

Winter Presentation

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Frank Musiol, Katelin Crook, Rebecca Diaz, Seale Wong

Owners: Erik Kneer, Hossein Nasseri

Professor: Renate Fruchter

Date: March 11, 2011

Island Team



Architecture

Site Conditions

Prevailing Winds:

NE Trade Winds

Basic Design Wind Speed:

145 mph

Seismic:

Site Classification D

Average Temp:

Max - 86° F

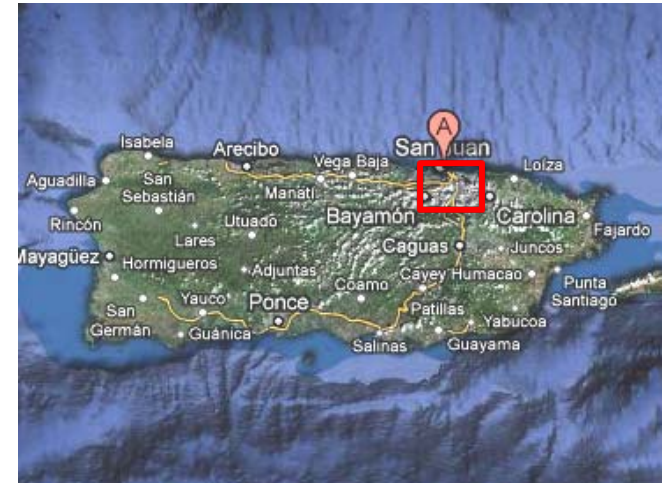
Min - 66.9° F

Average Sunlight:

8 hours per day

1,466 BTU/sqft/day

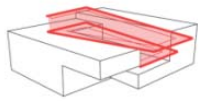
Precipitation: 60-90" annual



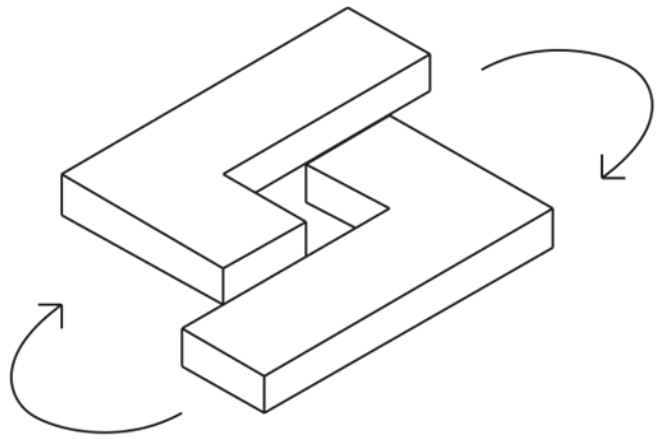
Architecture

Site Location, University of Puerto Rico

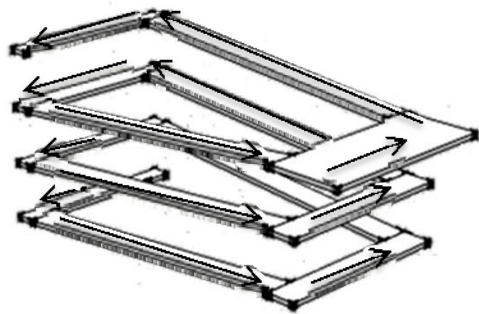
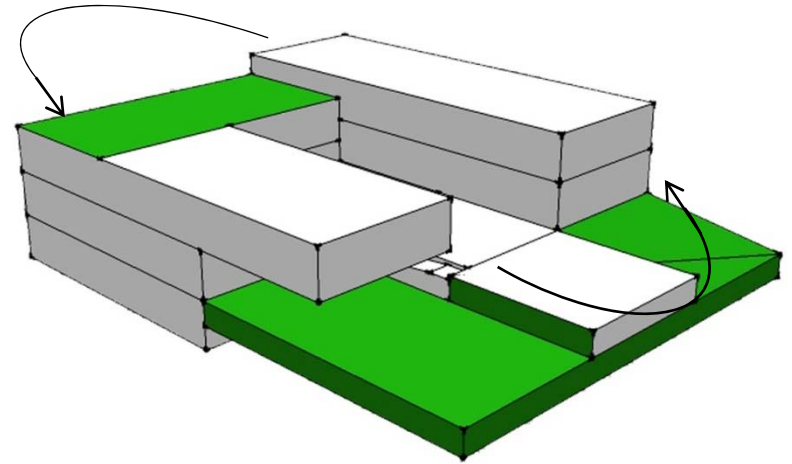




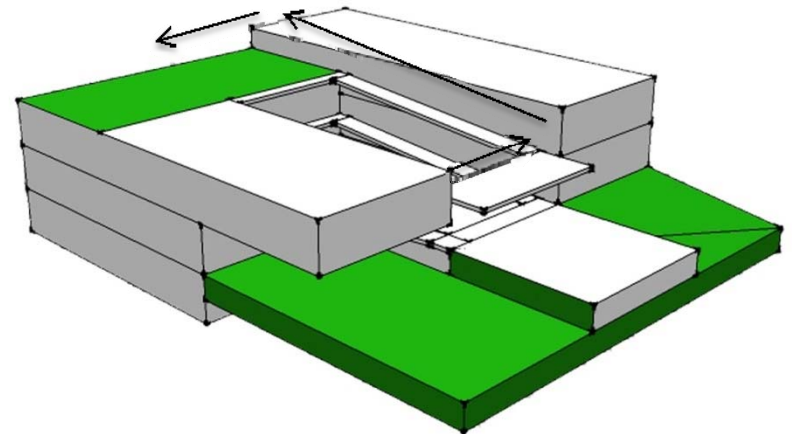
Hurricane Concept

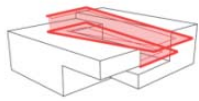


Shape



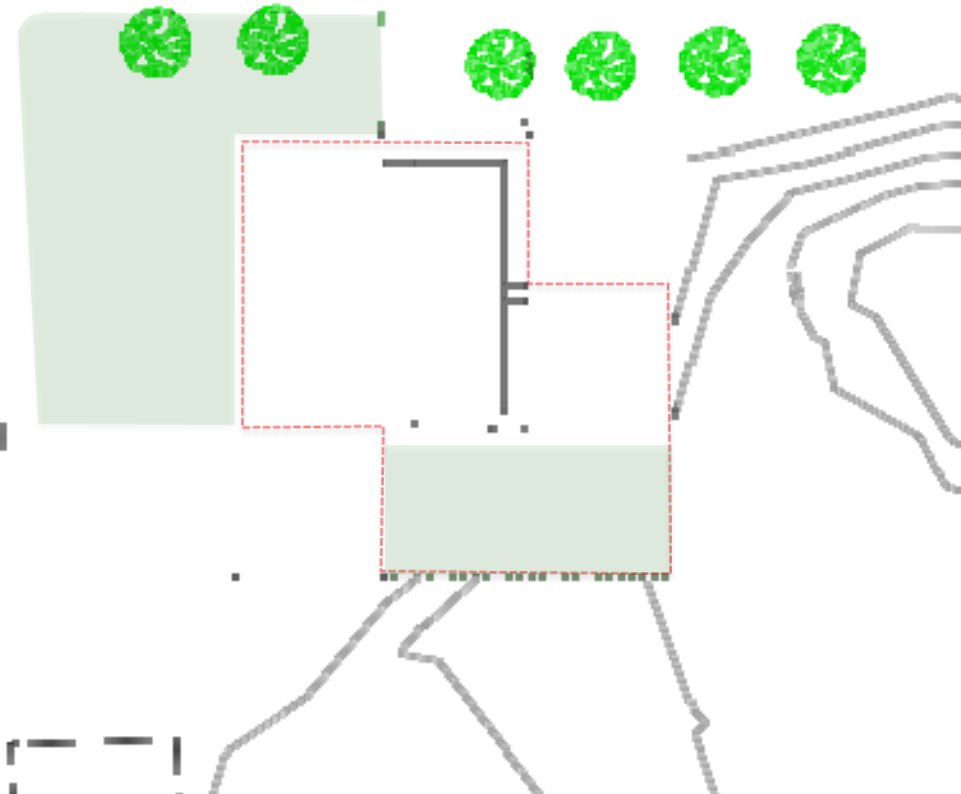
Circulation

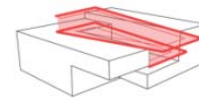




Student Center

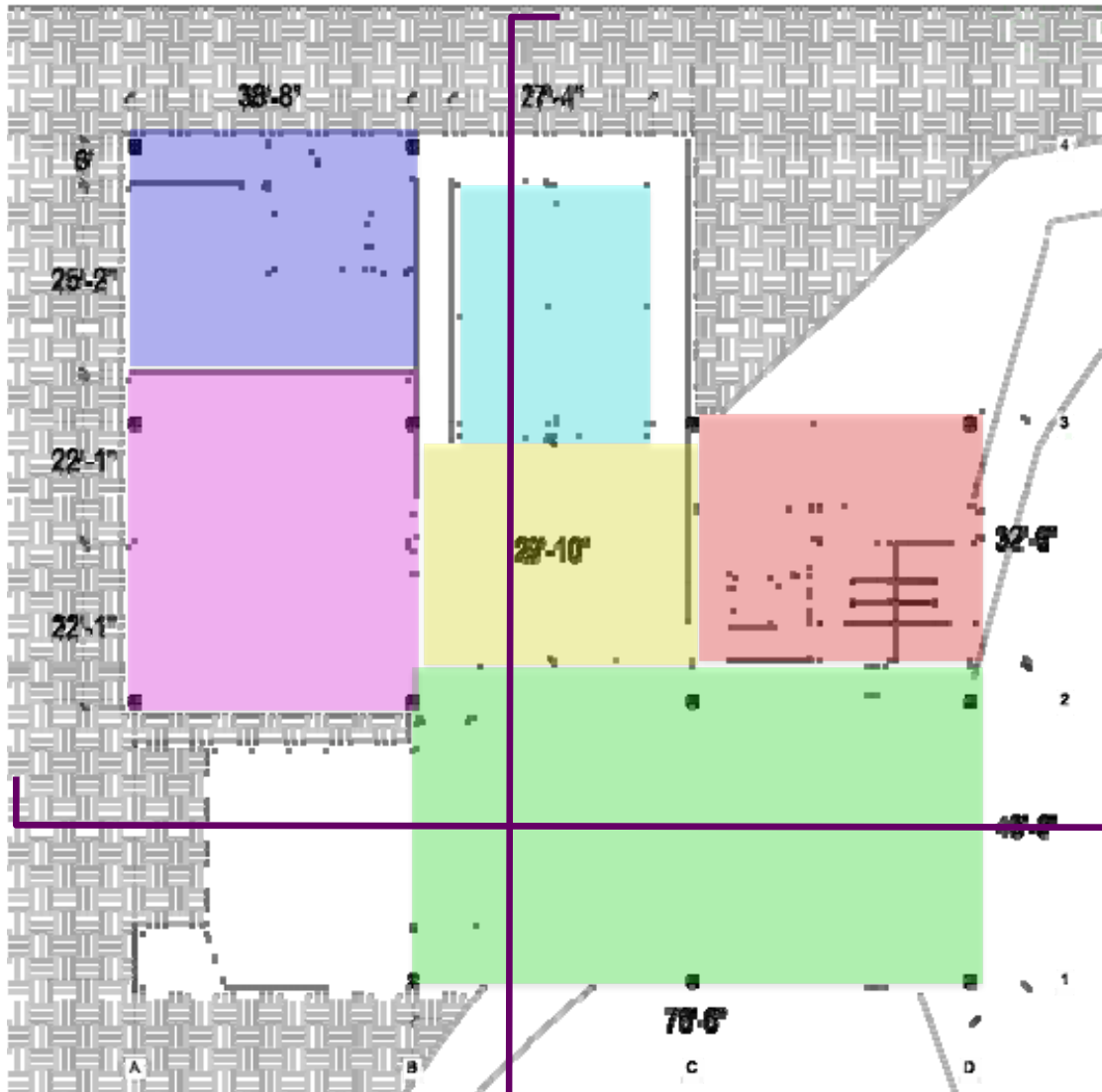
University Avenue

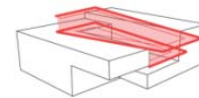




Basement Floor Plan

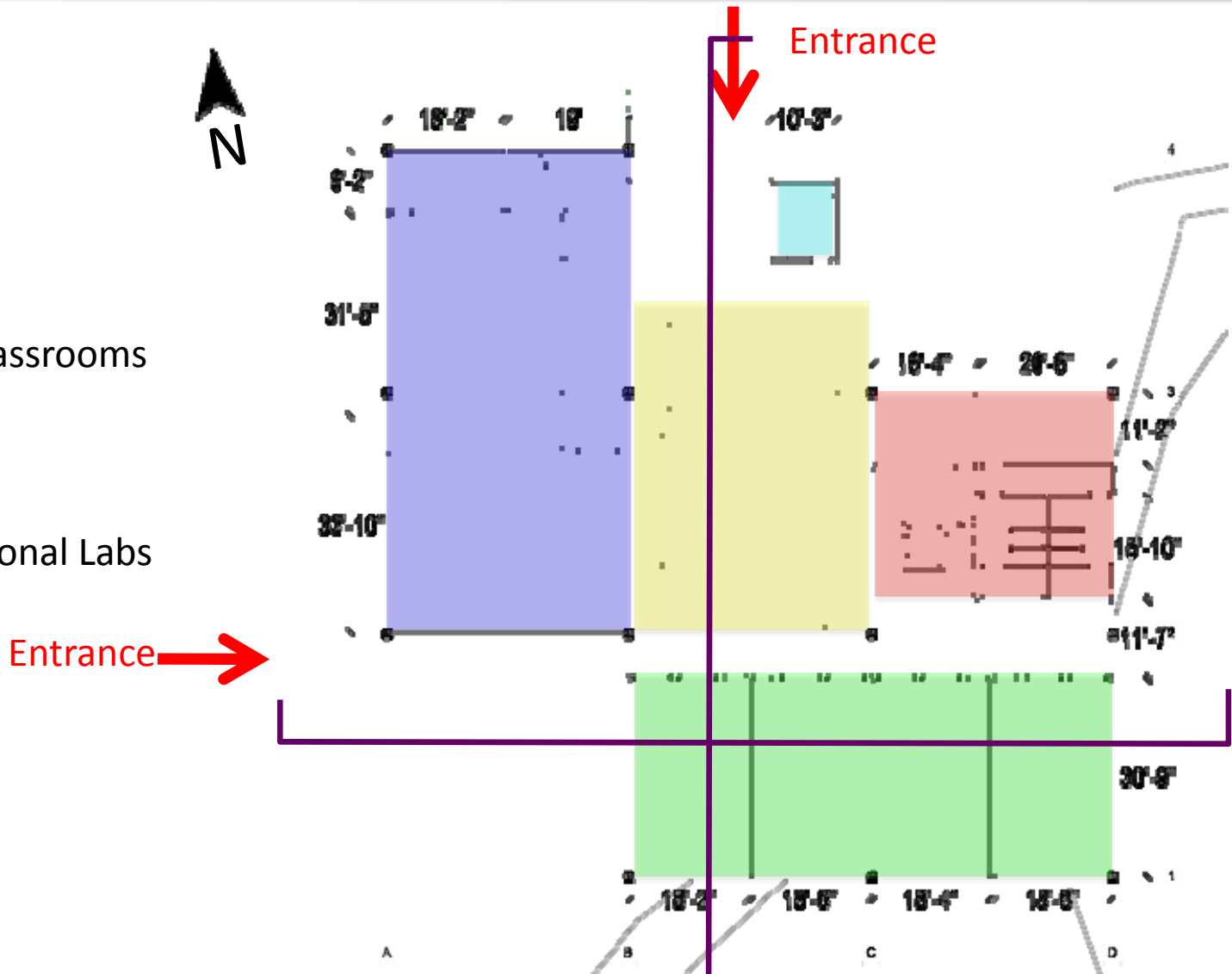
- Core
- Atrium
- Auditorium
- Seminar Rooms
- Server Room an Tech
- Large Classrooms

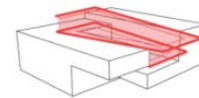




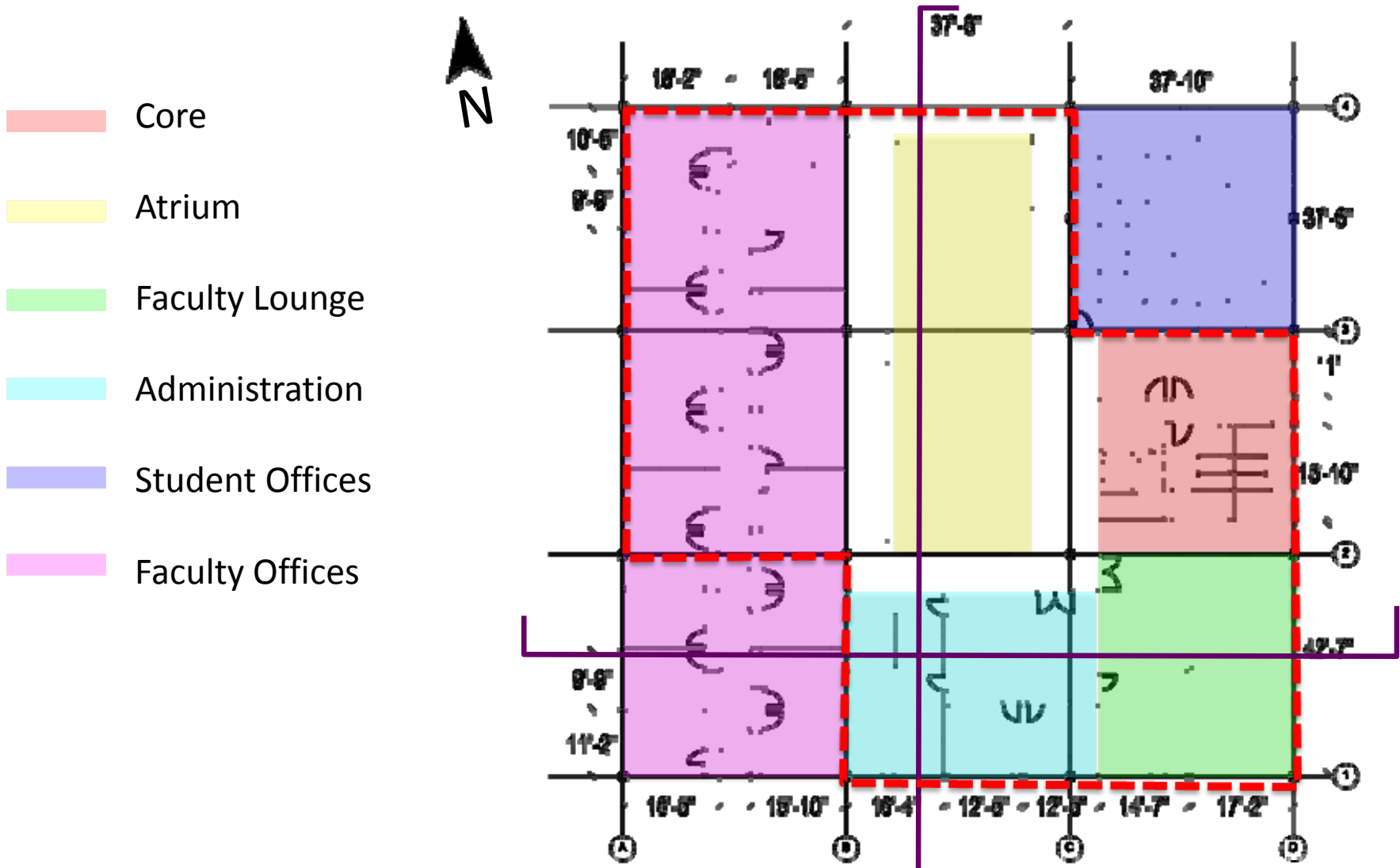
First Floor Plan

- Core
- Atrium
- Small Classrooms
- Café
- Instructional Labs

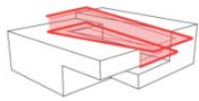




Second Floor Plan

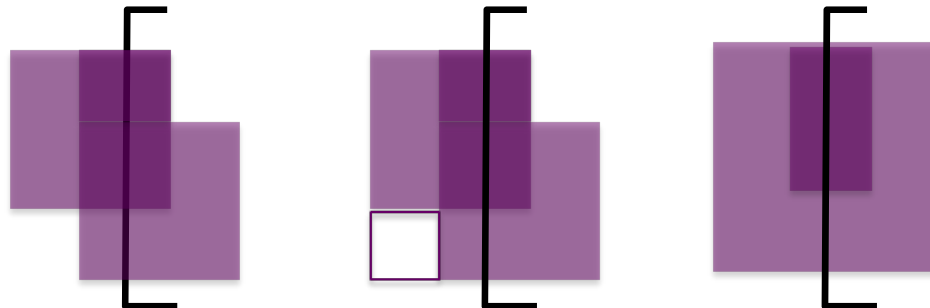


Architecture

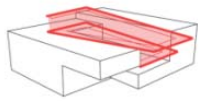


Section North to South, through Atrium

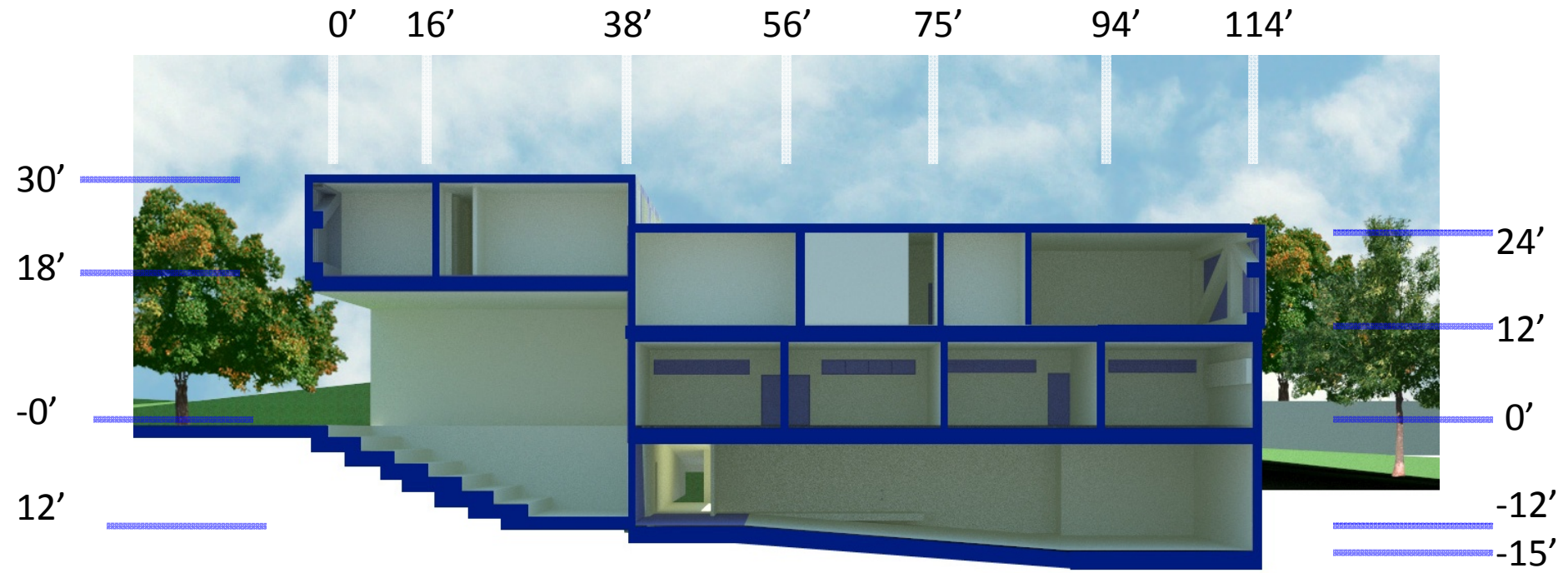
-7' 0' 11' 27' 40' 76' 83' 114'



Architecture

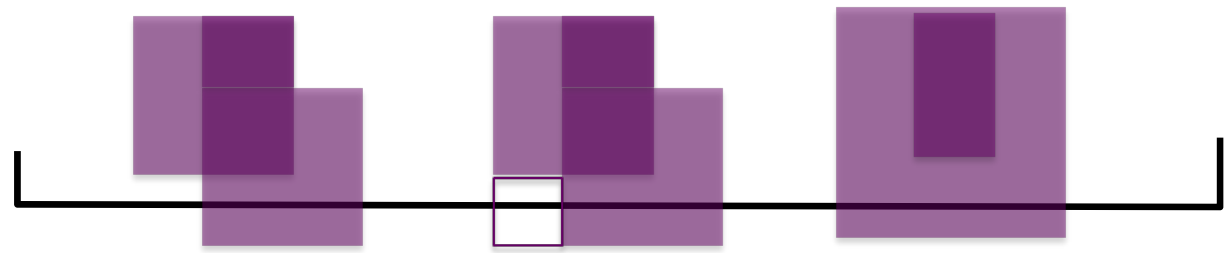


Section West to East, through Auditorium

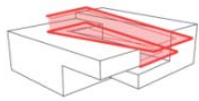


W

E

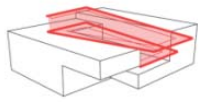


Architecture

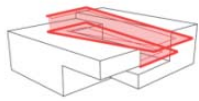


Axonometric View, North East Facade



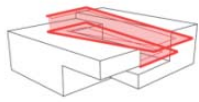


Architecture



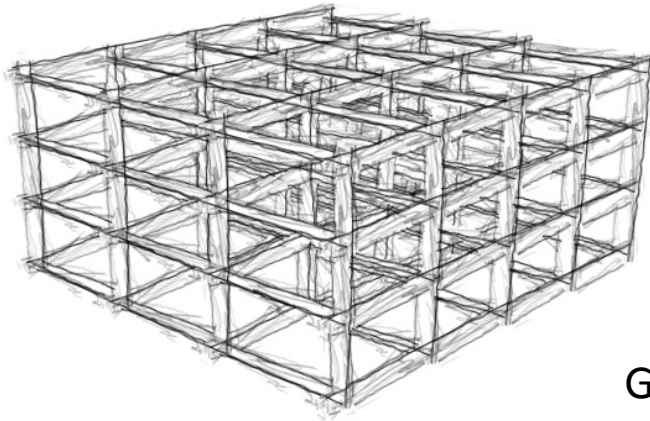
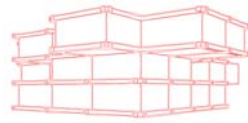
South West corner, view from the back road



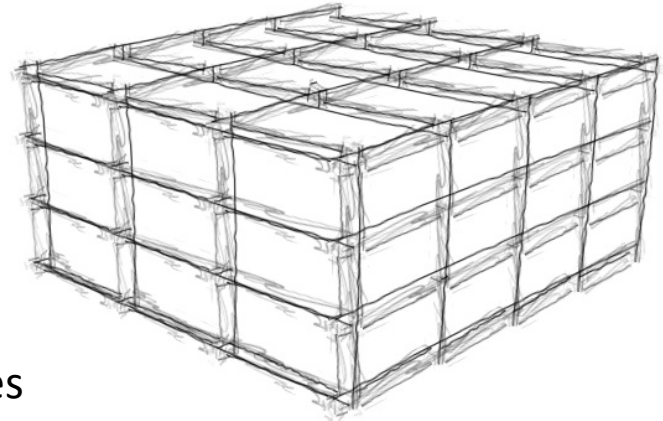


South West corner, Exterior Area

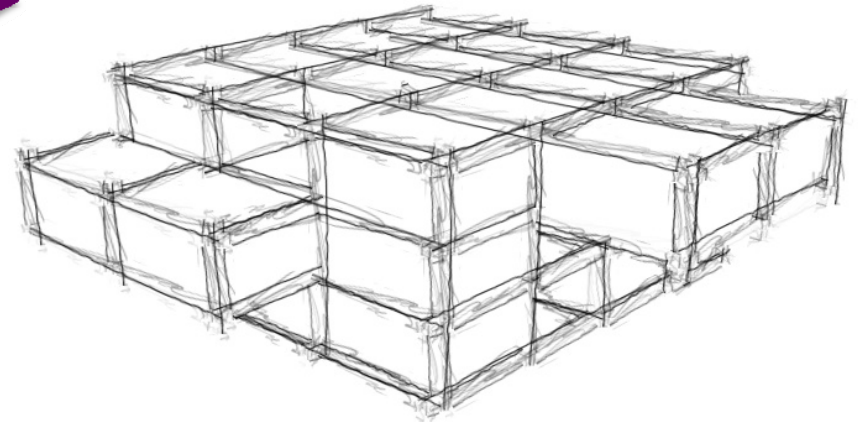
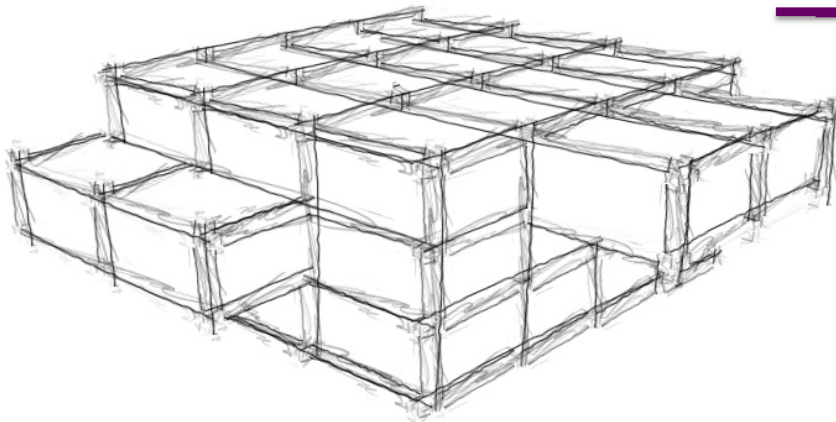


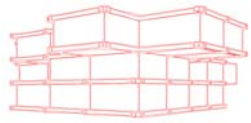


Grid & Modules



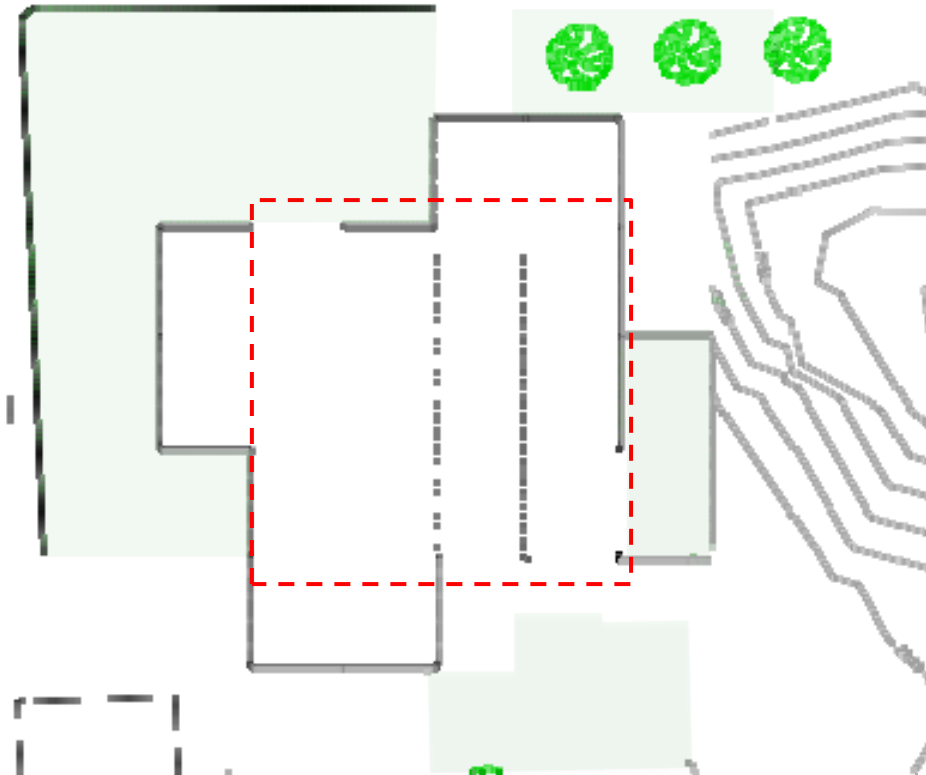
Cantilever & Open Spaces





University Avenue

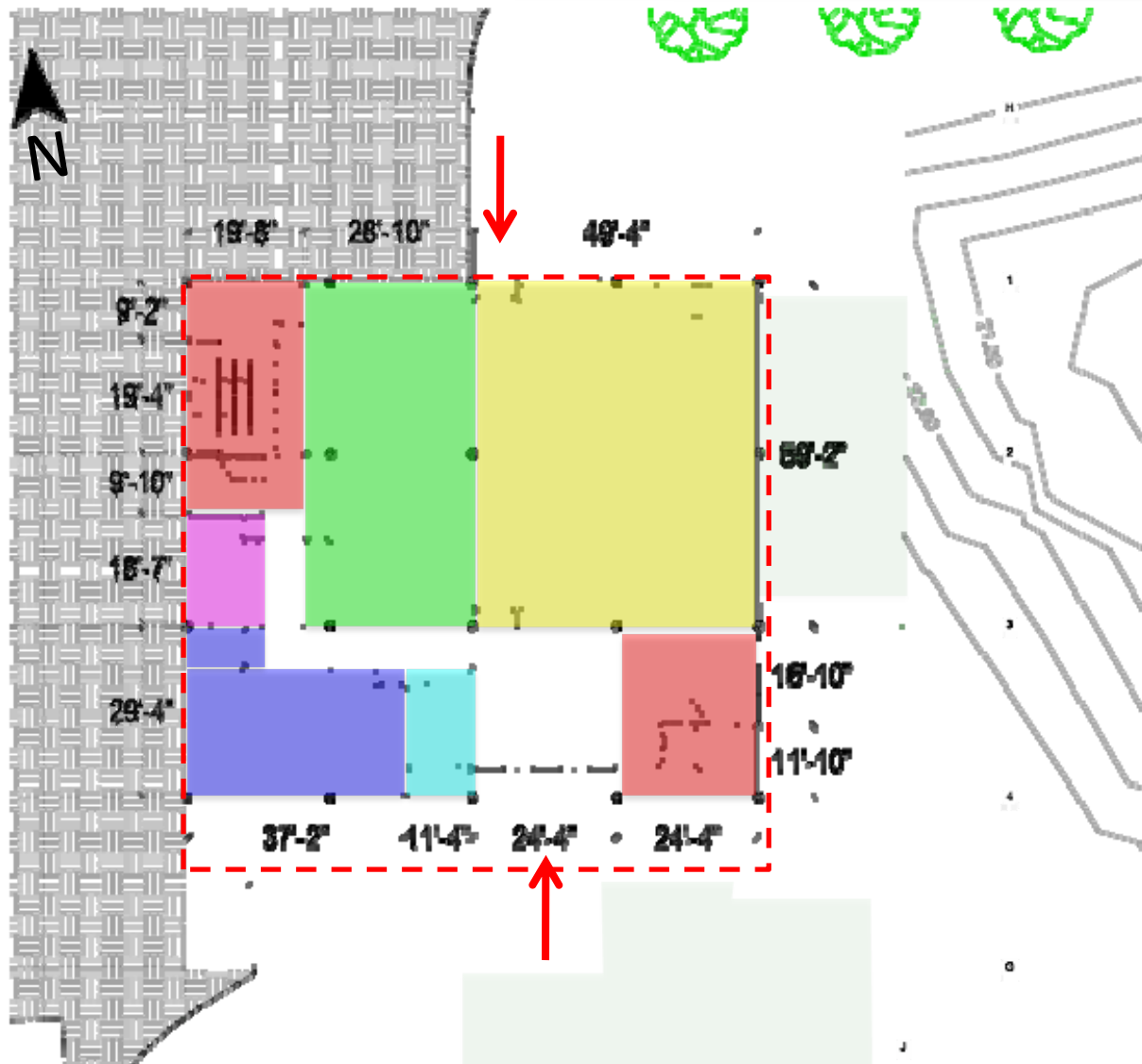
Student Center





Basement Floor Plan

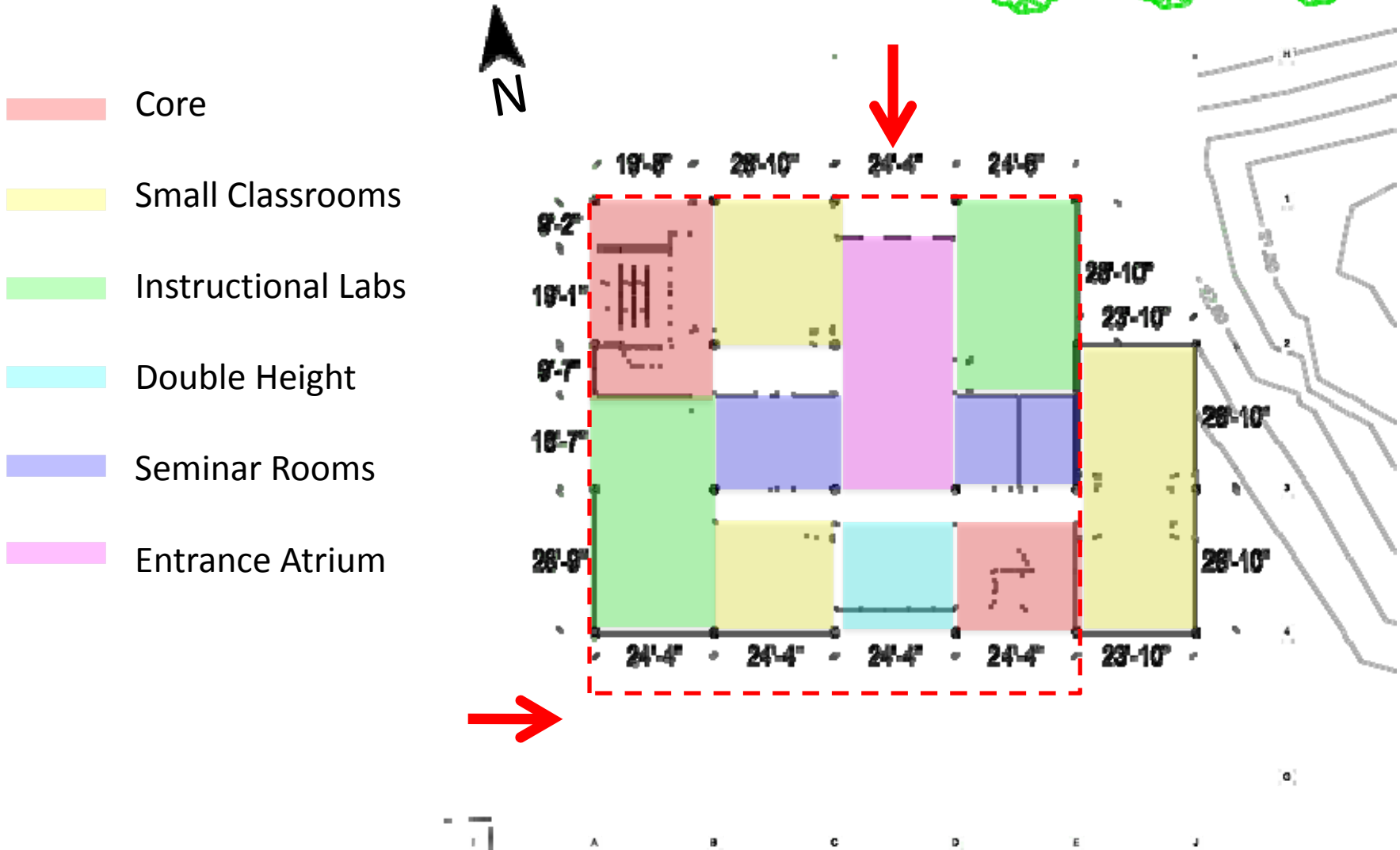
- Core
- Auditorium
- Large Classrooms
- Café
- Server Room
- Tech Support

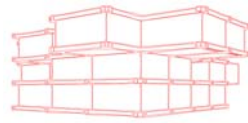


Architecture

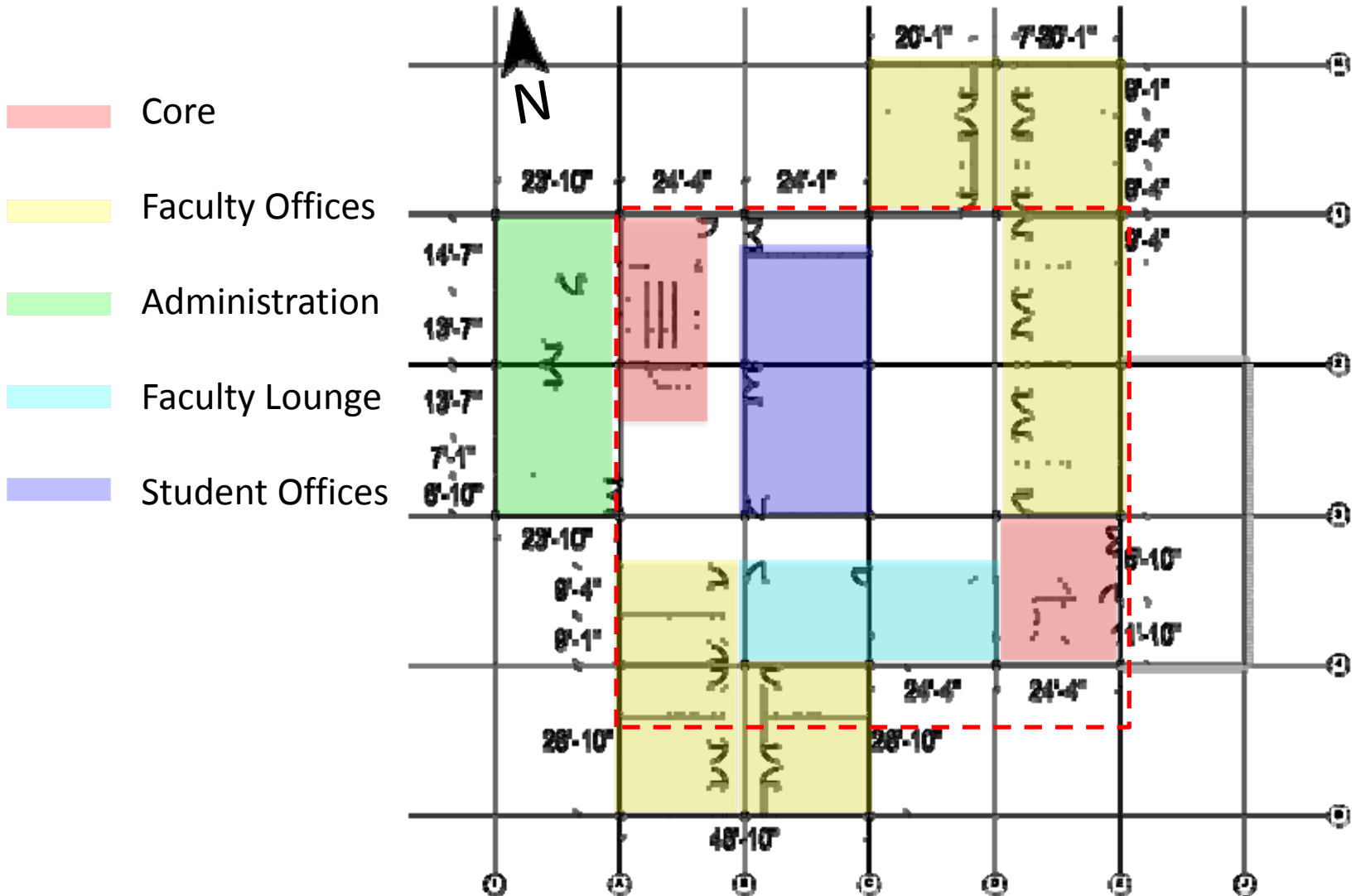


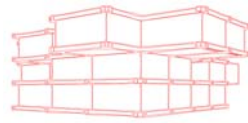
First Floor Plan



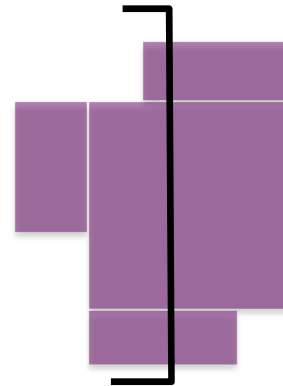
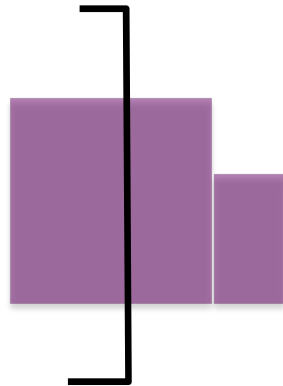
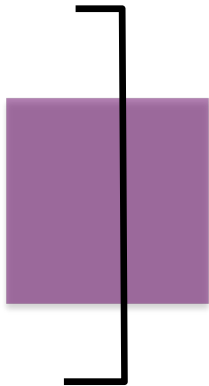


Second Floor Plan

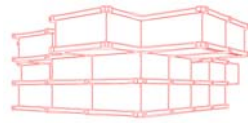




-30' 0' 5' 30' 60' 80' 90' 120'

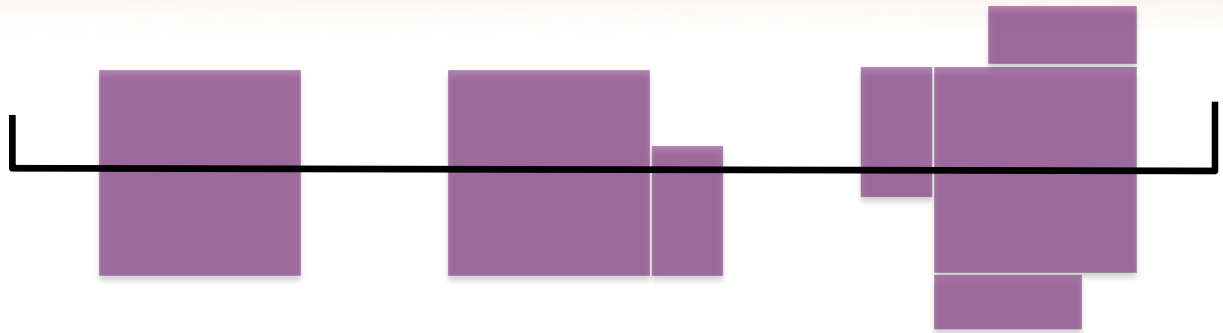


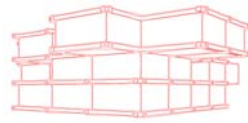
Architecture

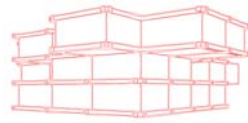


Section

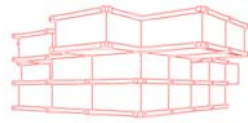
-25' 0' 25' 50' 75' 100' 125'







Architecture



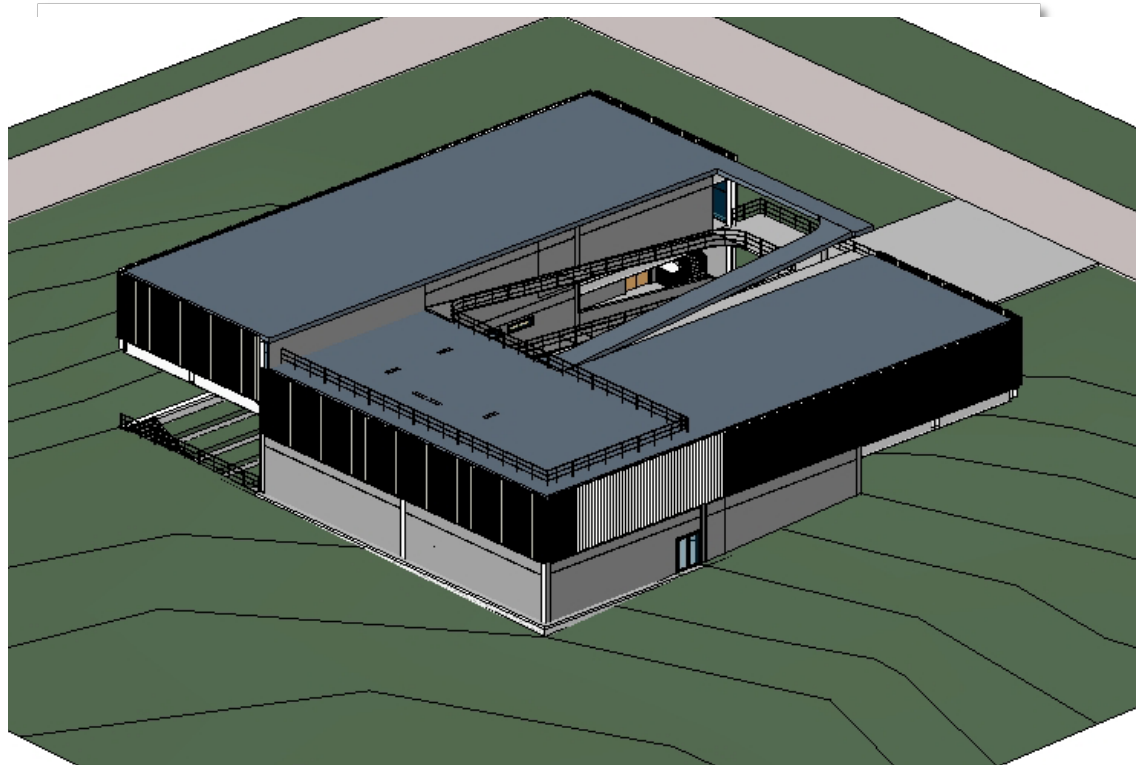
Central Atrium View (looking south)



Hurricane- Steel Solution- Design Loads

Dead	Roof	65	psf
	Green Roof	115	psf
	Floor	85	psf
Live	Roof	20	psf
	Green Roof	20	psf
	Floor	60	psf
Seismic	Second Story	70	kip
	Roof	165	kip
Wind	Second Story	75	kip
	Roof	30	kip

Basic Wind Speed	145 mph
Base Shear	230 kip
Site Class	D
Ss=	0.852
S1=	0.279



Hurricane- Typical Member Sizes

First Story:

Fill Beam: **W18x35**

Exterior Beam/Girder: **W24x131**

Frame Beam/Girder: **W30x99**

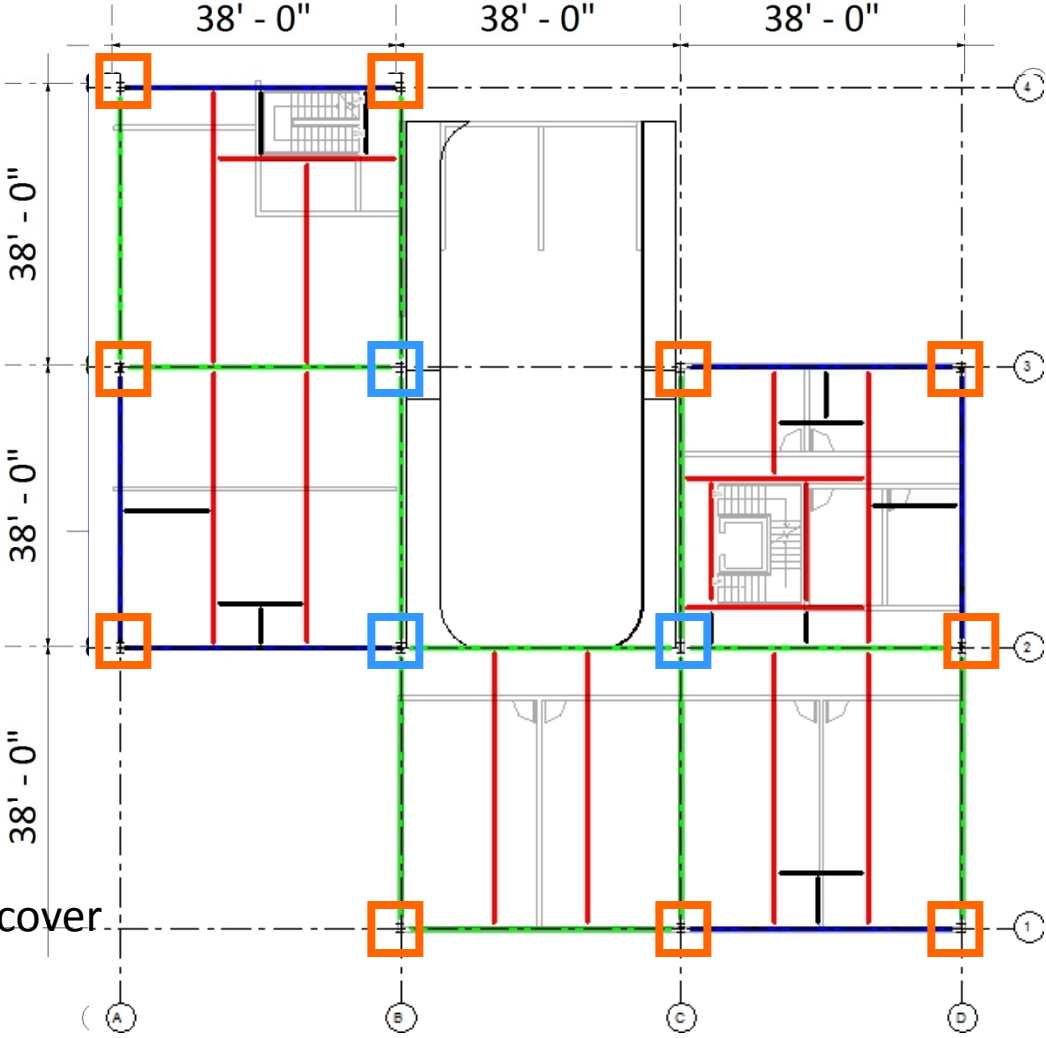
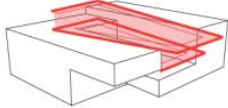
Kickers: **W12x26**

Frame/BRB Column: **W14x68**

Interior Column: **W14x74**

Composite Floor: **2VLI18**

2" Deck with 4.25" concrete cover



Hurricane- Typical Member Sizes

Second Story/Roof:

Beam 38' Span: **W18x35**

Interior Girder 38' Span: **W24x131**

Exterior Girder 38' Span: **W24x62**

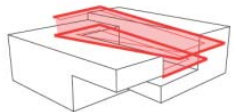
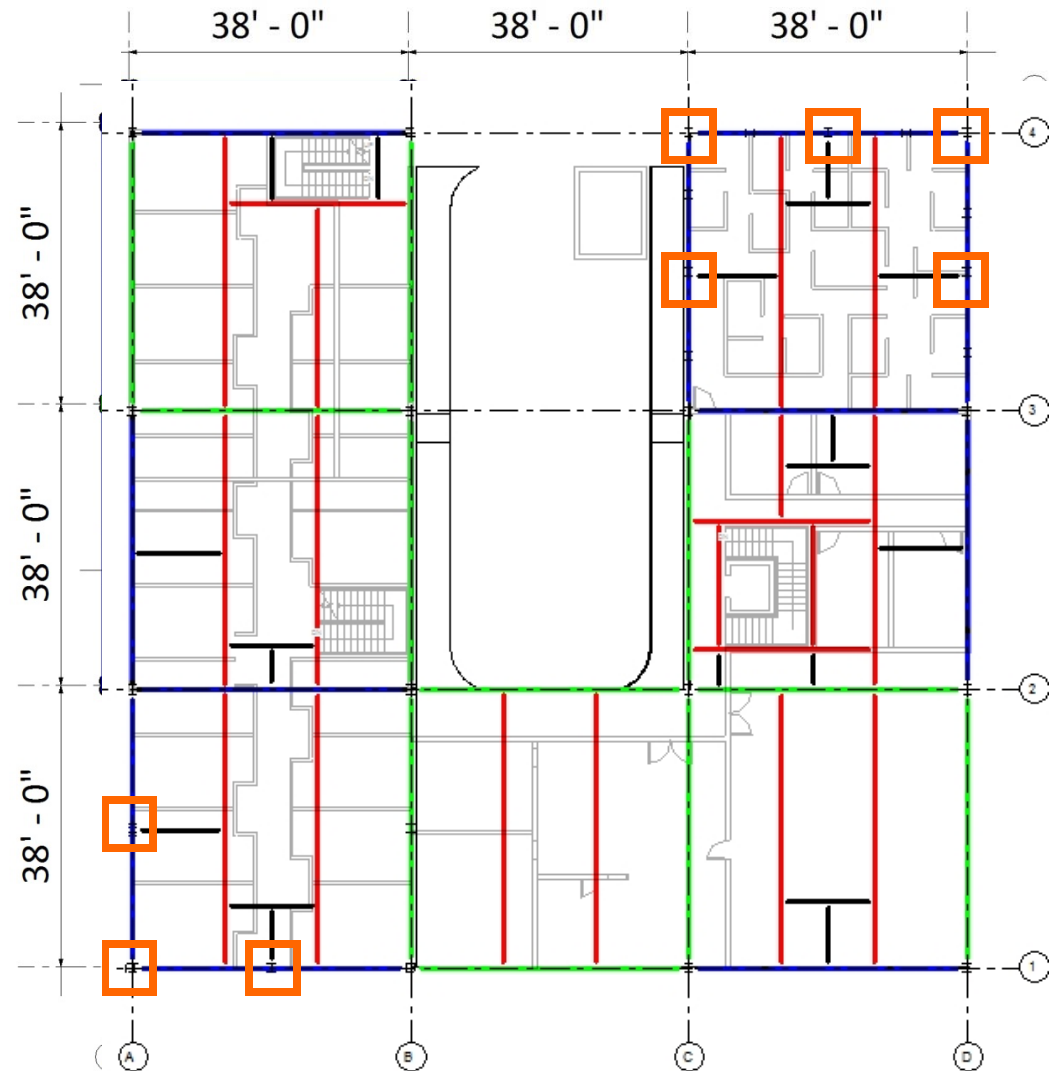
Corner Column: **W14x48**

Exterior Column: **W14x61**

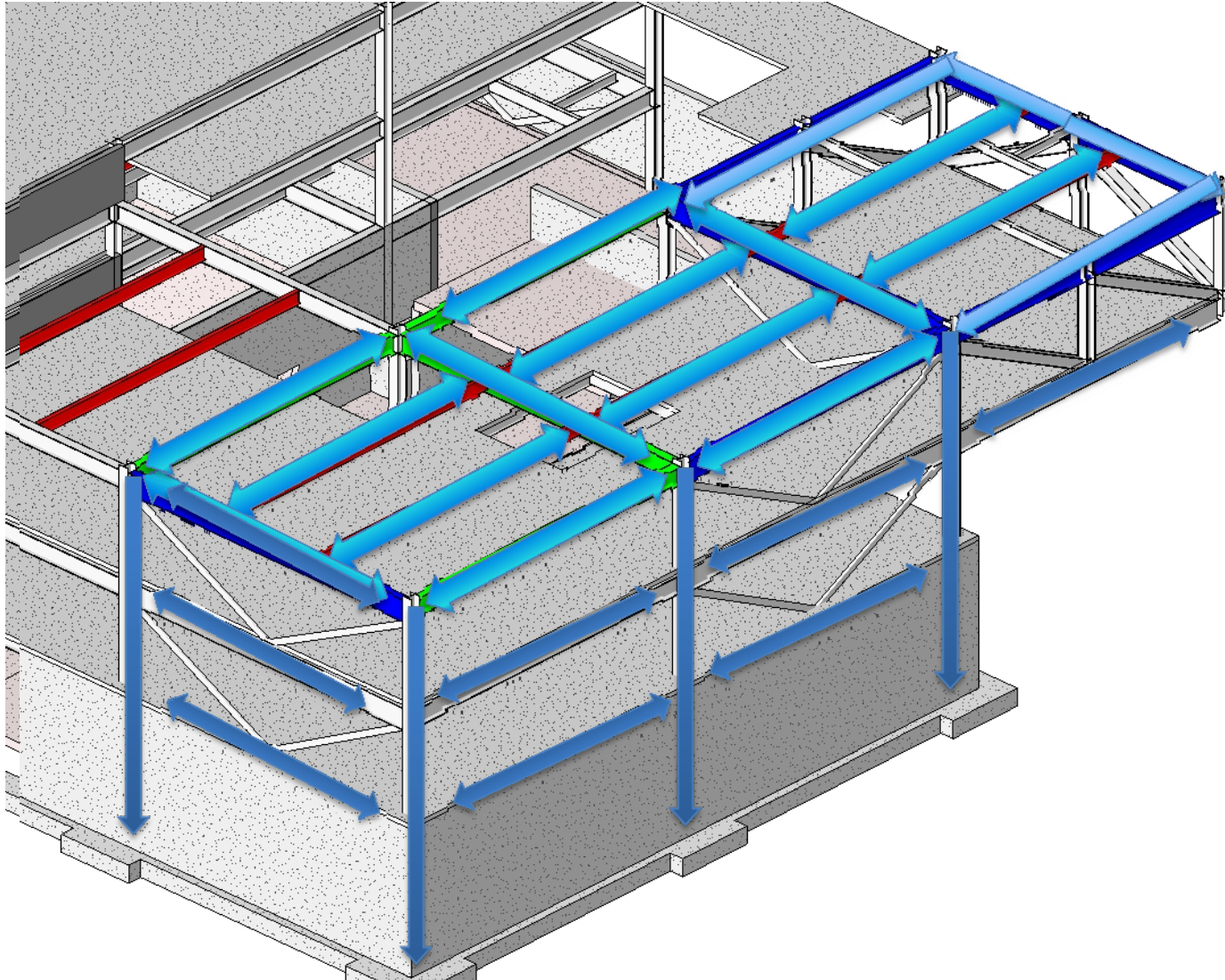
Interior Column: **W14x74**

Cantilever Beams: **W30x99**

Cantilever Columns: **W14x74**

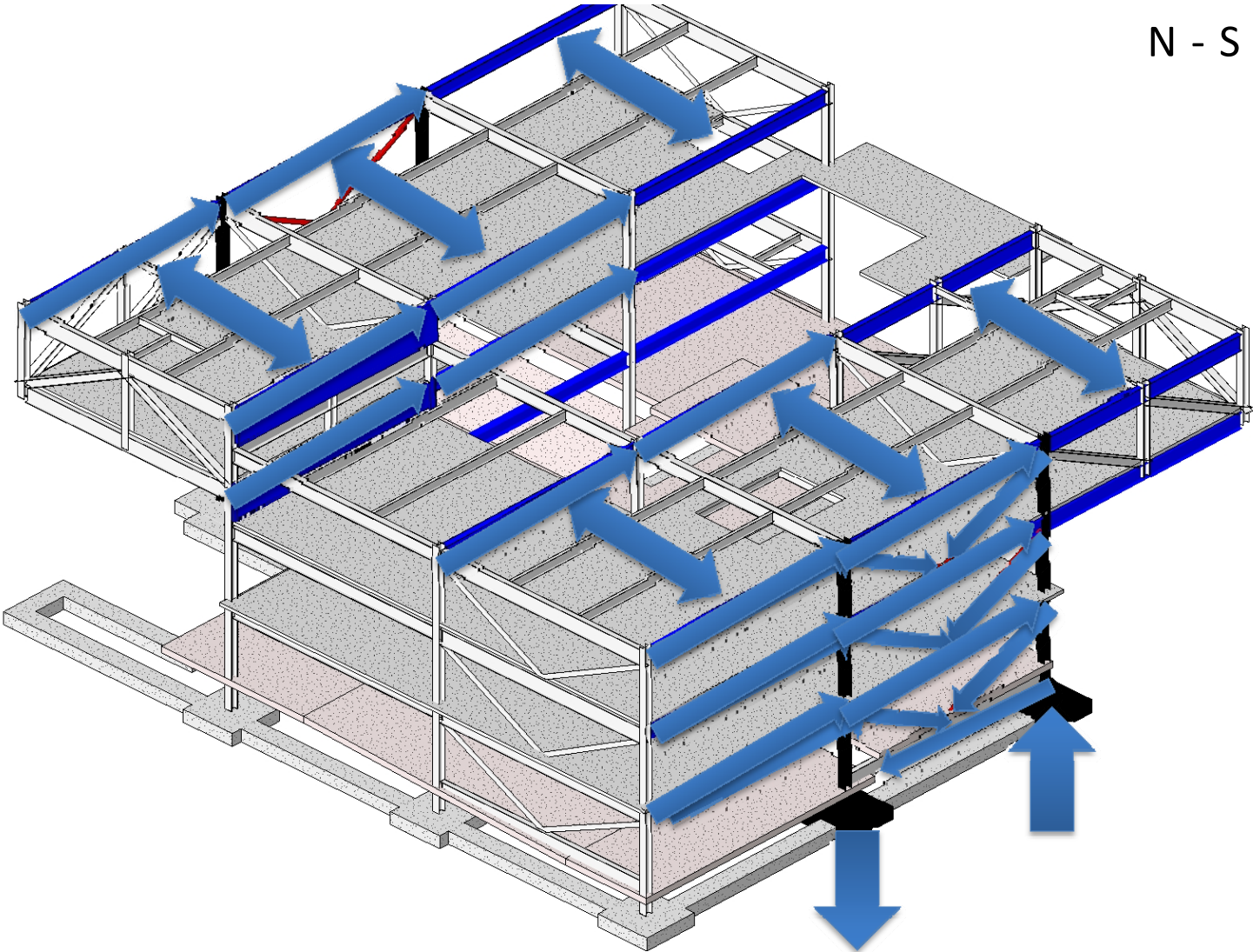


Hurricane- Gravity Load Path Diagram



Hurricane- Lateral Load Path Diagram

N - S Direction



Hurricane- Cantilever Solution

Truss Solution:

Truss Beams: **W30x99**

Truss Columns: **W14x74**

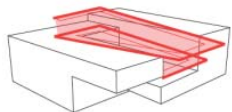
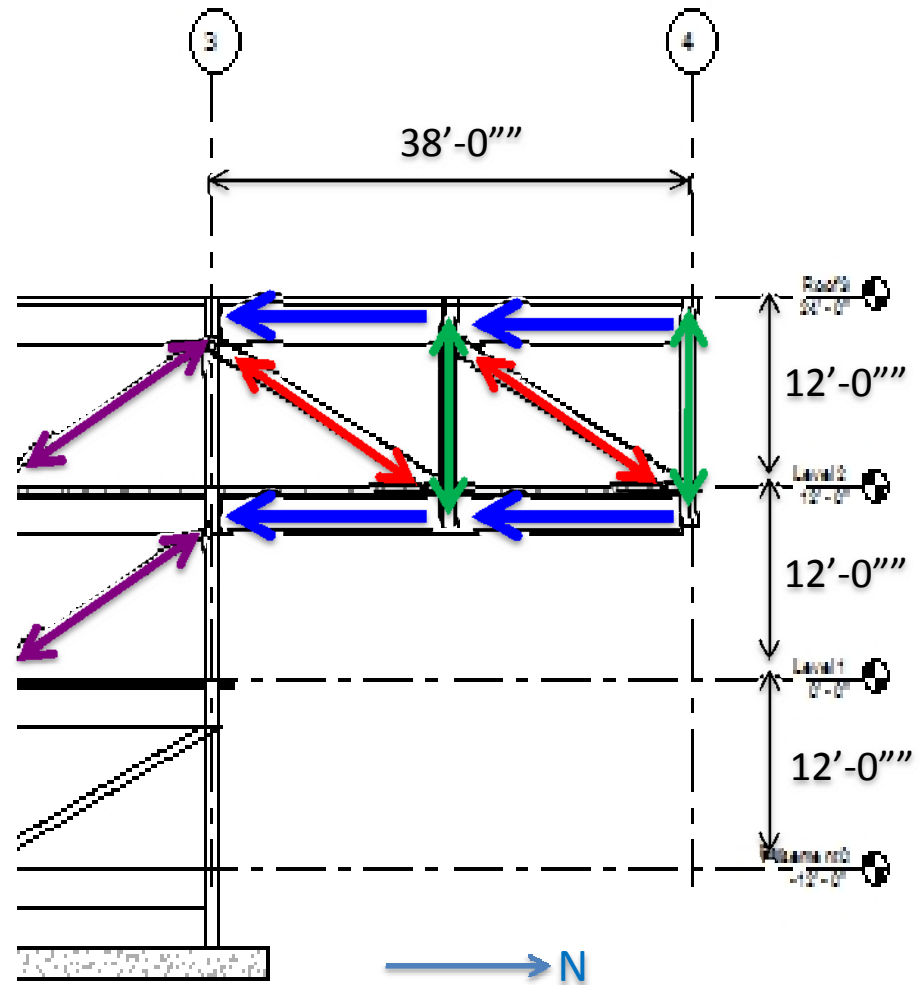
Truss Diagonals: **HSS**

6x6x5/8

Behavior:

Loads to Backspan and BRBF

Stiff Columns for Deflection



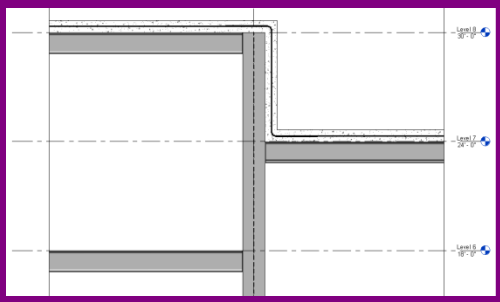
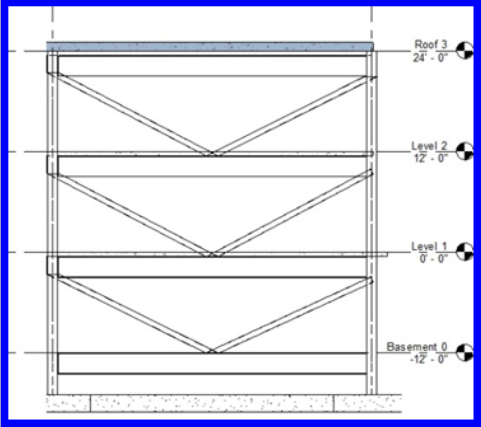
Hurricane- Lateral System

BRBFs:

Beam: W30x99

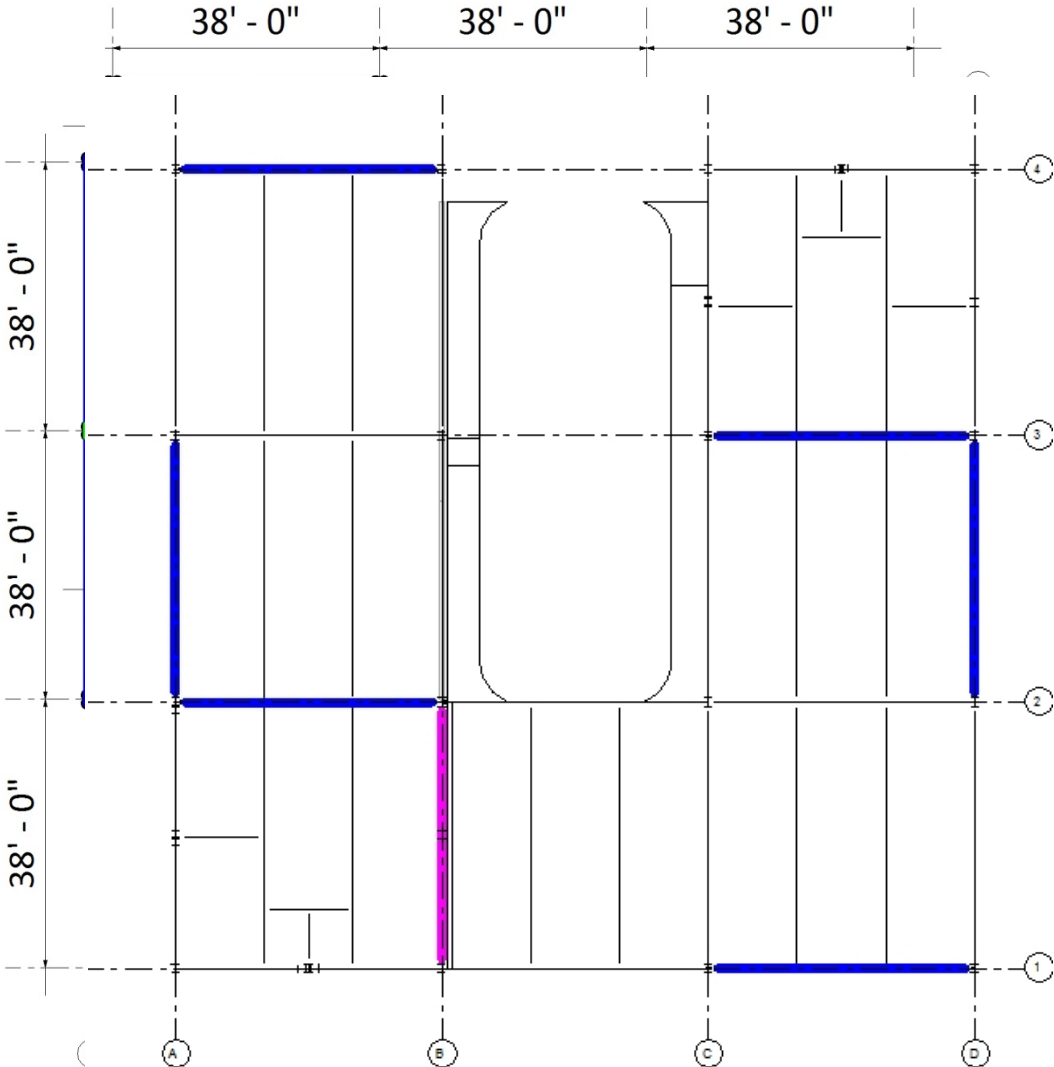
Column: W14x68

Brace: 3/4" x 3 1/4" plate



Lateral System

**Pony Wall
Connection
Critical**



Hurricane- Foundation Design

Spread Footings:

Exterior Column: 9'x9'x2'

Interior Column: 9'x9'x2'

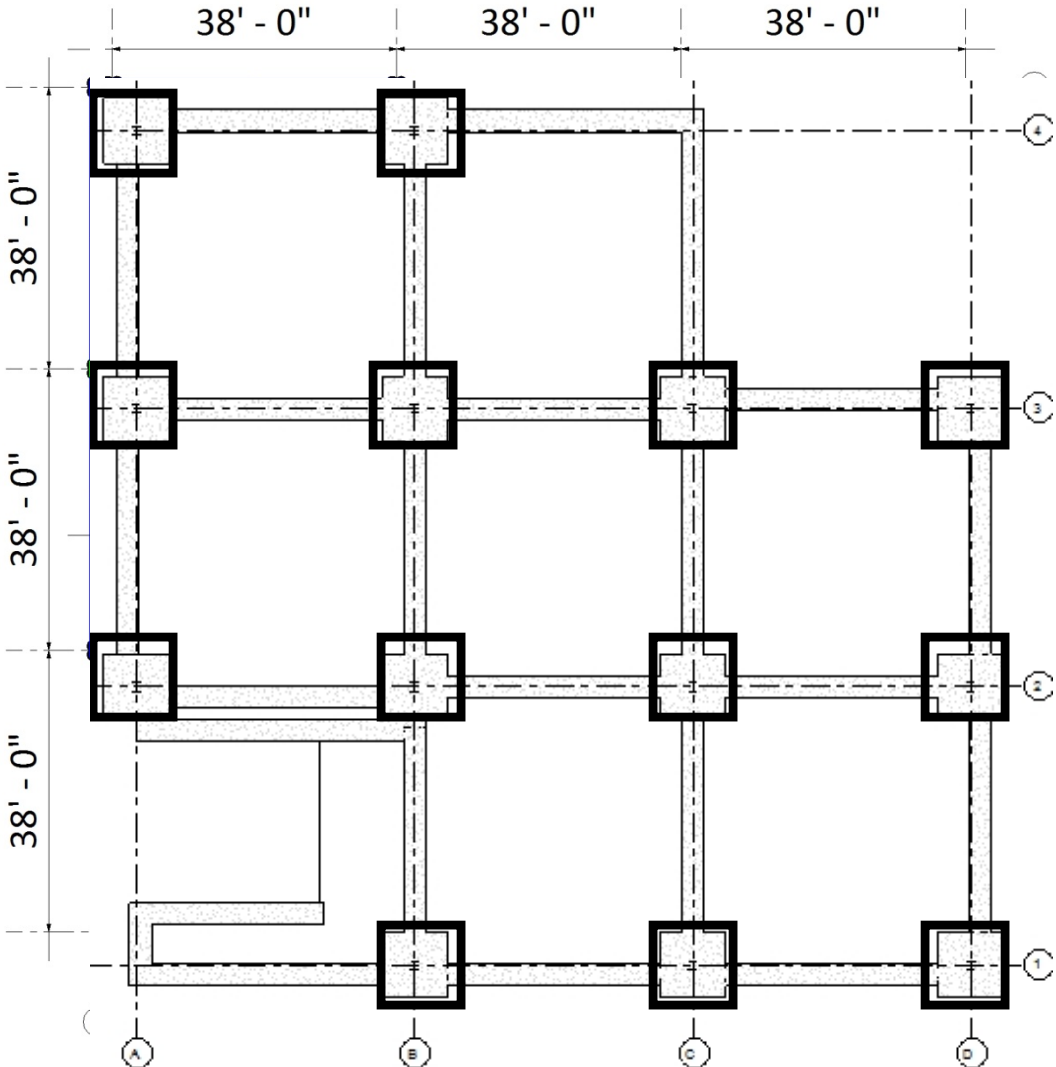
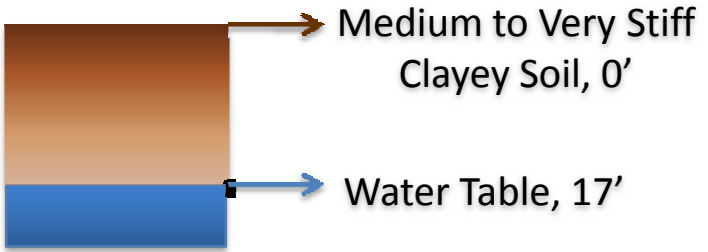
Continuous Footing: 2'x2'

Grade Beams

12" Retaining Wall

Soil Profile:

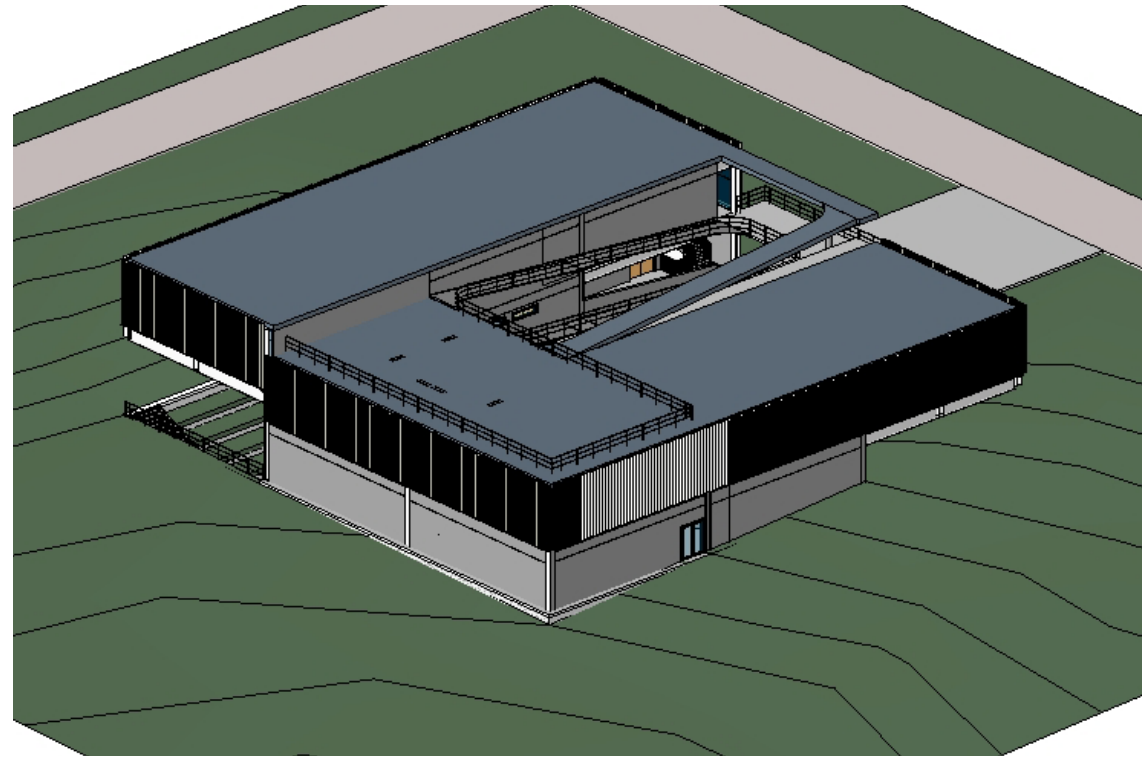
Bearing Capacity: 5000 PSF



Hurricane- Concrete Solution- Design Loads

Dead	Roof	70	psf
	Green Roof	120	psf
	Floor	120	psf
Live	Roof	20	psf
	Green Roof	20	psf
	Floor	60	psf
Seismic	Second Story	150	kip
	Roof	300	kip
Wind	Second Story	75	kip
	Roof	30	kip

Basic Wind Speed	145 mph
Base Shear	450 kip
Site Class	D
Ss=	0.852
S1=	0.279



Hurricane- Typical Member Sizes

First Story:

Post Tensioned Tapered:

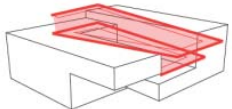
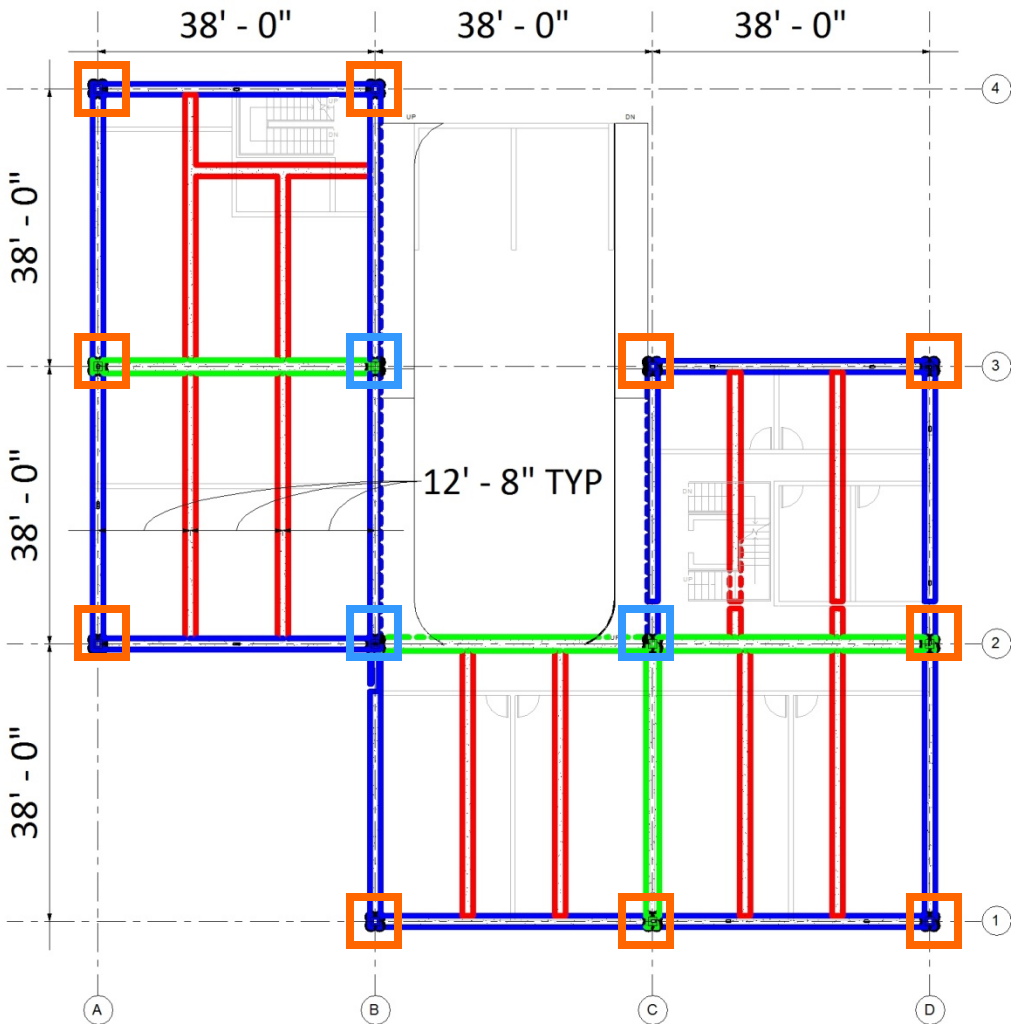
Beam 38' Span: **18"x24"**

Interior Girder 38' Span: **22"x36"**

Exterior Girder 38' Span: **18"x36"**

Exterior Column: **14"x14"**

Interior Column: **18"x18"**



Hurricane- Typical Member Sizes

Second Story/Roof:

Post Tensioned Tapered:

Beam 38' Span: **18"x24"**

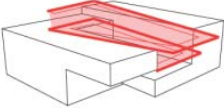
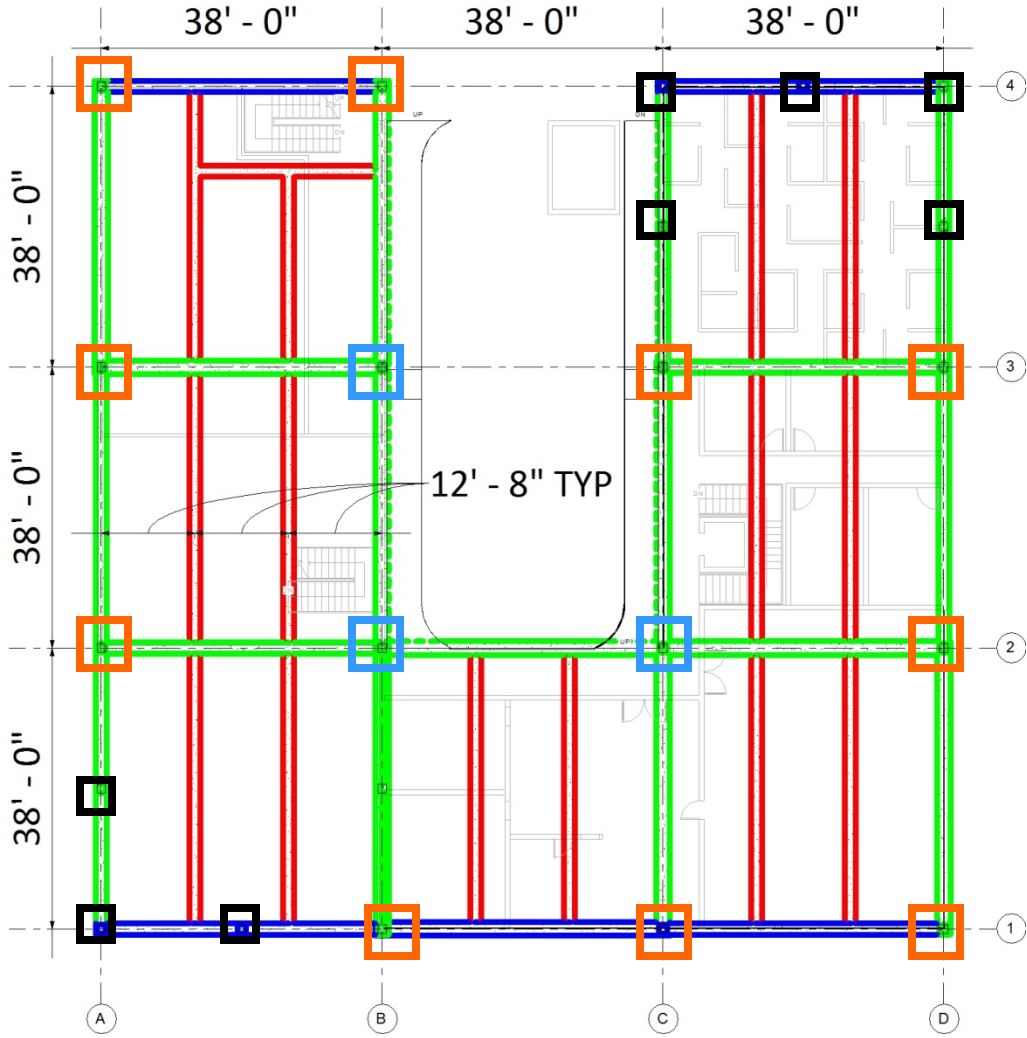
Interior Girder 38' Span: **22"x36"**

Exterior Girder 38' Span: **18"x36"**

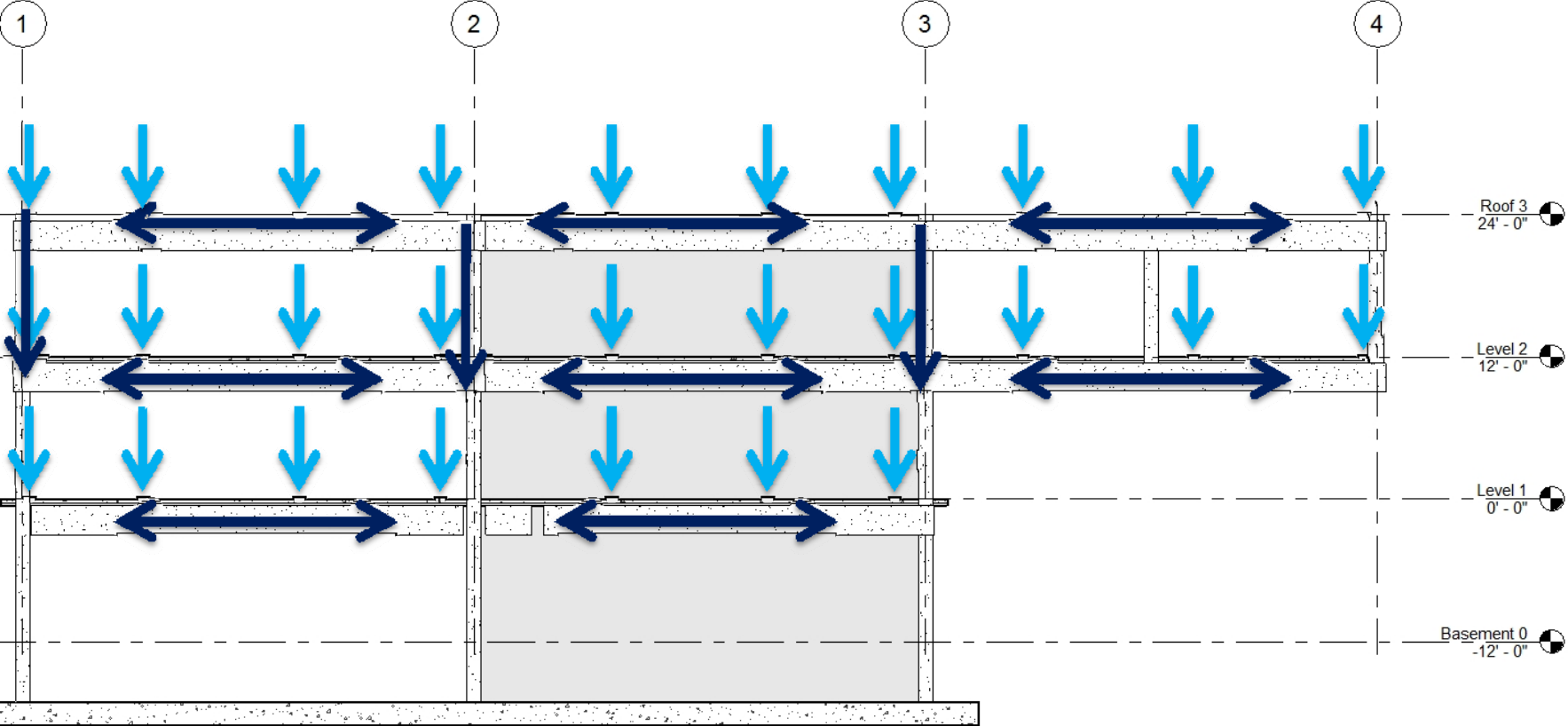
Cantilever Column: **12"x12"**

Exterior Column: **14"x14"**

Interior Column: **18"x18"**



Hurricane- Gravity Load Path

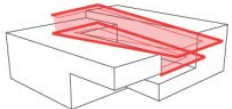
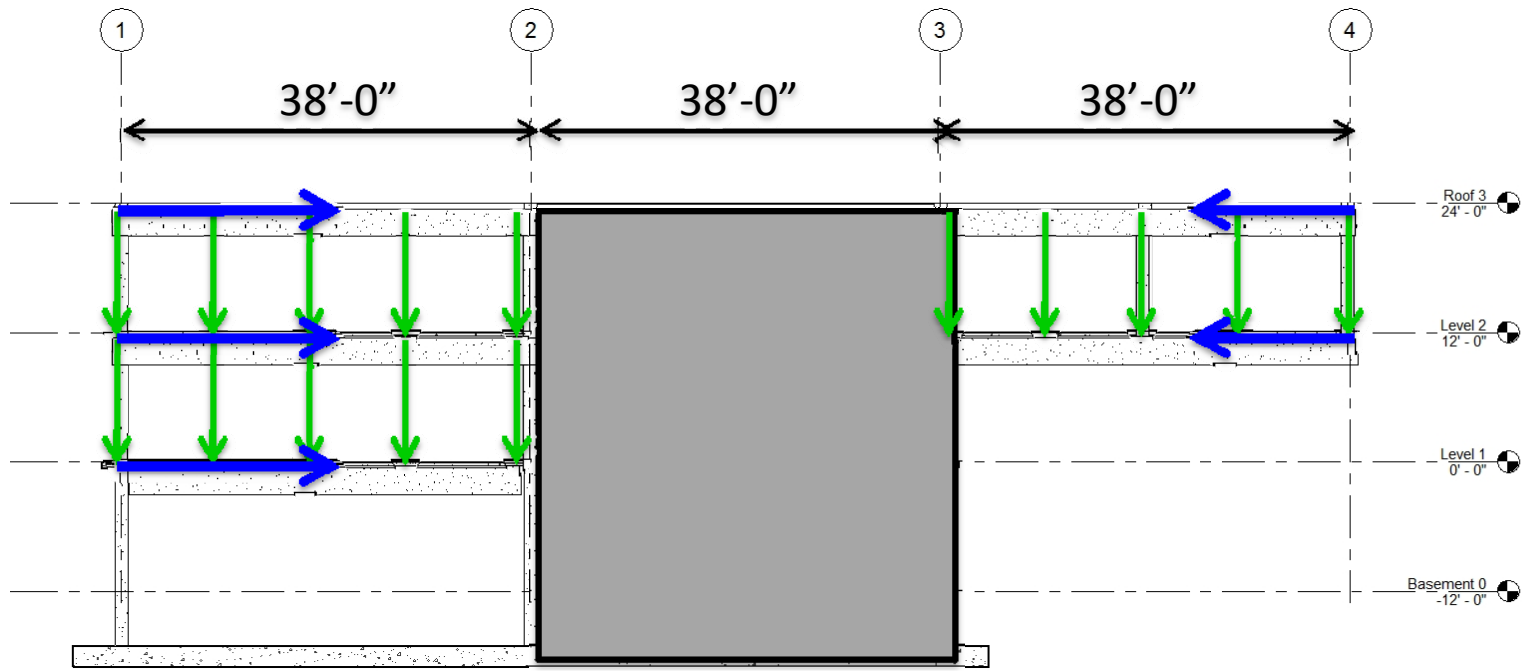


Hurricane- Cantilever Solution and Lateral System

Vierendeel Truss

Beams: **18"x36"**

Columns: **12"x12"**

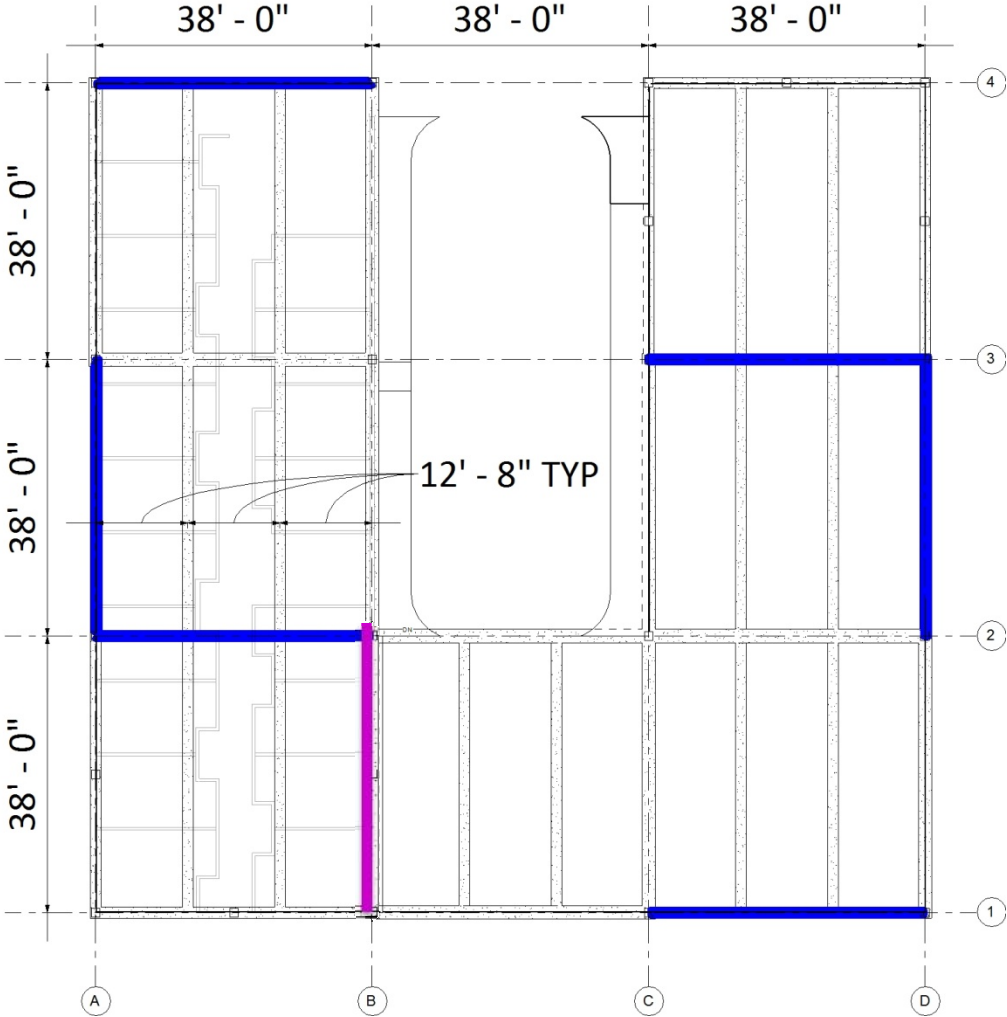
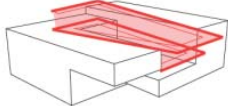
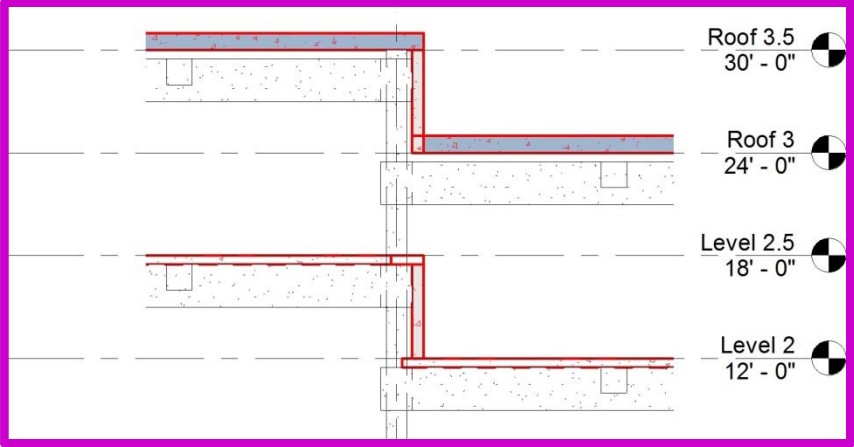


Hurricane- Lateral System

Lateral System:

8" Shear Walls

8" Pony Wall System



Hurricane- Foundation Design

Spread Footings:

Exterior Column: **9'x9'x2'**

Interior Column: **11'x11'x2'**

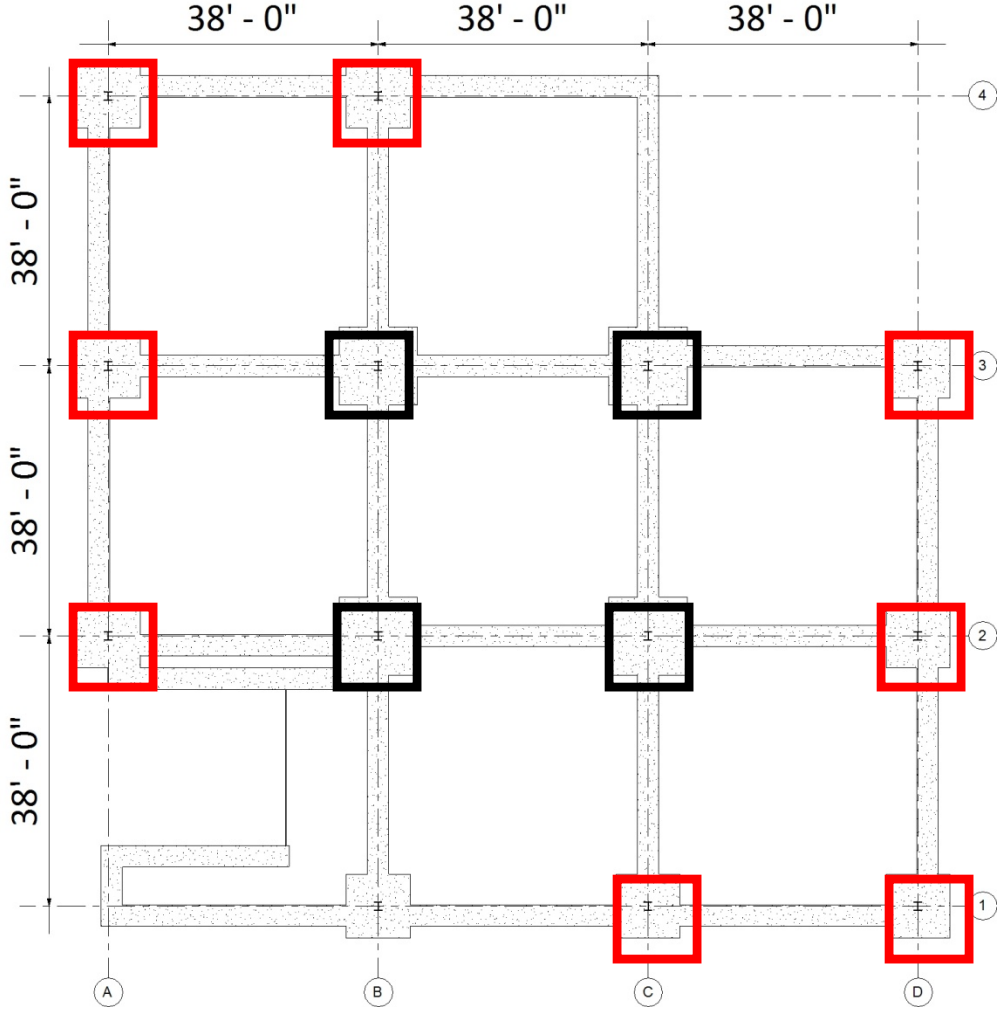
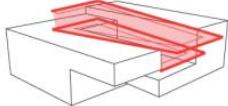
Continuous Footing:

2'x2'

Grade Beams

12" Retaining Wall

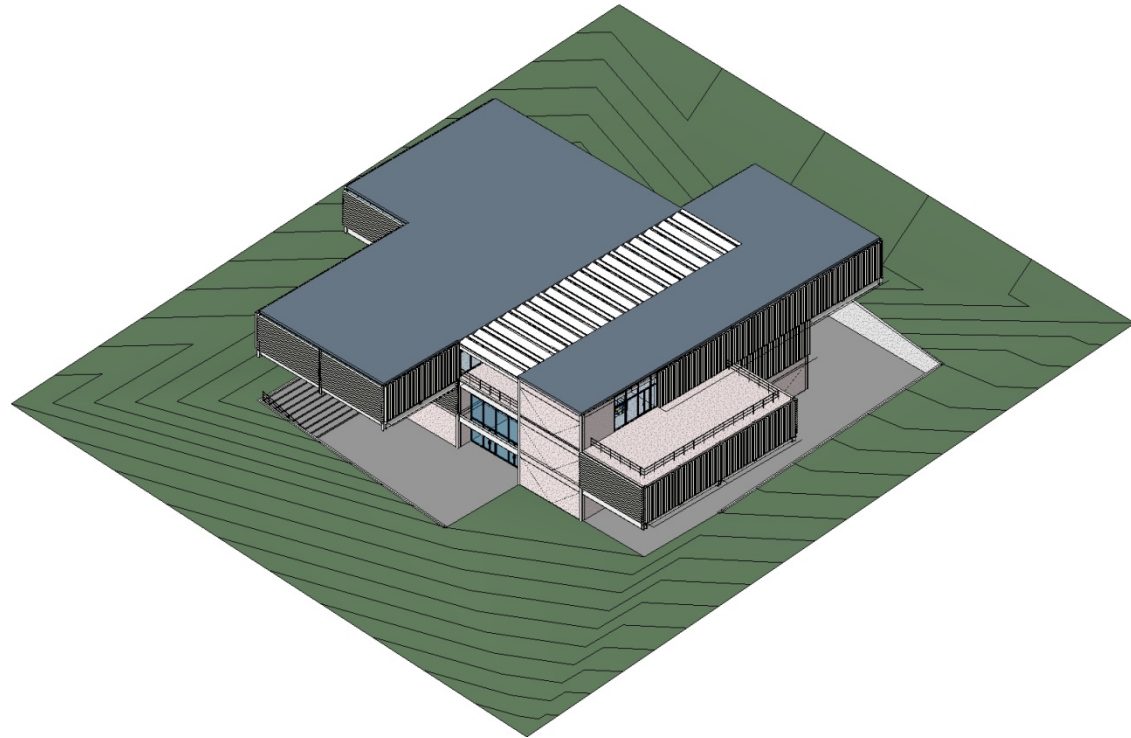
Slab on Grade



Puzzle- Steel Solution- Design Loads

Dead	Roof	65	psf
	Green Roof	115	psf
	Floor	85	psf
Live	Roof	20	psf
	Green Roof	20	psf
	Floor	60	psf
Seismic	Second Story	70	kip
	Roof	165	kip
Wind	Second Story	75	kip
	Roof	30	kip

Basic Wind Speed	145 mph
Base Shear	230 kip
Site Class	D
S_s=	0.852
S₁=	0.279



Puzzle- Typical Member Sizes

First Story:

Beam 25' Span: **W12x19**

Exterior Girder 30' Span: **W14x30**

Auditorium Beam 50' Span: **W24x94**

Auditorium Girder 30' Span: **W24x94**

Corner Column: **W14x43**

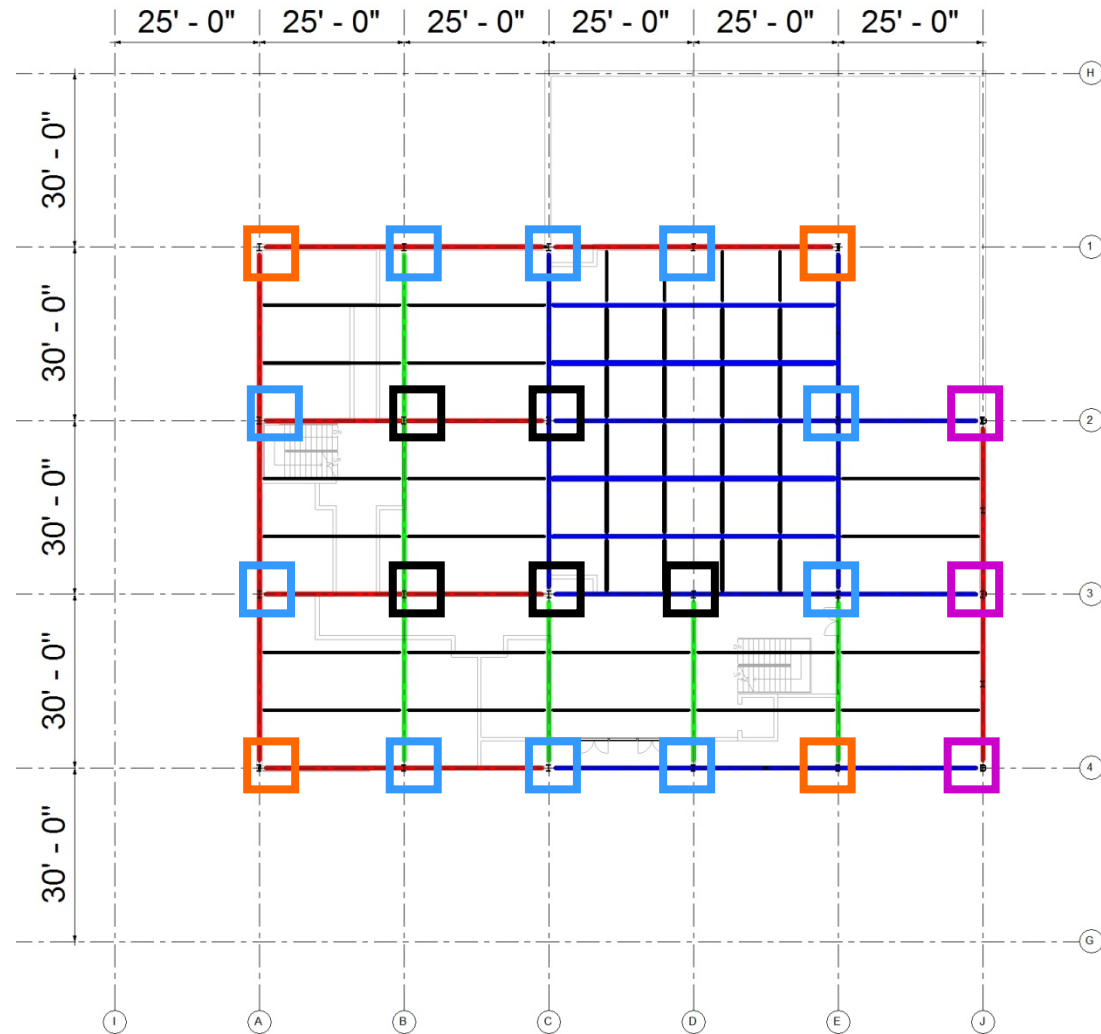
Exterior Column: **W14x43**

Interior Column: **W14x61**

Cantilever Column: **W24x94**

Composite Floor: **2VLI18**

2" Deck with 4.25" concrete



Puzzle- Typical Member Sizes

Second Story:

Beam 25' Span: **W12x19**

Exterior Girder 30' Span: **W14x30**

Cantilever Beam 25' Span: **W24x94**

Corner Column: **W14x43**

Exterior Column: **W14x4-3**

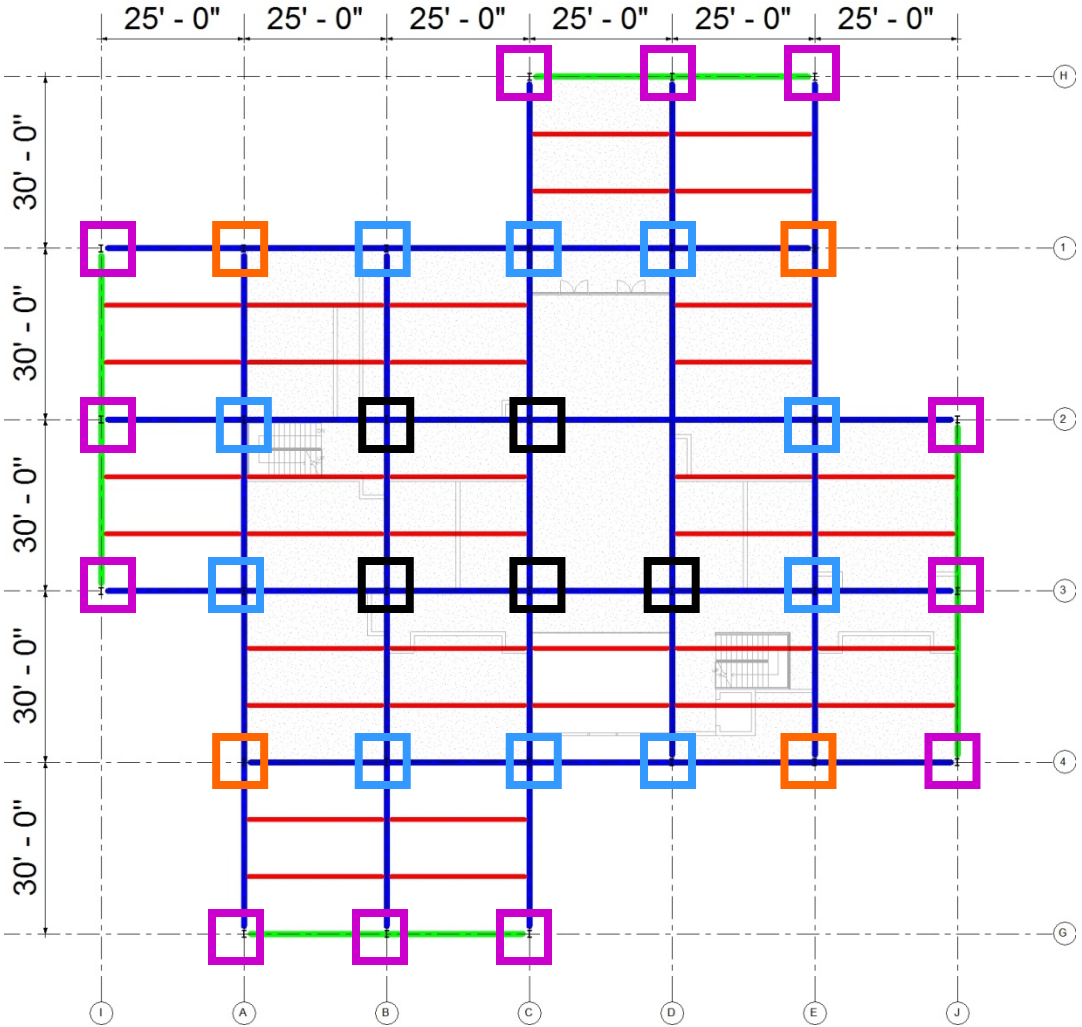
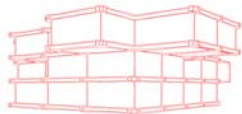
Interior Column: **W14x61**

Cantilever Column: **W24x94**

Composite Floor: **2VLI18**

2" Deck with 4.25" concrete

cover

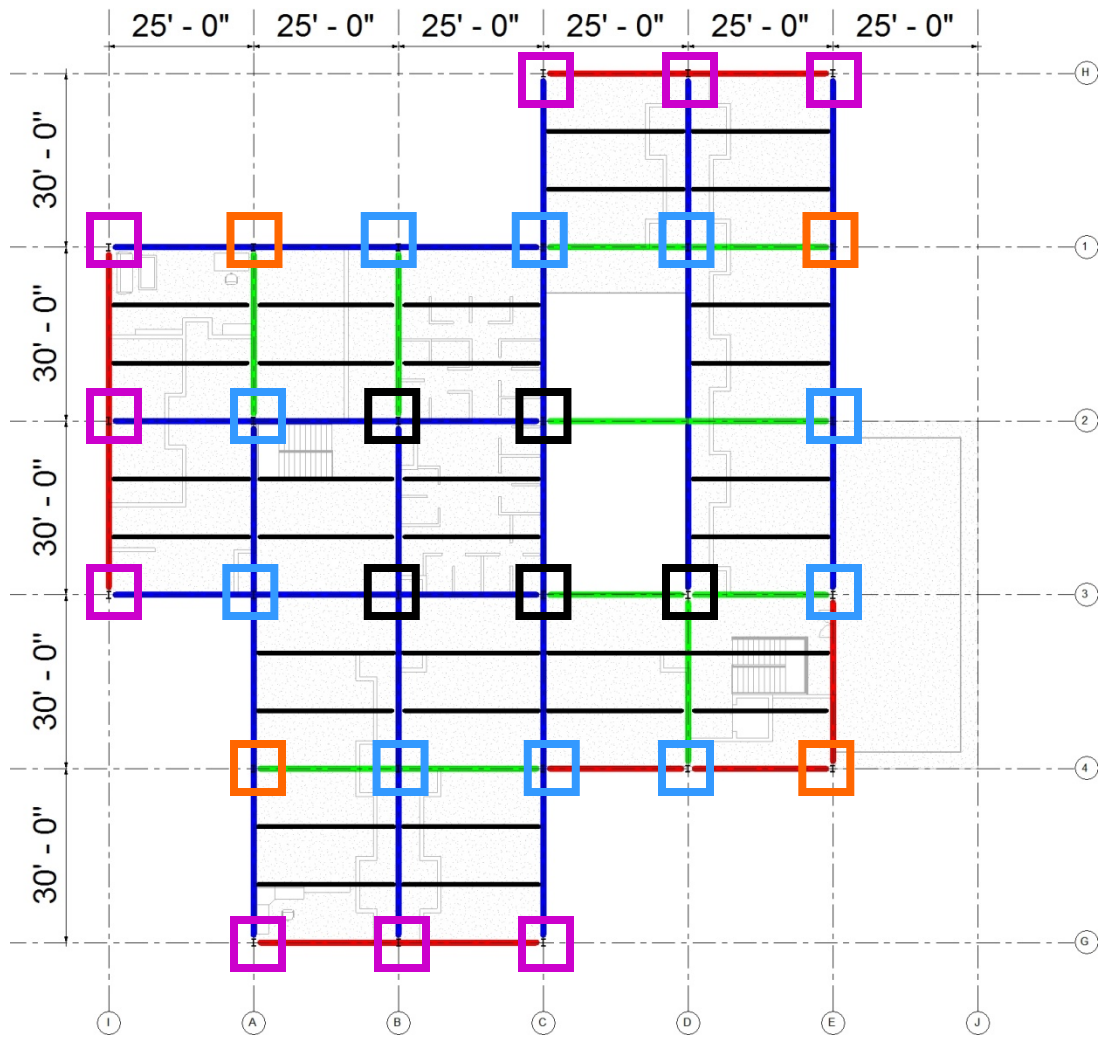


Puzzle- Typical Member Sizes

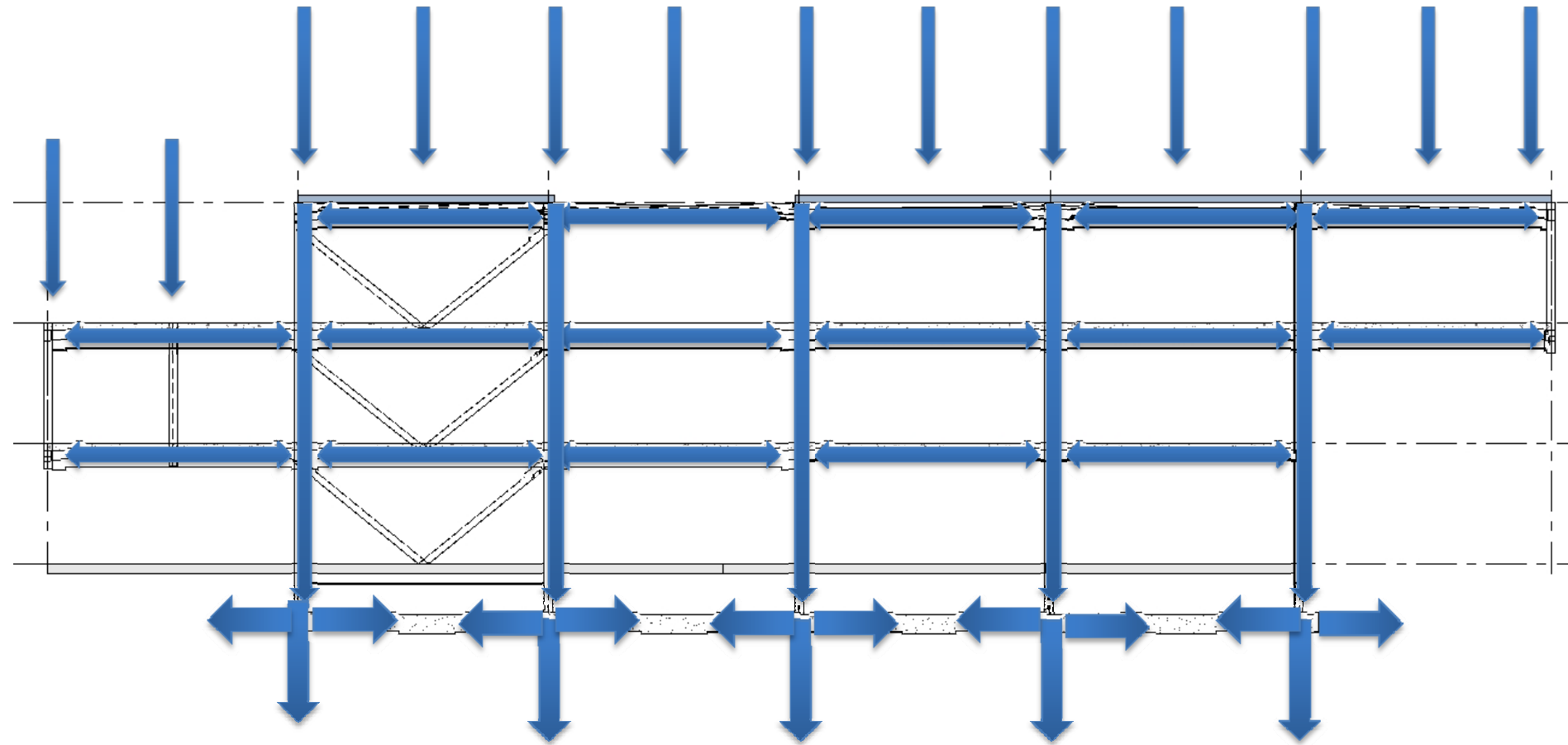
- Roof:**
 - Beam 25' Span: **W12x19**
 - Interior Girder 25' Span: **W14x45**
 - Exterior Girder 30' Span: **W14x30**
 - Cantilever Beam 25' Span: **W24x94**

- Corner Column: **W14x43**
- Exterior Column: **W14x43**
- Interior Column: **W14x61**
- Cantilever Column: **W24x94**

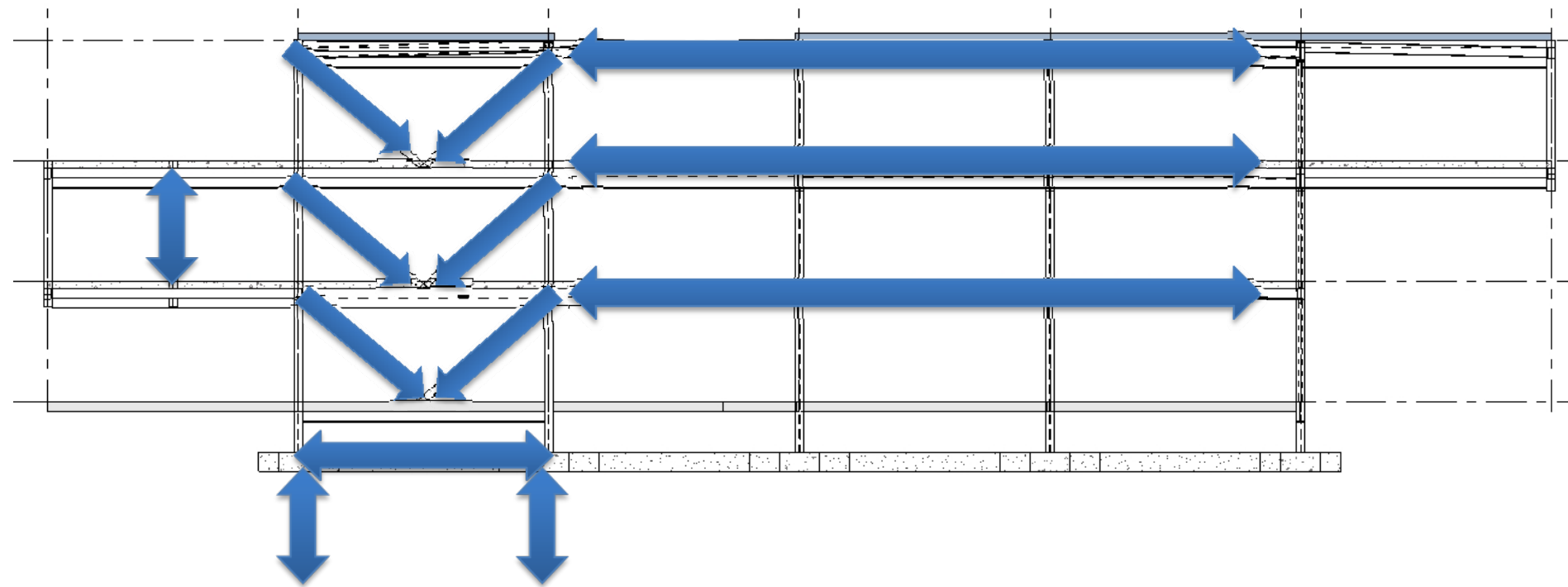
- Composite Floor: **2VLI18**
2" Deck with 4.25" concrete



Puzzle- Gravity Load Path Diagram



Puzzle- Lateral Load Path Diagram

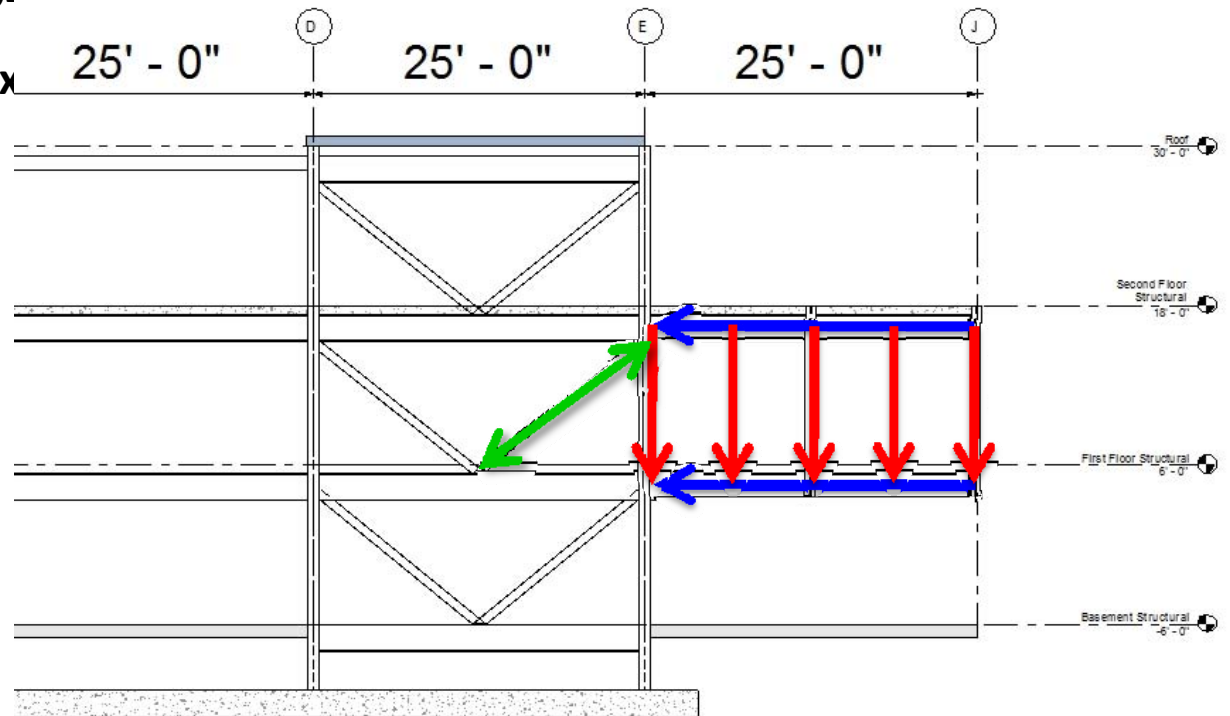


Puzzle- Cantilever Solution

Vierendeel Truss:

Beams: **W24x94**

Columns: **W24x**



Puzzle- Lateral System

BRBF Connection Typical:

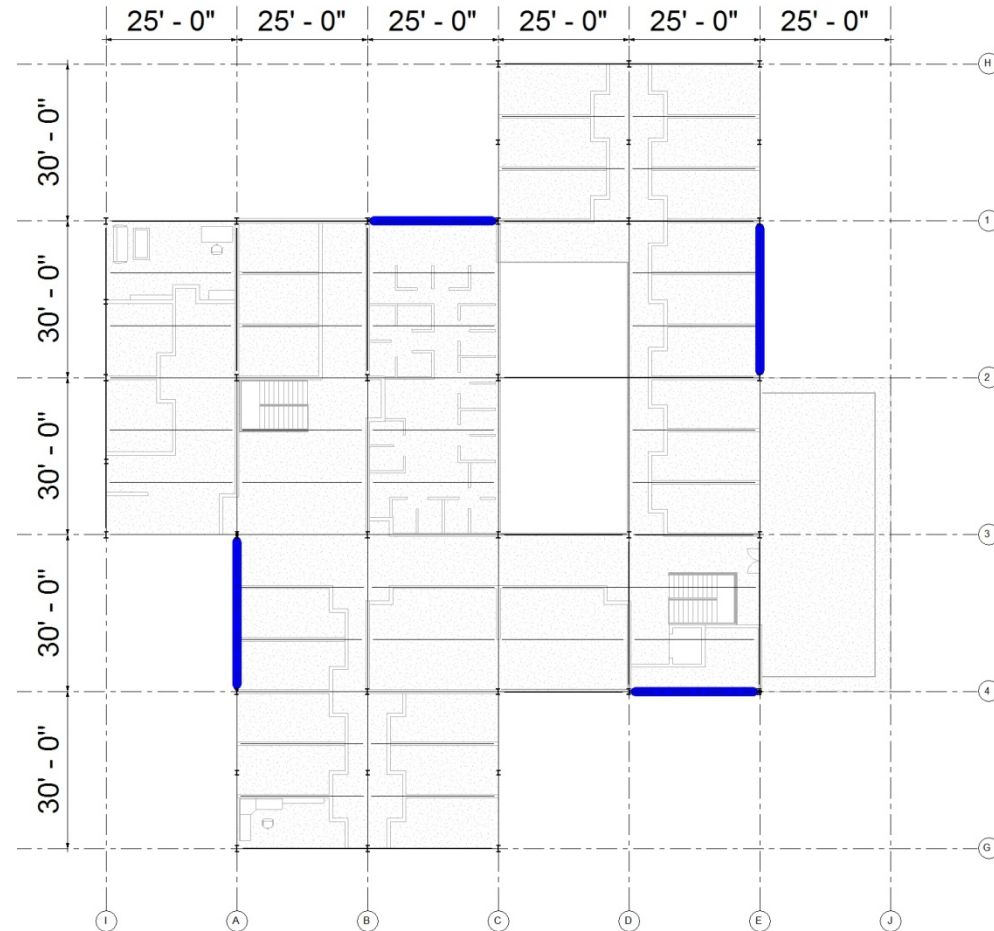
Beam: W30x90

Column: W14x53

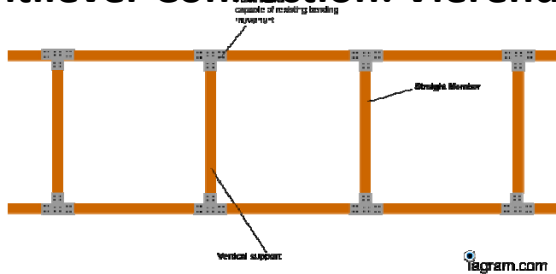
Brace: 3/4" x 3" Plat



Lateral System:



Cantilever Connection: Vierendeel Truss



Puzzle- Foundation Design

Spread Footings:

Exterior Column:

6'x6'x1.5'

Interior Column:

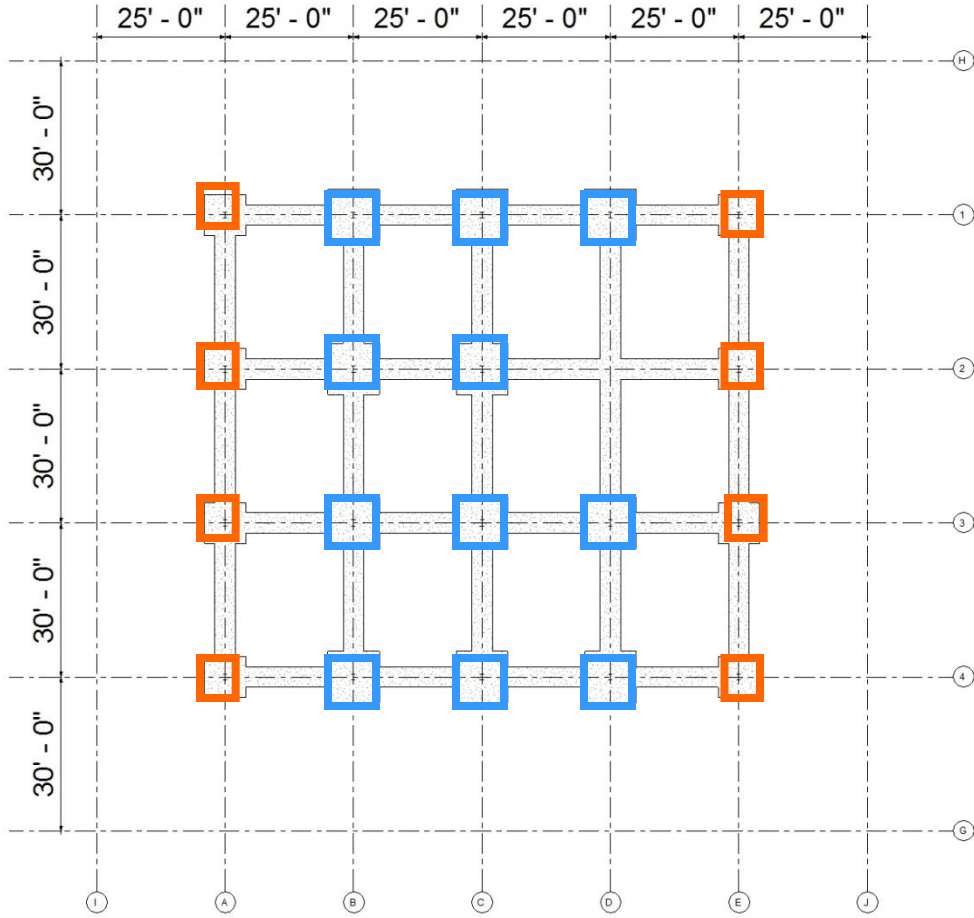
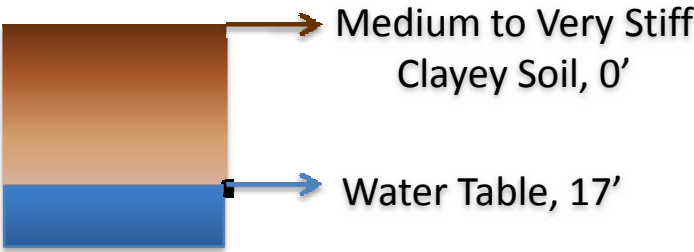
9'x9'x2'

Continuous Footing:

2'x2'

Soil Profile:

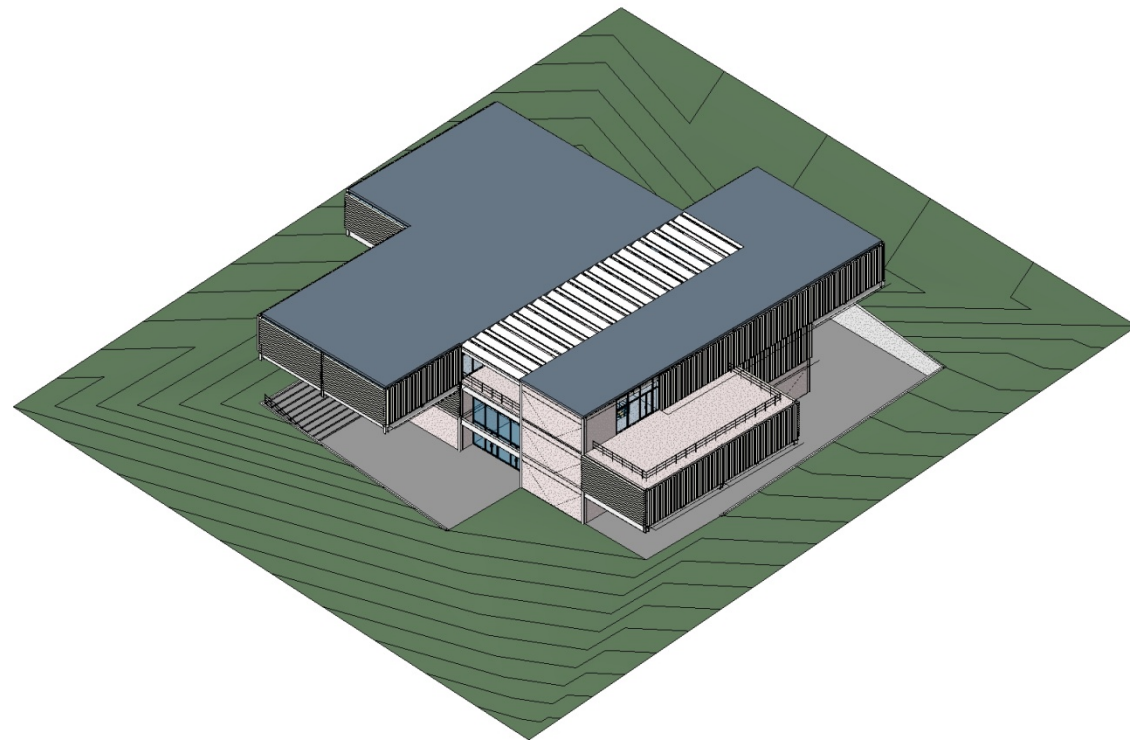
Grade Beams
12" Retaining Wall
Bearing Capacity: 5000 PSF



Puzzle- Concrete Solution- Design Loads

Dead	Roof	70	psf
	Green Roof	120	psf
	Floor	120	psf
Live	Roof	20	psf
	Green Roof	20	psf
	Floor	60	psf
Seismic	Second Story	150	kip
	Roof	300	kip
Wind	Second Story	75	kip
	Roof	30	kip

Basic Wind Speed	145 mph
Base Shear	450 kip
Site Class	D
Ss=	0.852
S1=	0.279



Puzzle- Typical Member Sizes

First Story:

Post Tensioned Tapered:

Interior Beam: **12"x18"**

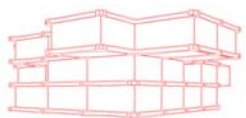
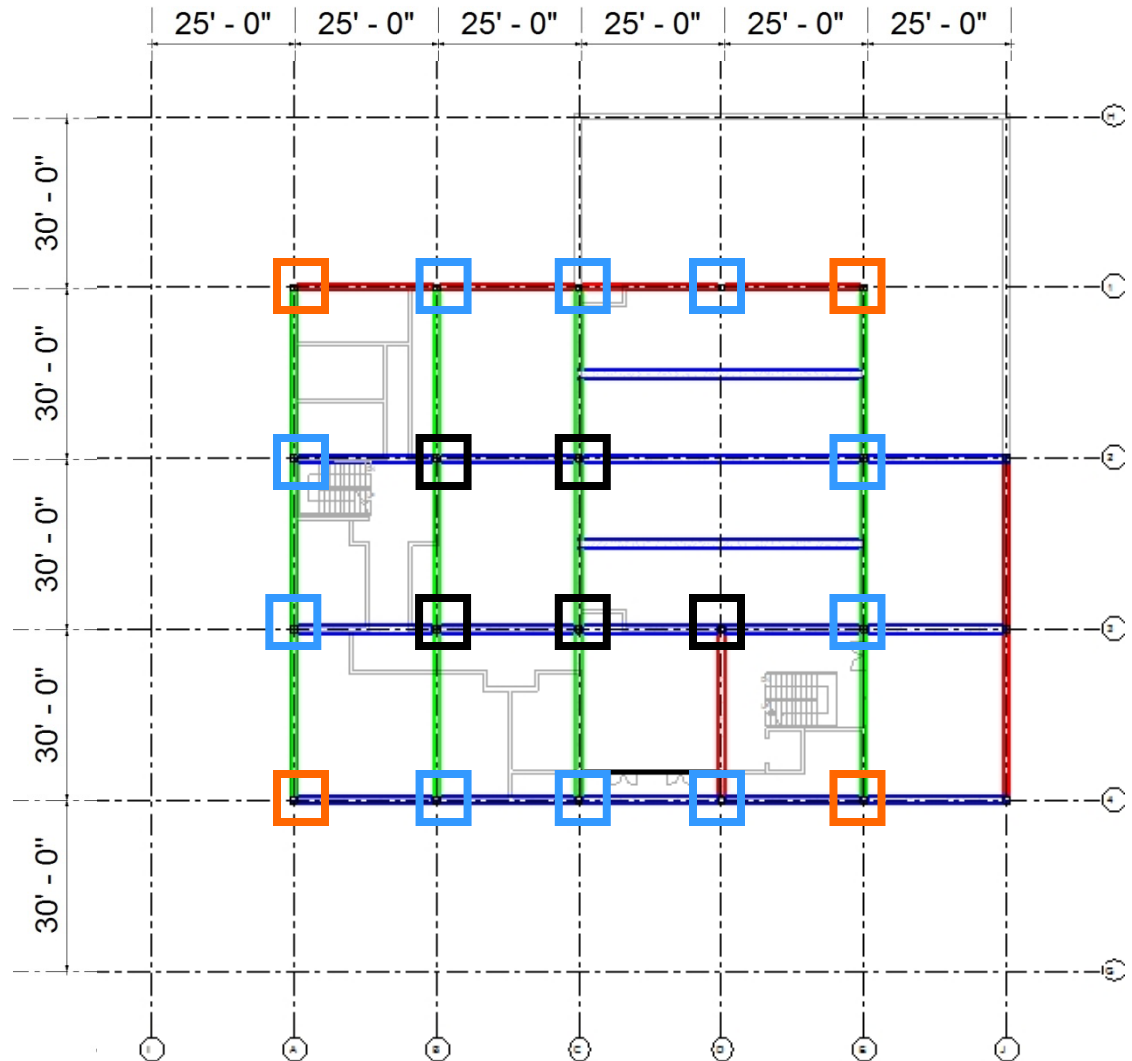
Interior Girder: **16"x30"**

Other Beam/Girder: **12"x24"**

Corner Column: **8"x8"**

Exterior Column: **12"x12"**

Interior Column: **16"x16"**



Puzzle- Typical Member Sizes

Second Story:

Post Tensioned Tapered:

Interior/Cantilever Girder: 16"x30"

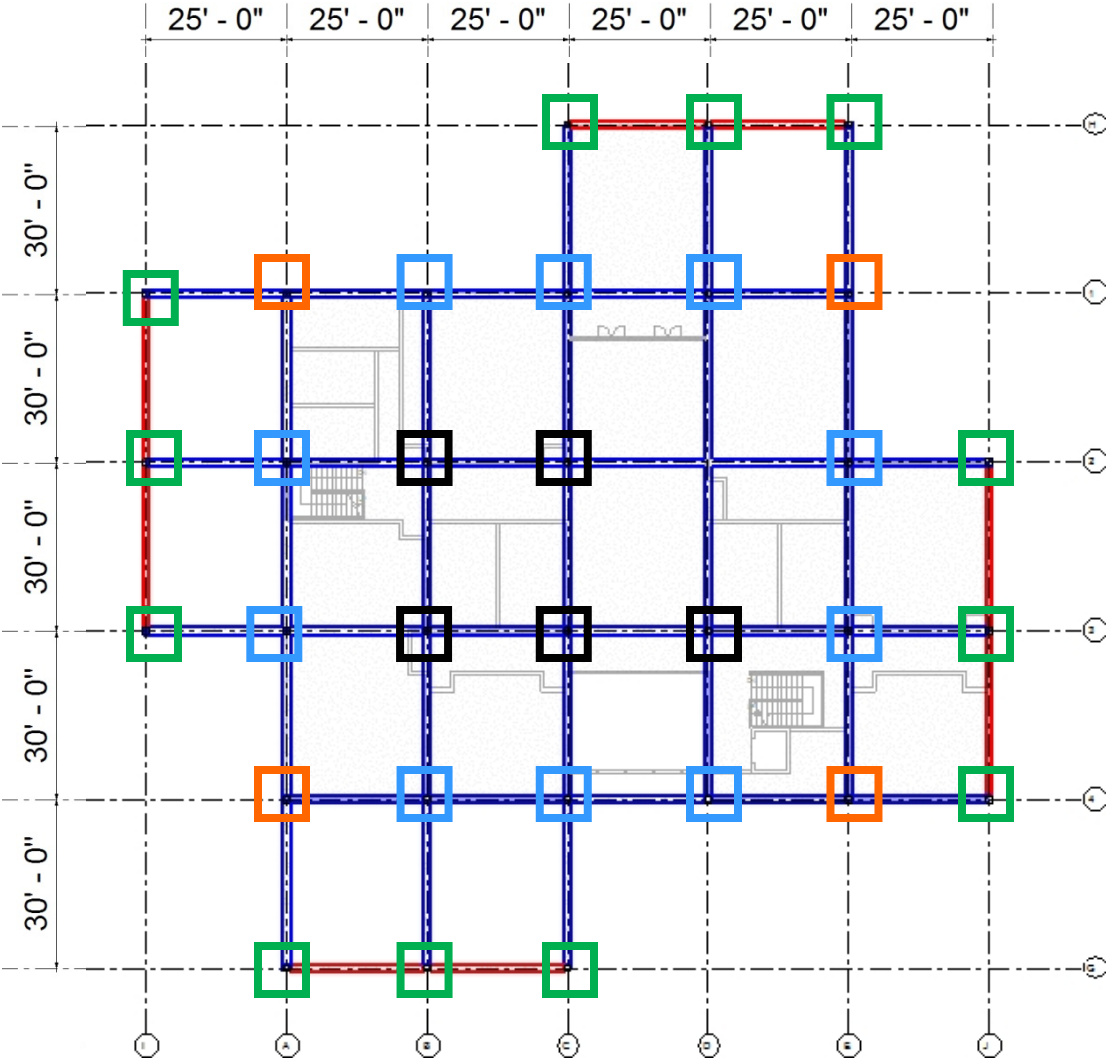
Other Beam/Girder: 12"x24"

Corner Column: 8"x8"

Exterior Column: 12"x12"

Cantilever Column: 10"x10"

Interior Column: 16"x16"



Puzzle- Typical Member Sizes

Second Story:

Post Tensioned Tapered:

Interior/Cantilever Girder: **16"x30"**

Other Beam/Girder: **12"x24"**

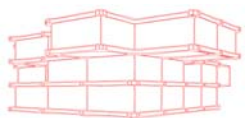
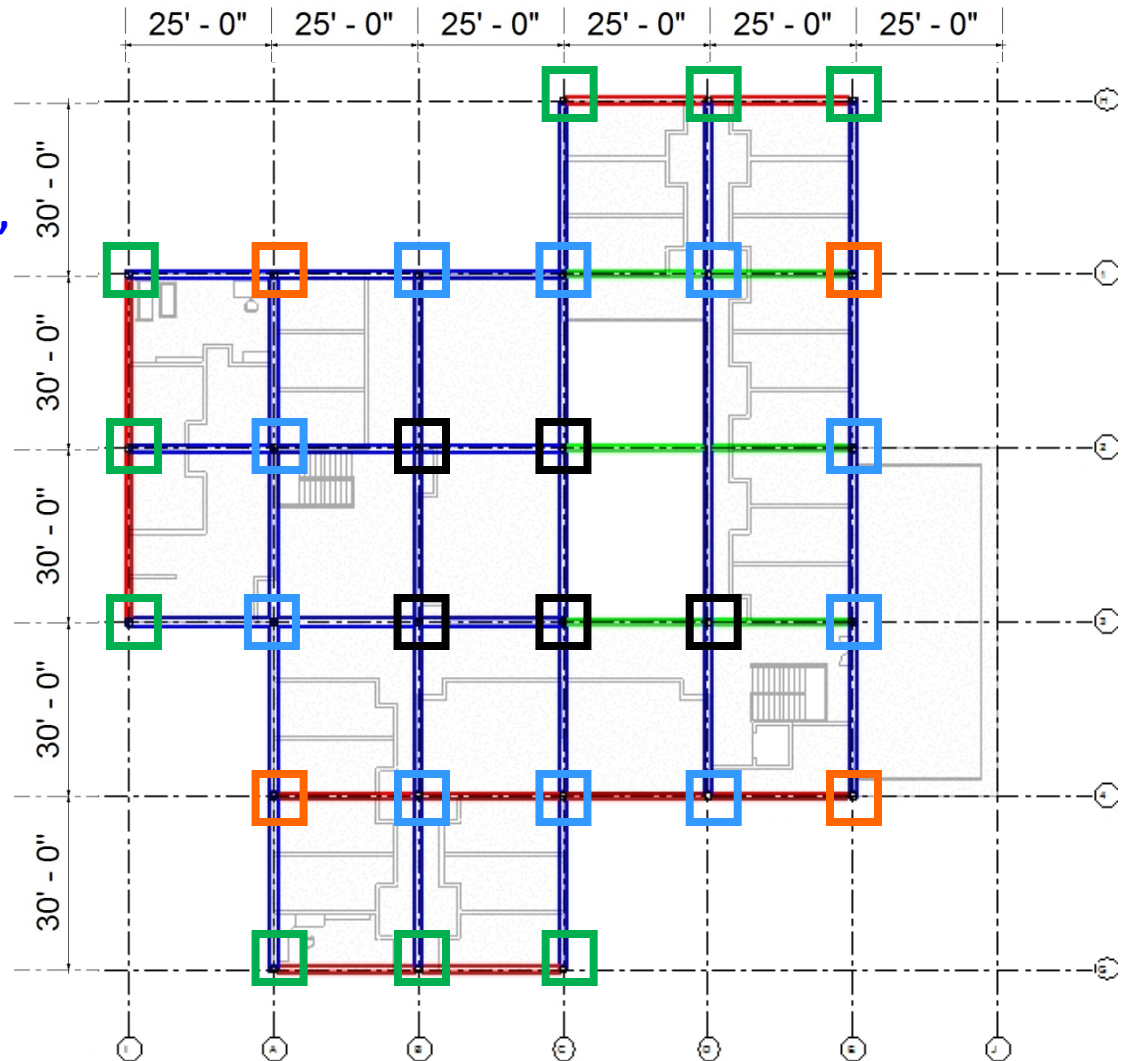
Interior Beam: **12"x18"**

Corner Column: **8"x8"**

Exterior Column: **12"x12"**

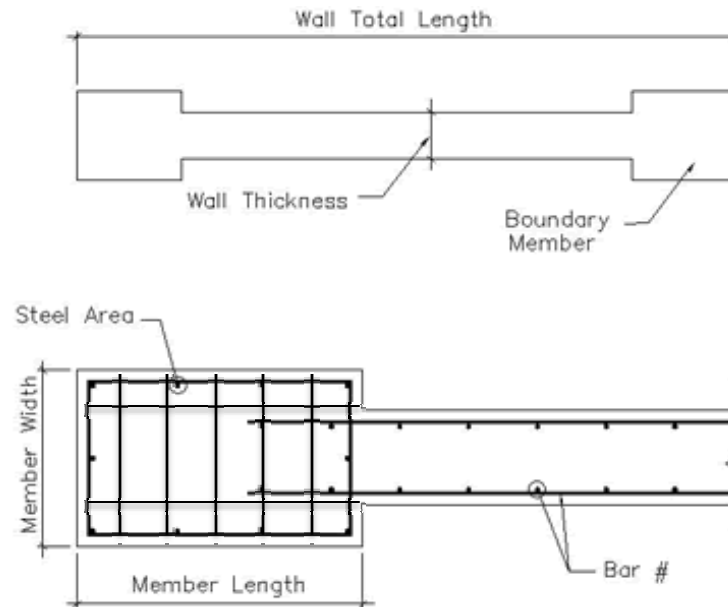
Cantilever Column: **10"x10"**

Interior Column: **16"x16"**



Puzzle- Details

Shear Wall Detail:



Typical Post Tensioned Beam:



Puzzle- Lateral System and Cantilever Solution

Cantilever Solution: **Lateral System:**

Vierendeel Truss

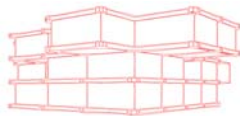
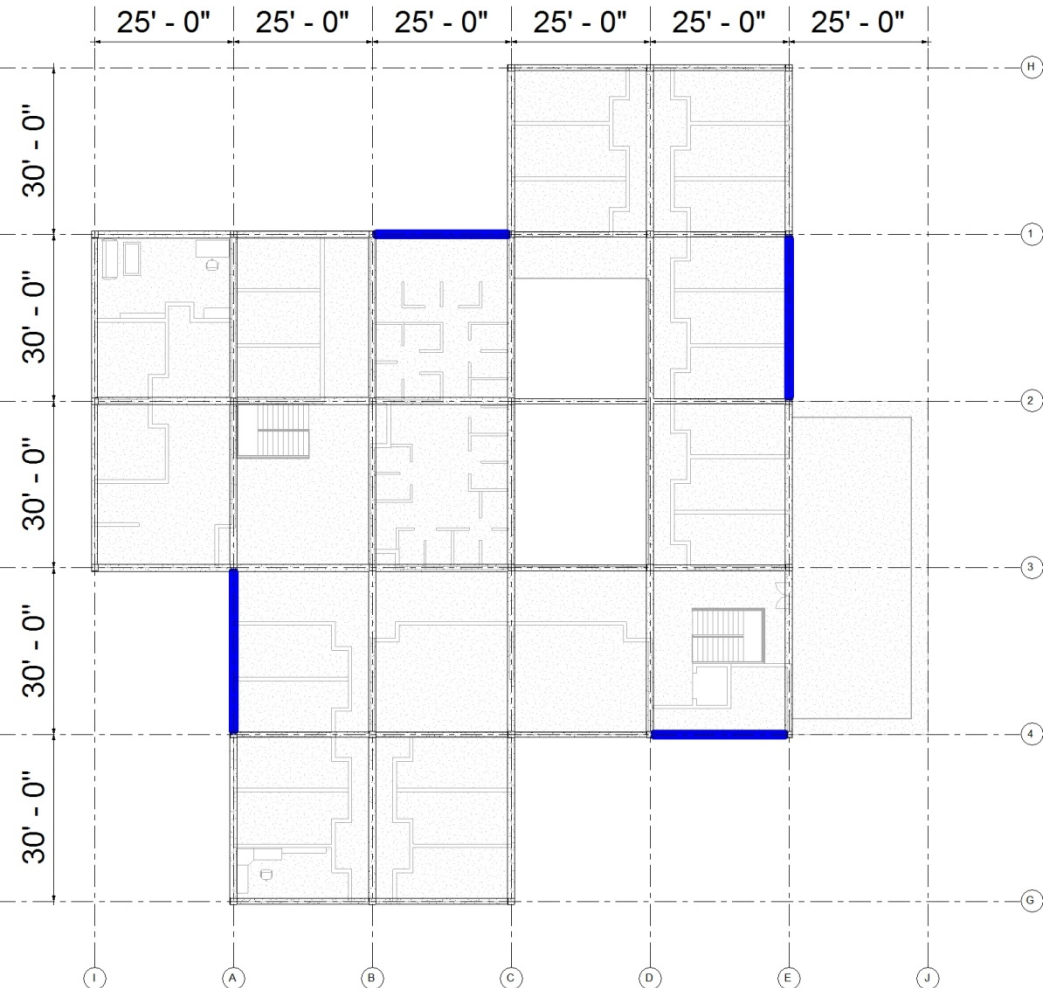
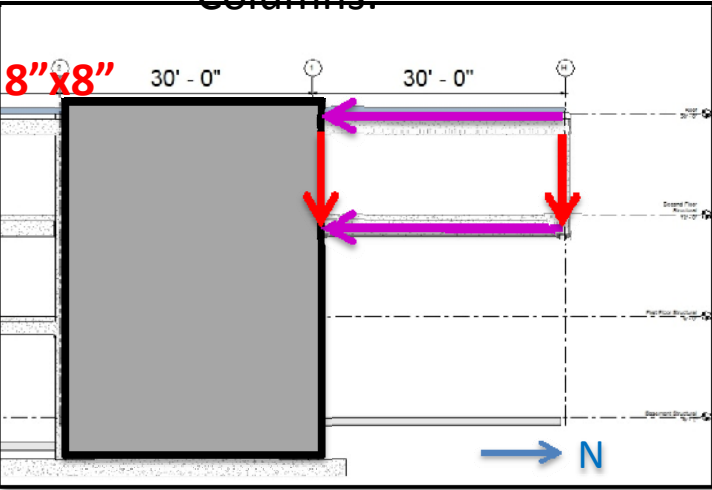
8" Shear Walls

Beam:

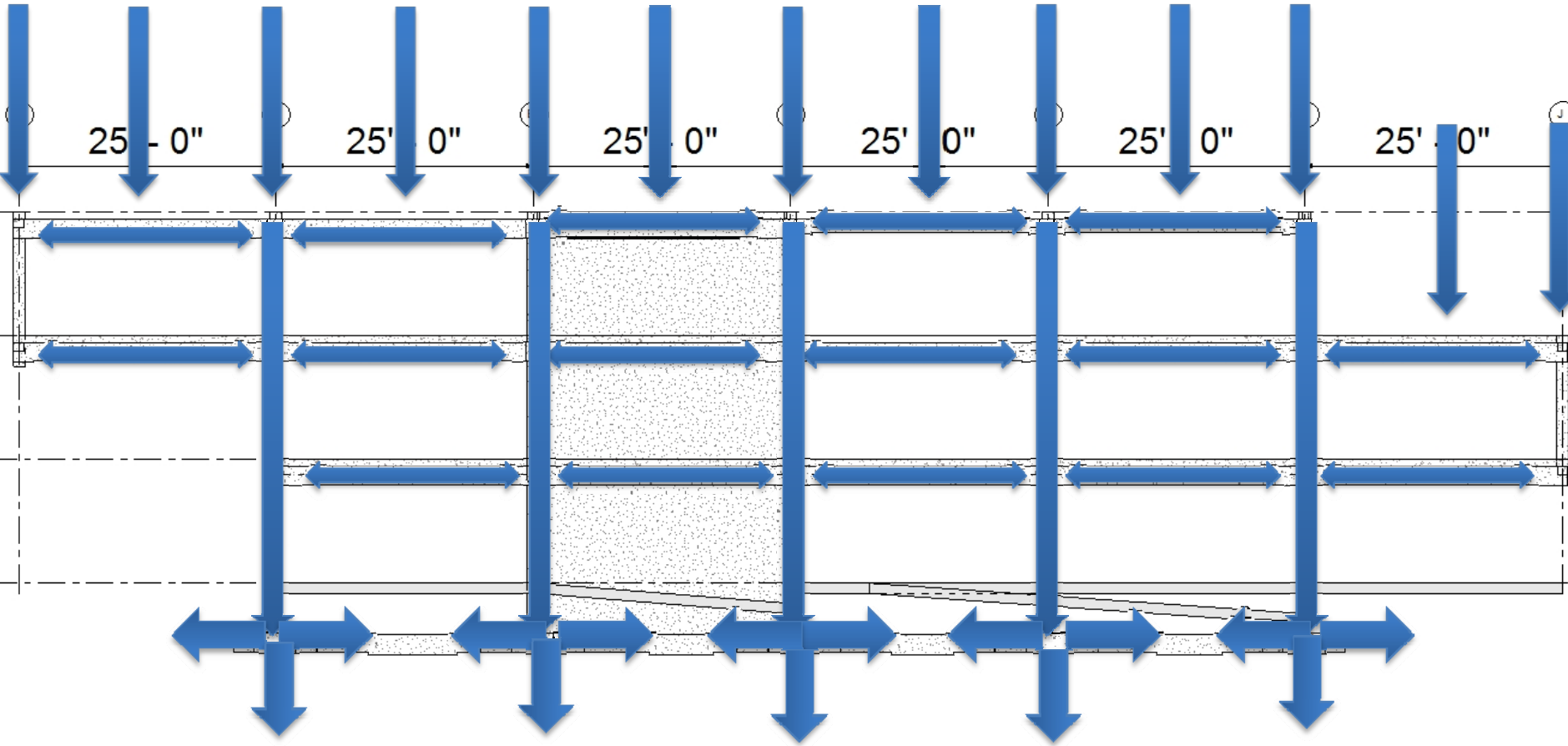
16"x30"

Columns:

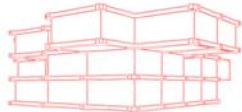
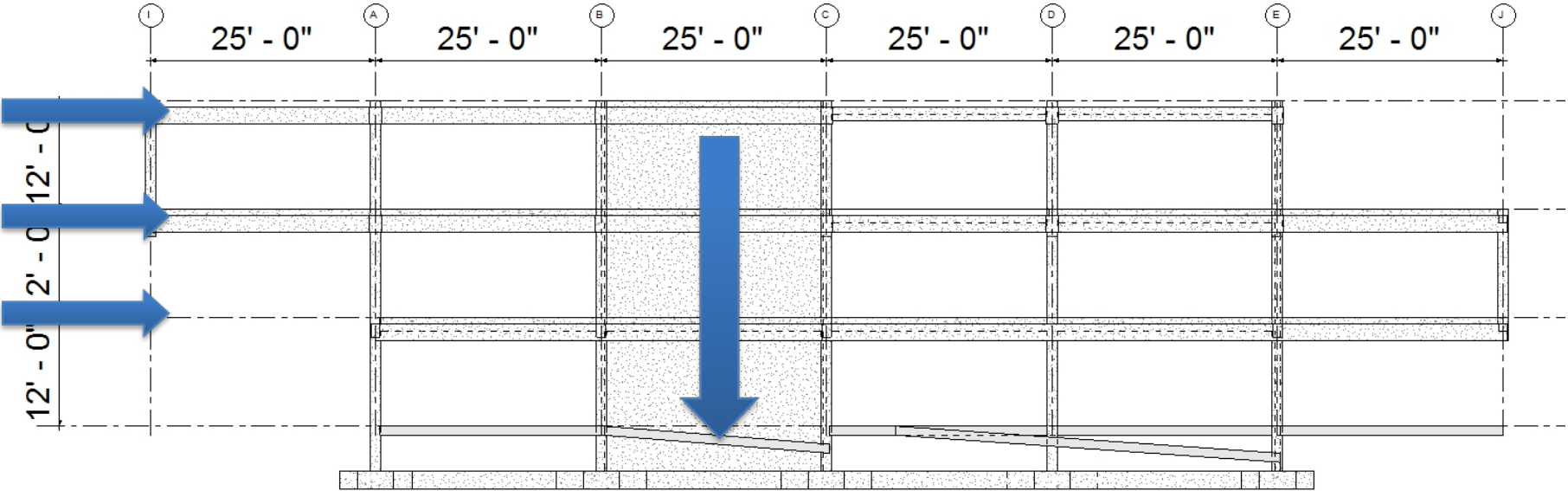
8"x8"



Puzzle- Gravity and Load Path Diagram



Puzzle- Lateral System



Puzzle- Foundation Design

Spread Footings:

Exterior:

8'x8'x2'

Interior/Cantilever: 10'x10'

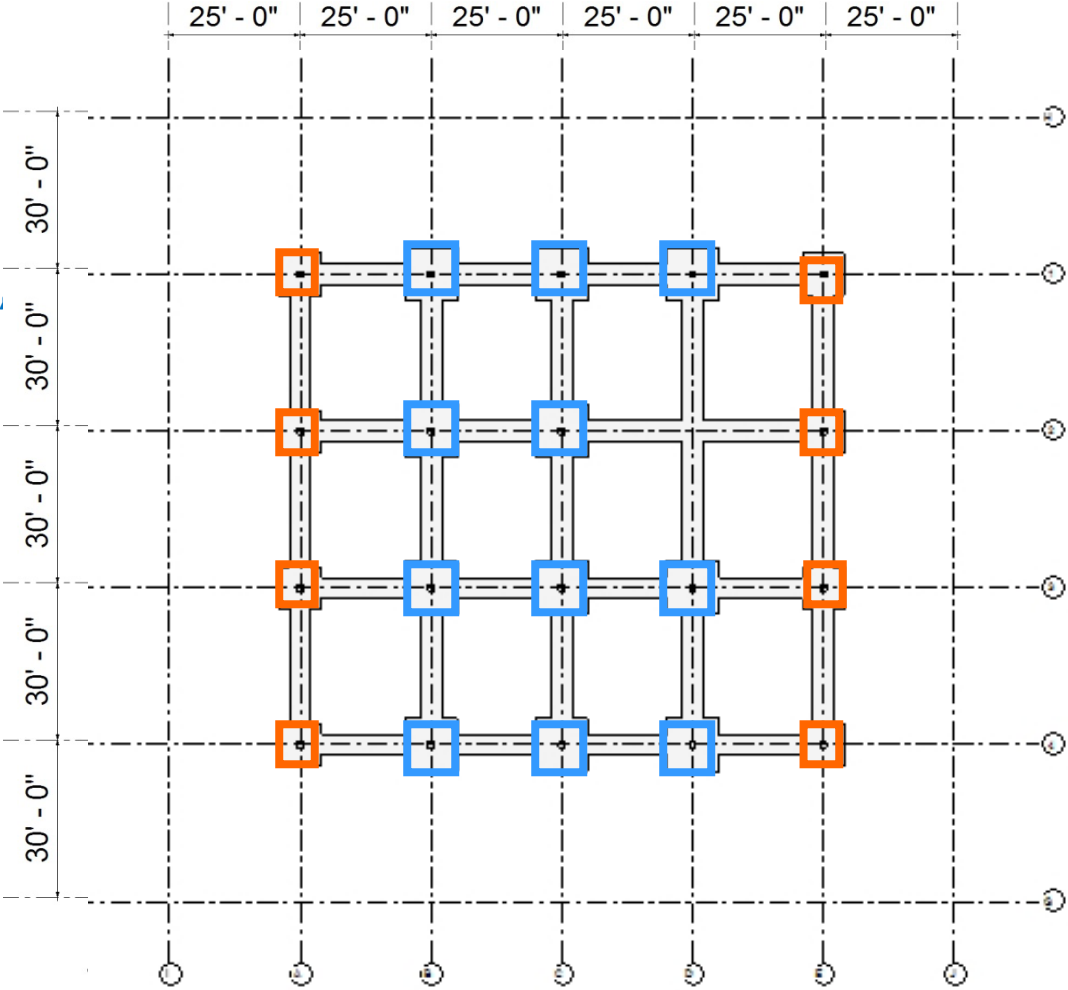
Continuous Footing:

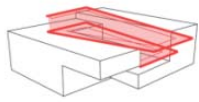
2'x2'

Grade Beams

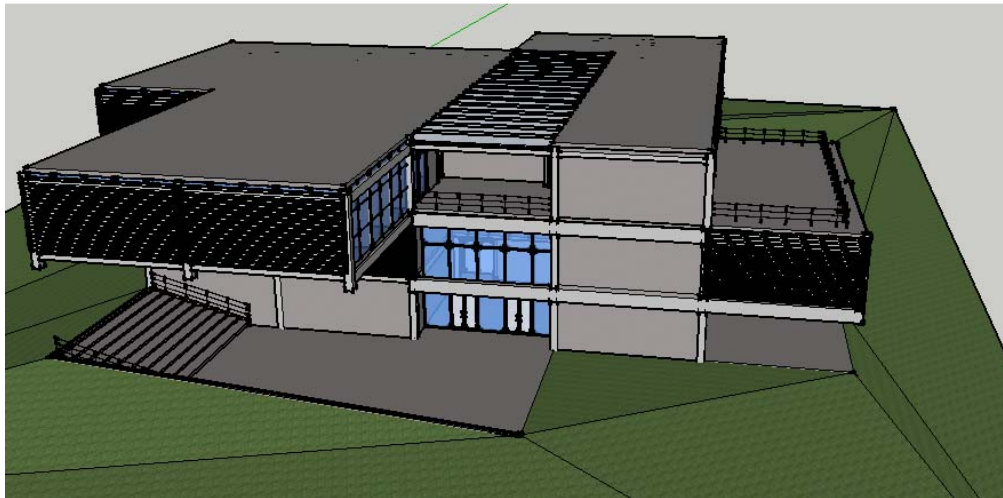
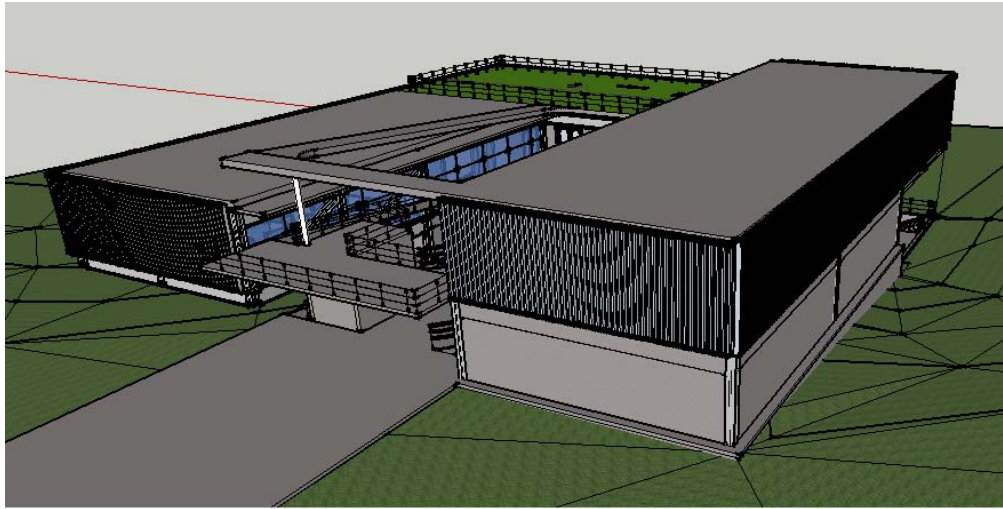
12" Retaining Wall

Slab on Grade





Utilities

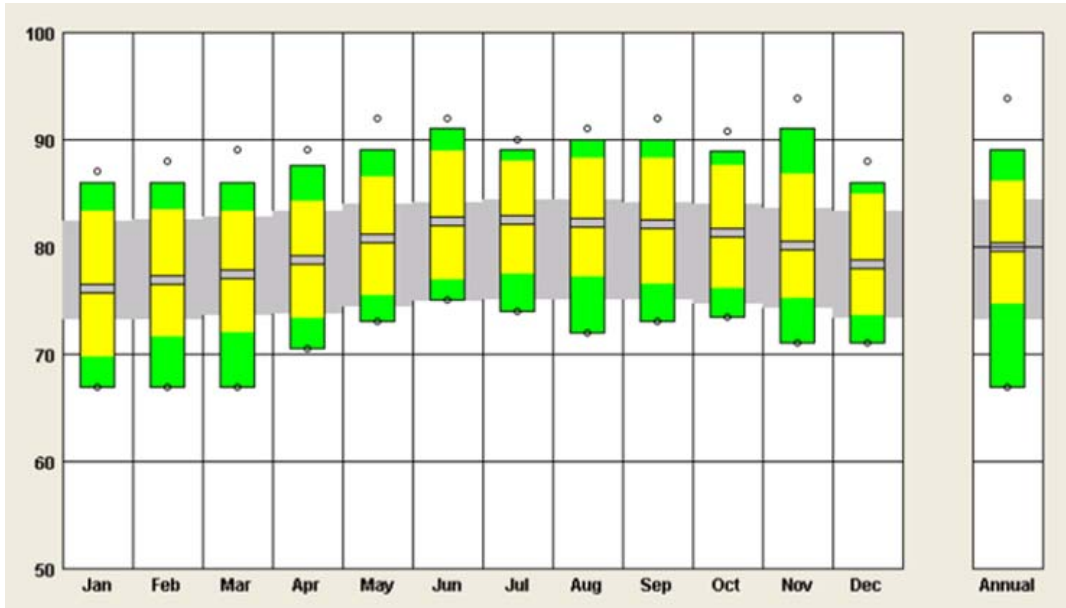


Cooling

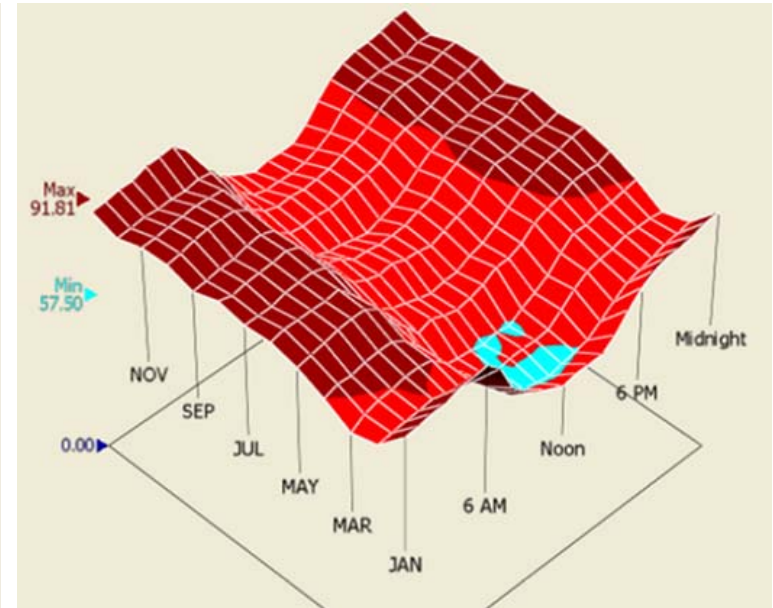
Electricity

Domestic Water

Heat and Humidity



Avg. temp range
76F – 83F

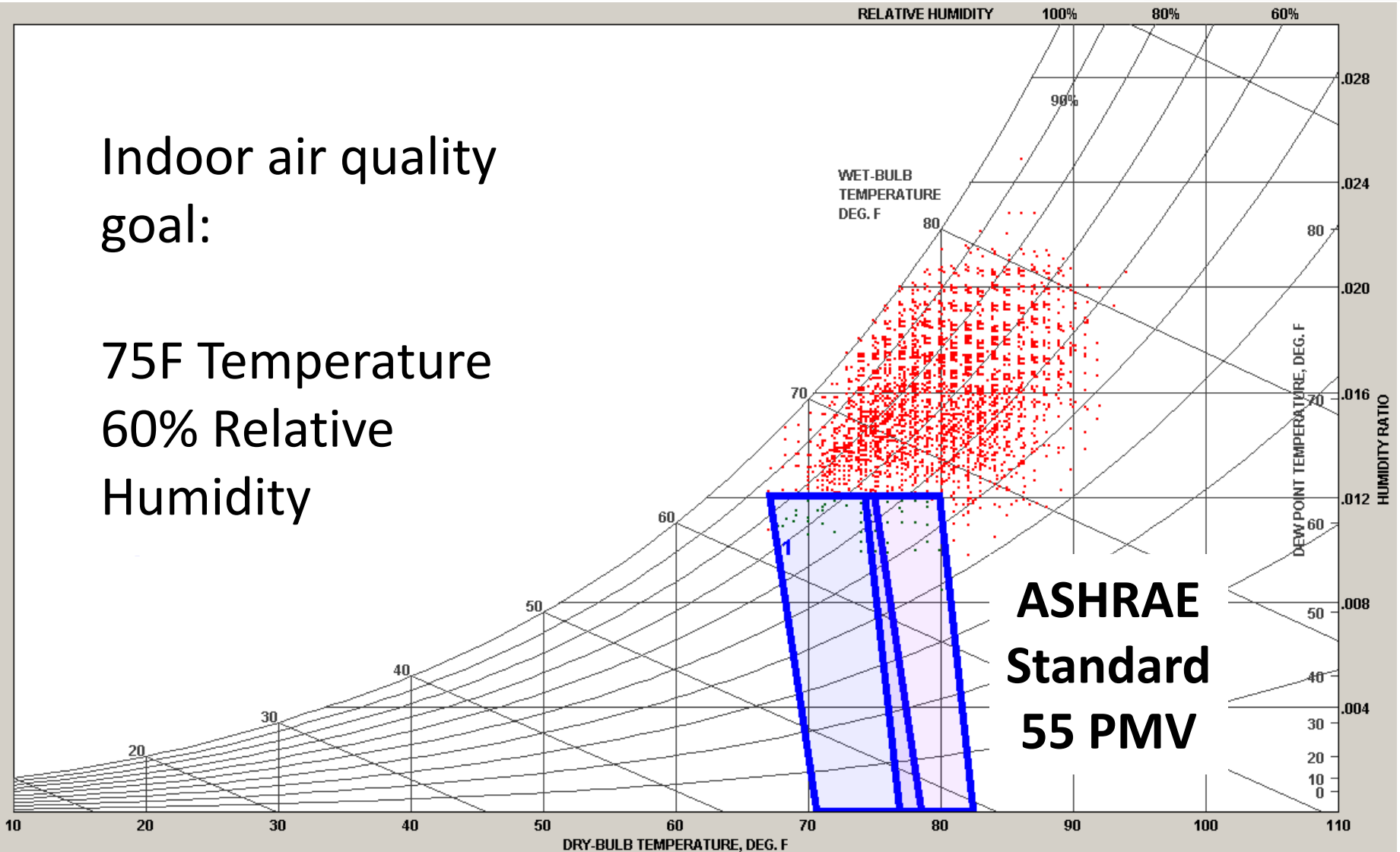


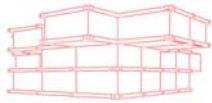
Avg. relative humidity range
60%-90%

Psychrometric Chart

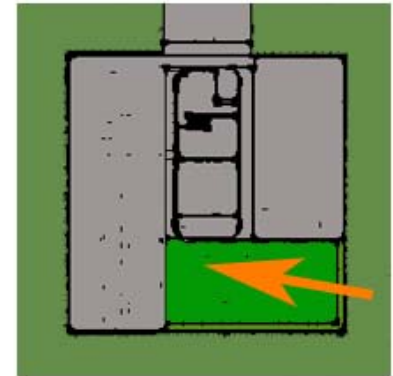
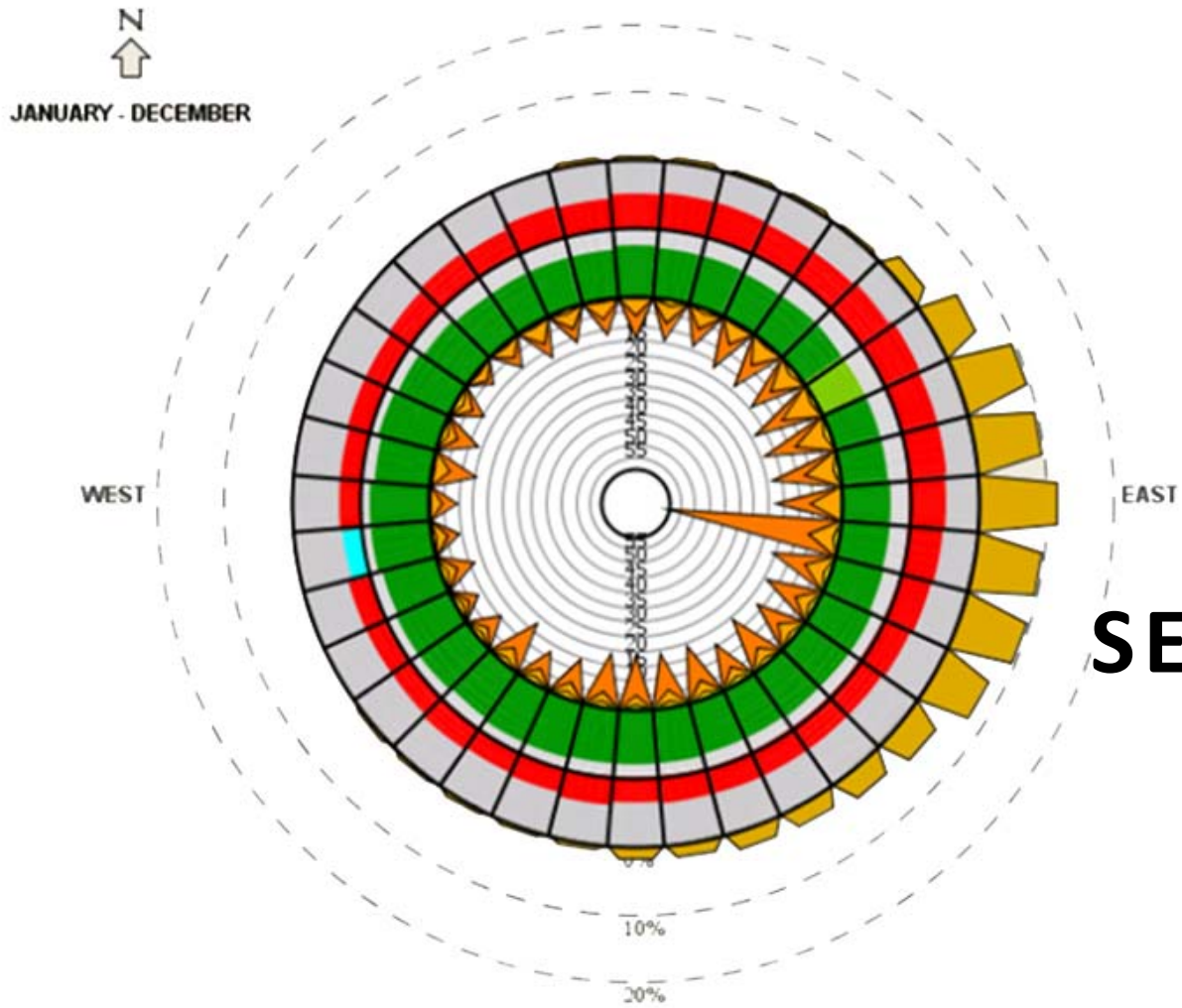
Indoor air quality goal:

75F Temperature
60% Relative Humidity



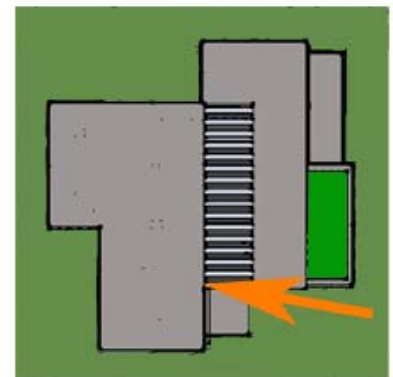


Wind Direction



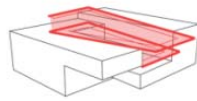
SE

Hurricane

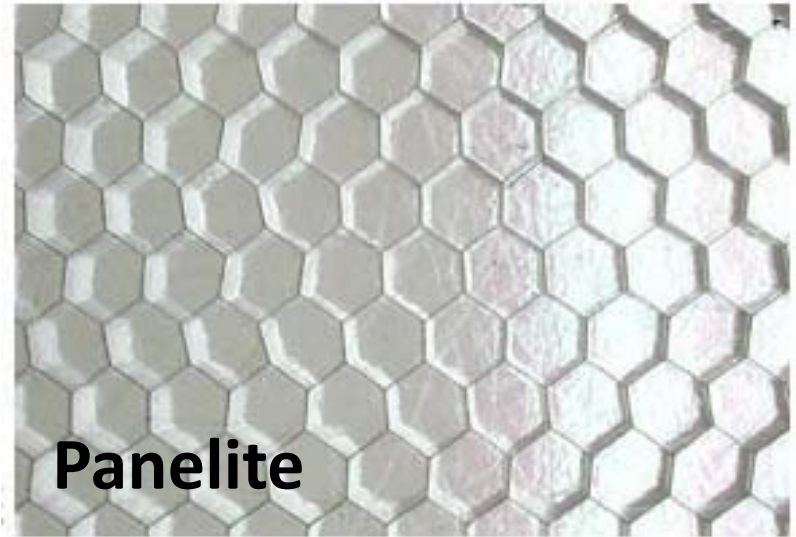
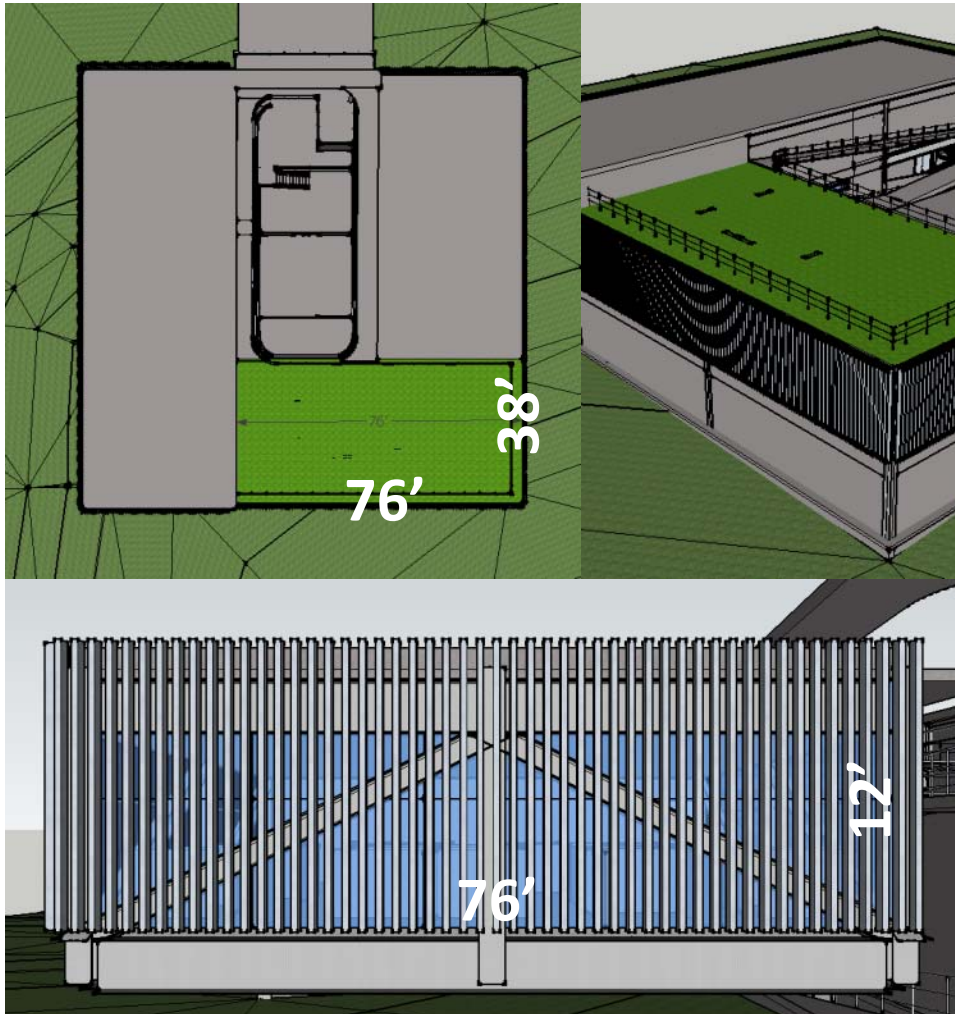


SE

Puzzle



Reduce Heat Loads



Panelite

- Cool and green roofs
- High efficiency façade and window materials
- Vertical/horizontal shading

Internal Heat Loads

	Hurricane (Btu/h)	Modules (Btu/h)
Lighting Loads	13557	12074
	78367	118119
Plug Loads	5649	5031
	32653	49216
Occupant Loads	156246	139163
	286471	323604

Legend

Auditorium

Building remainder

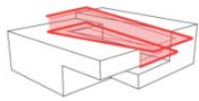
Loads	Method	Standard	Value	Type
Lighting	Building Area	ASHRAE 90.1	1.2 W/s.f.	University
Plug	Building Area	ASHRAE 90.1	0.5 W/s.f.	School
Occupant	Activity/room density	ASHRAE Fundamentals, Ch. 18	330 Btu/h	Seated, at rest
			400 Btu/h	Office work

External Heat Loads

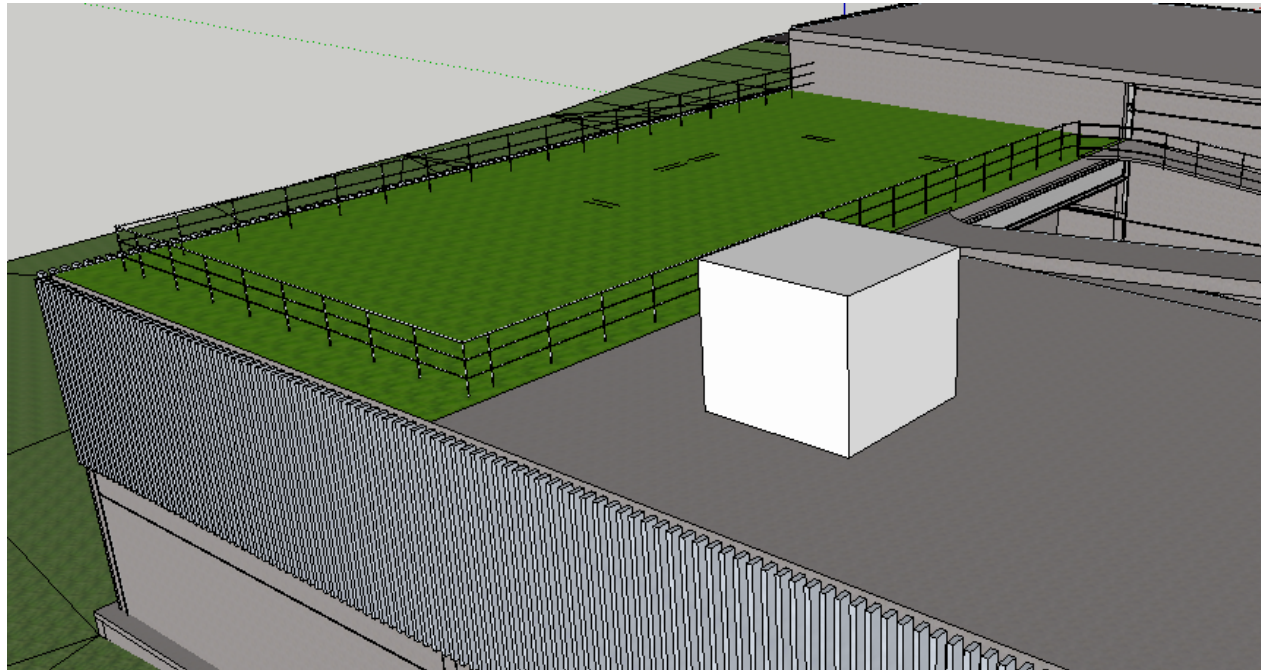
	Hurricane (Btu/h)	Modules (Btu/h)	
	0	0	
Solar radiation	37453	37453	
Conduction (windows)	8520	8520	
Conduction (façade)	4523	3297	
	50367	43443	

<u>Legend</u>	
Auditorium	
Building remainder	

Loads	Design Assumption	Data Assumption
Solar radiation	400 s.f. windows	Lat 18.5N
Conduction (windows)	U-factor 0.71	Indoor temp 75F, Outdoor temp 90F, Ground temp 80F
Conduction (façade)	R-value 10	



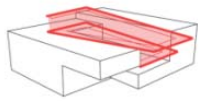
Rooftop Unit



Main duct size	Hurricane (s.f.)	Modules (s.f.)
Overhead	1.5	1.3
	4	5.5
Underfloor	2.5	2.3
	6	8

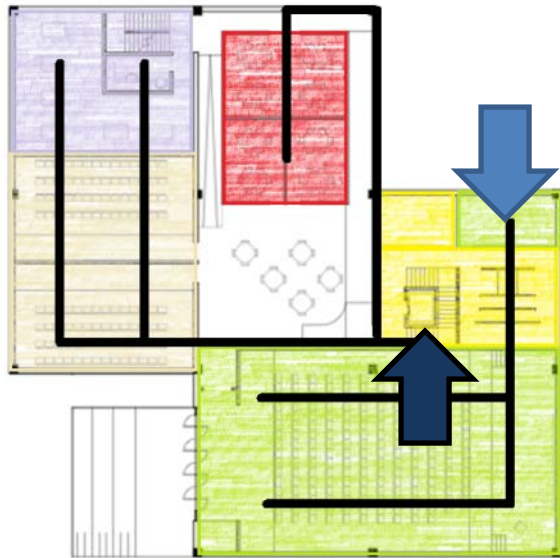
Legend

- Auditorium
- Building remainder

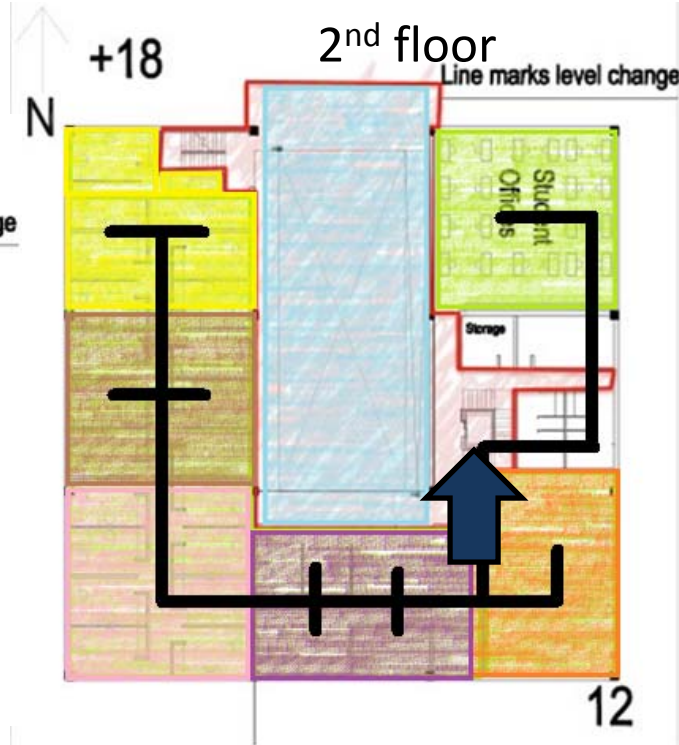
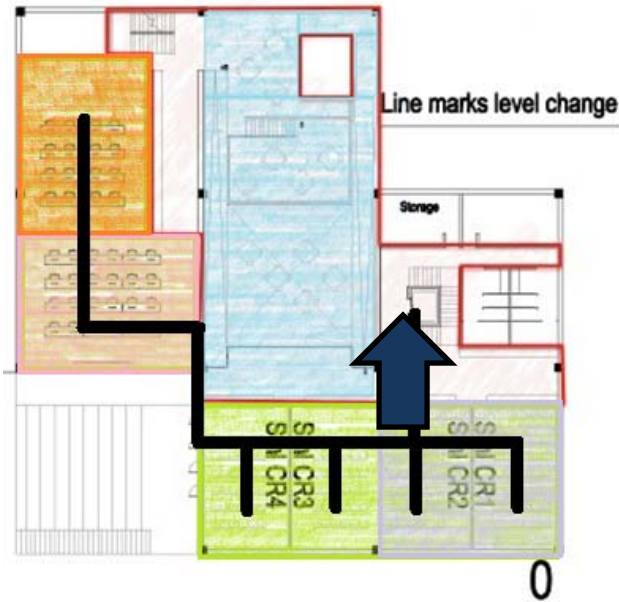


Ventilation – Hurricane

Basement



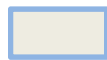
1st floor



Legend



Main duct



Atrium

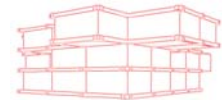


Auditorium AHU



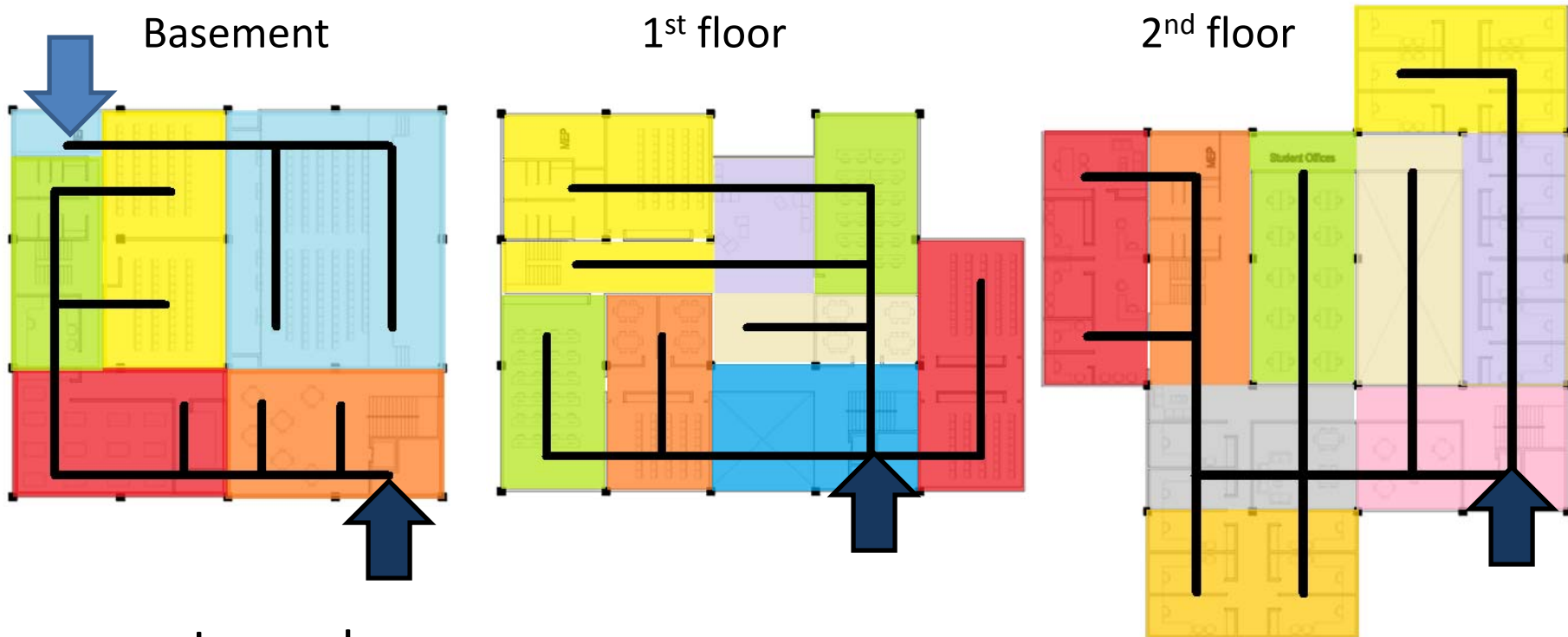
Natural ventilation

Auditorium: single-duct VAV
Building: single-duct VAV



M E P

Ventilation – Puzzle



Legend

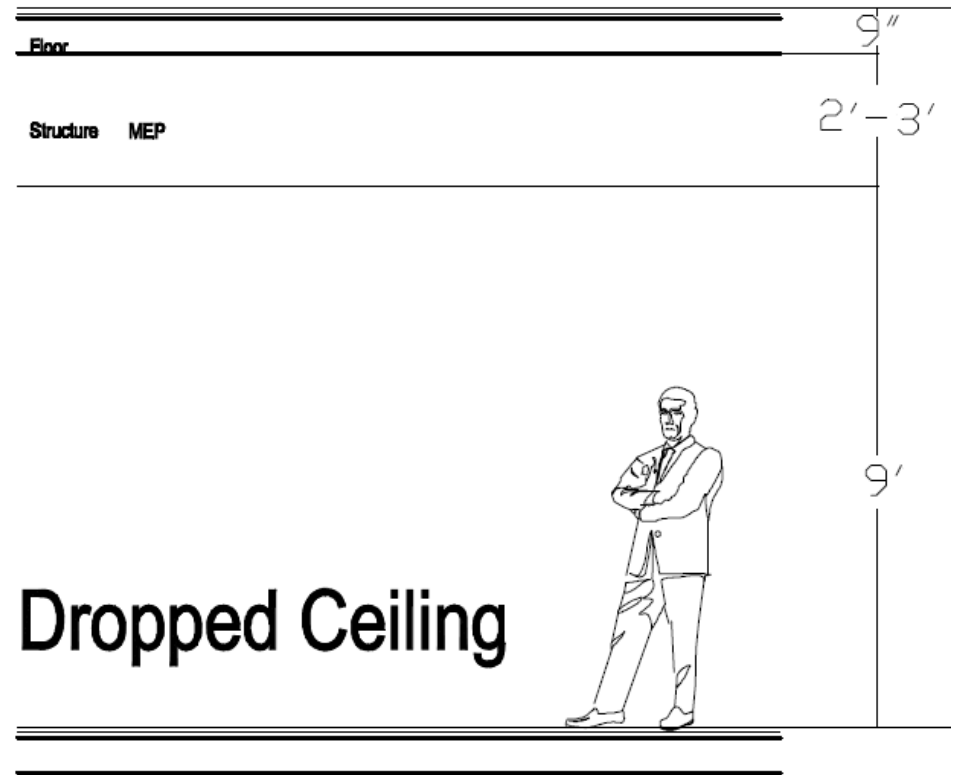
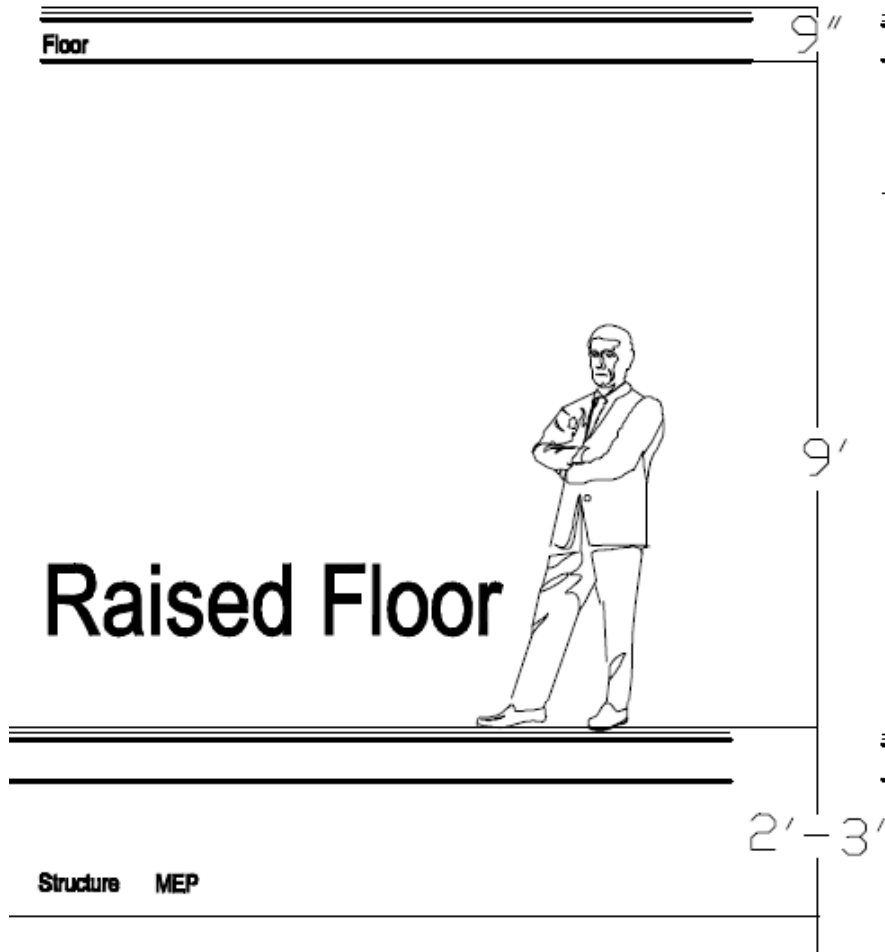


Main supply/return duct

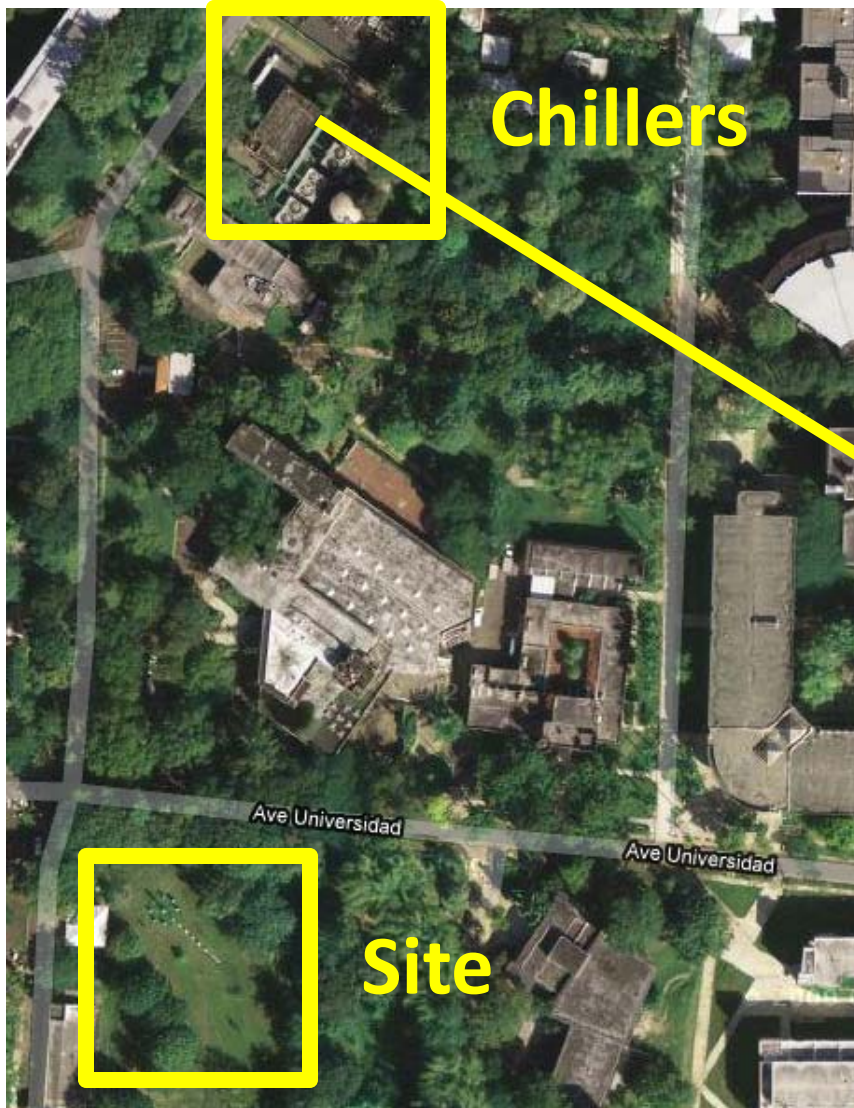


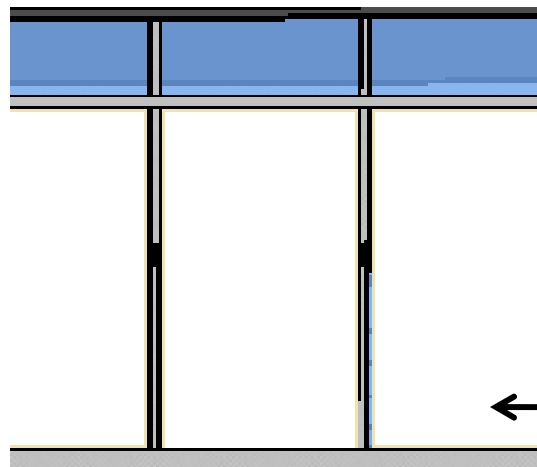
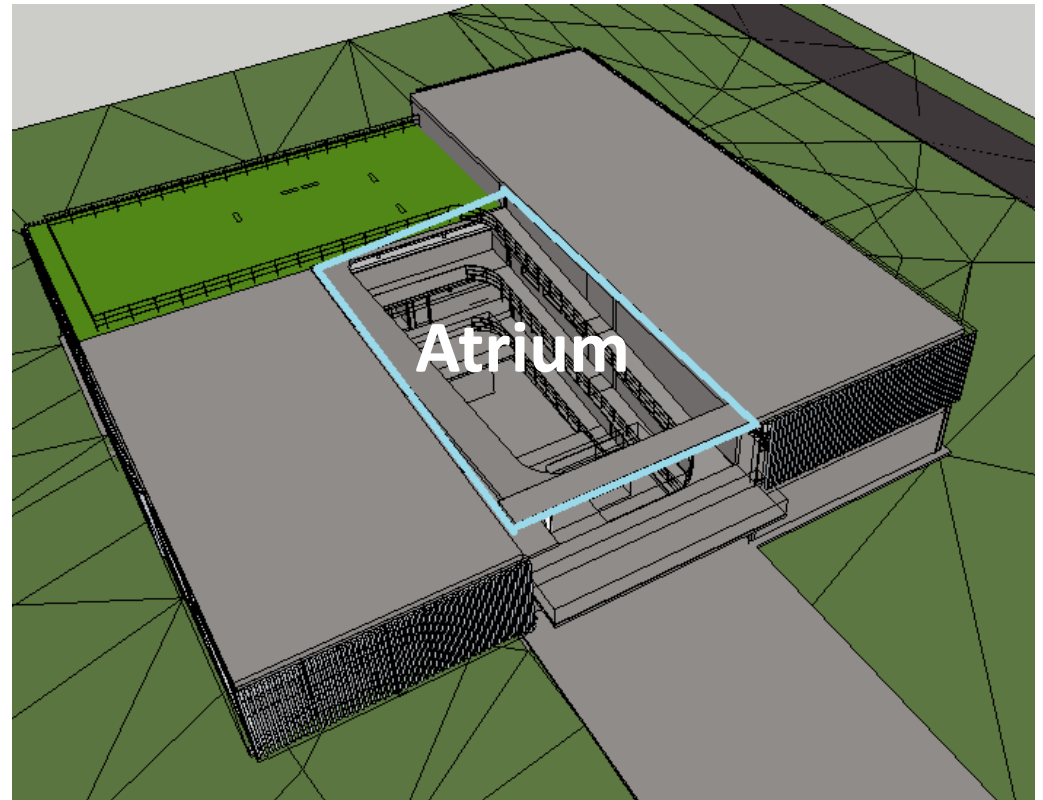
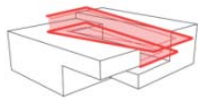
Auditorium AHU

Auditorium: single-duct VAV
Building: single-duct VAV



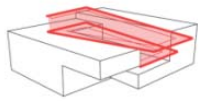
Chilled Water Location





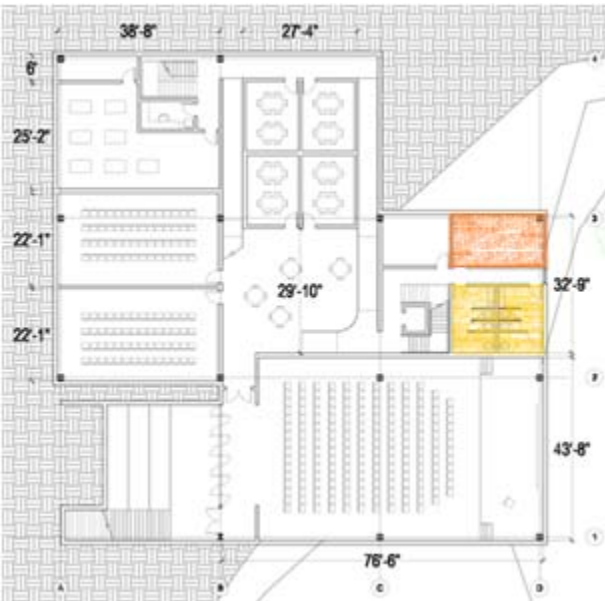
Glass material

Interior wall

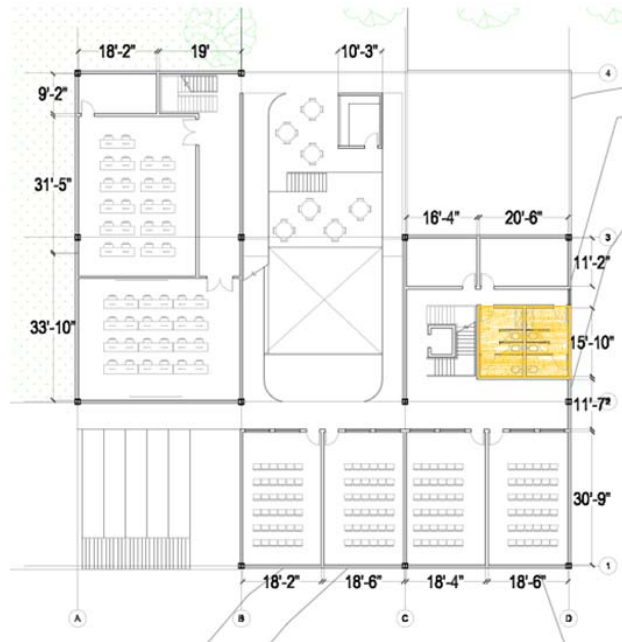


Domestic Water

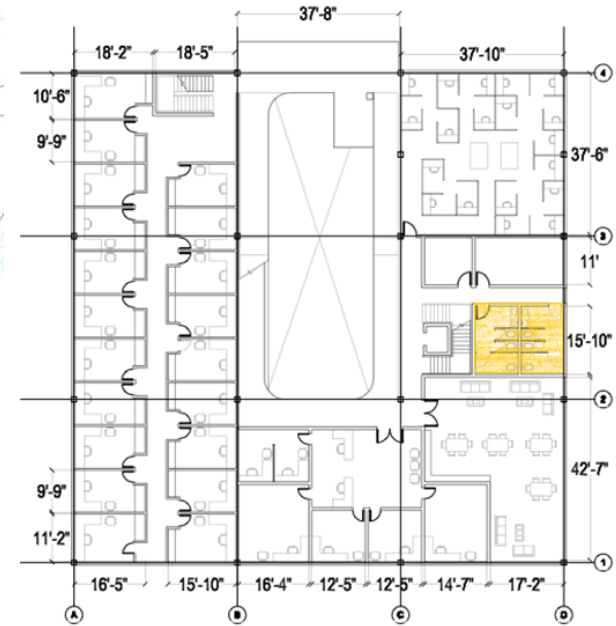
Basement



1st Floor



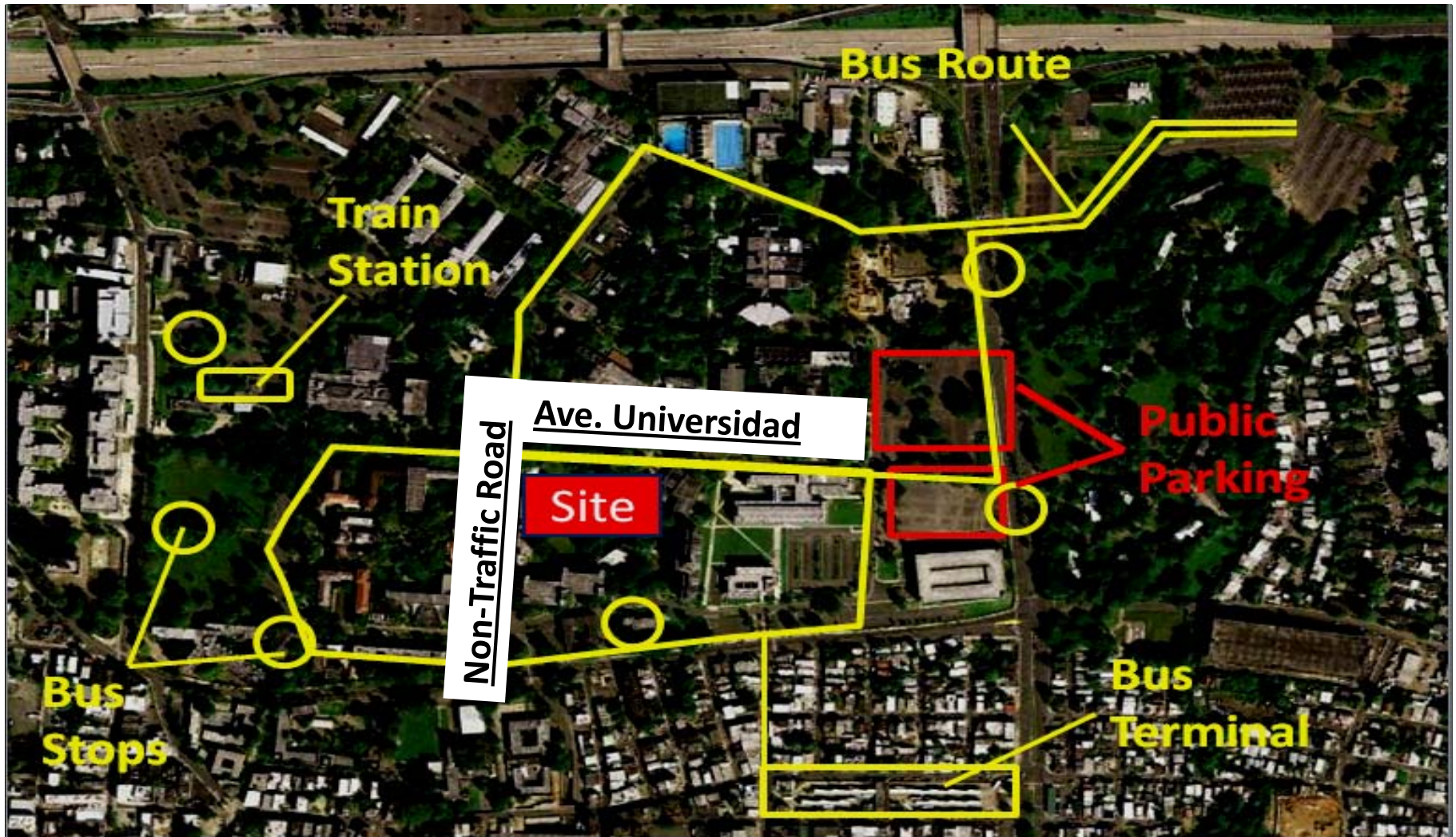
2nd Floor



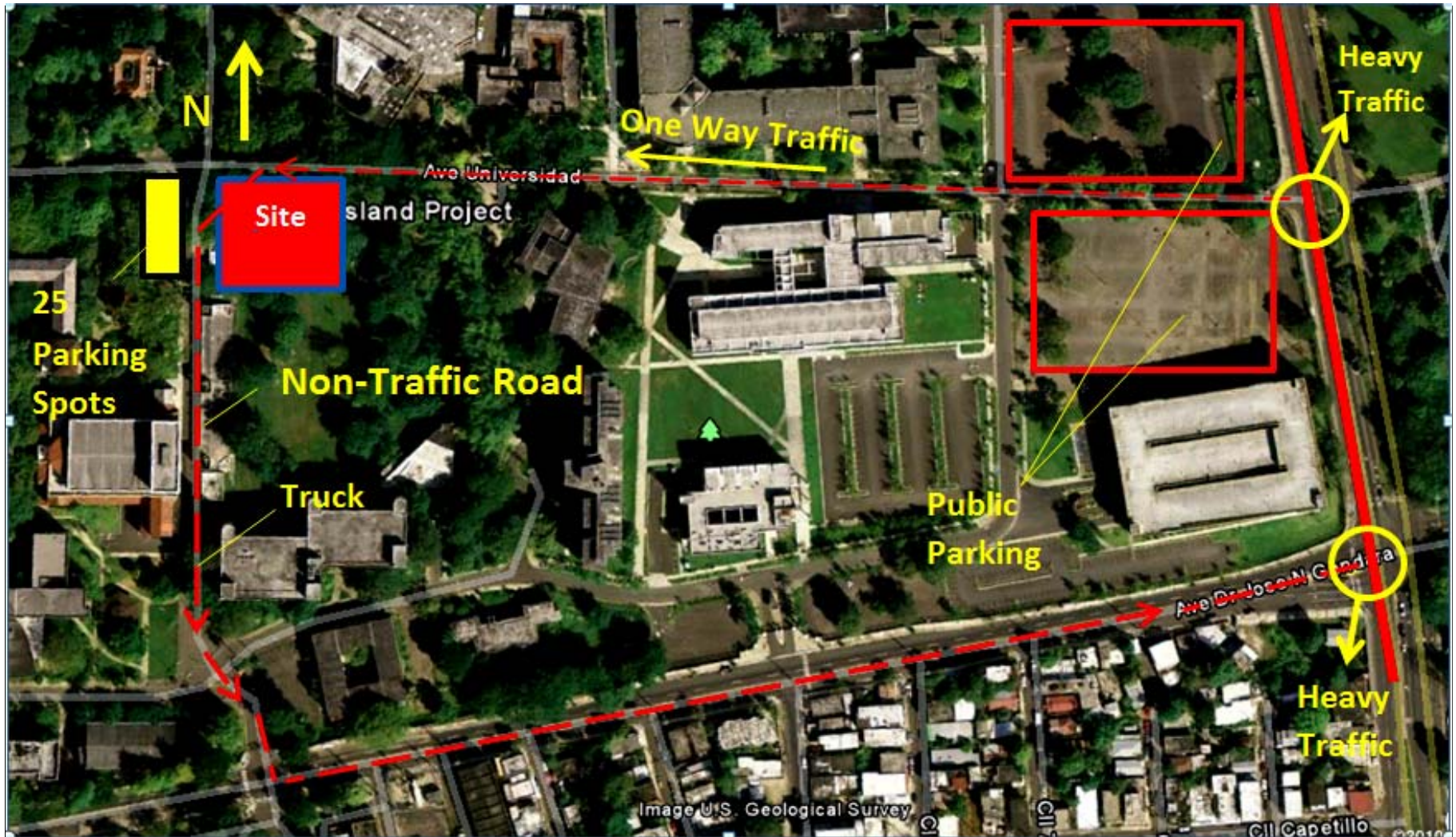
 Water pump

 Bathroom

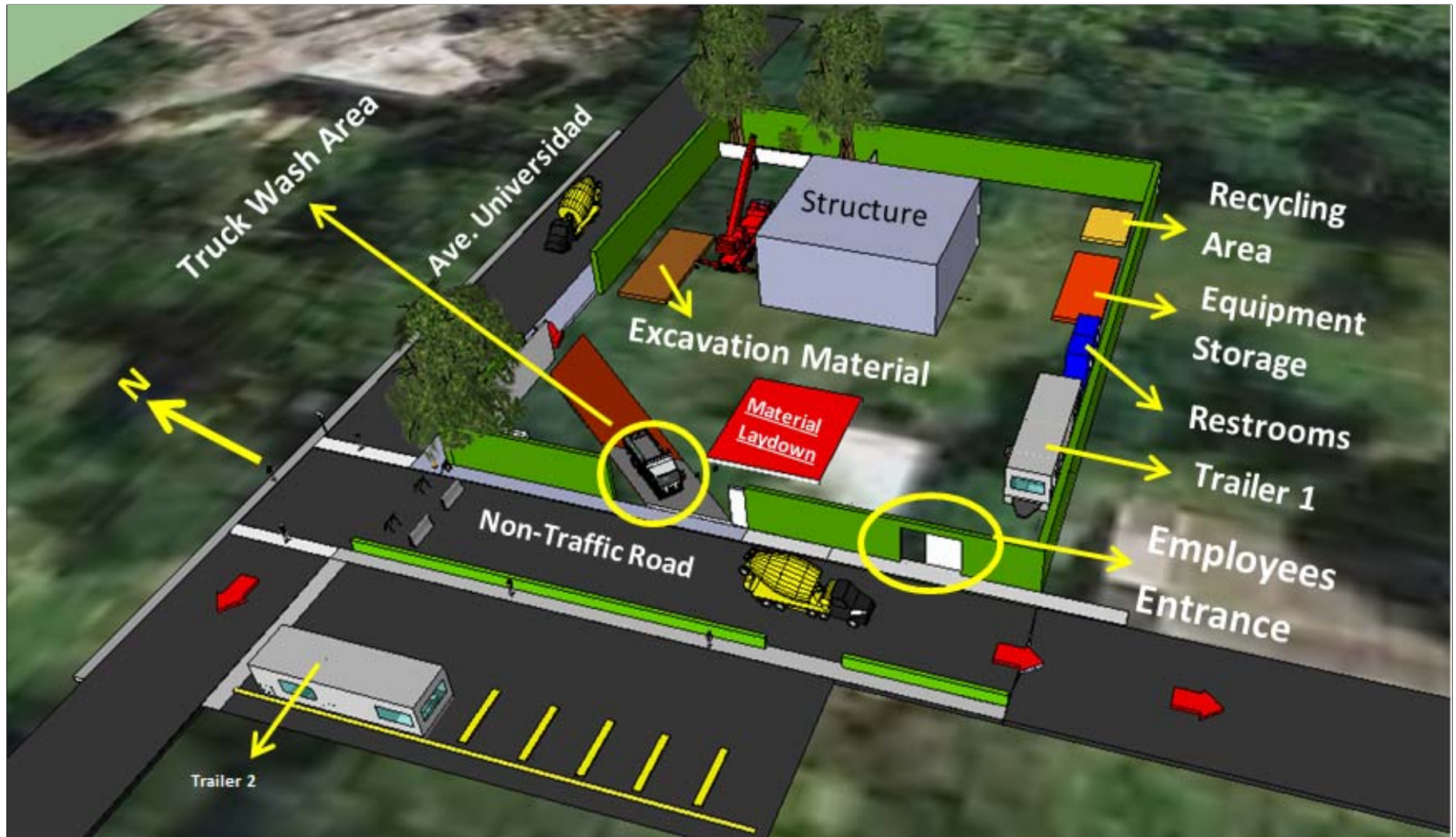
Site Logistics: Bus Stops, Train Station and Parking Lots



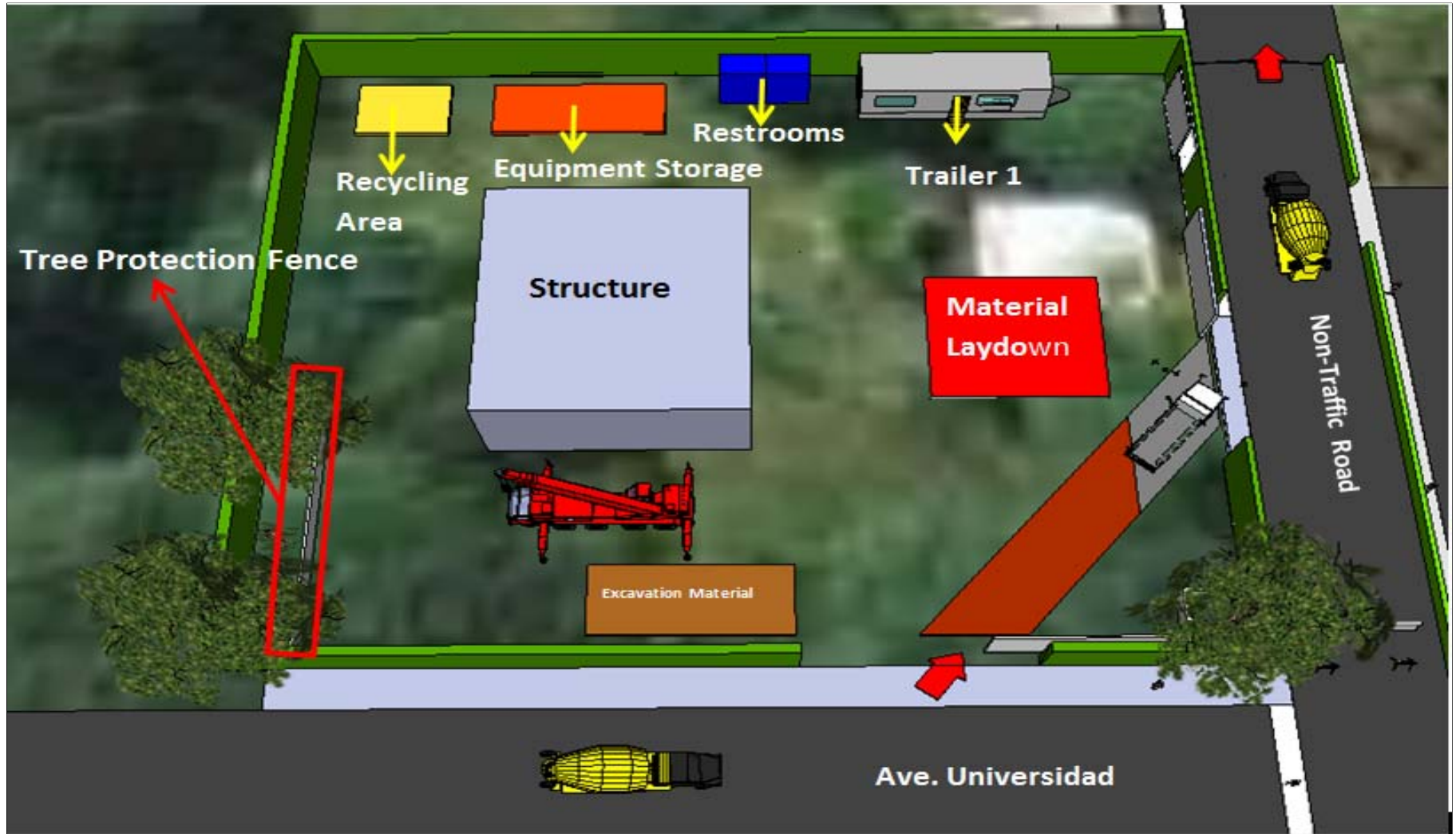
Site Logistics: Job Site Traffic Route



Site Logistics: Construction Site



Site Logistics: Construction Site



Site Logistics: Pedestrian Protection



Site Logistics: Equipment

Mobile Crane



Skip Loader



Excavator

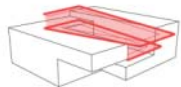


Heaviest Lift: 5.5 Kips

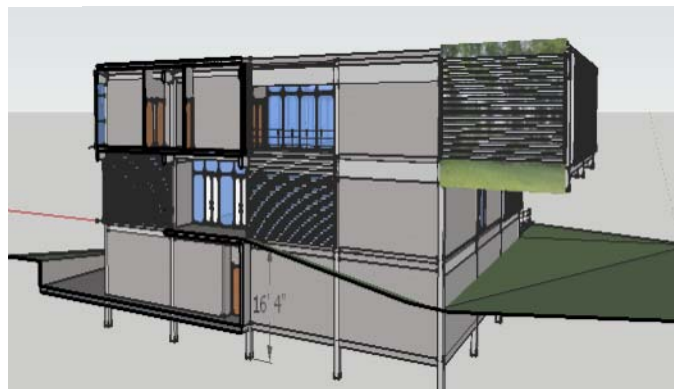
Reach: 160 ft.

- Rented 6.3 miles from the site at **Velázquez Hydraulic Services**.
- Use of Green Equipment to reduce CO2 Emissions.

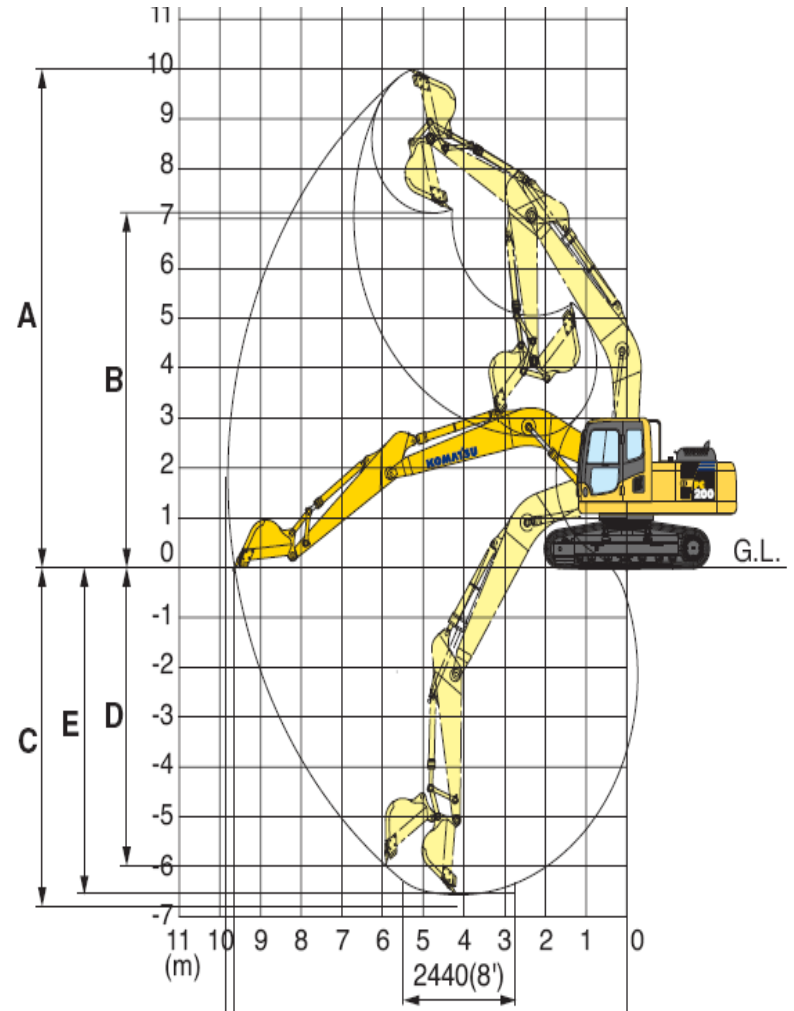
Site Logistics: Excavator Selection



Hurricane – 16' 5"



Puzzle – 16' 4"



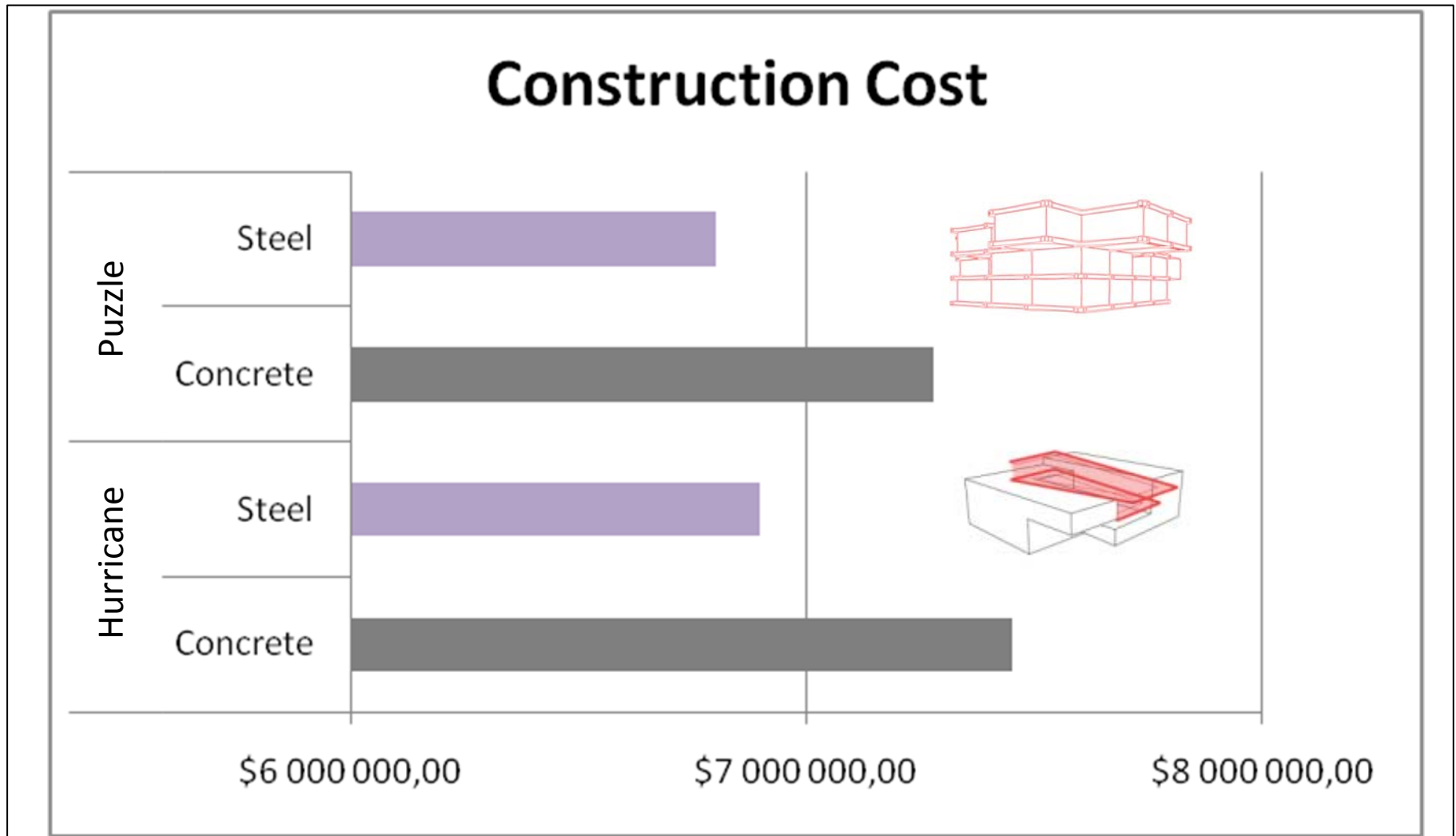
Cost Estimate: Methodology

Compare with existing building
using **SQFT Method** and **RS Means**



SUMMARY		
CRITERIA	ISLAND PROJECT 2015	JAIME BENITEX REXAC 2009
CAPACITY (SQ FT)	30,000	55,000
LOCATION	San Juan, Puerto Rico	
COST	\$8,759,017	\$13,000,000

Cost Estimate: Comparison

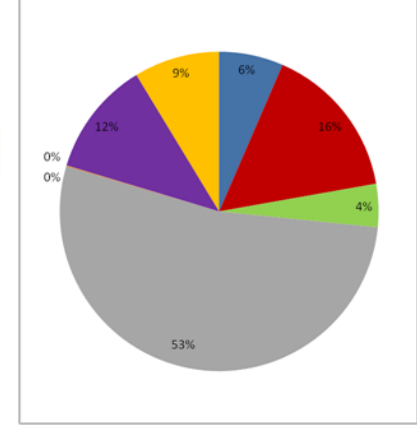
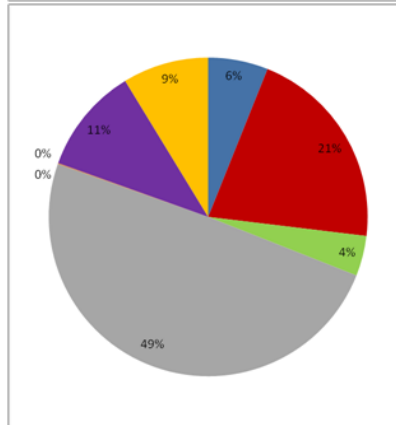
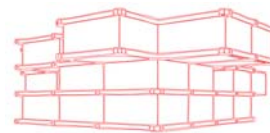
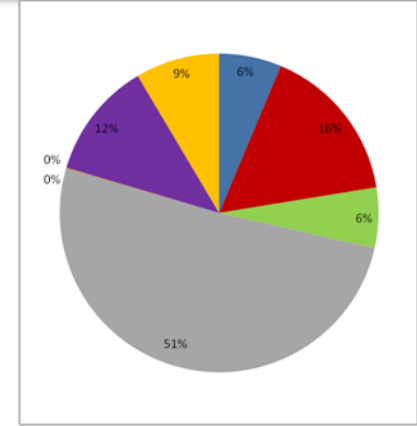
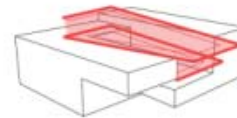
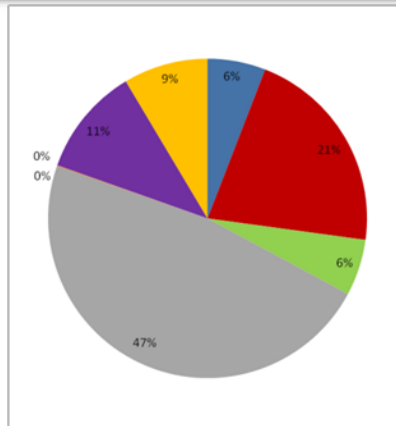


Cost Breakdown

Hurricane – Concrete : \$7,450,000

Hurricane – Steel : \$6,900,000

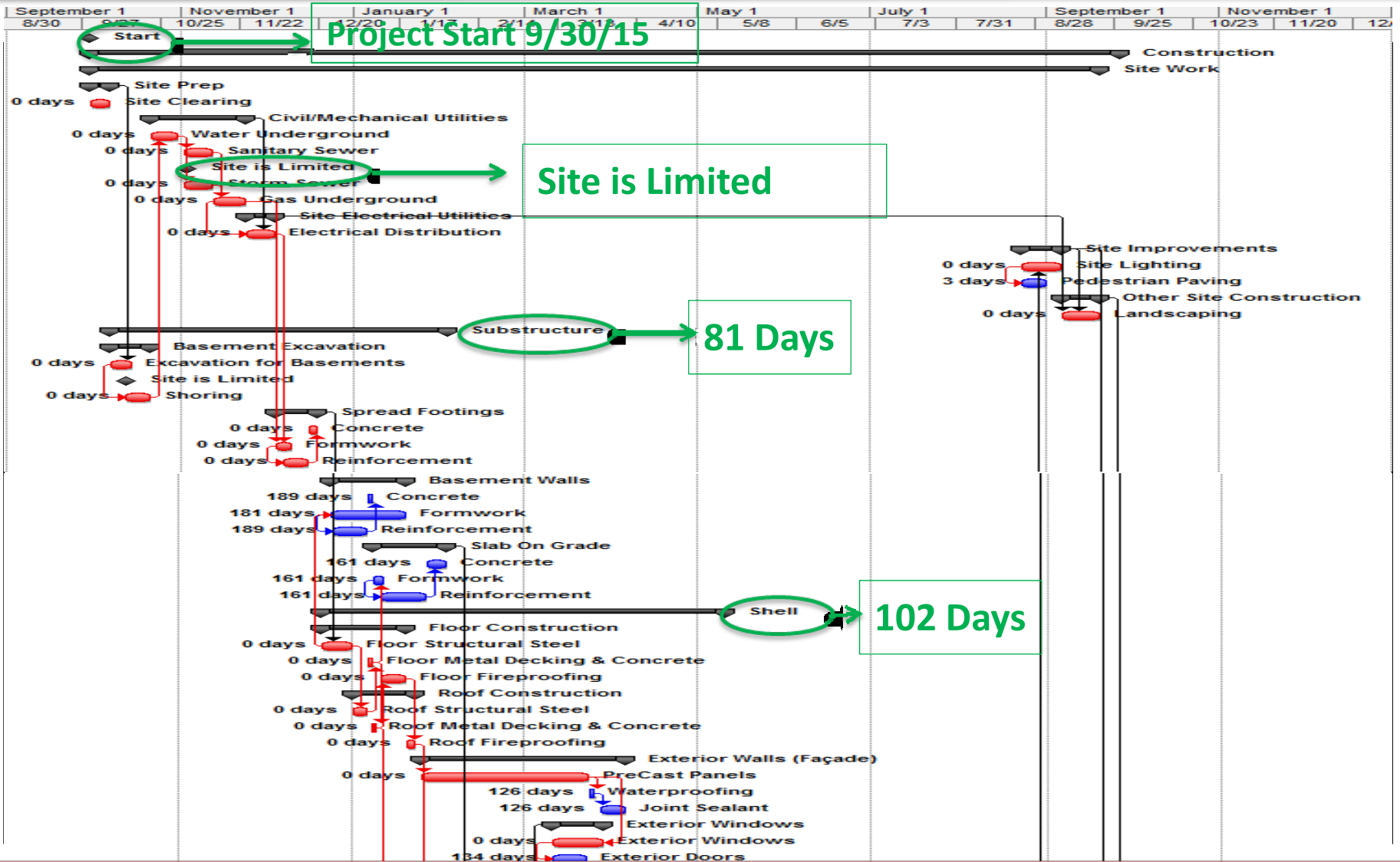
- A - Substructure
- B - Shell
- C - Interiors
- D - Services
- E - Equipment & Furnishings
- F - Special Construction & Demolition
- G - Building Sitework
- O&P



Module – Concrete : \$7,280,000

Module – Steel : \$6,800,000

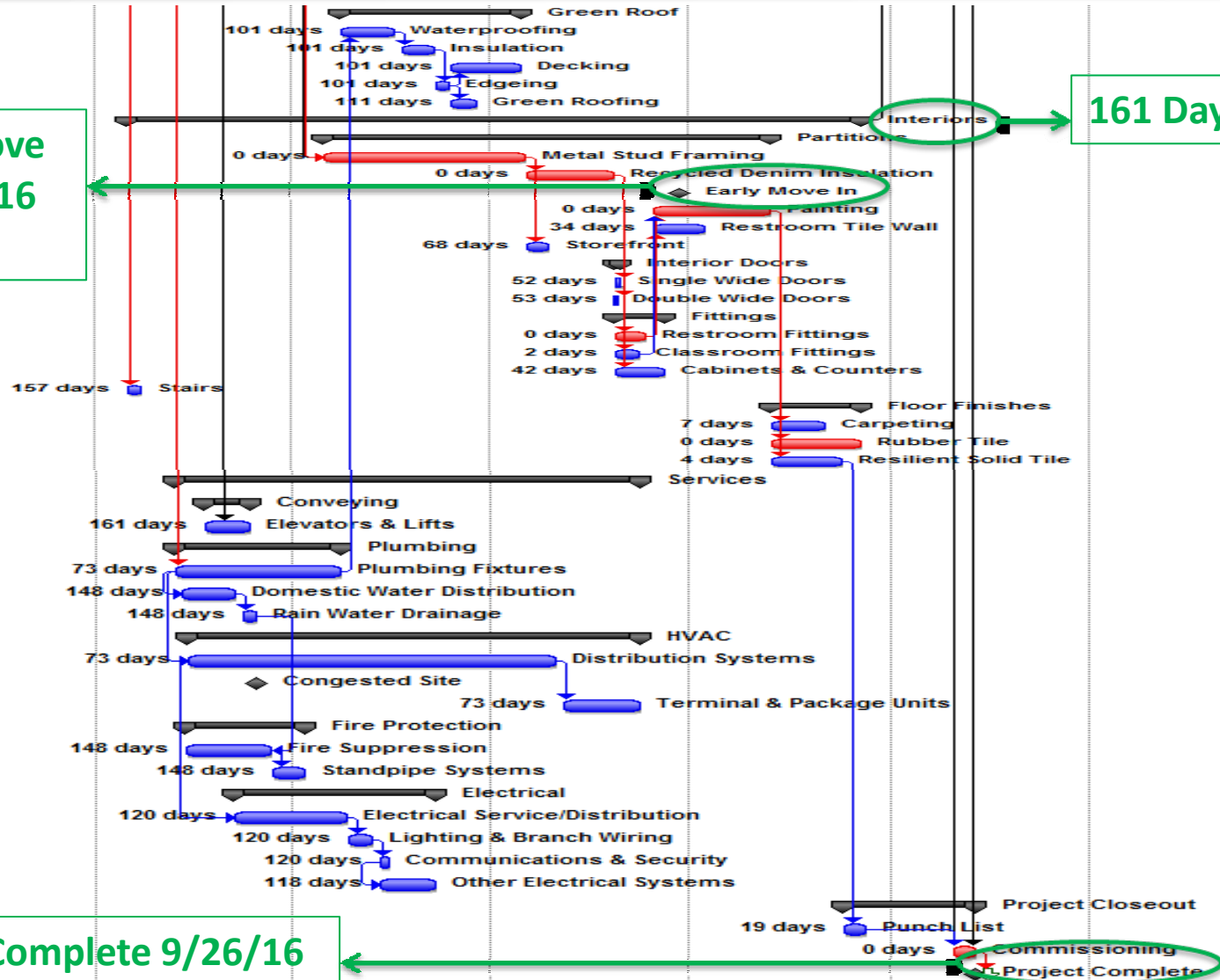
Schedule



Schedule

Early Move
In 5/15/16

161 Days



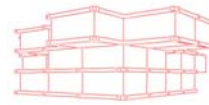
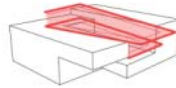
Project Complete 9/26/16

LEED: Sustainability Review

LEED Review:

Best Case Scenario: Platinum

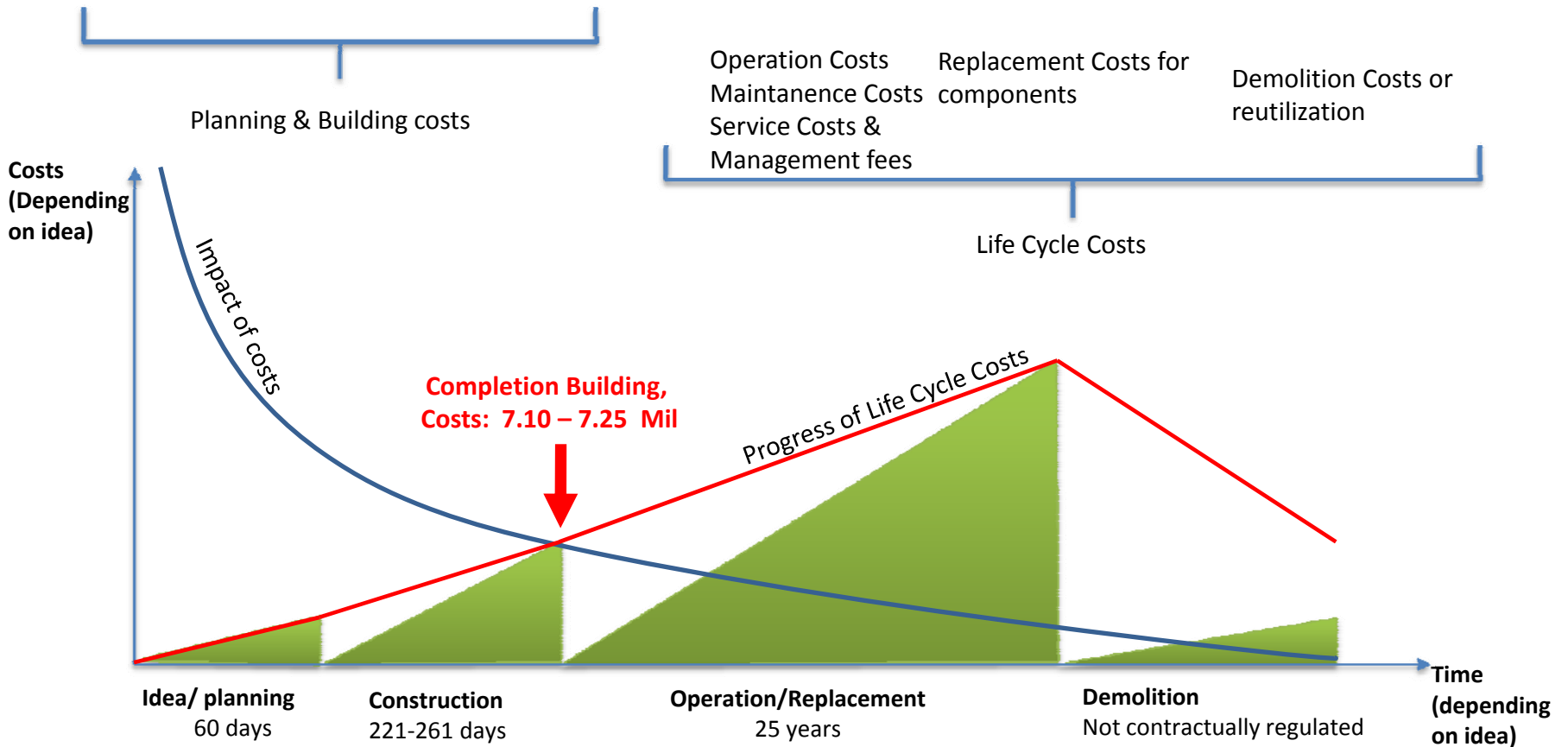
Worst Case Scenario: Certified



Credit	Possible Points	Points Awarded
Sustainable Site	26	16
Water Efficiency	10	8
Energy and Atmosphere	35	12
Materials and Resources	14	12
Indoor Environmental Quality	15	12
Gold Certification		60

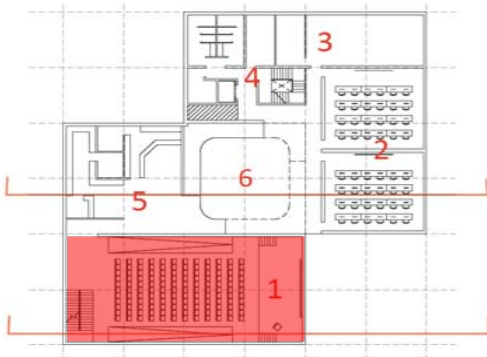
Life Cycle Costs of a building

Planning → Construction → Operation → Replacement → Demolition



Development of the room program (auditorium) from Feb 4th – Mar 11th

1. Auditorium
2. Instructional Labs
3. Server Room & Tech Support
4. Bathroom, MEP, Stairs, Elevator & Storage Core
5. Coffee Shop & Store
6. Atrium

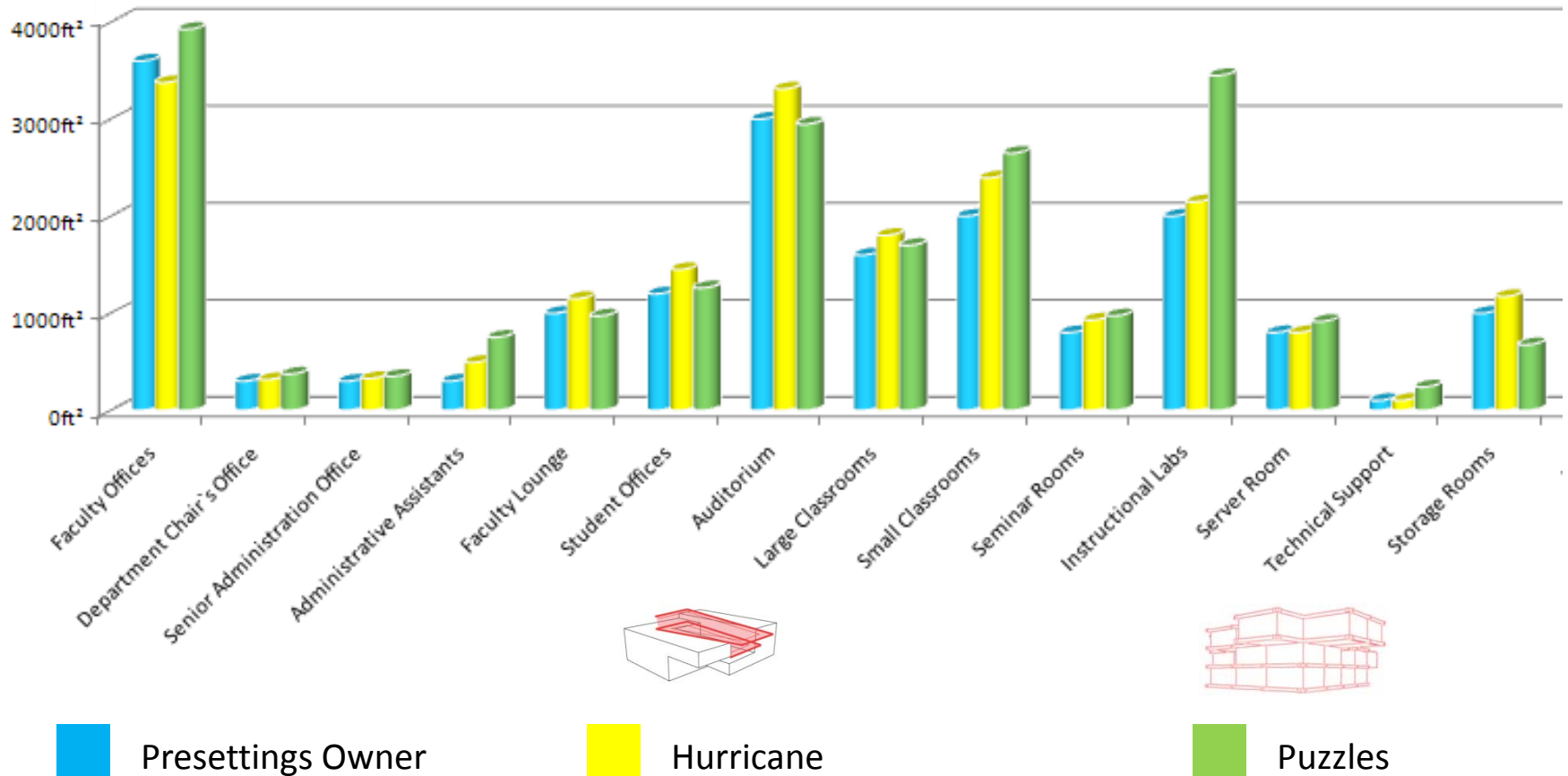


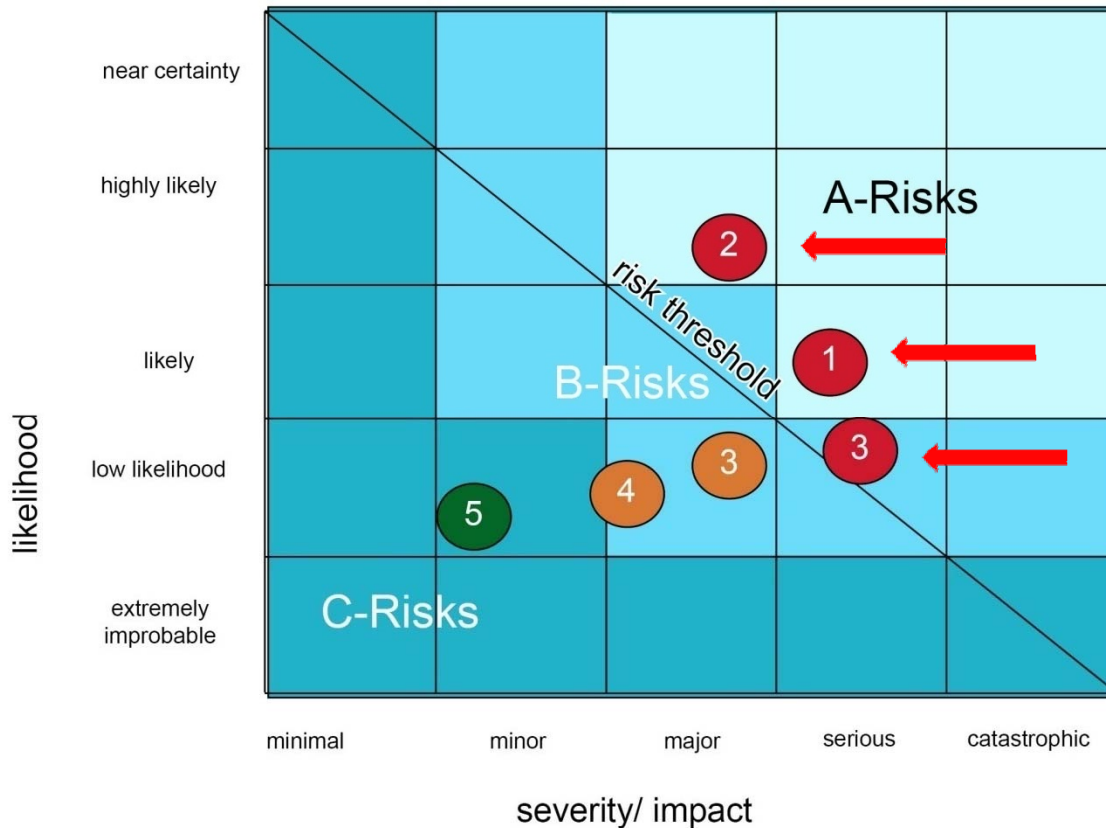
Development of the Auditorium

Date	Size	Achieved Presettings Owner	
Feb 05	2664 sf	88,8%	✗
Feb 27	2738 sf	91,3 %	✗
Mar 02	2818 sf	93,9%	✗
Mar 06	3311 sf	110,4 %	✓



Final room program Mar 11





Handling A-Risks:

- Insure
- Schedule to avoid bad weather during construction period
- Innovative protection:
 - Only partly maintenance
 - Base isolators against earthquakes

1 Earthquake

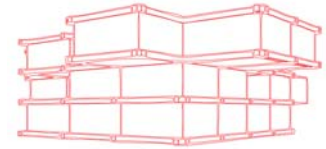
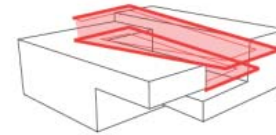
3 Steel price

5 Operating costs

2 Hurricane

4 Material quality

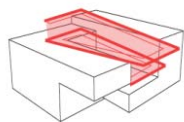
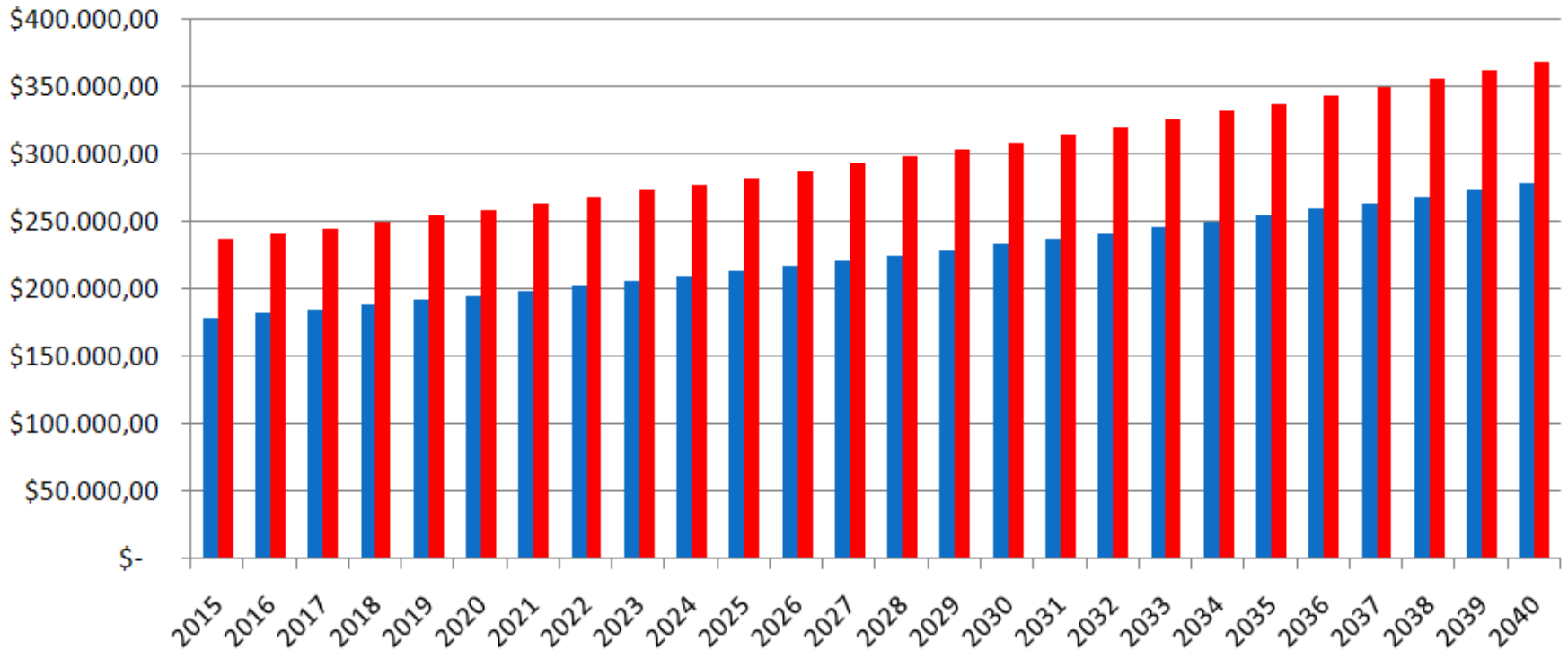
6 Building permission



Ratio	Goal	Hurricane	Puzzles
Non assignable area/ Assignable area	minimize	0,24	0,47
Building surface/ Building volume	< 0,25	0,19	0,14
Net floor area/ Gross floor area NFA/GFA	> 0,6	0,64	0,61

Average for university buildings

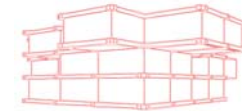
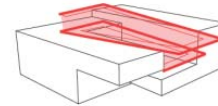
Operation & Maintenance Cost Estimate over 25 years



 Hurricane



 Puzzles



Evaluated by
quantitative
elements

Criteria	Weighting Everyone	Hurricane		Puzzles	
		concrete	steel	concrete	steel
A. Architecture	41,0	168,3	171,4	172,1	170,5
1. Aesthetics	9,2	3,9	4,1	4,4	4,1
2. Quality indoor space	10,6	3,6	3,7	4,3	4,3
3. Quality Outdoor space	7,2	4,3	4,1	3,9	4,0
4. NFA/GFA	5,9	4,0	4,0	3,0	3,0
5. Room Program	8,1	5,0	5,0	5,0	5,0
B. Costs	23,3	67,4	73,6	93,1	99,4
6. Construction cost	6,3	4,0	5,0	4,0	5,0
7. Energy Cost	8,3	3,0	3,0	4,0	4,0
8. Life cycle cost	8,7	2,0	2,0	4,0	4,0
C. Structure	21,0	84,0	87,2	84,0	87,2
9. Structure Performance	12,1	4,0	5,0	4,0	5,0
10. MEP implementation	8,9	4,0	3,0	4,0	3,0
D. Fabrication	15,3	61,1	69,7	60,0	60,0
11. Schedule	7,5	4,0	5,0	4,0	4,0
12. Sustainability	7,8	4,0	4,1	3,9	3,9
Ranking	100	380,7	401,9	409,2	417,1

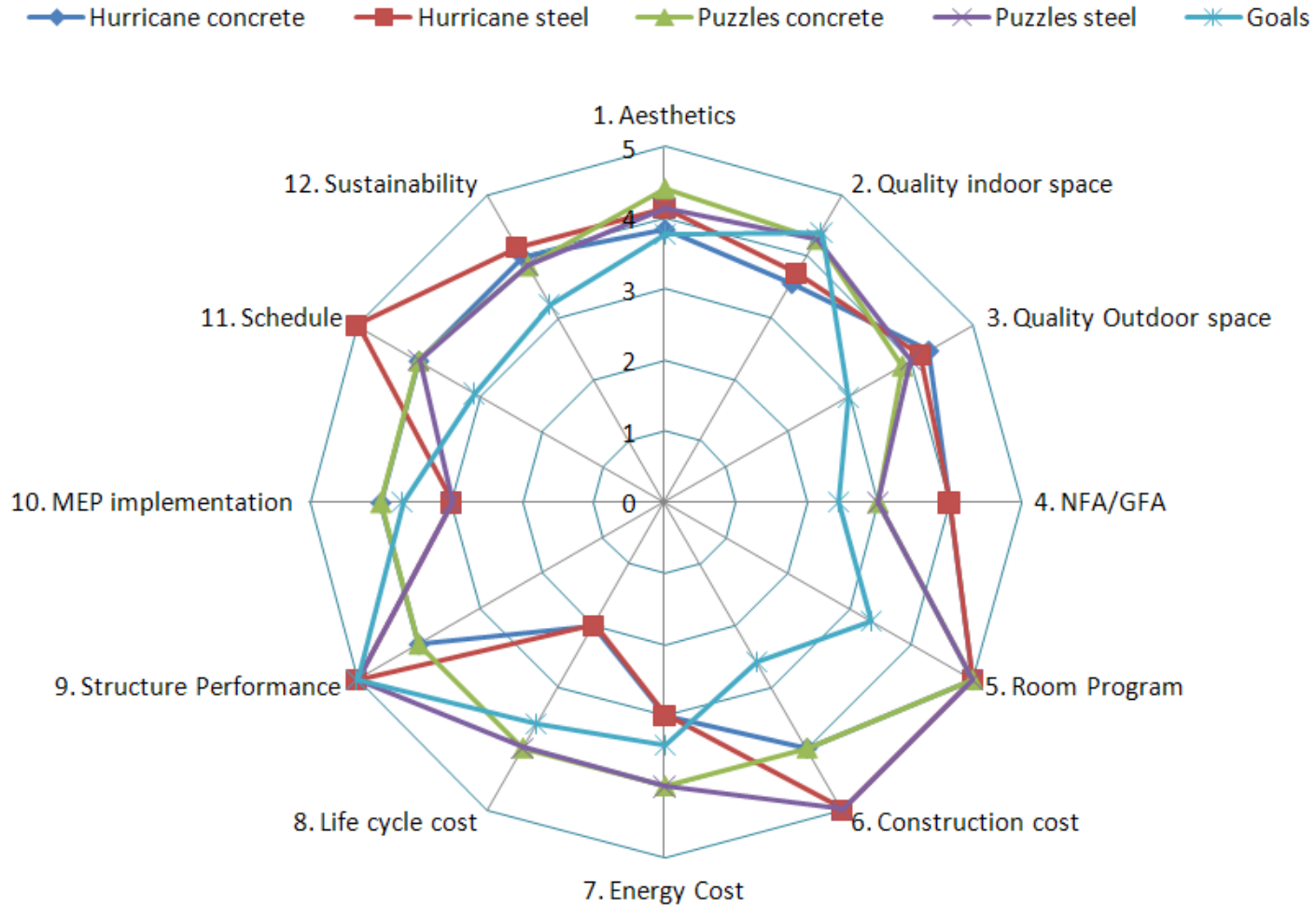
4.

3.

2.

1.

Decision Matrix





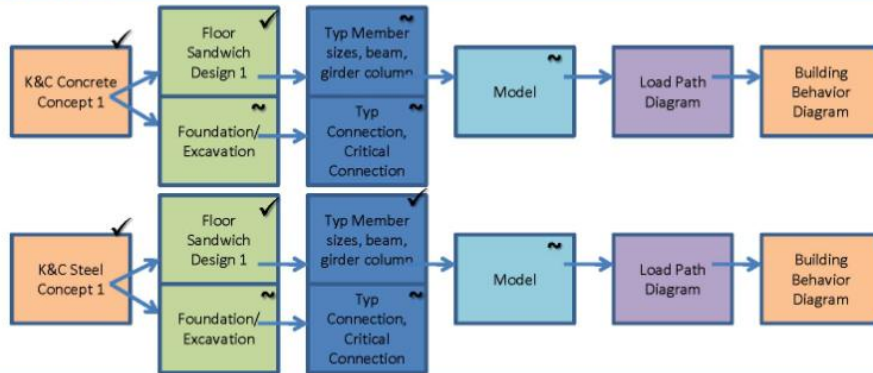
Puzzle Steel



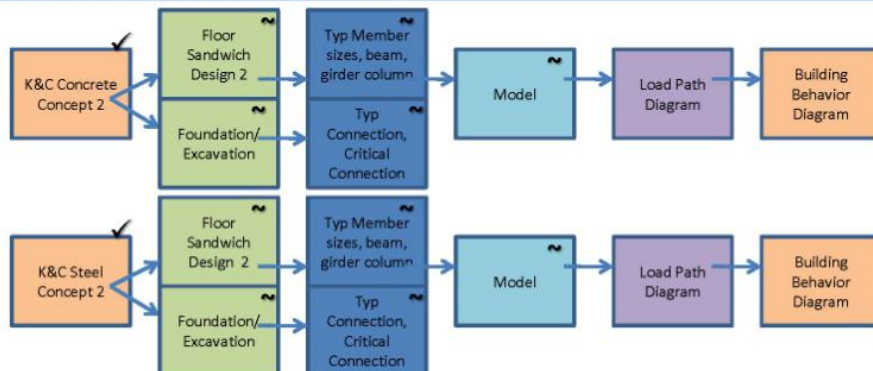
Weekly Interaction

Structural Flow Chart

Concept 1 - Double Diamond



Concept 2 - Square



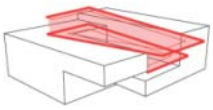
We Wish: Develop this flow chart and make it more like a launchpad and less like a record



Engagement in virtual Team workspace



Interacting within the Building model



Iteration and Reiteration



1. Hurricane, "flying box"



SE and CEM provide
Immediate feedback

2. Feasible structure & cost



Full team discussion
Many reiterations
Owners and mentors
provide input

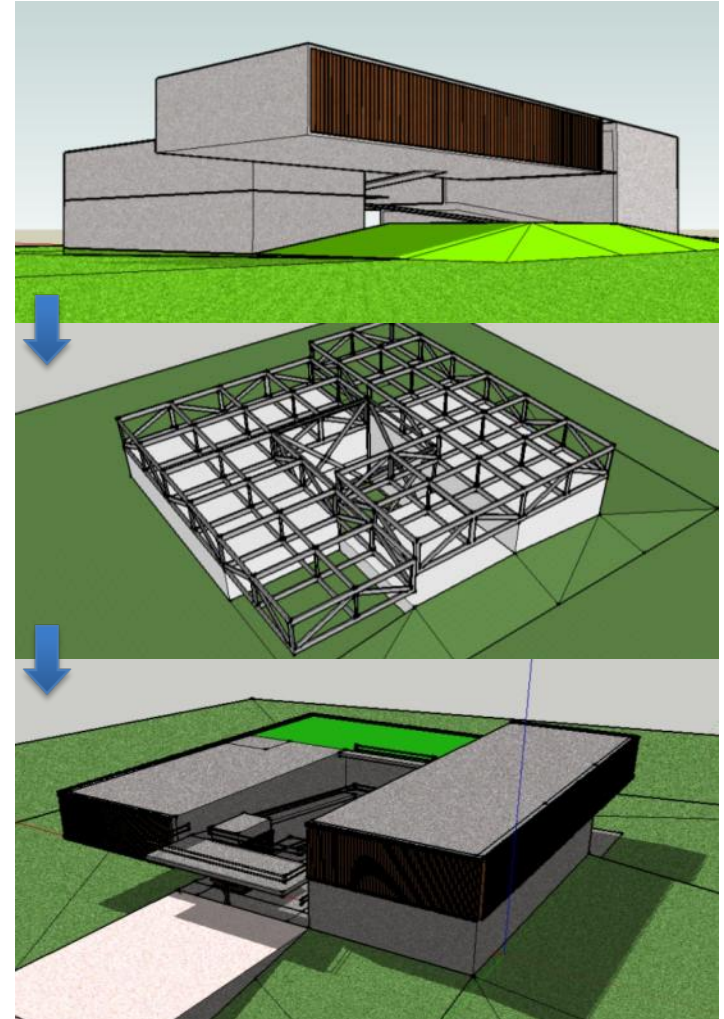
3. New solution, larger atrium



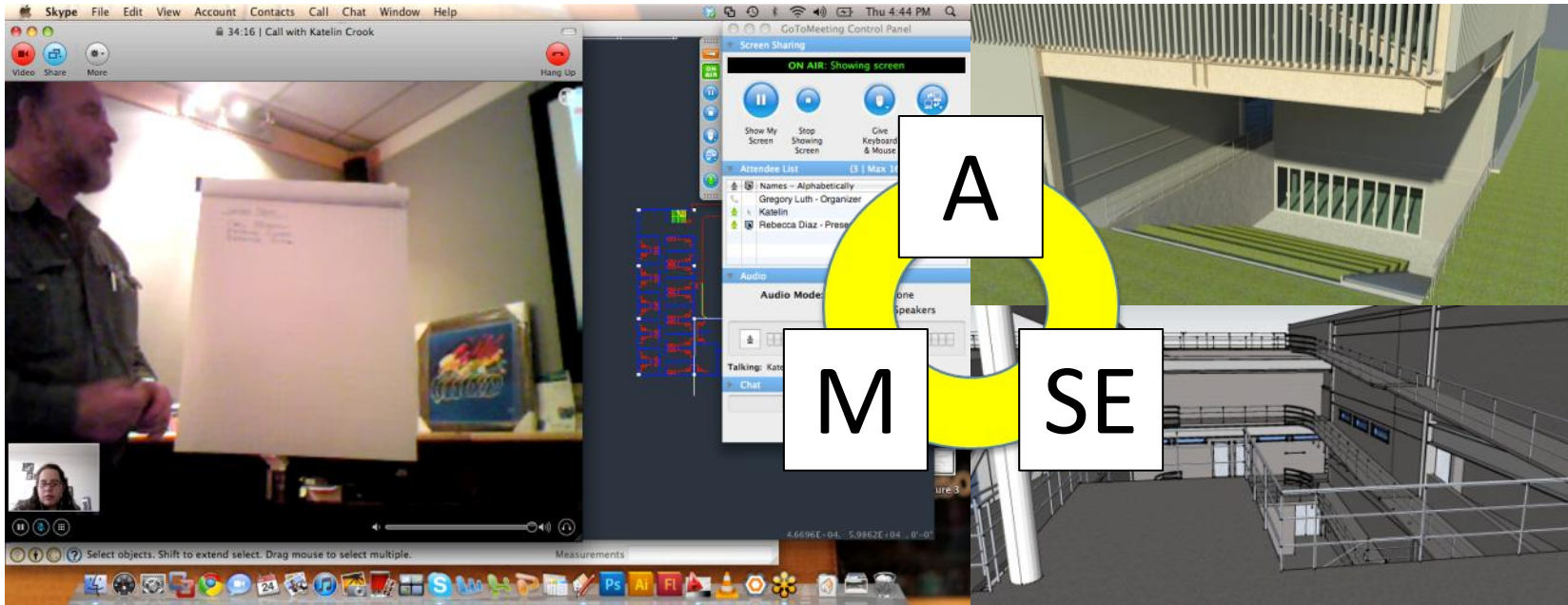
Entire team continues
to integrate design

4 major reiterations for Hurricane design

Over 1000 waves & 2000 MB files!



Mentorship



Interdisciplinary, multimedia
interaction with mentors

- **Physical meeting**
- **Integrate structure & architecture**
- **Screen share, physical & virtual notes**
- **Follow-up with reiterations**

Special Thanks to:

- Greg Luth (SE)
- Humberto Cavallin & David Bendet (A)
- John Nelson & Dennis Kwan (MEP)
- Dan Gonzalez, Henry Tooryani
& Dustin Rothwell (CEM)
- Björn Wündsich, Hans-Wilhelm Alfen,
Axel Seifert & Matthias Ehrlich (LCFM)

Architecture

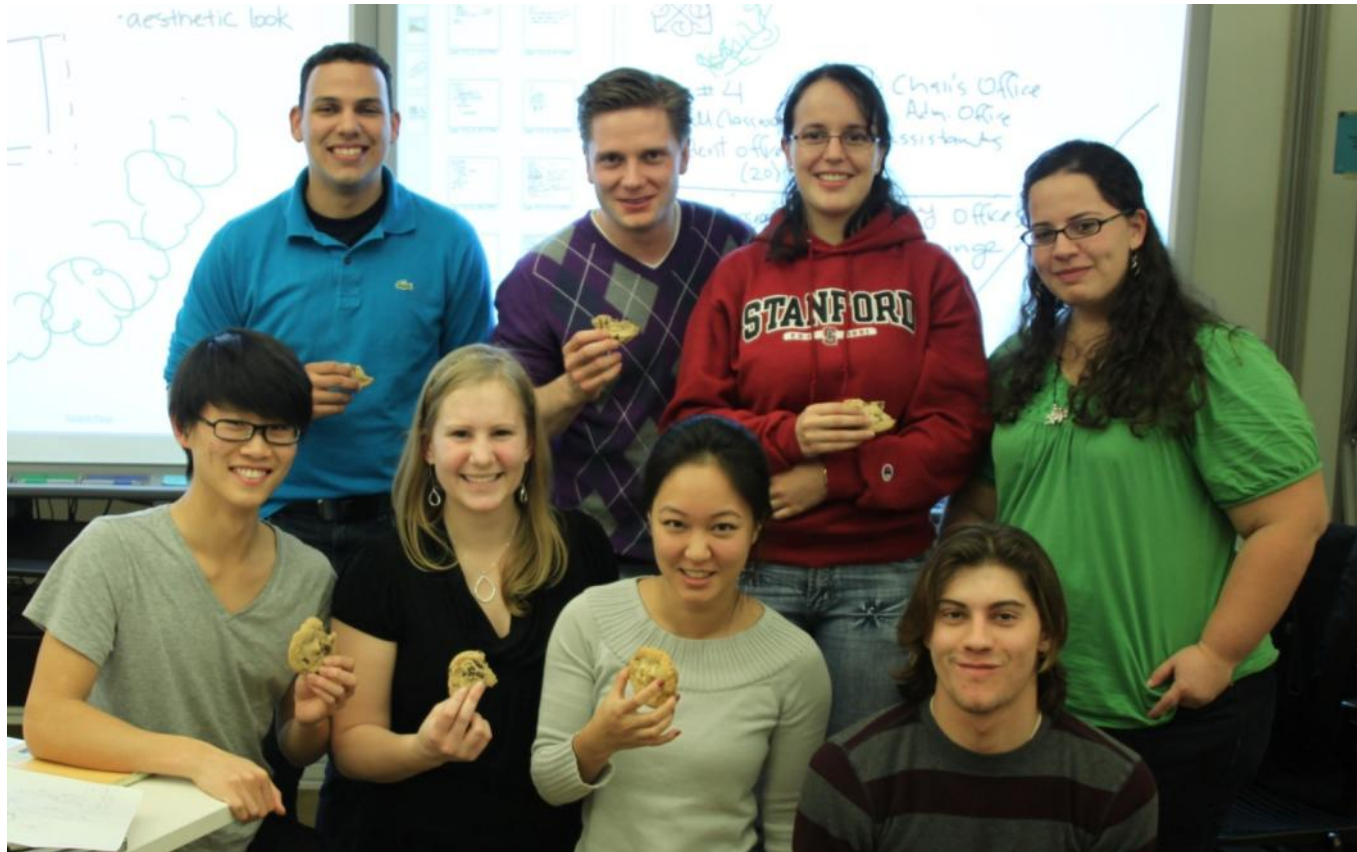
Mechanical

Life Cycle

Structure

Construction

Thank You!



Architecture

Mechanical

Life Cycle

Structure

Construction

References

Spread Footing Spreadsheet

<http://www.asdipsoft.com/Walls.htm>

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http://www.starseismic.net/pdf/Star_Seismic_2010.pdf