TECHNICAL REPORT

BOOK V.2

BASEL SCIENCE CAMPUS

BASEL INNOVATION CENTER

'INNOVATIVE HUB FOR CREATIVE MINDS'

POLITECNICO DI MILANO

MARY LYNN AL HADDAD

NANCY EL ASMAR

BASEL SCIENCE CAMPUS

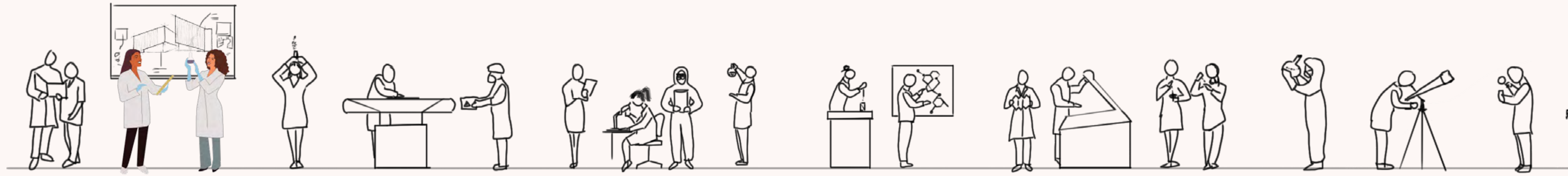
INNOVATIVE HUB FOR CREATIVE MINDS

Politecnico di Milano

School of Architecture Urban Planning Construction Engineering

Academic Year 2019/2020

Laurea Magistrale (equivalent to Master of Science) Thesis
Architecture Study Programme-**Building Architecture**



ABSTRACT

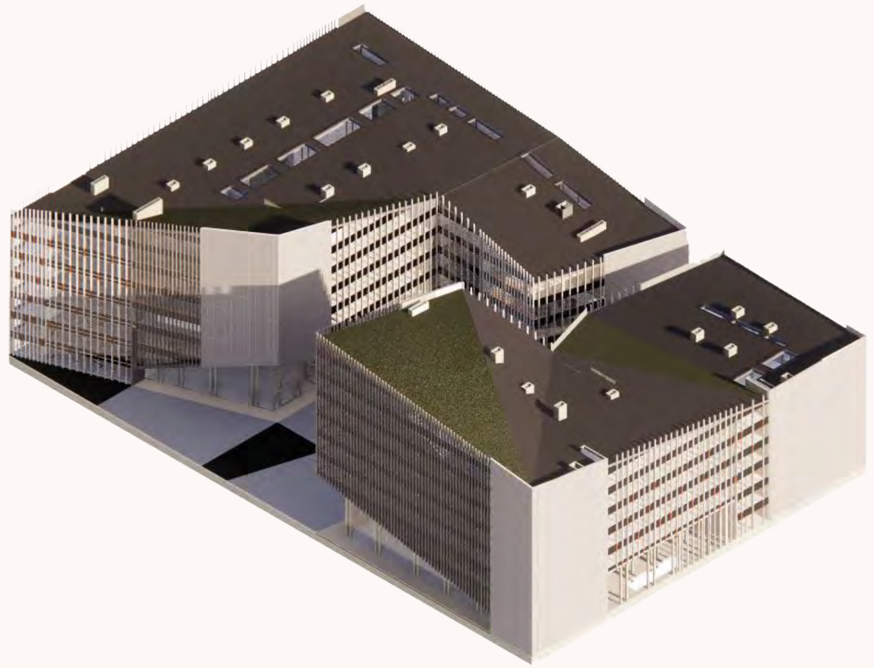
Basel has been a prominent city in the pharmaceutical and biochemistry industries since the 20th century, and the chronicles of the "Innovation Hub for Creative Minds" started when the decision was made to reinvent the 70-year-old Schällemätteli Campus, as per the request of the University of Basel, in order to become a prominent Life Science Campus. This is an innovative turning point for the Dreiland region, and Switzerland as a whole. This was not only a challenging task because the site, Plot n.4, was considered the heart of the campus accommodating the Chemistry, Physics, and Anatomy Departments, but also because it lies in between the actual campus and the residential district.

Therefore, the main aim was to design innovative laboratories with maximum efficiency, within a complex geometry reflecting the "Reimagined Urban Area" concept of an innovation center, and to restitch the urban fabrics of both the campus and the residential district by designing buildings that serve as a transition between the two scales.

'Basel Science Campus – Innovative Hub for Creative Minds' is based on a "3-belt" concept, which allows the new complex to act as a connector between different spaces, districts, and piazzas.

Conceived as a two-phase construction process, the architectural ensemble consists of two main buildings, connected underground, which provides two "urban layers". Both buildings allow for multi-use and interactive spaces, maximizing work performance as well as providing leisure and communication hubs. The building is accessible from every corner, and the porosity and ease of pedestrian accessibility facilitates circulation around the campus, and from one facility to the other.

Just as Plot n.4 is the heart of the Campus, a Forum extending from the second basement up to the roof is the heart of the complex; a contemporary "Lichthof" acting as a communication hub. The Forum substantiates the idea of a clear functional and spatial organization of the building, amidst its complexity. The Forum provides a powerful spatial experience by means of an architectural promenade throughout the building, in order to break the conventional perception of 'scientific laboratories' and reveal the "unexpected".



SOMMARIO

La città di Basel riveste un ruolo di importanza nell'industria farmaceutica e biochimica sin dal XX secolo e le cronache del "Innovative Hub for Creative Minds" sono iniziate quando è stata presa la decisione di reinventare il campus "Schällemätteli", vecchio ormai di 70 anni, per richiesta dell'Università di Basel, al fine di diventare un importante campus di "Life Science". Si tratta di una svolta innovativa per la regione del Dreiland e per la Svizzera nel suo complesso. Questo è stato un compito impegnativo non solo perché il sito Plot n.4 era considerato il cuore del campus, ospitante i dipartimenti di Chimica, Fisica e Anatomia, ma anche perché si trova tra il campus vero e proprio e il quartiere residenziale.

Pertanto l'obiettivo principale era quello di progettare con la massima efficienza laboratori innovativi, all'interno di una geometria complessa che riflettesse il concetto di "area urbana reimmaginata" di un centro di innovazione, e di ricucire i tessuti urbani sia del campus che del quartiere residenziale progettando edifici che fungessero da transizione tra le due scale.

Il **"Basel Science Campus - Innovative Hub for Creative Minds"** si basa sul concetto a 3 cinture ("3-belt"), che consente al nuovo complesso di funzionare da connettore tra diversi spazi, quartieri e piazze.

Concepito come un processo di costruzione in due fasi, l'insieme architettonico è costituito da due edifici principali, collegati sottoterra, che forniscono due "strati urbani". Entrambi gli edifici consentono spazi multiuso e interattivi, massimizzando l'efficienza lavorativa e fornendo centri di svago e comunicazione. L'edificio è accessibile da ogni angolo, la porosità e la facilità di accesso pedonale facilitano la circolazione all'interno del campus e tra le varie strutture.

Così come il Plot n.4 è il cuore del Campus, un Forum che si estende dal secondo seminterrato fino al tetto è il cuore del complesso; un "Lichthof" contemporaneo che funge da hub di comunicazione. Il Forum concretizza l'idea di una chiara organizzazione funzionale e spaziale dell'edificio, nella sua complessità. Il Forum offre una potente esperienza spaziale attraverso una passeggiata architettonica lungo tutto l'edificio, al fine di rompere la percezione convenzionale dei "laboratori scientifici" e *rivelare l'"inaspettato"*.

Born and raised in Lebanon, a country whose capital has been demolished and rebuilt over 7 times, I grew a passion for architecture and learned to see art in everything. The experiences I lived in my country made me realize that an architect can save lives; therefore, designing for the people and their needs became my top priority. I am always eager to learn more about different cultures and expand my knowledge on architecture and design every day. This led me to pursue my Master's Degree at Politecnico di Milano after earning my BArch from the Lebanese American University. On a social level, I dedicated my time for community services, scouting and volunteering which brought me an extensive experience in leadership, communication, adaptability, and perseverance.

My teammate Nancy and I formed a group (Grp 5) known as the 'power team' by some of our classmates and mentors. I am particularly grateful for my teammate without whom I would not have been able to complete this project. I would also like to thank my thesis advisor, Professor Francesca Battisti, and all the professors, and mentors, for their guidance, encouragement and useful critiques of this thesis project. To all my classmates, flat mates and friends, thank you for making my experience abroad exceptional and unforgettable and for always motivating me along the journey. Finally, the biggest thank you goes to my supportive parents and siblings that made all of this possible.

MARY LYNN AL HADDAD

I am a Lebanese, born and raised in Kuwait, and attended an international British school that shaped me into the culturally diverse individual that I am today. My architectural journey initiated when I became bewildered with the richness of my country's history and the fact that most areas in Lebanon are post-war zones, and countless ones rebuilt from scratch. This is when my passion to continue my higher studies in Architecture was born. My objective was to tackle the complexity of problems tied to design and construction. As a citizen of a "resilient country", I was driven to extend my knowledge in all aspects of architecture including the environment, technology and structure.

However, I would not have produced this thesis without the love, dedication, and support that my team mate, Mary Lynn Al Haddad, has showed me, not only throughout our past couple of years in Politecnico di Milano, but also throughout our BArch in the Lebanese American University. I would also like to thank the countless mentors, teachers and professors that pushed me to the limits and brought out the best in me throughout my academic career. Finally, and above all, I would like to thank my parents for their selfless support that bought me here today. "Mama" & "Baba", all that I am, or hope to be, I owe to you.

NANCY EL ASMAR

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Giovanni Dotelli | *Innovative Materials for Architecture*
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Matteo Pigni

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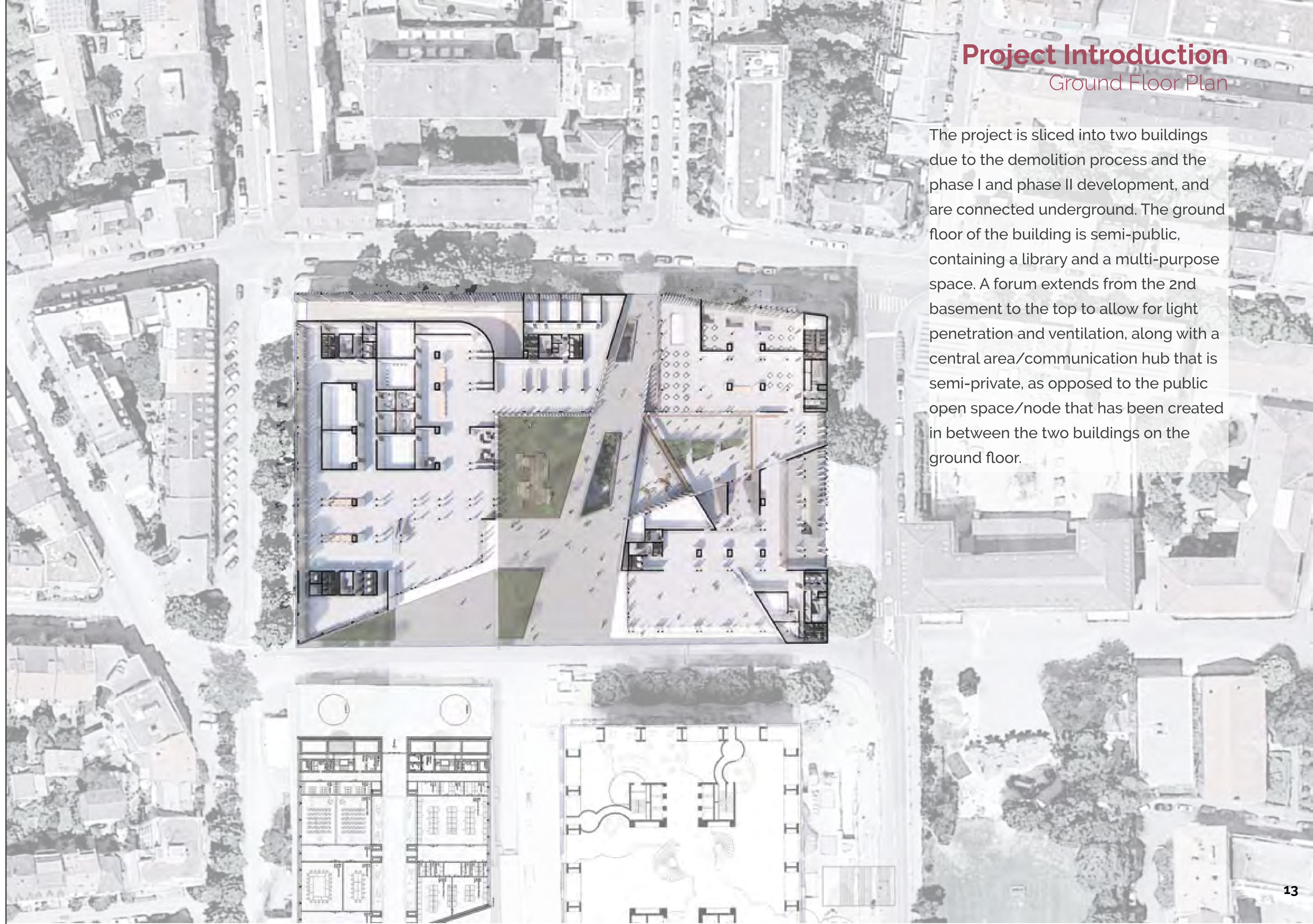
PROJECT INTRODUCTION

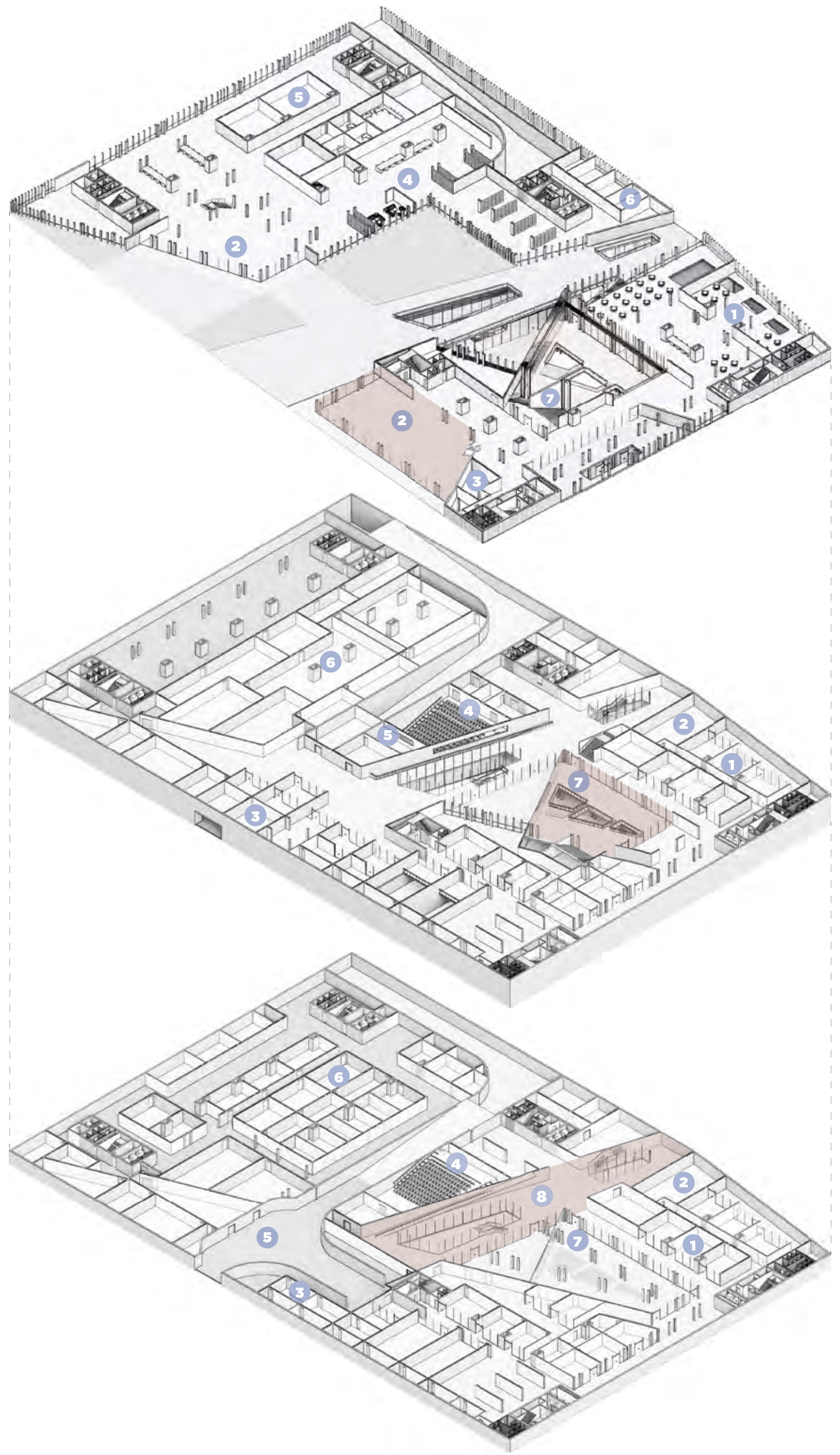
Project Introduction
Description

'Innovative Hub for Creative Minds' stitches the parts of the city that the campus divides. The form of the architectural building ensemble tackles the urban aspect of creating continuity and porosity throughout the campus, linking the residential districts to the campus through our central pathway. The project formes an 'architectural promenade' while simultaneously tackling the program requirements.
The main goal was to create the standard laboratories with maximum efficiency that are required, within a complex geometry that reflects the "Reimagined Urban Area" concept of an innovation center. The slopes of the roofs and entrances are derived from both the Biozentrum, and Biomedical center, along with the restrictions imposed on the site due to the height limits near the residential buildings.
One building is mainly Chemistry and the other is mainly Physics. Both buildings allow for multi-use and interactive spaces, maximizing work performance as well as providing leisure and communication hubs.

Project Introduction
Ground Floor Plan

The project is sliced into two buildings due to the demolition process and the phase I and phase II development, and are connected underground. The ground floor of the building is semi-public, containing a library and a multi-purpose space. A forum extends from the 2nd basement to the top to allow for light penetration and ventilation, along with a central area/communication hub that is semi-private, as opposed to the public open space/node that has been created in between the two buildings on the ground floor.





GF

1- Cantine
2- Entrance atriums
3- Storage room
4- Library
5- Meeting rooms
6- Forum seating steps

B1

1- Standard Labs
2- Dark room
3- Storage room
4- Theatre
5- Monitoring room
6- Animal Station
7- Forum

B2

1- Standard Labs
2- Dark room
3- Storage room
4- Theatre
5- Service truck access
6- Technical rooms
7- Forum
8- Double Connector

BUILDING PROGRAM

5TH

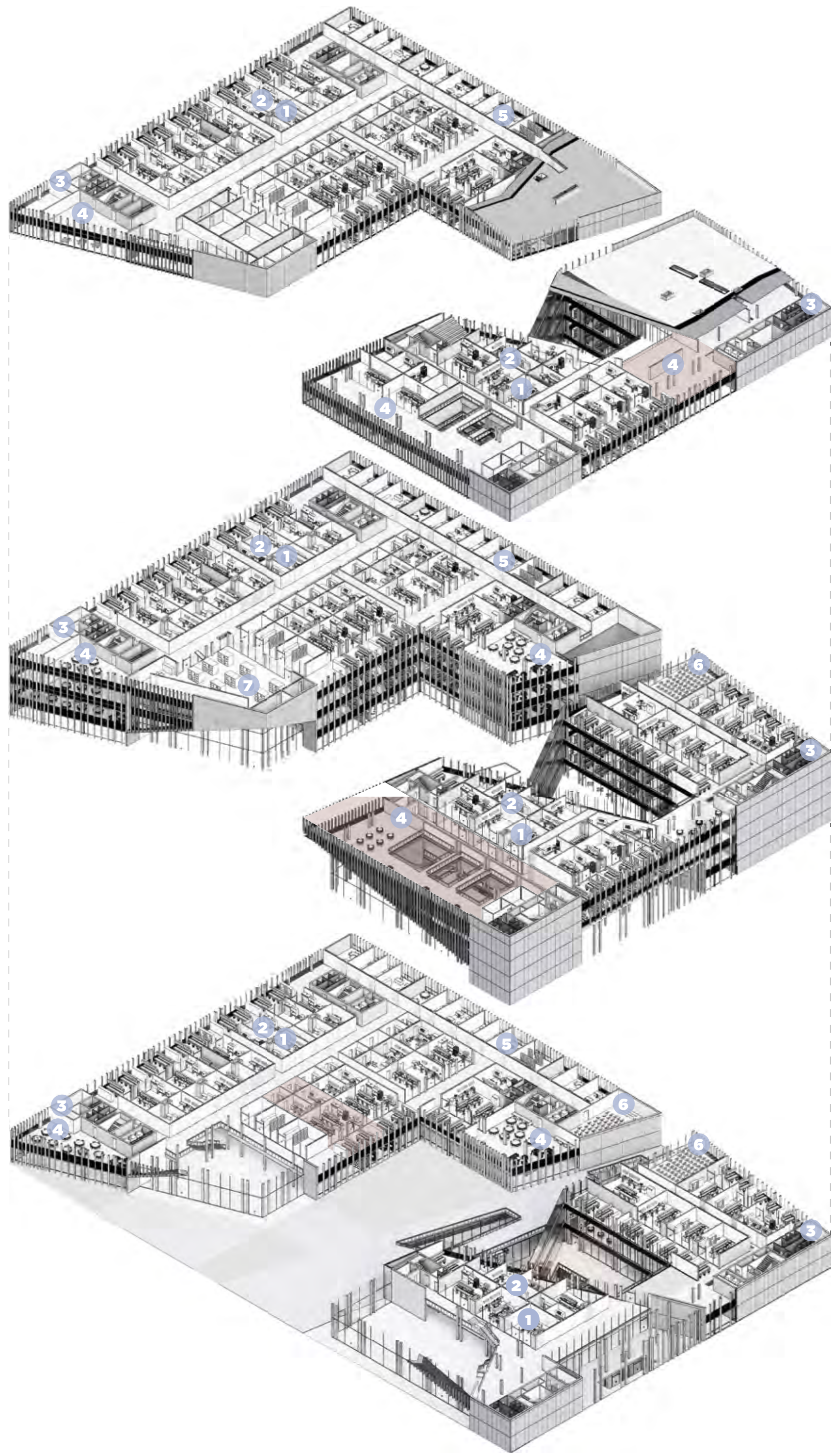
1- Standard Labs
2- Dark room
3- Storage room
4- Common Space
5- Offices

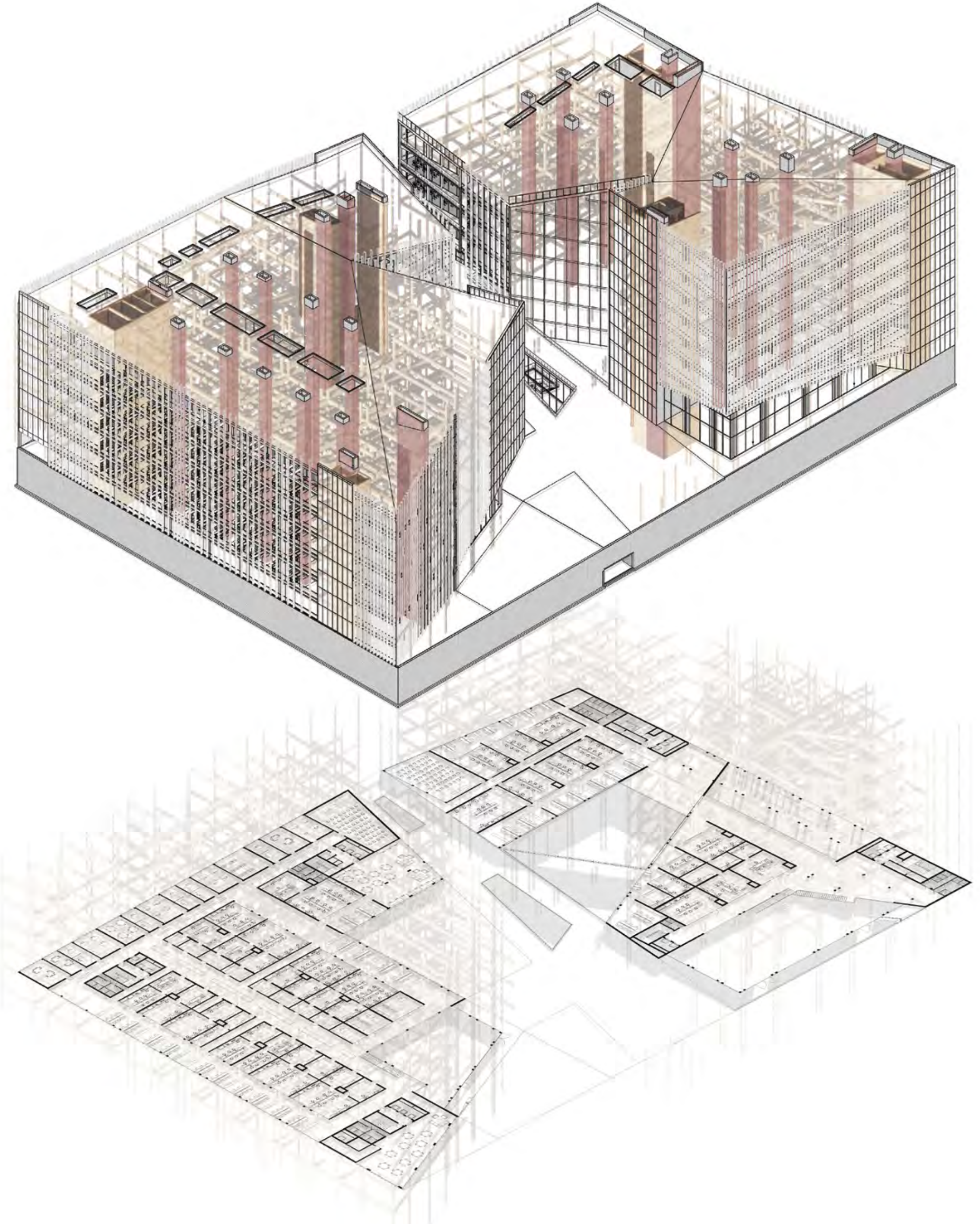
3RD

1- Standard Labs
2- Dark room
3- Storage room
4- Common Space
5- Offices
6- Lecture halls
7- Research and development

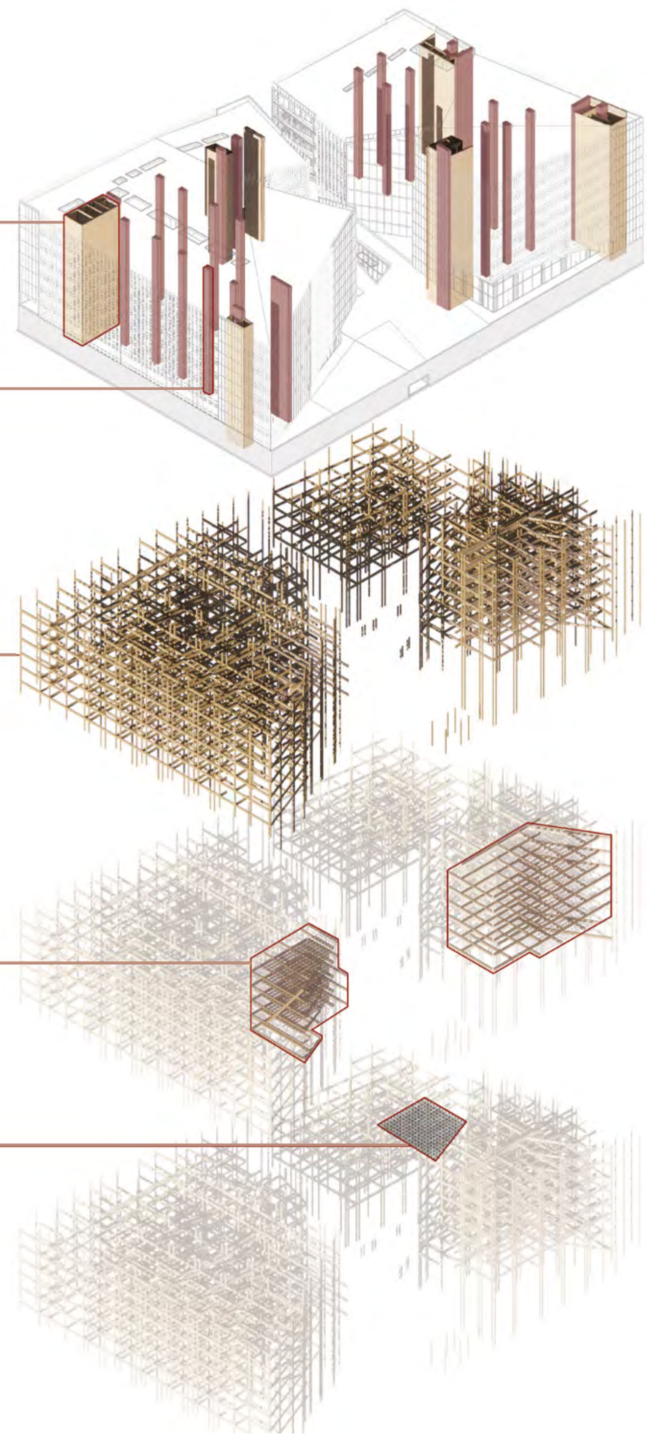
1ST

1- Standard Labs
2- Dark room
3- Storage room
4- Common Space
5- Offices
6- Lecture halls





STRUCTURAL DESIGN



STRUCTURAL COMPOSITION

Cores and Shafts: functioning as structural walls, cores serving as bracing elements for wind and earthquake loads, and for circulation.

Reinforced Concerete Columns and Beams: the use of a coupled columns system is adapted for both structural and aesthetical reasons. On one hand the coupled columns follow the grid of the structural shafts. On the other hand, they are used in the facades, and areas emphasizing the hierarchy of the spaces such as the entrances and the forum.

Composite Slabs: using steel decking and truss beams were adapted for the design of the slabs at the atriums. In this case, the floor slab comprises shallow steel decking and a concrete topping, which act together compositely. Mesh reinforcement is placed in the slab to enhance the fire resistance of the slab, to distribute localized loads, to act as transverse reinforcement around the shear connectors and to reduce cracking in the slab.

Space Frame Slab: or Space Structure is a type of two way truss system constructed from lightweight inlerlocking struts following a geometric pattern. Space Frames can be use to span large areas with few interior supports. The structures strength is due to the rigidity of the triangle and flexing loads that are transmitted as tension and compression loads along the length of each rod.

CODE ADOPTED

The eurocode series of **European standards** (EN) related to construction is the basis of structural design (informally Eurocode 0; abbreviated EN 1990). It establishes the basis that sets out the way to use Eurocodes for structural design. Eurocode 0 establishes Principles and requirements for the safety, serviceability and durability of structures, describes the basis for their design and verification and gives guidelines for related aspects of structural reliability. Eurocode 0 is intended to be used in conjunction with EN 1991 to EN 1999 for the structural design of buildings and civil engineering works, including geotechnical aspects, structural fire design, situations involving earthquakes, execution and temporary structures.

STRUCTURAL PLAN
Application and Components

When the ratio (L/S) is less than 2.0, slab is called two-way slab, as shown in the fig. below. Bending will take place in the two directions in a dish-like form. Accordingly, main reinforcement is required in the two directions.

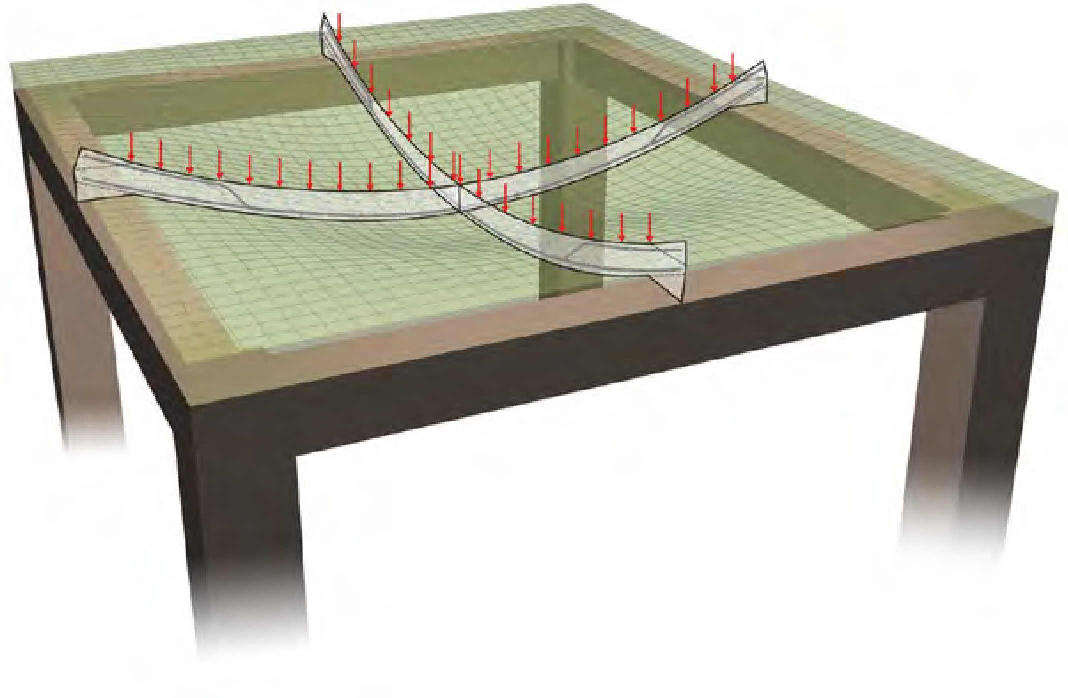


TABLE 9.5(a) — MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE CALCULATED

	Minimum thickness, *h*			
	Simply supported	One end continuous	Both ends continuous	Cantilever
Member	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections			
Solid one-way slabs	ℓ/20	ℓ/24	ℓ/28	ℓ/10
Beams or ribbed one-way slabs	ℓ/16	ℓ/18.5	ℓ/21	ℓ/8

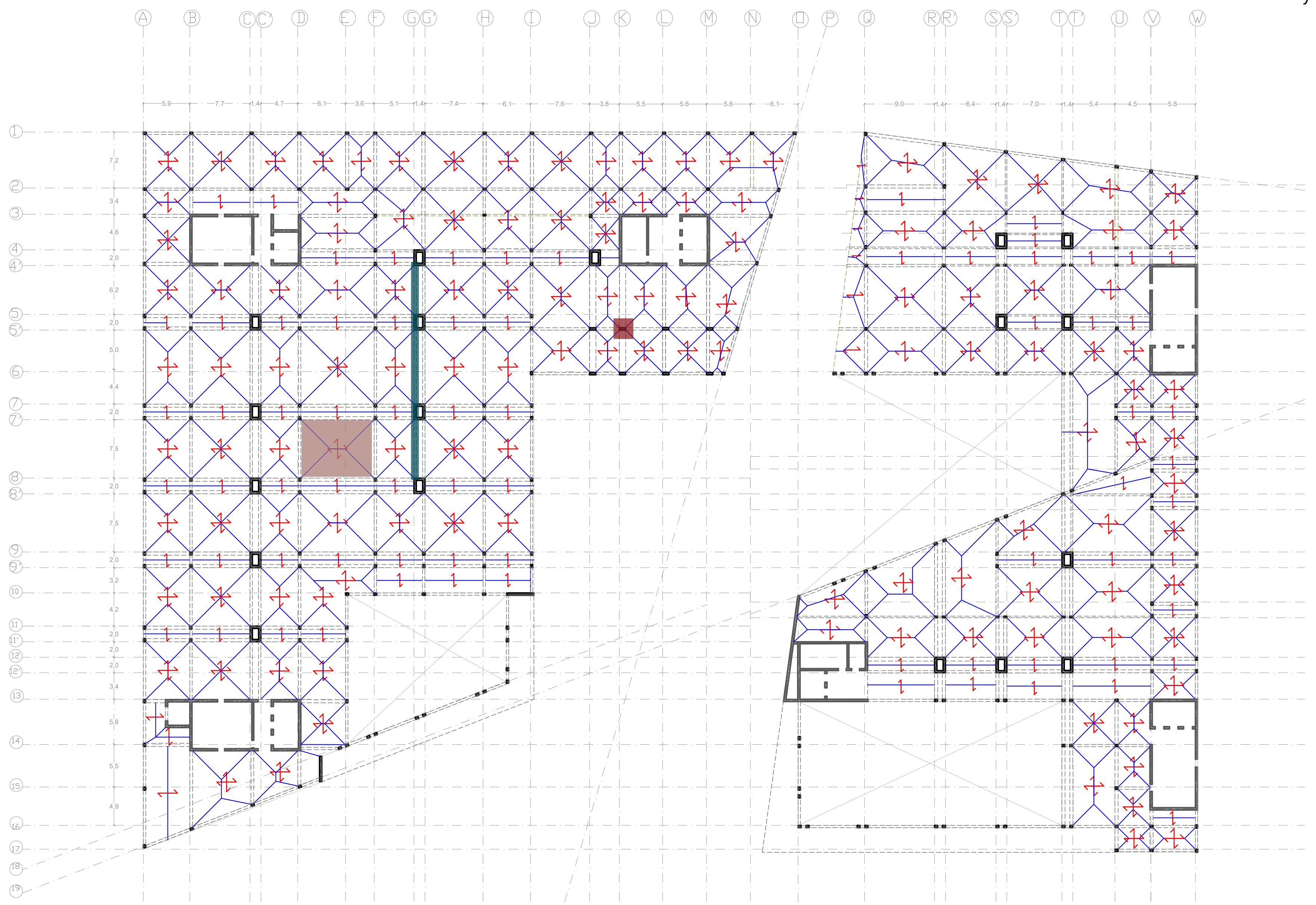
Notes:
Values given shall be used directly for members with normalweight concrete and Grade 420 reinforcement. For other conditions, the values shall be modified as follows:
a) For lightweight concrete having equilibrium density, w_c, in the range of 1440 to 1840 kg/m^3, the values shall be multiplied by $(1.65 - 0.0003w_c)$ but not less than 1.09.
b) For f_y other than 420 MPa, the values shall be multiplied by $(0.4 + f_y/700)$.

General Description - Design/Structural Decisions:
For example; the computed slab **L= 9.7m** & **S=7.5m**
L/S <2 L/S = 1.29 < 2 -> two way slab

-Drop Beams with both ends continuous:
l/21 = 9.7/21 = 0.46 ≈ 0.5m; therefore 0.5m is the largest drop beam found in the project
These values will be calculated precisely throughout the report

The concrete slab used is 0.2m (20cm) thick

STRUCTURAL PLAN
Beams Tributary Areas



Structural Map with Tributary Areas
- **Two-way slab**
- **Beam**
- **Column**

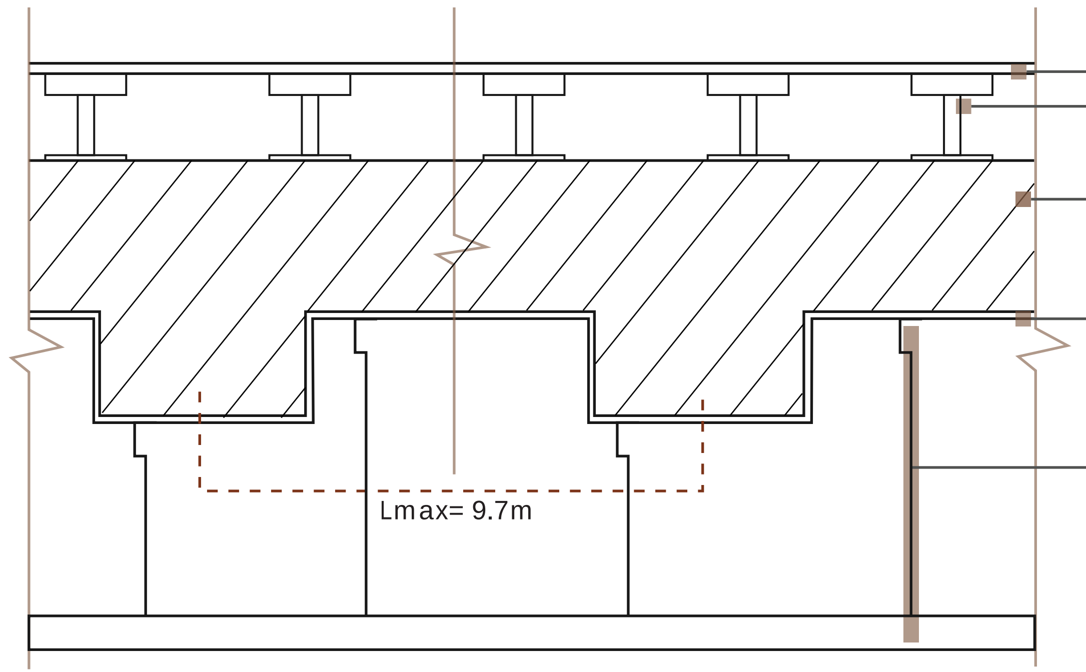
LOAD ANALYSIS

DEAD LOADS
In short, the dead load of a structure comprises its completed weight, before it goes into service. The floors, walls, roof, columns, stairs, permanent equipment and any fixed decor constitute a static load that normally doesn't change over the life of the building.
Therefore, calculations for the dead load before a building takes on the additional loads from occupancy or use, must include the concrete for the foundation system, planned building materials plus any service equipment such as elevators, HVAC units and ductwork, plumbing, fixed manufacturing equipment, and so on.

LIVE LOADS
Live loads refer to the dynamic forces from occupancy and intended use. They represent the temporary forces that can be moved through the building or act on any particular structural element; such as, the anticipated weight of people, furniture, appliances, automobiles, moveable equipment …

Reinforced concrete creates the heaviest dead loads but also supports the most weight with its compressive strength. Structural steel offers much less of a dead load and provides superior support for live loads in multi-story buildings.
The load path is transferred from slab to beams by distributing the load over the beam. The slab rests on the beam that carries its weight. In this case, the area weight is distributed along the beam by both a one-way slab and a two way slab system. In a one-way slab, the slab load is divided equally between adjacent beams. For an interior beam, the slab areas of both sides are divided by the corresponding width to obtain the lineal load of the beam. In a two-way slab, each direction of reinforcement is supposed to carry and transfer a portion of the slab load to the adjacent beam.

LOAD ANALYSIS
Typical Floor



Name	Thickness (m)	Weight Density (KN/m^3)	Area Load (KN/m^2)	References
Concrete	0.2	25	5	EuroCode
Elevated Slab (Raised floor SlimTech)			0.594	LEA Ceramiche
Plaster	0.02	8.5	0.17	Acqua Calc
False Ceiling + Steel framing			0.98	Gyproc Layin Grid Ceiling
			Total DL	
			6.74	

NB: C20/25 reinforced concrete was chosen as a material property of concrete

The area analyzed is subdivided into both categories C1 and C3 because part of it is a service lab, and the other is a corridor; therefore we selected the **Live Load** value to be ***4 KN/m²***

Category	Specific Use	Example
A	Areas for domestic and residential activities	Rooms in residential buildings and houses; bedrooms and wards in hospitals; bedrooms in hotels and hostels kitchens and toilets.
B	Office areas	
C	Areas where people may congregate (with the exception of areas defined under category A, B, and D[1])	C1: Areas with tables, etc. e.g. areas in schools, cafés, restaurants, dining halls, reading rooms, receptions. (Service Lab)
		C2: Areas with fixed seats, e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms.
		C3: Areas without obstacles for moving people, e.g. areas in museums, exhibition rooms, etc. and access areas in public and administration buildings, hotels, hospitals, railway station forecourts. (Corridor)
		C4: Areas with possible physical activities, e.g. dance halls, gymnastic rooms, stages.
		C5: Areas susceptible to large crowds, e.g. in buildings for public events like concert halls, sports halls including stands, terraces and access areas and railway platforms.
D	Shopping areas	D1: Areas in general retail shops
		D2: Areas in department stores

Service Lab

Corridor

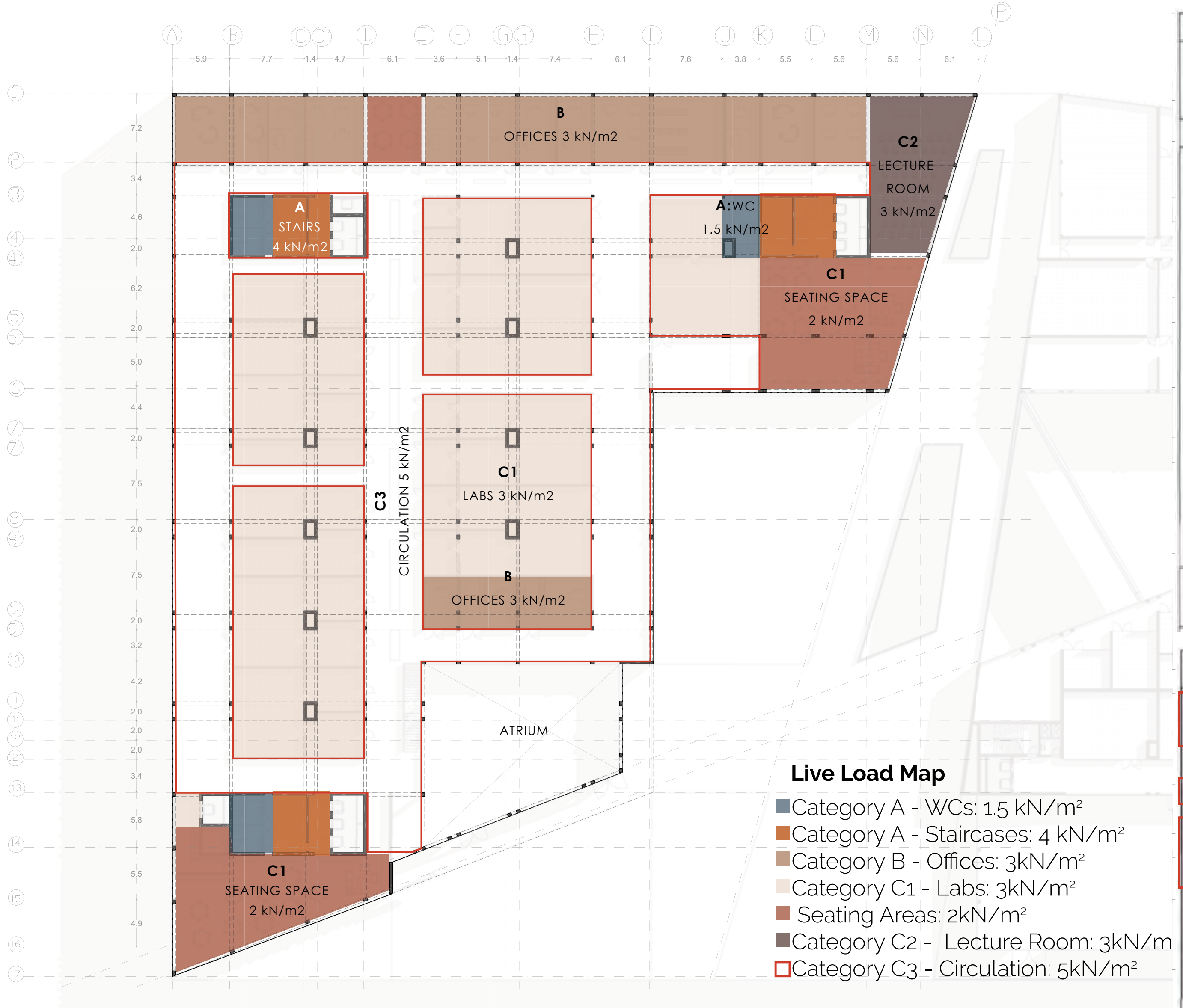
Categories of loaded areas	q_k [kN/m²]	Q_k [kN]
Category A		
- Floors	1,5 to 2,0	2,0 to 3,0
- Stairs	2,0 to 4,0	2,0 to 4,0
- Balconies	2,5 to 4,0	2,0 to 3,0
Category B	2,0 to 3,0	1,5 to 4,5
Category C		
- C1	2,0 to 3,0	3,0 to 4,0
- C2	3,0 to 4,0	2,5 to 7,0 (4,0)
- C3	3,0 to 5,0	4,0 to 7,0
- C4	4,5 to 5,0	3,5 to 7,0
- C5	5,0 to 7,5	3,5 to 4,5
category D		
- D1	4,0 to 5,0	3,5 to 7,0 (4,0)
- D2	4,0 to 5,0	3,5 to 7,0

Lab Live Load **4 KN/m2**

→ **Floor Load Combination** (simplified version)

$q_u = \gamma_G (DL) + \gamma_Q (LL) = 1.35(6.74) + 1.5(4) = 15.099\ KN/m^2$

According to EuroCode: $\gamma_G = 1.35$ $\gamma_Q = 1.5$



Category	Specific Use	Example
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Categories of loaded areas	q_k [kN/m²]	Q_k [kN]
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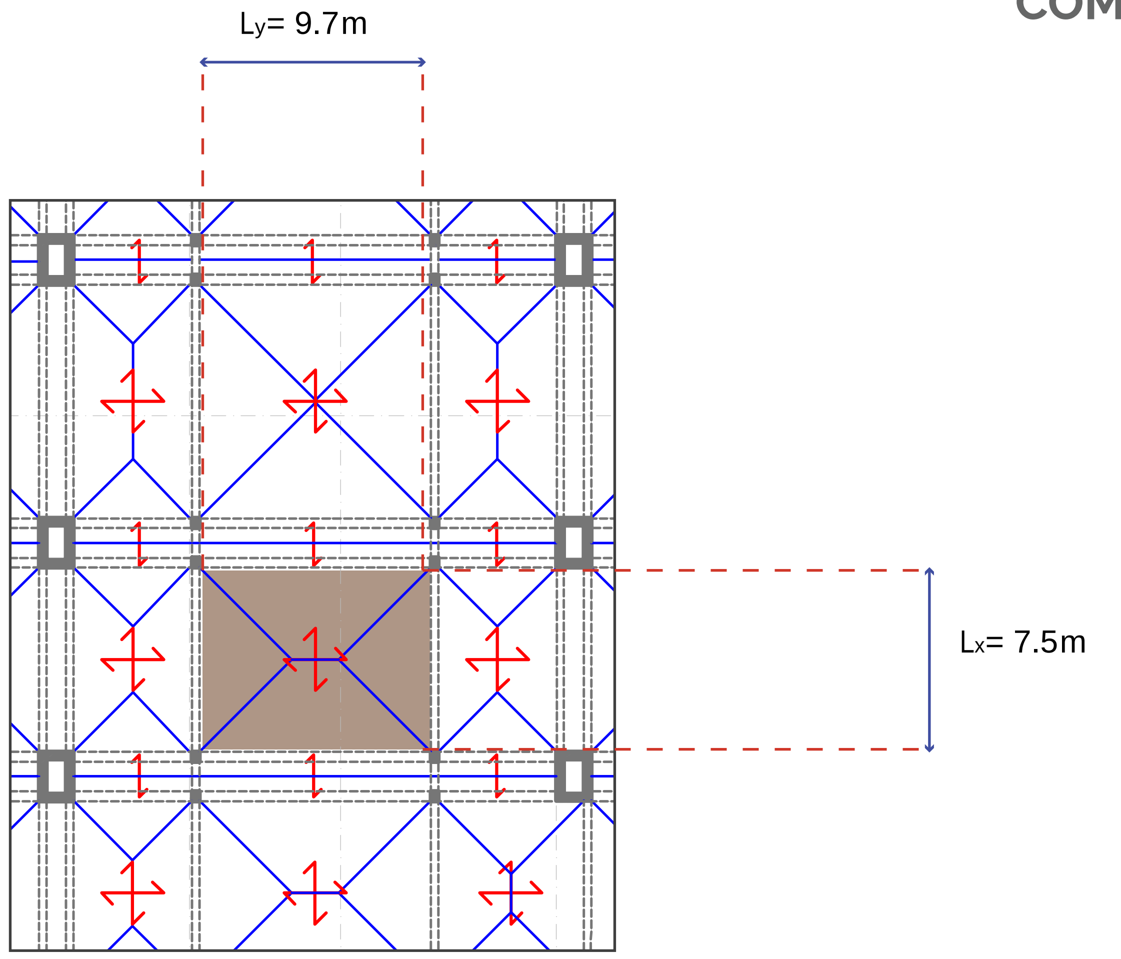
- Stairs	2,0 to 4,0	2,0 to 4,0
- Balconies	2,5 to 4,0	2,0 to 3,0
Category B	2,0 to 3,0	1,5 to 4,5
Category C		
- C1	2,0 to 3,0	3,0 to 4,0
- C2	3,0 to 4,0	2,5 to 7,0 (4,0)
- C3	3,0 to 5,0	4,0 to 7,0
- C4	4,5 to 5,0	3,5 to 7,0
- C5	5,0 to 7,5	3,5 to 4,5
category D		
- D1	4,0 to 5,0	3,5 to 7,0 (4,0)
- D2	4,0 to 5,0	3,5 to 7,0



Properties:

Thickness of the slab is decided 0.2 m

L_y/L_x = 1.29 < 2 -> two way slab

f_{ck}= 20 MPa f_y = 500 MPa

COMPUTATION
Two Way Slab

I- Calculation of the depth

cover = 25mm
b= 1000mm
diameter of the rebars= 10mm

d= 200mm-25mm-5mm =170mm

d=170 mm

II - Moment calculation: for two way slab -> we have 4 moment values

$M_x = \alpha_x W l_x^2$ $M_y = \alpha_y W l_y^2$

l_y/l_x = 1.29 ≈1.25 > Four edges continuous

α_- = 0.044 (negative moment at continuous edge)
α_+= 0.034 (positive moment at mid-span)
W= q_u= 15.099 KN/m^2 =15.1 KN/m^2

1- M_x^+ = 0.034 x 15.1 x 7.5 ^{2} = 28.88KN.m
2- M_y^+ = 0.034 x 15.1 x 9.7 ^{2} = 48.30 KN.m ⟵ Take the Largest positive bending Moment
3- M_x^- = 0.044 x 15.1 x 7.5 ^{2} = 37.37 KN.m
4- M_y^- = 0.044 x 15.1 x 9.7 ^{2} = 62.51 KN.m ⟵ Take the Largest negative bending Moment

III- Calculation of bending reinforcement (K)

K= M / fck x b x d ^{2}

on positive:
= 48.30 KN.m x 10^6 /(20 x 1000 x 170^2) ;
= 0.084

on negative:
= 62.51 KN.m x 10^6 /(20 x 1000 x 170^2) ;
= 0.108

Table 5.4 Bending moment coefficients for two-way spanning rectangular slabs

Type of panel and moments considered	Short span coefficients β_{sx}					Long-span coefficients β_{sy} for all values of l_y/l_x
	Values of l_y/l_x					
	1.0	1.25	1.5	1.75	2.0	
1. Interior panels						
Negative moment at continuous edge	0.031	0.044	0.053	0.059	0.063	0.032
Positive moment at midspan	0.024	0.034	0.040	0.044	0.048	0.024
2. One short edge discontinuous						
Negative moment at continuous edge	0.039	0.050	0.058	0.063	0.067	0.037
Positive moment at midspan	0.029	0.038	0.043	0.047	0.050	0.028
3. One long edge discontinuous						
Negative moment at continuous edge	0.039	0.059	0.073	0.082	0.089	0.037
Positive moment at midspan	0.030	0.045	0.055	0.062	0.067	0.028
4. Two adjacent edges discontinuous						
Negative moment at continuous edge	0.047	0.066	0.078	0.087	0.093	0.045
Positive moment at midspan	0.036	0.049	0.059	0.065	0.070	0.034

Table 5.5 Bending moment and shear force coefficients for flat slab panels of three or more equal spans

	Outer support column	Outer support wall	Near middle of end span	At first interior support	At middle of interior span(s)	At internal supports
Moment	– 0.04*Fl**	– 0.2*Fl*	0.09*Fl*†	– 0.11*Fl*	0.07*Fl*	– 0.1*Fl*
Shear	0.45*F*	0.4*F*	–	0.6*F*	–	0.55*F*
Total column moments	0.04*Fl*	–	–	0.22*Fl*	–	0.22*Fl*

F is the total design ultimate load ($1.35G_k + 1.5Q_k$)
*These moments may have to be reduced to be consistent with the capacity to transfer moments to the columns; the midspan moments † must then be increased correspondingly.

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IV- Calculation of lever-arm (z)

$z= d^* [0.5+ \sqrt{0.25-(K/1.134)}]$

for K=0.084 (positive)
z =156.3 mm

$z= d^* [0.5+ \sqrt{0.25-(K/1.134)}]$

for K=0.108 (negative)
z =151.9 mm

V- Calculation of reinforcement

$A_s= M/ (0.85 .f_{yk}. z)$

on positive:
A_s= 48.30 KN.m x 10^6 / (0.85 x 500 x 156.3)
= 727.1 mm^2= 785 mm^2

on negative:
A_s= 62.51 KN.m x 10^6 /(0.85 x500 x 151.9) ;
= 968.28 mm^2= 1130 mm^2

$A_{s\ min}$ = b*d*0.013 = 221mm^2

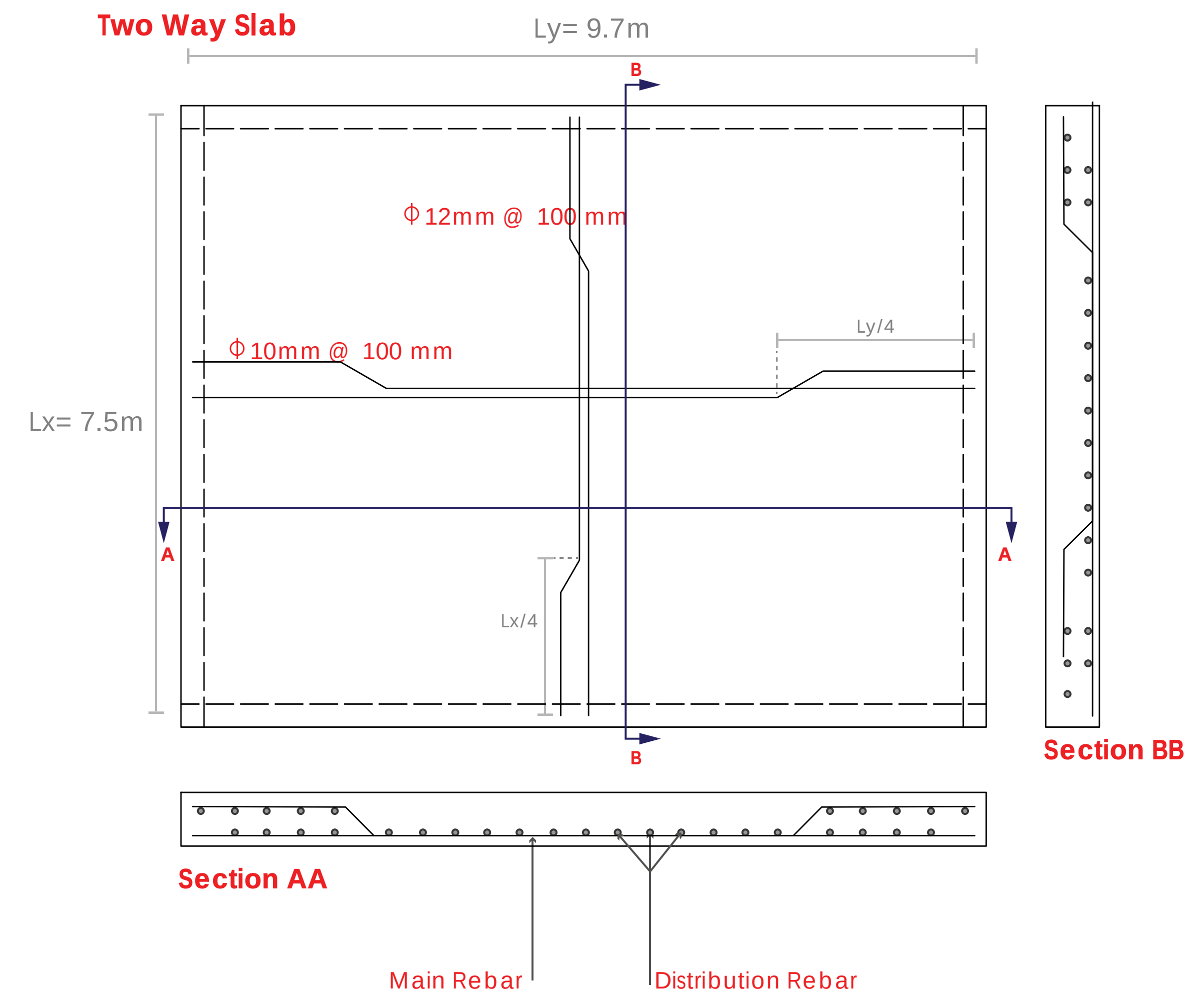
Bar size (mm)	Spacing of bars (mm) 50	75	100	125	150	175	200	250	300
6	566	377	283	226	189	162	142	113	94.3
8	1010	671	503	402	335	287	252	201	168
10	1570	1050	785	628	523	449	393	314	262
12	2260	1510	1130	905	754	646	566	452	377
16	4020	2680	2010	1610	1340	1150	1010	804	670
20	6280	4190	3140	2510	2090	1800	1570	1260	1050
25	9820	6550	4910	3930	3270	2810	2450	1960	1640
32	16100	10700	8040	6430	5360	4600	4020	3220	2680
40	25100	16800	12600	10100	8380	7180	6280	5030	4190

Table C Cross-sectional area per metre width for various bar spacing (mm^2)

From Table

ϕ10mm @ 100 mm c/c on positive

ϕ12mm @ 100 mm c/c on negative



Two-way slab: Minimum reinforcement is 0.12% for high yield strength deformed bars (HYSD) and 0.15% for mild steel bars. The diameter of bar generally used in slabs are: 6 mm, 8 mm, 10 mm, 12mm and 16mm.

The maximum diameter of bar used in slab should not exceed 1/8 of the total thickness of slab. Maximum spacing of main bar is restricted to 3 times effective depth or 300 mm whichever is less. For distribution bars the maximum spacing is specified as 5 times the effective depth or 450 mm whichever is less.

Minimum clear cover to reinforcements in slab depends on the durability criteria and this is specified in the code. Generally 15mm to 30mm cover is provided for the main reinforcements.

Properties:

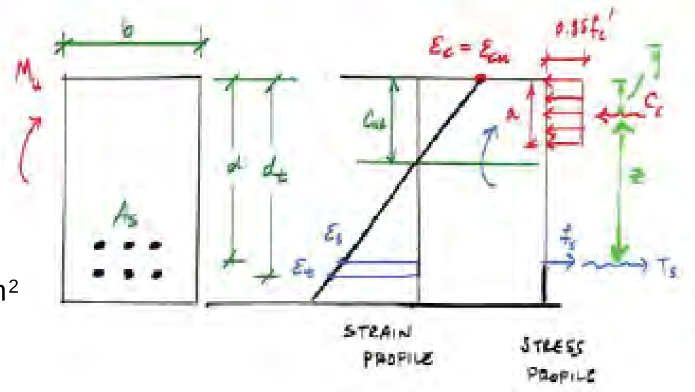
L_{max} = 9.4m

b = 300mm

h = 700mm

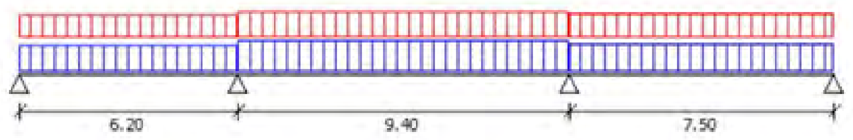
cover (c) = 25mm

Concrete weight = 25 KN/m²



Continuous Beam: 6.2+ 9.4+ 7.5 =23.1 m

The 2- meter spans of the shaft were neglected due to their high stiffness.



Effective depth (d) = 700 - 25 - 5 = 670 mm

Material Properties:

f_{yk}= 500 MPa

f_{ck}= 20 MPa

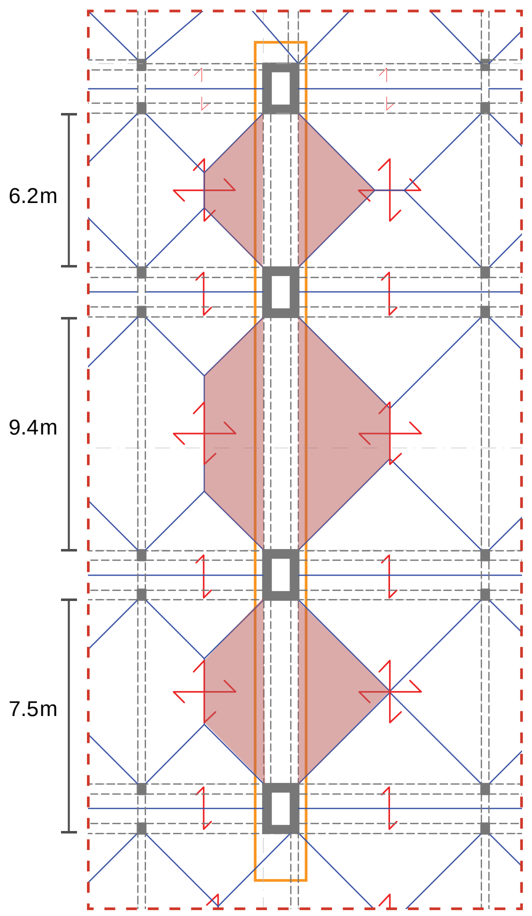
I- Load Calculated:

DL = 6.74 KN/m²   LL = 4 KN/m²

II- Floor Load Combination (simplified version)

$q_u = \gamma_G$ (DL) + γ_Q (LL) = 1.35 (6.74) + 1.5 (4) = 15.099 KN/m

[2] According to EuroCode: γ_G = 1.35 γ_Q= 1.5



Span 1 Tributary Area: 9.2 + 9.7 = 18.9 m² →

Span 2 Tributary Area: 16.85 + 21.35 = 38.2 m² →

Span 3 Tributary Area: 12 + 13.8 = 25.8 m² →

Floor Loads (KN):

For DL: 6.74 KN/m² x 18.9 m²= 127.4 KN

For LL: 4 KN/m² x 18.9 m²= 75.6 KN

For DL: 6.74 KN/m² x 38.2 m²= 257.5 KN

For LL: 4 KN/m² x 38.2 m²= 152.8 KN

For DL: 6.74 KN/m² x 25.8 m²= 174 KN

For LL: 4 KN/m² x 25.8 m²= 103.2 KN

The trapezoidal load of each beam is calculated by adding the tributary areas on both sides of the beam and multiplying the value by both the dead load and the live load determined previously.

Linear Loads on Beam (KN/m):

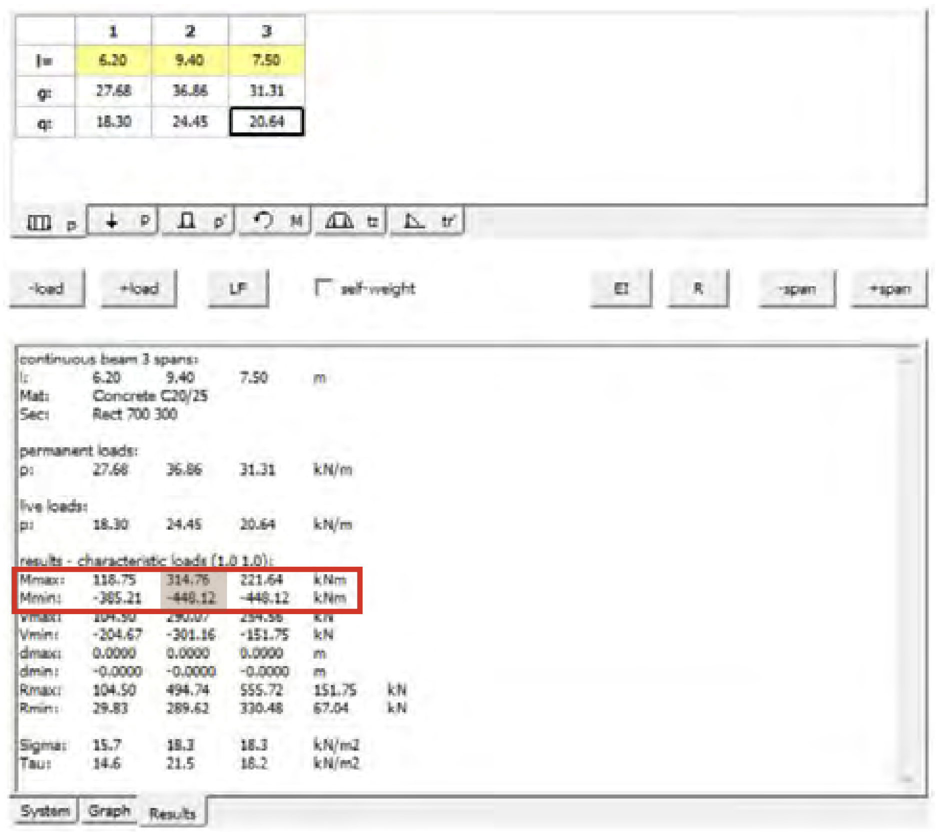
Span 1 →
For DL: 1.35 x 127.4 KN / 6.2 m = 27.675 KN/m
For LL: 1.5 x 75.6 KN/ 6.2 m = 18.3 KN/m

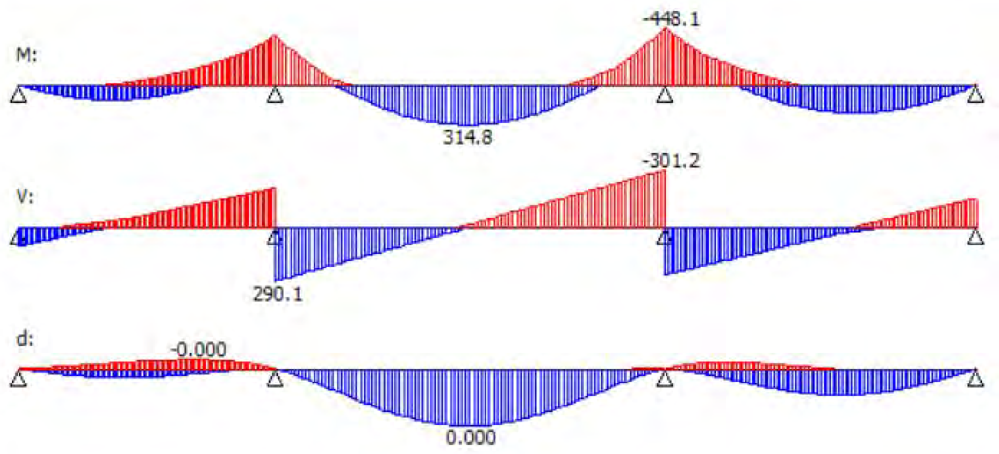
Span 2 →
For DL: 1.35 x 257.5 KN / 9.4 m = 36.86 KN/m
For LL: 1.5 x 152.8 KN / 9.4 m = 24.45 KN/m

Span 3 →
For DL: 1.35 x 174 KN / 7.5 m = 31.31 KN/m
For LL: 1.5 x 103.2 KN / 7.5 m = 20.64 KN/m

The linear loads are then computed for each span by multiplying the floor loads obtained above by the coefficients of the dead load and the live load respectively. The highlighted values are then plugged into the wxCBA software in order to obtain the bending moments.

III- Moment Computation (wxCBA software)





M_{max} = 314.8 KN.m ⟵ Largest bending moment at the span

M_{max} = -448.1 KN.m ⟵ Largest bending moment at the support

IV- Bending reinforcement (K)

$K = M / f_{ck} \times b \times d^2$

on span:
= 314.8 KN.m x 10^6/(20 x 300 x 670^2) ;
= 0.116

on support:
= 448.1 KN.m x 10^6/(20 x 300 x 670^2) ;
= 0.166

Table A.1 Sectional areas of groups of bars (mm^2)

Number of Bars										LENGTH/TON
Diameter	1	2	3	4	5	6	7	8	9	M
8	50,3	101	151	201	252	302	352	402	453	503
10	78,5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	565	678	791	904	1017	1130
16	201	402	603	804	1005	1206	1407	1608	1809	2010
20	314	628	942	1256	1570	1884	2198	2512	2826	3140
25	491	982	1473	1964	2455	2946	3437	3928	4419	4910
32	804	1608	2412	3216	4020	4824	5628	6432	7236	8040
40	1260	2520	3780	5040	6300	7560	8820	10080	11340	12600

V- Lever-arm (z)

$z = d^* [0.5 + \sqrt{0.25 - (K/1.134)}]$

for K=0.116 (span)
z =592.75 mm

$z = d^* [0.5 + \sqrt{0.25 - (K/1.134)}]$

for K=0.166 (support)
z = 551 mm

Table A.2 Perimeters and weights of bars

Bar size (mm)	6	8	10	12	16	20	25	32	40
Perimeter (mm)	18.85	25.1	31.4	37.7	50.2	62.8	78.5	100.5	125.6
Weight (kg/m)	0.222	0.395	0.616	0.888	1.579	2.466	3.854	6.313	9.864

Bar weights based density of 7850 kh/m^3

VI- Reinforcement

$A_s = M / (0.85 .f_{yk}. z)$

$A_{s\,min}$ = b*h*0.0013 = 273mm^2

on span:
A_s= 314.80 KN.m x 10^6 / (0.85 x 500 x 592.75)
= 1249.2 mm^2 ≈ 1260 mm^2 ⟶ 4 ϕ 20 mm

on support:
A_s= 448.1 KN.m x 10^6 /(0.85 x 500 x 551) ;
= 1914.5 mm^2 ≈ 1960 mm^2 ⟶ 4 ϕ 25 mm

VII- Reinforcement Ratio:

on span: ρ = A_s / bd = 1260 / (300 x 670) = 0.62% ; (0.13 % ≤ 0.62% ≤ 4%)

on support: ρ = A_s / bd = 1960 / (300 x 670) = 0.97% ; (0.13 % ≤ 0.97% ≤ 4%)

VIII- Compression Steel

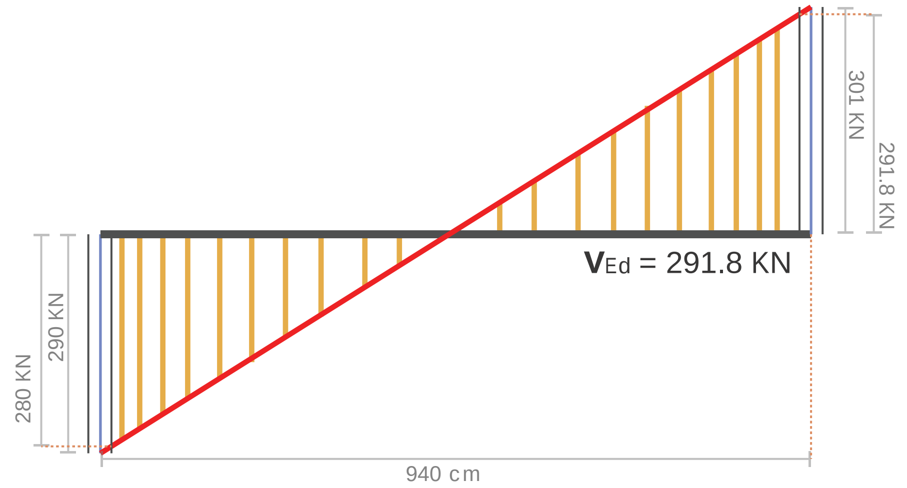
$K = M / f_{ck} \times b \times d^2$

on span:
0.116 < 0.167 ⟶ Compression steel is not required

on support:
0.166 < 0.167 ⟶ Compression steel is not required

$A'_s = M - 0.167 \times b \times d^2 \times f_{ck} / [0.87 \times f_{yk} \times (d - d')]$ ⟶ compression steel is required

Shear force at the face of the support:



Shear Resistance:

V_{Rdc} = 0.55 x b x d = 0.55 x 300 x 670 = 110.55 KN

$V_{Ed} > V_{Rdc}$ ⟶ Shear reinforcement is required

Minimum Reinforcement Required:

$A'_{s\,min}$ = 13% x b x d = 0.0013 x 300 x 700 = 273 mm^2 ≈ 314 mm^2

$V_{Ed} > V_{Rdc}$ Shear reinforcement is required

Number of Bars										LENGTH/TON
Diameter	1	2	3	4	5	6	7	8	9	M
8	50.3	101	151	201	252	302	352	402	453	503
10	78,5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	565	678	791	904	1017	1130
16	201	402	603	804	1005	1206	1407	1608	1809	2010
20	314	628	942	1256	1570	1884	2198	2512	2826	3140
25	491	982	1473	1964	2455	2946	3437	3928	4419	4910
32	804	1608	2412	3216	4020	4824	5628	6432	7236	8040
40	1280	2520	3780	5040	6300	7560	8820	10080	11340	12600

⟶ 4 Φ 10 mm needed for stirrups

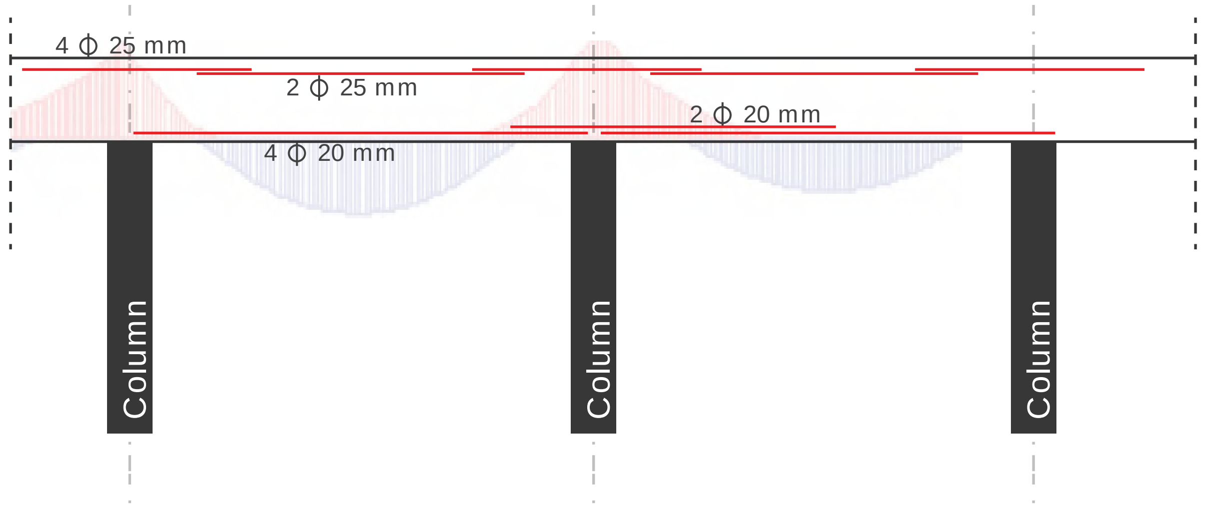
Reinforcement:

1- On span ⟶ 4 Φ 20 mm

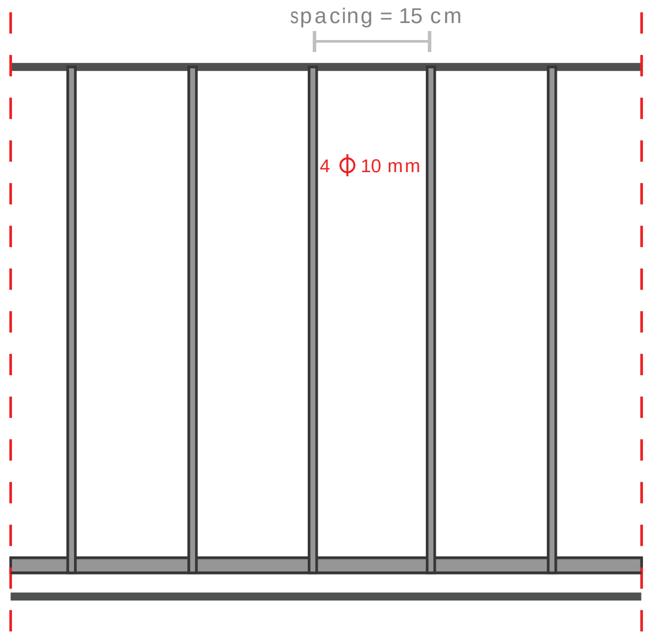
2- On support ⟶ 4 Φ 25 mm

Shear Reinforcement:

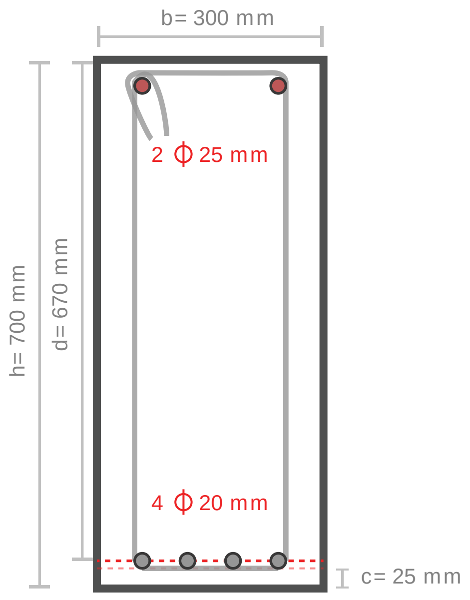
Stirrups ⟶ 4 Φ 10 mm



Transversal Section (strirrups):

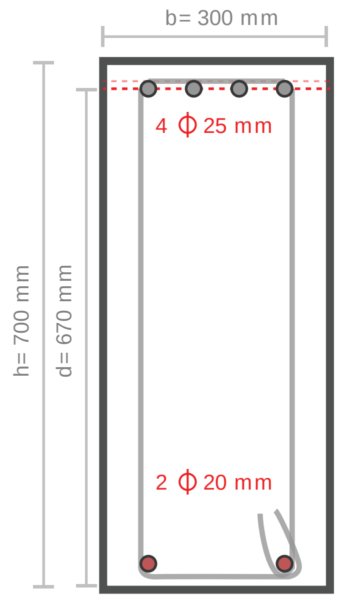


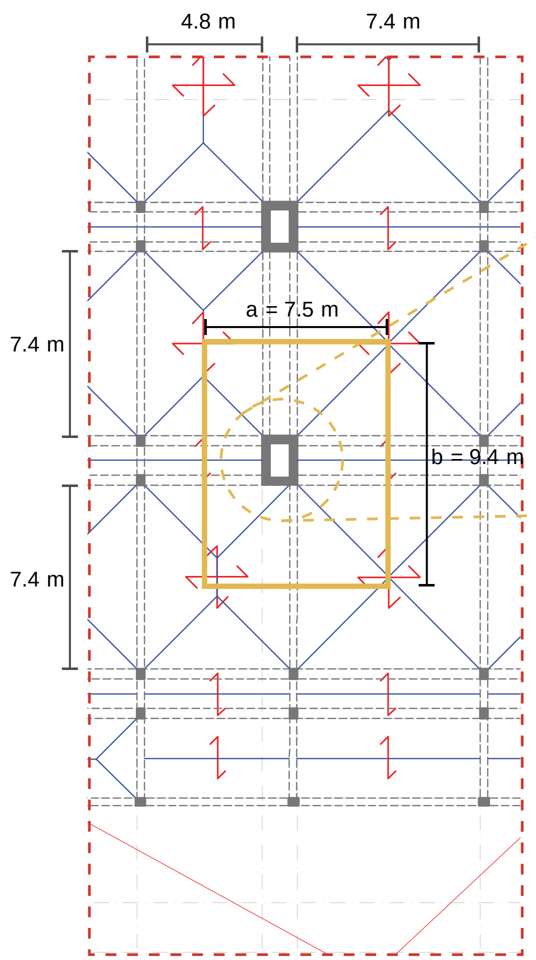
Beam Section | On span

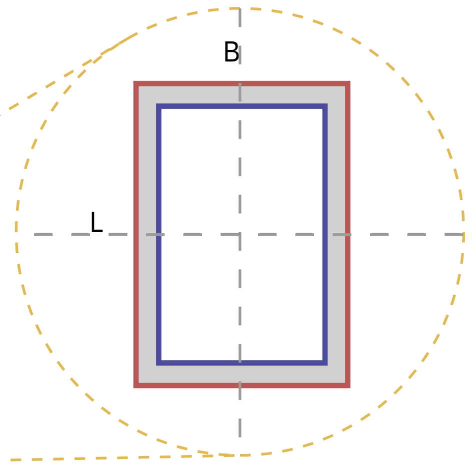


Scale 1:10

Beam Section | On support







Shaft acting as a column:

- **B = 1.4 m ; L = 2 m**
- **B = 0.8 m ; L = 1.4 m**
- **Influence area of column**

→ Thickness of assumed column = 30 cm

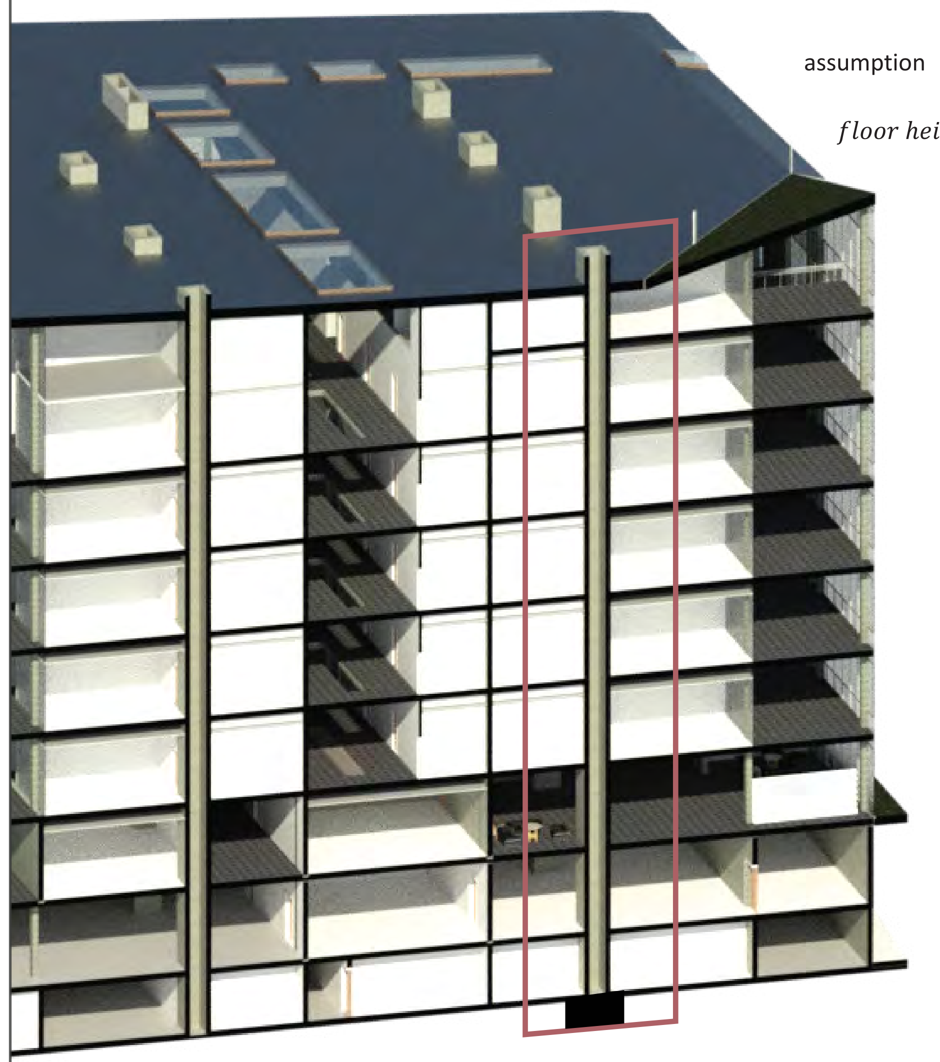
Area of "column":

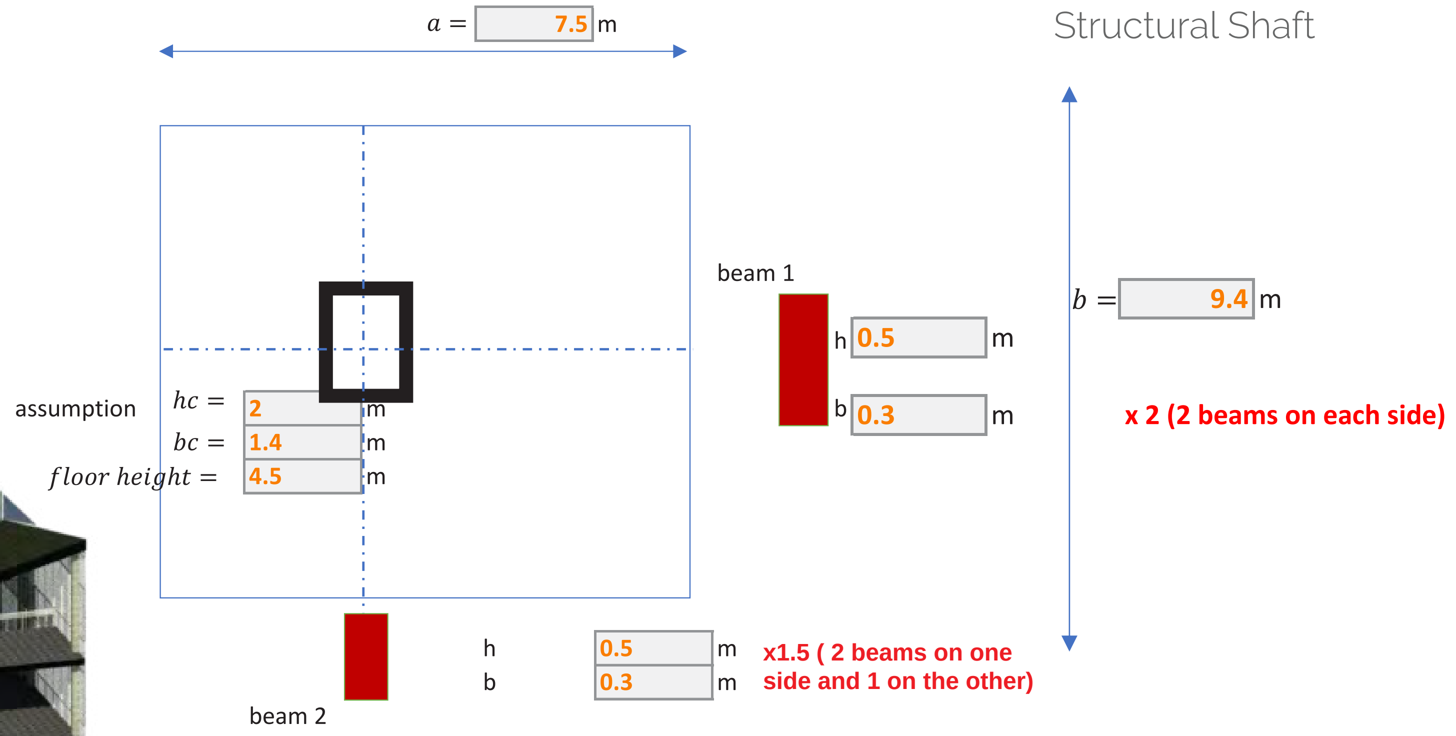
- 1.4 x 2 = 2.8 m^2
- 0.8 x 1.4 = 1.12 m^2

→ Total area = 2.8 - 1.12 = 1.68 m^2

Number of storeys n:

n_0 , n_1 , ... , n_8





Floor Weight w (kN/m^2):

25 kN/m^2 (weight of concrete)

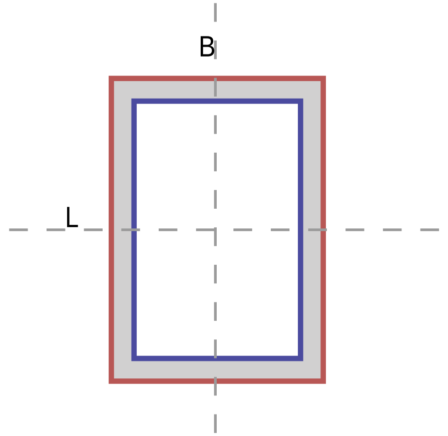
Axial Force in Column Base N:

N = n (a x b x w)

$f_{cd} = \alpha f_{ck} / \gamma_c$ = 0.85 x 20 / 1.5 = 11.33

Axial stress (σ) = N /A

→ Area A = N /σ → A = N/ 0.55 f_{cd}



COMPUTATION
Structural Shaft

Axial force

AREA LOADS

	Self-weight slab		Live Load	
	5	kN/m2	4	kN/m2
Coef.	1.35		1.5	
Combination	12.75	kN/m2		

N_area_load	899	kN	
N_beam_1	76	kN	→ 2* 1.35* h1* b1*a*25
N_beam_2	71.38125	kN	→ 1.5* 1.35* h2* b2*b*25
N_column	255.15	kN	
N_floor	1301	kN	this is the axial force per floor

Number of floor: 8

N_tot_floor: 10,411 kN

Column calculation

fck	30	Mpa	C30/37
fcd	17.0	Mpa	

$$f_{cd} = \frac{\alpha f_{ck}}{\gamma_c} = \frac{0{,}85 f_{ck}}{1{,}5}$$

Area (A): 1113449.2 mm2

1.1134492 m2

$$A = \frac{N}{coef_{moment} * f_{cd}}$$

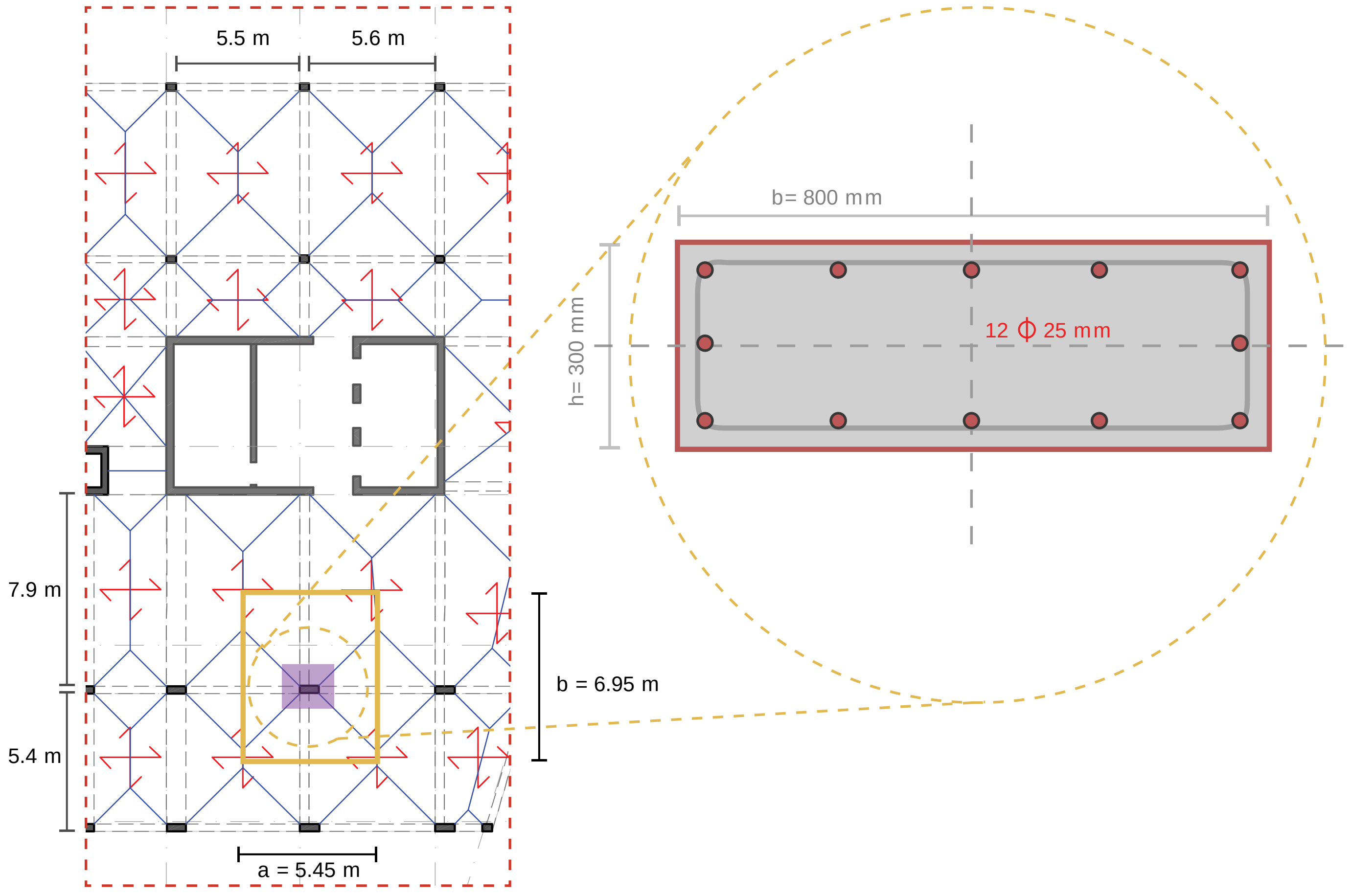
coef_moment: 0.55

0.45 - 0.85

Shaft area designed > Area needed
$1.68\ m^2 > 1.113\ m^2$

Column Checked ✓

COMPUTATION
Reinforced Concrete Column



Column:

B = 0.8 m ; L = 0.3 m

Influence area of column

Area of column:

$0.8 \times 0.3 = 0.24\ m^2$

Reinforcement Ratio:

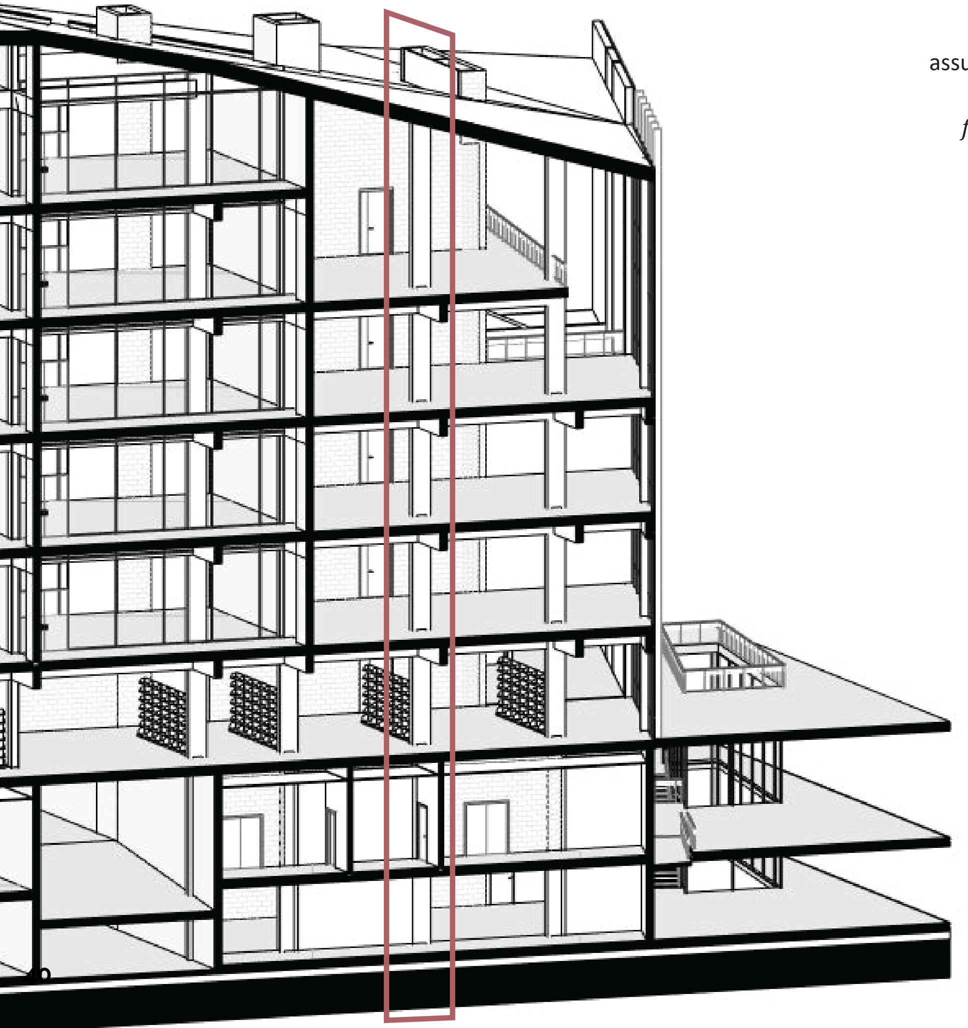
1.5% of total area = 3600 mm^2

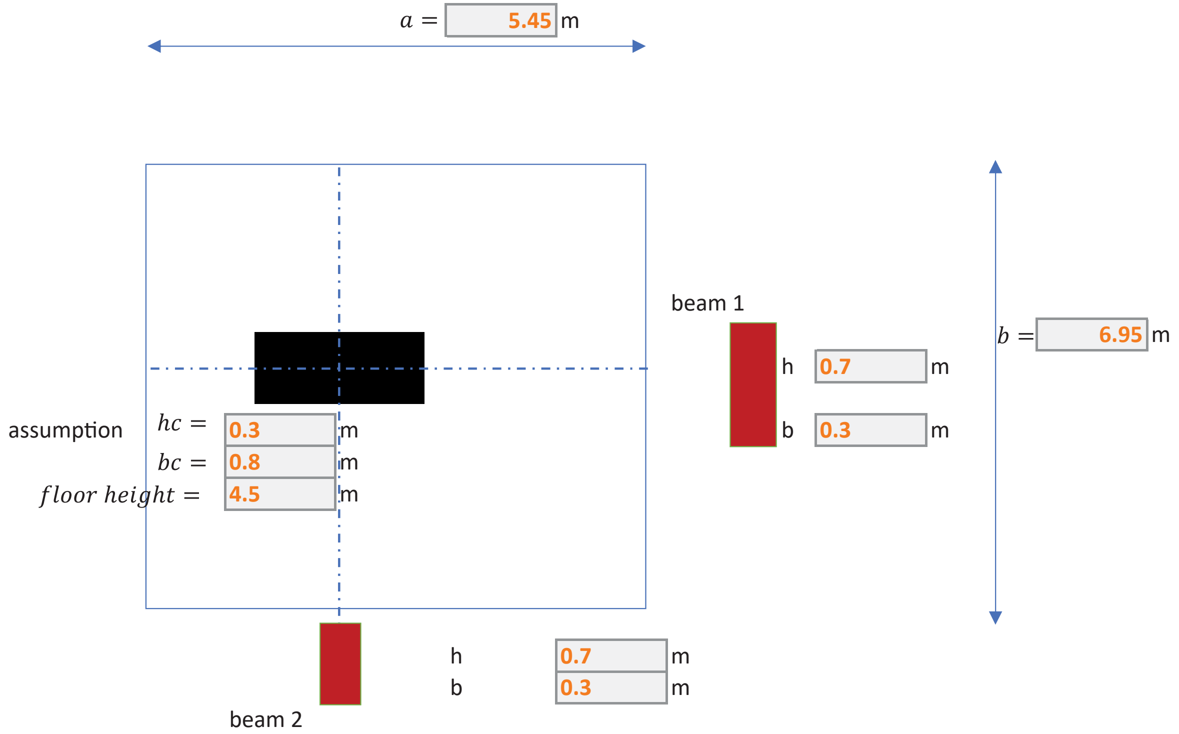
→ 8 Φ 25 mm is the minimum

Single Column: We can establish that the double column design system works both aesthetically and structurally in this building design. The same design of the column was studied but in its singular function rather than a double column system, with a higher design strength and a maximum coefficient. However, it was only sufficient to hold the load of the desired area, when its length was doubled. Therefore, the single columns should have a bigger area in order to carry the load.

Number of storeys n:

n_0, n_1, ... , n_6





Floor Weight w (kN/m²):

25 kN/m² (weight of concrete)

Axial Force in Column Base N:

N = n (a x b x w)

$f_{cd} = \alpha f_{ck} / \gamma_c = 0.85 \times 32 / 1.5 = 18.1$

Axial stress (σ) = N / A

→ Area A = N / σ → A = N/ 0.85 f_{cd}

Axial force

	Self-weight slab		Live Load	
AREA LOADS	5	kN/m2	4	kN/m2
Coef.	1.35		1.5	
Combination	12.75	kN/m2		

N_area_load	483	kN
N_beam_1	39	kN
N_beam_2	49.258125	kN
N_column	36.45	kN
N_floor	607	kN

this is the axial force per floor

Number of floor	6
N_tot_floor	3,644 kN

Column calculation

fck	32	Mpa	C32/40
fcd	18.1	Mpa	

$$f_{cd} = \frac{\alpha f_{ck}}{\gamma_c} = \frac{0{,}85 f_{ck}}{1{,}5}$$

Area (A)	236395.248	mm2
	0.23639525	m2

$$A = \frac{N}{coef_{moment} * f_{cd}}$$

coef_moment 0.85
0.45 - 0.85

Column dimensions calculation

if rectangular	assume one dimension	300	mm
		788	mm

Column area designed < Area needed
0.24m² > 0.236 m ²

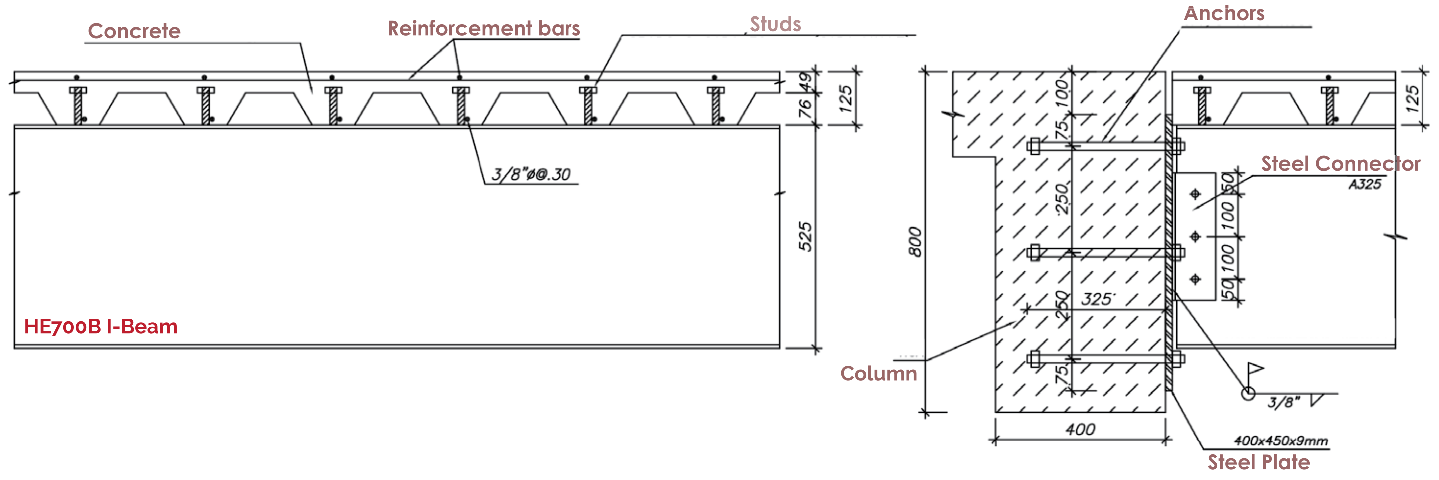
Column Checked ✓

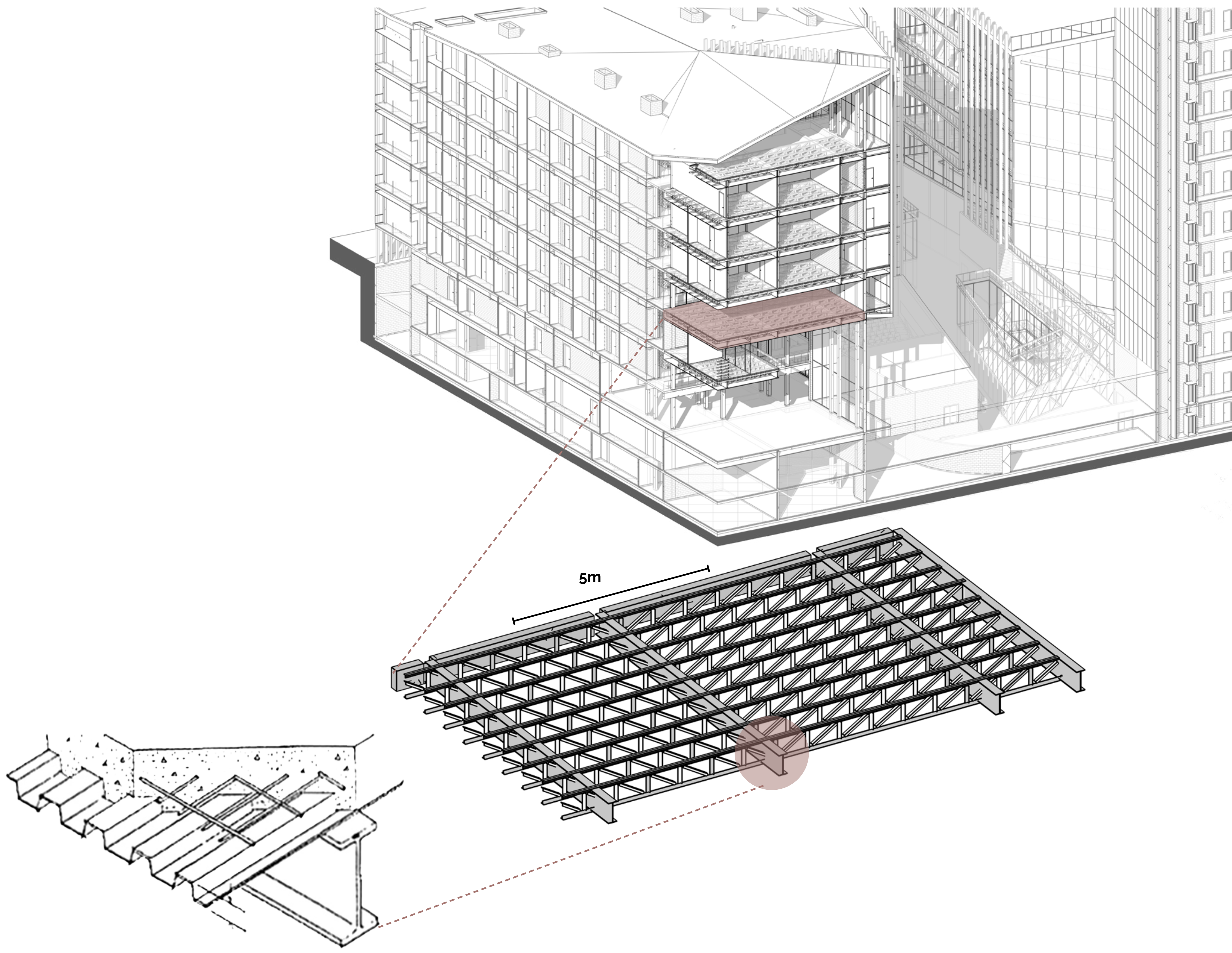
We can establish that the double column design system works both aestheticly and structurally in this building design. The same design of the column was studied but in its singular function rather than a double column system, with a higher design strength and a maximum coefficient. However, it was only sufficient to hold the load of the desired area, when its length was doubled. Therefore, the single columns should have a bigger area in order to carry the load.

COMPOSITE STEEL SLAB

The Composite Floor System provides innovative, results-driven building solutions that provide efficiency, safety, sound and fire ratings and economical design flexibility. Ideally suited for multistory buildings. It also allows for installation flexibility of HVAC and Electrical systems.The Composite Floor System provides innovative, results-driven building solutions that provide efficiency, safety, sound and fire ratings and economical design flexibility. Ideally suited for multistory buildings. It also allows for installation flexibility of HVAC and Electrical systems.Open web floor trusses are growing in popularity over engineered joist systems. Their superior span capability allows them to create more spacious rooms free of awkward columns. Rooms over structure can be built without the need for support beams and columns. This system will help us having the idea of an open space and cantilevered slabs to have the architectural initiative while staying efficient and functional. As spans between bearing walls increase, open web floor system can often be the more cost effective approach to building a floor system.

Tata Steel Galvatite®, hot dip zinc coated steel to BS EN 10346 S280GD+Z275, with guaranteed minmum proof strength of 280N/mm2 and zinc coating of total mass 275g/m2 (including both sides). This is sufficient for internal floors in a non-aggressive environment, which satisfies the requirement in Clause 4.2 BS EN 1994-1-1 - the exposed surfaces of the steel decking shall be adequately protected to resist the particular atmospheric conditions. A zinc coating, if specified, should conform to the requirements of BS EN 10346. The specification may be varied, depending on service conditions.





DEAD LOADS				
Name	Area Load (kN/m²)	Weight density (kN/m³)	Area (m²)	References
Concrete		25	0.0888 area of 1m² of concrete	EuroCode
		25 0.0888= 2.22 k ,*		
Partitions	1			gov.bd.bnbc.2012.06.02
Glass	0.081			gov.bd.bnbc.2012.06.02
False ceiling+ Steel framing	0.98			Gyproc Layin Grid Ceiling
LIVE LOADS				
Office Use	3	*3 *5m= 15 kN/m ; where x=5m length of tributary area*		EuroCode

→ **Floor Load Combination** (simplified version): $q_u = \gamma_G(DL) + \gamma_Q(LL) = 4.94 + 1.5\ (3) = 9.44$ kN/sqm

COMPOSITE STEEL SLAB
Truss Beam Plan (Cantilever)

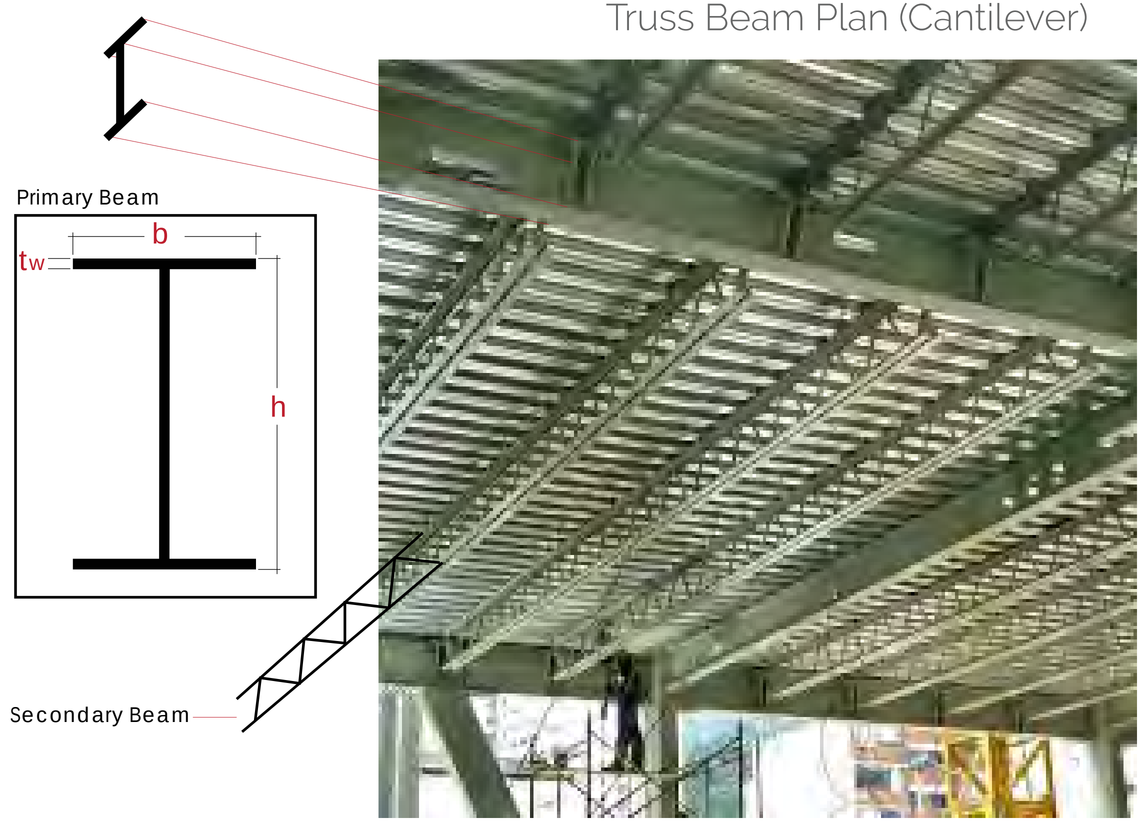
Floor Load Combination (simplified version):

$q_u = 1.35(DL) + 1.5(LL) = 3 + 22.5 =$ **25.5 kN/m**

$M_{max} = (q_u * L^2)/8 = (25.5*17.7^2)/8 =$ **998.7 kN.m**

$S_x = 998.7$ kN.m/ 1518 kN/m² = 0.6579 m³ = **6579 cm³** (Wely)
Beams selected are **A36** steel with an allowable compressive strength of 1518 kg/cm²= 151800 kN/cm²
From the data of HE sections: Wely value chosen= **7339.66cm³**

Took a higher value by assuming the point loads that will be applied at the intersection between the secondary and primary beam, in addition to the distributed loads already computed
The designated steel class chosen is **HE 700B** with the following dimensions:
h= 700mm
b= 300mm
tw= 17mm



Designation	G	h	b	tw	tf	r	I	Iy	Wely	Wply	iy	Iz	Welz	Wplz	iz
		Dimensions						Section properties: Strong axis				Weak axis			
	kg/m	mm	mm	mm	mm	mm	cm2	cm4	cm3	cm3	cm	cm4	cm3	cm3	cm
HE 700 B	240.5	700.0	300	17.0	32.0	27	306.38	256,888	7,339.66	8,327.22	28.96	14,440.85	962.72	1,495.06	6.87
HE 700 M	300.7	716.0	304	21.0	40.0	27	383.02	329,278	9,197.71	10,539.07	29.32	18,797.43	1,236.67	1,928.80	7.01
HE 700 x 352	352.2	728.0	308	25.0	46.0	27	448.62	389,681	10,705.52	12,385.99	29.47	22,506.45	1,461.46	2,292.86	7.08
HE 700 x 418	417.6	744.0	313	29.5	54.0	27	531.92	472,508	12,701.83	14,840.85	29.80	27,762.56	1,773.97	2,796.55	7.22

Date of last update : Jun, 11 2020

Technical data of sections HE
European wide flange beams

Tel : +33 3 44 77 30 00
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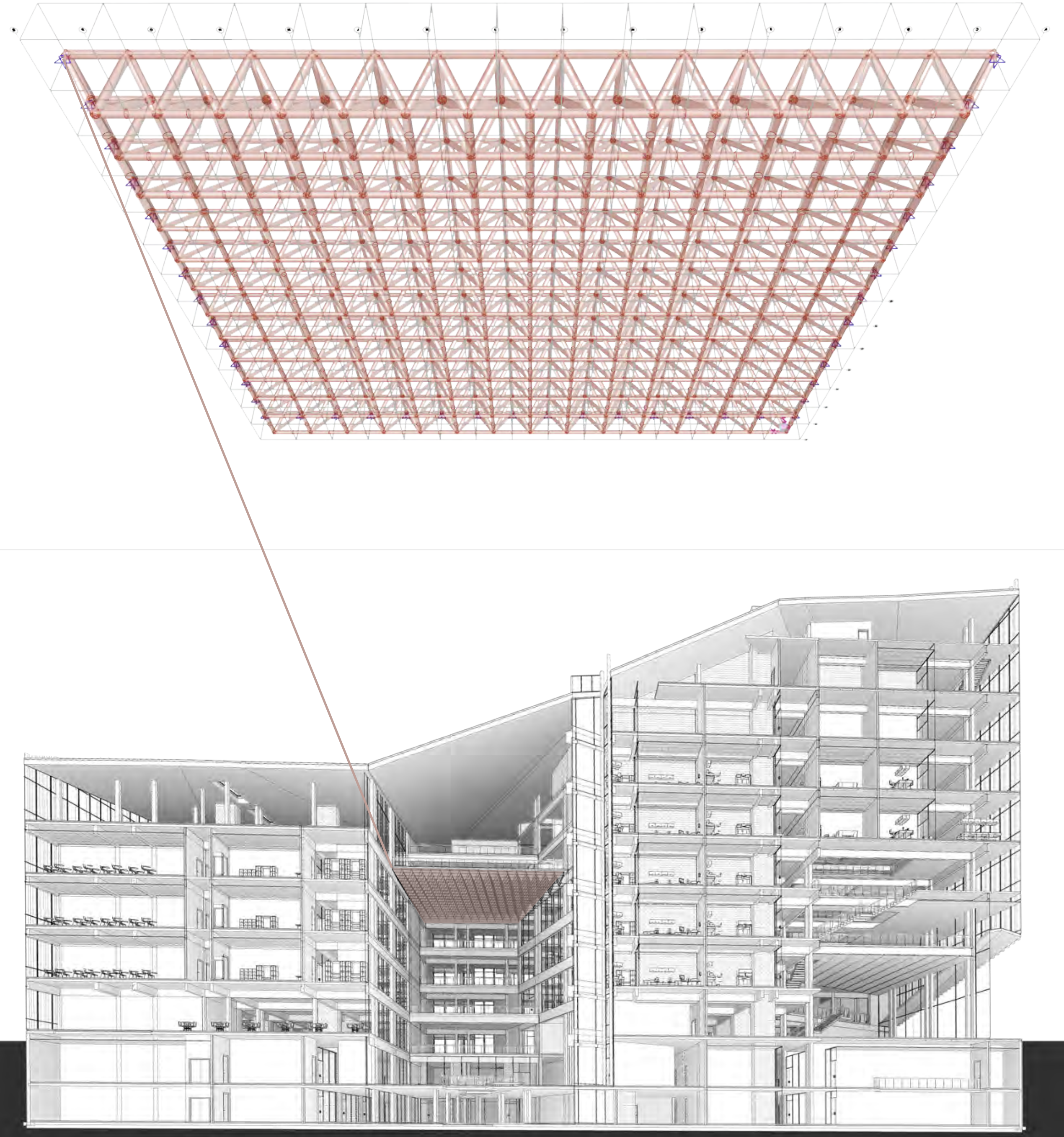
SPACE FRAME SLAB



SPACE FRAME SLAB

In a very broad sense, the definition of the space frame is literally a three-dimensional structure. However, in a more specific sense, a **space frame** or space structure is a structure system assembled of linear elements so arranged that forces are transferred in a three-dimensional manner. With the growth of new building techniques and construction materials, space frames frequently provide the right answer and satisfy the requirements

for lightness, economy, and speedy construction. It is a type of two-way truss system constructed from lightweight interlocking struts following a geometric pattern. Space Frames can be used to span large areas with few interior supports. The structures strength is due to the rigidity of the triangle and flexing loads that are transmitted as tension and compression loads along the length of each rod.

TYPES OF SPACE FRAMES **Stocked modules**

Classified into two categories, namely, Curvature Classification and Classification by the arrangement. In our case, we are using the structure on a flat slab, thus we will be using the Classification by Arrangement that can be classified as follows:

-Single-layer grid: All elements are located on the surface to be approximated.

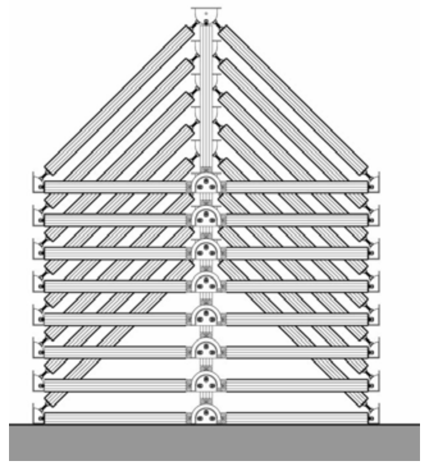
-Double layer grid: Elements are organized in two layers parallel to each other at a certain distance apart. Each of the layers forms a lattice of triangles, squares or hexagons in which the projection of the nodes in a layer may overlap or be displaced relative to each other. In this type of meshes, the elements are associated into three groups: upper cordon, cordon and cordon lower diagonal.

-Triple-layer grid: Elements are placed in three parallel layers, linked by the diagonals. They are almost always flat. Hanging cover

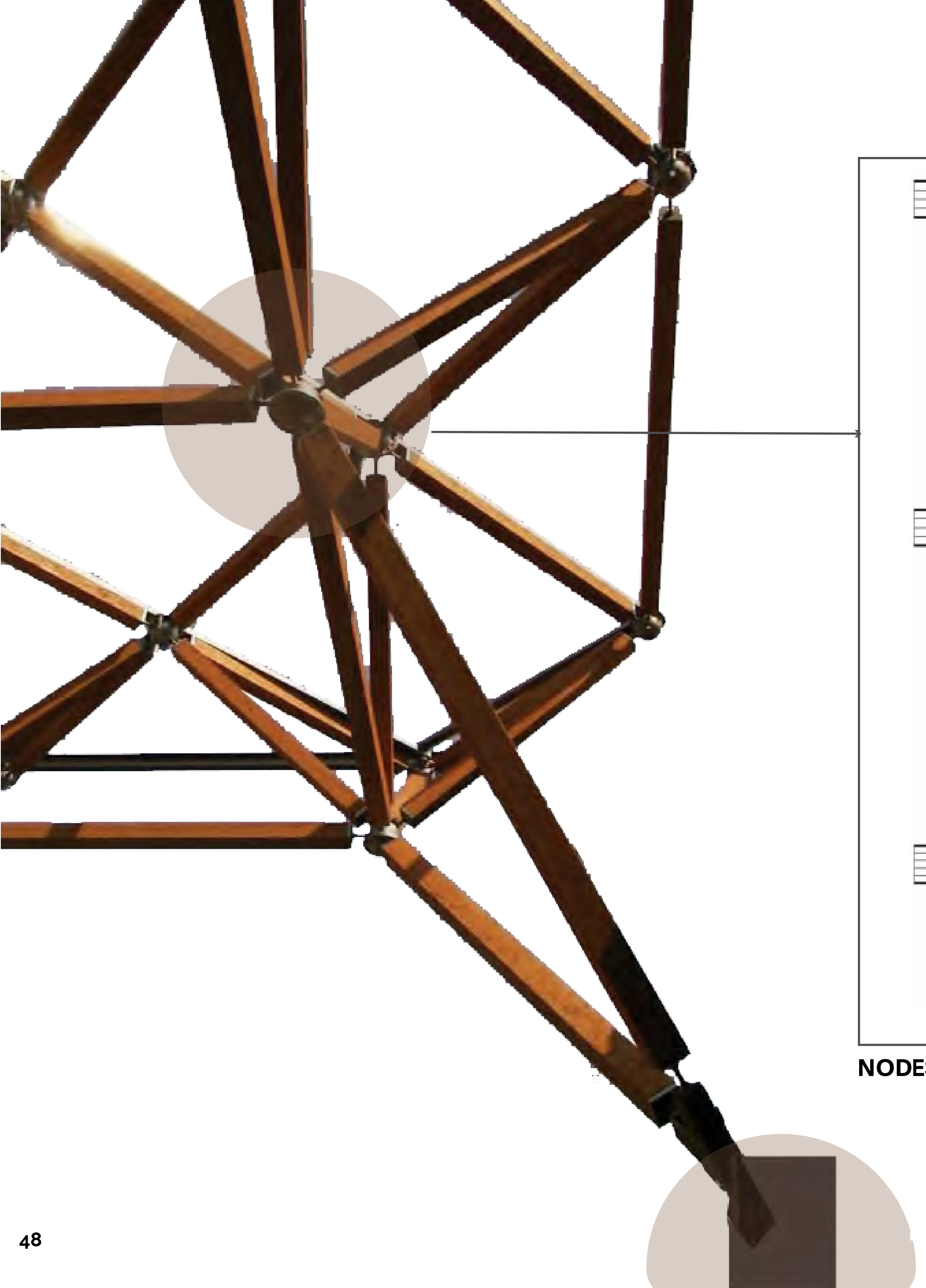
The efficiency of a timber truss solution depends, to a great extent, on the load transmitted to the bars then to the node. Resin epoxy is easy to join bars together using threaded steel rods inserted in timber. This is a highly efficient system which is can be stackable. Joining them together with glued bars gives great stiffness and strength, in addition to their ductile joints design. Pipes and ducts can also be installed in between the rods.

ADVANTAGES

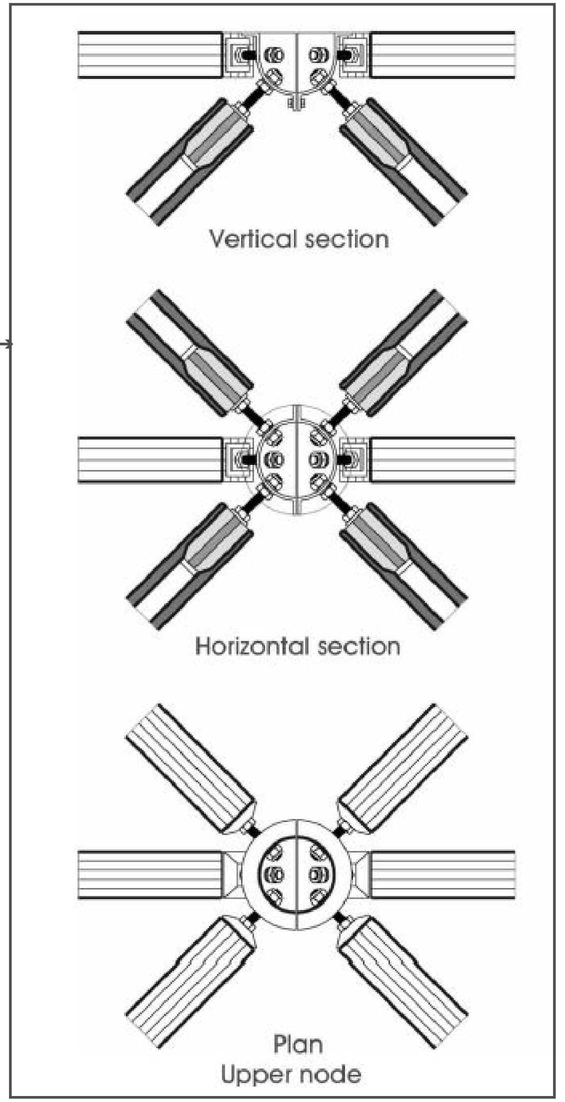
1. These three-dimensional structures aid load sharing with maximum precision.
2. Portable, lightweight, and their assembly is modular, secure and efficient.
3. It is capable of bearing heavy loadings with minimum deflections.
4. The cost of transportation is less as compared to conventional steel structures.
5. Space frame also allows odd placement of columns, along with integral cladding and glazing. Therefore, modularity is achieved with these structures.
6. They allow hassle free erection and a geometric balance, boosting the aesthetics of the construction and offers flexibility.
7. Easily expandable and are built following assembly line approaches with a very minimum amount of seismic resistance.



space frame's Stacking advantage

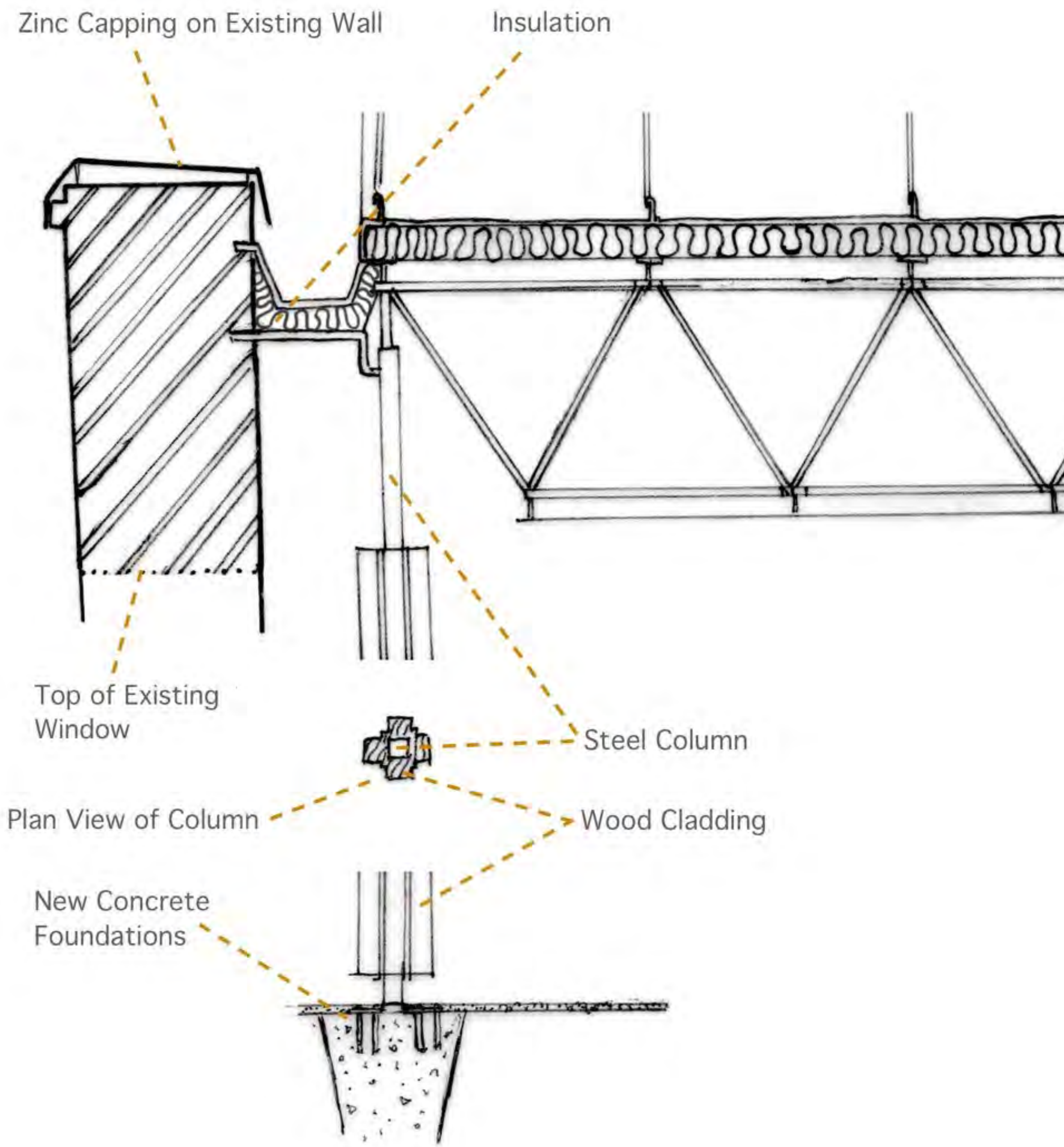


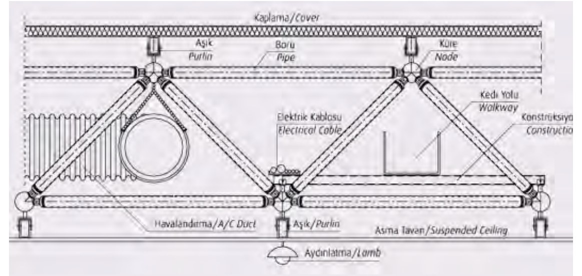
SPACE FRAME SLAB

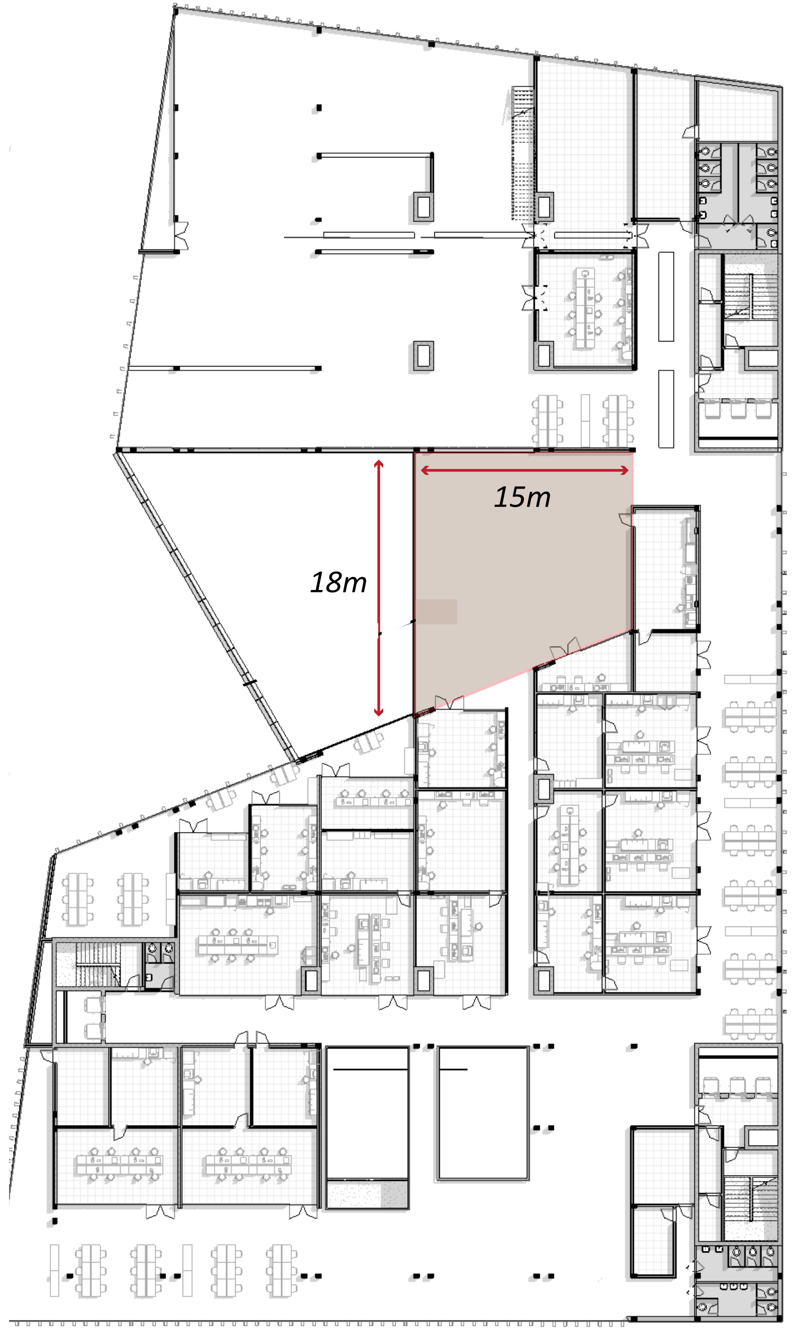


NODES

SPACE FRAME SLAB







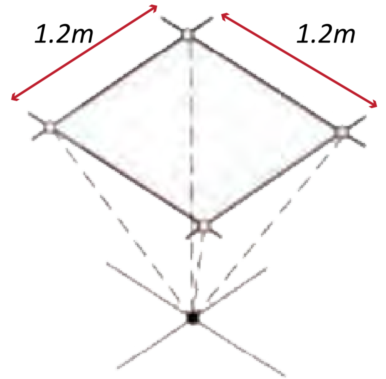
SPACE FRAME SLAB

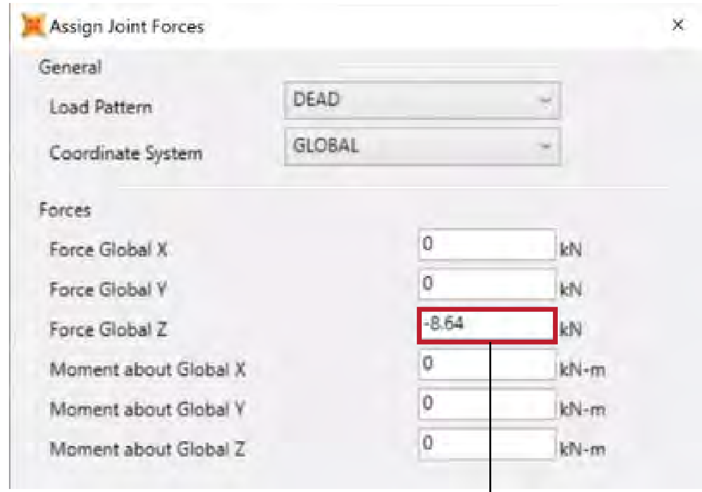
SAP2000 Software

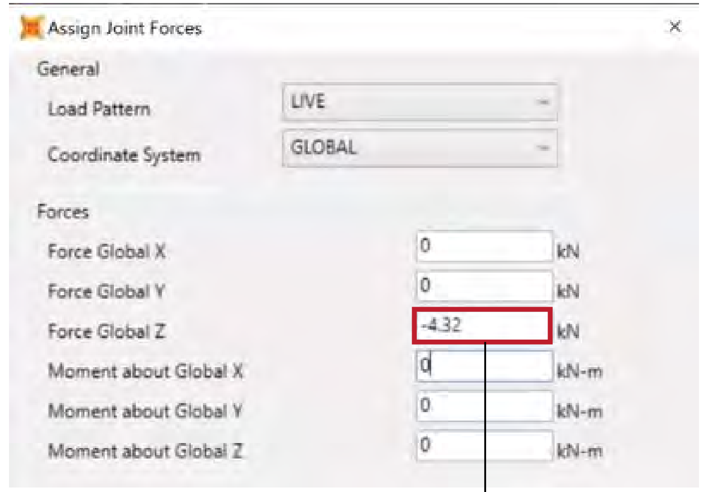
SAP2000 is general-purpose civil-engineering software ideal for the analysis and design of any type of structural system. Basic and advanced systems, ranging from 2D to 3D, of simple geometry to complex, may be modeled, analyzed, designed, and optimized using a practical and intuitive object- based modeling environment that simplifies and streamlines the engineering process. This software was used for the structural analysis procedure of the space frame. An additional suite of advanced analysis features are available to users engaging state-of-the-art practice with nonlinear and dynamic consideration. Created by engineers for effective engineering, SAP2000 is the ideal software tool for users of any experience level, designing any structural system. Using SAP we were able to identify the dimension needed for the space frame elements to hold the forum slab.

SPACE FRAME SLAB

SAP2000 Software







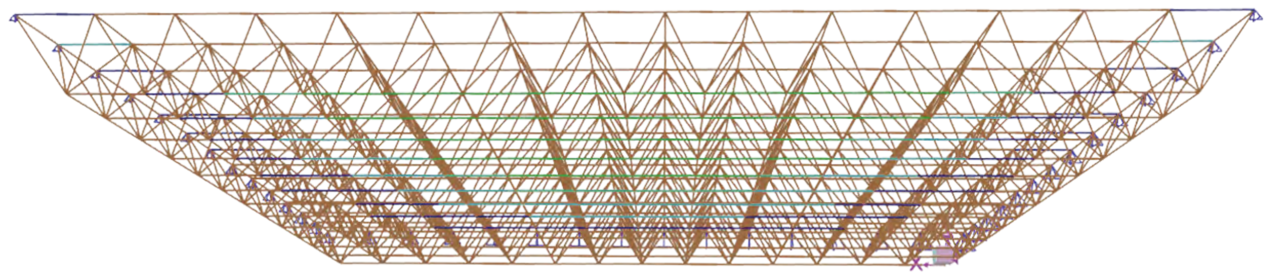
Dead Load = -6KN/m² * 1.2 m* 1.2m **= -8.64 kN**

Live Load = -3KN/m² * 1.2 m* 1.2m **= -4.32 kN**

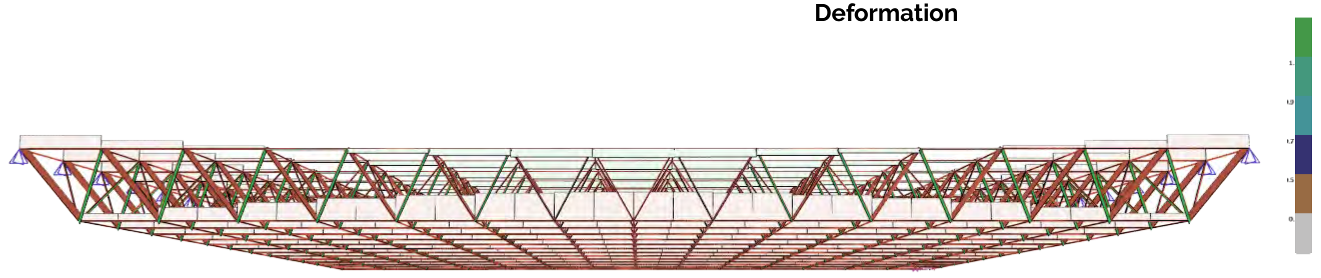
DEAD LOADS				
Name	Area Load (kN/m²)	Weight density (kN/m³)	Thickness (m)	References
Concrete	3.75	25	0.15	EuroCode
Glass rail	0.081			gov.bd.bnbc.2012.06.02
Tiles	0.5			gov.bd.bnbc.2012.06.02
Steel Deck	0.24			Gyproc Layin Grid Ceiling
Ducts and other	0.2			Walraven
	6			
LIVE LOADS	3			EuroCode

→ **Floor Load Combination DTSL2 on SAP2000** (simplified version): $q_u = \gamma_G(DL) + \gamma_Q(LL)$ = 1.35 DL+ 1.5 LL = 12.60 kN/sqm

SPACE FRAME SLAB
SAP2000 Software

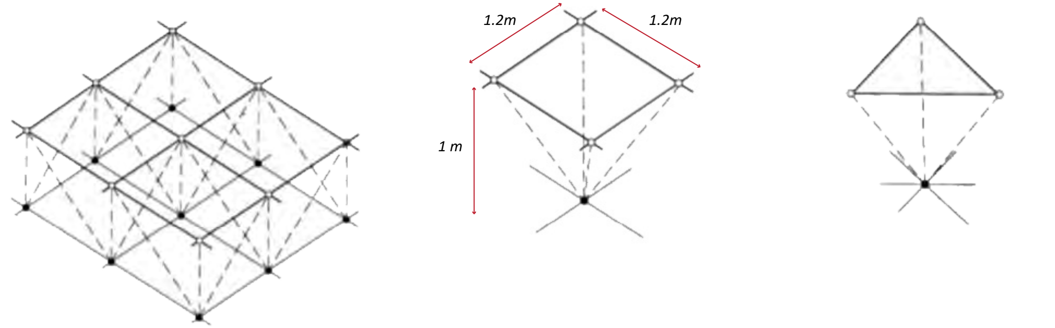


Deformation

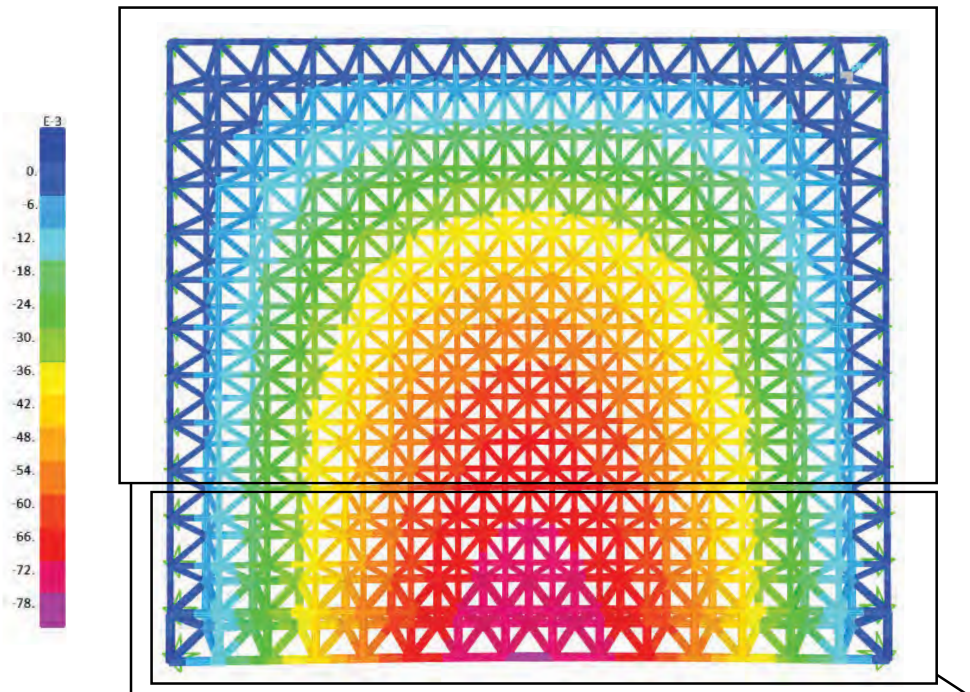


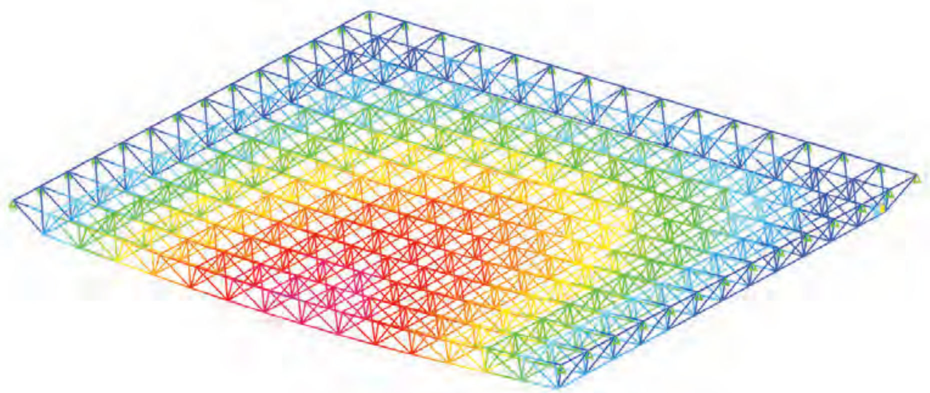
Axial Forces

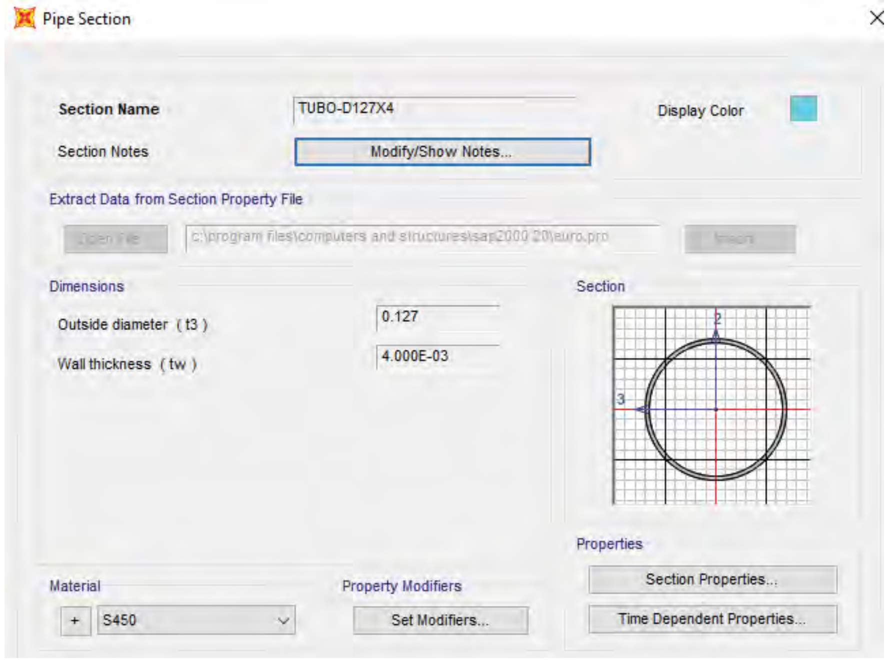
Deformation



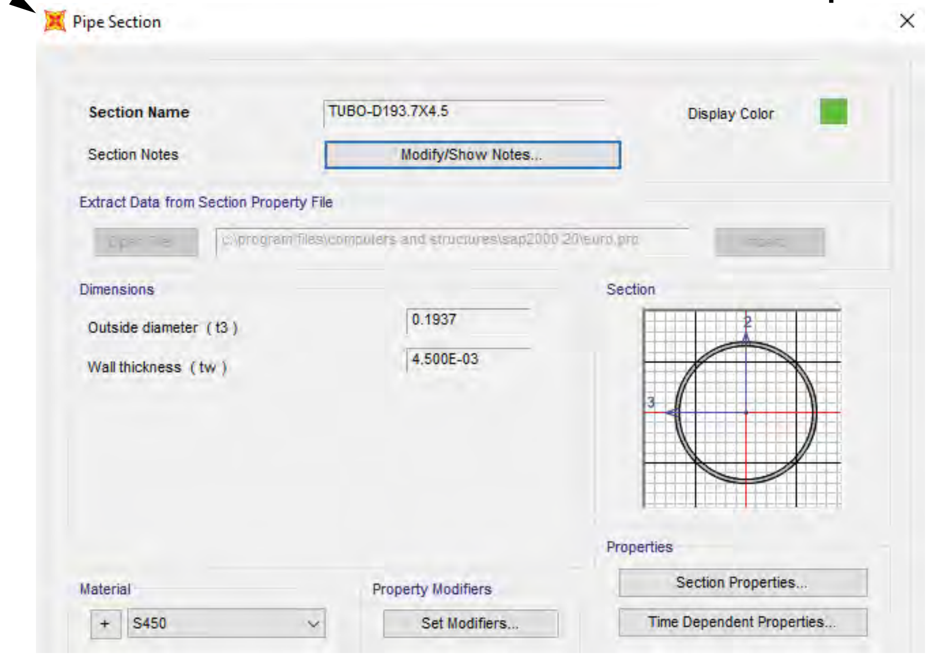
SPACE FRAME SLAB
SAP2000 Software





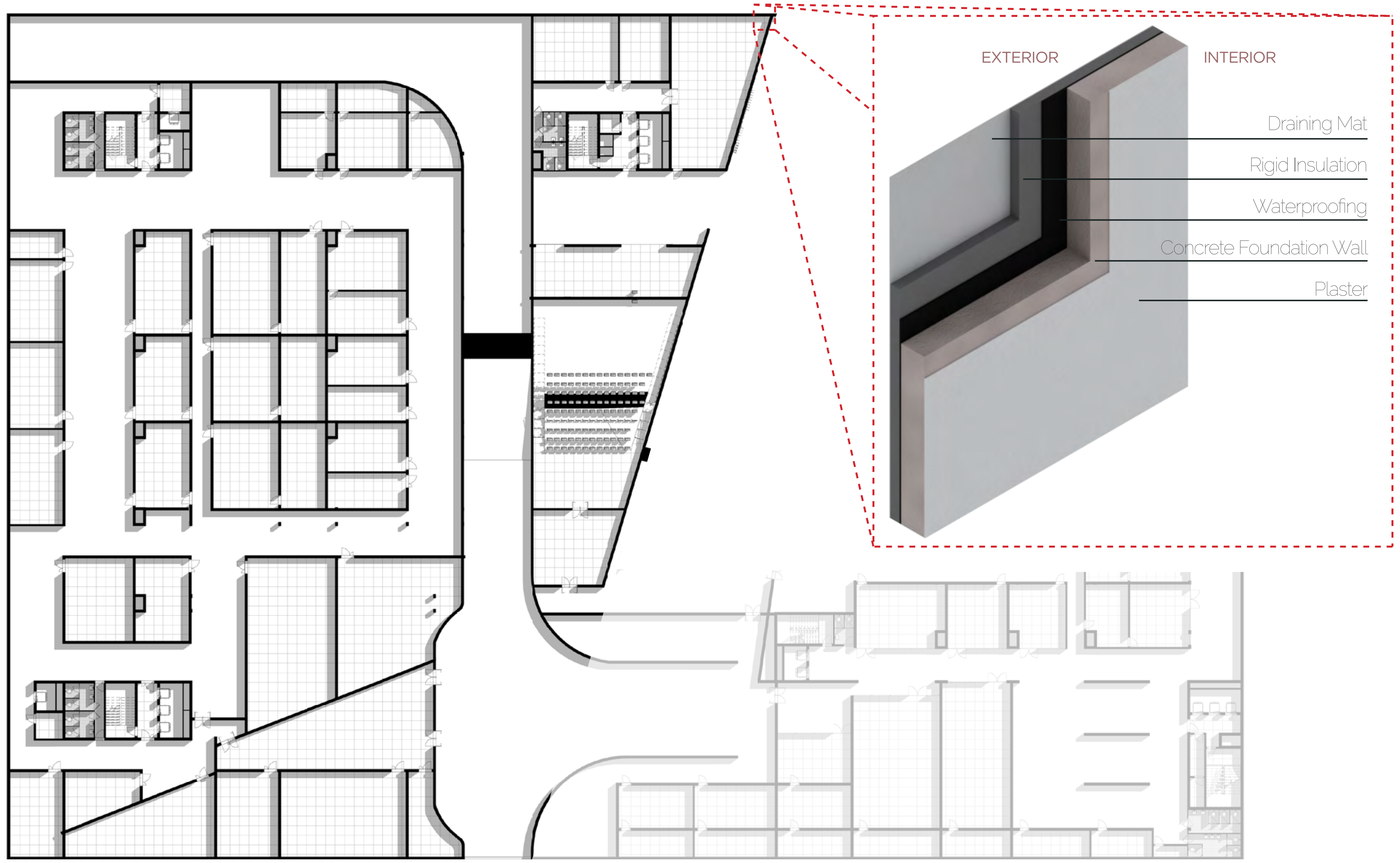


Deformation and Material Properties

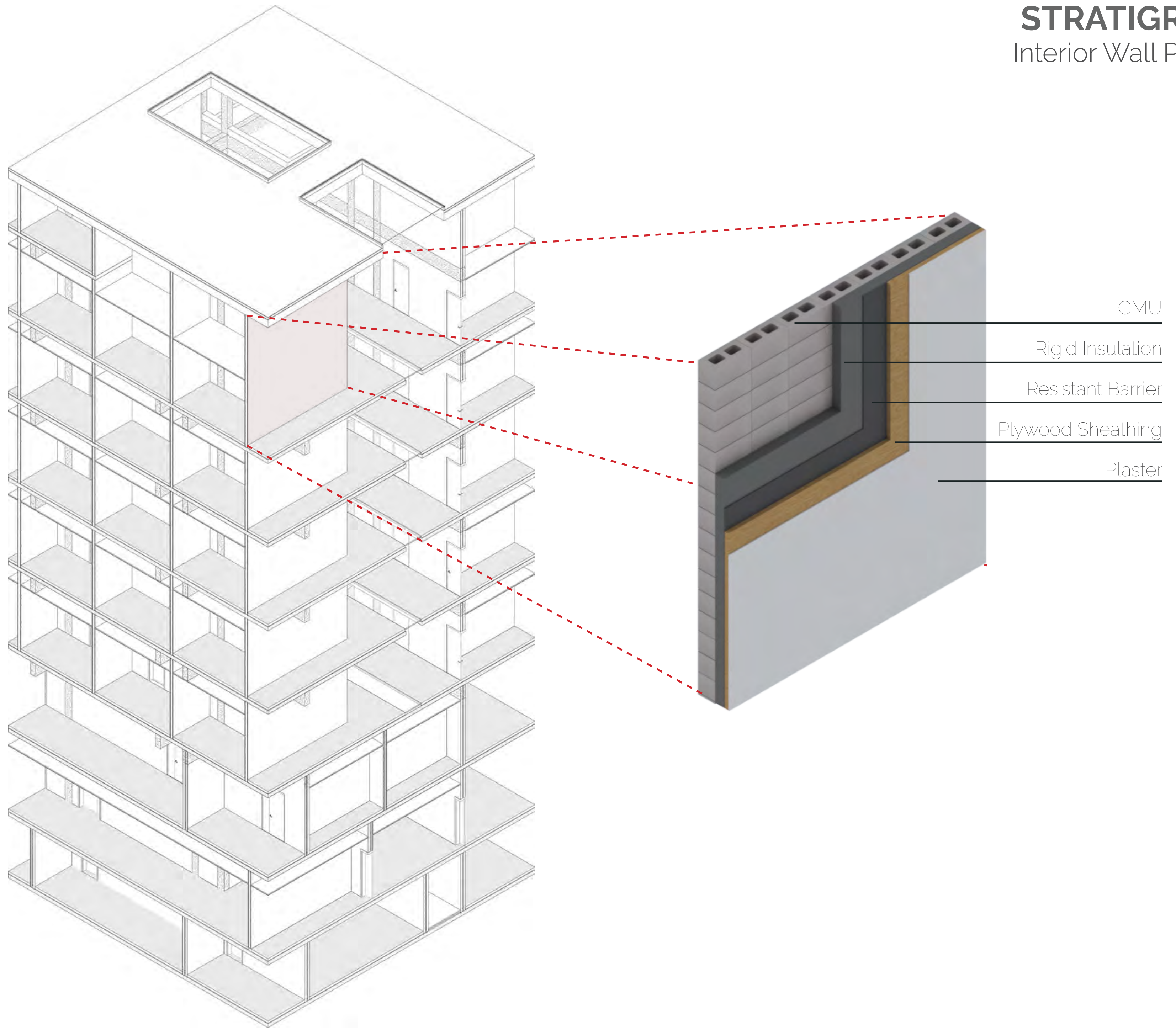


INNOVATIVE MATERIALS

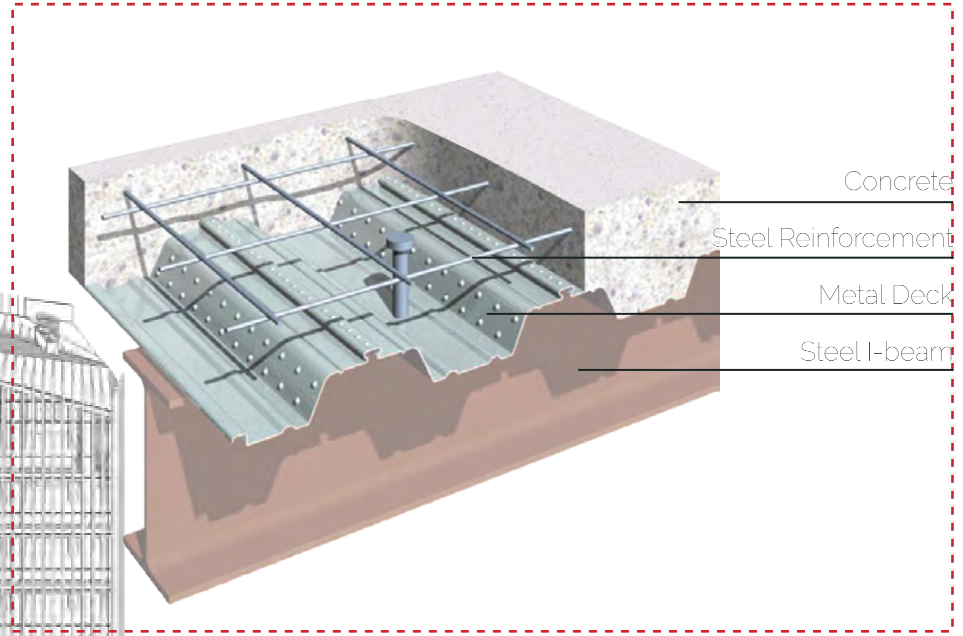
STRATIGRAPHY
Retaining Basement Wall

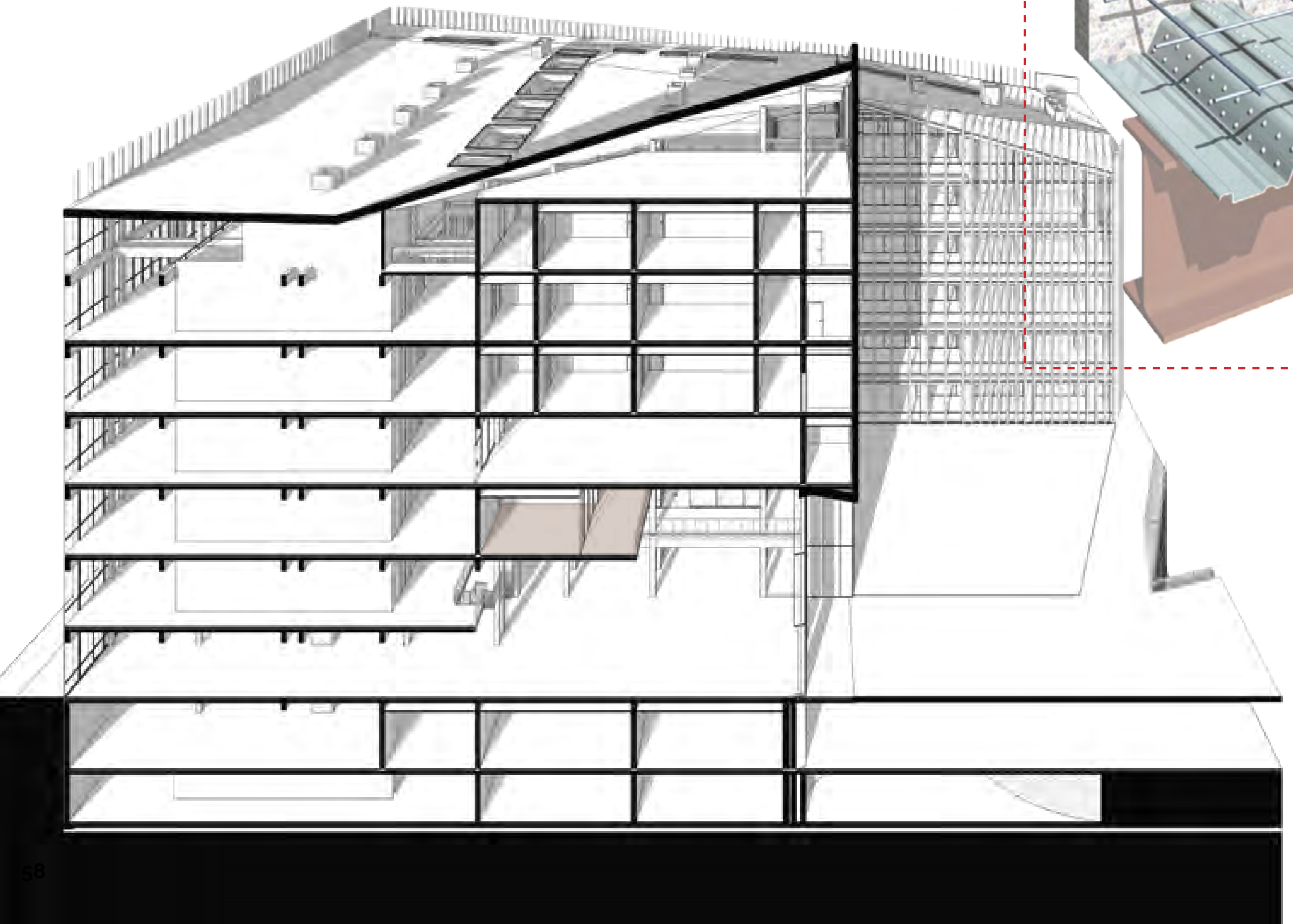


STRATIGRAPHY
Interior Wall Partitions



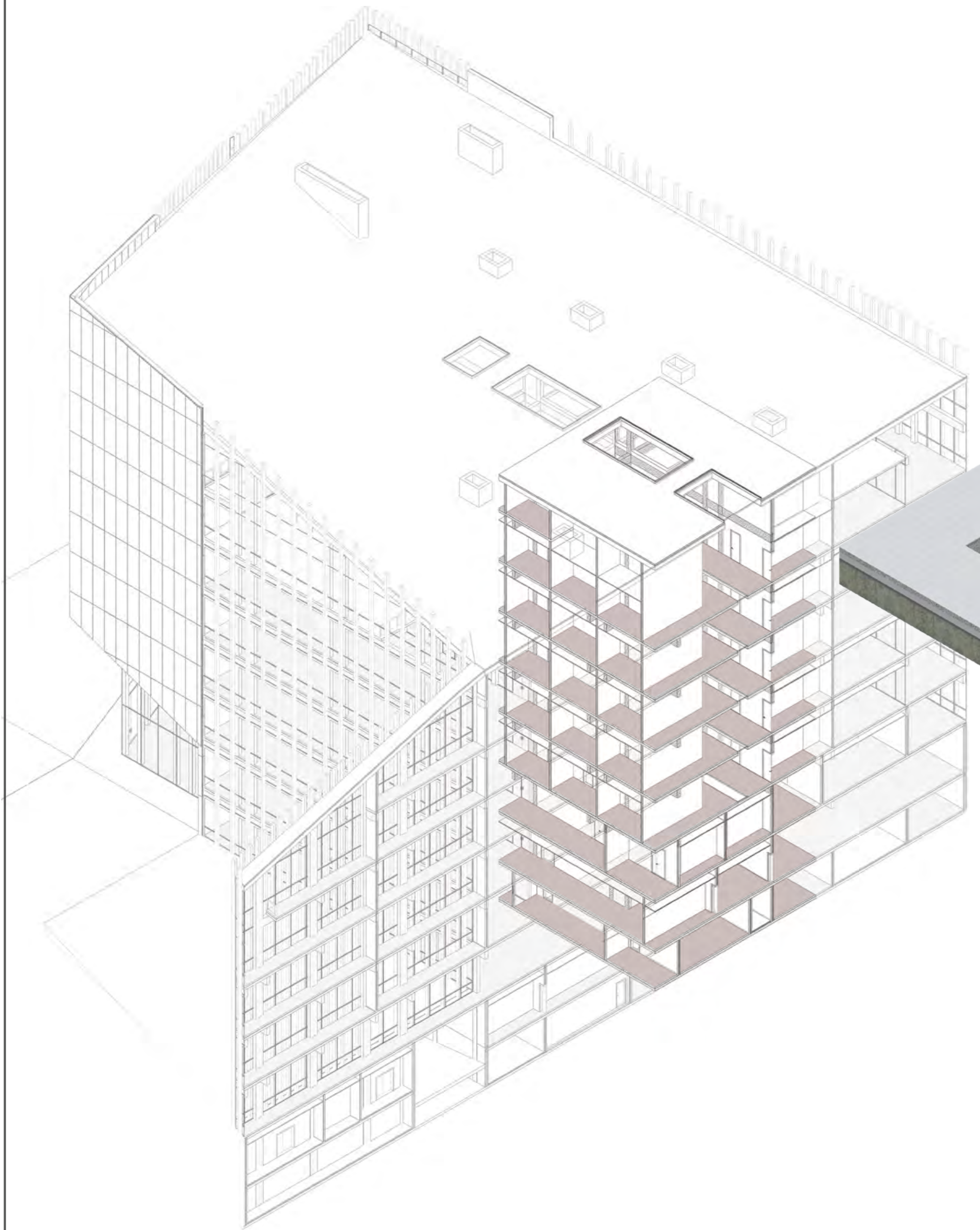
STRATIGRAPHY
Atrium Slab

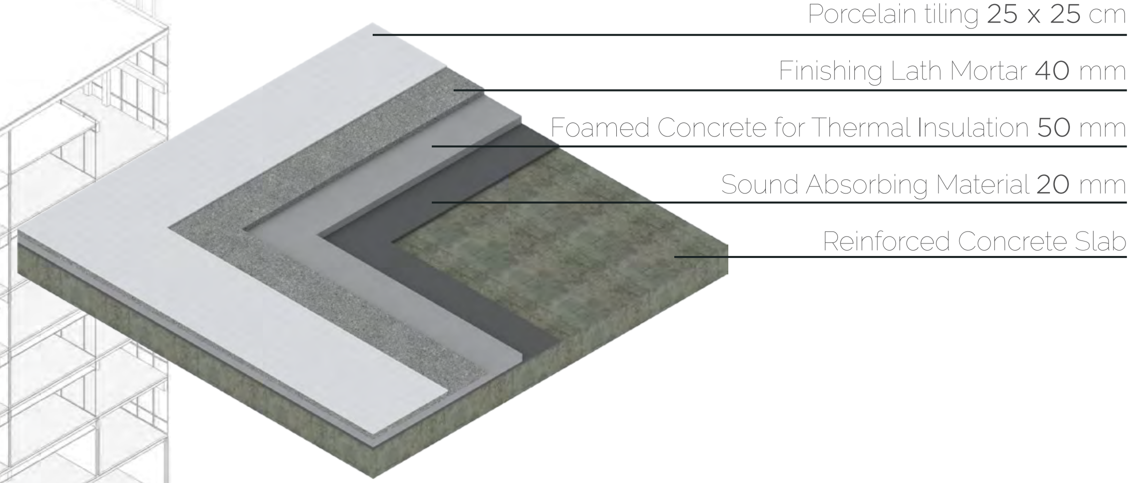




ComFlor®46 is a composite flooring profile, introduced in the early 1980s and is still popular today for its primary characteristics of being nestable, easily transported & simple and efficient. It is particularly suited for export or difficult access sites, due to the large area of flooring that will fit into a container and because the deck is fast amd easy to lay.

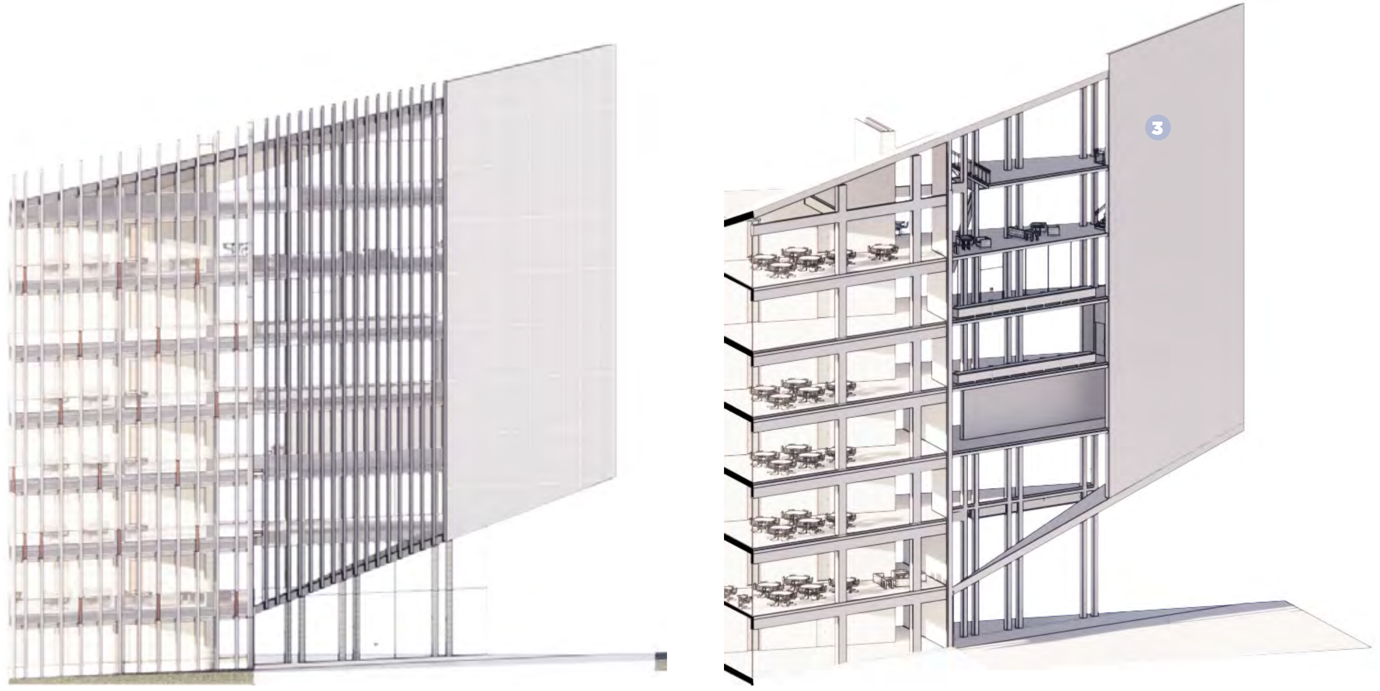
STRATIGRAPHY
Typical Floor Slab



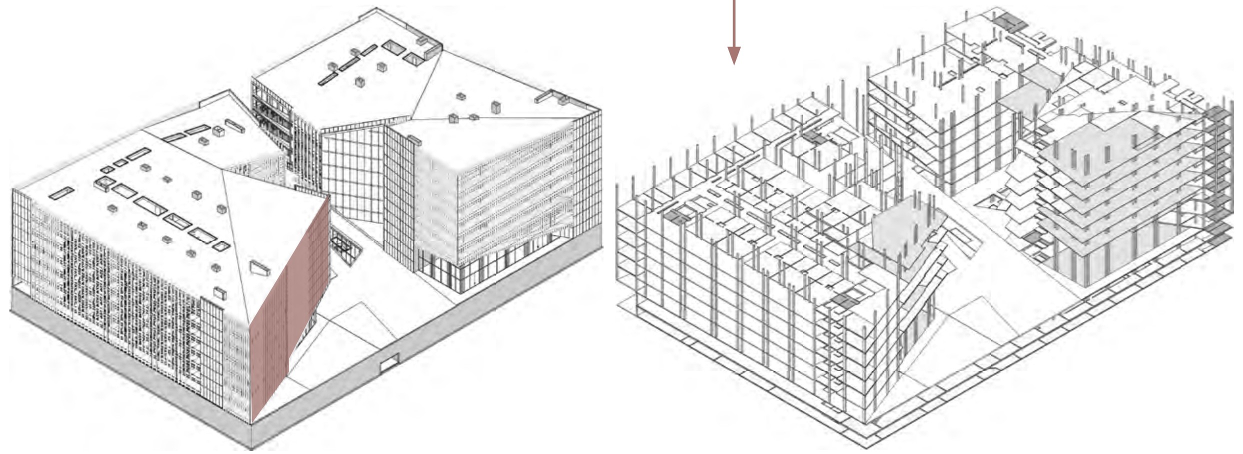


FACADE COMPONENTS

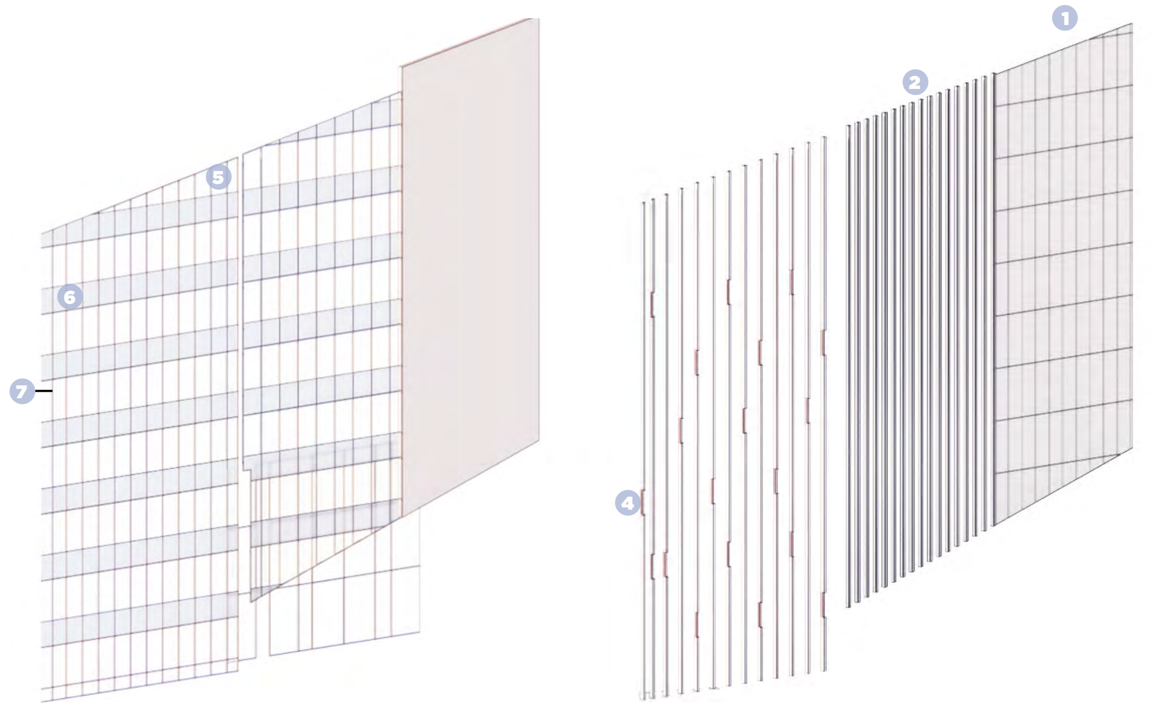
3-Layer Concept



Structural Layer

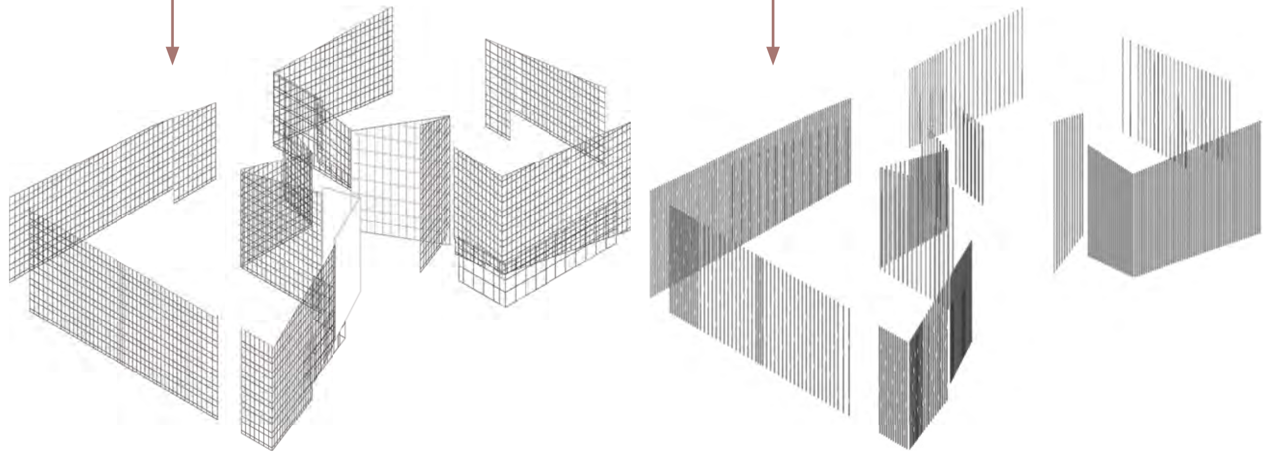


1. GFRC Cladding - Rieder® 3,600/1,200/13 mm
2. GFRC fibreC fins - Rieder® U-shape 300/200/13 mm
3. Concrete - FINJA® PreFab
4. Wooden Plank Fin Separators - HPL Board Parklex® 1,700/200/200 mm
5. Reflective Glass - Reflectasol® Ultra Grey 10 mm Triple Glazing
6. Translucent Spandrel Glass - EMALIT® 8 mm Enameled glass
7. Mullions - ETEM GESTAMP® Aluminium Extrusions S.A. 95/50 mm



Curtain Glass System Layer

Glassfibre Reinforced Concrete Fins
& Wood planks atspandrels to further define the scale of the building



1. GFRC Cladding - Rieder® 3,600/1,200/13 mm
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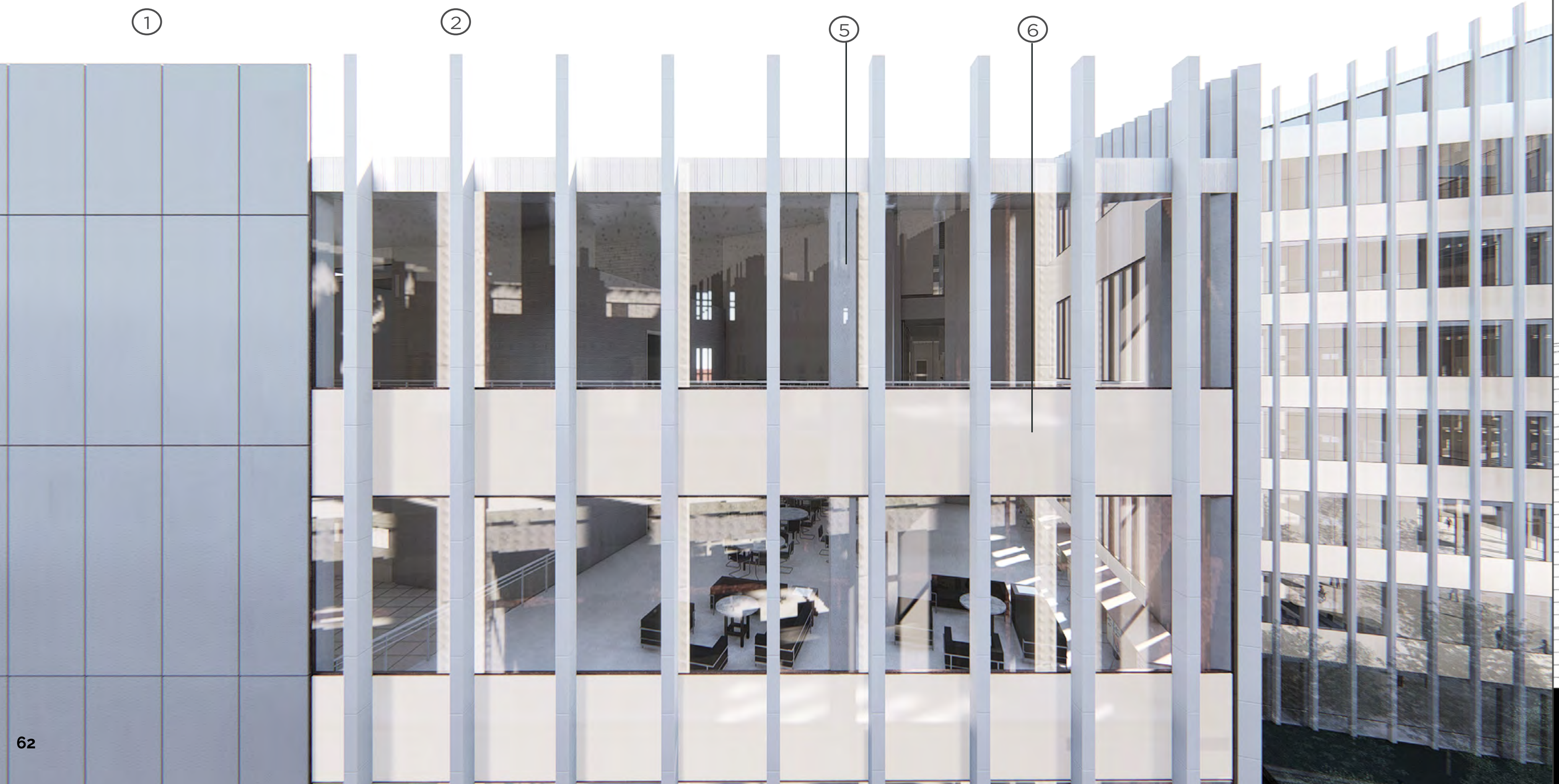
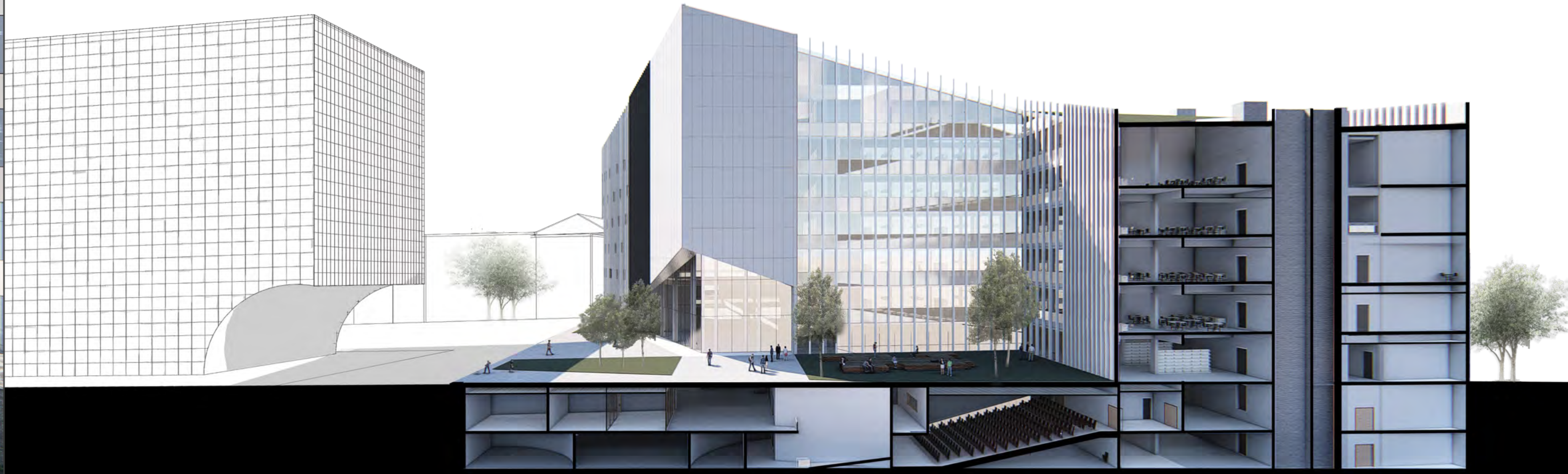


Facade Components
3-Layer Concept

Our facades are cladded with glassfibre reinforced concrete (GFRC) fins and panels, following a certain grid, but simultaneously reflecting the interior functions. The blind walls are cladded with GFRC panels of 3.6m by 1.2m, and they implicate that the function is either vertical circulation, or a private space that does not require natural daylight. The curtain glass is cladded with U-shaped GFRC fins of 30cm by 20m, and are placed at distances ranging from 0.6m to 2m, depending on the function of the space in the interior and the amount of light penetration it requires. In order to display the hierarchy of the entrances on the southern façade, the GFRC fins are chrome in color, while the rest are off-white. This strategy explicitly places the main entrances under the spotlight, making them easy to perceive from afar, and as they are being approached.



GREEN INITIATIVES

#zerowastecompany

ZERO WASTE

Waste materials resulting from the production can be used as side-products like filling materials for noise protection embankments or for sub-constructions.

CRYSTALLINE SILICA FREE

All Rieder products have always been free of crystalline silica and other hazardous components (< 1 M.-%).

GREENCRETE

Rieder's aim is to reduce or avoid pre- and post-consumer wasteby replacing raw material with recycled glassfibre reinforced concrete and by reusing offcuts.

FIRE SAFETY

Glassfibre reinforced con - crete ensures absolute fire resistance.
Panel:fire rating A1 non-combustible tested by BBA/UK
System:A-2s1, d0 non-combustible tested by MPA Braunschweig

SCRAPCRETE

Reduction of offcuts by providing intelligent tools: inverse design process 'creating from what you have' by data driven process and machine vision.

DURABILITY

Facades by Rieder require no maintenance over the years. With their long-term stability of more than 50 years, they do not need be sanded or painted.

GREEN BUILDING

Many projects built with Rieder facade products have been evaluated in accordance with building certification systems like DGNB , LEED and BREEAM .

ECO-EFFICIENCY

Only a small amount of primary energy is consumed during the production of glassfibre reinforced concrete, in turn resulting in a low CO2 load and a minimal greenhouse effect.

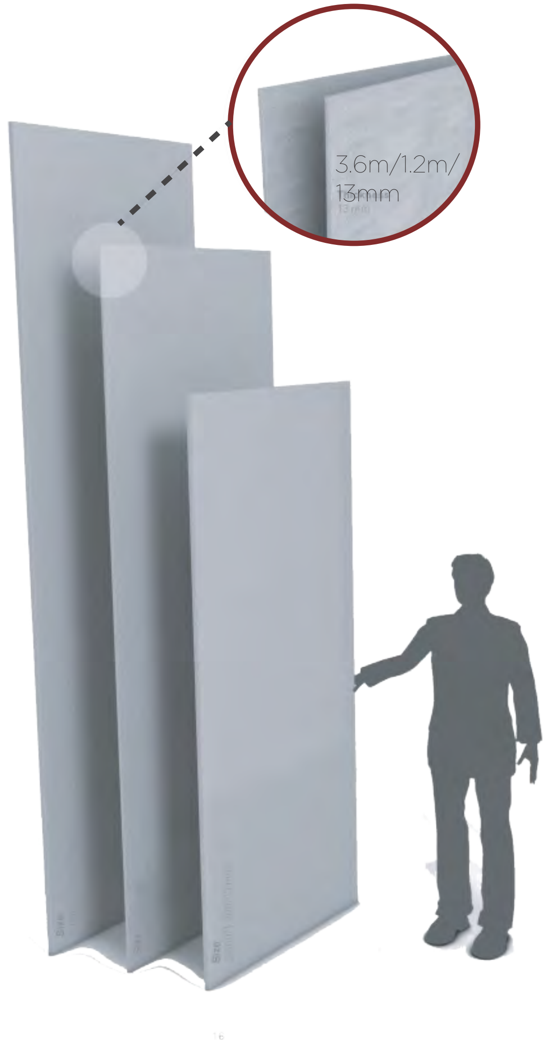
CERTIFICATES

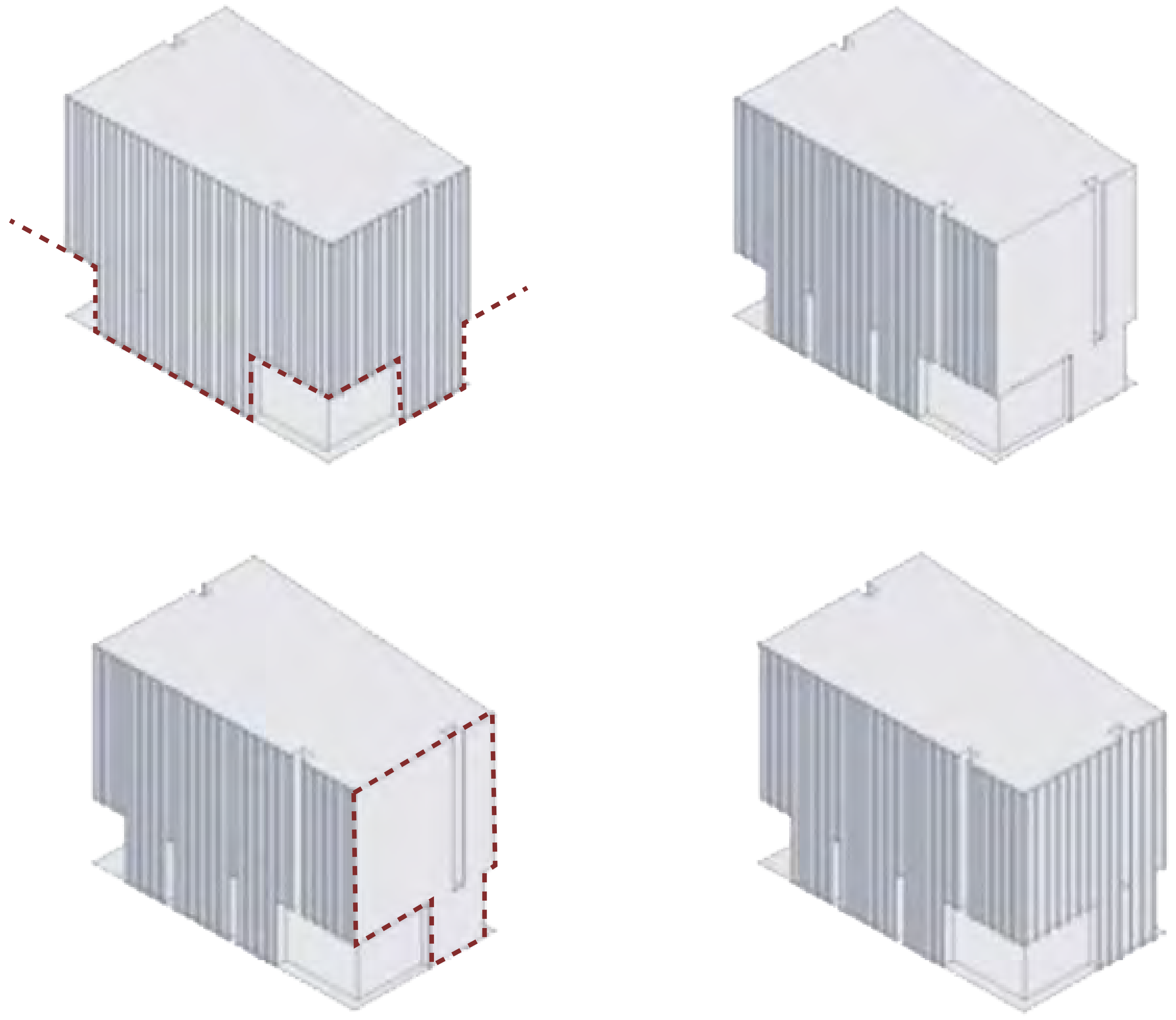
With its ISO 9001 and ISO 14001 certifications, Rieder sets high standards for environmental protection. The environmental product declaration EPD give precise indicators for lifecycle assessments.

RESPONSIBILITY

The biggest impetus for continuous development is the demand to create more than just sustainable concrete products in order to make an active contribution to the energy revolution.

Adjustable and adequate for our design; available as fins and panels.





Facade Components
Glassfibre Reinforced Concrete (GFRC)

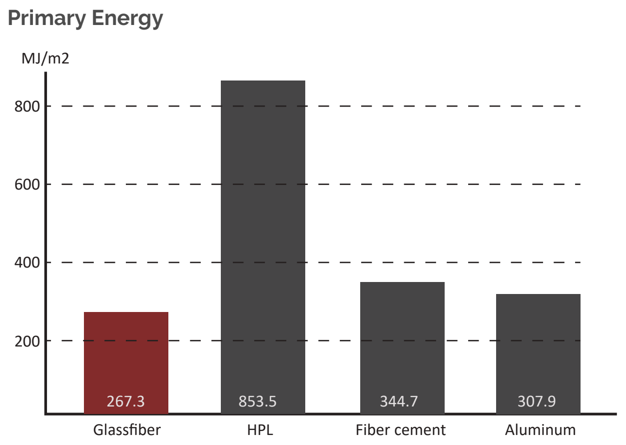
Despite their enormous length (each piece being up to 4.5 meters long), fibreC formparts can be attached to the building with only 2 fixing points per element (according to static requirements). At the crossover points i.e. where horizontal and vertical elements meet, both elements can be mounted at a common point on the building; this also allows for substructure savings. Thanks to the light weight of the elements that are only 13 mm thin, as well as the great spans, less material is necessary in the substructure.

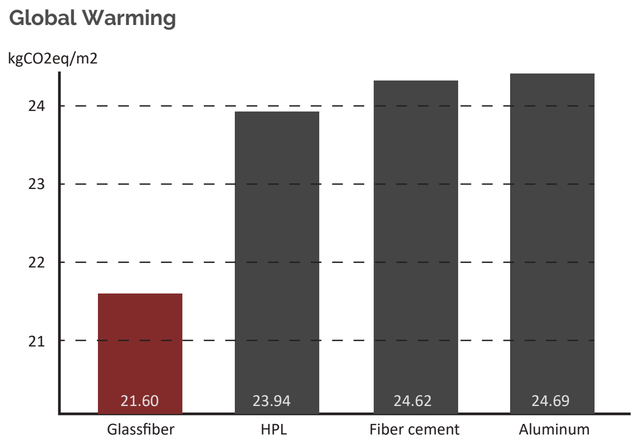
Intelligent mounting system for formparts:

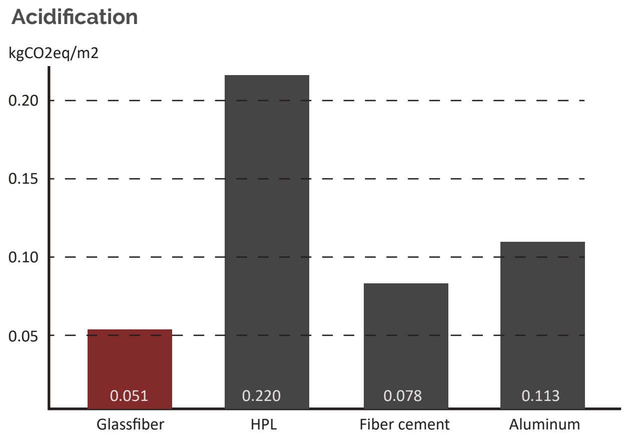
- Offsite pre-assembly of fastening brackets
- Fast and easy installation onsite
- Concealed fasting with integrated brackets
- Simple mounting and fine adjustment
- Economical solution

LIFE CYCLE ASSESSMENT

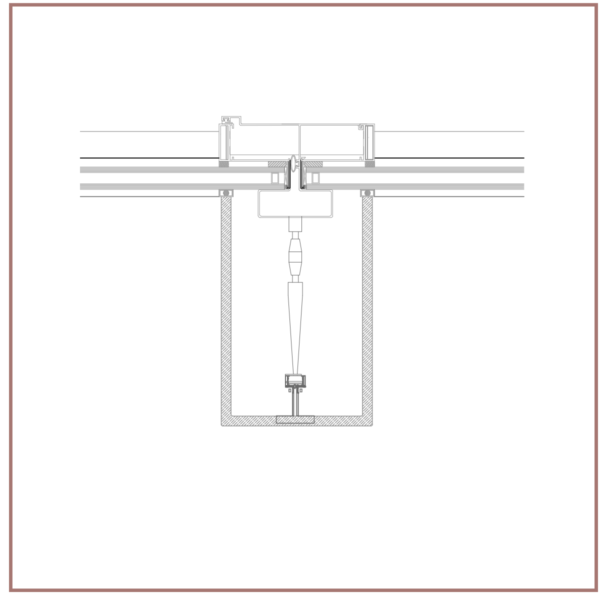
Unlike other facade materials, such as aluminum, fibre cement and HPL, only a small amount of primary energy is consumed during the production of fibreC, resulting in a low CO_2 load and a minimal greenhouse effect. (Source IBO product testing 2016/12)

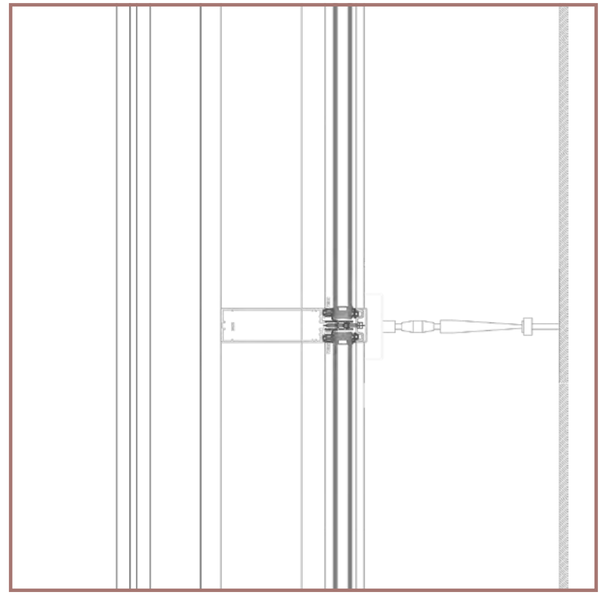


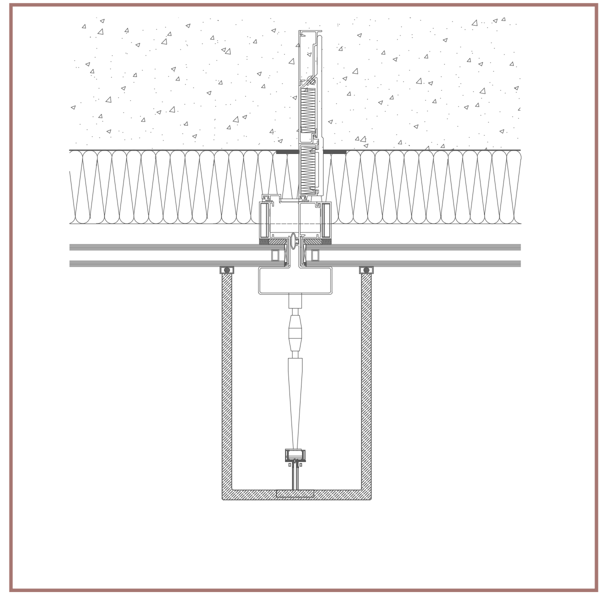


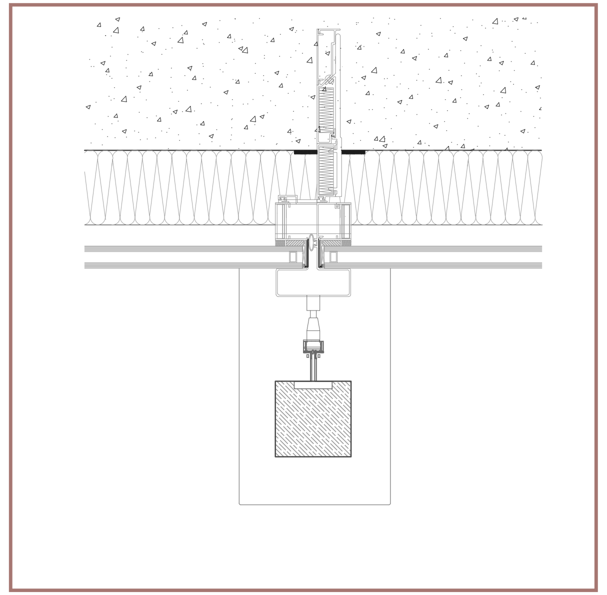


Facade Components
GFRC Fins


GFRC fin connection on curtain glass


Curtain glass section detail- Fin in projection


GFRC fin connection at spandrel


Wood plank connection at spandrel

Facade Components
Concrete (FINJA PreFab)

Concerete Columns: the use of a coupled columns system is adapted for both structural and aesthetical reasons. On one hand the coupled columns follow the grid of the structural shafts. On the other hand, they are used in the facades, and areas emphasizing the hierarchy of the spaces such as the entrances and the forum.

Concrete Beams

Cradle to Gate lifecycle stages

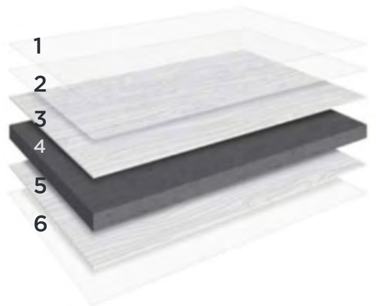
Module A1 Raw materials	Module A2 Transport	Module A3 Manufacturing	Module A4 Transport
Steel Cement Aggregates Water etc.	Truck transport from suppliers	Internal storage Mould assembly Fixing of rebars Casting Curing Demoulding Storage	Truck transport to customers

Weight % per tonne of precast concrete product	Reinforcement	Cement	Aggregate	Water
Solid precast concrete walls, balconies, columns, beams and stairs	5,2	16,1	71,7	7,0

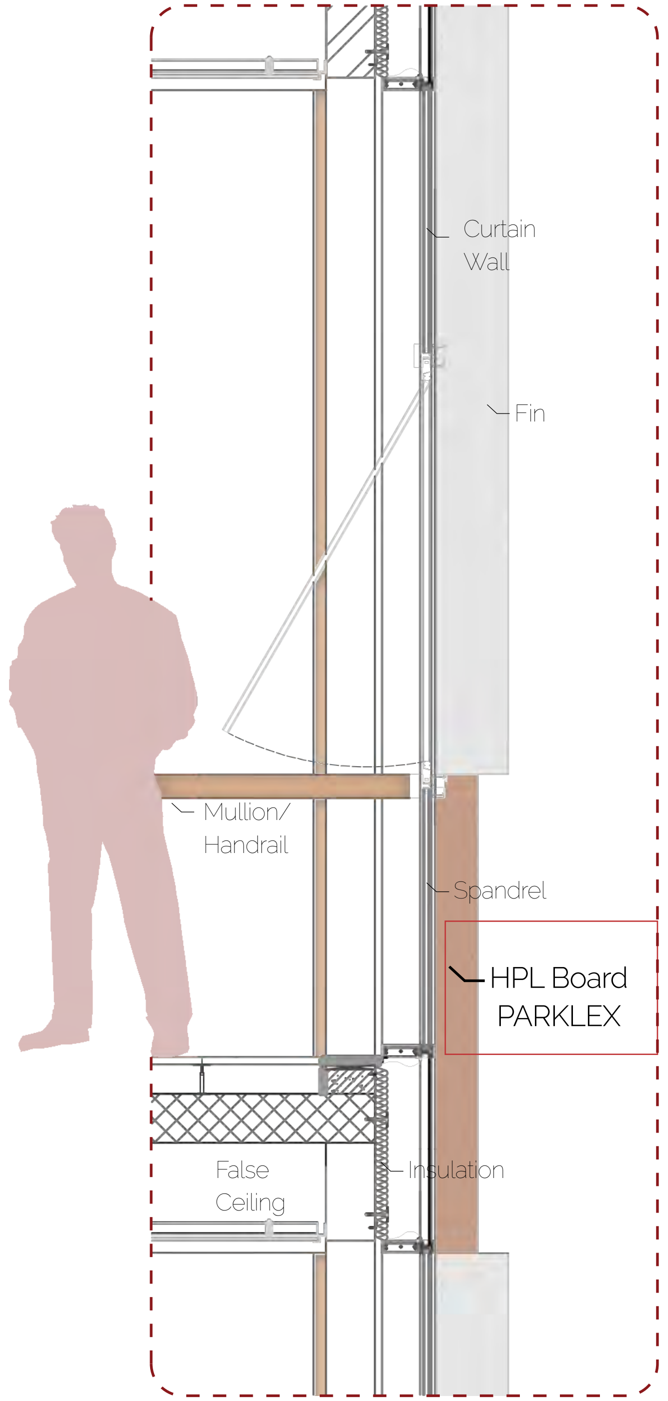
Facade Components
Wood Plank-Fin Seperator

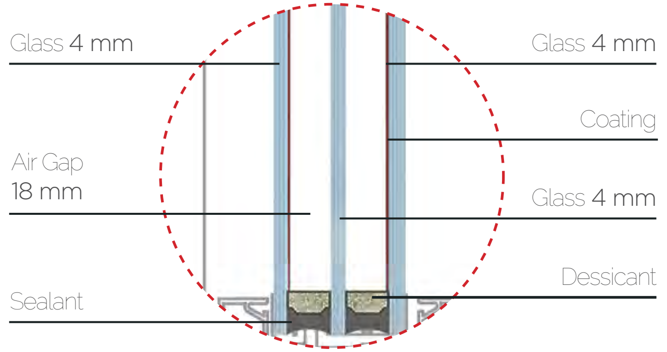
Parklkex The company has acquired a commitment to nature by promoting a respectful and sustainable management with the environment, and particularly with the sustainable exploitation of forests. The panels are formed of a high density bakelite core, coated with a natural wood treated with synthetic resin. In the case of facade an additional film improves the durability of the panels, conferring anti-adherent properties protecting against of solar radiation, atmospheric agents, dirt and chemical attacks.

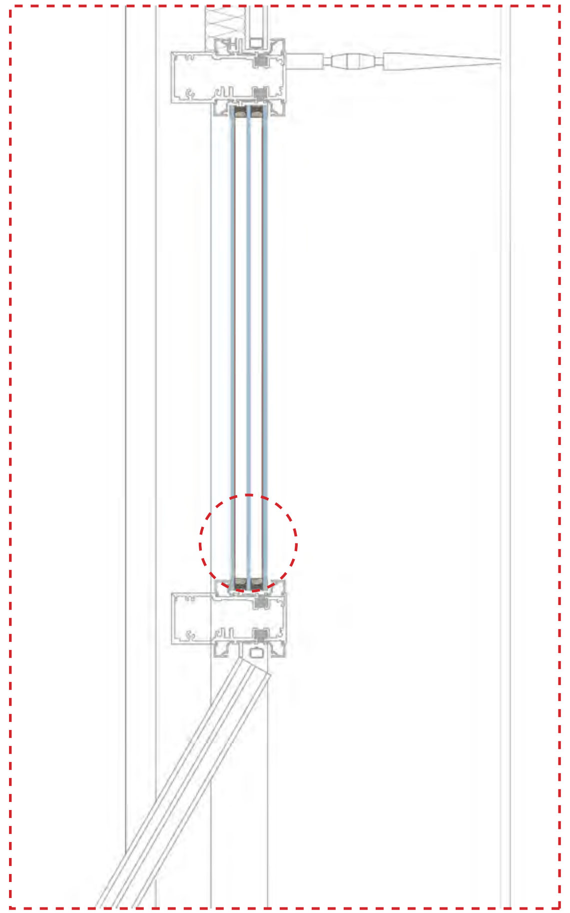
Both product families are produced in two different ranges in relation to their fire behaviour, standard (S) and fireproof (F) for the improved fire reaction class.

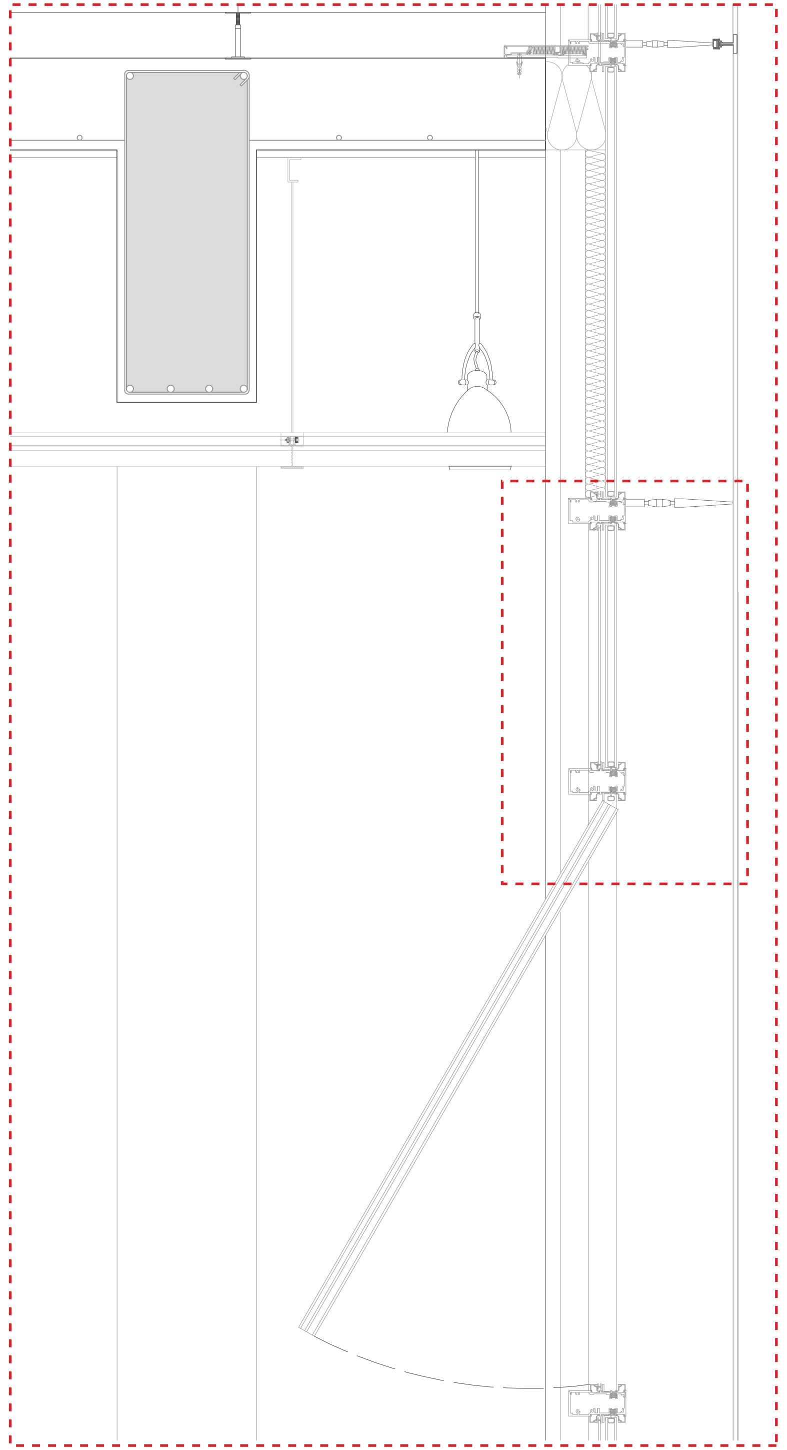


1- Additional Film on exterior
2- Synthetic Resin
3- Natural Wood
4- Bakelite Core
5- Natural Wood
6- Synthetic Resin









Facade Components
Reflective Glass

Facade Components
Reflective Glass

Reflectasol: reflective, solar control glass - soda-lime silicate glass produced using the float procedure, on which a CVD coating has been applied. The glass is meant to be used in building, furniture & industrial applications. It is manufactured by a process known as 'On-line pyrolitic coating' (or Pyrolytic Chemical Vapor Deposition) wherein a coating is applied to the glass surface by means of pyrolysis. Also known as hard coating, the process fuses precious metal oxides on the surface of the float at high temperature while the glass is in formation. This gives it a number of properties:

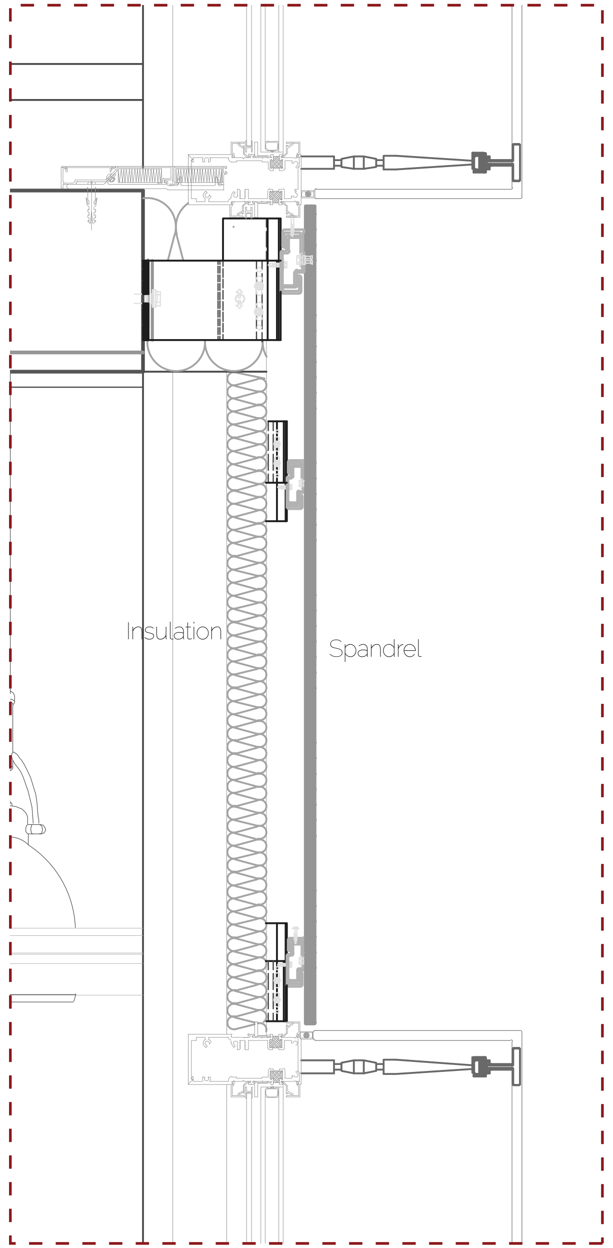
- Total integration with the surface of the glass.
- Strength and stability over time.
- Solar control properties and a reflective appearance.

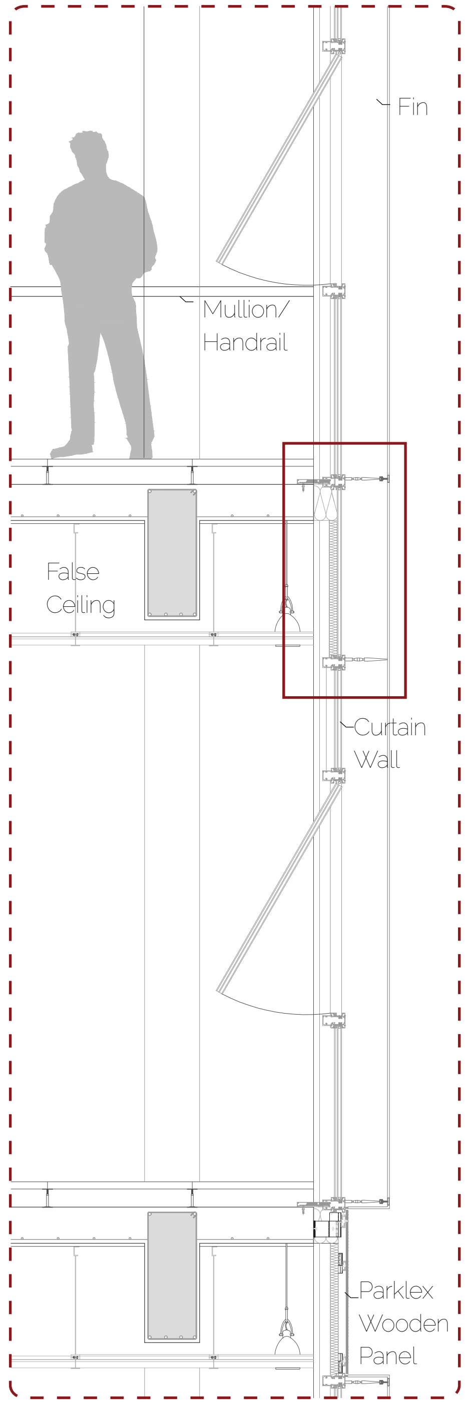
SGG REFLECTASOL Ultra Grey (on SGG PARSOL Ultra grey)

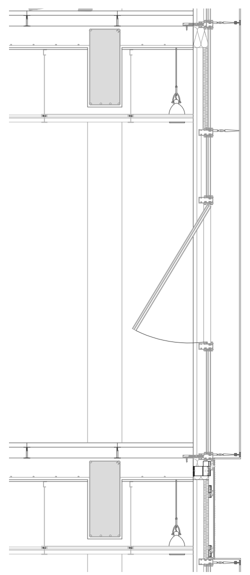
Thickness (mm)	4	5	6	8	10
Visible parameters					
Light transmittance (LT) %	3.4	1.9	1.1	0.4	0.1
External light reflection (RLE) (%)	4.8	4.5	4.4	4.3	4.3
Energetic parameters					
Energy transmittance (ET) %	4.4	2.6	1.5	0.5	0.2
Energy absorbance (EA) %	91.0	93.1	94.2	95.2	95.5
Solar factor g	0.26	0.25	0.24	0.23	0.23

Declaration of the main product components and/or materials

Components	Weight (in %)	Comments
Glass	More than 99.99%	CAS number 65997-17-3, EINECS number 266-046-0
Coating	Less than 0,01%	Metal oxides, which bring all the thermal properties to the glazing

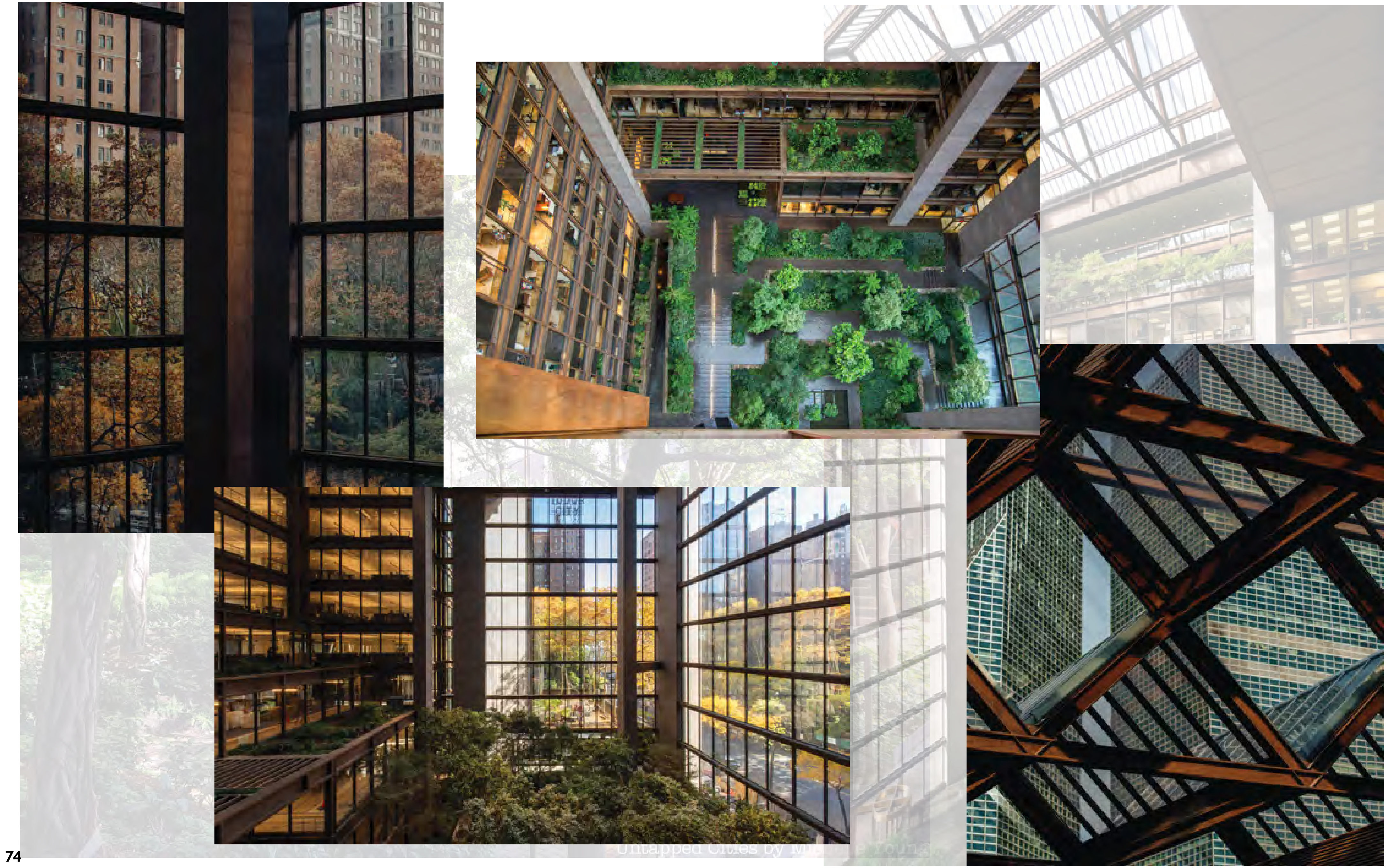






Facade Components
Translucent Glass Spandrel

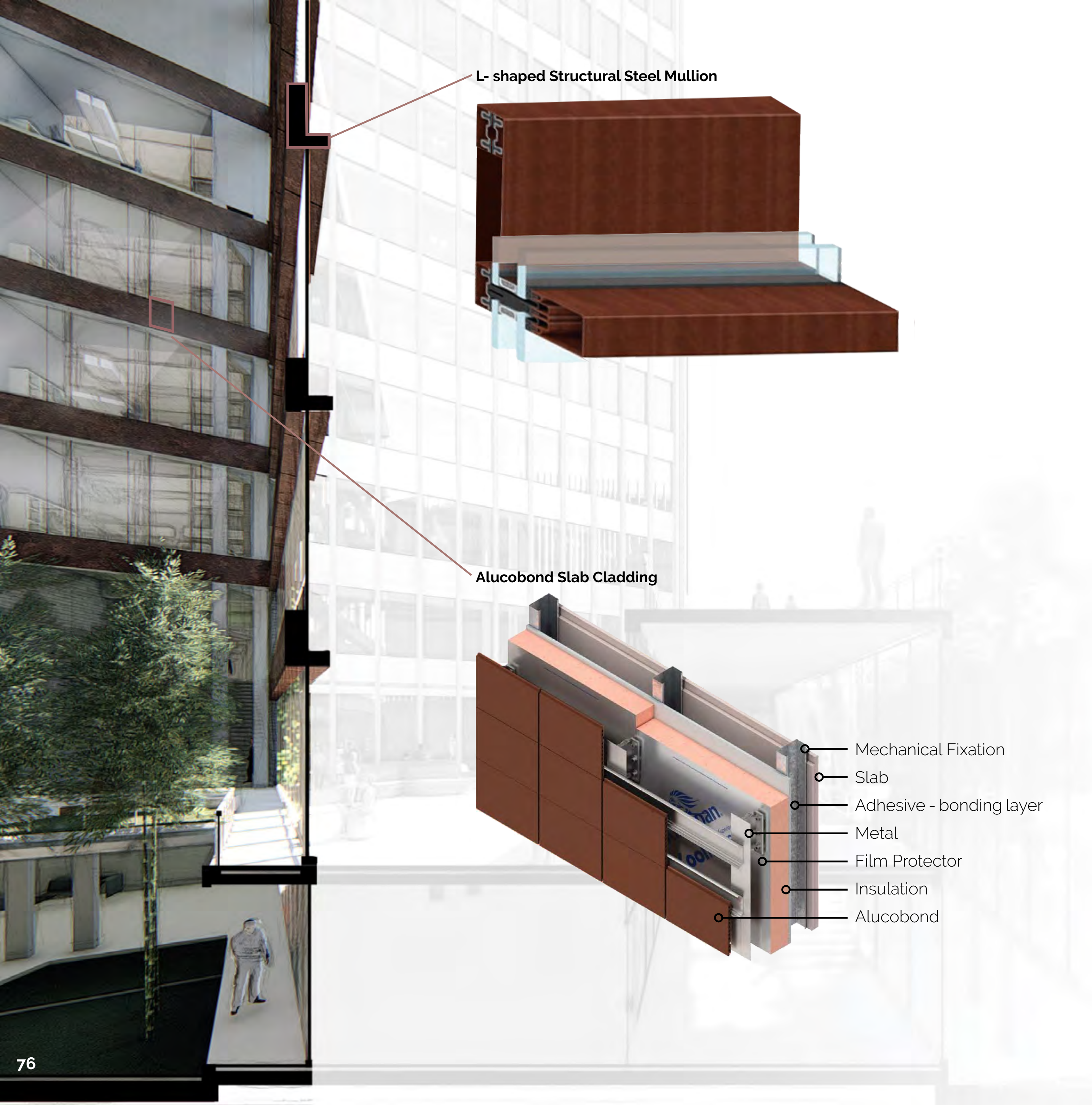
Ford Foundation - New York
Precedent



Forum Proposal
Heart of the Building

The slabs will be cladded with aluminum with the steel "feel" rather than actual steel because it is more sustainable and lightweight. As it is lighter, aluminum cladding is easier to install than steel, and this can sometimes save costs. Being a product that is virtually maintenance free (aside from a yearly wash) metal cladding is also resistant to fading or bleaching from the sun. It is typically coated with a tinted weatherproof topcoat that should last for many years. Steel cladding can be vulnerable to rust however, so any chips that are noted in the finish should be addressed immediately.

8- Aluminum Cladding
9- Structural Steel L-profile
10- Switchable Glass
12- Steel Space Frame



FORUM

Structural Steel L Mullion
Aluminum Composite Panel

FORUM

Structural Steel L Mullion
Aluminum Composite Panel

Hot Rolled Structural Steel: The products included in this EPD do not contain any substances of high concern as defined by European REACH regulation. When a structure reaches its end-of-life, the majority of the steel used in the structure is recovered.

The typical composition of OneSteel's hot rolled sections is:

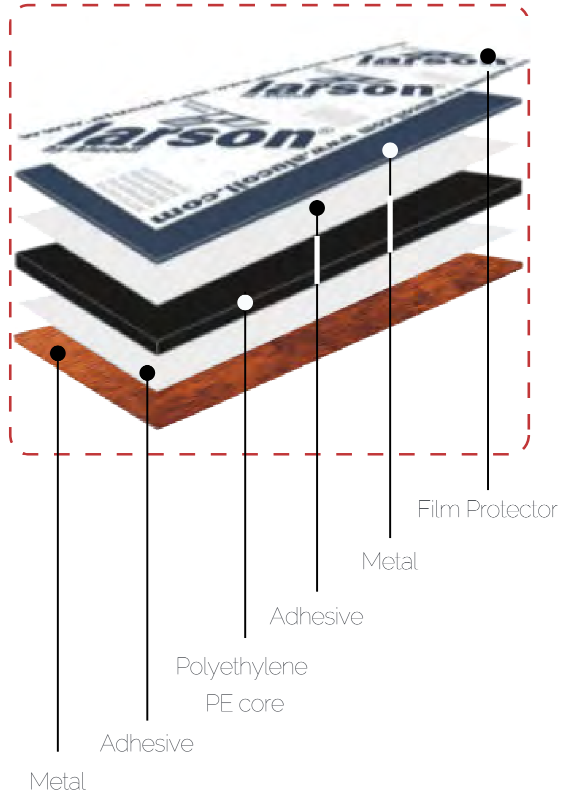
Iron >%98

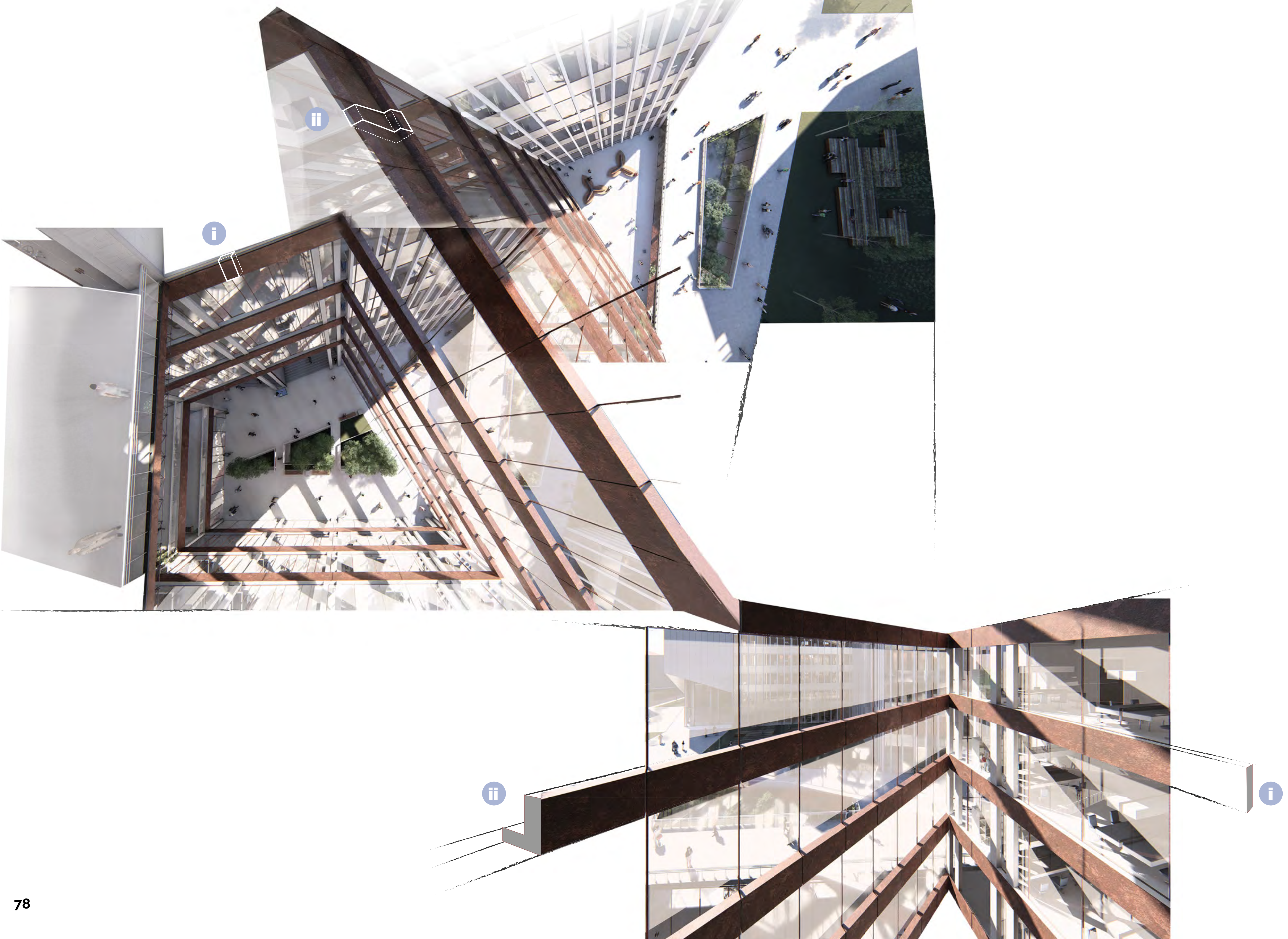
Manganese <%1.6

Carbon <%0.5

Other <%0.5

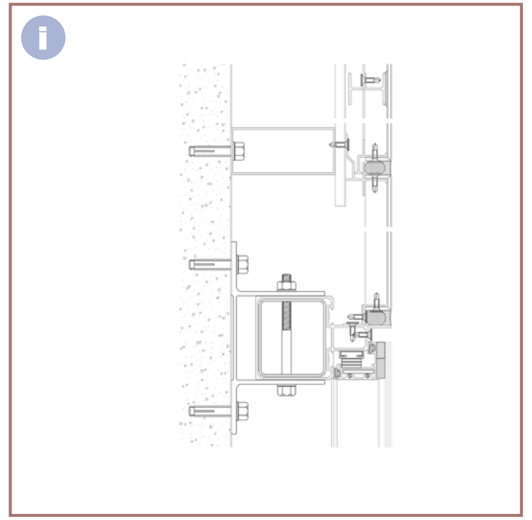
Aluminum Cladding larson pe®-larson fr® The products are composite panels or sandwich panels of various dimensions made of two aluminium sheets, which are joined together by a thermoplastic resin polyethylene (PE) core or a mineral (FR) core. Aluminium front sheet: it is coated of PVdF %70 Kynar 500 or similar. Both sides require anticorrosion pretreatment to facilitate the adherence and a primer layer. Aluminium back sheet: it is treated to provide the product with a regular and well attached layer which will protect it against corrosion and increase the adherence of the core.



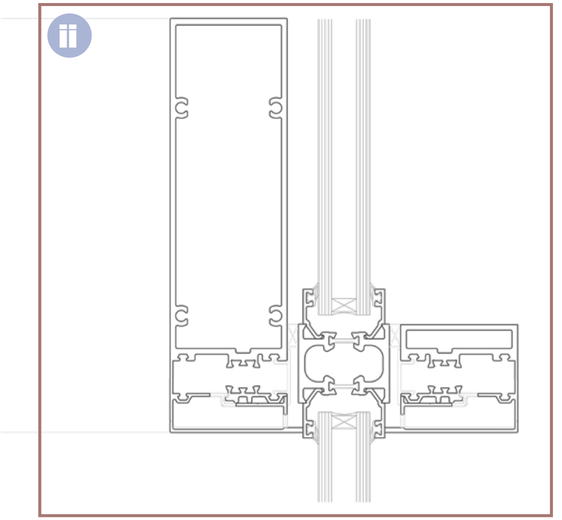


FORUM

Structural Steel L Mullion
Aluminum Composite Panel



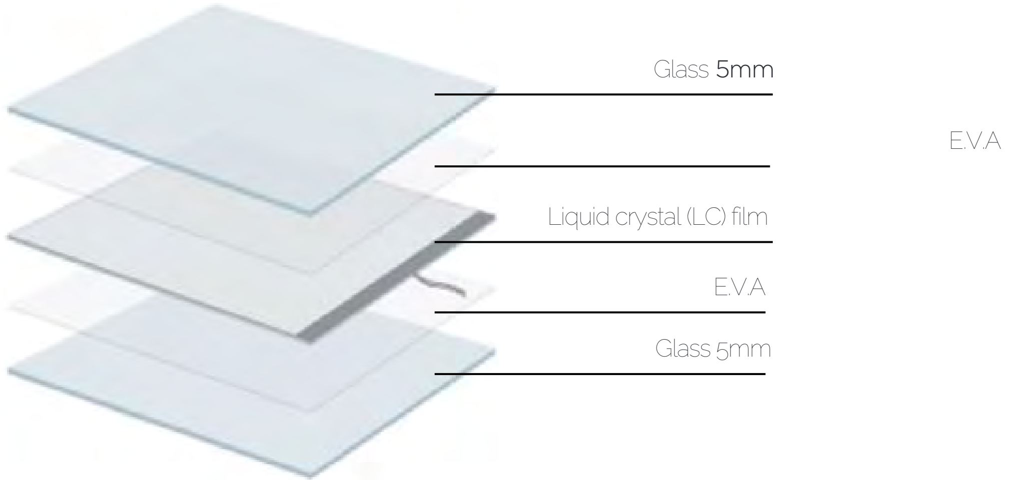
Alucobond Slab Cladding

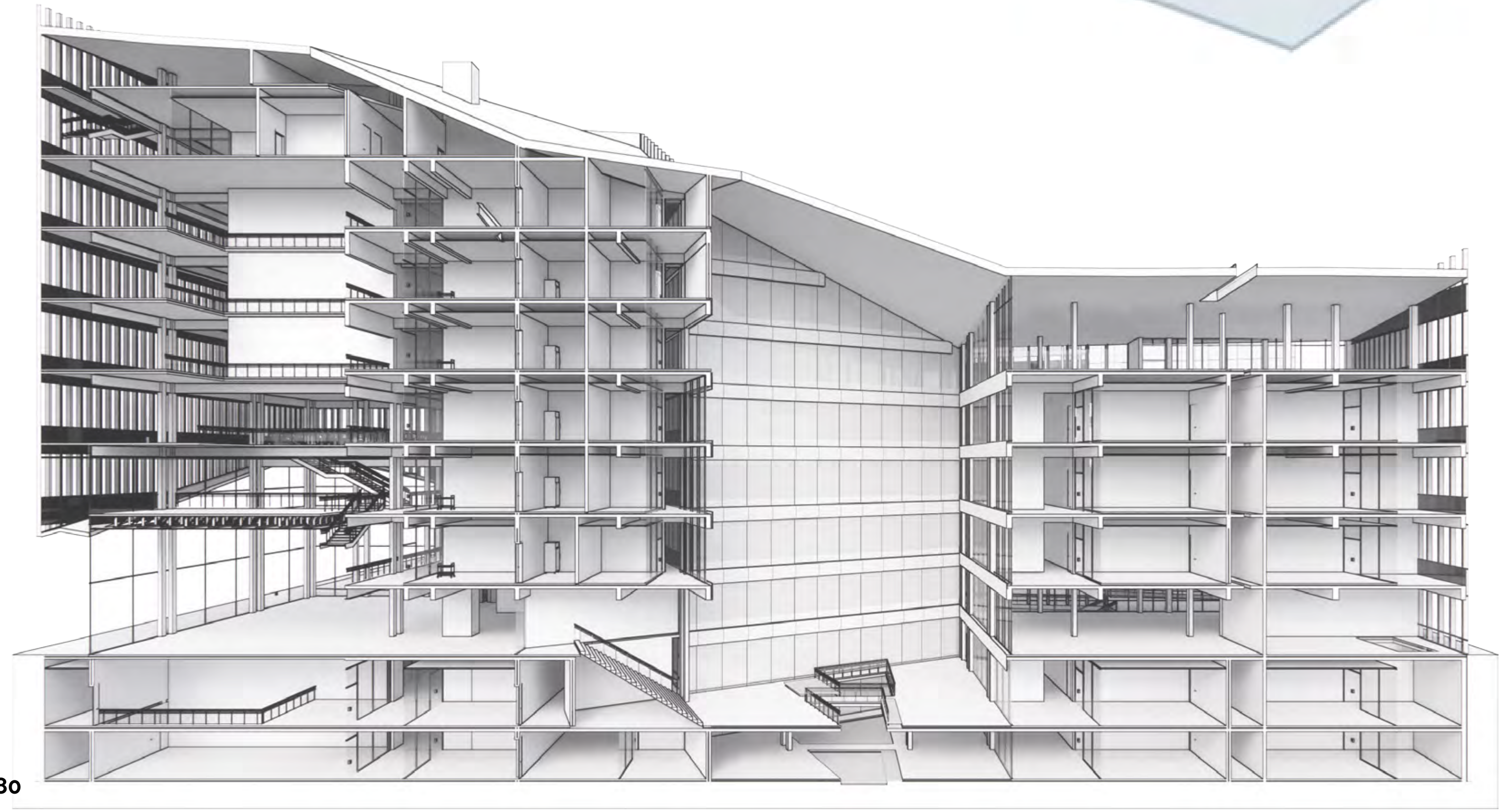


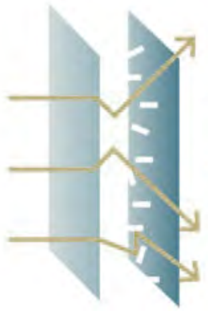
L- shaped Structural Steel Mullion

PRIVA-LITE® Transparent/translucent switchable glass: It is a thermal and sound-insulating laminated glazing solution incorporating a liquid crystal film that can manage transparency on demand, changing instantly from clear state to translucent, and vice versa.

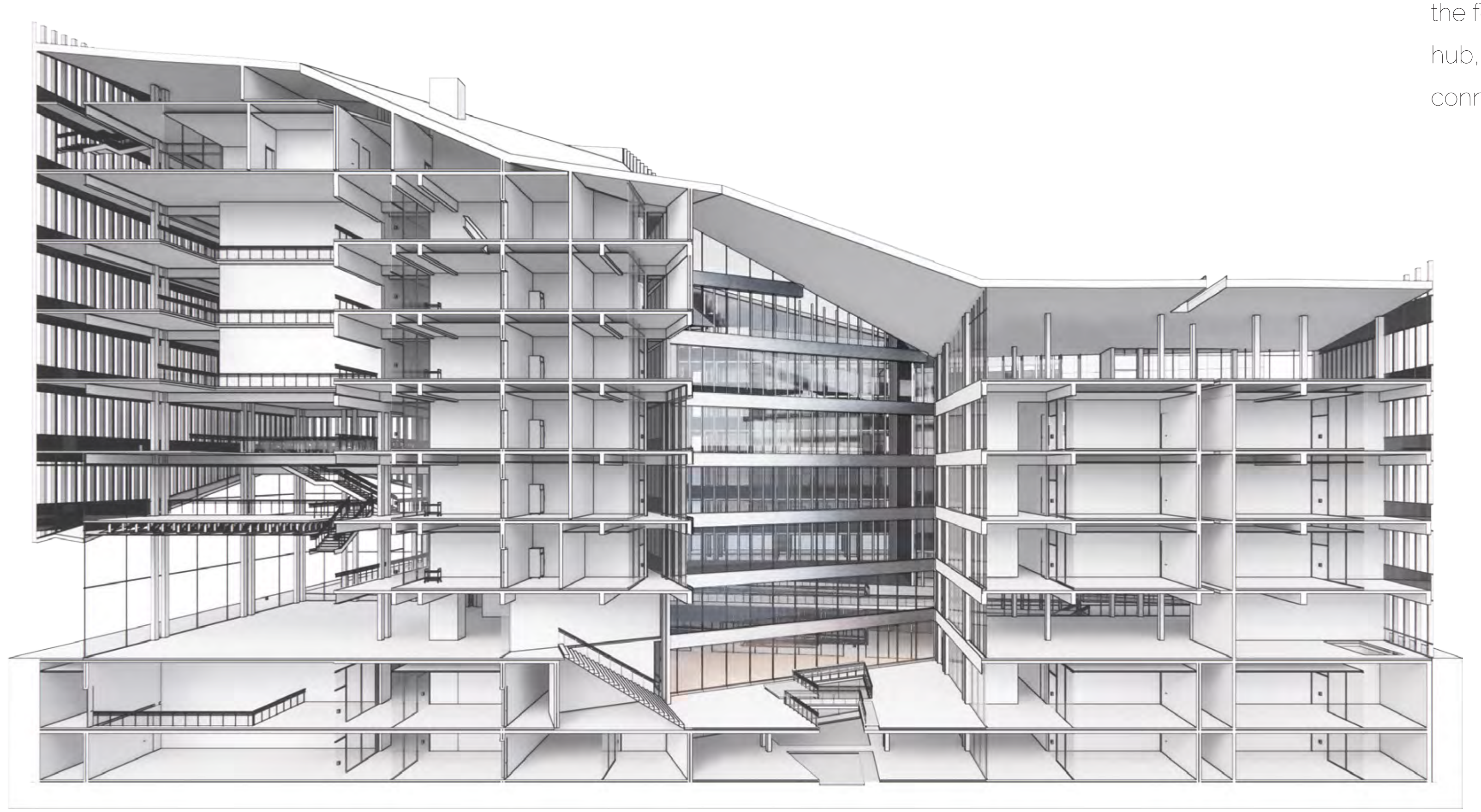
Power off: the glass has a naturally opaque appearance, blocking vision (total privacy), yet permitting light to pass through (translucent). This is needed when the forum is closed off for seminars, guest spokespeople, etc; hence, serving as a hall like the Patio in Politecnico di Milano.

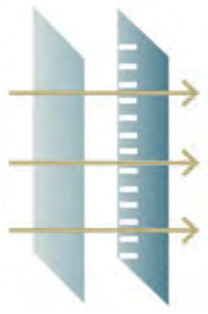


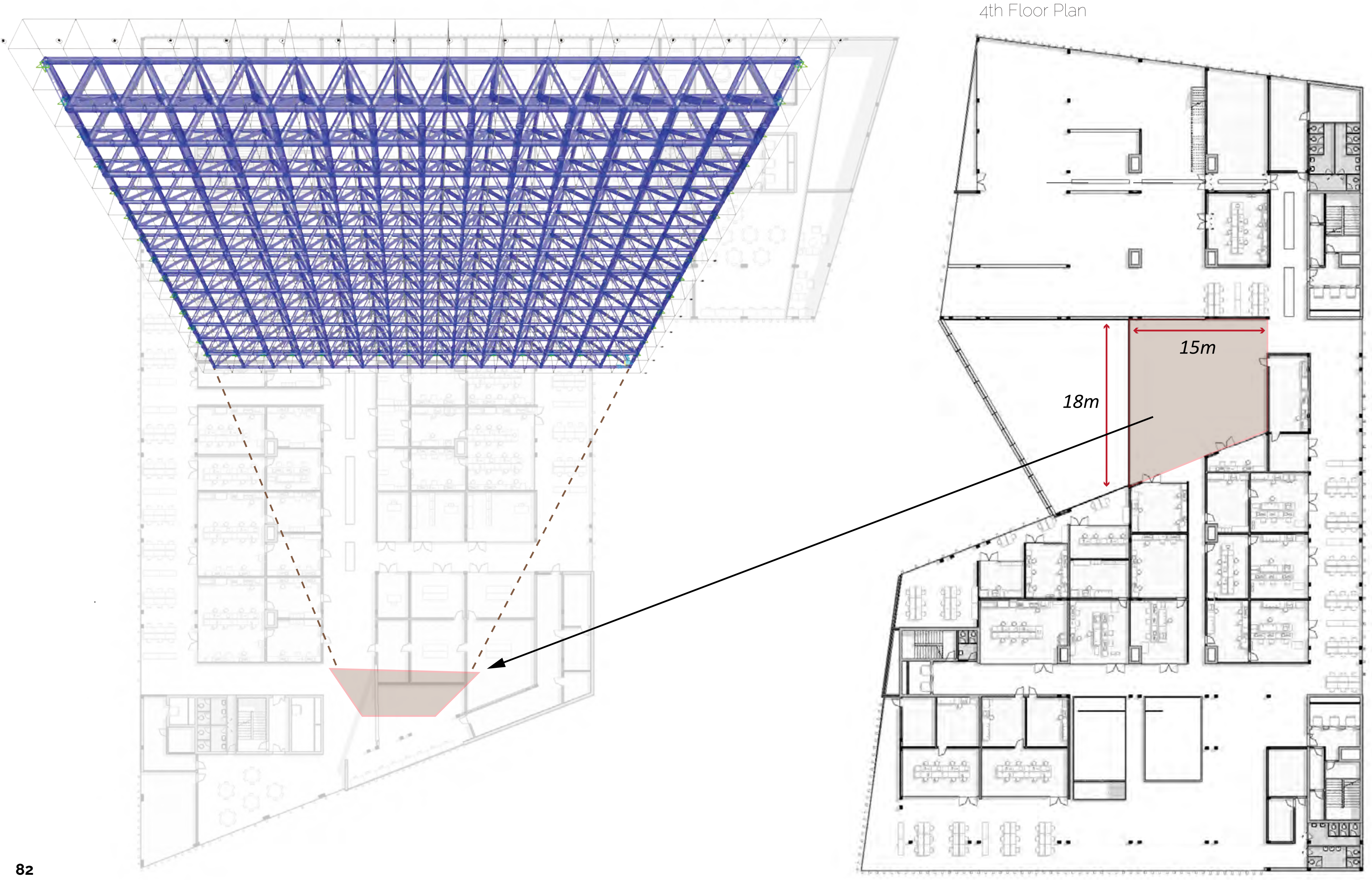




Power on: The liquid crystals are aligned when the electrical current is switched on, causing the glass to turn transparent instantly. Transparency is needed when the forum is acting as a communication hub, and the two buildings are in visual connection as well.







A **Space Frame** or Space Structure is a type of two way truss system constructed from inlerlocking steel struts following a geometric pattern. Space Frames can be use to span large areas with few interior supports. The structures strength is due to the rigidity of the triangle and flexing loads that are transmitted as tension and compression loads along the length of each rod.

Advantages:

1.These three-dimensional structures aid load sharing with maximum precision.

2.Portable, lightweight, and their assembly is modular, secure and efficient.

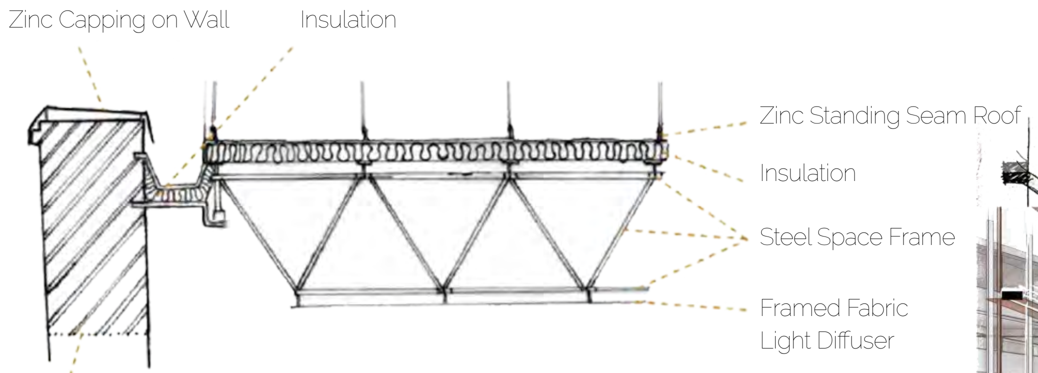
3.It is capable of bearing heavy loadings with minimum deflections.

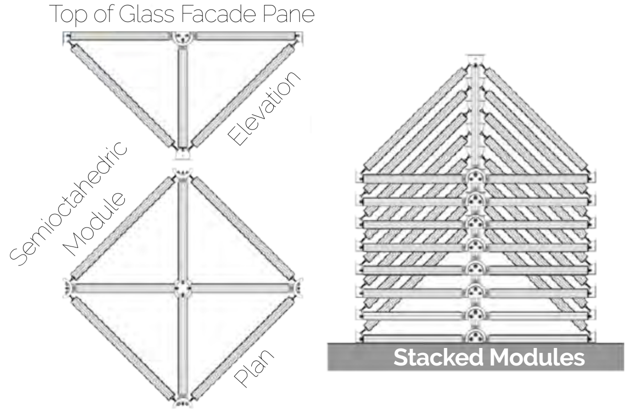
4.The cost of transportation is less as compared to other conventiona structures.

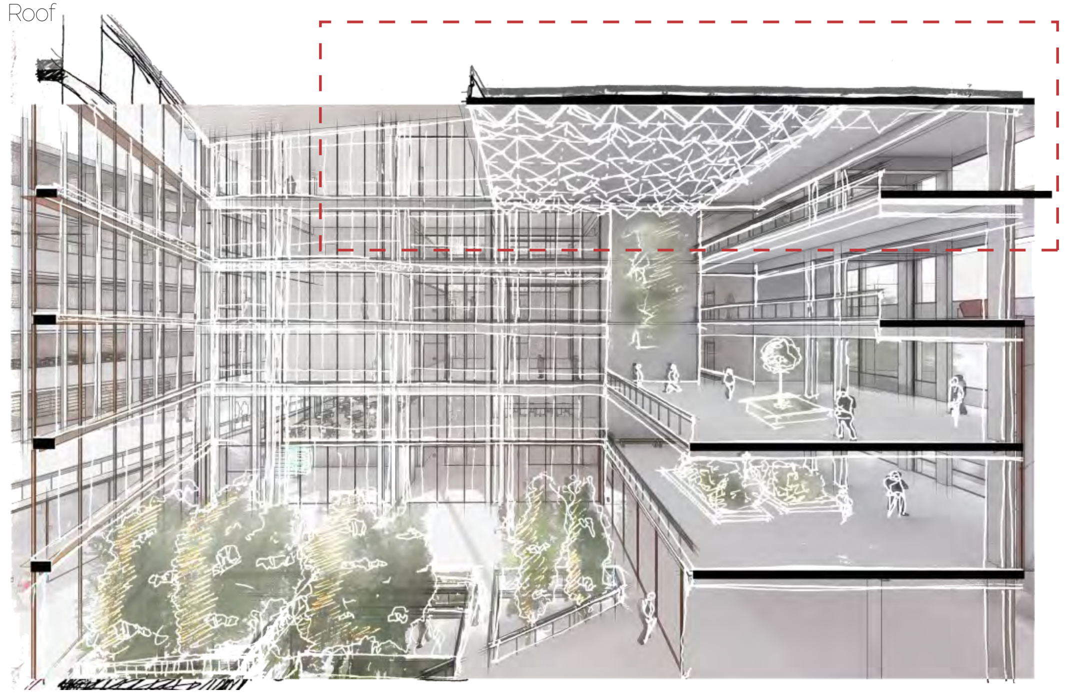
5.Space frame also allows odd placement of columns, along with integral cladding and glazing. Therefore, modularity is achieved with these structures.

6.They allow hassle free erection and a geometric balance, boosting the aesthetics of the construction and offers flexibility.

7.Easily expandable and are built following assembly line approaches with a very minimum amount of seismic resistance.

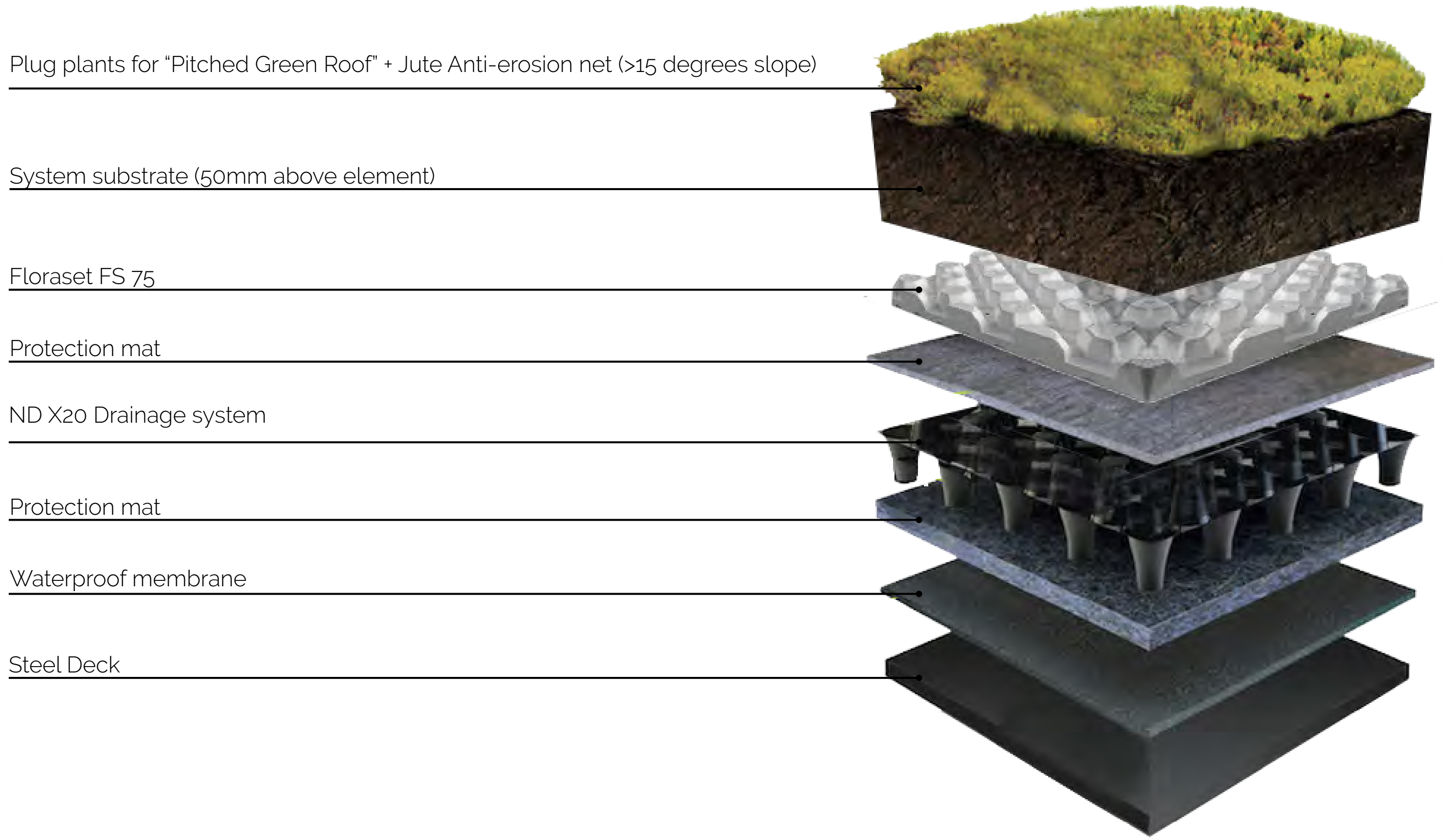


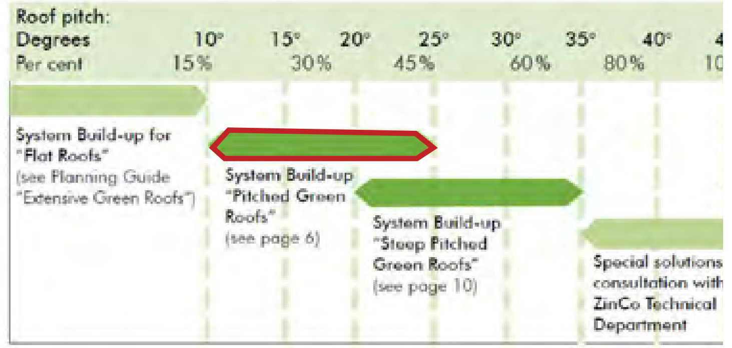


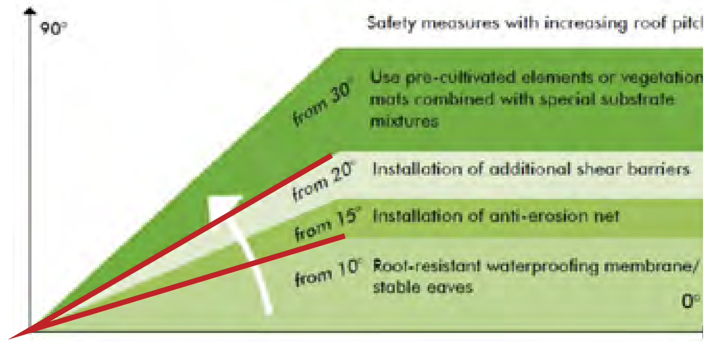


GREEN ROOF

Now that you have been introduced to our façade's components, it is time to meet our fifth façade. According to general regulations for roofs with waterproofing, flat roofs should have a fall of at least 2 %. The substrate layer has to be protected against erosion. Plant selection and planting methods are to be adjusted to the relevant slope and exposure. The future is green energy, sustainability, and renewable energy. Our roofs are designed in a manner to accommodate the hybrid photovoltaic/solar panels on the shallow slope, and the green roofs on the other steeper slopes. The green roofs have a layer of Floraset FS 75 that keep the soil intact and slide-resistant on the slopes that exceed 15°, and they are one of our water management systems, collecting rainwater that goes through a purification process in order to be reusable.







GREEN ROOF

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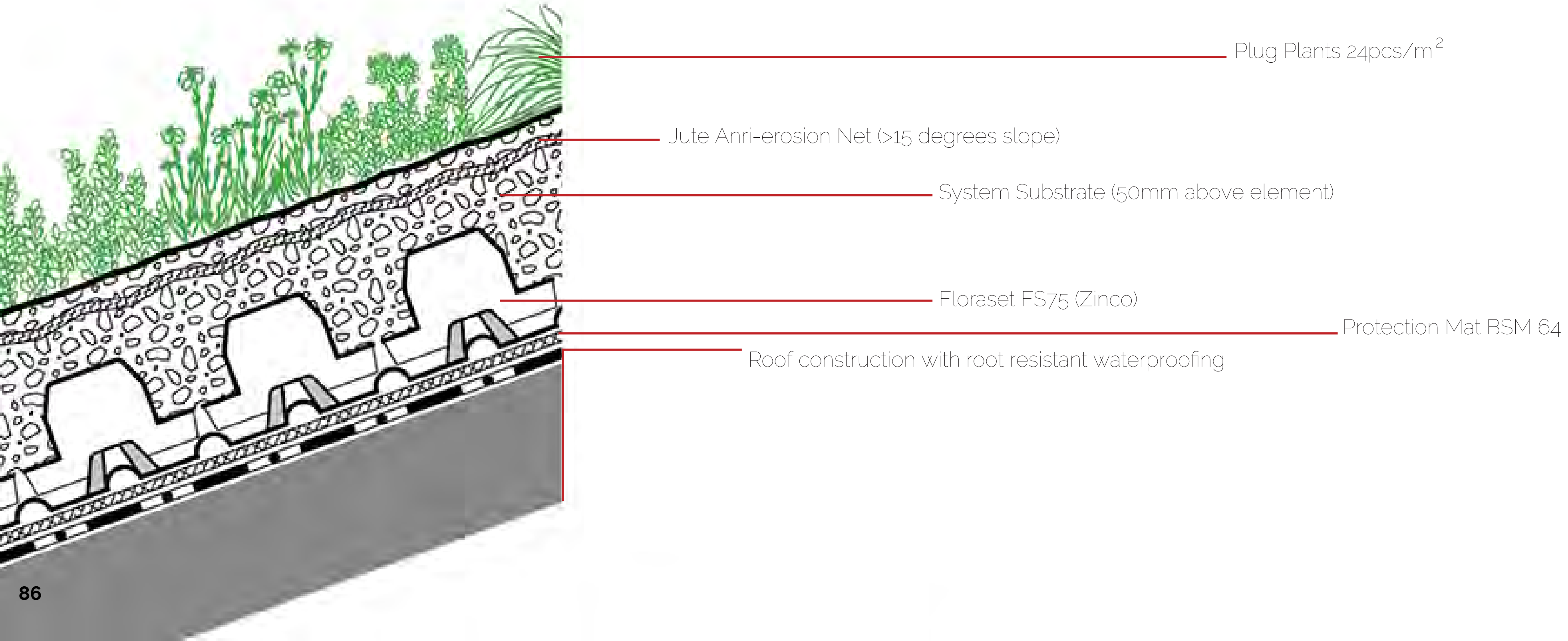
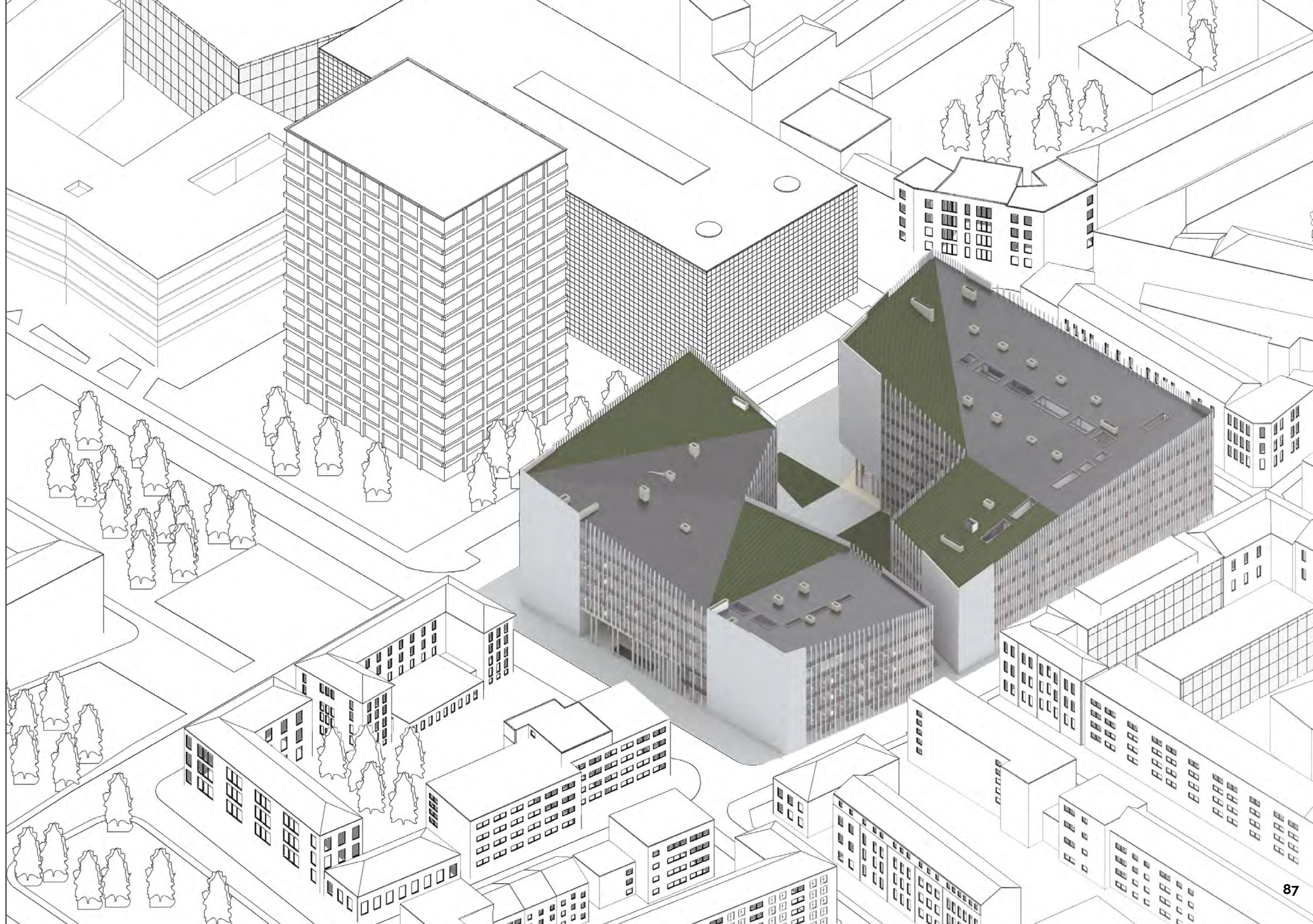
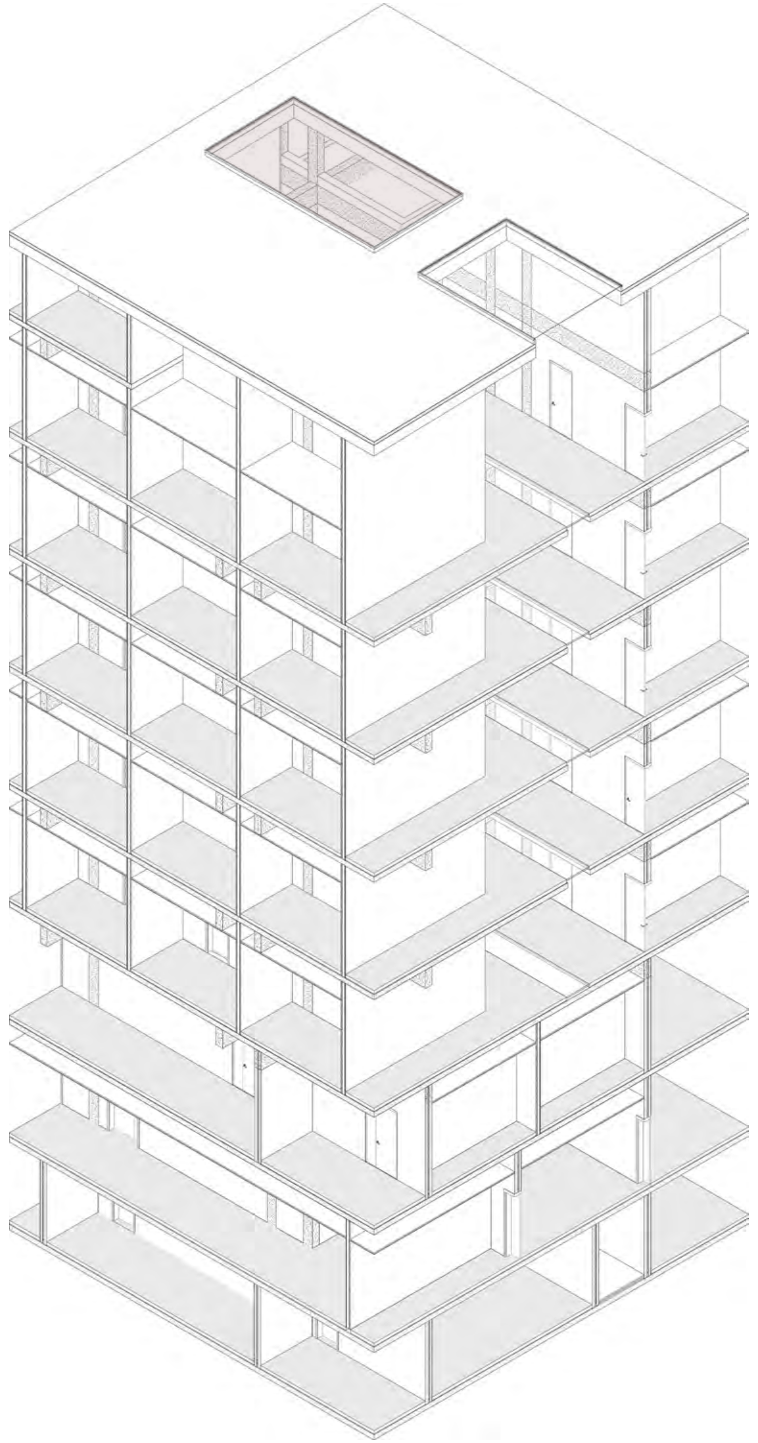


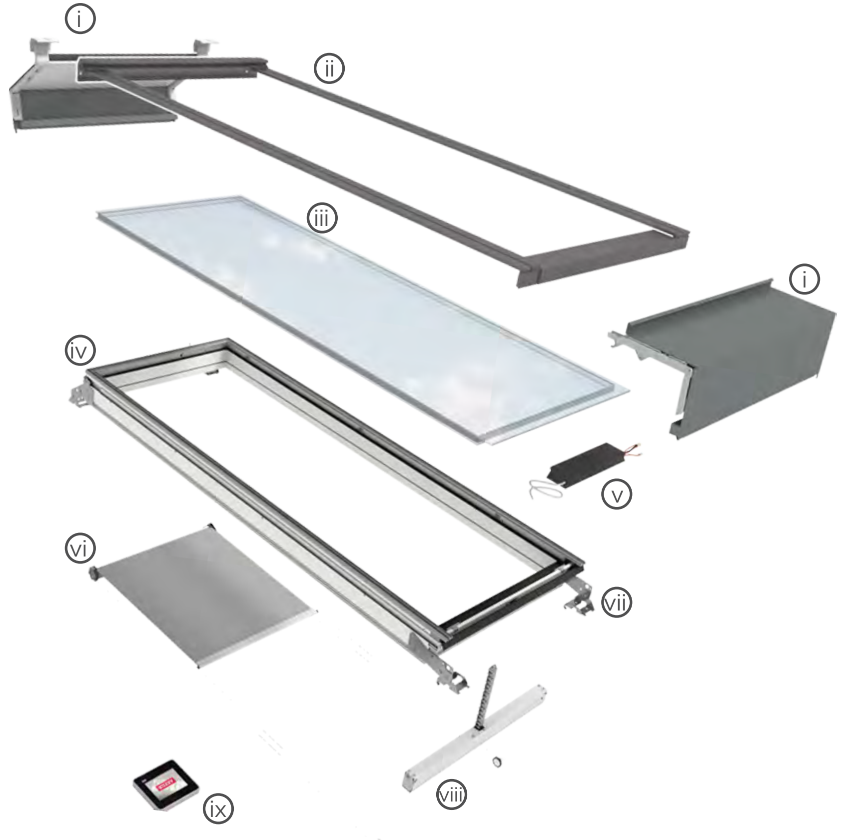




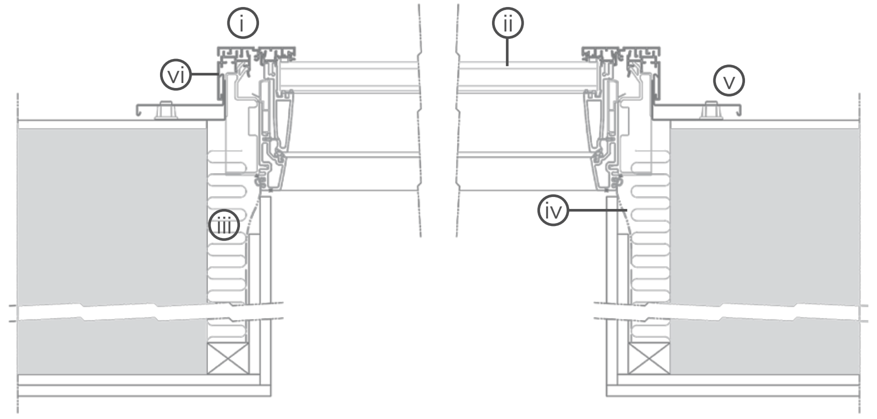
Mechanical Skylight
VELUX

Motorized comfort venting skylight module - Opening up to 410 mm

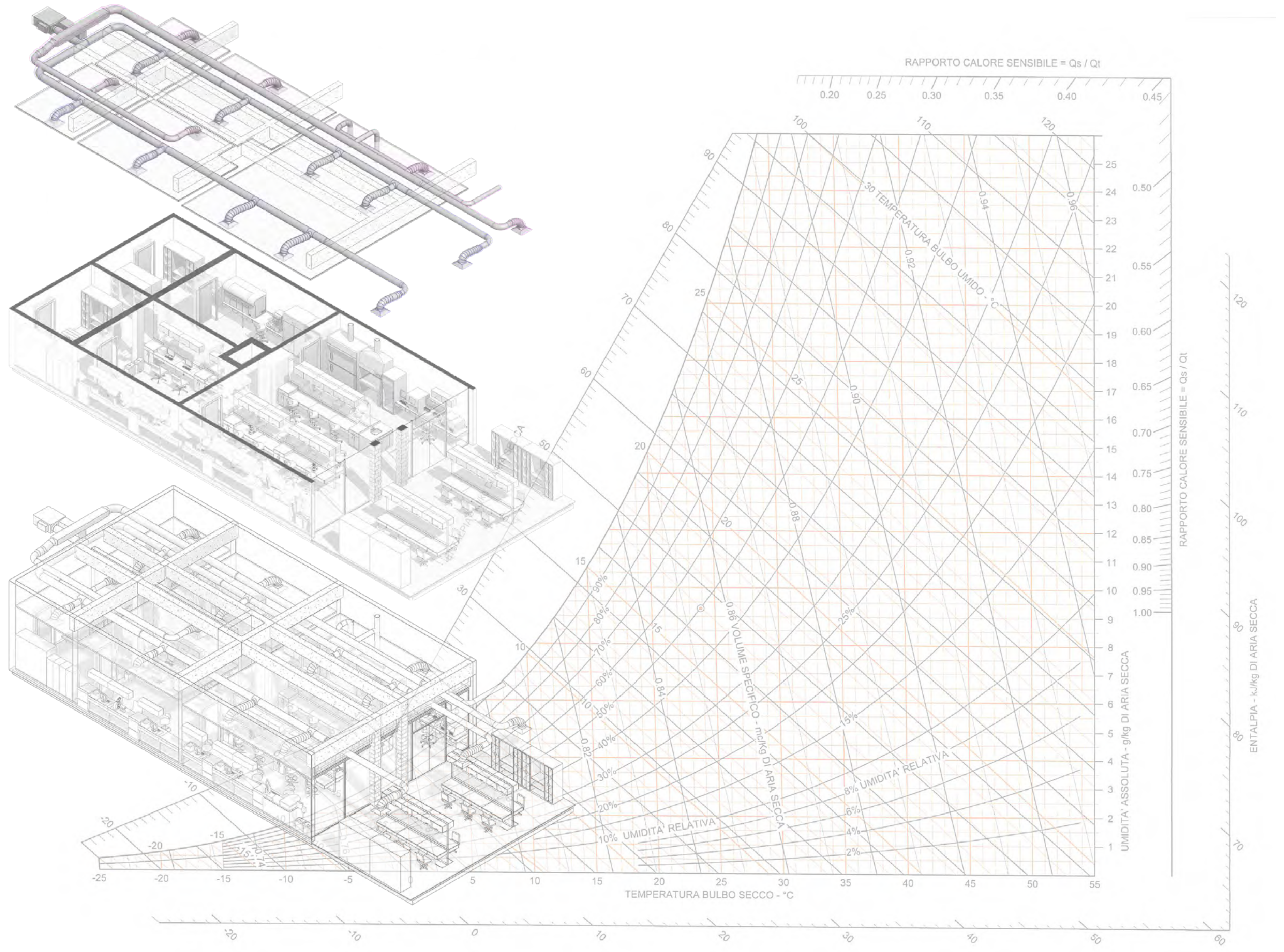
Mechanical Skylight
VELUX



i. Flashing
ii. Cladding
iii. Glazing Unit
iv. Frame
v. Power Supply & Control Unit
vi. Roller Blind
vii. Mounting Bracket
viii. Chain Actuator
ix. Remote Control



i. Covering
ii. Insulating Glass Unit 46 mm
iii. Insulation
iv. Vapor Barrier Connection Strip (BCX)
v. Side Flashing
vi. Side Covering



BUILDING SERVICES

GENERAL DATA

Climate Basel- Meteoblue

Location	Basel, Switzerland
Latitude	47.55°
Longtitude	7.58°

Heating Degree Days (HDD)	2617°C
Winter lowest Design External Temperature (Te,min)	-5°C
Summer highest Design External Temperature (Te,max)	32°C
Average Humidity	70%
Average Seasonal External Temperature (Tavg,e)	12°C
Design Internal Temperature (Tint,e)	20°C

GENERAL DATA TAKEN FROM MONTHLY CLIMATE INFORMATION

Location 55.0' 33'47"N 46.8'34"7"E

- The warmest month (with the highest maximum temperature) is July (32°C). The month with the lowest average high temperature is January (-5°C).

- The warmest month (with the highest average high temperature) is July (25.3°C). The month with the lowest average high temperature is January (4.5°C).

- The month with the highest average low temperature is July (14.5°C). The coldest month (with the lowest average low temperature) is January (-1.1°C).

- Months with the highest relative humidity are November and December (82%). The month with the lowest relative humidity is April (68%).

- The wettest month (with the highest rainfall) is May (99mm). The driest month (with the lowest rainfall) is February (45mm).

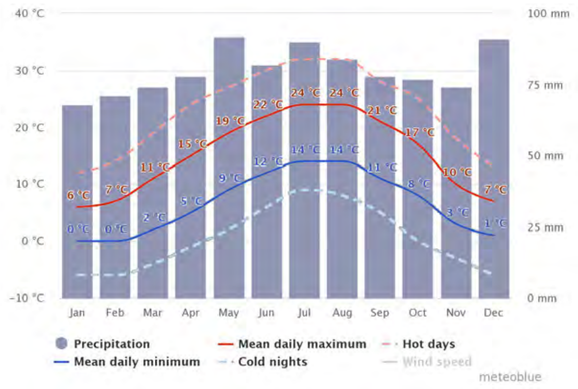
- The month with the highest number of rainy days is May (12.4 days). The month with the lowest number of rainy days is February (8.4 days).

- The month with the highest number of snowfall days is January (3 days). Months with the lowest number of snowfall days are May, June, July, August and September (0 days).

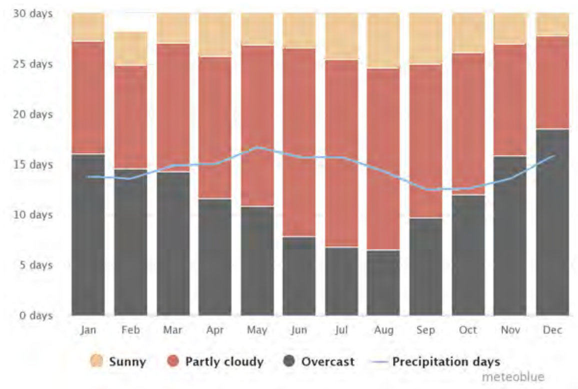
- The month with the longest days is June (Average daylight: 15.9h). The month with shortest days is December (Average daylight: 8.5h).

- The month with most sunshine is July (Average sunshine: 7.2h). The month with least sunshine is December (Average sunshine: 1.7h).

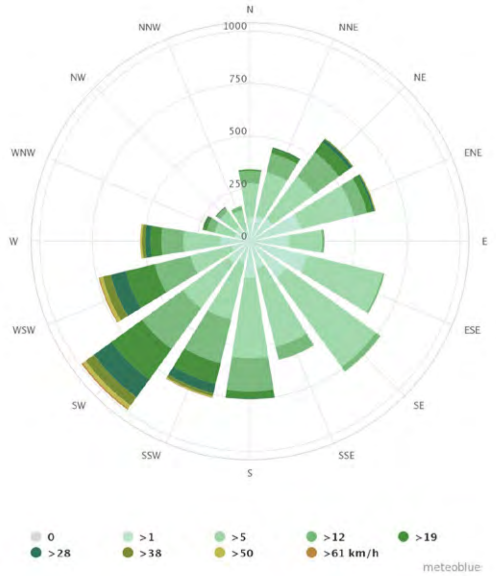
- Months with the highest UV index are June and July (UV index 7). Months with the lowest UV index are January, November and December (UV index 1).



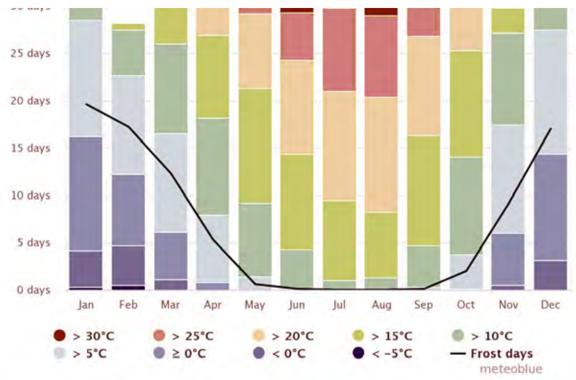
Average temperature and precipitation



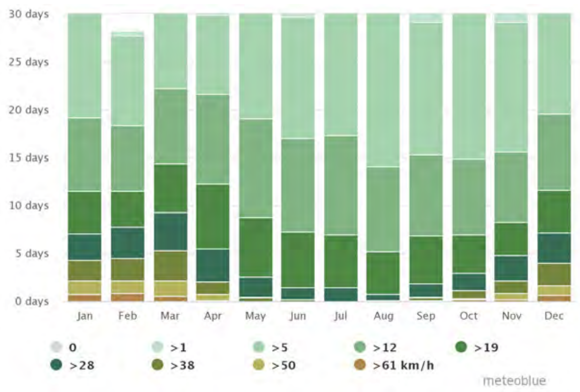
Cloudy, Sunny and precipitation days



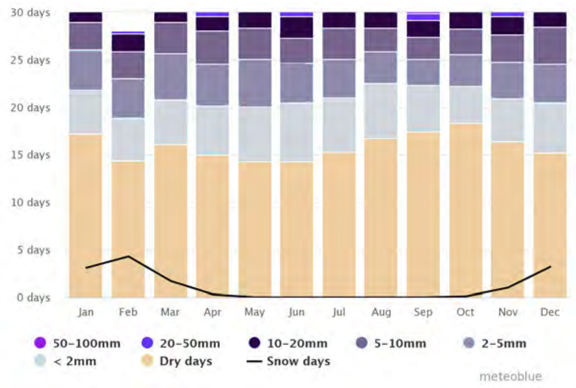
Wind Rose



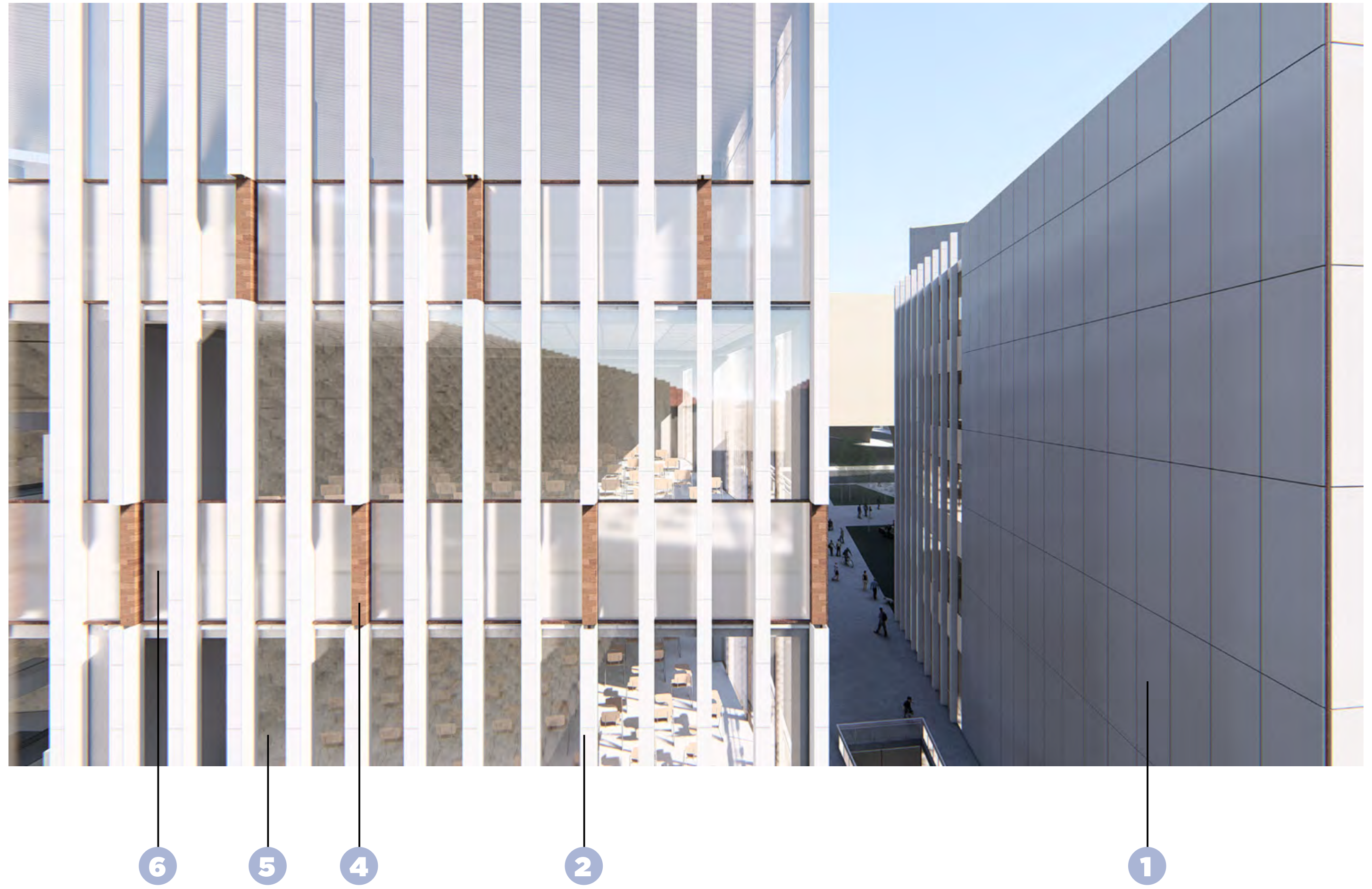
Maximum Temperature



Wind Speed



Precipitation amount



Thermal transport properties, such as thermal conductivity, thermal diffusivity or specific heat capacity, characterizing the ability of materials to conduct, transfer, store and release heat.

1. GFRC Cladding - Rieder® 3,600/1,200/13 mm
2. GFRC fibreC fins - Rieder® U-shape 300/200/13 mm
4. Wooden Plank Fin Separators - HPL Board Parklex® 1,700/200/200 mm
5. Reflective Glass - Reflectasol® Ultra Grey 10 mm Triple Glazing
6. Translucent Spandrel Glass - EMALIT® 8 mm Enameled glass

I- Opaque Material

Opaque Wall		Density	Thermal Conductivity	Thickness	Thermal Resistance	Specific Heat	Mass =SUM (pi*si)	Thermal Transmitttance
		ρ	λ	s	R	c	Ma	U
homogeneous layer description		kg/m³	W/mK	cm	m²K/W	J/kg K	kg/m²	W/m²K
Superficial heat transfer coefficient	**internal**				0.130			**0.4**
Gypsum plasterwork		1200	0.2	1	0.050	840	12.0	
Expanded Polystyrene		960	0.033	5	1.515	1170	48.0	
Reinforced Concrete		2400	0.9	24	0.267	840	576.0	
GFRC Fibre C Panel		2000	2	0.13	0.001	840	2.6	
Superficial heat transfer coefficient	**external**				0.040			
							639	

Thermal Resistance, R:

R = R1 +R2 + R3 = s1/ λ1 + s2/ λ2 + s3/ λ3+ s4/ λ4= 1.833

Thermal Transmittance, U:

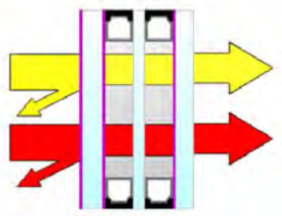
U = 1/R

U= 0.49 W/(m2*K)

II- Transparent Material | Triple Glazed Curtain Wall

Glass 1 Pilkington Activ Suncool 40/22, Annealed, 10 mm
Glass 2 Pilkington Optiwhite, Toughened, 5 mm
Glass 3 Pilkington Optiphon Therm S3 S, Laminated, 8.8 mm (44.2)

Cavity 1 14 Gas 1 Argon (90%)
Cavity 2 14 Gas 2 Argon (90%)



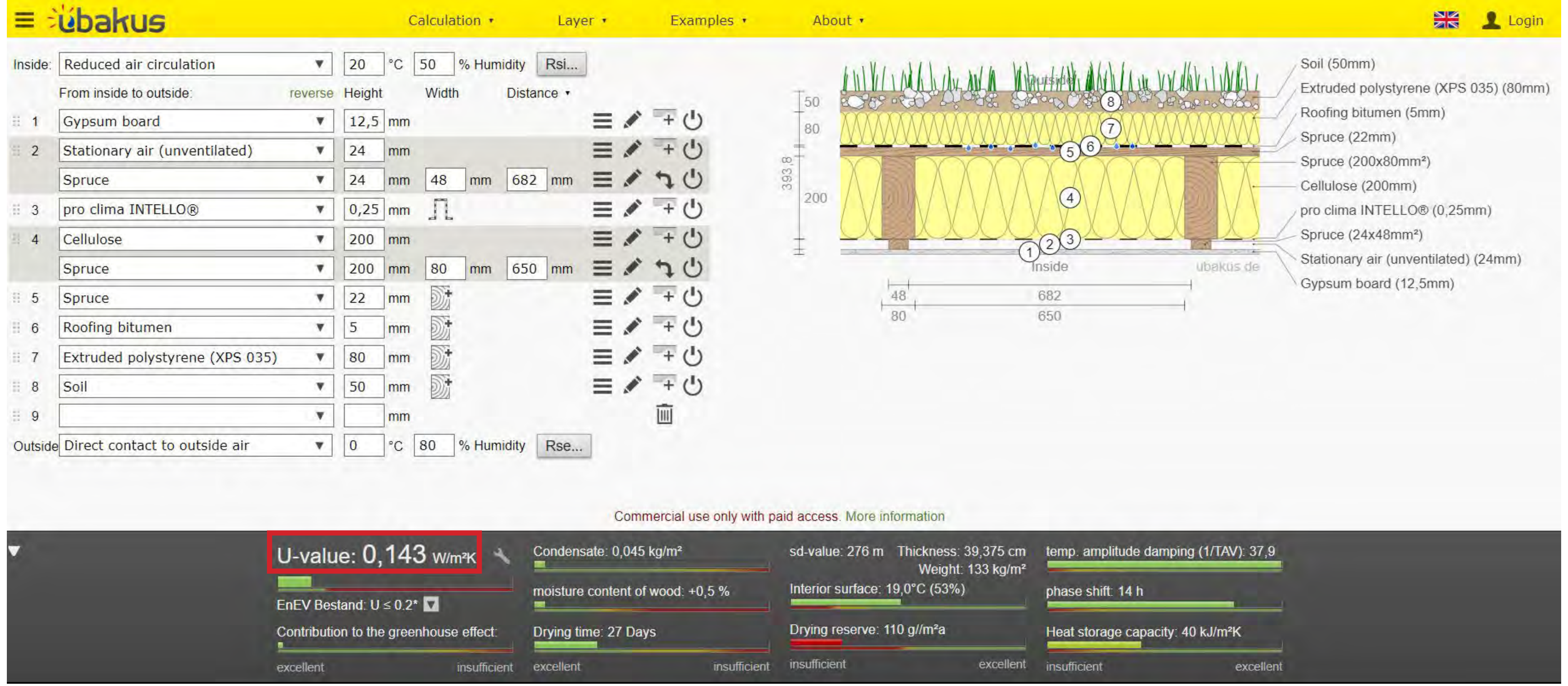
Product Code	U_g-value	UV %	Light %			Energy %			Solar Factor	Shading Coeff.	
	W/m²K	T_{uv}	LT	LR out	LR in	ET	ER	EA	g	T SC	S SC
A10C(40)-14Ar-5wT-14Ar-S(3)8.8Lp	0.6	0	33	25	25	15	34	51	0.18	0.21	0.17

Performance Code	Sound Reduction	Ra	Thickness	Weight	Selectivity	Date
U_g-value/Light/Energy	R_w (C;C_{tr}) dB	89	mm	kg/m²	1.76	29/06/2020
0.6 / 33 / 18	NPD		51.8	58.26		

Thermal Transmittance, U:

U= 0.6 W/(m2*K)

I- Green Roof



Thermal Transmittance, U:
U= 0.143 W/(m2*K)

Total power is calculated with the following formula:
QHL,i = QT,i + QV,i + Qhu,i

Where,
QT,i= Thermal dispersion by transmission [W]
QV,i= Thermal dispersionby ventilation [W]
Qhu,i=Extraction power needed for compensating the effects of the intermitting heating [W]

I- Thermal dispersion by transmission (QT)

Formula: **QT= QT,ie+ QT,ia+ QT,ig**

i-QT,ie= Thermal dispersion by transmission of heated spaces towards external [W]

QT,ie=Σ[eiAiUi(Tint,i−Te)] +Σ[eiLiΨi(Tint,i−Te)]+Σ[xmei(Tint,i−Te)]

Where,
ei= Exposition correction factors which take into account of climaticin fluenceson absorptionof humidity, wind velocity, etc.
Ai= dispersing surface[m2]
Ui=Thermal transmittance of building component [W/m2/K]
Li= Length of thermal bridge[m]
Ψi= Linear thermal transmittance of thermal bridge [W/m/K]
Tint,i=internal design temperature[°C]
Te=external design temperature[°C]

Orientation	Exposure factor ei
North	1.20
South	1.10
West	1.00
East	1.15
Floor	1.00

Orientation	Thermal bridges Ψ (W/mK)
Ceiling	0.8
Column	0.9
Corner column	0.1
Window	0.15
Partition wall	0.1

ii-QT,ia= Thermal dispersion by transmission from heated space towards a heated space at different temperature (QT,ia) [W]

QT,ia=ΣAiUifia,k(Tint,i-Te)

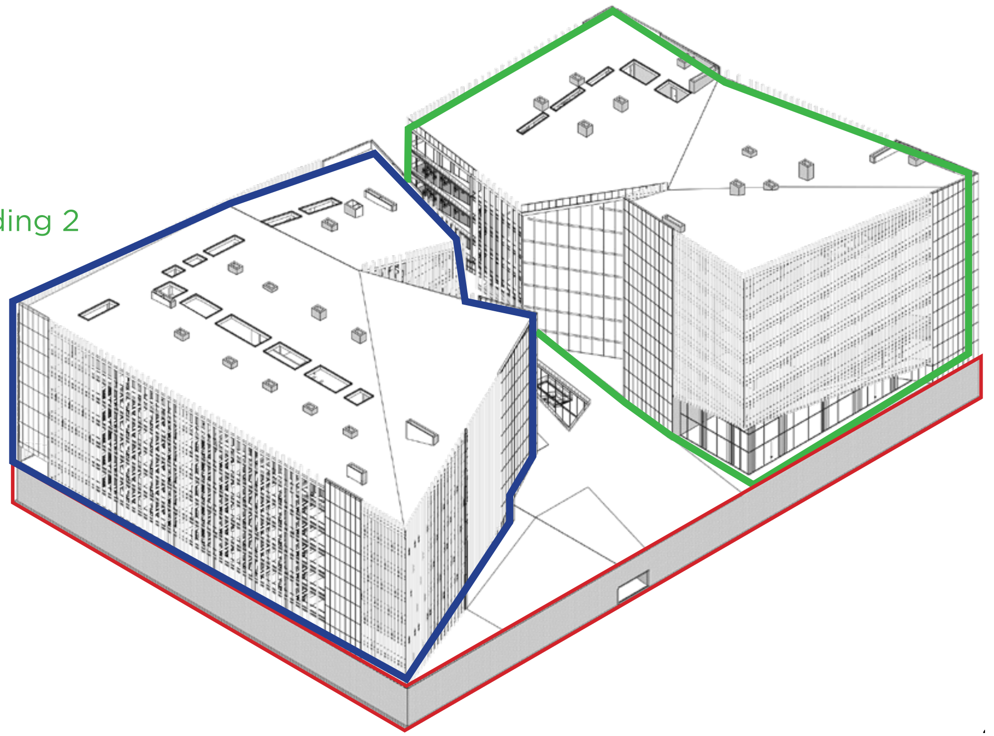
Where,
fia,k= Ta−Tnr/ Ta−Te = 20-20/20-(-5)=1/25=0.04

iii-QT,ig= Thermal dispersion by transmission from heated space towards ground [W]

QT,ig=f θ,annΣ[Ai.Ueq,i.fig,k.fwg,k (Tint,i-Te)

Where,
f θ,ann = 1.45, correction factor taking into account the annual variation of the external temperature
fwg,k = 1, a correction factor which takes into account presence of water in the underground
fig,k= 0.36, is a correction factor which takes into account the influence of variation of external temperature

The building was divided into 3 blocks; basement, building 1, and building 2



I- Basement

Surface Type	Thermal transmittance U (W/m²K)	Area (m²)
Surface towards heated space	1.7	3200+ 2300= 5500
Surface towards heated space	0.22	1488
Surface towards ground	0.2	3050+12060+2*(135*7.5)+2*(92.5*7.5) =18522.5

Thermal dispersion:
QT_1= QT,ig +QT,ia+ QT,ie

| Ground: QT,ig=f θ,annΣ[Ai.Ueq,i.fig,k.fwg,k (Tint,i-Te)= 1.45*18522*0.2*0.36*1* (20-(-5)) **=48342.42 W**

| Heated: QT,ia=ΣAiUifia,k(Tint,i-Te) = 5500*1.7* 0.04*25 **= 9350 W**

| Exterior: QT,ie=Σ[eiAiUi(Tint,i−Te)] +Σ[eiLiΨi(Tint,i−Te)]+Σ[xmei(Tint,i−Te)]= [1.0*1488*0.22 (20-(-5)] **=8184 W**

QT_1= QT,ig +QT,ia QT,ie = 48342.42+ 9350 + 8184**= 65876 W**
QT_1 = 66 kW

I- Building I

Surface Type	Thermal transmittance U (W/m²K)	Area (m²)
Opaque External wall North	0.4	289
Transparent Curtain wall North	0.6	1705.5
Opaque External wall South	0.4	458.6
Transparent Curtain wall South	0.6	2164.6
Opaque External wall West	0.4	434
Transparent Curtain wall West	0.6	2312.6
Opaque External wall East	0.4	981
Transparent Curtain wall East	0.6	1240
Opaque Roof	0.15	4831
Transparent Skylights Roof	0.6	228
Surface towards Heated Space	1.7	3200

Thermal dispersion:
QT_2= QT,ia +QT,ie

| Heated: QT,ia=ΣAiUifia,k(Tint,i-Te) = 3200*1.7* 0.04*25 = **5440 W**

| Exterior: QT,ie=Σ[eiAiUi(Tint,i−Te)] +Σ[eiLiΨi(Tint,i−Te)]+Σ[xmei(Tint,i−Te)]= [(1.2*1138.6+ 1.1*1482.2+ 1*1561.2+ 1.15*1136.4+861.45)*(20-(-5)] + [(1.2*0.1*36 + 1.1*0.1*18 + 1*0.1*63 + 1.15*0.1*36)*25] **=168574.75 W**

QT_2= QT,ia +QT,ie = 5440 + 168574.75 = **174,014.75W**

QT_2= 174 kW

Thermal Bridge	Length (m)
towards North	36
towards South	18
towards West	63
towards East	36

I- Building II

Surface Type	Thermal transmittance U (W/m²K)	Area (m²)
Opaque External wall North	0.4	174.5
Transparent Curtain wall North	0.6	885
Opaque External wall South	0.4	412.2
Transparent Curtain wall South	0.6	1896.6
Opaque External wall West	0.4	575.7
Transparent Curtain wall West	0.6	2891
Opaque External wall East	0.4	1433
Transparent Curtain wall East	0.6	1918
Opaque Roof	0.15	4179
Transparent Skylights Roof	0.6	68.6
Surface towards Heated Space	1.7	2300

Thermal dispersion:
QT_3= QT,ia +QT,ie

| Heated: QT,ia=ΣAiUifia,k(Tint,i-Te) = 2300*1.7* 0.04*25 = **3910 W**

| Exterior: QT,ie=Σ[eiAiUi(Tint,i−Te)] +Σ[eiLiΨi(Tint,i−Te)]+Σ[xmei(Tint,i−Te)]= [(1.2*600.8+ 1.1*1302.8+ 1*1964.8 + 1.15*1724+668)*(20-(-5)] + [(1.2*0.1*18 + 1.1*0.1*54 + 1*0.1*108 + 1.15*0.1*36)*25] **=169812 W**

QT_3= QT,ia +QT,ie = 3910 + 168574.75 = **173,722 W**
QT_3= 174 kW

Thermal Bridge	Length (m)
towards North	18
towards South	54
towards West	108
towards East	36

II-Intermitting Heating Calculation

Surface area in touch with the ground: Ai = 5500 m^2
Correction factor for additional heating load for heating up : φhu,i = 16 W/m2

Qhu,i=Aiφhu,i = 5500 m^2 *16 W/m^2 **= 88,000 W = 88 kW**

III-Ventilation Calculation

Qv = V· ρ c_p(Ta-Te)

Qv = (V* n /3600)*ρ c_p(Ta-Te) =47.28*31885 = **1,516,568 W = 1,516.5 kW**
where,
V·= fresh air flow rate [m^3/s]
ρ= air density [kg/m^3]= 1.2754 kg/m^3
c_p= specific heat of air[J/kg/K]= 1006 J/kg K
V= volume of the room conditioned [m^3]= 340403 m^3
n= Air change per hour (0,5 - 2 by standard) =0.5 V/h
Ta=design ambient temperature[°C]=20
Te= design external temperature[°C]=-5

IV-Calculation of Total Power

QHL,i = QT,i + QV,i + Qhu,i

QHL,i = QT,i + Qhu,i
QHL,i = (QT_1+QT_2 +QT_3)+ Qhu,i= 66 + 174+ 174 +88 **= 502 kW**

With Ventilation| QHL,i = QT,i **+ QV,i** + Qhu,i

= 502 + 1,516.5 **= 2,018 kW**

QHL,i = 2,018 kW

Dati Generali				Note
Località		Milano	-	
Temperatura esterna progetto	T_e	32	°C	*Valore compreso fra 5 e 17 °C
Escursione termica giornaliera*	ΔT_e	12	°C	**Valore compreso fra:
Umidità assoluta esterna massima	X_e	22.5	g/kg	pareti verticali: 100 e 700 kg/mq
Latitudine		47	°	orizzontale sole: 50 e 400 kg/mq
		33	'	orizzontale ombra: 100 e 300 kg/mq
Temperatura ambiente progetto	T_a	20	°C	***Valore compreso fra 150 e 730 kg/mq
Umidità ambiente progetto	X_a	7.5	g/kg	**RIEMPIRE CAMPI CON BORDO** ARANCIONE
Massa in pianta***	M_a	640	kg/mq	
Portata aria esterna di rinnovo	V	100000.0	mc/h	

Dati Involucro							
	Superfici Opache			Finestre			
Esposizione	U_p W/(mq K)	$M_{f,p}$** kg/mq	S_p mq	U_F W/(mq K)	f -	F=SC F_{vs} -	S_F mq
NORD	0.4	100	463.2	0.6	0.96	0.16	2590.3
EST	0.4	500	2413.7	0.6	0.96	0.16	2158.4
OVEST	0.4	400	1009.7	0.6	0.96	0.16	5203.6
SUD	0.4	400	870.8	0.6	0.96	0.16	4061.2
ORIZZONTALE OMBRA		250	5600				
ORIZZONTALE SOLE		200	9030				

OPAQUE COMPONENTS CONTRIBUTION TO THE COOLING LOAD

M_f =	**639**	kg/m²	Latitude	47.55	°		$T_{ae,max}$	32	°C	T_{pi}	20 °C
U wall	0.50	W/K m²	Absorbanc	0.5	-	**Wall areal mass used for $\Delta\theta_{eq}$**	Δtae max d	12	°C	ΔT_{e-i}	12 °C
						Value 600 kg/m²				correction to eq t	

Solar HOUR h	July S	E	W	N	shadowed
1	4.20	4.70	6.40	1.3	1.30
2	3.6	4.2	5.8	1.3	1.30
3	3	3.6	5.3	0.8	0.80
4	3	3.6	4.7	0.8	0.80
5	2.5	3	4.2	0.2	0.20
6	9.7	7.4	10.8	2.50	2.50
7	8.1	7.4	13.6	2.5	2.50
8	7.4	7.4	15.2	4.2	4.20
9	5.8	6.9	14.7	3.6	3.60
10	5.3	6.4	14.1	3	3.00
11	4.7	5.8	10.2	2.5	2.50
12	4.2	5.3	7.4	1.9	1.90
13	4.2	4.7	6.4	1.3	1.30
14	3.6	4.2	5.8	1.3	1.30
15	3	3.6	5.3	0.8	0.80
16	3	3.6	4.7	0.8	0.80
17	2.5	3	4.2	0.2	0.20
18	9.7	7.4	10.8	2.50	2.50
19	8.1	7.4	13.6	2.5	2.50
20	7.4	7.4	15.2	4.2	4.20
21	5.8	6.9	14.7	3.6	3.60
22	5.3	6.4	14.1	3	3.00
23	4.7	5.8	10.2	2.5	2.50
24	4.2	5.3	7.4	1.9	1.90

Total power is calculated with the following formula:

$Q_{Tot} = Q_S + Q_L$

Calculation done on hour basis on the most adverse day of the year (July 21st)

I- Sensible load

$Q_S = Q_{OP,T,E} + Q_{OP,T,NC} + Q_{OP,T,C} + Q_{T,T,E} + Q_{T,I,E} + Q_{V,S} + Q_{INT,S}$

Where,
(thermal bridges neglected)

$Q_{OP,T,E}$ -External opaque structures | $Q_{OP,T,E} = \Sigma AiUi(T'e,i-Ta+ \Delta Ti') = \Sigma AiUi(\Delta T_{eq,i})$

$Q_{OP,T,NC}$ -Opaque structures uncondit. spaces | $Q_{OP,T,NC} = \Sigma AiUi(T_{NC,i}-Ta) = \Sigma AiUi(\Delta T_{eq,i})$

$Q_{OP,T,C}$ -Opaque structures condit. spaces | $Q_{OP,T,C} = \Sigma AiUi(T_{C,i}-Ta) = \Sigma AiUi(\Delta T_{eq,i})$

$Q_{T,T,E}$ -External transparent structures (convection) | $Q_{T,T,E} = \Sigma A_{FIN,i} U_{FIN,i} (T_e - T_a)$

$Q_{T,I,E}$ -External transparent structures(rad.) | $Q_{T,I,E} = \Sigma A_{wind,i} * I * F_{vs} * SC * f * f_a$

$Q_{V,S}$ -Ventilation | $Q_{V,S} = [V\ n\ \rho\ c_p (T_e - T_{int,i})] / 3600$

$Q_{INT,S}$ -Internal loads | $Q_{INT,S} = Q_{INT,S,PP}\ n_{PP} + \Sigma Q_{INT,S,app}$

For permanent:

$Q_{INT,S} = (400*800+ 500*12+150*12+ 175*10+ 550*10+100*12+ 40*40)$

=332850 W

For Variable: we multiply by the assumption of number of people occupying the building during the different hours of the day

$Q_{INT,S} = 80 * n_{pp/hr}$

Attività	applicazioni	$Q_{INT,S,pp}$
Seduto a riposo	teatro	65
Seduto in attività leggera	ufficio, appartamento	70
Seduto in attività media	ufficio, appartamento	75
Seduto al ristorante	ristorante	80
In piedi, lavoro leggero	negozio	75
In piedi, lavoro medio	officina	80
In piedi, lavoro pesante	officina, cantiere	185
In movimento	banca	75
Danza moderata	sala da ballo	90
In cammino a 1,3 m/s	corridoi	110
Attività atletica	palestra, discoteca	210

Internal loads (People)

They must be estimated in fuction of personal activity and occupational profile [W/pp]:

Apparecchiatura	P_{max}	$Q_{INT,S,app}$
Apparecchiature per ufficio		
Personal computers	100÷600	90÷550
Minicalcolatori	2000÷6500	2000÷6500
Stampanti laser	850	350
Copiatrici eliografiche	1100÷12500	1100÷12500
Fotocopiatrici	450÷6600	450÷6600
Scanner	1700	1500
Imbustatrici ed etichettatrici	600÷6000	400÷4000
Distributori di acqua refrigerata	700	1750
Distributori di bevande fredde	1200-1900	550-900
Macchine del caffè	1500	1000
Forni a microonde	600	400
Distruttori di documenti	250÷3000	200÷2400

Internal loads (Equipment)

They must be estimated in fuction of the equipment installed and temporal profile of usage [W]

II- Latent load

$Q_L = Q_{V,L} + Q_{INT,L}$

Where,
$Q_{V,L}$ - Ventilation | $Q_{V,L} = [V\ n\ \rho\ \lambda (X_e - X_{int,i})] / 3600$
$Q_{INT,L}$ - Internal loads | $Q_{INT,L} = Q_{INT,L,PP}\ n_{PP} + \Sigma\ Q_{INT,L,app}$

For permanent: $Q_{INT,L} = 0 + 650 * 12 = 7800$ W

For Variable: we multiply by the assumption of number of people occupying the building during the different hours of the day
$Q_{INT,L} = 200 * n_{pp/hr}$

Attività	applicazioni	$Q_{INT,V,pp}$
Seduto a riposo	teatro	45
Seduto in attività leggera	ufficio, appartamento	65
Seduto in attività media	ufficio, appartamento	80
Seduto al ristorante	ristorante	115
In piedi, lavoro leggero	negozio	80
In piedi, lavoro medio	officina	200
In piedi, lavoro pesante	officina, cantiere	410
In movimento	banca	100
Danza moderata	sala da ballo	230
In cammino a 1,3 m/s	corridoi	265
Attività atletica	palestra, discoteca	450

Internal loads (People).
They must be estimated in fuction of personal activity and occupational profile [W/pp]:

Apparecchiatura	$Q_{INT,V,app}$
Apparecchiature per ufficio	0
Personal computers	0
Minicalcolatori	0
Stampanti laser	0
Copiatrici eliografiche	0
Fotocopiatrici	0
Scanner	0
Imbustatrici ed etichettatrici	0
Distributori di acqua refrigerata	0
Distributori di bevande fredde	650
Macchine del caffè	0
Forni a microonde	0
Distruttori di documenti	

Internal loads (Equipment)
They must be estimated in fuction of the equipment installed and temporal profile of usage [W]

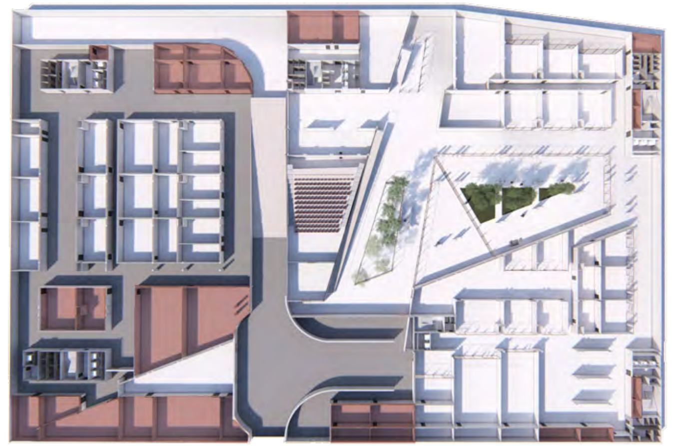
The values obtained for peermanent and variable sensible and latent loads were placed in the excel sheet along with the general data to get:
| Maximum Sensible Load = 1277024 W
| Maximum Latent Load = 1558300 W

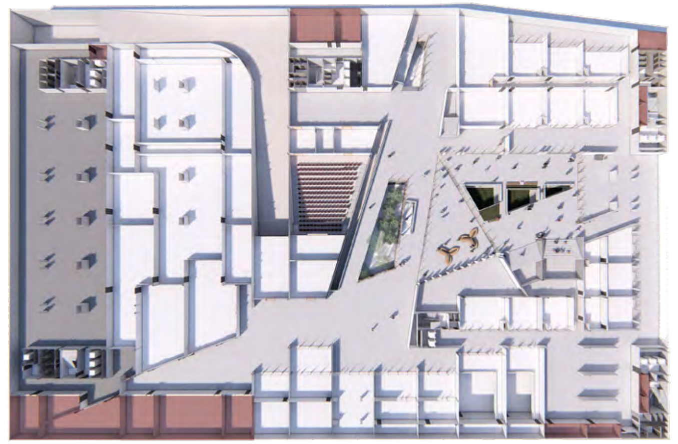
Carichi Interni							
Carico interno sensibile costante	$Q_{int,s,cost}$		332850	W			
Carico interno latente costante	$Q_{int,l,cost}$		7800	W			
Carichi interni totali	Ora		Costante	Variabile	Costante	Variabile	
	H		$Q_{int,s,cost}$	$Q_{int,s,var}$	$Q_{int,l,cost}$	$Q_{int,l,var}$	
	h		W	W	W	W	
		8	332850	80000	7800	200000	
		9	332850	96000	7800	240000	
		10	332850	120000	7800	300000	
		11	332850	120000	7800	300000	
		12	332850	96000	7800	240000	
		13	332850	80000	7800	200000	
		14	332850	80000	7800	200000	
		15	332850	120000	7800	300000	
		16	332850	120000	7800	300000	
		17	332850	80000	7800	200000	
		18	332850	80000	7800	200000	
		19	332850	64000	7800	160000	
		20	332850	40000	7800	100000	
		21	332850	16000	7800	40000	
		22	332850	0	7800		
		23	332850	0	7800	0	
		24	332850	0	7800	0	

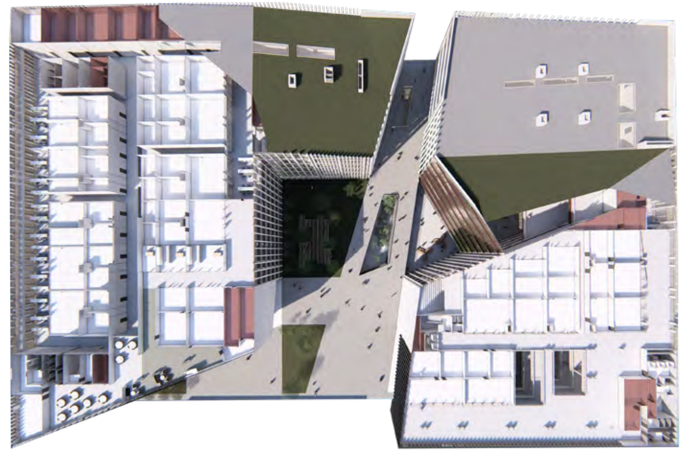
III- Summer Heat Load

$Q_{Tot} = Q_S + Q_L = 1277024 + 1558300$ **= 2,835,324W**

Q_{Tot} = 2,835 kW







TECHNICAL ROOMS AND SHAFTS

Technical rooms are mainly allocated in the Basement 1 and 2 levels, and in the upper floors where the roof starts sloping with inadequate clear height for normal functions. Those rooms and spaces are used for technical, mechanical, storage, and electrical rooms.

Mechanical rooms typically house the following equipment:

-Air handlers

-Boilers

-Chillers

-Heat exchangers

-Water heaters and tanks

-Water pumps (for domestic, heating/cooling, and firefighting water)

-Main distribution piping and valves

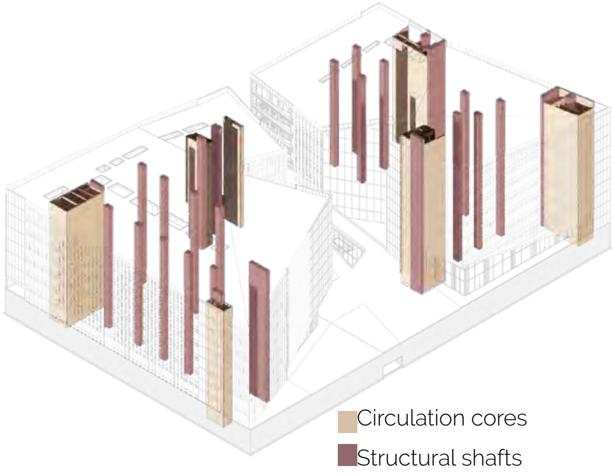
-Sprinkler distribution piping and pumps

-Back-up electrical generators

-Elevator machinery

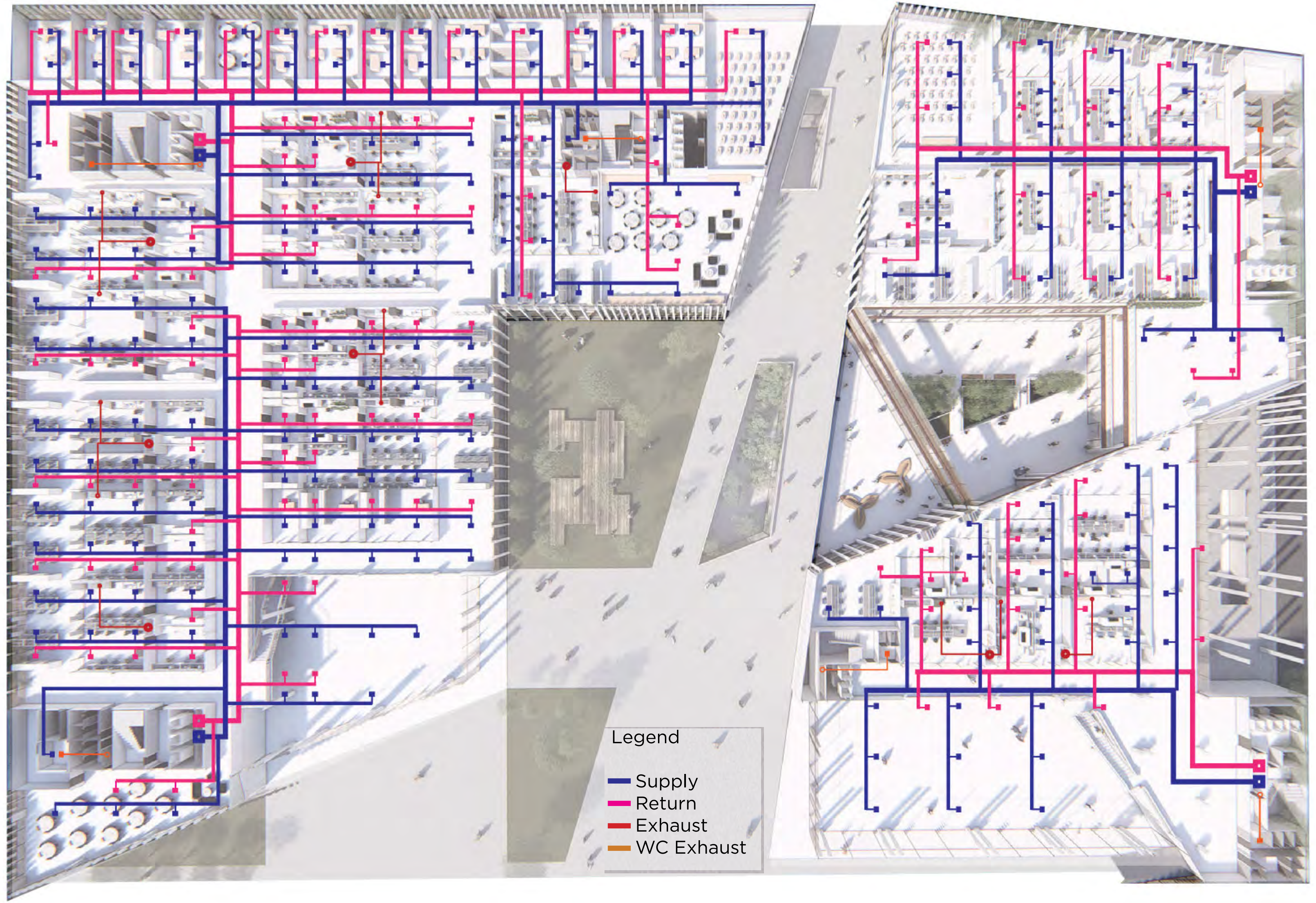
-Other HVAC (heating, ventilation and air-conditioning) equipment

Equipment in mechanical rooms is often operated and maintained by a stationary engineer or a maintenance technician. Modern buildings use control systems to manage HVAC cycles, lighting, communications, and life safety equipment. Often, the control system hardware is located in the mechanical room and monitored or accessed remotely. Rooms with only electrical or electronic equipment are not considered mechanical rooms but are instead called electrical rooms.

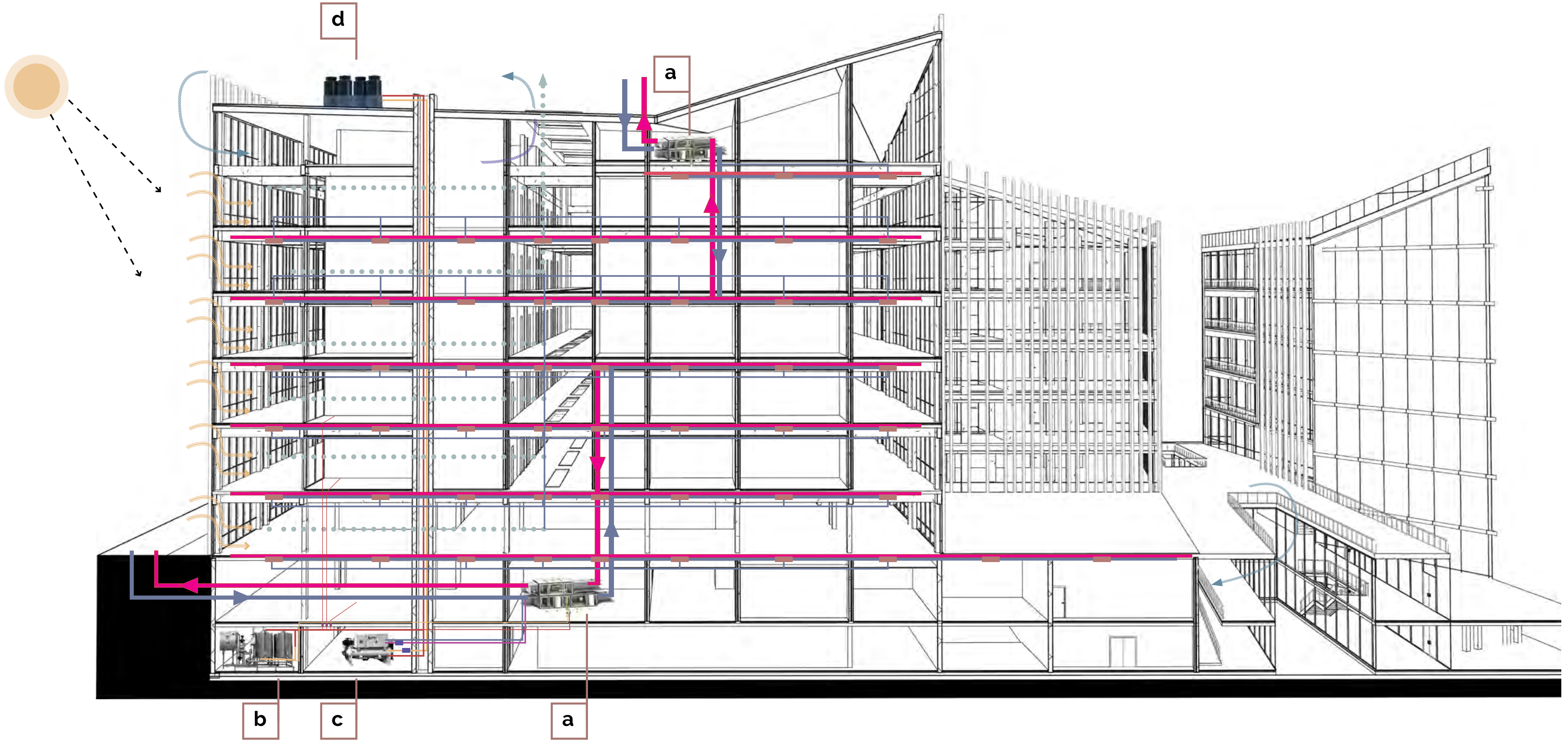


ALL AIR HVAC SYSTEM

Layout and Distribution



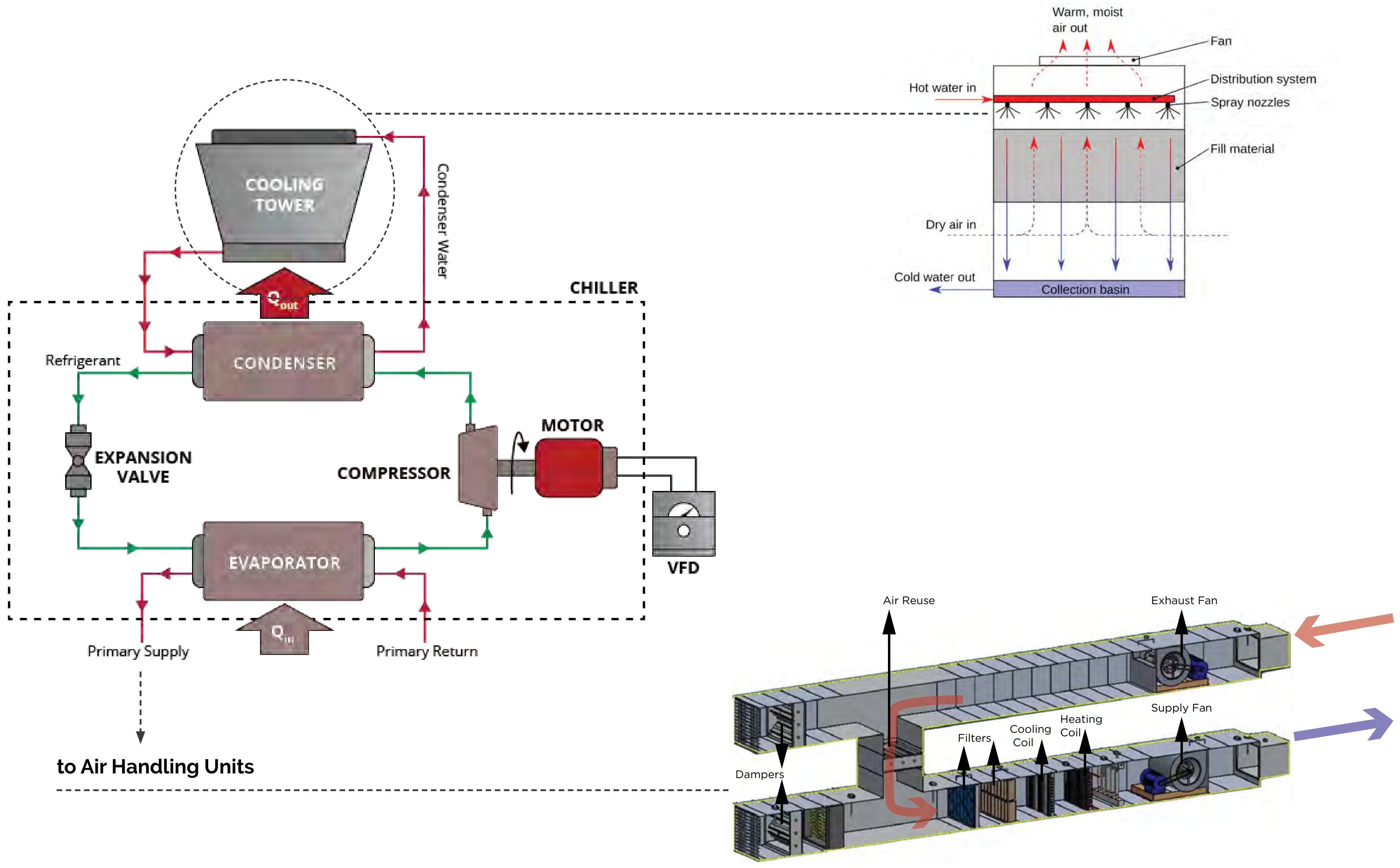
ALL AIR HVAC SYSTEM
Section

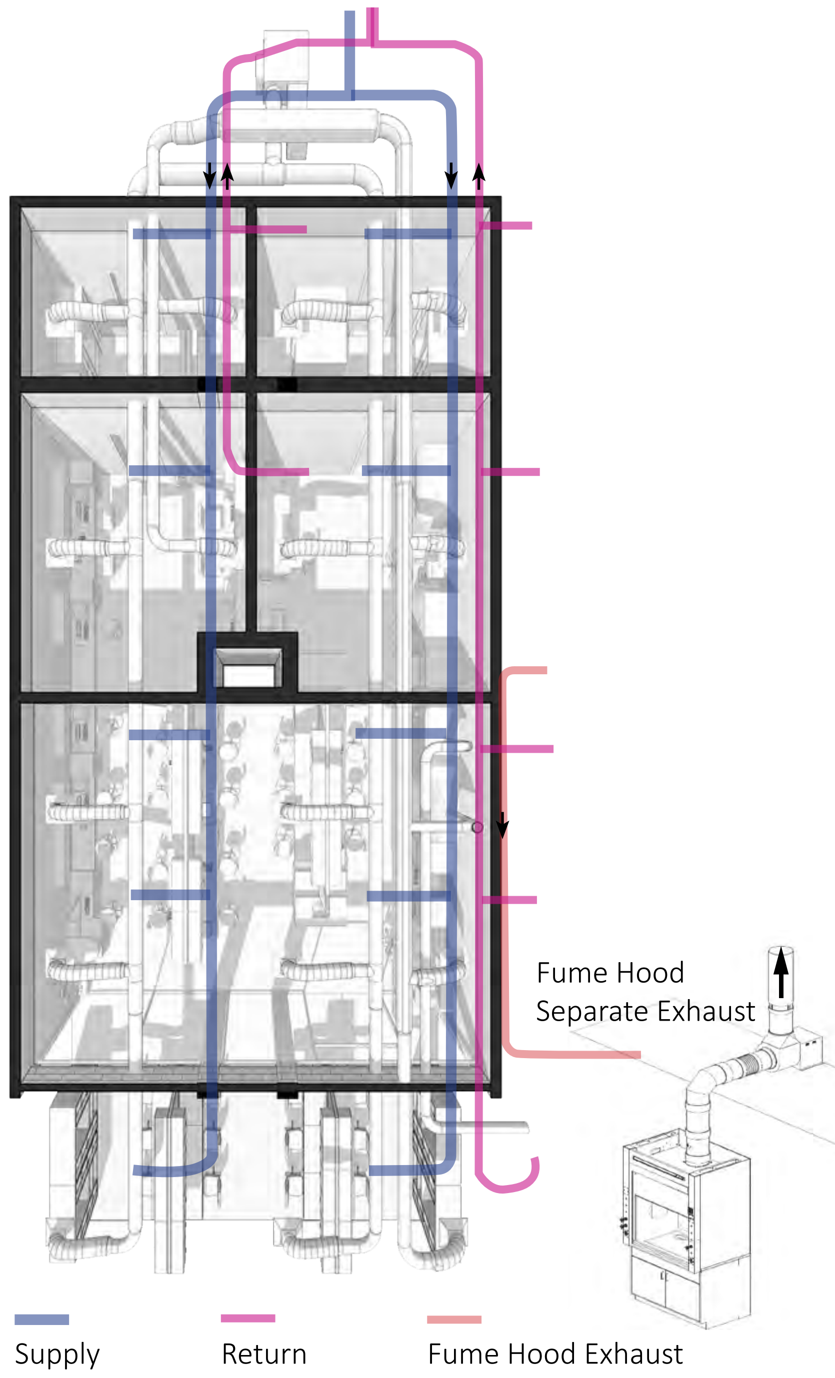


An 'All-Air Central System' supply the latent and sensible cooling and heating with the same airstream, either placed in the central system or separated by zones controlled by a thermostat. All-air systems fall into two classes - constant volume and variable air volume (VAV). This system is advantageous when it comes to maintenance, since the main equipment are centrally located.

The HVAC equipment are mainly placed in the basement level's technical rooms. On the roof, the cooling towers and the hybrid solar panels are positioned. The **cooling towers** are designed to remove heat from a building or facility by spraying water down through the tower to exchange heat into the inside of the building. Those towers are connected to the chiller in the basement level, through the shaft. Typically in heating, ventilation and air conditioning systems, **chiller units** produce chilled water that is piped to air handling units (AHU) or fan coil units where it is used to cool the air that ventilates the building. Simultaneously, the warmed water is then returned to the chiller unit to be re-cooled. AHUs are located in the basement levels and in the last floor where the roof starts sloping and creating spaces with inadequate clear height for a commercial function. **Air Handling units** are used to recondition and circulate air as part of a heating, ventilating and air-conditioning system. The basic function of the AHU is taking outside air into the unit, recondition it and supply it as fresh air to the different spaces of the building. In addition to supply ducts, exhaust air ducts return air to the AHU to be partially reconditioned and recirculated again , which creates an acceptable indoor air quality. In each lab fume hoods carries the contaminated air in a separate exhaust duct to be treated and thrown outside. Some recirculated air could also be contaminated; therefore, using filtering and natural ventilation is key to avoid toxins.

Exhaust
Supply
Terminal units
Fresh air, natural ventilation
a Air Handling Units
b Boiler
c Chiller
d Cooling Towers





Safety is key when designing laboratories. "In laboratories where hazardous substances are handled, the design of the HVAC system has to focus on the protection of staff and of the environment." Matthias Olders of Trox.

Planning a laboratory layout from an HVAC design viewpoint should be done with the objective of making each room and set up in the laboratory as safe as possible. Air quality must be tightly controlled to avoid contaminants, fire risks, recirculation of toxic air, and various other hazards that might affects workers. Also, carrying toxins directly outside can cause the contamination of external air. Labs are classified based on the type of materials and contaminants handled and the hazards posed. Laboratory classifications can be classified by industry and type. Following our program, the building includes the following types of labs:

Animal Station

The animal station is located in the basement level and demands similar requirements to those of biological labs, with extra attention for temperature and humidity control. Air change rates must be fairly high and airflow must be sufficient to keep animals healthy and comfortable. Contamination control should also be taken into consideration whether in the air or in the water pipes.

Chemistry labs

Chemical laboratories require both careful planning and execution to avoid contamination of air from the workspace to the other rooms (offices, lecture halls, common spaces, even other labs) or from the exhaust system to unpolluted parts of the facility. These type of labs are more complex and require several different types of filtration to reduce risk. Fume hoods will require regular testing to ensure the HVAC system and VAV are operating at optimum efficiency. This is particularly important in large facilities, such as in our case, with multiple fume hoods simultaneously running.

Physics labs

Physics or research and design labs may be more concerned with particulates from dust, mists and aerosols that require filtering out of the air than gaseous chemicals or biological substances. In open-floor workspaces, safety precautions should be followed strictly to avoid polluted spaces while profiting from the open common spaces and hubs. Personal protective equipment such as goggles, face shields, gloves and suits combined with an HVAC system that delivers strong filtration and high air change rates may be sufficient.

VENTILATION SYSTEM DESIGN & DUCTS AREA COMPUTATION

Values used for Heat Load Calculation

Function	Area (m^2)	Volume (m^3)	Area per Person (m^2)	Crowding Rate (ρ/m^2)	Maximum Number of people	Designed Number of people	Volume of air flow (l/s person)	Ventilation Rate per person (m^3/h)	Avg Air flow Volume (m^3/h)	Ventilation rate (m^3/s)
1 Laboratory Single unit	120	408	3.3	0.3	36	12	7	25.2	302	0.08
1 Laboratory Double unit	160	544	3.3	0.3	48	20	7	25.2	504	0.15
Forum	480	15,120	3.3	0.3	144	120	10	36	4320	1.2
Cafeteria	1,020	4,080	1.3	0.8	816	140	11	39.6	5544	1.54
1 Multi Office unit	43	130	15	0.08	4	3	11	39.6	118.8	0.033
1 Lecture Room unit	141	431	1.7	0.6	85	60	7	25.2	2142	0.6
1 Meeting Room unit	25	100	1.7	0.6	15	10	10	36	540	0.15
Auditorium	242	1,452	0.7	1.5	363	346	12.5	45	15,570	4.3
Hallway & Evaluation spaces on one floor	4,497	17,988	2.1	0.5	2,248	700	10	36	25,200	7
Animal Station	1,667	6,668	3.3	0.3	500	120	7	25.2	3060	0.85

i- Maximum number of people
= Area [m^2] * standard crowding rate value [ρ/m^2]

ii-Ventilation rate per person - to convert from l/s to m^3/h
= Standard volume air flow*3.6
e.g : 7l/s * 3.6 = 25.2 m^3/h

iii- Total Volume of air flow [m^3/h]
= Ventilation rate per person * number of people

iv-Ventilation Rate [m^3/s]
= Total Volume of air flow / 3600 (m/s)

Area of the ducts [m^2]

= Total Volume of air flow / 3600 (m/s) : velocity
velocity considered= 5m/s
For Double Laboratory Unit
Area of the ducts [m^2]= 0.15 m^3/s :5 m/s = **0.03 m^2**

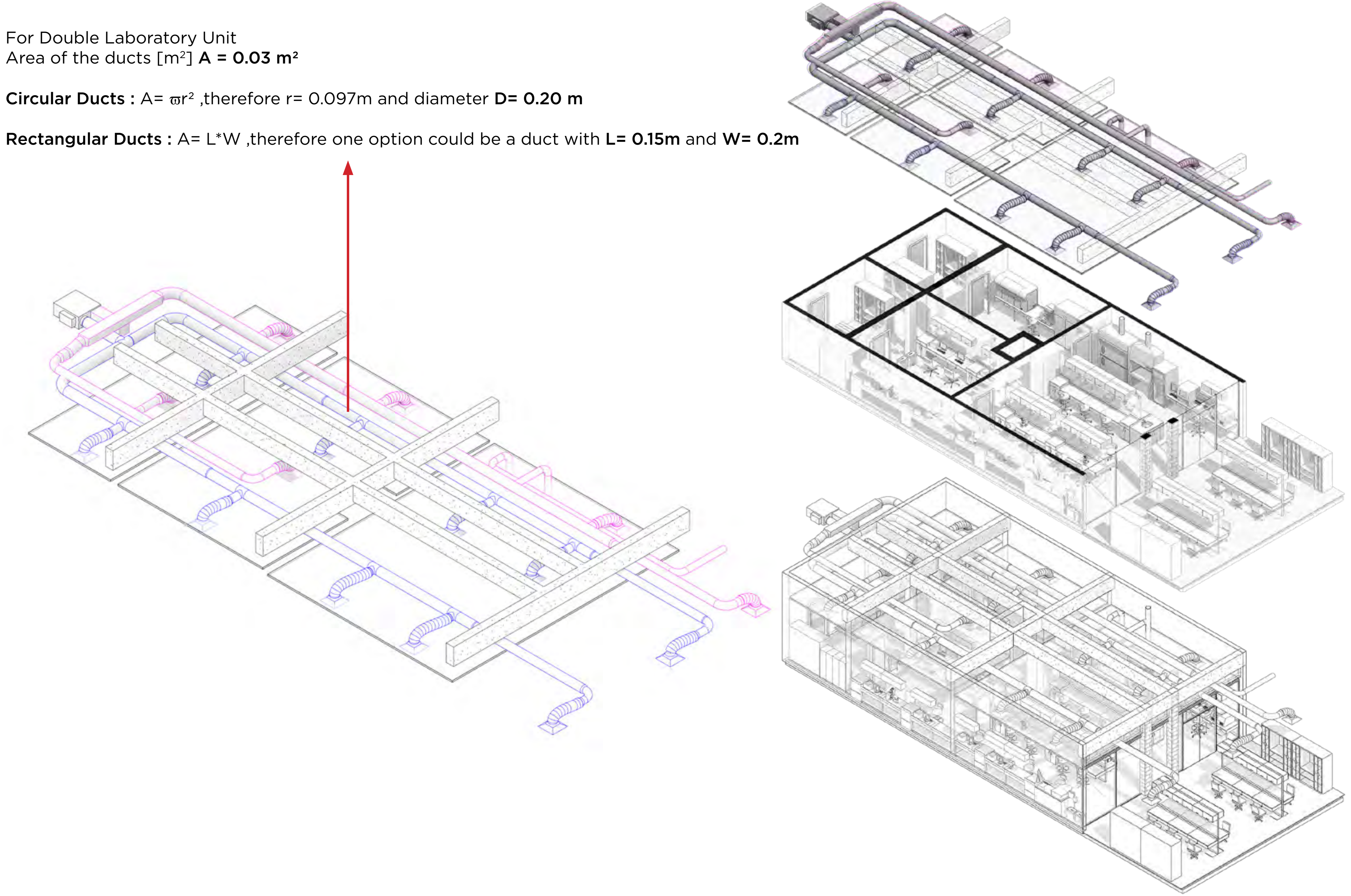
VENTILATION SYSTEM DESIGN & DUCTS

Area Computation

For Double Laboratory Unit
Area of the ducts [m^2] **A = 0.03 m^2**

Circular Ducts : A= πr^2 ,therefore r= 0.097m and diameter **D= 0.20 m**

Rectangular Ducts : A= L*W ,therefore one option could be a duct with **L= 0.15m** and **W= 0.2m**



HOT & COLD WATER SYPPLY

Water supply is always driven by pressure and we chose to have a top down water supply system with the use of solar panels to heat up the water for a more sustainable result

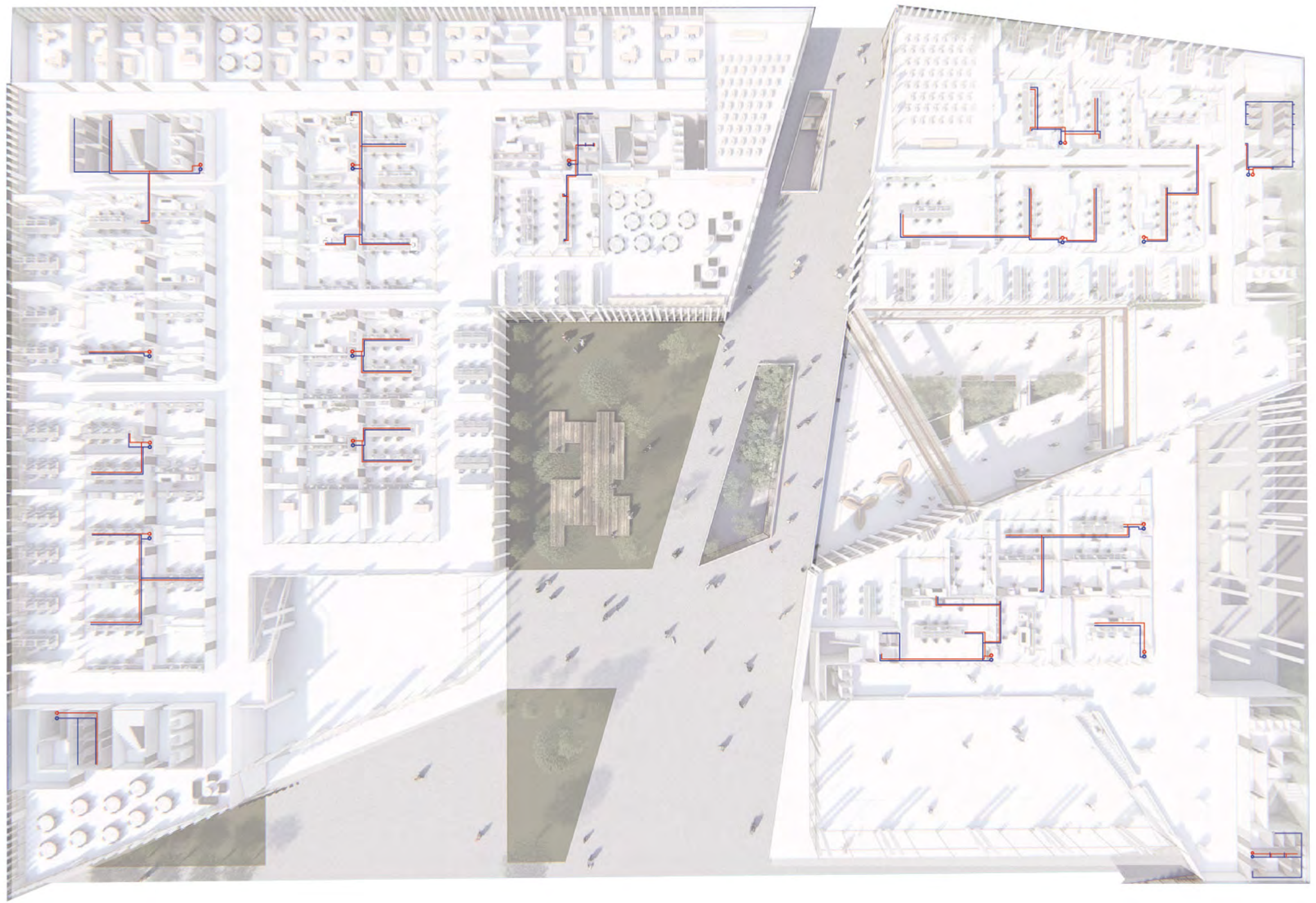
A lab water system (or laboratory water purification system) provides a consistent, pure, and adjustable source of water essential for many laboratory experiments. There are a variety of laboratory water systems, including deionized water systems, high flow lab water systems, reagent grade water systems, reverse osmosis water purification systems, and ultrapure water systems. Laboratory water purification systems can use ultra-violate radiation to eliminate microorganisms. A laboratory water system can either draw water directly from the tap or from an accompanying reservoir. Hot water is provided from two sources in our building; from the hybrid solar panels placed on the roof that heats water and uses it for the different purposes, or from the boiler that heats the water to generate steam. Steam produced in a boiler can be used for a variety of purposes other than hot water supply, including space heating, sterilisation, drying, humidification and power generation.

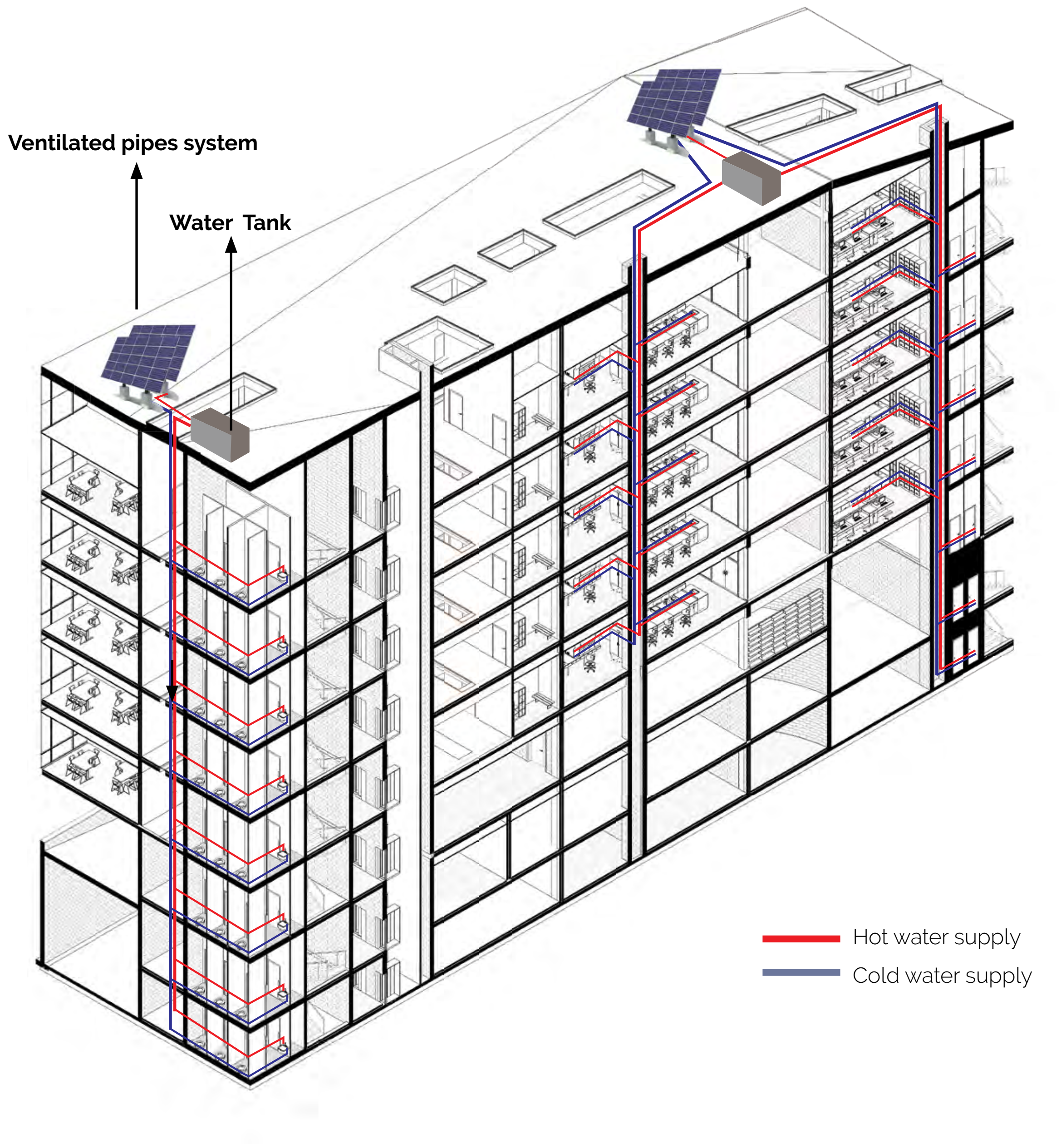
Hot water supply

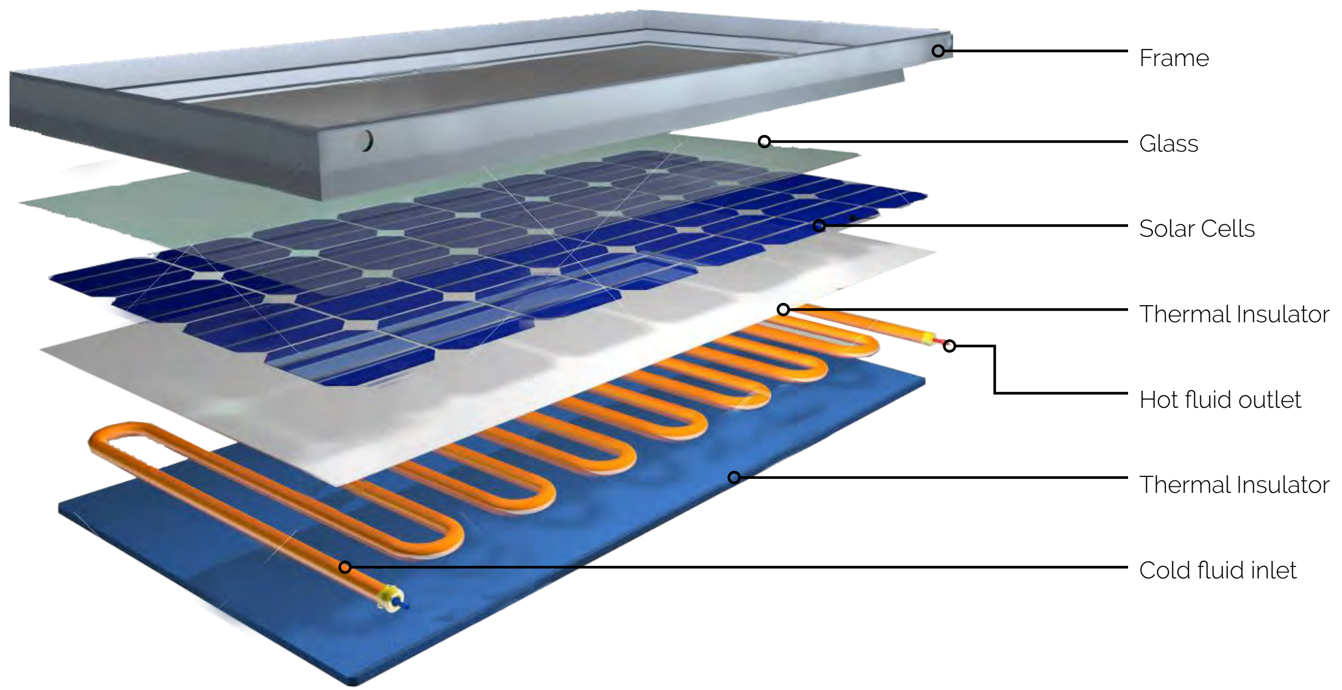
Cold water supply

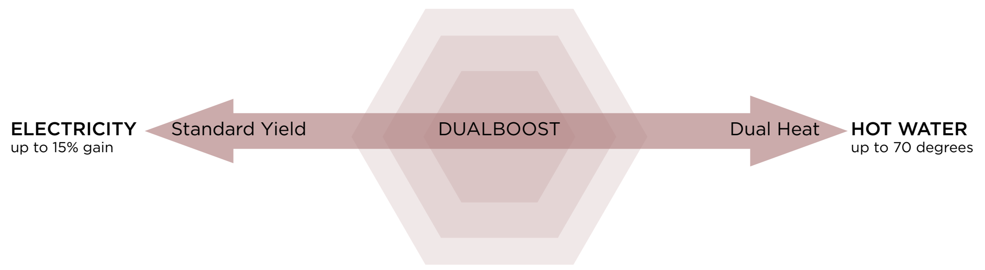
HOT & COLD WATER SYPPLY

Layout and Distribution

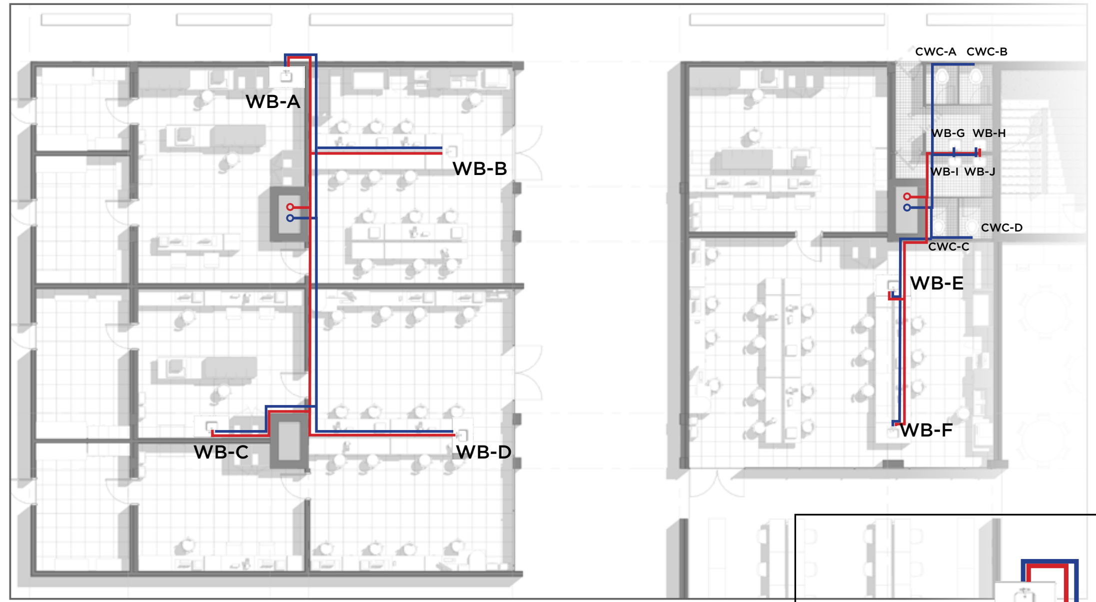


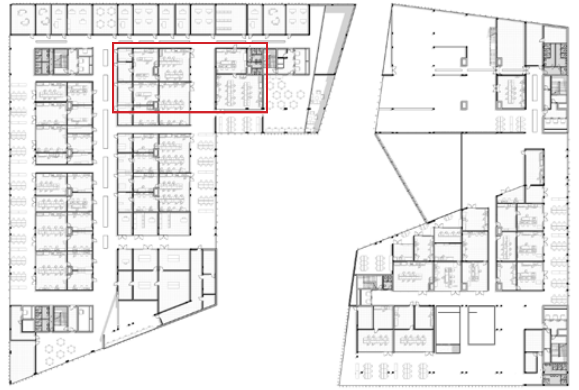






The hybrid soalr panel fulfills two functions at the same time; a double boost, it generates electricity and heats water given its combination of a photovoltaic module for generating electric power and a solar thermal collector. The front of the PVT panel absorbs solar radiation and generates electricity and heat. A high efficiency absorber, integrated in the upper part of the solar cells, assimilates the heat and by means of a propylene glycol heats the water. Thanks to the integration of heat, the photovoltaic cells are constantly cooling, increase their productivity and operate with optimal efficiency. This system not only helped in generating electricity and hot water in one panel, but also increased the energy efficiency and saving on both bills.



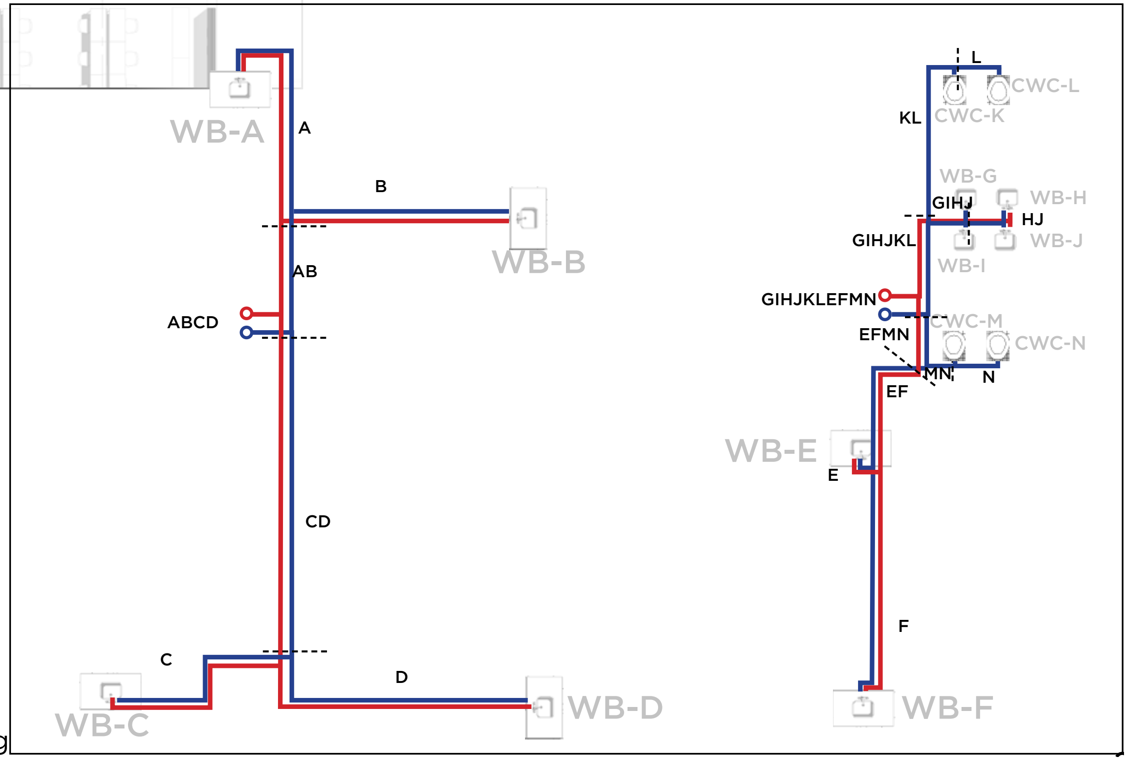


Legend

Cold water supply

Hot water supply

Water supply is always driven by pressure and we chose to have a top down water supply system with the use of solar panels to heat up the water for a more sustainable result



Branching and Pipes Lettering

HOT & COLD WATER SYPPLY
Top Down System

I- Hot Water Supply

Branch	A	B	AB	C	D	CD	ABCD	E	F	EF	H	J	HJ	G	I	GIHJ	GIHJEF
LU tot	1	1	2	1	1	2	4	1	1	2	1	1	2	1	1	4	6
LU max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pipe diameter and thickness	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	18x2.0

We use a pipe if diameter 16mm with a material thickness of 2mm for all the hot supply pipes except for pipe GIHJEF for which we use a diameter of 18mm and a thickness of 2mm.

I- Cold Water Supply

Branch	A	B	AB	C	D	CD	ABCD	E	F	EF	N & M	MN	EFMN	L	KL	GIHJ	GIHJKL	GIHJKLEFMN
LU tot	1	1	2	1	1	2	4	1	1	2	1	2	4	1	2	4	6	10
LU max	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pipe diameter and thickness	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	16x2.0	18x2.0	20x3.0

In the case of cold water pipes we use a pipe if diameter 16mm with a material thickness of 2mm for all the pipes except for pipe GIHJKL for which we use a diameter of 18mm and a thickness of 2mm and the main pipe with diameter of 20mm and a thickness of 3mm

Draw-off point	Q_A	Q_{min}	Loading units
	l/s	l/s	
Washbasin, handbasin, bidet, WC-cistern	0,1	0,1	1
Domestic kitchen sink, - washing machine [a], dish washing machine, sink, shower head	0,2	0,15	2
Urinal flush valve	0,3	0,15	3
Bath domestic	0,4	0,3	4
Taps /garden/garage)	0,5	0,4	5
Non domestic kitchen sink DN 20, bath non domestic	0,8	0,8	8
Flush valve DN 20	1,5	1,0	15
[a] For non domestic appliances check with manufacturer.			

Table 3 showing draw-off flow-rates Q_A , minimum flow-rates at draw-off points Q_{min} and loading units LU for draw-off points

Material Chosen

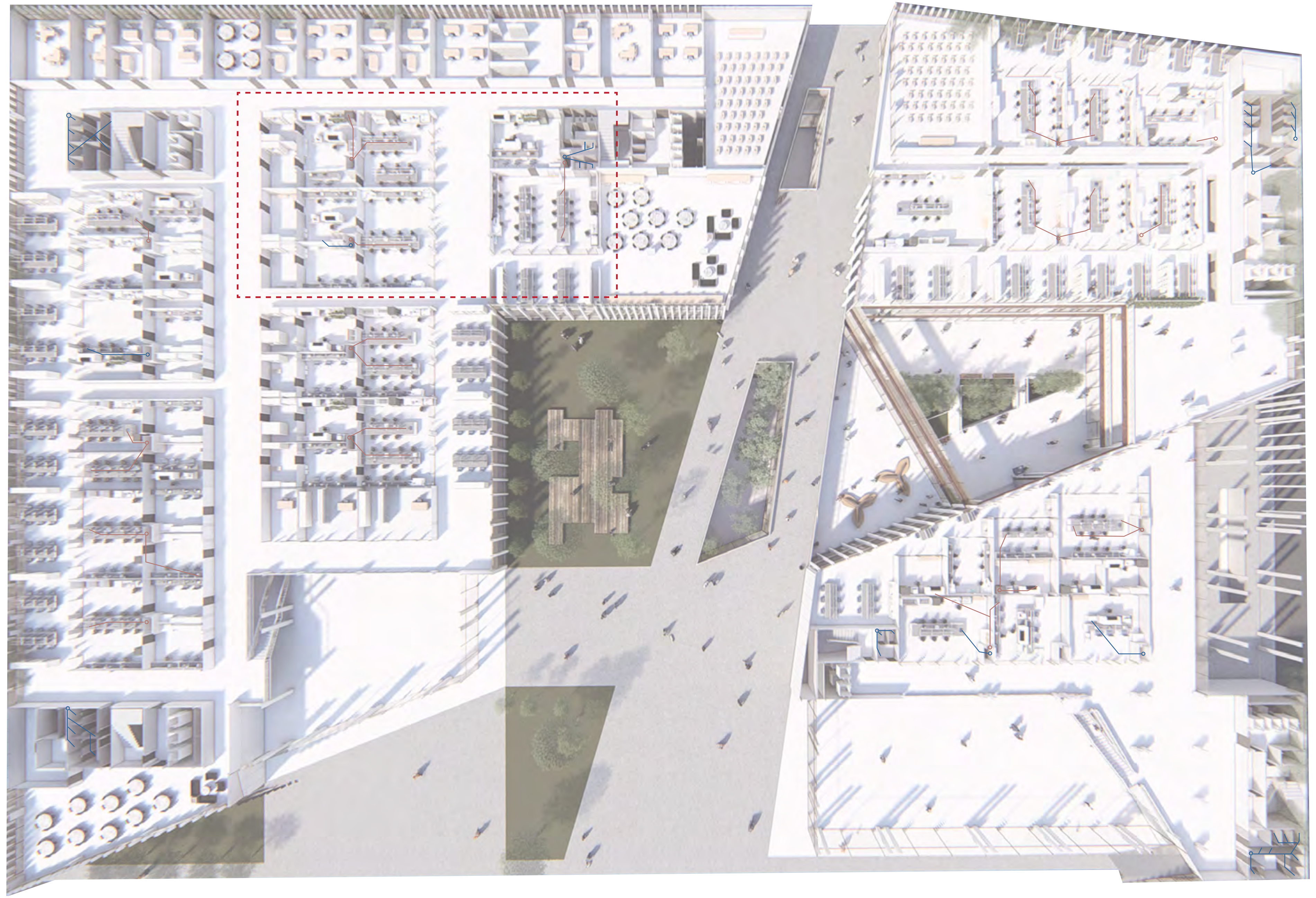
Table 3.8 — PEX/AL/PE-HD resp. PE-MD/AL/PE-HD

Max. load	**LU**	**3**	**4**	**5**	**6**	**10**	**20**	**55**	**180**	**540**	**1 300**
Highest value	LU			4	5	5	8				
d_a x s	mm	16 x 2,25/16 x 2,0			18 x 2	20 x 2,5	26 x 3	32 x 3	40 x 3,5	50 x 4	63 x 4,5
d_i	mm	11,5/12,0			14	15	20	26	33	42	54
Max length of pipe	m	9	5	4							

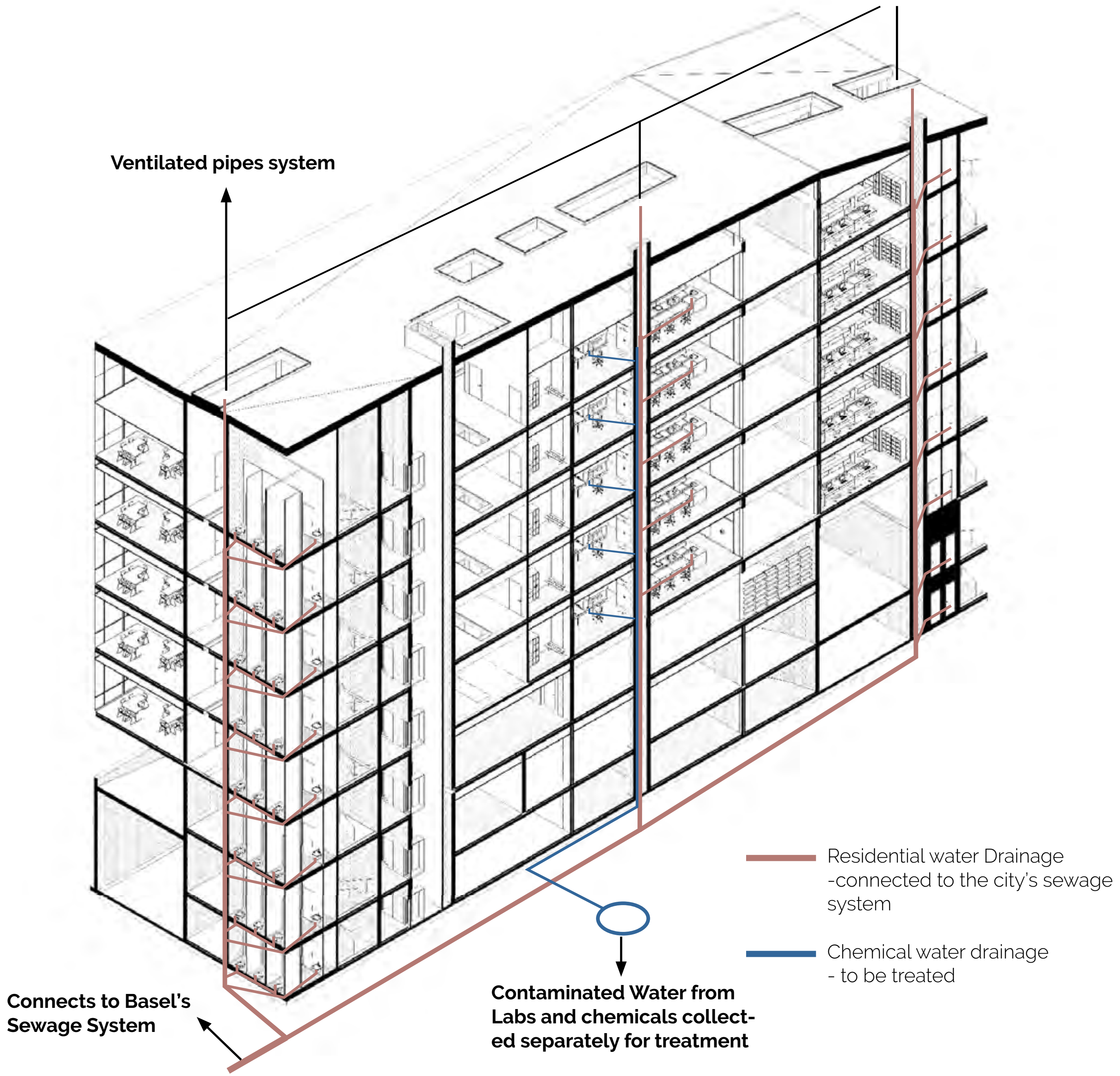
Sewage system pipes are driven by gravity thus their dimensions are bigger than the water pipes and they require to have a slope. The project has enough clear height provided for the technical ducts and pipes and for the sloping of the drainage pipes, a floor height of 4.5m and a false ceiling that can reach 1m. Waste is produced at fixtures such as toilets, sinks, and showers, laboratory sinks. A ventilated pipe avoids a vacuum from being created inside the pipes. As the water runs down air must be allowed into the waste pipe either through a roof vent, or the "drain waste. This allows neutral air pressure in the drains and free flow of water and sewage down the drains. It is critical that a sufficient downward slope be maintained throughout, to keep liquids and solids flowing freely towards the municipal drain. In some situations, "sewage ejector" pumps are needed. Traps are used for every fixture to avoid sewer gases from leaking and causing bad odor. Through traps, all fixtures are connected to waste lines, which in turn take the waste to a "soil stack", or "soil vent pipe". At the building drain system's lowest point, the drain-waste vent is attached, and rises (usually inside a wall) to and out of the roof. Waste exits from the building through the building's main drain and flows through a sewage line. In our building drained water is either connected directly to Basel's sewage system or treated firstly is it generated from chemical based water and waste.

Residential water Drainage
-connected to the city's sewage system

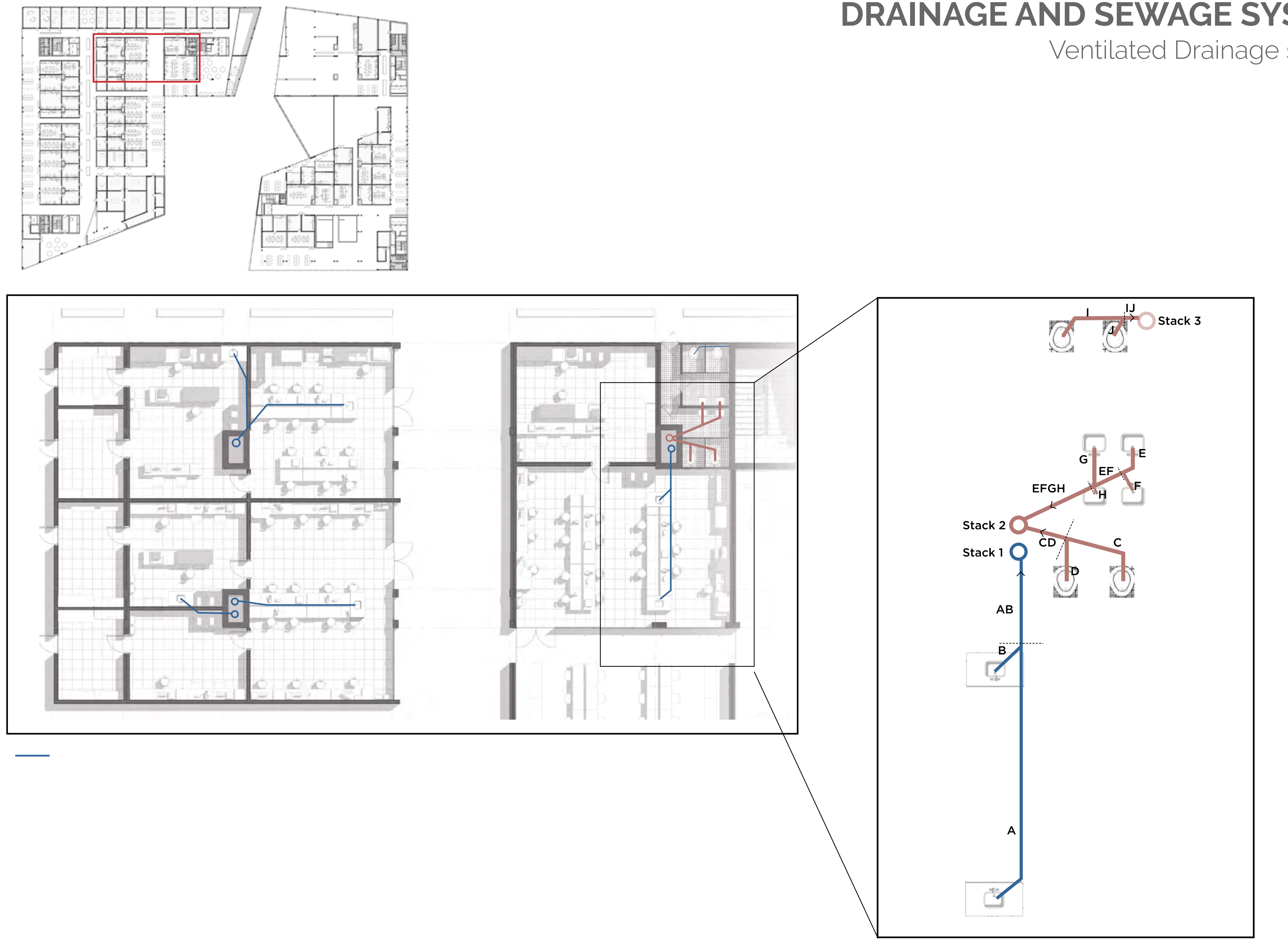
Chemical water drainage
- to be treated



Ventilated Drainage system Axo



Ventilated Drainage system



I- Ventilated System

Table 4: Typical frequency factor (K) from EN UNI 12056-2.

Usage of appliances	K
intermittent use e.g. in Dwelling, Guesthouse, Office	0,5
frequent use e.g. in Hospital, School, Restaurant, Hotel	0,7
congested use e.g. in Toilets and/or Showers open to Public	1,0
special use e.g. Laboratory	1,2

Q_{max} l/s	System I DN Branch/Vent	System II DN Branch/Vent	System III DN Branch/Vent	System IV DN Branch/Vent
0,60 (0.3)	*	30/30	see table 6	30/30
0,75	50/40	40/30		40/30
1,50	60/40	50/30		50/30
2,25 (2.0)	70/50	60/30		60/30
3,00	80/50**	70/40**		70/40**
3,40	90/60***	80/40****		80/40****
3,75	100/60	90/50		90/50

* not permitted
** no WC's
*** not more than two WC's and a total change in directions of not more than 90°
**** not more than one WC

Table 6 Hydraulic capacity Qmax and Nominal Diameter DN EN UNI 12056-2

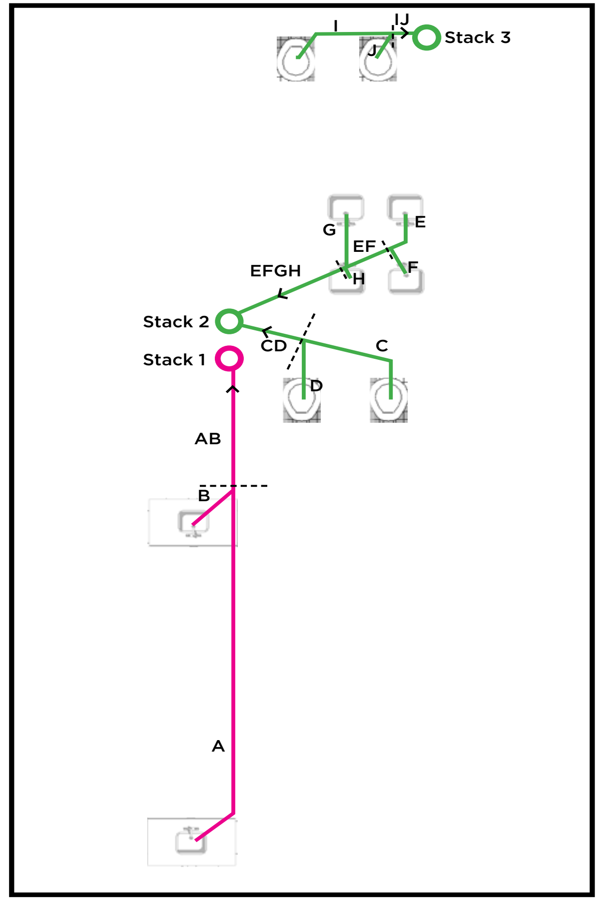
Appliance	System I DU l/s	System II DU l/s	System III DU l/s	System IV DU l/s
Wash Basin, Bidet	0,5	0,3	0,3	0,3
Shower without Plug	0,6	0,4	0,4	0,4
Shower with Plug	0,8	0,5	1,3	0,5
Single Urinal with Cistern	0,8	0,5	0,4	0,5
Urinal with Flushing Valve	0,5	0,3	-	0,3
Slab Urinal	0,2*	0,2*	0,2*	0,2*
Bath	0,8	0,6	1,3	0,5
Kitchen Sink	0,8	0,6	1,3	0,5
Dishwasher (Household)	0,8	0,6	0,2	0,5
Washing Machine up to 6 kg	0,8	0,6	0,6	0,5
Washing Machine up to 12 kg	1,5	1,2	1,2	1,0
WC with 4,0 l Cistern	**	1,8	**	**
WC with 6,0 l Cistern	2,0	1,8	1,2 to 1,7***	2,0
WC with 7,5 l Cistern	2,0	1,8	1,4 to 1,8***	2,0
WC with 9,0 l Cistern	2,5	2,0	1,6 to 2,0***	2,5
Floor Gully DN 50	0,8	0,9	-	0,6
Floor Gully DN 70	1,5	0,9	-	1,0
Floor Gully DN 100	2,0	1,2	-	1,3

* per person
** not permitted
*** depending upon type (valid for WC's with siphon flush cistern only)
\- not used or no data

Table 5 DU discharge unit fro each appliance EN UNI 12056-1

System II : Single discharge stack system with amall bore discharge branch pipes

Sanitary appliances are connected to small bore branch discharge pipes that are designed with a 70% filling degree.



Branch	A	B	AB	C	D	CD	E	F	EF	G	H	EFGH	I	J	IJ
	Stack 1			Stack 2									Stack 3		
Q_{ww} Single flow rate of DU [l/s]	-	-	0.93	-	-	2.68	-	-	0.93	-	-	1.3	-	-	2.68
Qmax [l/s] Ventilated System II				2.0	2.0	2.0	0.3	0.3	0.3	0.3	0.3	0.3	2.0	2.0	2.0
Qmax [l/s] Ventilated System II	0.3	0.3	0.3												
Nominal Diameter DN Branch/Vent	30/30	30/30	30/30	60/30	60/30	60/30	30/30	30/30	30/30	30/30	30/30	30/30	60/30	60/30	60/30

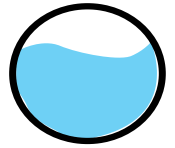
I-Waste water flowrate (Q_{ww})
N.B: it is useful where we have a connection of more than 2 stacks
$\mathbf{Q_{ww} = K \sqrt{\Sigma DU}}$
where,
Q_{ww}: Waste water flowrate [l/s]
K: Frequency factor = 1.2 in this case
DU: Discharge Unit
from Table 3: for washing basin **DU= 0.3** and for WC cistern 9.0l **DU=2.5**
$\mathbf{Q_{EFGH} = 1.2 \sqrt{(0.3+0.3+0.3+0.3)} = 1.3}$ **l/s**

II-Total water flowrate (Q_{max})

$\mathbf{Q_{tot} = Q_{ww} + Q_c + Q_p}$
where,
Q_{ww}: Waste water flowrate [l/s]
Q_c: Continuous flow rate [l/s]
Q_p: Pumped water flow rate [l/s]

III-Find the DN from Table 5 (DN)

70 % filling degree pipe
70% filled an 30% air



-minimum slope of pipe= 1% or 1.5%

Primary ventilated discharge stacks

Stack and stack vent	System I, II, III, IV	
	Q_{max} (l/s)	
DN	Square entries	Swept entries
60 (0.3)	0,5	0,7
70	1,5	2,0
80*	2,0	2,6
90	2,7	3,5
100**	4,0	5,2
125	5,8	7,6
150	9,5	12,4
200	16,0	21,0

* minimum size where WC's are connected in system II
** minimum size where WC's are connected in system I, III, IV

Table 7 Hydraulic capacity Qmax and Nominal Diameter DN from EN UNI 12056-1

IV- Ventilated discharge branches Limitations from Table 7 and 8

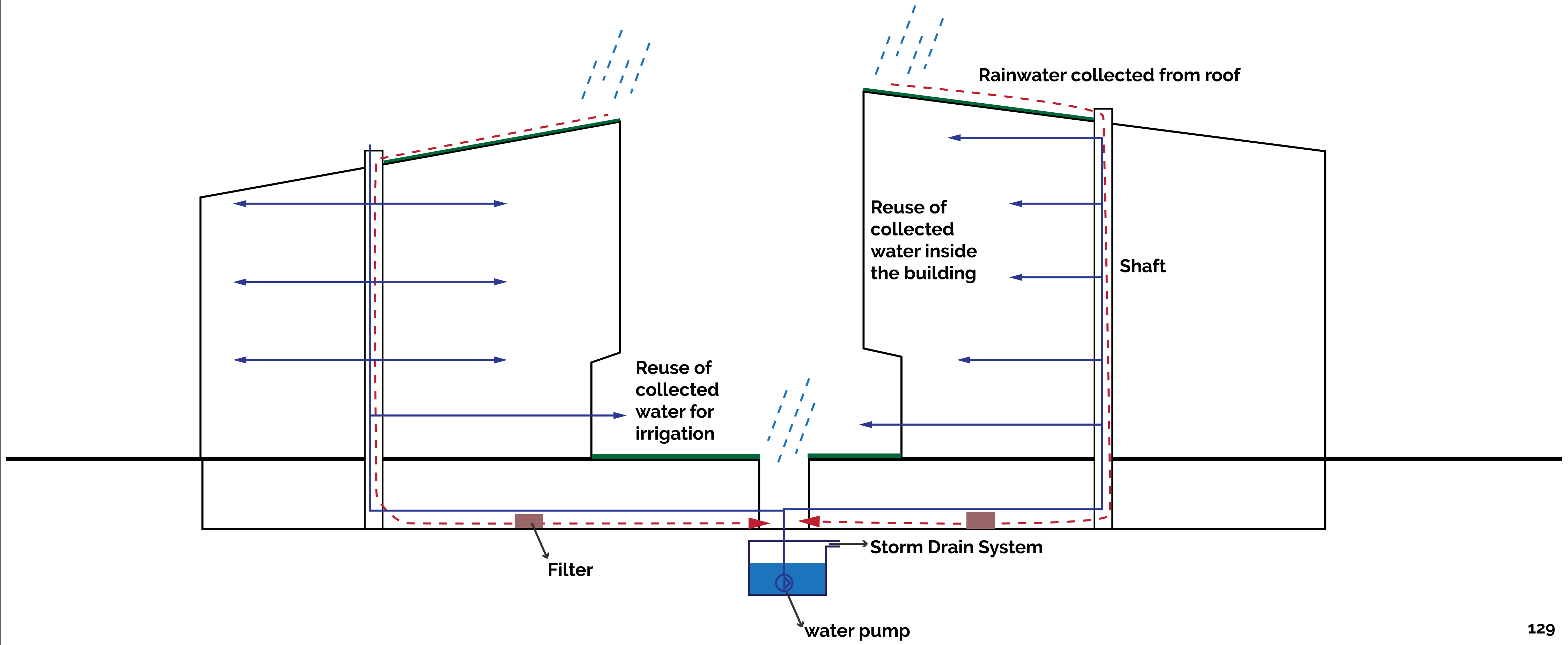
Stack 1: Q_{max}= 0.3 >> DN= 60 (no WCs so we can take a value less than 80)- Stack 1 will carry contaminated chemical water for the labs to a separate place for treatment.
Stack 2: Q_{max}= 2.0 >> DN = 80 which is the minimum allowed size for WC of system II
Stack 2: Q_{max}= 2.0 >> DN = 80

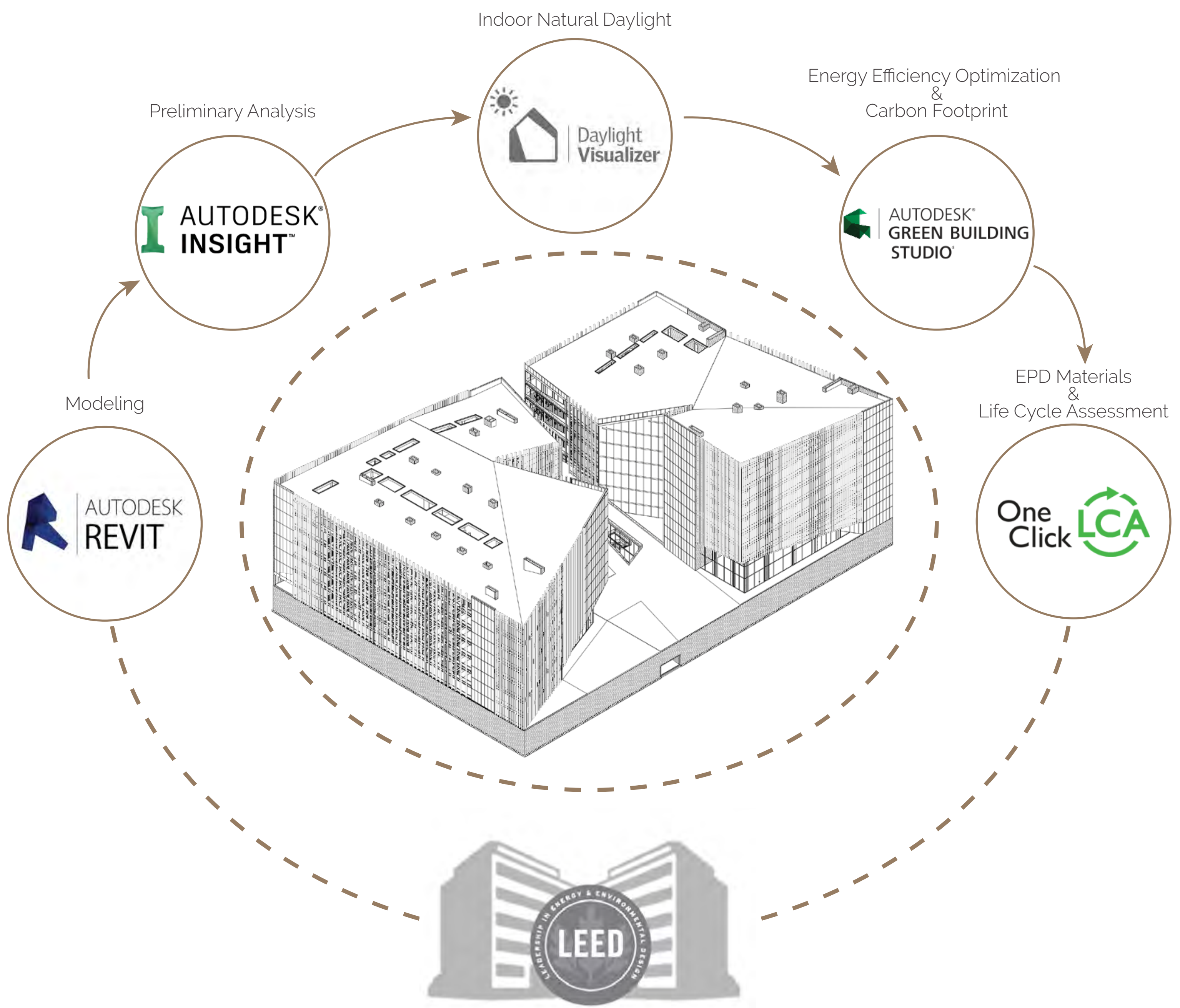
V-Sizes and limitations ventilated discharge stacks

Limitations	System I	System II	System III	System IV
maximum length (*L*) of pipe	10,0 m	no limit		10,0 m
maximum number of 90° bends*	no limit	no limit	see	no limit
maximum drop (*H*) (45° or more inclination)	3,0 m	3,0 m	table 9	3,0 m
minimum gradient	0,5 %	1,5%		0,5%

* Connection bend not included

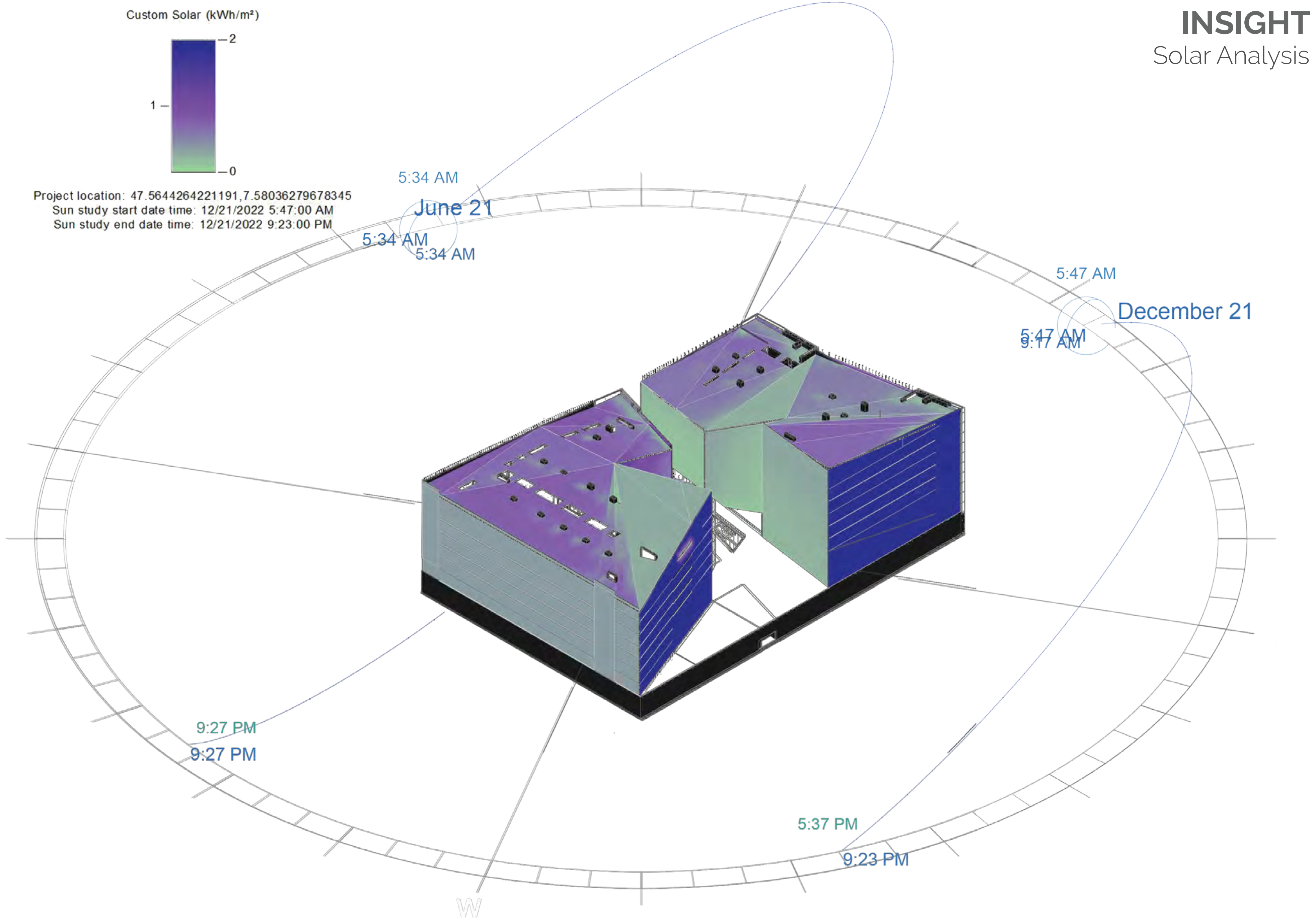
Table 8 Limitations for ventilated pipes EN UNI 12056-2





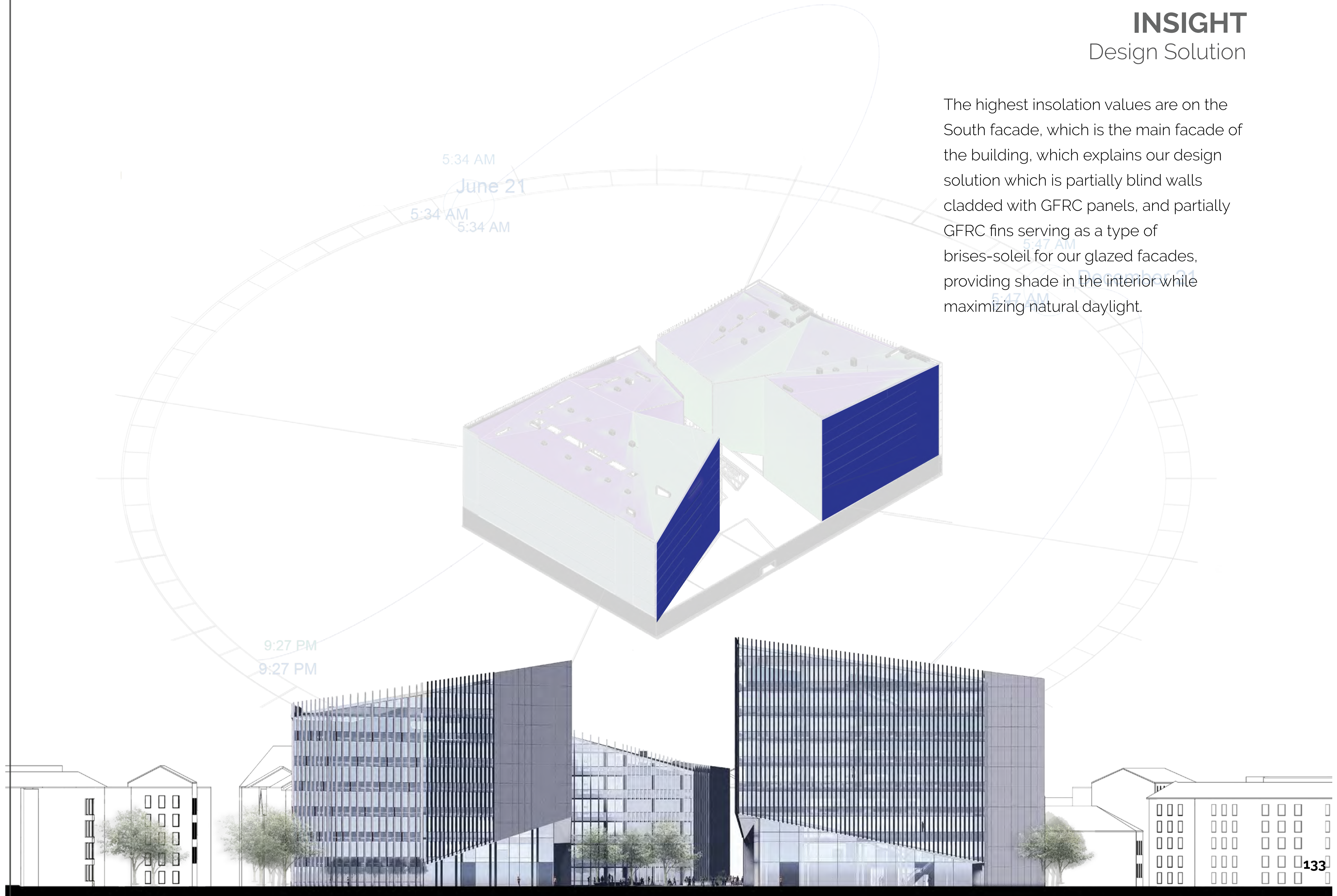
BUILDING INFORMATION MODELING.BIM

INSIGHT
Solar Analysis

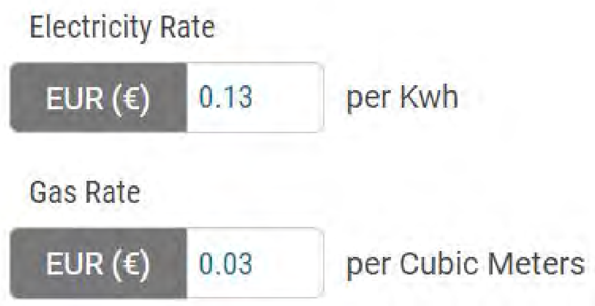


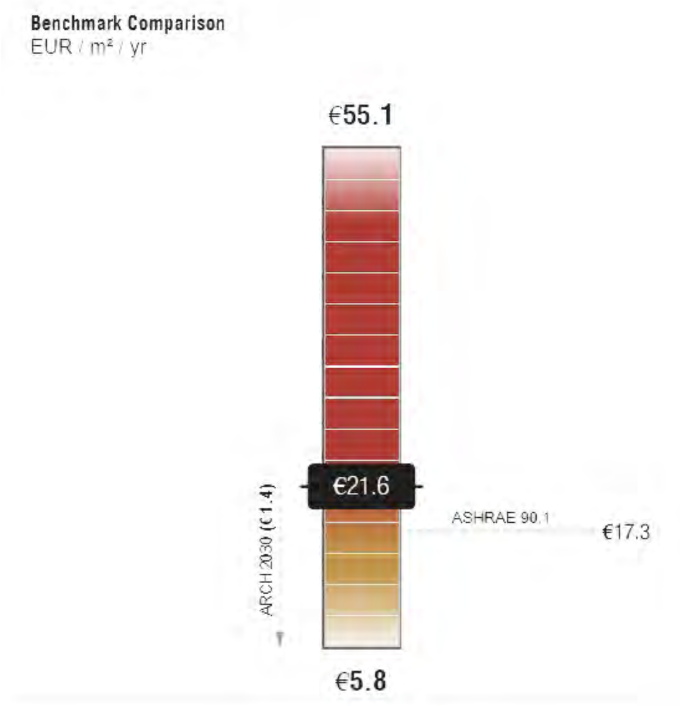
INSIGHT
Design Solution

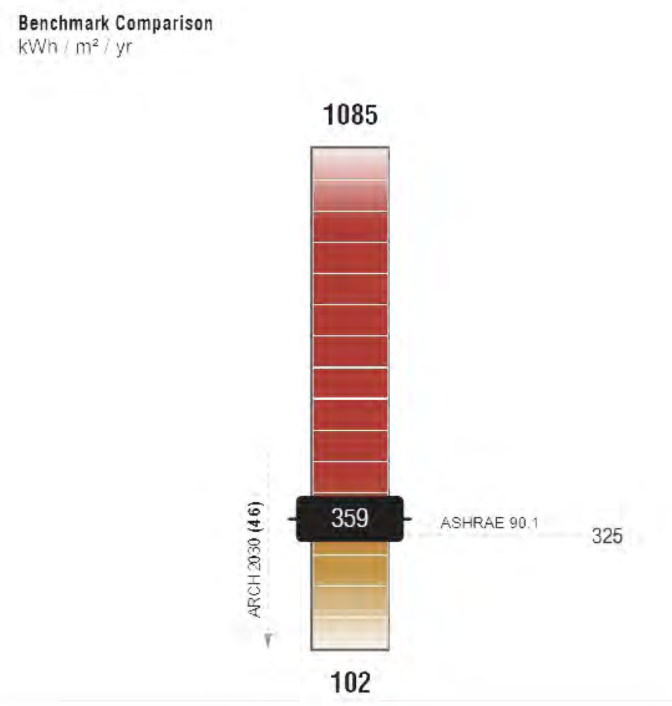
The highest insolation values are on the South facade, which is the main facade of the building, which explains our design solution which is partially blind walls cladded with GFRC panels, and partially GFRC fins serving as a type of brises-soleil for our glazed facades, providing shade in the interior while maximizing natural daylight.



Insight focuses on the energy use intensity, or EUI. The EUI is a key metric in benchmarking buildings. It is essentially a building's annual energy use divided by the total area. The resulting calculation gives you the energy use per area per year. Depending on the building type, the EUI should be within a certain range. In this case, the value we obtained is very close to the ASHRAE 90.1 benchmark, which is a good start for our preliminary analysis.

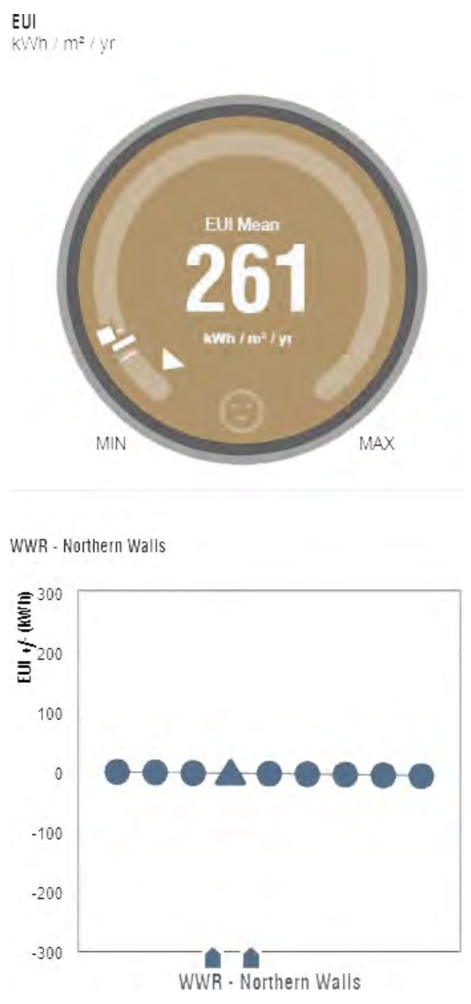


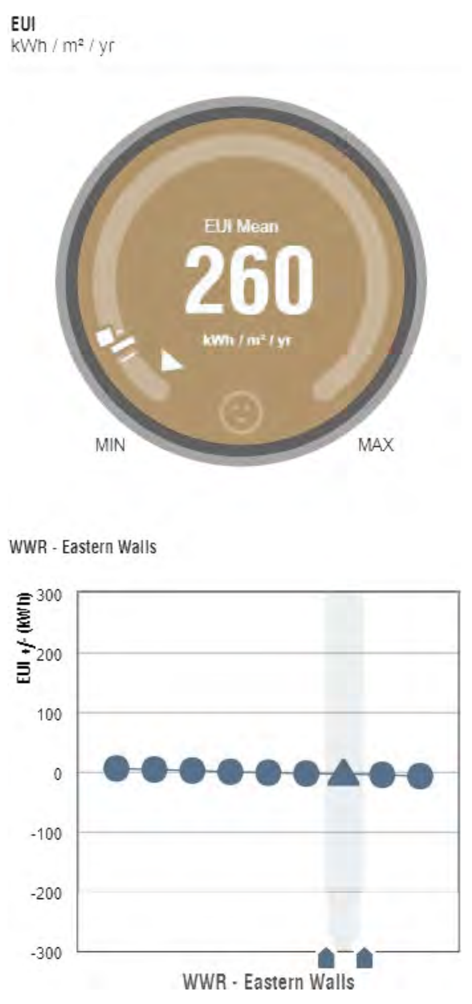


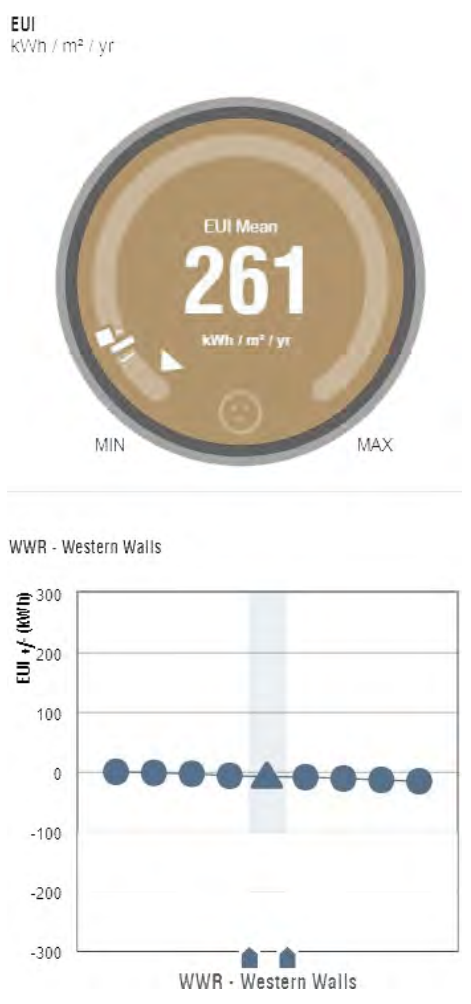


The Benchmark Comparison shows how the design's current performance stacks up against industry benchmarks such as ASHRAE 90.1 and Architecture 2030. It assigns a cost for energy use euros per square meter per year.

Window to wall ratio is one of the big factors that relate to daylighting in Insight. It does it for each elevation for the building - North, South, East & West. The graph represents energy performance in terms of either energy use intensity or euros per square meter per year of energy use, with a range of different options. If it is a steep line on the graph, it means that this factor has a big impact on the energy use of the building. On the contrary, the shallow lines mean that this factor does not have as big of an impact as other factors on this building, which is the case in all of ours facades. It is the same procedure for window glass. We can find the mean value and the different range of values when we change the type of glass to see how glazing type affects performance.





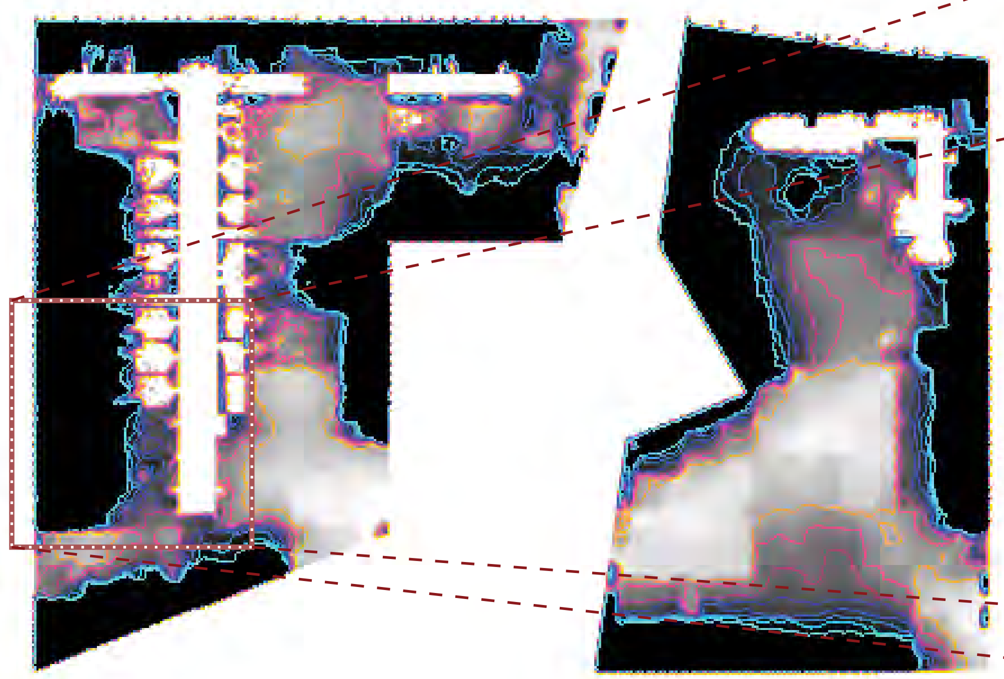


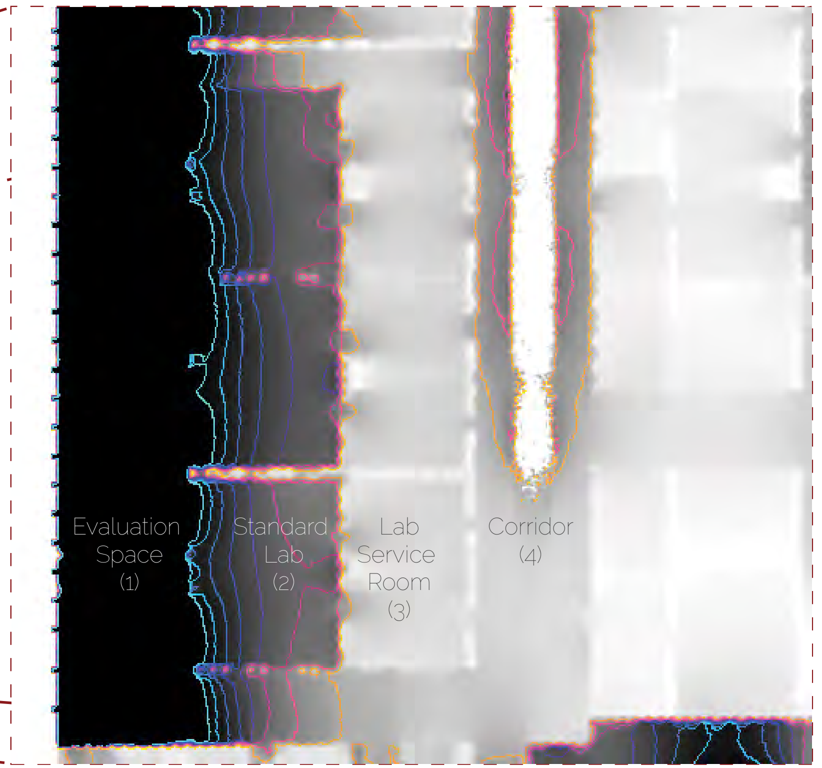
VELUX Daylight Visualizer
Indoor Daylight Analysis

Typical Floor Plan

Chemistry Wing

Physics Wing

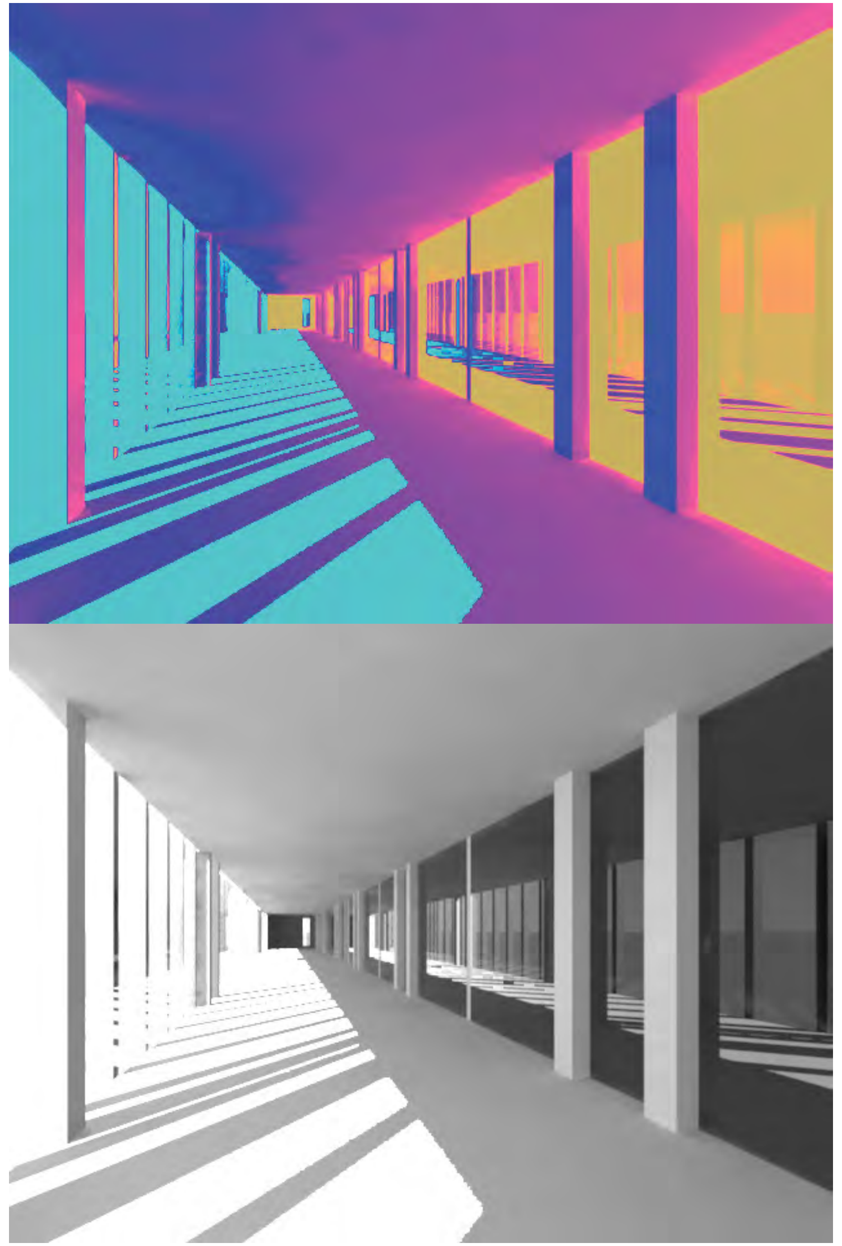


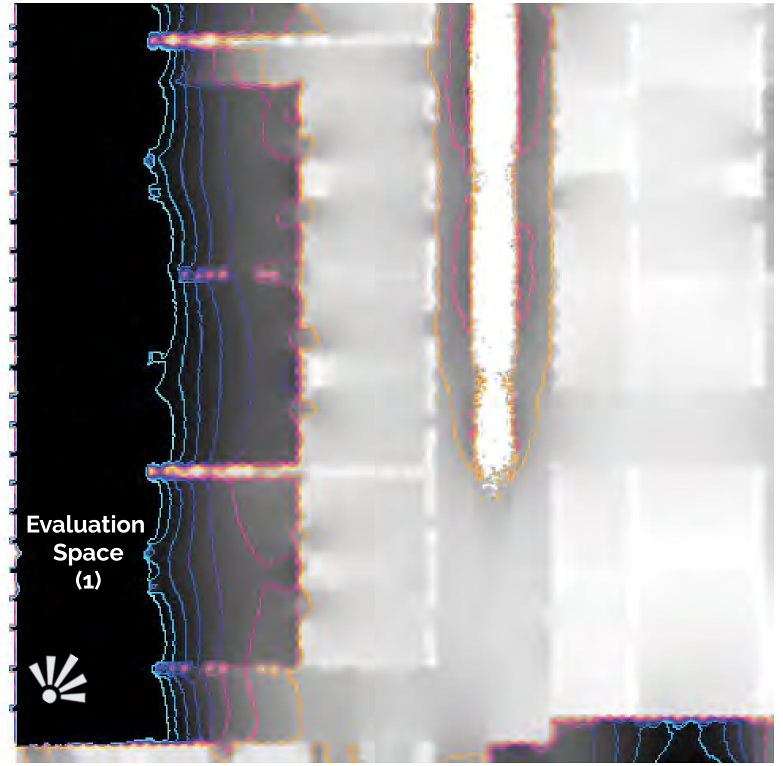


Daylight Factor
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00

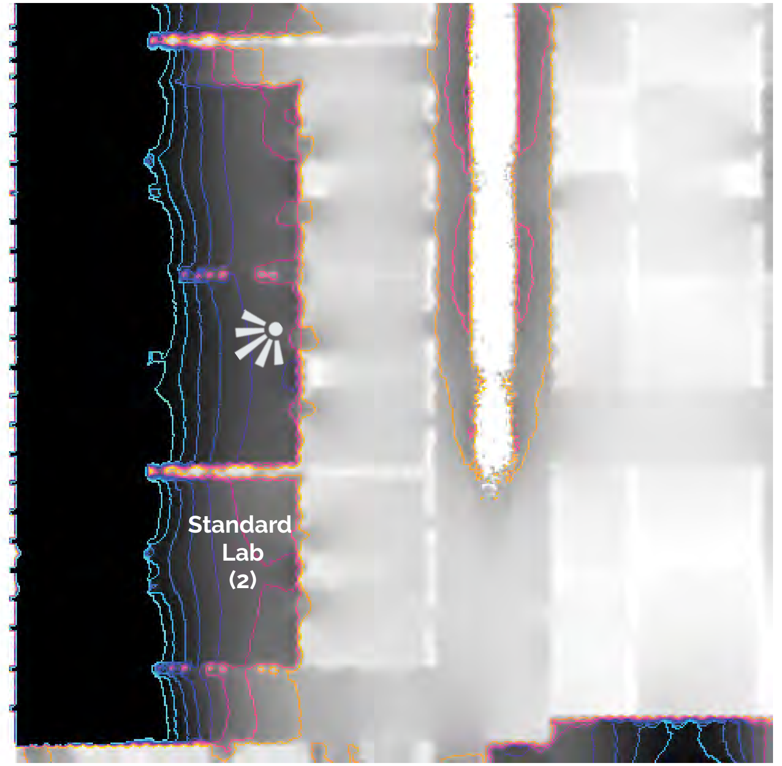
Scan for the indoor daylight analysis video on lux

VELUX Daylight Visualizer
Indoor Daylight Analysis

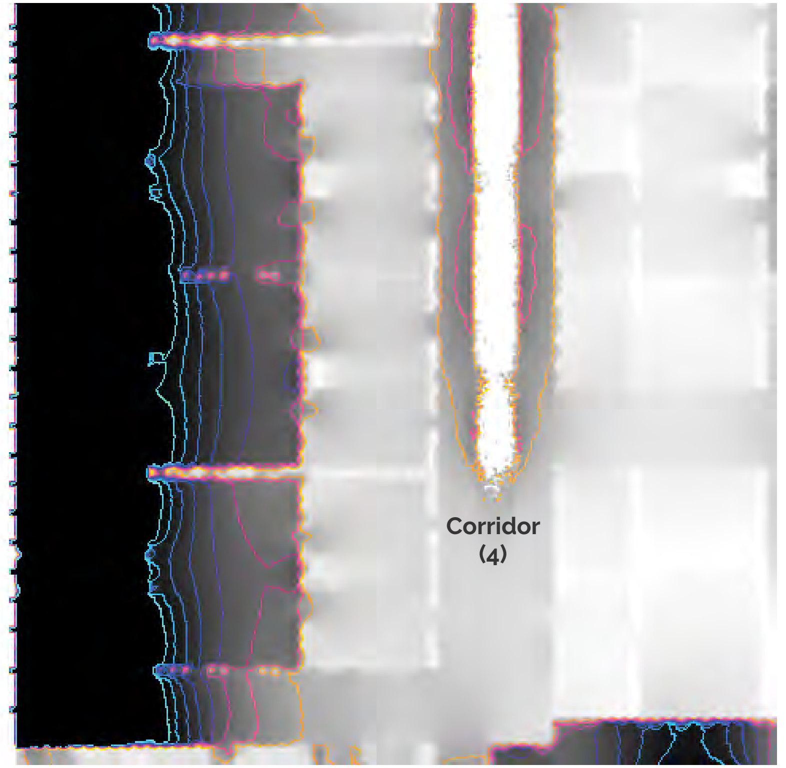




lux
500
438
375
313
250
188
126
63



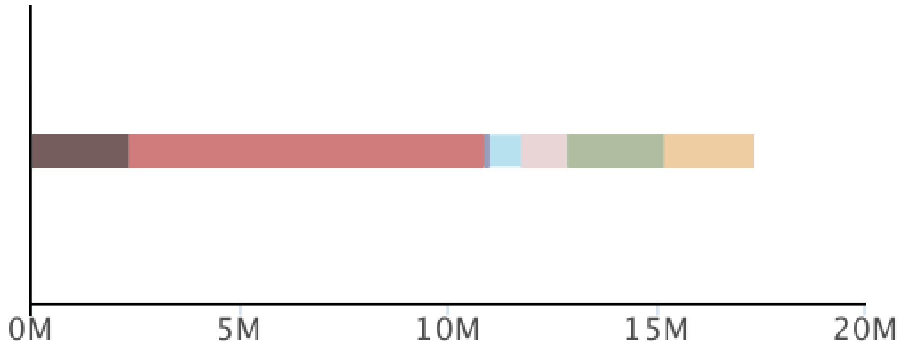
lux
500
438
375
313
250
188
126
63



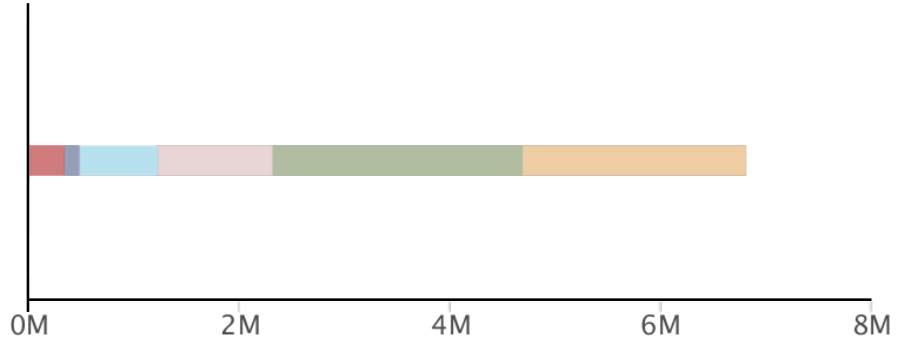
lux
500
438
375
313
250
188
126
63

Green Building Studio
Annual Data

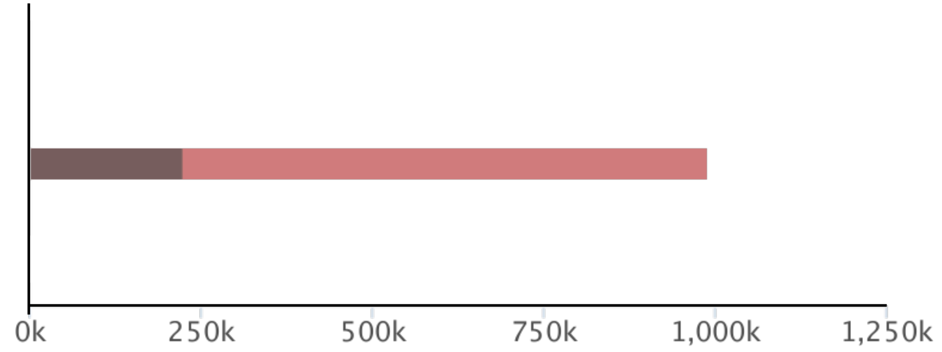
Total Energy (kWh)



Electricity (kWh)



Fuel -Natural Gas (m^3)



Total Energy = 17,343,056 kWh → 255 kWh/m^2

Hot Water - 14%
Space Heat - 49%
Pumps - 1%
Vent Fans - 4%
Space Cooling - 6%
Equipment - 14%
Area Lights - 12%

Total Electricity= 6,811,247 kWh

Space Heat - 5%
Pumps - 2%
Vent Fans - 11%
Space Cooling - 16%
Equipment - 35%
Area Lights - 31%

Fuel (Natural Gas) = 987,037 m^3

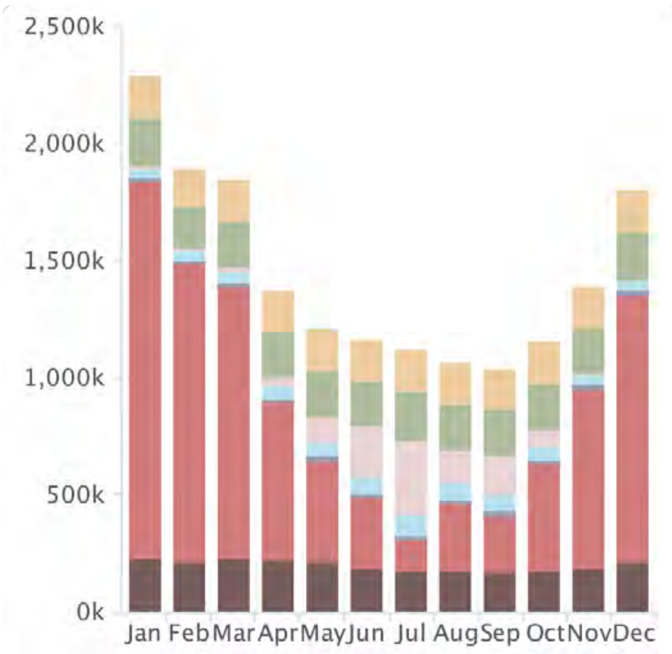
Hot Water - 22%
Space Heat - 78%

- Area Lights
- Misc Equip
- Space Cooling
- Vent Fans
- Pump Aux
- Space Heat
- Hot Water

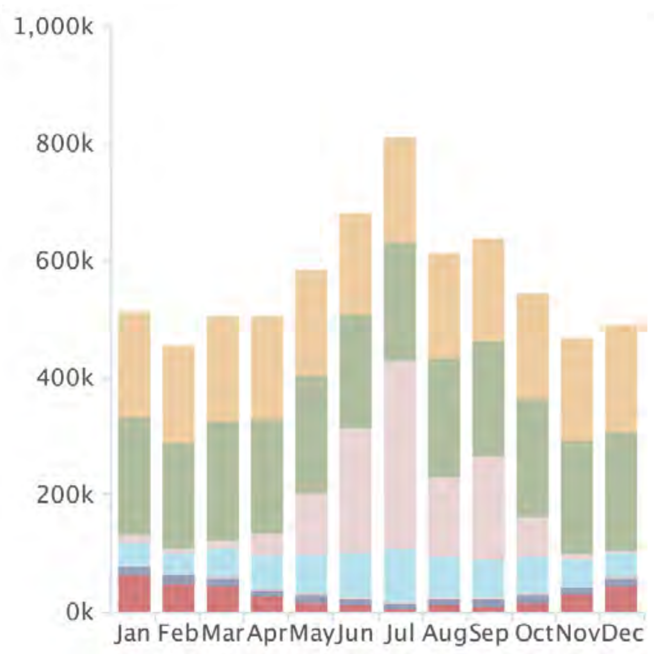
Green Building Studio
Monthly Data

Autodesk Green Building Studio (GBS) was used to optimize the energy efficiency and carbon footprint of the building design. The BIM data was imported directly from the Revit model, providing a fast and efficient workflow for energy analysis.

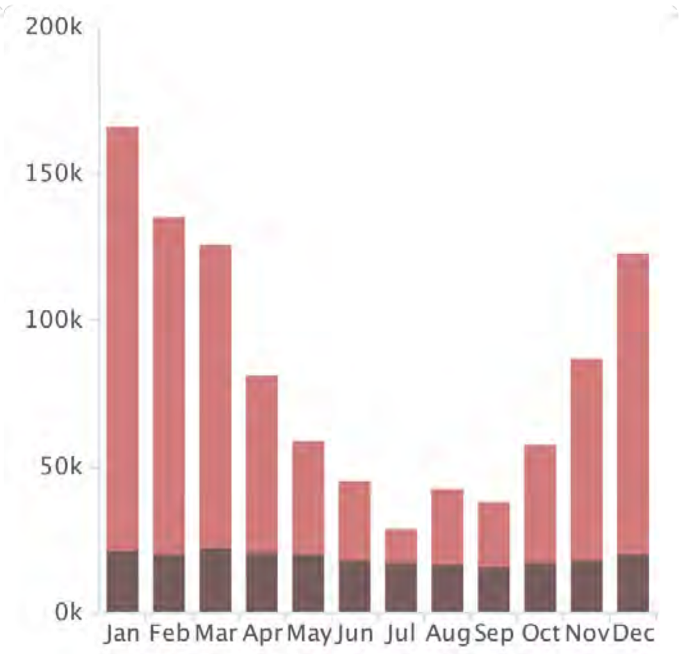
Total Energy (kWh)



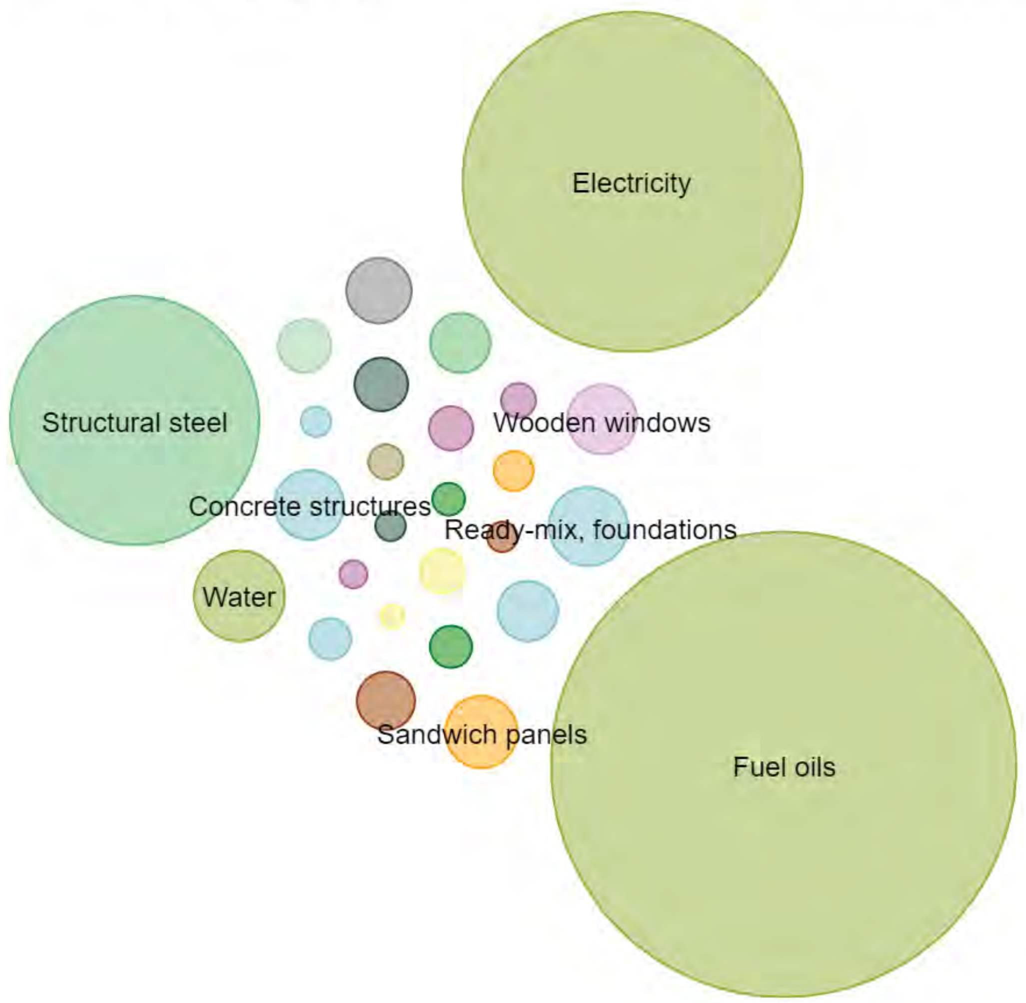
Electricity (kWh)



Fuel -Natural Gas (m^3)



Bubble chart, total life-cycle impact by resource type and subtype



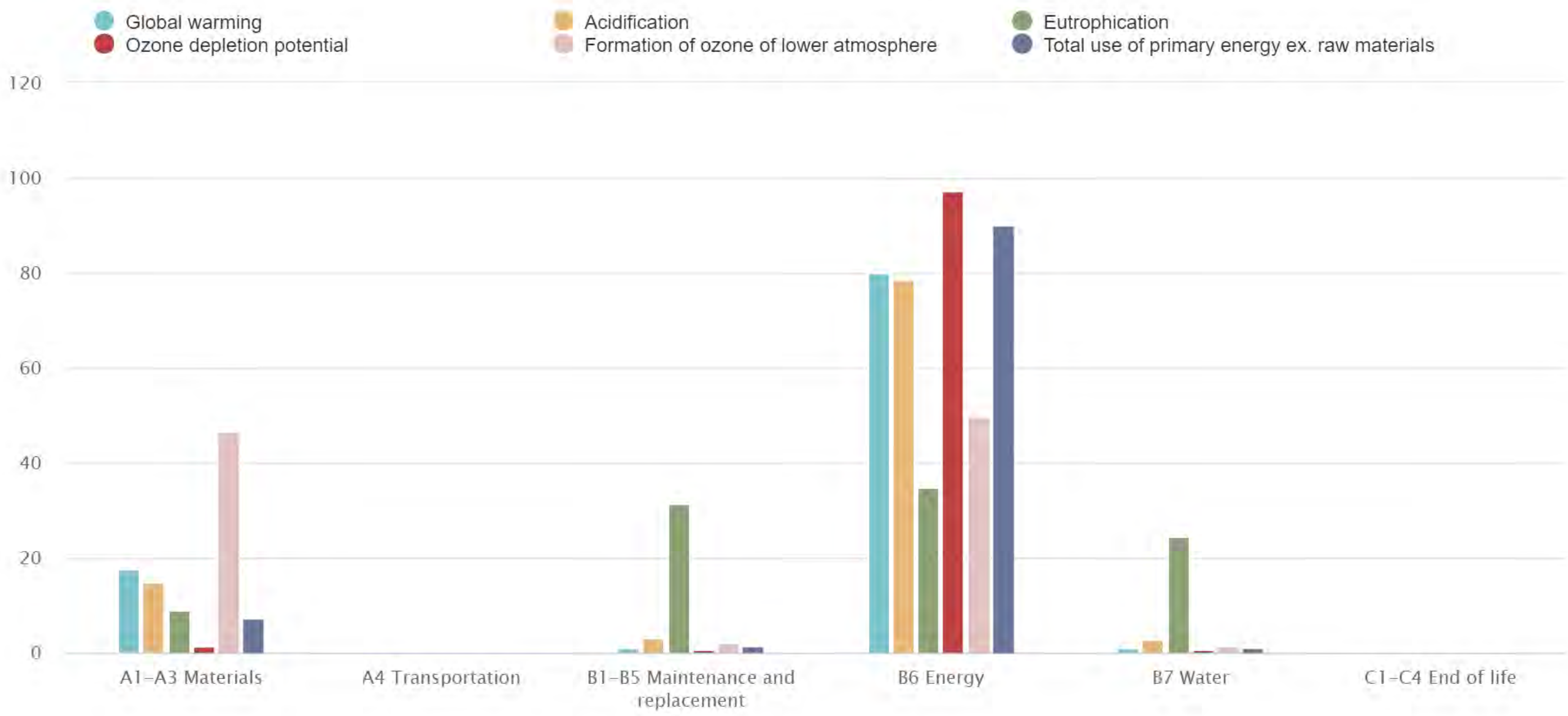
- Concrete
- Insulation
- Gypsum, plaster and cement
- Glass
- Wood
- Plastics, membranes and roofing
- Steel and other metals
- Earth, masses and stones
- Bricks and ceramics
- Flooring
- Coatings and pastes
- Doors, windows and parts
- Utilities

587 389 Tons CO_2e

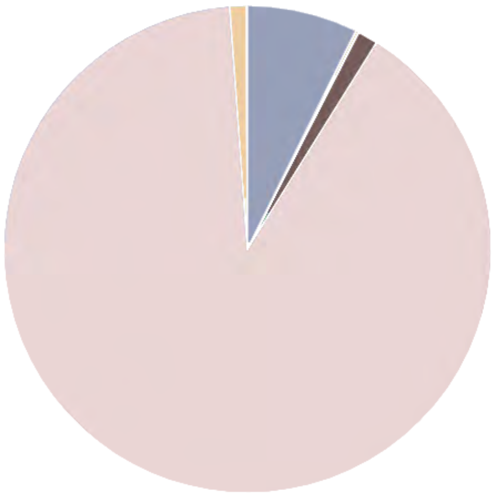
86 kg CO_2e / m2 / year

29 369 428 € Social cost of carbon

Results by life-cycle stage (percentage)

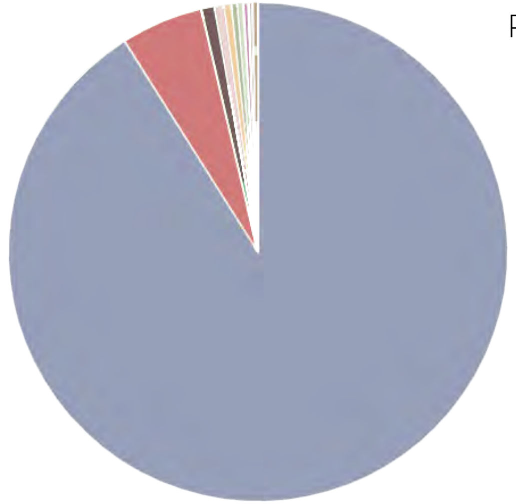


OneClick LCA
Life Cycle Assessment Results



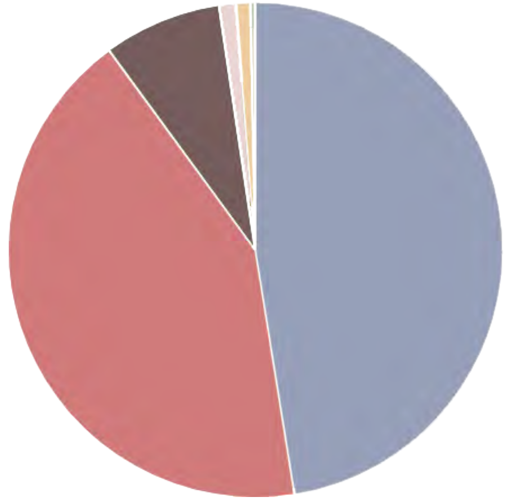
Life-cycle stages

- A1 - A3 Materials - 7.3%
- A4 Transportation - 0.2%
- B1 - B5 Maintenance & replacement - 1.4%
- B6 Energy - 89.9%
- B7 Water - 1.1%
- C1 - C4 End of life - 0.1%



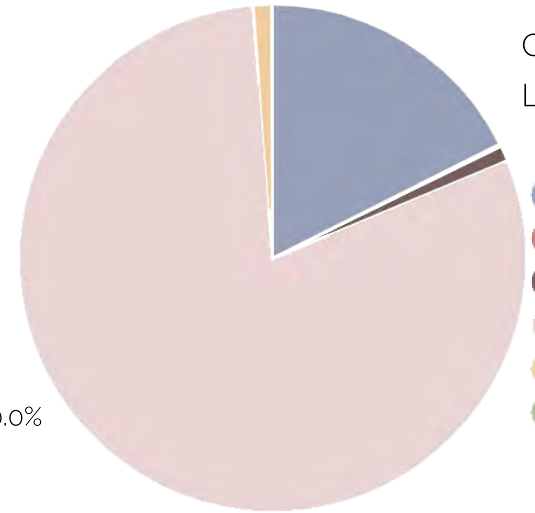
Resource types

- Utilities - 91.0%
- Metals - 5.3%
- Concrete - 0.9%
- Bricks & ceramics- 0.6%
- Doors & windows - 0.5%
- Masses - 0.4%
- Wood - 0.4%
- Flooring - 0.4%
- Coatings & pastes - 0.3%
- Other resource types - 0.3%



Classifications

- Electricity use - 47.5%
- Fuel use - 42.5%
- Floor slabs, ceilings, roof, beams- 7%
- Total water consumption - 1.1%
- External walls & facade - 0.9%
- Load-bearing vertical structures - 0.3%
- Other structures & materials - 0.0%
- Foundation, basement & retaining walls - 0.0%



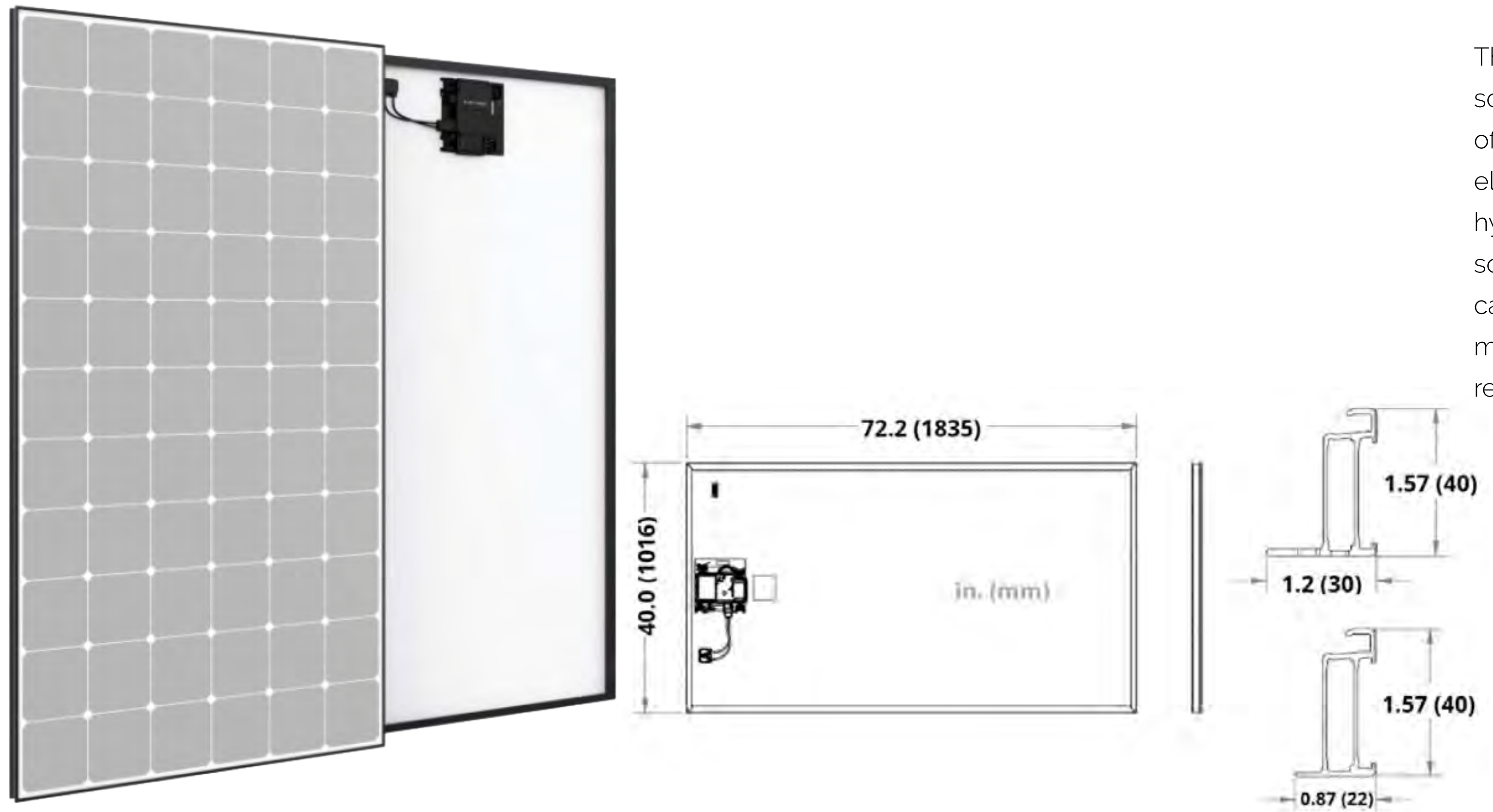
Global warming, kg CO2e - Life-cycle stages

- A1 - A3 Materials - 7.3%
- A4 Transportation - 0.2%
- B1 - B5 Maintenance - 1.4%
- B6 Energy - 89.9%
- B7 Water - 1.1%
- C1 - C4 End of life - 0.1%

Building Optimization
Why do we need further optimization?

Total Electricity= 6,811,247 **kWh**

Our building envelope is mainly glazing, therefore the facility ought to be optimized in order to meet the sustainability requirements. Hence, hybrid solar panels are needed to convert energy from the sun and turn it into electricity. The energy generated by the panels should outweigh the energy consumed in the building, and the number of panels is calculated accordingly.



The term "hybrid solar panels" refers to solar and battery storage which unlike off-grid systems is connected to the electricity grid. The best thing about hybrid solar systems is that they store solar energy and low-cost electricity, they can be used for advanced energy management, and they are a great way to reduce power consumption from the grid.

DC Power Data			
	SPR-A425-G-AC	SPR-A415-G-AC	SPR-A400-G-AC
Nom. Power [5] (Pnom)	425 W	415 W	400 W
Power Tol.	+5/−0%	+5/−0%	+5/−0%
Module Efficiency	22.8	22.3	21.5
Temp. Coef. (Power)	−0.29%/°C		
Shade Tol.	Integrated module-level max. power point tracking		

PVGIS-5 estimates of solar electricity generation:

Provided inputs:

Latitude/Longtitude: 47.565, 7.579
Horizon: Calculated
Database used: PVGIS-SARAH
Hybrid solar panel technology: Crystalline silicon
Installation: 425 kWp
System loss: 14%

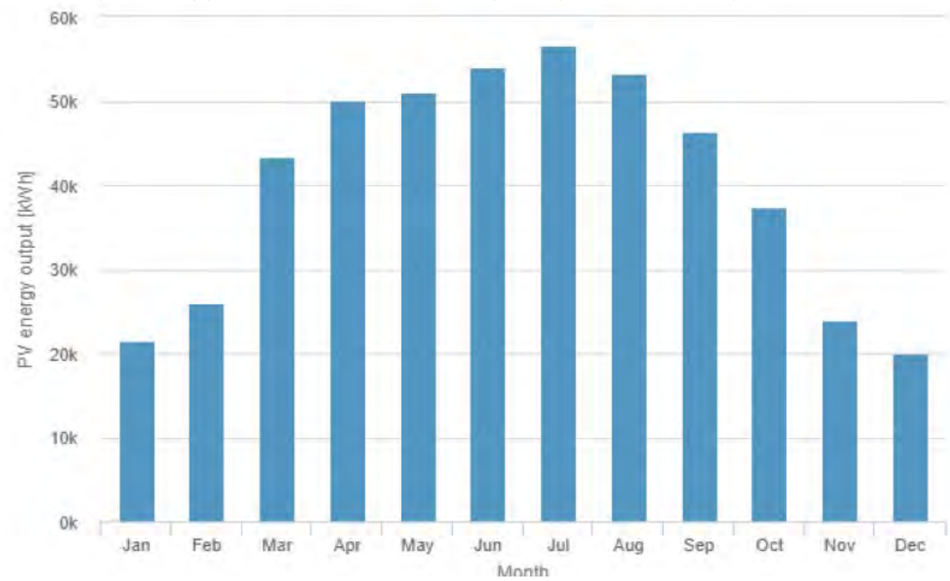
Simulation outputs:

Slope angle: 35°
Azimuth angle: 0°
Yearly energy production: 483798.32 kWh
Yearly in-plane irradiation: 1438.84 kWh/m^2
Year-to-year variability: 31439.10 kWh
Changes in output due to:

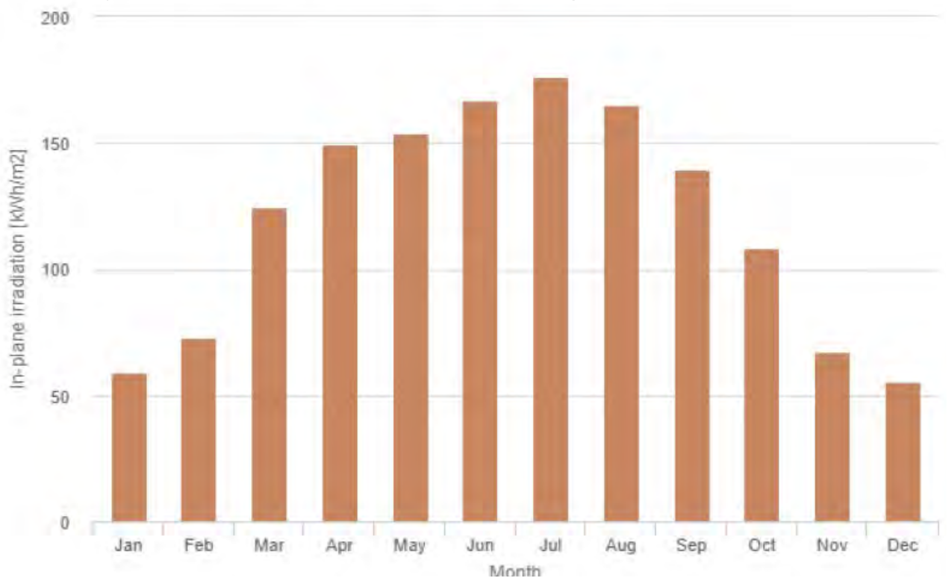
- Angle of incidence: -2.87%
- Spectral effects: 1.48%
- Temperature and low irradiance: -6.67%

Total loss: -20.88%

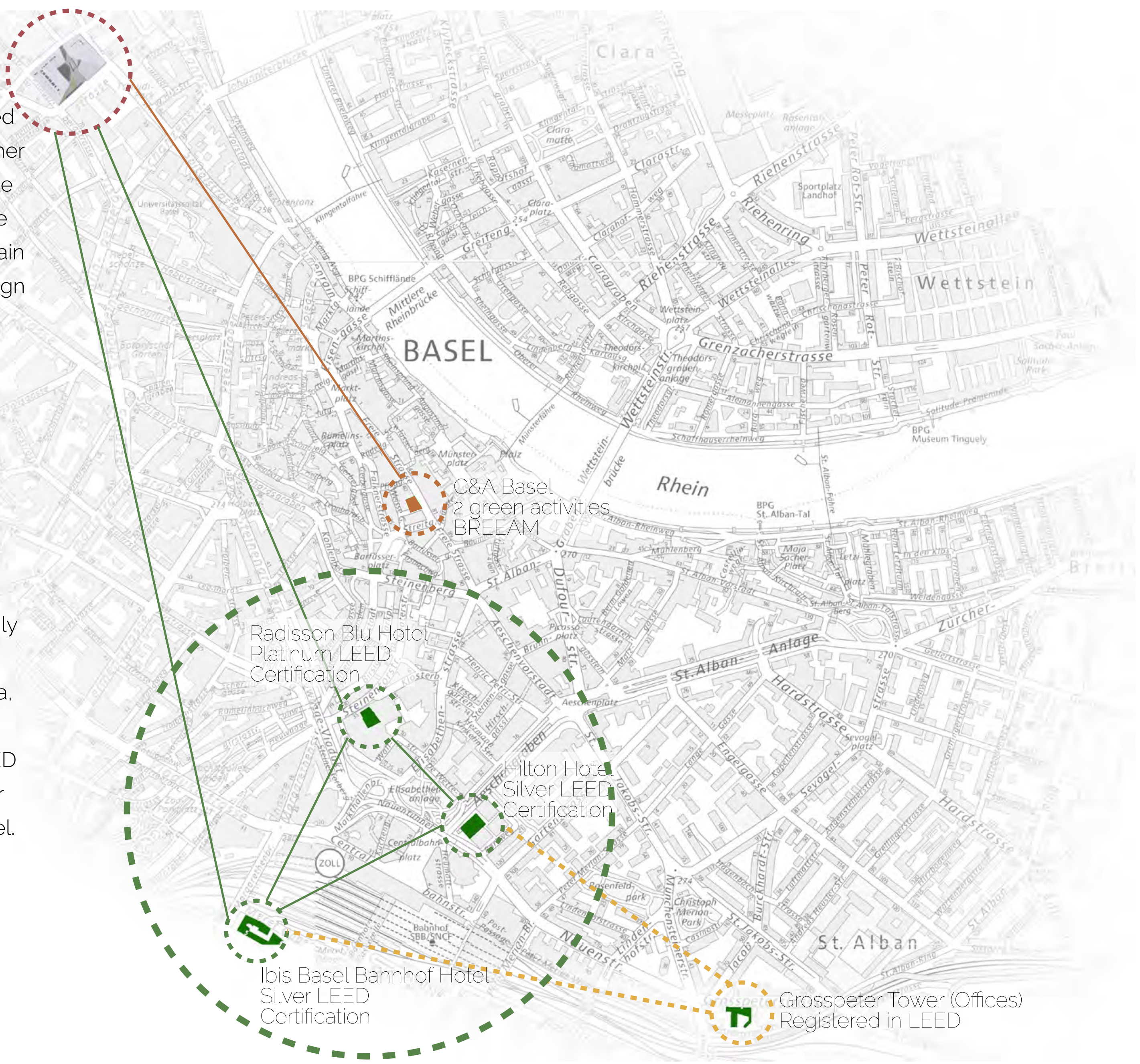
Monthly energy output from fix-angle hybrid solar system:



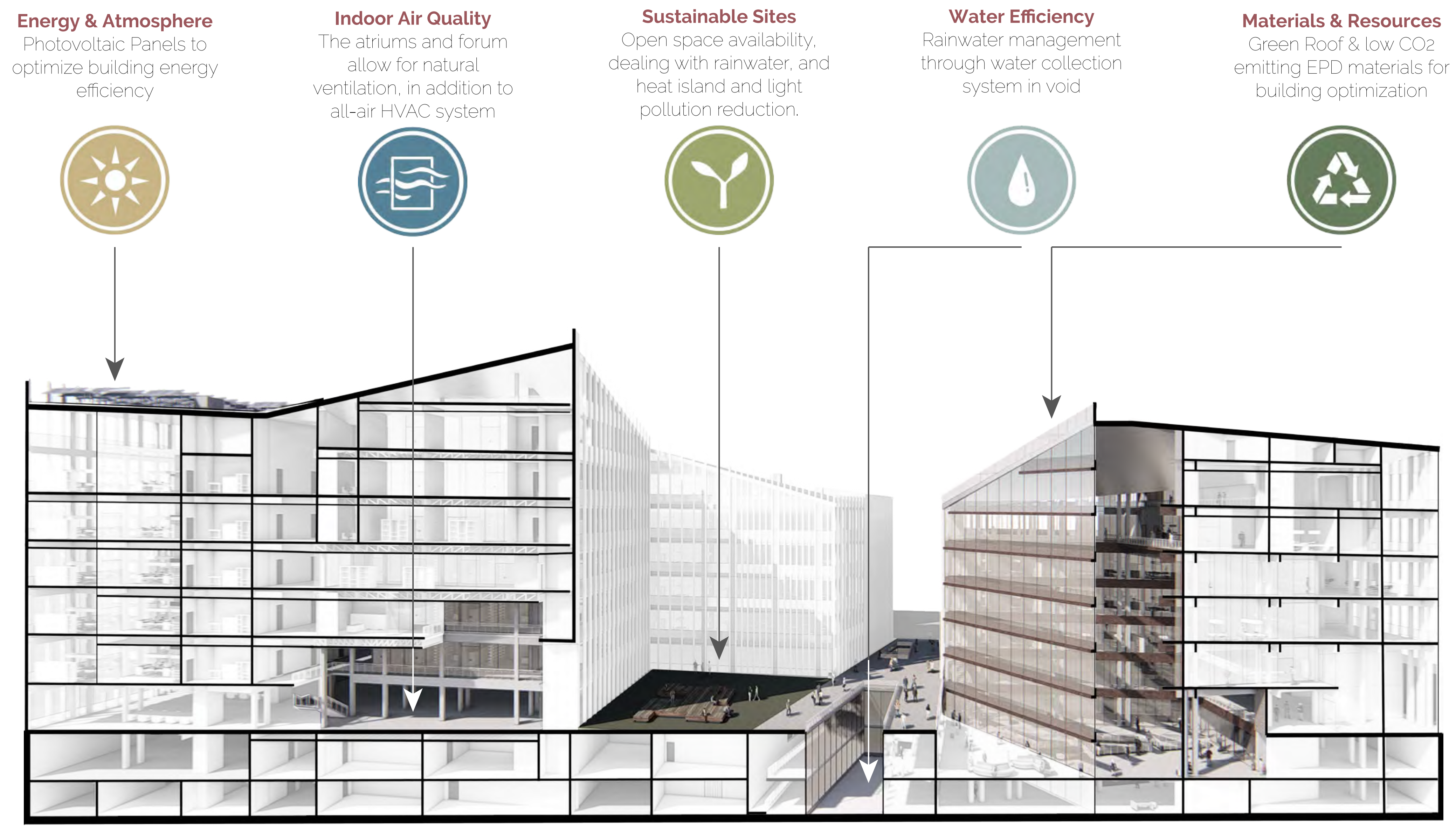
Monthly in-plane irradiation for fixed-angle:



LEED, which stands for Leadership in Energy and Environmental Design, is a certification program focused primarily on new, commercial-building projects and based upon a points system. The more points you earn, the higher your rating. This process is aimed at rewarding sustainable and environmentally friendly decisions that are part of the construction process. It is a way to demonstrate that certain environmental goals have been achieved during the design and construction of the structure or facility that is being certified. To be certified, the building project needs to obtain certain points and meet green building standards that will, later on, be validated during the certification process. When LEED-certified buildings are well maintained, they produce less waste products and are more energy efficient. The ratings system by which buildings can achieve certification, however, has come under scrutiny as well as criticism for granting points that require little effort on behalf of the builder. Points are easily granted for check-list items such as proximity to public transportation or location within a densely populated area, and this can mean the difference between silver, gold or platinum certification. Nevertheless, we followed the LEED project checklist in order to determine whether or not our building is LEED certified, and if yes, what is its rating level.



LEGEND
- LEED Certified
- LEED Registered
- BREEAM
- Project

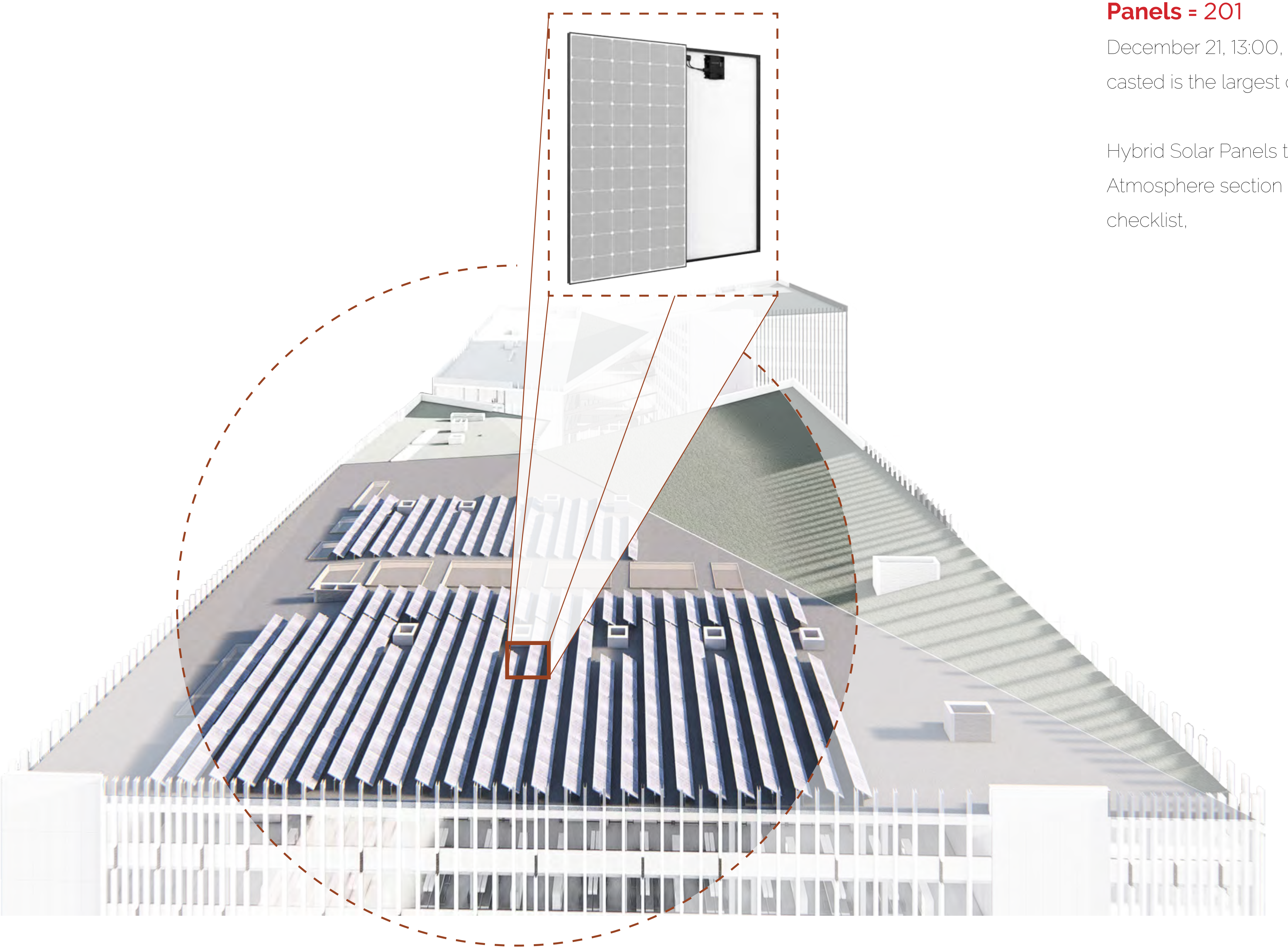


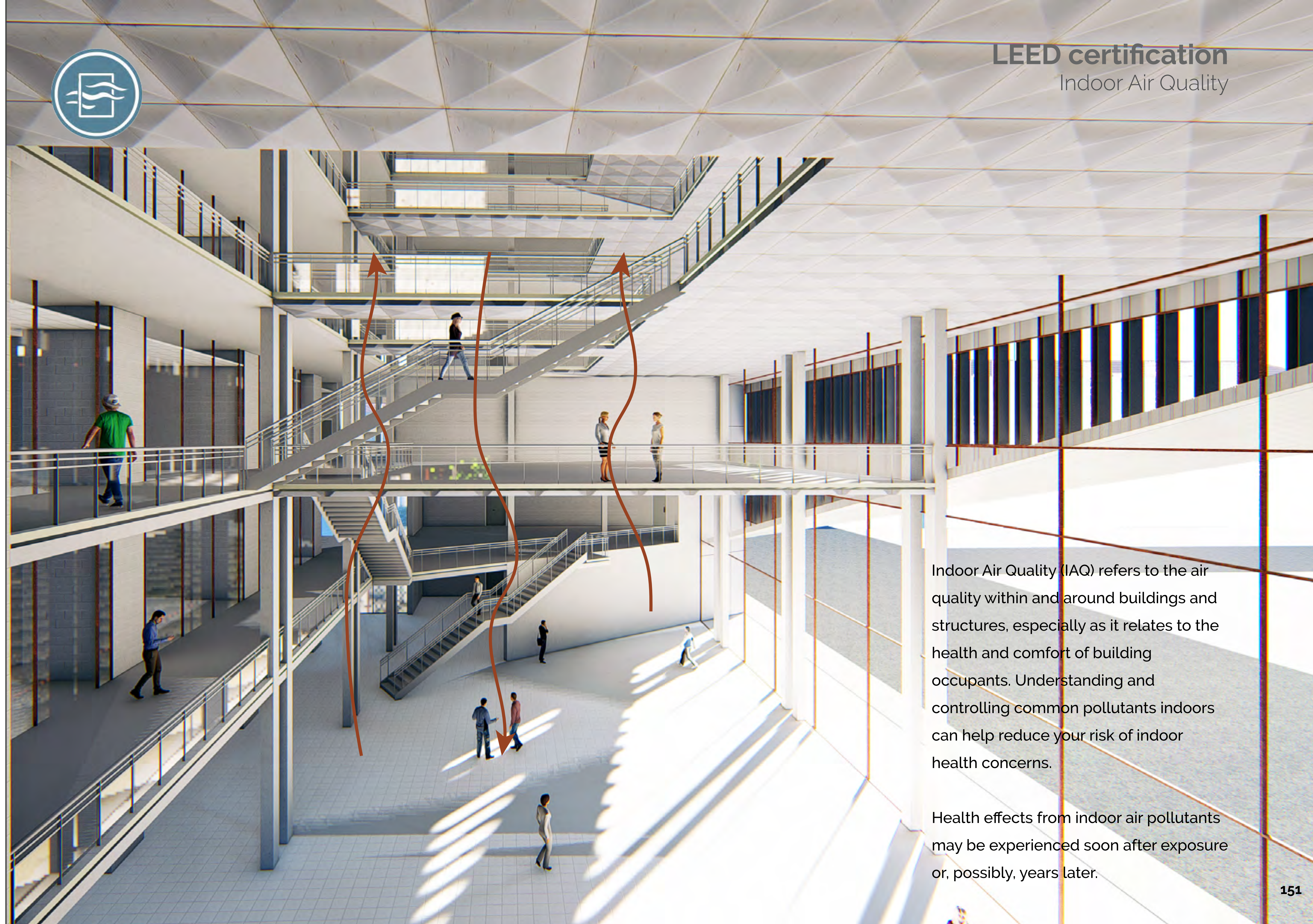
LEED certification
Energy & Atmosphere

Total Number of Hybrid Solar Panels = 201

December 21, 13:00, when the shadow casted is the largest during the year.

Hybrid Solar Panels tackle the Energy and Atmosphere section in the LEED project checklist.



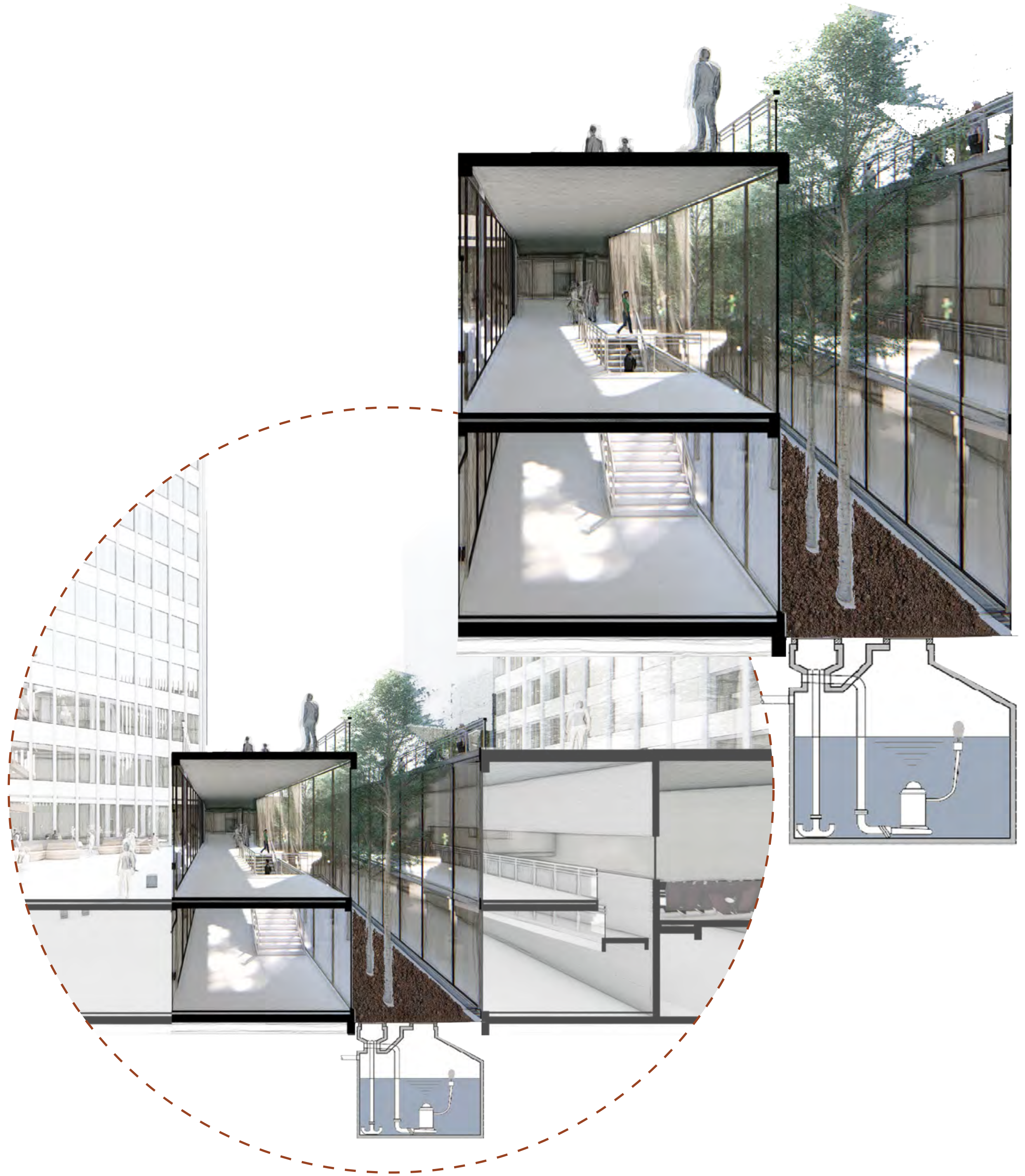


LEED certification
Indoor Air Quality

Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. Understanding and controlling common pollutants indoors can help reduce your risk of indoor health concerns.

Health effects from indoor air pollutants may be experienced soon after exposure or, possibly, years later.

LEED certification
Water Efficiency



We conducted a rainwater management method through the water collection system in the void. It is used to mitigate extreme rainfall events without increasing the capacity of existing sewer system, and to mitigate urban heat island problems. Rainwater is collected from the roof and voids on the ground floor. On the roof, the rain will collect in gutters that channel the water into downspouts and then redirected to a tank or cistern. As for the water collection in the ground, water can be obtained by drilling or digging wells. A well is usually a pipe in the ground that fills with ground water. This water can then be brought to the land surface by a pump. It undergoes water treatment and a purification process before it is re-used.

LEED certification
Sustainable Sites

The Sustainable Sites (SS) credit category of LEED v4 was created to ensure that a project's natural environment would be valued and respected throughout every step of the building process, from planning to construction to management, and to ensure open space availability, dealing with rainwater, and heat island and light pollution reduction.

LEED certification

Materials & Resources

The Materials and Resources (MR) category is about minimizing the energy and environmental impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials.

What materials are used, where they come from, how they are made, and how they are disposed of are instrumental in determining how green a project is. Using more green materials, including renewable materials, recycled materials, and natural materials, is good for the building occupants and the environment. For instance, we integrated green roofs & and used low CO2 emitting EPD materials for building optimization.

LEED v4 for BD+C

New Construction & Major Renovation
Project Checklist

Certified: 40 to 49 points,

Silver: 50 to 59 points,

Gold: 60 to 79 points,

Platinum: 80 to 110

0	0	0	Water Efficiency		8
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
•			Credit	Outdoor Water Use Reduction	1
•			Credit	Indoor Water Use Reduction	1
•			Credit	Cooling Tower Water Use	5
	•		Credit	Water Metering	1

0	0	0	Energy and Atmosphere		10
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
	•		Credit	Enhanced Commissioning	0
•			Credit	Optimize Energy Performance	6
		•	Credit	Advanced Energy Metering	0
		•	Credit	Demand Response	0
•			Credit	Renewable Energy Production	3
		•	Credit	Enhanced Refrigerant Management	0
	•		Credit	Green Power and Carbon Offsets	1

0	0	0	Location and Transportation		16
•			Credit	LEED for Neighborhood Development Location	1
	•		Credit	Sensitive Land Protection	1
		•	Credit	High Priority Site	0
•			Credit	Surrounding Density and Diverse Uses	4
•			Credit	Access to Quality Transit	5
•			Credit	Bicycle Facilities	5
•			Credit	Reduced Parking Footprint	1
		•	Credit	Green Vehicles	0

0	0	0	Sustainable Sites		16
Y			Prereq	Construction Activity Pollution Prevention	Required
•			Credit	Site Assessment	5
	•		Credit	Site Development - Protect or Restore Habitat	2
•			Credit	Open Space	5
•			Credit	Rainwater Management	3
		•	Credit	Heat Island Reduction	0
	•		Credit	Light Pollution Reduction	1

0	0	0	Materials and Resources		10
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
•			Credit	Building Life-Cycle Impact Reduction	3
•			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
•			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	1
•			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
•			Credit	Construction and Demolition Waste Management	2

0	0	0	Indoor Environmental Quality		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
•			Credit	Enhanced Indoor Air Quality Strategies	4
•			Credit	Low-Emitting Materials	3
•			Credit	Construction Indoor Air Quality Management Plan	1
	•		Credit	Indoor Air Quality Assessment	1
•			Credit	Thermal Comfort	1
	•		Credit	Interior Lighting	1
•			Credit	Daylight	4
•			Credit	Quality Views	1
		•	Credit	Acoustic Performance	0

0	0	0	Innovation		0
		•	Credit	Innovation	0
		•	Credit	LEED Accredited Professional	0

0	0	0	Regional Priority		0
		•	Credit	Regional Priority: Specific Credit	0
		•	Credit	Regional Priority: Specific Credit	0
		•	Credit	Regional Priority: Specific Credit	0
		•	Credit	Regional Priority: Specific Credit	0

There are 93 LEED either certified or registered buildings in Switzerland, 1 LEED silver certification in Basel-Landschaft, and 1 LEED silver certification in Basel-Stadt. Innovation Hub for Creative Minds is Basel's 3rd LEED certified building, and its rating level is Gold.

Possible Points = 77

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