

EXPRESS

Ljubljana



INTRODUCTION

Team

A



Rok

University of
Ljubljana
Slovenia

SE



Ying

Stanford
University
USA

SE



Aleshia

Stanford
University
USA

MEP



Ewa

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University
Denmark

CM



Samer

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University
UK

CM



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LCFM



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Walt Disney
Imagineering
USA



Nick Zeman
Project Engineer
The Boldt
Company
USA

Ljubljana

Capital city of Slovenia

300,000 inhabitants

50,000 students

Green capital of Europe 2016

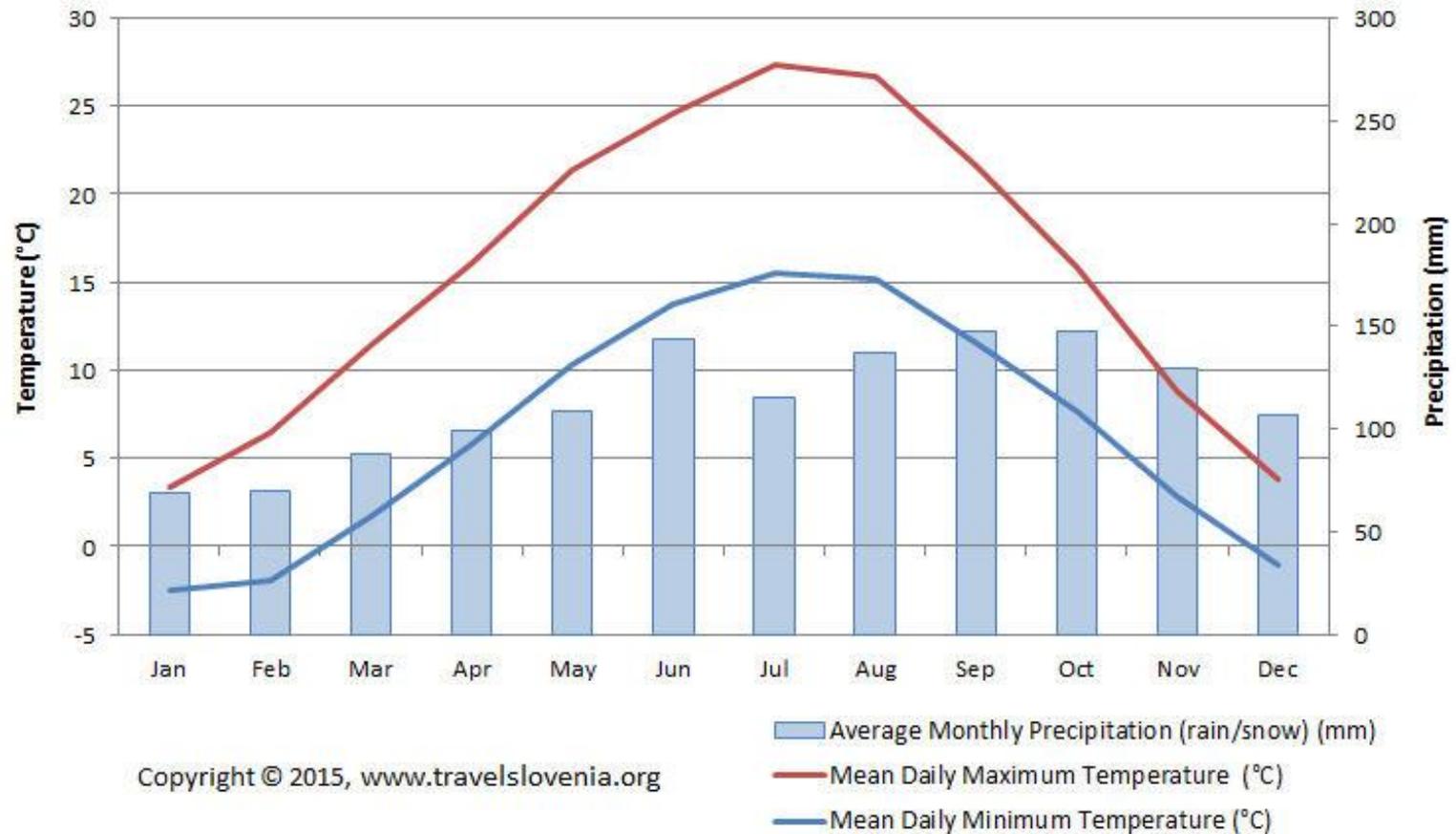
People-friendly city

Walking distances



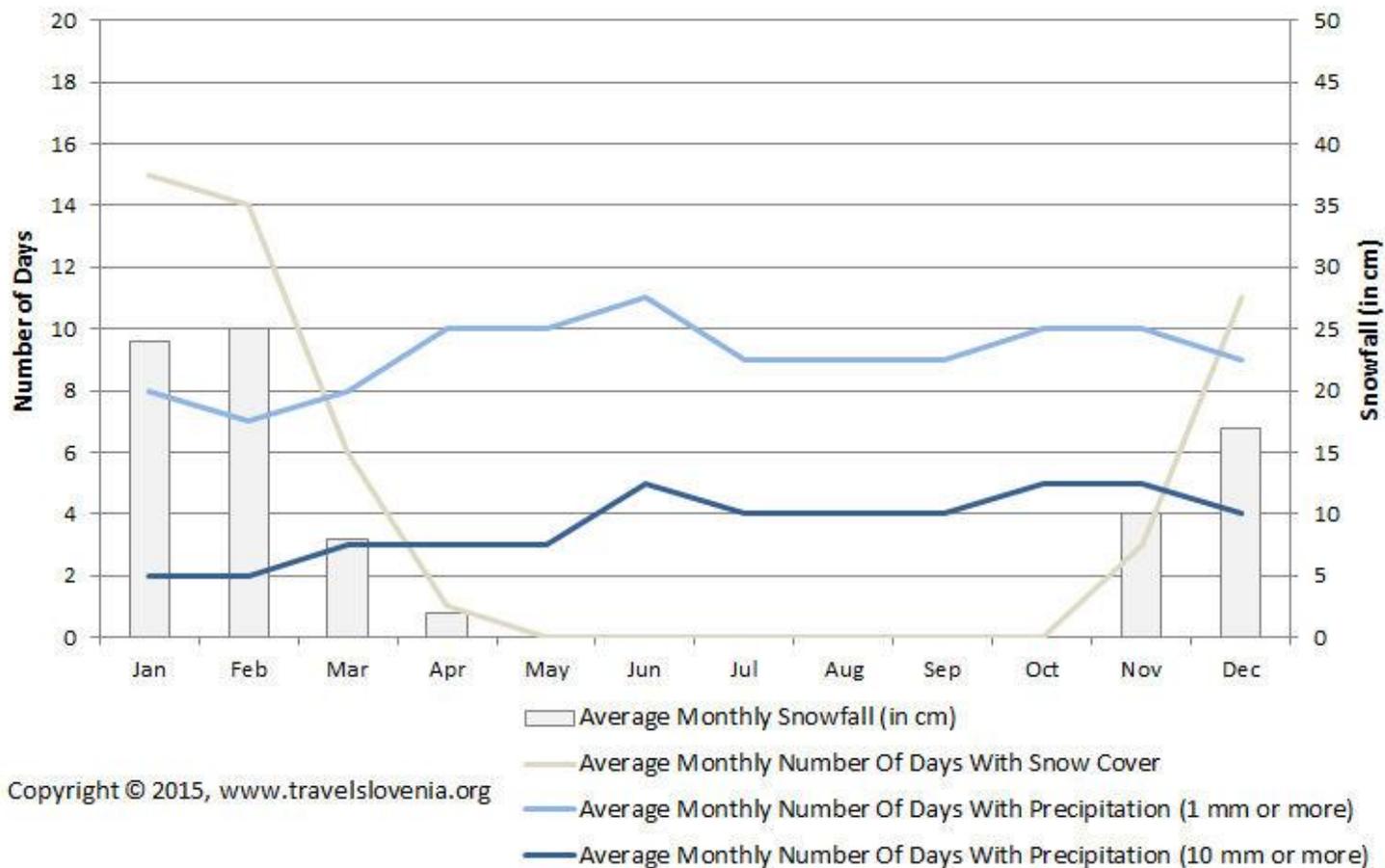
Temperature

A Climate Graph for Ljubljana, Slovenia



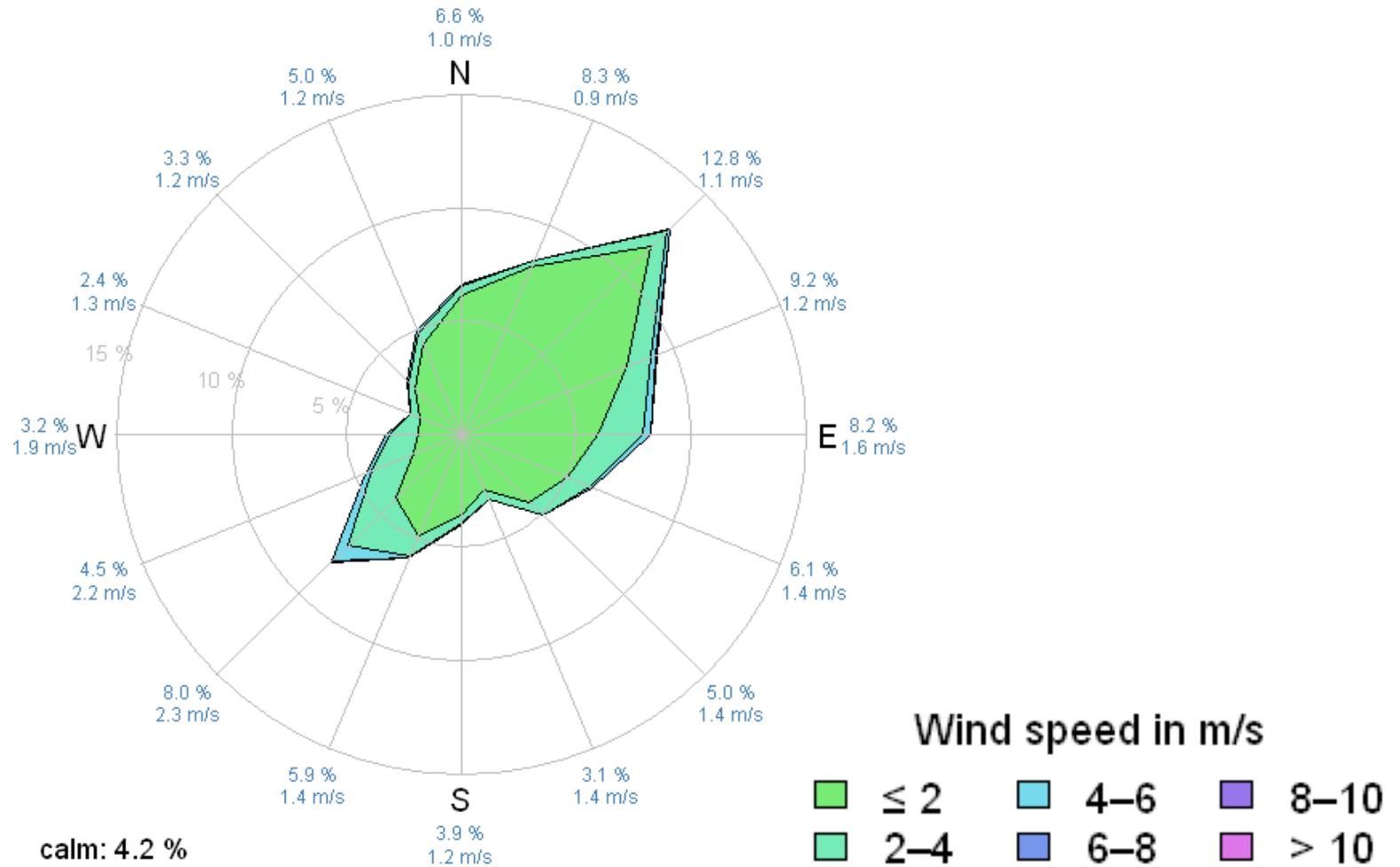
Precipitation

Precipitation, Snowfall and Snow Cover for Ljubljana, Slovenia



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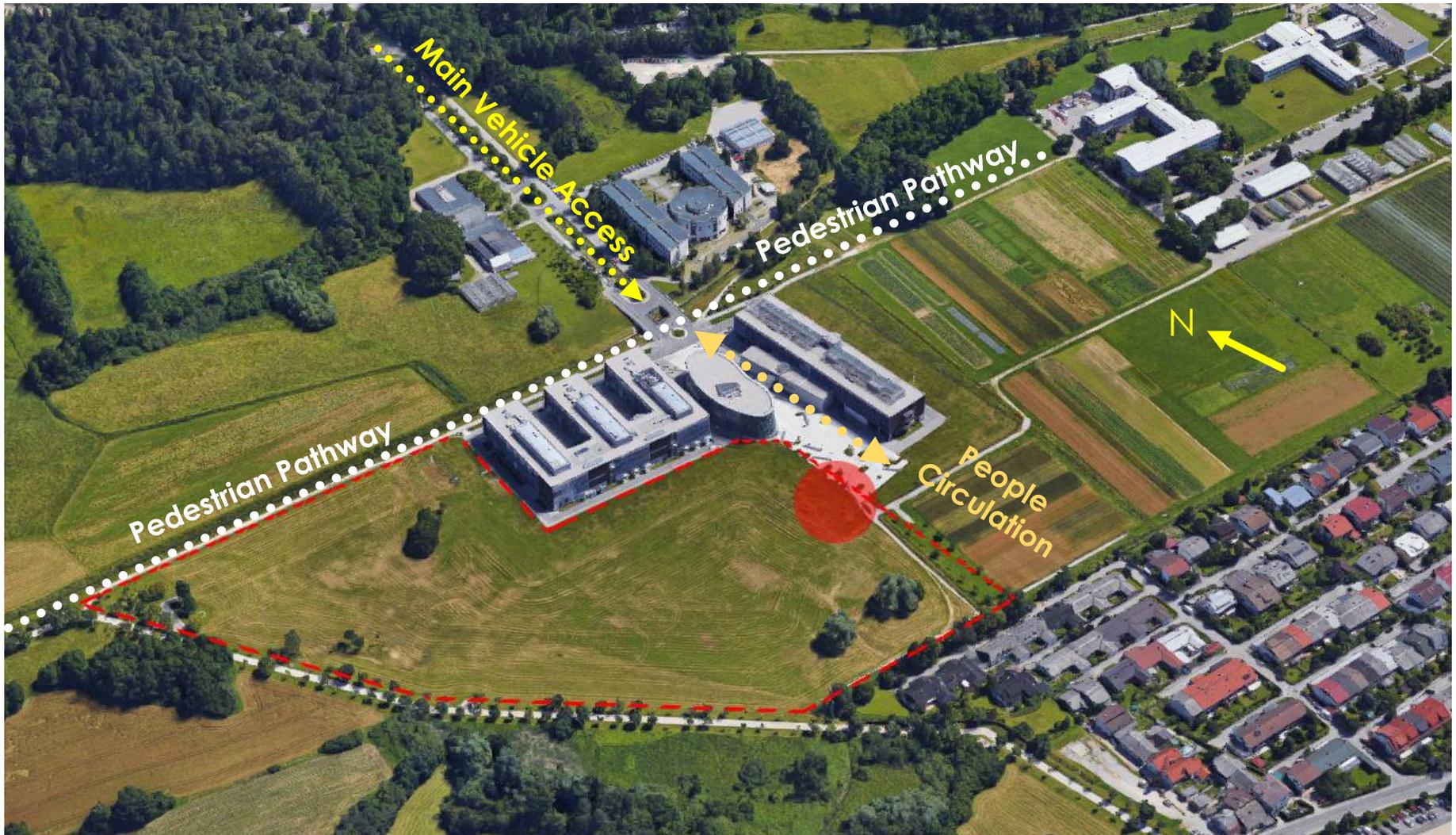
Wind



Location

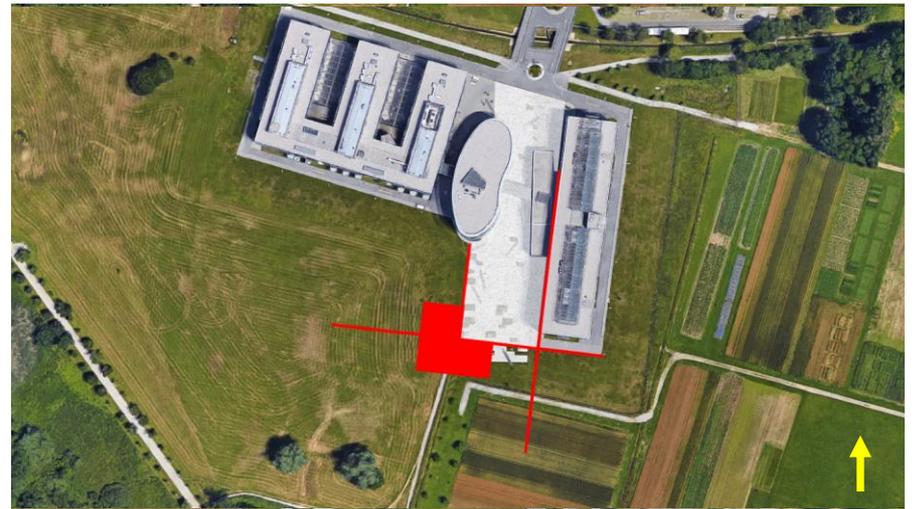
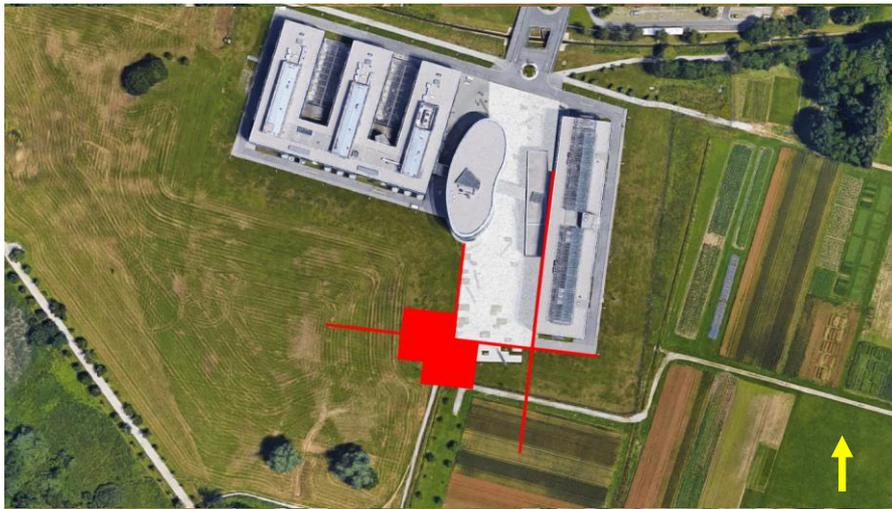


Site Analysis



Building Placement

- Connection with the existing faculties
- Alignment with existing footprints
- Forming an entrance square
- Closing the SW corner



Challenges

Challenge

High risk of a flood

High water level: -1,5 m



Risk Mitigation

Raise critical program above ground

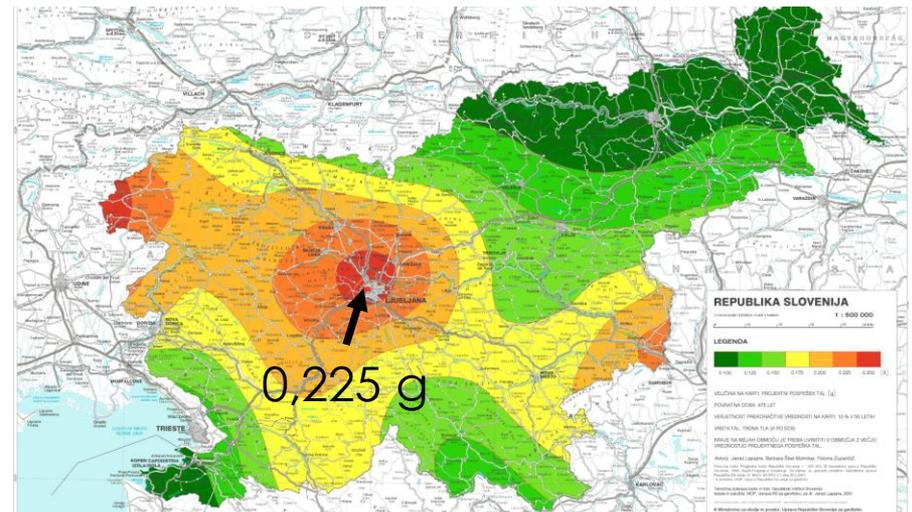


Challenge

Earthquake zone

Risk Mitigation

Design strong, but ductile lateral system



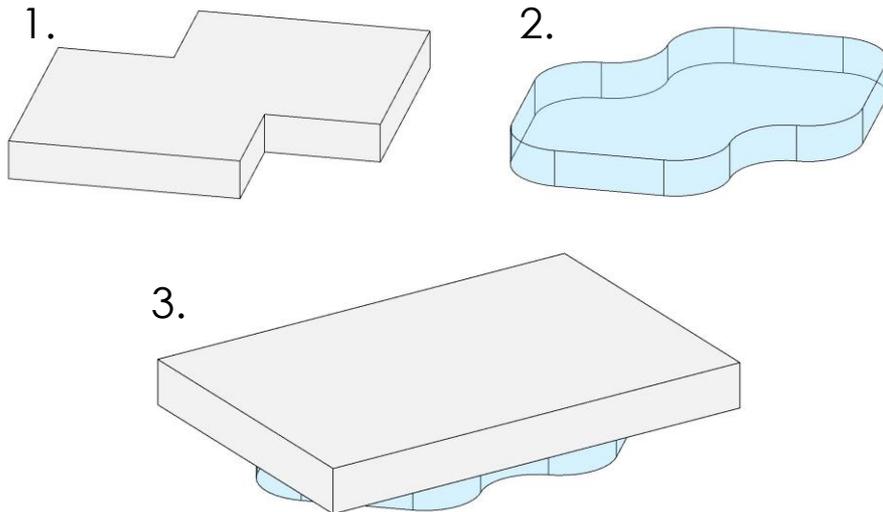
ECONDUSTRY

ARCHITECTURE

Ecology + Industry

ECOLOGY

- Fluid forms- WATER
- Ecological use of materials
- Design for disassembly and re-use
- Organic circulation
- Transparent facade

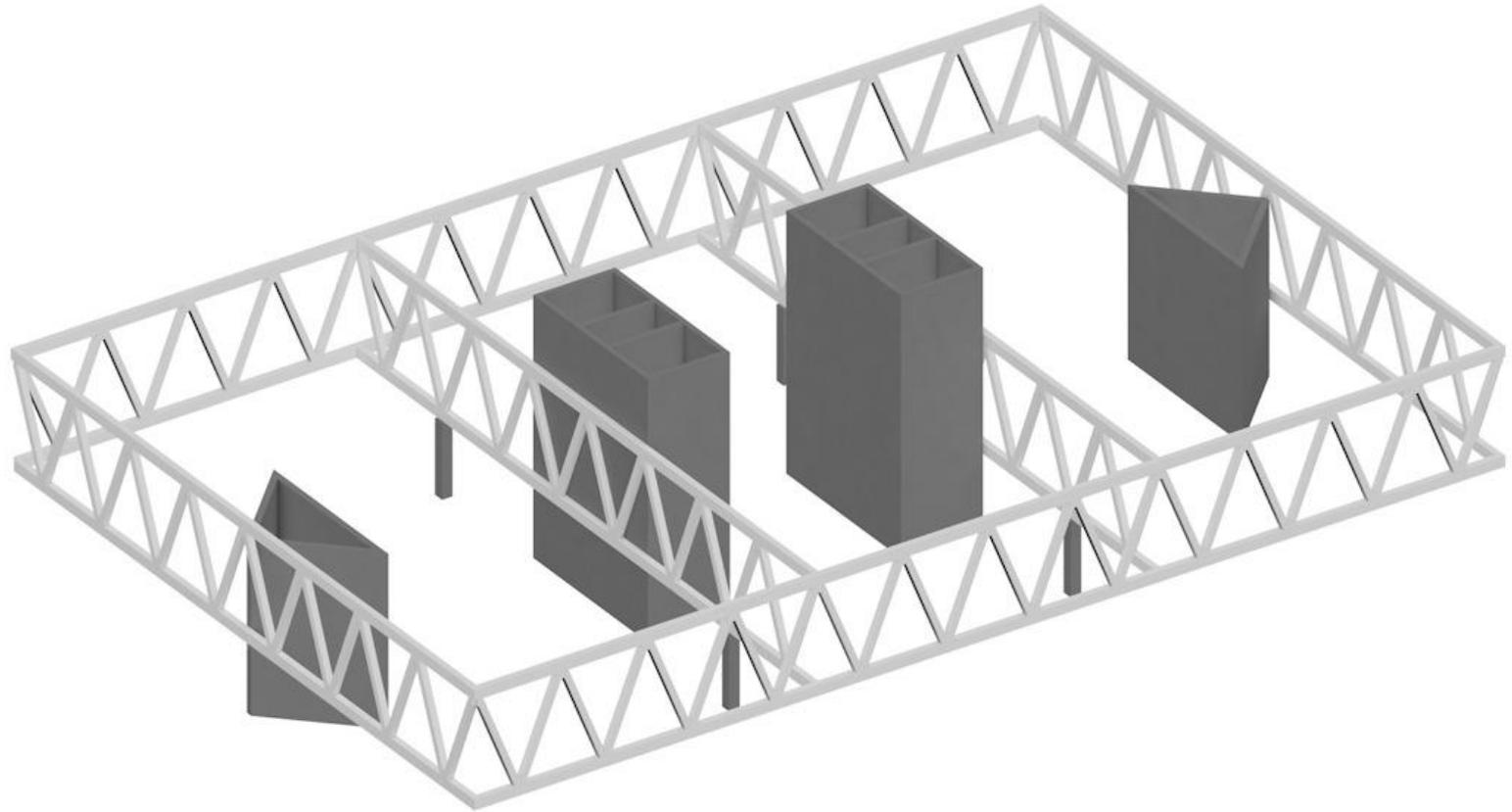


INDUSTRY

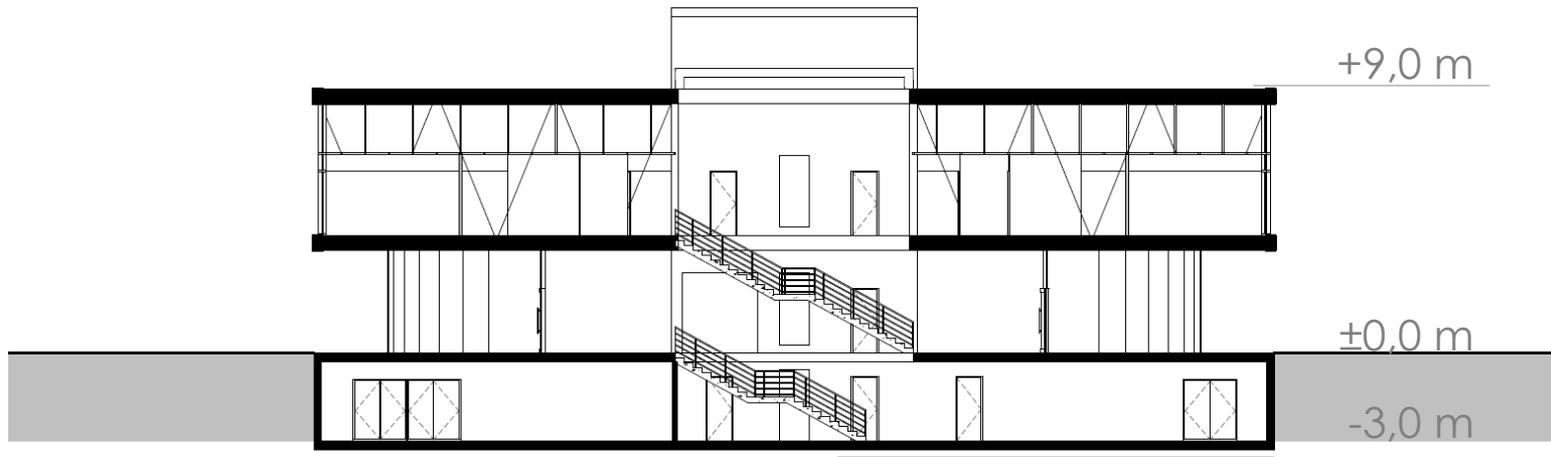
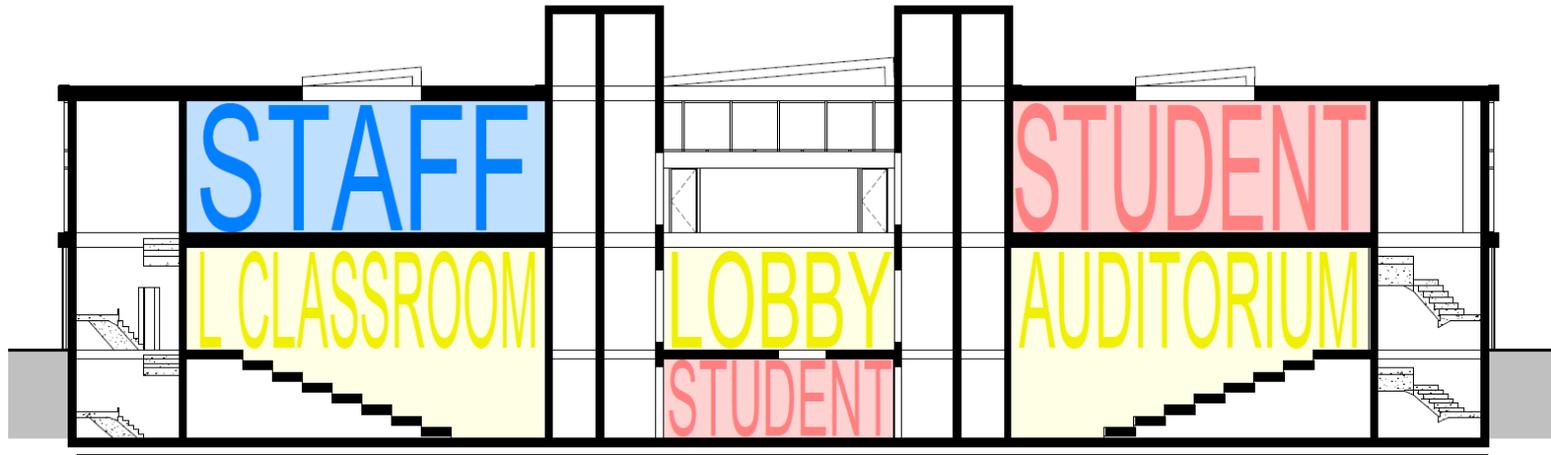
- Visible structure
- Economical use of space
- Flexibility
- Orthogonality
- Efficiency



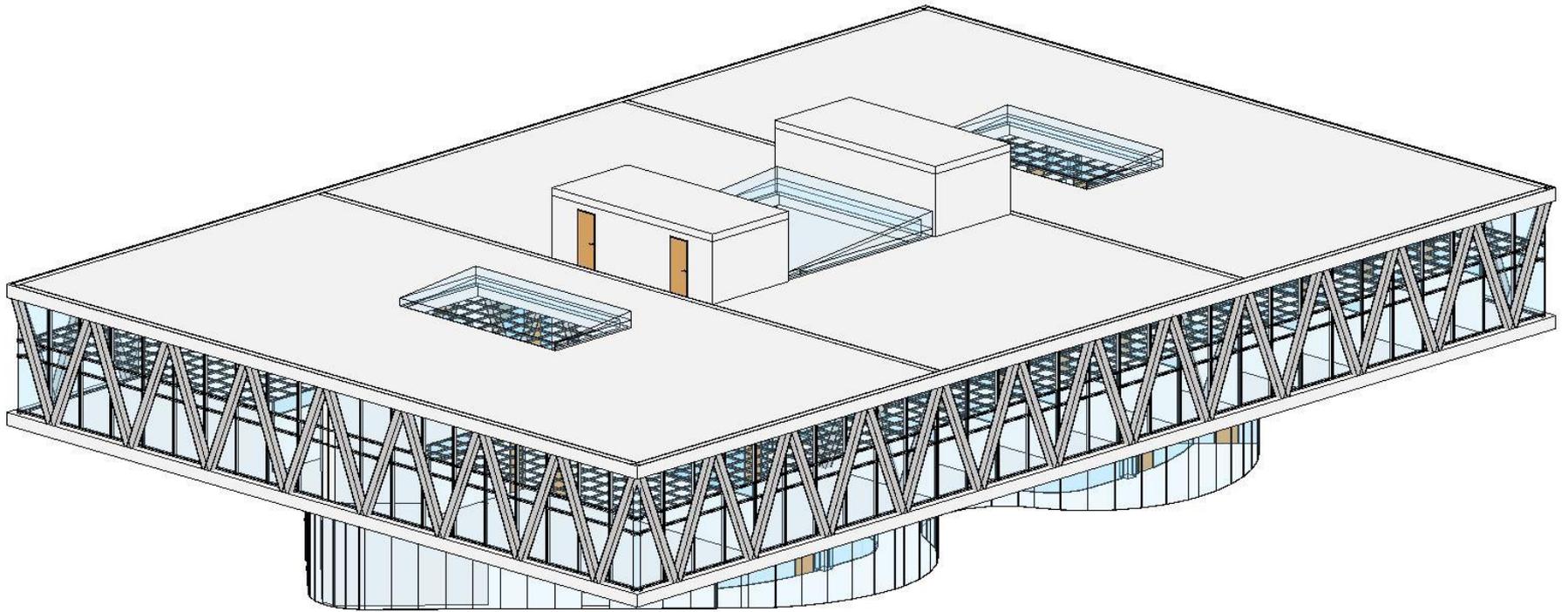
Structural Concept



Program Distribution



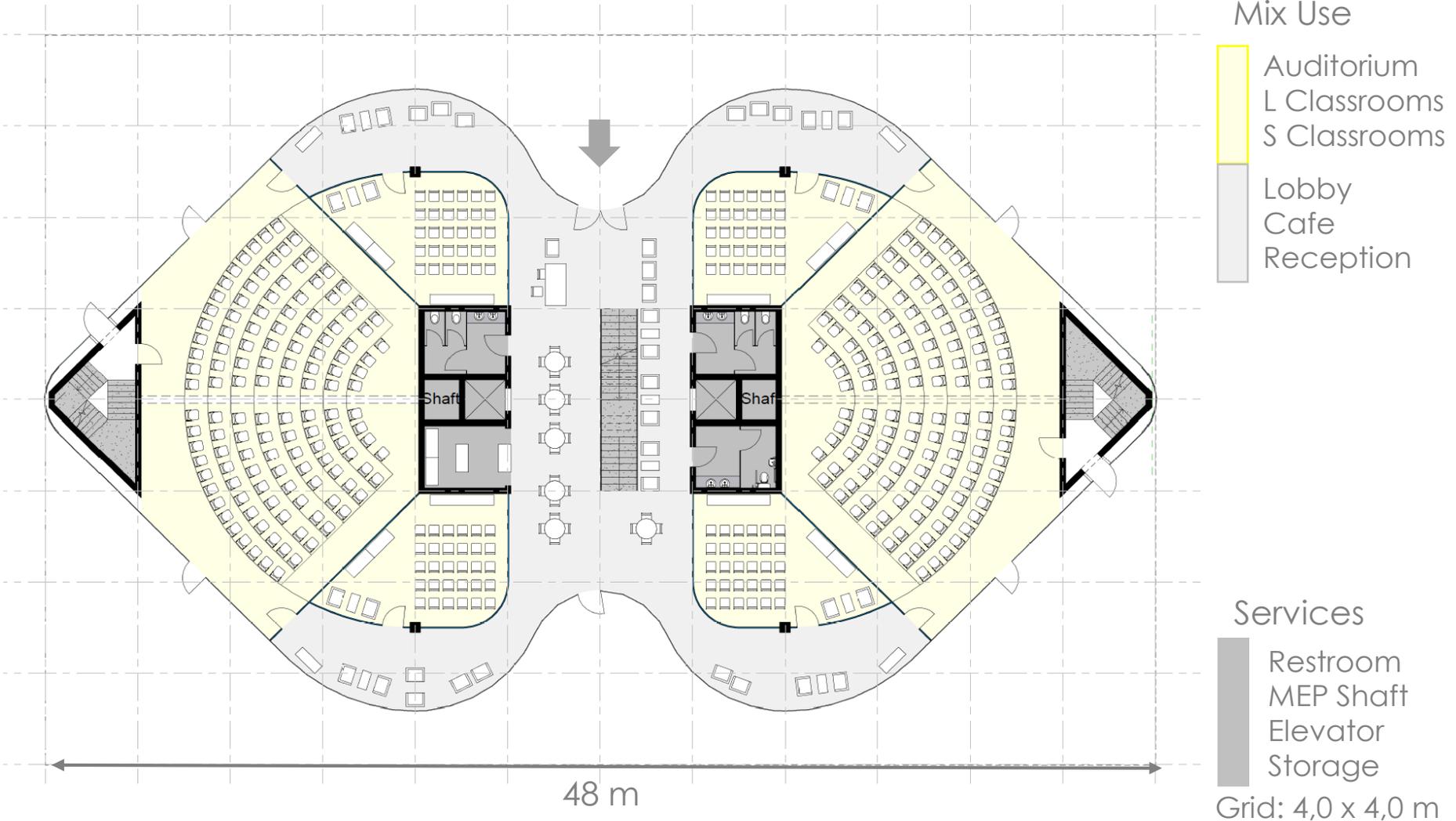
3D View



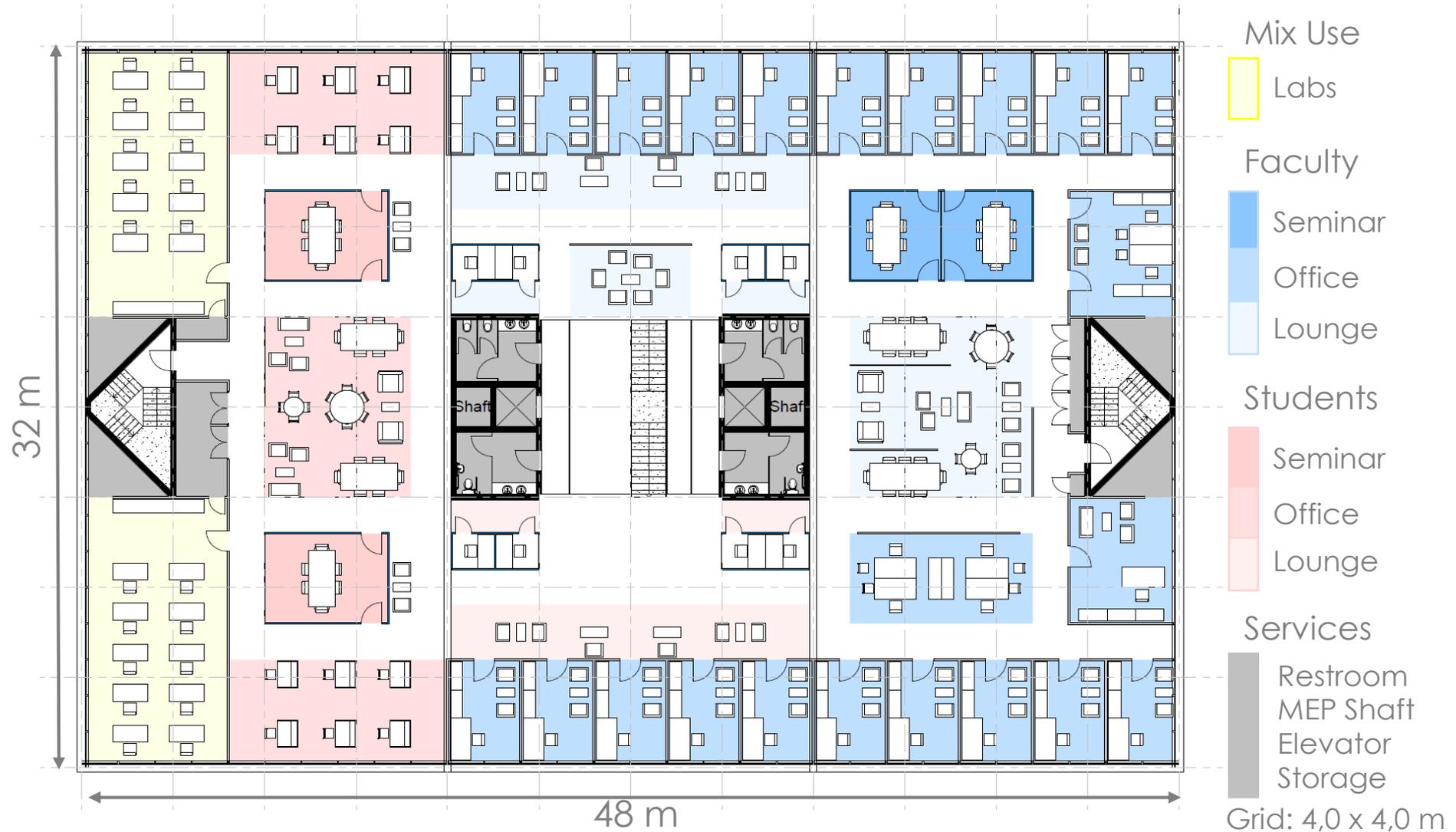
Site Plan



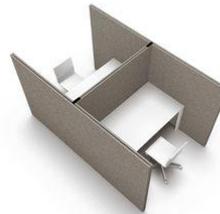
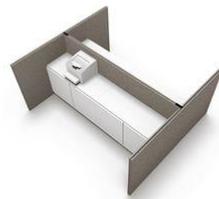
Ground Floor



1st Floor



Isolated Spaces



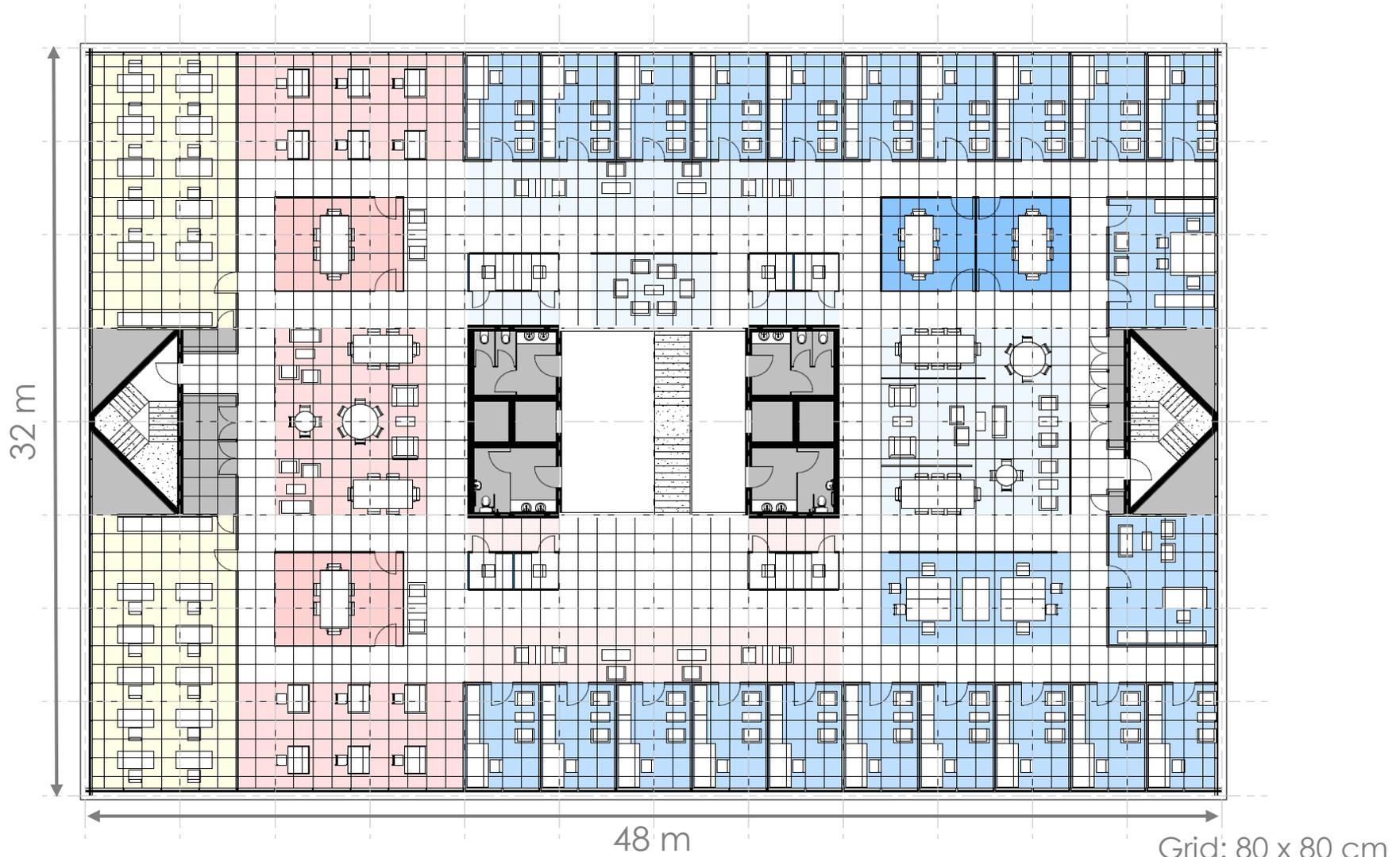
Isolated Spaces



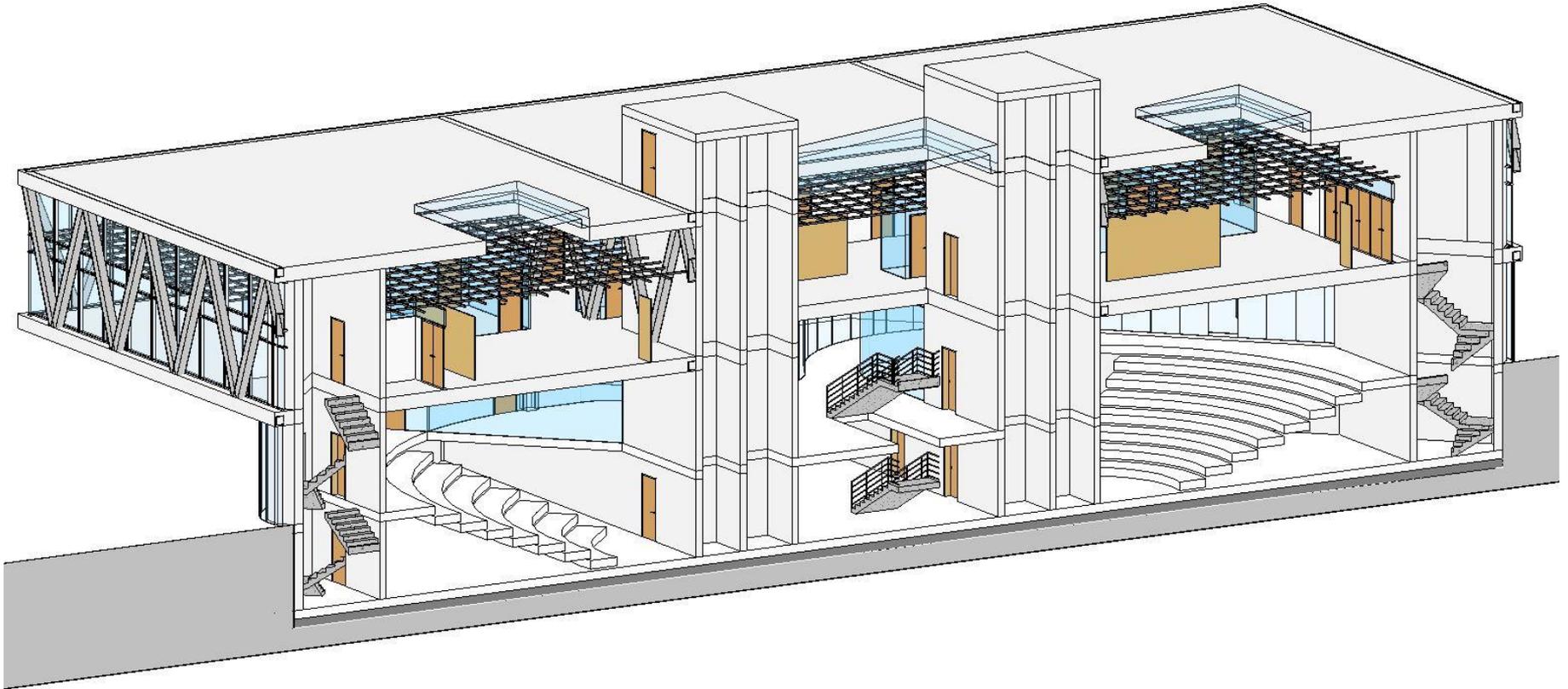
Moving Walls



Suspended Ceiling



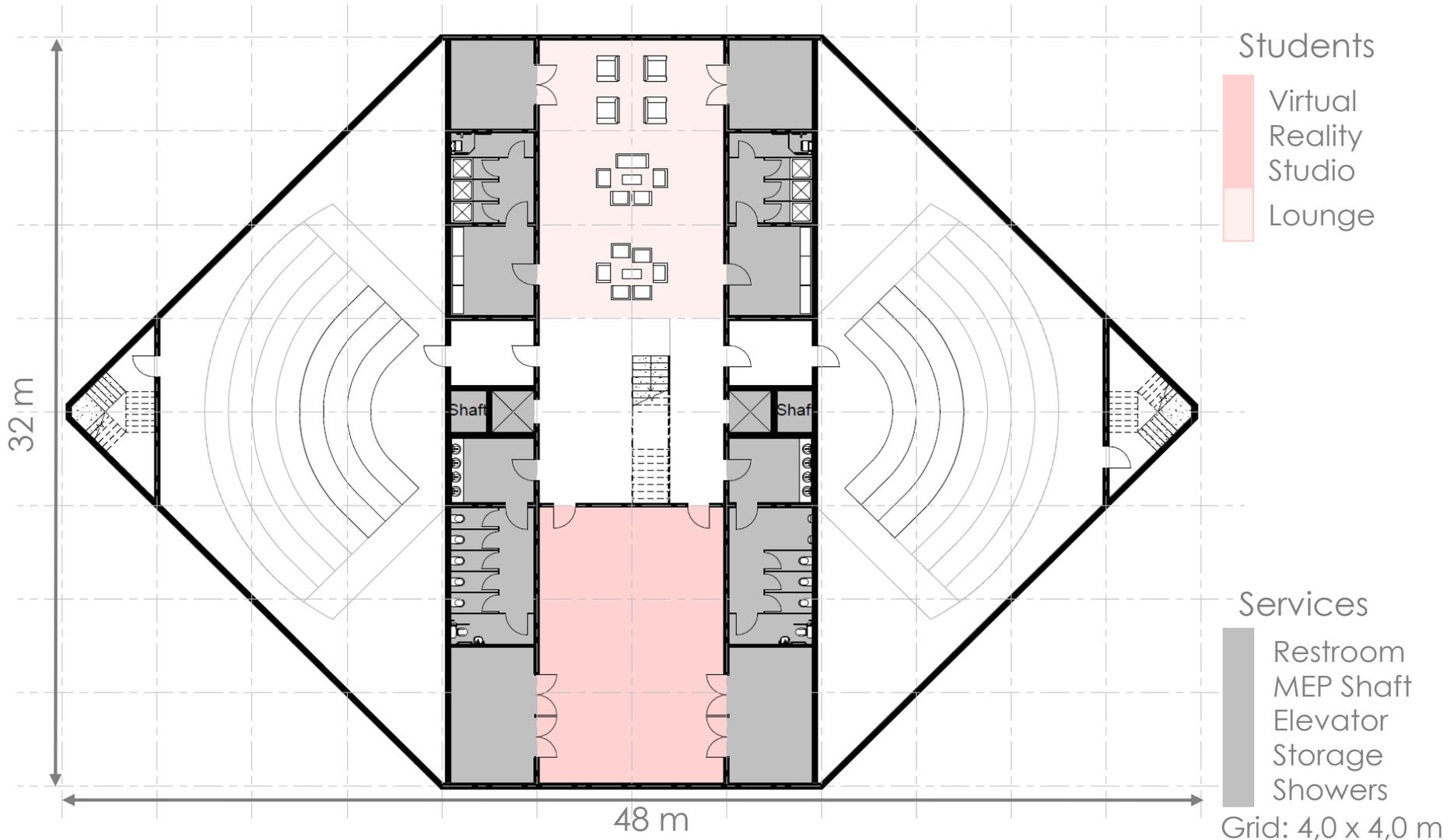
Longitudinal Section



Student Space



Basement



Entrance/ East Facade



Entrance Square

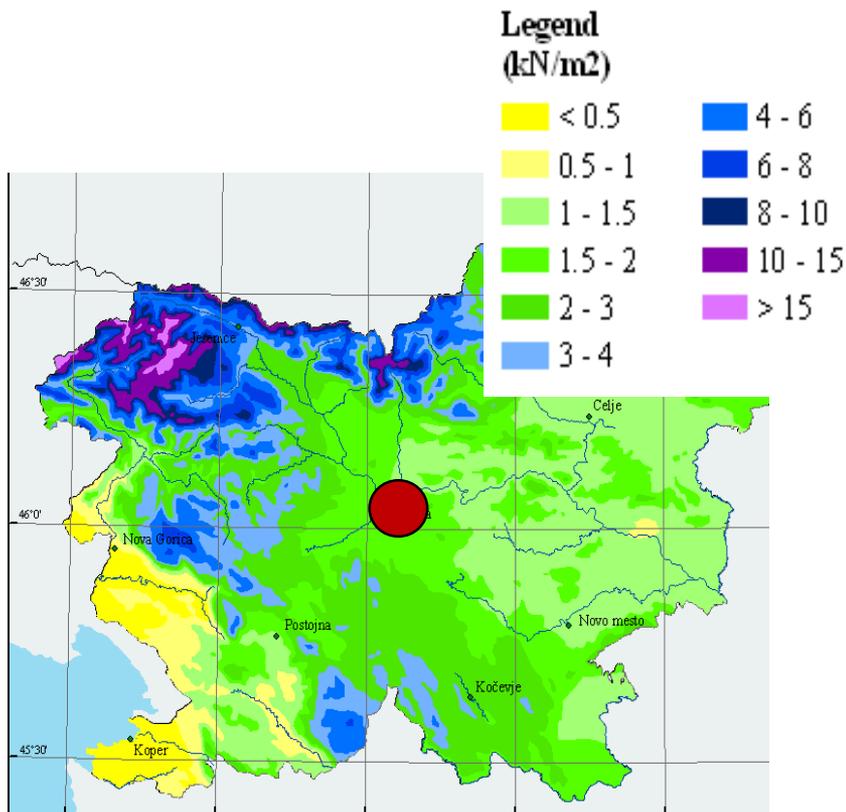


STRUCTURE

Site Conditions

Snow Loads

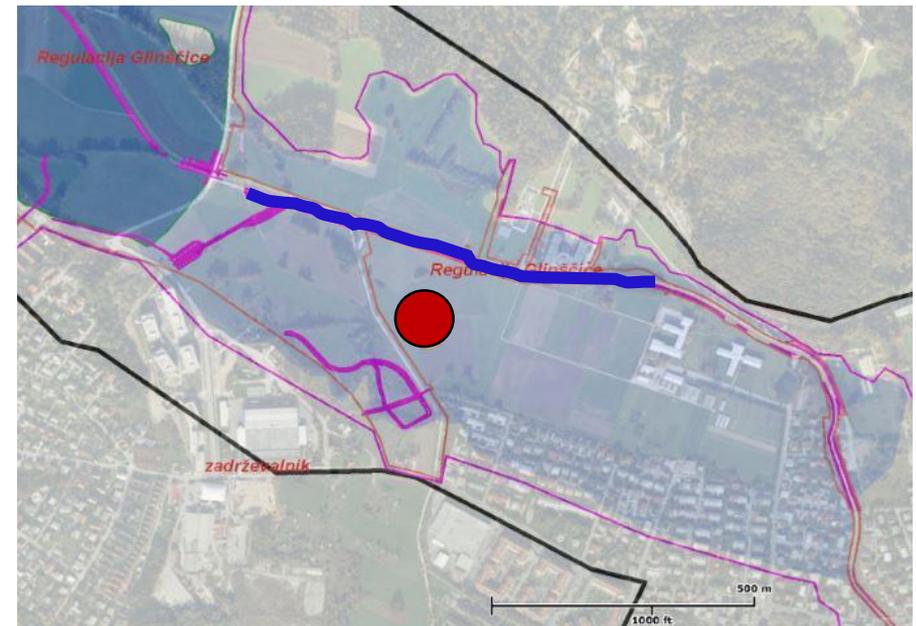
Ground Snow Loads: 40 psf



Flood Zone

Man-made creek reduces flood risk

- Moderate Flood Risk
- Low Flood Risk
- Not in Flood Zone



Load Overview

Live Load:

- 40 psf – Seminar Rooms, Small Classrooms
- 50 psf – Offices, Lounges, Labs
- 60 psf – Auditorium, Large Classrooms
- 100 psf – Lobby, Corridors, MEP & Storage Rooms
- 20 psf – Roof

Snow Load:

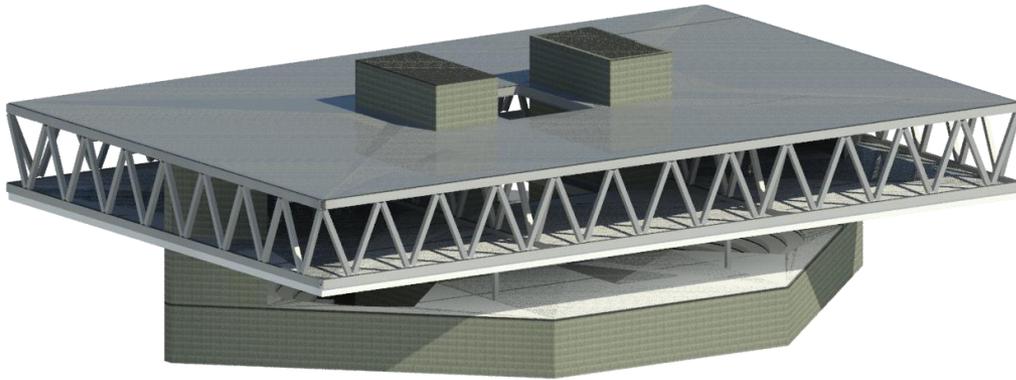
- 30 psf

Seismic:

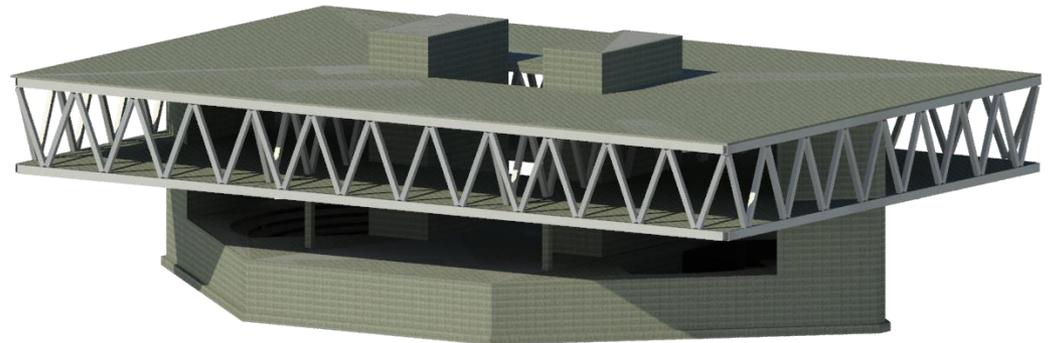
- Base Shear = $0.073W$

Structural Alternatives

Steel Composite Floor Systems

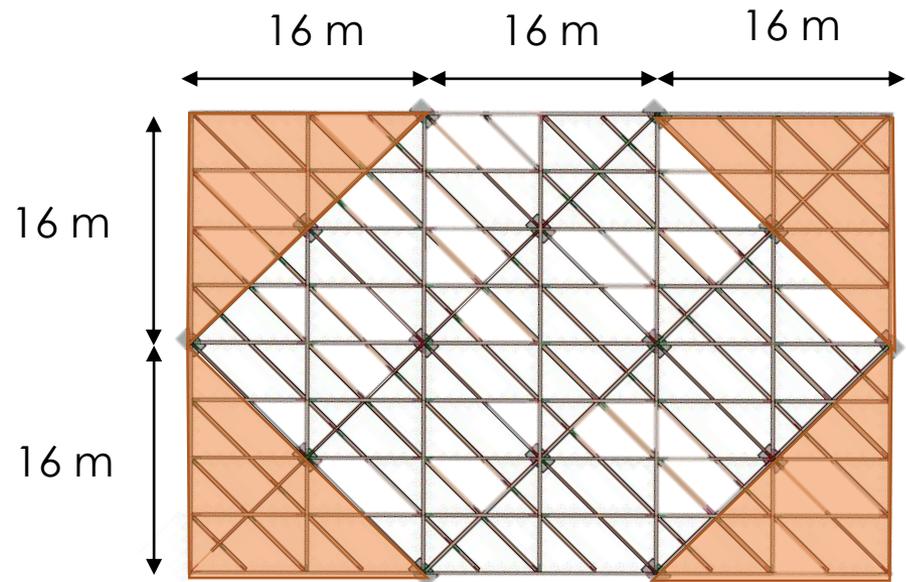
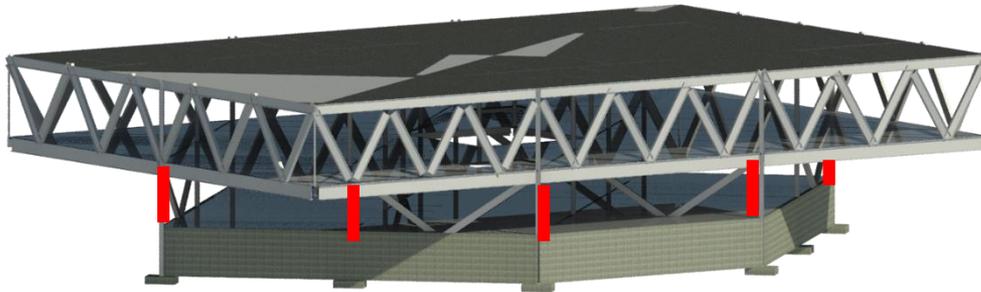


Post-Tensioned Concrete Floor



Cantilever Evolution

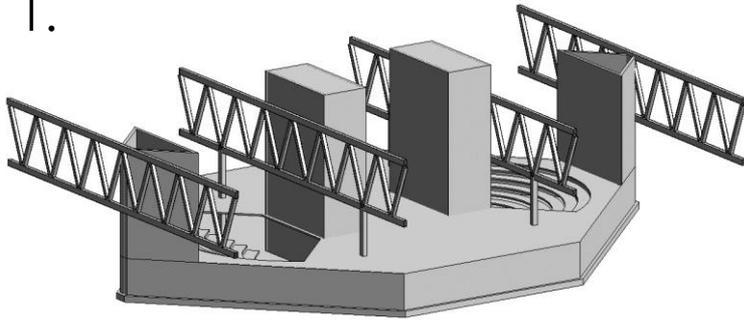
Previous Design



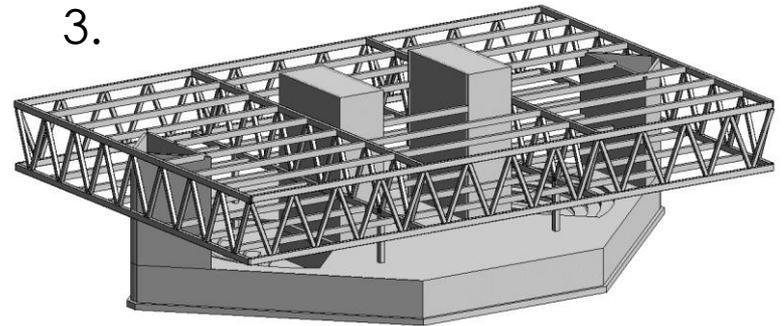
Cantilever Evolution

New Design

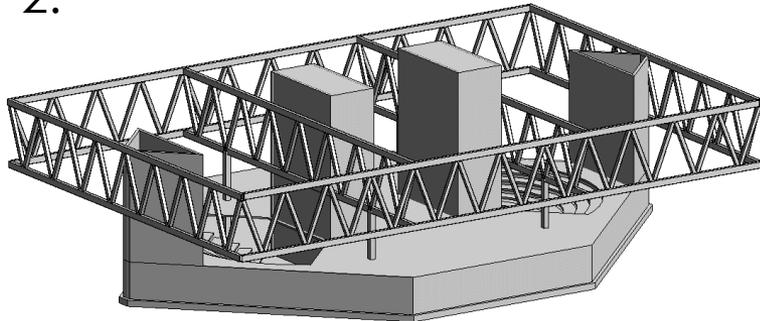
1.



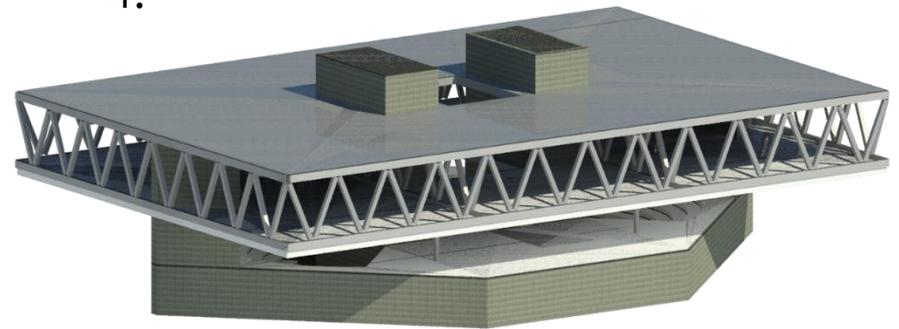
3.



2.

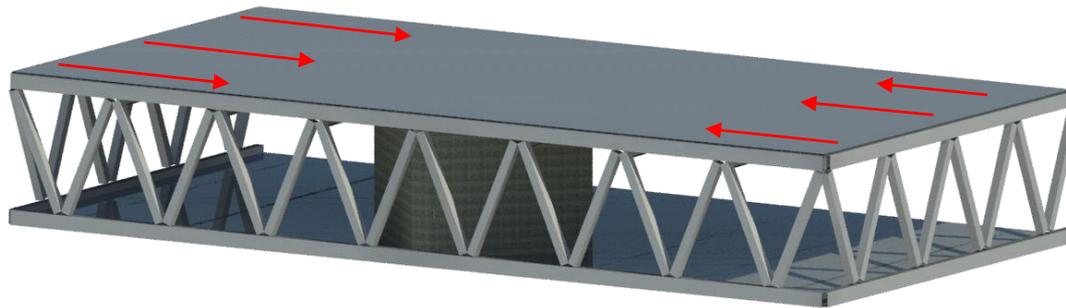


4.



Torsional Resistance

Connection to floor and roof slabs create
a torsional-resistant shape

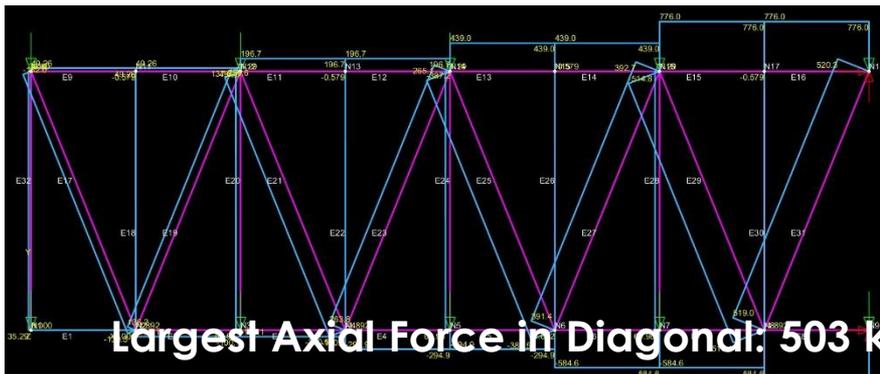
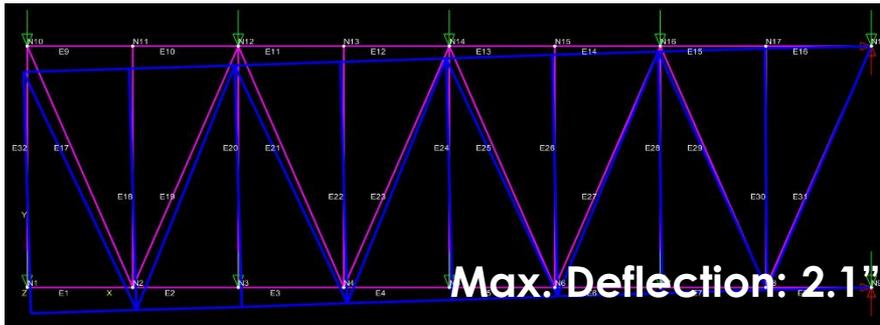


Post-tensioned roof slabs composite with top of
trusses reduce deflections

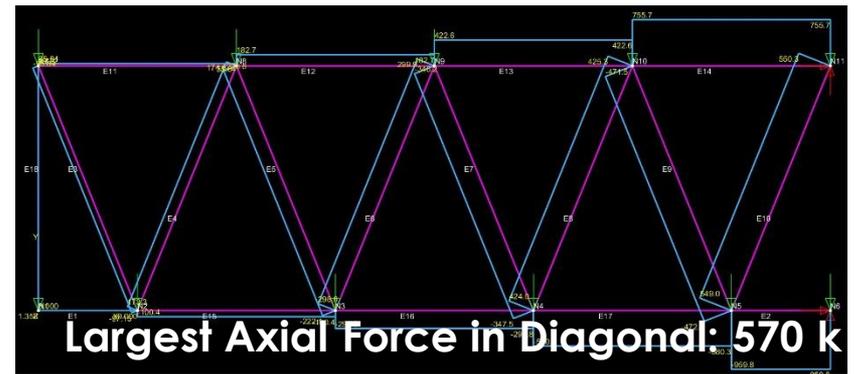
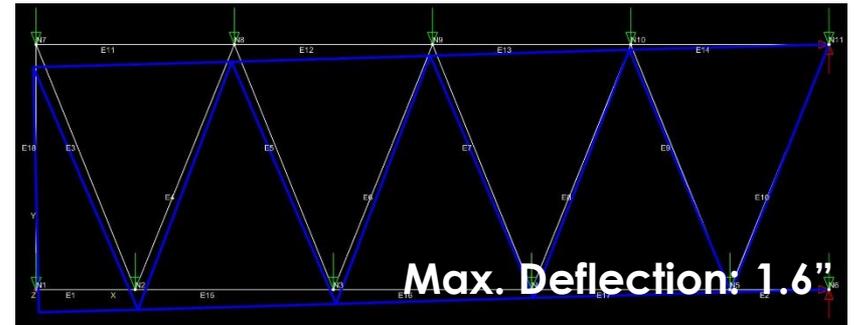
Truss Analysis



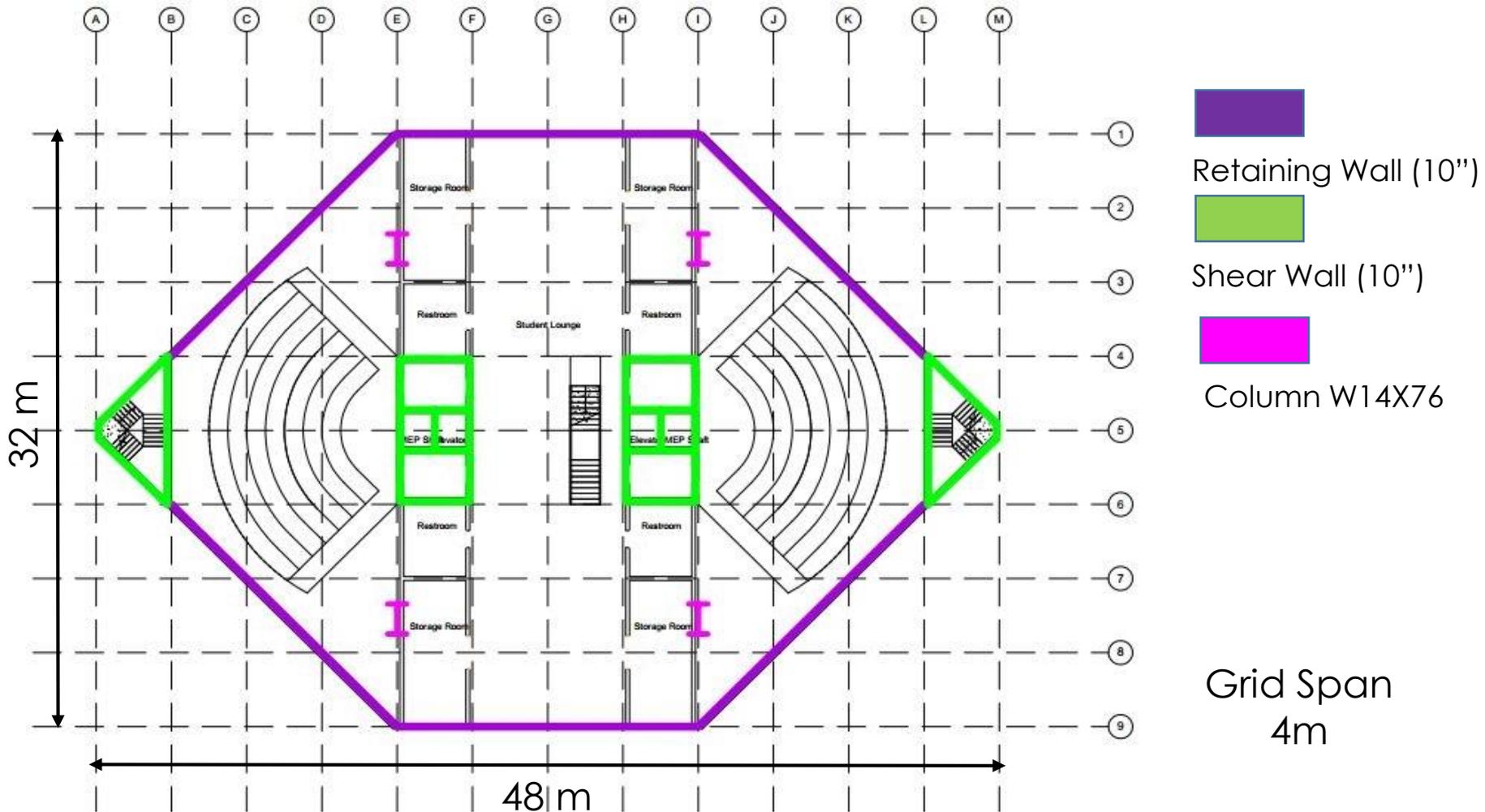
WITH VERTICALS



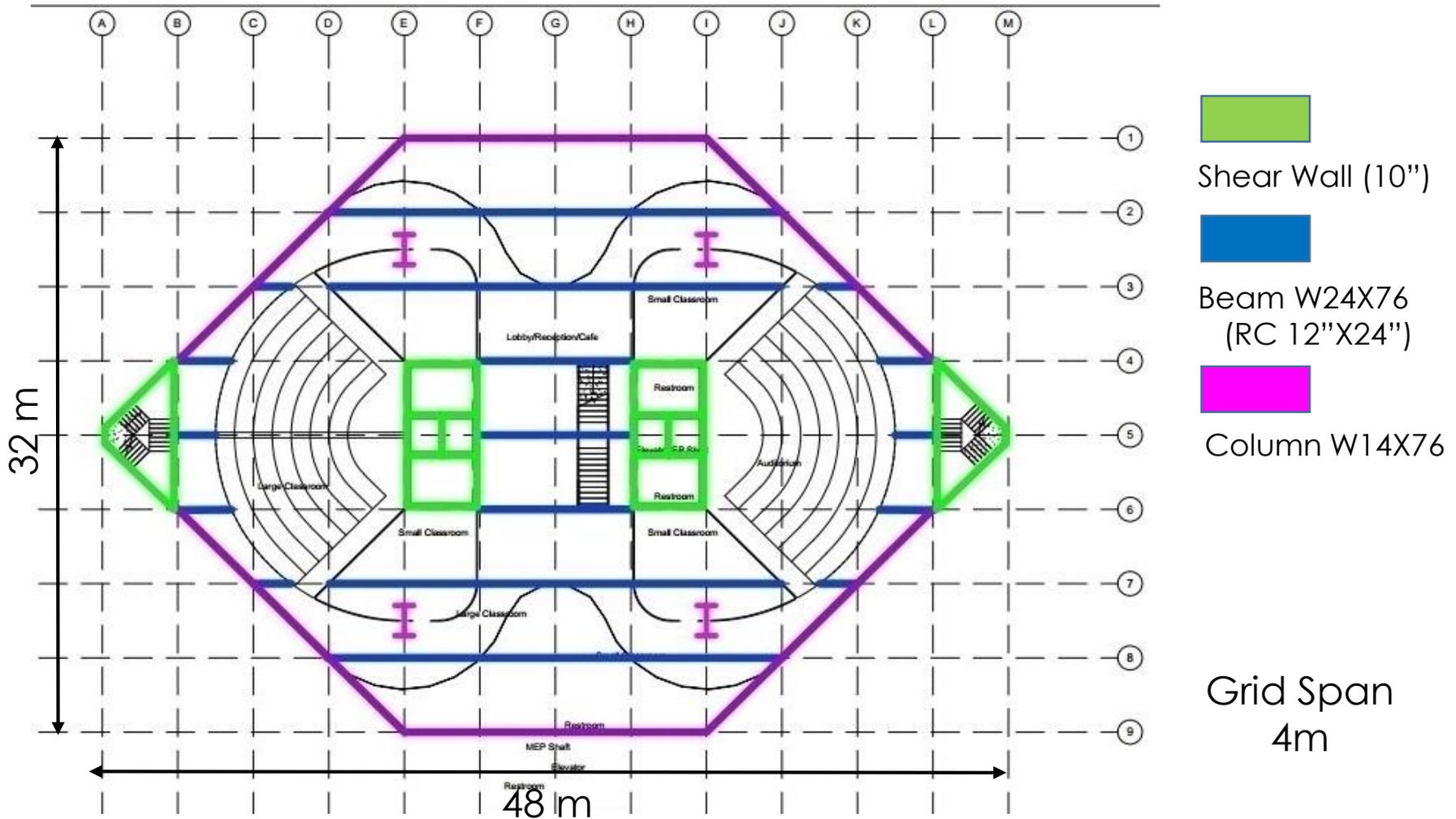
WITHOUT VERTICALS



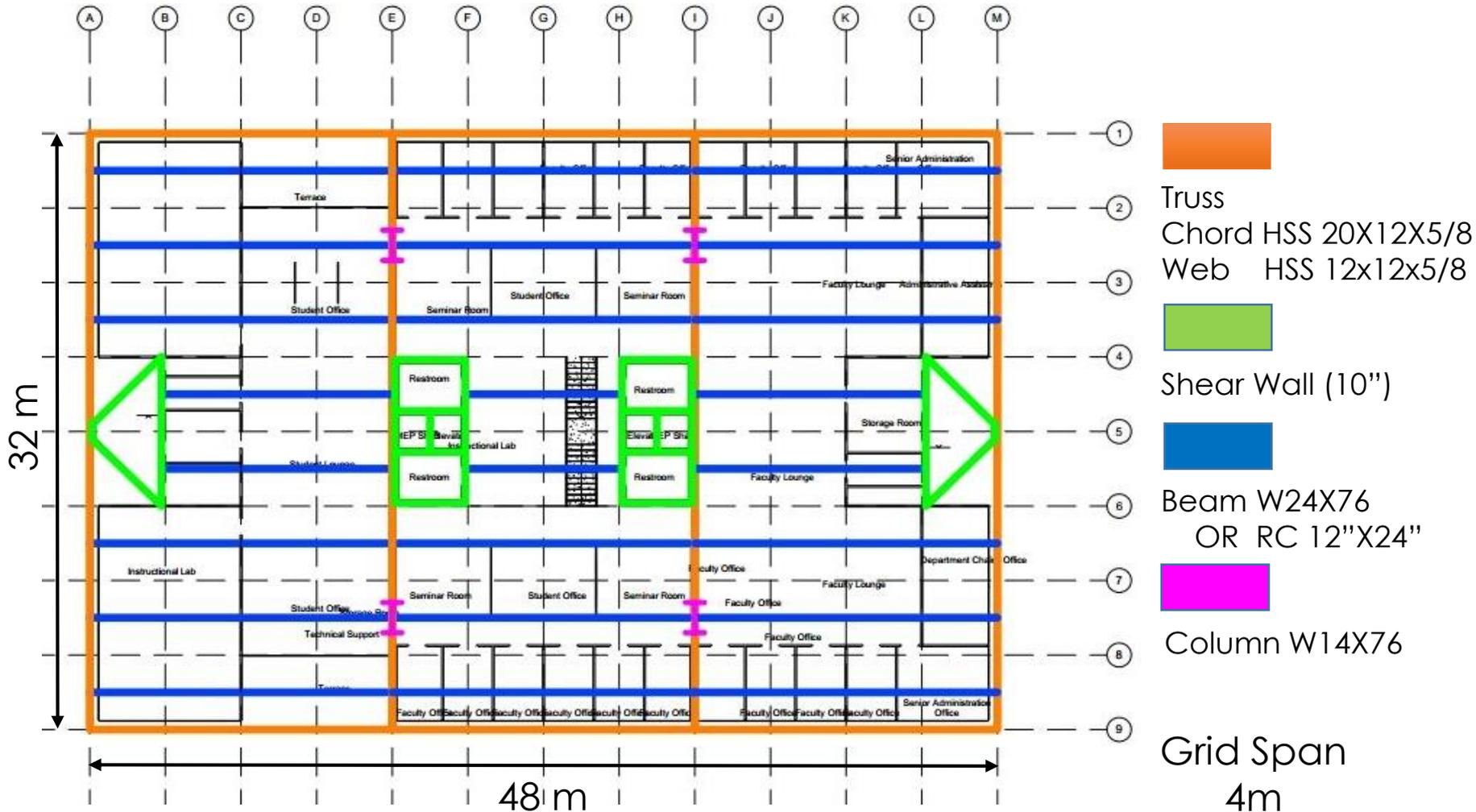
Basement



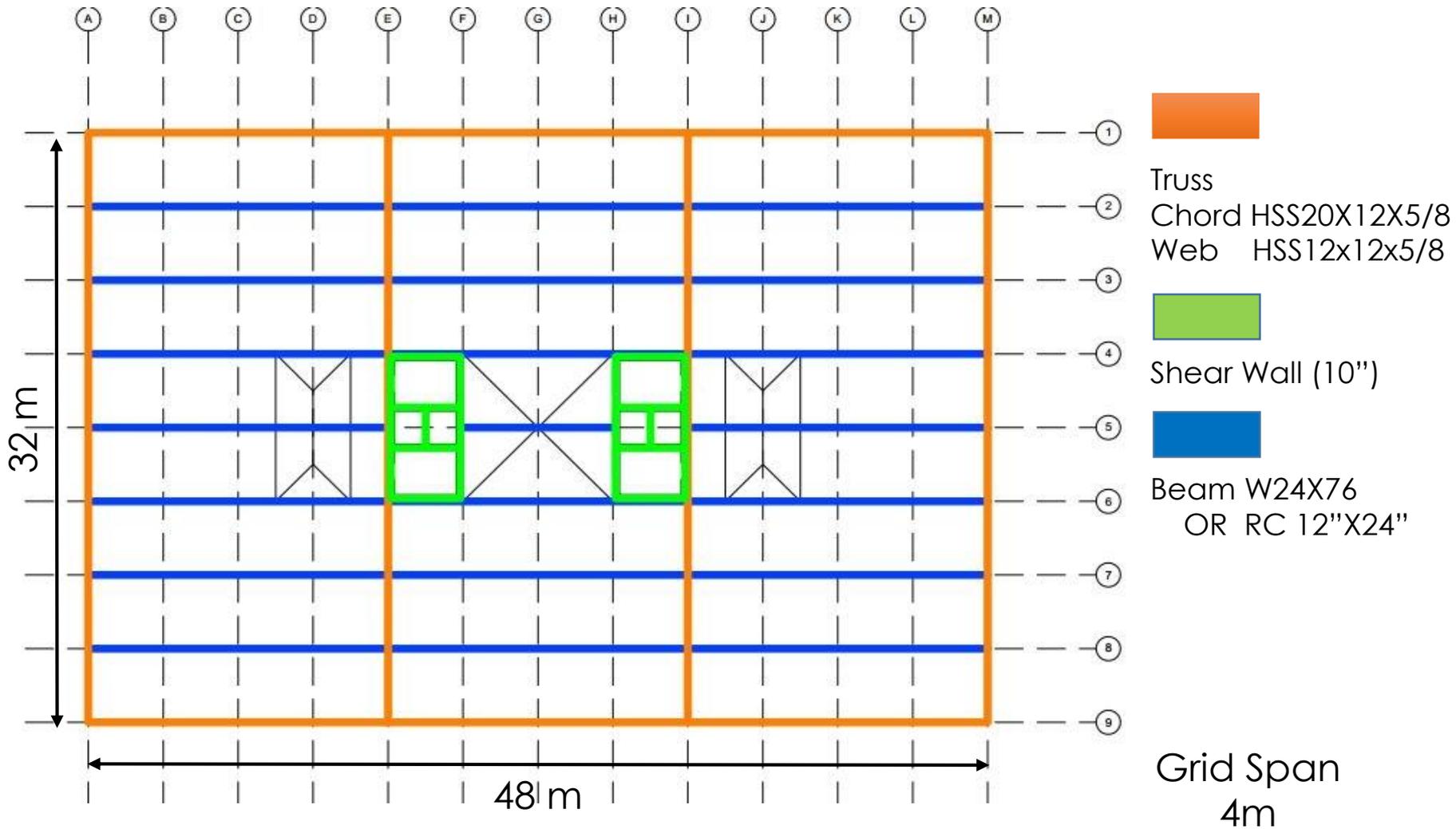
Ground Floor



First Floor

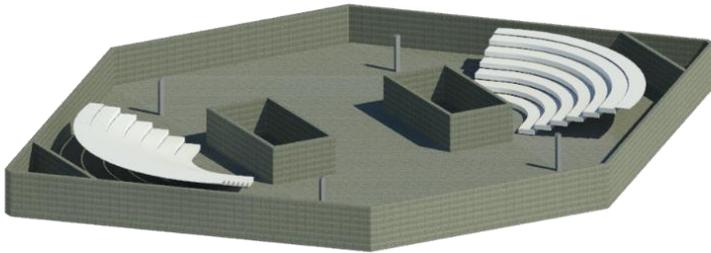


Roof

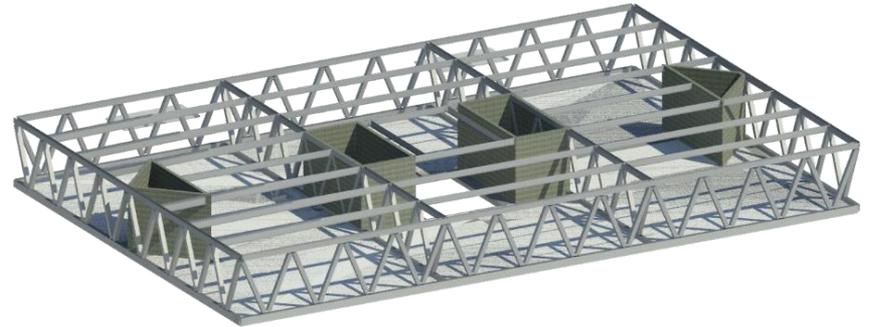


Steel

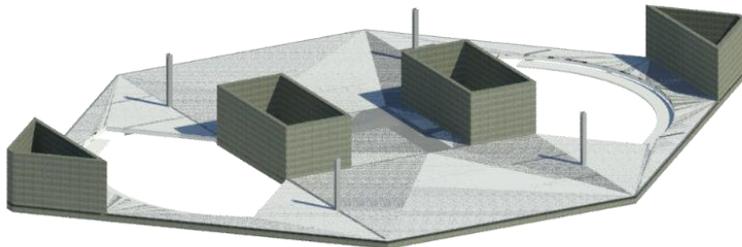
Basement



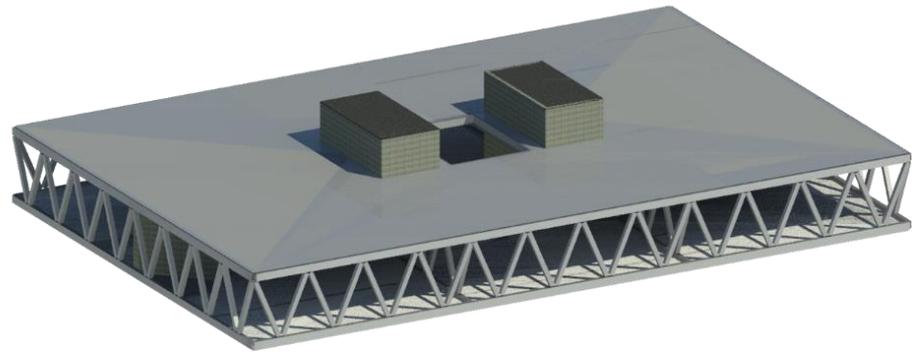
1st Floor



Ground Floor

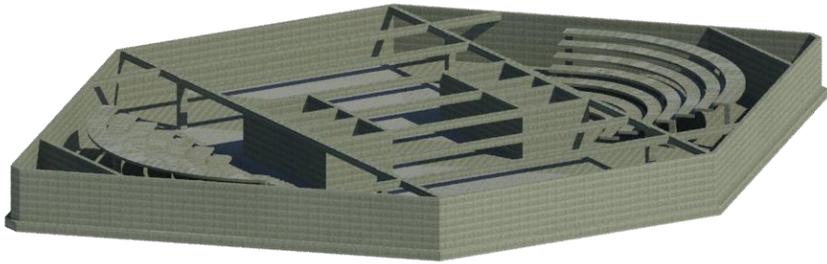


Roof

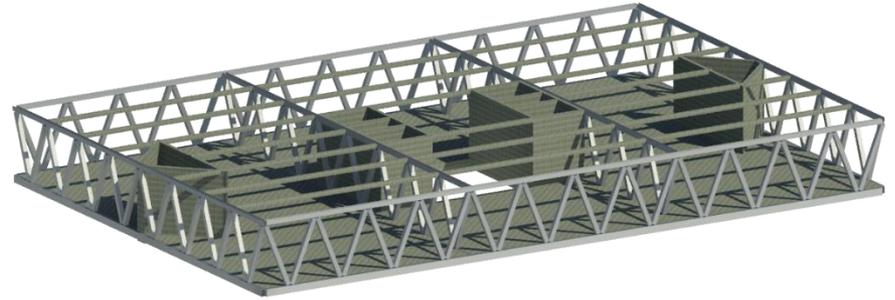


Concrete

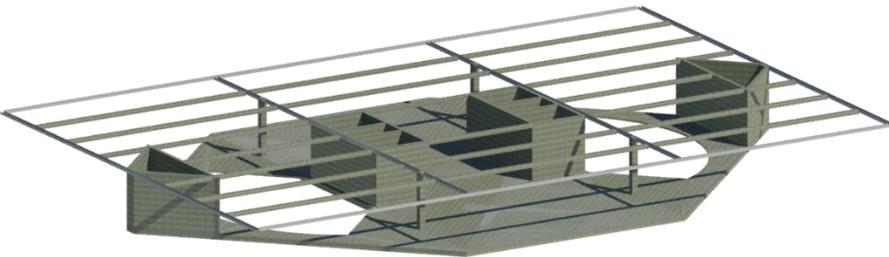
Basement



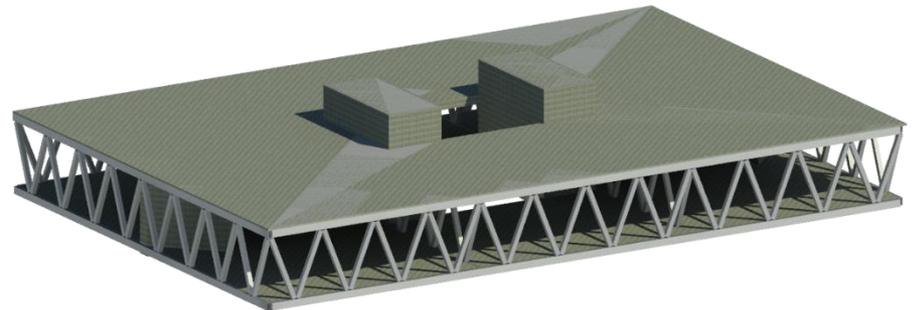
1st Floor



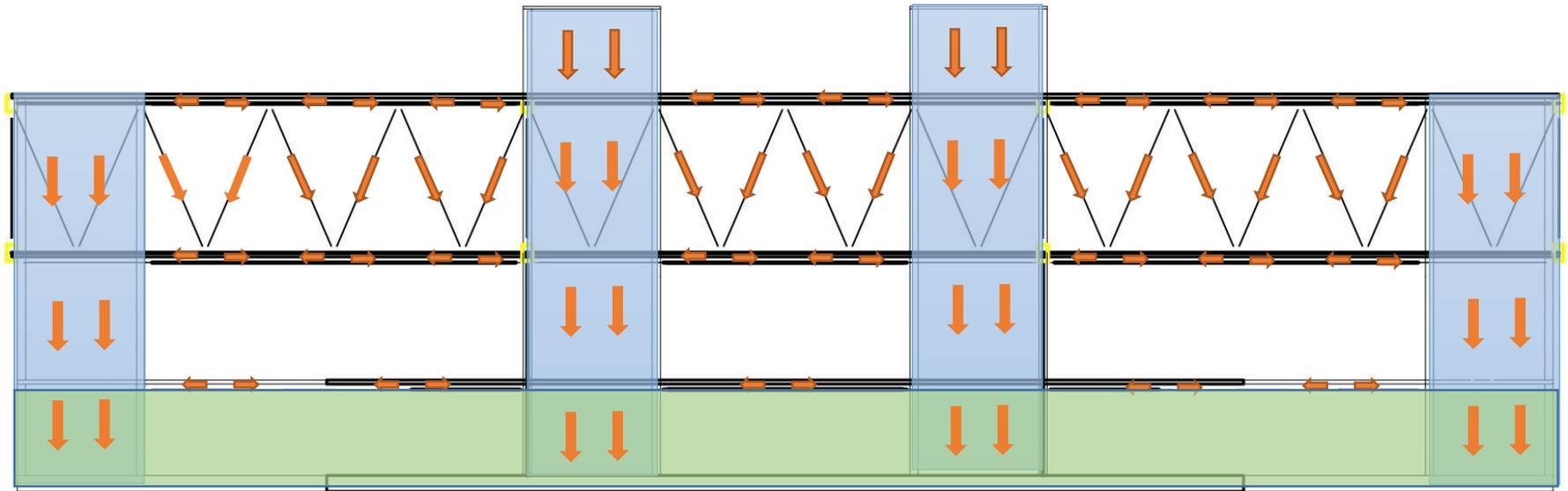
Ground Floor



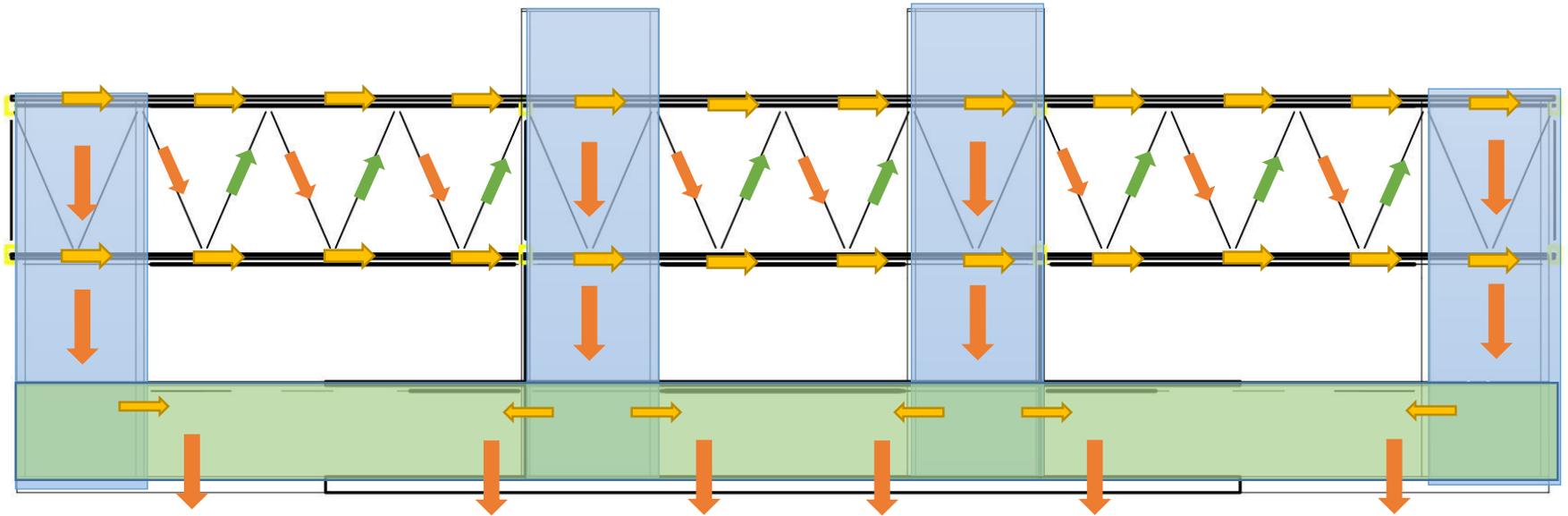
Roof



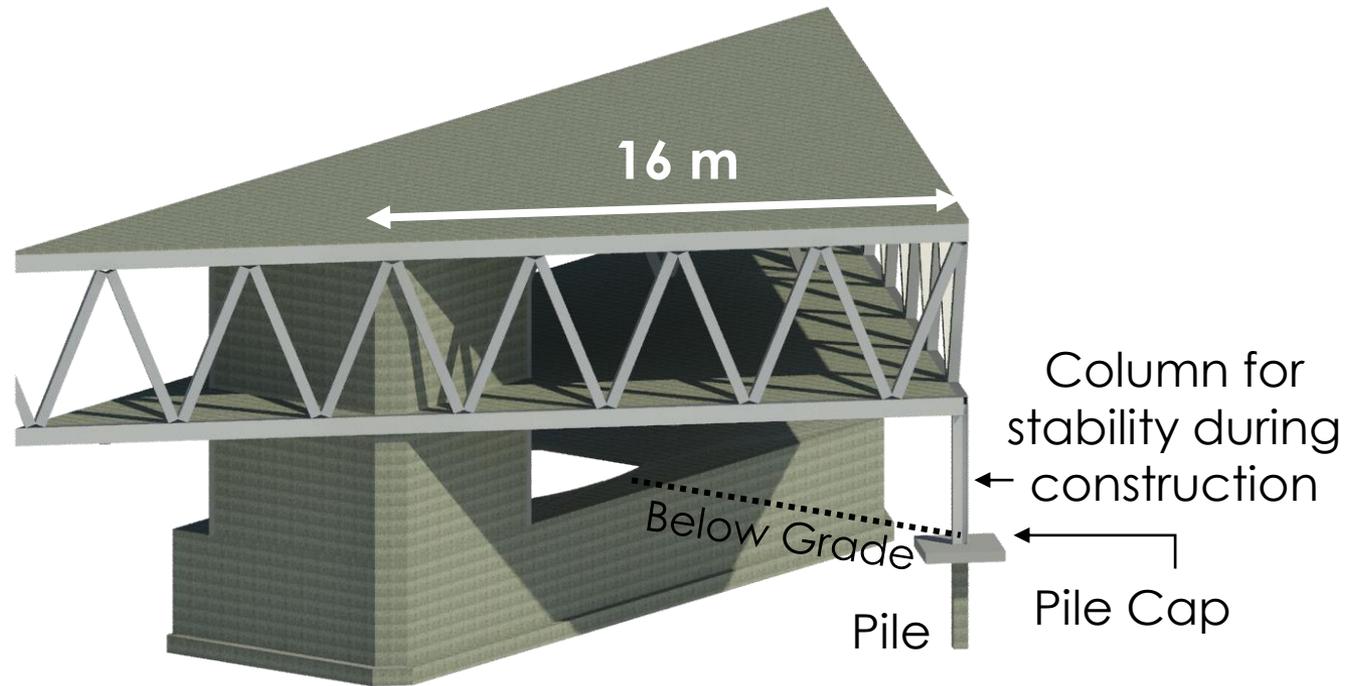
Gravity Load Path



Lateral Load Path



Key Coordination



Zero Waste: Find use for columns after construction to prevent waste

MEP

Zero building strategies

Building envelope

| HEAT TRANSFER COEFFICIENT | | |
|---------------------------|----------------------|-----|
| External wall | [W/m ² K] | 0,1 |
| Slab on ground | [W/m ² K] | 0,4 |
| Roof | [W/m ² K] | 0,1 |
| Glazing | [W/m ² K] | 0,8 |

- Renewable energy sources
- Well insulated and tight
- Highest efficiency of appliances

Other requirements

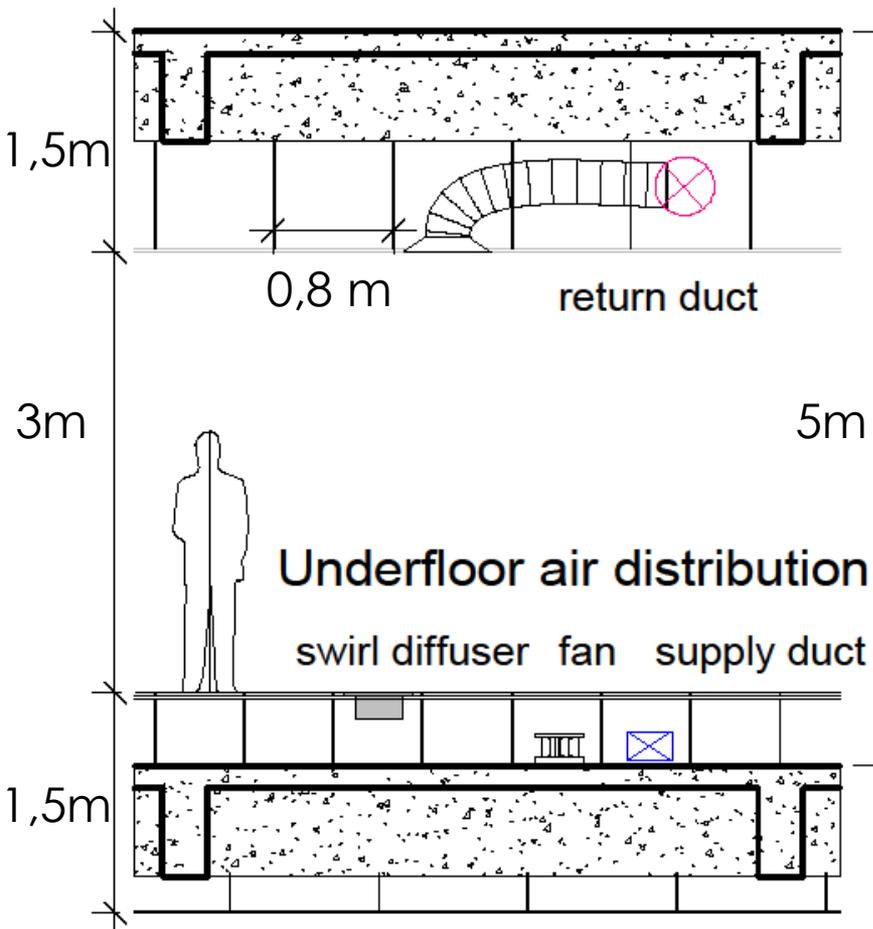
| | | |
|------------------|------------------------------------|-----|
| Daylight factor | [%] | 2 |
| Infiltration | [m ³ /m ² h] | 1,8 |
| Ventilation rate | [L/sm ²] | 0,3 |

| Solar heat gain coefficient | |
|-----------------------------|-----|
| Glazing | 0,5 |



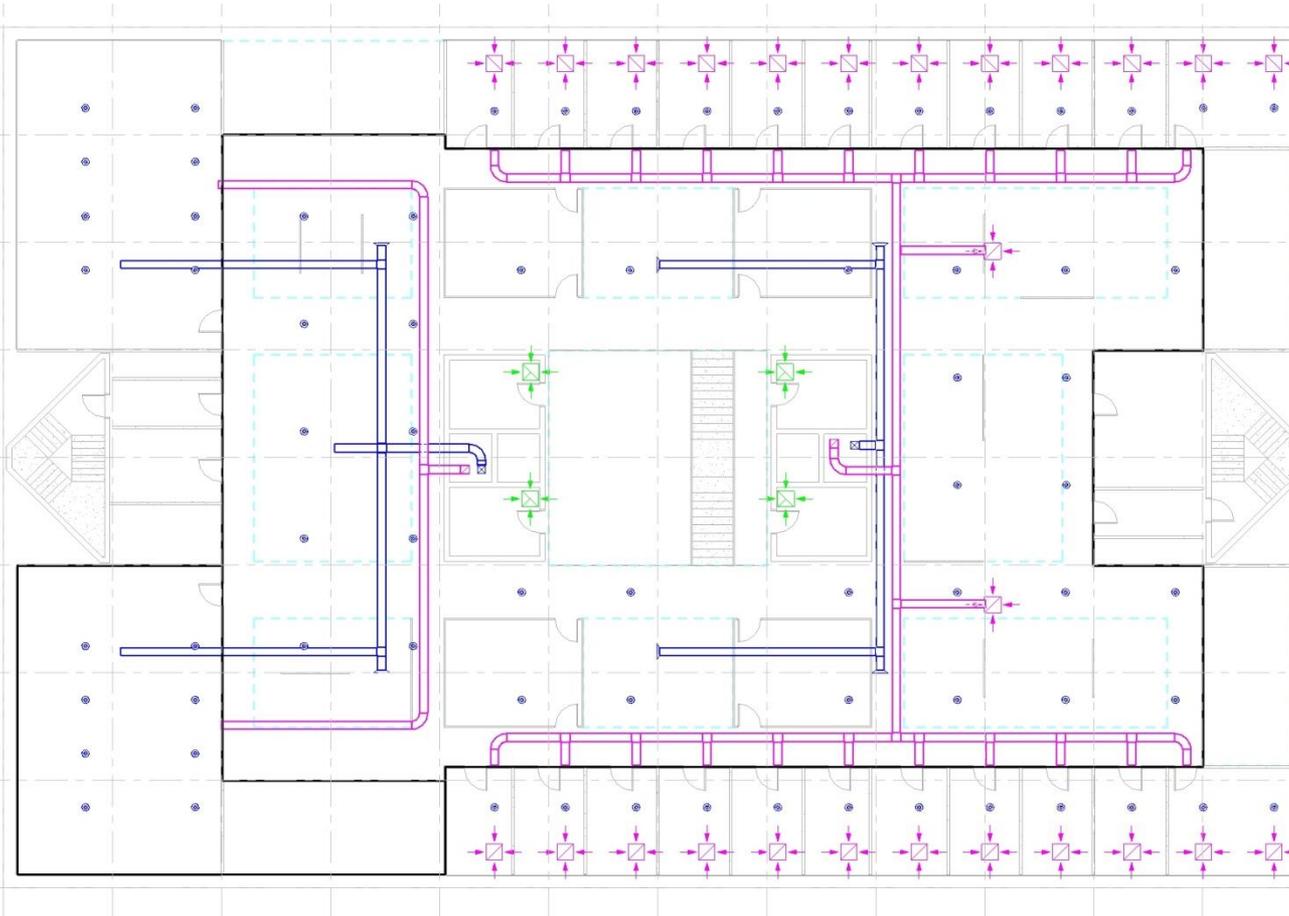
2020

Options



| | Option 1 | Option 2 |
|-----------------|---|---------------------|
| Primary | AHU with Economizer | Water-air heat pump |
| User comfort | <ul style="list-style-type: none"> •High •Fast adjustable •Easy to control | |
| Electricity use | high | low |
| Initial cost | low | high |

Distribution



Under floor air distribution

Open space:

- Ducted return

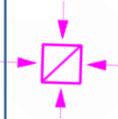
Offices and laboratories:

- Plenum return

*MEP room on the roof

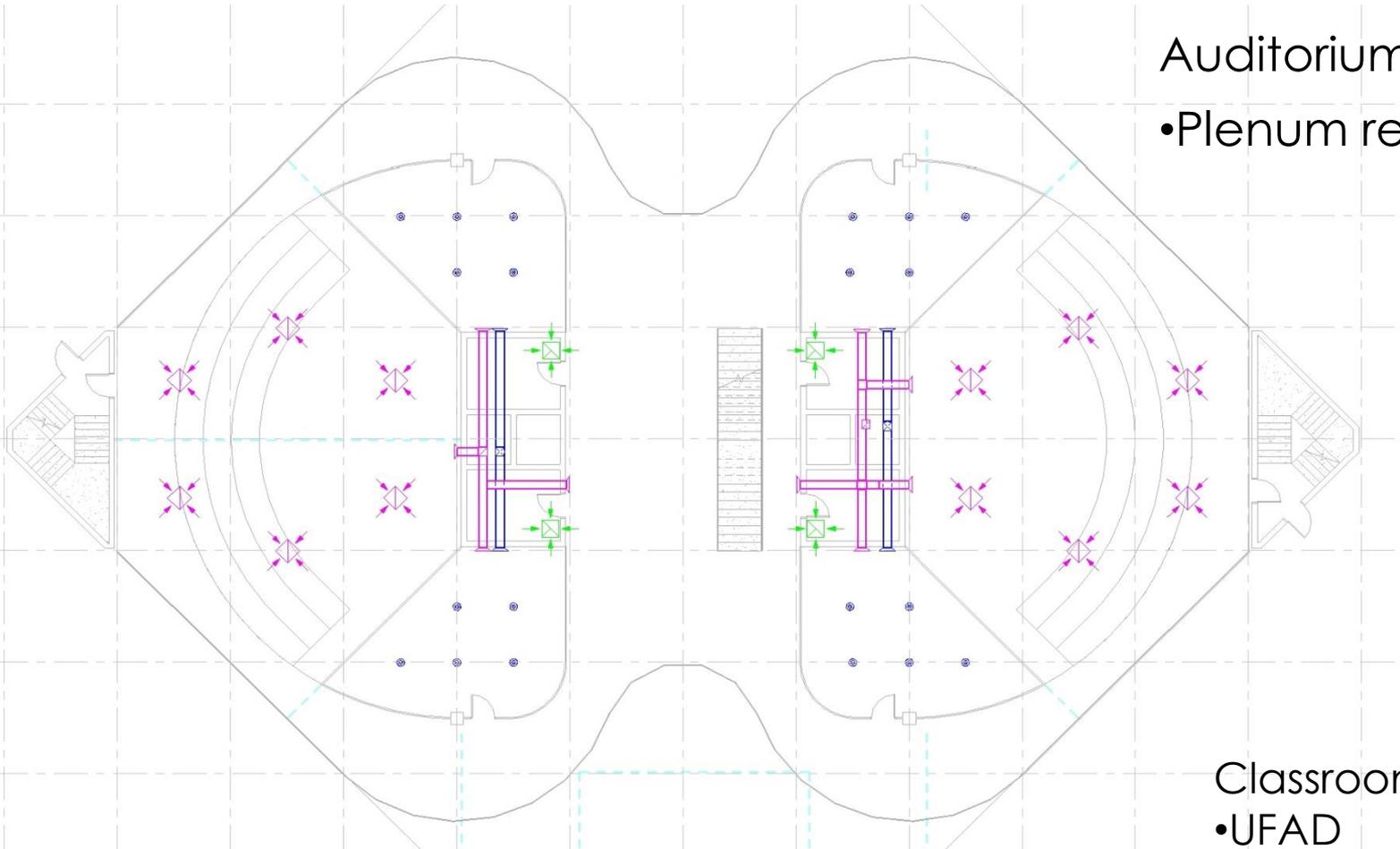


Supply diffusers



Return terminal

Distribution



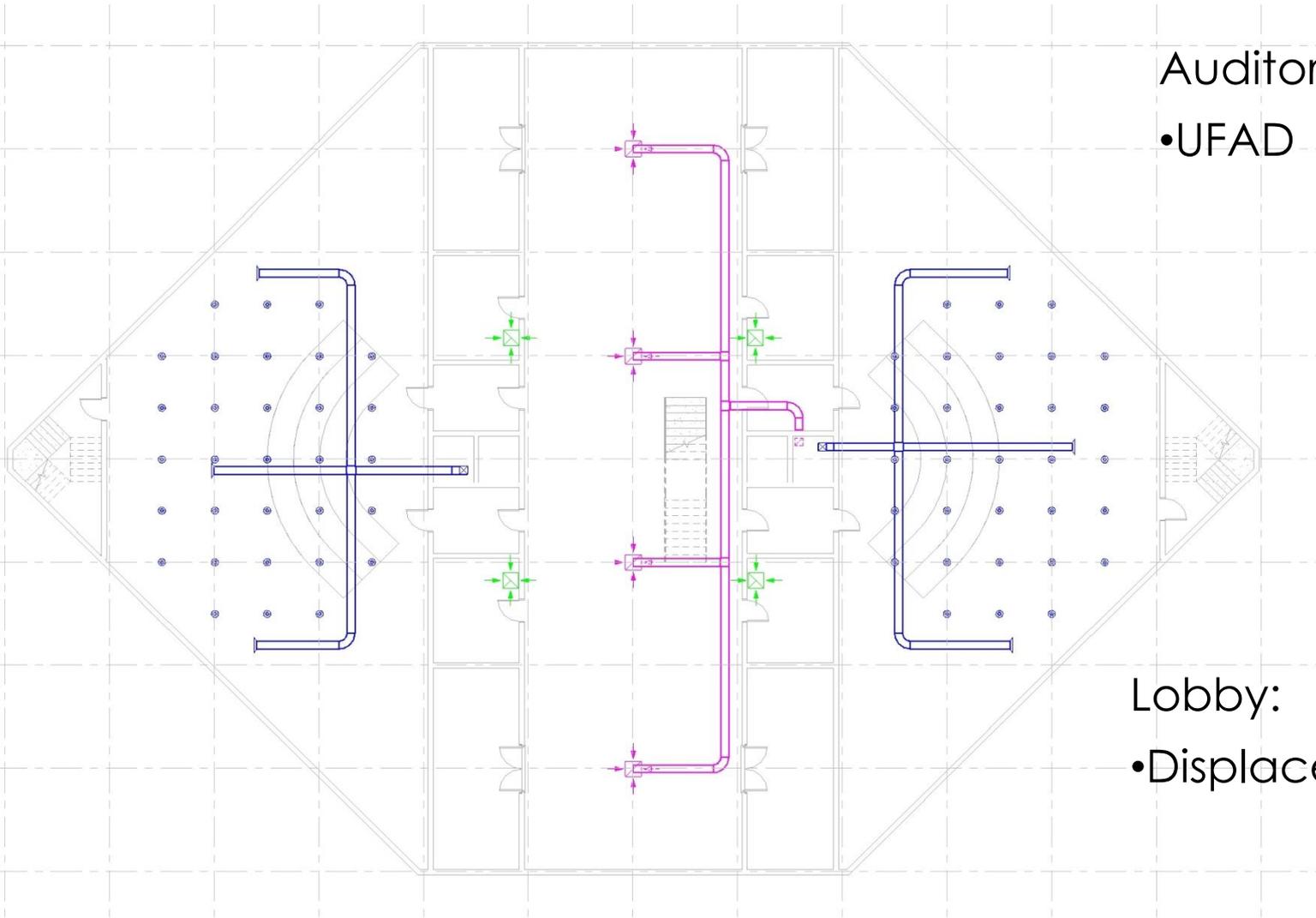
Auditoriums :

- Plenum return system

Classrooms:

- UFAD
- Displacement return

Distribution



Auditorium:

- UFAD

Lobby:

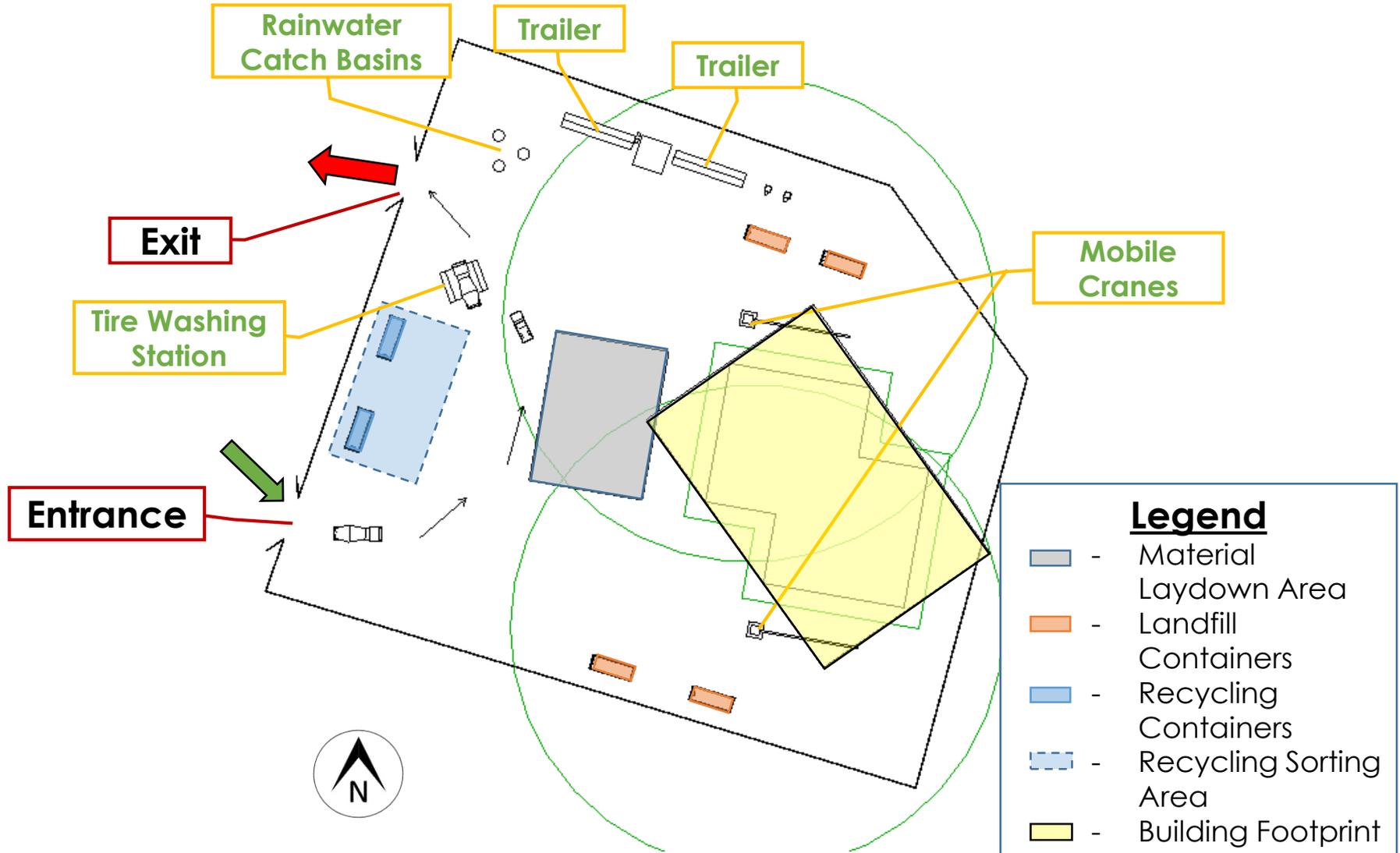
- Displacement return

CONSTRUCTION MANAGEMENT

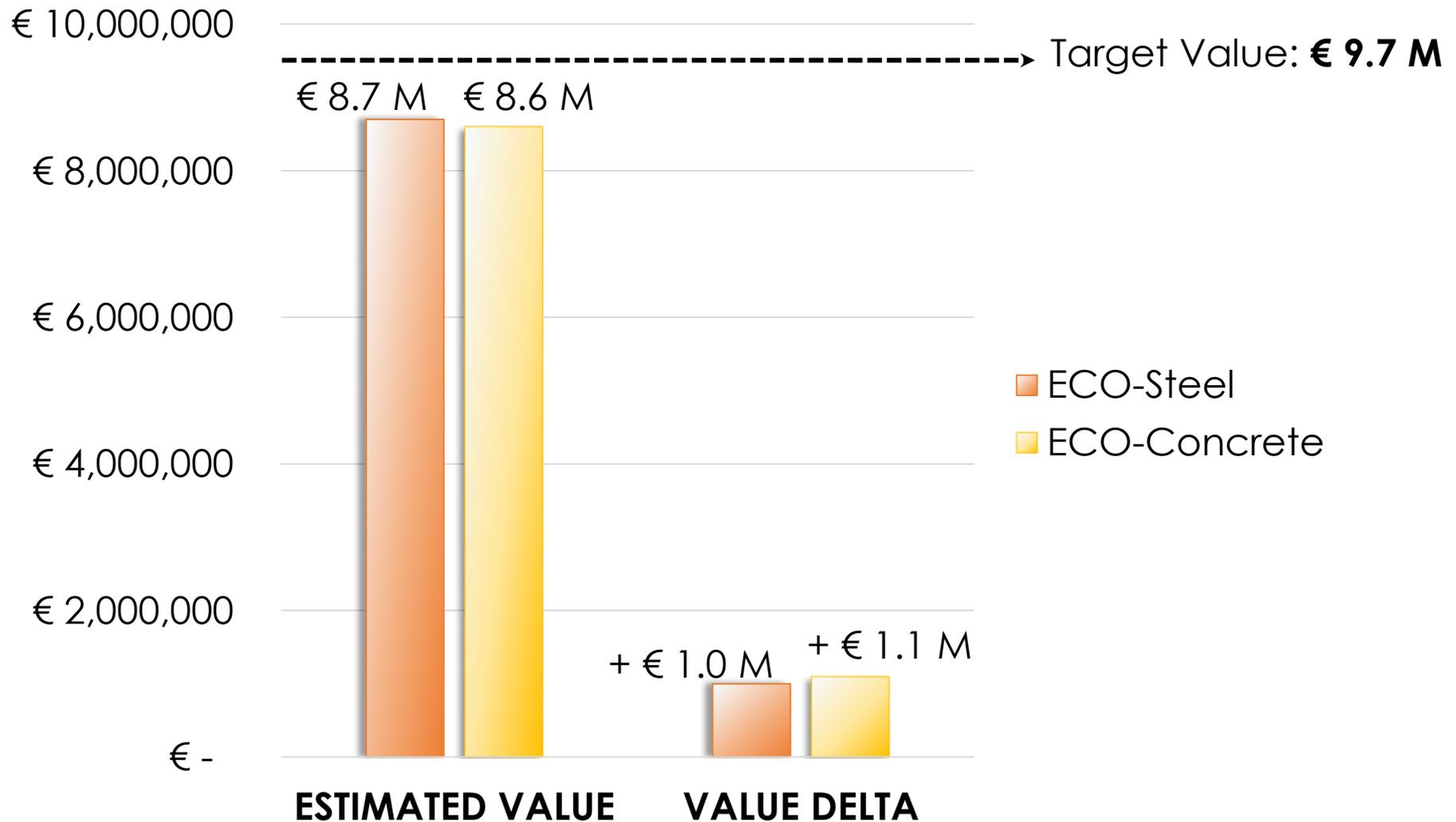
Site Plan Overview



Detailed Site Plan

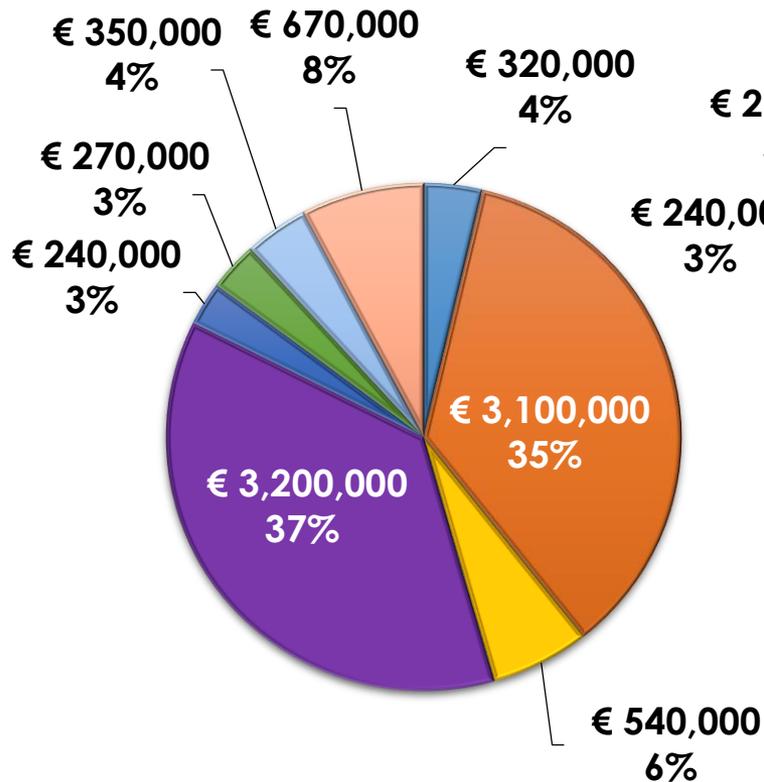


Total Cost Comparison

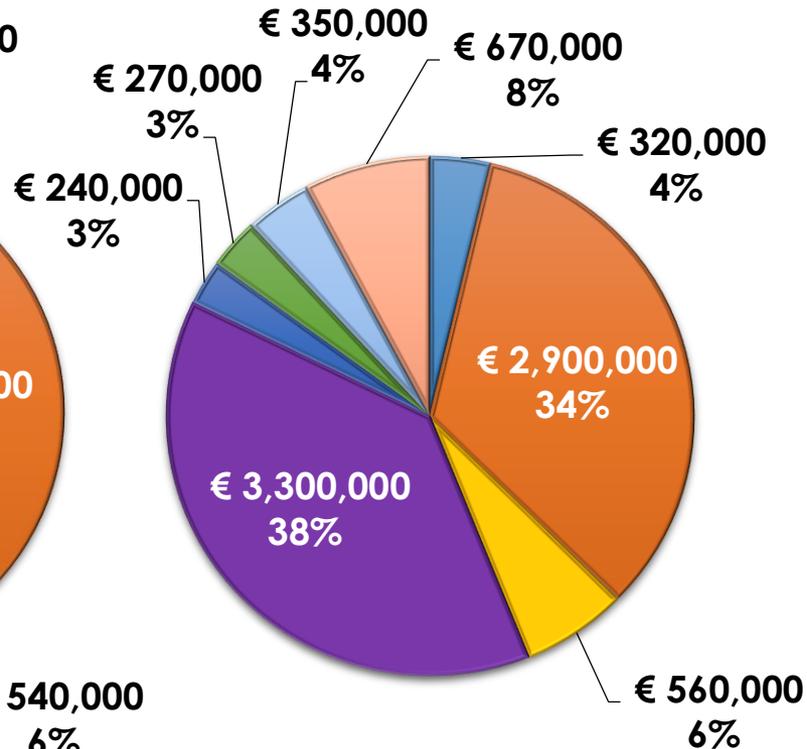


Cost Breakdown Comparison

ECO-Steel

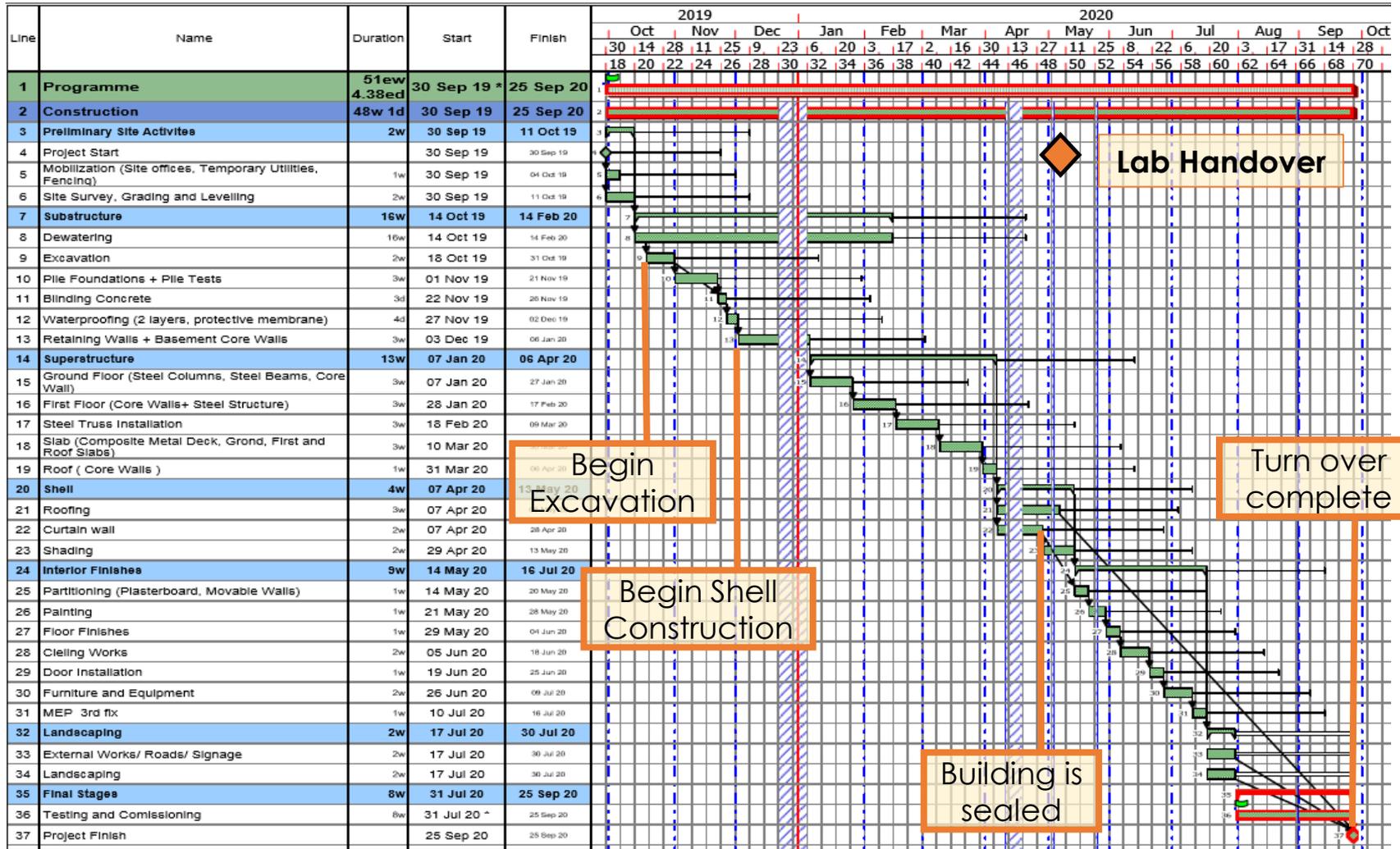


ECO-Concrete



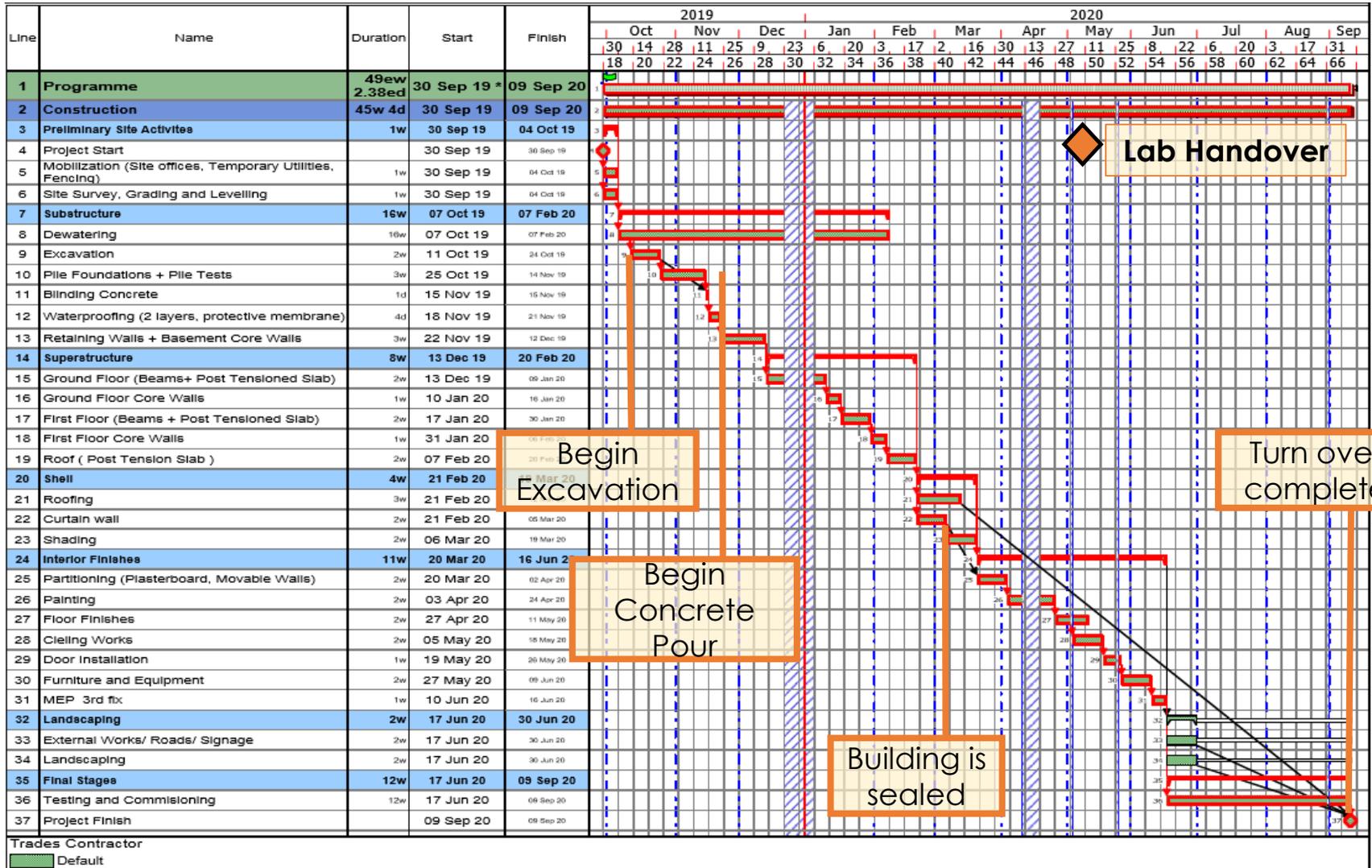
- A Substructure
- B Shell
- C Interiors
- D Services
- E Equipment and Furnishing
- F Specialty Construction
- G Building Sitework
- H General Conditions

Steel

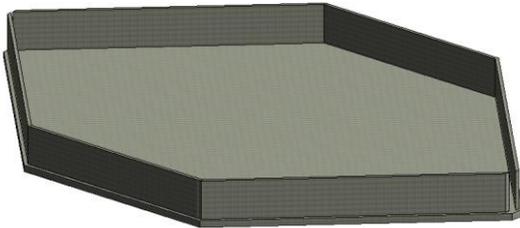


Trades Contractor
 Default

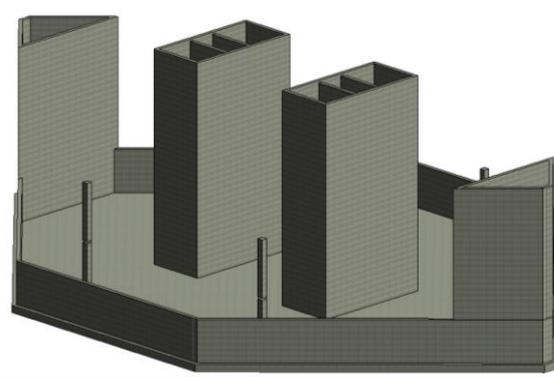
Concrete



Milestones

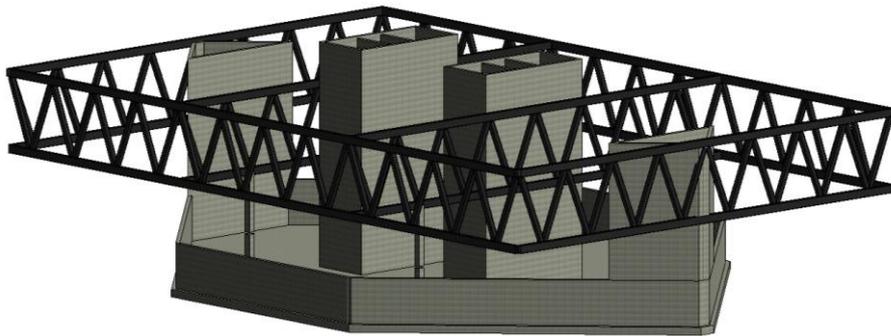


1. Seal Basement
[6-Jan-20/6-Jan-20]

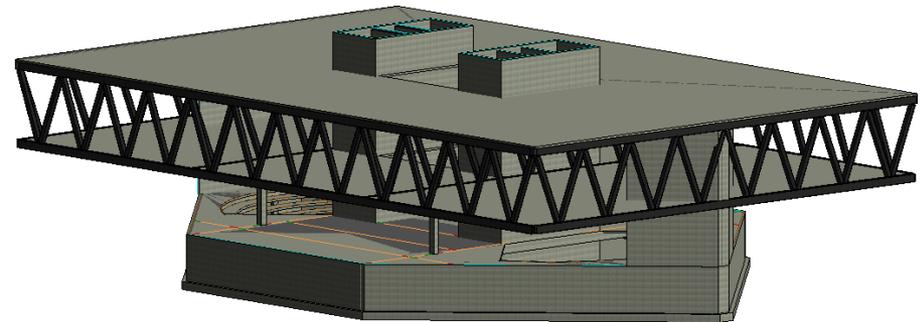


2. Place Support Columns/Shear Walls
[27-Jan-20/27-Jan-20]

Milestone Date
[xxx] – Steel
[xxx] – Concrete



3. Erect Truss Systems
[9-Mar-20/19-Feb-20]



4. Pour Floor Slabs & Roof
[31-Mar-20/5-Mar-20]

5. Seal Envelope
[28Apr-20/31-Mar-20]

DAY N NIGHT

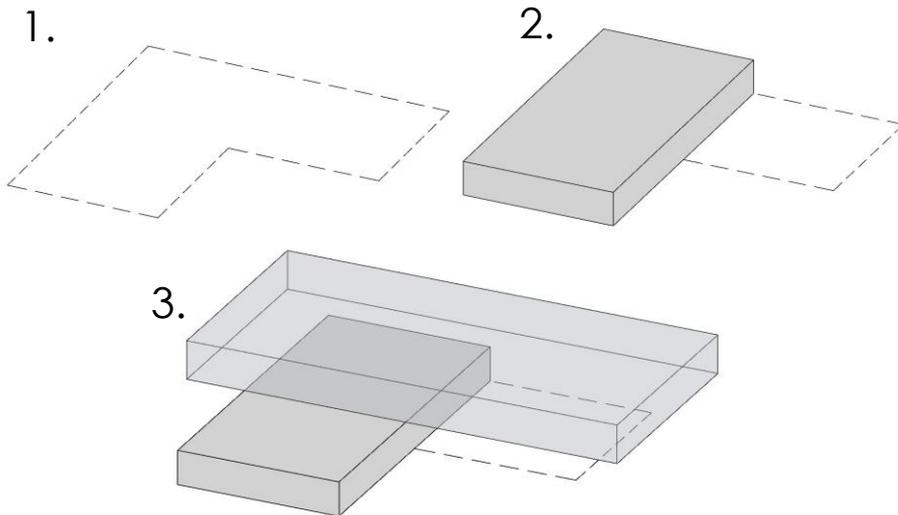
ARCHITECTURE

Day N Night

DAY – 1st Floor

- Light
- Transparent
- Naturally lighted

Terrace above the ground floor volume



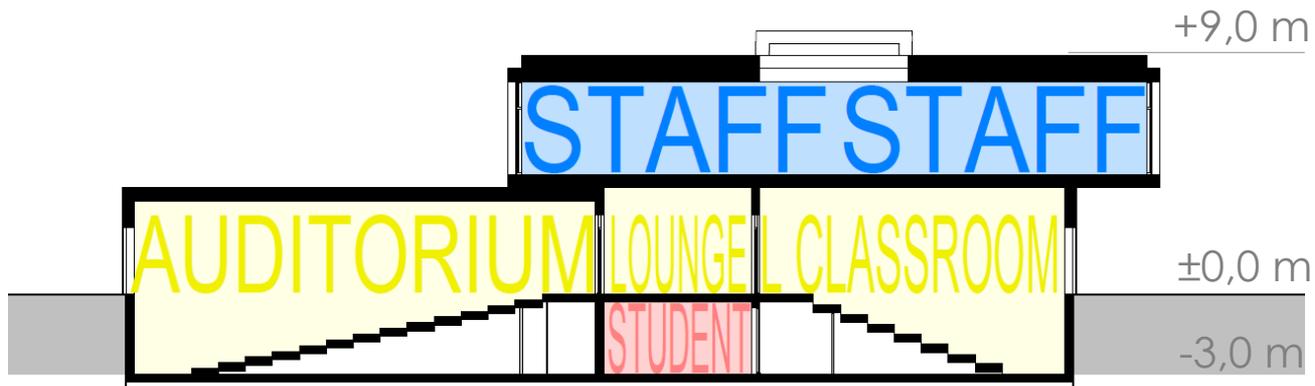
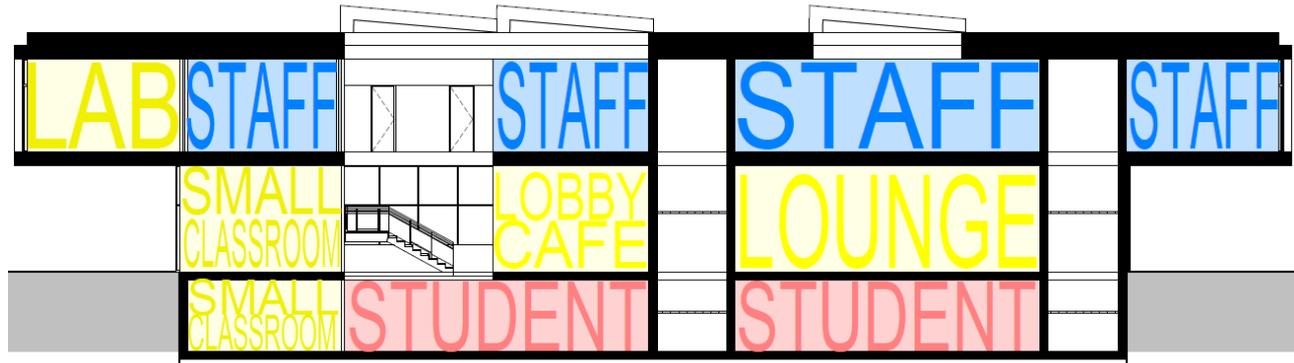
NIGHT – Ground Floor

- Heavy
- Enclosed
- Dark

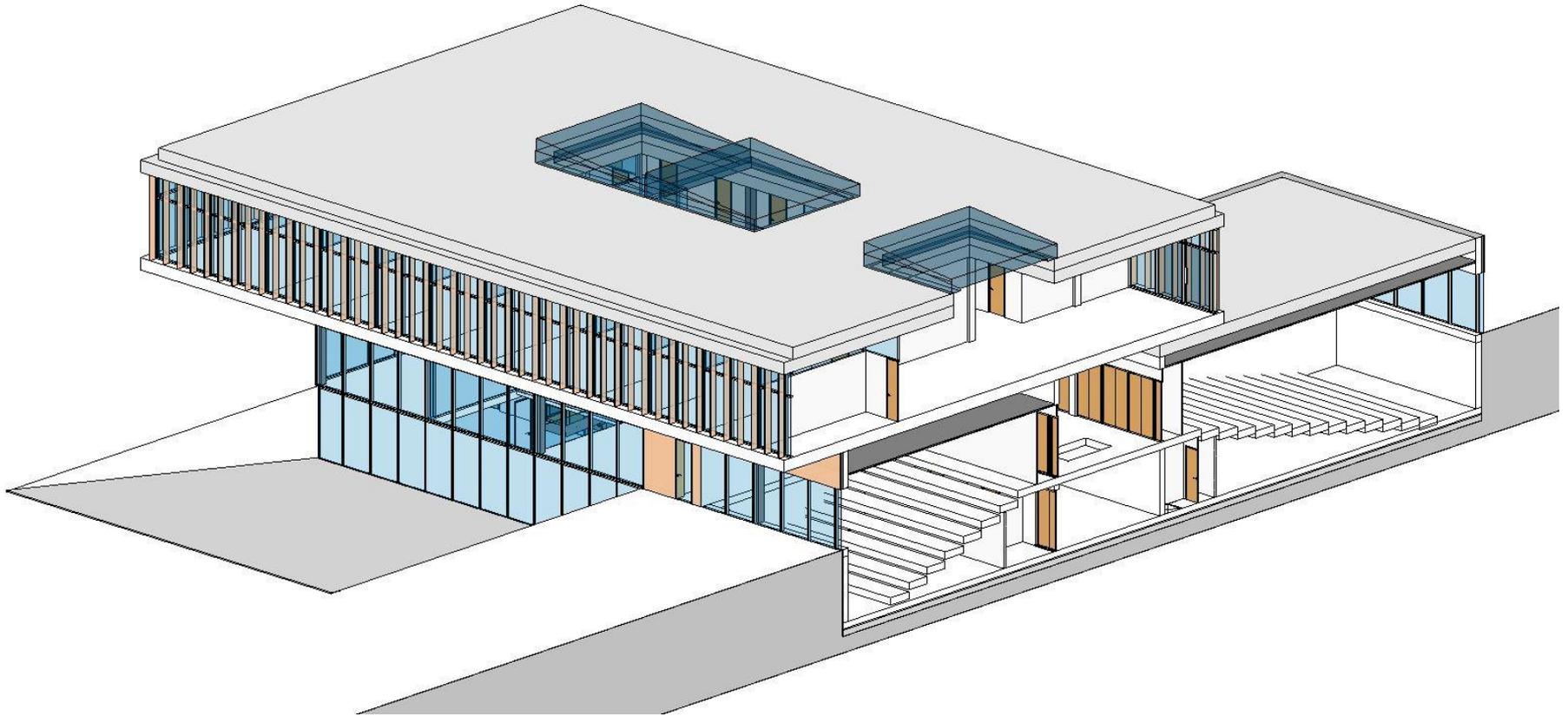
Transparent space under 1st floor volume



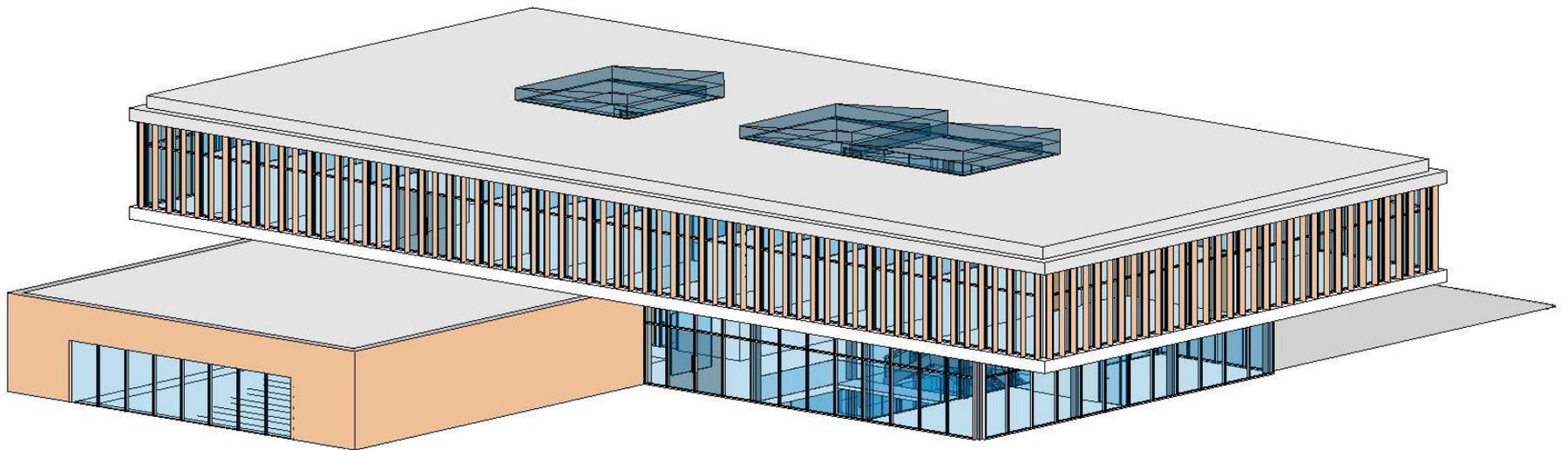
Program Distribution



Cross Section



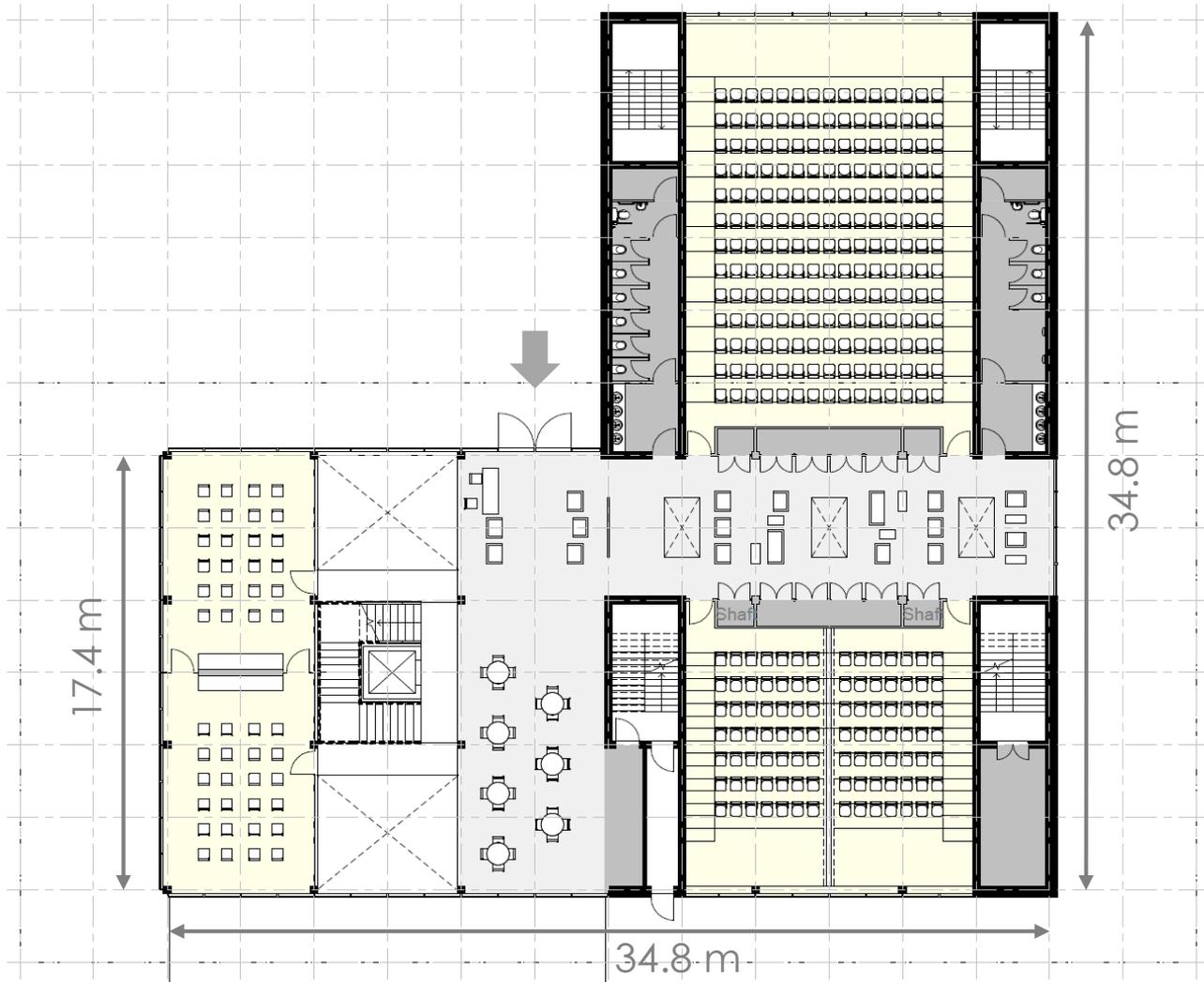
3d View



Site Plan



Ground Floor



Mix Use

- Auditorium
- L Classrooms
- S Classrooms
- Lobby
- Cafe
- Reception

Services

- Restroom
- MEP Shaft
- Storage

Grid: 2,9 x 2,9 m

Lobby & Cafe



1st Floor



Mix Use

Labs

Faculty

Seminar

Office

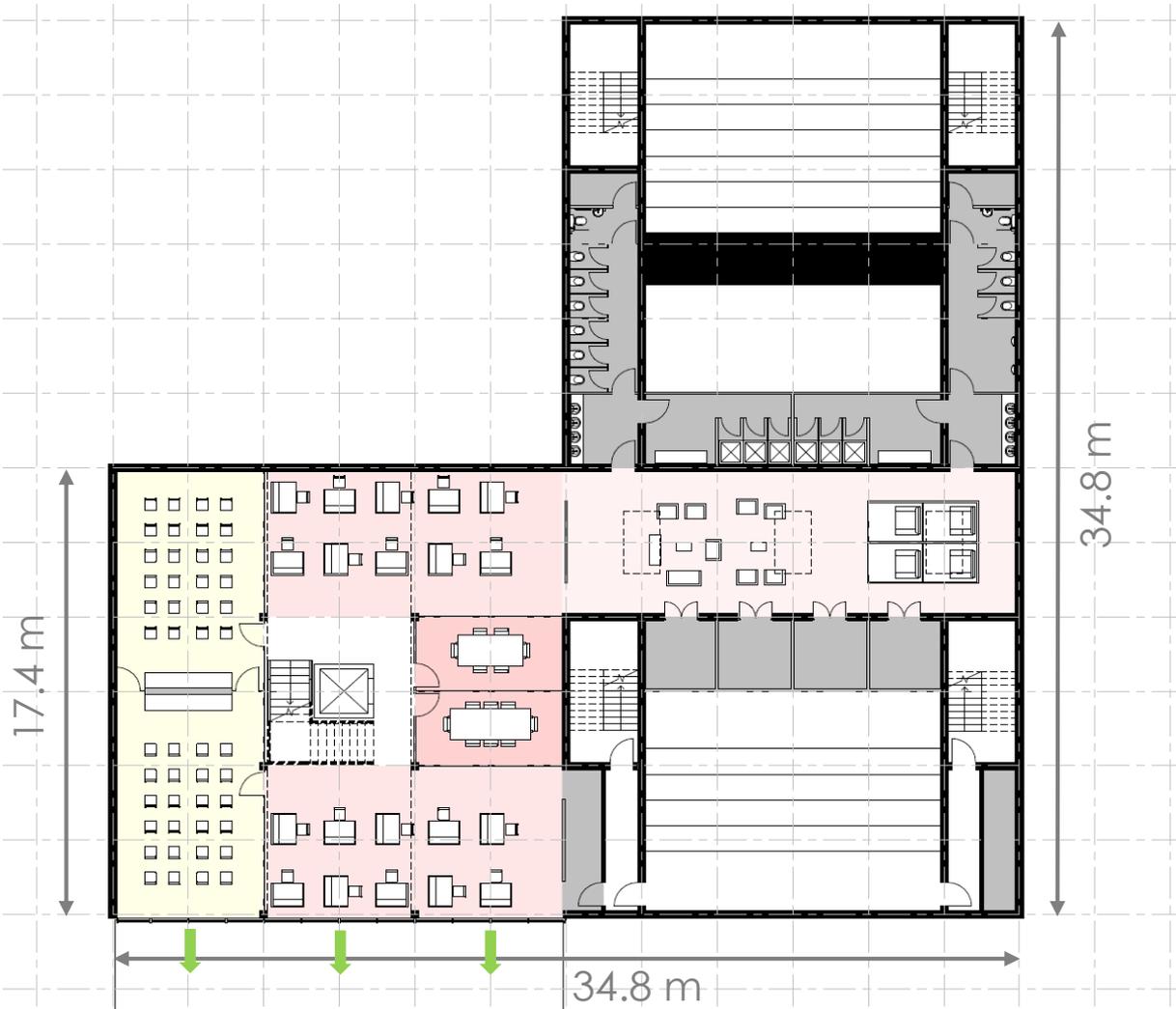
Lounge

Services

Restroom
MEP Shaft
Storage

Grid: 2,9 x 2,9 m

Basement



Mix Use

S Classroom

Students

Seminar
Office
Lounge

Services

Restroom
MEP Shaft
Storage
Showers

Grid: 2,9 x 2,9 m

External Shading



Winter 2017

Express

A

References

74

Entrance / East Facade



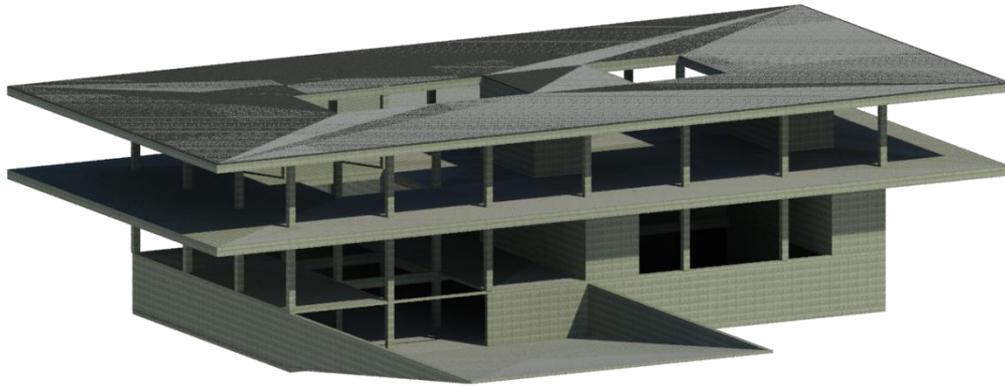
Entrance Square



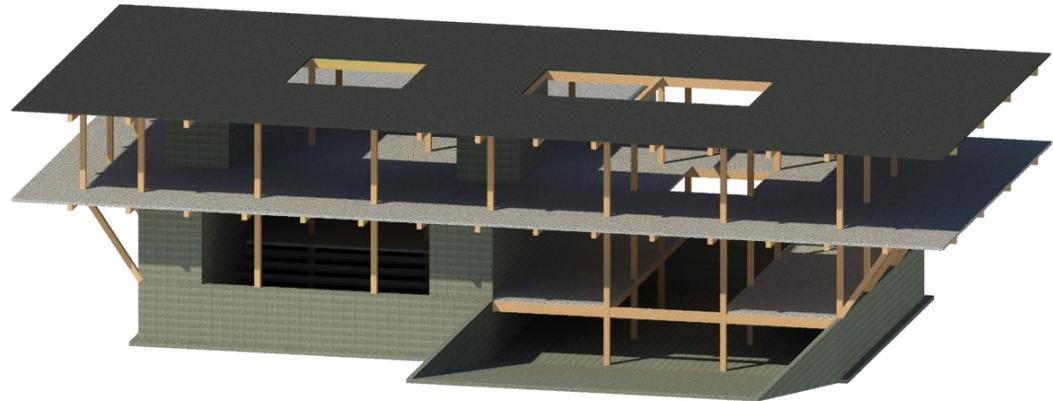
STRUCTURE

Structural Alternatives

Concrete



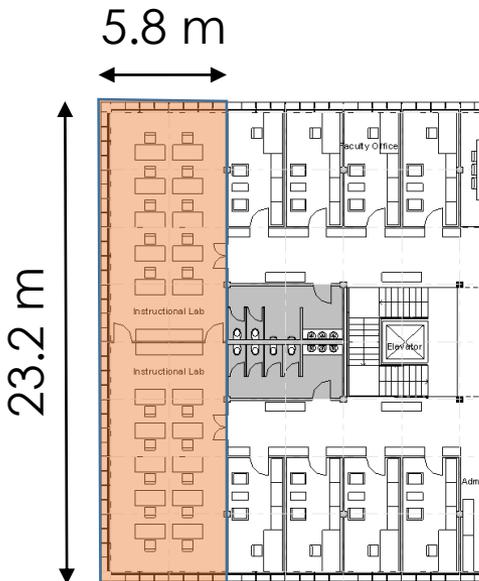
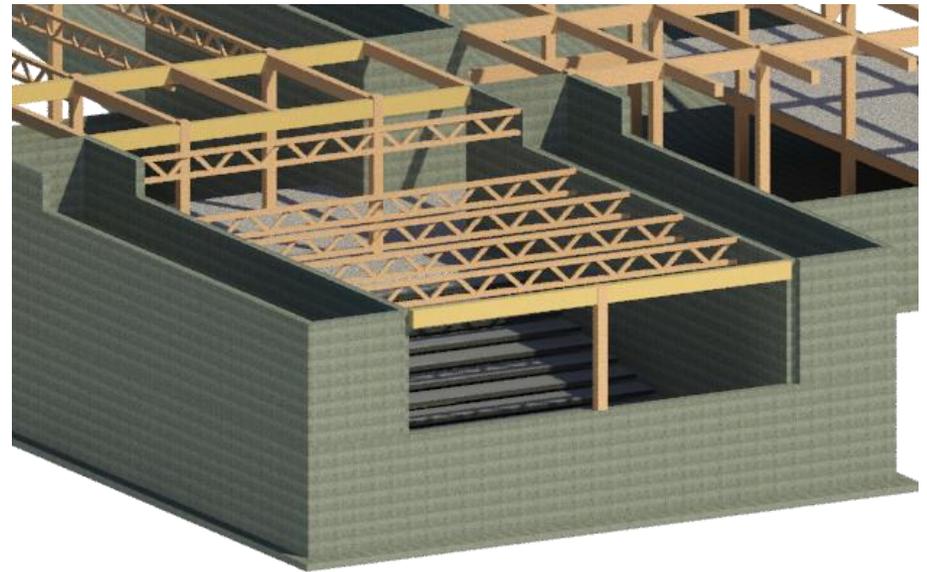
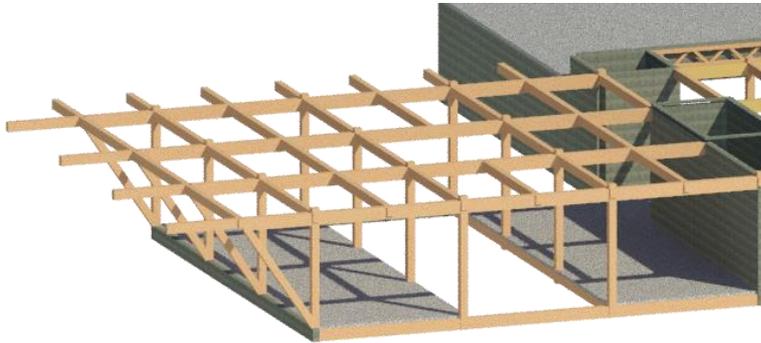
Timber



Timber Design

Cantilevers

Long Spans

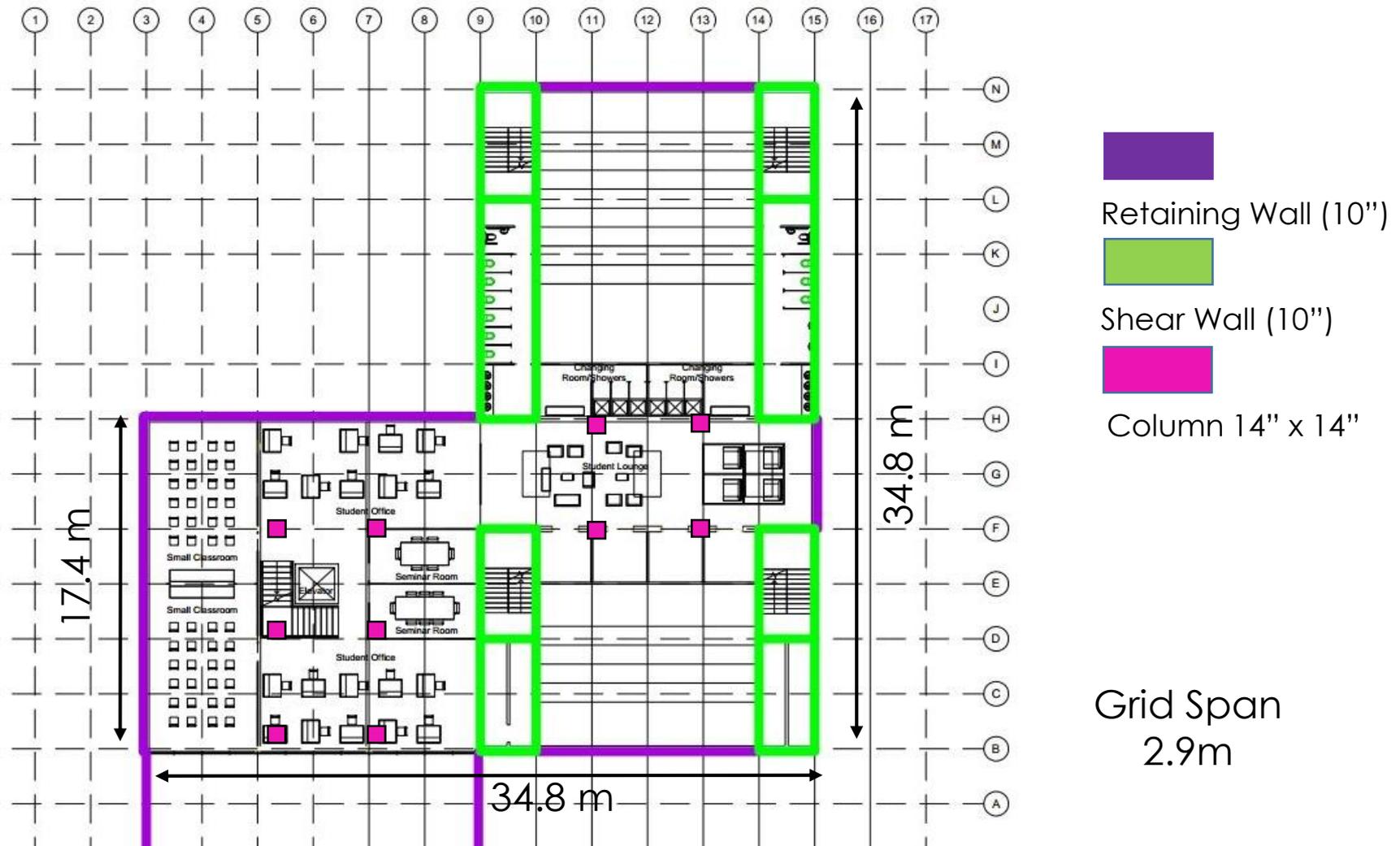


Slanted columns cut cantilever in half

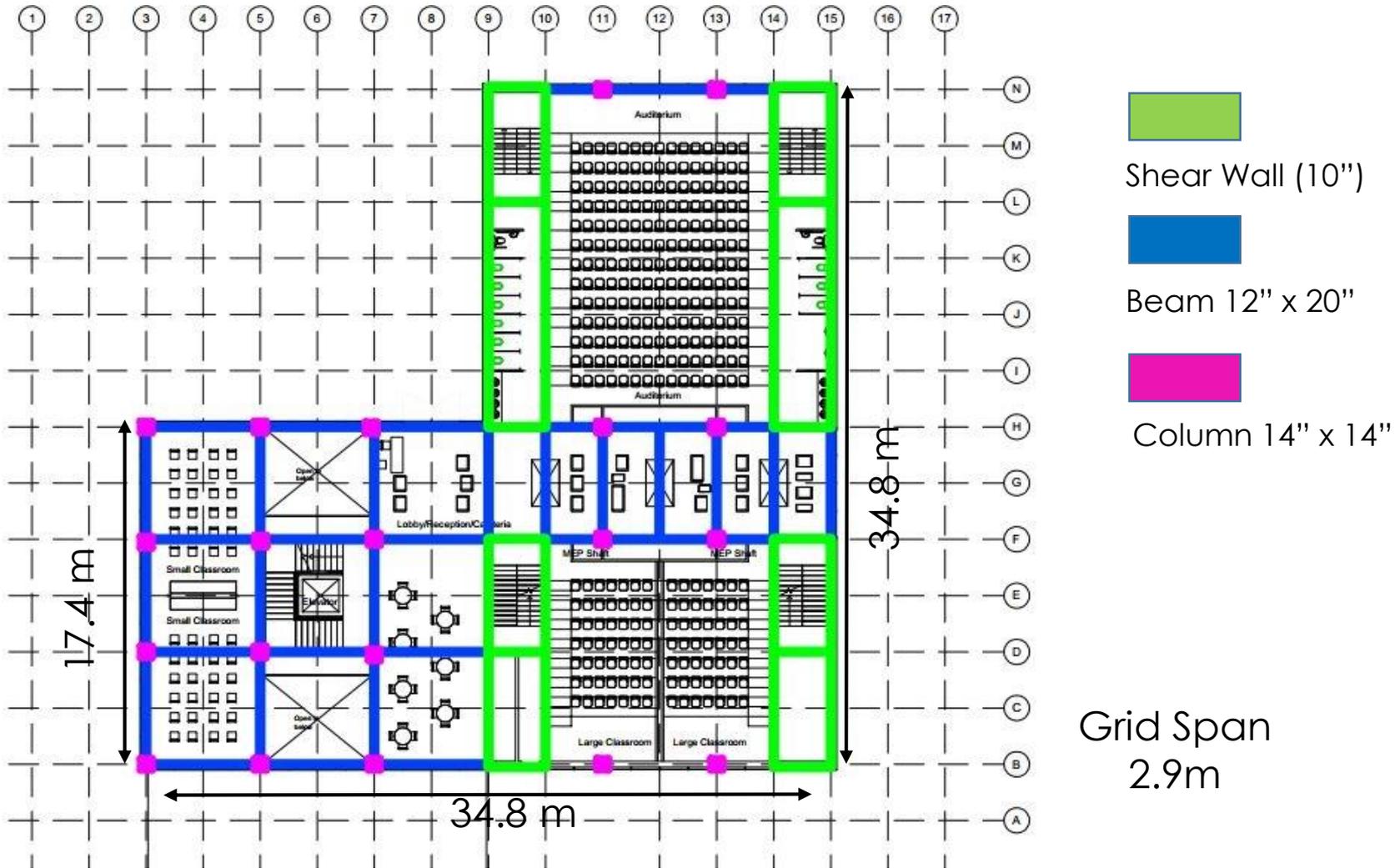
Lightweight roof

BauBuche Lattice Girders

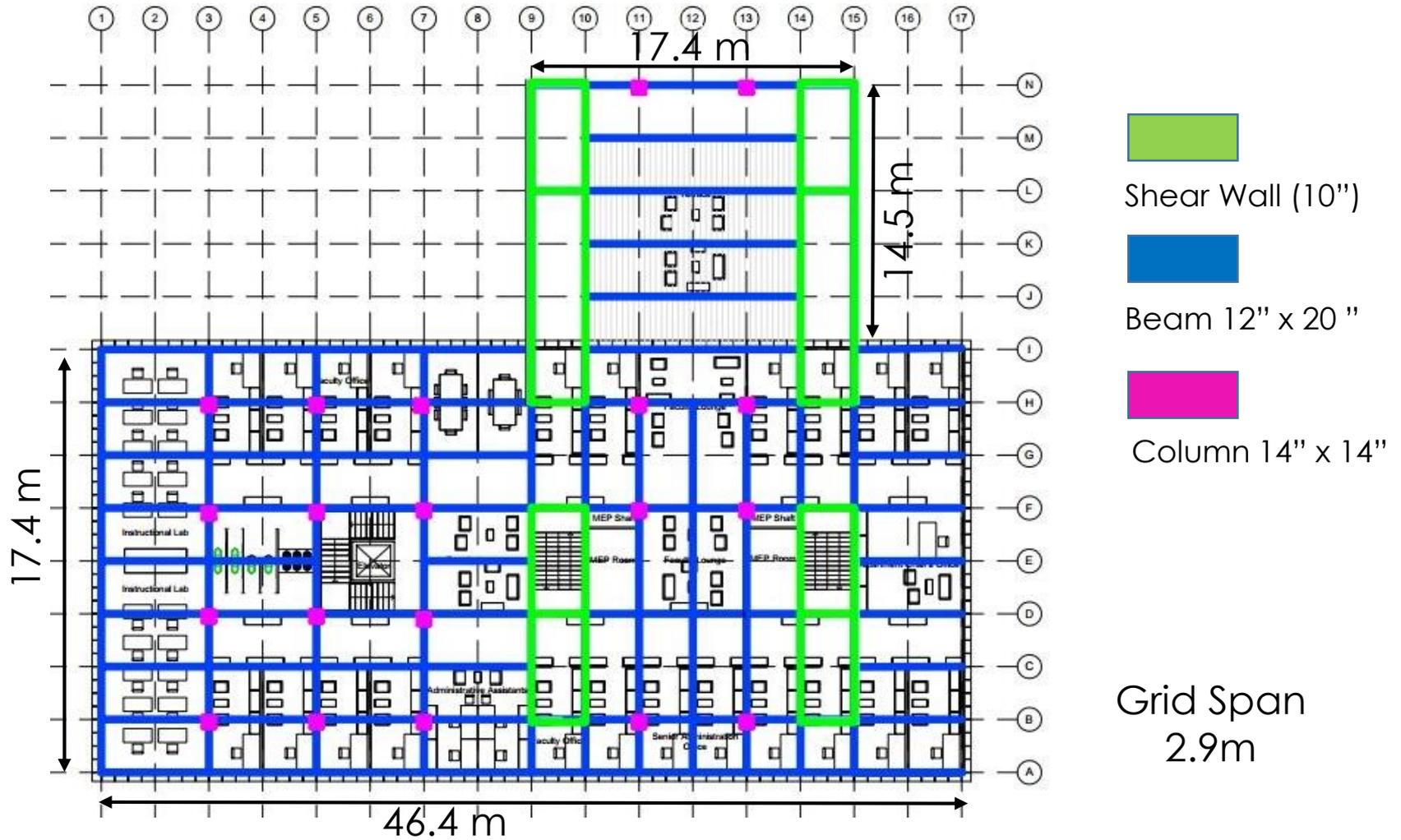
Basement - Concrete



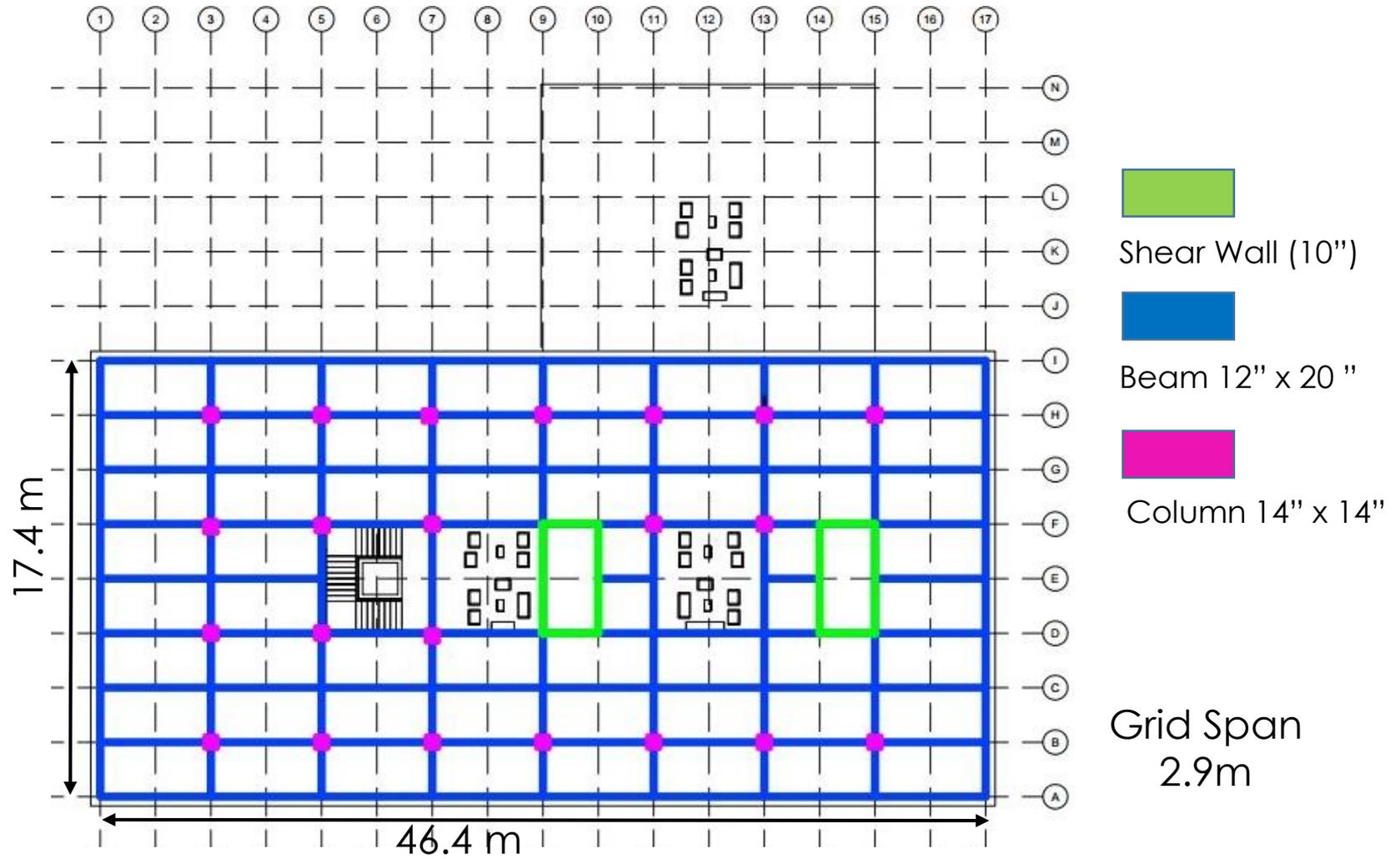
Ground Floor - Concrete



First Floor - Concrete

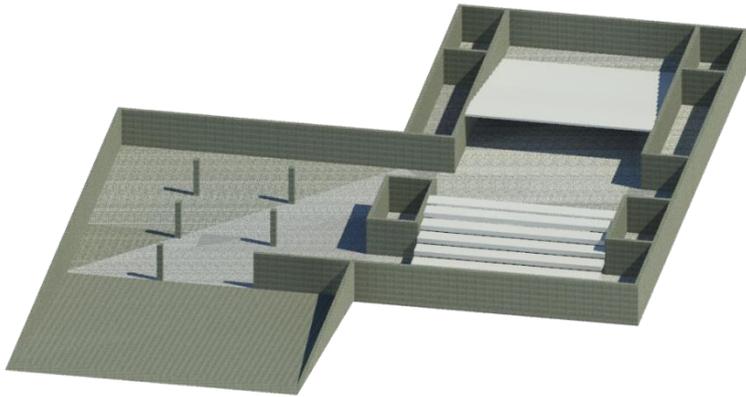


Roof - Concrete

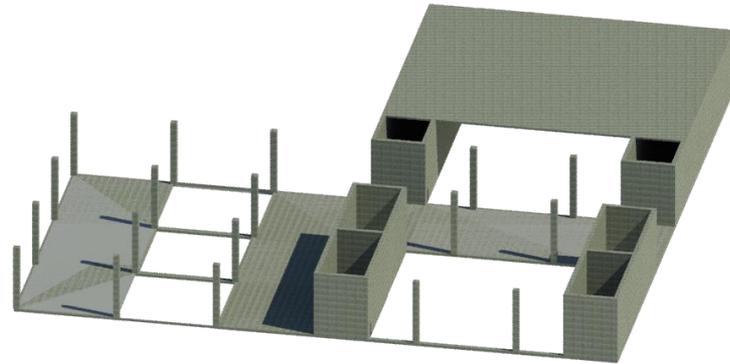


Concrete

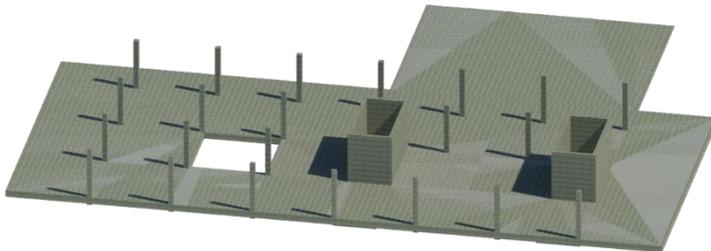
Basement



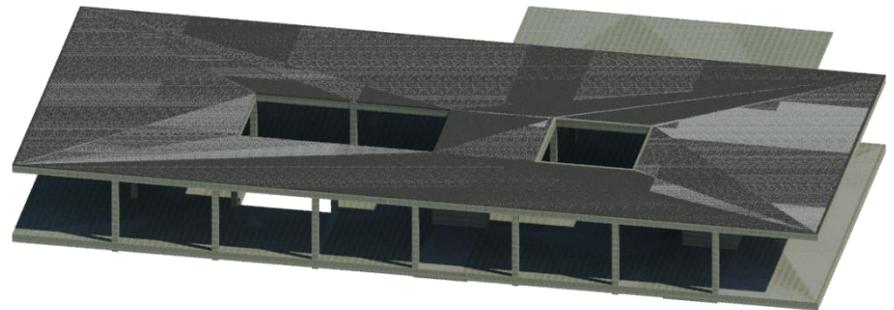
1st Floor



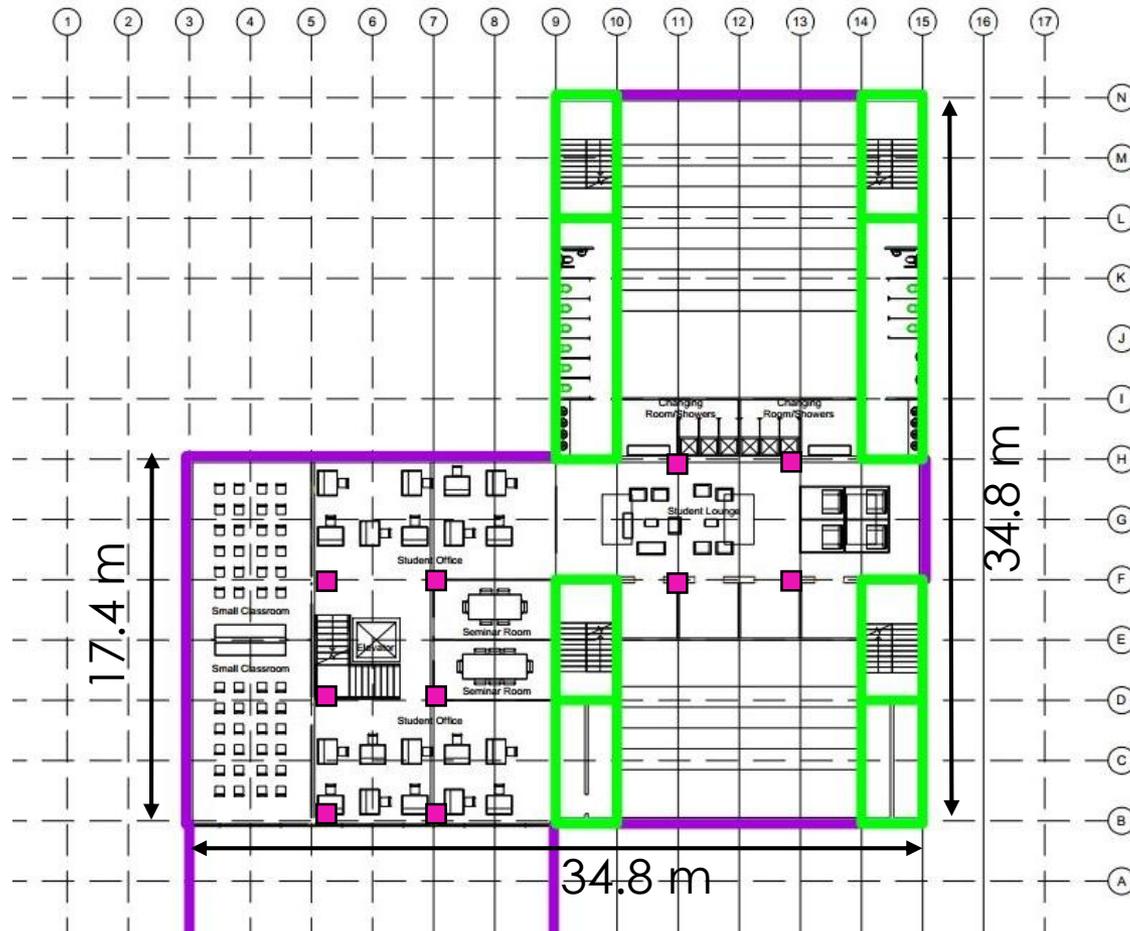
Ground Floor



Roof



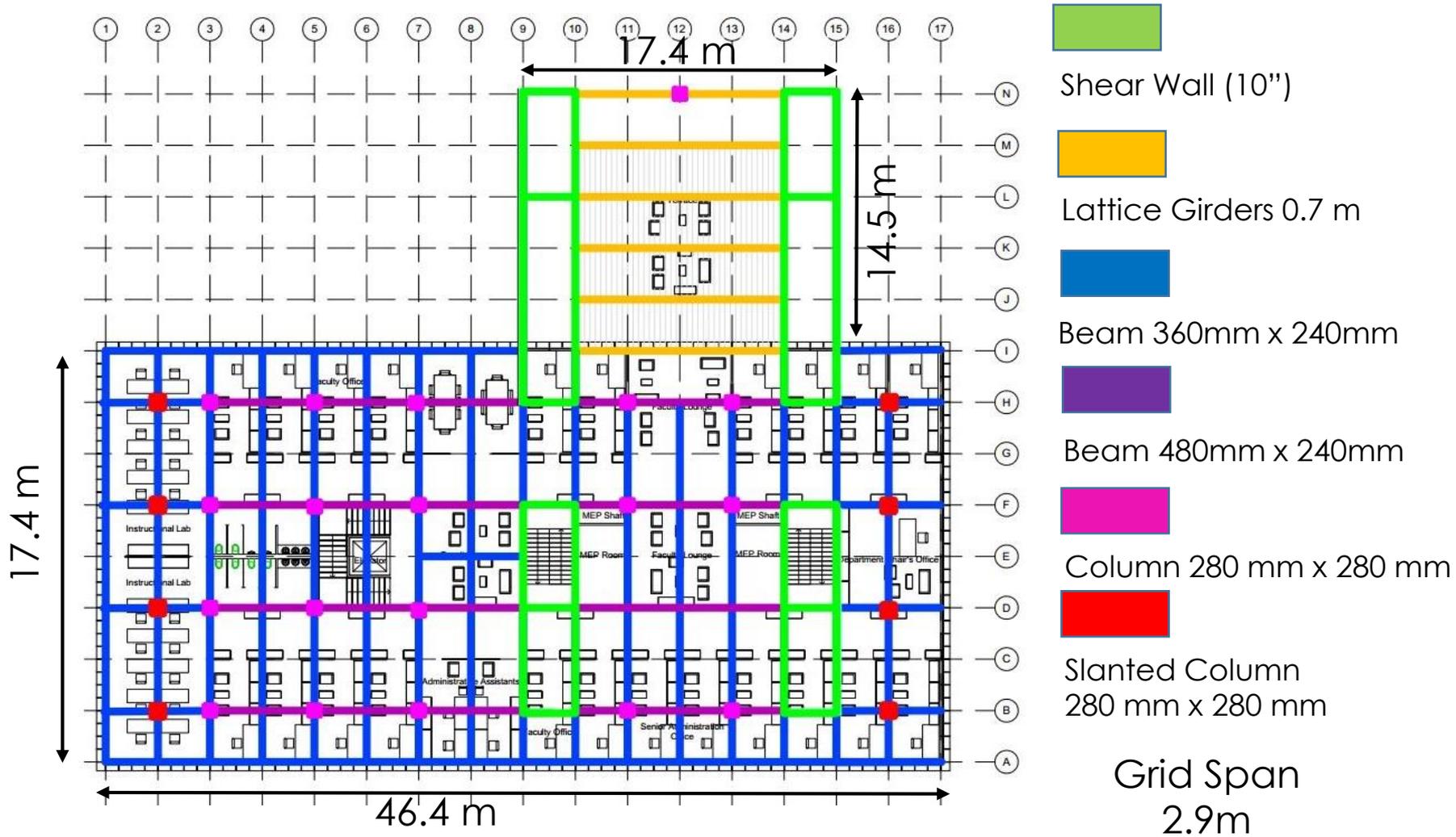
Basement - Timber



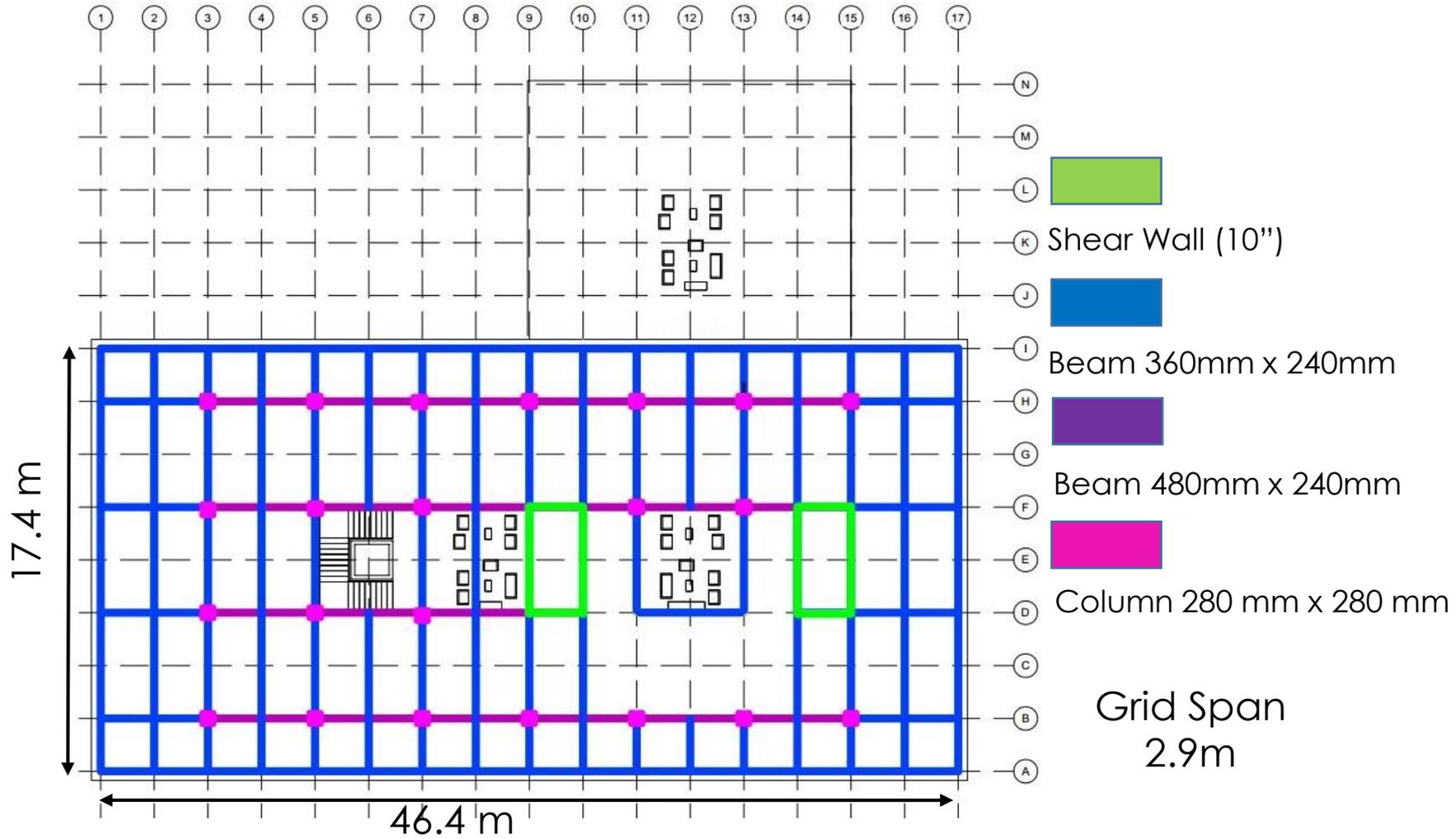
-  Retaining Wall (10")
-  Shear Wall (10")
-  Column 280 mm x 280 mm

Grid Span
2.9m

First Floor - Timber

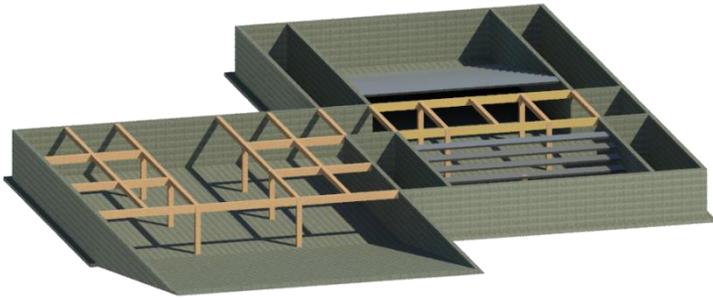


Roof - Timber

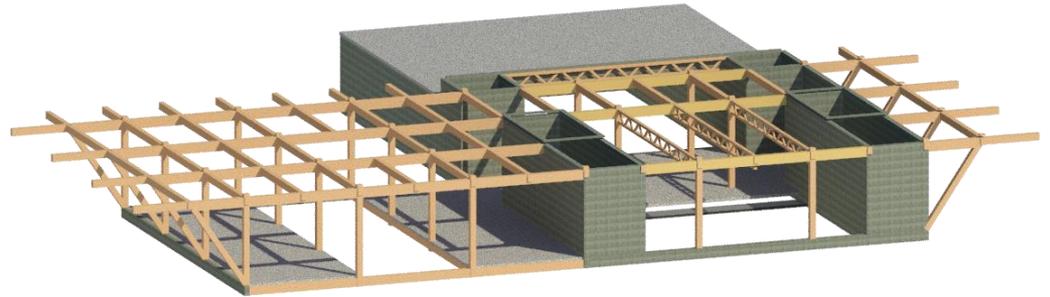


Timber

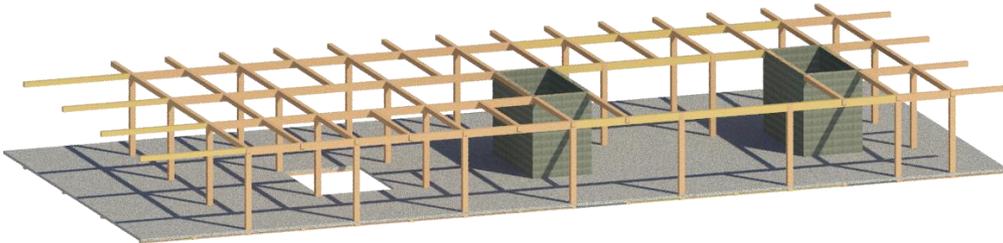
Basement



1st Floor



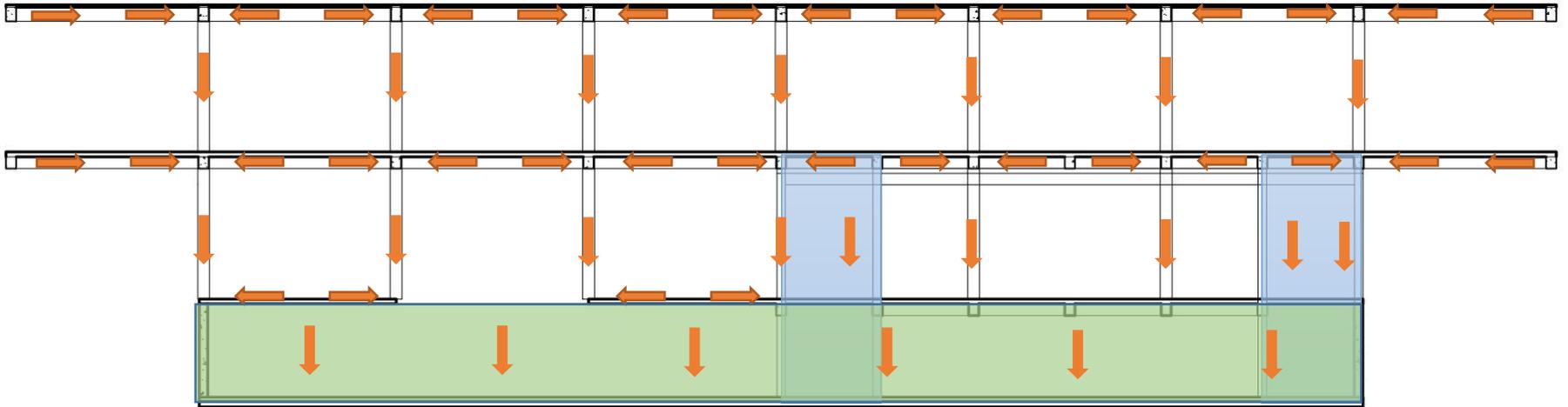
Ground Floor



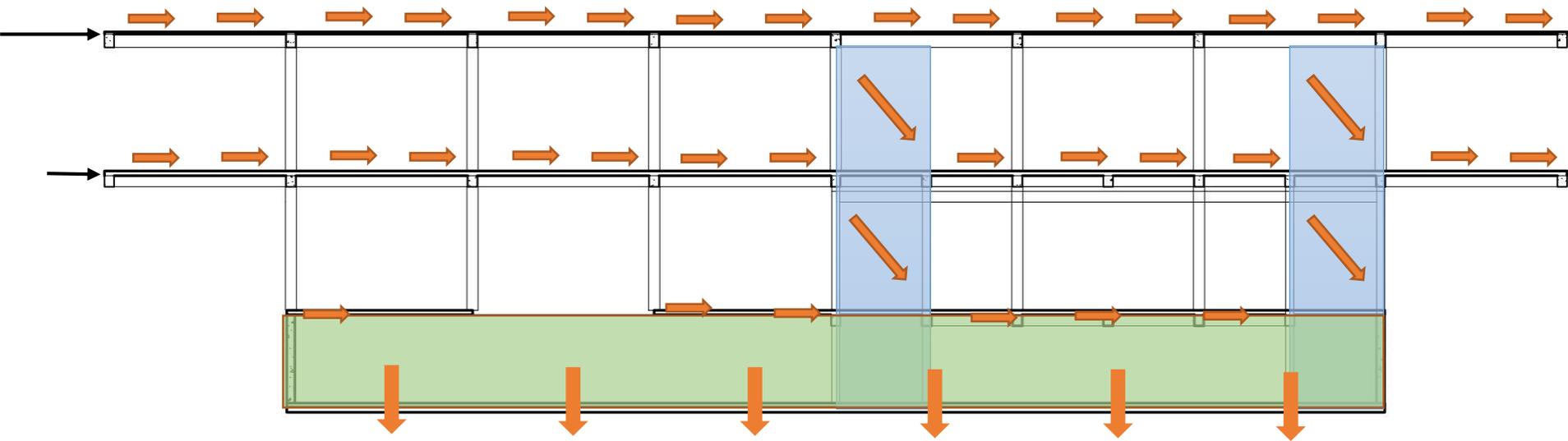
Roof



Gravity Load Path

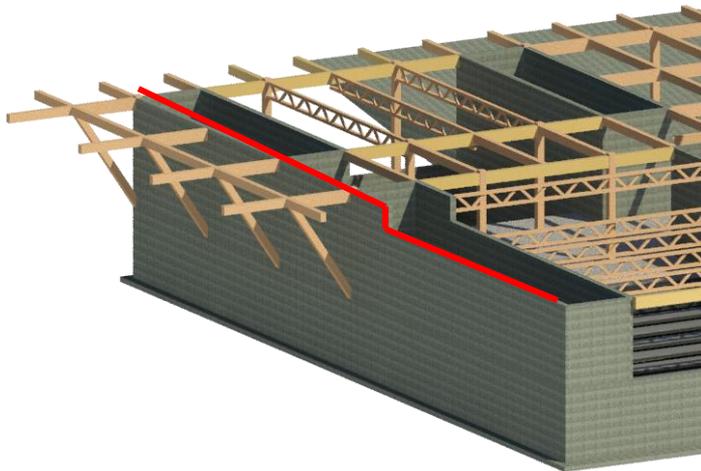


Lateral Load Path

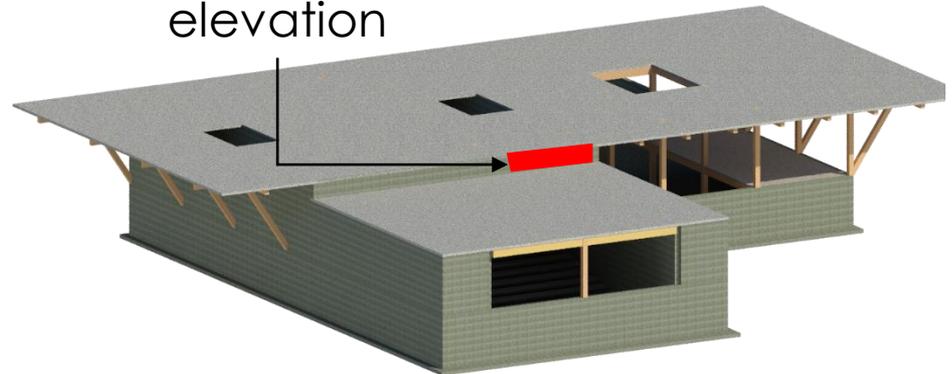


Key Coordination

ARCHITECTURAL – STRUCTURAL



0.5 m difference in elevation



Keep the appearance of two separate boxes, one atop the other.

Foundation Evolution

January

February

March

Original Design:

Mat Foundations

Considerations:

- Timber design would “float” from large buoyancy forces
- Weak soils on top layers in nearby projects
- Neighboring university buildings on concrete piles

Mentor Meeting:

Mentor familiar with site relayed actual site conditions from nearby projects

Updated Design:

Econdustry:

26 Rein. Concrete Piles
400 mm x 400 mm
12 m long

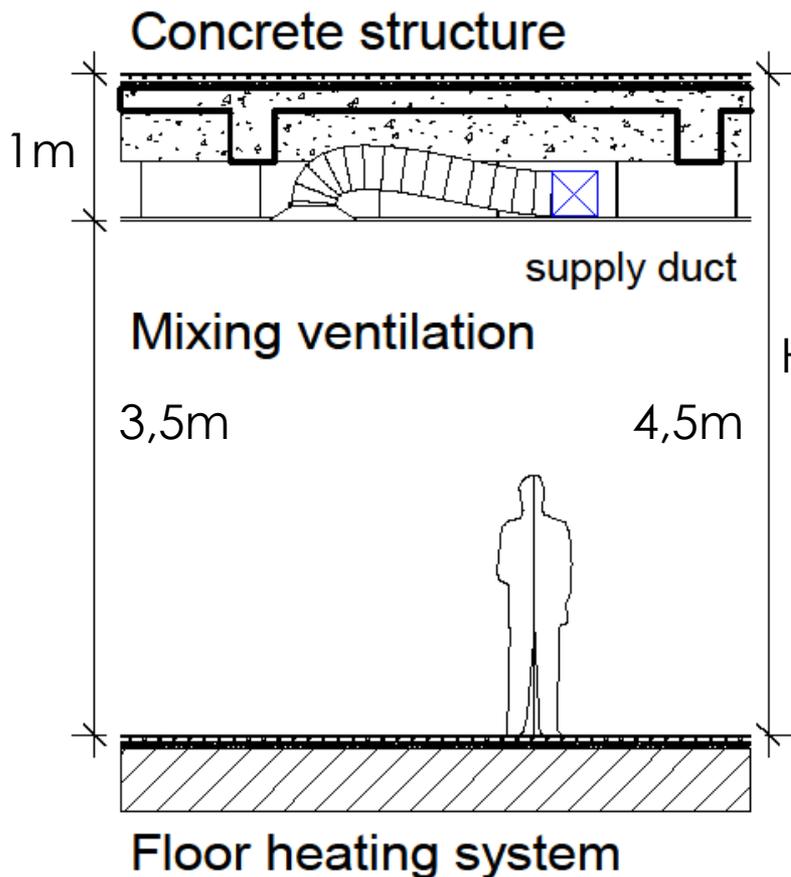
Day N' Night:

38 Rein. Concrete Piles
235 mm x 235 mm
9 m long

MEP

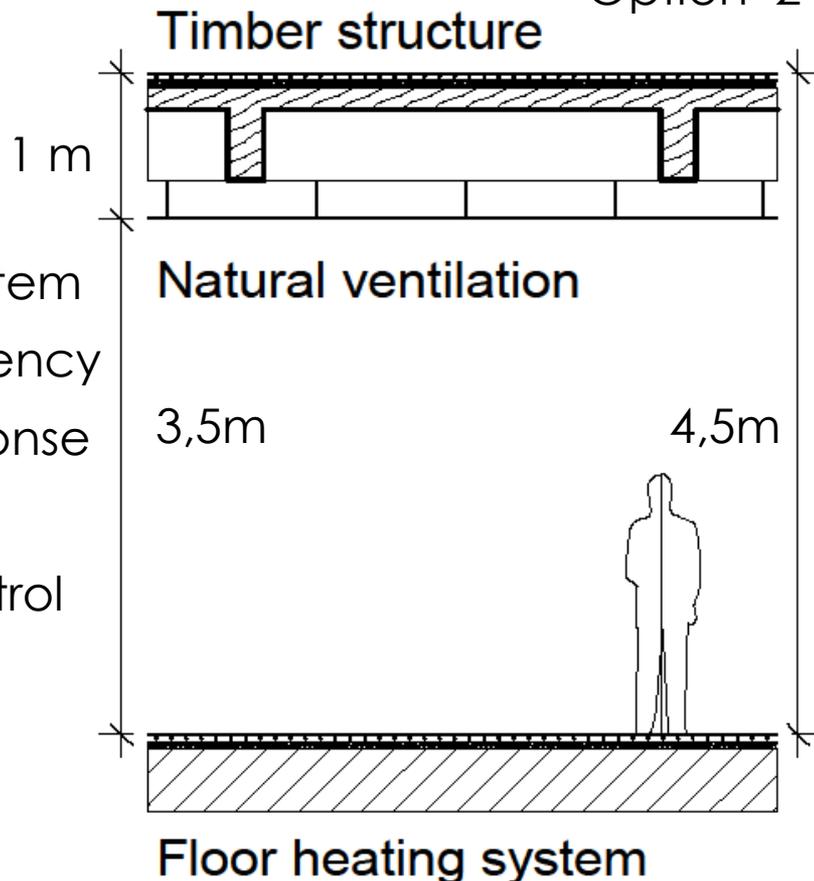
Options

Option 1

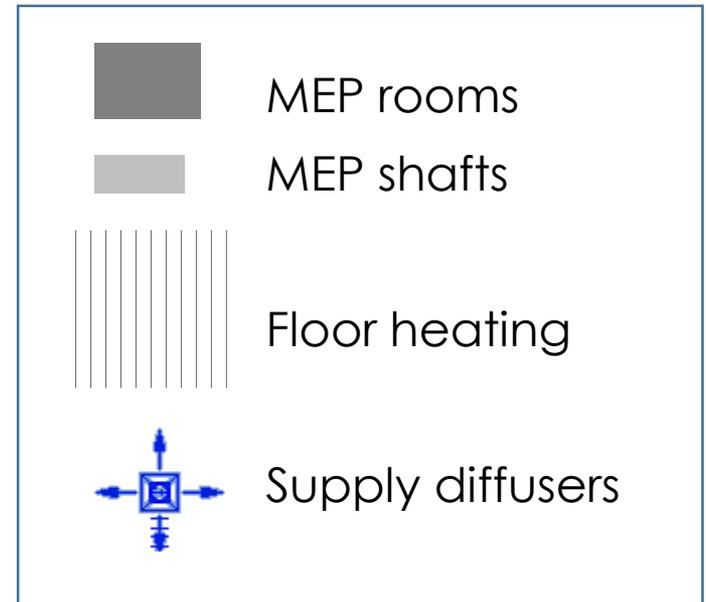
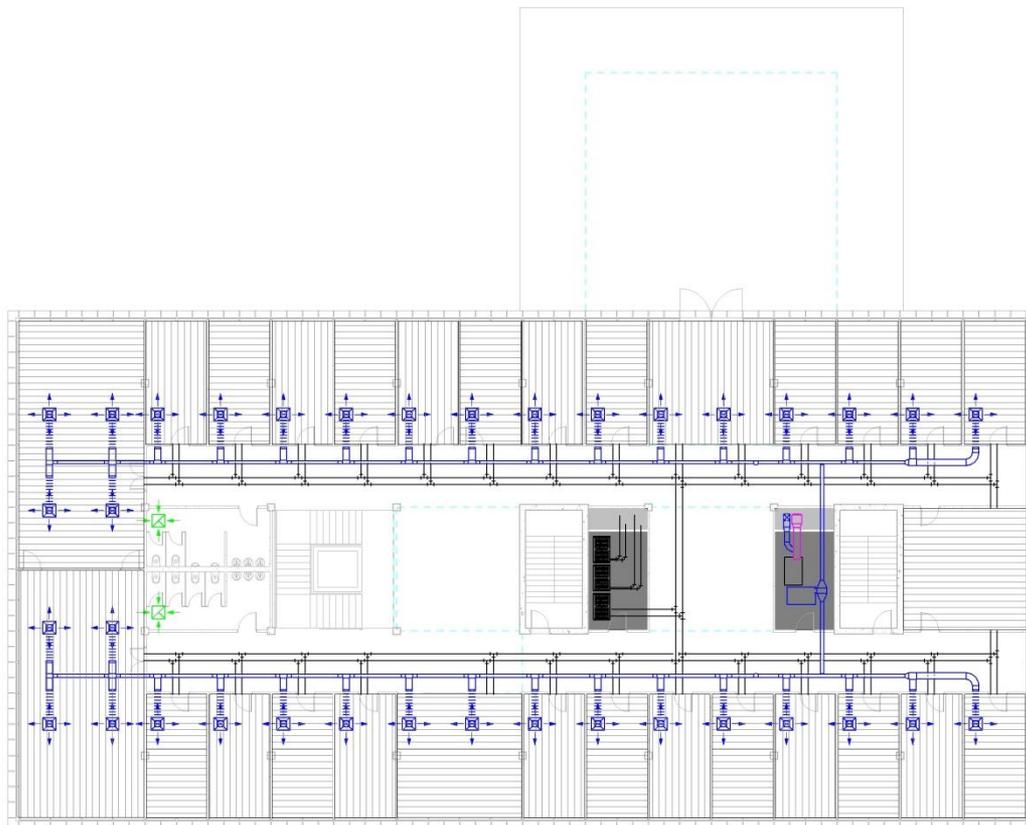


Water system
High efficiency
Slow response
User control

Option 2



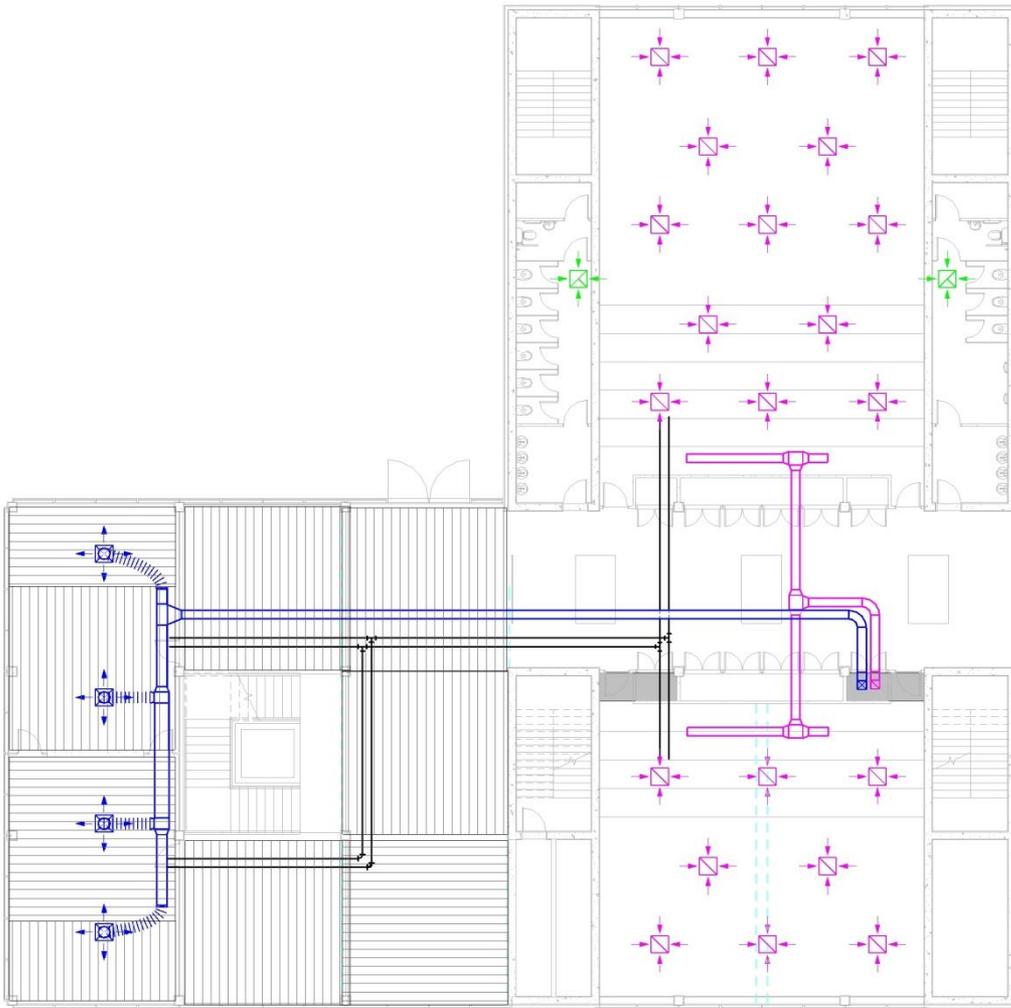
Distribution



Offices and classrooms :

- Radiant floor heating
- Mixing ventilation

Distribution



Entrance area:

- Floor heating

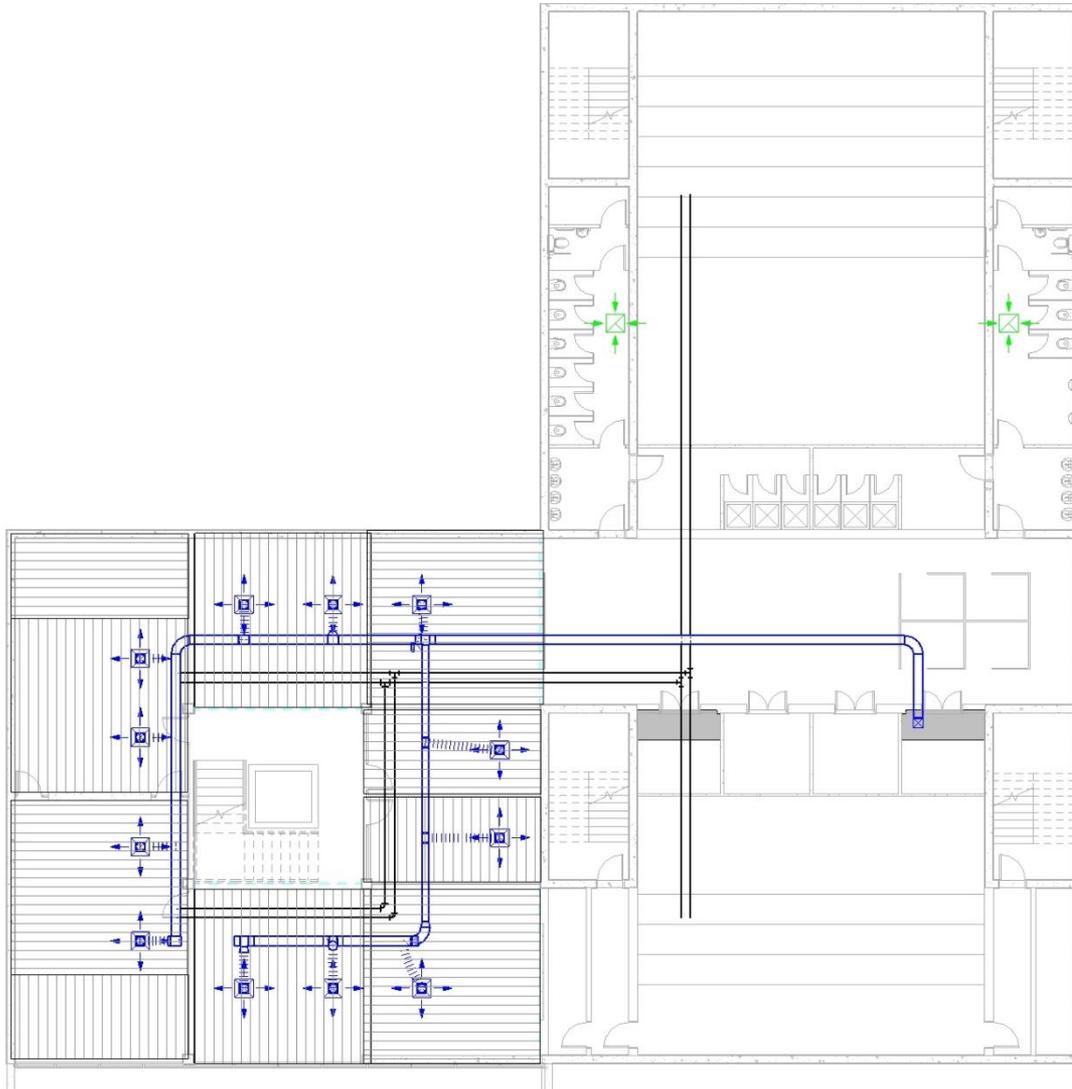
Auditoriums:

- Radiant wall panels
- plenum return air

Laboratories:

- Floor heating
- Mixing ventilation

Distribution



Auditorium:

- Radiant wall panels

Laboratories:

- Floor heating
- Displacement ventilation

Open space:

- Floor heating
- Displacement ventilation

Sun path and shadows

1974 h of sunshine



No shadows



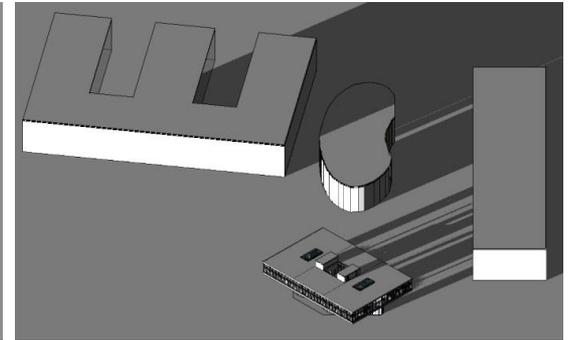
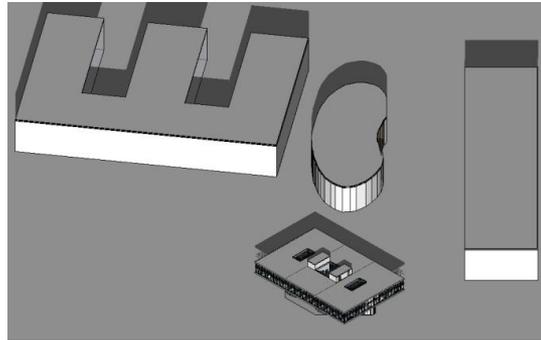
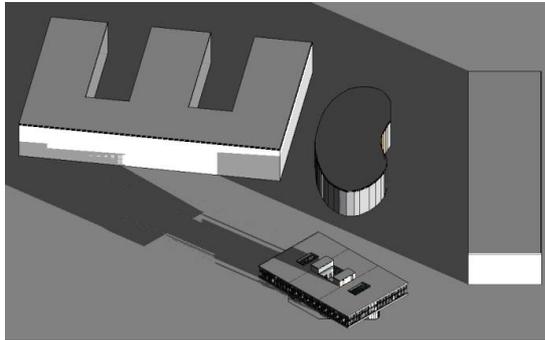
PV potential

Sunrise

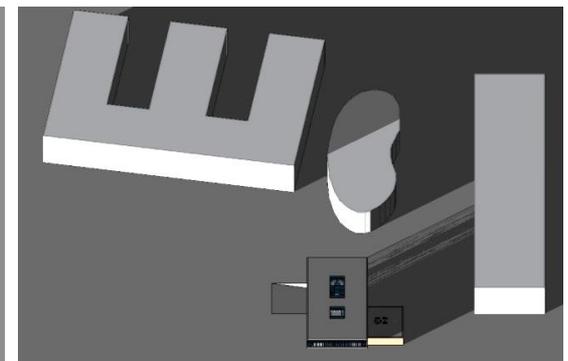
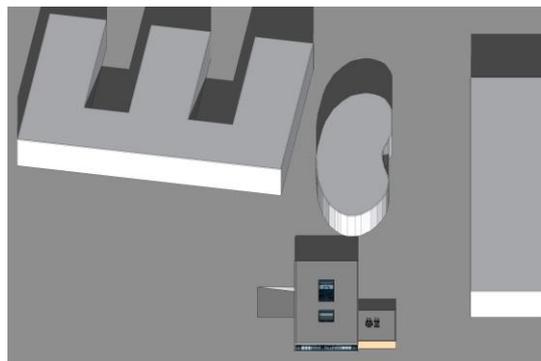
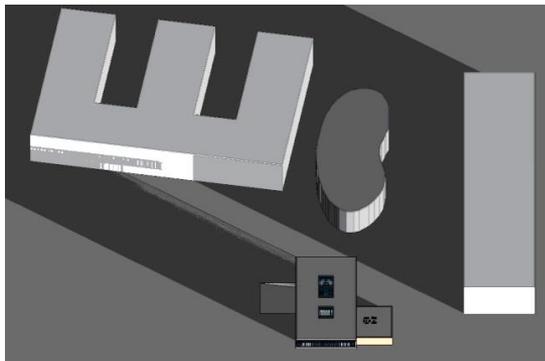
Noon

Sunset

Economy

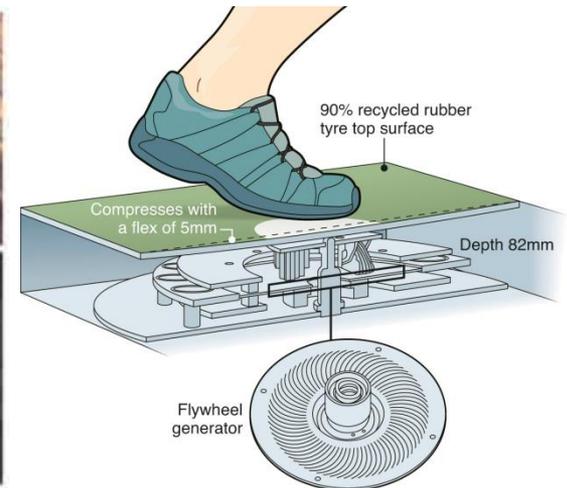


Day n' Night



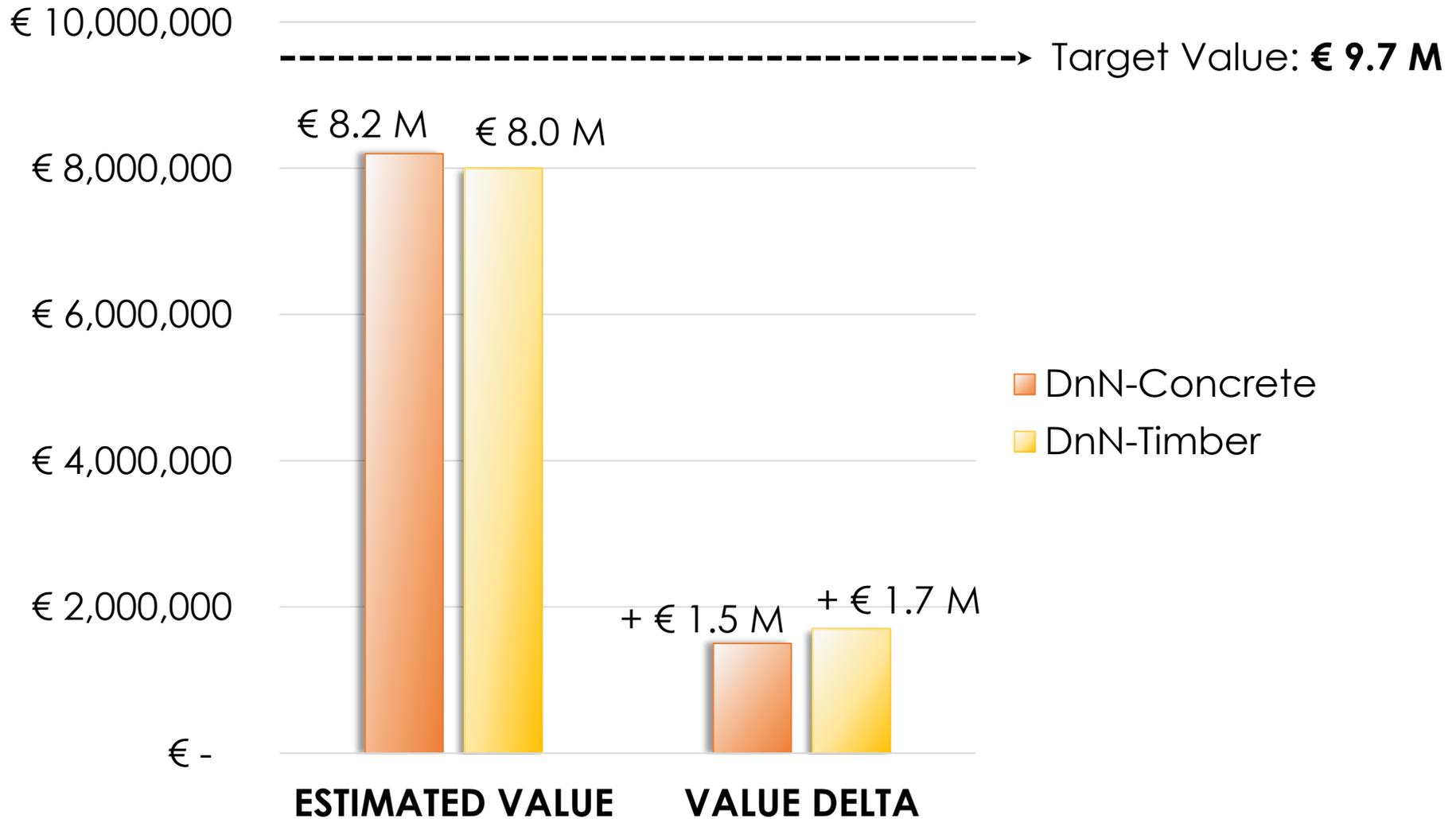
On-site renewable...

| | | Econdustry | Day n' Night |
|--|-------------------|--------------------------------------|---------------------|
| PV facade | [m ²] | 1103 | 756 |
| PV roof (Tesla) | [m ²] | 1498 | 1281 |
| Pavegen floor tiles | | Number of tiles independent of shape | |
| Water collection potential [m ³ /y] | | 2087 | 1784 |



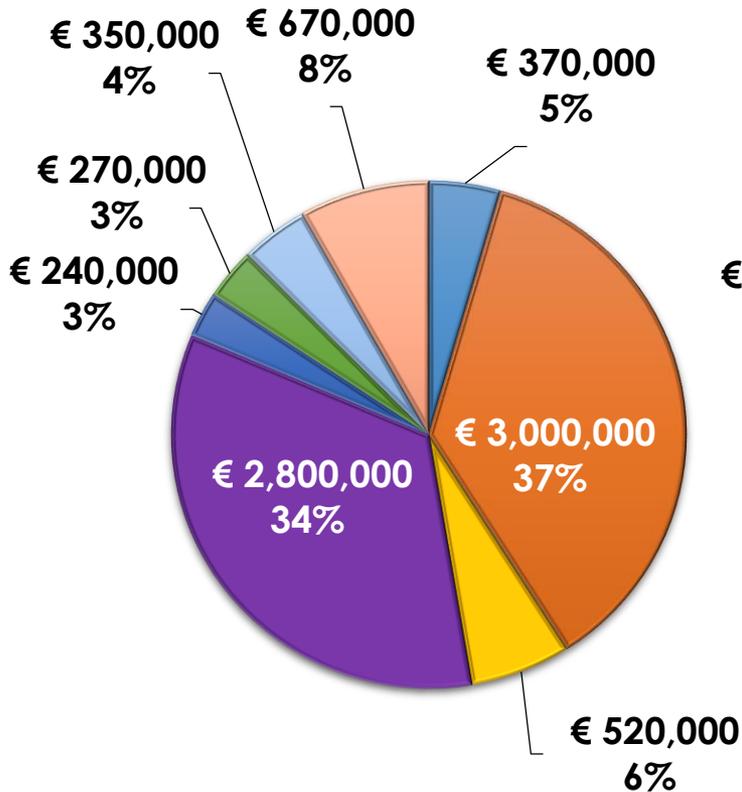
CONSTRUCTION MANAGEMENT

Total Cost Comparison

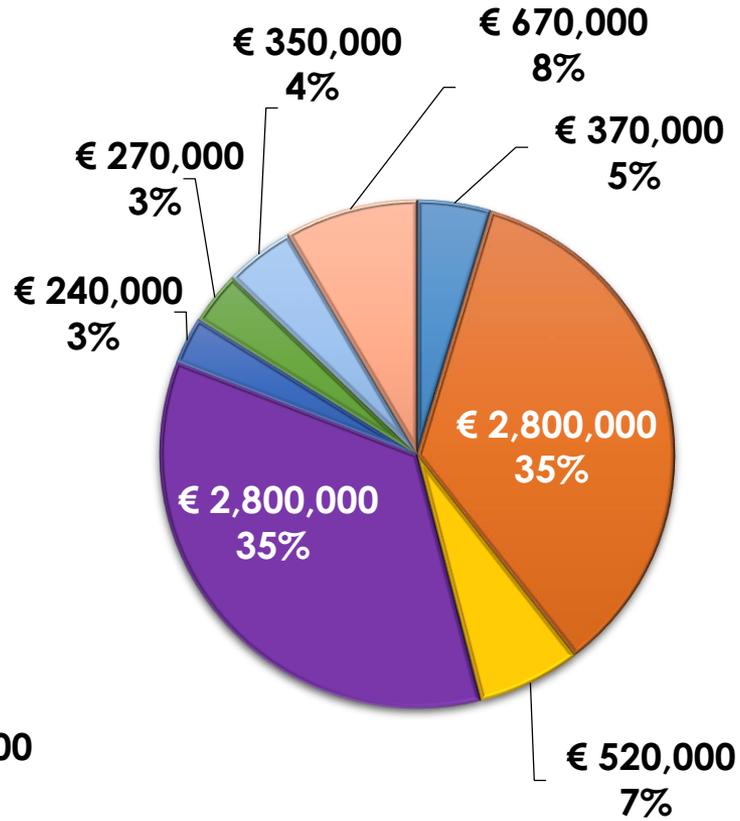


Cost Breakdown Comparison

Day N Night - Concrete

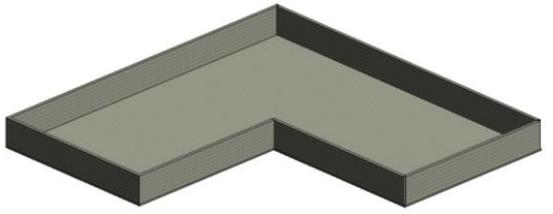


Day N Night - Timber

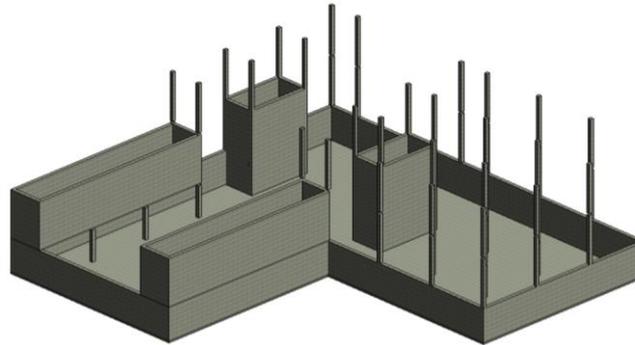


- A Substructure
- B Shell
- C Interiors
- D Services
- E Equipment and Furnishing
- F Specialty Construction
- G Building Sitework
- H General Conditions

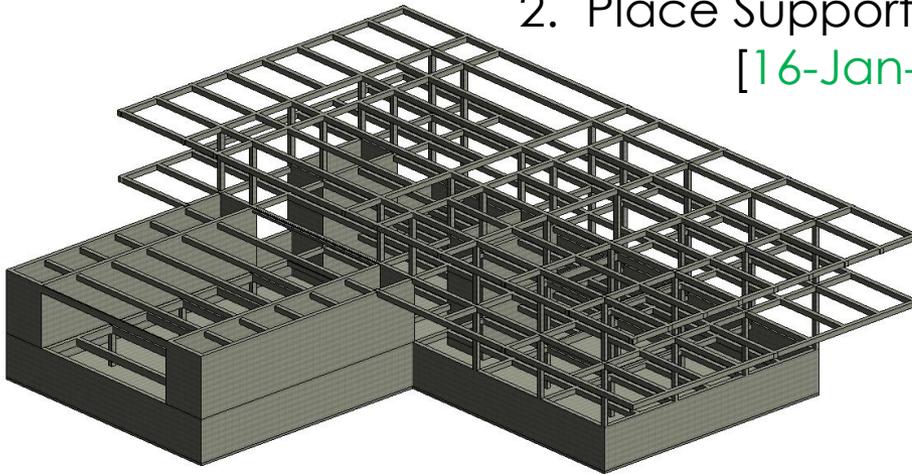
Milestones



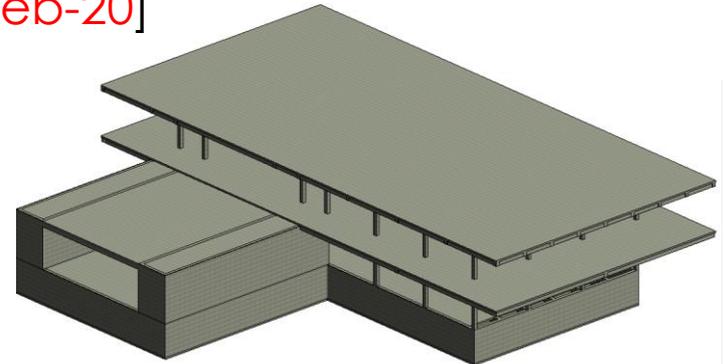
1. Seal Basement
[12-Dec-19/6-Jan-20]



2. Place Support Columns/Shear Walls
[16-Jan-20/3-Feb-20]



3. Erect Framing Systems
[6-Feb-20/20-Feb-20]



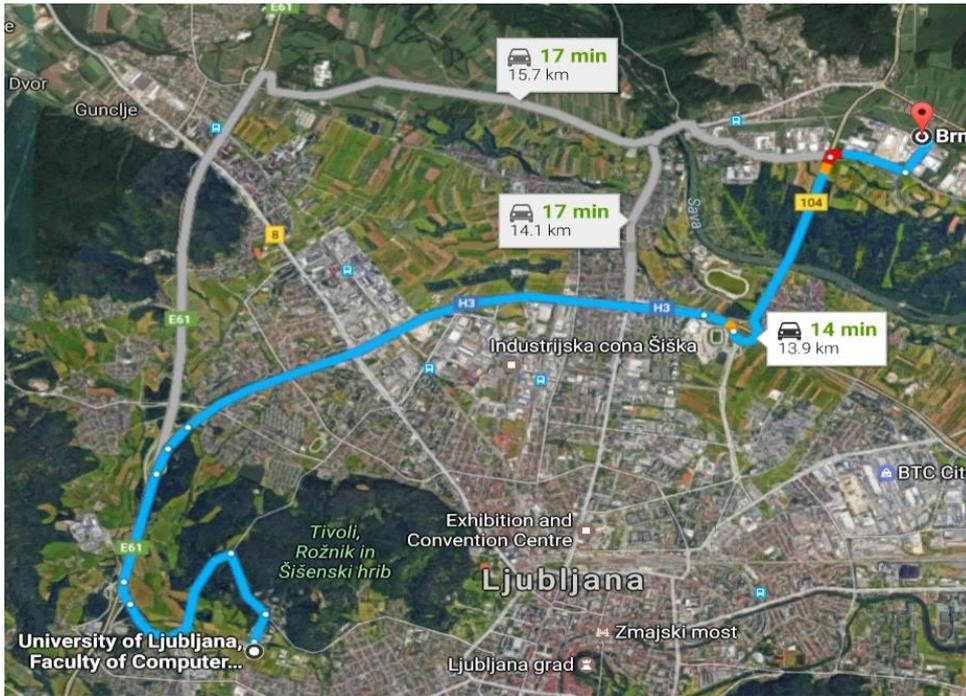
4. Pour Floor Slabs & Roof
[20-Feb-20/12-Mar-20]

5. Seal Envelope
[5-Mar-20/26-Mar-20]

| Milestone Date |
|------------------|
| [xxx] – Concrete |
| [xxx] – Timber |

Equipment

TERRA



Wheel Loader



Maximum Engine Power 56 kW
Operating Weight 5820 kg
Standard Bucket Capacity 1.2 m³

Equipment



Excavator

Maximum Bucket Capacity 1.19 m³
Maximum Engine Power 128 kW
Operating Weight 21675 kg



Forklift

Maximum Engine Power 55 kW
Maximum Lift Capacity 4000 kg
Maximum Lift Height 6.7 m



Grader

Maximum Engine Power 98 kW
Operating Weight 12000 kg
Blade Width 3,05 m

- Scissor Lifts
- Compactor

Equipment



Mobile
Crane

Crane Requirement

- Minimum Range:
 - L- Shape: 40m-45m
 - Double Diamond: 50m-60m
- Minimum Height: 15m-18m
- Minimum Load Capacity: 12.5-25 Ton? **Air Handling Unit**



Concrete
Pump

Range :
20m-42m

Challenges for Spring Quarter

🕒 Reduce

Construction site footprint

🕒 Refine

Construction sequence plan

🕒 Explore

Pre-fabrication
Just-in-time delivery

🕒 Develop

Dewatering system

🕒 Incorporate

Slovenian labor/material prices



LIFE-CYCLE FINANCIAL MANAGEMENT

Integrated Risk Analysis

IDENTIFICATION

What could happen, under which circumstances, to what/whom?

INFLUENCERS

Who can have impact on these risks and which one are priority risks?



DEFINE & PREVENT

What consequences could follow in best, average and worst case? How could **WE** prevent it?

RISK MITIGATION

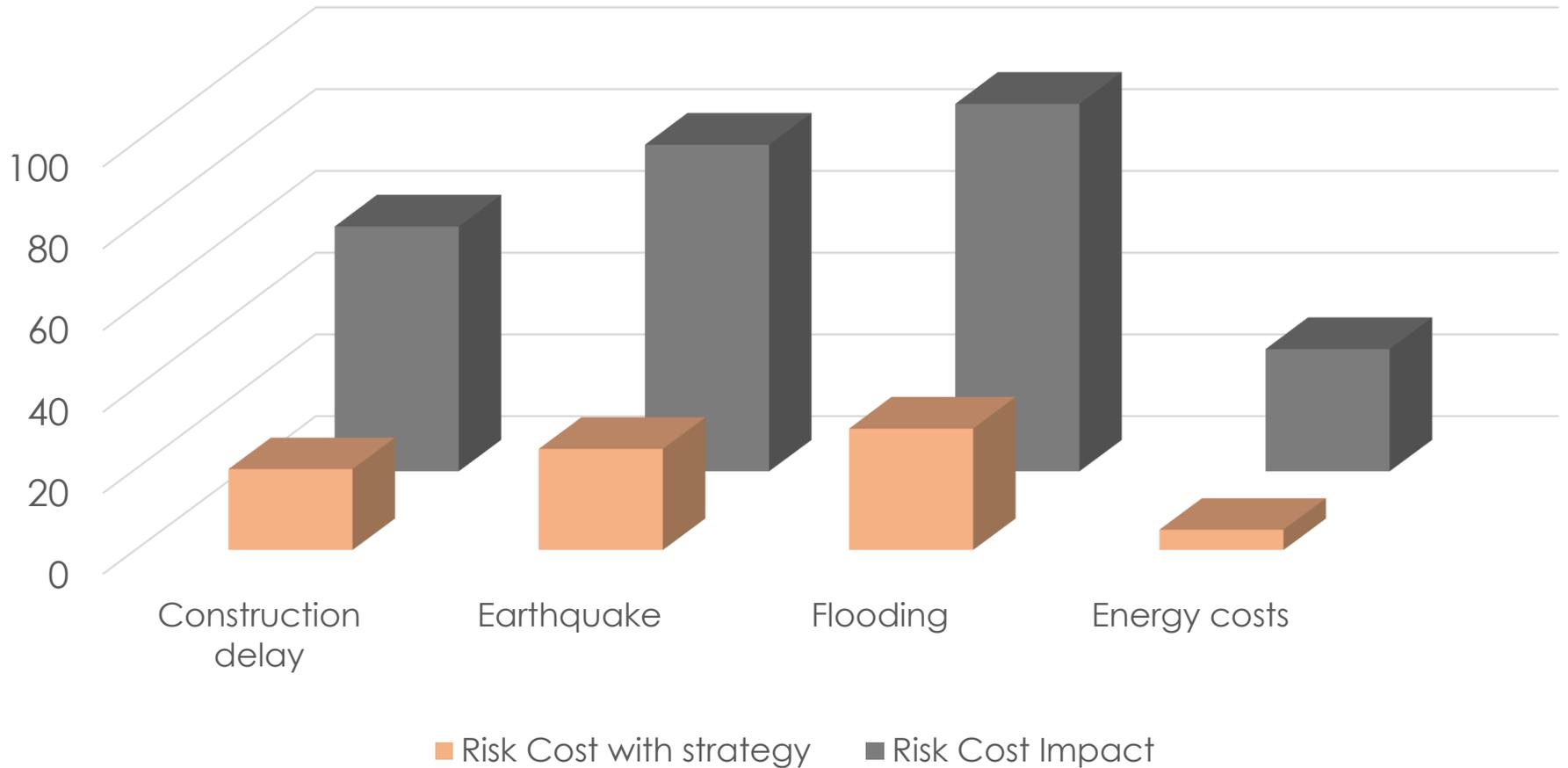
Less risk, less cost!

Risk Management

| Risk | Description | Consequences | Risk Management |
|--|---|---|--|
| <i>Construction period</i> | | | |
| Construction delay | Miscalculation of schedule, Changes in planning | Delay for operation period, loss of rental income | Precise calculations including contingency buffer, Reliable subcontractors |
| <i>Construction and Operation period</i> | | | |
| Earthquake | Damaged building | Availability, O&M and replacement cost | Safe structural solution which can withstand an earthquake |
| Flooding | Damaged building | Availability, O&M and replacement cost | Flooding prevention system, avoiding technical equipment in flooding zones |
| Energy costs | Energy cost is higher than expected | O&M Cost | Include inflation and contingency buffer, Energy production |

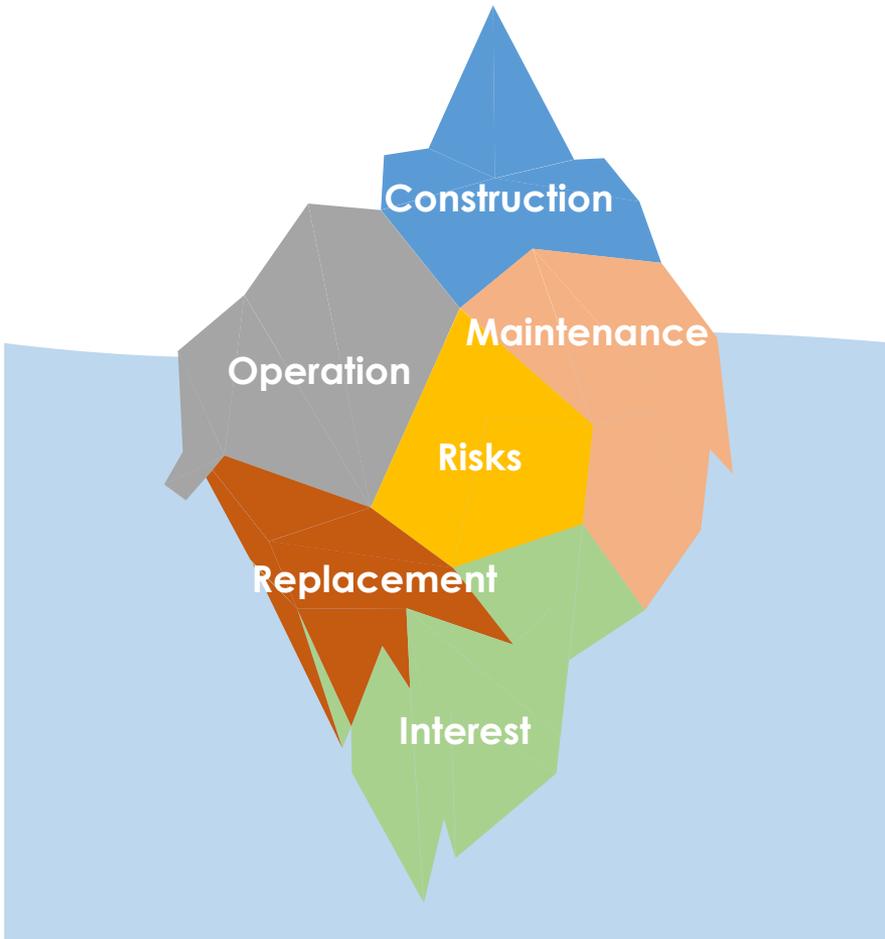
Risk Management

RISK MANAGEMENT IMPACT



Life-Cycle-Cost

“Costs below the horizon”



CM

TVD

**CONSTRUCTION
& REPLACEMENT**

MEP

Consumption & Production

**OPERATION &
MAINTENANCE**

A

Area & Design

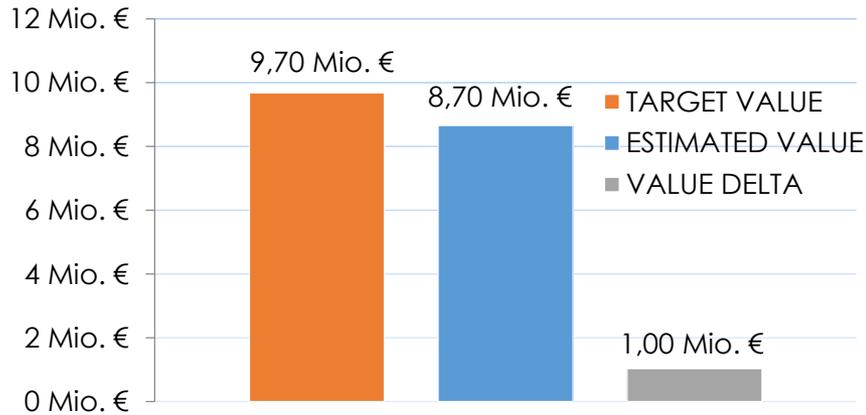
SE

Safe Structural System

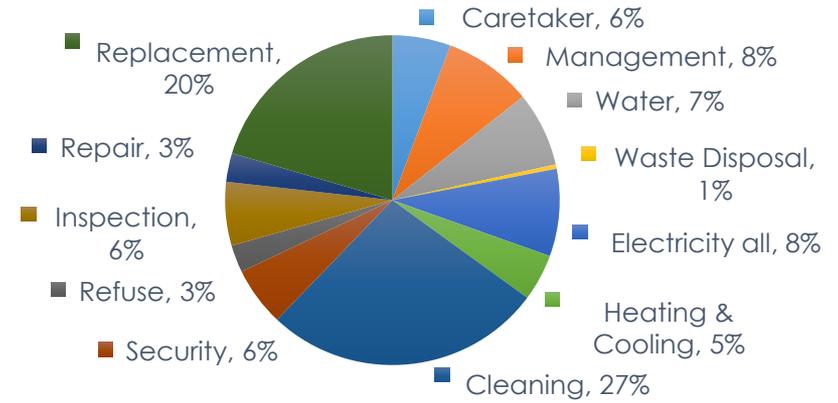
RISK

LCC-Links

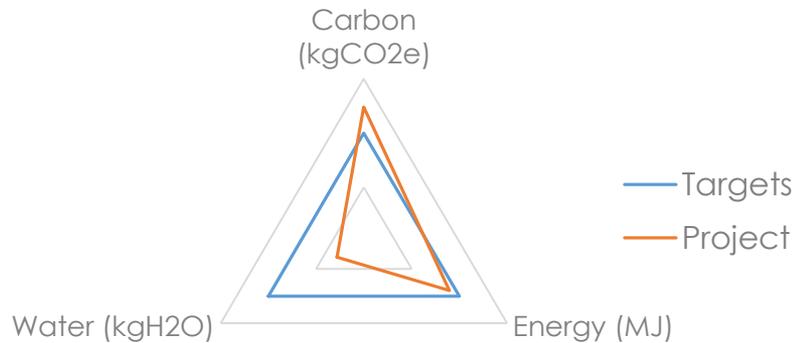
TVD - SUMMARY



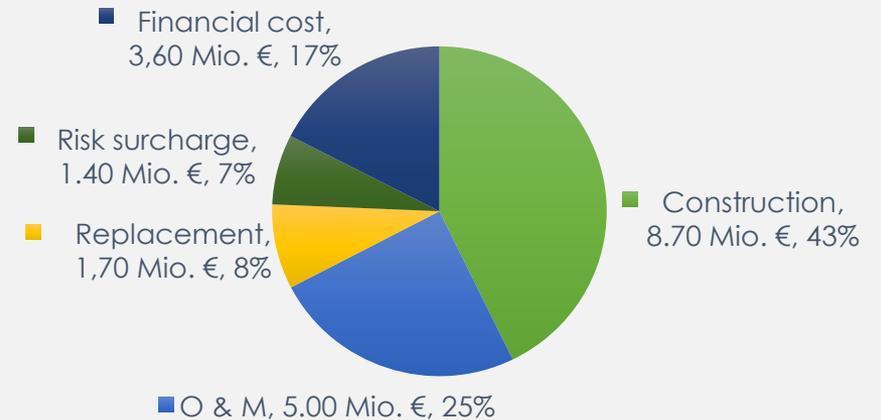
O&M + REPLACEMENT



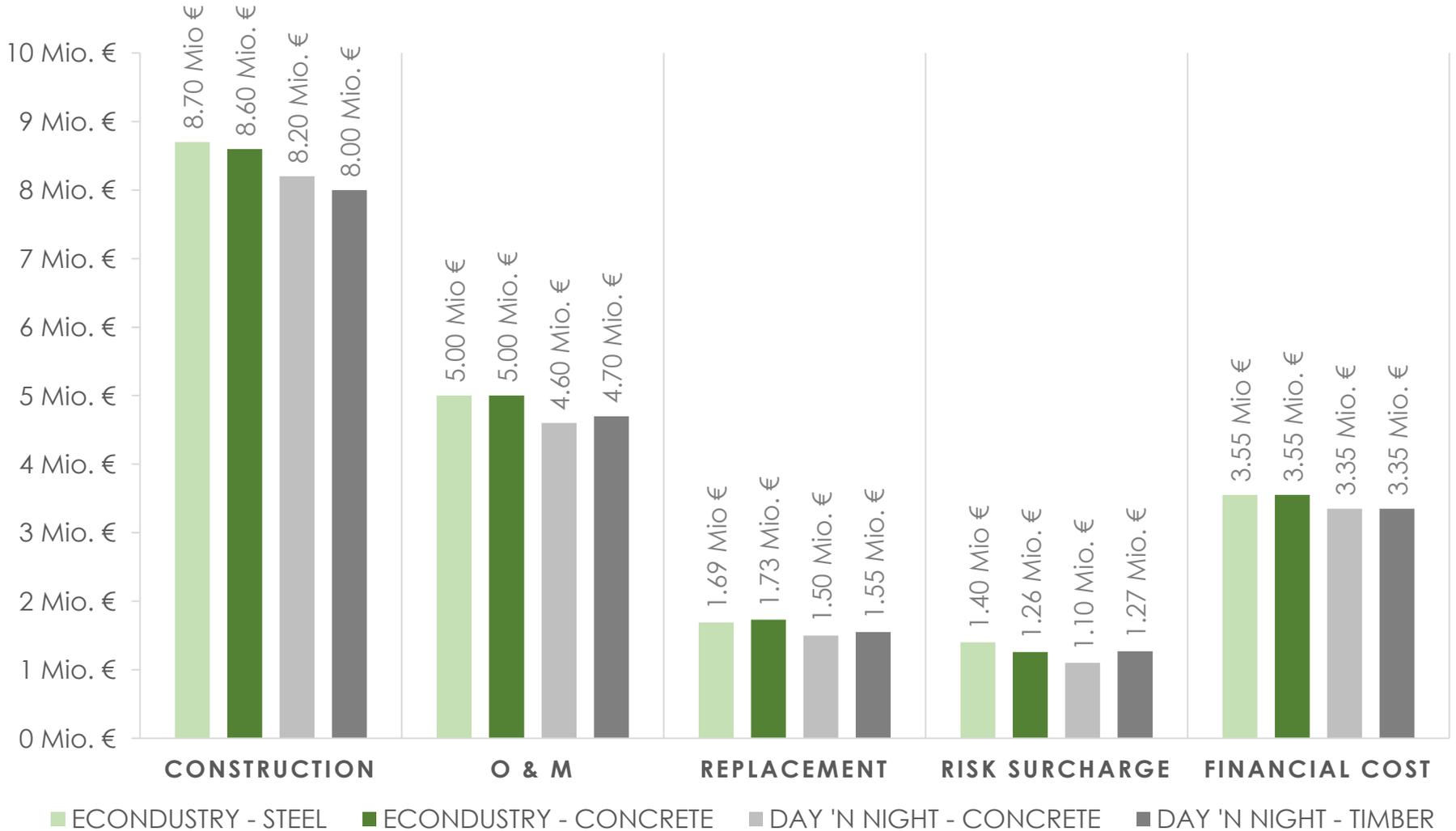
STV - SUMMARY



LIFE-CYCLE-COST

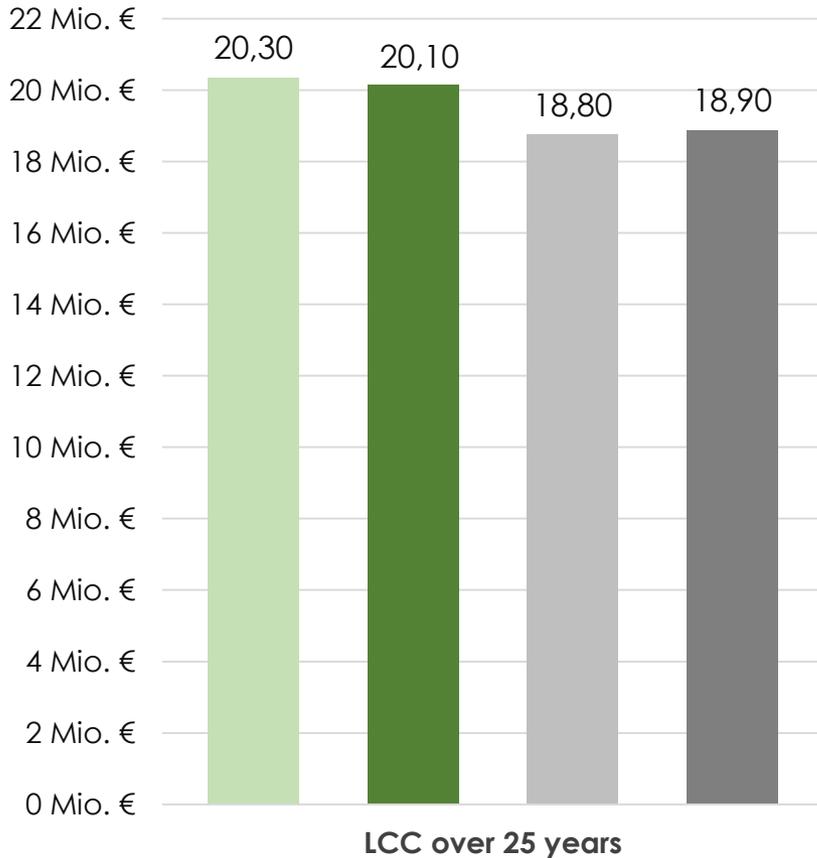


LCC by Position

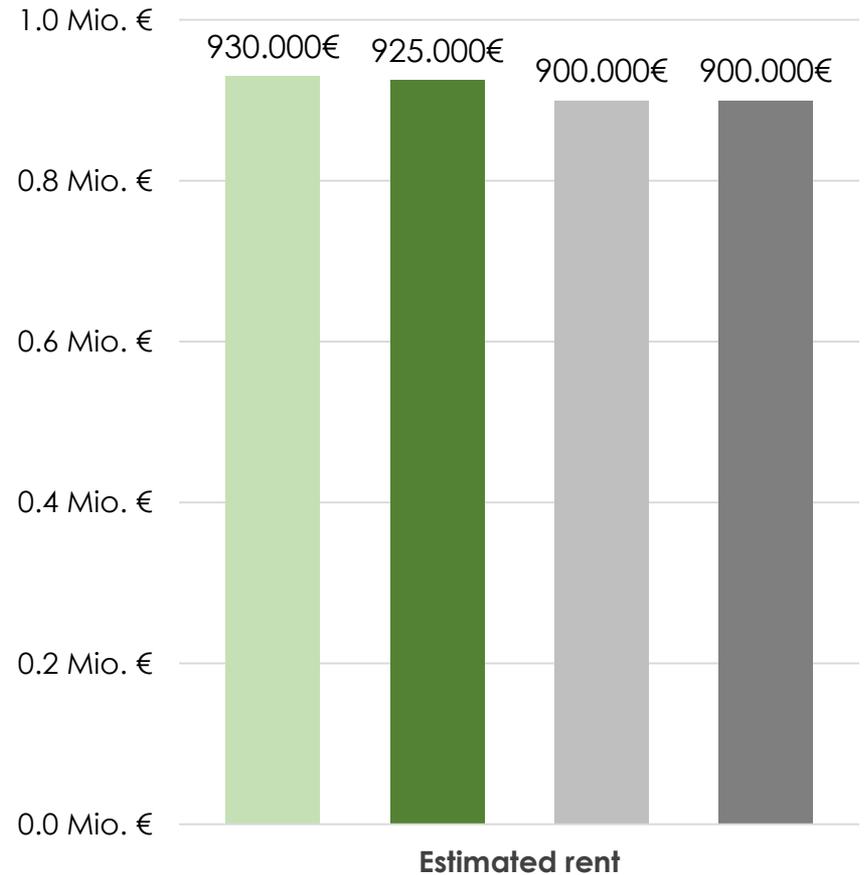


LCC-Rent-Relation

Life-Cycle-Cost



Rent



ECONDUSTRY - STEEL

ECONDUSTRY - CONCRETE

DAY 'N NIGHT - CONCRETE

DAY 'N NIGHT - TIMBER

ECONDUSTRY - STEEL

ECONDUSTRY - CONCRETE

DAY 'N NIGHT - CONCRETE

DAY 'N NIGHT - TIMBER

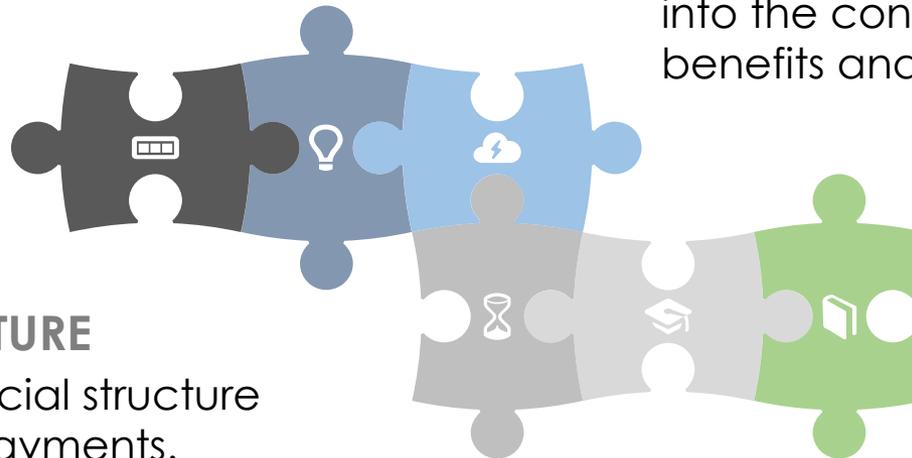
Lifecycle-Strategy

EFFICIENT DESIGN

Collaboration within all disciplines through all steps to create an efficient building related to space, cost, risk and future operations.

ADDITIONAL PROGRAM

Integrate program related solutions for additional income into the concept by showing benefits and value to owners.



FINANCIAL STRUCTURE

Optimizing the financial structure to reduce interest payments.

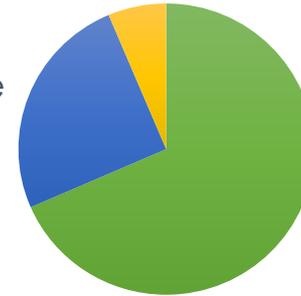
Space Efficiency



GROSS FLOOR AREA DISTRIBUTION

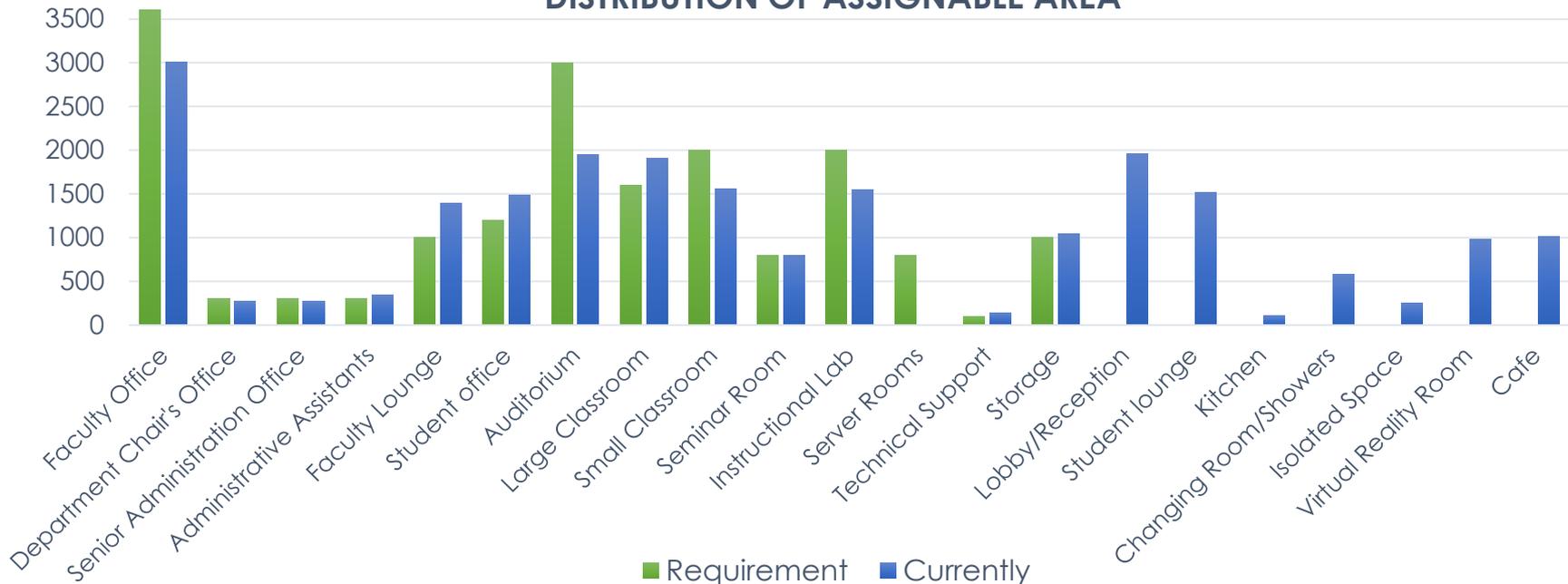
Structural area 6%

Non assignable area 25%



Assignable area 69%

DISTRIBUTION OF ASSIGNABLE AREA

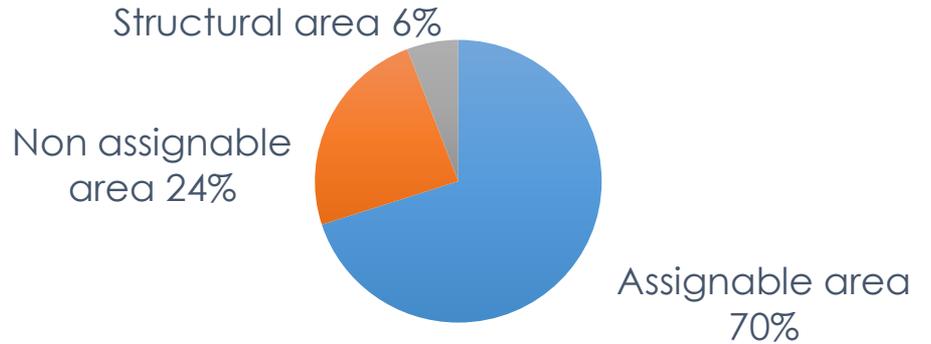


■ Requirement ■ Currently

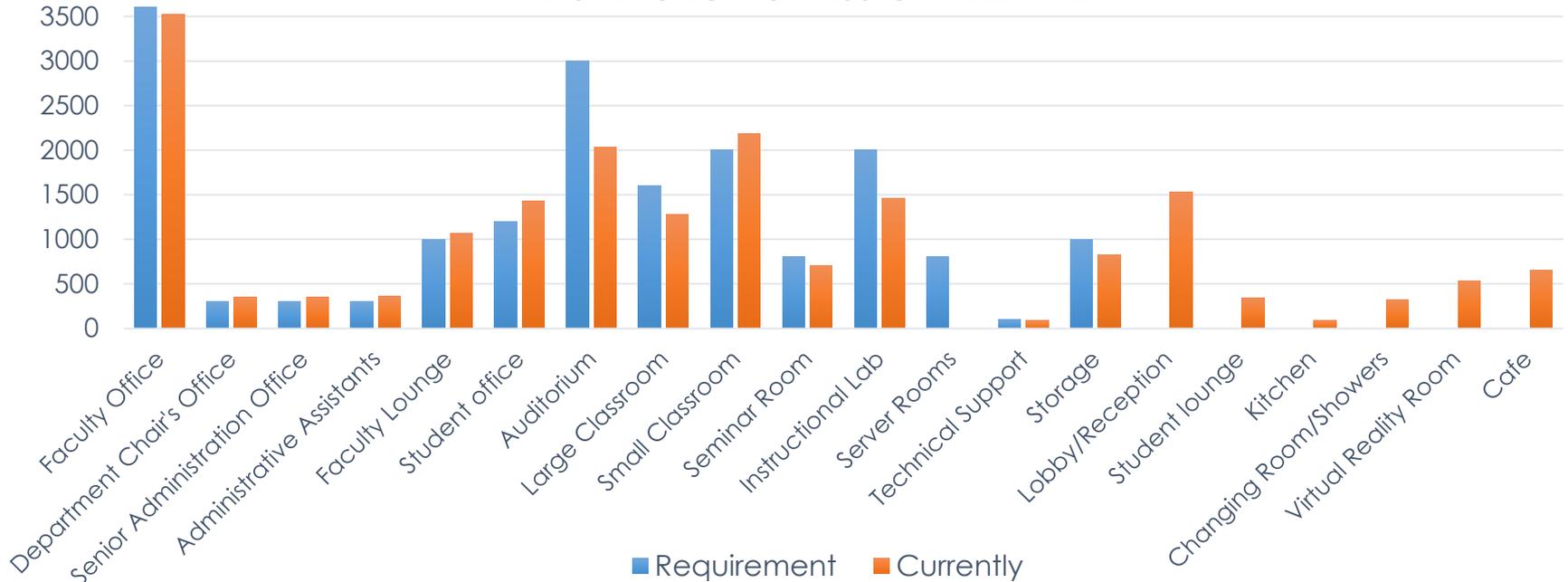
Space Efficiency



GROSS FLOOR AREA DISTRIBUTION



DISTRIBUTION OF ASSIGNABLE AREA



Space Efficiency

Increasing efficiency and flexibility by outsourcing:

- Data access from all around the globe is necessary in today's and future society
- Cloud services getting more and more reliable
- University learning concept is changing
- Online education is a developing sector

Cloud services:



Hybrid solution:



LCFM - Summary



| | ECONDUSTRY – STEEL | ECONDUSTRY – CONCRETE | DAY 'N NIGHT – CONCRETE | DAY 'N NIGHT – TIMBER |
|-------------------------------|--------------------|-----------------------|-------------------------|-----------------------|
| Construction cost | 8,70 Mio. € | 8,60 Mio. € | 8,20 Mio. € | 8,00 Mio. € |
| O & M | 5,00 Mio. € | 5,00 Mio. € | 4,60 Mio. € | 4,70 Mio. € |
| Replacement | 1,70 Mio. € | 1,70 Mio. € | 1,50 Mio. € | 1,60 Mio. € |
| Risk surcharge | 1,40 Mio. € | 1,30 Mio. € | 1,10 Mio. € | 1,30 Mio. € |
| Financial cost | 3,60 Mio. € | 3,60 Mio. € | 3,40 Mio. € | 3,40 Mio. € |
| LCC | 20,30 Mio. € | 20,10 Mio. € | 18,80 Mio. € | 18,90 Mio. € |
| LCC p.a. | 814.000 € | 806.000 € | 750.000 € | 755.000 € |
| LCC p.a. / m ² GFA | 271 € | 269 € | 275 € | 276 € |
| GFA in m ² | 3000 | 3000 | 2730 | 2730 |
| Rent | 930.000 € | 925.000 € | 900.000 € | 900.000 € |
| Rent per m ² /GFA | 310 € | 308 € | 330 € | 330 € |

Econdustry vs Day 'N Night



Methodology

CRITERIA DEFINITION

Brainstorming of different criteria, which are related to green building, the challenges and specific point of views.

OVERALL WEIGHT

This step relates to the decision of the overall score weighting between the PPP organization and how to integrate the user.



INDIVIDUAL SCORING

Every team member and owner could decide about the individual weight of each criteria and how well each concept assesses to it.

COMPARATIVE RESULT

The final step was a comparative analyses of the individual scoring to determine the favorite concept.

Decision Matrix

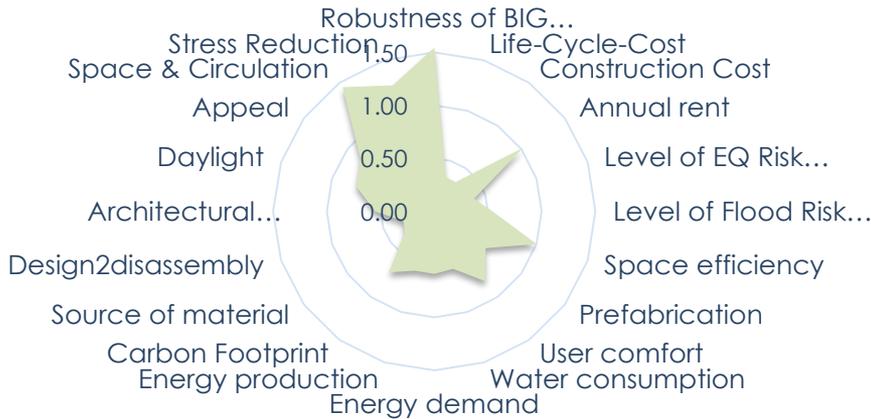
TEAM EXPRESS – DECISION MATRIX



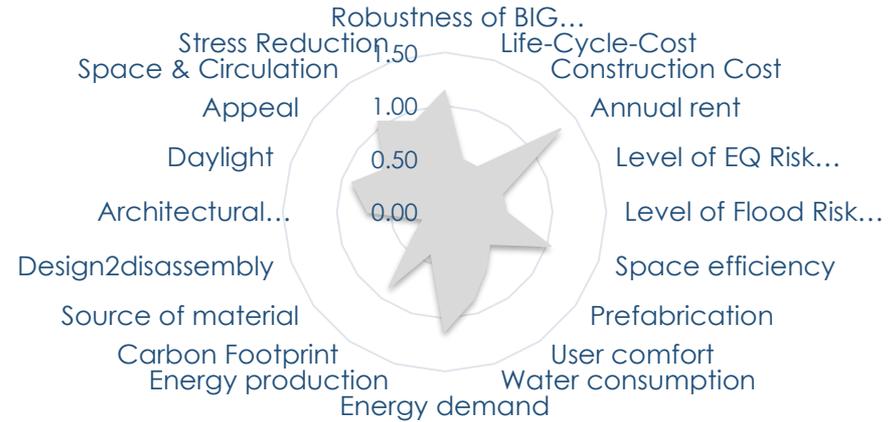
| CATEGORY | CRITERIA | WEIGHT | STEEL | CONCRETE | CONCRETE | TIMBER |
|----------------------------------|----------------------------|--------|-------------|-------------|-------------|-------------|
| GENERAL | Robustness of BIG Idea | 5,0% | 5 | 3 | 2 | 4 |
| ECONOMIC | Life-Cycle-Cost | 5,0% | 2 | 3 | 4 | 5 |
| ECONOMIC | Construction Cost | 5,0% | 2 | 3 | 4 | 5 |
| ECONOMIC | Annual rent | 5,0% | 3 | 4 | 5 | 5 |
| ECONOMIC | Level of EQ Risk Impact | 5,0% | 2 | 2 | 3 | 4 |
| ECONOMIC | Level of Flood Risk Impact | 5,0% | 4 | 4 | 5 | 2 |
| ECONOMIC | Space efficiency | 5,0% | 4 | 4 | 3 | 3 |
| ECONOMIC | Prefabrication | 5,0% | 3 | 2 | 3 | 4 |
| ECOLOGIC | User comfort | 7,0% | 5 | 5 | 4 | 3 |
| ECOLOGIC | Water consumption | 3,0% | 3 | 3 | 4 | 4 |
| ECOLOGIC | Energy demand | 7,0% | 2 | 4 | 5 | 3 |
| ECOLOGIC | Energy production | 5,0% | 3 | 3 | 2 | 2 |
| ECOLOGIC | Carbon Footprint | 7,0% | 3 | 2 | 1 | 1 |
| ECOLOGIC | Source of material | 5,0% | 3 | 3 | 3 | 1 |
| ECOLOGIC | Design2disassembly | 2,0% | 3 | 2 | 2 | 4 |
| SOCIAL | Architectural Integration | 2,0% | 3 | 3 | 4 | 4 |
| SOCIAL | Daylight | 5,0% | 4 | 4 | 5 | 5 |
| SOCIAL | Appeal | 3,0% | 5 | 5 | 4 | 3 |
| SOCIAL | Space & Circulation | 7,0% | 5 | 5 | 3 | 3 |
| SOCIAL | Stress Reduction | 7,0% | 5 | 5 | 3 | 4 |
| INDIVIDUAL WEIGHTED SCORE | | | 3,51 | 3,56 | 3,43 | 3,35 |

Scoring Focus - Owner

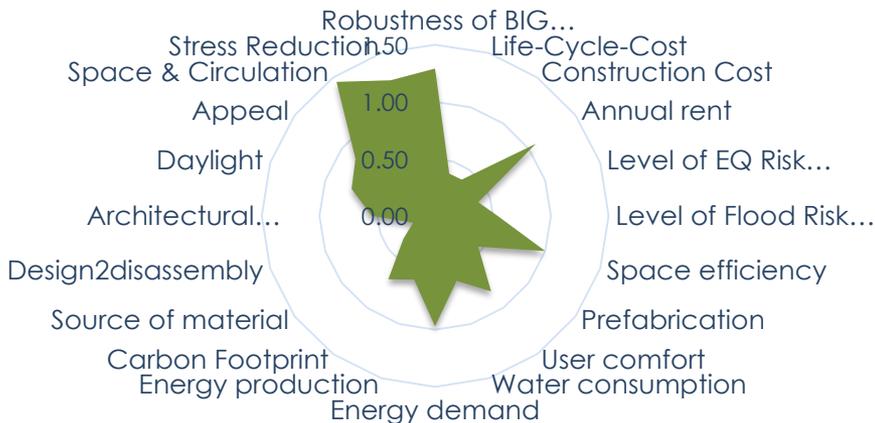
ECONDUSTRY - STEEL



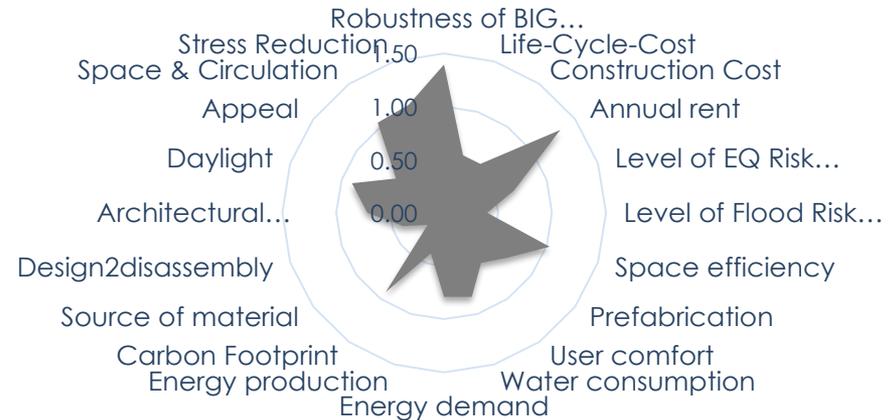
DAY 'N NIGHT - CONCRETE



ECONDUSTRY - CONCRETE

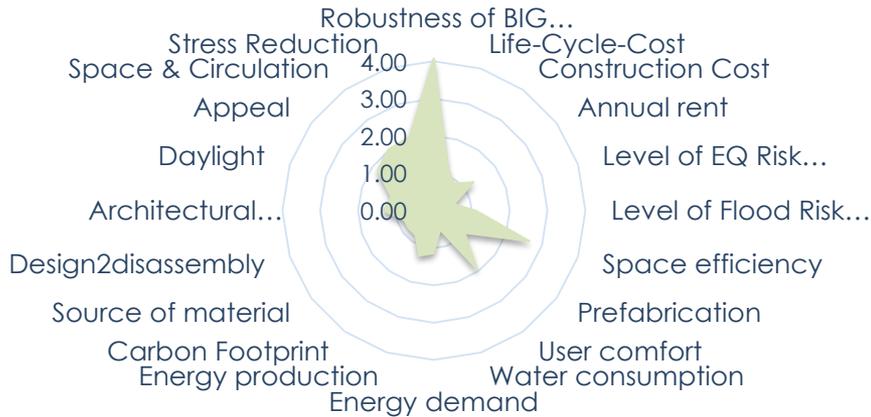


DAY 'N NIGHT - TIMBER

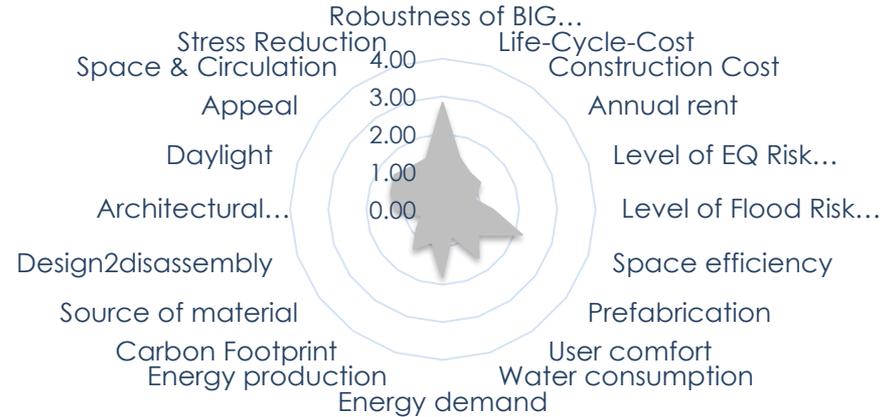


Scoring Focus - Team

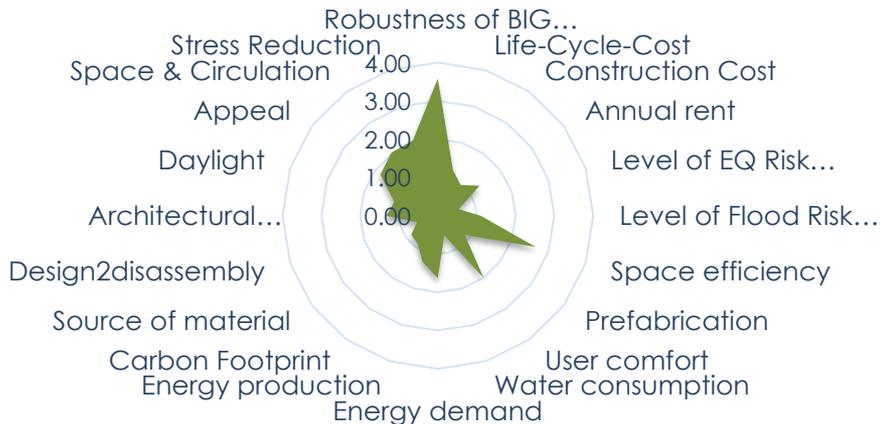
ECONDUSTRY - STEEL



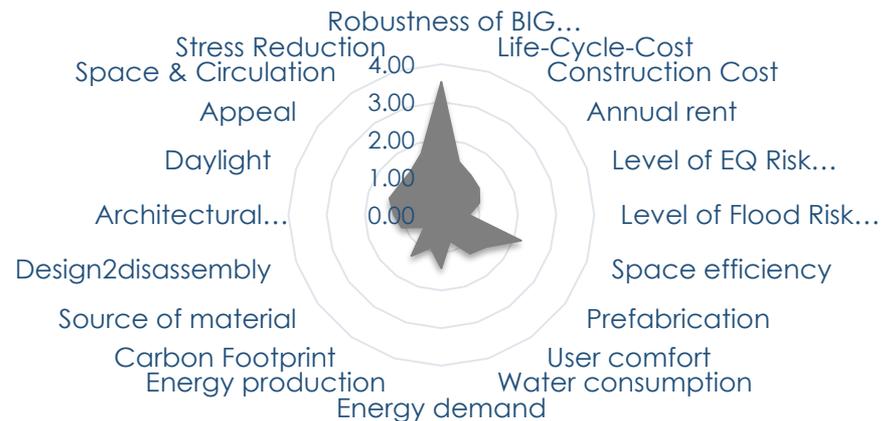
DAY 'N NIGHT - CONCRETE



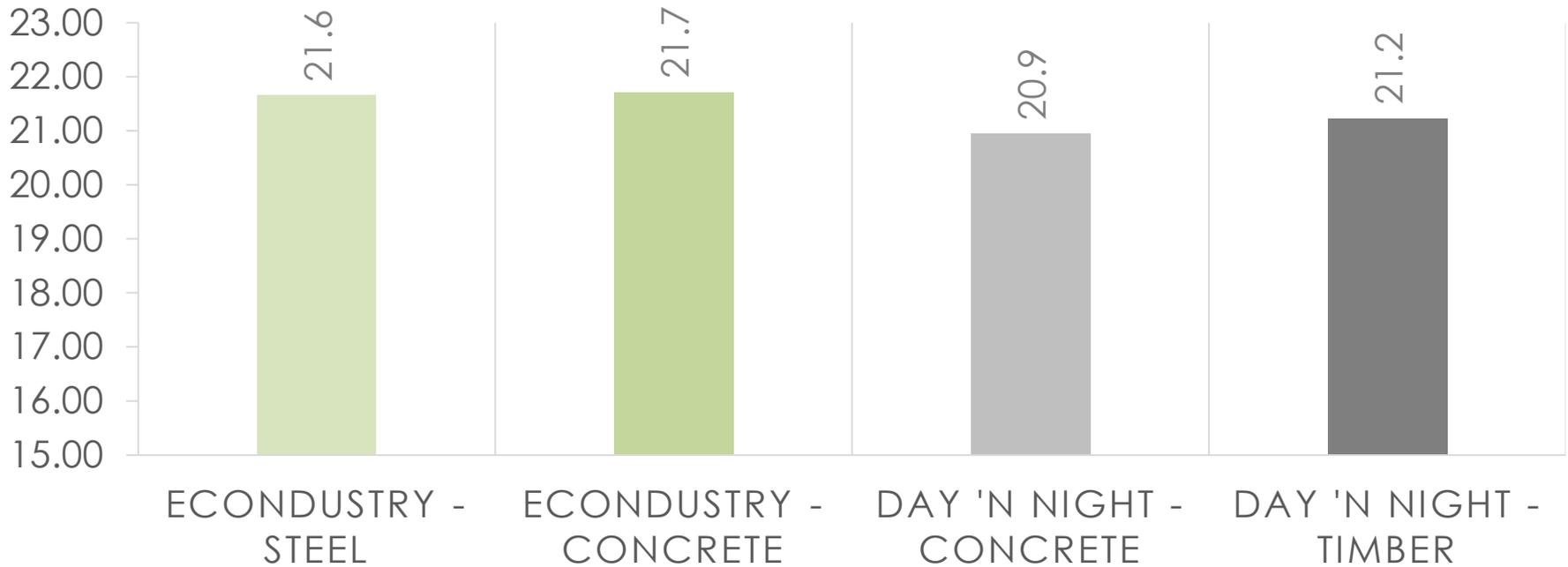
ECONDUSTRY - CONCRETE



DAY 'N NIGHT - TIMBER



Total Score Overview



The Winner



Winter 2017

Express

LCFM

Final Concept: Eindustry -Concrete

130

Team Process

Communicate - collaborate - Coordinate



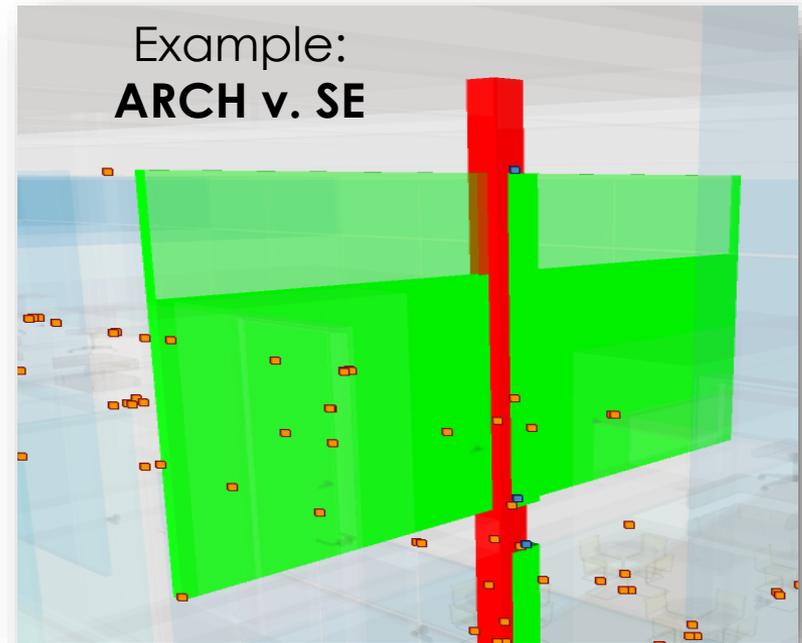
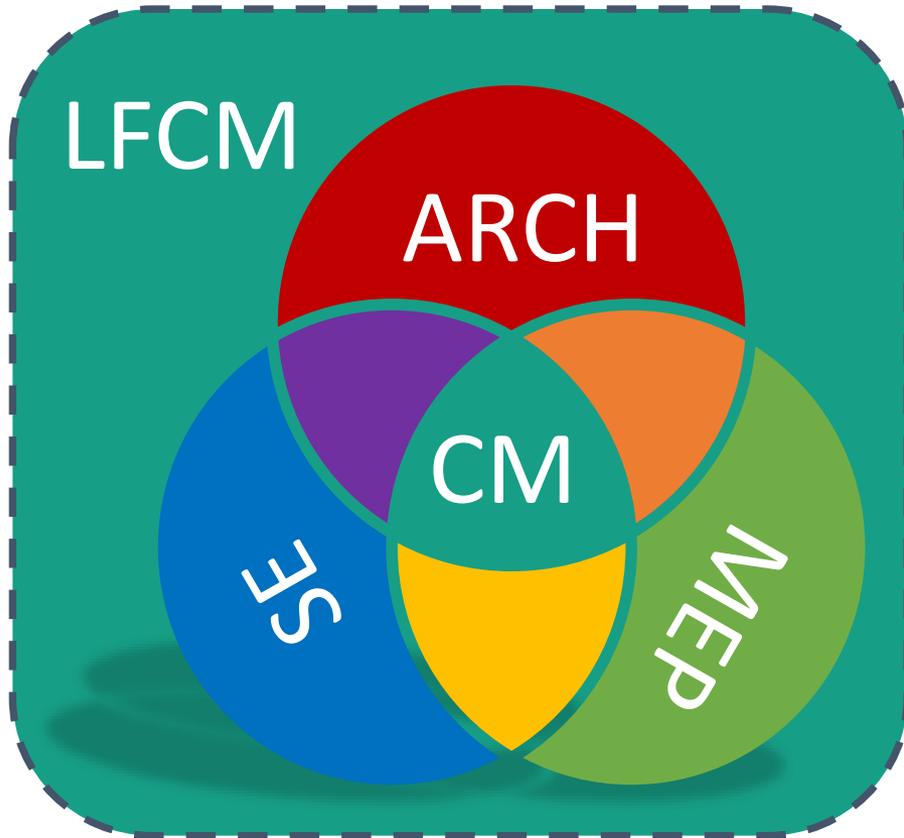
GoToMeeting
by **CITRIX**



INSTANT COMMUNICATION
Keep everyone in the loop



Collaborate-Collaborate- Coordinate



Column clash with Partition Wall



AUTODESK® 360



AUTODESK®
BIM 360™



AUTODESK®
REVIT®

Thank You!