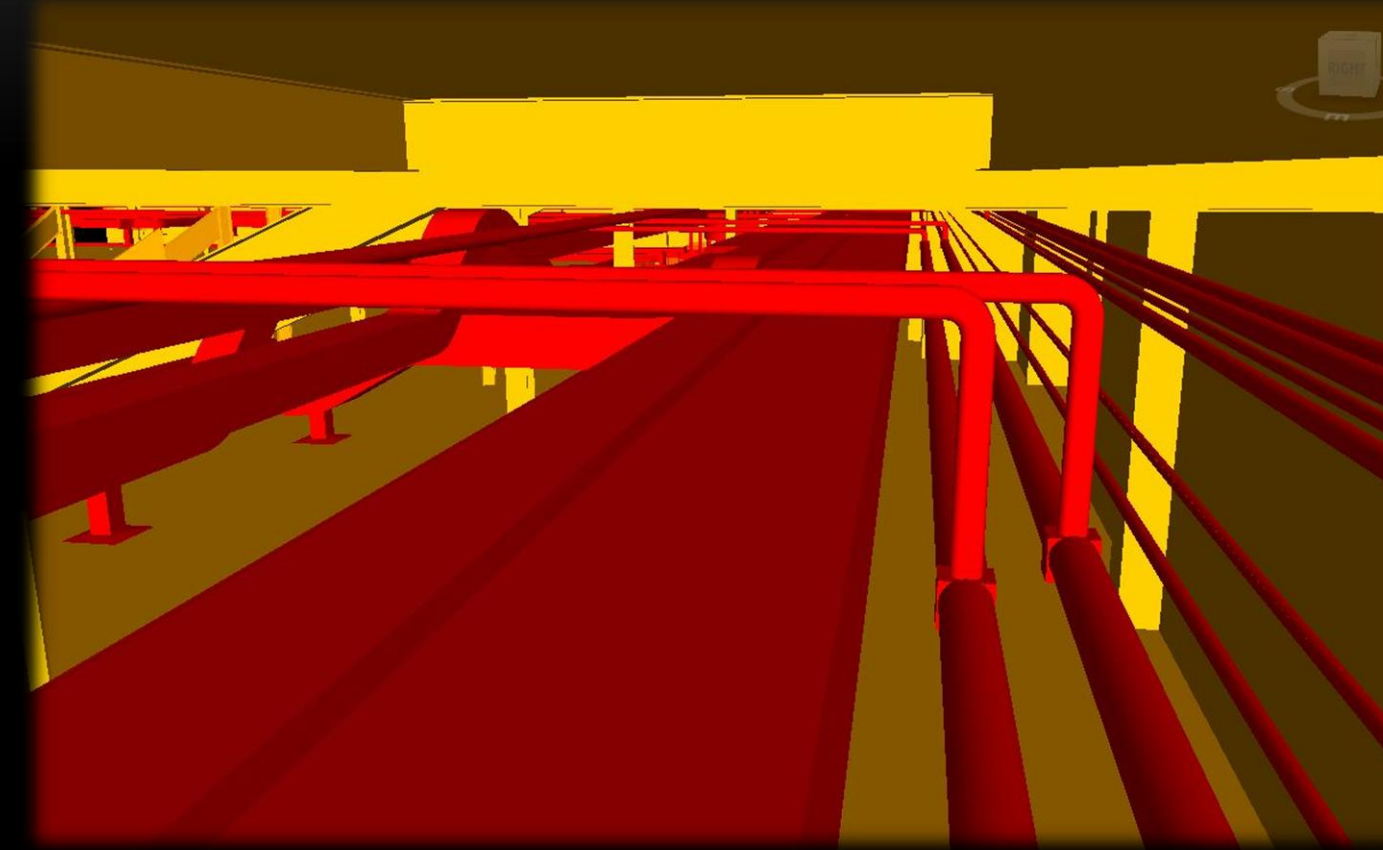


Alex Schreffler



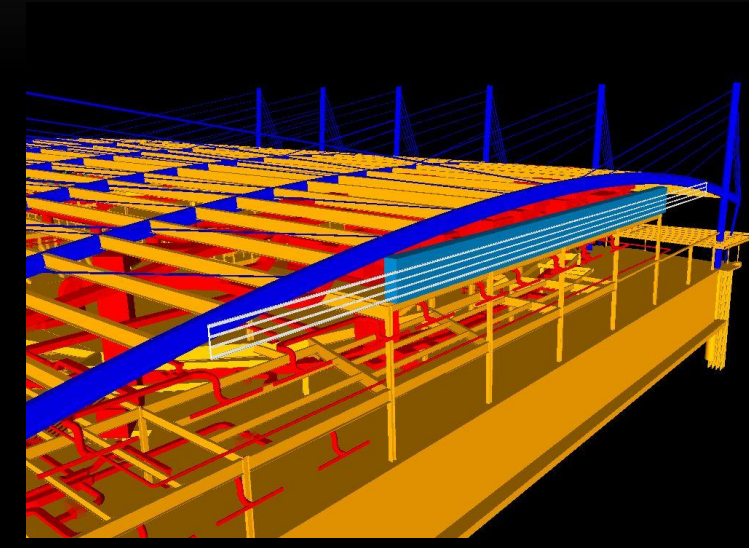
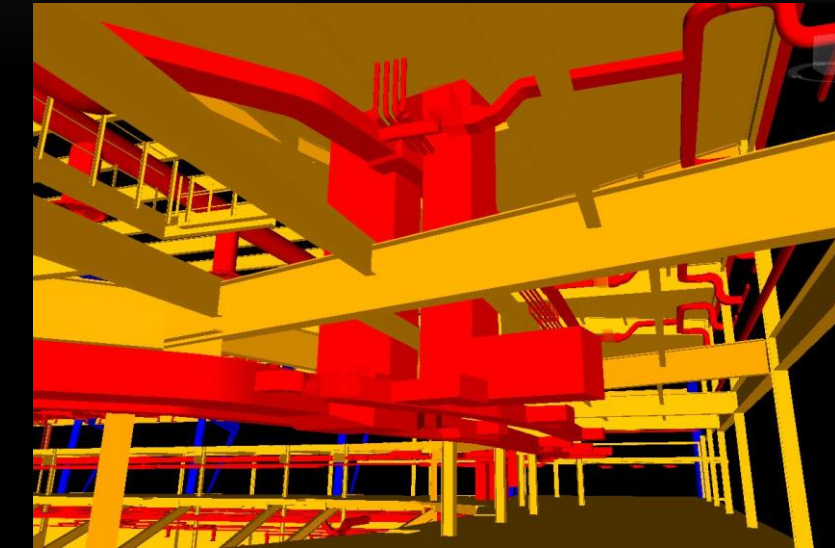
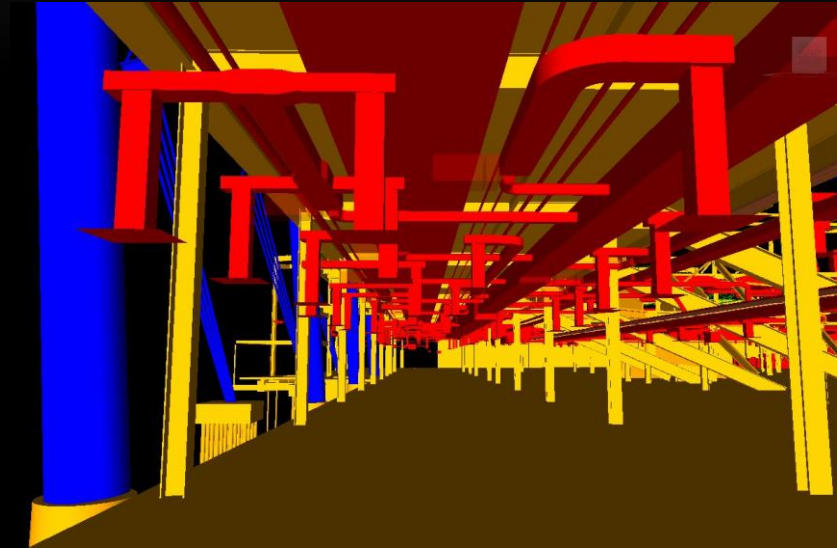
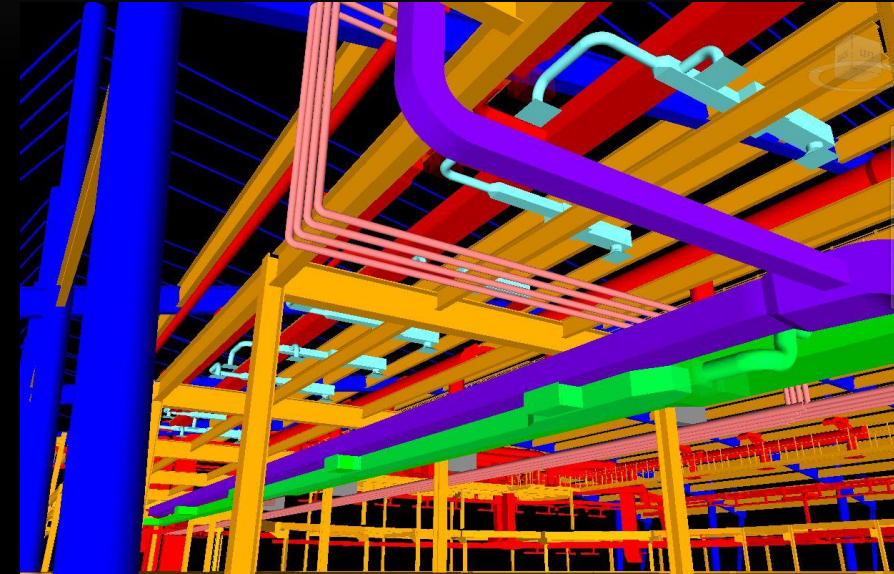
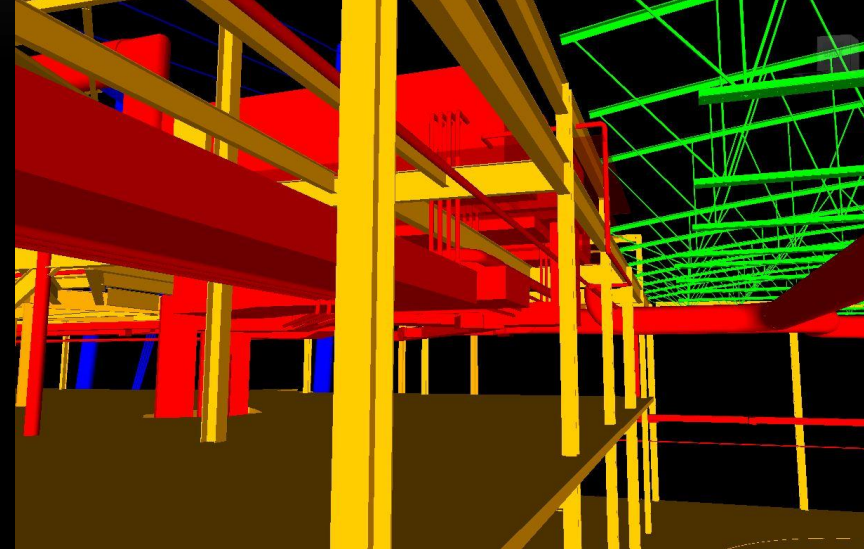
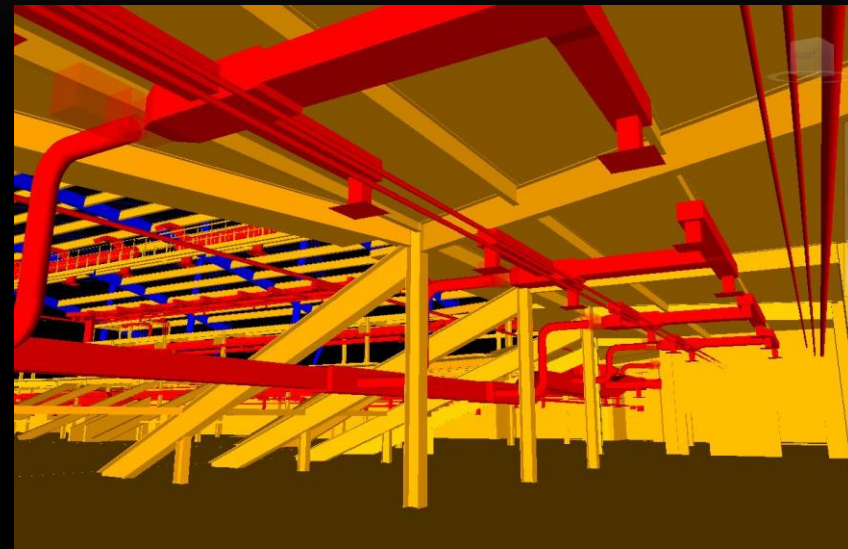


# ENGINEERING COORDINATION





# ENGINEERING COORDINATION





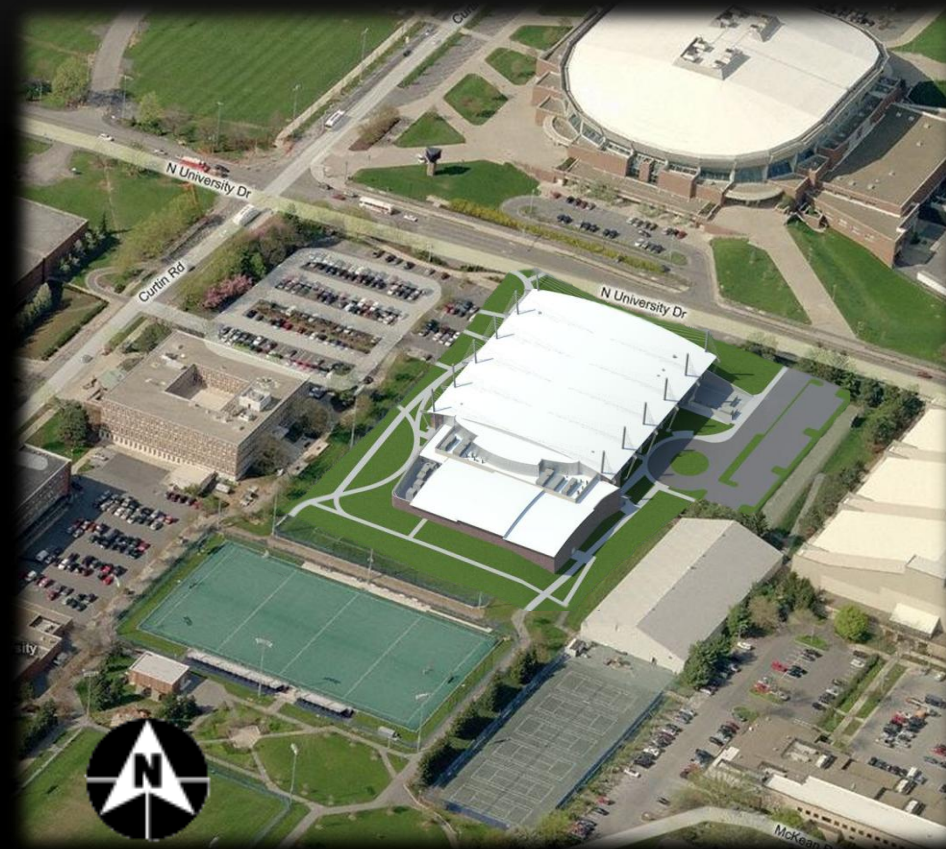
# REFLECTIONS

Collaboration = IMPORTANT

Missing Architect?

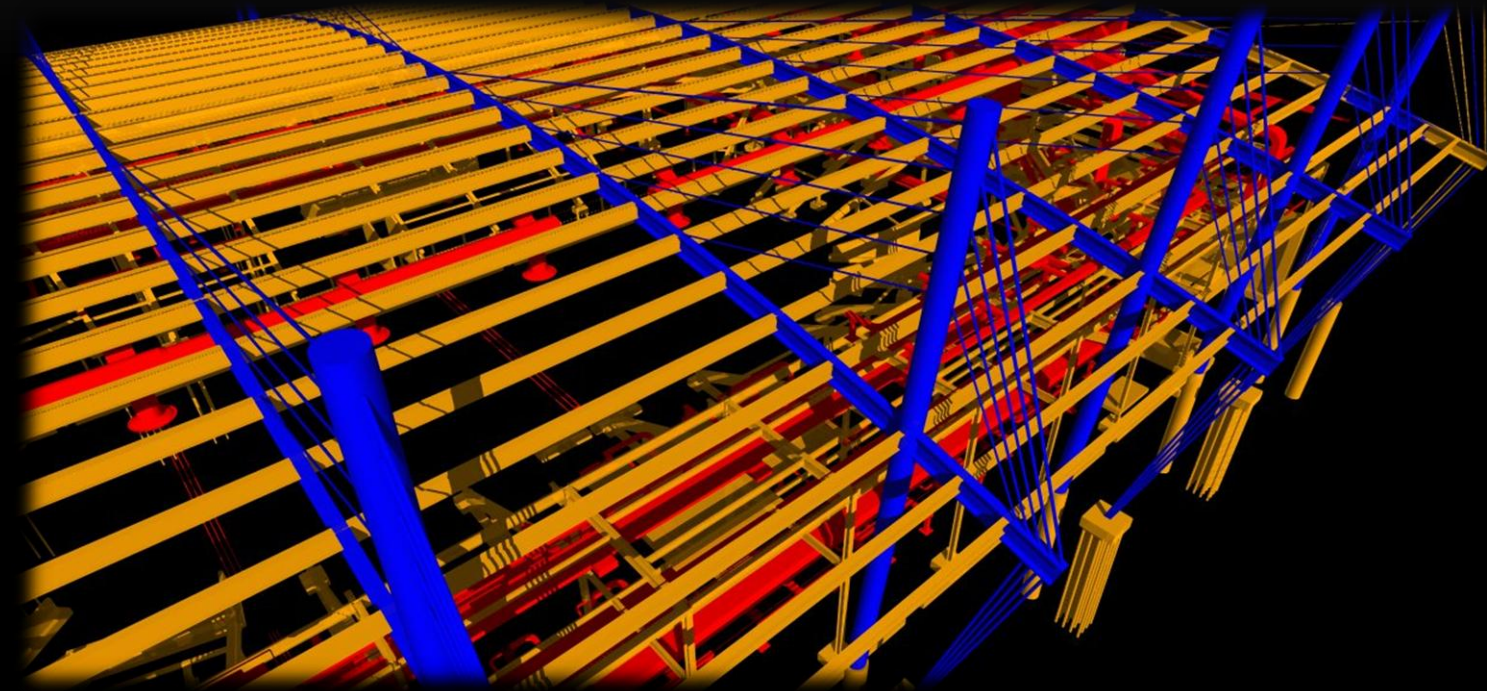
Design Challenge

Construction Benefits





## ROOF REDESIGN CONCLUSION



Long Span Challenge

Iterations

Foundation Investigation

Construction/Manufacturer Involvement

IMPROVEMENTS NECESSARY





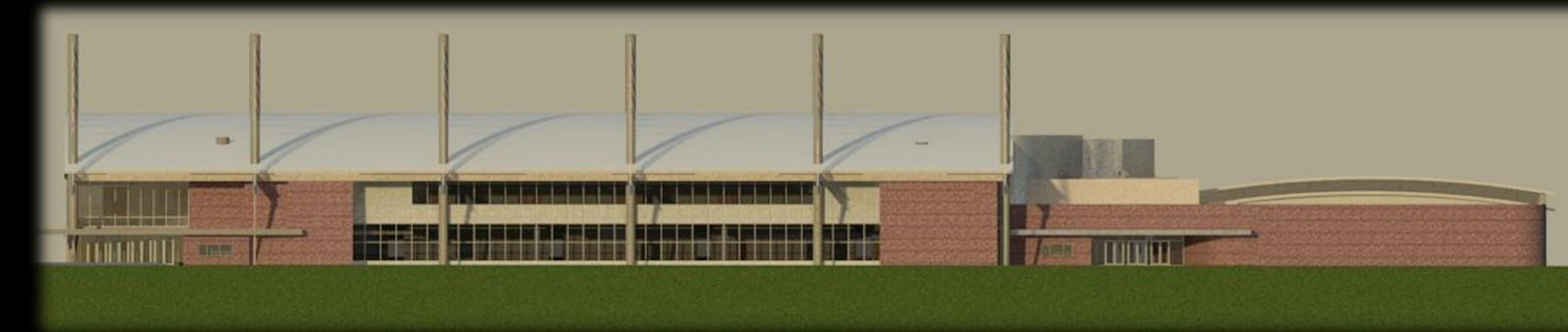
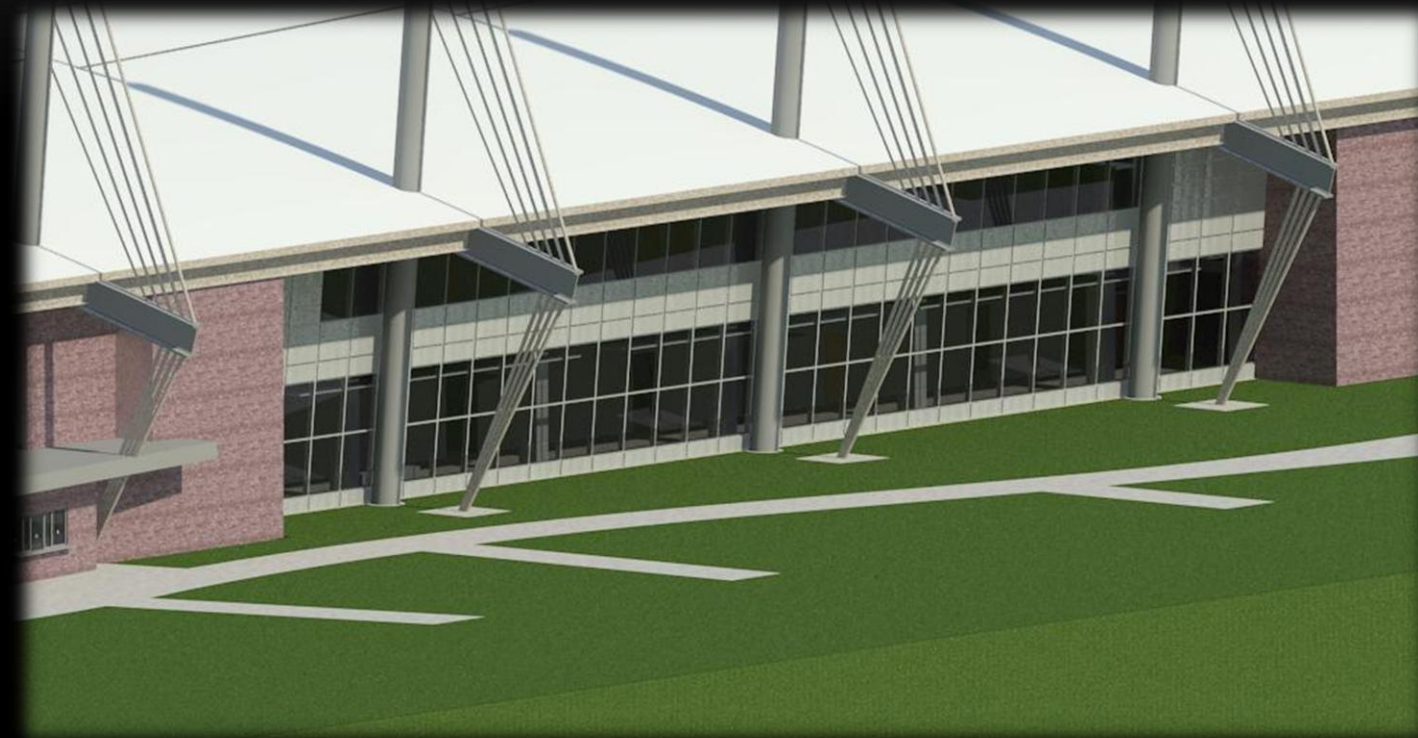
## FAÇADE CONCLUSIONS

Architectural Necessity

Concourse Daylighting

Minimal Energy Impact

FEASIBLE





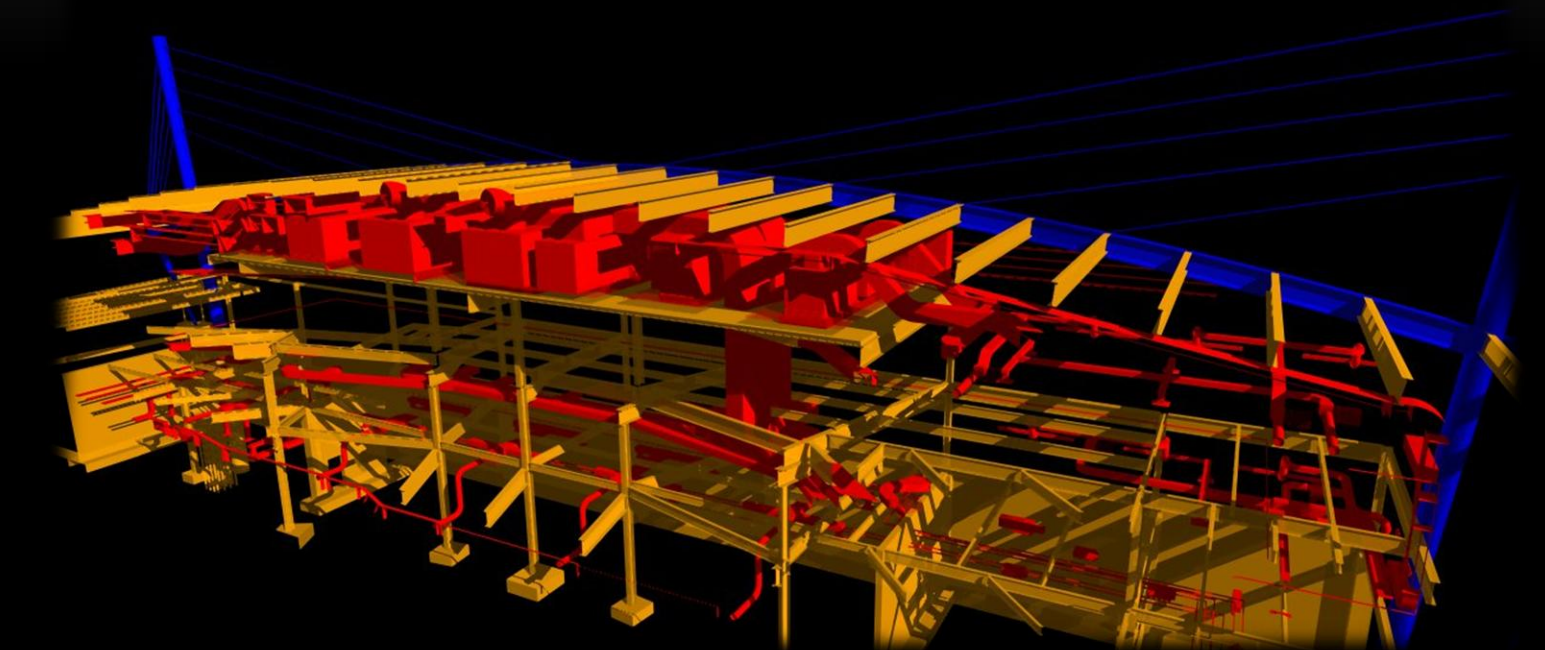
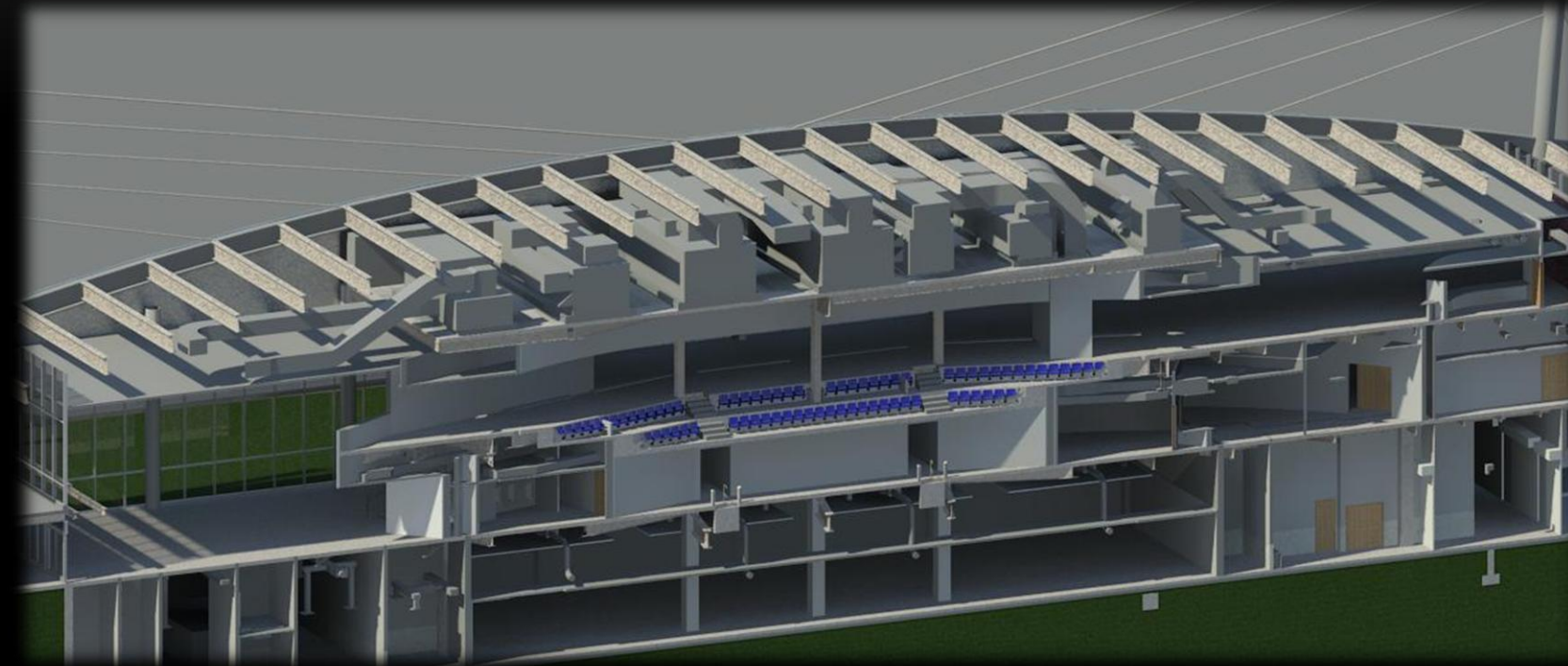
# LOFT CONCLUSIONS

Improved Mechanical Efficiency

Earlier Planning

Architectural Impact

**FEASIBLE**





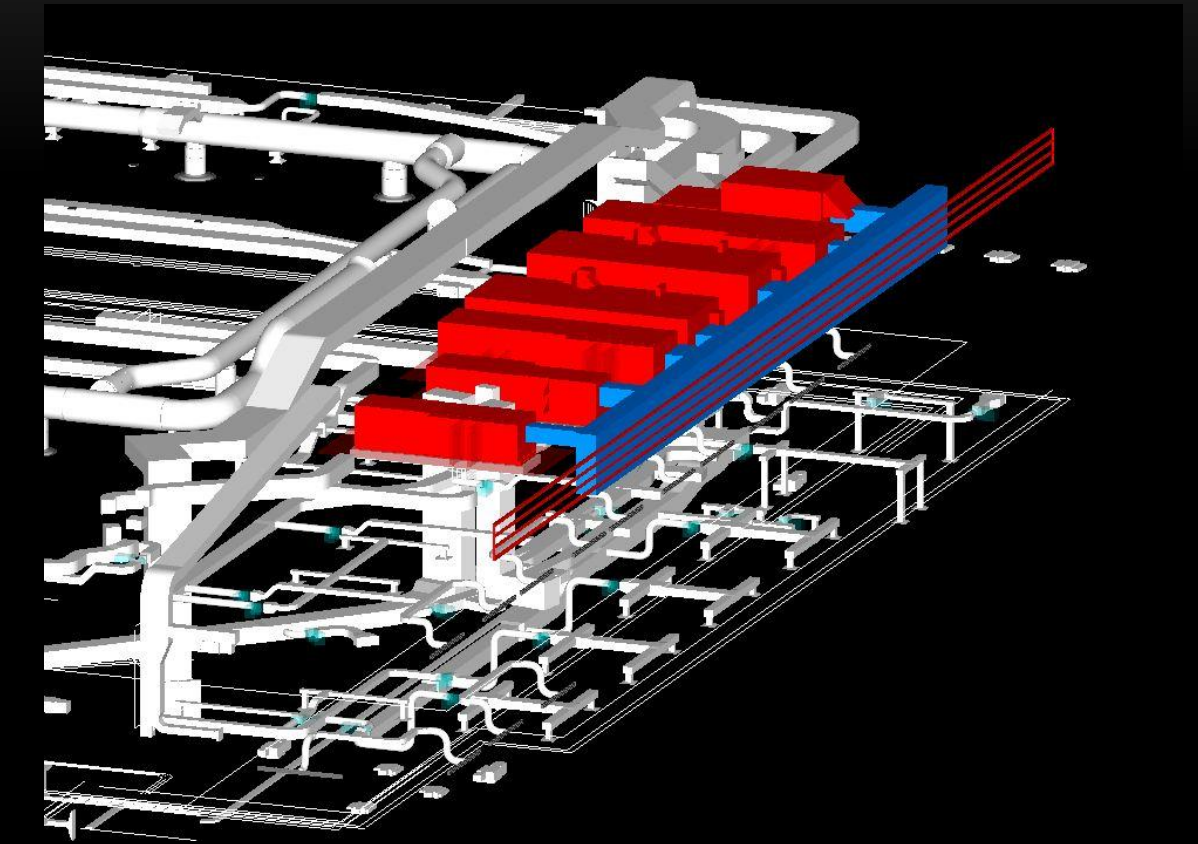
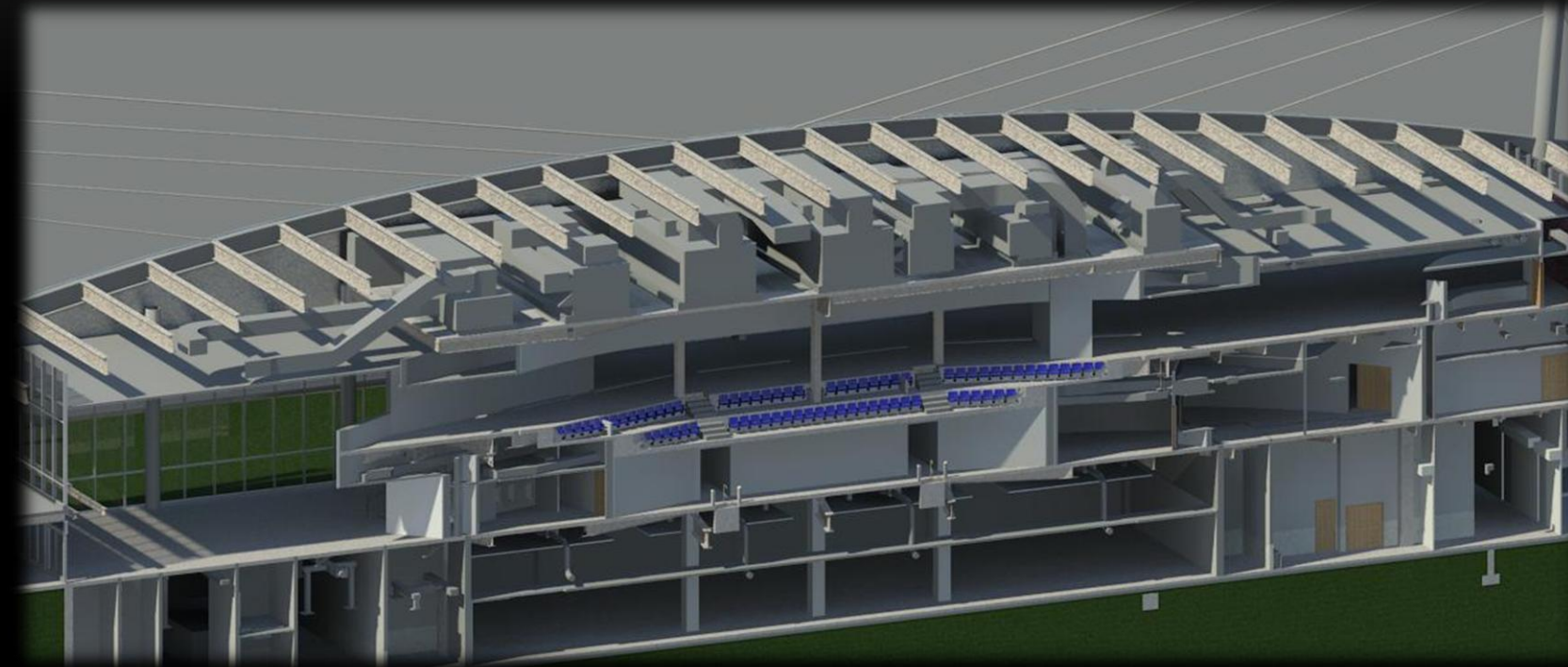
# LOFT CONCLUSIONS

Improved Mechanical Efficiency

Earlier Planning

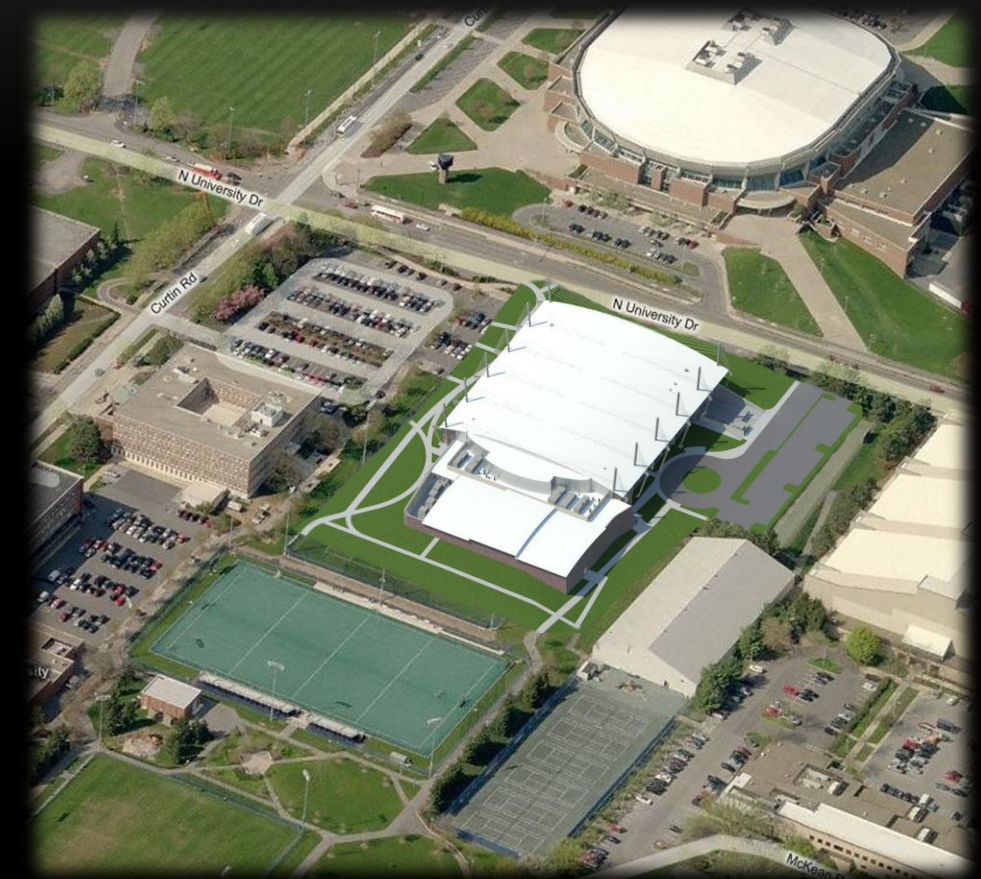
Architectural Impact

FEASIBLE





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## QUESTIONS/COMMENTS

