# Winter Presentation
## March 15th, 2013

*Ridge Team 2013*

*"We are the Ridge Team, which, from now on, stands for awesome."*

# Ridge Team 2013

Architecture
Structure
MEP
Construction

Owners: Sinan M., Anirudh R., & Maria S.

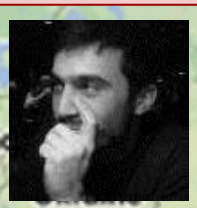
Chico, CA
Laura M. (CM)

Stanford, CA
Stephanie C. (SE)
Ramon I. (CM)

Puerto Rico
Pablo C. (A)
Jorge S. (A)

Germany
LCFM Consultants:
Stefan E. (LCFM)
Toni G. (LCFM)

Denmark
Kleanthis C. (MEP)

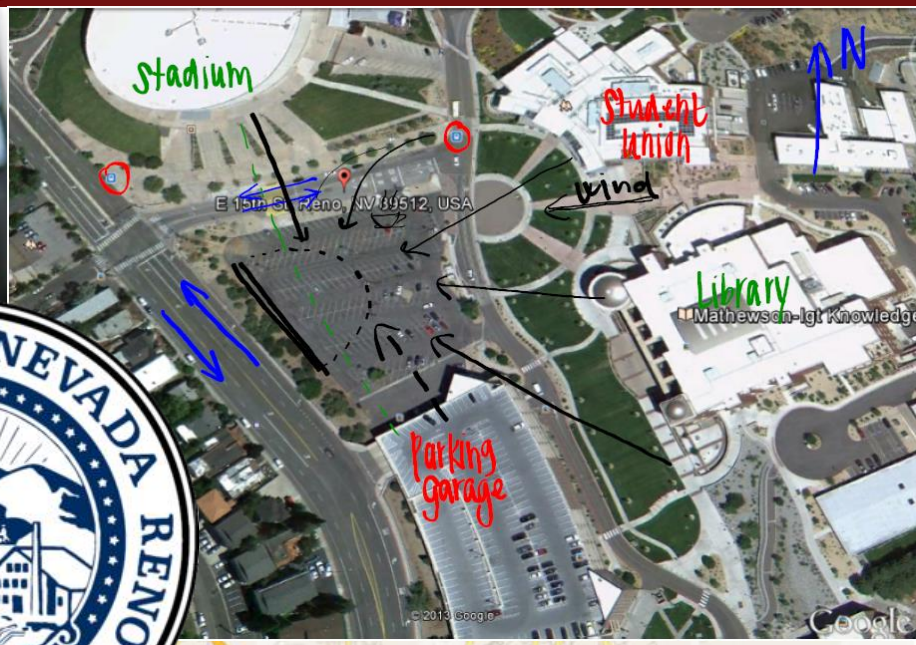


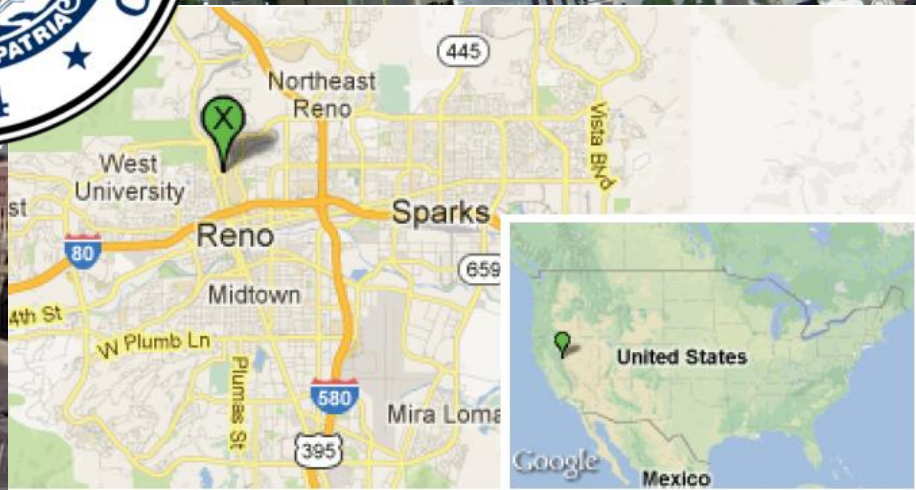
Slovenia
Stefan M. (SE)

Iceland
France
Spain
United States
Mexico
Algeria
Libya
Mali
Niger
Chad
Nigeria
Ethiopia
Kenya
DR Congo
Tanzania
Angola
Namibia
Brazil
Peru
Bolivia
Colombia

# Project Overview

Architecture
Structure
MEP
Construction



# SITE UNIVERSITY OF NEVADA, RENO

# Climate Challenges



- Sunshine:

3650 hr/yr

- Precipitation:

7,30 inches/yr

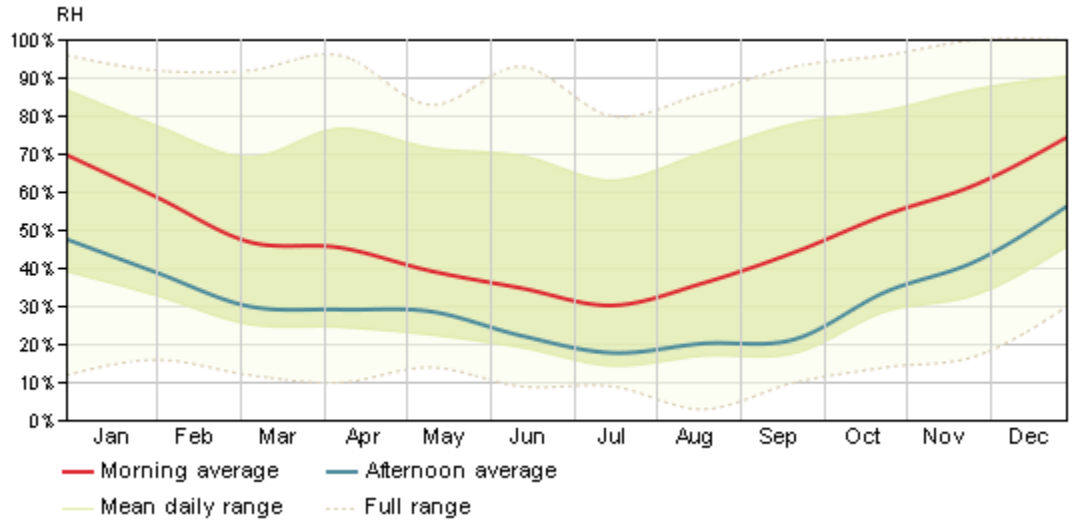

- Heating degrees:

5680 hr/yr

- Cooling degrees:

508 hr/yr

Average humidity: 55%



# Available Resources



Available in Campus

- Natural Gas for heating and DHW
- Chilled water

Alternative sources

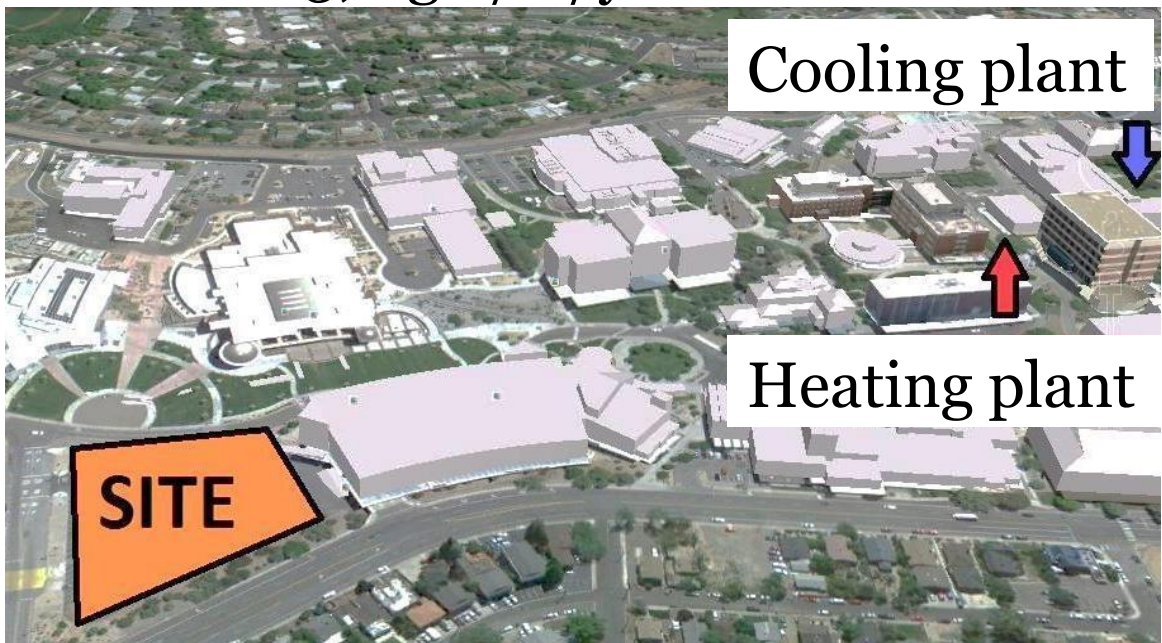
- Ground source heat pump for heating/cooling
- Hybrid Systems

Renewable energy potential

- Photovoltaics
- Wind turbine

Harvest Rainwater

~3,6 gal/sf/yr



# Reno's University Energy Goals



1. Reduce energy consumption & use renewable energy

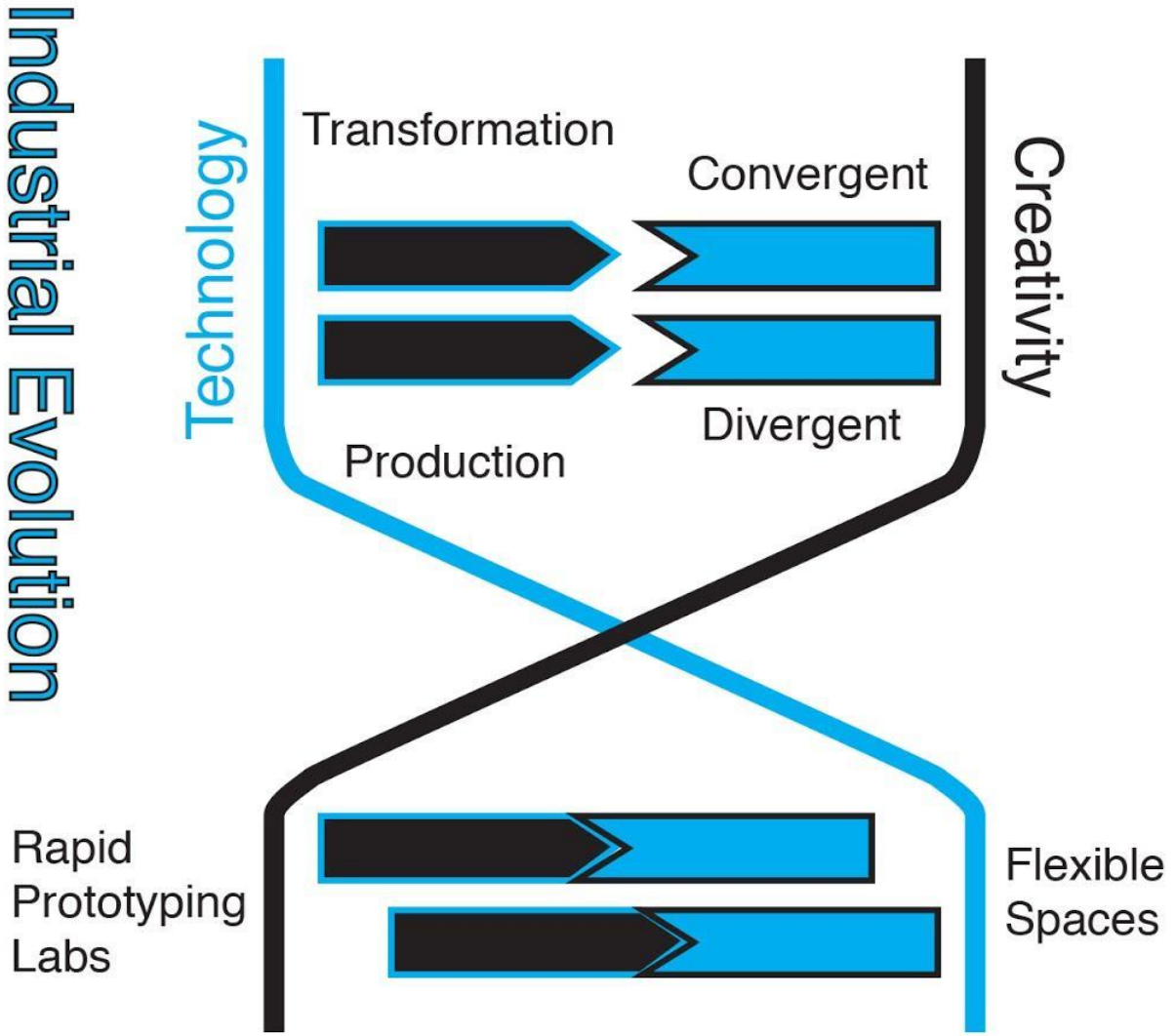
2. Minimize evening building usage

3. Maximize building utilization

4. Winter space temperatures: 68F
   Summer space temperatures: 78F

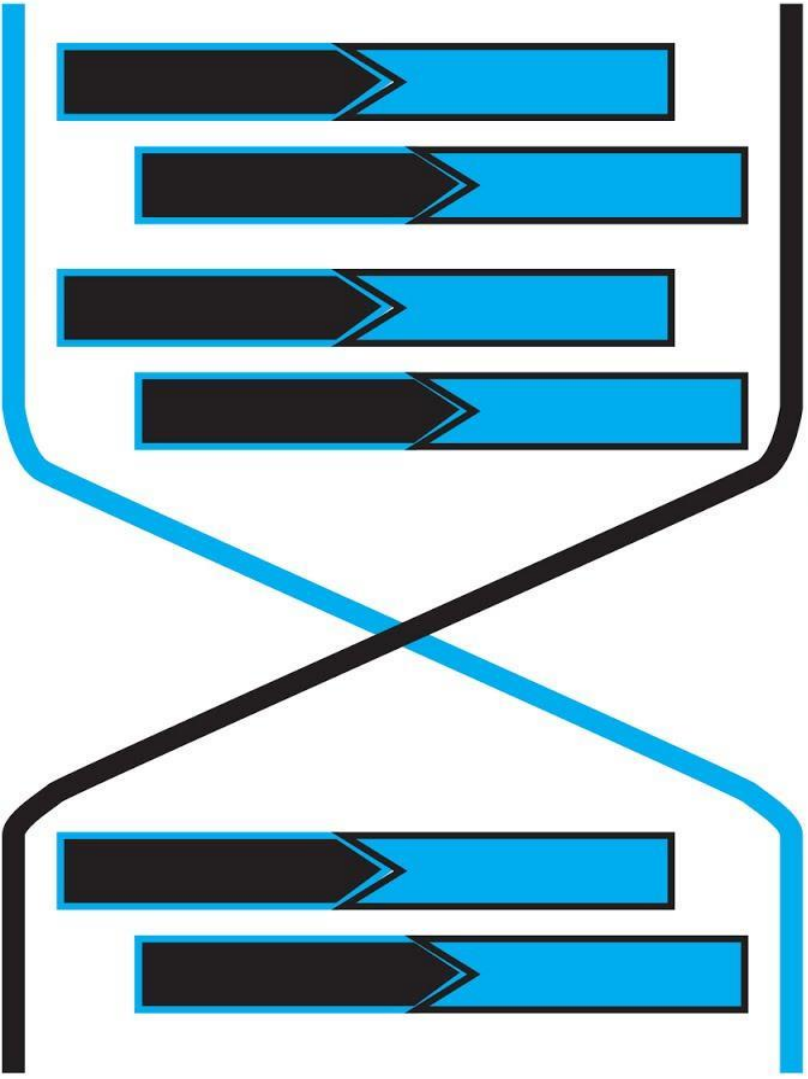
# Big Idea

**Architecture**
Structure
MEP
Construction



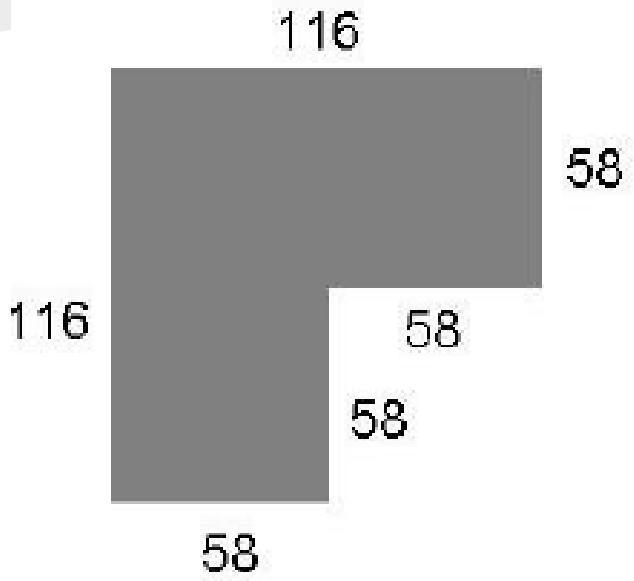
# Big Idea

**Architecture**
Structure
MEP
Construction



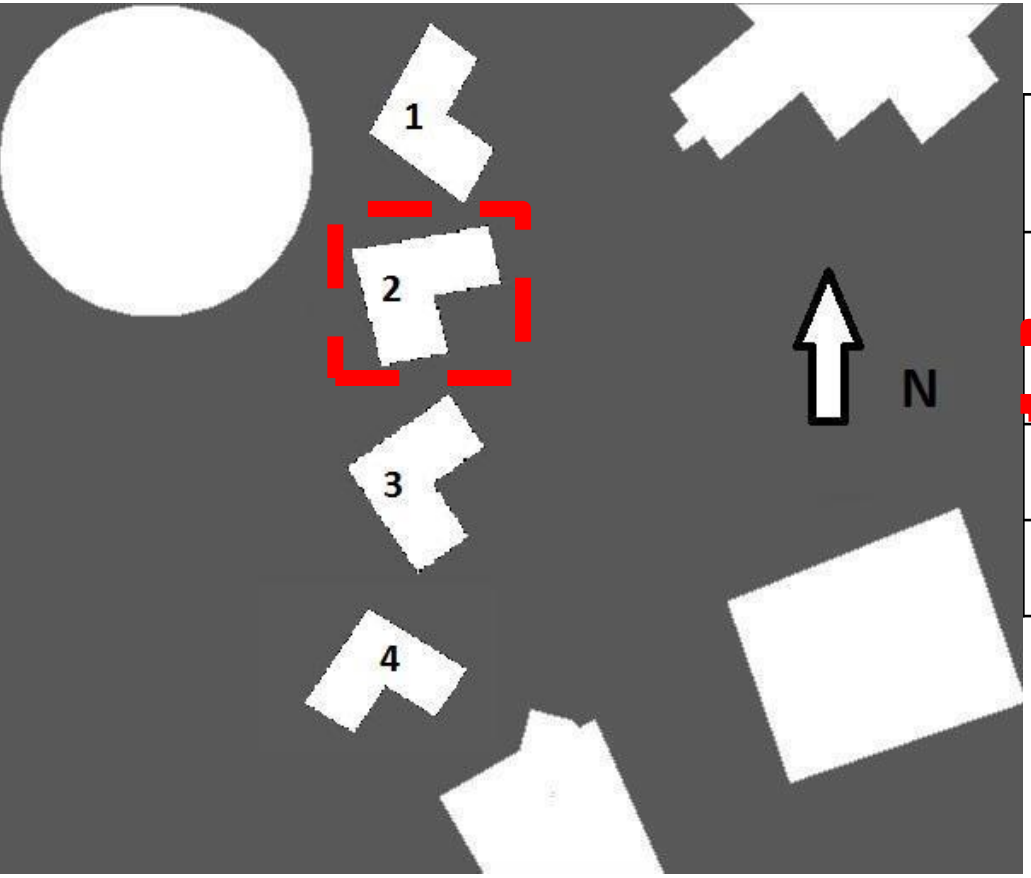

# Transparent Engineering Building (TEB)

1. Steel
2. Concrete



# Orientation

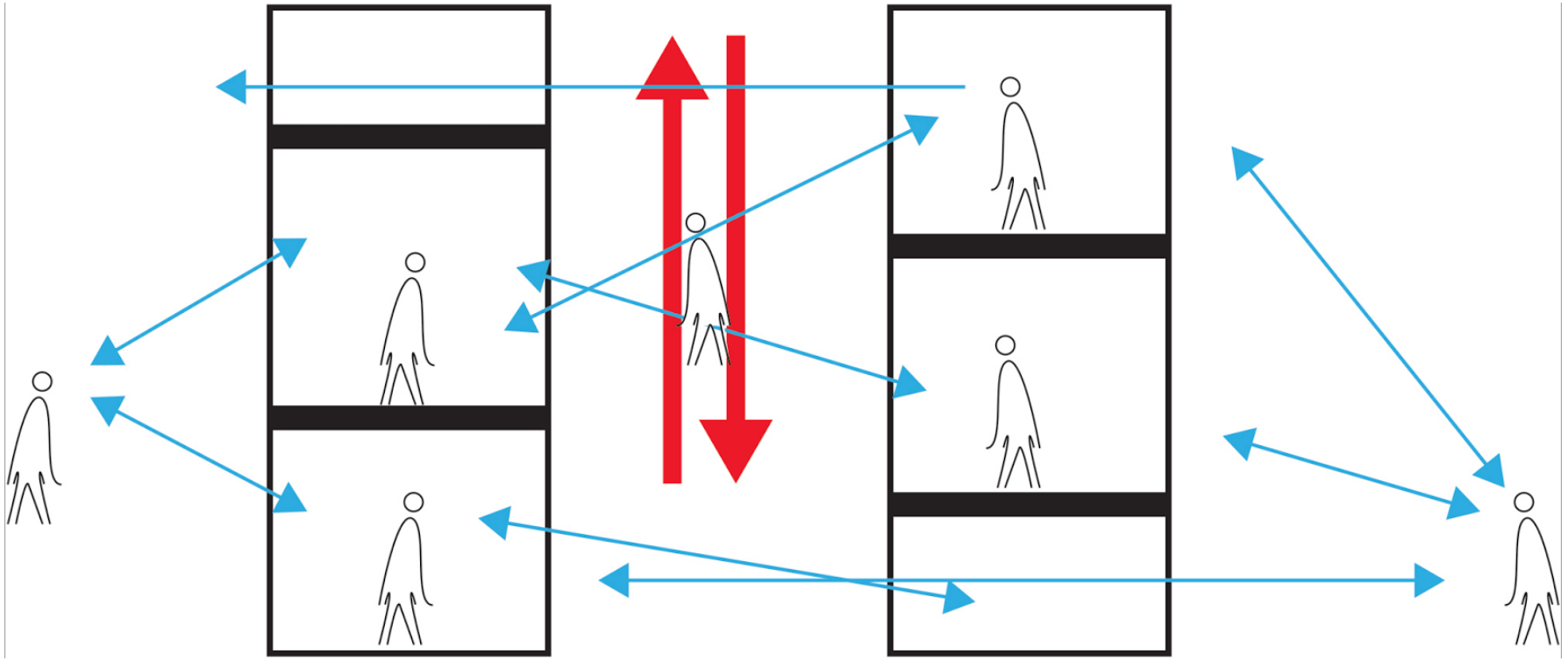





| | Total EUI (kBtu/sf/yr) | Life Cycle Energy Cost ($) | Net $CO_2$ (tn/year) |
|---|---|---|---|
| 1 | 70 | 640,000 | 167 |
| 2 | 67 | 600,000 | 140 |
| 3 | 68 | 620,000 | 147 |
| 4 | 67 | 610,000 | 144 |

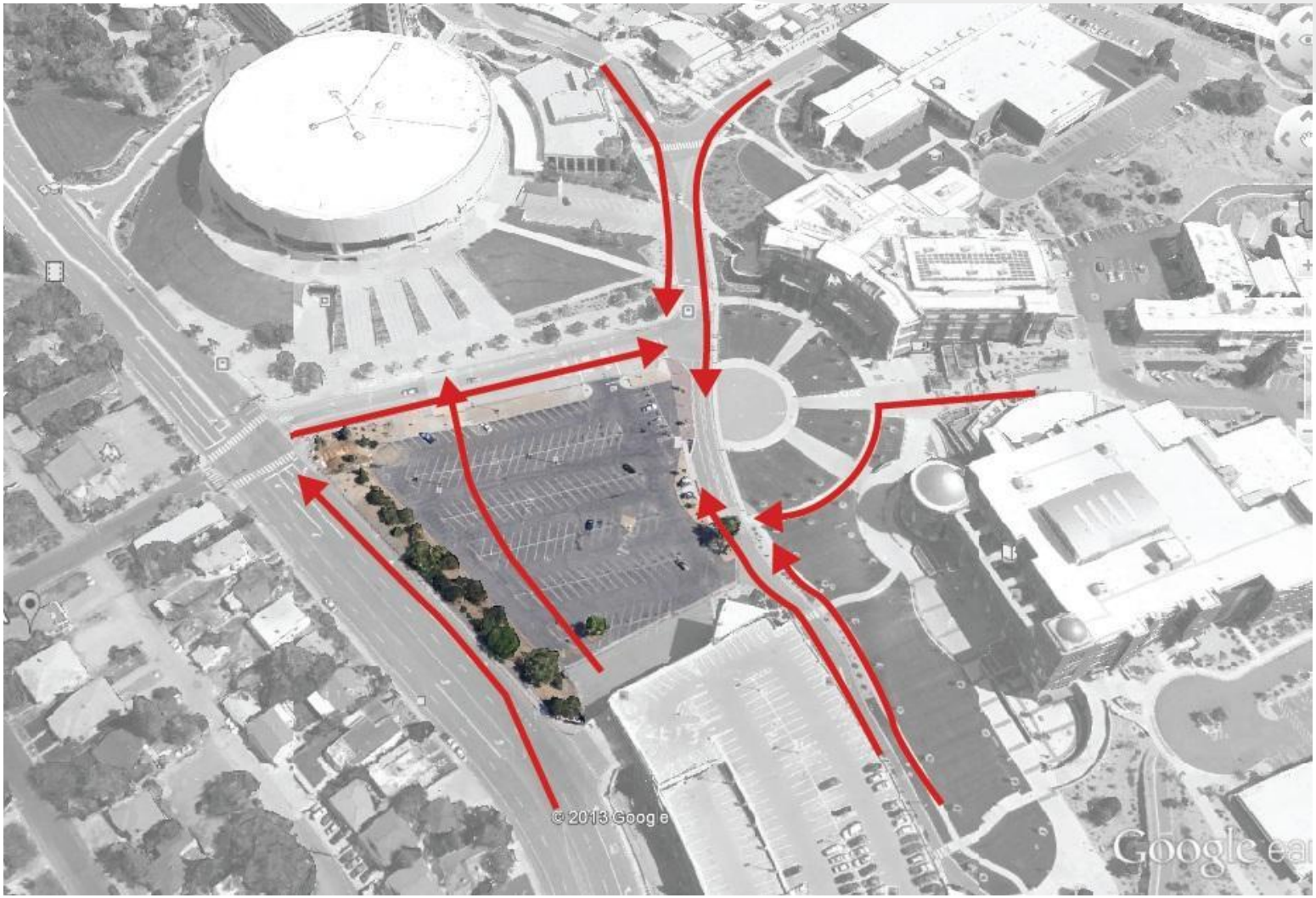
# Concept





# Site/ TEB Concept



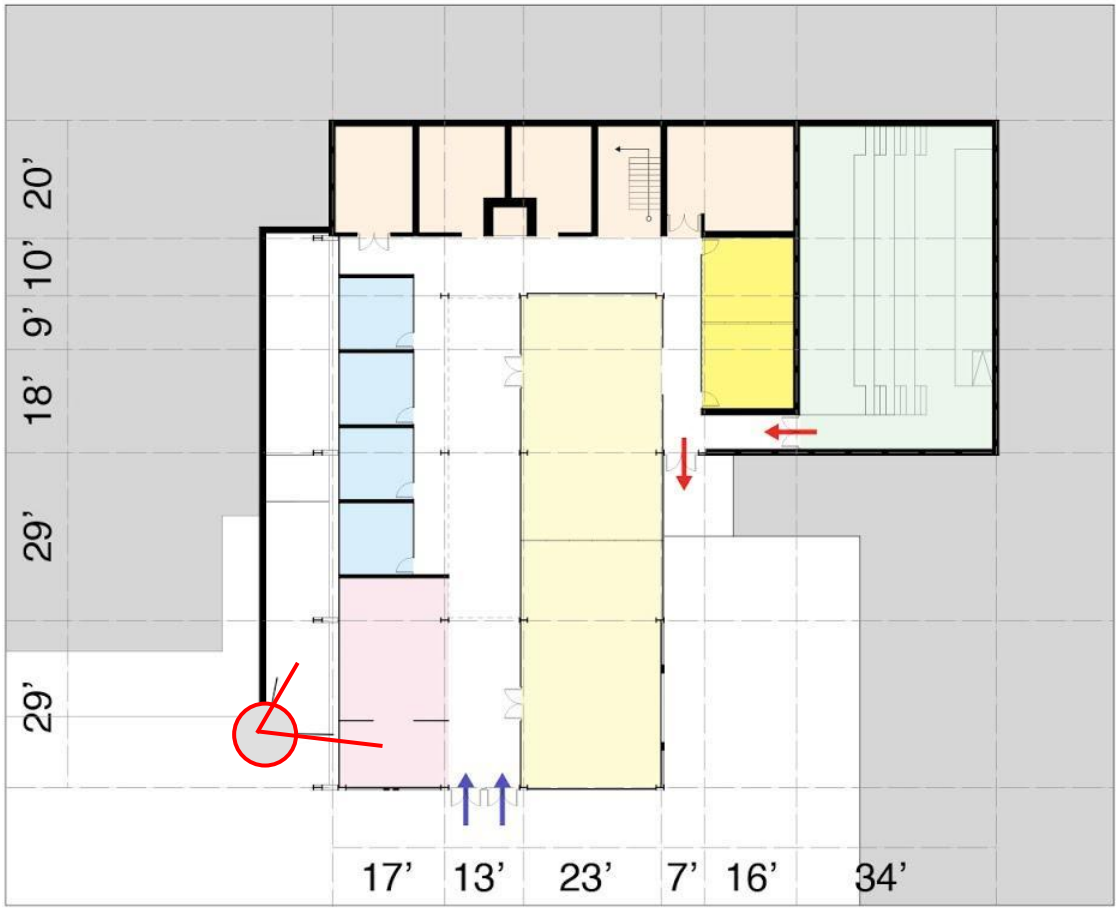


# Site/ TEB Concept



# Level -1 (Basement)






- Rapid Prototyping Labs
- Faculty Offices
- Auditorium
- Bathroom, cores, stairs, elevator...
- Student Offices & area
- Seminar Rooms

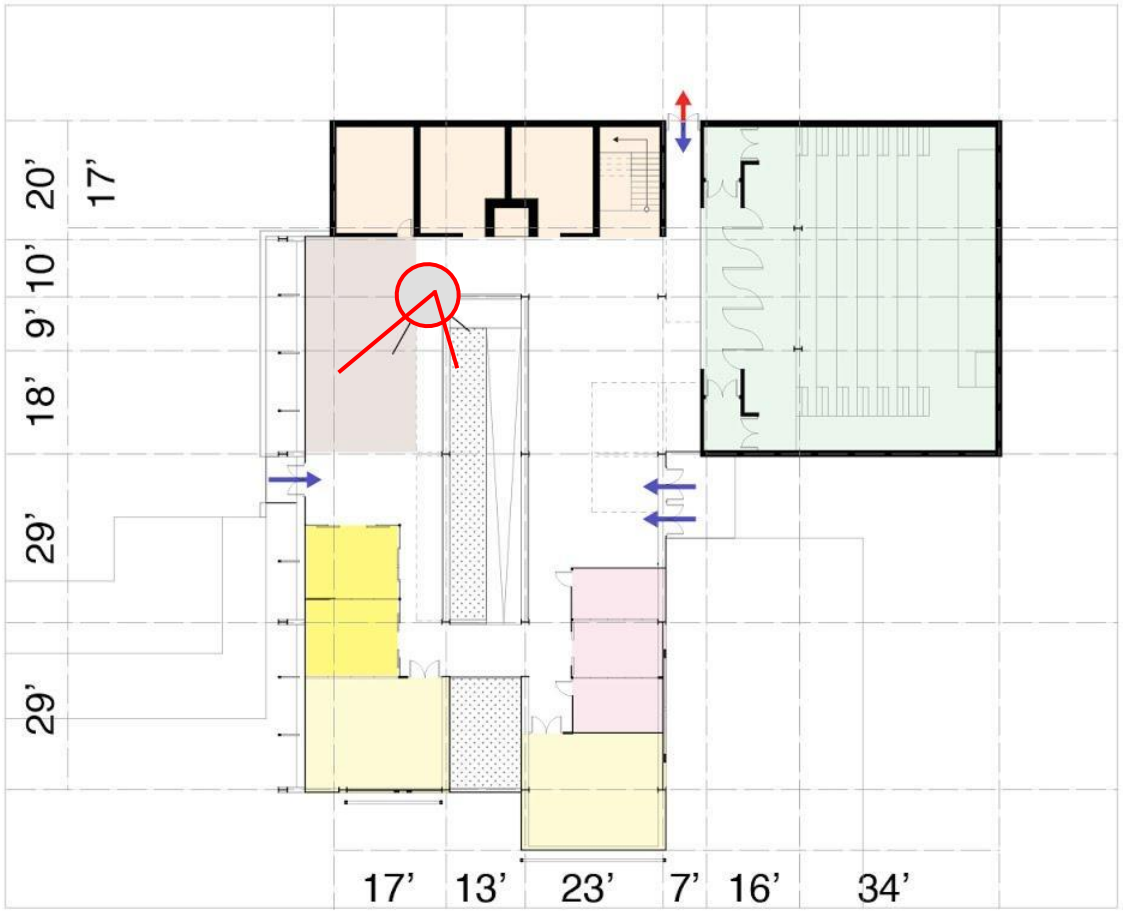
- Emergency Exit
- Entrance

# Level -1 (Basement)

**Architecture**
Structure
MEP
Construction

# Level 0 (Campus Entrance)



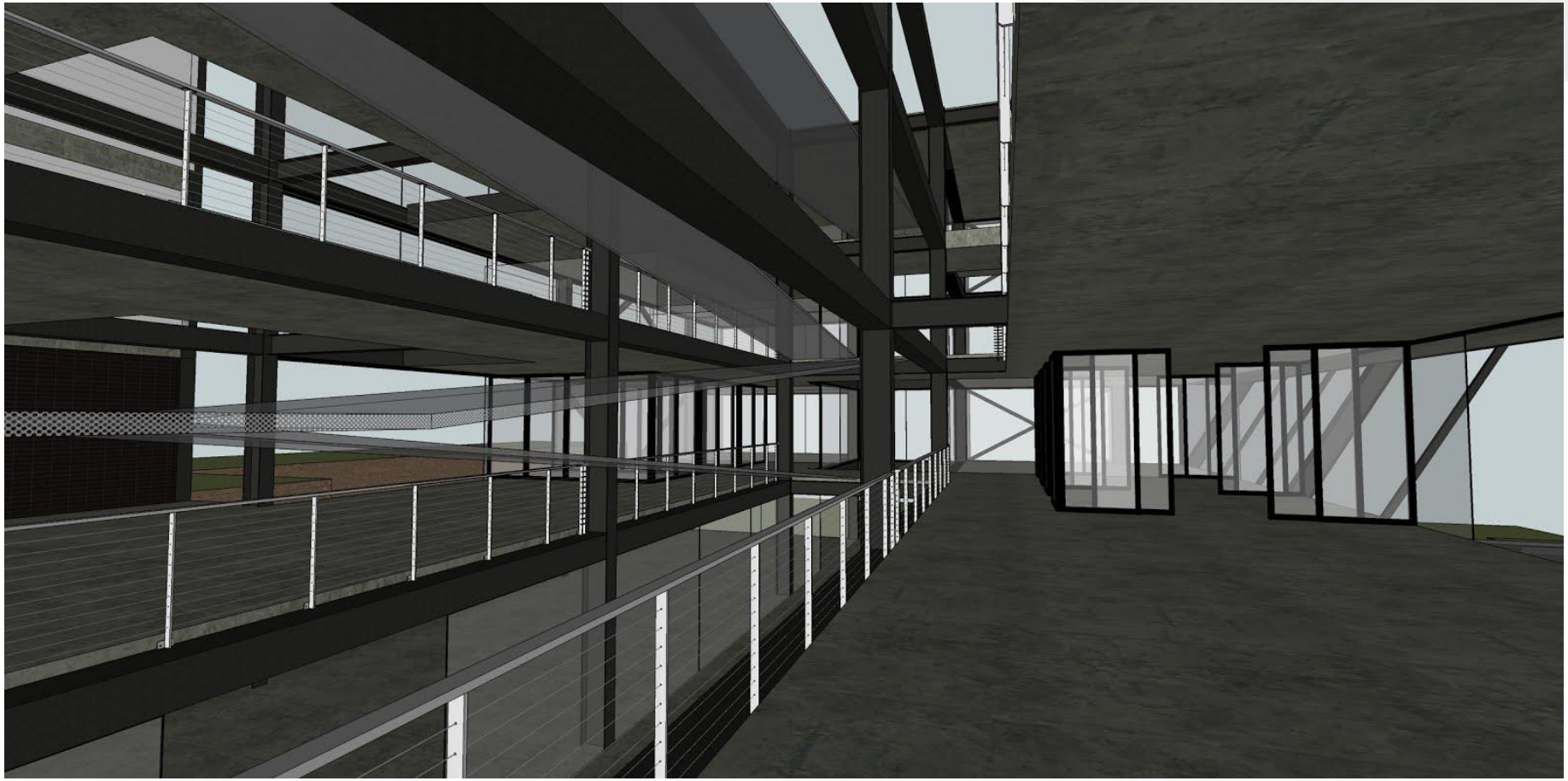



- Small Classrooms
- Cafe
- Auditorium
- Bathroom, cores, stairs, elevator...
- Student Offices & area
- Seminar Rooms

- Emergency Exit
- Entrance

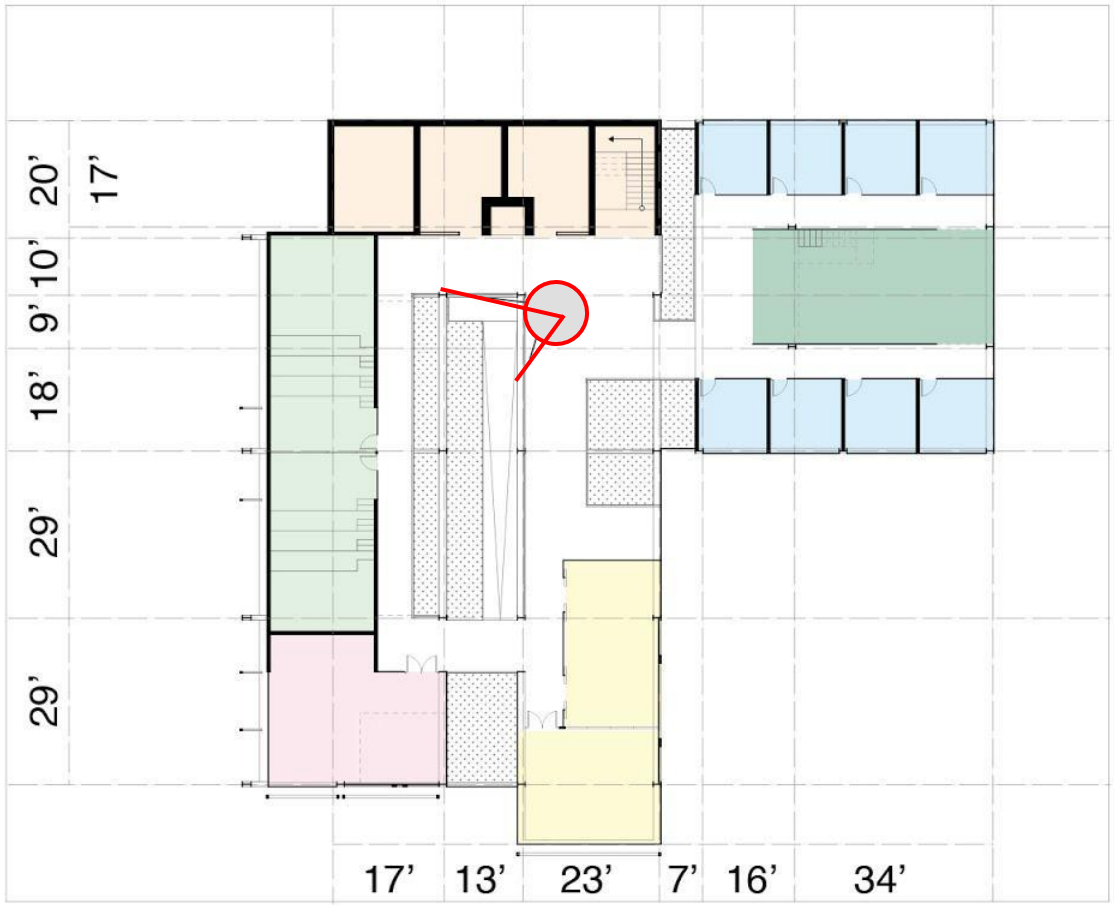
# Level 0 (Campus Entrance)

**Architecture**
Structure
MEP
Construction



# Level 1

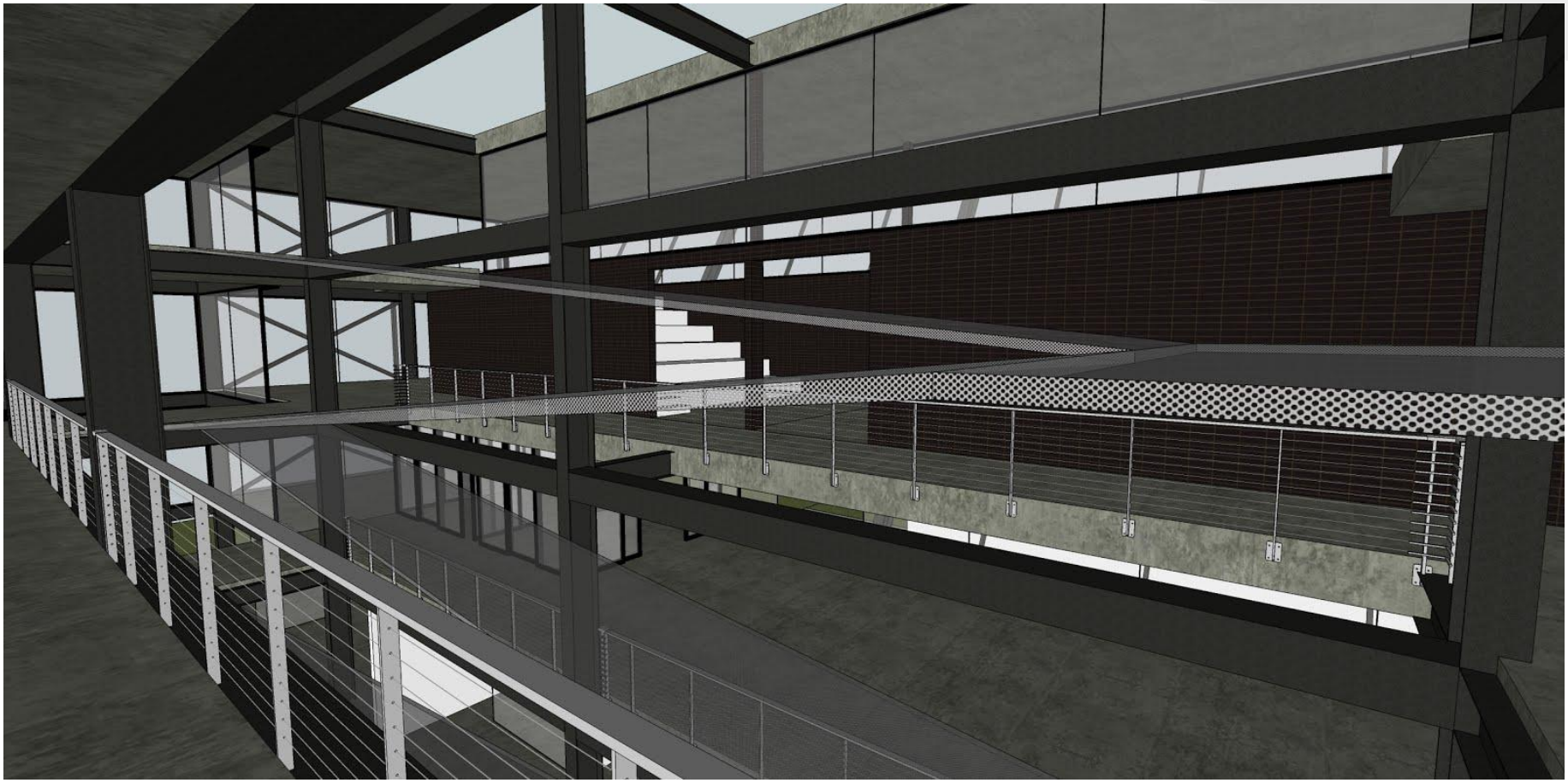





- Small Classrooms
- Large Classrooms
- Faculty Offices
- Bathroom, cores, stairs, elevator...
- Student Offices & area
- Faculty Lounge

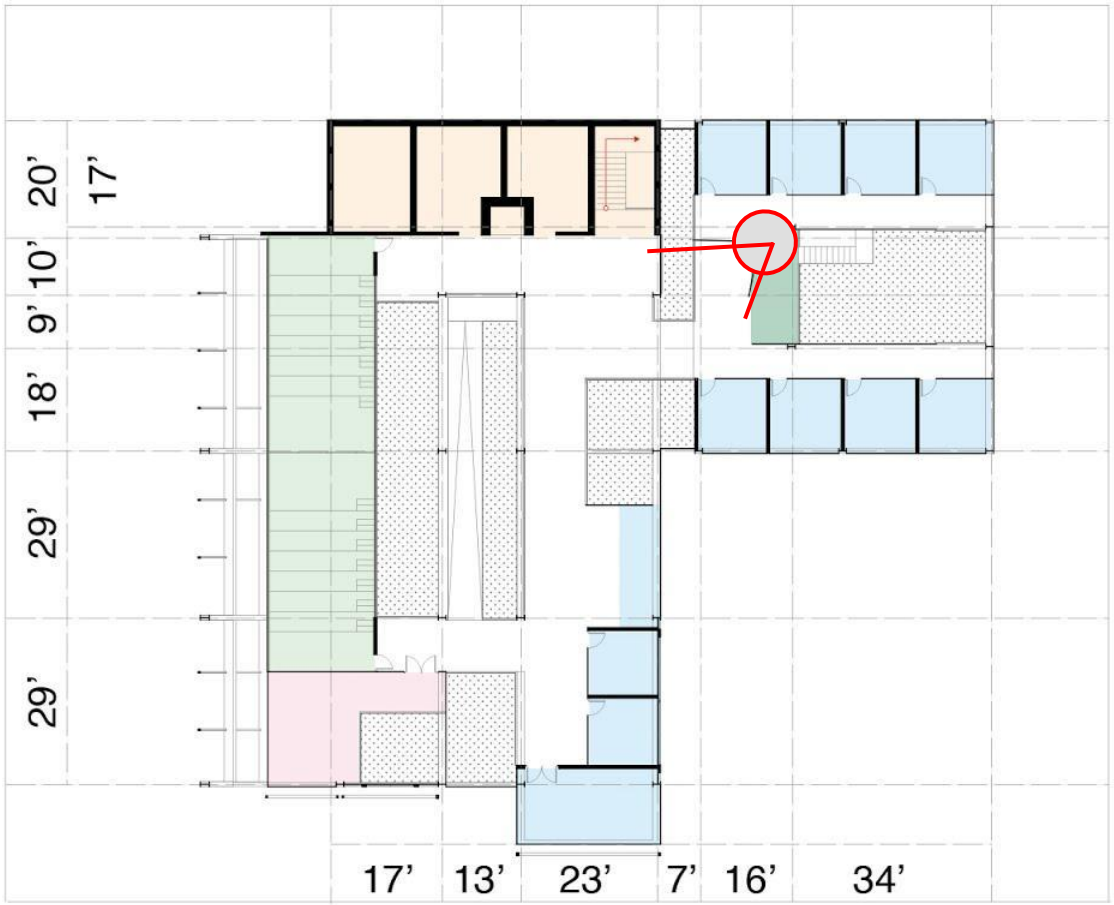
# Level 1

**Architecture**
Structure
MEP
Construction



# Level 2

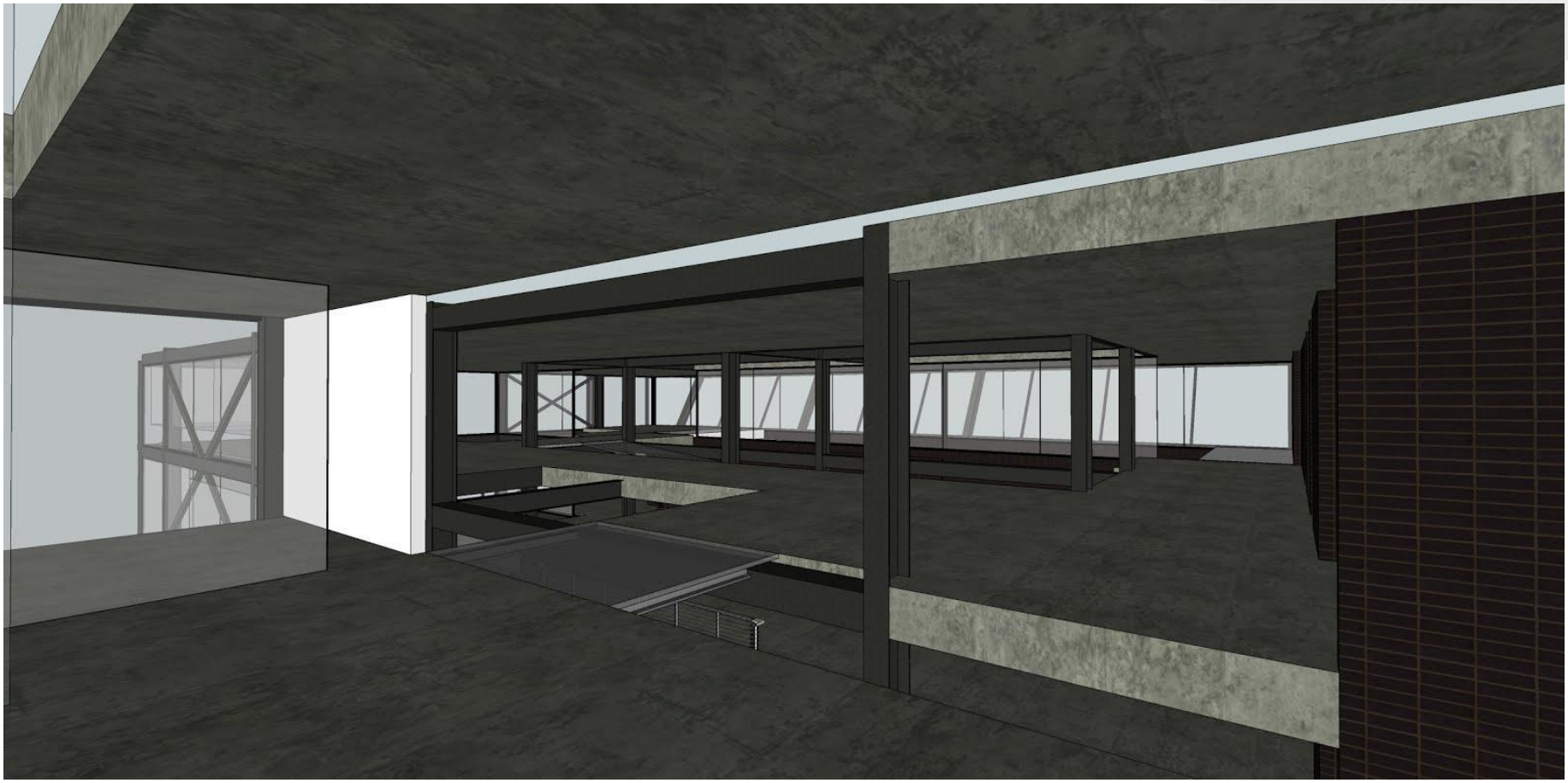





- Large Classrooms
- Faculty Offices
- Bathroom, cores, stairs, elevator...
- Student Offices & area
- Faculty Lounge

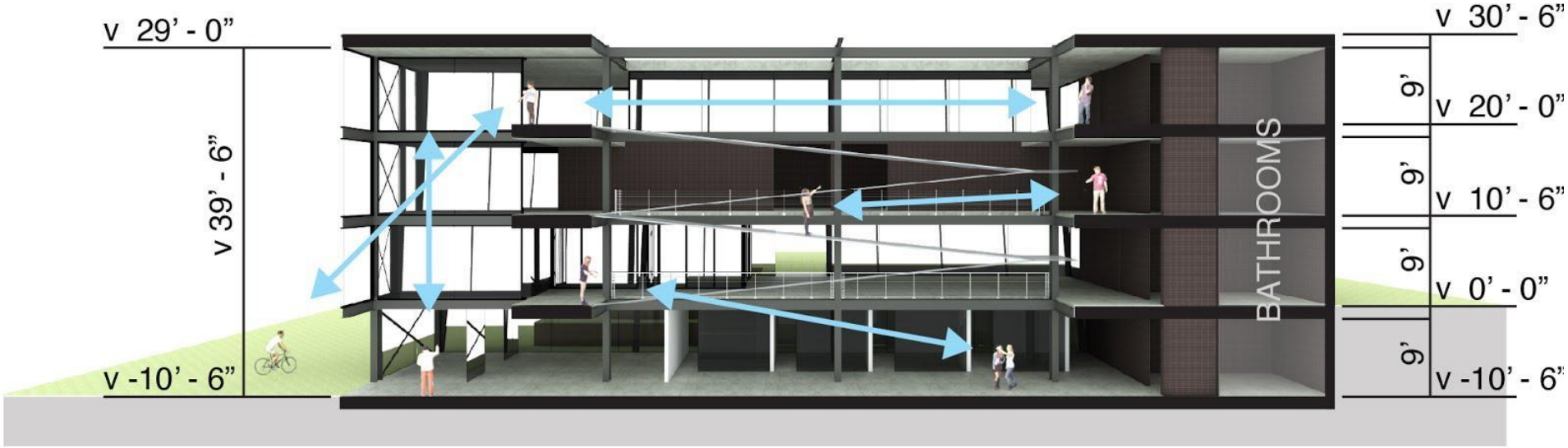
# Level 2

**Architecture**
Structure
MEP
Construction



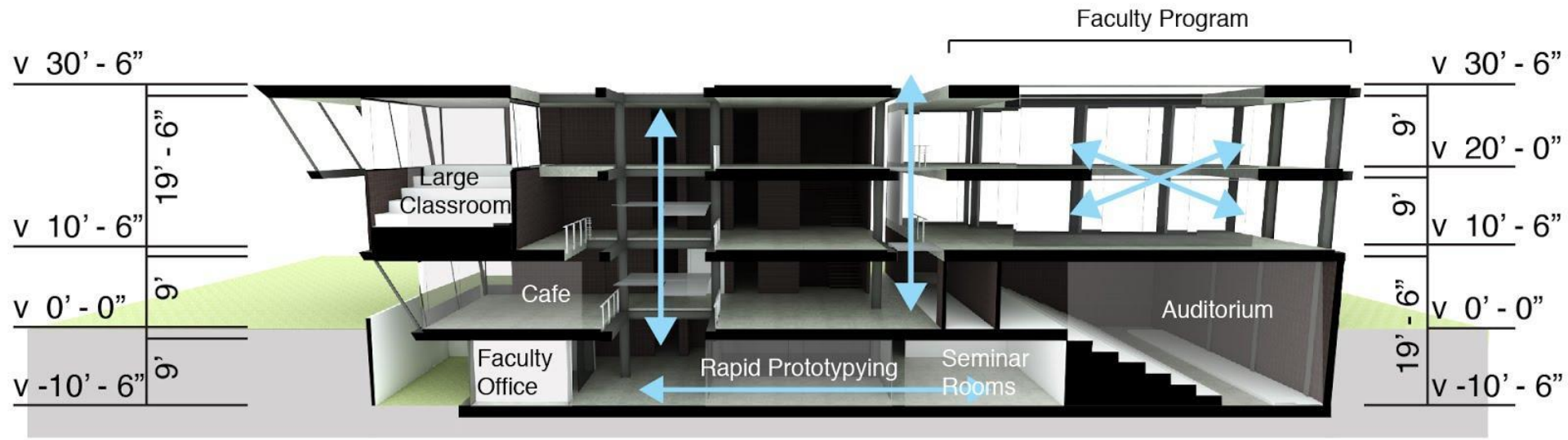
# Section aa

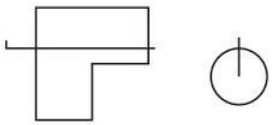




# Section bb

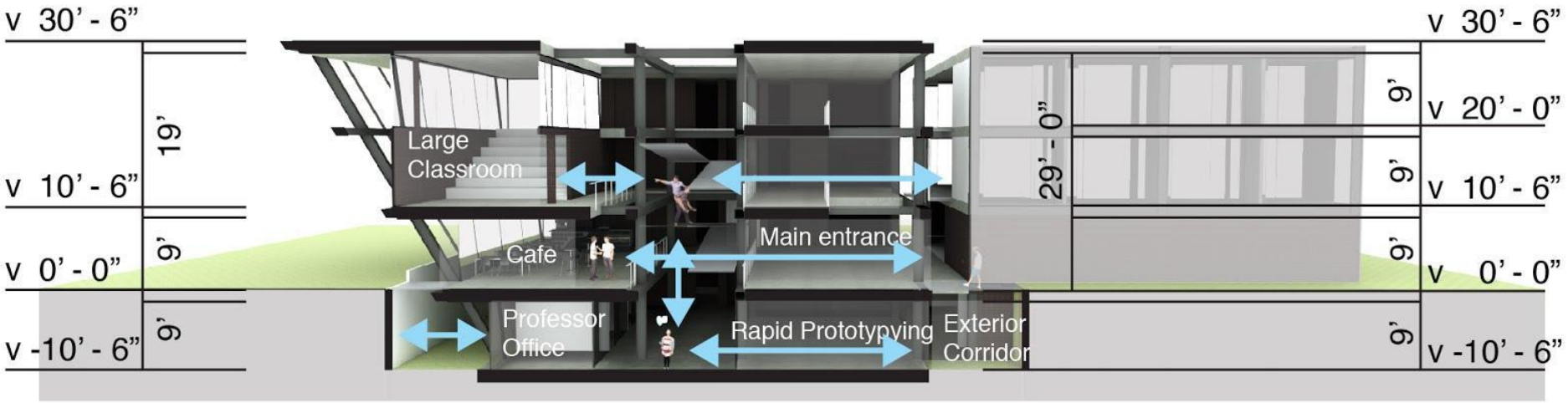


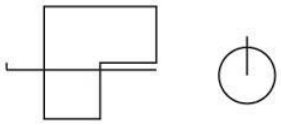

Faculty Program
v 30' - 6"
v 10' - 6"
v 0' - 0"
v -10' - 6"
19' - 6"
9'
9'
v 30' - 6"
9'
v 20' - 0"
9'
v 10' - 6"
19' - 6"
v 0' - 0"
v -10' - 6"
Large Classroom
Cafe
Auditorium
Faculty Office
Rapid Prototypying
Seminar Rooms



# Section cc



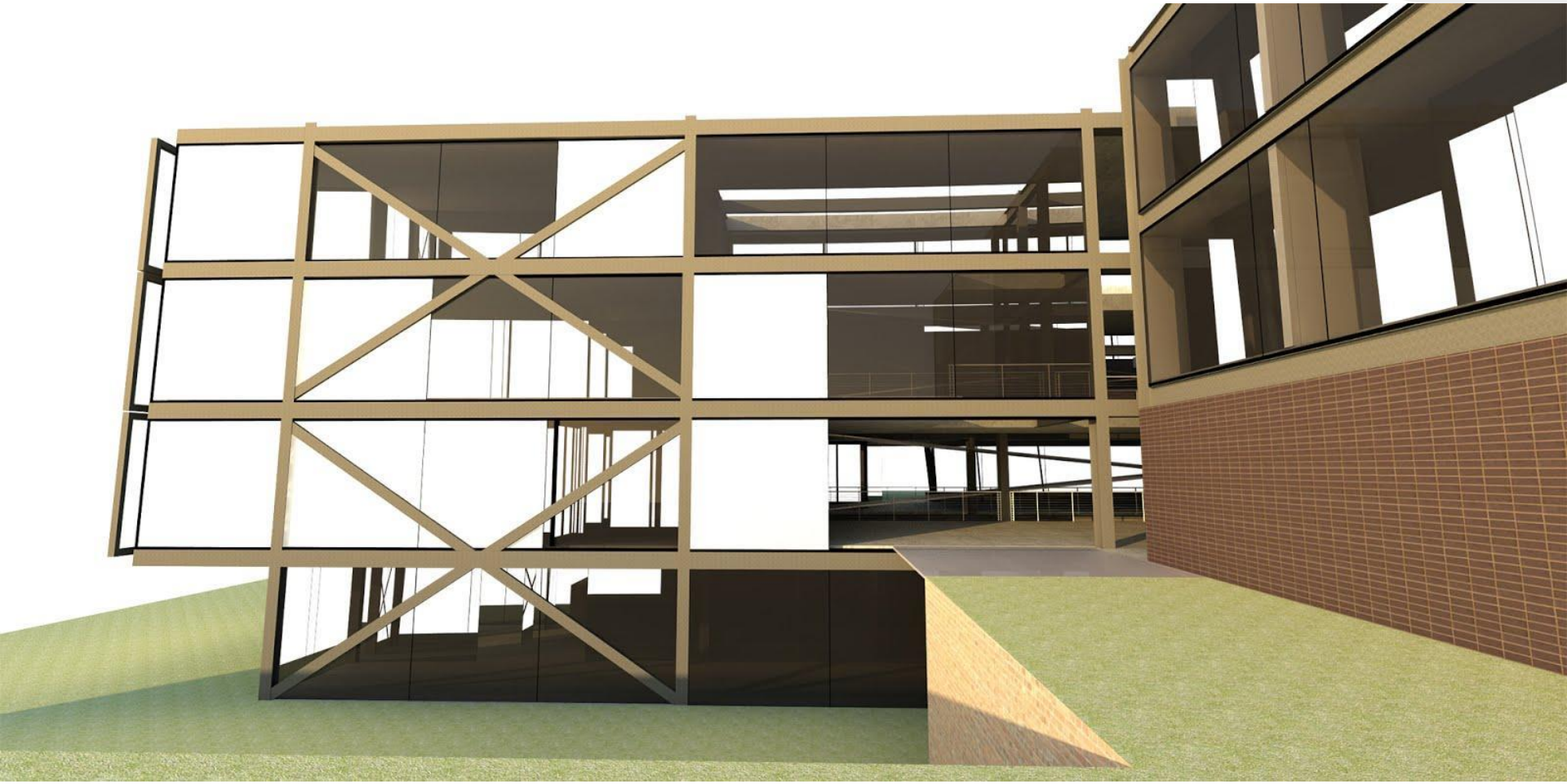

v 30’ - 6”
v 10’ - 6”
v 0’ - 0”
v -10’ - 6”
19’
9’
9’
Large Classroom
Cafe
Professor Office
Main entrance
Rapid Prototyping
Exterior Corridor
29’ - 0”
9’
9’
9’
v 30’ - 6”
v 20’ - 0”
v 10’ - 6”
v 0’ - 0”
v -10’ - 6”



# Dynamic Façade System

**Architecture**
Structure
**MEP**
Construction

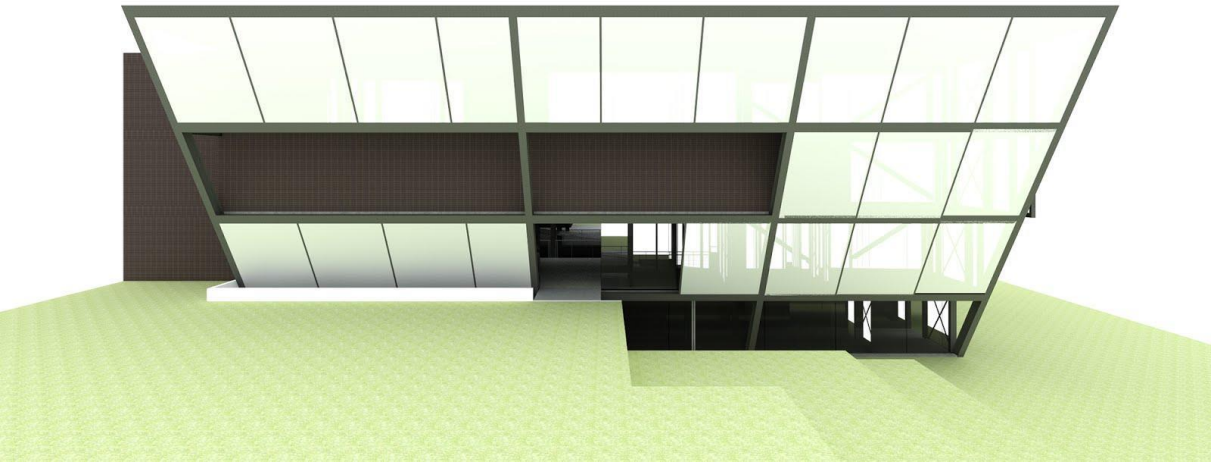
Campus Entrance / East Façade / Privacy Glass



# Dynamic Façade System

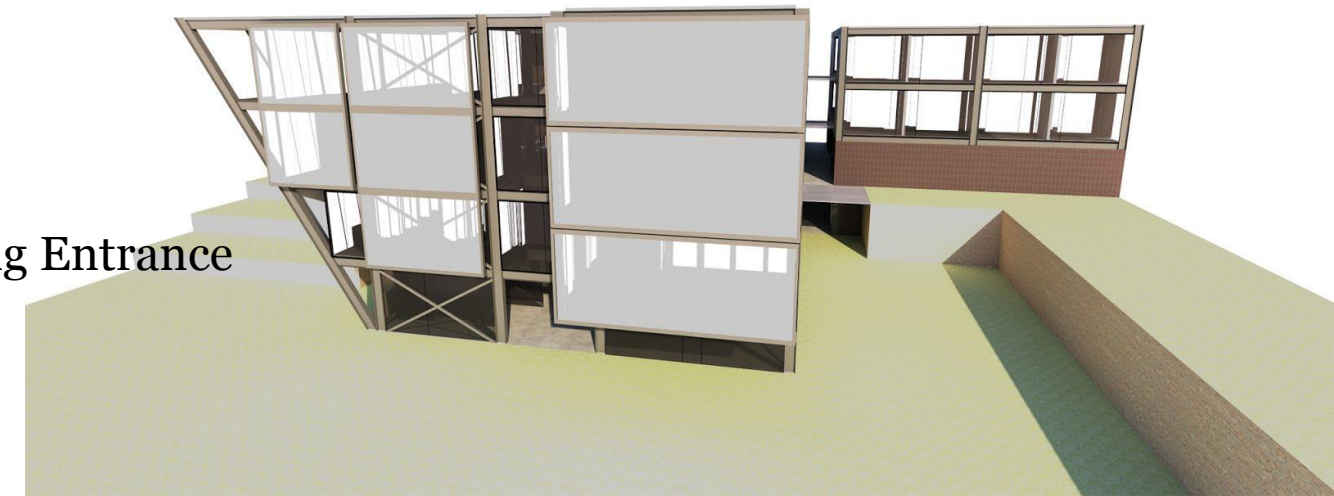


West Façade - Roller Blinds



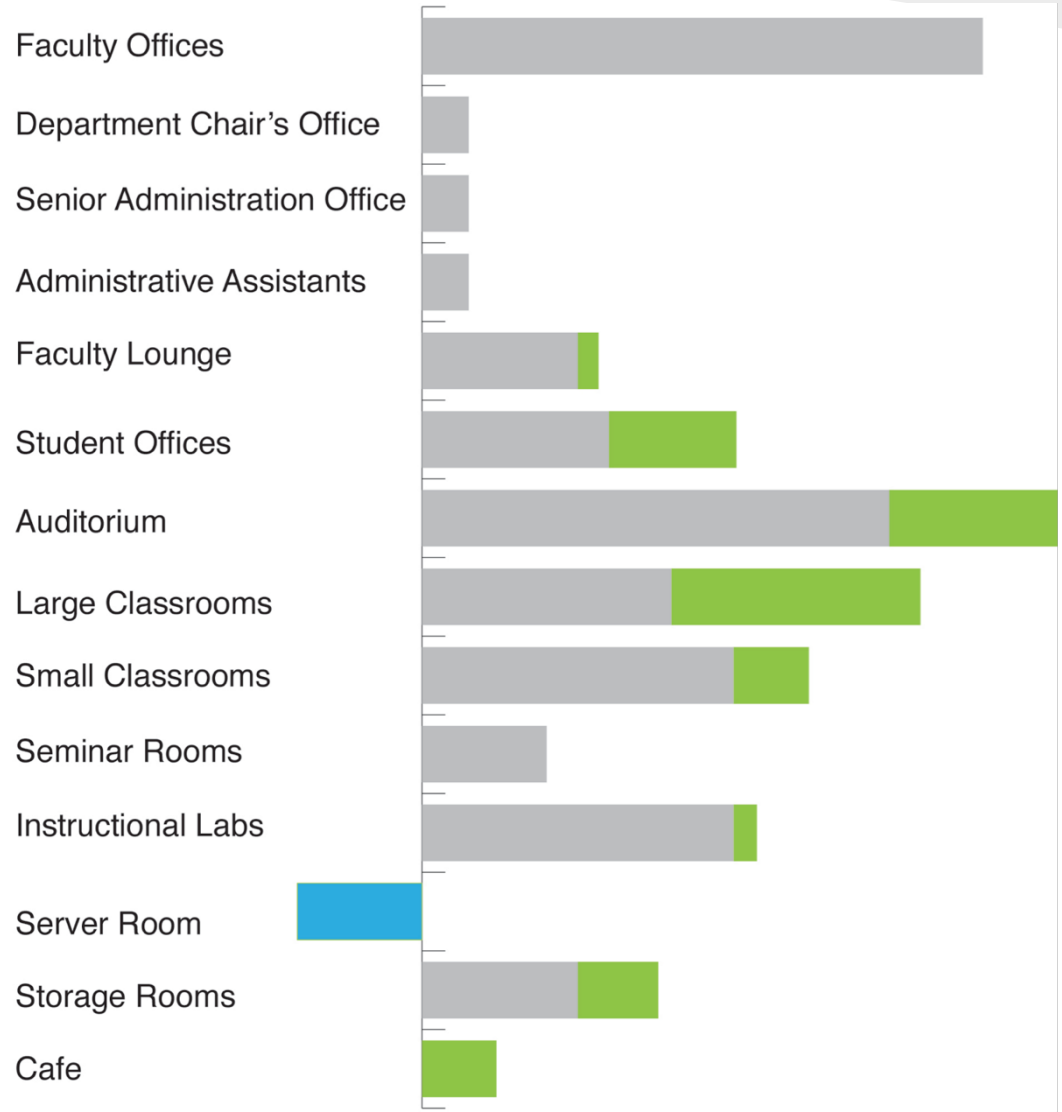
- Simple device
- Keeps out glare and UV rays
- Easy to operate

South Façade / Parking Entrance



# Square Footage Graph





# Load Calculation



| | Steel | Concrete |
|---|---|---|
| **Roof Dead Load** | 90 psf | 180 psf |
| **Roof Live Load** | 20 psf | -- \|\| -- |
| **Roof Snow Load** | 40 psf | -- \|\| -- |
| **Other Floor Dead Loads** | 74 psf | 150 psf |
| **Other Floor Live Loads** | 60-100 psf | -- \|\| -- |
| **Wind Shear** | 100 mph => 1.5 kips / foot | -- \|\| -- |
| **Earthquake Shear** | Sa = 0.4g => 680 kips | 870 k |
| **Retaining-soil Shear** | 4.7 kips / foot | -- \|\| -- |

-- || -- means same load

Per International Building Code (IBC) 2006 with amendments provided by the city of Reno, Nevada

# Soil Conditions



Slope: 7' - 14' above volcanic rock

110000 cf excavation

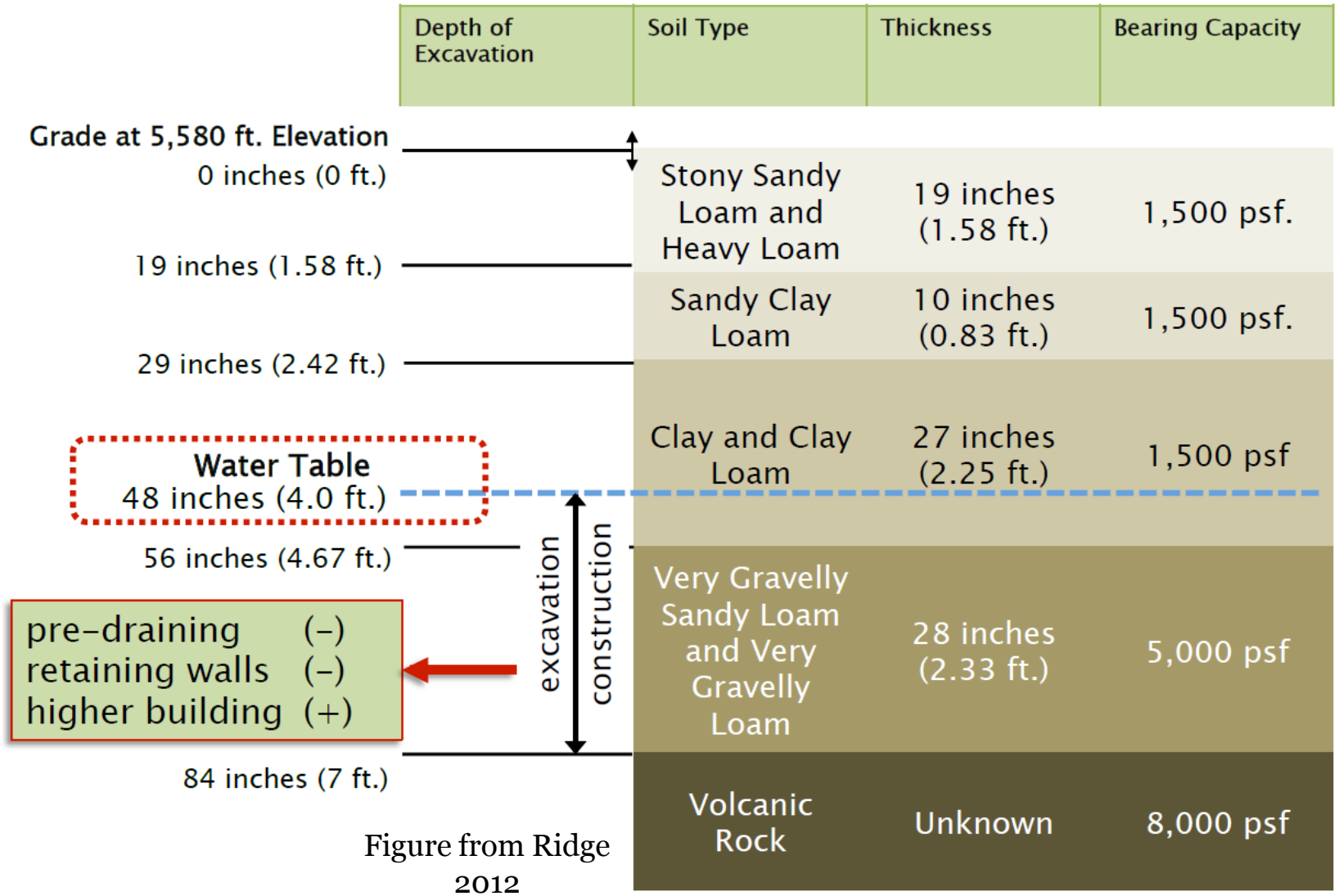
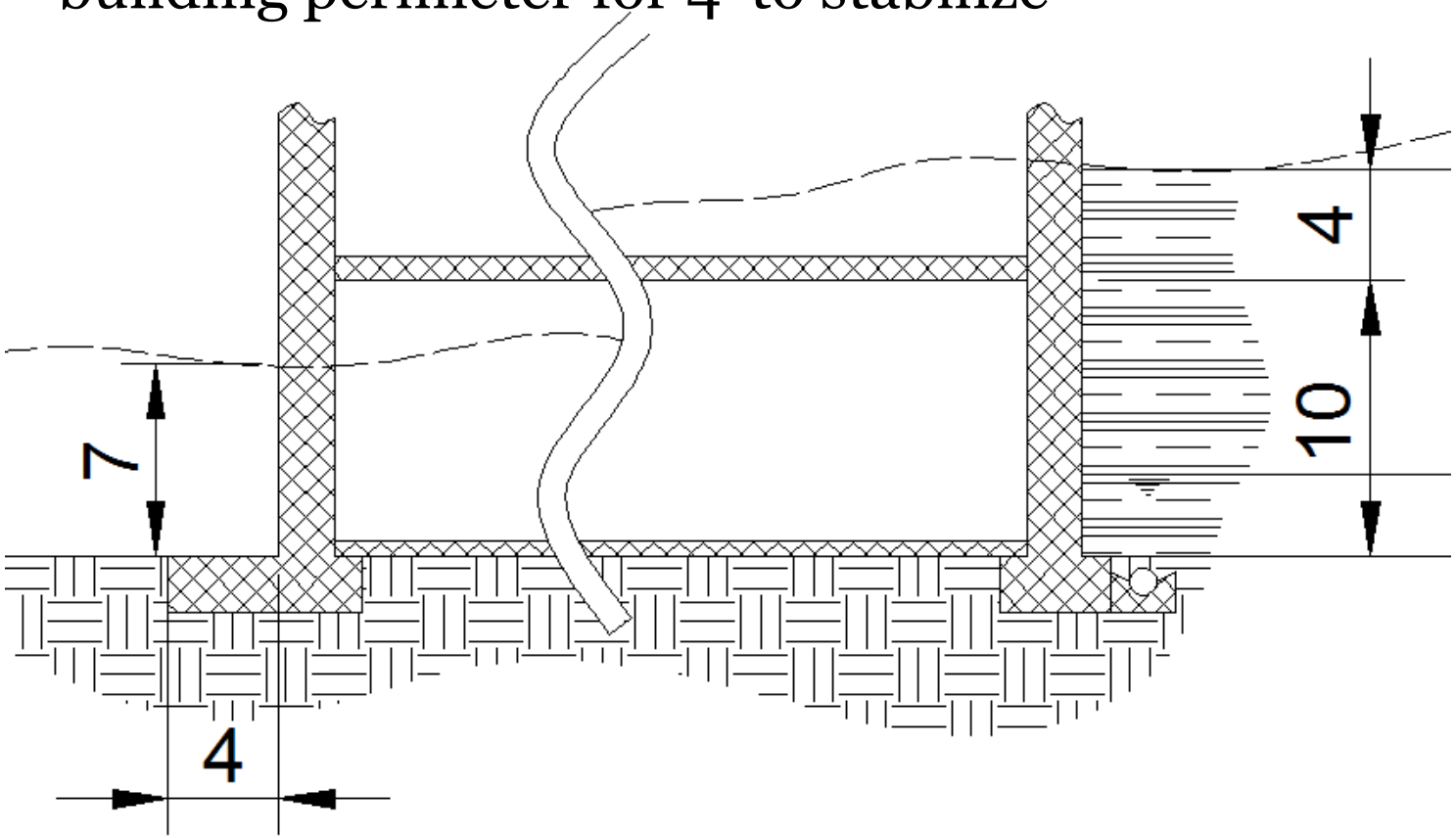



Figure from Ridge 2012

# Foundations



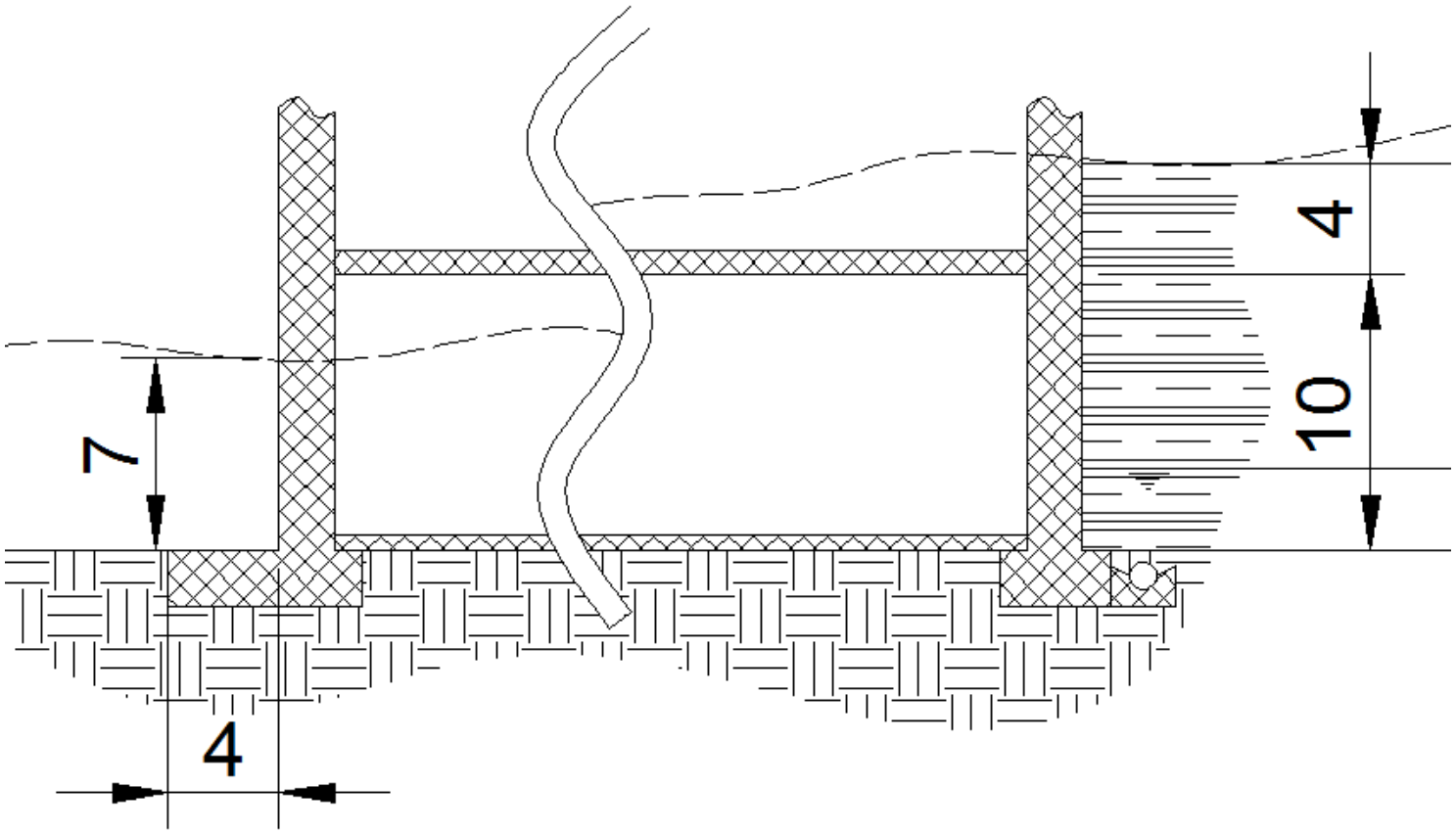
- 6" - 1' slab & 1' - 2' pad footings
- Idea: to extend horizontally outside the building perimeter for 4' to stabilize



# Retaining Walls

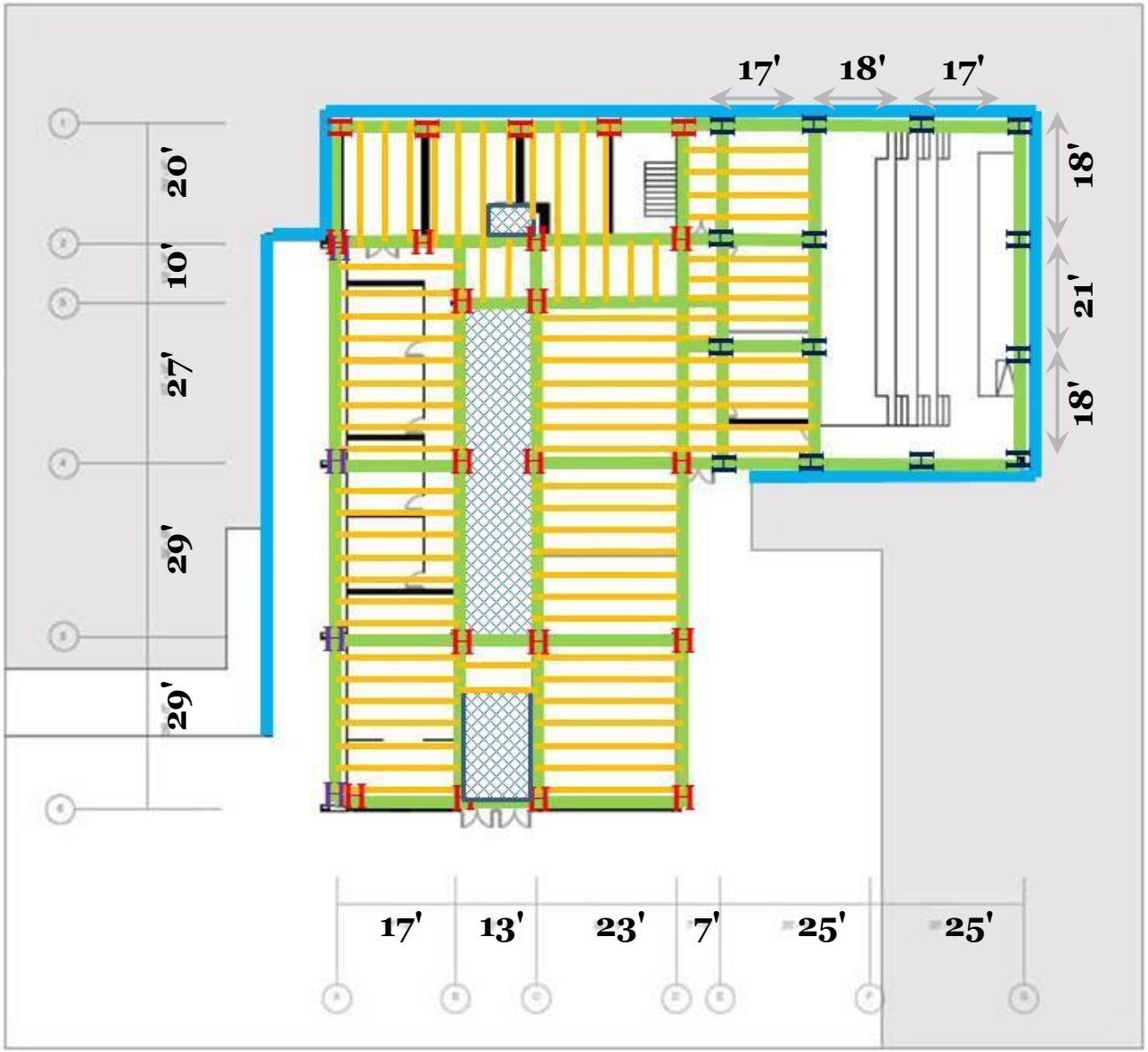


- height: 10' - 14'
- Idea: drain the water and collect it



# Steel : Level -1






**BLUE** - Retaining Wall

**GREEN** – W14x43 Girders

**ORANGE** – W8x31 Beams @ 4' Spacing

**RED** – W14x61 Columns

**PURPLE** – W14x61 Slanted Columns

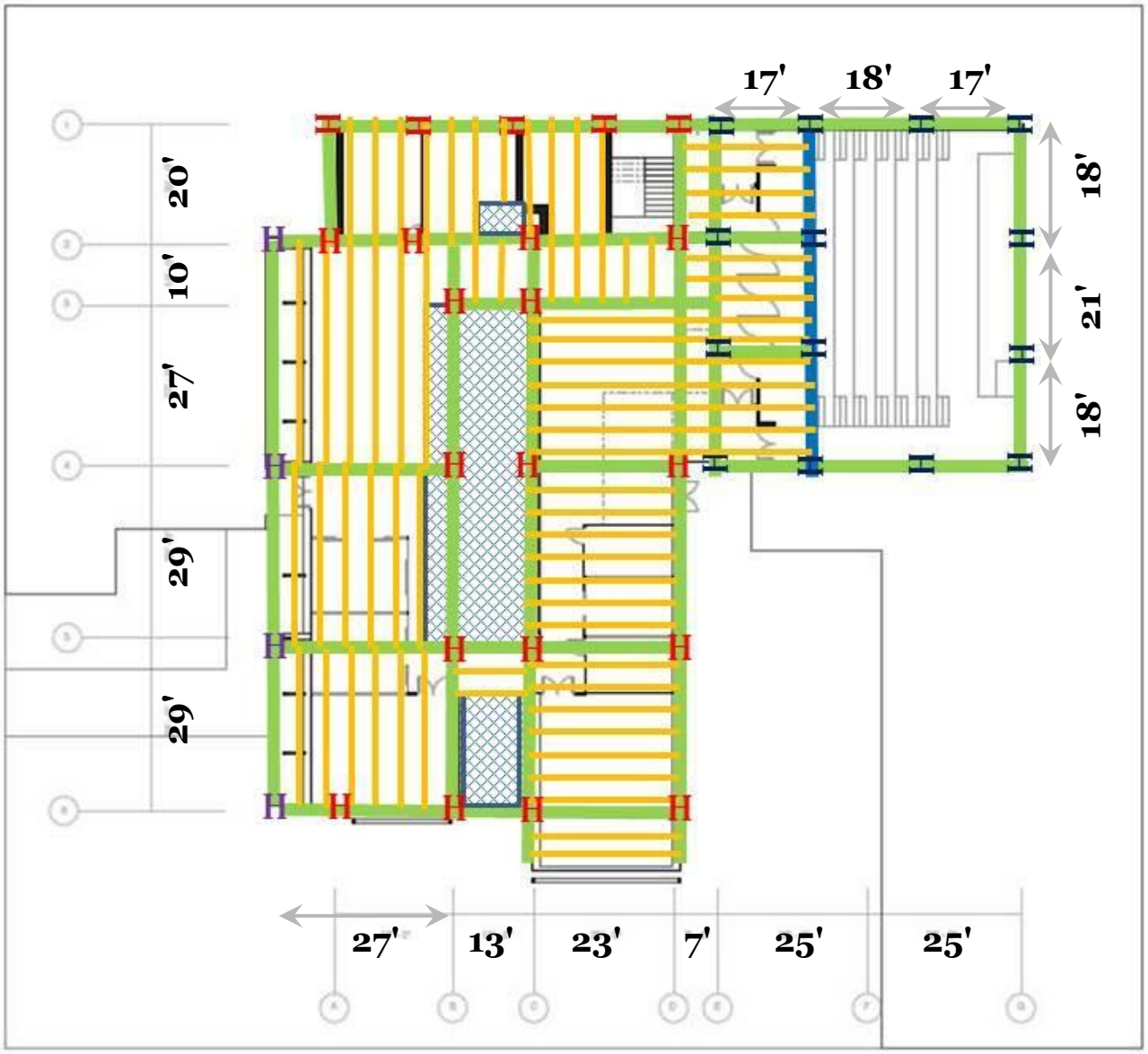
**NAVY** – W12x40 Columns

▭ - Slab Openings

Composite Slab:
6" Concrete on Steel Deck

# Steel : Level 0






**GREEN –**
W14x43 Girders
**BLUE –**
W14x74 Girders
**ORANGE –**
W8x31 Beams @ 4' Spacing
**RED –**
W14x61 Columns
**PURPLE –**
W14x61 Slanted Columns
**NAVY –**
W12x40 Columns
▭ - Slab Openings

Composite Slab:
6" Concrete on Steel Deck
Auditorium Slab:
Prefab PT 2' Slab

# Steel : Level 1




**GREEN –**
W14x43 Girders
**ORANGE –**
W8x31 Beams @ 4' Spacing
**BLUE –**
W8x28 Beams @ 6' Spacing
**RED –**
W14x61 Columns
**PURPLE –**
W14x61 Slanted Columns
**NAVY –**
W12x40 Columns

-

Slab Openings

<u>Composite Slab:</u>
6" Concrete on Steel Deck

# Steel : Level 2 (Roof)

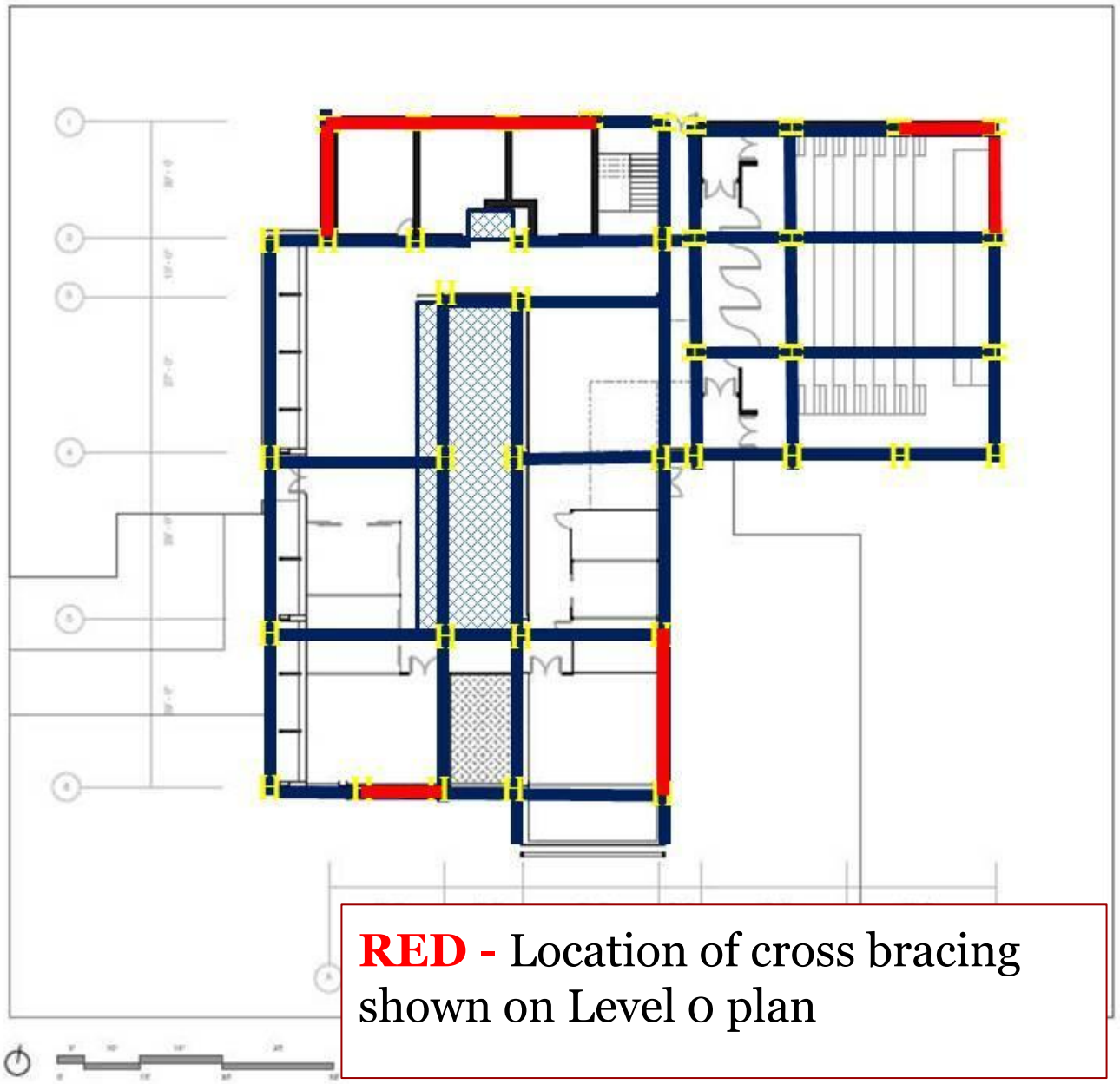



**GREEN –**
W14x43 Girders
**ORANGE –**
W8x31 Beams @ 4' Spacing
**BLUE –**
W8x28 Beams @ 6' Spacing
**RED –**
W14x61 Columns
**PURPLE –**
W14x61 Slanted Columns
**NAVY –**
W12x40 Columns
- Slab Openings

Composite Slab:
6" Concrete on Steel Deck

# Lateral Systems





**RED -** Location of cross bracing shown on Level 0 plan

Challenge: Torsion due to irregularity

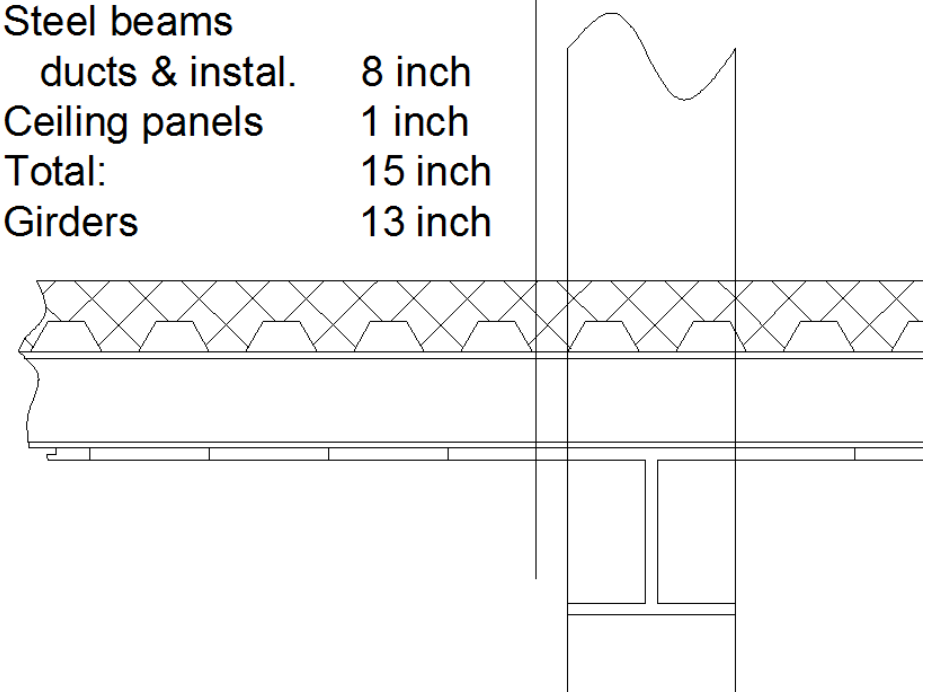
Cross bracing will be exposed, so aesthetics will also play a role in selection

# Floor Sandwich: Steel

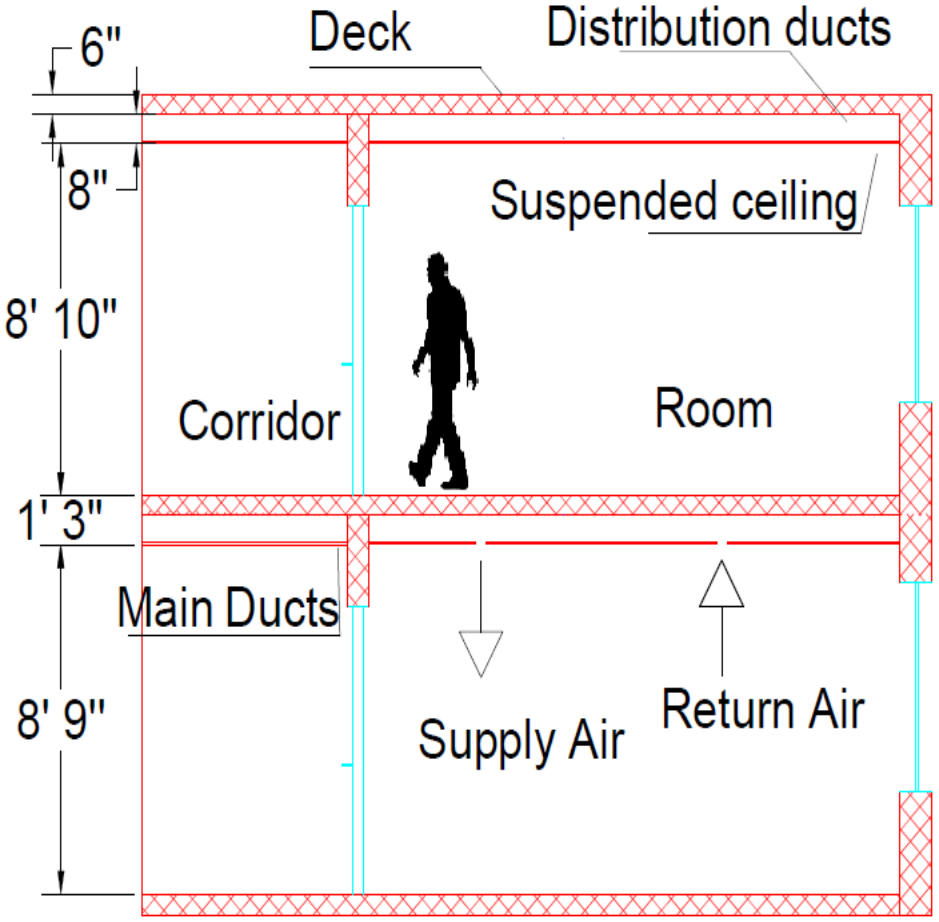


Total height: 15 inch
Distribution

| | |
|---|---|
| Composite slab | 6 inch |
| Steel beams | |
| ducts & instal. | 8 inch |
| Ceiling panels | 1 inch |
| Total: | 15 inch |
| Girders | 13 inch |

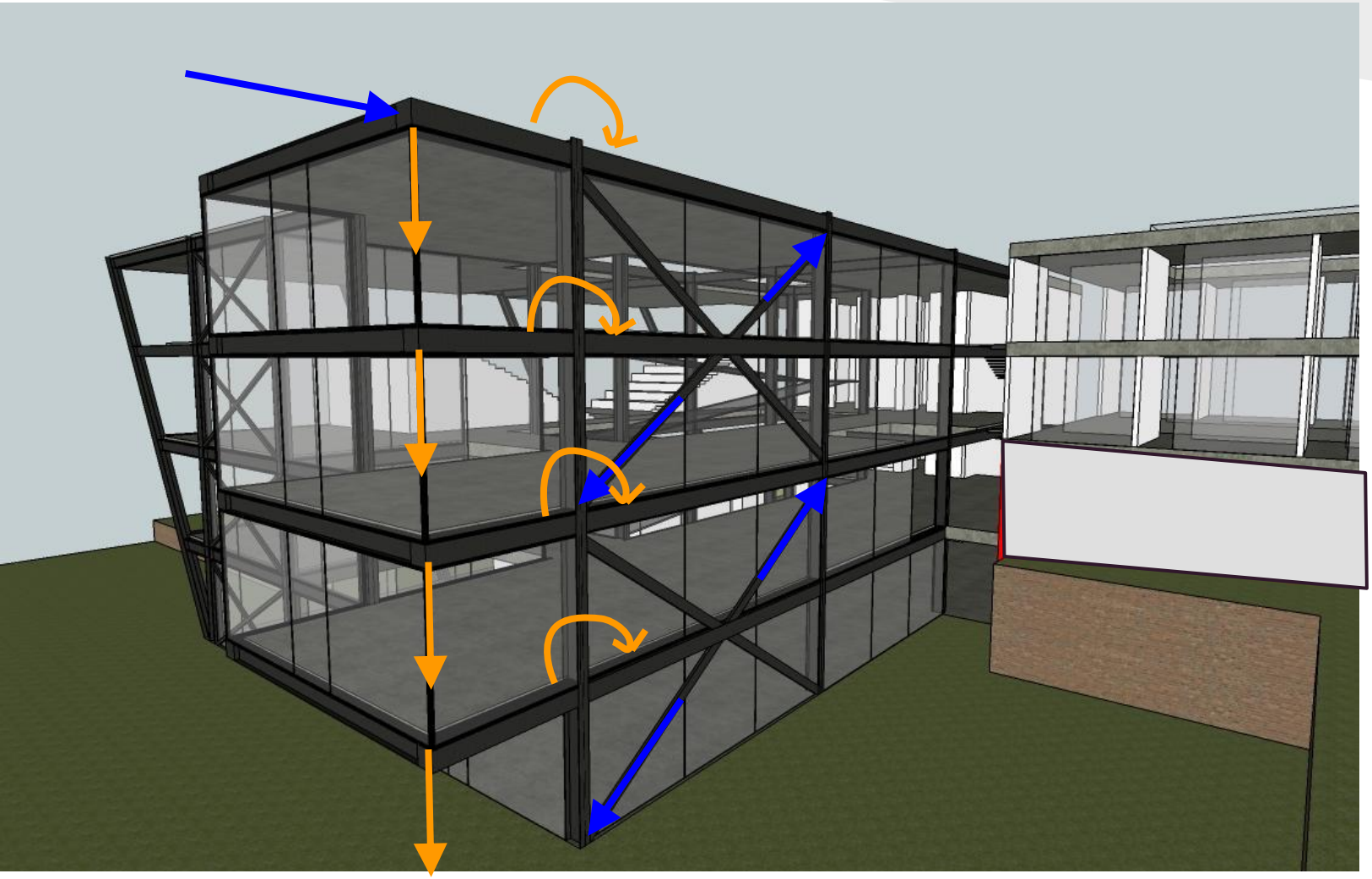


Overhead



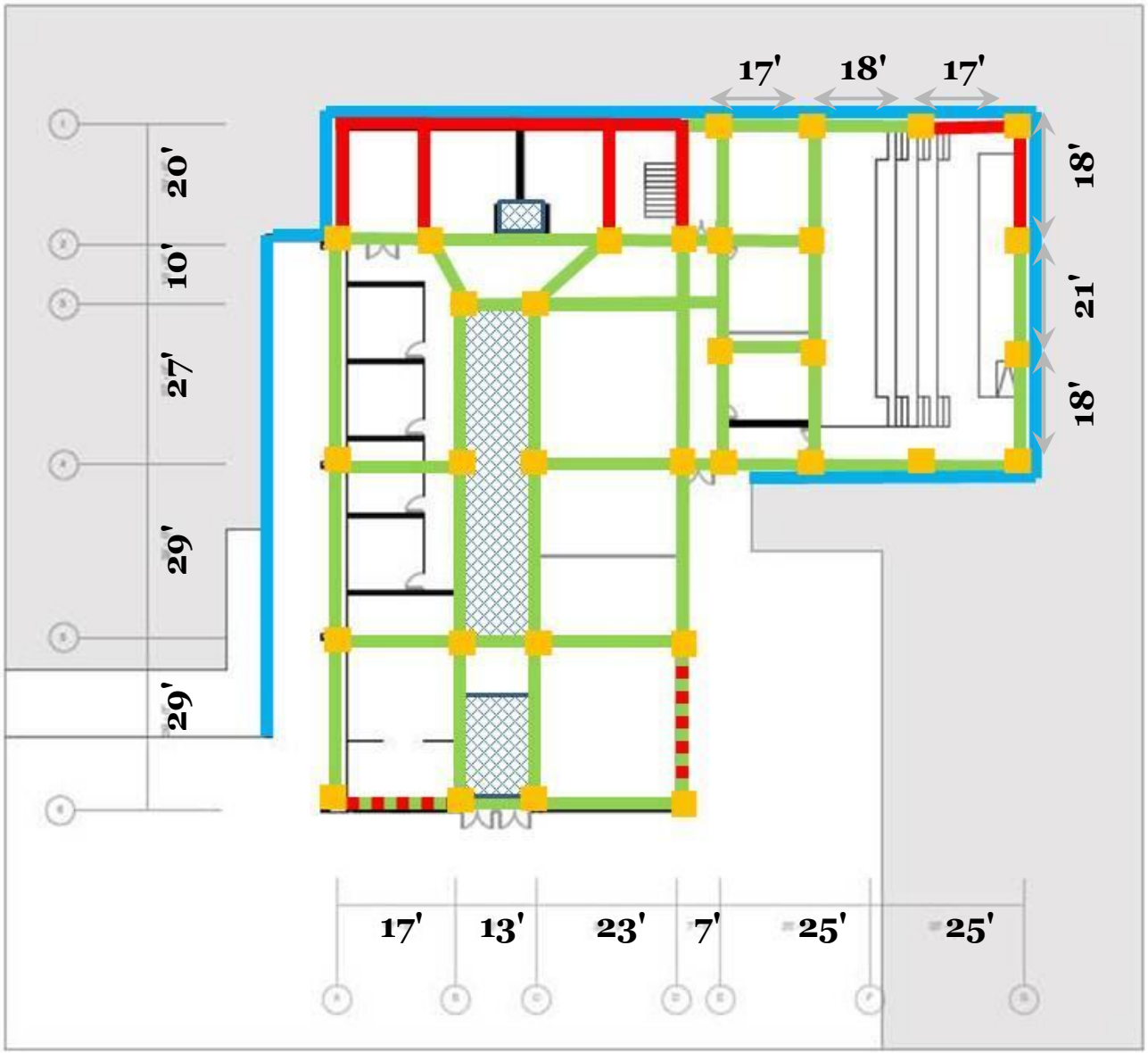
# Load Paths





# Concrete: Level -1



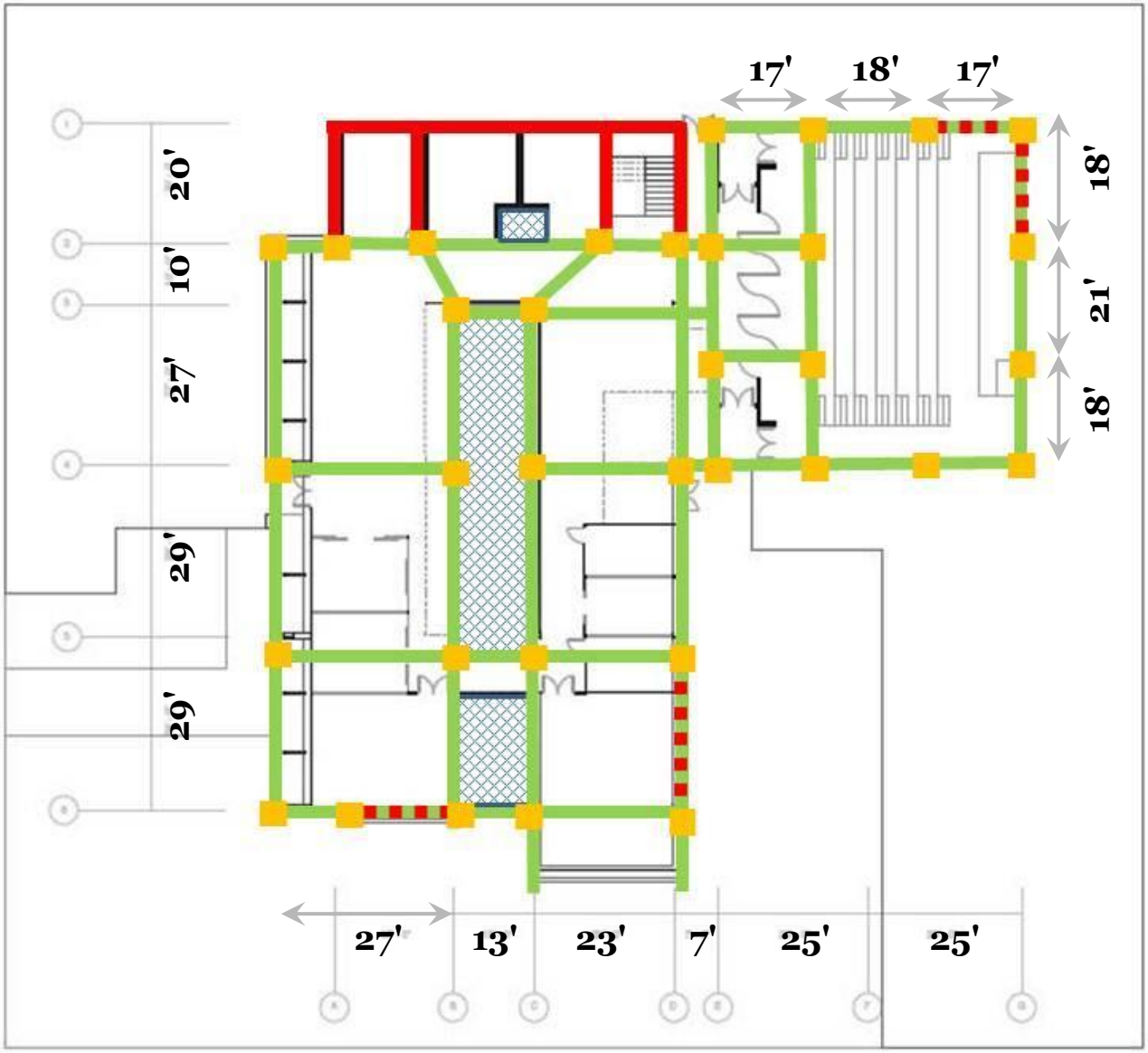



**BLUE** - Retaining Wall
**ORANGE**
2'x2' Columns
**GREEN** –
1,5'x2' Beams
**RED** –
Shear Walls & Bracing
▨ - Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# Concrete: Level 0





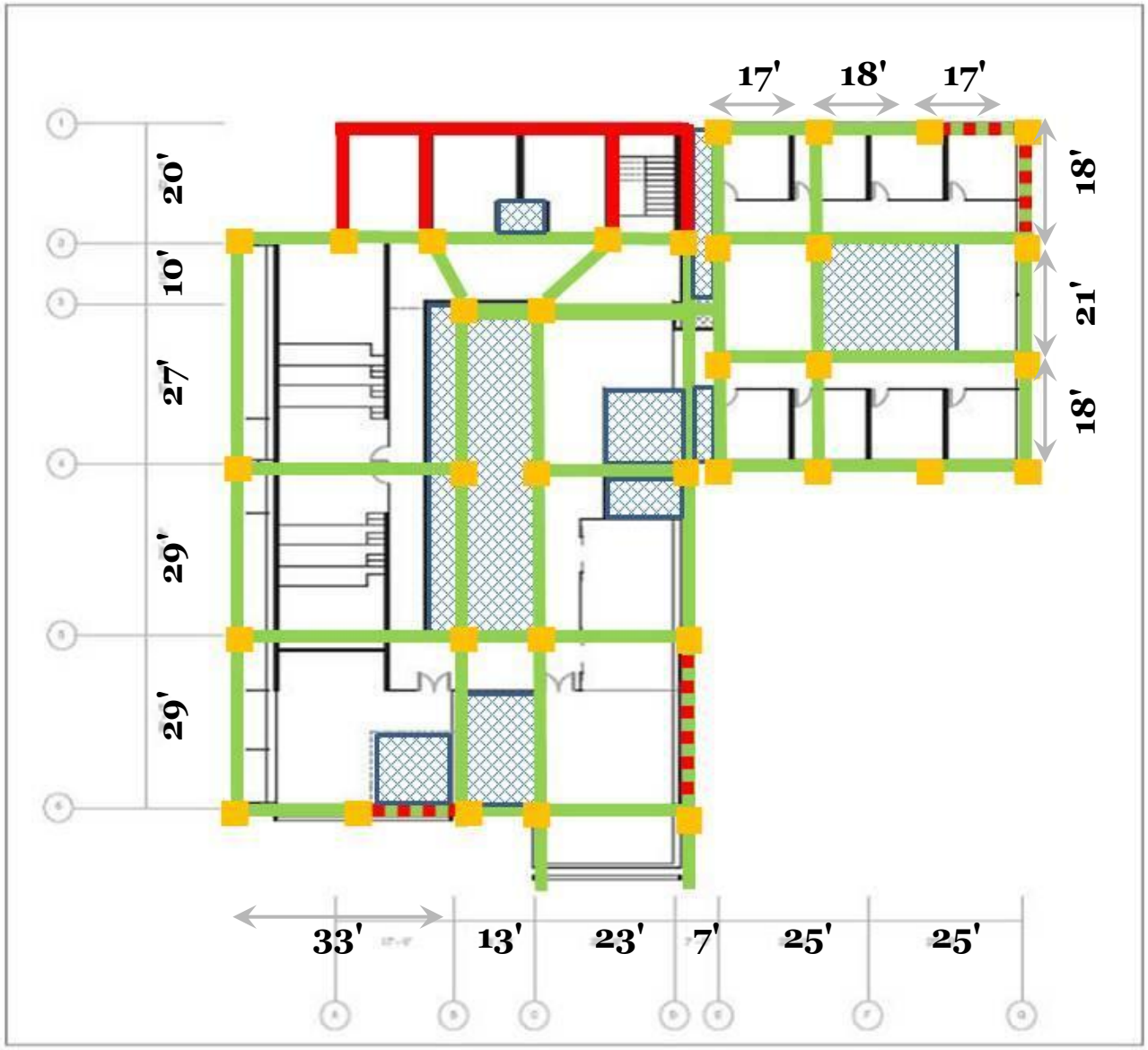

**ORANGE –**
2'x2' Columns
**GREEN –**
1.5'x2' Beams
**RED –**
Shear Walls & Bracing
- Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

Auditorium Slab:
Prefab PT 2' Slab

# Concrete: Level 1






**ORANGE –**
2'x2' Columns
**GREEN –**
1.5'x2' Beams
**RED –**
Shear Walls & Bracing
- Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# Concrete: Level 2 (Roof)




**ORANGE –**
2'x2' Columns
**GREEN –**
1.5'x2' Beams
**RED –**
Shear Walls & Bracing
▭ - Slab Openings

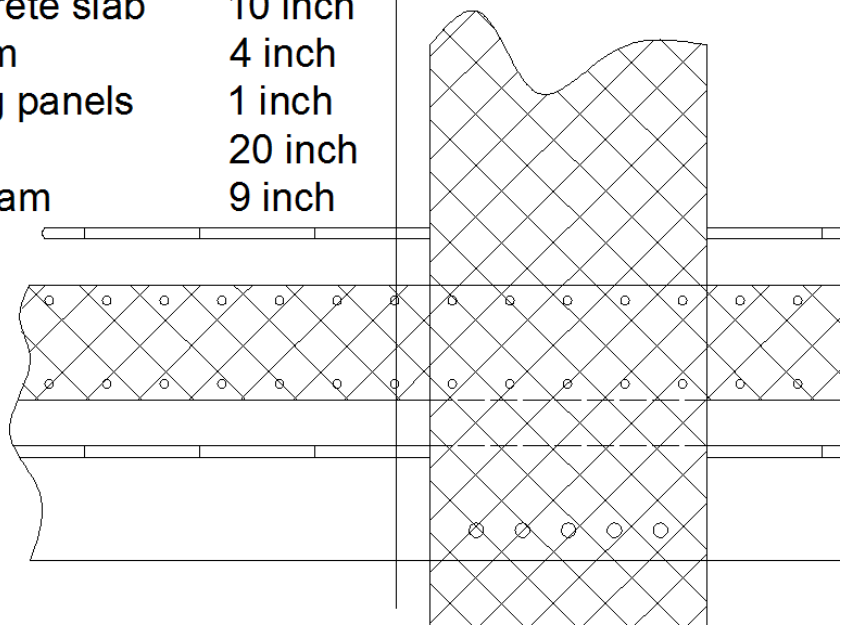
Floor Slab:
10" Reinforced Concrete Slab

# Floor Sandwich: Concrete

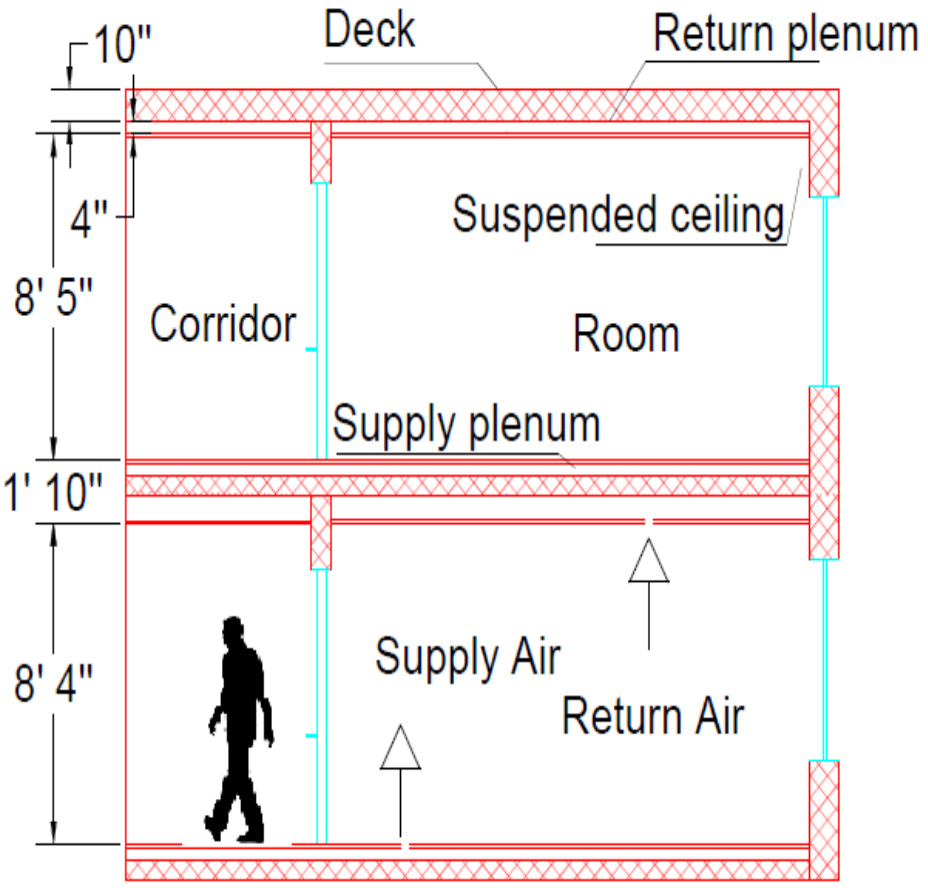


## Total height: 20 inch

| | |
|---|---|
| Floor finish | 1 inch |
| Plenum | 4 inch |
| Reinforced concrete slab | 10 inch |
| Plenum | 4 inch |
| Ceiling panels | 1 inch |
| Total: | 20 inch |
| RC beam | 9 inch |



## Underfloor Distribution

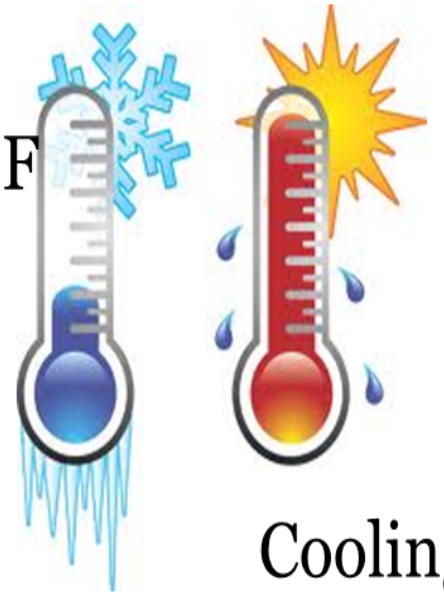


# HVAC Requirements



Heating Set Points: 68 F

Outdoor temperature: 19,9 F



Cooling Set Points: 78 F

Outdoor temperature: 92,2 F

Indoor Relative Humidity: 50%

# Heating/Cooling



Ground Source Heat Pump

- Energy efficient with low GHG emissions
- High capital cost and low operational costs (payback ≥5 years, Commercial Buildings Tax Deduction)

## Hybrid Systems

Dual Source :
decrease cost & efficiency

Solar Thermal :
Dump excess solar energy to the ground, decrease cost and groundwater well depth ~11%

System ~80 tons

- Boreholes ~300 ft
- Water-to-water system
- Seasonal heat/cold storage
- Energy recovery savings up 9%

# Air Distribution



Mechanical Ventilation

- Overhead air distribution - VAV system
- Underfloor air distribution
- Displacement Ventilation

Natural ventilation

- Stack ventilation

Control systems (of occupancy, $CO_2$ concentration, weather provision)

# UFAD & DV



## UFAD

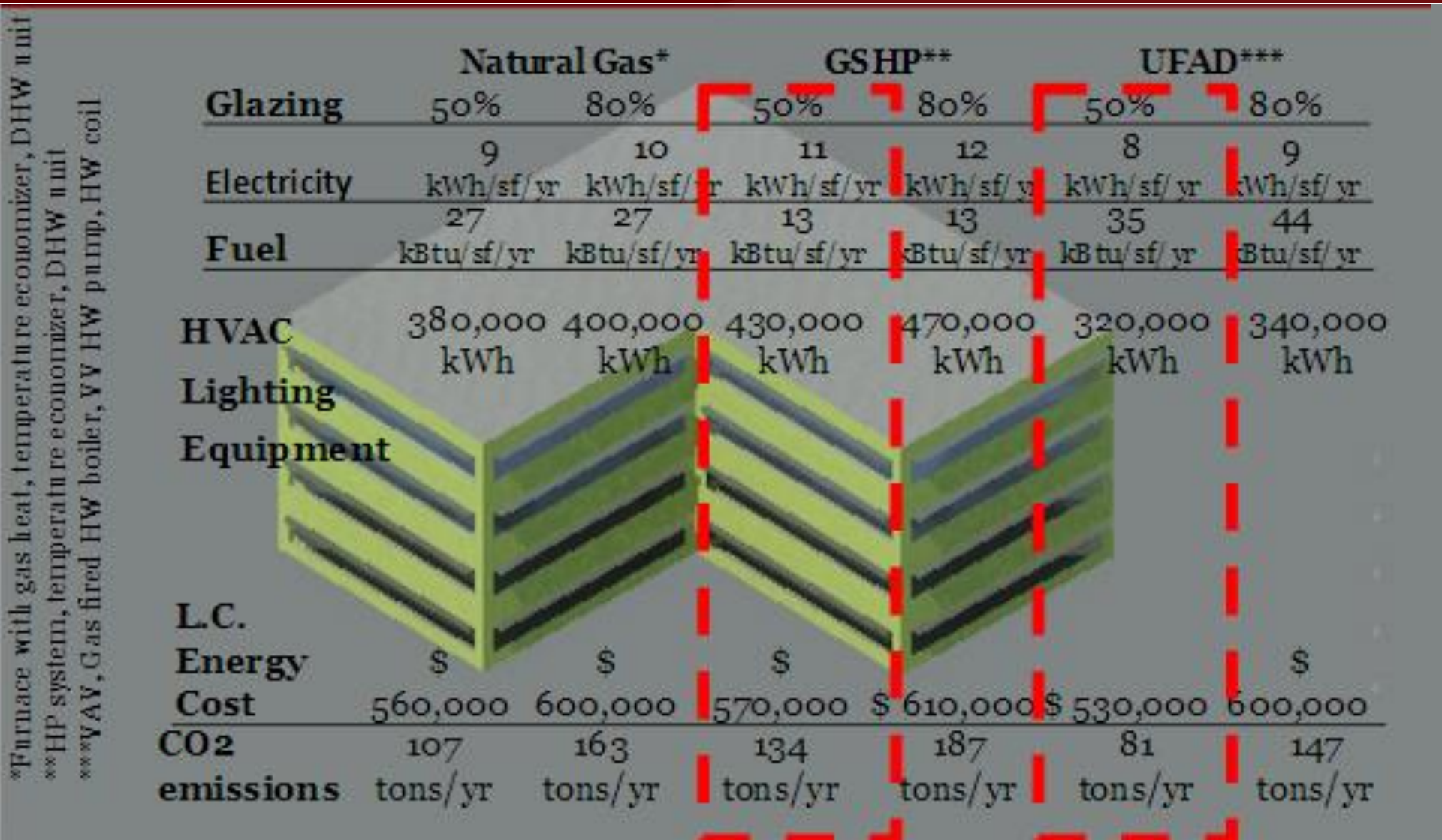
- Improved thermal comfort
- Improved ventilation efficiency and IAQ
- Reduce energy use
- Fan energy savings
- Reduced electrical demand

## UFAD/DV - System

- 4” pressurized supply & return plenum
- Passive floor mounted diffusers
- Dehumidification with portion of return air
- Passive VAV cooling and fin tube heating on perimeter

# Vasari Analysis

Architecture
Structure
**MEP**
Construction

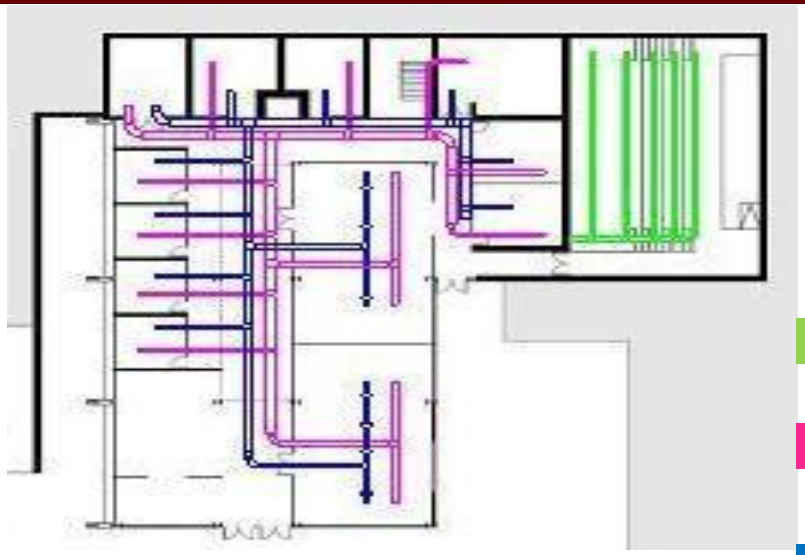


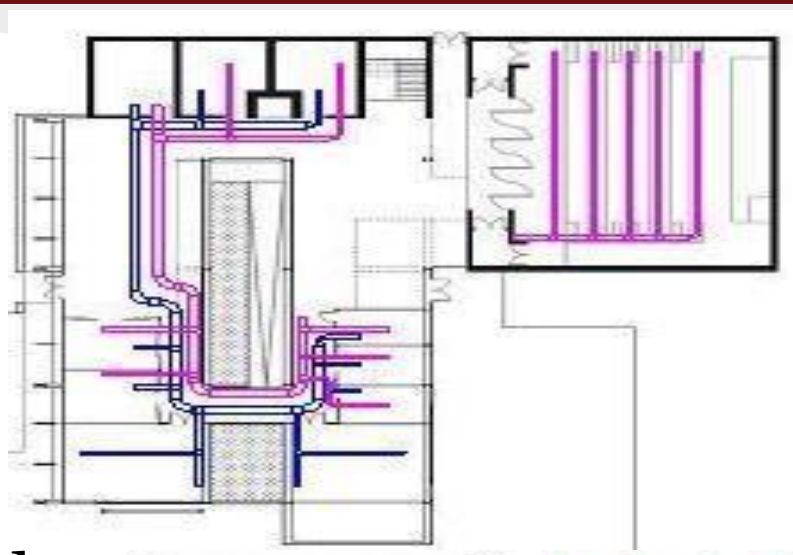
| | Natural Gas* | | GSHP** | | UFAD*** | |
|---|---|---|---|---|---|---|
| Glazing | 50% | 80% | 50% | 80% | 50% | 80% |
| Electricity | 9 kWh/sf/yr | 10 kWh/sf/yr | 11 kWh/sf/yr | 12 kWh/sf/yr | 8 kWh/sf/yr | 9 kWh/sf/yr |
| Fuel | 27 kBtu/sf/yr | 27 kBtu/sf/yr | 13 kBtu/sf/yr | 13 kBtu/sf/yr | 35 kBtu/sf/yr | 44 kBtu/sf/yr |
| HVAC | 380,000 kWh | 400,000 kWh | 430,000 kWh | 470,000 kWh | 320,000 kWh | 340,000 kWh |
| Lighting | | | | | | |
| Equipment | | | | | | |
| L.C. Energy Cost | $ 560,000 | $ 600,000 | $ 570,000 | $ 610,000 | $ 530,000 | $ 600,000 |
| CO2 emissions | 107 tons/yr | 163 tons/yr | 134 tons/yr | 187 tons/yr | 81 tons/yr | 147 tons/yr |

*Furnace with gas heat, temperature economizer, DHW unit
**HP system, temperature economizer, DHW unit
***VAV, Gas fired HW boiler, VV HW pump, HW coil

# Duct Network



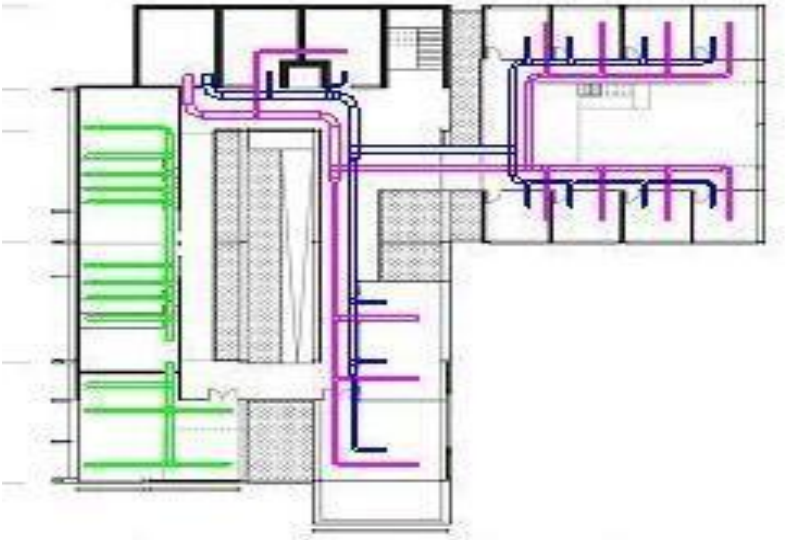


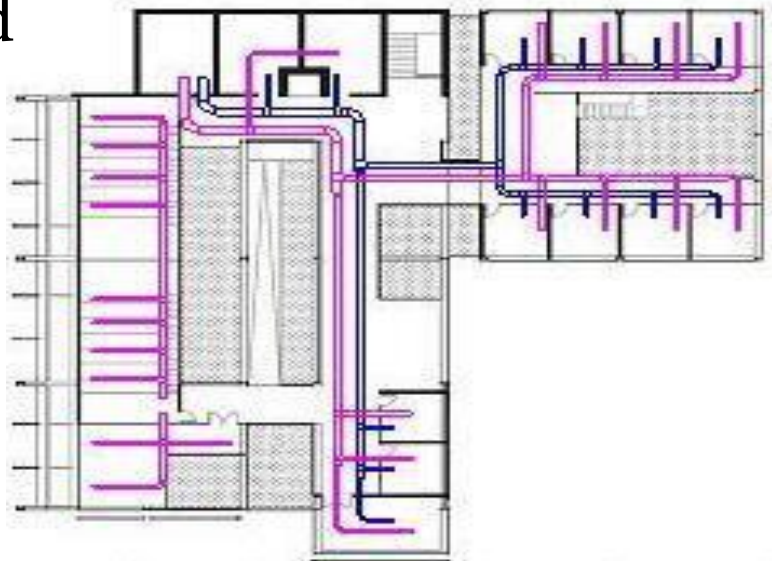


DV

Return

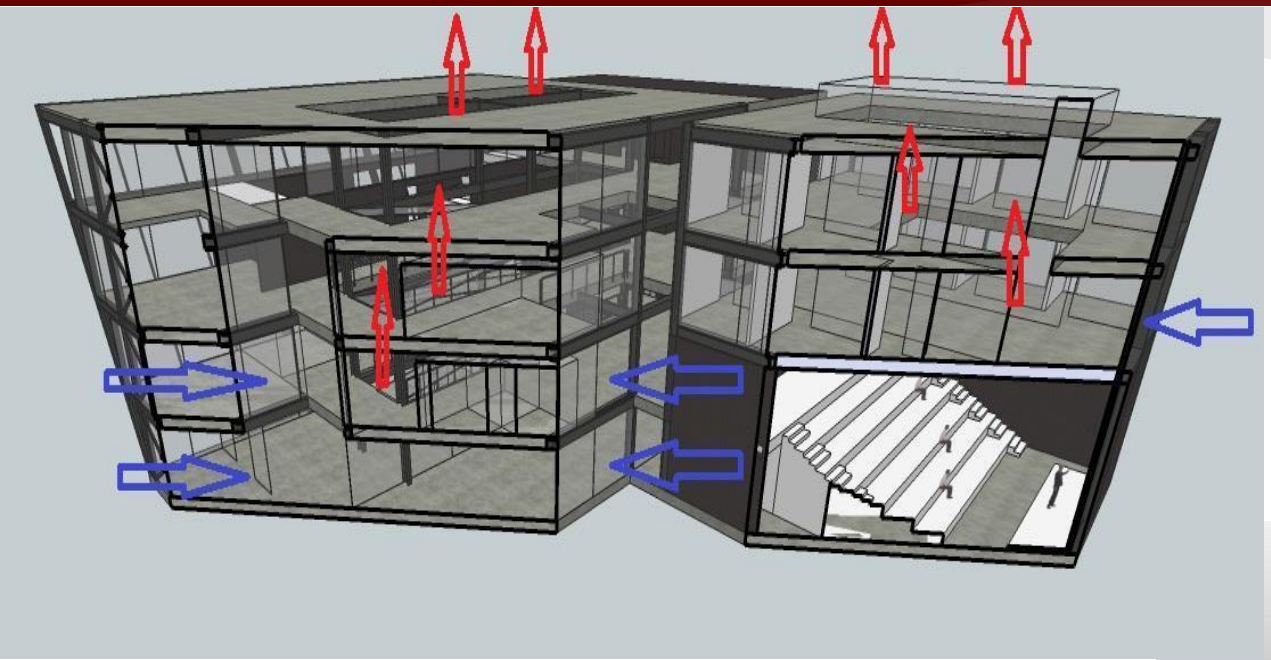
Overhead

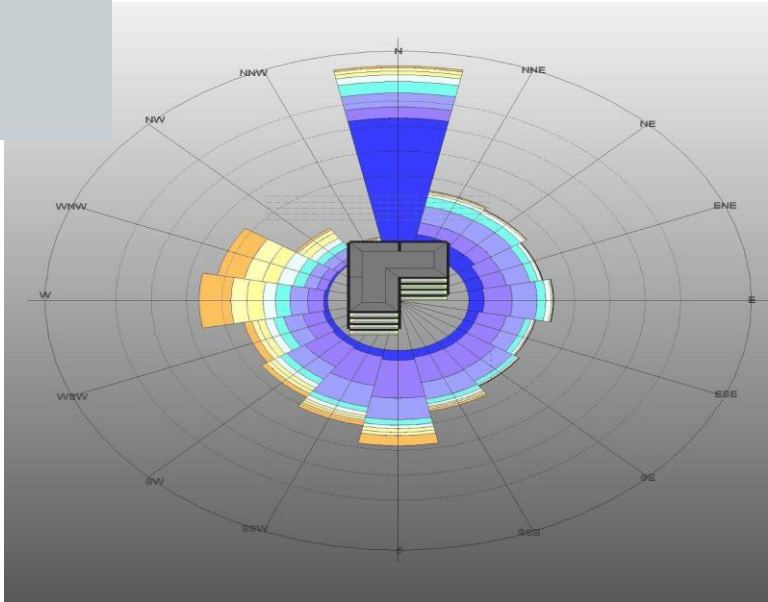




# Natural Ventilation

Architecture
Structure
**MEP**
Construction






- Natural stack ventilation in corridor, atriums and perimeter
- Low energy fan during winter

# Site Logistics



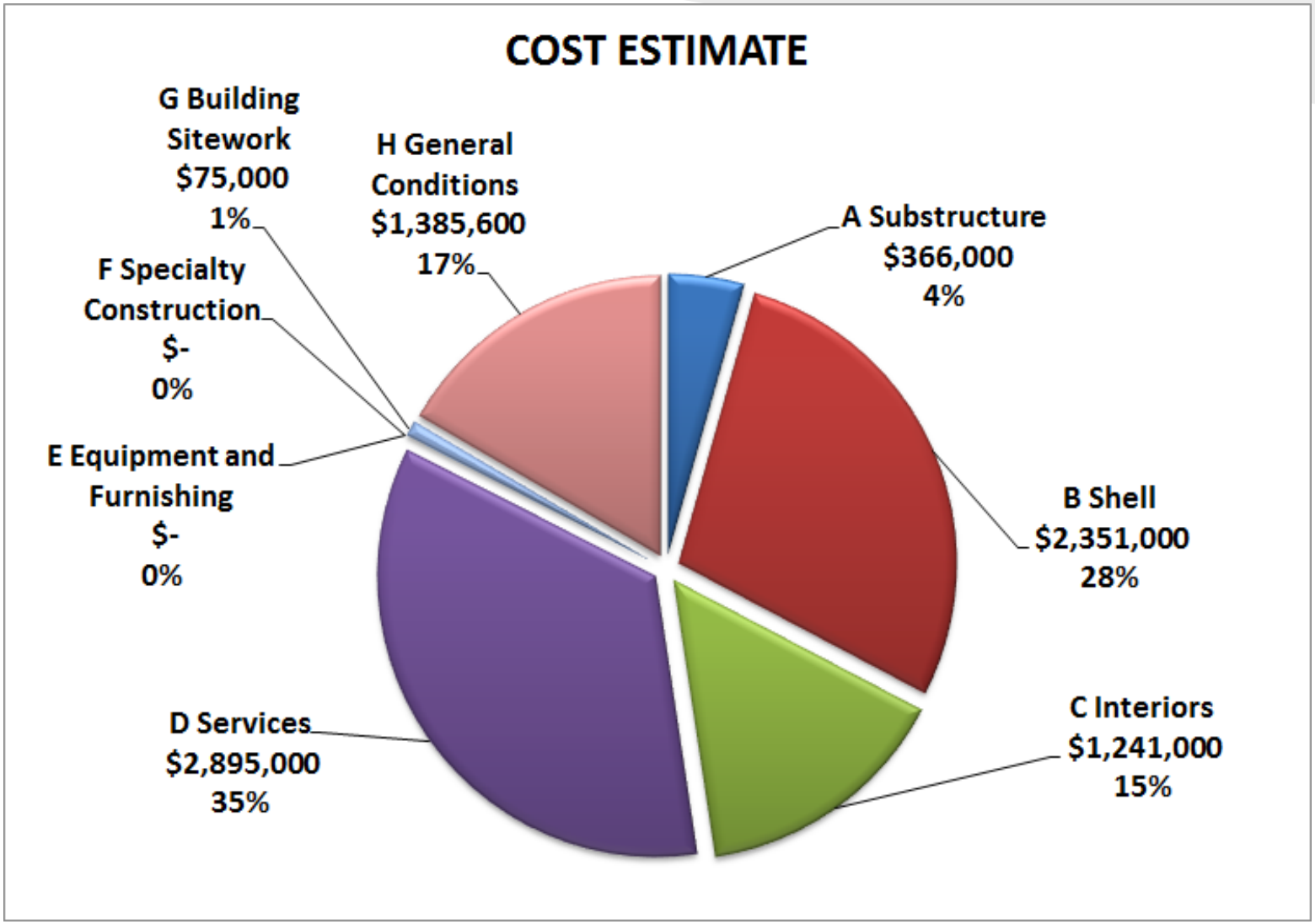
# Cost Estimate



| Concept | **Estimate** | **Difference From Target** |
|---|---|---|
| L -Steel | **$ 8,313,600** | **$ (13,600)** |
| L-Concrete | **$ 8,296,800** | **$ 3,200** |

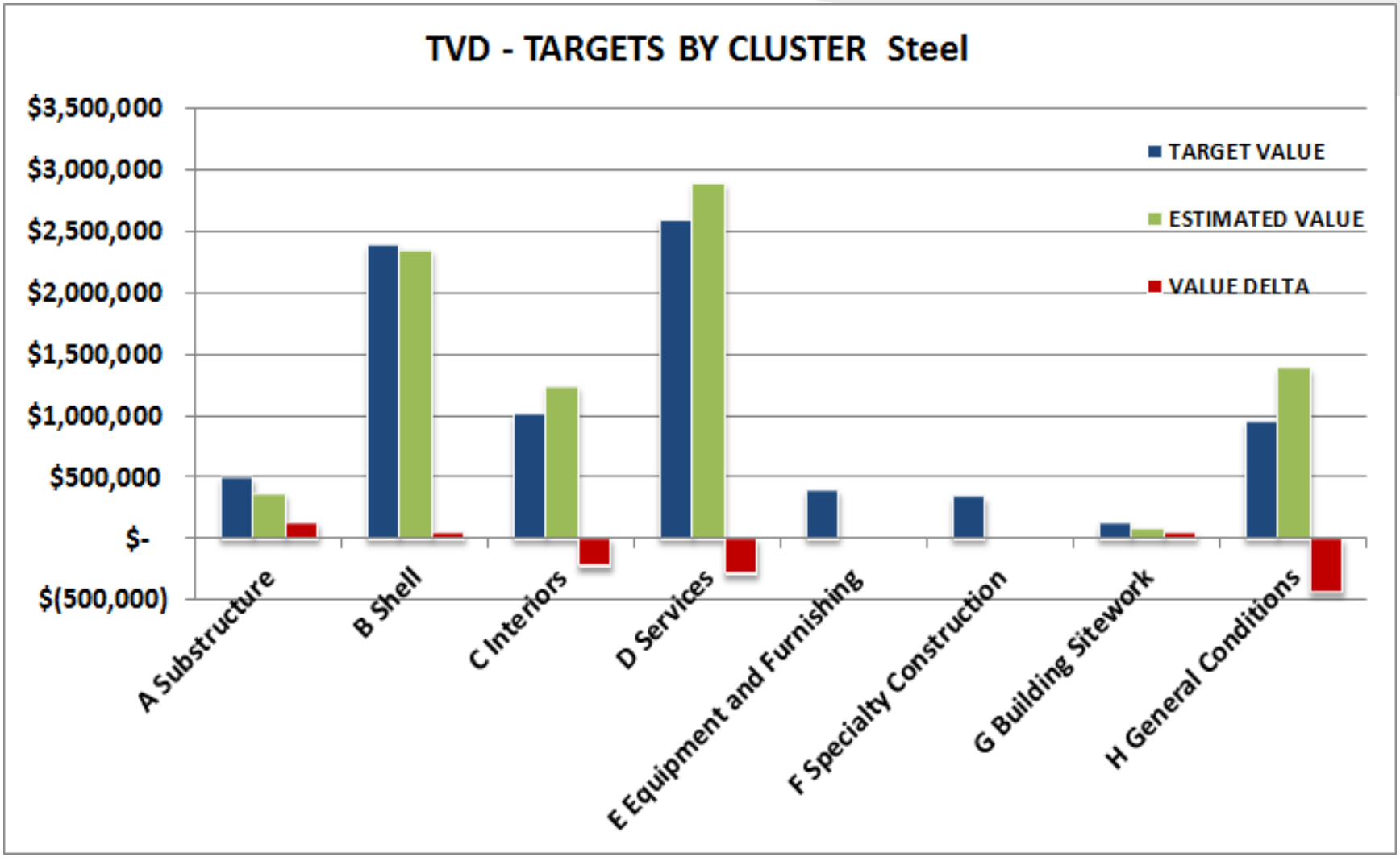
# Cost distribution

Architecture
Structure
MEP
**Construction**



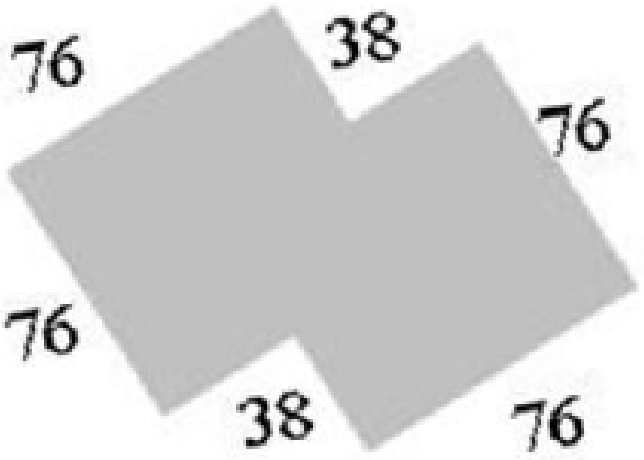
# TVD - Concrete

Architecture
Structure
MEP
**Construction**



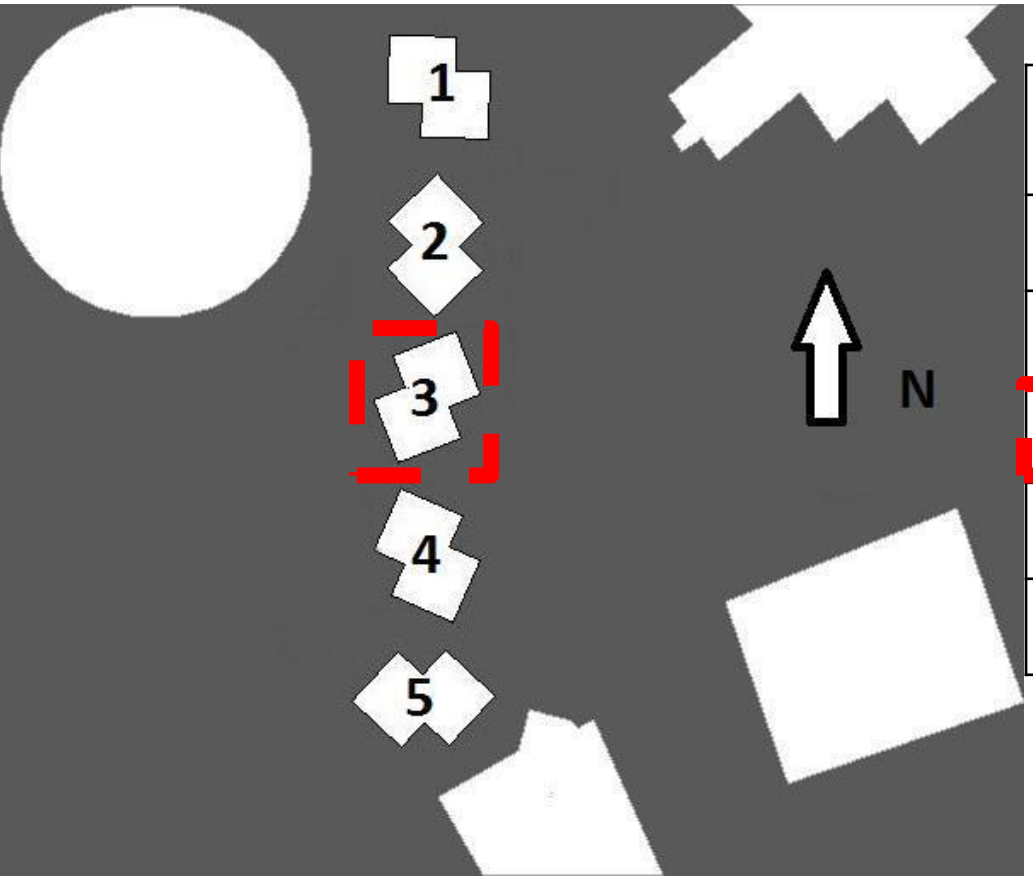
# Double Diamond (DD)

1. Central (C)
2. X - Lattice (X)



# Orientation

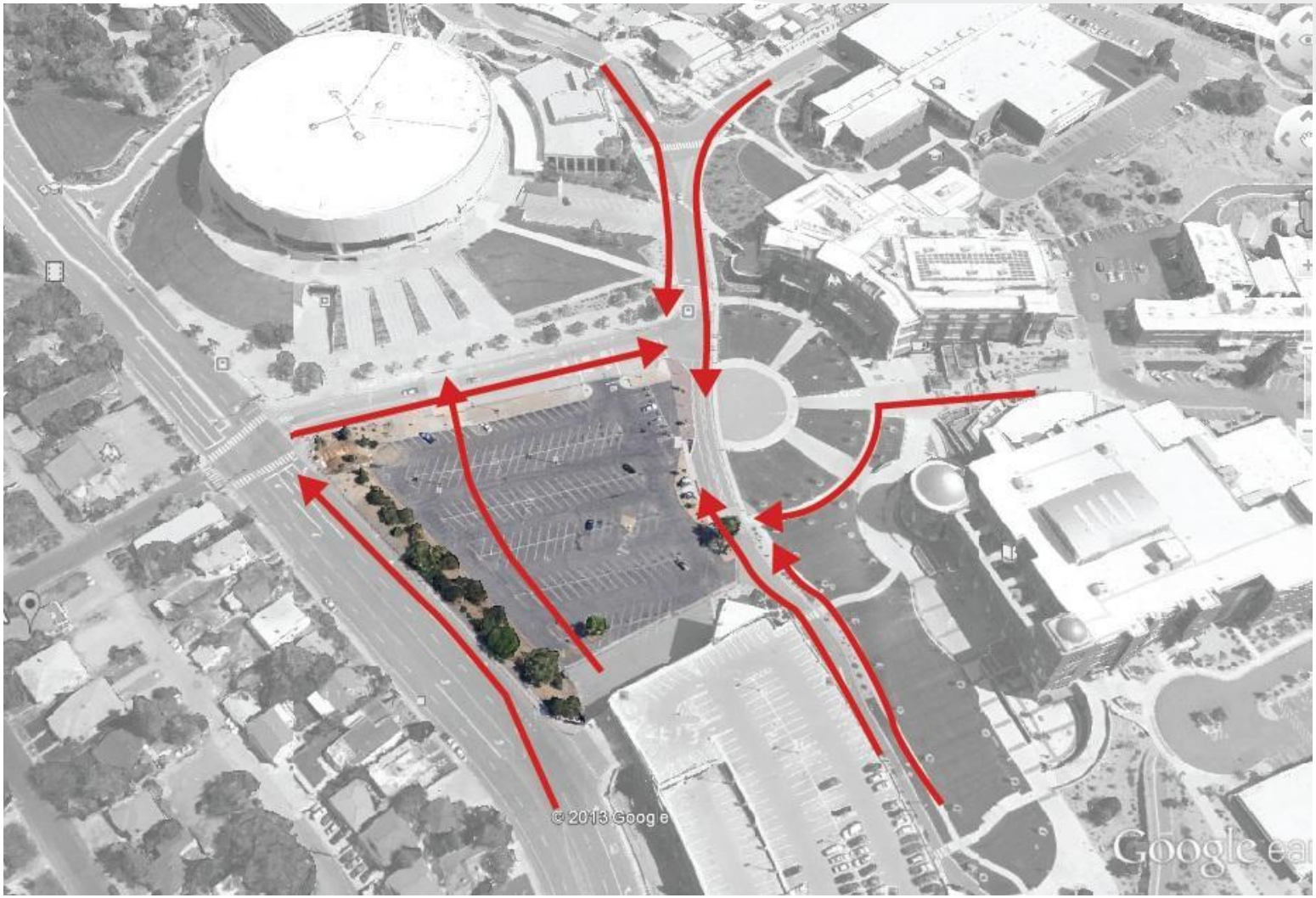





| | Total EUI (kBtu/sf/yr) | Life Cycle Energy Cost ($) | Net $CO_2$ (tn/year) |
|---|---|---|---|
| 1 | 68 | 610,000 | 235 |
| 2 | 71 | 650,000 | 165 |
| 3 | 68 | 615,000 | 145 |
| 4 | 68 | 630,000 | 245 |
| 5 | 70 | 630,000 | 155 |

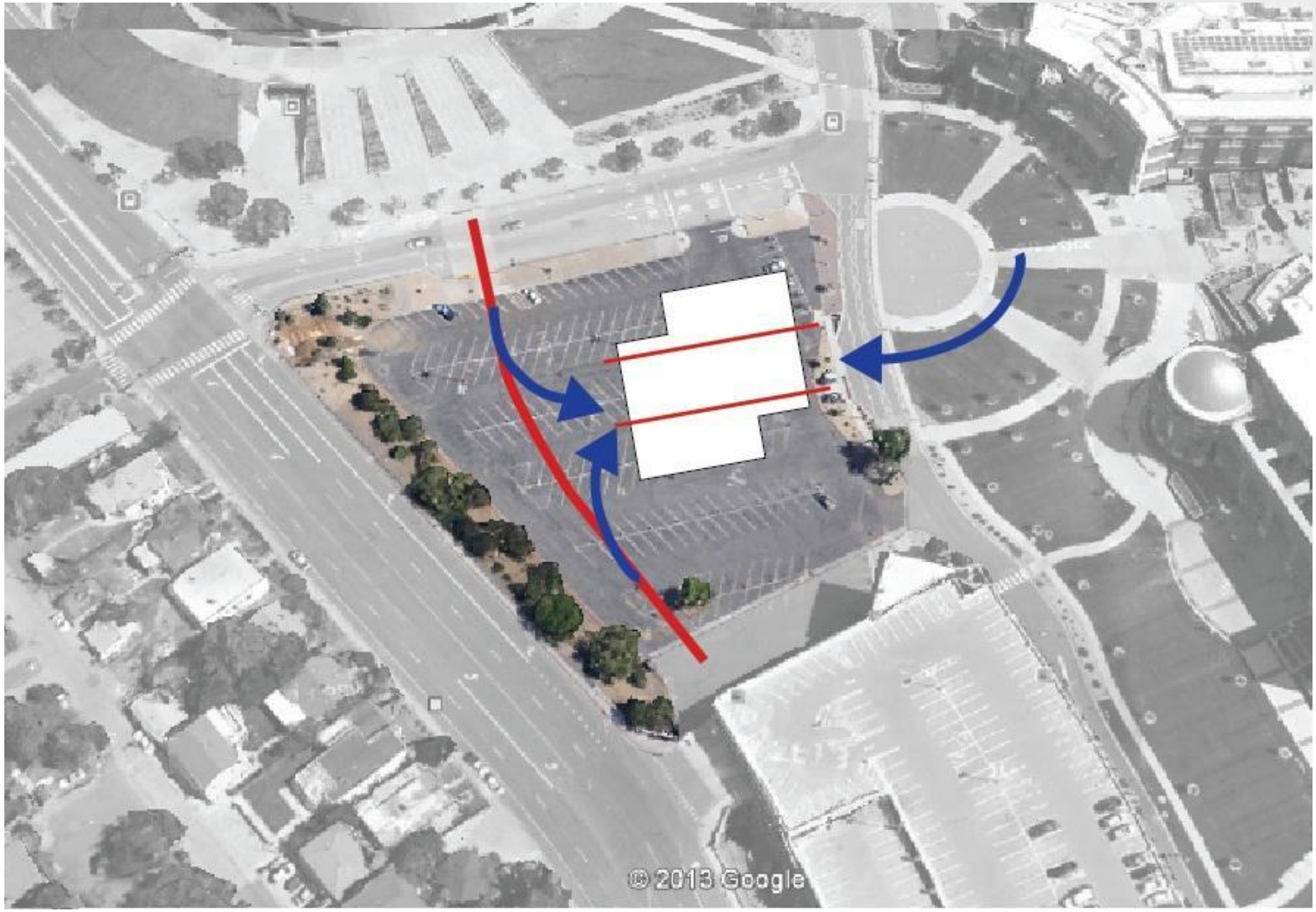
# Site/Second Concept





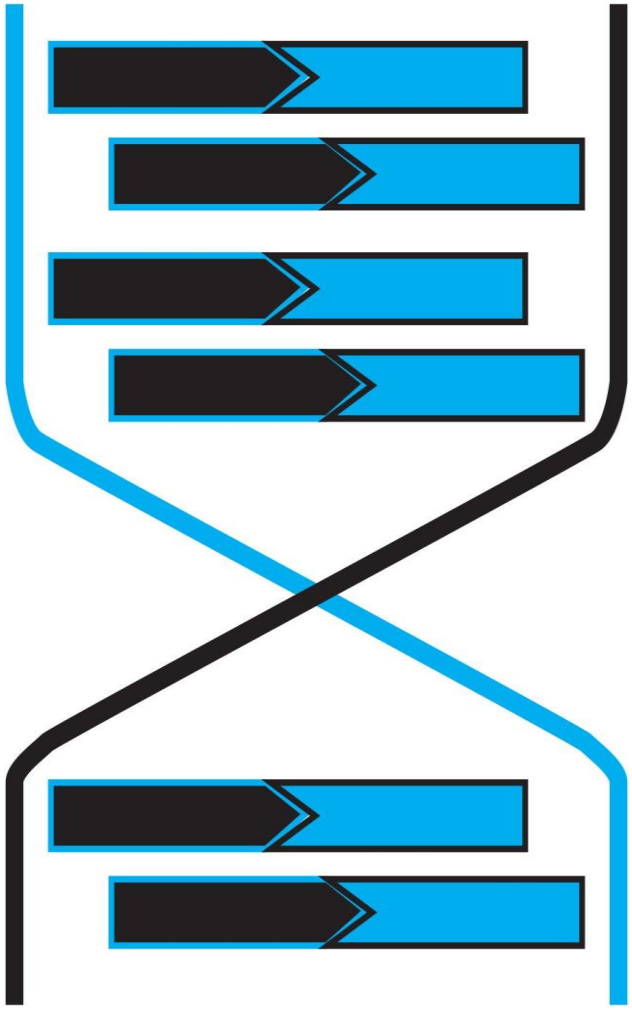
# Site/Second Concept

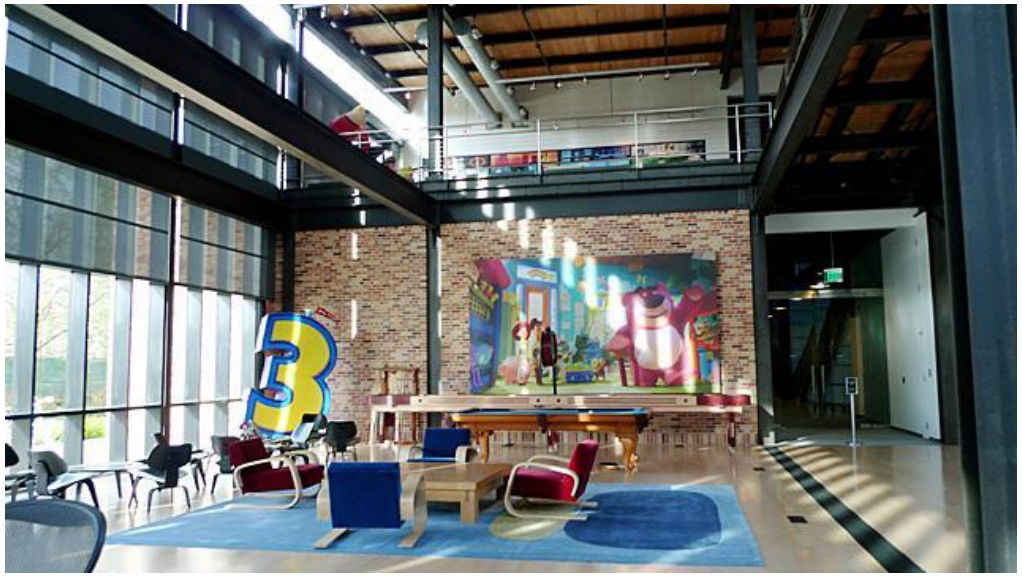




# Concept

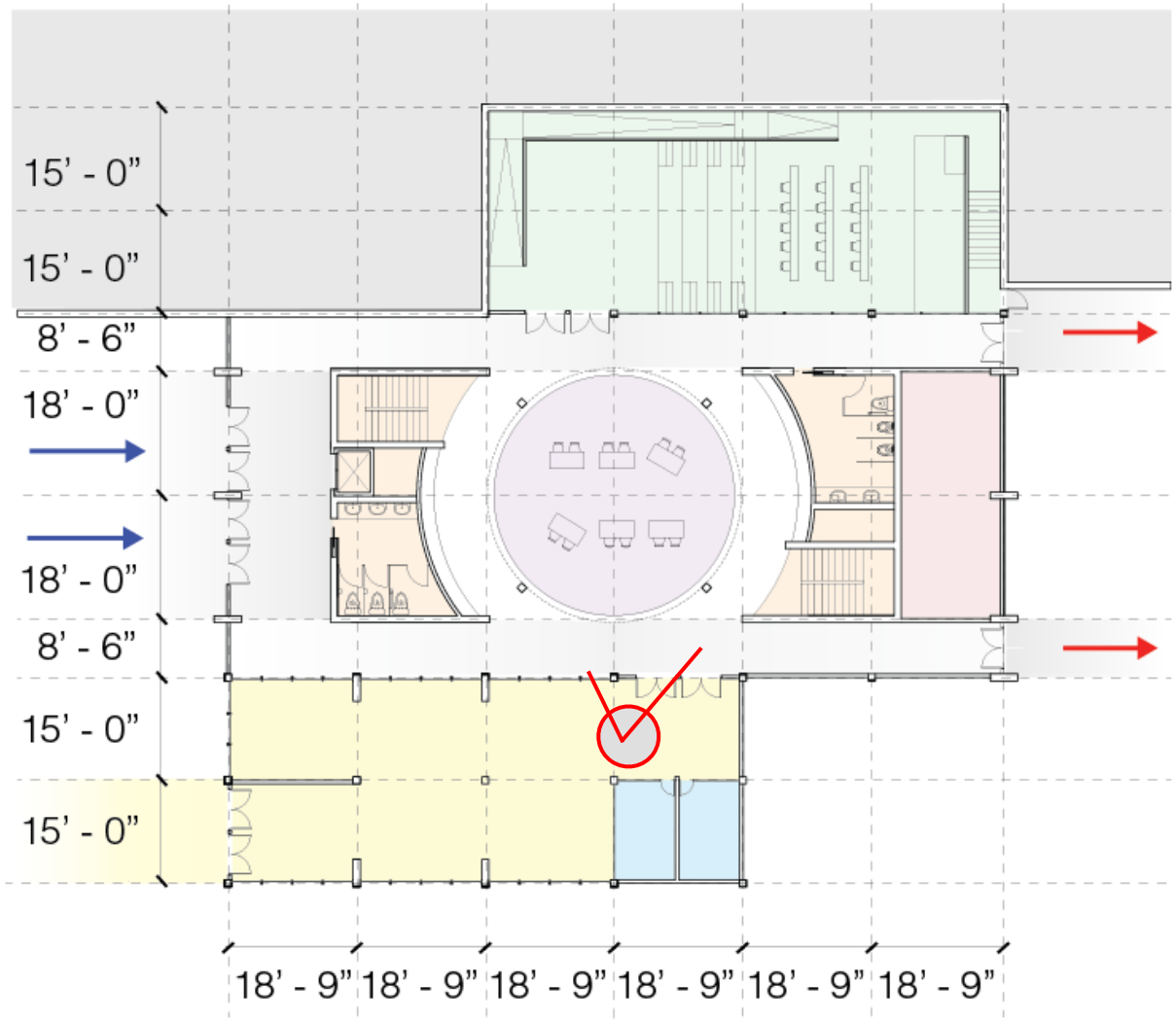
**Architecture**
Structure
MEP
Construction



# Level -1 (Basement)





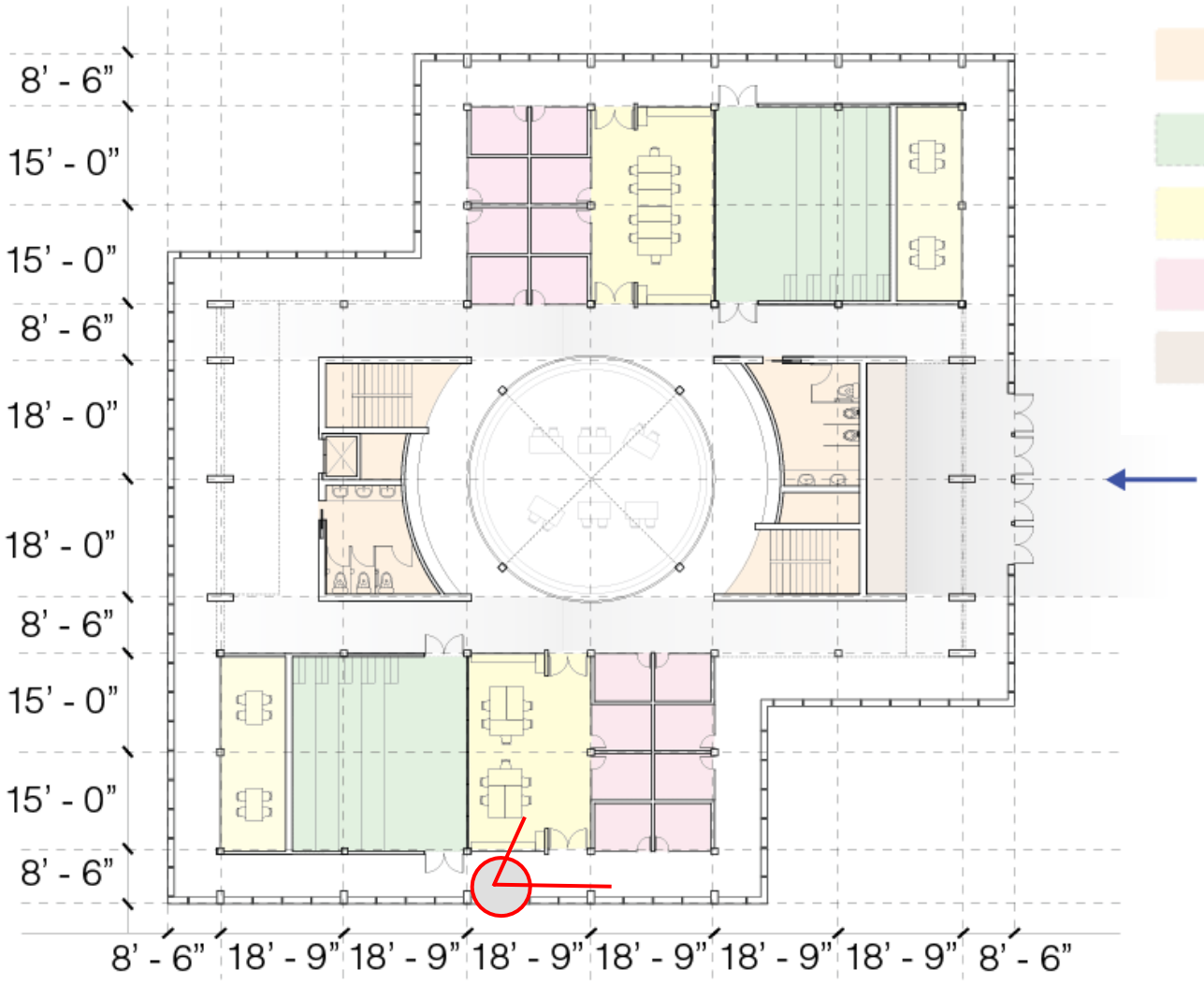

- Core
- Prototyping Lab
- Auditorium
- Faculty Offices
- Collaboration Space

# Level -1 (Basement)



# Level 0 - (Campus Entrance)



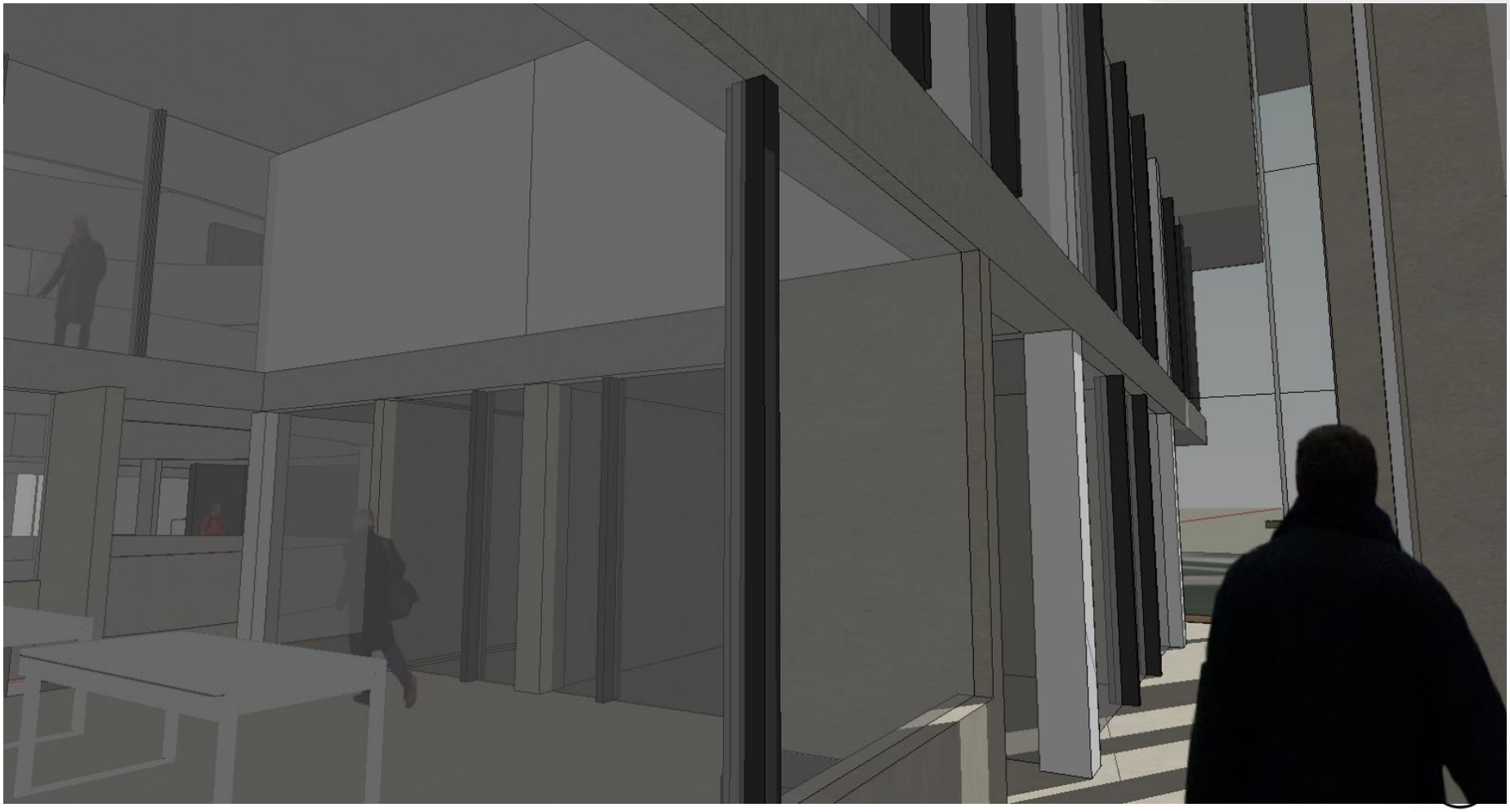



Core
Large Classrooms
Seminar Rooms
Student Offices
Cafe

0' 5' 10' 20' 35' 50'

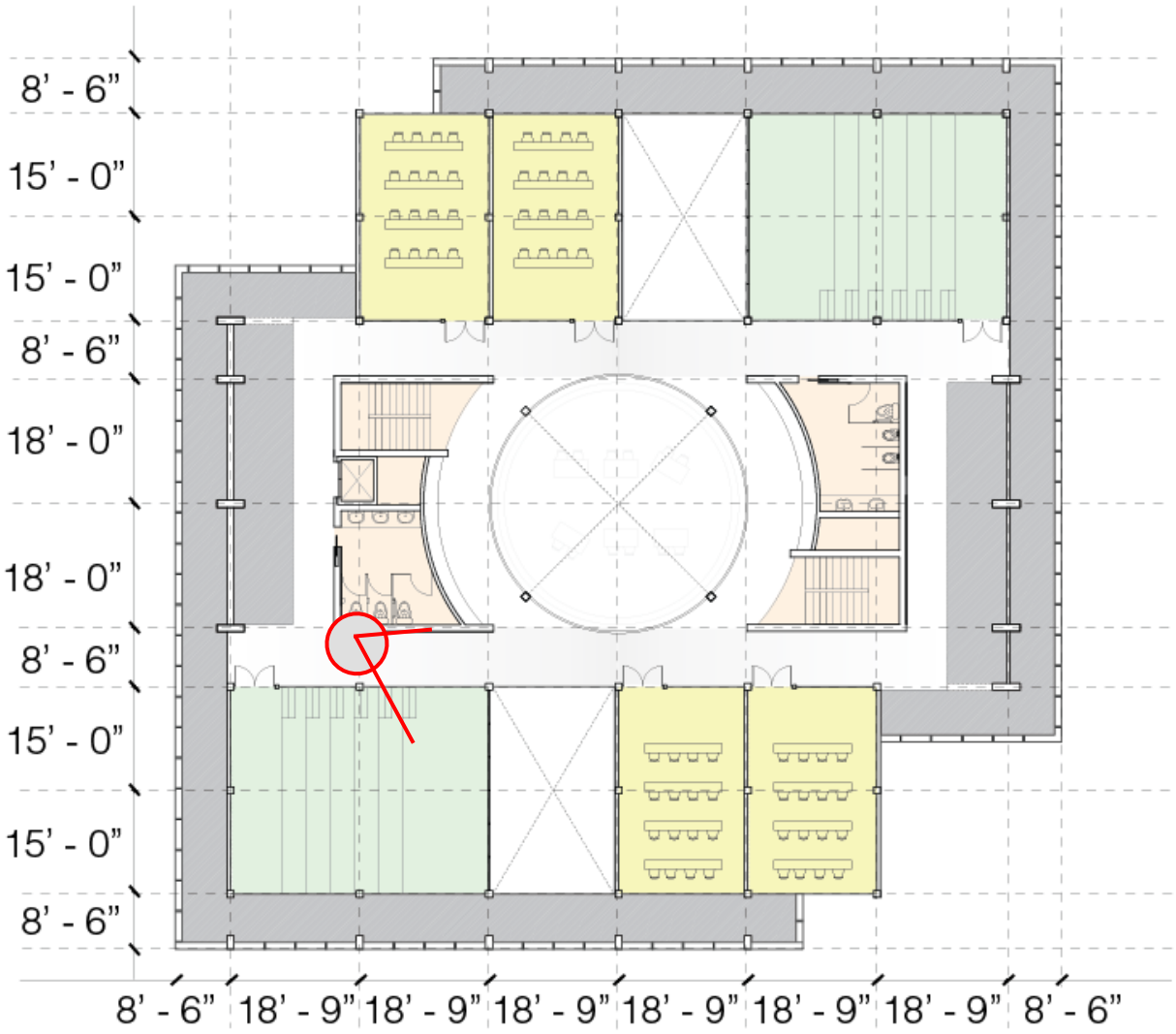
# Level 0 - (Campus Entrance)





# Level 1

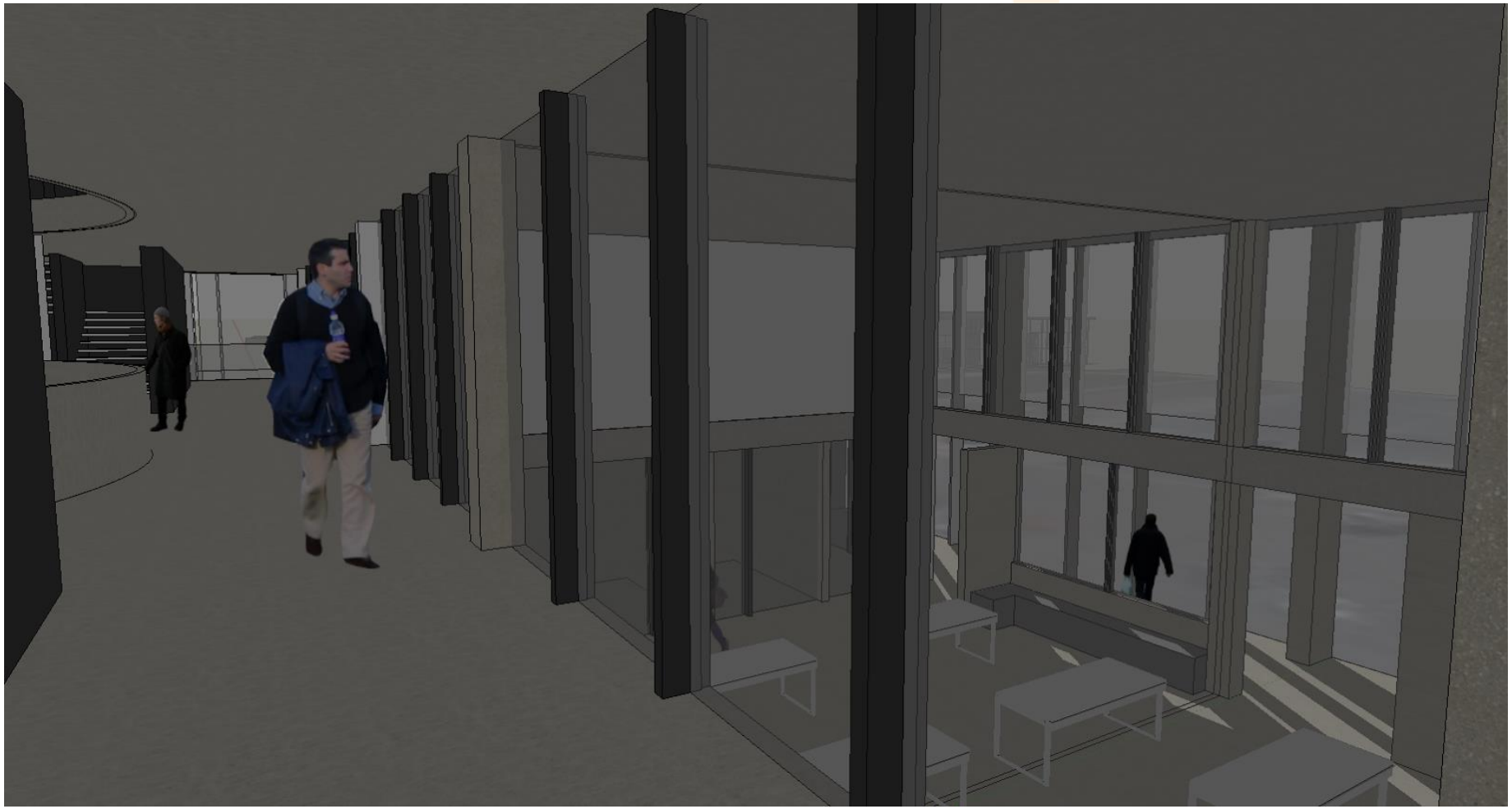





Core
Large Classrooms
Small Classrooms

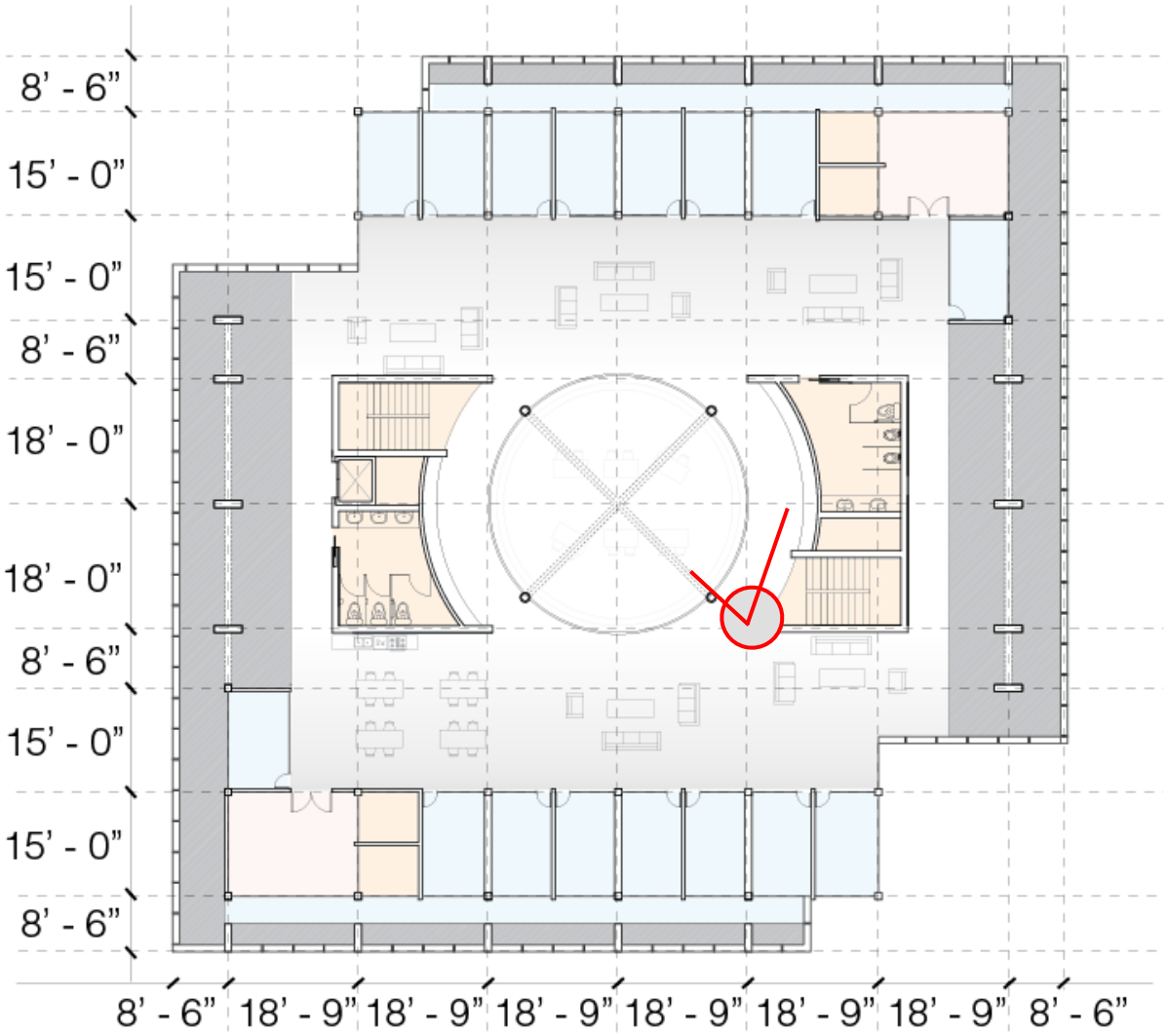
# Level 1

**Architecture**
Structure
MEP
Construction



# Level 2





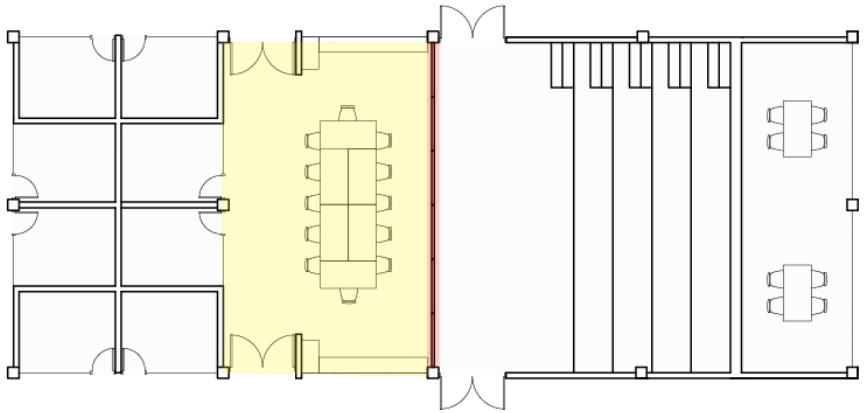

- Core
- Faculty Lounge
- Faculty Offices
- Administration
- Assistants Offices

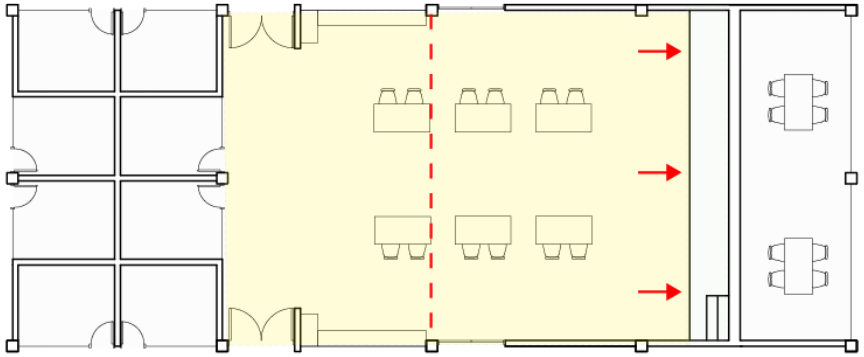
# Level 2

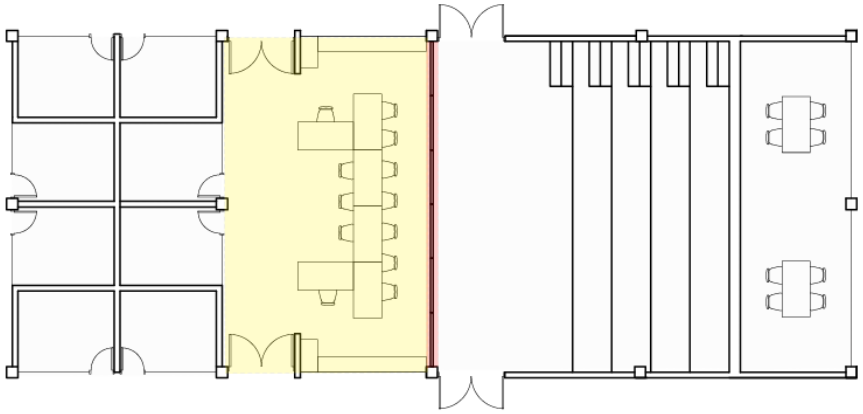
**Architecture**
Structure
MEP
Construction

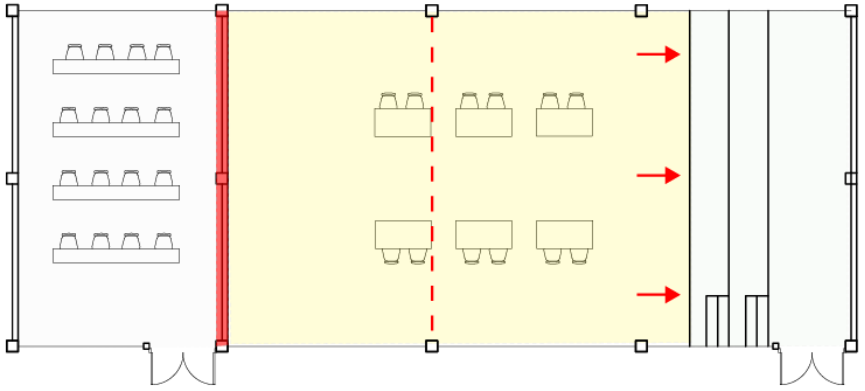
# Flexible Spaces

**Architecture**
Structure
MEP
Construction



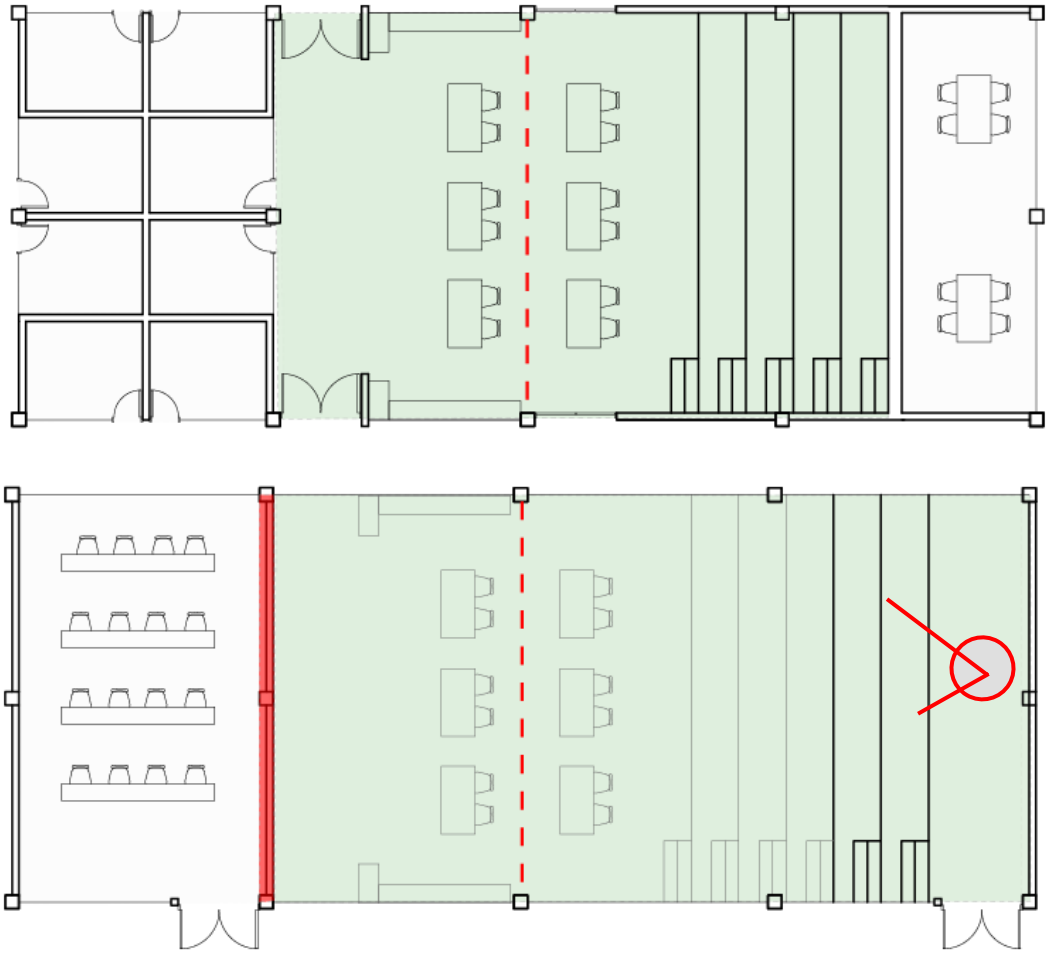






# Flexible Spaces

**Architecture**
Structure
MEP
Construction

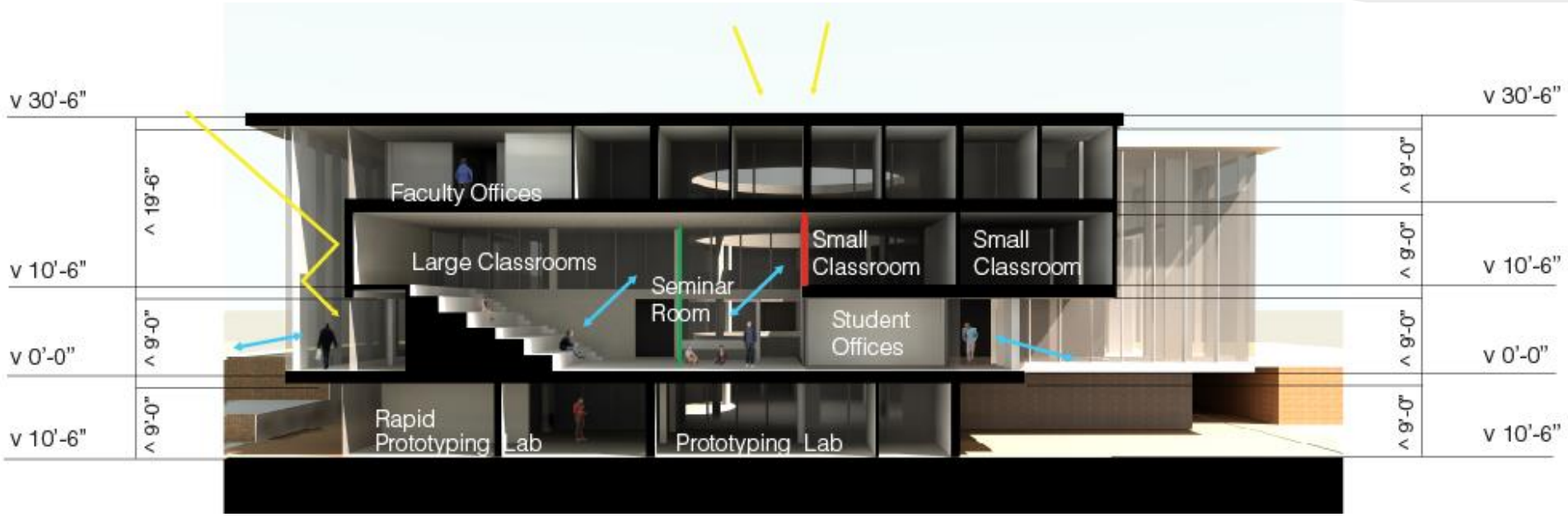


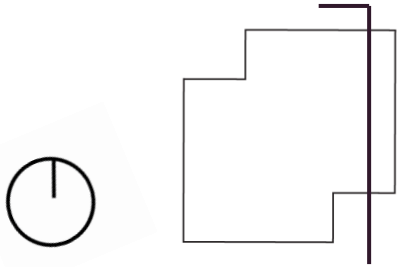
# Flexible Spaces

**Architecture**
Structure
MEP
Construction

# Section aa

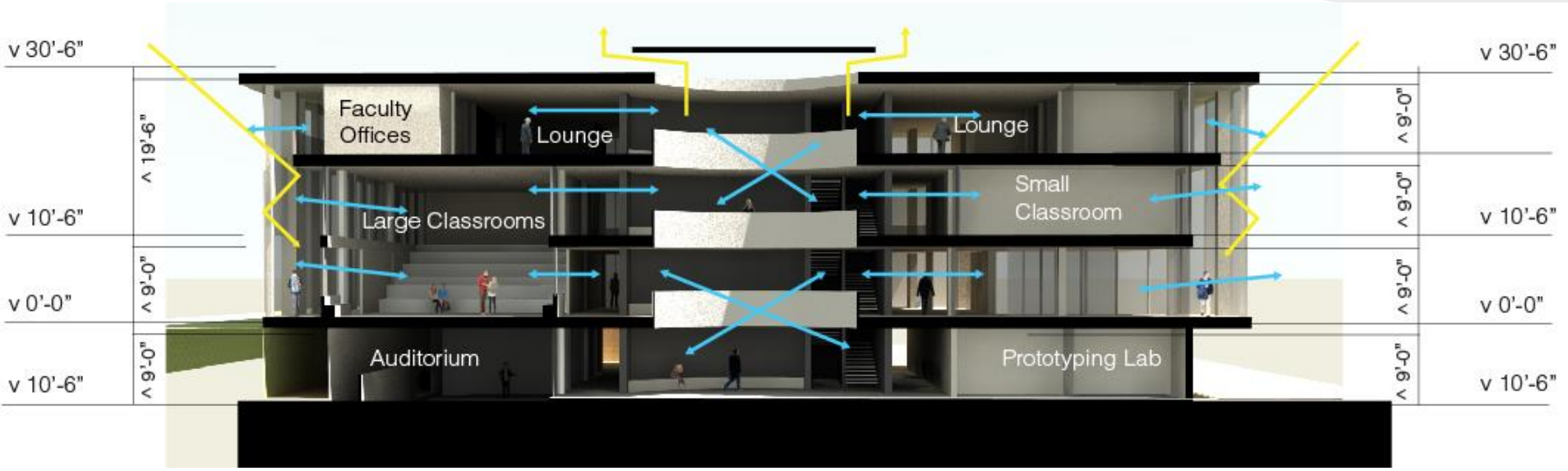
**Architecture**
Structure
MEP
Construction

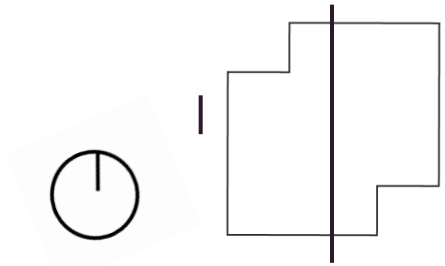


# Section bb





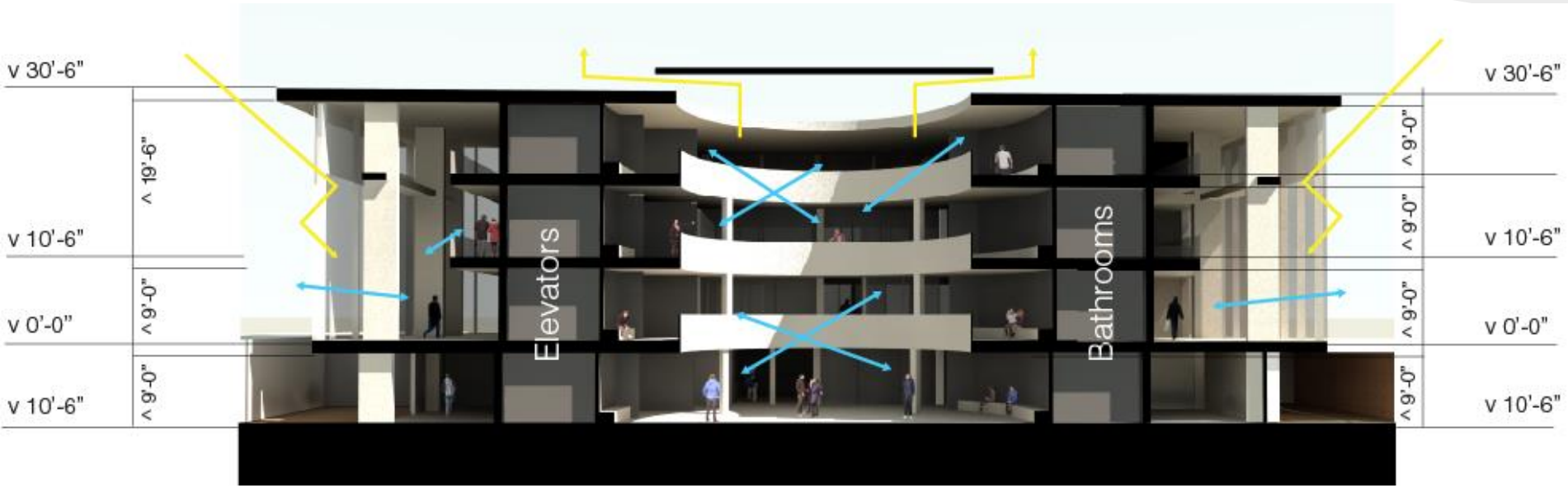



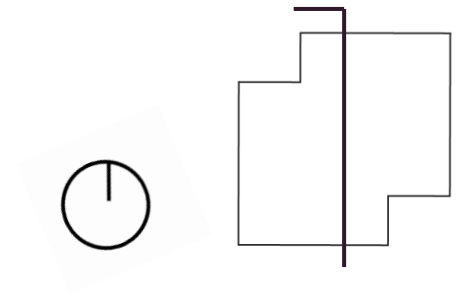
Summer

Winter

# Section cc

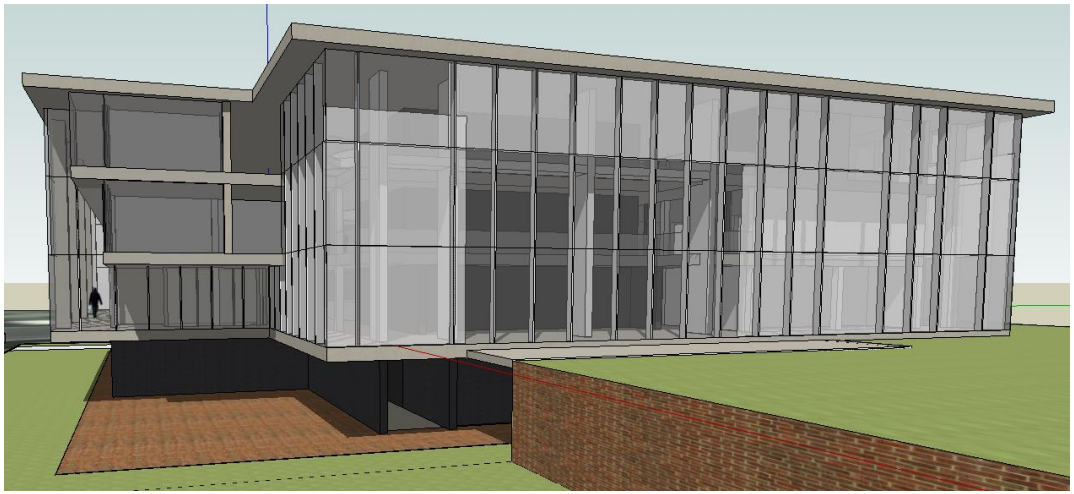
**Architecture**
Structure
MEP
Construction



# 3d views



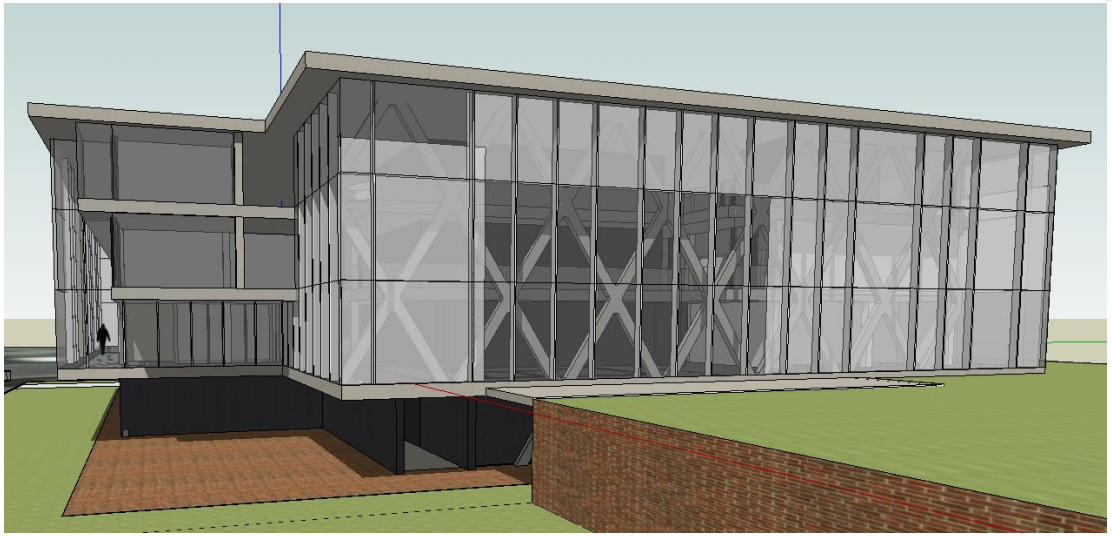


East Facade/
DD Central

South Façade/
DD Central

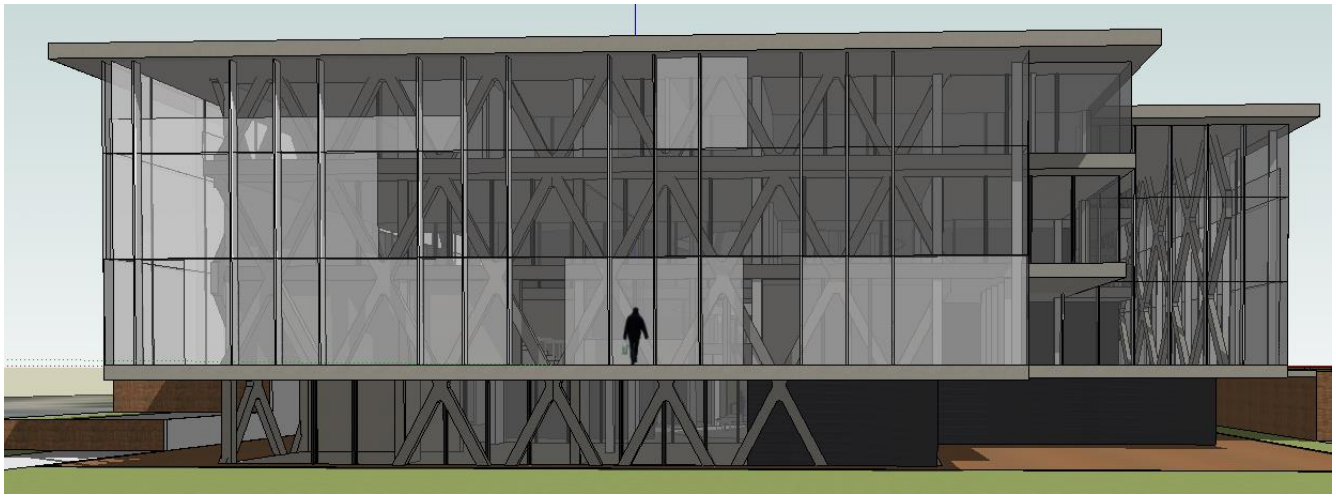
# 3d views





East Facade/
X Lattice

South Façade/
X Lattice

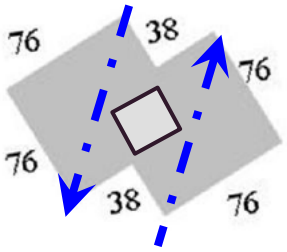


# Atrium Design Evolution



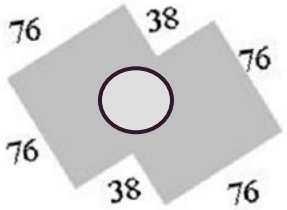
## Rectangle

+ Easier to fit program
- Concern about shearing along weak axis



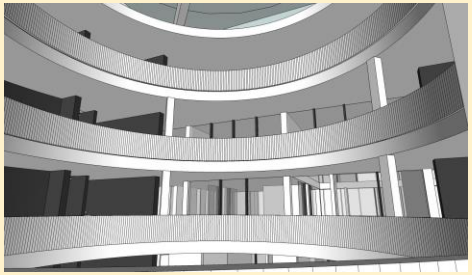

## Circle

+Stronger in the weak axis
- More challenging programmatically

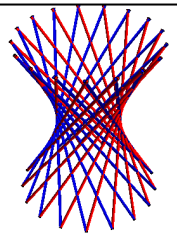



## Cylinder

+ Simpler form while maintaining circular shape



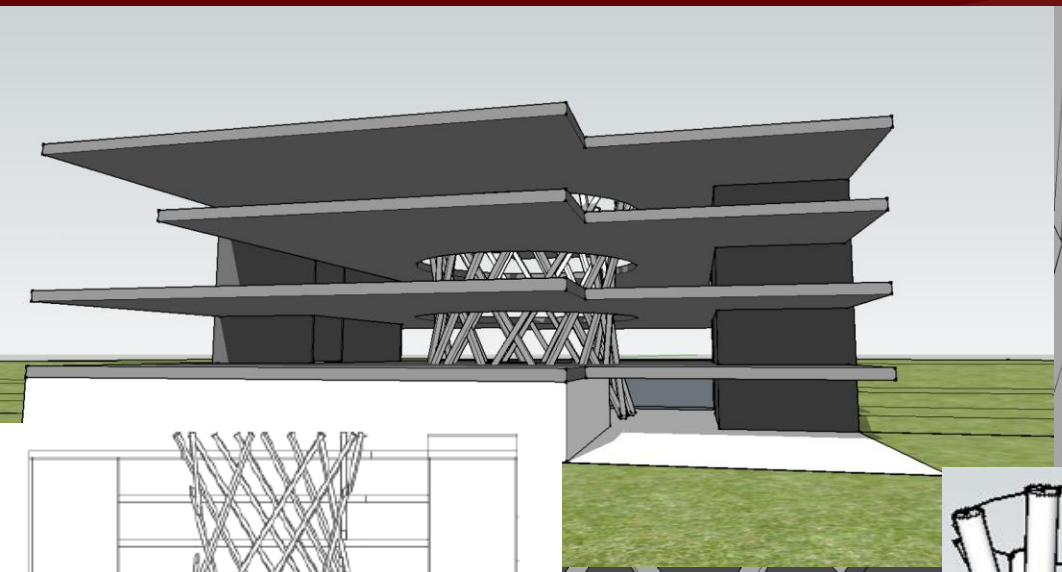
## Hyperboloid

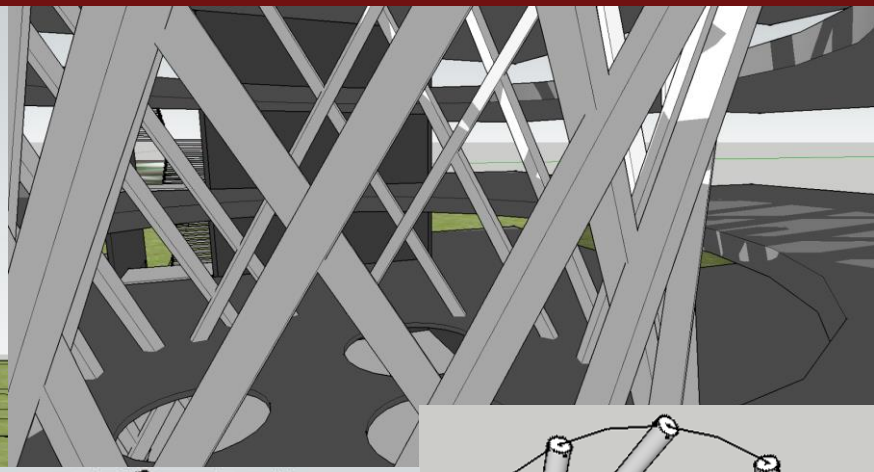


+Interaction between A + SE
+Interesting, iconic form
+Added strength in multiple directions
- More challenging/costly to design & build
- Does not fit architectural scheme well

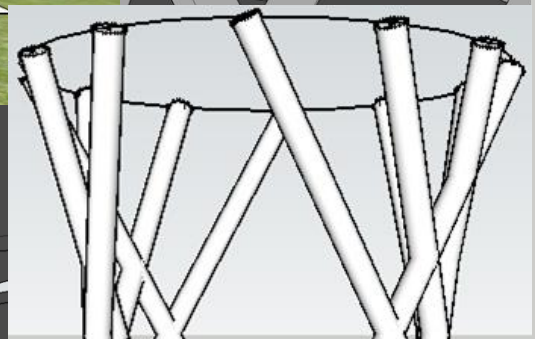
# Hyperboloid Exploration

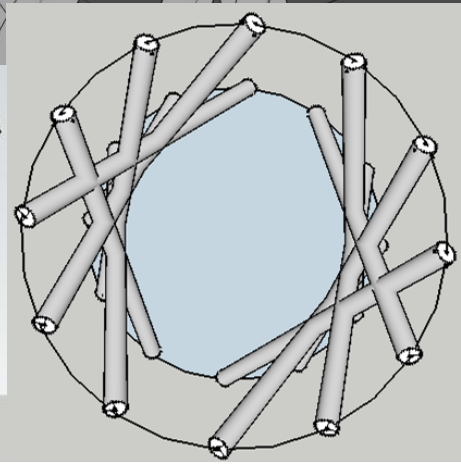
**Architecture**
**Structure**
MEP
Construction

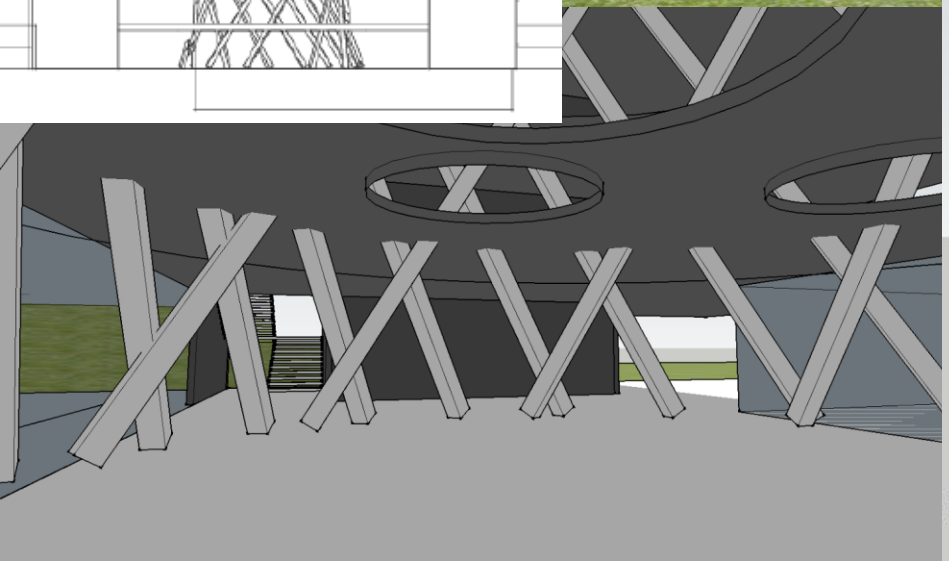


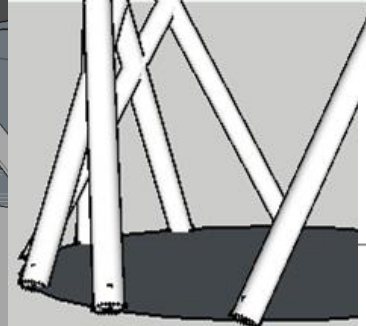


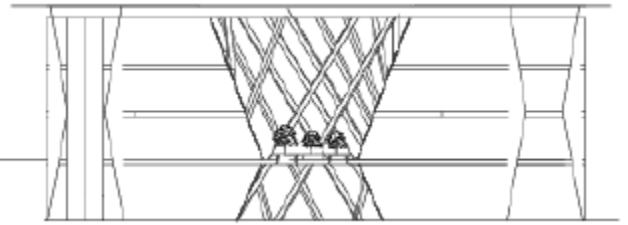






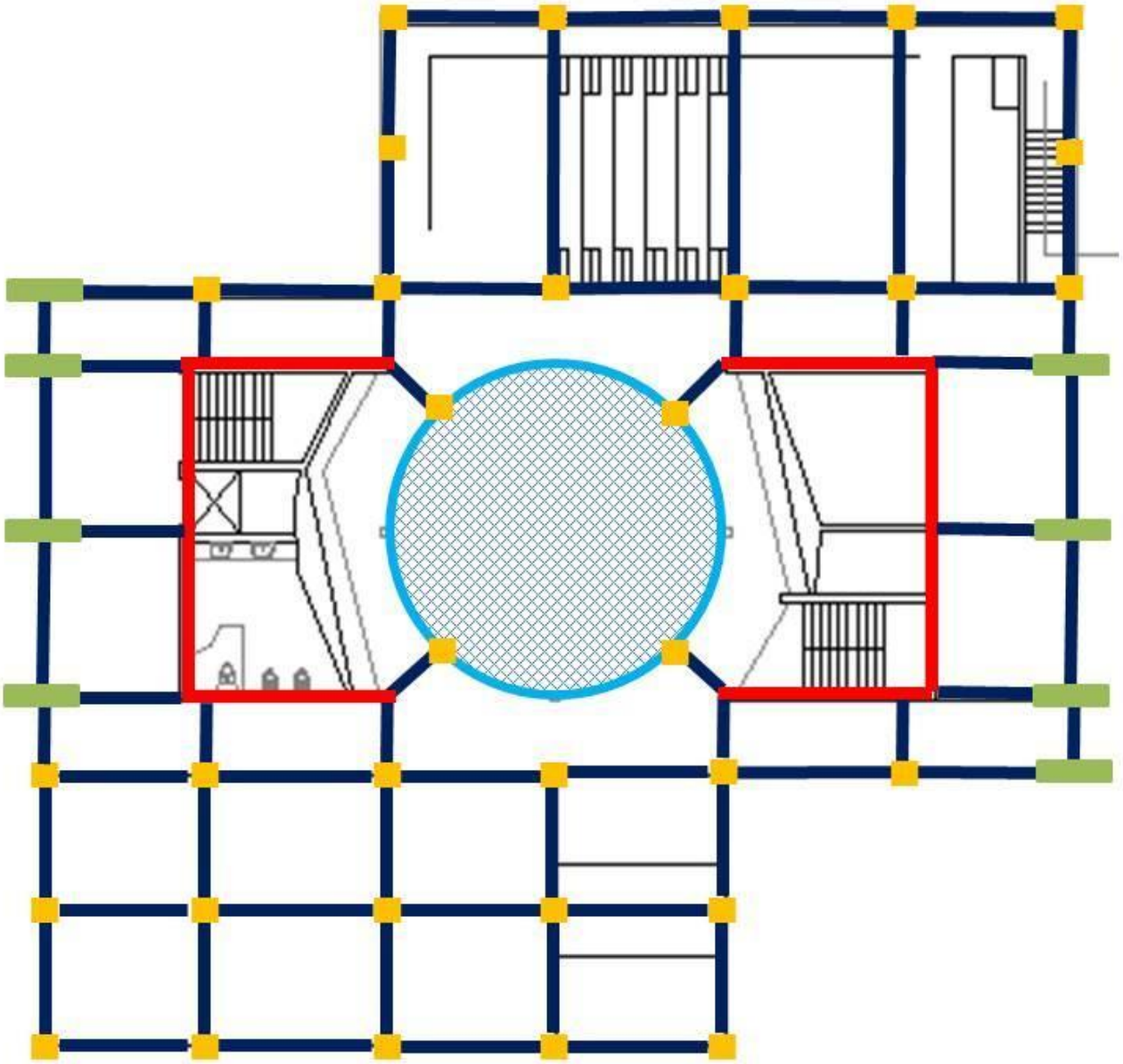






# Central: Level -1



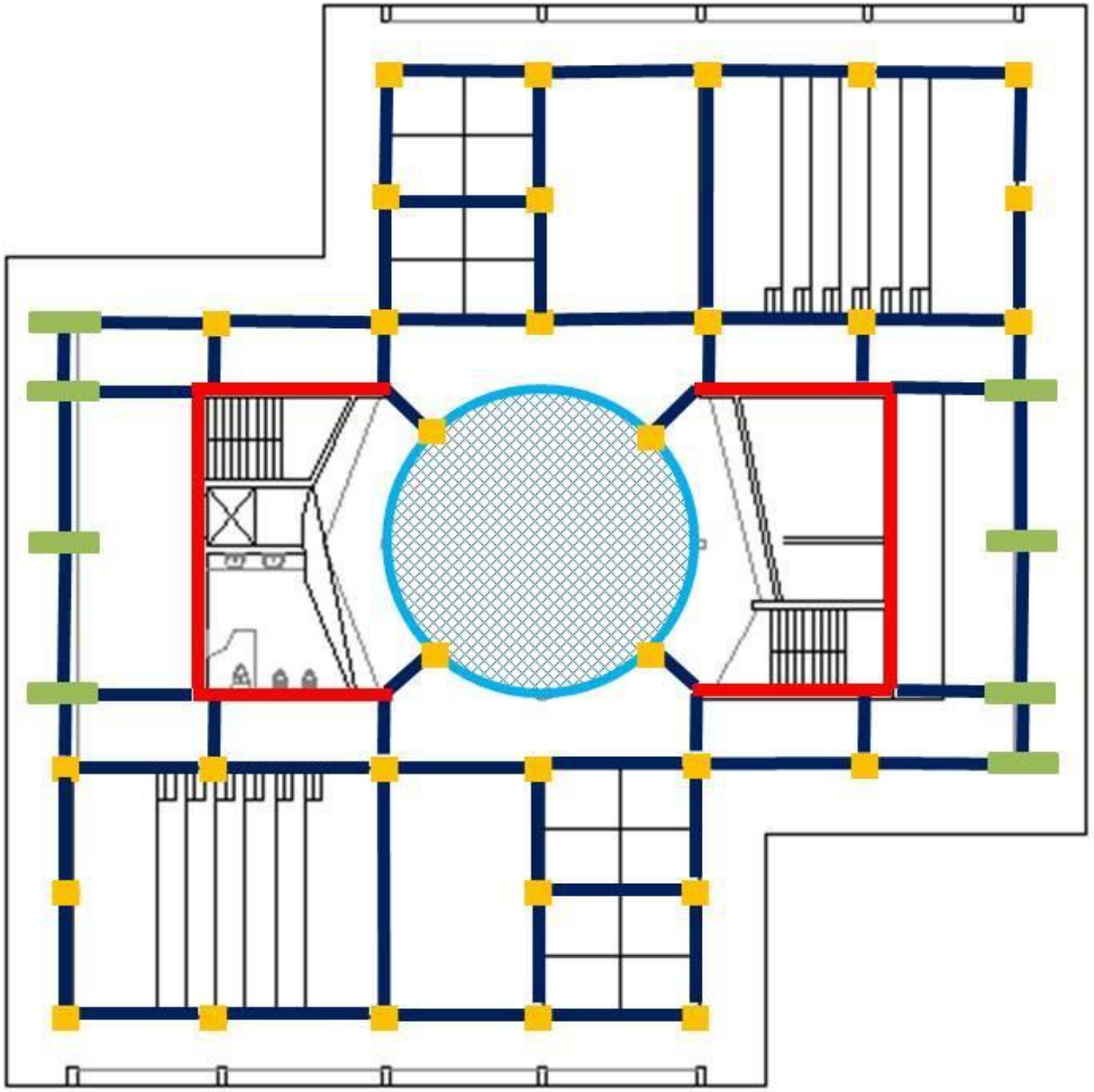


**ORANGE –**
1.5'x1.5' Columns
**GREEN –**
4'x1' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
Shear Walls
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# Central: Level 0



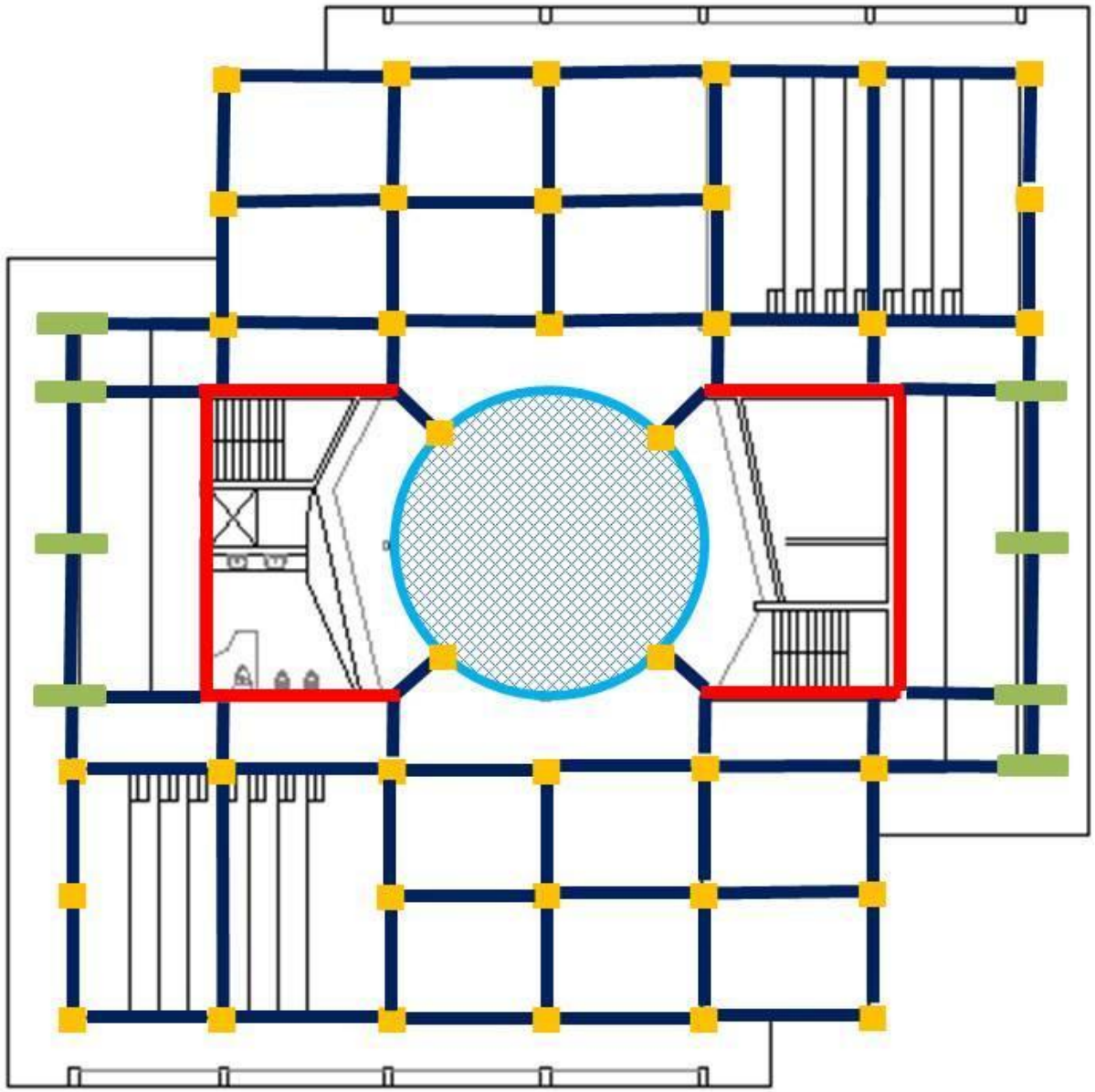


**ORANGE –**
1.5'x1.5' Columns
**GREEN –**
4'x1' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
Shear Walls
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# Central: Level 1



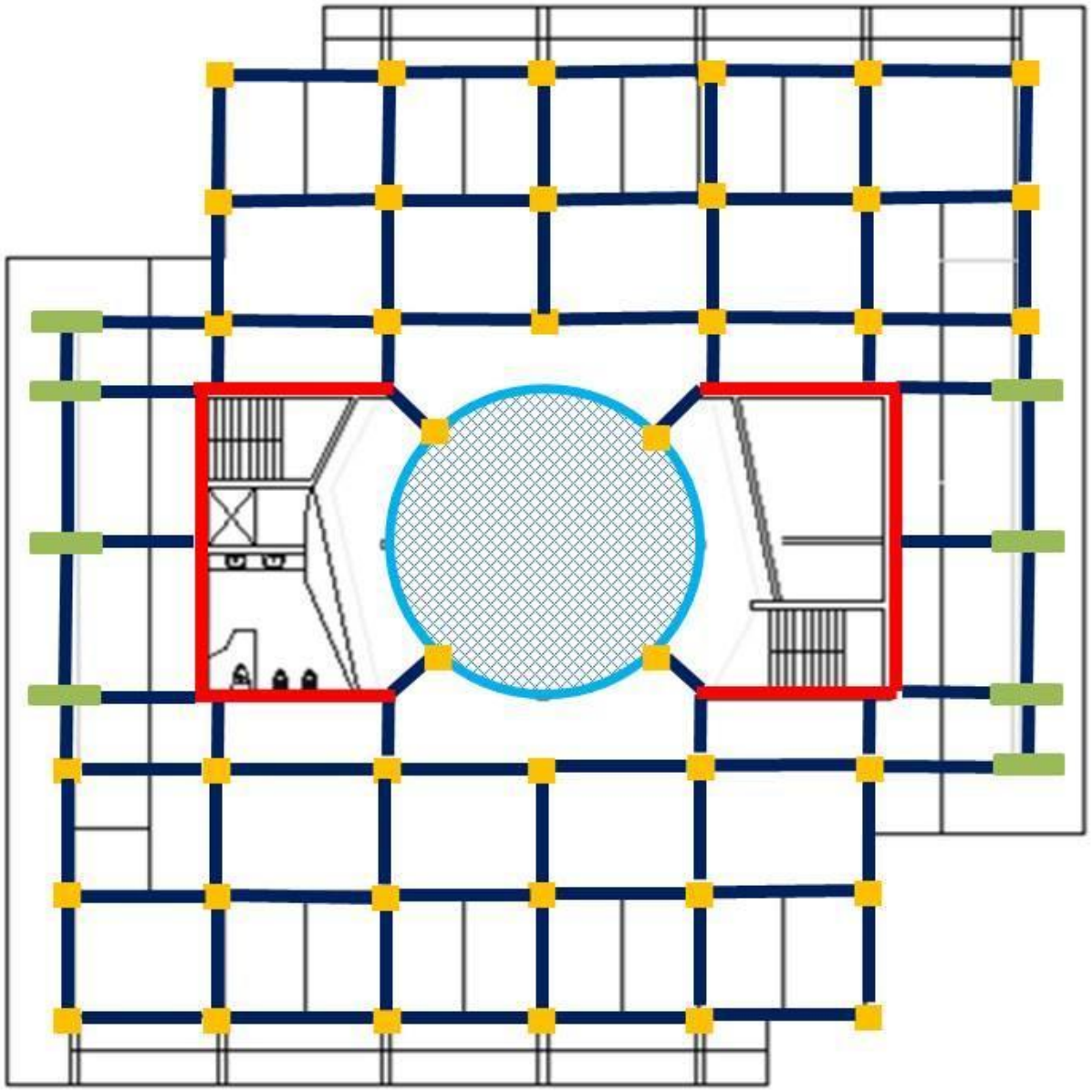


**ORANGE –**
1.5'x1.5' Columns
**GREEN –**
4'x1' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
Shear Walls
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# Central: Level 2 (Roof)



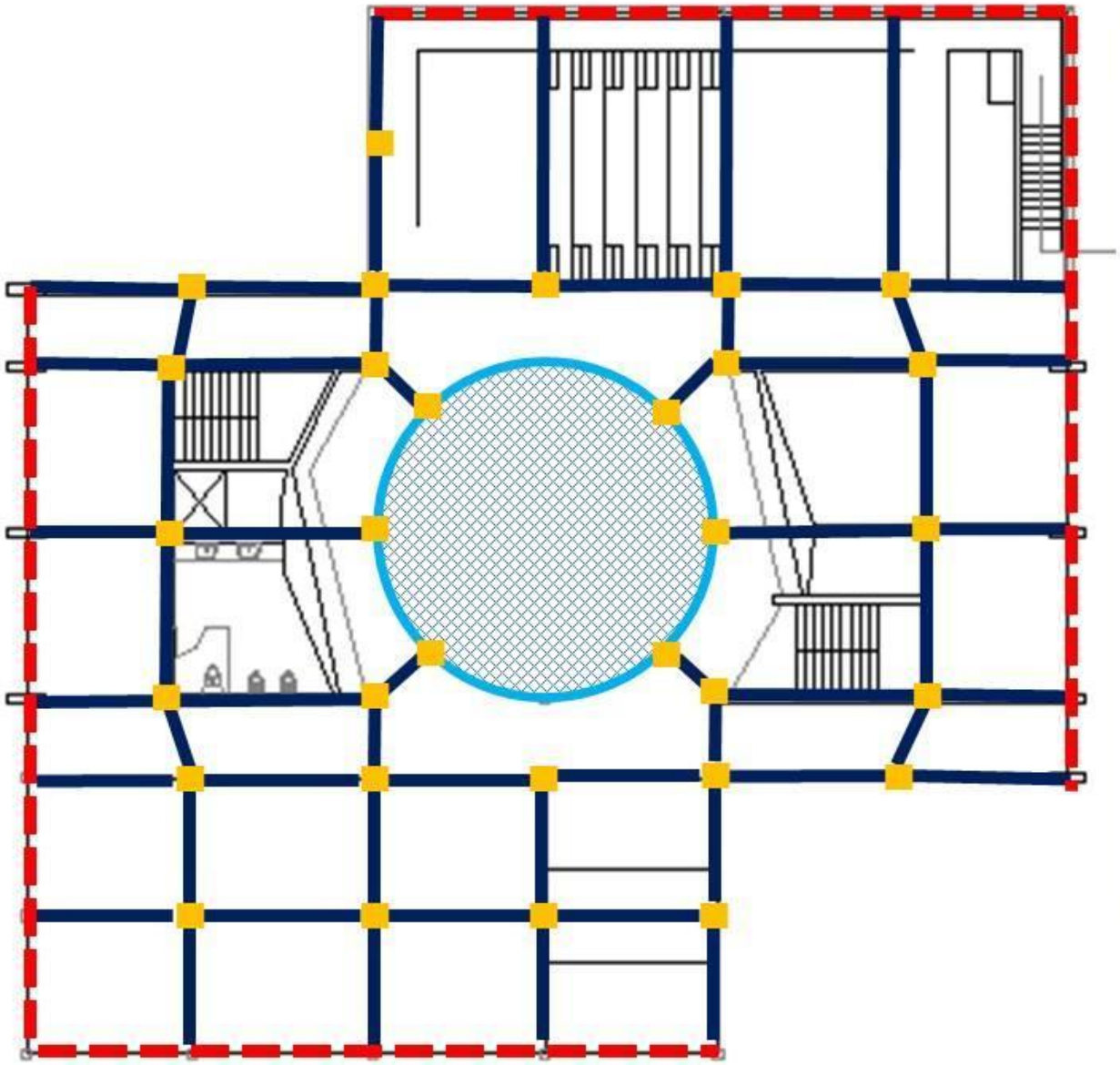


**ORANGE –**
1.5'x1.5' Columns
**GREEN –**
4'x1' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
Shear Walls
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# X-Lattice: Level -1



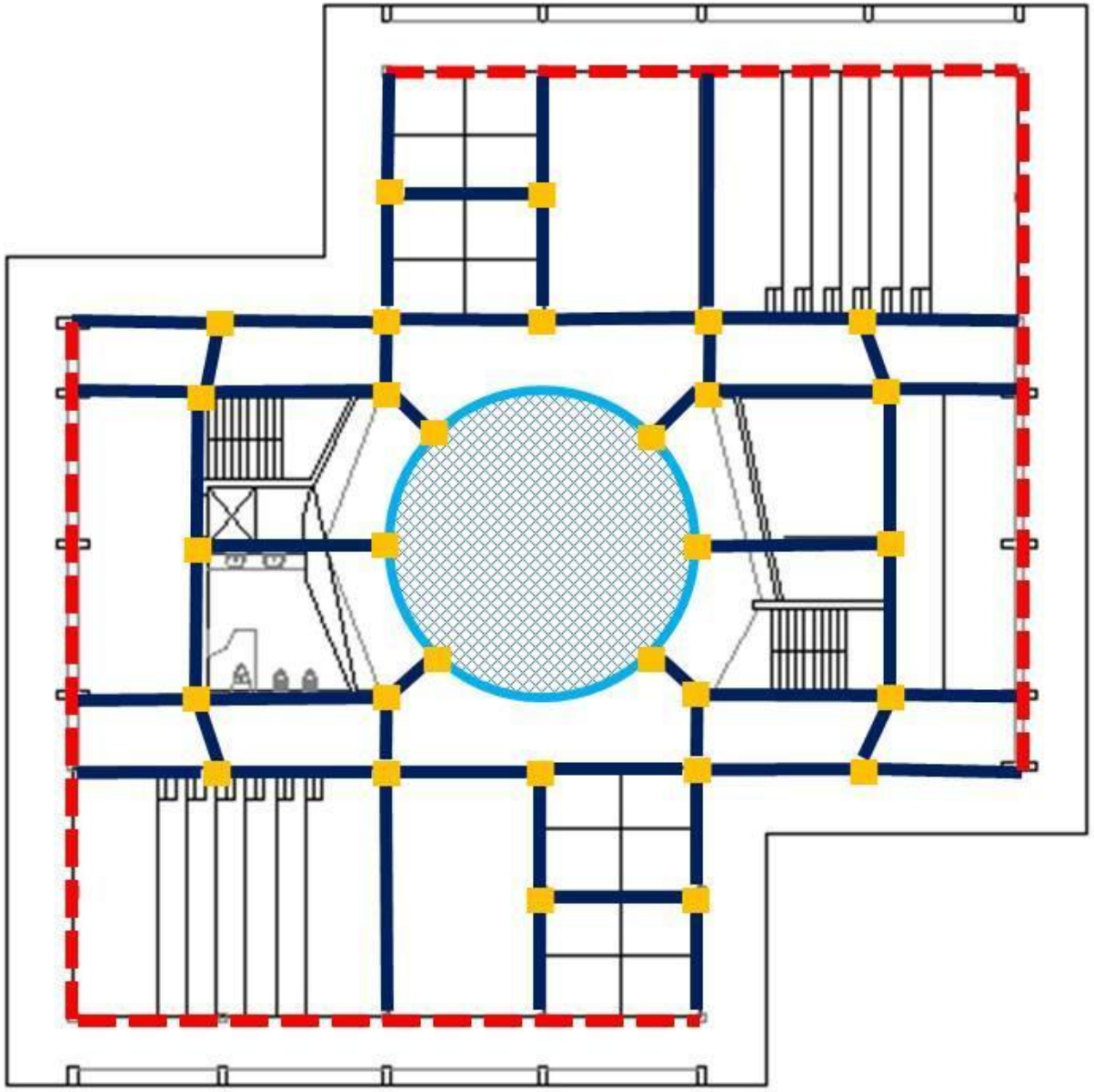


**ORANGE –**
1.5'x1.5' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
X-Lattice Wall
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# X-Lattice: Level 0



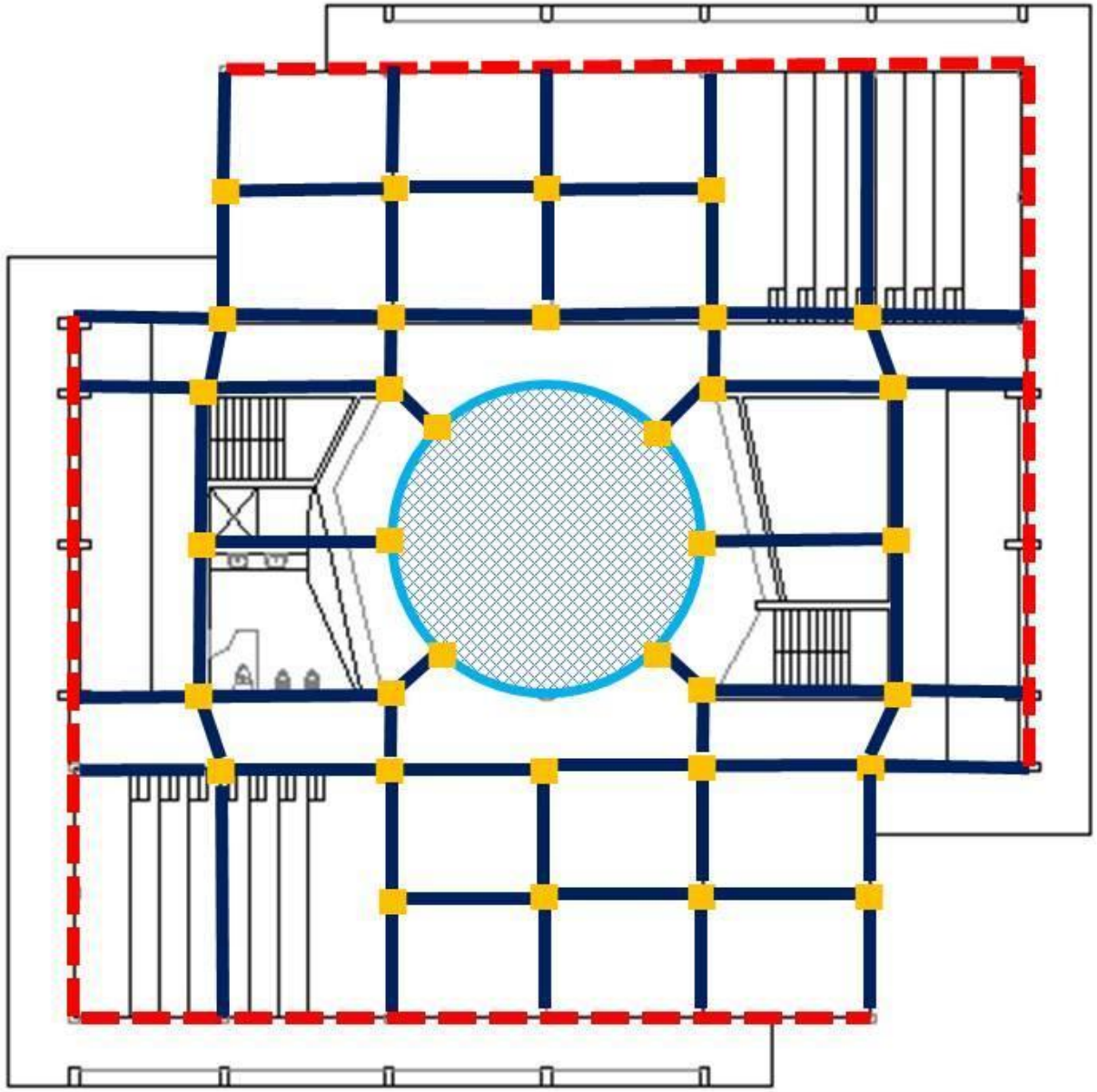


**ORANGE –**
1.5'x1.5' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
X-Lattice Wall
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# X-Lattice: Level 1



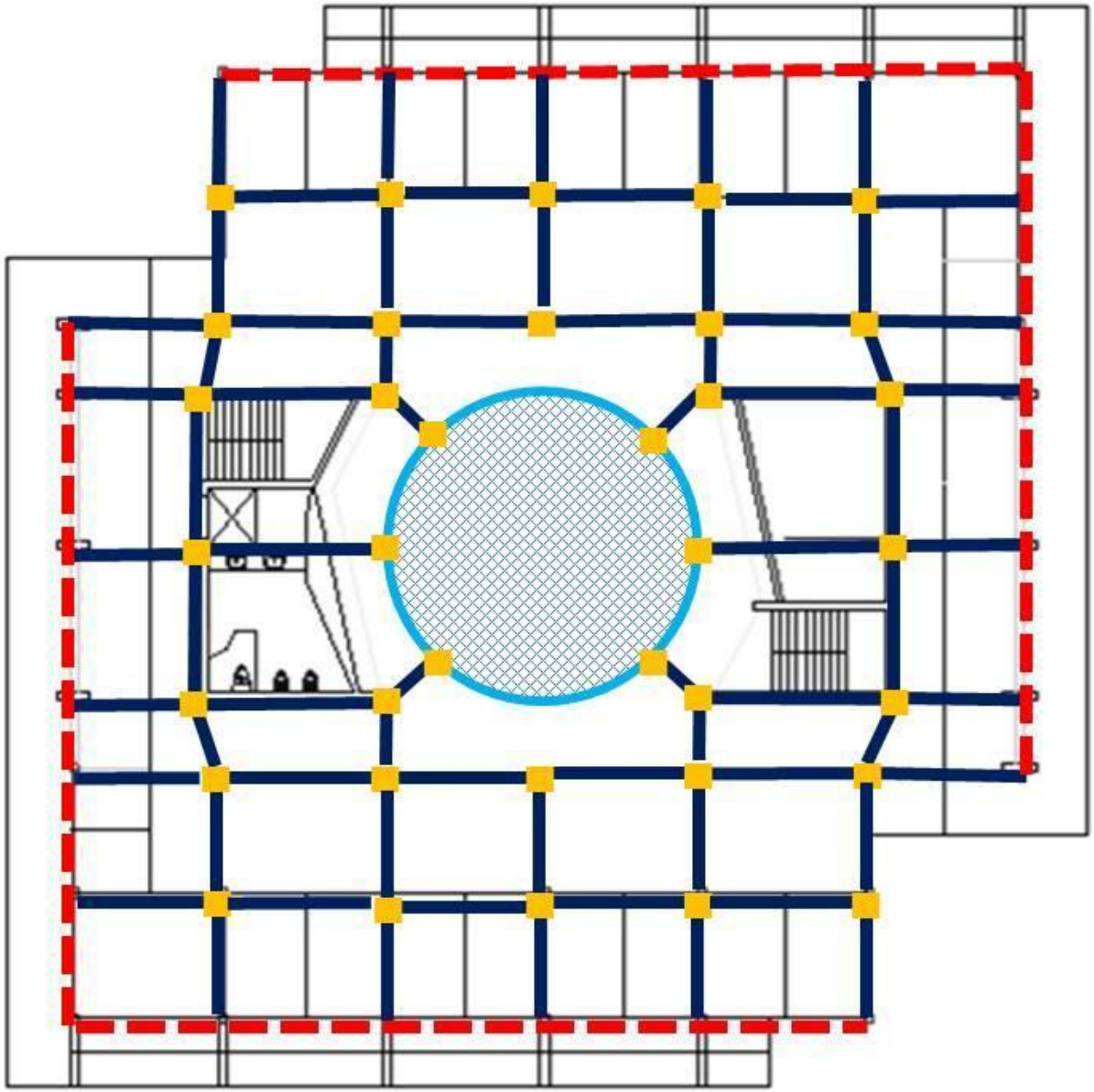


**ORANGE –**
1.5'x1.5' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
X-Lattice Wall
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

# X-Lattice: Level 2 (Roof)



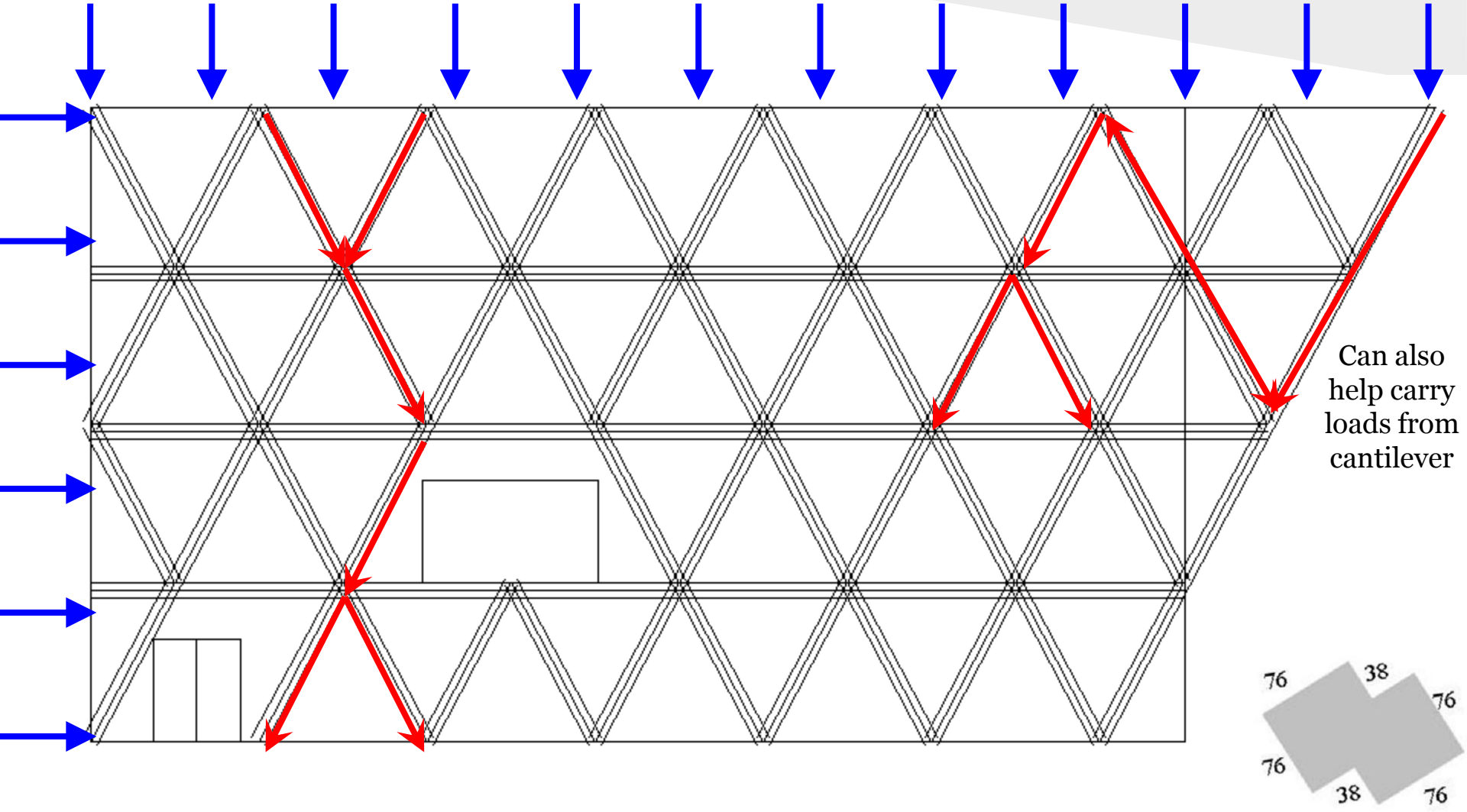


**ORANGE –**
1.5'x1.5' Columns
**NAVY –**
1.5' x2' Beams
**BLUE –**
Tension Ring
**RED –**
X-Lattice Wall
– Slab Openings

Floor Slab:
10" Reinforced Concrete Slab

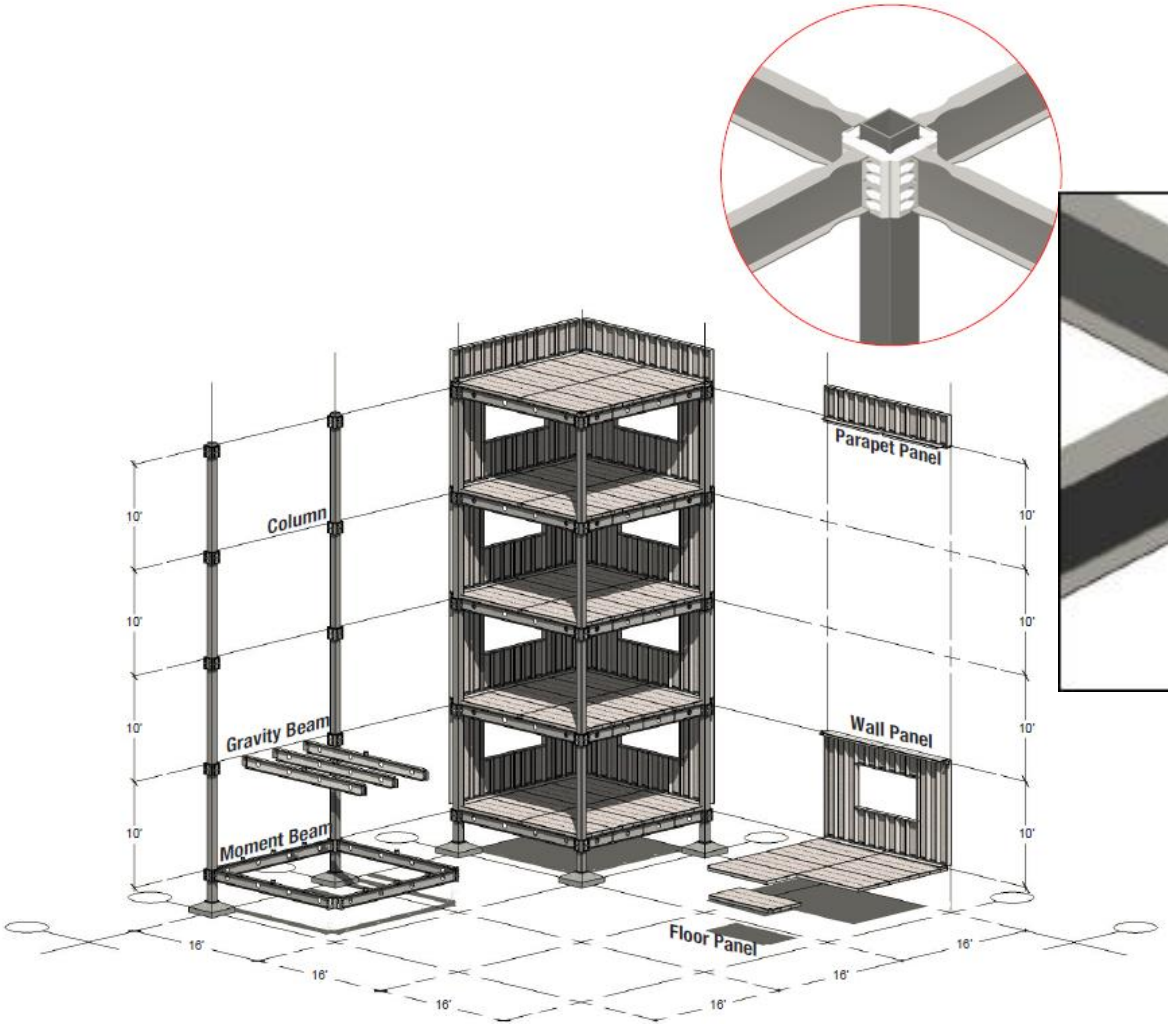
# X Lattice Wall

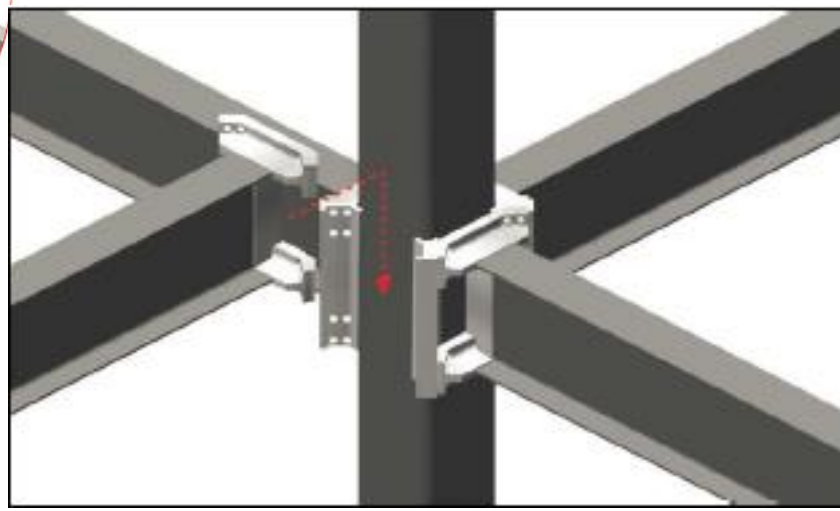




# ConXTech

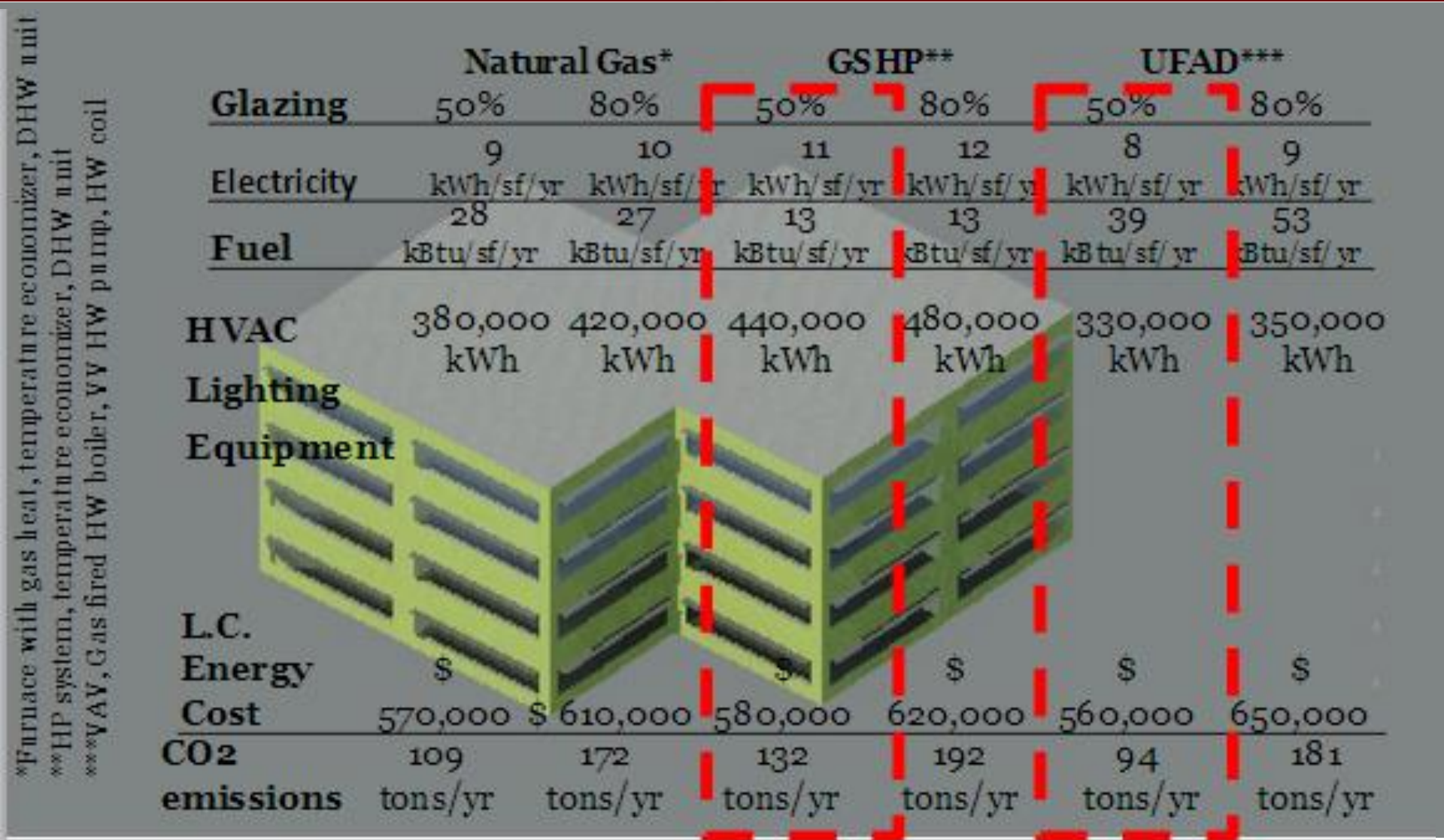
Architecture
Structure
MEP
**Construction**



# Vasari Analysis



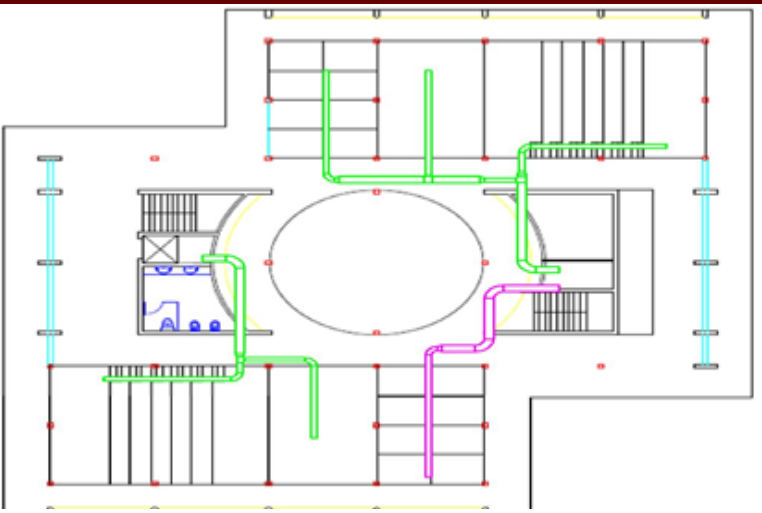


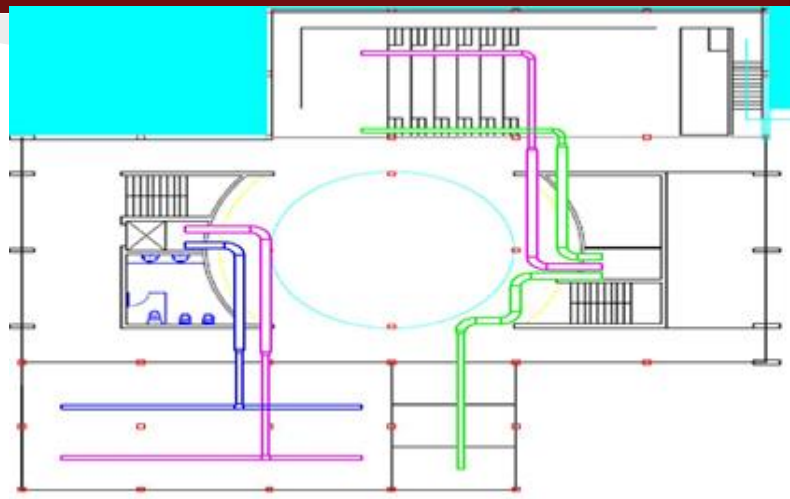
| | Natural Gas* | | GSHP** | | UFAD*** | |
|---|---|---|---|---|---|---|
| Glazing | 50% | 80% | 50% | 80% | 50% | 80% |
| Electricity | 9 kWh/sf/yr | 10 kWh/sf/yr | 11 kWh/sf/yr | 12 kWh/sf/yr | 8 kWh/sf/yr | 9 kWh/sf/yr |
| Fuel | 28 kBtu/sf/yr | 27 kBtu/sf/yr | 13 kBtu/sf/yr | 13 kBtu/sf/yr | 39 kBtu/sf/yr | 53 kBtu/sf/yr |
| HVAC | 380,000 kWh | 420,000 kWh | 440,000 kWh | 480,000 kWh | 330,000 kWh | 350,000 kWh |
| Lighting | | | | | | |
| Equipment | | | | | | |
| L.C. Energy Cost | $ 570,000 | $ 610,000 | $ 580,000 | $ 620,000 | $ 560,000 | $ 650,000 |
| CO2 emissions | 109 tons/yr | 172 tons/yr | 132 tons/yr | 192 tons/yr | 94 tons/yr | 181 tons/yr |

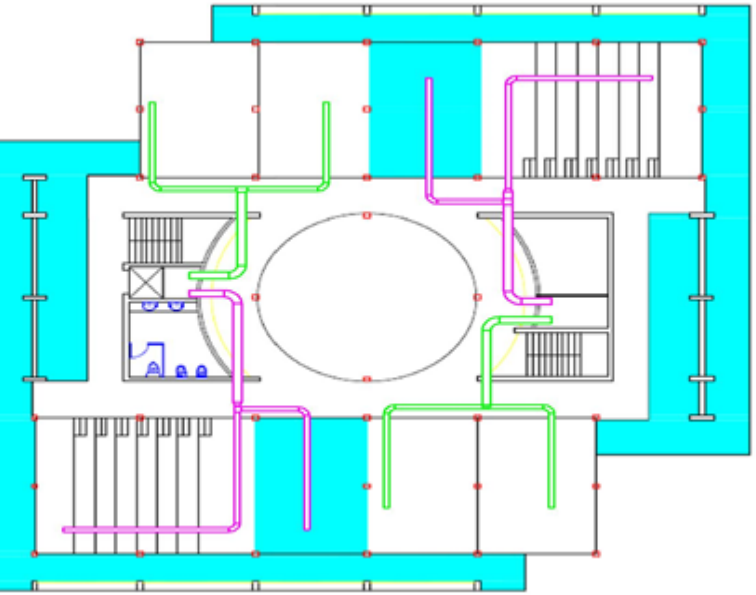
*Furnace with gas heat, temperature economizer, DHW unit
**HP system, temperature economizer, DHW unit
***VAV, Gas fired HW boiler, VV HW pump, HW coil

# Duct Network





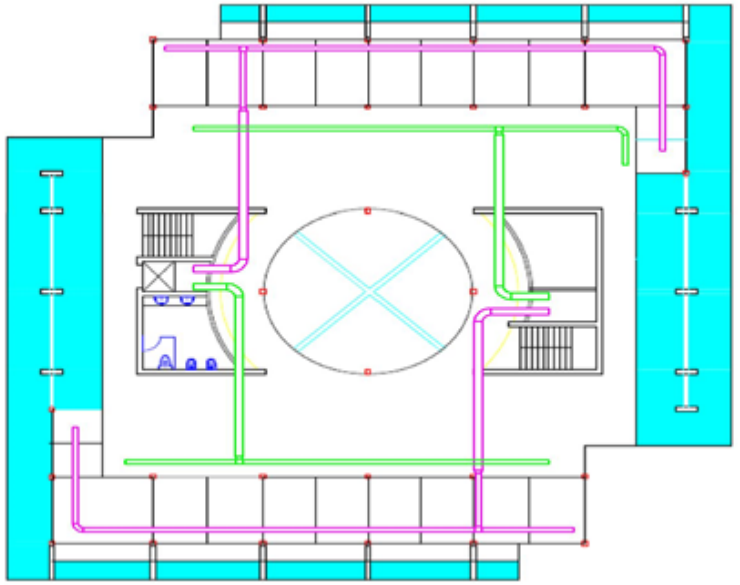




DV

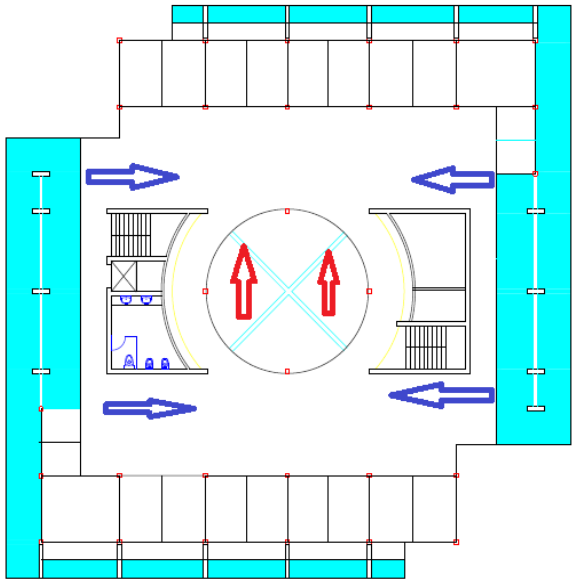
Return

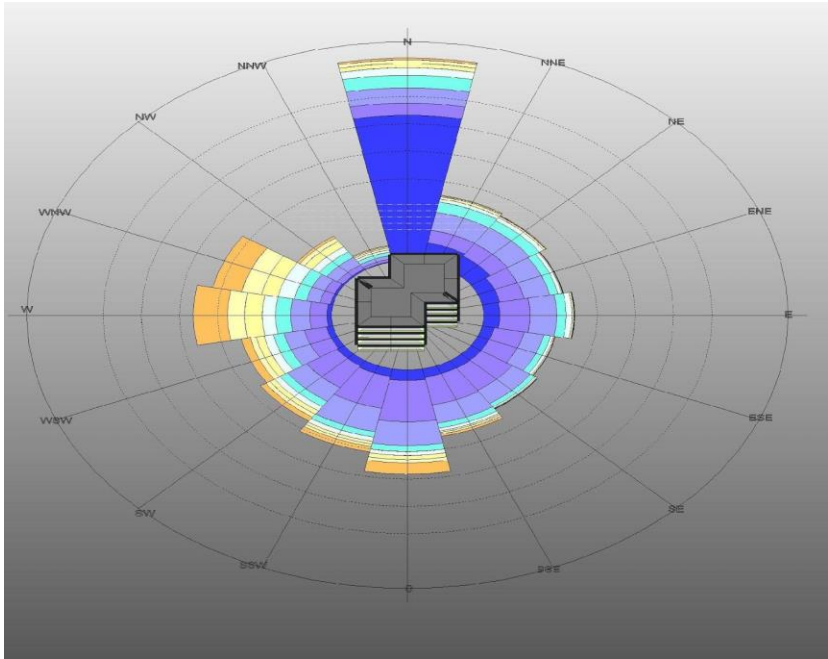
Overhead



# Natural Ventilation

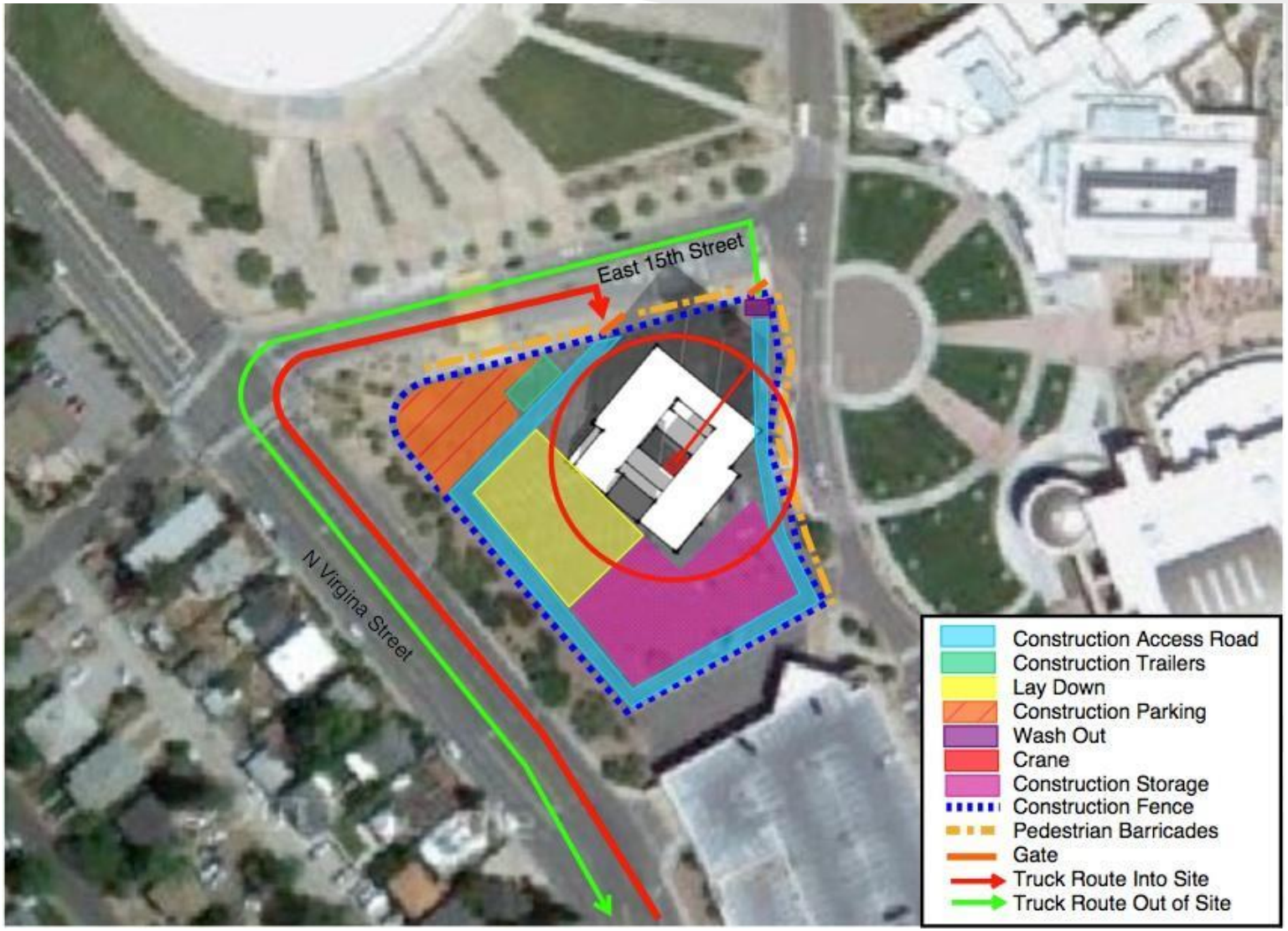







- Natural stack ventilation in corridor, atriums and perimeter
- Low energy fan during winter

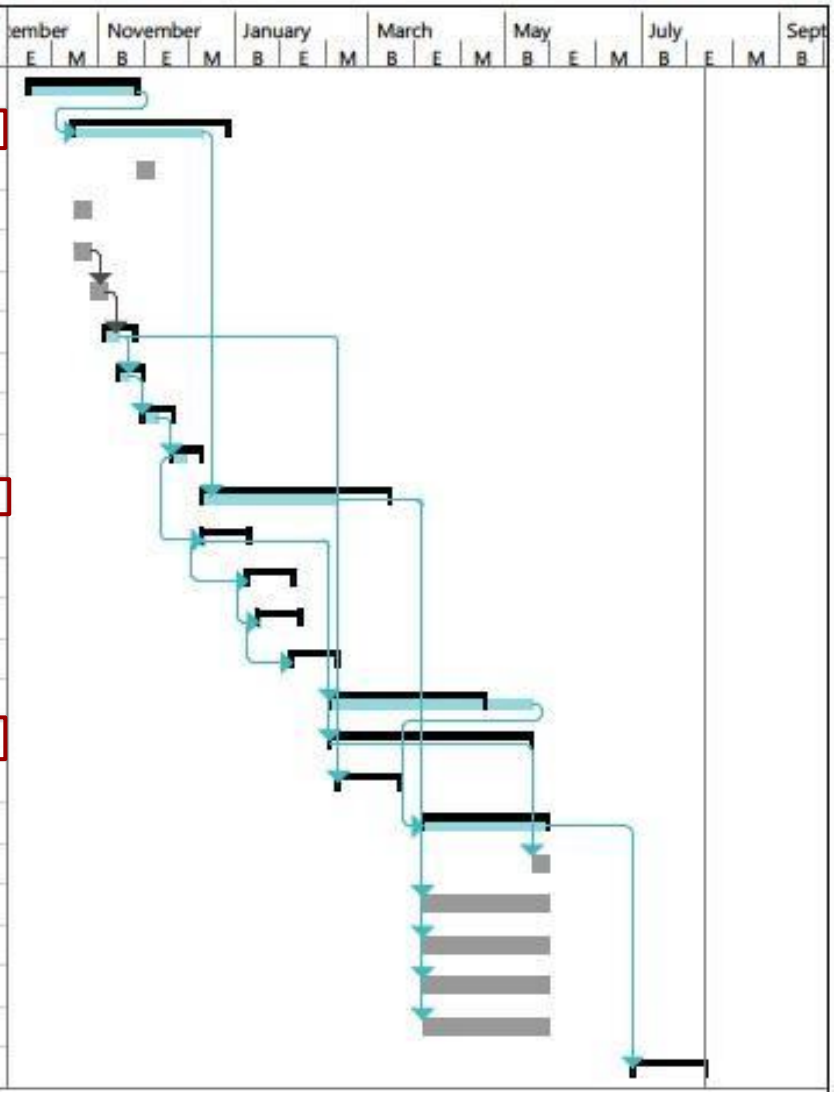
# Double Diamond Site Logistics



# Preliminary Schedule

Architecture
Structure
MEP
**Construction**

| Task Name | Duration | Start | Finish |
|---|---|---|---|
| **Sitework** | **35 days** | **Wed 9/30/15** | **Tue 11/17/15** |
| **Substructure** | **50 days** | **Tue 10/20/15** | **Mon 12/28/15** |
| Mat Slab | 5 days | Wed 11/18/15 | Tue 11/24/15 |
| Pile Caps | 5 days | Wed 10/21/15 | Tue 10/27/15 |
| Grade Beams | 5 days | Wed 10/21/15 | Tue 10/27/15 |
| Slab | 5 days | Wed 10/28/15 | Tue 11/3/15 |
| **Level -1** | **10 days** | **Tue 11/3/15** | **Mon 11/16/15** |
| **Level 0** | **10 days** | **Mon 11/9/15** | **Fri 11/20/15** |
| **Level 1** | **10 days** | **Fri 11/20/15** | **Thu 12/3/15** |
| **Level 2** | **10 days** | **Thu 12/3/15** | **Wed 12/16/15** |
| **Shell** | **60 days** | **Thu 12/17/15** | **Wed 3/9/16** |
| **Level -1** | **15 days** | **Thu 12/17/15** | **Wed 1/6/16** |
| **Level 0** | **15 days** | **Wed 1/6/16** | **Tue 1/26/16** |
| **Level 1** | **15 days** | **Mon 1/11/16** | **Fri 1/29/16** |
| **Level 2** | **15 days** | **Tue 1/26/16** | **Mon 2/15/16** |
| **Interiors** | **50 days** | **Fri 2/12/16** | **Thu 4/21/16** |
| **Interior Construction** | **65 days** | **Fri 2/12/16** | **Thu 5/12/16** |
| **Stairs** | **20 days** | **Tue 2/16/16** | **Mon 3/14/16** |
| **Services** | **40 days** | **Fri 3/25/16** | **Thu 5/19/16** |
| Elevator | 5 days | Fri 5/13/16 | Thu 5/19/16 |
| Plumbing | 40 days | Fri 3/25/16 | Thu 5/19/16 |
| HVAC | 40 days | Fri 3/25/16 | Thu 5/19/16 |
| Fire Protection | 40 days | Fri 3/25/16 | Thu 5/19/16 |
| Electrical | 40 days | Fri 3/25/16 | Thu 5/19/16 |
| **Site Improvements** | **25 days** | **Mon 6/27/16** | **Fri 7/29/16** |



# Cost Estimate

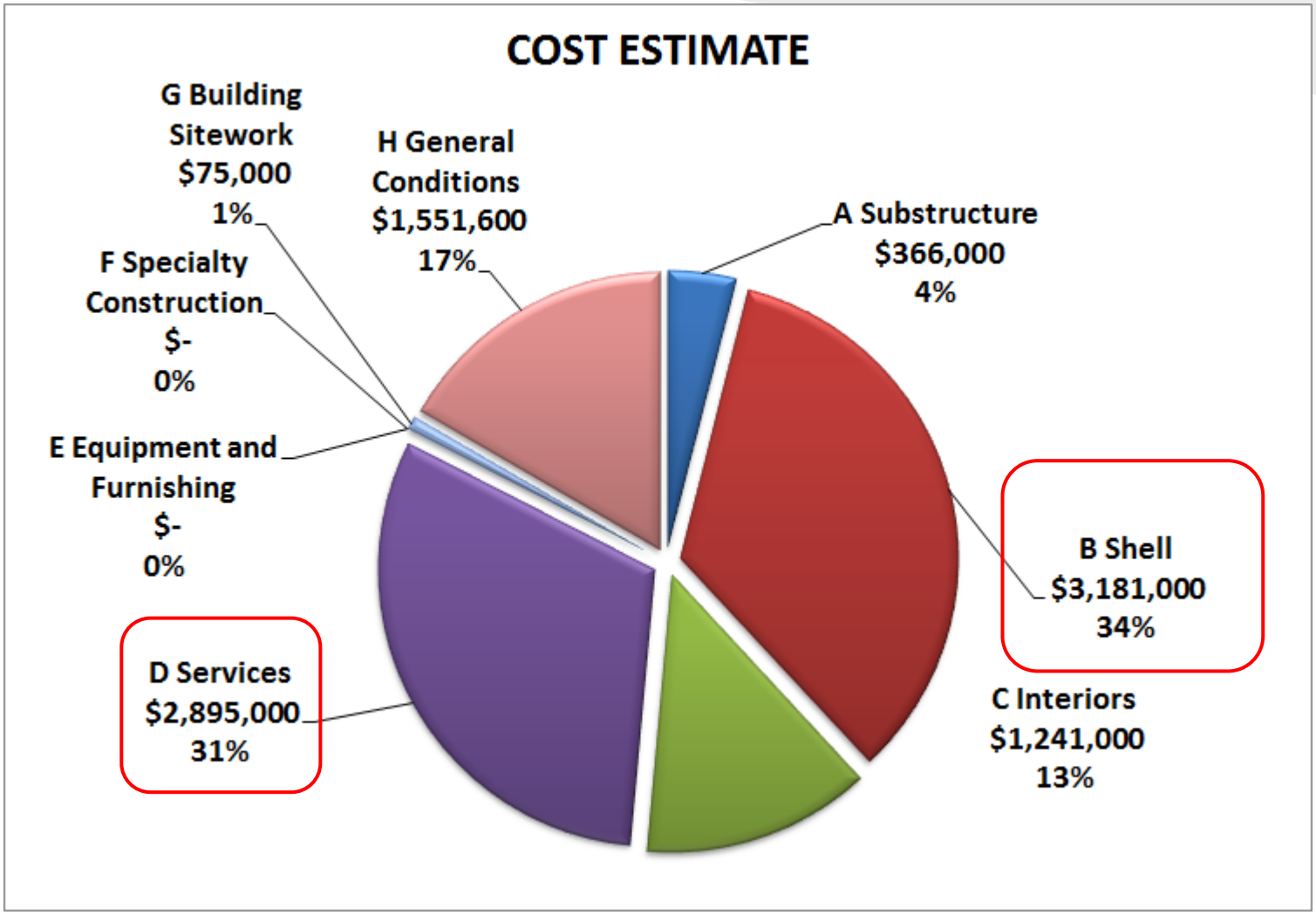


| Concept | **Estimate** | **Difference From Target** |
|---|---|---|
| D-Concrete | **$ 8,744,400** | **$ (444,400)** |
| D-Steel | **$ 9,309,600** | **$ (1,009,600)** |

Pricier than L due to larger Floor and Facade SF

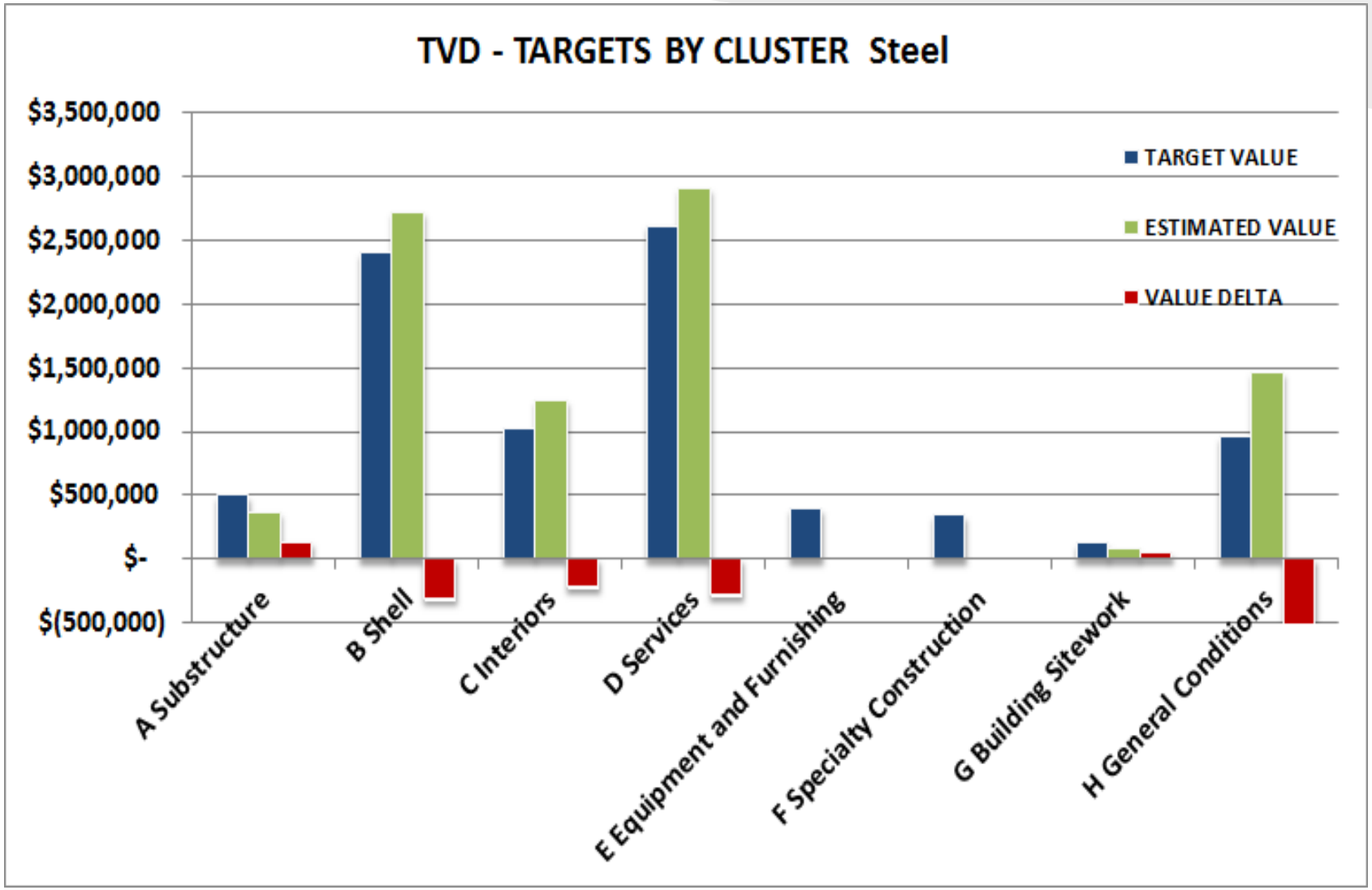
# Cost distribution

Architecture
Structure
MEP
**Construction**



# TVD - Concrete

Architecture
Structure
MEP
**Construction**



# Leapfrog Sustainability & Whole Life Cost Challenges

DPR CONSTRUCTION

SWINERTON BUILDERS

# Innovation in Concrete

Architecture
**Structure**
MEP
Construction

Use of translucent concrete to allow light in restrooms while maintaining structural integrity of shear walls
(L-shape Concrete option)

theguardian

News | US | World | Sports | Comment | Culture | Business | Environr

Environment › Carbon emissions

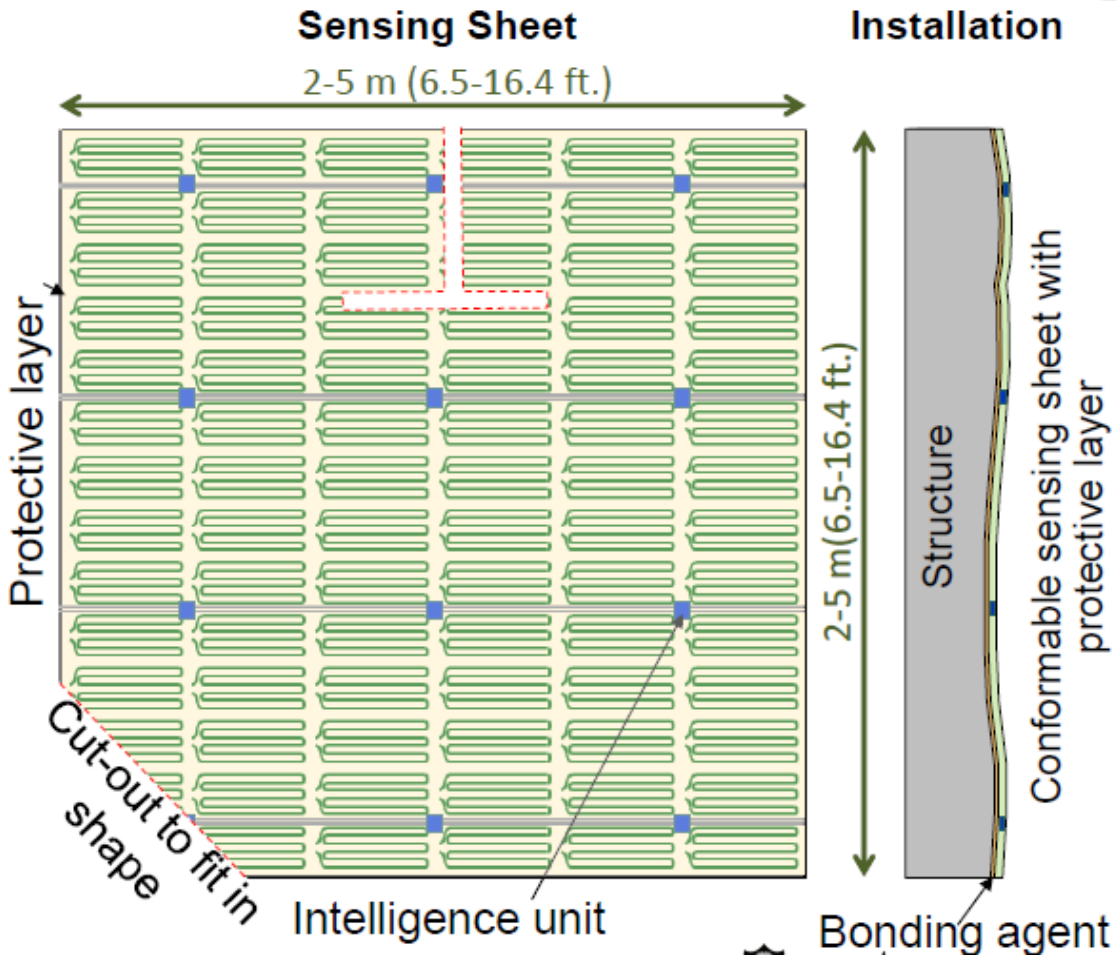
## Revealed: The cement that eats carbon dioxide

**Alok Jha**, green technology correspondent
guardian.co.uk, Wednesday 31 December 2008 09.59 EST
Jump to comments (36)

Cement works in Clitheroe, Lancashire. Cement accounts for 5% of the world's CO2

# Structural Health Monitoring






A nervous system for the building, with sensors detecting anomalous strains

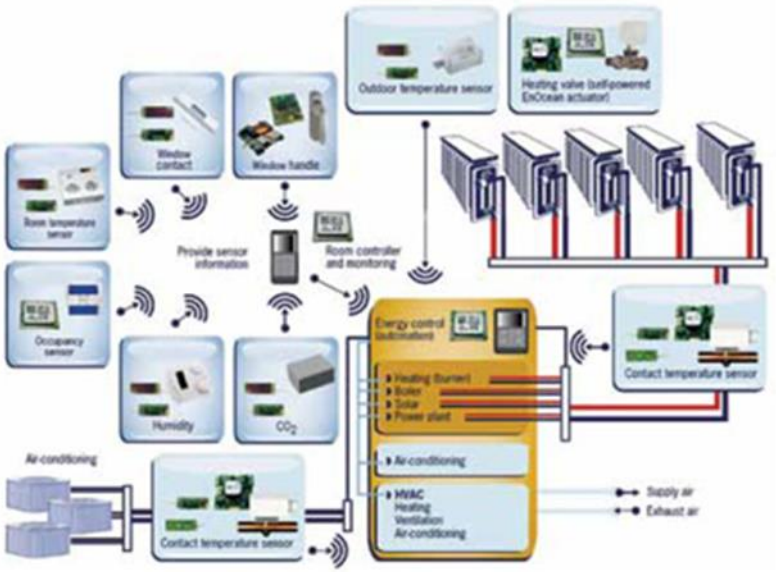

High initial cost --> lower OM cost, better safety, especially after EQ event

Cost: ~$40/ft²

# Smart Operation



- Room controllers with batteryless sensors
- Control of HVAC and lighting




- Thermostats
- Window contacts
- Humidity sensors
- Occupancy sensors
- CO2 sensors

# Building Integrated PV 30kW



Mounted On : Roof 30°
Area : 2700 sf
Annual Energy Yield : 51,7 MWh/year
Gross Evaluation: 240,000 $

Mounted On : Atrium 30°
Area : 5400 sf
Annual Energy Yield : 51,7 MWh/year
Gross Evaluation: 290,000 $

Mounted On : Façade 30°
Area : 2700 sf
Annual Energy Yield : 51,7 MWh/year
Gross Evaluation: 260,000 $

Mounted On : BIPV
Area : 2700 sf
Annual Energy Yield : 33,4 MWh/year
Gross Evaluation: 250,000 $

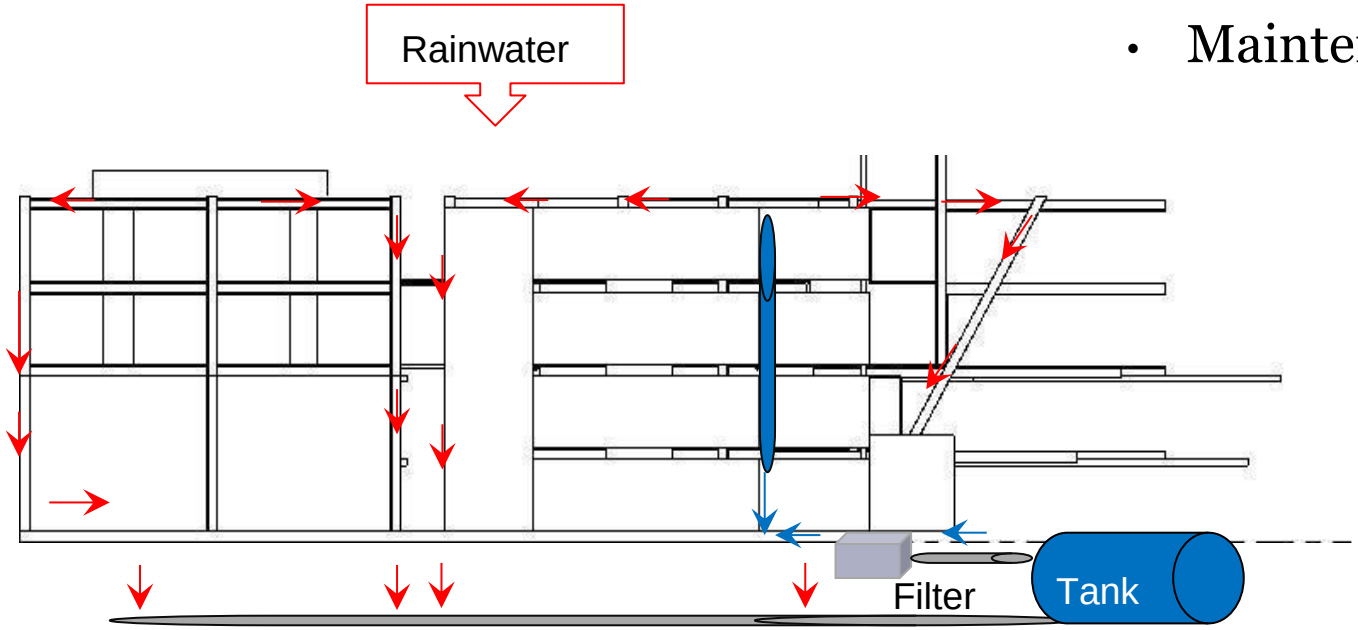
# Rainwater Harvesting



- 36000 gal /year rainwater
- Snow melting
- Drain groundwater

Use for:

- Toilet flushing
- Plants irrigation
- Maintenance/cleaning

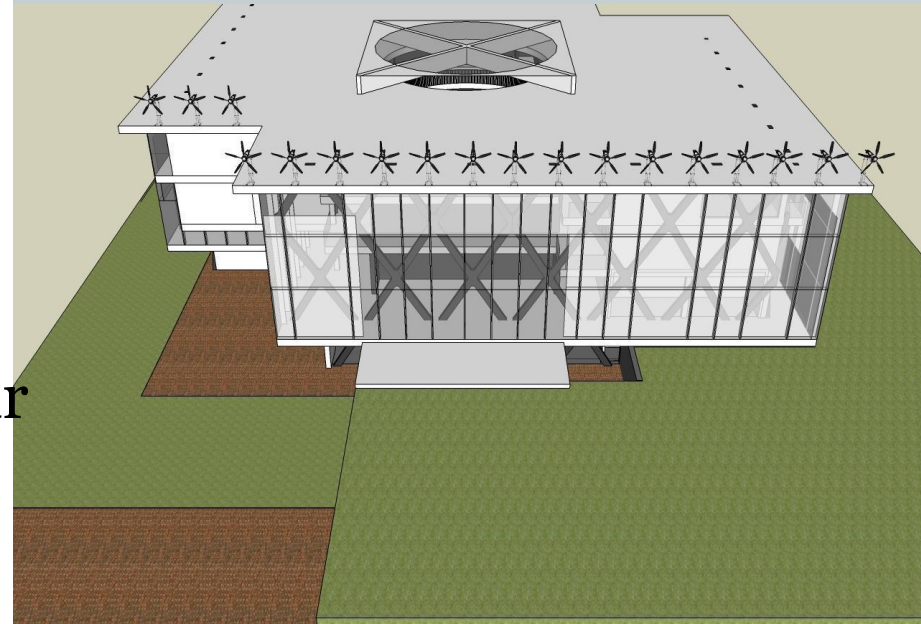


# Building Integrated W/T 18kW



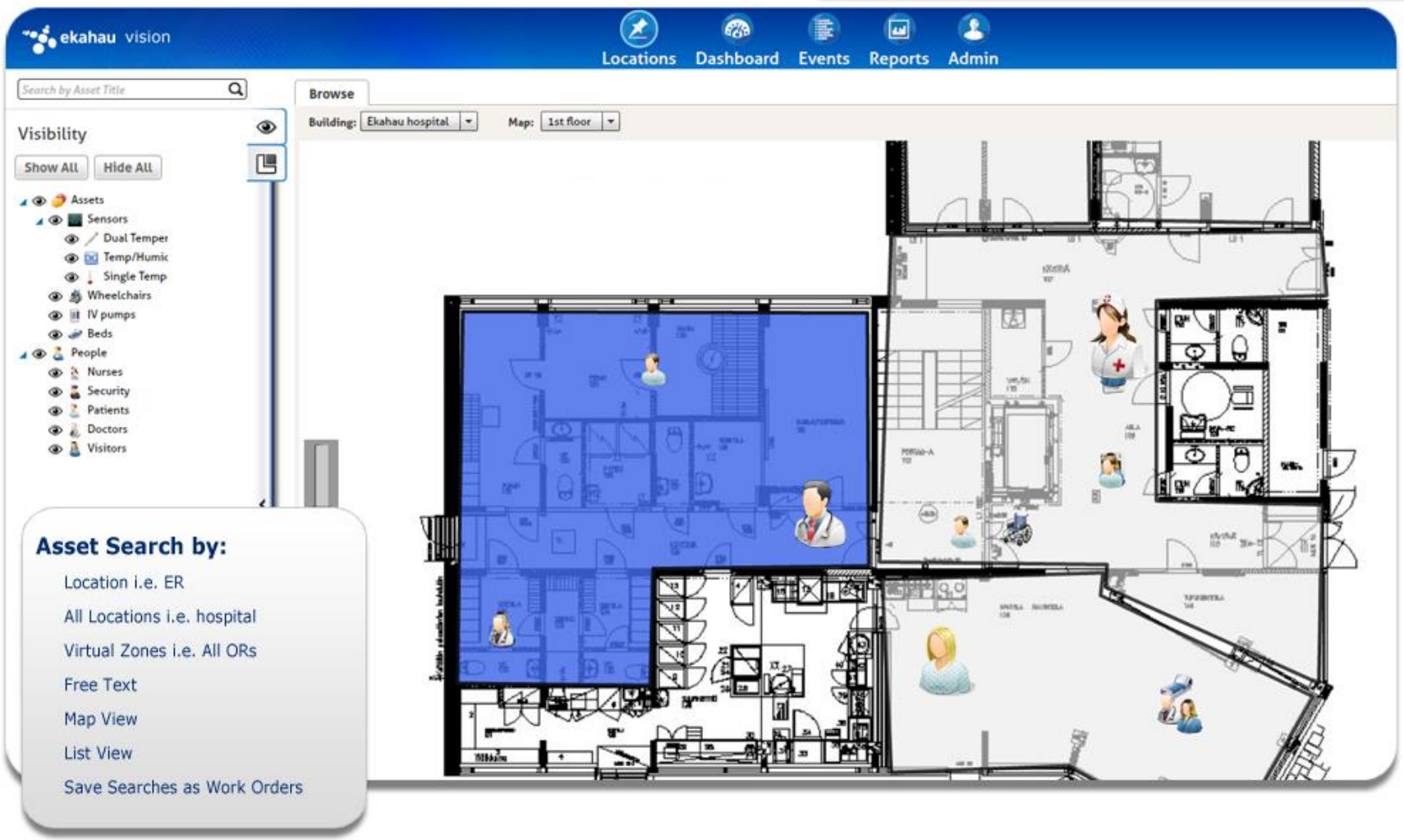
- Operate at low wind speed ~5 mph and up to 120 mph
- Take advantage of ‘chimney effect’
- Low Noise levels


- 18 W/T Mounted On Roof
- Energy produced: 19.4 MWh/year
- Gross evaluation: 130,000 $
- Electricity Produced: 17,500 $/year



# Real Time Positioning

Architecture
Structure
MEP
**Construction**

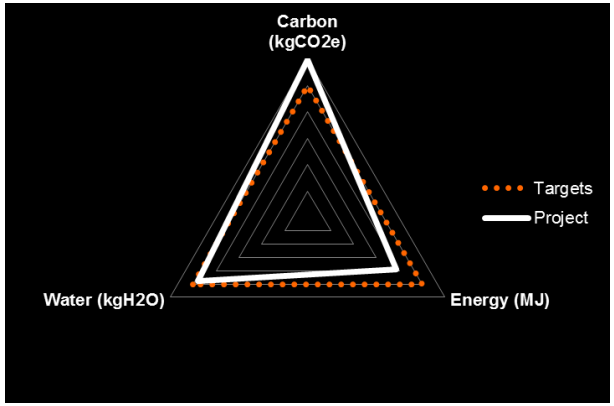



http://www.ekahau.com/products/real-time-location-system/vision.html

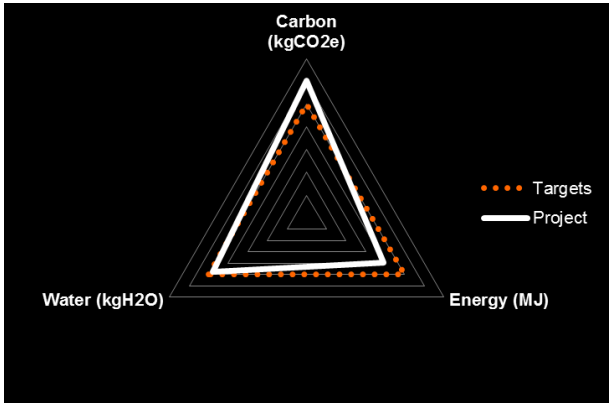
# Sustainable Target Value

Architecture
**Structure**
**MEP**
**Construction**

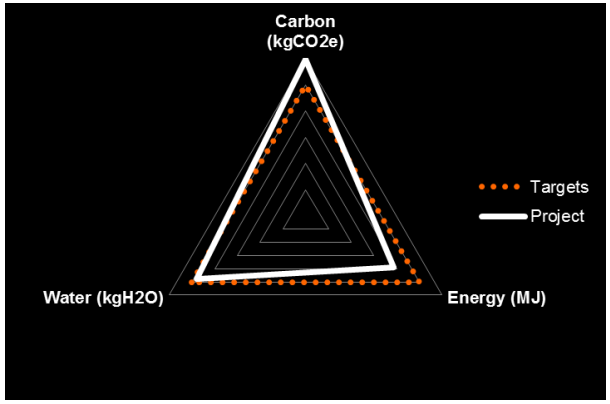
## L-Concrete



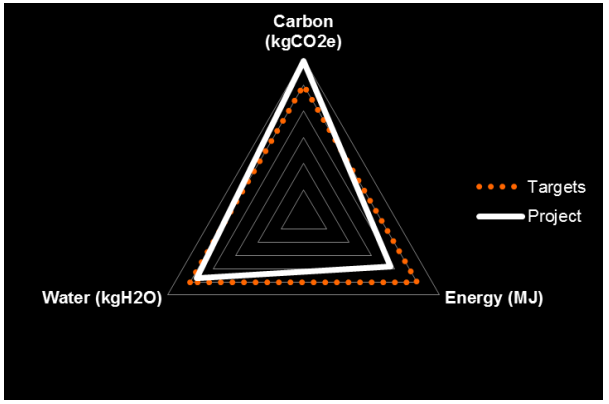

## DD-Central




## L-Steel




## DD-X

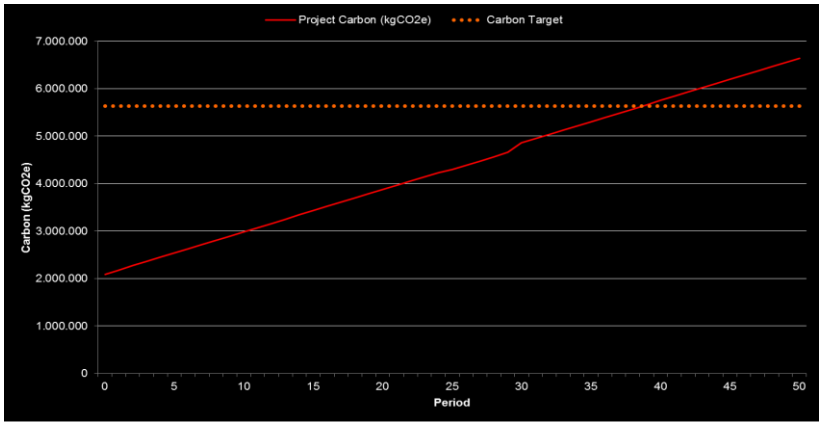


# Sustainable Target Value

Architecture
Structure
**MEP**
Construction

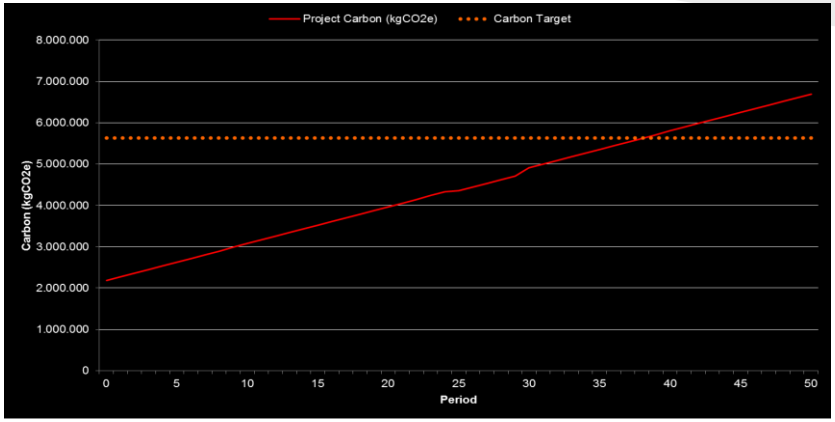
## L-Concrete

*1.013 mtCO2e $31,000



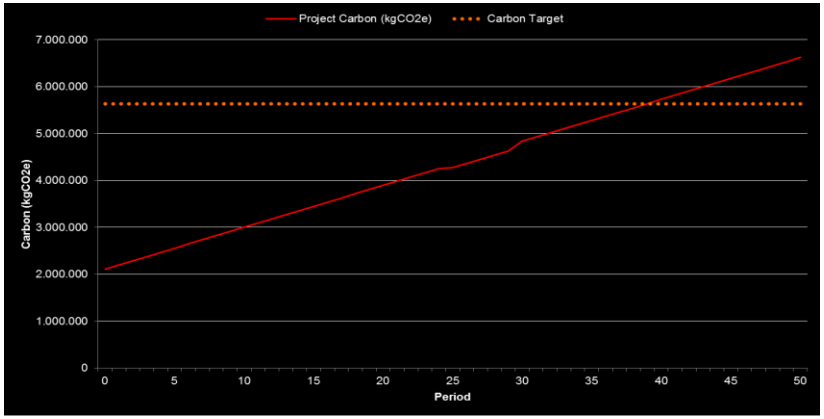

## DD-Cylinder

*1065 mtCO2e $32,000



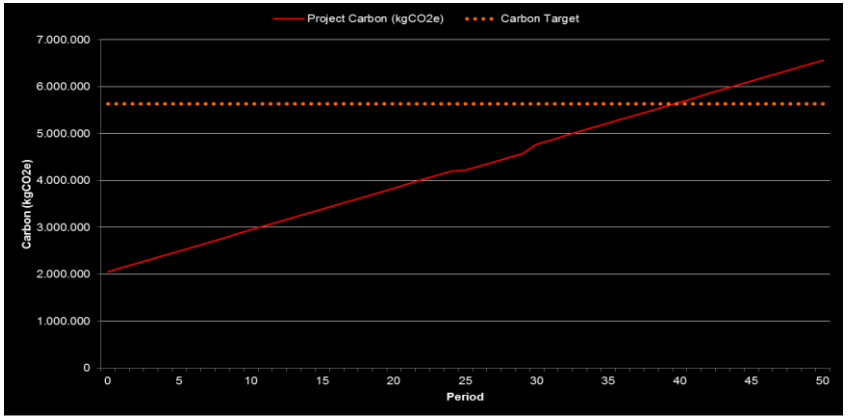

## L-Steel

*993 mtCO2e $30,000




## DD-X

*934 mtCO2e $28,000



# Sustainability Goals & LEED

Architecture
Structure
MEP
Construction

Kickoff
-shoot for "net zero" energy
-don't design explicitly for the LEED checklist

Winter Quarter
- Incorporation of passive solar heating & lighting
- Decision to use rainwater harvesting and PV
- Exploration of GSHP & wind turbines


Looking Ahead to Spring Quarter
- Evaluation of design under LEED+ criteria
- Continue to design for sustainability, including Energy & Atmosphere, Indoor Environmental Quality, etc.

# Decision Process

# Decision Matrix

Architecture
Structure
MEP
Construction

0. Decision Matrix Framework provided by LCFM consultants

2. Owners choose weight distribution

1. Team & owners add/modify criteria such as:
- cost
- sustainability
- constructability
- flexibility
- innovation
- efficiency
- concept clarity

3. Team rates concepts

4. Scores are calculated

**Decision Matrix**

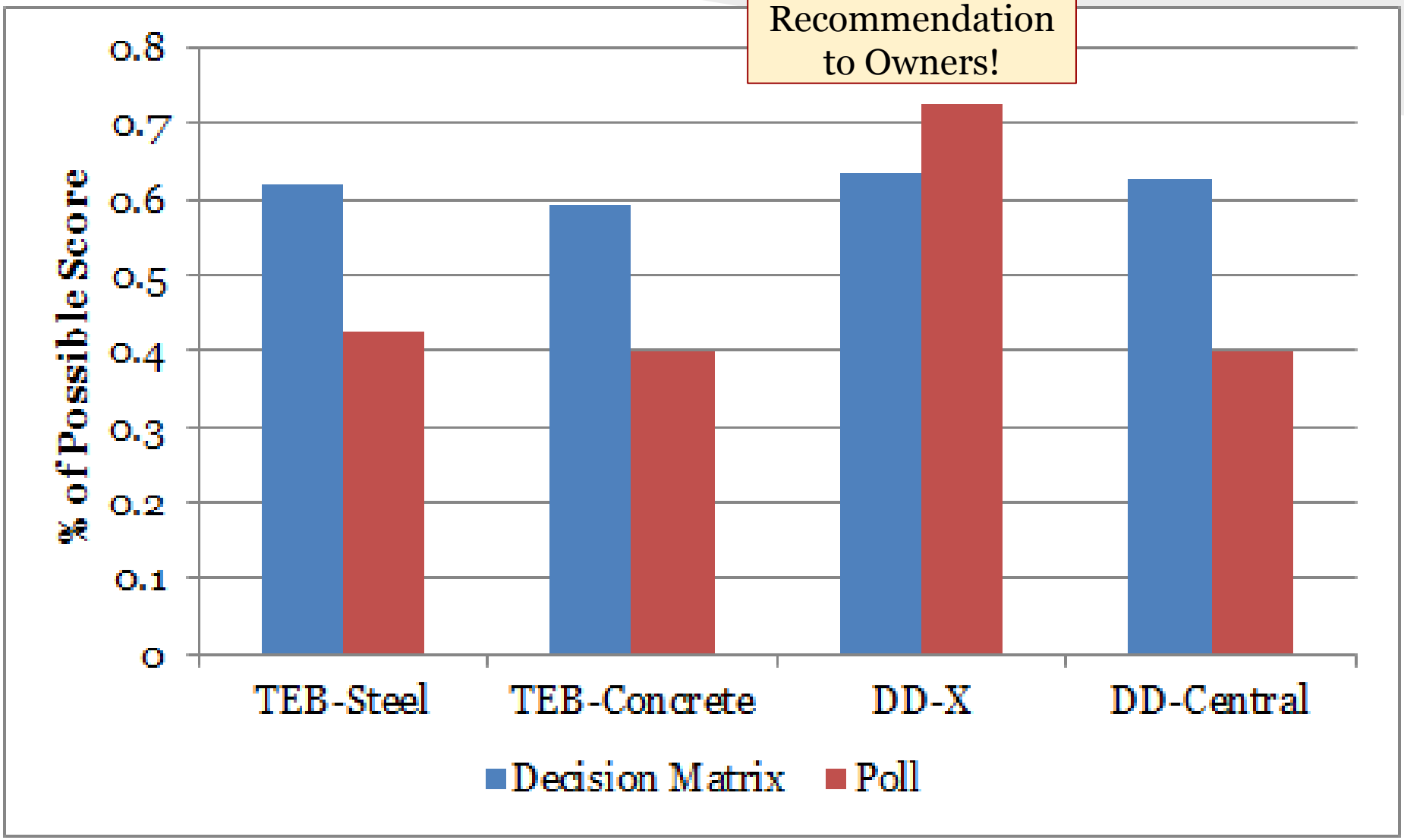
| Subcriteria | Description | Weighting [100 Points available] | DD-Cylinder [Scale from 1 to 5] | DD-X | L-Shape- | L-Shape- |
|---|---|---|---|---|---|---|
| **Economical** | | 31.7 | 115.0 | 102.7 | 109.3 | 90.0 |
| Construction Costs | Calculation of the construction costs by RSMeans. | 7.7 | 4.0 | 4.0 | 3.0 | 3.0 |
| Operation & Maintenance Costs | administration as well as there for maintenance and replacements (scenario: inspection after an earthquake). | 7.3 | 3.0 | 3.0 | 4.0 | 4.0 |
| NEA/GEA | The ratio of net external area to gross external area to determine the space efficiency. | 4.3 | 3.0 | 3.0 | 3.0 | 3.0 |
| Construction Time | Required construction time according to the work schedules of the different alternatives. | 7.0 | 4.0 | 3.0 | 4.0 | 2.0 |
| ~~Income~~ | ~~Additional income~~ | 0.0 | | | | |
| Constructability | How the building will be built and what techniques will be used (complexity associated with the production of the property). | 5.3 | 4.0 | 3.0 | 3.0 | 2.0 |
| **(SIA)** | | 22.7 | 58.7 | 58.7 | 64.3 | 69.7 |
| CO2-Emissions | CO2-Emission in tons per year. | 5.3 | 2.0 | 2.0 | 3.0 | 4.0 |
| Renewable Energy | Usage of renewable energy (e.g. PV, wind turbine, earth heat). | 6.3 | 3.0 | 3.0 | 3.0 | 3.0 |
| Life Cycle of Material | Lifespan of used materials. | 5.0 | 3.0 | | 4.0 | 4.0 |
| Recycled Material | Usage of recycled materials. | 4.7 | 3.0 | 3.0 | 2.0 | 2.0 |
| ~~Structural~~ | ~~Performance of the building in seismic activity.~~ | 1.3 | | | | |
| Ventilation | ~~The possibility to integrate natural ventilation system in a building.~~ | 0.0 | | | | |
| **Social** | | 31.7 | 97.7 | | | |
| Comfort | Comfort of the users and employees (mostly depending on the lighting conditions and the indoor | 7.7 | 4.0 | | | |
| Flexibility | Flexibility describes how spaces can be customized to different requirements. | 5.3 | 3.0 | | | |
| Student/Faculty Collaboration | Interaction and collaboration between students and faculty members to enable a fruitful work | 6.3 | 3.0 | 3.0 | 4.0 | 4.0 |
| Design/Iconicity | Attractiveness and iconicity of the design/building. | 5.0 | 2.0 | 4.0 | 3.0 | 3.0 |
| Innovation | In which extend innovations are included in the construction project. | 7.3 | 3.0 | 3.0 | 3.0 | 3.0 |
| **Discipline specific** | | 14.0 | 42.0 | 48.7 | 35.3 | 35.3 |
| Architectual/structual unity | Clarity of the structural and architectual concepts throughout the building | 6.7 | 3.0 | 4.0 | 2.0 | 2.0 |
| Context connection | How the design of the building connects with surroundings and campus' vision | 7.3 | 3.0 | 3.0 | 3.0 | 3.0 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Total Score** | | | 313.33333 | 317.66667 | 310.33333 | 296.33333 |

| Rating System [column D] | |
|---|---|
| 10 | Highest Value/Most important |
| 9 | |
| 8 | Highly Valued/Very Important |
| 7 | |
| 6 | |
| 5 | Moderate Value/Average Importance |
| 4 | |
| 3 | |
| 2 | Some Value/Somewhat Important |
| 1 | |
| 0 | No Value/Rather not have |

smart glass

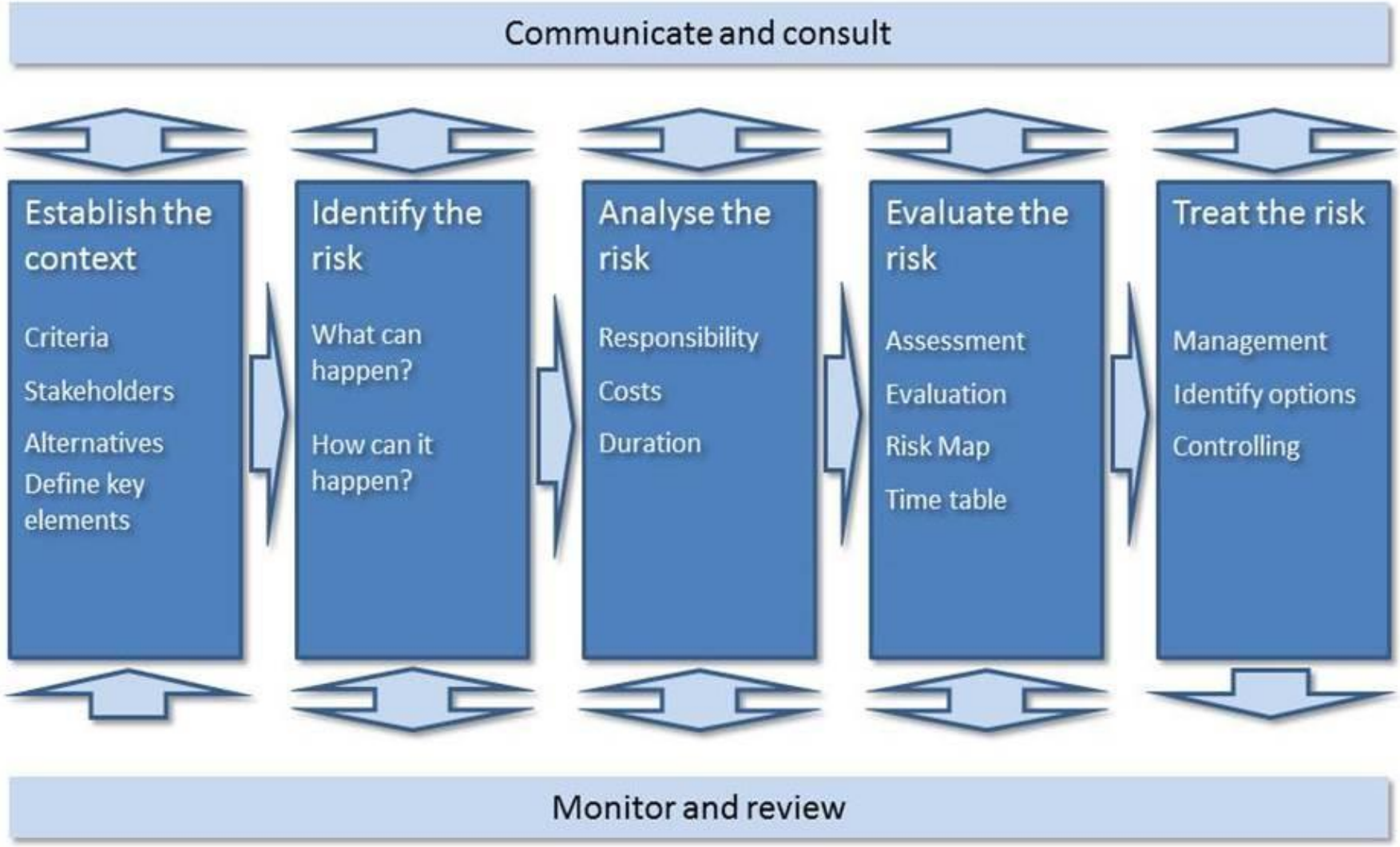
# Decision Process

Architecture
Structure
MEP
Construction



# LCFM Consulting in Spring

Architecture
Structure
MEP
Construction



# Team Process

# Modes of Communication

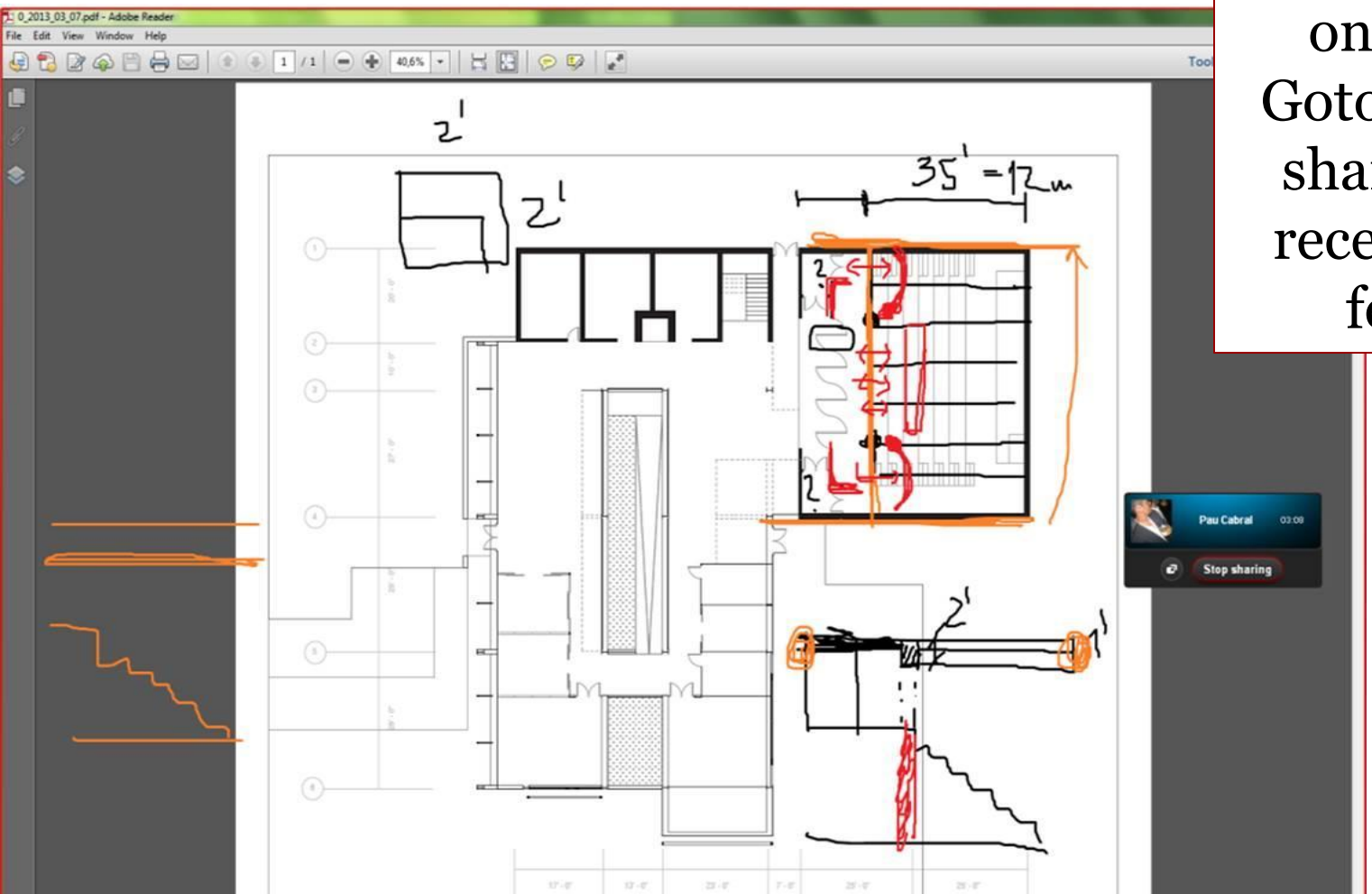
Architecture
Structure
MEP
Construction

| | Primary | Secondary |
|---|---|---|
| Text, images, videos, links to other websites, etc. | facebook | Gmail by Google |
| Instant messaging | facebook | talk skype |
| Voice | GoToMeeting | skype 3D I.C.C. IMMERSIVE COLLABORATION CONSULTING |
| File Sharing | Google Drive | Dropbox box |

# Team Design Process

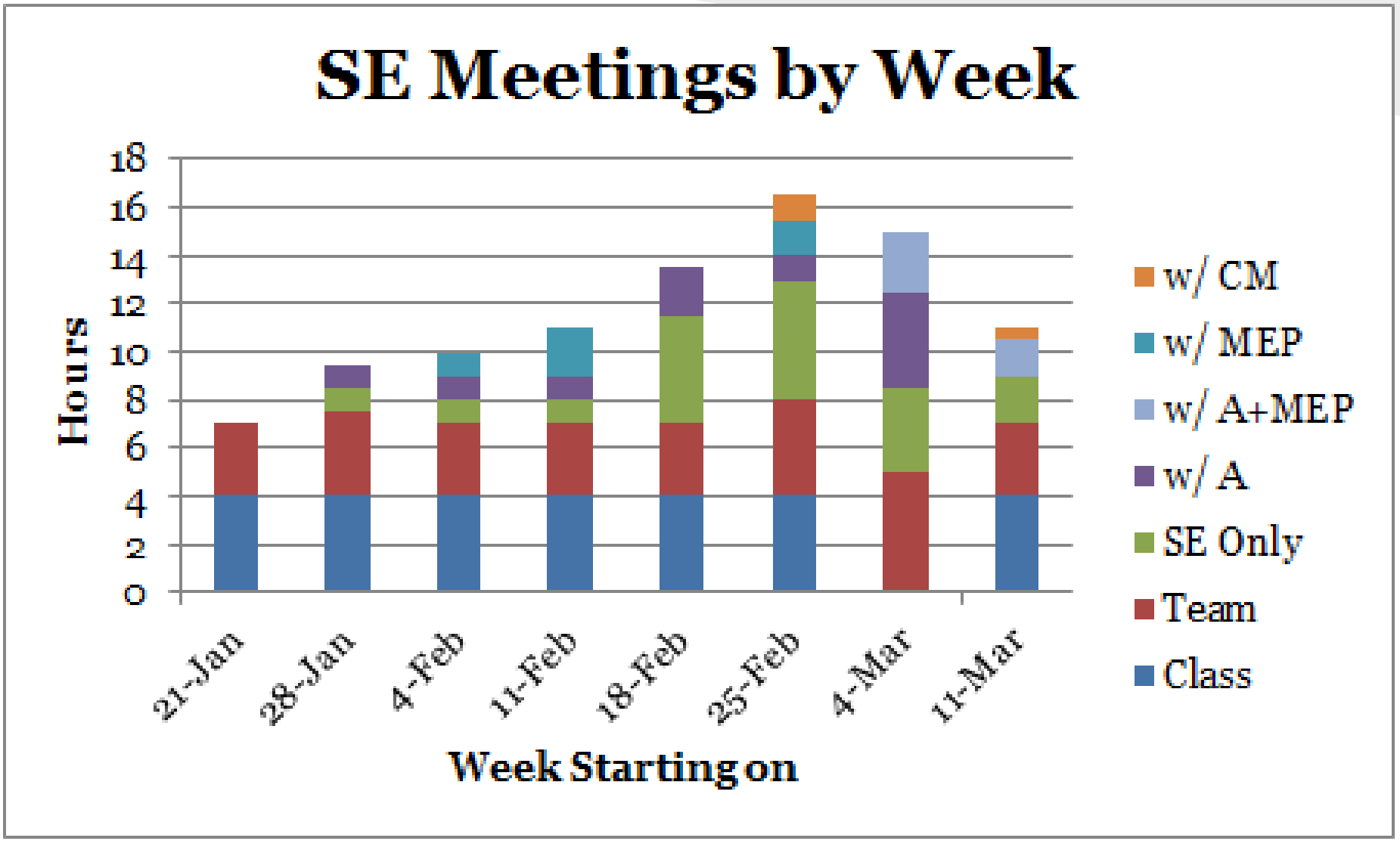
Architecture
Structure
MEP
Construction

Sketching while on Skype or Gotomeeting to share ideas or receive instant feedback



# Example of Interdisciplinary Collaboration

Architecture
Structure
MEP
Construction



# Thank You!

Architecture
Structure
MEP
Construction

Your time and feedback are greatly appreciated!