POLITECNICO
MILANO 1863

AMAZON HEALING
Tower for the Amazon

THESIS PRESENTATION
19th December 2023

MASTER OF SCIENCE IN ARCHITECTURE - BUILDING ARCHITECTURE
A.Y. 2022-2023

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Services design for sustainable buildings: Prof. Lorenzo Pagliano

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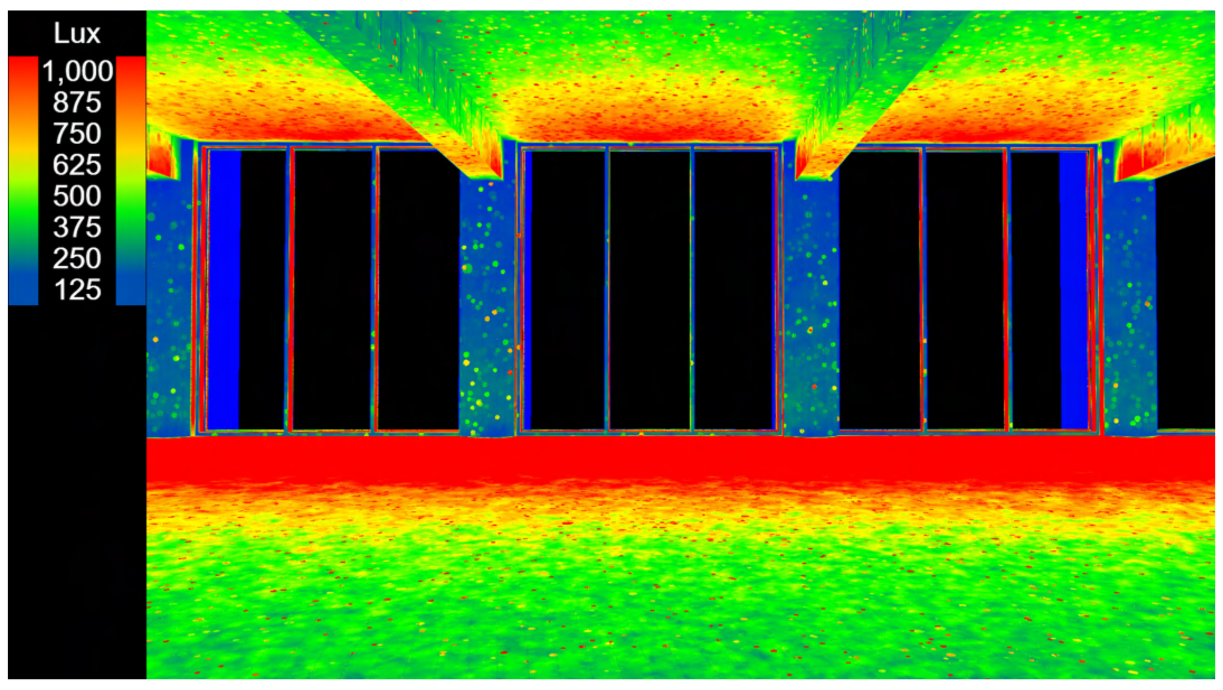
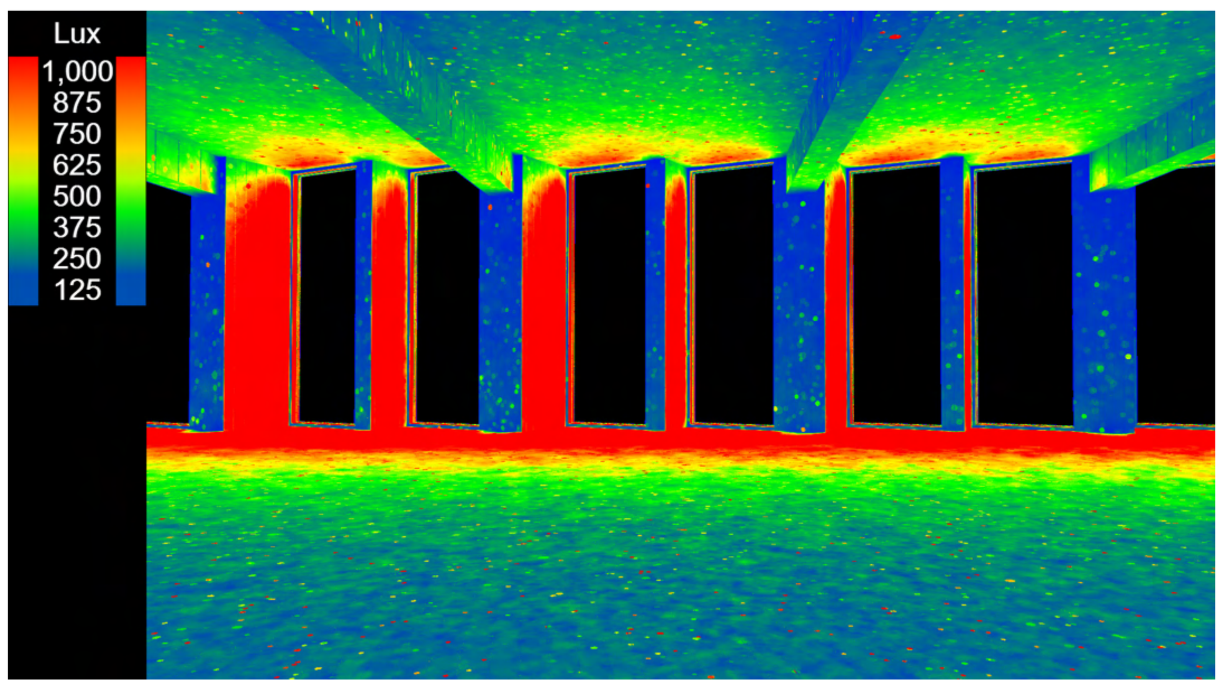
AMAZONAS

0m
4m
8m
12m
16m
20m

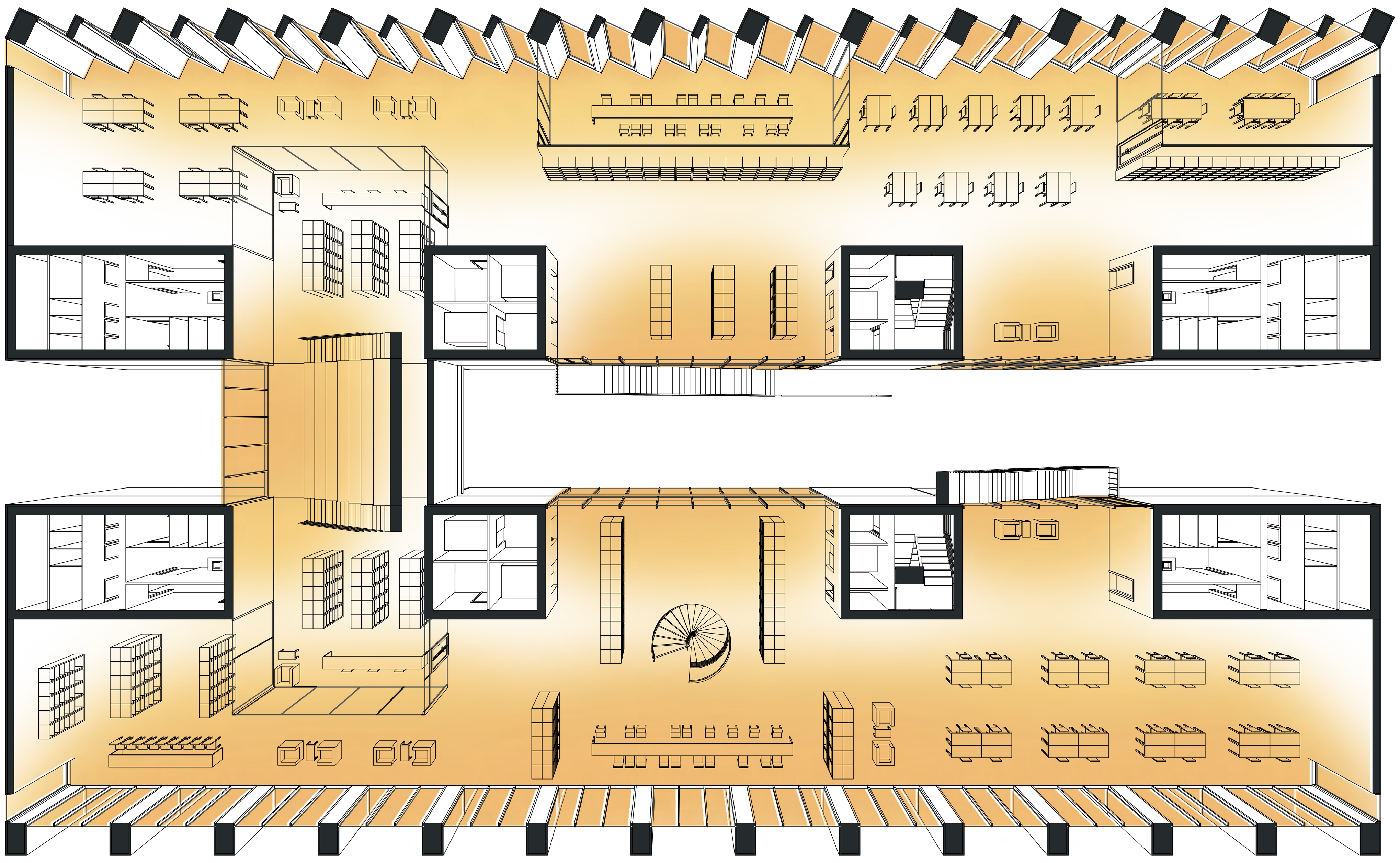
FACADE DIFFERENTIATION



STRAIGHT FACADE | Greater light entry

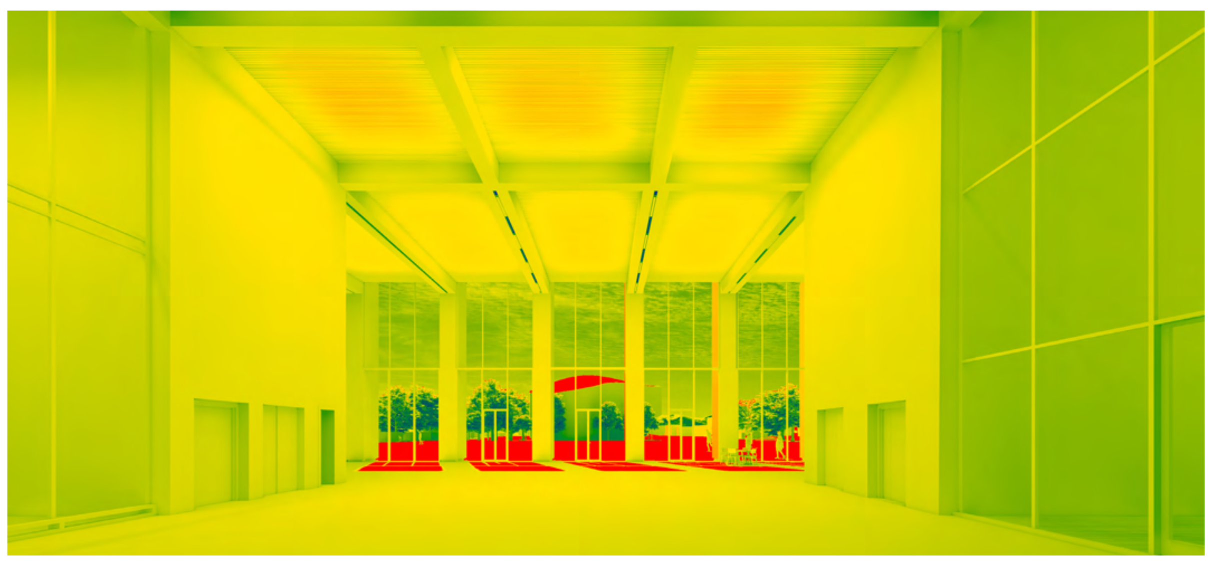


SKEWED FACADE | Less light entry


DAYLIGHT

DAY LIGHT ANALYSIS

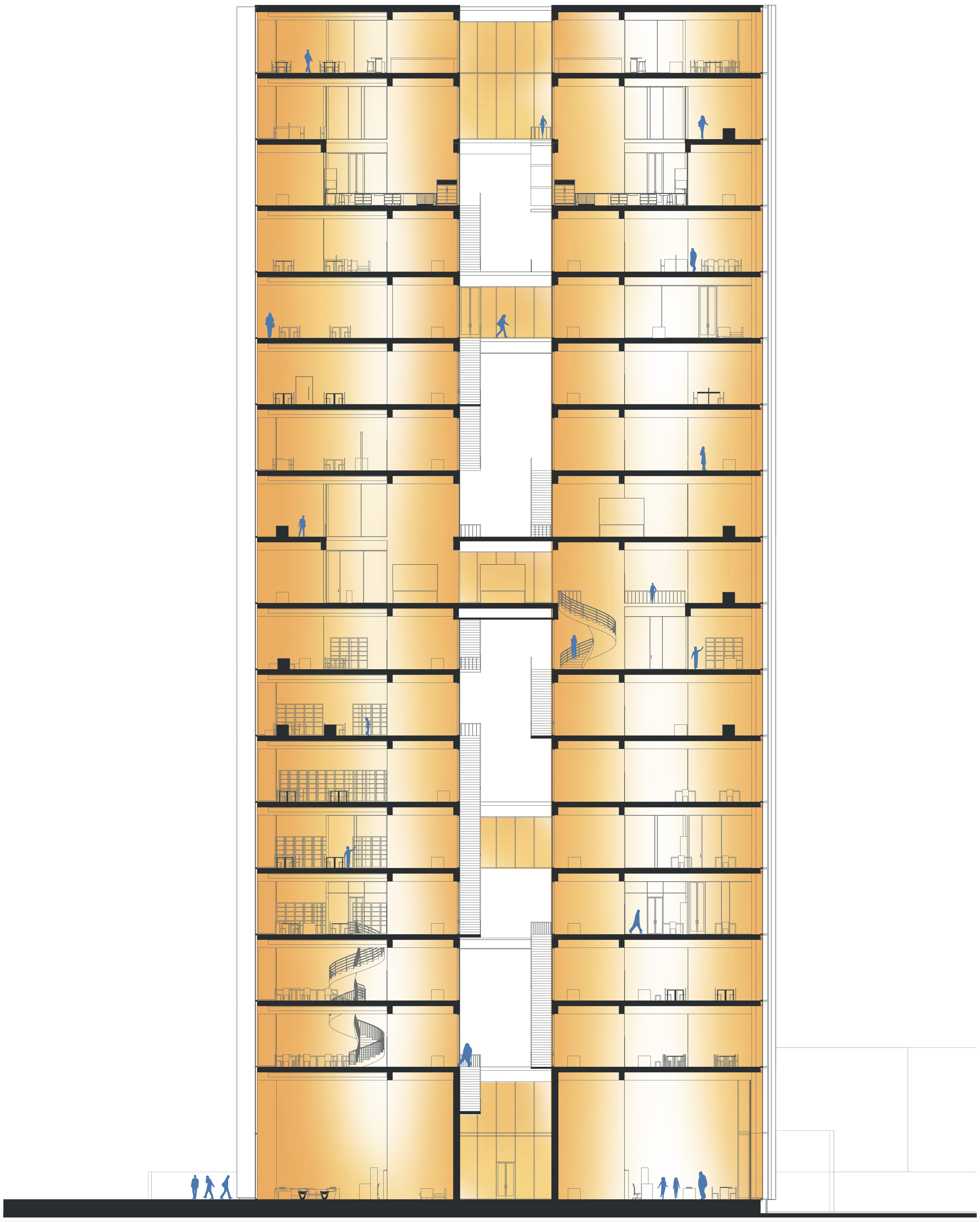

View towards the west entrance (straight facade)


Light analysis of the view

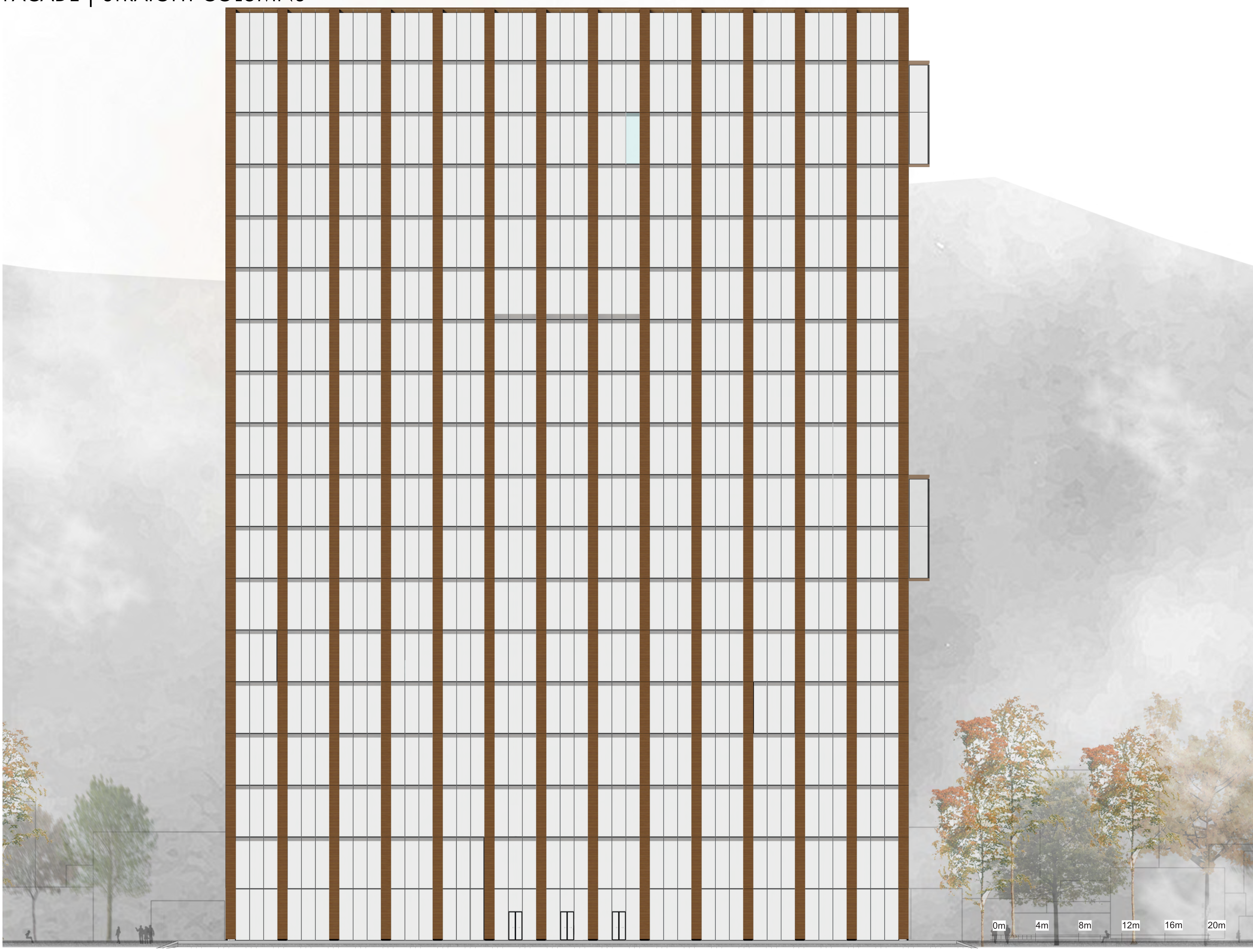

View towards the east entrance (skewed facade)

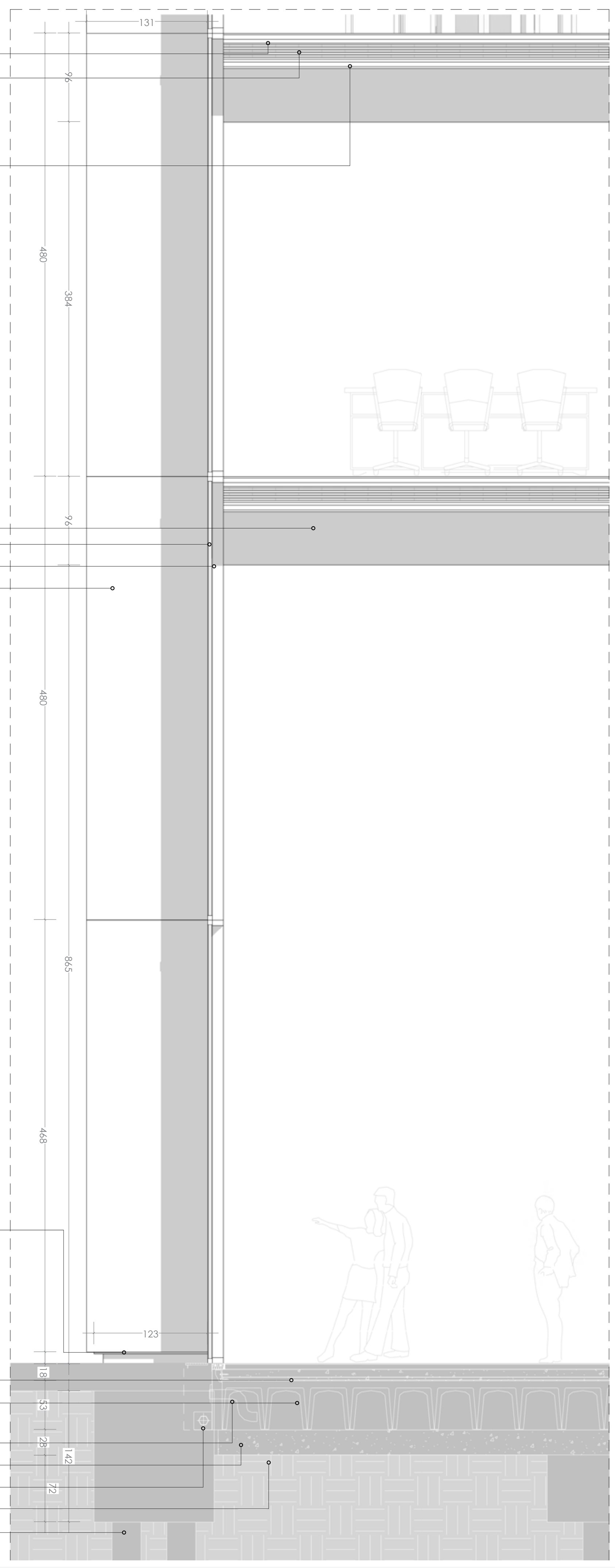

Light analysis of the view

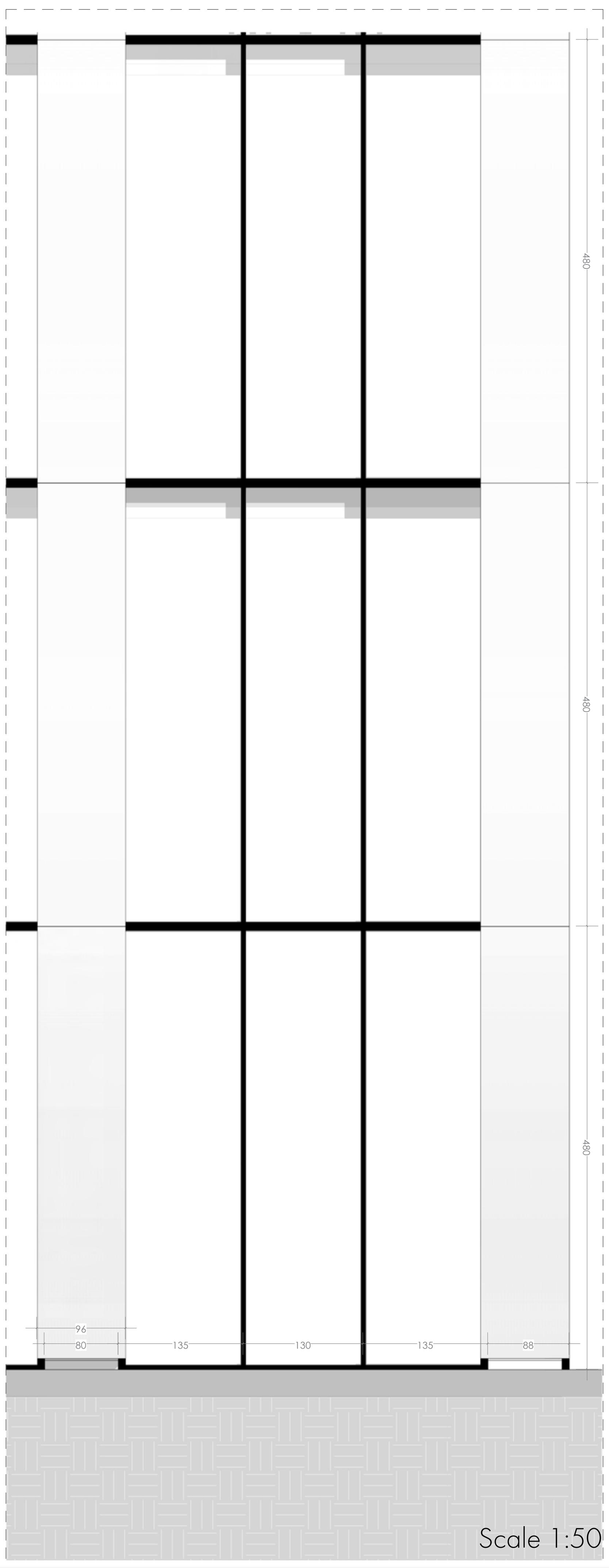
RELATION WITH THE CONTEXT

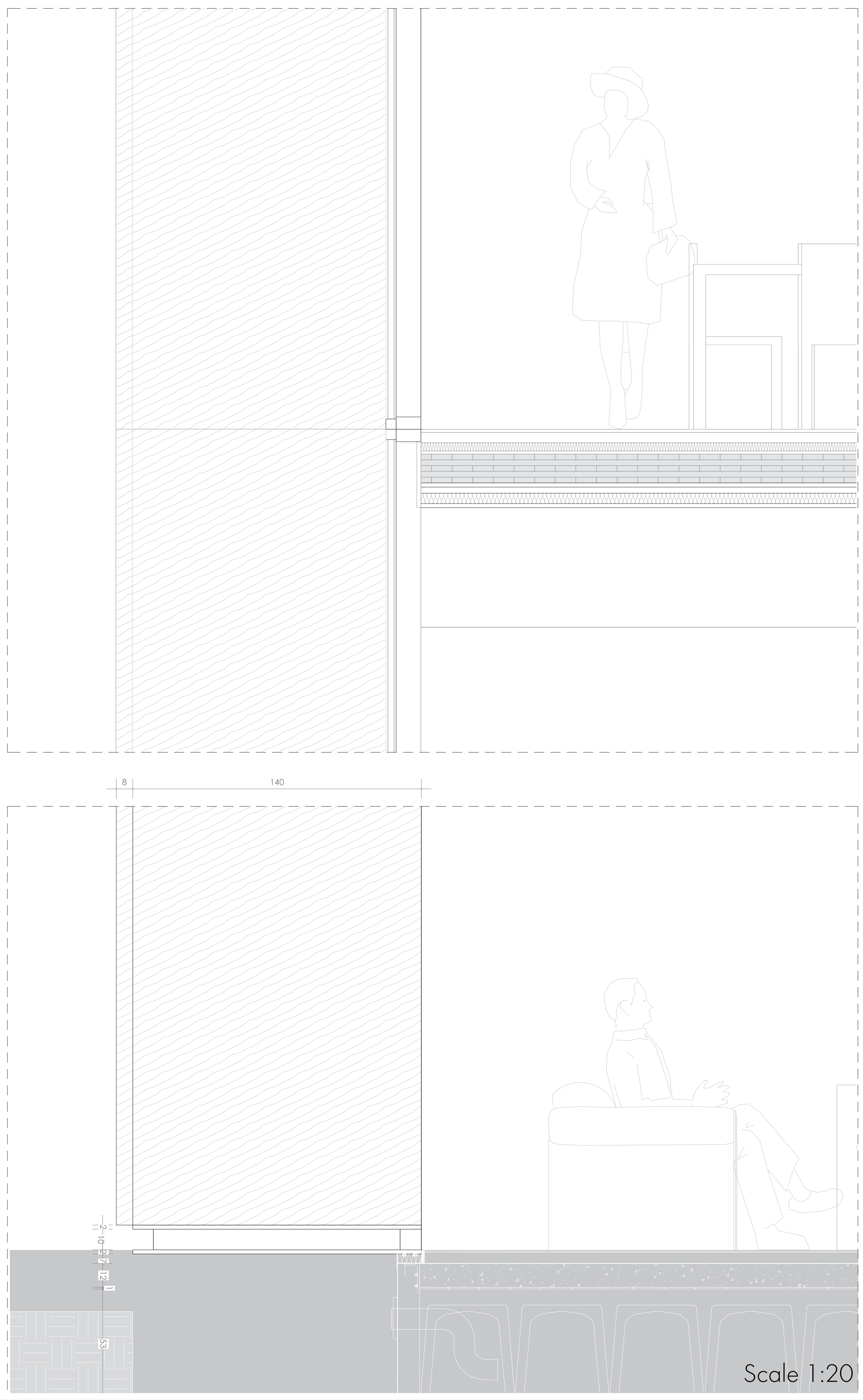


FACADE | STRAIGHT COLUMNS









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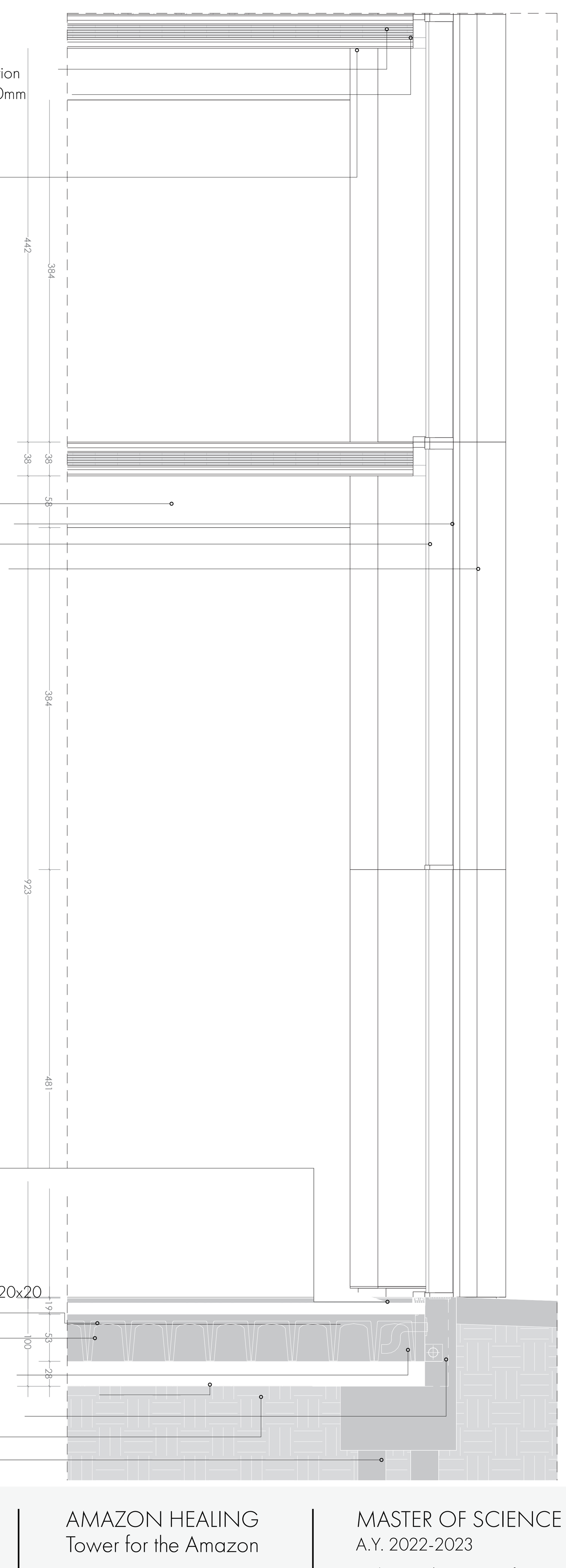
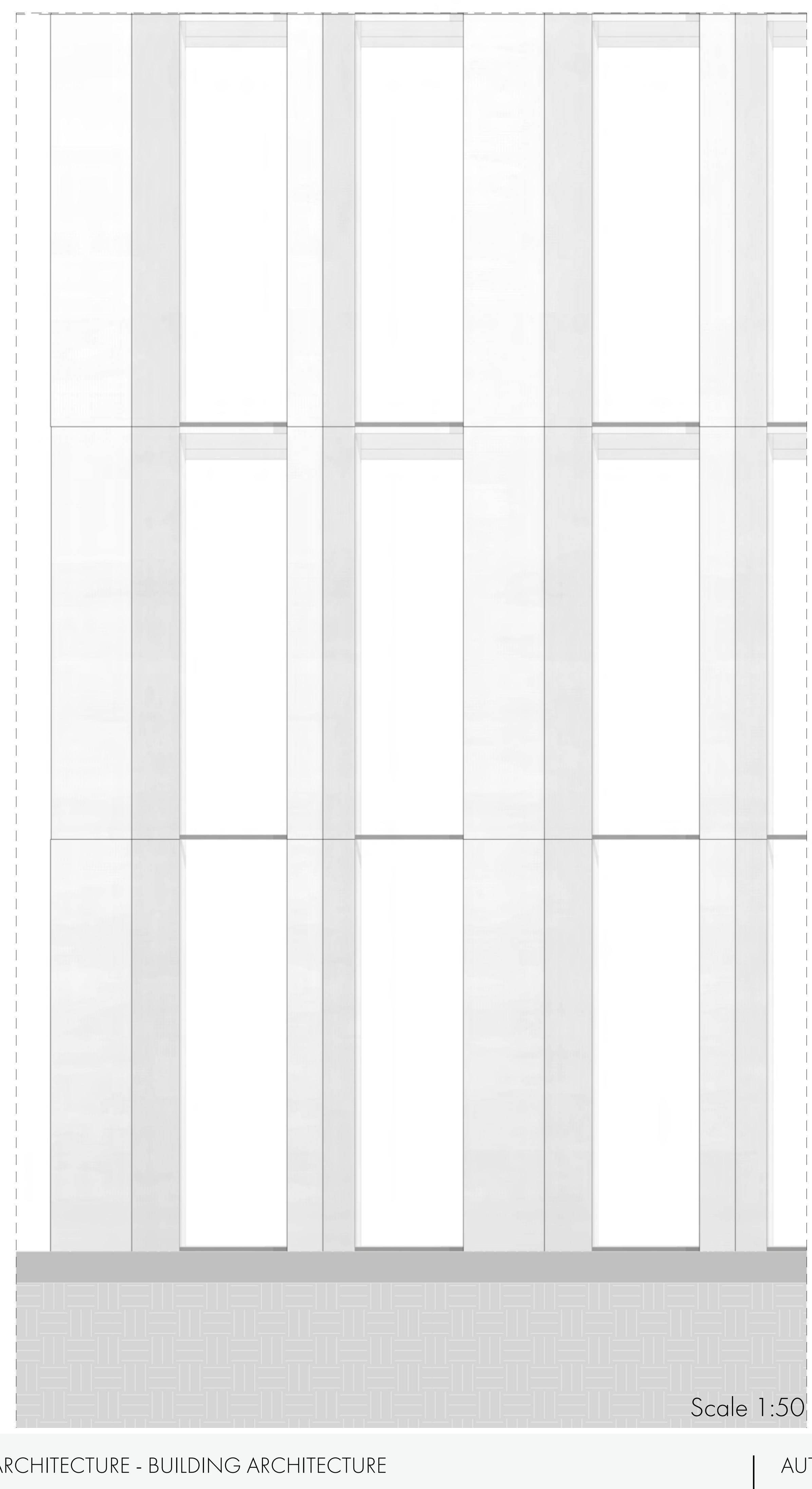
FACADE | SKEWED COLUMNS

1.Flooring
2.Concrete screed
3.Mineral wool sound insulation
4.Cross laminated timber 140mm
5.OSB panel 15 mm
6.Gypsum fireboard 18 mm
7.Insulation cavity 30 mm
8.Insulation 50 mm
9.Wooden ceiling 20 mm

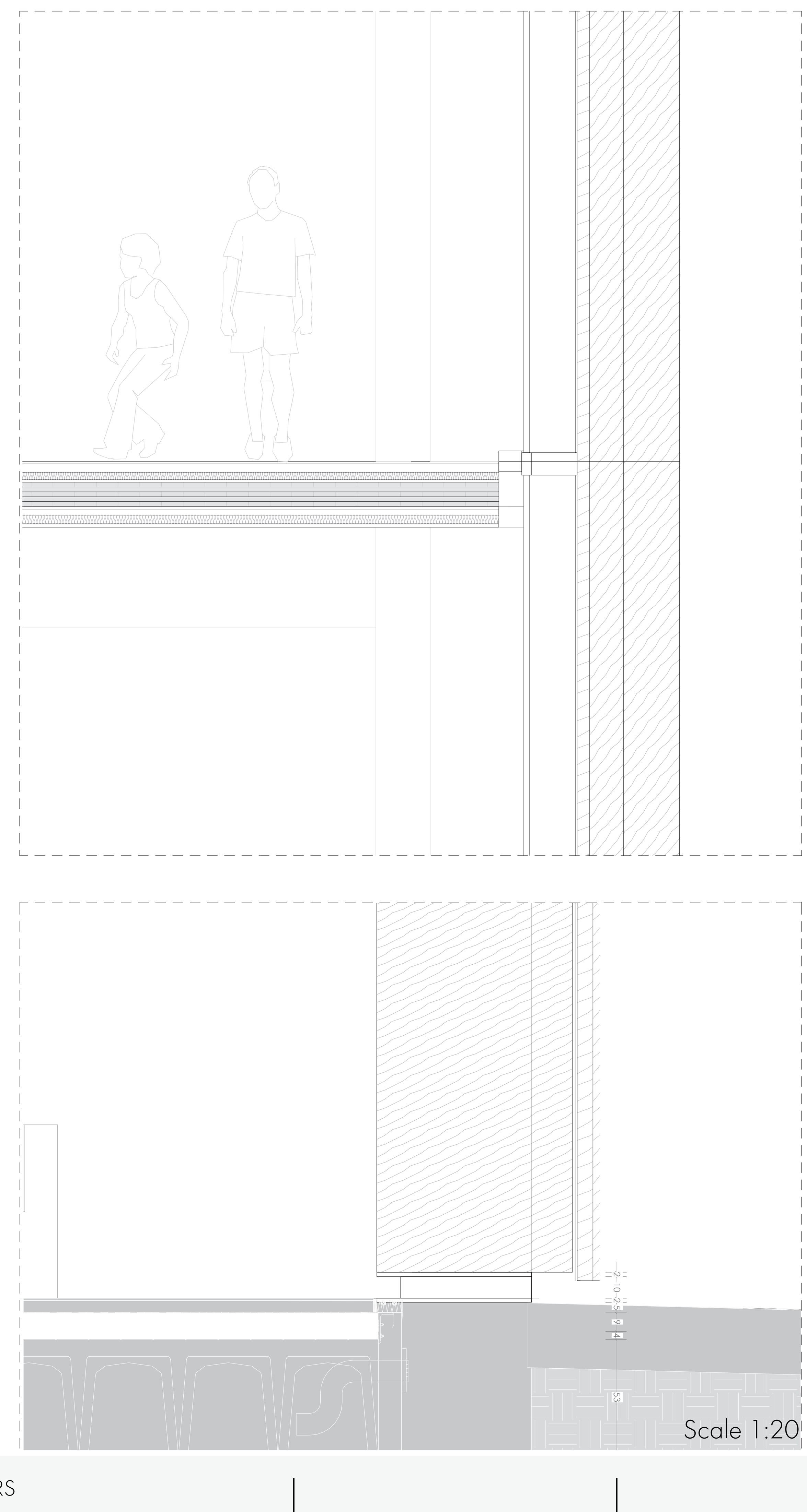
10.Glulam beam
11.Aluminium curtain wall
12.Timber frame
13.Recycled wood cover

14.Steel column base
15.Flooring
16.Underfloor layer
17.Concrete screed 56mm
18.Insulation 85 mm
19.Vapour barrier
20.Electrowelded mesh Ø6 20x20
21.Concrete casting
22.Igloo
23.Drainage gravel
24.Aeretion pipe Ø 90mm
25.Reinforced concrete slab
26.Drinage pipe Ø100 mm
27.Concrete 150 mm
28.Pile foundations





Scale 1:50



Scale 1:20

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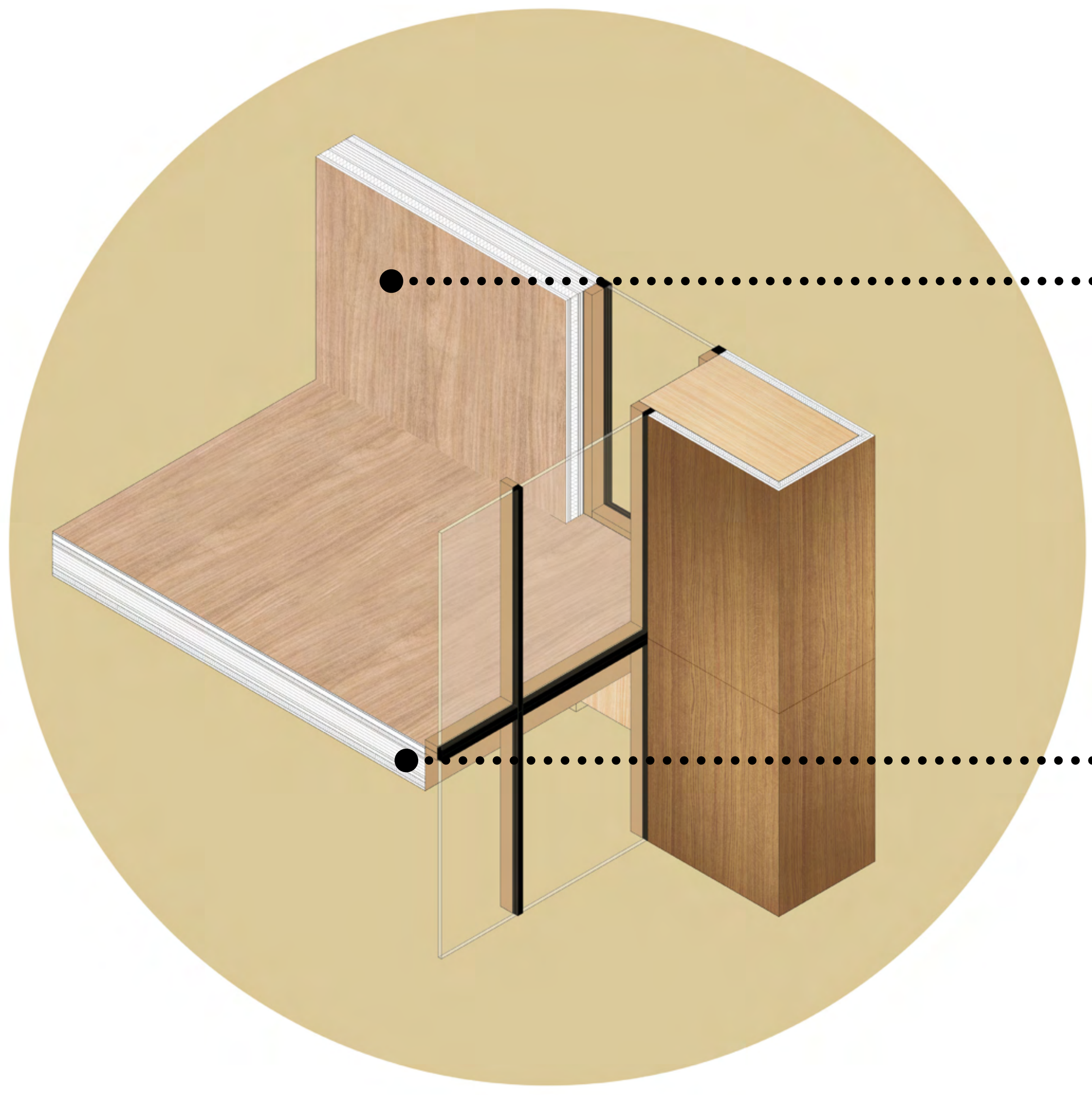
MATERIAL PALETTE

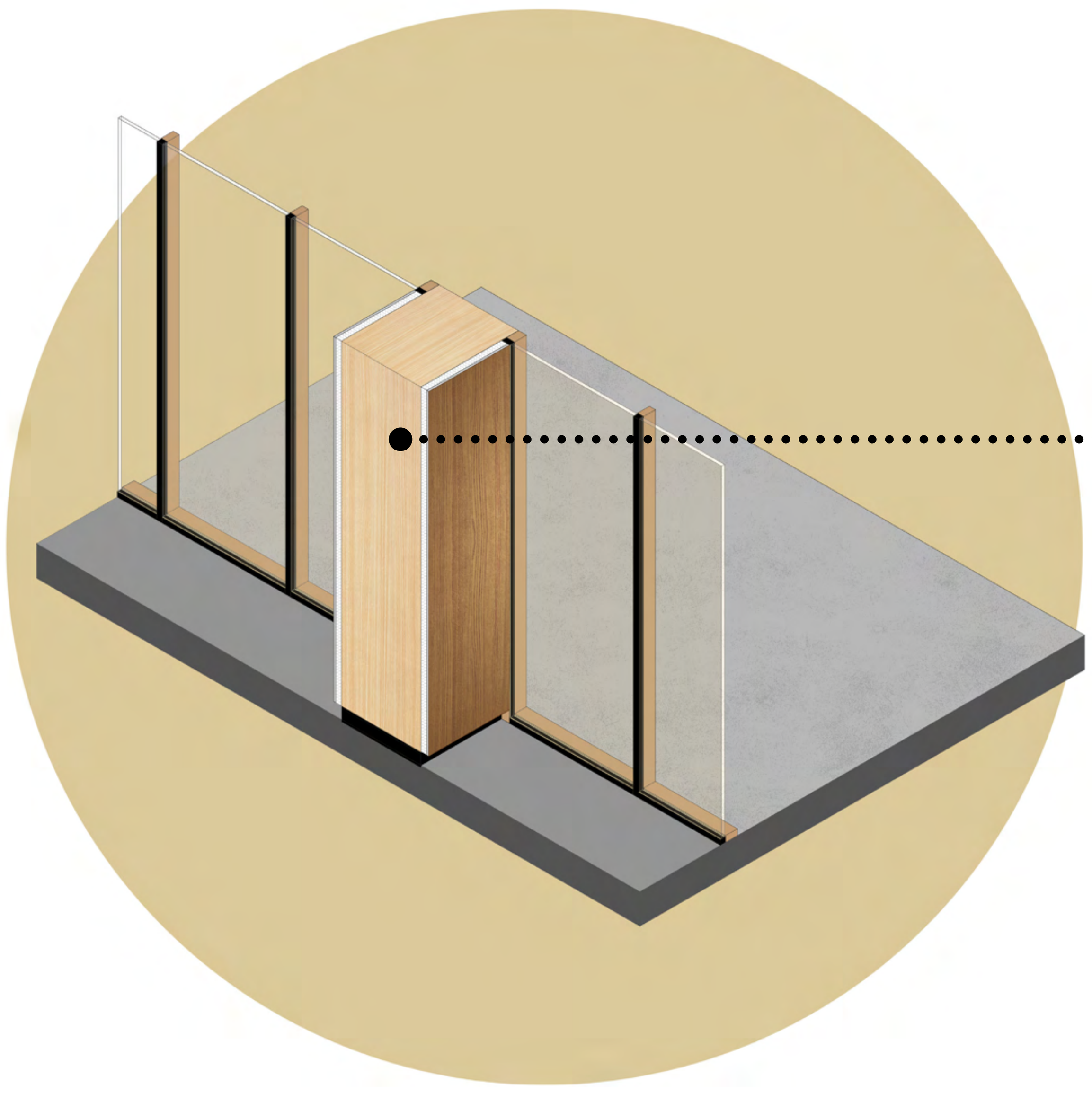


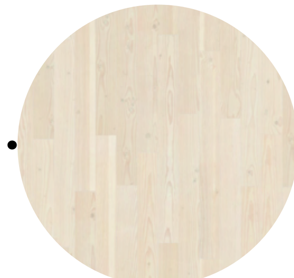
GLULAM TIMBER

PRECIOUS WOODS
'Piquia'
Origin: Amazon region of Brazil

ROCK MINERAL
WOOL INSULATION

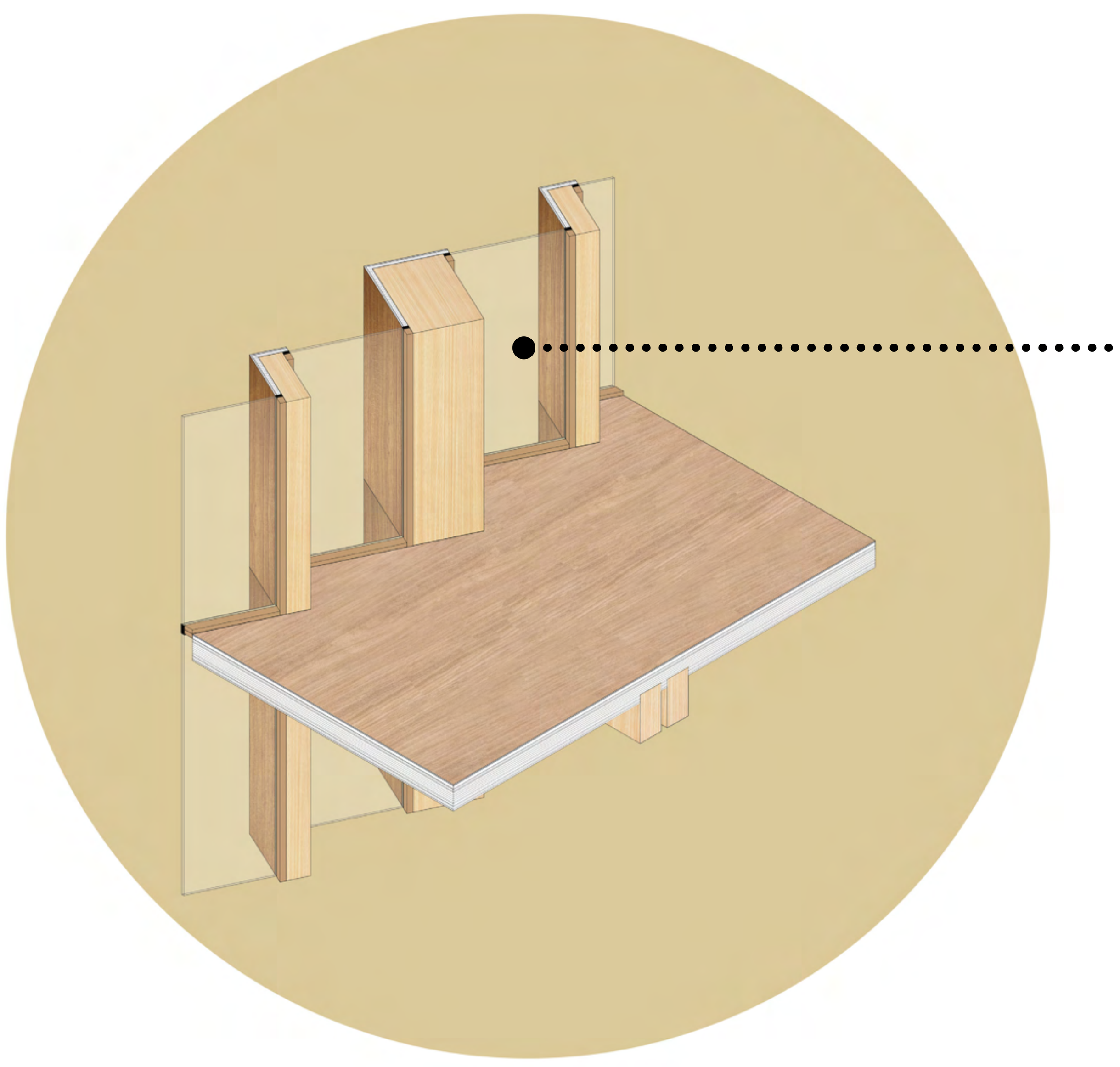
ROCK FIBRAS
THERMAX® mineral wool (basalt rock fibers)
Origin: São Paulo, Brazil





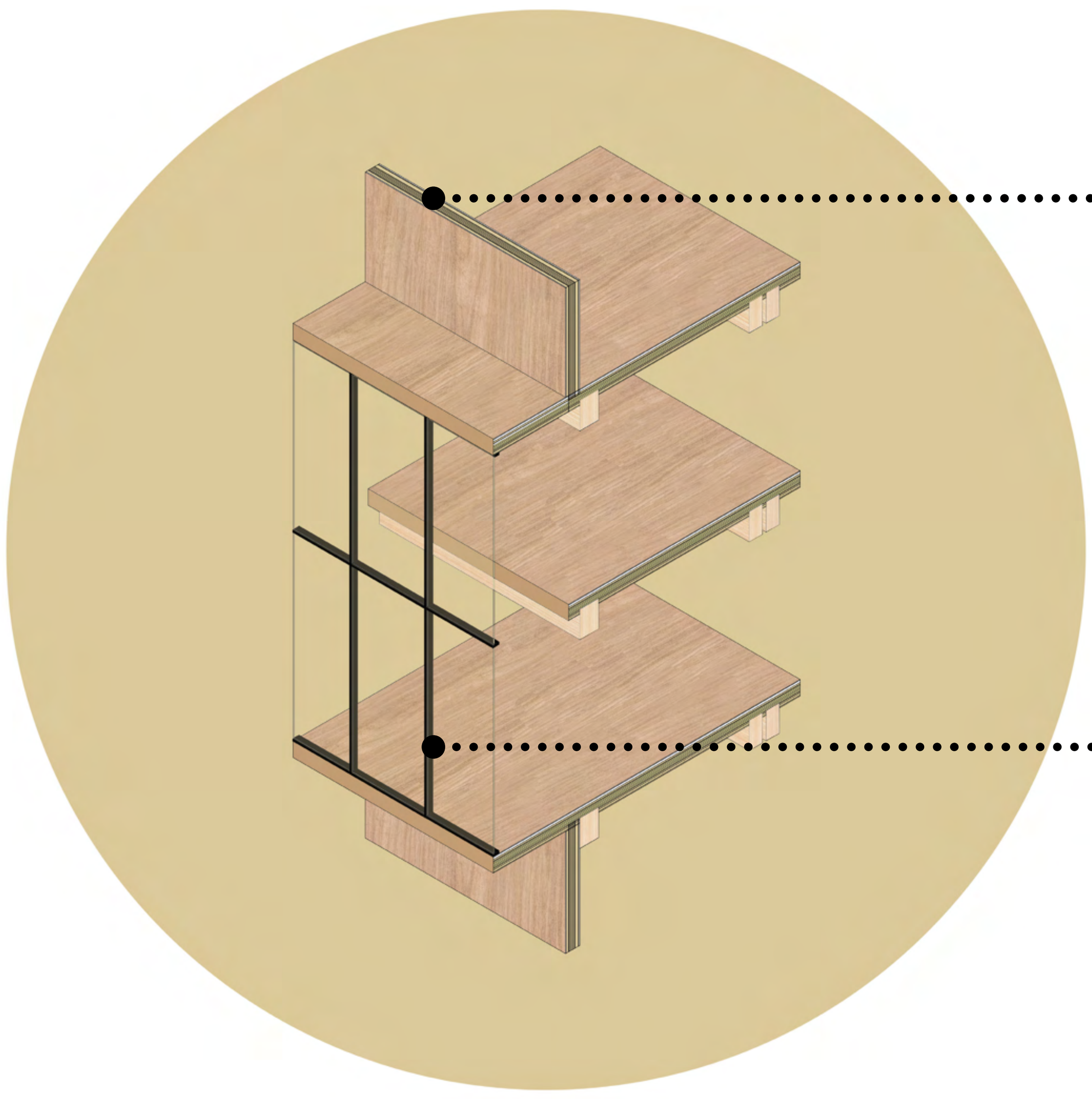
CLT TIMBER

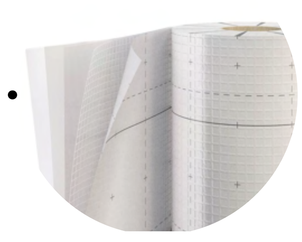
PRECIOUS WOODS
'Piquia'
Origin: Amazon region of Brazil



DOUBLE GLASS FACADE

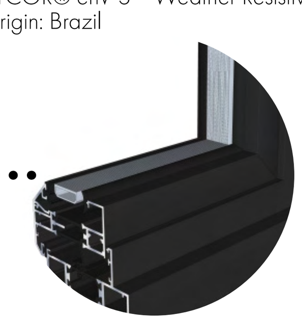
VETRIKO
Vetriko-IG, Insulated Glass
Origin: Ecuador





SELF ADHESIVE
VAPOR BARRIER

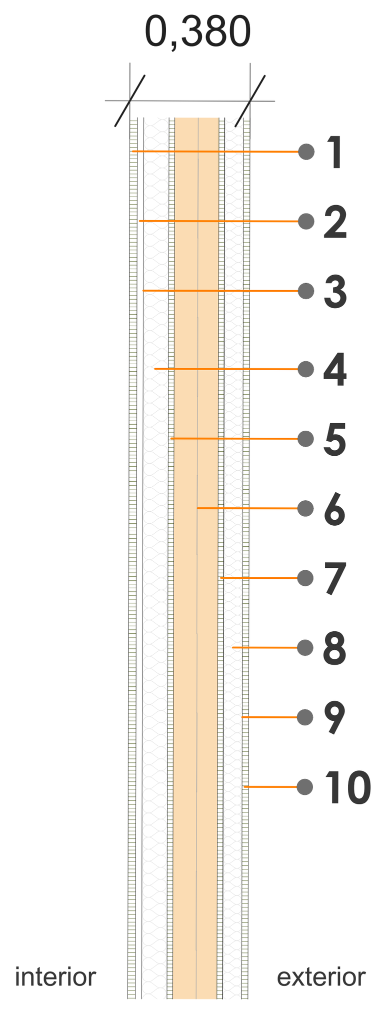
gcp
VYCOR® enV-S™ Weather Resistive Barrier
Origin: Brazil



ALUMINUM
WINDOW FRAME

WINDOW WORLD
Europeo
Origin: Ecuador

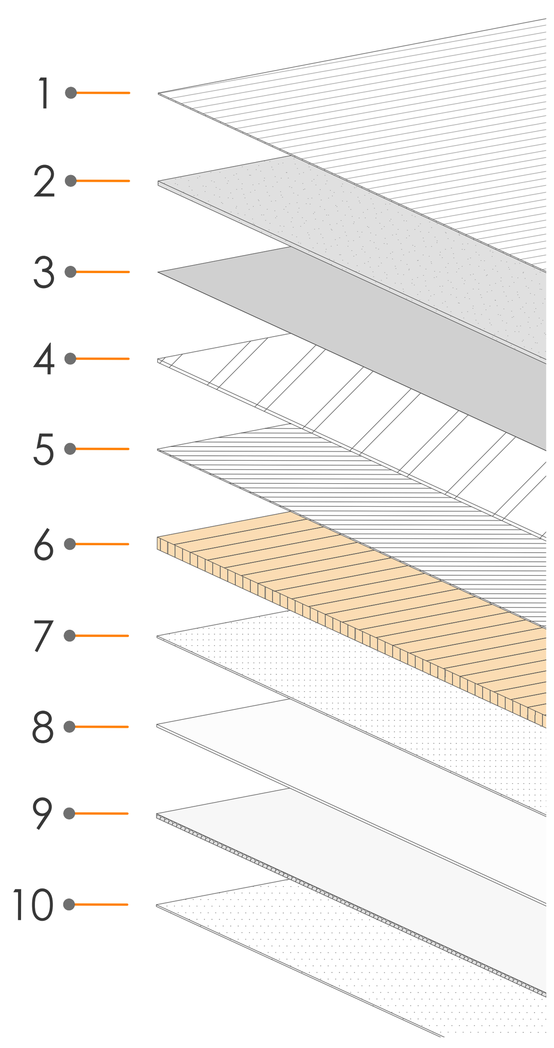
EXTERNAL WALL FACADE



1. Wooden finishing (24 mm)
2. Air gap (2 mm)
3. Vapor membrane
4. Mineral wool insulation (80 mm)
5. OSB Panel (18 mm)
6. CLT Panel (140 mm)
7. OSB Panel (18 mm)
8. Waterproof membrane
9. Mineral wool insulation (60mm)
10. Treated wood covering (24mm)

TYPICAL SLAB LAYERS

1. Flooring (15 mm)
2. Concrete Screed (50 mm)
3. Waterproof membrane (0,5 mm)
4. Mineral wool insulation (40 mm)
5. OSB Panel (18 mm)
6. CLT Slab (140 mm)
7. Gypsum fibreboard (20 mm)
8. Instalation cavity (30 mm)
9. Insulation (50 mm)
10. Wooden ceiling (20 mm)

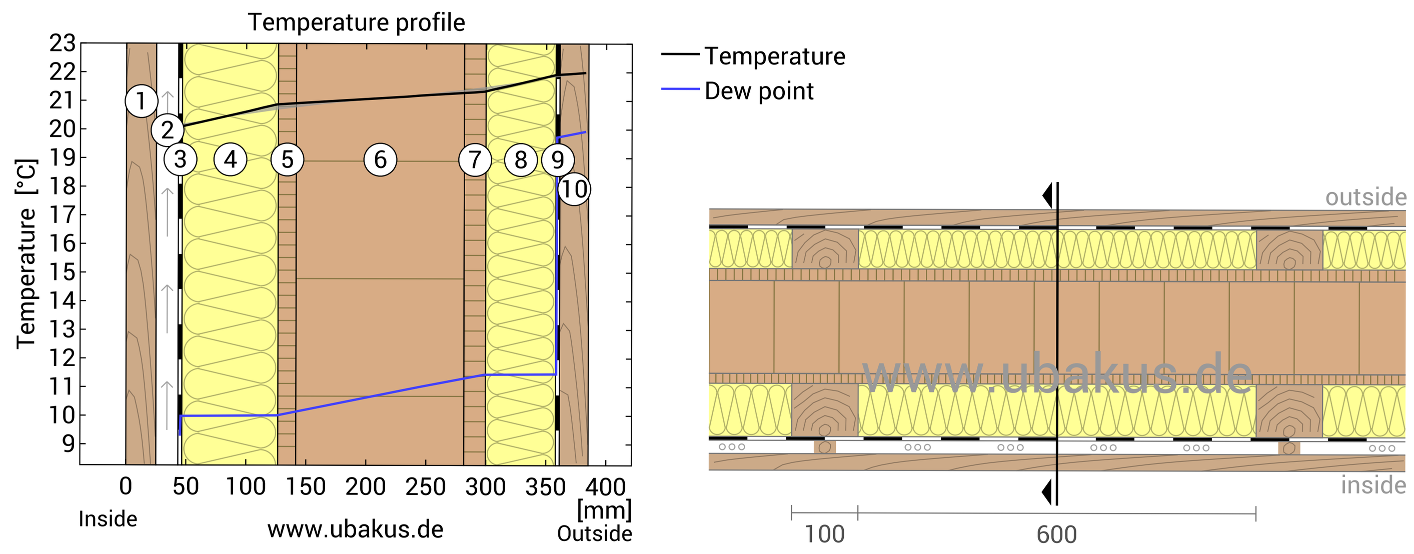


Thermal protection
U = 0,21 W/(m²K)
GEG 2020 Bestand*: U<0,24 W/(m²K)
excellent — insufficient

Moisture proofing
No condensate
excellent — insufficient

Heat protection
Temperature amplitude damping: 55
phase shift: 14,8 h
Thermal capacity inside: 80 kJ/m²K
excellent — insufficient

Temperature profile

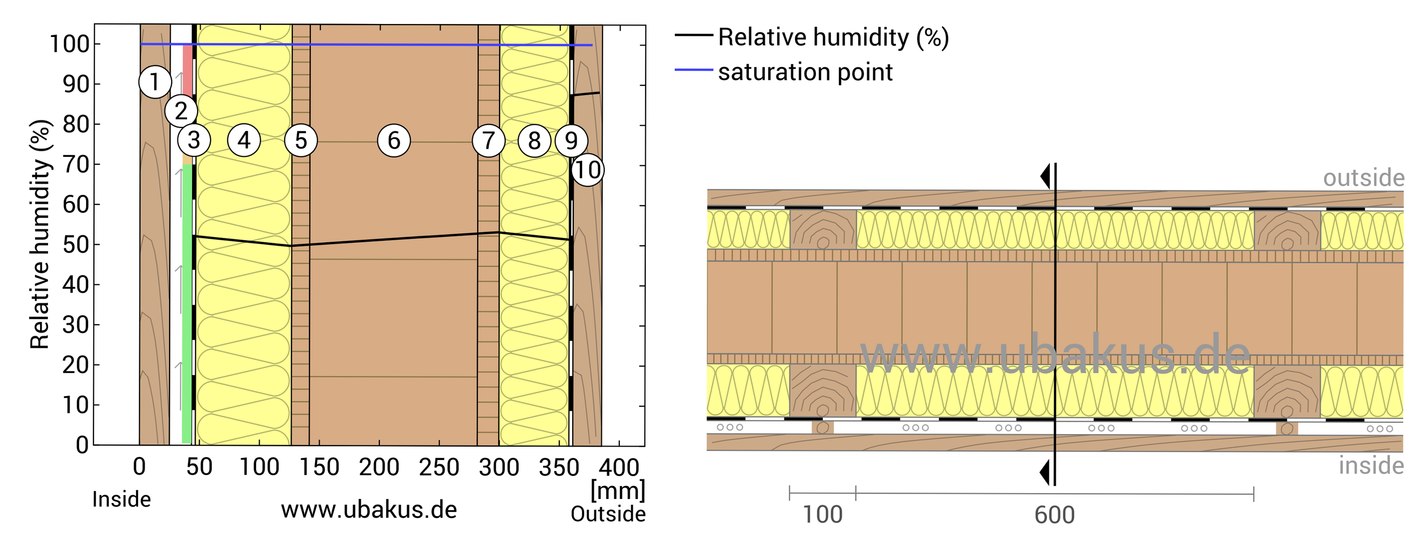


Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 20°C und 50% Humidity; outside: 22°C und 88% Humidity (Climate according to user input).

Humidity

The temperature of the inside surface is 20,0 °C leading to a relative humidity on the surface of 50%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



Thermal protection
U = 0,21 W/(m²K)
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Temperature amplitude damping: 55
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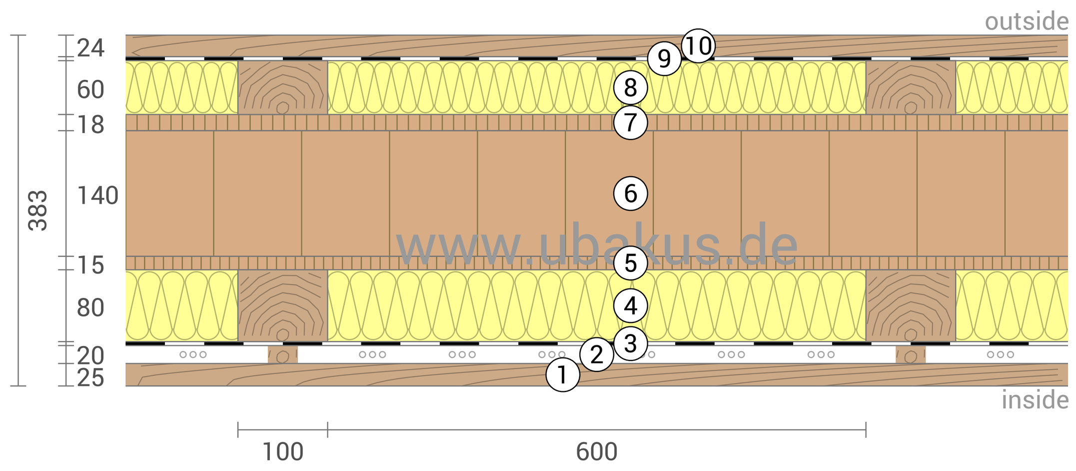
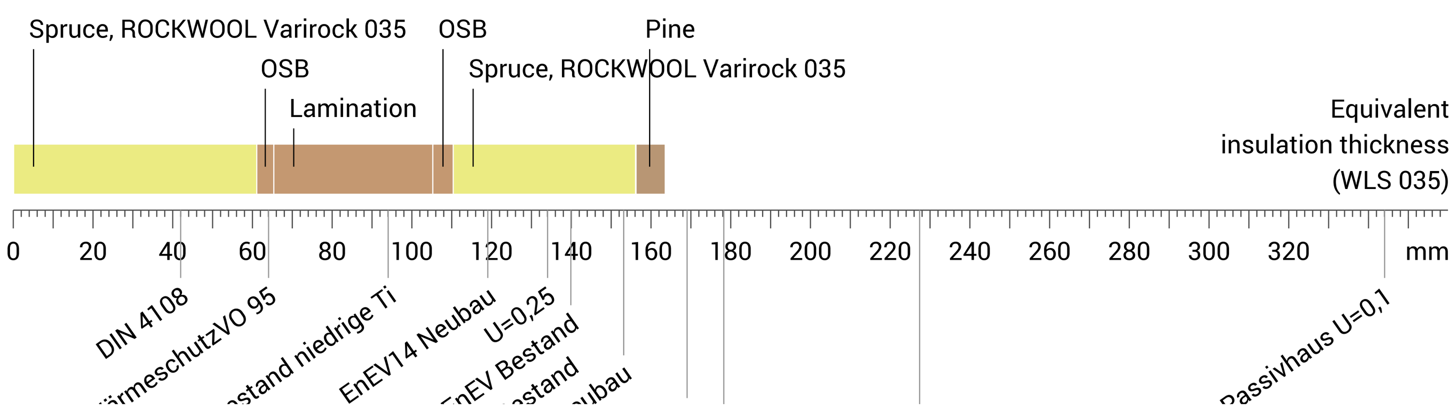


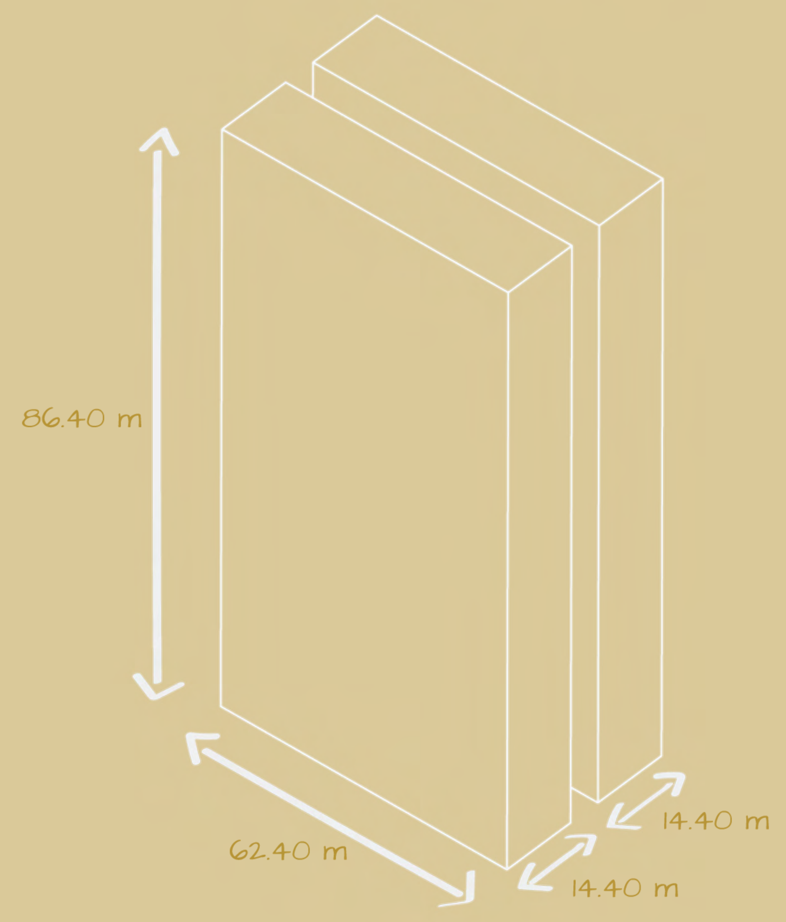
1. Oak (25 mm)
2. Rear ventilated level (20 mm)
3. Vapor retarder sd=2,3m
4. ROCKWOOL Varirock 035 (80 mm)
5. OSB (15 mm)
6. Lamination (140 mm)
7. OSB (18 mm)
8. ROCKWOOL Varirock 035 (60 mm)
9. BITUMAT PVC Waterproofing Membrane
10. Pine (24 mm)

Impact of each layer and comparison to reference values

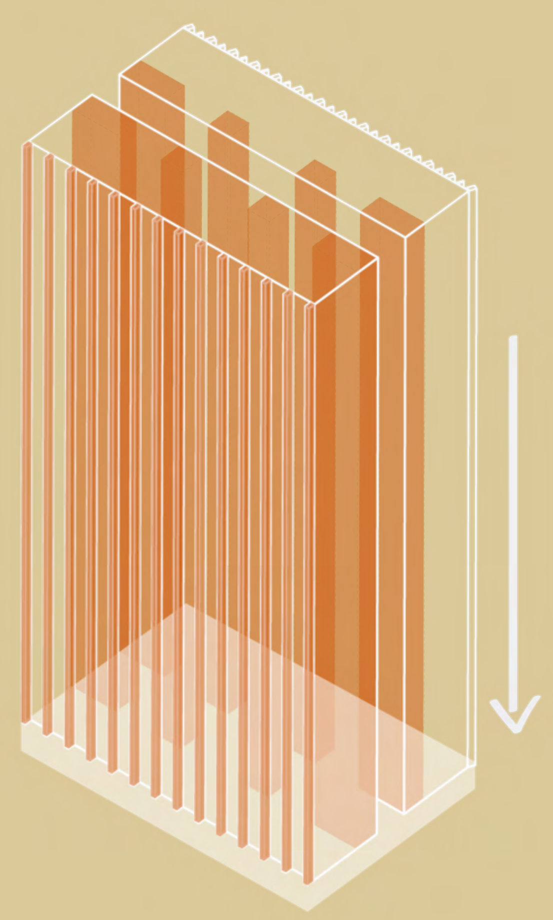


STRUCTURES | CONCEPT AND MECHANICAL BEHAVIOR

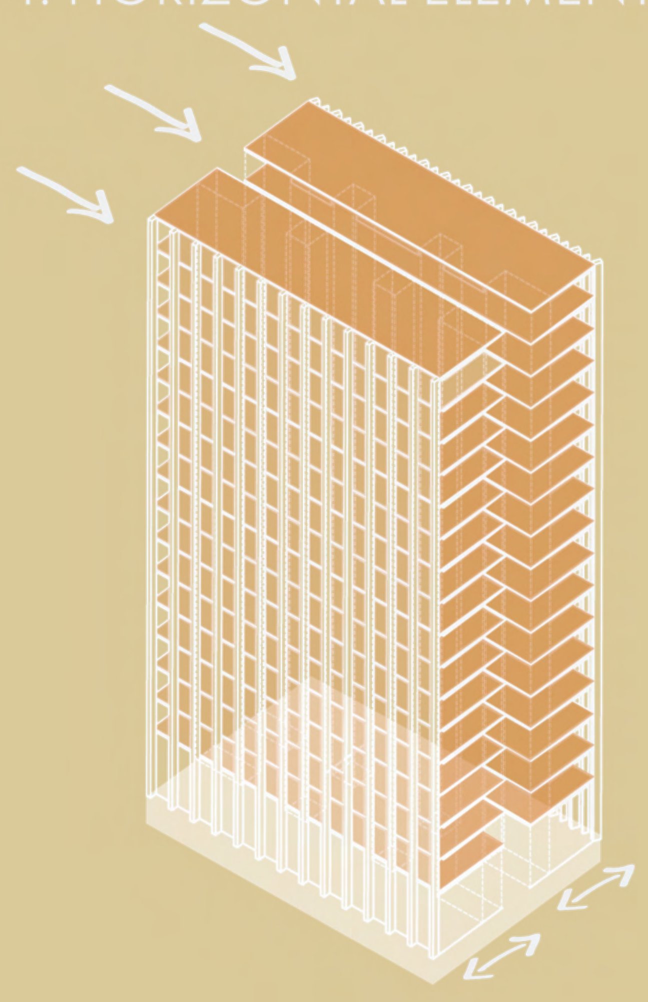
1. INITIAL VOLUME



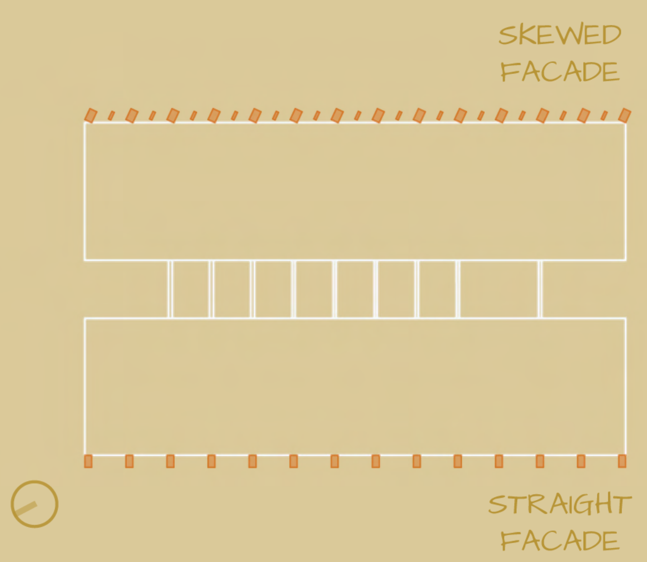
3. VERTICAL SUPPORTS

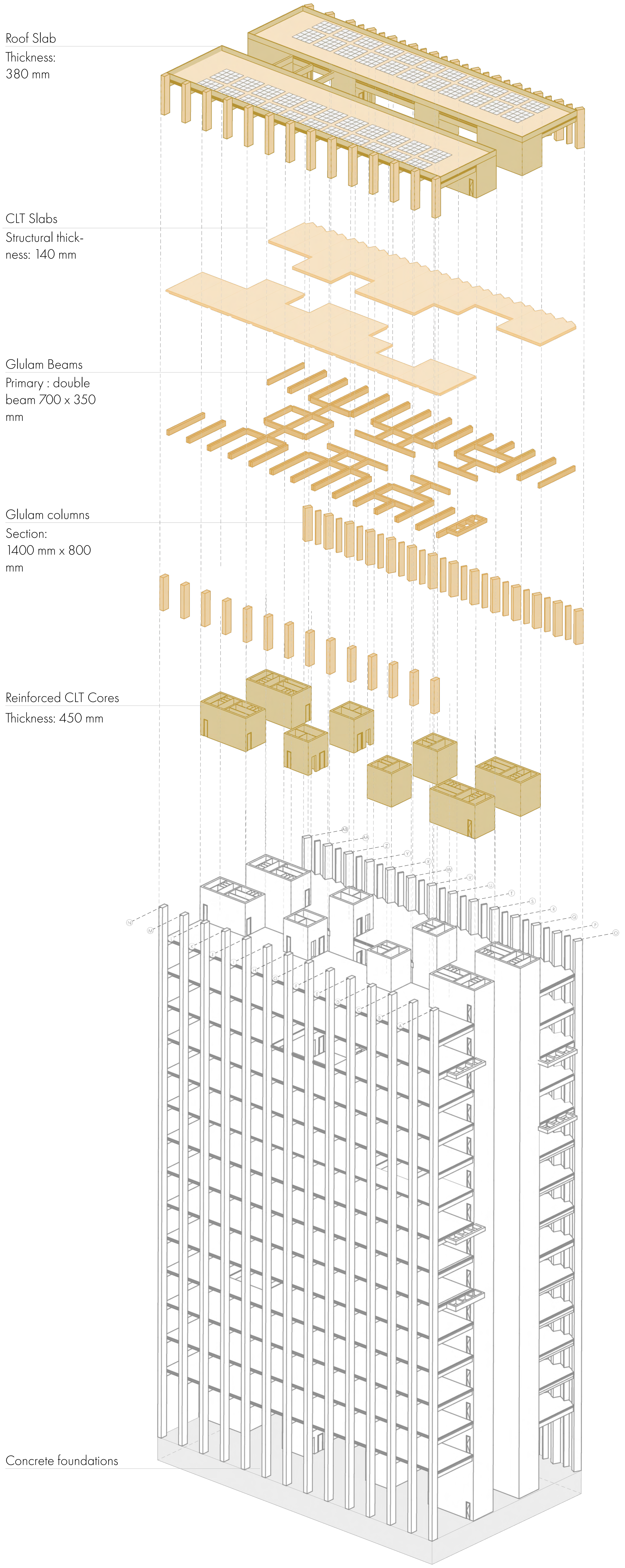


4. HORIZONTAL ELEMENTS



5. FACADE DIFFERENCE





1
Recycled wood covering

2
Insulation
Waterproof membrane

3
Glulam timber columns

4
Upper finishing of the slabs

5
CLT slabs

6
Bottom finishing of the slabs

7
Steel connections

8
Glulam timber beams

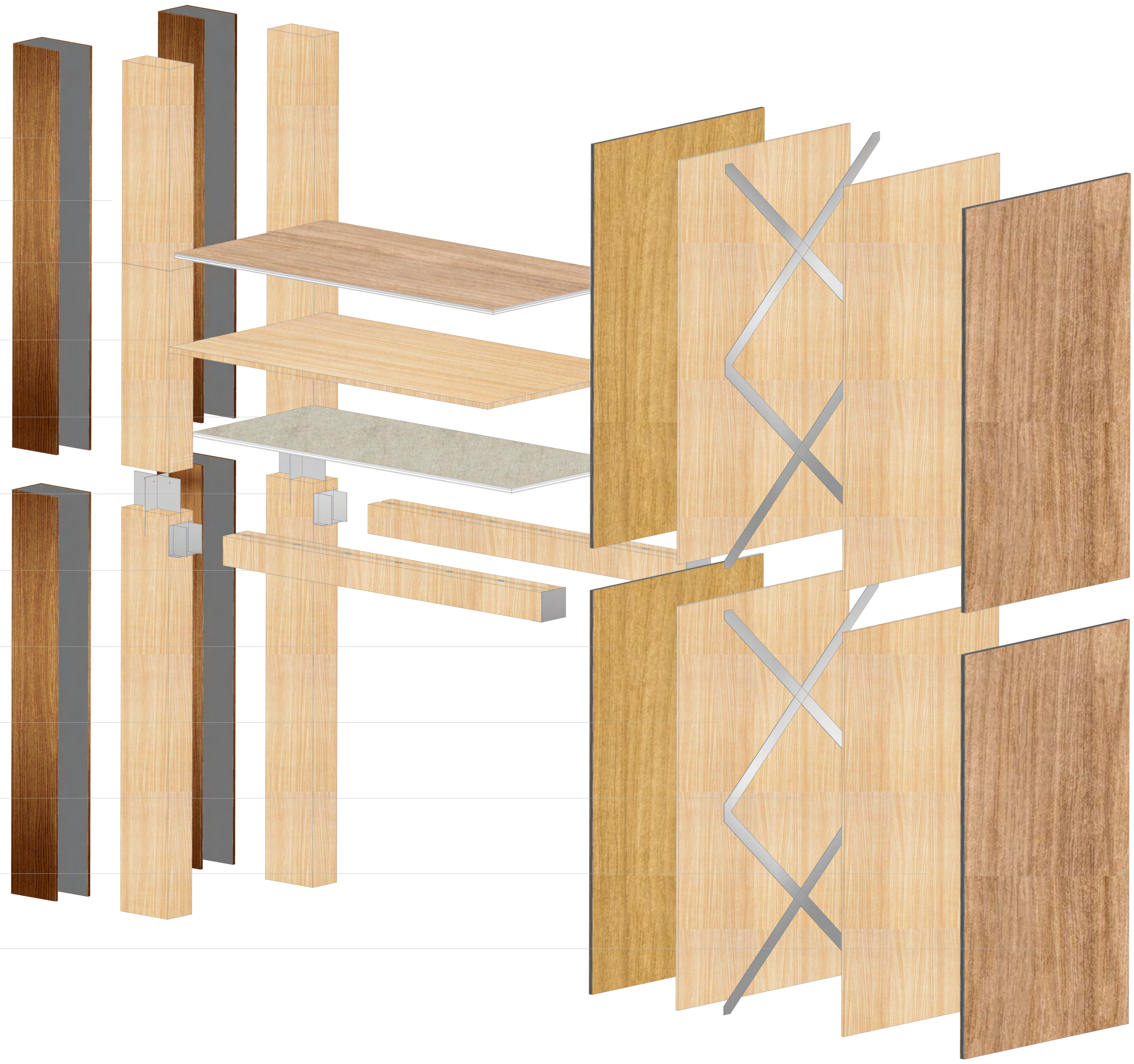
9
External layers core

10
CLT wall panel

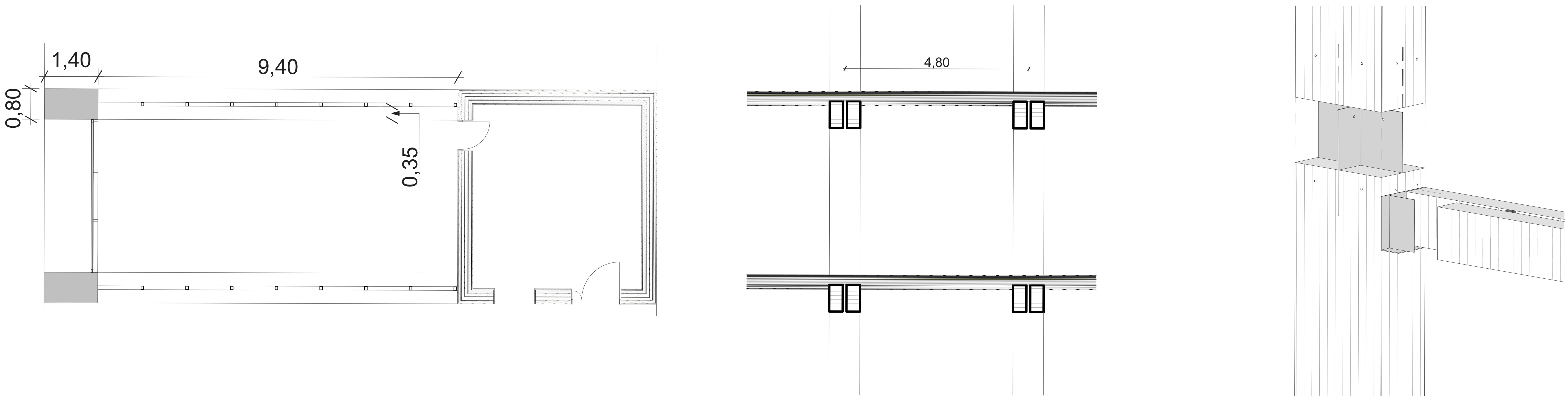
11
Steel reinforcement

12
CLT wall panel

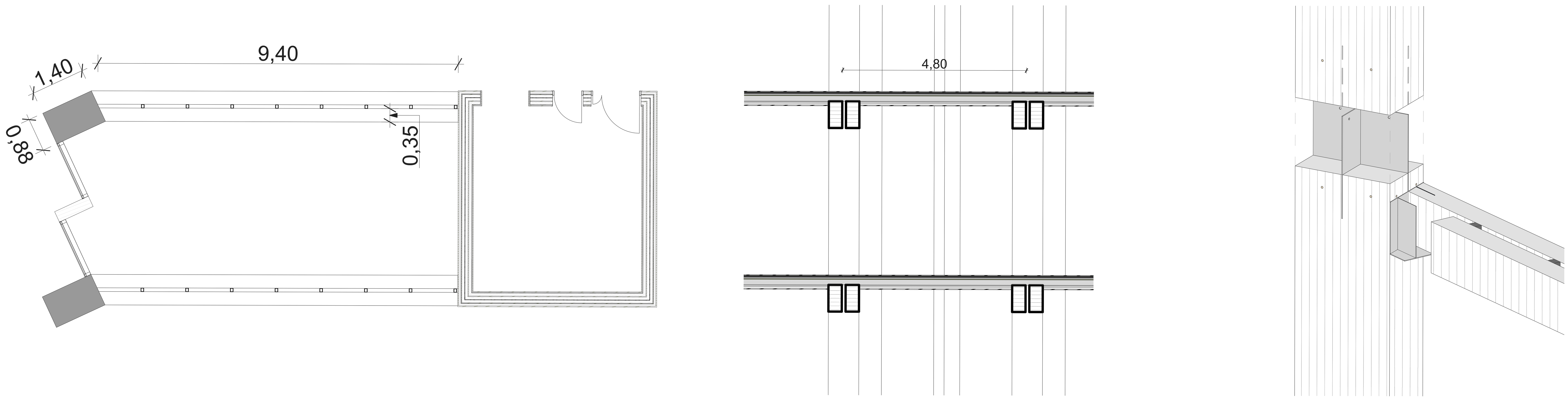
13
Internal layers core



STRUCTURAL ELEMENTS LAYERING

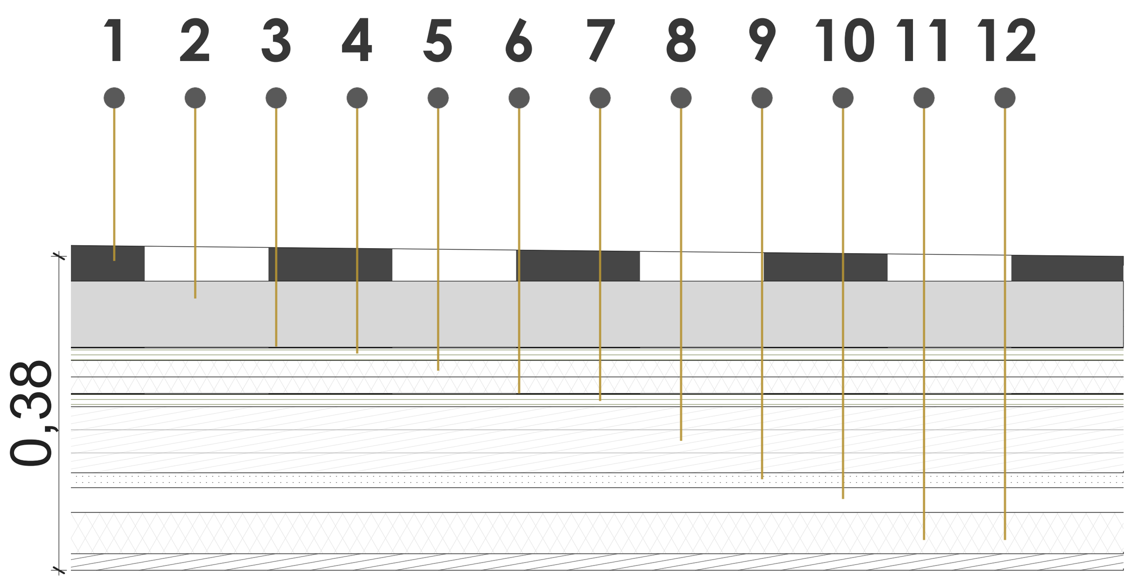


CONNECTION BEAM - COLUMN (STRAIGHT FACADE)

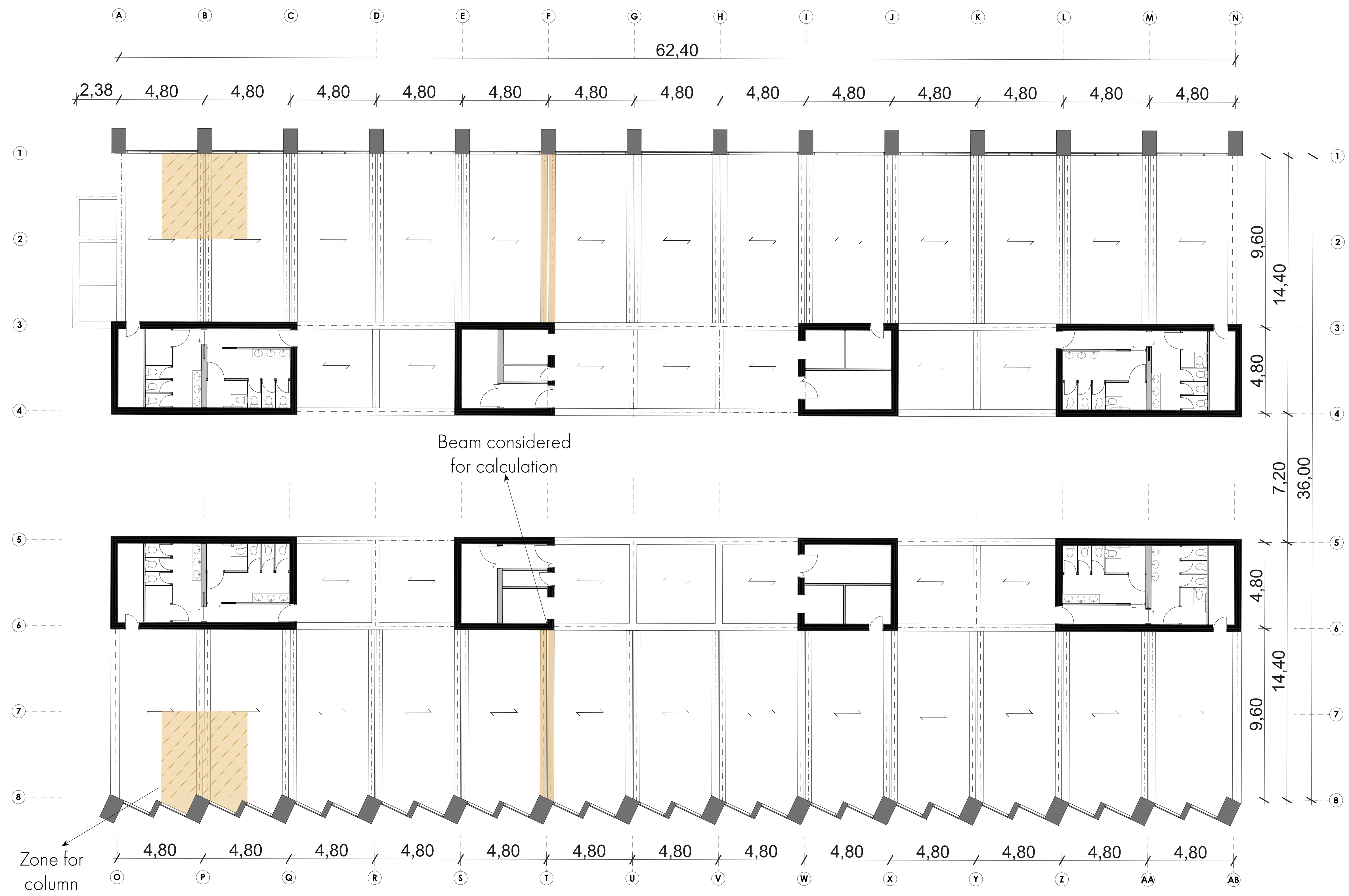


CONNECTION BEAM - COLUMN (SKEWED FACADE)

STRUCTURES | CALCULATIONS



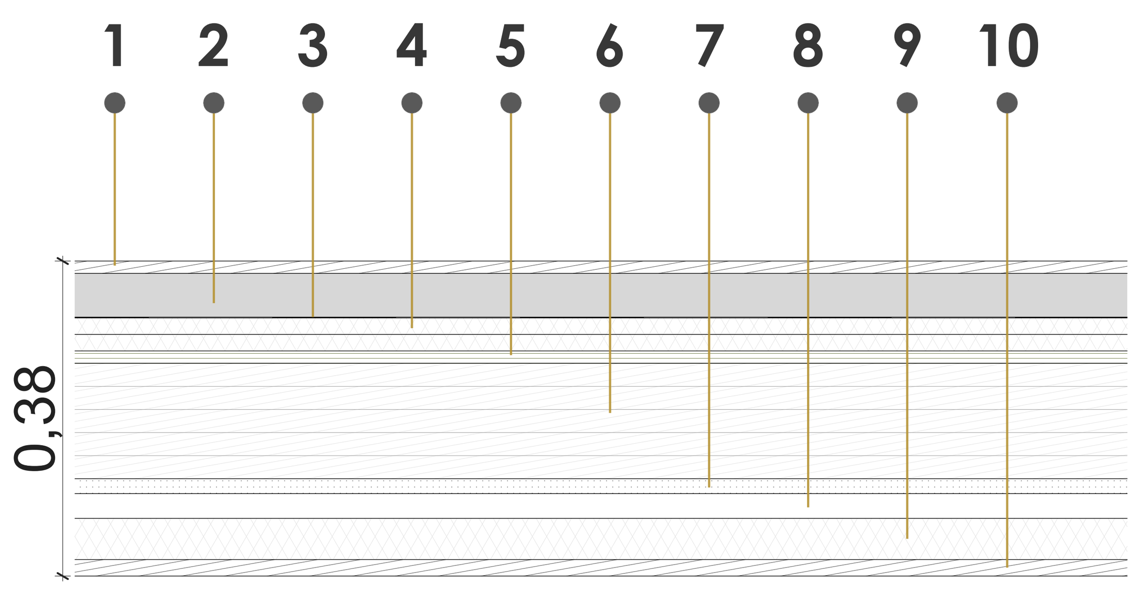
ROOF SLAB SECTION



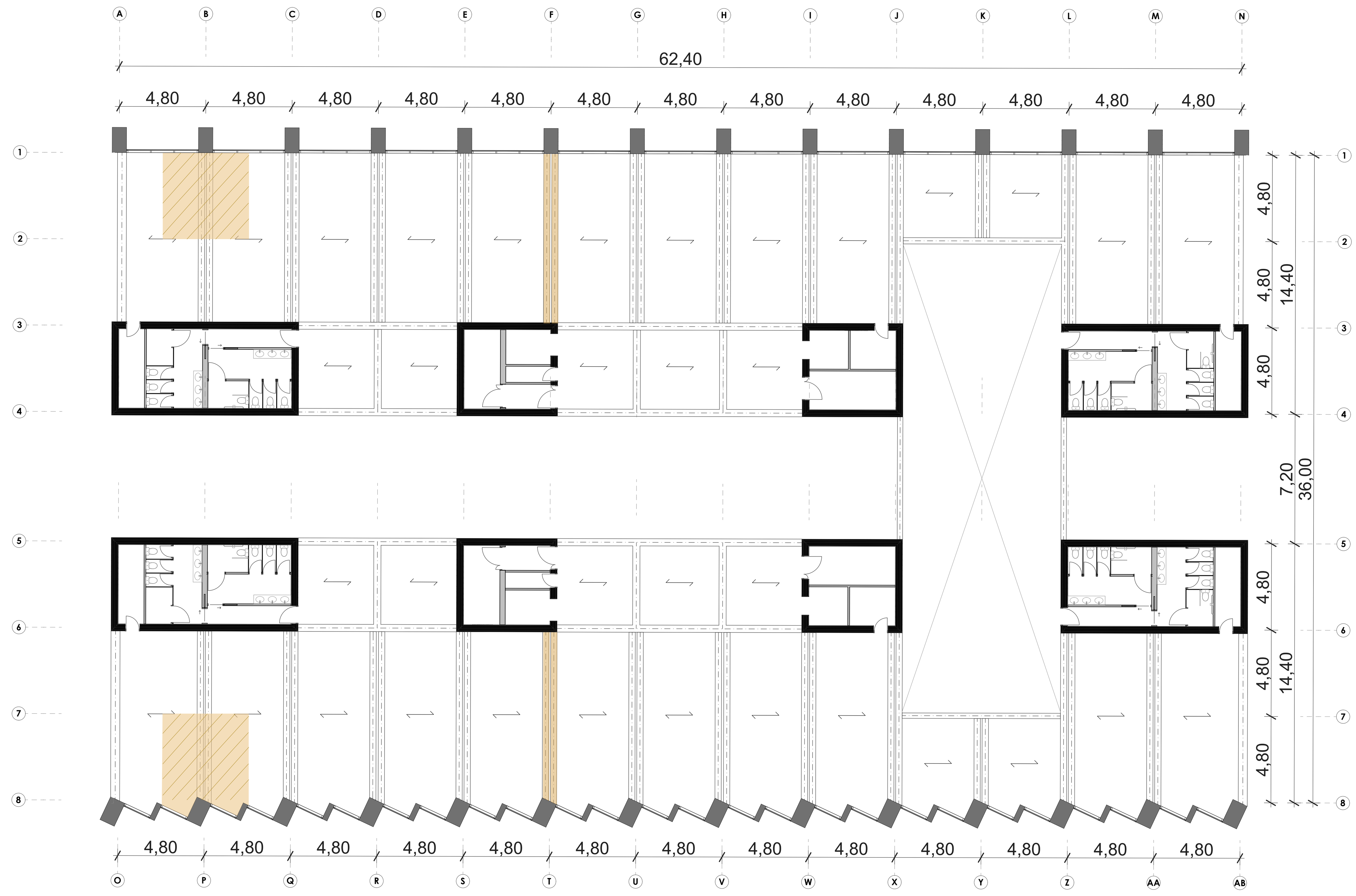
Description	Unit Weight (Kg/m3)	Thickness (m)	Weight kg/m2	Weight KN/m2
STRUCTURAL LOAD				
8. Cross laminated timber slab	500	0.08	40.00	0.40 kN/m2
		TOTAL	40.00	0.40 kN/m2
NON-STRUCTURAL LOAD				
Description	Unit Weight (Kg/m3)	Thickness (m)	Weight kg/m2	Weight KN/m2
1. Flooring (rainproof)	1500	0.03	45.00	0.45 kN/m2
2. Concrete screed	1000	0.08	80.00	0.80 kN/m2
3. Waterproof membrane	0	0.001	0.00	0.00 kN/m2
4. OSB panel	600	0.015	9.00	0.09 kN/m2
5.Mineral wool footfall sound insulation	34	0.04	1.36	0.01 kN/m2
6. Waterproof membrane	0	0.001	0.00	0.00 kN/m2
7. OSB panel	600	0.015	9.00	0.09 kN/m2
9. Gypsum fibreboard	800	0.018	14.40	0.14 kN/m2
10. Instalation cavity	0	0.03	0.00	0.00 kN/m2
11. Insulation	34	0.05	1.70	0.02 kN/m2
12. Wooden ceiling	740	0.02	14.80	0.15 kN/m2
		TOTAL	175.26	1.75 kN/m2
			TOTAL DEAD LOAD	2.15 kN/m2
			TOTAL LIVE LOAD	0.50 kN/m2

ROOF WEIGHT CALCULATION

TYPICAL FLOOR PLAN



TYPICAL SLAB SECTION

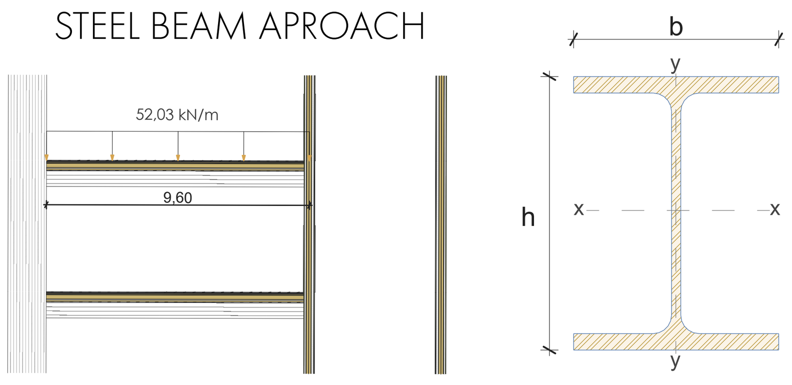


Description	Unit Weight (Kg/m3)	Thickness (m)	Weight kg/m2	Weight KN/m2
STRUCTURAL LOAD				
6. Cross laminated timber slab	500	0.14	70.00	0.70 kN/m2
		TOTAL	70.00	0.70 kN/m2
NON-STRUCTURAL LOAD				
Description	Unit Weight (Kg/m3)	Thickness (m)	Weight kg/m2	Weight KN/m2
1. Flooring (wood layer)	830	0.015	12.45	0.12 kN/m2
2. Concrete screed	1000	0.05	50.00	0.50 kN/m2
3. Waterproof membrane	0	0.001	0.00	0.00 kN/m2
4. Mineral wool footfall sound insulation	34	0.04	1.36	0.01 kN/m2
5. OSB panel	600	0.015	9.00	0.09 kN/m2
7. Gypsum fibreboard	800	0.018	14.40	0.14 kN/m2
8. Instalation cavity	0	0.03	0.00	0.00 kN/m2
9. Insulation	34	0.05	1.70	0.02 kN/m2
10. Wooden ceiling	740	0.02	14.80	0.15 kN/m2
		TOTAL	103.71	1.04 kN/m2
			SLAB DEAD LOAD	1.74 kN/m2
			WALLS DEAD LOAD	0.83 kN/m2
			TOTAL DEAD LOAD	2.57 kN/m2
			TOTAL LIVE LOAD	5.00 kN/m2

TYPICAL SLAB WEIGHT CALCULATION

SPECIAL SPACES FLOOR PLAN

STEEL BEAM APROACH



DATA

h = 0.40 m
b = 0.30 m
L = 9.60 m
E = 210000 N/mm²
I = 576800000 mm⁴
W_{pl} = 3232000 mm³
A_v = 6998 mm²

ULTIMATE LIMIT STATE ANALYSIS

N = (1.30 x g + 1.5 x q) x d = 52,03 kN/m

BENDING MOMENT

$$M_{pl} = \frac{W_{pl}\ x\ F_y}{\gamma M_0} = \left(\frac{3232000\ mm^3\ x\ 235\ N/mm^2}{1.05}\right) x\ 2 = 723.35\ kN\ m$$

$$M_{max} = \frac{Q\ x\ l}{8} = \frac{52.03\ kN/m\ x\ (9.60\ m)^2}{8} = 599.35\ kN\ m$$

$$M_{pl} \geq M_{max}$$

SHEAR FORCE

$$V_{max} = \frac{Q\ x\ l}{2} = \frac{52.03\ kN/m\ x\ 9.60\ m}{2} = 249.73\ kN$$

$$V = \frac{A_v\ x\ f_y}{\sqrt{3}\ x\ 1.05} = \frac{0.006998\ m^2\ x\ 235000\ kN/m^2}{\sqrt{3}\ x\ 1.05} = 904.26\ kN$$

$$V \geq V_{max}$$

SERVICIABILITY LIMIT STATE ANALYSIS

N = (1.00 x g + 1.00 x q) x d = 36,33 kN

ALLOWABLE DEFLECTION

$$\delta_{max} = \frac{}{250} = \frac{}{250} = 38.40\ mm$$

$$\delta_{max} = \frac{5}{384} x \frac{q^{sls}\ l^4}{EJ} = \frac{5}{384} x \frac{36.33\ N/mm\ (9600mm)^4}{210000\ N/mm^2\ x\ 576800000mm^4} = 33.17\ mm$$

$$\delta_{max} \geq \delta$$

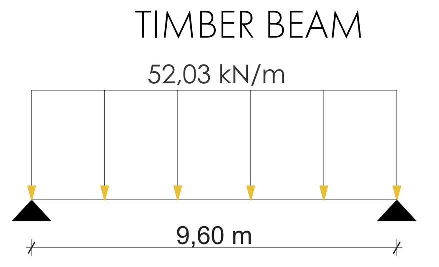
ALLOWABLE DEFLECTION FOR LIVE LOAD

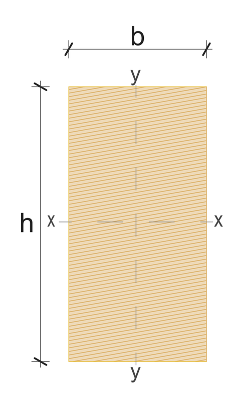
$$\delta_{max} = \frac{l}{300} = \frac{9600\ mm}{300} = 32.00\ mm$$

$$\delta_{max} = \frac{5}{384} x \frac{q^{LL}\ l^4}{EJ} = \frac{5}{384} x \frac{24\ N/mm\ (9600mm)^4}{210000\ N/mm^2\ x\ 576800000mm^4} = 21.91\ mm$$

$$\delta_{max} \geq \delta$$

TIMBER BEAM





DATA

h = 0.70 m
b = 0.35 m
L = 9.60 m
f_{bx} = 11 MPa = 11000 kN/m²

ULTIMATE LIMIT STATE ANALYSIS

N = (1.30 x g + 1.5 x q) x d = 52,03 kN/m

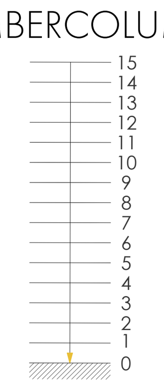
BENDING MOMENT

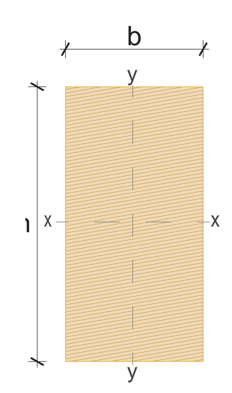
$$M = \frac{f_{bx}\ x\ b\ x\ h^2}{6} = \frac{11000\ kN/m^2\ x\ 2(0.35m\ x\ (0.70m)^2)}{2} = 628.83\ kN\ m$$

$$M_{max} = \frac{Q\ x\ l^2}{8} = \frac{52.03\ kN/m\ x\ (9.60\ m)^2}{8} = 599.35\ kN\ m$$

$$M \geq M_{max}$$

TIMBERCOLUMN





DATA

h= 1,40 m
b= 0,80 m
H = 9,60 m
E = 12000 N/mm2
I = 182933333333,33 mm4
π = 3,1416
fcd = 19 MPa
β = 0,1 (glulam)

LOAD

A = (4.80 x 9.60) / 2 = 23.04 m²
N = (1.30 x g + 1.50 x q) x 23.04 x 15 x 1.3 = 5825.65 kN

CRITICAL LOAD | EULER

$$N_{cr} = \frac{EI\ x\ \pi^2}{8} = 653023.59\ kN$$

INERTIA

$$i_{max} = \sqrt{\frac{b\ x\ h^3}{12\ x\ b\ x\ h}} = \frac{1400mm}{2\sqrt{3}} = 404.15\ mm$$

$$i_{min} = \frac{b}{2\sqrt{3}} = \frac{800mm}{2\sqrt{3}} = 230.94\ mm$$

$$l_0 = 0.6\ x\ H = 0.6\ x\ 9600\ mm = 5760.00\ mm$$

$$\lambda = \frac{l_0}{i_{min}} = \frac{5760mm}{203.94\ mm} = 24.94\ mm$$

$$\lambda_{cr} = \pi\sqrt{\frac{E}{f_{cd}}} = \pi\sqrt{\frac{12000\ N/mm^2}{19\ N/mm^2}} = 78.95$$

$$\lambda_{ref} = \frac{\lambda}{\lambda_{cr}} = \frac{24.94}{78.945} = 0.3159$$

$$k = \frac{1 + \beta(\lambda_{ref} - 0.3) + \lambda_{ref}^2}{2} = 0.55$$

$$k_{cr} = \frac{1}{k + \sqrt{k^2 + \lambda_{ref}^2}} = 0.84$$

REAL STRENGHT OF THE MATERIAL

$$N_{rd,b} = A\ x\ f_{cd} x\ K_{cr} = 168075.60\ kN$$

$$\frac{N}{N_{rd,b}} = 1.60\%$$

$$N_{rd,b} > N$$

$$N_{cr} > N$$

AUTHORS
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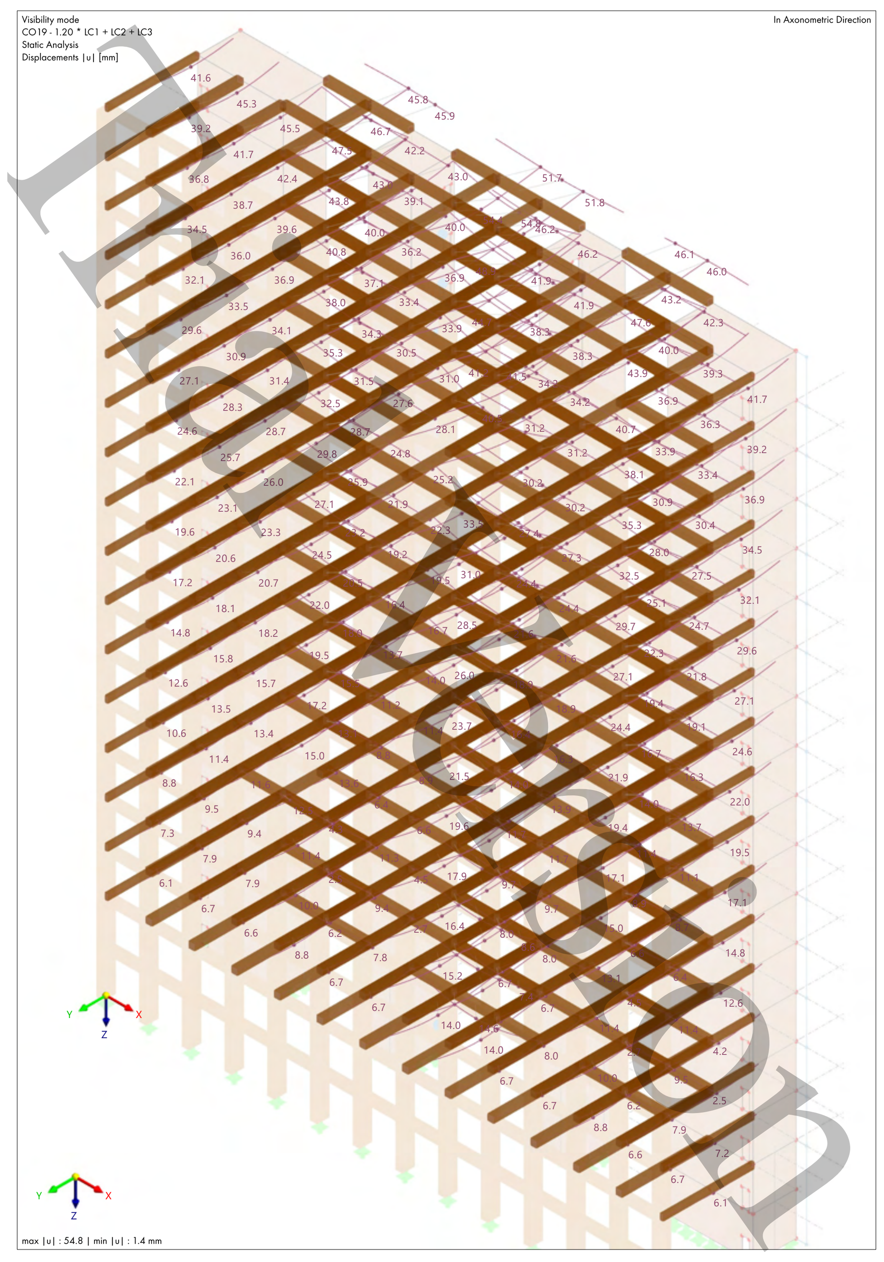
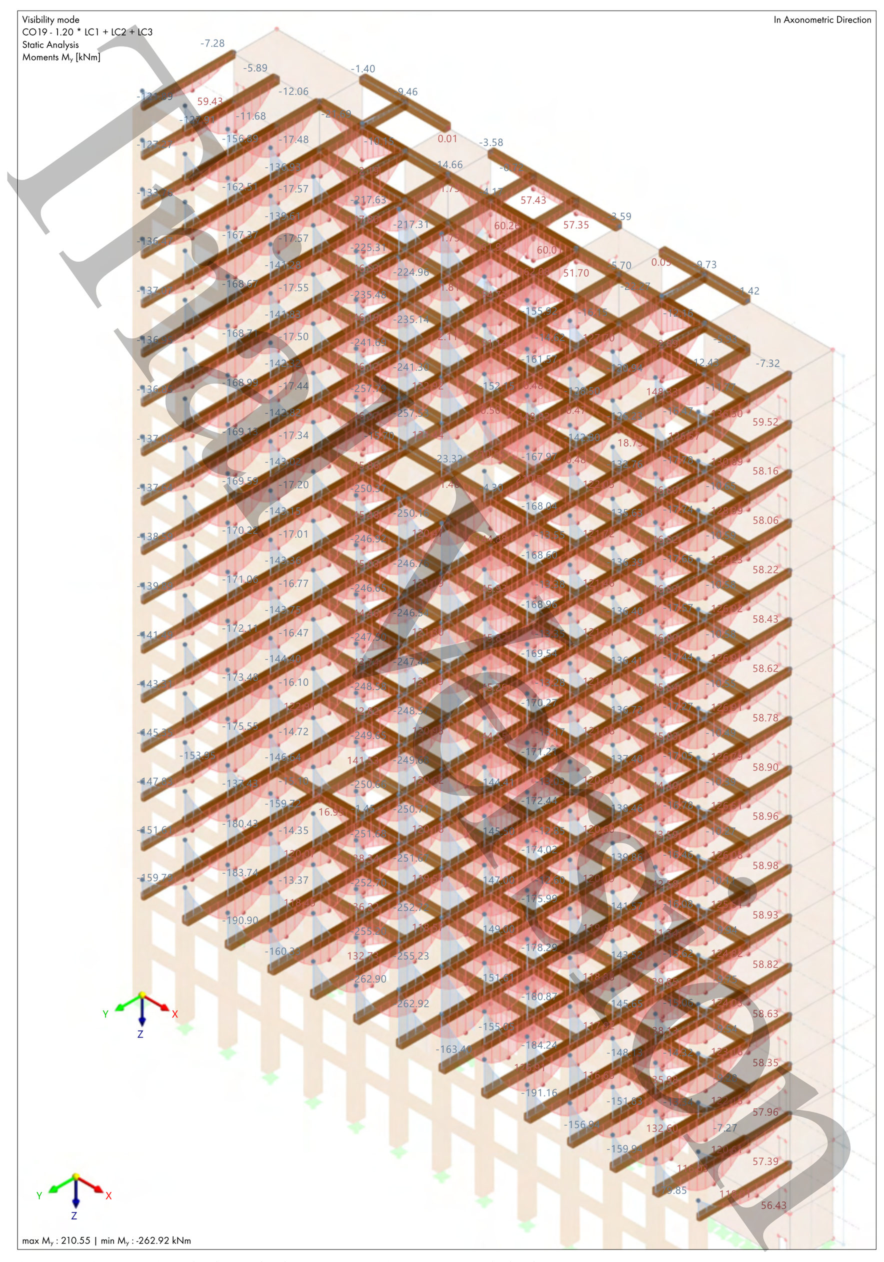
Yuce Isilay 988623

STRUCTURES | DLUBAL ANALYSIS

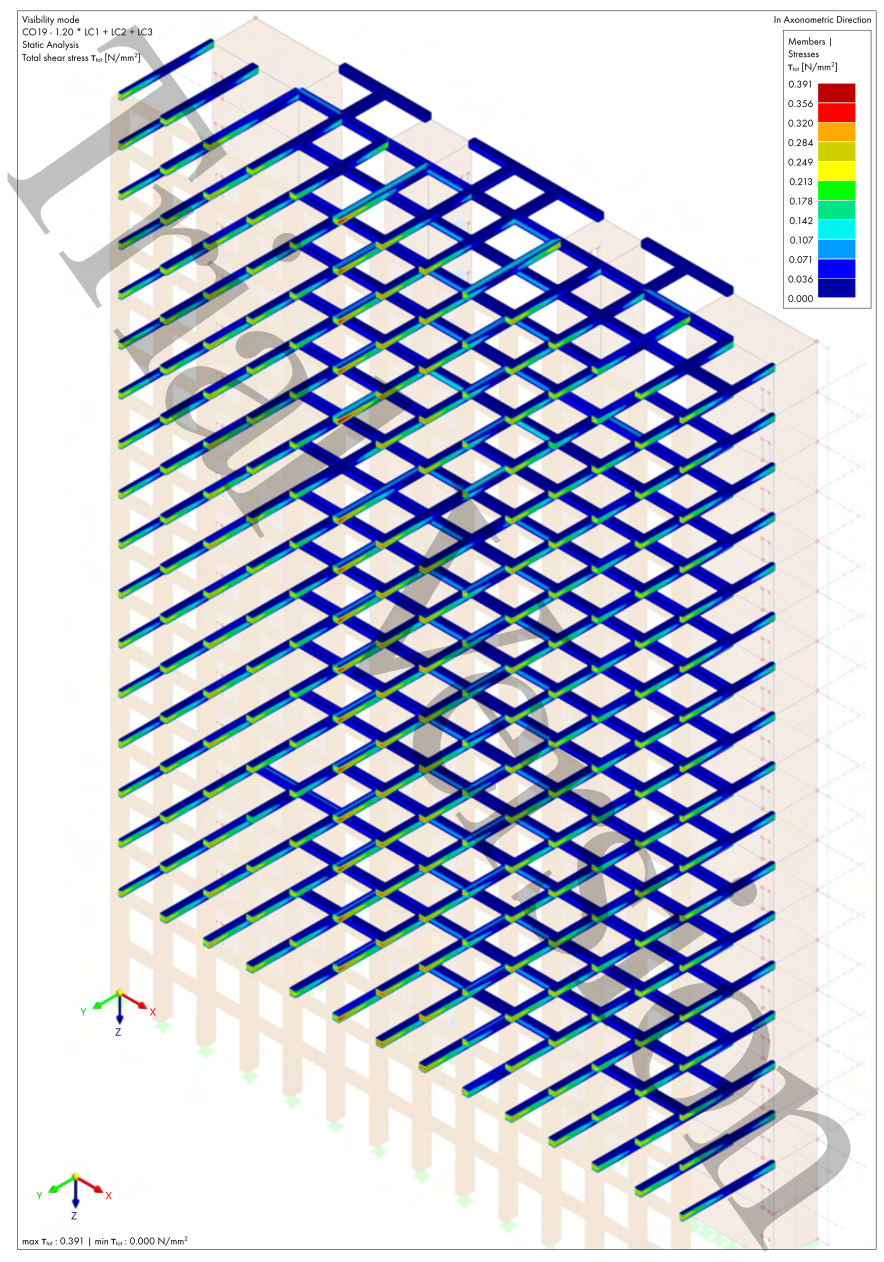
ULS



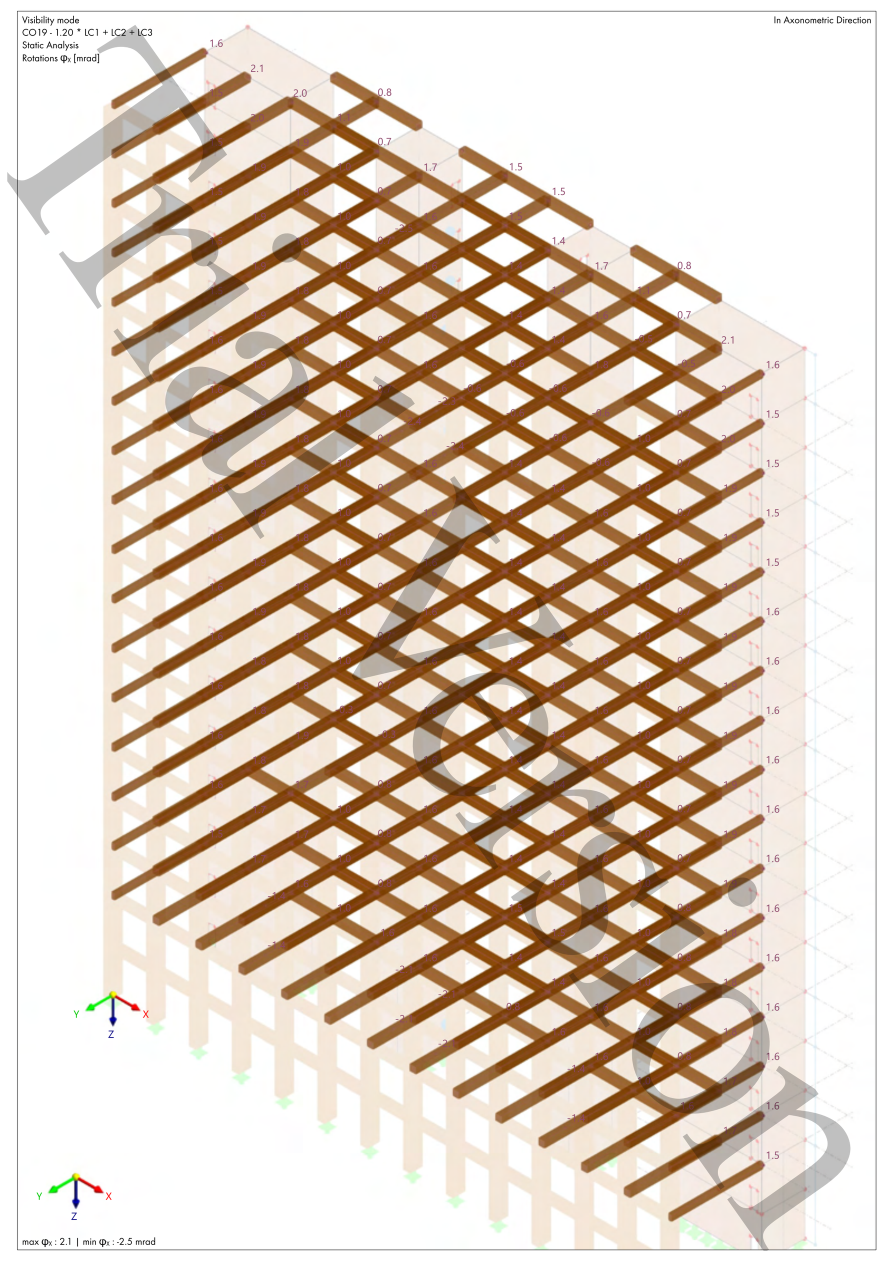
DISPLACEMENT ON BEAMS



BENDING MOMENT ON BEAMS

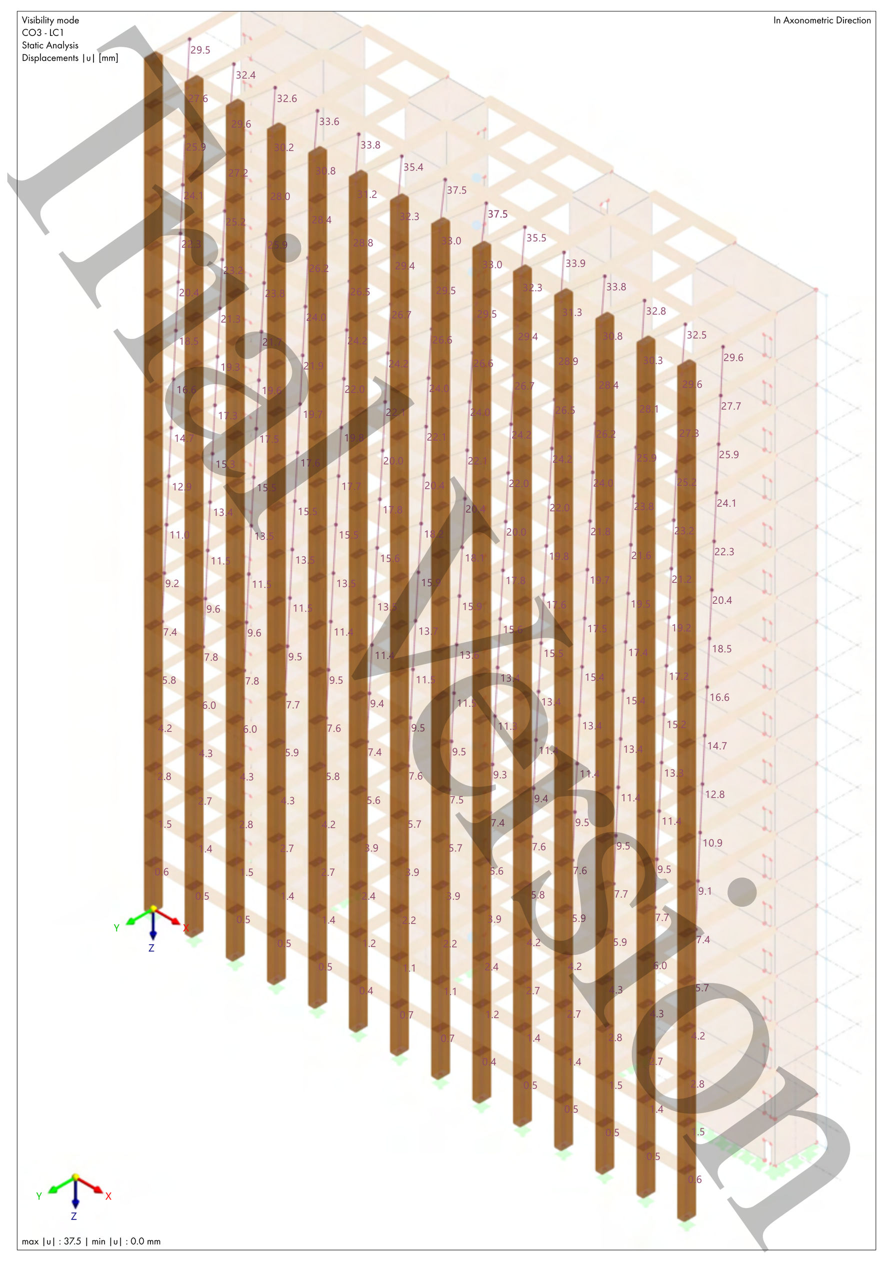


SHEAR STRESS ON BEAMS

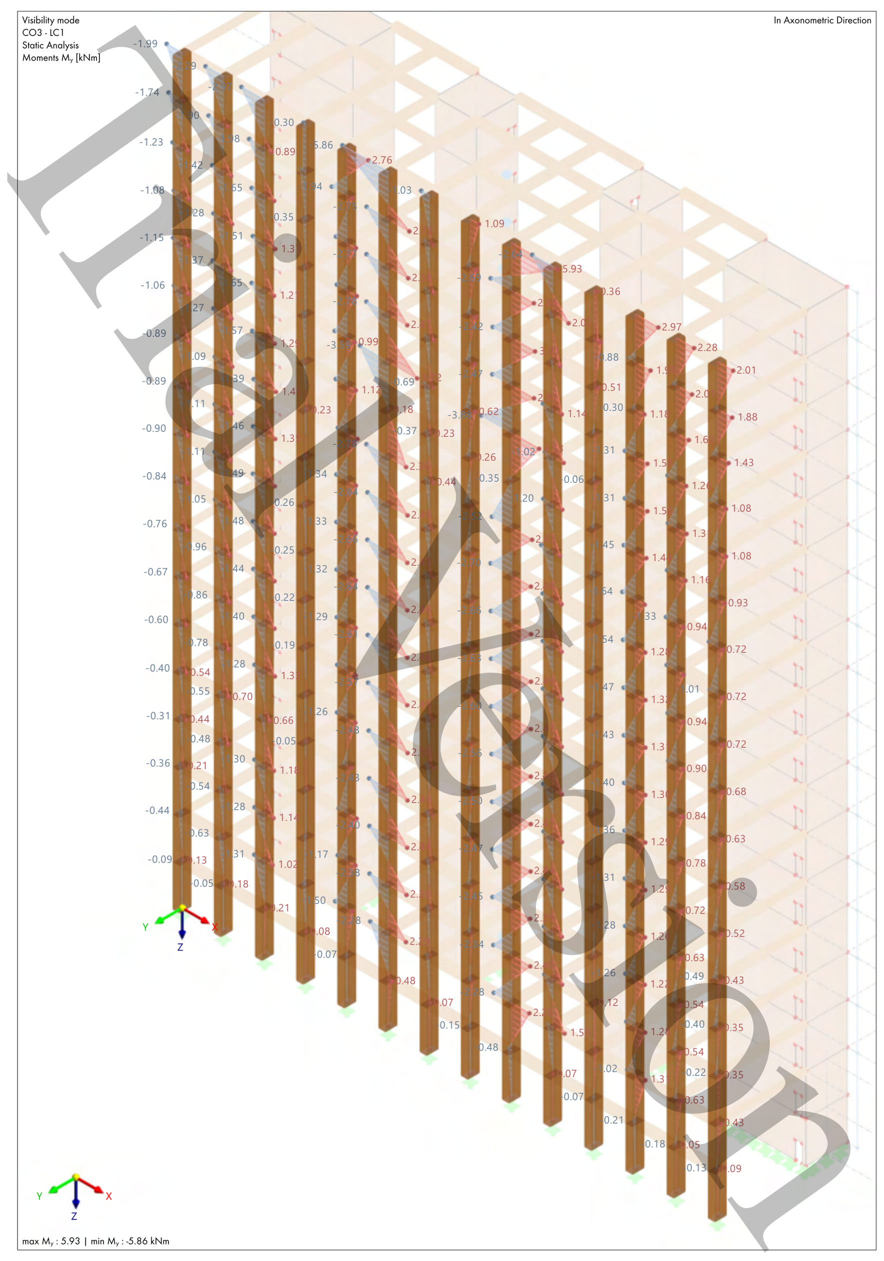


TORSION ON BEAMS

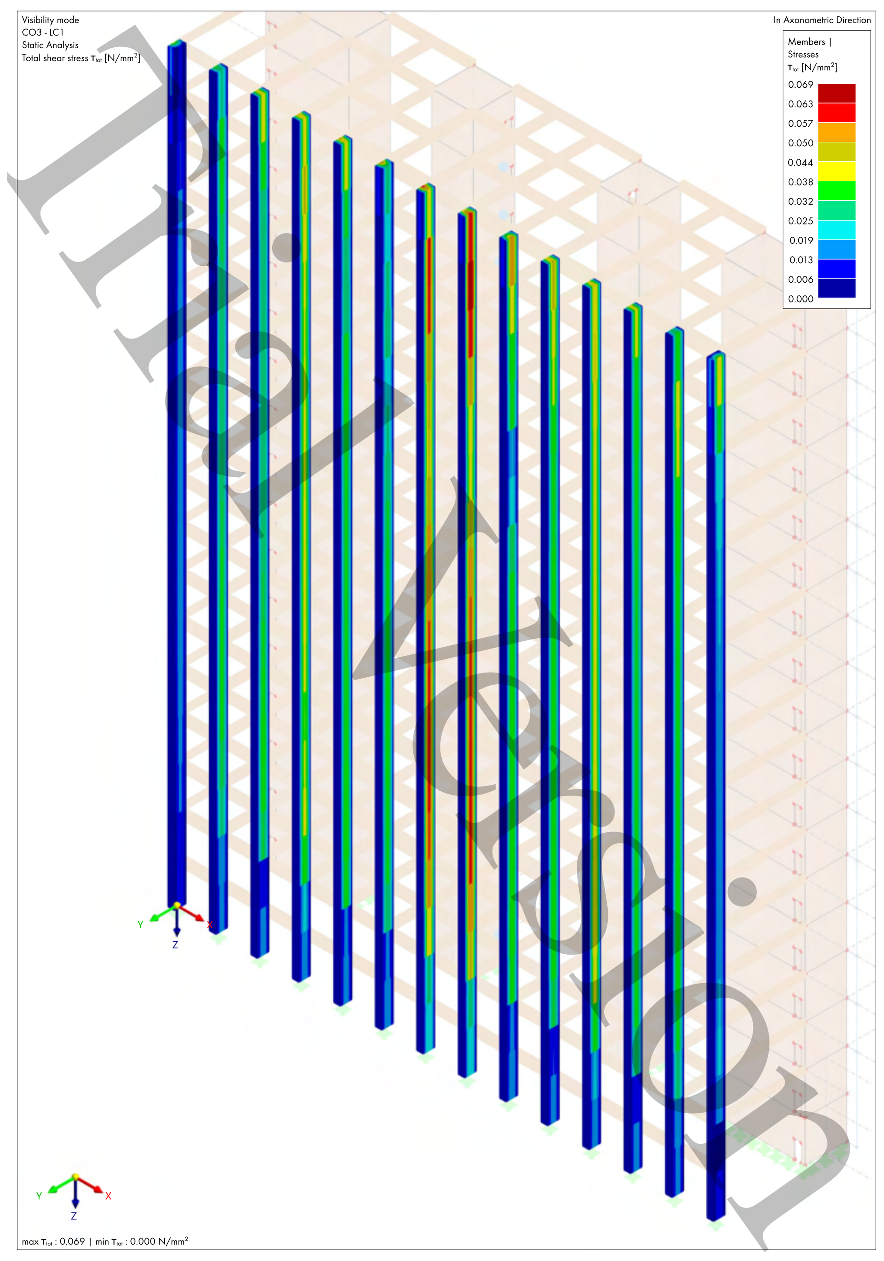
SLS



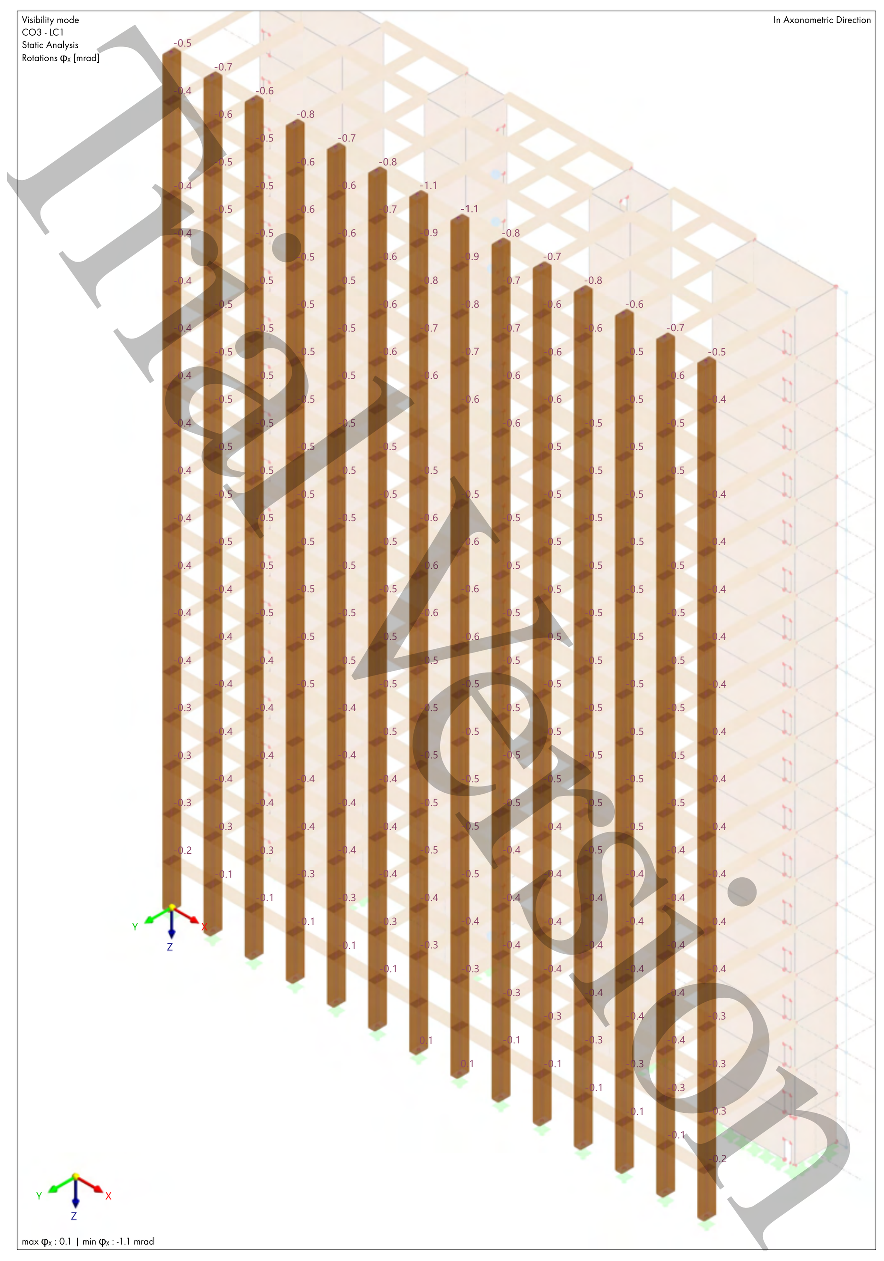
DISPLACEMENT ON COLUMNS



BENDING MOMENT ON COLUMNS



SHEAR STRESS ON COLUMNS



TORSION ON COLUMNS

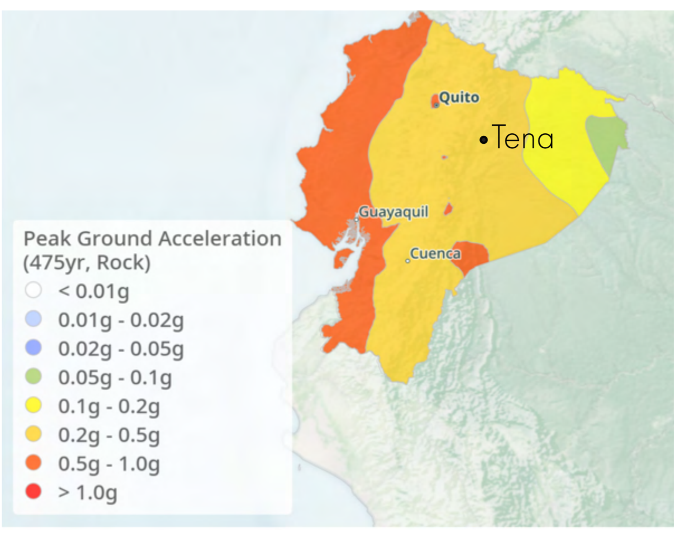
Member	27,30	x: 10.300	DS1	CO2		0.783 ✓
Member	10,48	x: 10.300	DS1	CO2		0.707 ✓
Member	21,36	x: 10.300	DS1	CO3		0.618 ✓
Member	53,55	x: 4.200	DS1	CO2		0.456 ✓
Member	13,45	x: 4.682	DS2	CO8		0.366 ✓
Member	10,48	x: 1.873	DS1	CO2		0.295 ✓

Member	21,36	x: 10.300	DS1	CO1		0.285 ✓
Member	28,31	x: 4.800	DS1	CO2		0.267 ✓
Member	25,34	x: 4.800	DS1	CO2		0.204 ✓
Member	28,31	x: 0.000	DS1	CO1		0.166 ✓
Member	28,31	x: 4.800	DS1	CO1		0.166 ✓
Member	28,31	x: 4.800	DS1	CO2		0.147 ✓

Member	1036,1042	x: 1.800	DS1	CO1		0.121 ✓
Member	24,33	x: 0.000	DS1	CO2		0.112 ✓
Member	1018,1057	x: 2.400	DS1	CO1		0.054 ✓
Member	1017,1055	x: 5.618	DS2	CO6		0.031 ✓
Member	913,922	x: 8.427	DS1	CO1		0.012 ✓
Member	972,981	x: 0.000	DS1	CO1		0.003 ✓

AUTOMATIC CHECKS

EARTHQUAKE ANALYSIS



STEPS

1. Calculation of floor areas for
   - Typical floors
   - Special floors
   - Roof
2. Definition of total dead load
3. Calculation of total weight and weight for each floor
4. Total base shear

(NEC Peligro Sísmico, 2014)

$$\mathbf{V} = \sum_{i=1}^{n} F_i \;;\; \mathbf{V}_x = \sum_{i=x}^{n} F_i \;;\; \mathbf{F}_x = \frac{w_x h_x^k}{\sum_{i=1}^{n} w_i h_i^k} V$$

1.2 DL + 1.6 LL + 0.5 Wind
1.2 DL + 1.0 Wind + 1.0 LL

EN 1998-1 :2004 (E)

$$F_b = S_d(T_1) \cdot m \cdot \lambda$$

1.35 DL + 1.5 LL
1.35DL + 0 .75 Wind + 1.5 LL

LATERAL FORCE CALCULATION ON EACH FLOOR

LEVEL	hi	Hi	Wi	Hi(k=1.60)	$Wi(Hi)^k$(k=1.60)	αi	Fi
1	9.6	9.6	1756.34	37.29	65500.19	0.0041	23.56
2	4.8	14.4	1756.34	71.35	125310.82	0.0078	45.07
3	4.8	19.2	1756.34	113.05	198559.45	0.0123	71.41
4	4.8	24	1555.02	161.56	251231.43	0.0156	90.35
5	4.8	28.8	1756.34	216.29	379871.38	0.0235	136.62
6	4.8	33.6	1756.34	276.79	486128.90	0.0301	174.83
7	4.8	38.4	1756.34	342.71	601919.69	0.0373	216.47
8	4.8	43.2	1756.34	413.78	726745.89	0.0451	261.37
9	4.8	48	1756.34	489.76	860190.36	0.0533	309.36
10	4.8	52.8	1756.34	570.45	1001896.52	0.0621	360.32
11	4.8	57.6	1756.34	655.66	1151554.68	0.0714	414.14
12	4.8	62.4	1281.34	745.24	954904.03	0.0592	343.42
13	4.8	67.2	1756.34	839.06	1473667.24	0.0914	529.99
14	4.8	72	1756.34	936.98	1645661.79	0.1020	591.84
15	4.8	76.8	1555.02	1038.91	1615525.92	0.1001	581.01
16	4.8	81.6	1756.34	1144.73	2010540.59	0.1246	723.07
17	4.8	86.4	2058.33	1254.36	2581885.58	0.1601	928.55

$\sum Wi(Hi)^k$(k=1.6)= 16131094.48 ∑αi= 1

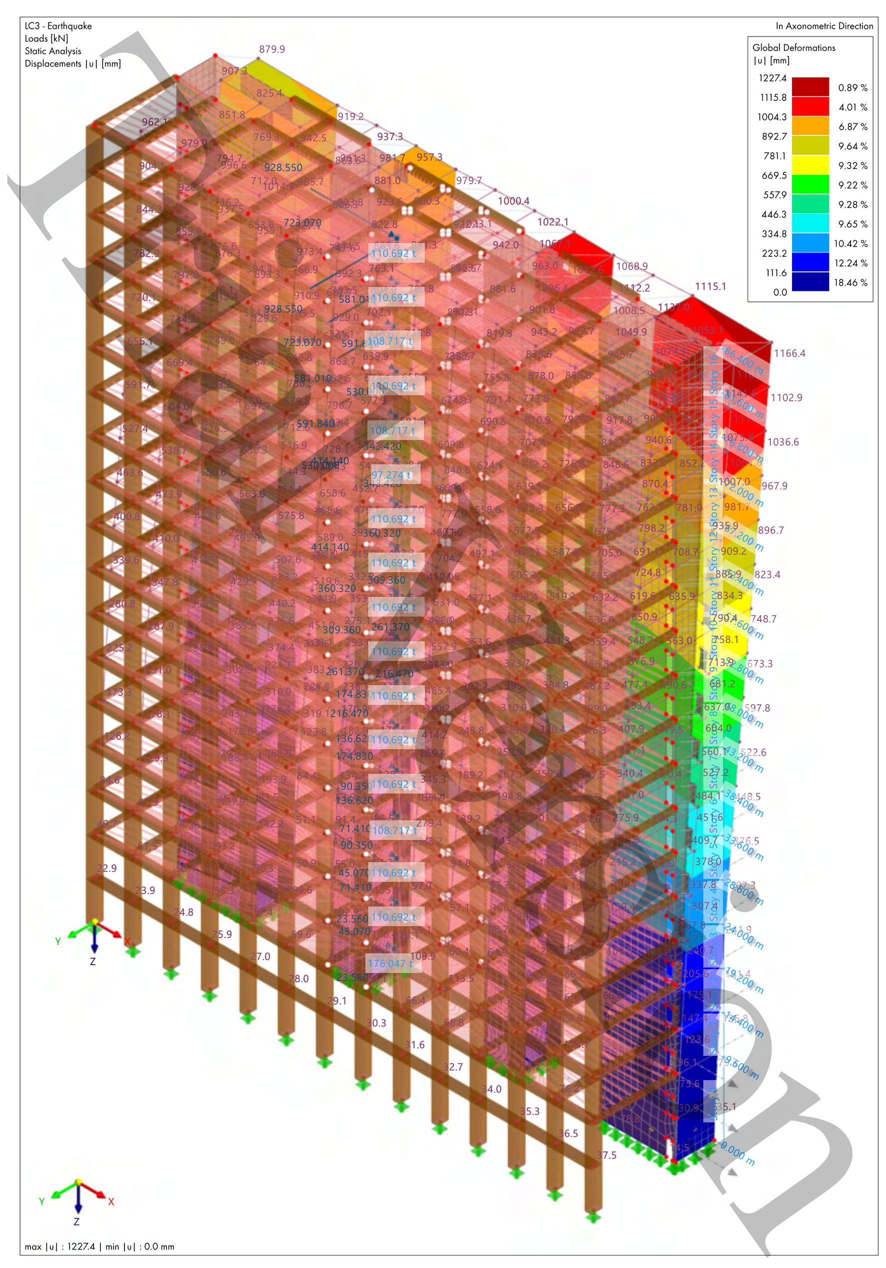
V total shear base= 5801.37

V TOTAL BASE SHEAR

V= I x Sa (Ta) x Wtotal / R x ϕp x ϕe

I = 1.3
Sa(Ta) = 0.381g
Wtotal = 29282.1 kN
R = 2.5
ϕp = 1.0
ϕe = 1.0

V= 5801.37 kN



CHECK OF DRIFT

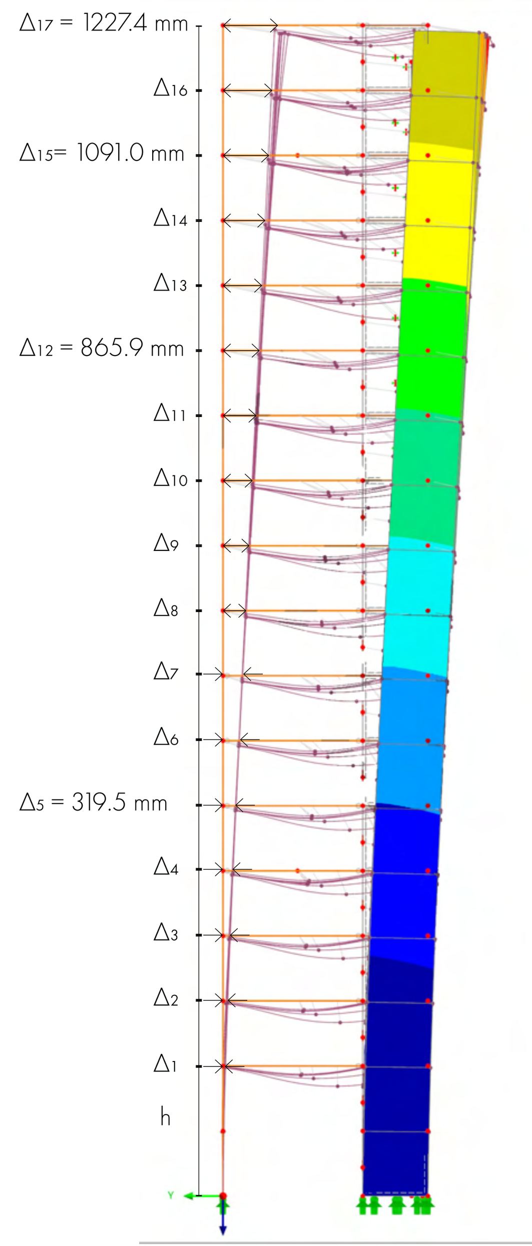
ui < 0.02 x hi
ui = displacement at 'i' floor
hi = height of 'i' floor from ground level

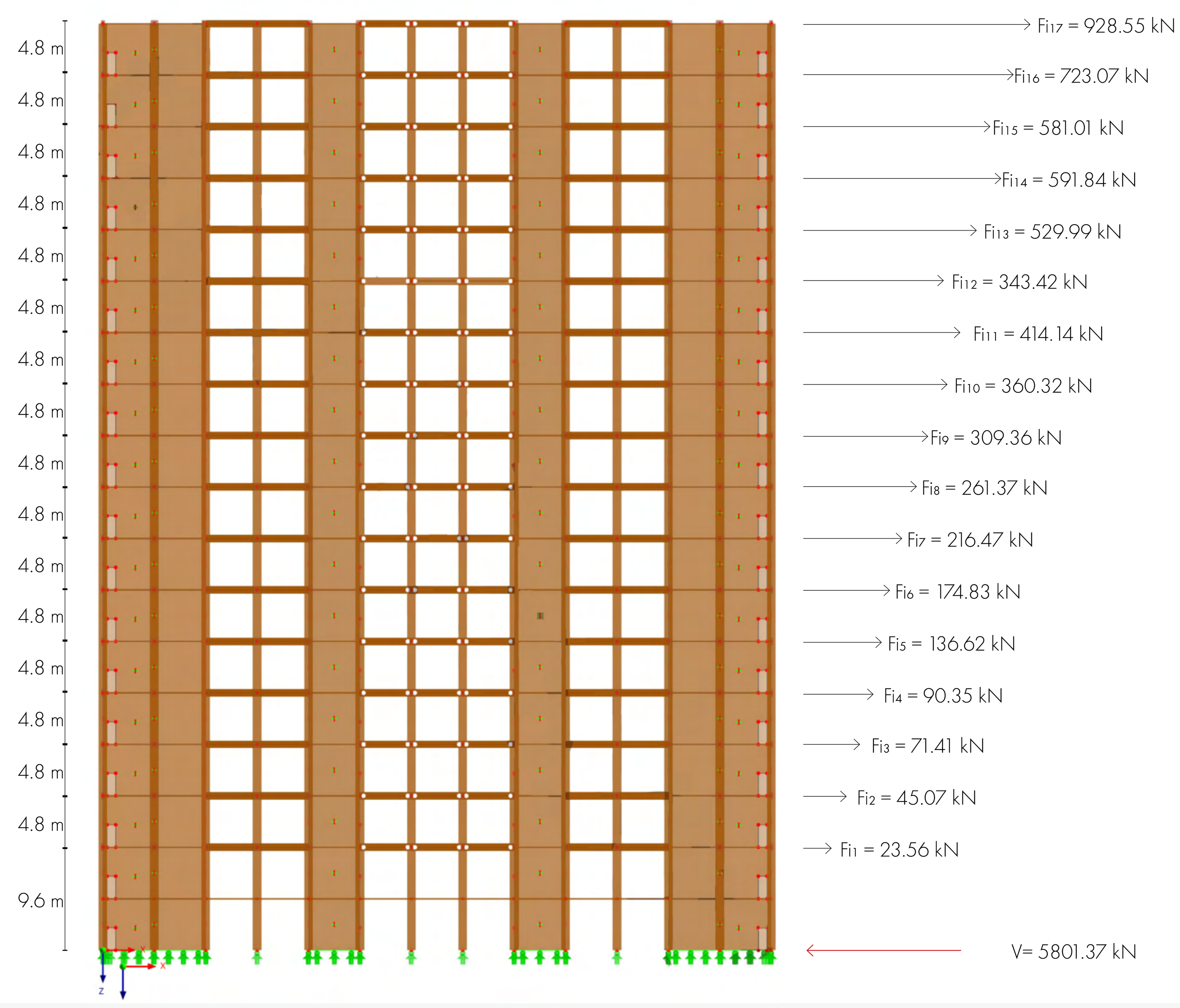
Slab 17 (Roof)
u 17 = 1227.4 mm h= 86400 mm
1227.4 mm < 0.02 x 86400 mm
1227.4 < 1728 mm

Slab 15
u 15 = 1091.0 mm h= 76800 mm
1091.0 mm < 0.02 x 76800 mm
1091.0 mm < 1536 mm

Slab 12
u 12 = 865.9 mm h= 62400 mm
865.9 mm < 0.02 x 62400 mm
865.9 mm < 1248 mm

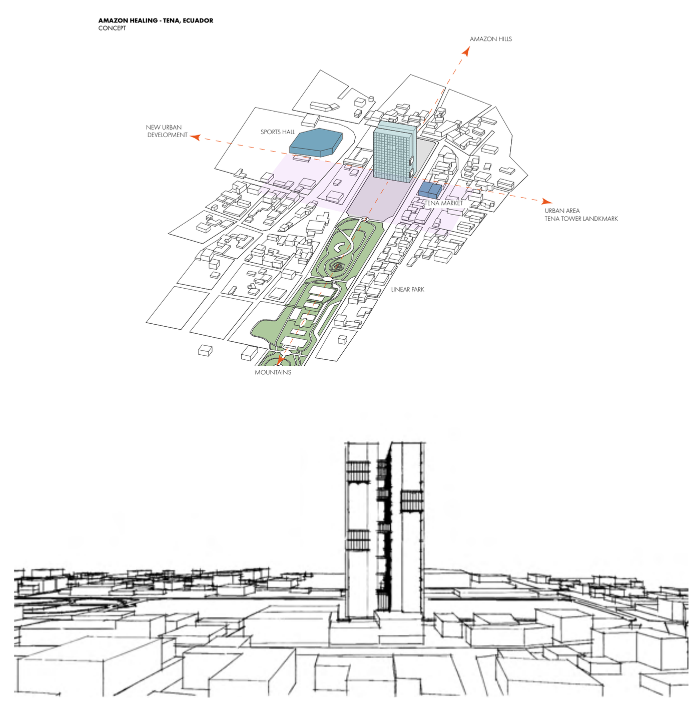
Slab 5 (Typical Slab)
u5 = 319.5 mm h= 28800 mm
319.5 mm < 0.02 x 28800 mm
319.5 mm < 576 mm



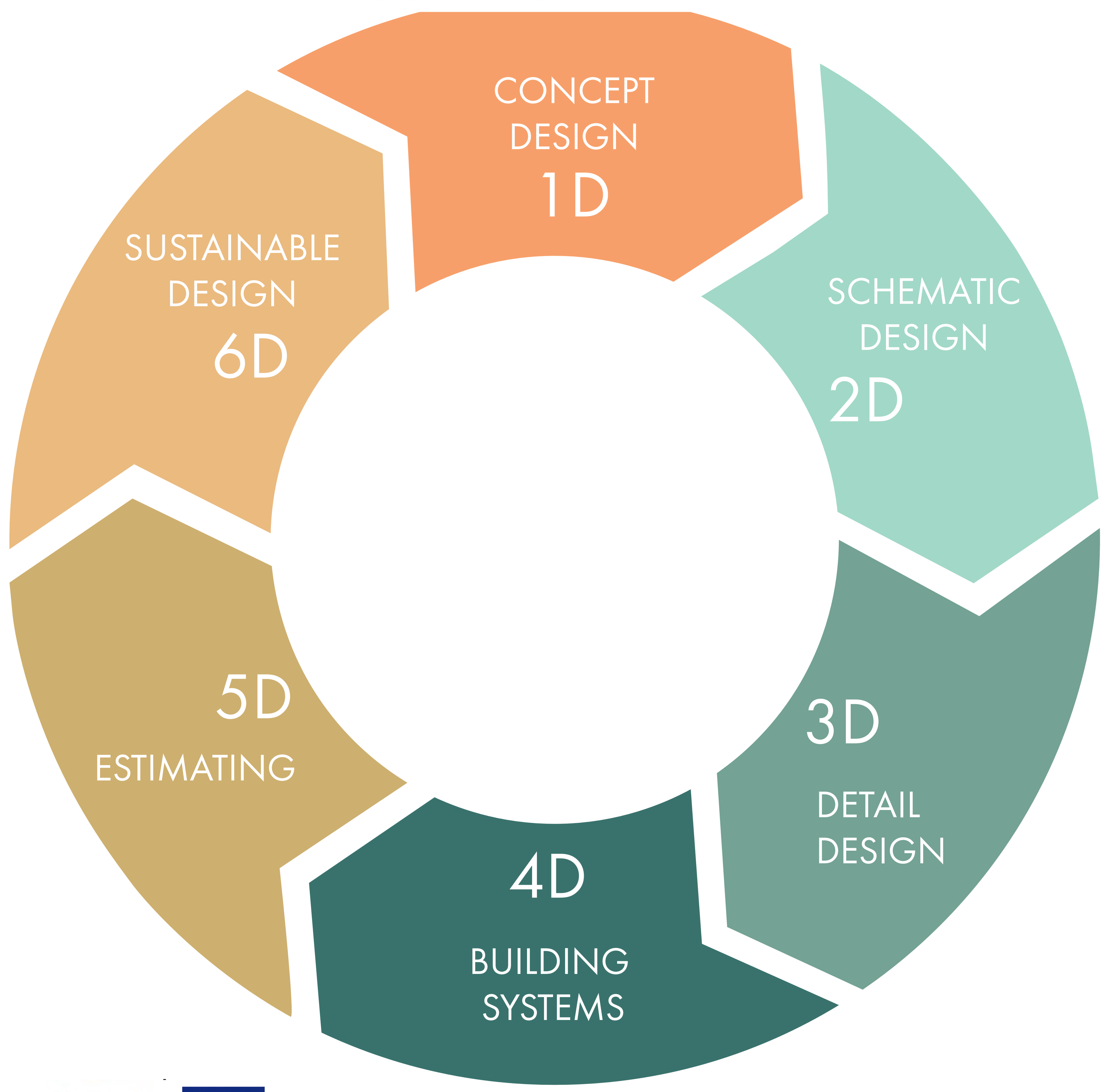


BIM | LEVELS OF DESIGN & WORKFLOW

RESEARCH AND DATA ANALYSIS



INITIAL DRAWINGS



Ladybug/ Honeybee

Snail (Grasshopper plug-in)

TESTING

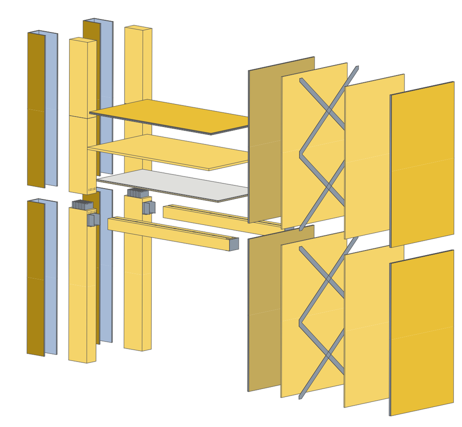
Category	Steel	Timber	Benchmark
Cost	£ 14,092,389.60	£ 9,972,440.02	£ 113,000,000.00
Time	408	172	426
Sustainability	2	6	5
Amount of Material	4854.959367	9065.8	2600
MEP Savings	100.00	200.00	300.00

Revit Excel

COST ESTIMATION

Revit Daylight Visualizer

grasshopper



DETAILED DESIGN

Tekla/ Dlubal

STRUCTURE DESIGN

Solibri

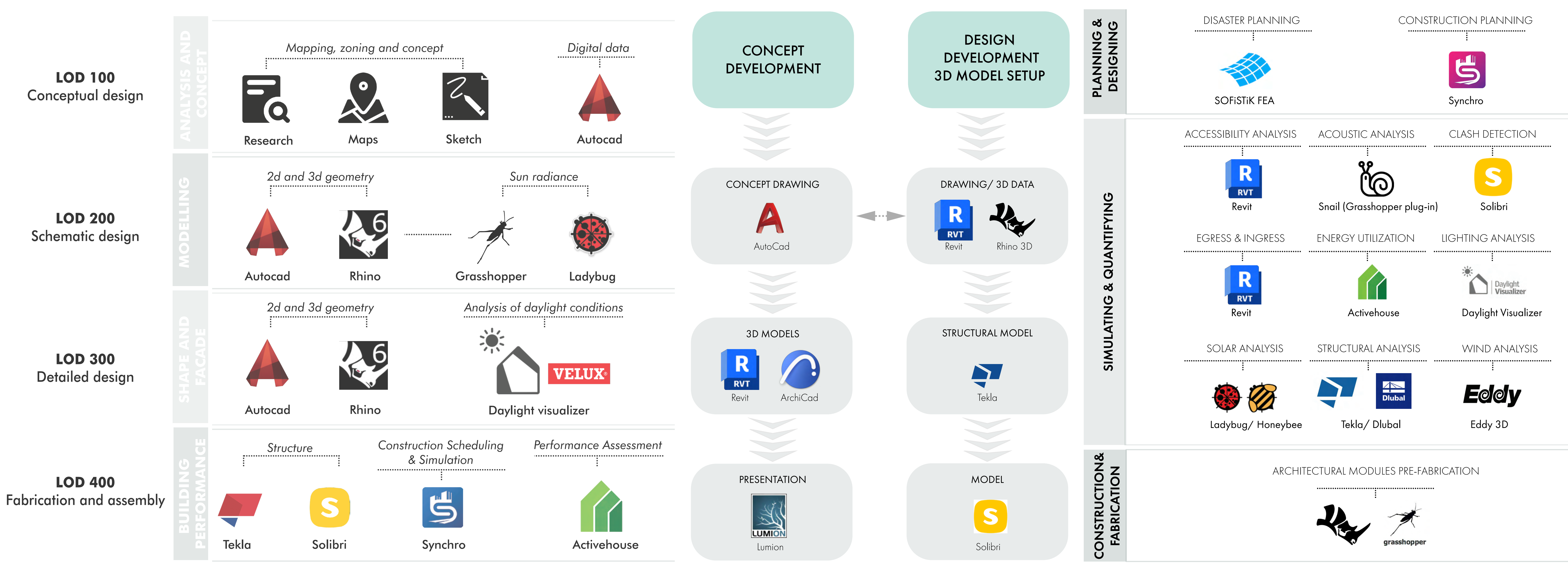
STRUCTURE + MEP

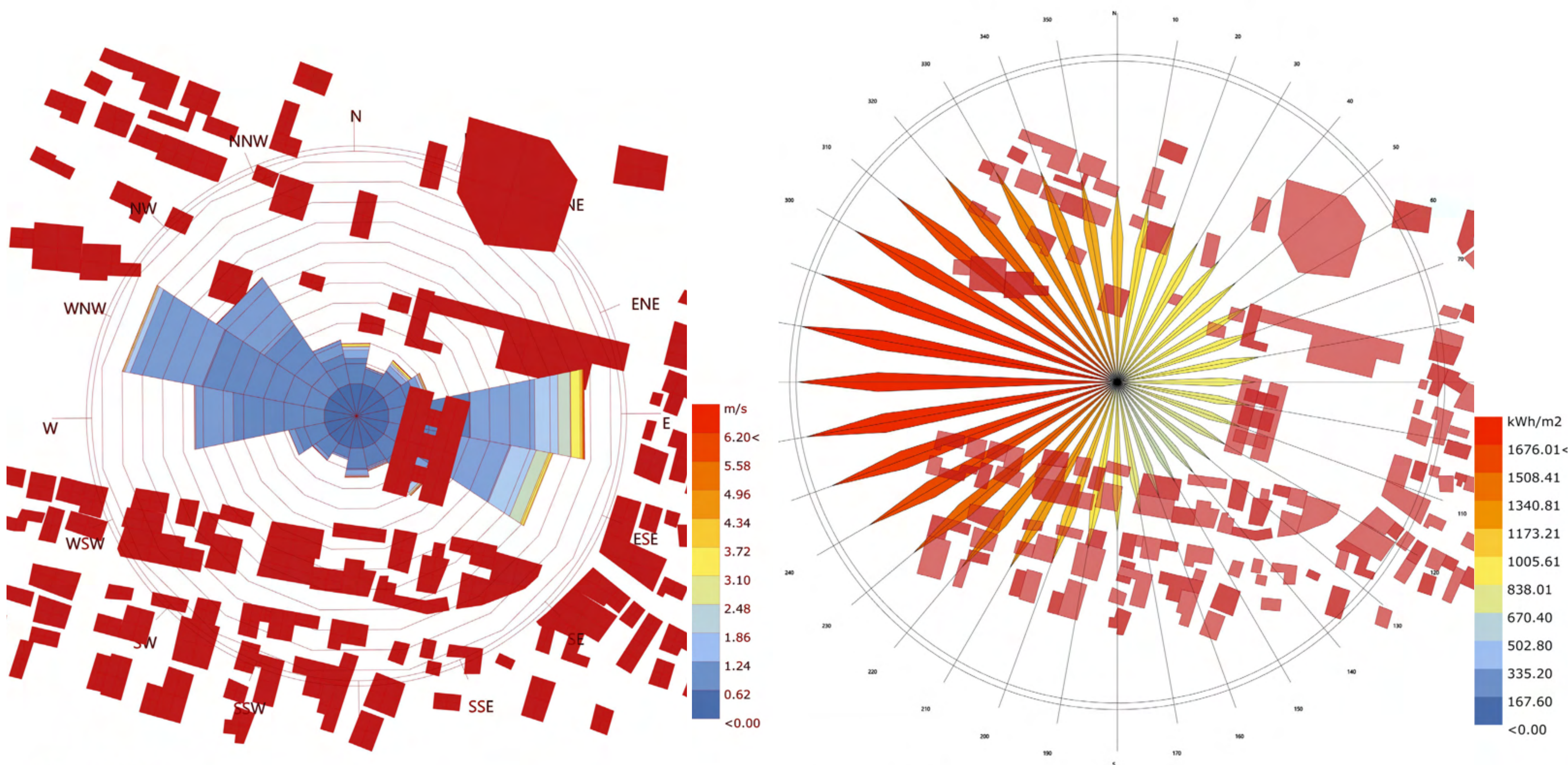
Synchro

PROJECT MANAGEMENT

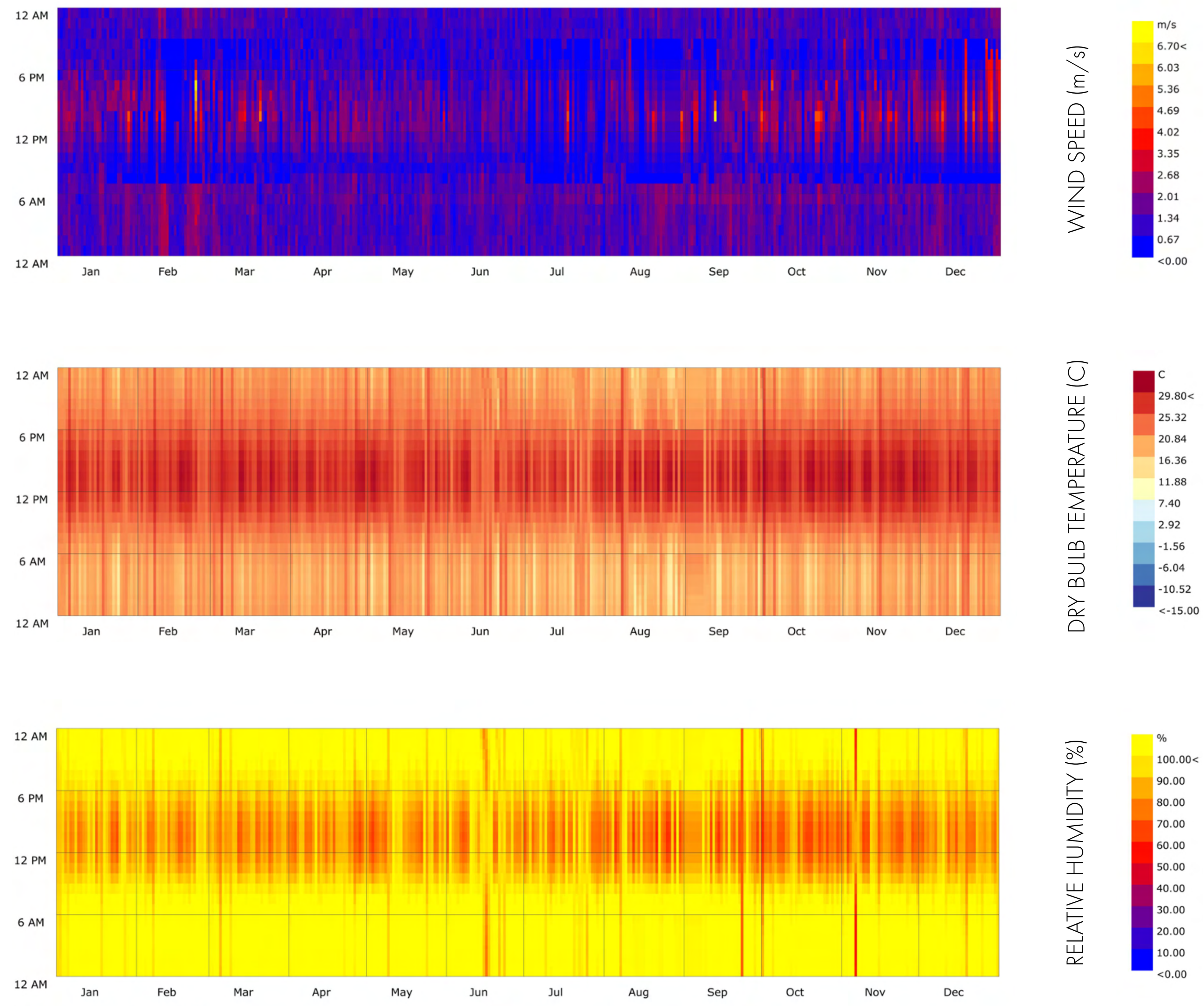
BIM USES DOMAINS		OVERALL BIM MODEL USES APPROPRIATE FOR THE PROJECTS	BIM MODEL USES TO BE EXPLORED
Capturing & Representing BIMe Topic under Operation Competency: Using software tools and specialized equipment to capture and represent	Operation Competency	2010 2D Documentation 2020 3D Detailing 2080 Surveying 2090 Visual Documentation	2010 2D Documentation 2020 3D Detailing 2080 Surveying 2090 Visual Documentation
Planning & Designing BIMe Topic under Operation Competency: Using software tools for conceptualization, planning and design	Operation Competency	3010 Conceptualization 3050 Disaster Planning 3060 Lean Process Analysis 3110 Urban Planning 3020 Construction Planning	3010 Conceptualization 3050 Disaster Planning 3110 Urban Planning 3020 Construction Planning
Simulating& Quantifying BIMe Topic under Operation Competency: Using software tools to conduct various types of model-based simulations and estimations	Operation Competency	4010 Accessibility Analysis 4020 Acoustic Analysis 4040 Clash Detection 4080 Egress & Ingress 4070 Cost Estimation 4090 Energy Utilization 4100 Finite Elements Analysis 4120 Lighting Analysis 4140 Reflectivity Analysis 4190 Solar Analysis 4210 Structural Analysis 4229 Sustainability Analysis 4250 Life-Cycle Assessment 4260 Wind Studies	4010 Accessibility Analysis 4020 Acoustic Analysis 4040 Clash Detection 4080 Egress & Ingress 4070 Cost Estimation 4090 Energy Utilization 4100 Finite ELements Analysis 4120 Lighting Analysis 4140 Reflectivity Analysis 4190 Solar Analysis 4210 Structural Analysis 4229 Sustainability Analysis 4250 Life-Cycle Assessment 4260 Wind Studies
Construction & Fabrication BIMe Topic under Operation Competency: Using BIModels for the specific purposes of construction and fabrication	Operation Competency	5020 Architectural Modules Pre-fabrication 5050 Construction Logistics 5055 Construction Waste Management 5080 Site Set-Outs	5020 Architectural Modules Pre-fabrication 5050 Construction Logistics 5055 Construction Waste Management 5080 Site Set-Outs

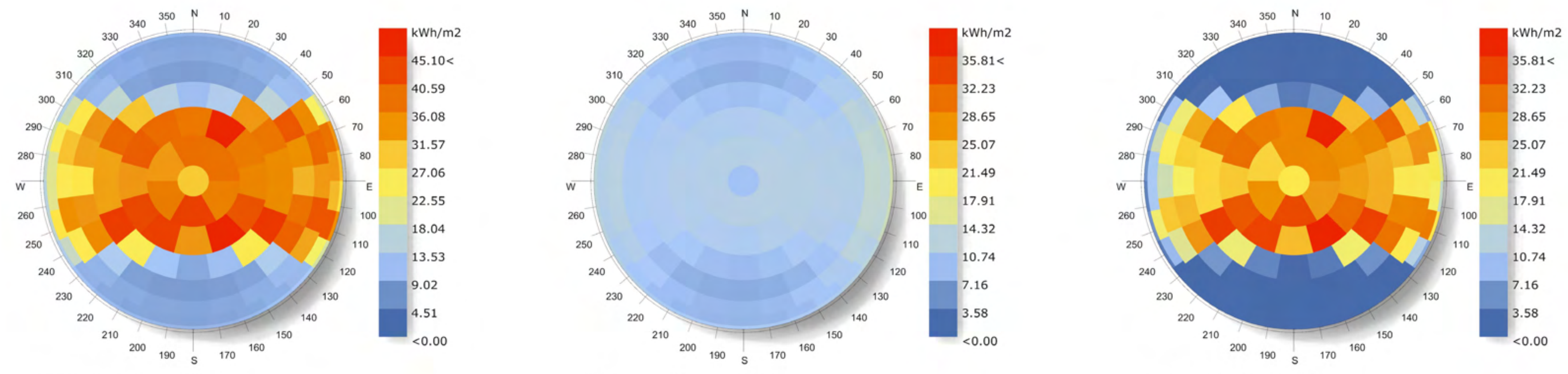
BIM MODEL USES TO BE EXPLORED IN DETAIL	DEFINITIONS AND KEY PERFORMANCE` INDICATORS
3050 Disaster Planning 3020 Construction Planning	3050 -A Model Use where 3D models are used to simulate a building fire, an explosion, an earthquake or similar. The behavior of building systems, individuals and crowds are included within this term. ***KPI - the resistance of the structure and building in case of en exogenous activities such as earthquakes since Ecuador is a seismic active country and therefore the structure and building should be tested for earthquakes.*** 3020 - BIModel is used to plan, organise or test construction activities against constraints (e.g. time, human resources and materials). The scheduling of the construction process shall ensure the efficiency and cost-effectiveness during construction.
4010 Accessibility Analysis 4020 Acoustic Analysis 4040 Clash Detection 4080 Egress & Ingress 4090 Energy Utilization 4120 Lighting Analysis 4140 Reflectivity Analysis 4190 Solar Analysis 4210 Structural Analysis 4220 Sustainability Analysis 4250 Life-Cycle Assessment 4260 Wind Studies	4010 - 3D models are used to assess whether a Facility allows direct (unassisted) or indirect access for people with disabilities, or special needs such as vision, hearing and mobility impairment. ***KPI - Ensuring the barrier free accessibility of the tower and the auditorium;*** 4020 - 3D models are used to conduct sound studies, test the placement of sound equipment, simulate sound insulation/attenuation, and inform the choice of materials used within a space. ***KPI - ensuring the acoustic quality of the auditorium and the conference room.*** 4040 - Use of 3D Models to coordinate different disciplines and to identify/resolve possible clashes between virtual elements prior to actual construction or fabrication. ***KPI - Checking the 3D model for clashes with the HVAC systems and plumbing.*** 4080 - 3D models are used to simulate individual/crowd behaviour within a Facility, either during normal operations or during emergency situations. ***KPI - Improve circulation and access to spaces within the tower.*** 4090 - A metric measuring how and how-much a Facility consumes energy. ***KPI - ensuring a high-performance building based on material choices and system atomization.*** 4120 - 3D models are used to simulate natural and artificial lighting levels. This Model Use is a form of Building Performance analysis. ***KPI - ensuring a high-performance building, optimizing day lighting and lighting conditions in the library and co-working spaces.*** 4140 - 3D models are used to simulate the impact (angle and intensity) of sunlight reflected of building surfaces. ***KPI - reduced reflectivity and light comfort.*** 4190 - 3D models are used to conduct shadow studies, simulate solar radiance on building envelops, and analyses the effect of building location/shape on solar heat loads. ***KPI - ensuring a high-performance building, optimizing day lighting, available solar radiation and facade design.*** 4210 - 3D models are used to analyses the behaviour of the structural system. Structural analysis typically includes the study of the effects of static/dynamic loads on buildings. ***KPI - building design can be subsequently optimized.*** 4220 - 3D models are used to calculate the environmental impact of a new construction project or an existing Facility. These calculations may include Carbon Footprint, Life Cycle Assessment, Embodied Energy and other sustainability metrics. ***KPI - Improving the building performance.*** 4260 - 3D models are used to simulate the effects of wind on structures. The simulation is intended to inform the design process by identifying optimal orientations and shapes. ***KPI- optimizing building shape and identifying wind corridors which effect could be reduced with the design of vegetations and building shape.***





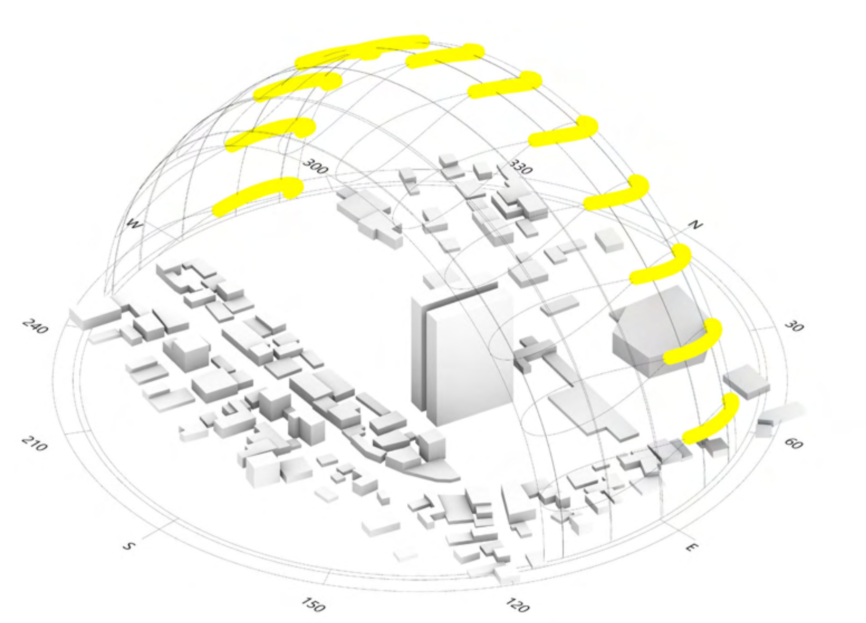
WIND INTENSITY & TOTAL RADIATION ANALYSIS



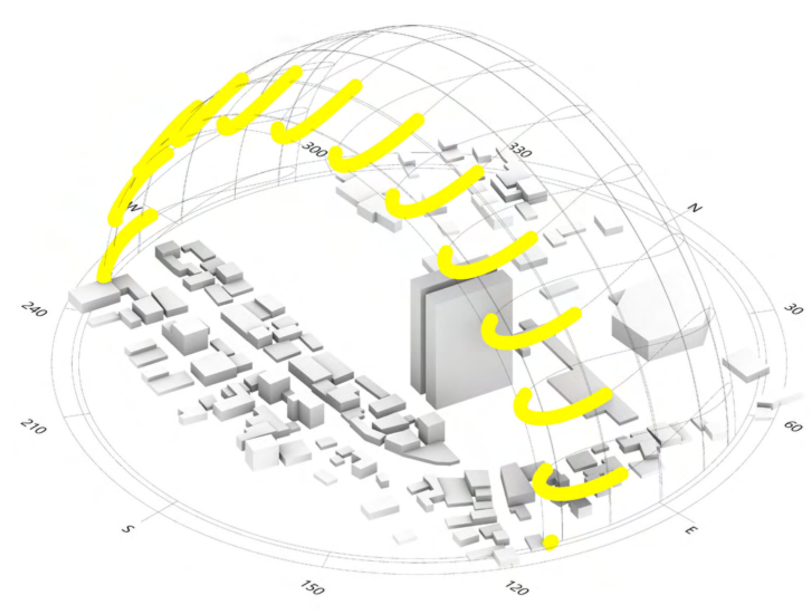


SUNLIGHT HOURS ANALYSIS

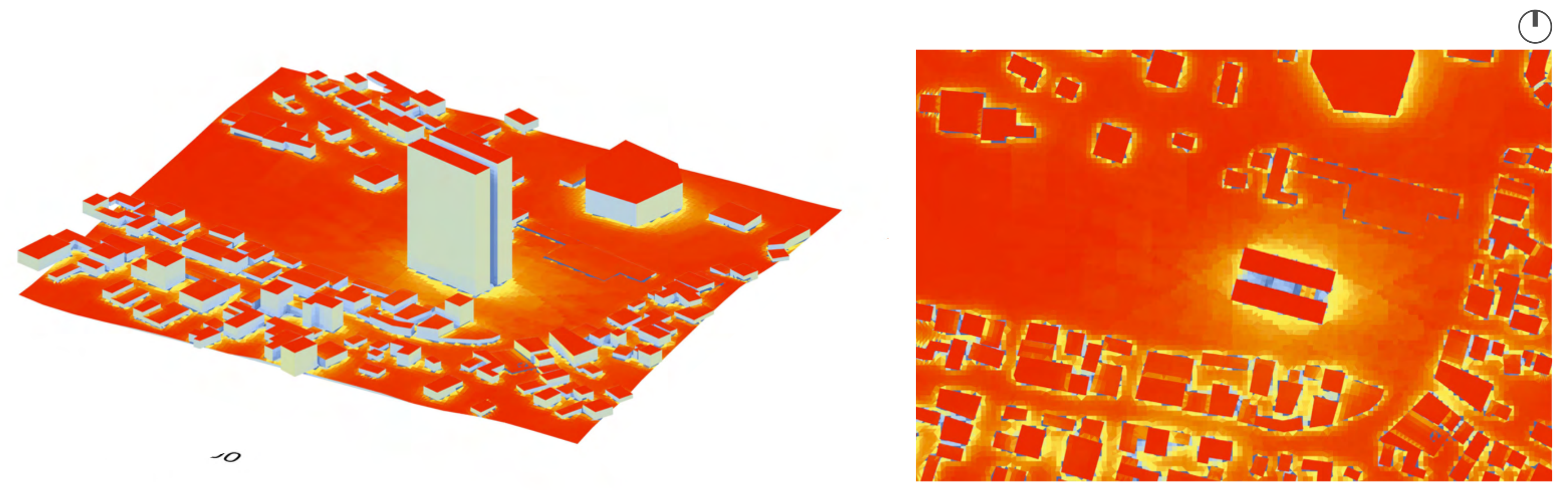
SOLAR RADIATION ANALYSIS



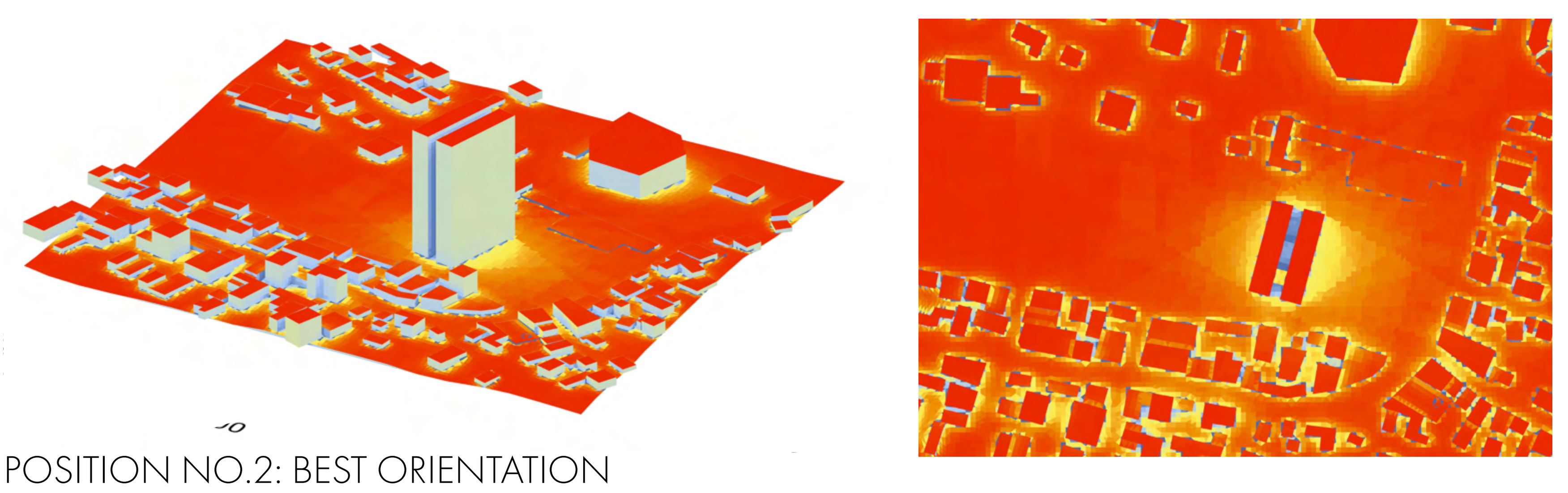
SUNPATH SUMMER ANALYSIS



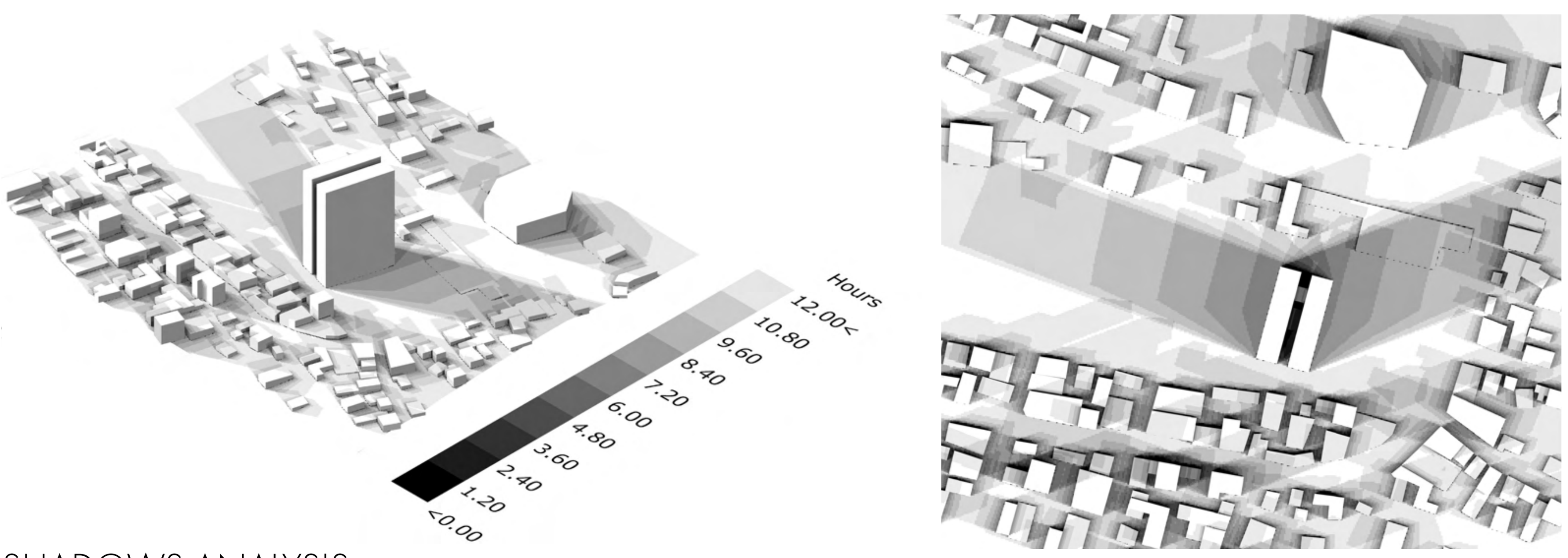
SUNPATH WINTER ANALYSIS



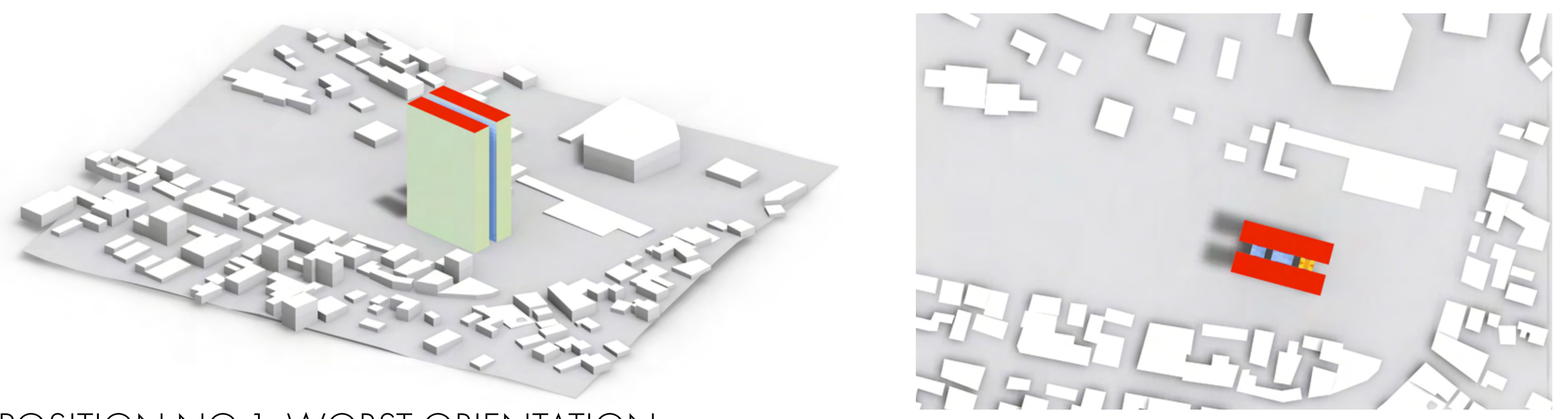
POSITION NO.1: WORST ORIENTATION



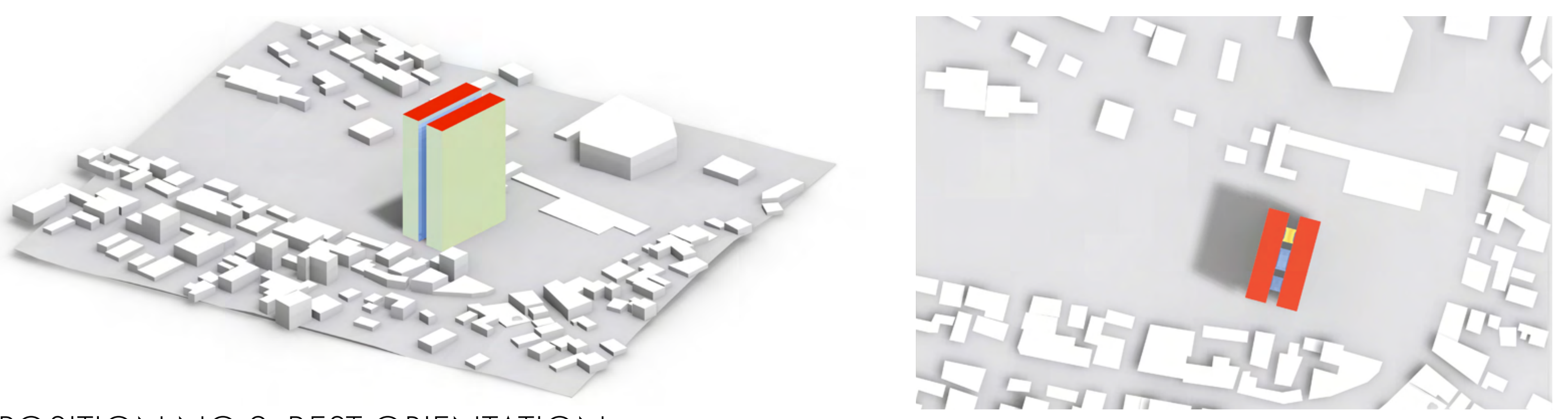
POSITION NO.2: BEST ORIENTATION



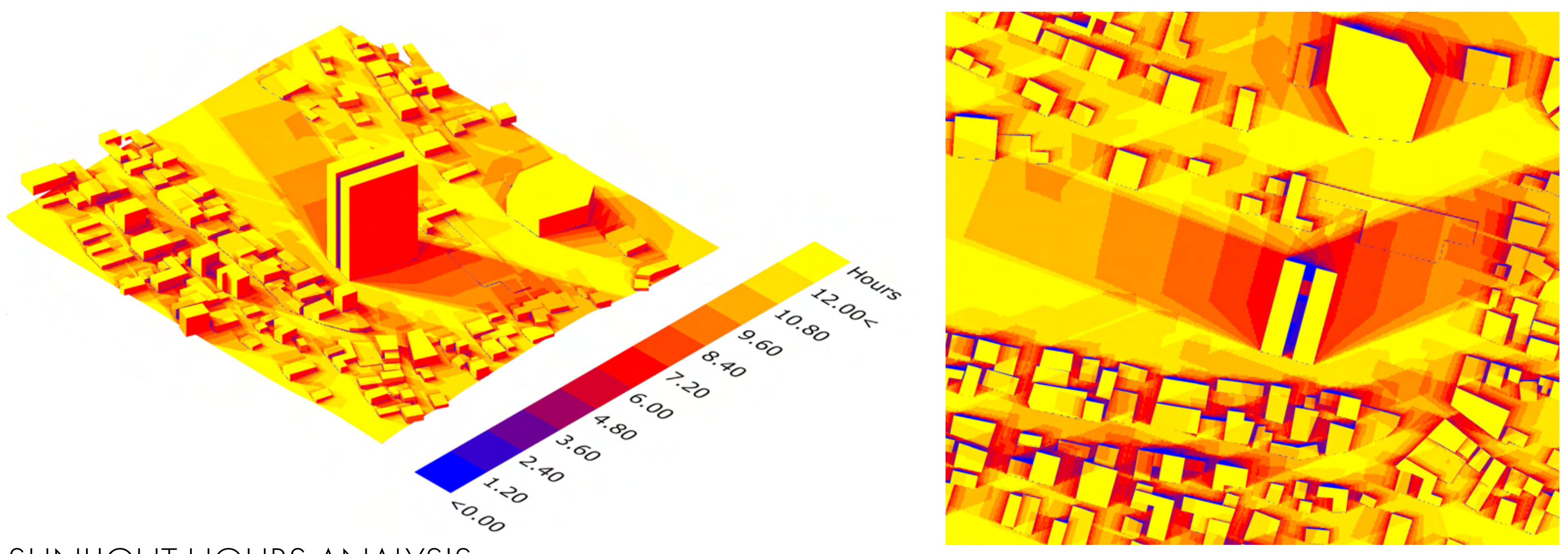
SHADOWS ANALYSIS



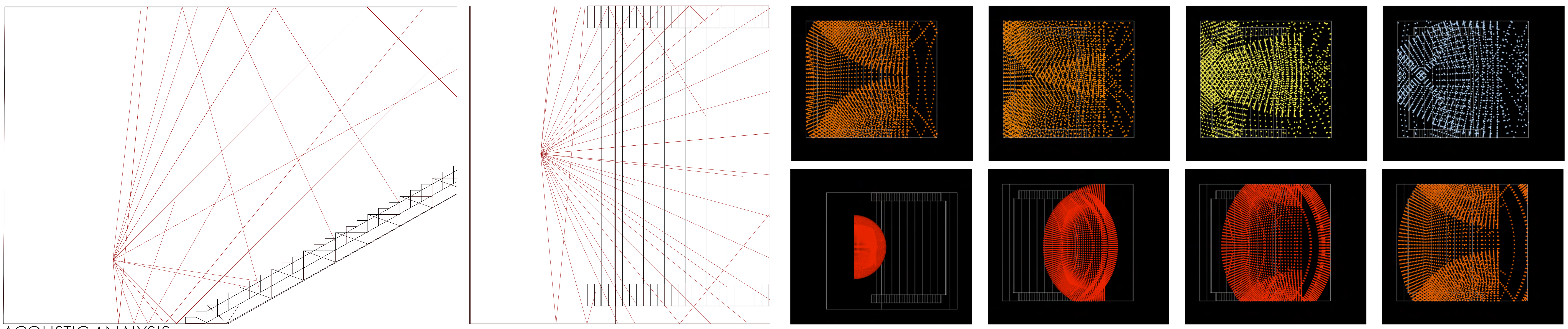
POSITION NO.1: WORST ORIENTATION



POSITION NO.2: BEST ORIENTATION



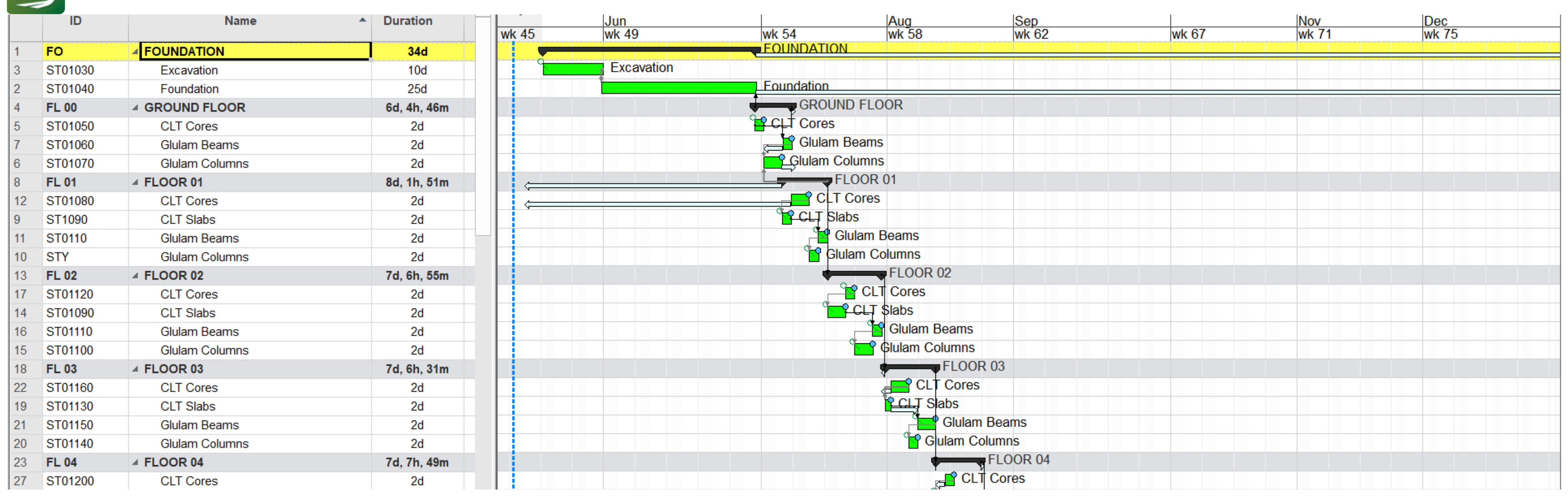
SUNLIGHT HOURS ANALYSIS



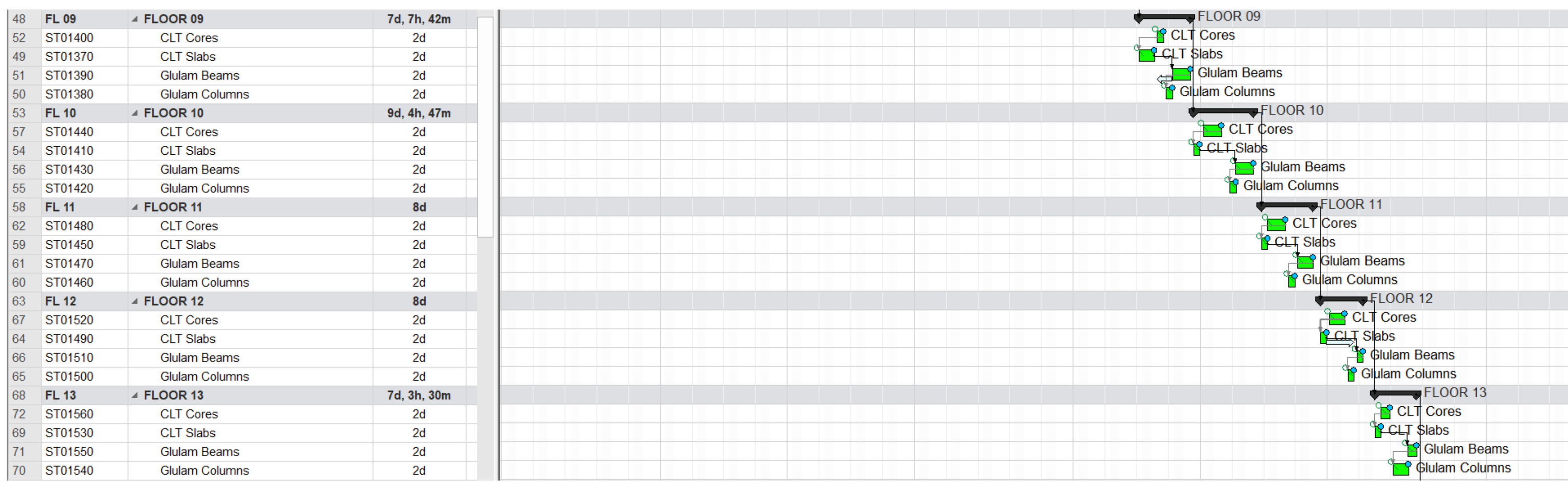
ACOUSTIC ANALYSIS

BUILDING INFORMATION MODELING

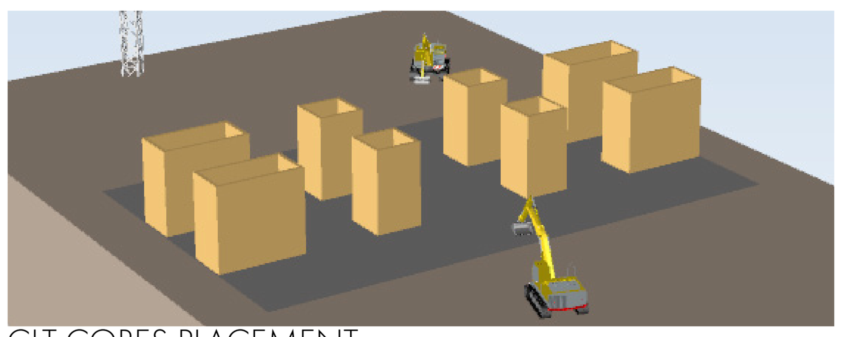
SYNCHRO CONSTRUCTION STAGES SCHEDULING

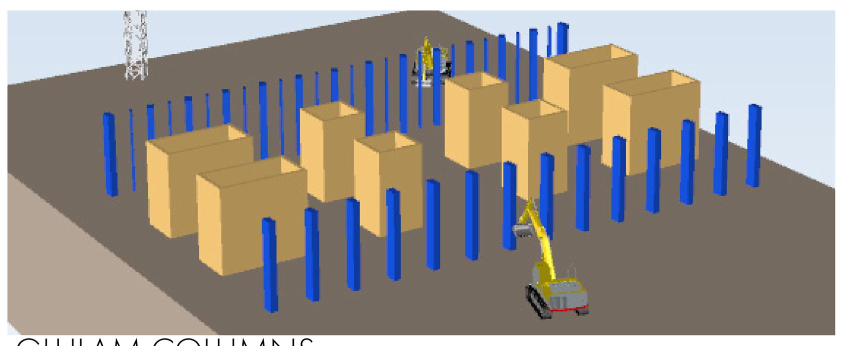


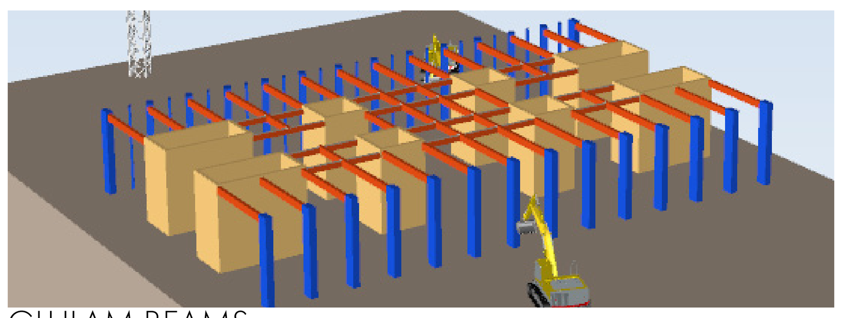
	ID	Name	Duration
1	FO	FOUNDATION	34d
3	ST01030	Excavation	10d
2	ST01040	Foundation	25d
4	FL 00	GROUND FLOOR	6d, 4h, 46m
5	ST01050	CLT Cores	2d
7	ST01060	Glulam Beams	2d
6	ST01070	Glulam Columns	2d
8	FL 01	FLOOR 01	8d, 1h, 51m
12	ST01080	CLT Cores	2d
9	ST1090	CLT Slabs	2d
11	ST0110	Glulam Beams	2d
10	STY	Glulam Columns	2d
13	FL 02	FLOOR 02	7d, 6h, 55m
17	ST01120	CLT Cores	2d
14	ST01090	CLT Slabs	2d
16	ST01110	Glulam Beams	2d
15	ST01100	Glulam Columns	2d
18	FL 03	FLOOR 03	7d, 6h, 31m
22	ST01160	CLT Cores	2d
19	ST01130	CLT Slabs	2d
21	ST01150	Glulam Beams	2d
20	ST01140	Glulam Columns	2d
23	FL 04	FLOOR 04	7d, 7h, 49m
27	ST01200	CLT Cores	2d

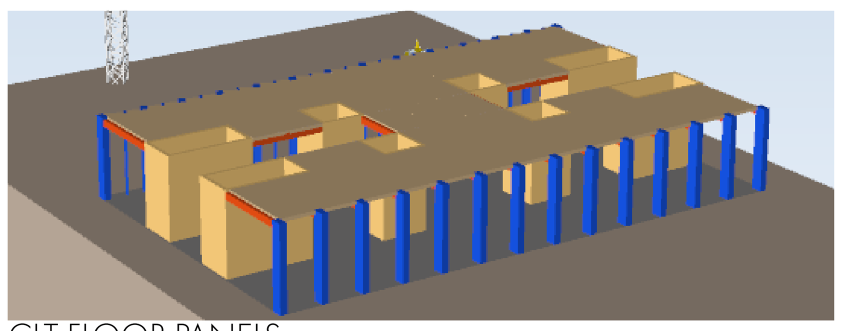


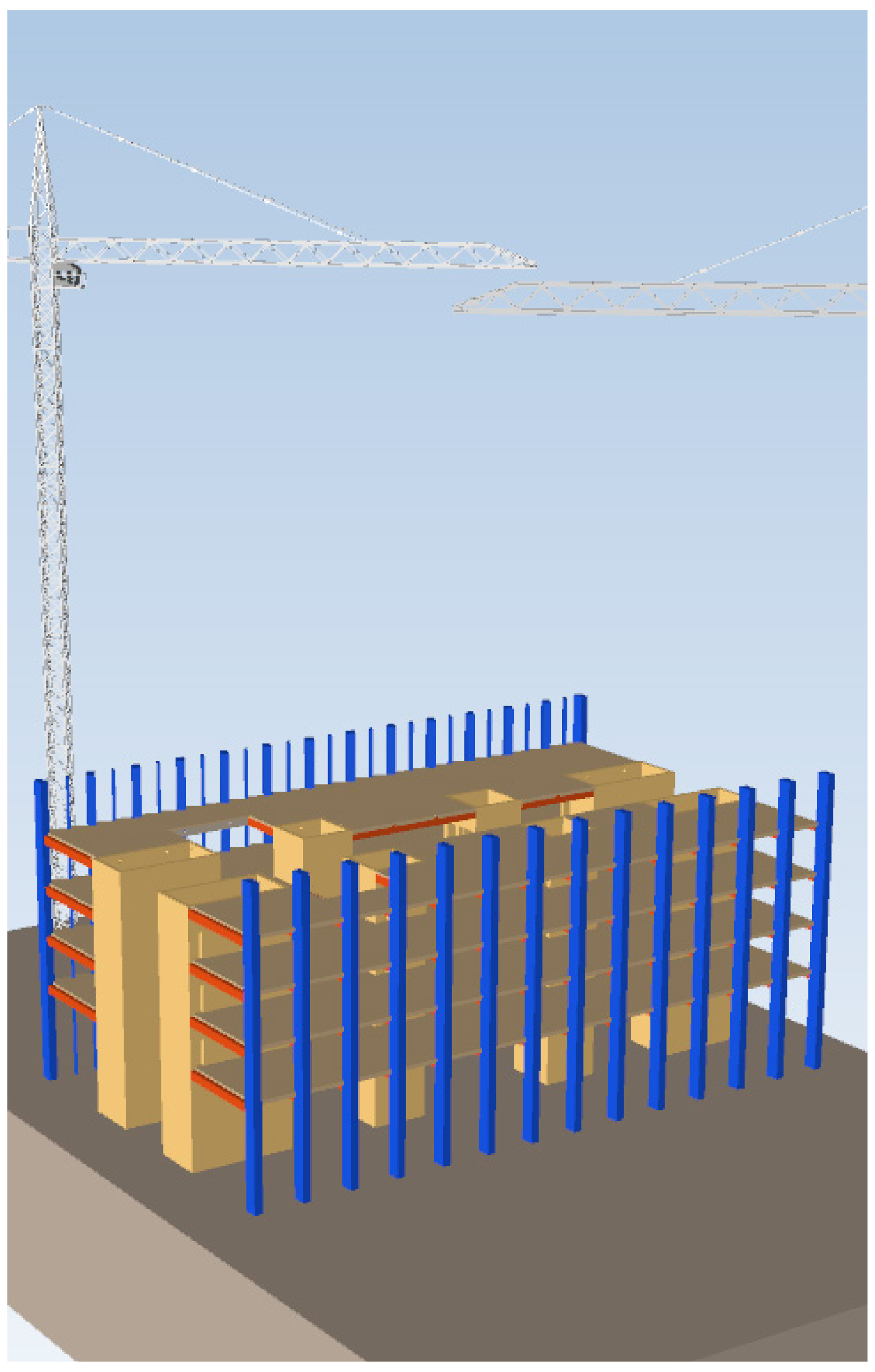
48	FL 09	FLOOR 09	7d, 7h, 42m
52	ST01400	CLT Cores	2d
49	ST01370	CLT Slabs	2d
51	ST01390	Glulam Beams	2d
50	ST01380	Glulam Columns	2d
53	FL 10	FLOOR 10	9d, 4h, 47m
57	ST01440	CLT Cores	2d
54	ST01410	CLT Slabs	2d
56	ST01430	Glulam Beams	2d
55	ST01420	Glulam Columns	2d
58	FL 11	FLOOR 11	8d
62	ST01480	CLT Cores	2d
59	ST01450	CLT Slabs	2d
61	ST01470	Glulam Beams	2d
60	ST01460	Glulam Columns	2d
63	FL 12	FLOOR 12	8d
67	ST01520	CLT Cores	2d
64	ST01490	CLT Slabs	2d
66	ST01510	Glulam Beams	2d
65	ST01500	Glulam Columns	2d
68	FL 13	FLOOR 13	7d, 3h, 30m
72	ST01560	CLT Cores	2d
69	ST01530	CLT Slabs	2d
71	ST01550	Glulam Beams	2d
70	ST01540	Glulam Columns	2d

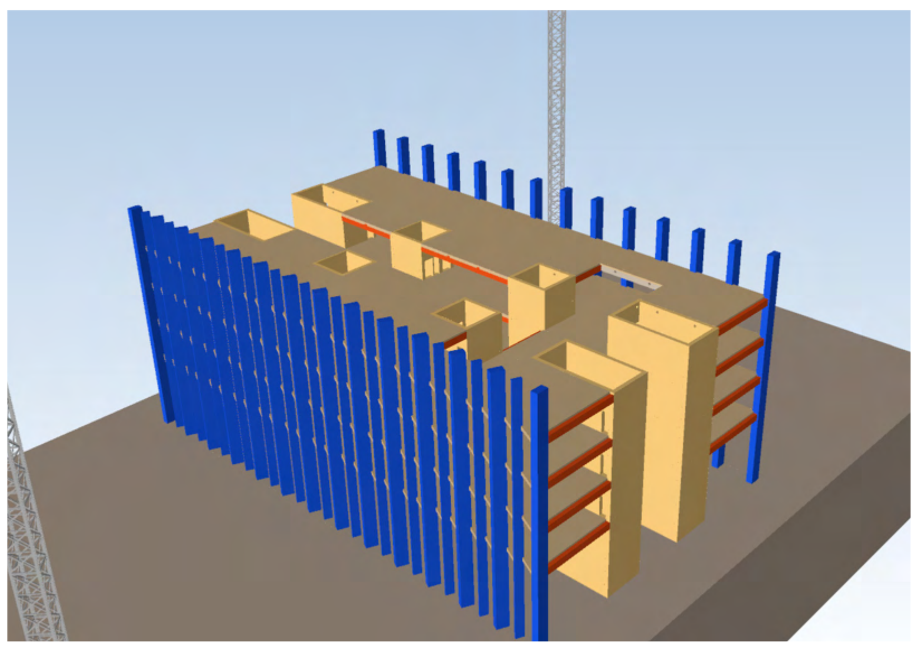

CLT CORES PLACEMENT

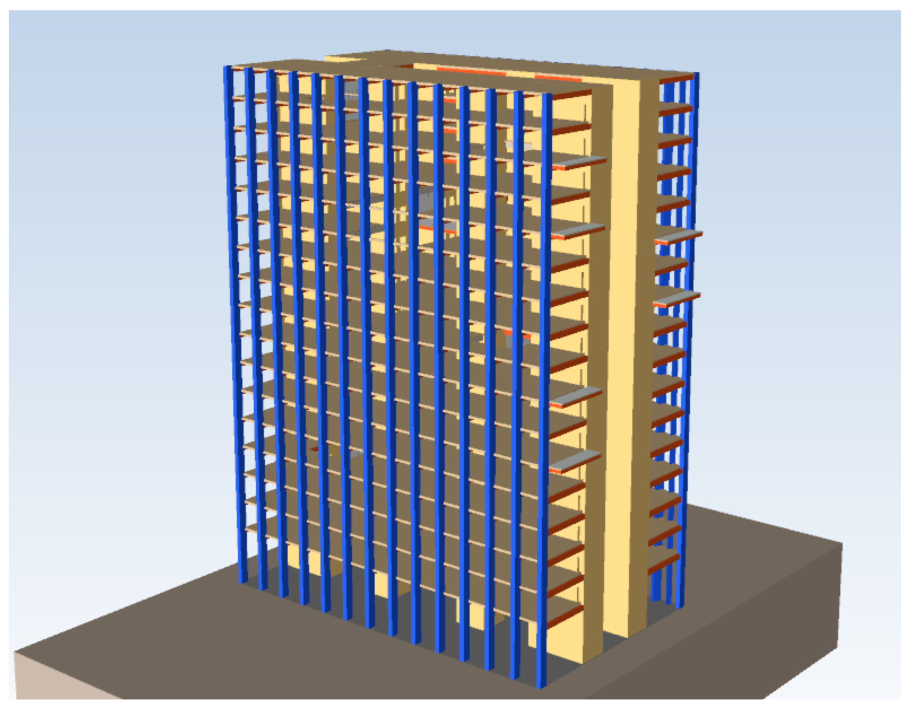

GLULAM COLUMNS

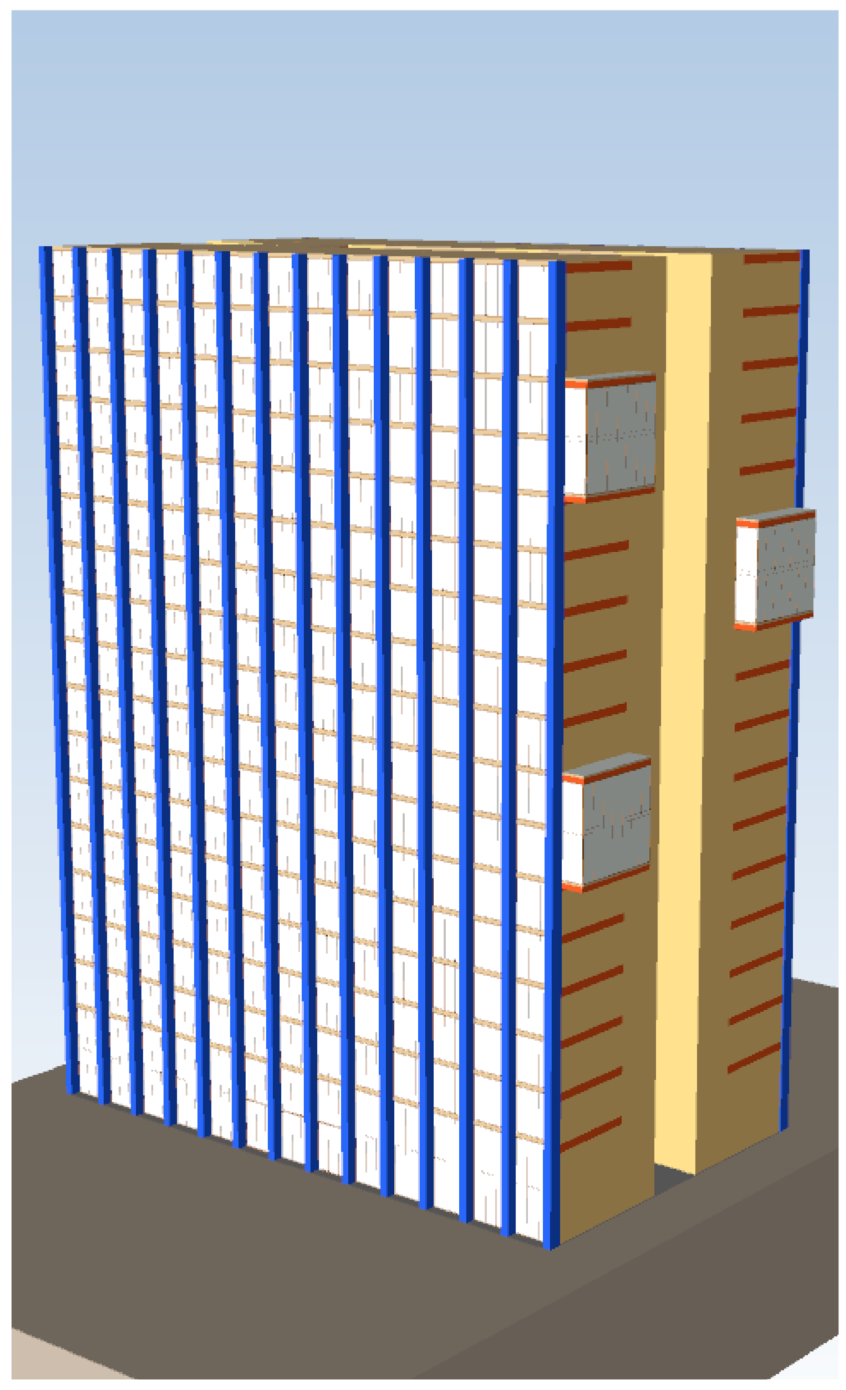

GLULAM BEAMS


CLT FLOOR PANELS



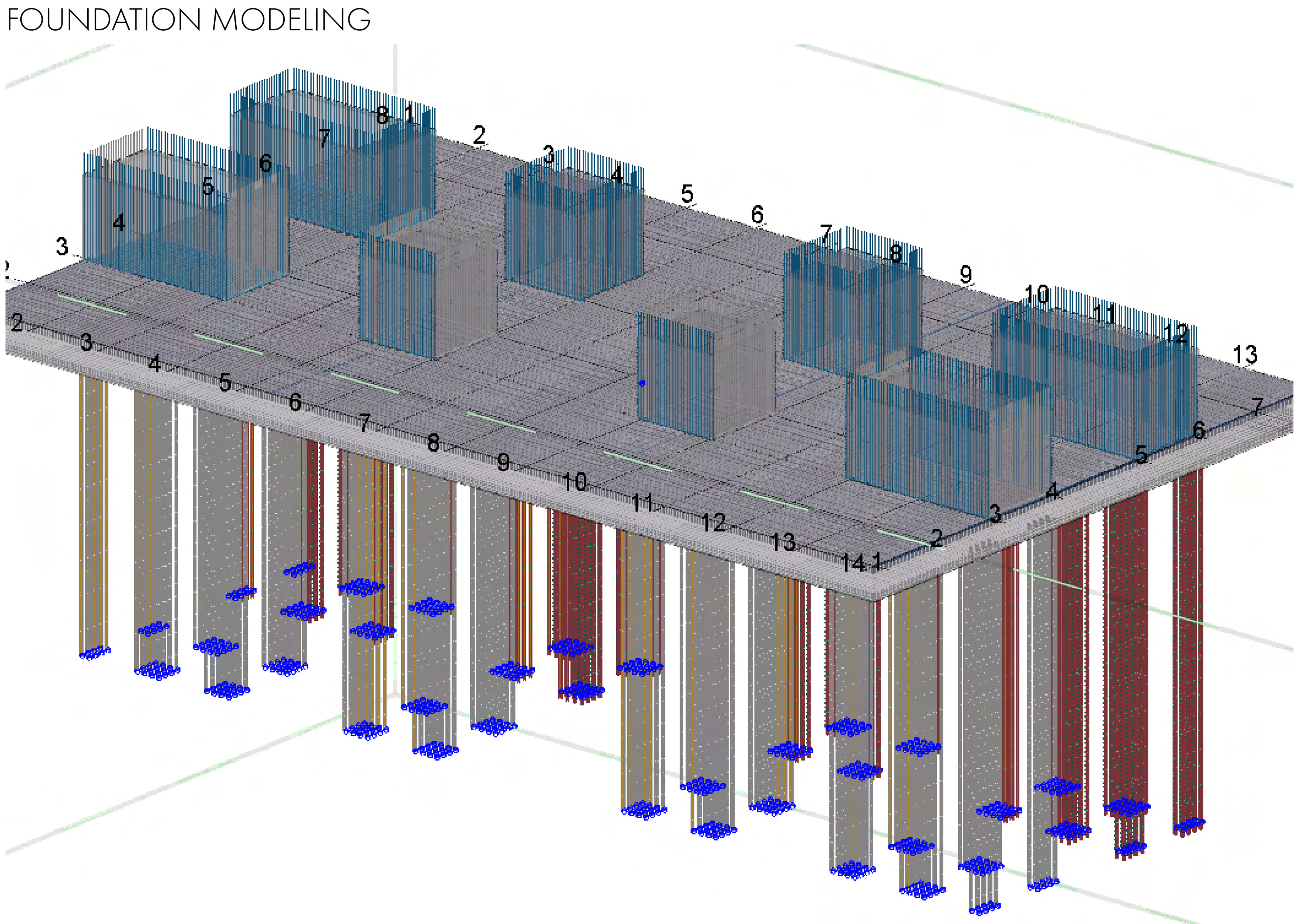


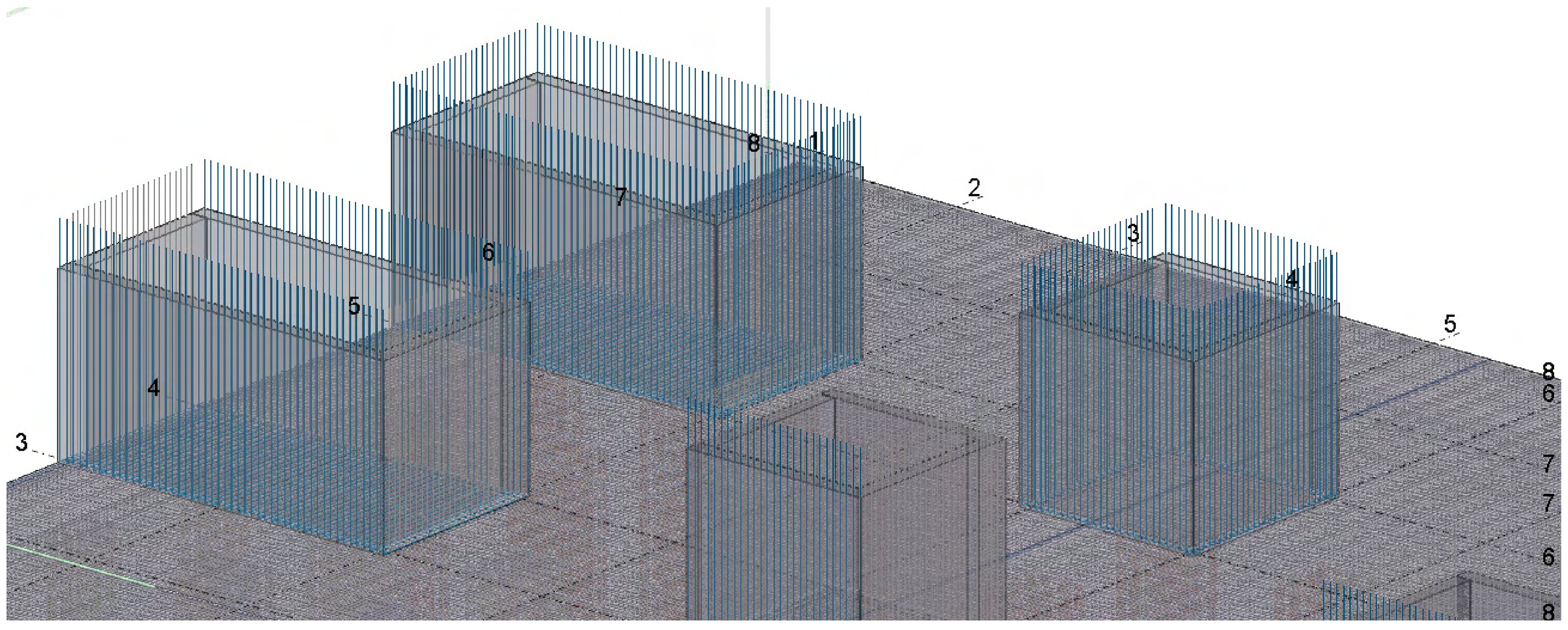



COMPLETED CONSTRUCTION WITH CURTAIN WALLS

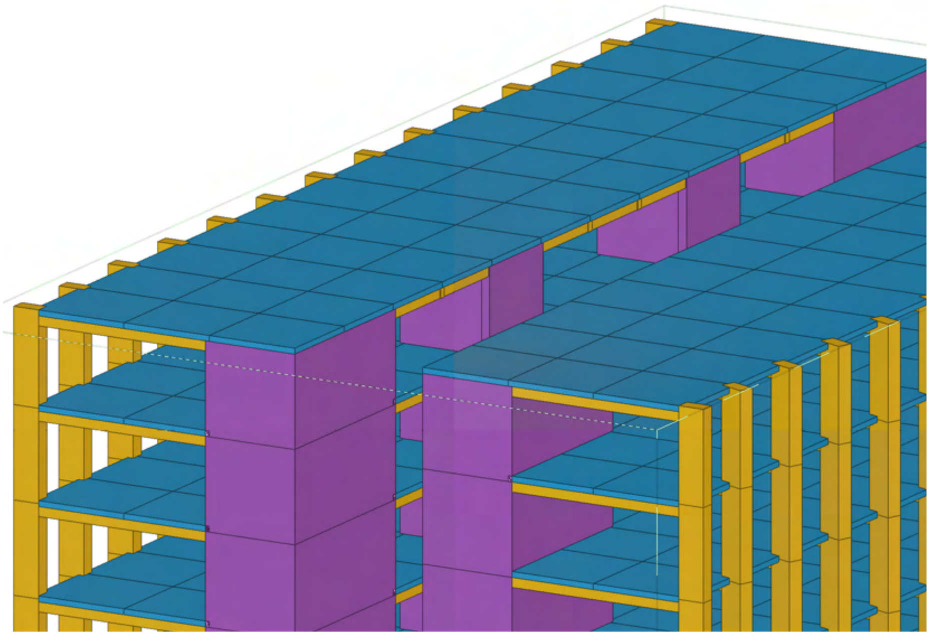
Tekla TEKLA STRUCTURE DETAILS

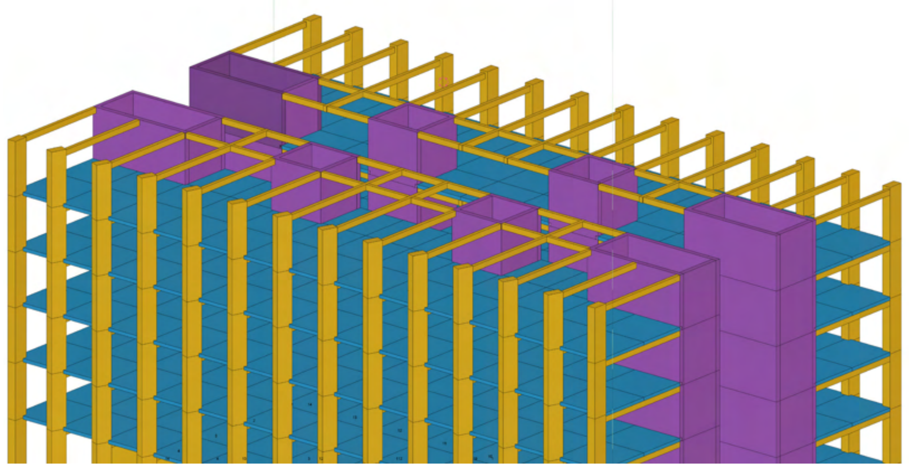
FOUNDATION MODELING

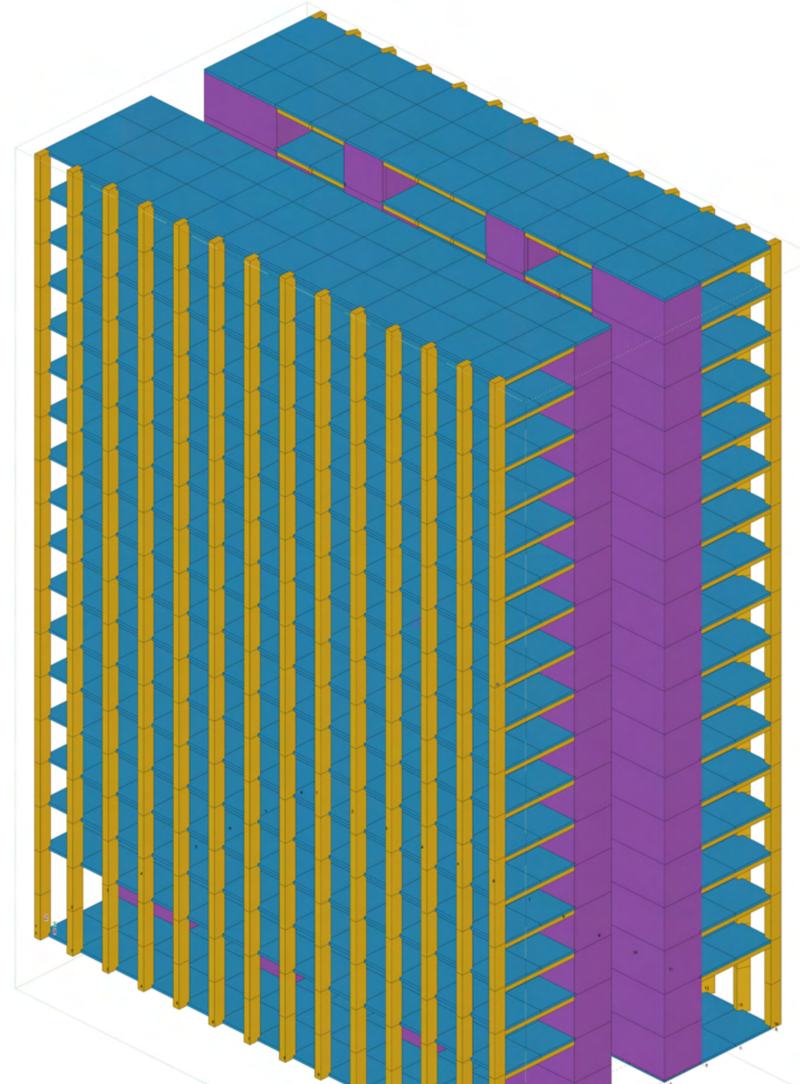




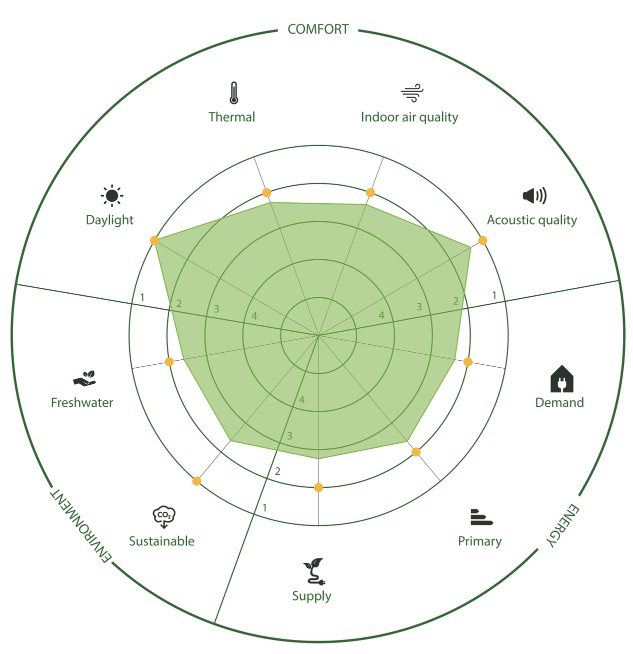
STRUCTURAL MODELING

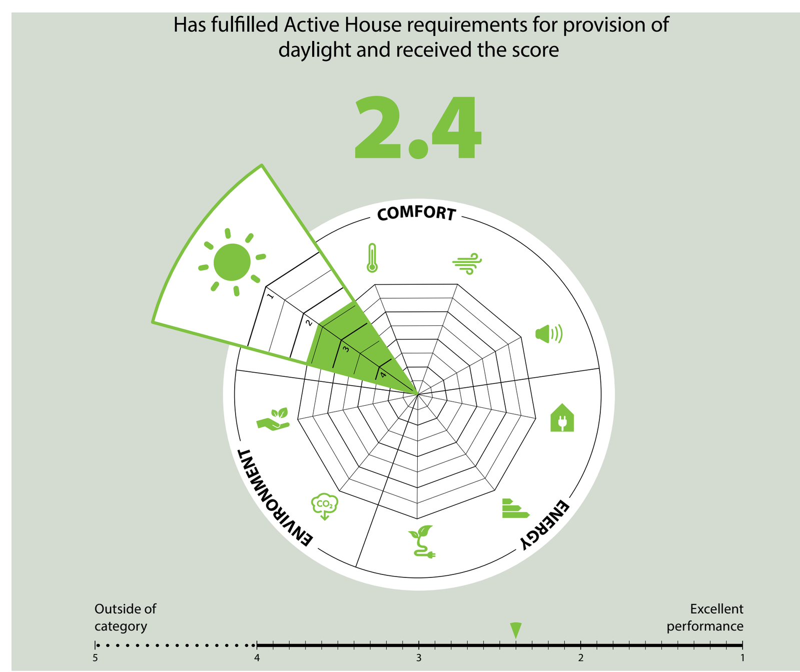




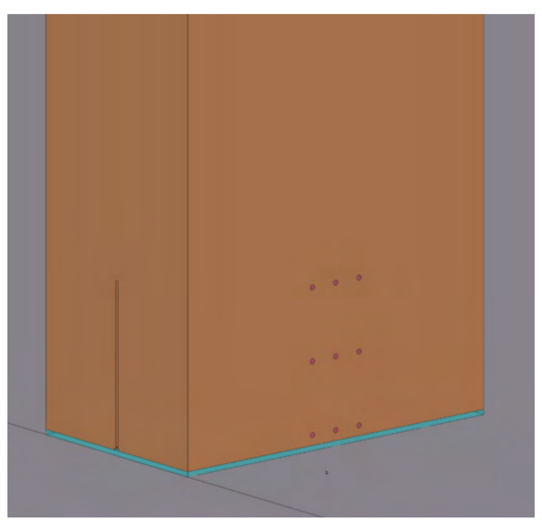


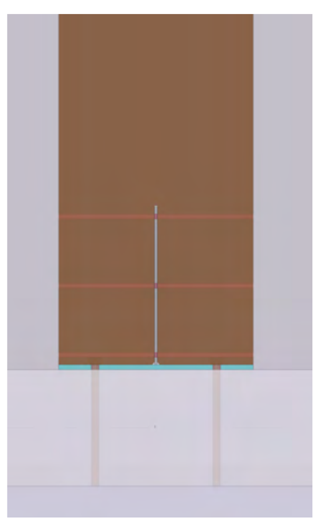
Tekla AKTIVE HOUSE

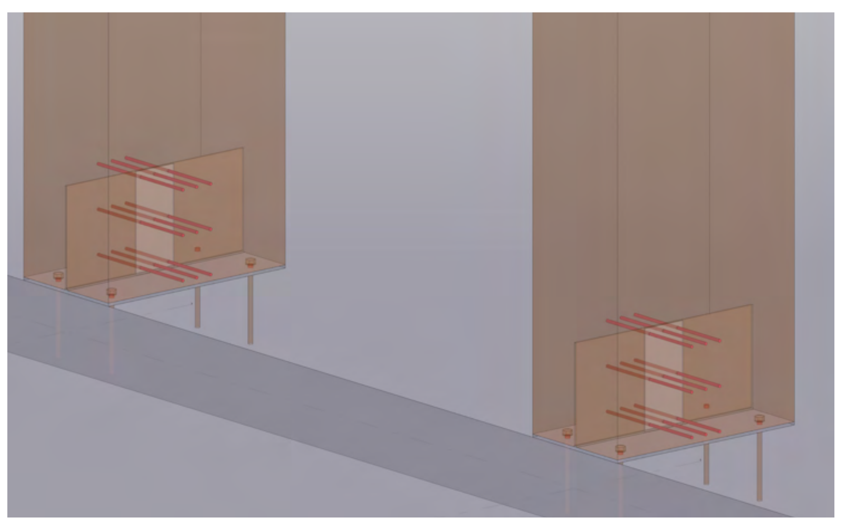




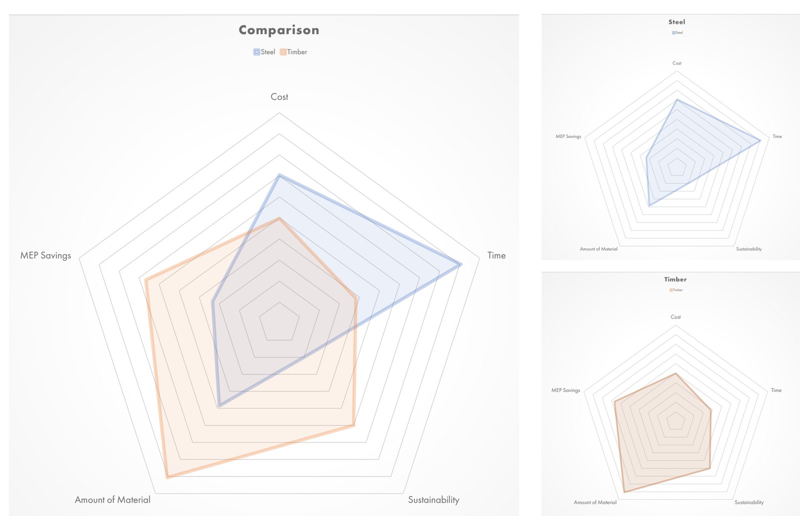
CONNECTION MODELING







COMFORT	VALUE	CATEGORY
1.1 Daylight	6.00%	1
1.2 Thermal Environment	Good Level	2.6
1.3 Indoor Air Quality	<700	2.7
1.4 Acoustic quality	4	1.6
ENERGY	**VALUE**	**CATEGORY**
2.1 Energy Demand	51.0 kWh/m^2	2.6
2.2 Energy Supply	54.2 kWh/m^2	2.8
2.3 Primary Energy	20.7 kWh/m^2	2.2
ENVIRONMENT	**VALUE**	**CATEGORY**
3.1 Freshwater	30% savings	2.6
3.2 Sustainable Construction	Better Level	2.7



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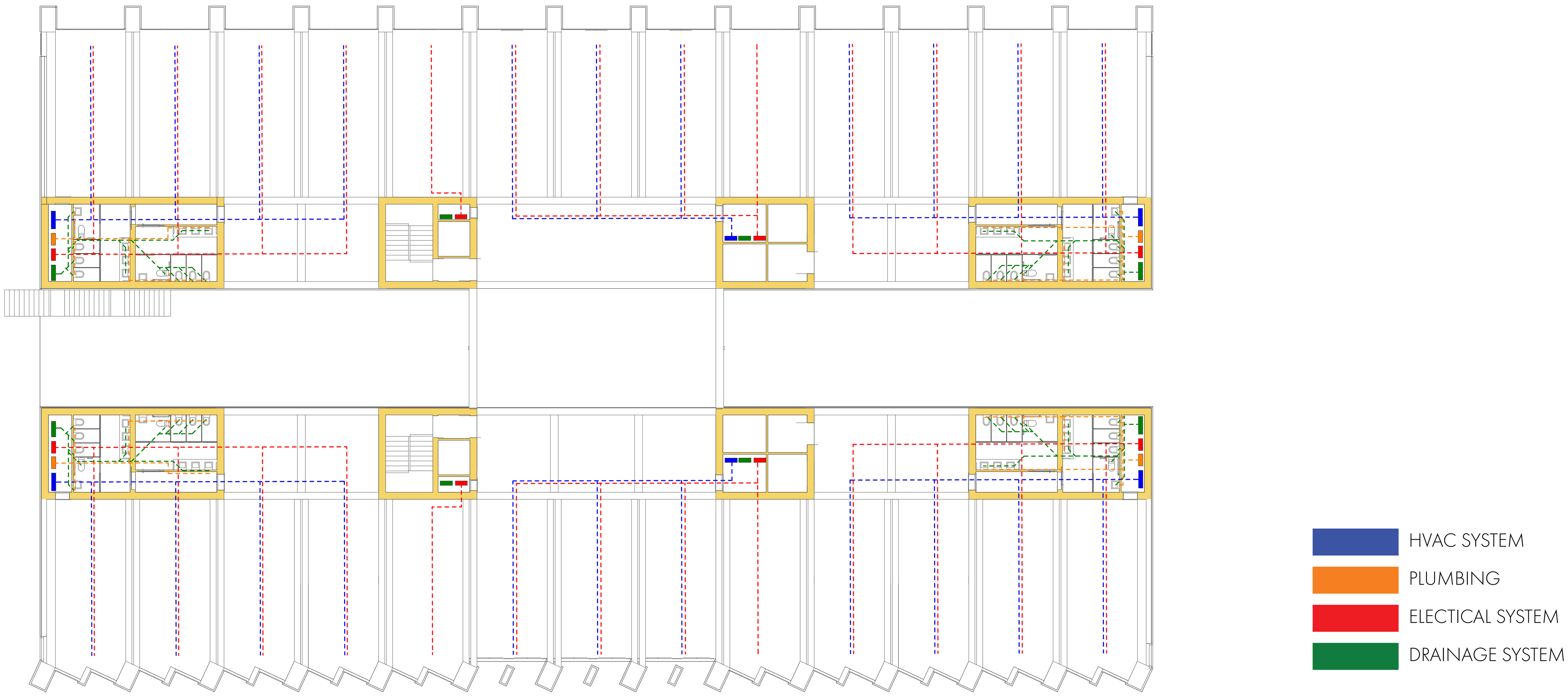
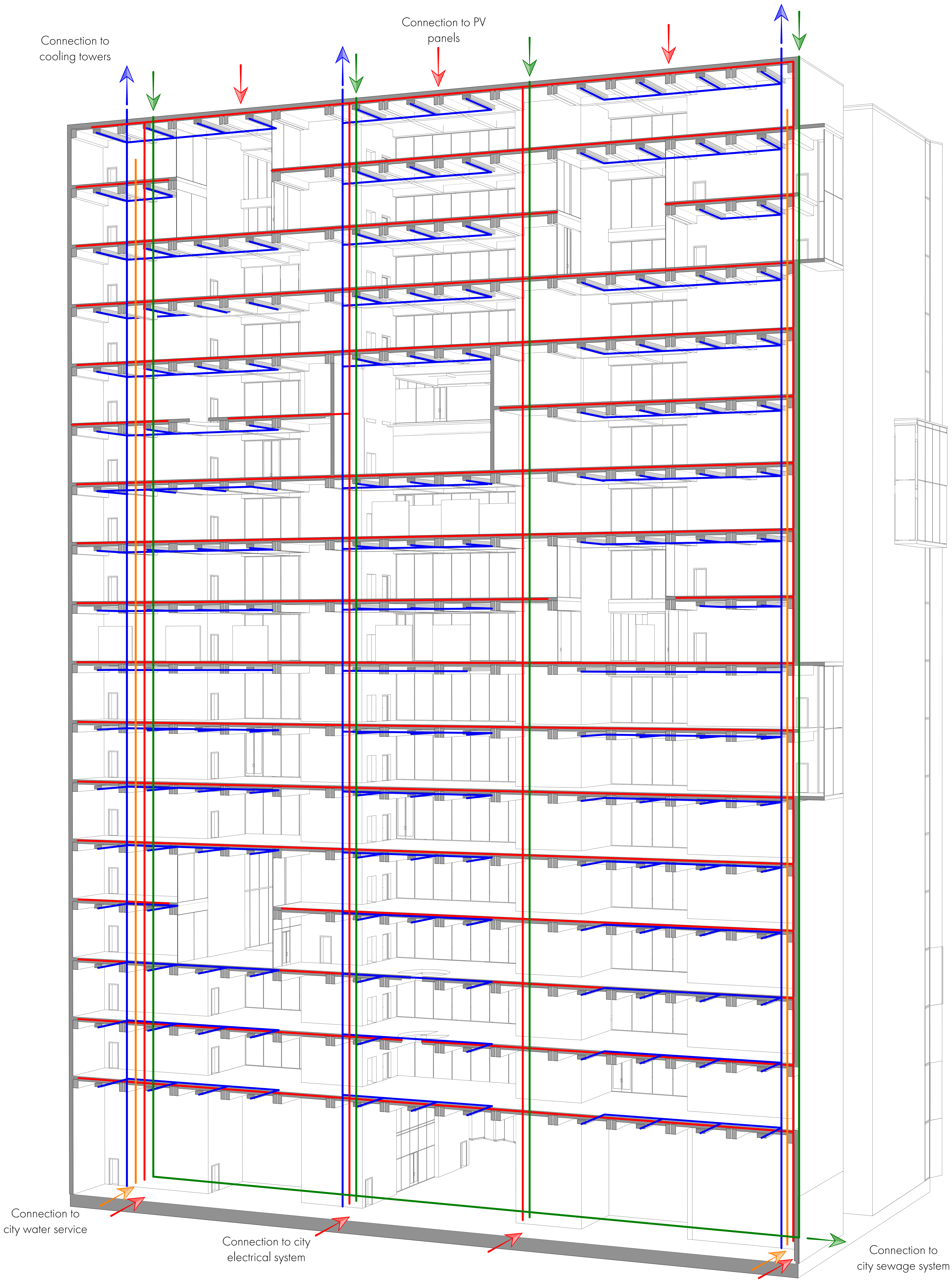
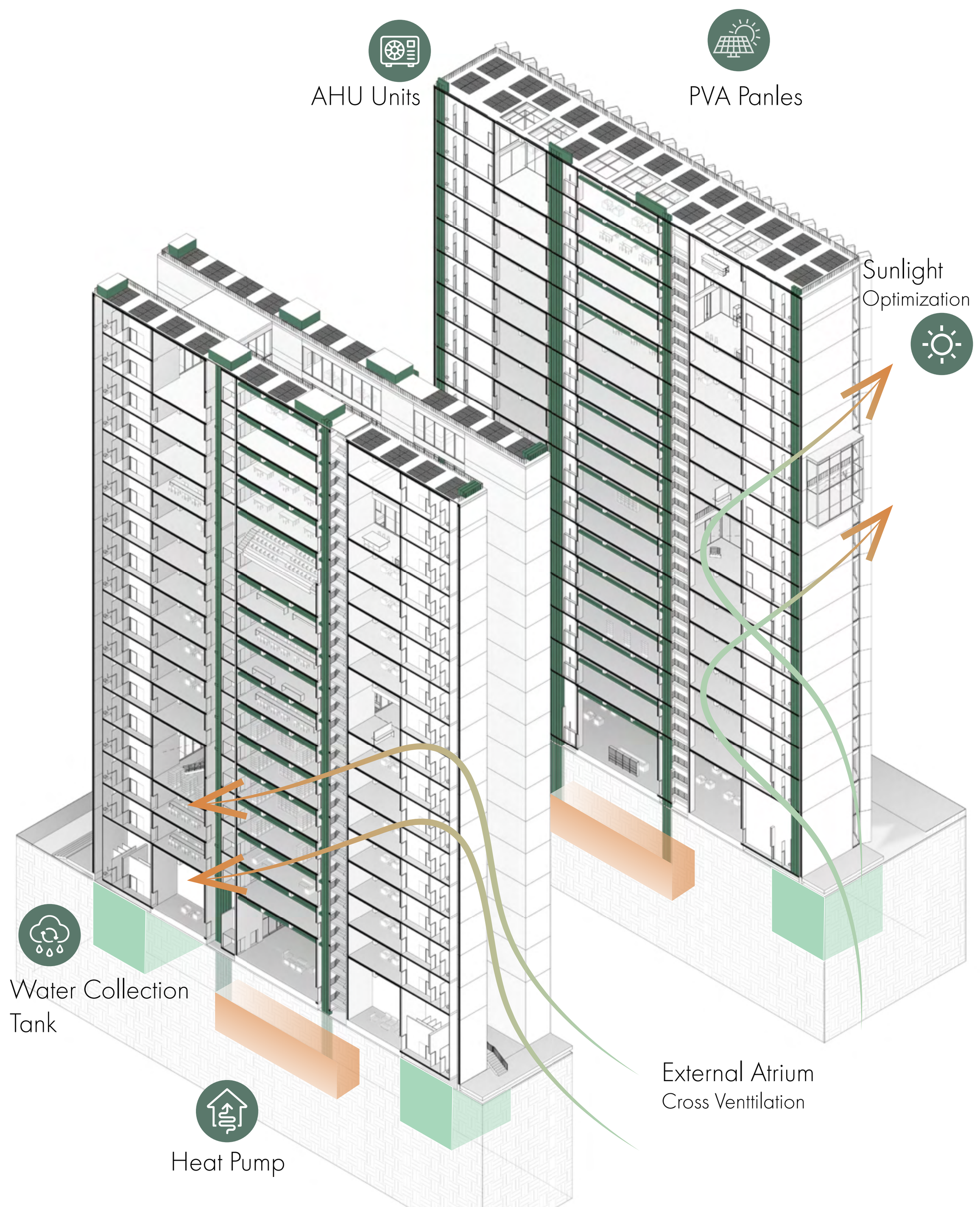
SERVICES DESIGN | MEP DISTRIBUTION

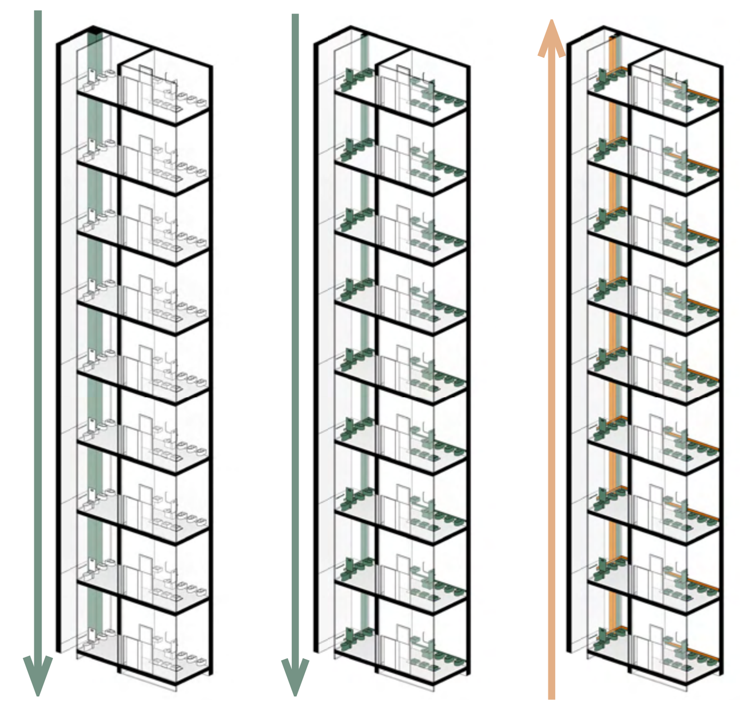




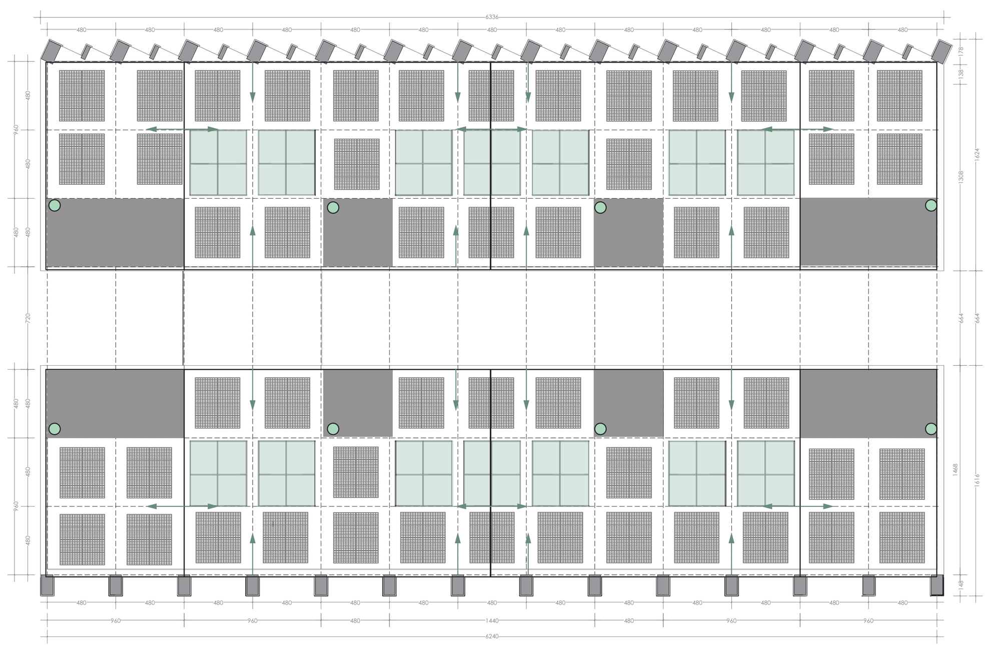
SERVICES DESIGN| MEP DISTRIBUTION



GENERAL SCHEME



DRAINAGE DIAGRAMS



DRAINAGE ROOF PLAN

	Estimating Daily users of tower		
	sqm	yearly users	daily users
Tena Tower	27,000	547500	1500
Sara Cultural Centre Skellefteå	30,000	857750	2350

Plumbing water consumption		
average daily users	1500	people
avg time spent / visit	3	hours
avg water use / person / hour	3.5	litres
avg daily water condumpsion	15,750.00	L/day

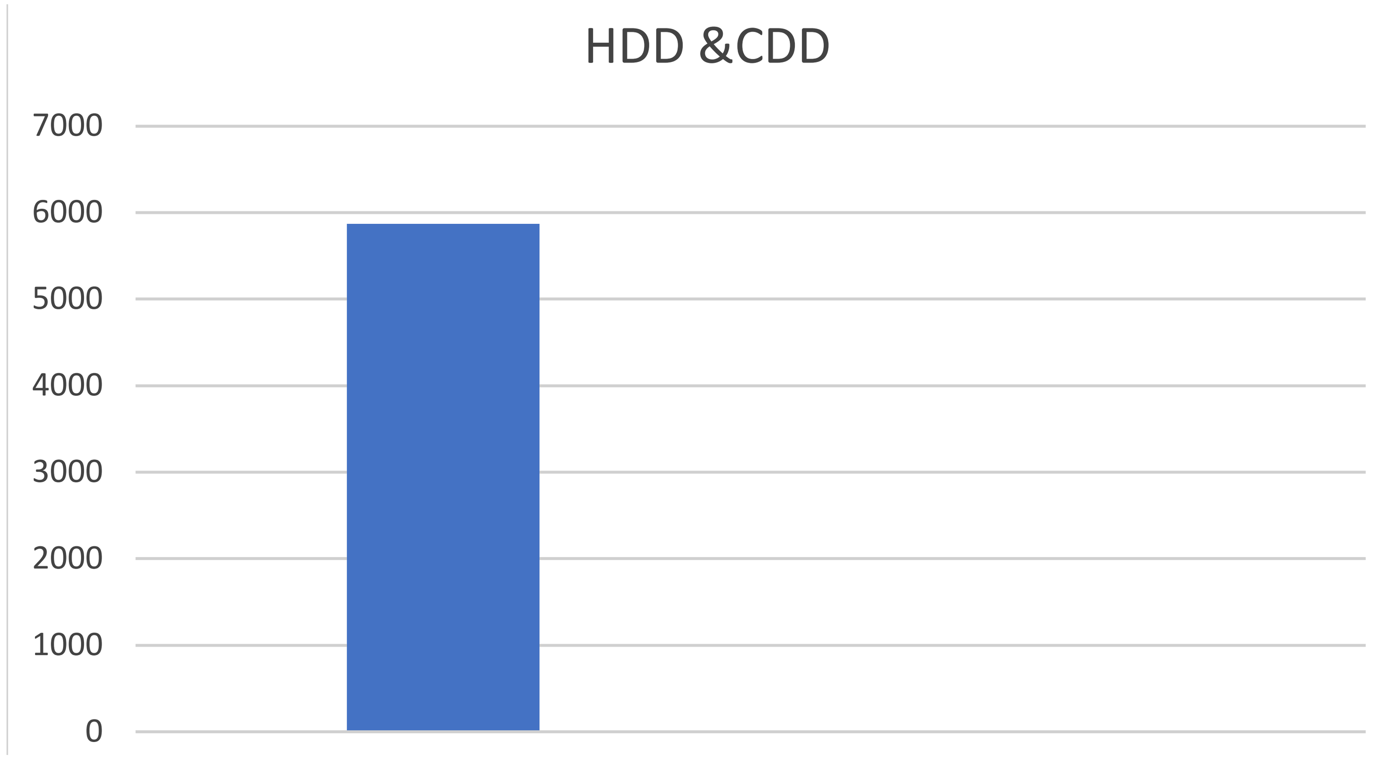
Cafe Water Consumption		
average consumption per sqm	21	litres/sqm
café LFA	1200	sqm
total café water consumption	25,200.00	L/day

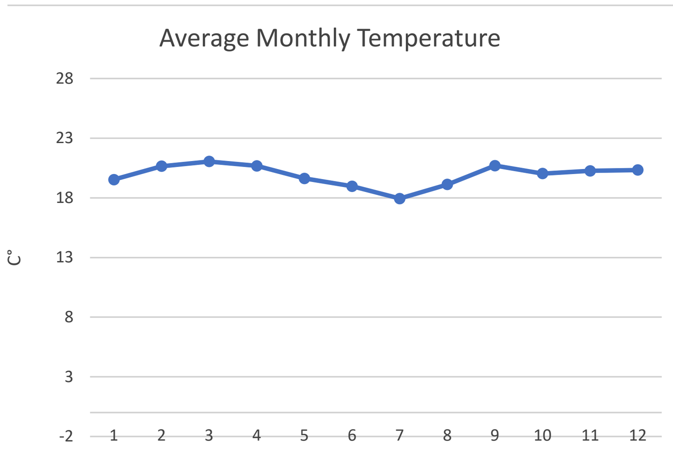
Water Collection		
For every sqm 1mm of rainfall = 1L of water		
Tena avg yearly precipitation	4,359.91	mm
Total roof surface area	1,600	sqm
Total water collected per year	6,975,856.00	L/year
Total water collected per day	19,111.93	L/day

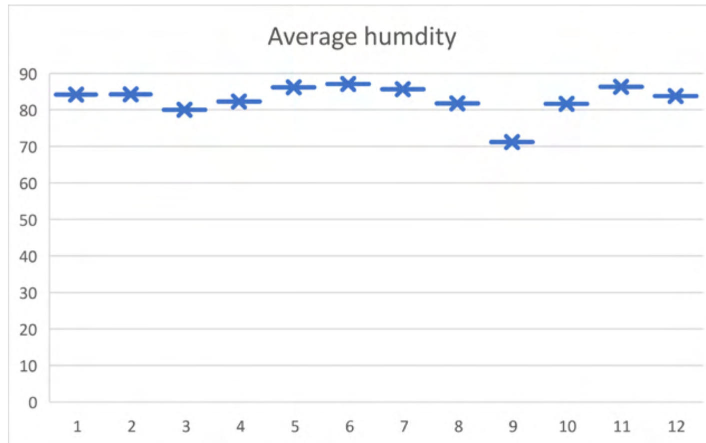
Total daily water consumption	40,950.00	L/day
Total daily water collection	19,111.93	L/day
Total Daily water deficit	21,838.07	Litres

WATER CONSUMPTION

In the context of the provided data for Tena, the calculation yields 5872 Heating Degree Days, representing the cumulative demand for heating, and 0 Cooling Degree Days, indicating no cooling requirements over the course of one year. These metrics are essential for understanding and estimating the energy needs for heating and cooling systems in a specific climate, aiding in efficient energy management and building design.







HDD AND CDD DIAGRAMS

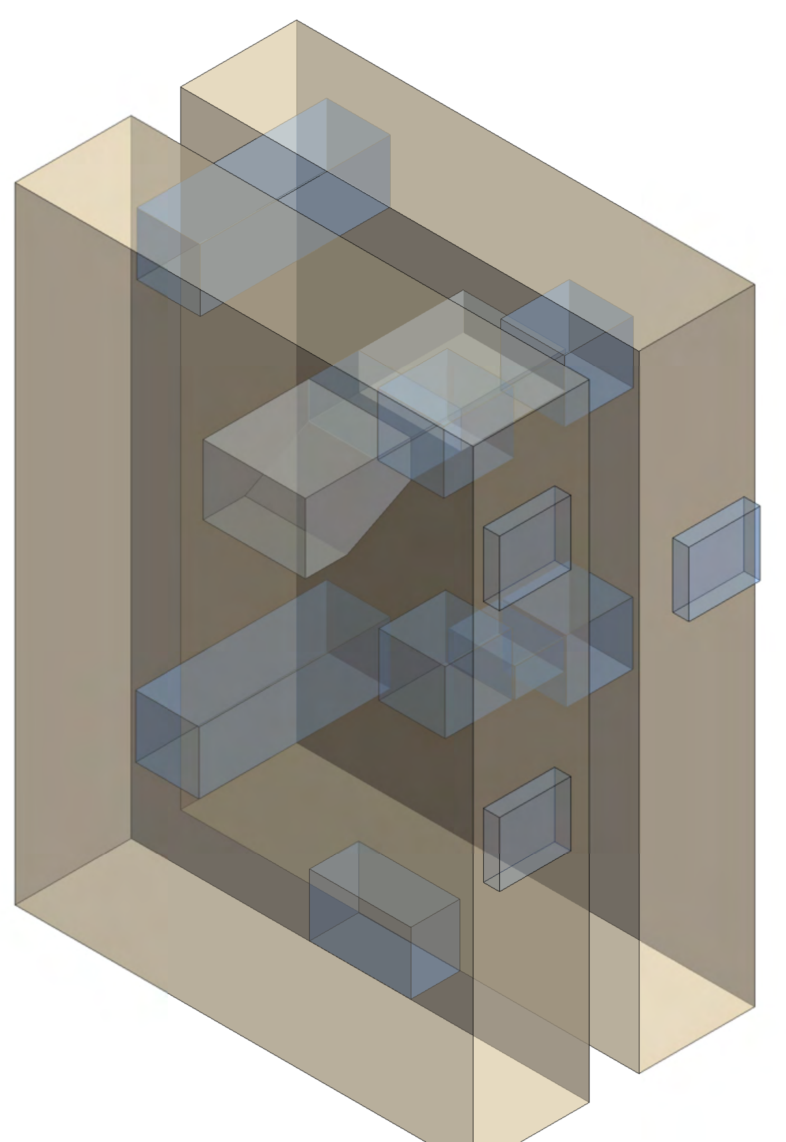
time(UTC)	T2m	RH	G(h)	Gb(n)	Gd(h)	IR(h)	WS10m	WD10m	SP
20060101:	19.33	85.08	0	0	0	359.95	0.84	320	95148
20060101:	19.01	85.65	0	0	0	357.68	0.86	269	95242
20060101:	18.69	86.21	0	0	0	355.42	0.88	289	95317
20060101:	18.36	86.78	0	0	0	353.15	0.9	288	95383
20060101:	18.04	87.35	0	0	0	350.89	0.92	288	95401
20060101:	17.72	87.91	0	0	0	348.62	0.94	302	95373
20060101:	17.4	88.48	0	0	0	346.36	0.96	297	95307
20060101:	17.07	89.05	0	0	0	344.09	0.98	293	95213
20060101:	16.87	83.8	0	0	0	330.8	1.17	290	95157
20060101:	17.02	80.85	0	0	0	328.2	1.17	296	95195
20060101:	16.9	79.9	0	0	0	331.2	1.24	296	95232
20060101:	17.16	79.7	0	0	0	362.8	1.1	292	95317
20060101:	17.3	80.2	14	0	14	338.8	1.03	292	95392
20060101:	18.6	87.85	32	0	32	352.4	0.34	278	95505
20060101:	20.25	83.25	146	6.51	142	346.2	0.83	129	95543
20060101:	21.48	81.25	616	262.72	413	336.6	1.24	132	95524
20060101:	22.29	80.5	672	201.45	495	345.4	1.86	128	95496
20060101:	23.23	81.7	981	900.38	148	348.8	1.72	116	95439
20060101:	22.19	80.6	960	894.29	147	353	1.66	123	95345
20060101:	22.04	83.45	863	867.06	142	361.4	0.97	101	95251
20060101:	22.5	81.8	701	815.44	132	380.8	1.17	103	95195

month	year	Average Temperature	Average Humidity	Average Wind Speed	Average Surface	Average Global Irradiance
1	2006	19.52864474	84.14751316	0.910881579	95410.68947	357.7424868
2	2015	20.65	84.21	1.01	95462.5	368.87
3	2006	21.045	80.05	0.9	95335.5	361.755
4	2010	20.685	82.275	0.91	95415.5	362.595
5	2007	19.63	86.185	0.72	95486.5	361.2
6	2006	18.97	87.085	0.51	95618	366.29
7	2007	17.945	85.65	1.115	95594.5	355.165
8	2012	19.125	81.745	0.755	95505	357.195
9	2014	20.7	71.19	1.245	95523.5	339.45
10	2005	20.035	81.635	1.12	95486.5	357.315
11	2009	20.26	86.295	0.895	94964	363.46
12	2014	20.33	83.795	0.81	95387	361.715

BASE W	RESULTS	POSITIVE RESULTS	BASE S		POSITIVE RESULTS	HDD SUM	HDD	CDD SUM	CDD
19	-0.33	0	27	-7.67	0	5872.41	244.68375	0	0
19	-0.01	0	27	-7.99	0				
19	0.31	0.31	27	-8.31	0				
19	0.64	0.64	27	-8.64	0				
19	0.96	0.96	27	-8.96	0				
19	1.28	1.28	27	-9.28	0				
19	1.6	1.6	27	-9.6	0				
19	1.93	1.93	27	-9.93	0				
19	2.13	2.13	27	-10.13	0				
19	1.98	1.98	27	-9.98	0				
19	2.1	2.1	27	-10.1	0				
19	1.84	1.84	27	-9.84	0				
19	1.7	1.7	27	-9.7	0				
19	0.4	0.4	27	-8.4	0				
19	-1.25	0	27	-6.75	0				
19	-2.48	0	27	-5.52	0				
19	-3.29	0	27	-4.71	0				
19	-4.23	0	27	-3.77	0				

HDD SUM	HDD	CDD SUM	CDD
5872.41	244.68375	0	0

HDD AND CDD CALCULATIONS



Glass facade

U-value = 1.10
Area = 3,510

Roof

U-value = 0.39
Area = 1,600

Glass facade

U-value = 1.10
Area = 4,492.8

Spandrel panels

U-value = 0.21
Area = 59 sqm

Glass facade

U-value = 1.10
Area = 3,812

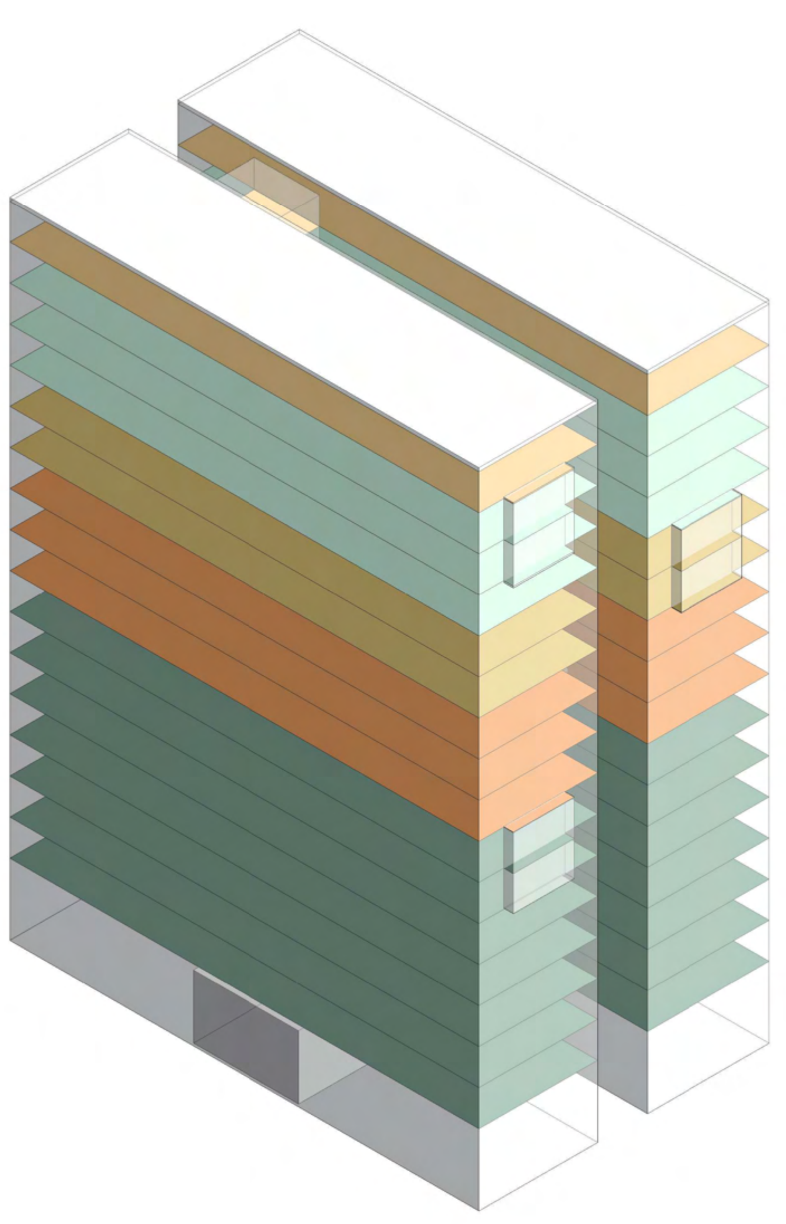
Opaque walls

U-value = 0.21
Area = 10,080 sqm

BUILDING ENVELOPE SUMMARY

	U-Value (W/(m²K)	sqm	ΔT	Heat Loss (W)	Heat Loss (kW)	HDD (hrs)	Annual Energy Loss (kWh)
Opaque Wall	0.18	10,080 sqm	16	29,030.4	29.03	5,872	170,404
Roof	0.39	1,600 sqm	16	9,984	9.9	5,872	58,132
Curtain Wall	1.10	11,815 sqm	16	12,996.5	13	5,872	76,336
Spandrel Panels	0.21	59 sqm	16	198.24	0.21	5,872	1,233
			16				306,105

ANNUAL ENERGY LOSS CALCULATION



Zone 1 (l.01 tol.07) - Library & Co-working - Opening 09:00/ Closing 21:00 / 12h

Zone 2 (l.08 to.l10) - Arts & Crafts - Opening 09:00/ Closing 17:00 /8h

Zone 3 (l.11 to l.12) - Conference - Opening 09:00/ Closing 15:00 / 6h / when needed

Zone 4 (l.13 to l.15) - Offices and Labs - Opening 08:30/ Closing 18:30 / 10h

Zone 5 (l.16) - Cafe - Opening 08:30/ Closing 16:30 / 8h

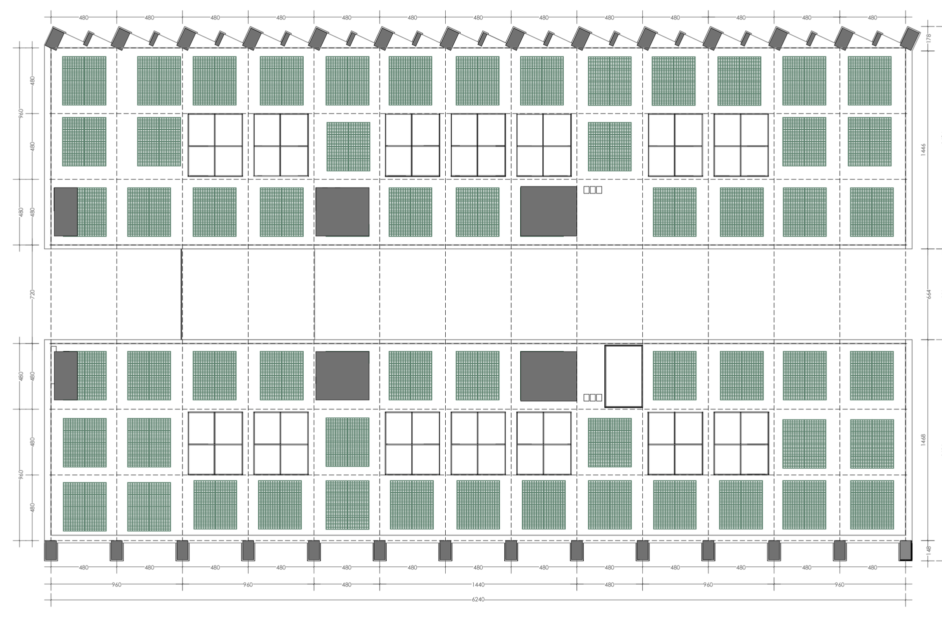
WORKING HOURS SCHEME

To determine the power generated by the solar panels, we multiply the output of a single panel by the total number of panels installed on the roof. Additionally, we factor in the average daily sunlight hours for the city of Tena. The resulting calculation yields a total annual output of 1,681,920 kilowatt-hours (kWh). This amount is a lot more than the combined energy demand for heating and lighting, which is estimated at 482,060 kWh + 306,105 kWh = 788,165per year. This indicates that the solar panel system is capable of meeting the energy requirements for both heating and lighting in the specified location, highlighting the efficiency and sustainability of the solar power solution.

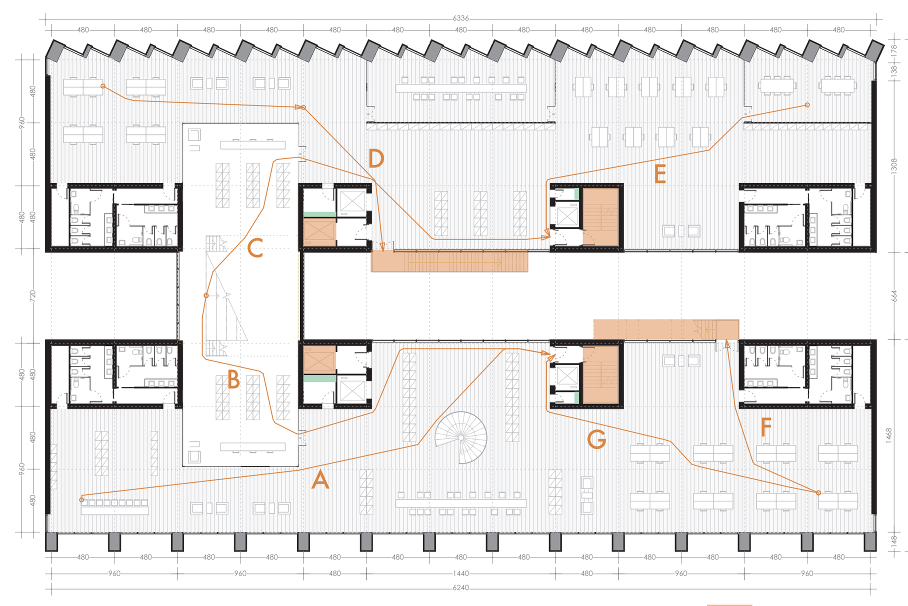
ENERGY CONSUMPTION DUE TO LIGHTING USING FLUORESCENT LAMPS		
Average Target Illuminance Level	100	lux
Zone 1: Period Of Illumination	12	h/day
Zone 1: Total Floor Area	10,780	sqm
Zone 2: Period Of Illumination	8	h/day
Zone 2: Total Floor Area	4.656	sqm
Zone 3: Period Of Illumination	6	h/day
Zone 3: Total Floor Area	4,943	sqm
Zone 4: Period Of Illumination	10	h/day
Zone 4: Total Floor Area	3116	sqm
Zone 5: Period Of Illumination	8	h/day
Zone 5: Total Floor Area	1588	sqm
W/M² Required To Reach 150 Lux	5.5	W/m2
Daily Energy Demand For Zone 5	69.87	kWh
Daily Energy Demand For Zone 4	171.38	kWh
Daily Energy Demand For Zone 3	163.12	kWh
Daily Energy Demand For Zone 2	204.86	kWh
Daily Energy Demand For Zone 1	711.48	kWh
Total Daily Lighting Demand	1320.72	kWh
Total Yearly Lighting Demand	**482,060.98**	kWh

ENERGY CONCUMPTION CALCULATION

SOLAR PANEL OUTPUT		
Solar Panel Size (90X150Cm)	1.35	sqm
Ideal Tilt For Panels In Tens	0	degrees
Effective Usable Roof Area	1152	sqm
Roof Area Used For 1 Panel	1.35	sqm
Number Of Panels On The Roof	**400**	
Output Of 1 Solar Panel (W)	450	w
Average Direct Sun Hours	6	hours/day
Daily Energy Output Per Panel	1.92	kWh/day
Total Daily Energy Output	**4,608.00**	kWh/day
Total Annual Energy Output	**1,681,920.00**	**kWh/year**



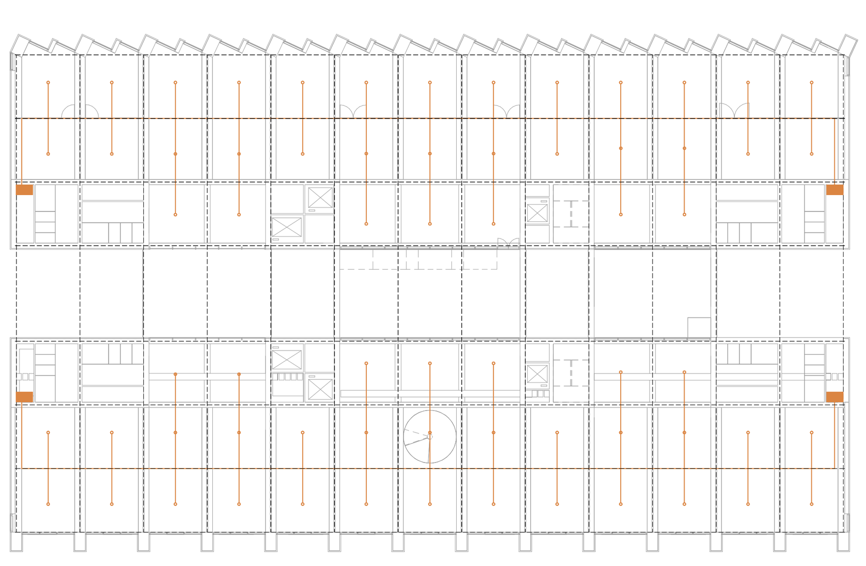
PV PANELS ROOF PLAN AND CALCULATION



FIRE EXTI SCHEME LEVEL 02

Fire escape routes
Smoke shafts

In timber buildings, fire protection is a crucial consideration to ensure the safety of occupants and minimize the risk of fire-related damage. In Ecuador, adherence to local fire codes is imperative to establish standards for fire safety. Fire protection measures in timber structures typically involve the use of fire-resistant materials, such as treated timber or fire-retardant coatings, to enhance the building's resistance to ignition and slow the spread of flames. Additionally, the design and implementation of exit fire routes are fundamental in ensuring swift and secure evacuation during emergencies.



REFLECTED CEILING PLAN LEVEL 02

Sprinkler shaft
Sprinklers

	Lenght	Time	Speed
Path A	35m	25.7s	4.828 km/h
Path B	37m	28.3s	4.828 km/h
Path C	25m	18.7s	4.828 km/h
Path D	38m	28.1s	4.828 km/h
Path E	26m	19.4 s	4.828 km/h
Path F	15m	11.5 s	4.828 km/h
Path G	26m	19.8 s	4.828 km/h

EXIT ROUTE CALCULATIONS

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