Spring Presentation
May 10th, 2019
Our Owners

San Francisco State University

Renate

Hussain

Ewa

Karolina

Adrian

Jure
PASSAGE Journey

Project overview

PASSAGE through a day

PASSAGE through life cycle

Team process

Summary of challenges
New engineering building
30,000 sq.ft.
30 ft. above grade
Construction Challenges

- Tapered Site
- Proximity to a university building
- Existing tree inside site zone
- Site inaccessible from 3 faces
- 9 ft. elevation difference
Hazards and Challenges

Earthquake Outlook for the San Francisco Bay Region 2014–2043

Using information from recent earthquakes, improved mapping of active faults, and a new model for estimating earthquake probabilities, the 2014 Working Group on California Earthquake

72% probability of one or more $M \geq 6.7$ earthquakes from 2014 to 2043 in the San Francisco Bay Region

of causing widespread damage; therefore, communities in the region should take simple steps to help reduce injuries, damage, and disruption, as well as accelerate recovery from these earthquakes.
Climate Conditions & Challenges

Max. 64.04°F (17.8°C)
Min. 50.9°F (10.5°C)

Sun hours: 3070 h
Sundays: 259 days

Humidity: 75.0%

Most wind July.
Least wind January.

Rainy days: 73.0 days

Precipitation: 600.0 mm (23.62 in)
Project Goals

- Embodied Nature
- Interactive User Experience
- Design for Adaptability
- Economically Sustainable
- Educational Building Components
- Design for Maintenance
Design Alternatives - Winter

Intersection

Passage
Decision Matrix Summary - Winter

Criteria Comparison Alternatives

- Program Requirement
- User Experience
- Negative Carbon
- IT Integration
- DPR - Prefabrication
- Life Cycle Costs
- Implementation Big Idea
- Aesthetic Design
- Integrated AEC Design
- Floorplan
- Energy Demand
- CO² Footprint
- Construction Costs
- Construction Time

Passage Timber
Passage Steel
Intersection Mixed
Intersection Timber
Influencing Factors

Height difference integration  Joining communities  Nature
Concept Evolution

Winter
Presentation
15th March

Spring
Presentation
10th May
Theme of Building

PASSAGE

Passage of Knowledge

Passage of Light

Passage of Users
Access to Building

Main road
Pedestrian flow
Recreational path

Lake Merced
Stadium
San Francisco State University
Concept Evolution

Winter Presentation
15th March

Spring Presentation
10th May
Second Floor

- Large Classroom
- Student Offices
- Seminar Room
- Study area
- VR room
- Corridor
- Toilets
- Faculty Office
Structural System Selection

Carbon Footprint

Site Safety (No Welding)

Organic Atmosphere

Resilient
Timber Structural Design Components

- CLT ROCKING WALL
- POST-TENSIONING ELEMENT
- CONCEALED CONNECTION
- GLULAM BEAM
- LATERAL SYSTEM
- FRAMING
- CLT PANEL
- GLULAM COLUMN
- FLOOR PANELS
Structural Framing Plan - Level 1

- Glulam columns 8’x 8’
- Glulam columns 12’x12’
- Glulam columns 14’x14’
- CLT shear rocking walls 5’x 8”
- Glulam beams 8.75’x13.5’
- Glulam beams 10.75’x 13.5’
- Glulam girders 12.25’x 31.5’
Structural Framing Plan - Level 2 / Roof

- **Glulam columns 8’x 8’**
- **Glulam columns 12’x12’**
- **Glulam columns 14’x14’**
- **CLT shear rocking walls 5’x 8’**
- **Glulam beams 8.75’x13.5’**
- **Glulam beams 10.75’x13.5’**
- **Glulam girders 12.25’x31.5’**
HVAC Systems

**PRIMARY SYSTEMS**

- Heating and Cooling - Water - Air Exchange + Natural Ventilation
- Water Heating
- Electricity

**SECONDARY SYSTEMS**

- Office, Small Class - Plenum Supply and Return
- Auditorium - Displacement Ventilation
Second Floor

- SHAFT
- FLOOR SUPPLY DIFFUSERS
- RETURN TERMINAL
- EXHAUST
- PERIMETER RADIATORS
Third Floor

SHAFT
FLOOR SUPPLY DIFFUSERS
RETURN TERMINAL
EXHAUST
PERIMETER RADIATORS
A Day of a Future Student

- Digital native
- Environmentally conscious
- Spends 60% of the day at the faculty
- Collaborator
- Immersed in VR
- Participant of cyber classes
A Day of a Future Student

8 am
10 am
12 am
2 pm
4 pm
6 pm
8 pm

LECTURE
VR SESSION
COLLABORATION
SEMINAR
CYBER MEETING
Way Through the PASSAGE
Our Location

1. Bridge Entrance
2. Cafe
3. Lounge
4. Auditorium
5. Classrooms and offices
6. Exterior
PASSAGE Journey

- Project overview
- PASSAGE through a day
- PASSAGE through life cycle
- Team process
- Summary of challenges
Functions in PASSAGE

Auditorium
Cafe
Lounge
Collaboration Space
Living PASSAGE

5774 SF

CARBON SEQUESTRATION -4770kg/year
SOUND ABSORPTION 0.4
(1.0 the highest, 0.0 the lowest)
SOME OF THESE ORGANIC COMPOUNDS ARE RELEASED INTO THE SOIL

BACTERIA BREAKS DOWN THE ORGANIC COMPOUNDS RELEASING ELECTRONS

ELECTRONS ARE CAPTURED BY THE CONDUCTIVE MATERIALS CREATING ANODE
A parallel circuit has reached a peak power of ca. 4.6W per square meter

**PASSAGE [Watt]**
- Maximum 2466W

**PASSAGE [kWh]**
- 979 kWh/y—moss wall

**PASSAGE [day]**
- LED Lighting- 268
- Smartphone- 134
- Single board computer- 107
- Laptop- 67
Our location

1. Bridge Entrance
2. Cafe
3. Lounge
4. Auditorium
5. Classrooms and offices
6. Exterior
Let’s create a more open Passage feel!

ARCH

Let’s expose the structure!

SE

22'-0”
1'-0" tolerance for lateral displacement of the bridge.
1. Bridge Entrance
2. Cafe
3. Lounge
4. Auditorium
5. Classrooms and offices
6. Exterior
Cafe Rent

- Passage to rest, lounge and chat
- How increase comfort?
- Cafe, Sodas, Snacks

→ Adds Value and Comfort to occupants

→ Helps to decrease owner rent

Yearly Rent: 21,000 $
Cleaning: 1,500 $
Total Yearly: 19,500
Initial: 15,000
Total LC: 453,000

Yearly Rent: 21,000 $
Cleaning: 1,500 $
Total Yearly: 19,500
Initial: 15,000
Total LC: 453,000
Our Location

1. Bridge Entrance
2. Cafe
3. Lounge
4. Auditorium
5. Classrooms and offices
6. Exterior
Experience from cyber classes at the Stanford University:

Lesson learned: More cyber students in the future
Cyber Auditorium

- Livestream of lectures
- 360 camera
- Microphones for cyber students
- Screen for projections
- Speakers’ laptop connected to screens
Auditorium Rent

- Available: weekends, nighttimes
- Better use of space → rent for events
  → Value and comfort to occupants
  → Decrease owner rent

Yearly Rent: 130,000 $
Catering: 26,000 $
Total Yearly: 104,000 $
Total LC: 2,500,000 $
1. Bridge Entrance
2. Cafe
3. Lounge
4. Auditorium
5. Classrooms and offices
6. Exterior
Exaggerated Deflected Shape - ETABS
Subjected to Dead + Live Loads (Gravity)

Max Deflection = 1.46in
12 ¼" x 31 ½" Glulam Beam
L/240 = 2.2 in
Let’s expose the beams!

We need a structurally efficient solution!

Not another manufacturer!

ARCH

SE

CM

Option #1

Option #2

Option #3

Structural Analysis - Long Span Auditorium
Auditorium Sandwich

DISPLACEMENT VENTILATION
Cantilever Load Transfer

GRAVITY LOAD

COMPRESSION

TENSION

LATERAL LOAD
Typical Connection Details

Column to Column Connection

Beam to Beam Connection

Column to Foundation Connection
Panel to Panel and Column Connections

CLT Panel to Panel Connection

Column to Column Connection

Source: Structurlam
Concealed Glulam Beam Connections

Typ. Concealed Beam Connection
Offices and Classrooms - Sandwich

UNDERFLOOR AIR DISTRIBUTION
Natural Ventilation
Flexible Spaces

- Moveable walls between classrooms and offices
- Sliding doors for open learning spaces
Flexible MEP
Our location

1. Bridge Entrance
2. Cafe
3. Lounge
4. Auditorium
5. Classrooms and offices
6. Exterior
Creating PASAGE of Light

We need shading!

MEP

vertical mixed horizontal

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Creating PASSAGE of light

We would like horizontal or vertical solution

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>SE</th>
<th>MEP</th>
<th>CM</th>
<th>LCFM</th>
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<td>3</td>
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</table>

OWNERS

Winter presentation 15th March
Owner meeting 14th April
Owner meeting 28th April
Spring presentation 10th May
Creating PASSAGE of light

Vertical or horizontal shading?

ARCH

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Let’s get inspired by the nature

ARCH

Winter presentation
15th March

Owner meeting
14th April

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Spring presentation
10th May

PASSAGE of Light
What materials are we going to use?

**LCFM**

<table>
<thead>
<tr>
<th>FACADE</th>
<th>WOODEN PANELS</th>
<th>ALUMINIUM PANELS</th>
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<tbody>
<tr>
<td>CARBON IMPACT</td>
<td>4800 kg CO2-eq</td>
<td>12650 kg CO2-eq</td>
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</table>

**Winter presentation**
15th March

**Owner meeting**
14th April

**Owner meeting**
28th April

**Spring presentation**
10th May
PASSAGE of Light

LCC Comparison Facade Materials

- Aluminium: 12650 kg CO2-eq
- Wooden: 4800 kg CO2-eq

We would like a wooden facade

OWNERS

Winter presentation 15th March
Owner meeting 14th April
Owner meeting 28th April
Spring presentation 10th May
PASSAGE of Light

We need to think about solar gains

MEP
Identifying Outputs/Constraints

How about parametric optimization?

How about parametric optimization?

Winter presentation
15th March

Owner meeting
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28th April

Spring presentation
10th May

SE

Volume

Summer Energy Gain

Winter Energy Gain
Parametrization of the Problem

- # Sun rays passing through the shading
- Size and location of the “wooden knots”
- Curvature and depth of the shading panels
- Density of the shading panels

- Winter presentation 15th March
- Owner meeting 14th April
- Owner meeting 28th April
- Spring presentation 10th May
Optimization in Autodesk Refinery

Manual Changing Parameters

---

**Y-Axis**
- Depth sequence

**X-Axis**
- Number of divisions

**Size**
- Total Volume

**Color**
- Summer Number of blocked rays

---

Winter presentation
15th March

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Spring presentation
10th May

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(Amount of sun rays that pass through the shading in winter)
Fog Collection

Fog: 0.05-0.5 grams of water per cm

1 sq ft 0.12 → 0.60 gall/day

1 [SF] - 0.12-0.60 [gal/day]
3202 [SF] - 384-1921 [gal/day]
140160- 701238 [gal] - yearly
Fog Collection
Where can I put my doors?

ARCH
Rocking CLT Shear Walls - Connection Details

- **CONCEALED STEEL CONNECTOR**
- **GLULAM BEAM (GRAVITY)**
- **KRAWINKLER BUTTERFLY FUSE**
- **SLOTTED POST TENSIONED STEEL CABLES**
- **GLULAM COLUMN**
- **SLOTTED CONNECTIONS**
Lateral System - Base Shear

1466 K

13'-0"

797 K

599 K

2062 K

SHEAR

COMPRESSION

TENSION
Lateral System - Sizing Rocking Walls

Moss Wall Contribution

PV Panels Contribution

Total Mass Contribution

824 k

Allowable Shear Stress

9.625" Thick

7-Ply Layer CLT Wall

.68 k

1.34 k

454 k

.84 k

246 k

.21 k

124 k

Governing Tributary Area
Rocking CLT Shear Walls

UCSD Testing of Comparable System

Slotted cables
Lateral System - Structural Analysis

Stress Check

Ground Motions

Scale Factor - DBE

Analysis

Further Nonlinear Analysis

Δ max = .18 in
Multi Disiplinary Panel Optimisation

Manual Layout
3 Iterations
- 40% other
- 33% 10’x 24’
- 17% 10’x 22’
- 10% 9’x 22’

Parametric Layout
200 Iterations
- 53% 10’x 24’
- 28% other
- 11% 8’x 24’
- 8% 6’x 24’

We need to consider the zoning layout

CM
Multi Disiplinary Panel Optimisation

Dynamo
- Parametrization
- Autodesk Project Refinery
- Optimization studies
- Developing the panel distribution

Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Y-Pos X-Shift Y</th>
<th>X-Axes X-Shift X</th>
<th>X-Pos</th>
<th>Y-Pos</th>
<th>Default</th>
<th>S</th>
<th>C2</th>
<th>C1</th>
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<td>10/10</td>
<td>10/10</td>
<td>10/10</td>
<td>5/5</td>
<td>5/5</td>
<td>5/5</td>
<td>5/5</td>
<td>5/5</td>
</tr>
</tbody>
</table>
Site Layout

- Crane position
- Material laydown
- Pedestrian diversion
- Extended footprint
- Existing tree
Criteria for Luffer Crane Selection

**Luffer Crane**
- Jib Length: 130 ft.
- Height: 40 ft.
- Capacity: 8 t

**Mobile Crane**
- Jib Length: 80 ft.
- At 40 ft. height
- Capacity: 50 t

VS.

40 ft.
Criteria for Luffer Crane Selection
Overall Schedule Strategy
Construction Schedule

Project Duration: 288 Calendar days
Project Completion: 14th July 2025
Total Construction Cost: ~10 M

Is this the best alternative?

Infinite Resources
Organizational Setup & Analysis

- Weekly Team Coordination Meeting for 1 hour
- 30% chances to communicate
- 5% chance of a functional error
- 5% chance of interruption
- 5% chance of project error (rework)

Anticipated Project Completion **A: 16th Feb. 2026 (217 days)**
Ideal Organizational Setup & Analysis

- Lower Task Complexity
- Less prob. of rework
- Less uncertainty of information bottleneck

Updated anticipated project completion date **A: 22nd August 2025**
Identification of Logistical Bottleneck

6/17/2025 11:42:00 PM
Week 38
Day 262 (Tuesday)
4D Simulation of Construction Plan

10/7/2024 6:00:00 AM
Week 2
Day 9 (Monday)
Construction Coordination with Structural Framing

6.75” x 13.5”

8.75” x 13.5”

6.75” x 13.5”

10.75” x 13.5”

Zone A

Zone B

Zone C
Schedule Correction

Project duration: 341 days
Project Completion: 5th Sept. 2025
Total Construction Cost: ~10.5 M

Reduced risks
Untangled bottlenecks

Infinite Resources
Construction KPI

- Truck Delivery to loading area: 1 min ± 10 sec
- Lifting and Delivery to erection zone: 7 min ± 3 min
- Unloading of truck: 15 min ± 5 min
- Crane loading: 15 min ± 5 min
- Truck leaves site zone: 1 min ± 10 sec
Construction KPI - Monte Carlo Simulation

Upper Control Limit: 46.75 min.
Avg. : 38.34 min.
Progressive Cost Estimation

BIM Model

Quantity Take Off

Data Flow

Cost Database

Data Entry

Target Value Design Sheet
Digital Replica to Improve Functionality

**WHY?**
- Student Focus
- Operational Costs
- Expensive Repairs

**RISK?**
- A 400-ppm increase in CO2 was associated with a 21% decrease in cognitive scores - Harvard T.H. Chan School of Public Health

**WHO?**
- Occupants
- Owners + Environment
- Owners

"A 400-ppm increase in CO2 was associated with a 21% decrease in cognitive scores" - Harvard T.H. Chan School of Public Health
Digital Replica to Improve Functionality

- Water
- Electricity
- Strain Gauge
- Acceleration

- Temperature
- Presence
- Humidity
- CO₂
- Light

ARDUINO

Digital PASSAGE
Digital Replica to Improve Functionality

First Floor

Occupancy
Temperature
Humidity
CO2

Physical asset integrated with real time data + insights

Computer Lab #1
Occupancy: 85%
E. Eng. 12pm - 16pm

Humidity
81%
Displays Sensor Data
Rooms Displays Sensor Data
LCC Impact Digital Twin / IoT Sensors

LCC Comparison

- Passage 28th April:
  - $2,700,000 (Interest Costs)
  - $950,000 (Risk Costs)
  - $1,020,000 (R&M Costs)
  - $4,320,000 (O&M Costs)
  - $9,220,000 (Initial Costs)

- Passage Sensors:
  - $2,760,000 (Interest Costs)
  - $960,000 (Risk Costs)
  - $980,000 (R&M Costs)
  - $3,870,000 (O&M Costs)
  - $9,380,000 (Initial Costs)

Total Savings: $260,000 ($1.4%)

- $60,000 ($1.1%)
- $10,000 ($1.1%)
- $40,000 ($3.9%)
- $450,000 ($10.4%)
- $160,000 ($1.7%)
Negative Carbon Strategy

Reducing Embodied Energy
- Carbon Natural Materials
- Reducing Construction Emission

Energy Plus Building
- Energy storage
- Maximising Energy Generation

Recovering Carbon
- Carbon Capture
- Recycling Material
- Reuse Elements

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Negative Carbon Strategy

**Negative Carbon Challenge Over 60 Years**

- **Total Carbon Consumed (TCC)**
  - Embodied Construction Energy
  - C_Energy
  - O_Energy
  - Generation
- **Construction & Planning (2 yr)**
- **Leasing Agreement (25yr)**
- **Total Carbon Saved (TCS)**
  - Capture C
  - Recycling
  - Re-Use

**Negative Carbon = TCS > TTC**

**Events**
- **Winter presentation**
  - 15th March
- **Owner meeting**
  - 14th April
- **Owner meeting**
  - 28th April
- **Spring presentation**
  - 10th May
Reducing Embodied Energy

**Performance Relative to Life Cycle Impact Targets**

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<tr>
<th>Impact</th>
<th>Target</th>
<th>Project</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Carbon (kgCO2e)</td>
<td>3 714 897</td>
<td>2 644 733</td>
<td>71%</td>
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<tr>
<td>Energy (MJ)</td>
<td>120 509 807</td>
<td>59 132 476</td>
<td>49%</td>
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<tr>
<td>Water (kgH2O)</td>
<td>73 347 945</td>
<td>82 414 777</td>
<td>112%</td>
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<tr>
<td>Ozone (kgCFC11)</td>
<td>-</td>
<td>8.78E-02</td>
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**Performance Relative to Life Cycle Impact Targets**

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<td>Carbon (kgCO2e)</td>
<td>3 714 897</td>
<td>3 640 162</td>
<td>98%</td>
</tr>
<tr>
<td>Energy (MJ)</td>
<td>120 509 807</td>
<td>93 261 510</td>
<td>77%</td>
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<tr>
<td>Water (kgH2O)</td>
<td>73 347 945</td>
<td>82 557 766</td>
<td>113%</td>
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<tr>
<td>Ozone (kgCFC11)</td>
<td>-</td>
<td>1.12E-01</td>
<td>-</td>
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**WOOD AND CONCRETE**

**STEEL AND CONCRETE**

- Winter presentation: 15th March
- Owner meeting: 14th April
- Owner meeting: 28th April
- Spring presentation: 10th May
Reduced Embodied Energy

EMBODIED CARBON IMPACT

Carbon [kgCO2e]

- 600 000
- 500 000
- 400 000
- 300 000
- 200 000
- 100 000
- 0

WALLS  WINDOW  ROOF  STRUCTURE  FOUNDATIONS  ENERGY  MEP

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Reducing Embodied Energy
-7%

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Energy Plus Building

- Glass properties - Triple glass
- Roof/wall heat losses and gains
- Lighting/plug load power consumption
- HVAC-heat pump with geothermal
- PV- Surface coverage
- Shading devices

Winter presentation 15th March
Owner meeting 14th April
Owner meeting 28th April
Spring presentation 10th May
Energy Plus Summary

Benchmark Comparison
kWh / m² / yr

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Energy Plus Building

-76%

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Design for Disassembly & Maintenance
- Reuse Elements as new components
- Scrap Material on Site

Reuse: 7800 kg CO2-eq
Recycling Material

Volumetric Material Distribution

Reuse Timber Frame %33
Reuse Wood %24
Recycle Concrete %23

Recycling: 1650 kg CO2-eq

Replacement of Insulation (Recycling) & Scarping Elements

Winter presentation 15th March
Owner meeting 14th April
Owner meeting 28th April
Spring presentation 10th May
Recovering Carbon

-17%

- Winter presentation | 15th March
- Owner meeting | 14th April
- Owner meeting | 28th April
- Spring presentation | 10th May
STV Evolution

STV EVOLUTION

- Carbon (kgCO2e
- Energy (MJ)
- Water (kgH2O)
- Target

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Carbon Balance

Carbon Reduction
28k kg CO2-eq / year
Negative Carbon Target
57 years

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May
Recovering Carbon

Winter presentation
15th March

Owner meeting
14th April

Owner meeting
28th April

Spring presentation
10th May

-17%
Integration of Disciplines

- A: Areas
- MEP (STV): Consumptions
- CM (TVD): Initial Costs
- SE: Safety

- O&M Costs
- R&M Costs
- Risk Costs

Integration of Disciplines:
- Rent, CashFlow, Financing, etc.

LIFE CYCLE COSTS (LCC)
- Initial Costs + Future Costs

INITIAL COSTS
- Planning & Design
- Construction & Site Development
- FFE

FUTURE COSTS
- Energy
- Maintenance & Repair
- Staffing & Operations
- Intercosts
- Interest
- Balloons

15% (35-50%)
Risk Management Steps

Risk Identification

- Create Risk List
  - Risks over different stages (planning, construction, etc.)
  - Identify as many as possible

Risk Evaluation

- Calculate Risk Priority Figure
  - Consequences, occurrence- and discovery probability
  - Identify main risks

Risk Strategies

- Avoid
  - Eliminate Risks

- Mitigate
  - Reduce Probability or impact

- Accept
  - Build up reserves

- Transfer
  - Third party takes responsibility (e.g. insurance)

Risk Costs

- Calculate remaining risk costs for project
  → Add to Cash Flow
Risk Maps Before Risk Strategies

![Risk Map Diagram]

- Vandalism risk
- Act of nature risk
- Management risk
- Operation risk
- Requirement risk
- Inflation risk
- Planning risk
- Income risk
- Earthquake risk

- Probability
- Consequences
Risk Maps After Risk Strategies

Lower risks through mitigation and transfer
Life Cycle Cost Development

LCC

- **Arrange HS Rooms, etc.**
  - $19,250,000
  - $2,600,000
  - $19,010,000
  - $6,730,000
  - $18,000,000

- **Shading, PV, Fog**
  - $19,400,000
  - $2,360,000
  - $19,040,000
  - $8,080,000
  - $18,210,000

- **Moss Wall, Green Roof, Sensors**
  - $19,140,000
  - $2,700,000
  - $19,140,000
  - $9,220,000
  - $4,050,000

Legend:
- **Interest Costs**
- **Risk Costs**
- **R&M Costs**
- **O&M Costs**
- **Initial Costs**
Yearly Rent Development

Rent Comparison

- Mentor Crit: $1,000,000
- Winter Presentation: $941,000
- 14th April: $1,051,000
- 28th April: $1,031,000
- Spring Presentation: $1,101,000

- Auditorium Rent
- Cafe Rent
- Owner Rent
LCC Increase 28th April - Spring

LCC Comparison

Passage 28th April
- Interest Costs: $2,700,000
- Risk Costs: $950,000
- R&M Costs: $1,020,000
- O&M Costs: $4,320,000
- Initial Costs: $9,220,000
Total: $18,210,000

Passage Moss
- Interest Costs: $2,890,000
- Risk Costs: $970,000
- R&M Costs: $1,040,000
- O&M Costs: $4,260,000
- Initial Costs: $9,890,000
Total: $19,050,000

Passage Green Roof
- Interest Costs: $2,750,000
- Risk Costs: $960,000
- R&M Costs: $920,000
- O&M Costs: $4,490,000
- Initial Costs: $9,410,000
Total: $18,530,000

Passage Sensors
- Interest Costs: $2,760,000
- Risk Costs: $960,000
- R&M Costs: $980,000
- O&M Costs: $3,870,000
- Initial Costs: $9,380,000
Total: $17,950,000
LCC Increase 28th April - Spring

LCC Comparison

- Passage 28th April: $18,210,000
  - Interest Costs: $2,700,000
  - Risk Costs: $950,000
  - R&M Costs: $1,020,000
  - O&M Costs: $4,320,000
  - Initial Costs: $9,220,000

- Passage Combined (Moss Wall, Green Roof, Sensors): $19,140,000
  - Interest Costs: $2,970,000
  - Risk Costs: $980,000
  - R&M Costs: $990,000
  - O&M Costs: $4,050,000
  - Initial Costs: $10,150,000

- Passage Combined without Moss Wall: $18,280,000
  - Interest Costs: $2,770,000
  - Risk Costs: $960,000
  - R&M Costs: $960,000
  - O&M Costs: $4,110,000
  - Initial Costs: $9,480,000

- Passage Combined without Green Roof: $18,980,000
  - Interest Costs: $2,910,000
  - Risk Costs: $980,000
  - R&M Costs: $1,000,000
  - O&M Costs: $4,120,000
  - Initial Costs: $9,970,000
LCC Increase 28th April - Spring

Comparison Yearly Owner Rent

- Passage 28th April: $880,000
- Passage Combined (Moss Wall, Green Roof, Sensors): $950,000
- Passage Combined Without Moss Wall: $910,000
- Passage Combined Without Green Roof: $935,000

Owner Rent
## Value for Money

<table>
<thead>
<tr>
<th></th>
<th>Passage</th>
<th>Passage Combined</th>
<th>Passage Combined without Moss Wall</th>
<th>Passage Combined without Green Roof</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aesthetic Design</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Big Idea</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Connection to Surroundings</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Occupants Comfort</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Carbon Sequestration</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Water Collection</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Educational Value</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Innovation</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td><strong>Total Value</strong></td>
<td>8</td>
<td>23</td>
<td>13</td>
<td>20</td>
</tr>
<tr>
<td><strong>LCC Costs in $</strong></td>
<td>18.21 M</td>
<td>19.14 M</td>
<td>18.28 M</td>
<td>18.98 M</td>
</tr>
<tr>
<td><strong>Value for Money</strong></td>
<td>0.44</td>
<td>1.20</td>
<td>0.71</td>
<td>1.05</td>
</tr>
<tr>
<td><strong>Yearly Owner Rent in $</strong></td>
<td>0.88 M</td>
<td>0.95 M</td>
<td>0.91 M</td>
<td>0.935 M</td>
</tr>
<tr>
<td><strong>Value for Rent</strong></td>
<td>9.09</td>
<td>24.21</td>
<td>14.29</td>
<td>21.39</td>
</tr>
</tbody>
</table>

| Legend:                        |         |                 |                                     |                                     |
|                                | Good = 1 Point | Better = 2 Points | Best = 3 Points          |                                     |
Cash Flow / Financial Figures of Passage

Break Even: 22 Years

NPV: 1,810,000 $

IRR: 16.1%

Owner Rent: 950,000 $
Equity/Debt Ratio

Debt Service Cover Ratio

Loan Life Cover Ratio

Actual DSCR | Minimum DSCR
Actual LLCR | Minimum LLCR
PASSAGE Journey

Project overview
PASSAGE through a day
PASSAGE through life cycle
Team process
Summary of challenges
Team Process Integration

Kick Off

More meetings, voice channels,

Winter Presentation

Even more meetings, better use of asana, VR

Spring Presentation
<table>
<thead>
<tr>
<th>Event</th>
<th># Team Meetings</th>
<th># Subgroup Meetings</th>
<th># Owner Meetings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick Off</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Mentor Crit</td>
<td>×</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>Winter Presentation</td>
<td>×</td>
<td>× ×</td>
<td>×</td>
</tr>
<tr>
<td>12th April</td>
<td>×</td>
<td>× × ×</td>
<td>× ×</td>
</tr>
<tr>
<td>Spring Presentation</td>
<td>× × × ×</td>
<td>× × ×</td>
<td>× ×</td>
</tr>
</tbody>
</table>

- **VR** = Virtual Reality
- **Zoom**
- **Biweekly**

- **#39 Team Meetings**
- **#33 Sub Meetings**
- **#7 Owner Meetings**
- **#2 Teambuilding**

**#81 Meetings Total**
How did we use VR to solve problems?

Understanding problems

Running simulations

Clash detections

Spatial flow
Team Protocols & Practices : BEP

Strong BIM Manager Team
- project info
- rules
- protocols
- goals
- solutions

Level 1 - clashes with structural elements
- Floors should connect to the edge of the structural walls.
- Architectural wall should not cut through structural floors.

Additional Level
Common Level

Architectural wall
Void
Combined wall
Structural wall

4.6 - Levels
Levels should be drawn in each discipline model to acquire level constraints as they cannot be acquired from linked models. Common levels should be positioned on top face of the structural floors, because the floor sandwich above the structural part (insulation, different finishes, ...) can vary in thickness.

Example of wrong positioning of the floors:

Example of correct positioning of the floors:

Architectural floors should be positioned with an offset or with a help of additional level.

Naming Convention
Levels should be named in the following order: Discipline mark, position of level, description. Position 00 should mark the lowest level.

Example
S.01: First floor - meaning: Structure, Second lowest level, First floor
PASSAGE Journey

Project overview
PASSAGE through a day
PASSAGE through life cycle
Team process

Summary of challenges
DPR Challenge

- Reduced Waste
- Reduced Risk
- Optimal Cost
- Process integrated KPI

- Balanced information flow & workload
- Work packages match with logistical packages
- Bottleneck resolved
IT Integration Proposal & Benefits

Support Project Development
- %10 Cooling (Solar Gains)
- %5 Material (Structure)
- %40 Material (Facade)

Increase Efficiency and Performance
- %10 Time (Schedule)
  %1.91 kg CO2/yr (Carbon Reduction)

Schedule Optimization (AI, VR, POP, Parametric)
- %10 Time (Schedule)

User Integration
- %10 O&M Cost (Sensors)

Design Optimization (AI and Generative Design)

Dynamic TVD and STV Monitoring

Innovation
Reducing Embodied Energy

Energy Plus Building

Recovering Carbon

Carbon Reduction
28k kg CO2-eq / year

Negative Carbon Target
57 years

Carbon Natural Materials
Reducing Construction Emission
Energy storage
Maximising Energy Generation
Carbon Capture
Recycling Material
Reuse Elements
Project Goals

- Embodied Nature
- Interactive User Experience
- Design for Maintenance
- Educational Building Components
- Design for Adaptability
- Economically Sustainable
Thank You

Owners:
Jure Česnik
Hussain Parsianfar
Ewa Kunkel
Adrian Koeve
Karolina Ostrowska

Mentors:
Renate Fruchter
Jamie Chung
Erik Kneer
Greg Luth
Tim Schrotenboer
Justin Schwaiger
Reid Zimmerman
Mary Haywood
Prashant Sharma
Eric Luttman
Mike Miller
Peter Hau

Tomo Cerovšek
Kean Walmsley
Francisco Galvis
Gregory Deierlein
Eduardo Miranda
Anja Jutraz
Humberto Cavallin
Willem Kymmel
Nick Zeman
Forest Olaf Peterson
Norayr Badasyan
Charles Bovet

Adam Pekala
Pawel Baran
Artur Tomczak
Spring Presentation
May 10th, 2019
"We are all architects here" - Agnieszka

"Propose the change instead what the change should do" - Sara

"Plan before you start" - Sylwia

"Listen first before you speak" - Varun

"Multi-tasking in virtual meetings leads to loss of focus" - Gianluca

"Nothing is created perfect in the start, only with iterations does it become ideal" - Luka

"I never thought globally distributed online work would actually be that hard" - Florian