pro:Holz
Austria

Master class

international and interdisciplinary workshop

Densification of the city districts with CLT modular elements

The Master class is organized by **proHolz Austria**, an association for the promotion of wood, in collaboration with:

TU Graz
Univ. Prof. Dr. Gerhard Schickhofer,
Institute of Timber Engineering and Wood Technology;
Univ. Prof. Arch. Hans Gangoly,
Institute for Design and architectural Typologies

University of Ljubljana
Prof. Dr. Roman Kunic,
Prof. Dr. Bostjan Brank
Faculty of Civil and Geodetic Engineering;
Prof. Marusa Zorec
Faculty of Architecture

University of Zagreb
Prof. Dr. Sc. Vlatka Rajcic
Faculty of Civil Engineering
Prof. Ivica Plavec,
Prof. Dr. Sc. Sanja Filep,
Faculty of Architecture

Winning project

Matija Babic, Faculty of Architecture, University of Zagreb
Luka Roso, Faculty of Civil Engineering, University of Zagreb

Hybrid structure

living + working / co-living + co-working

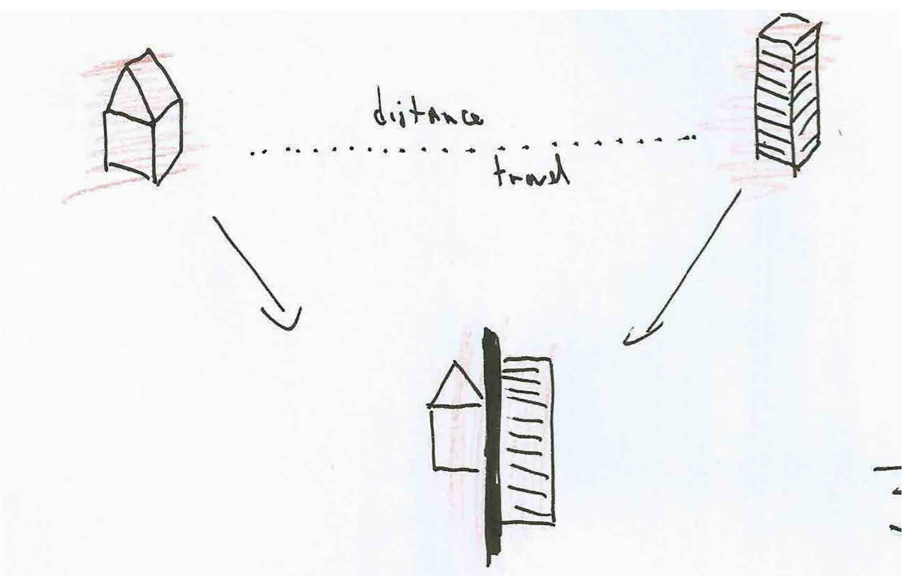
work + living

Under the influence of the globalisation, quick social, economic and political changes.
It's becoming more and more inconstant. Fixed offices and fixed apartments are slowly starting to be obsolete.

Work is going in the way of living. People are working everywhere, constantly.

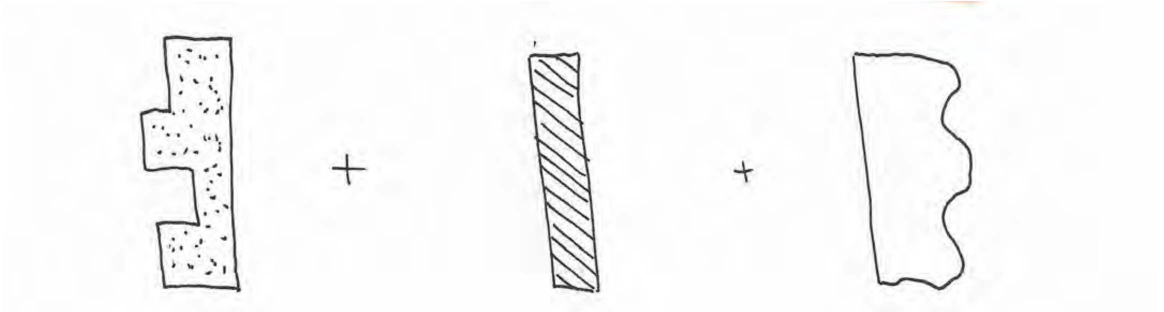
When does the work stop and living / being begins?

There is a need for a clear distinction between work and living.

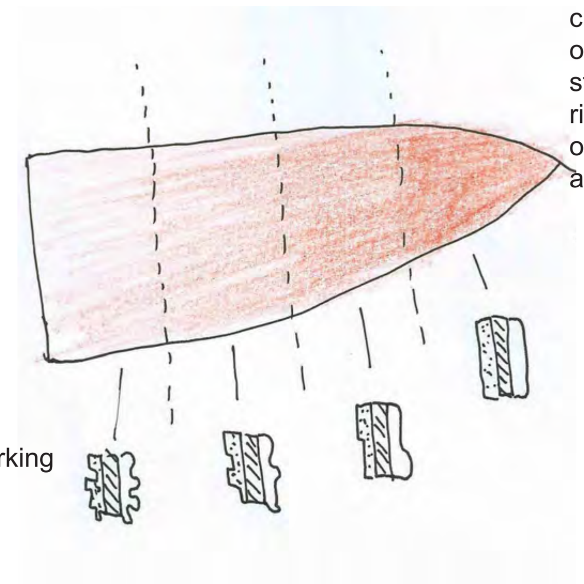


site plan
M 1:2000

LIVING	CORE	WORK
living co-living small apartments quick residence changes minimal living quarters possibility to extend the apar-ment maximum common areas social interaction	division connection service vertical communication interaction	maximum open plan modular office boxes fexibility social interaction

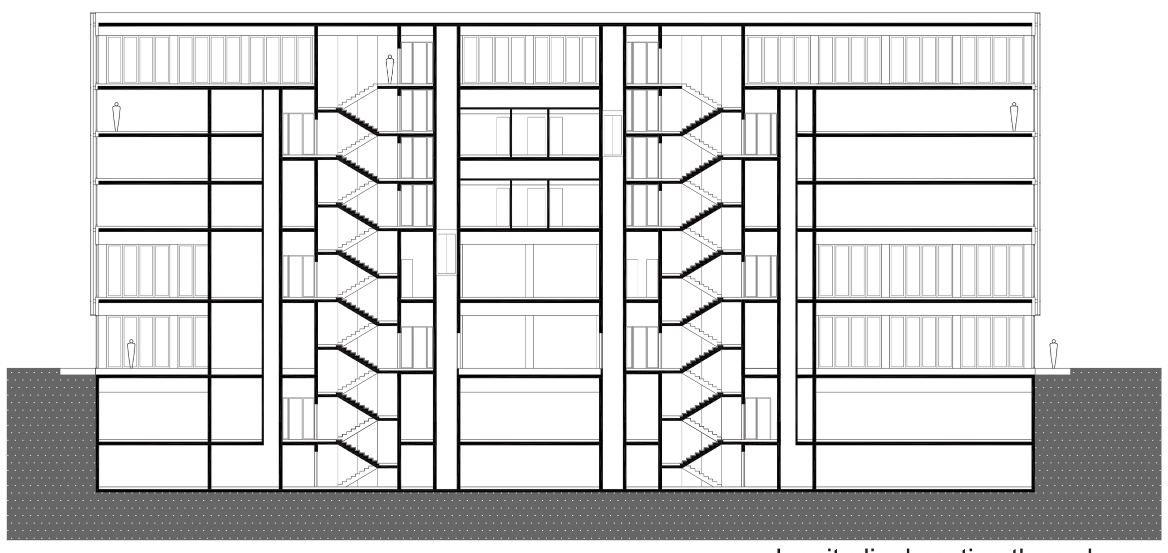


city centre
old town
strict ortogonal system
rigid
old types of apartments
and workv

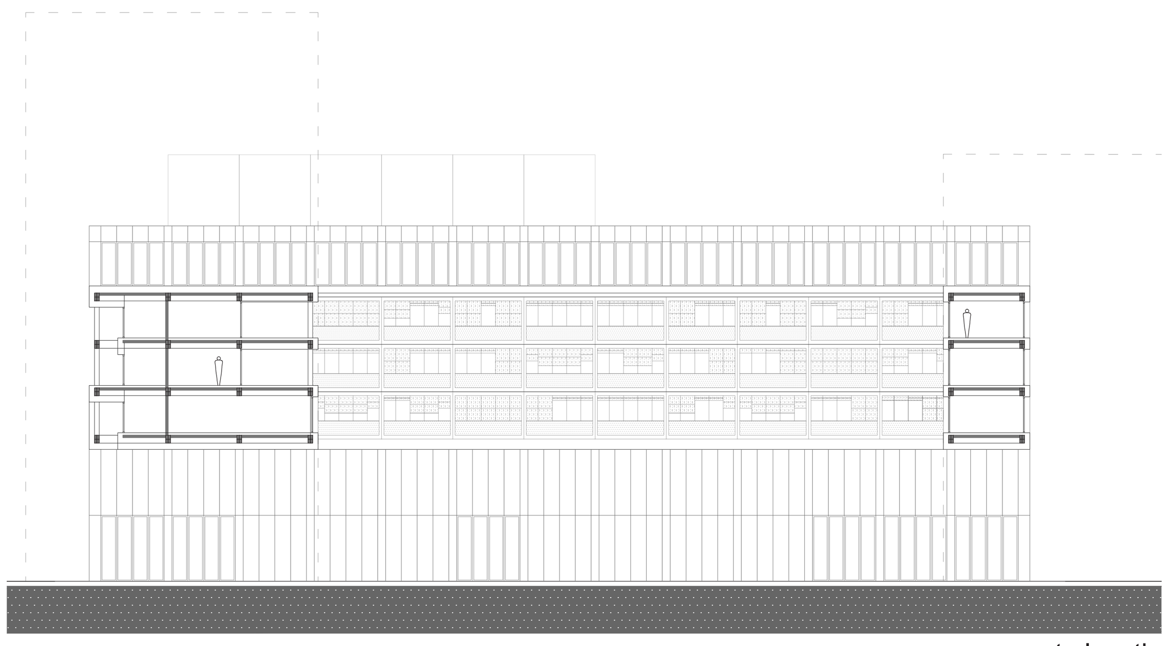


newer part of Zagreb
more flexible system
freed urban system
newer type of living, working

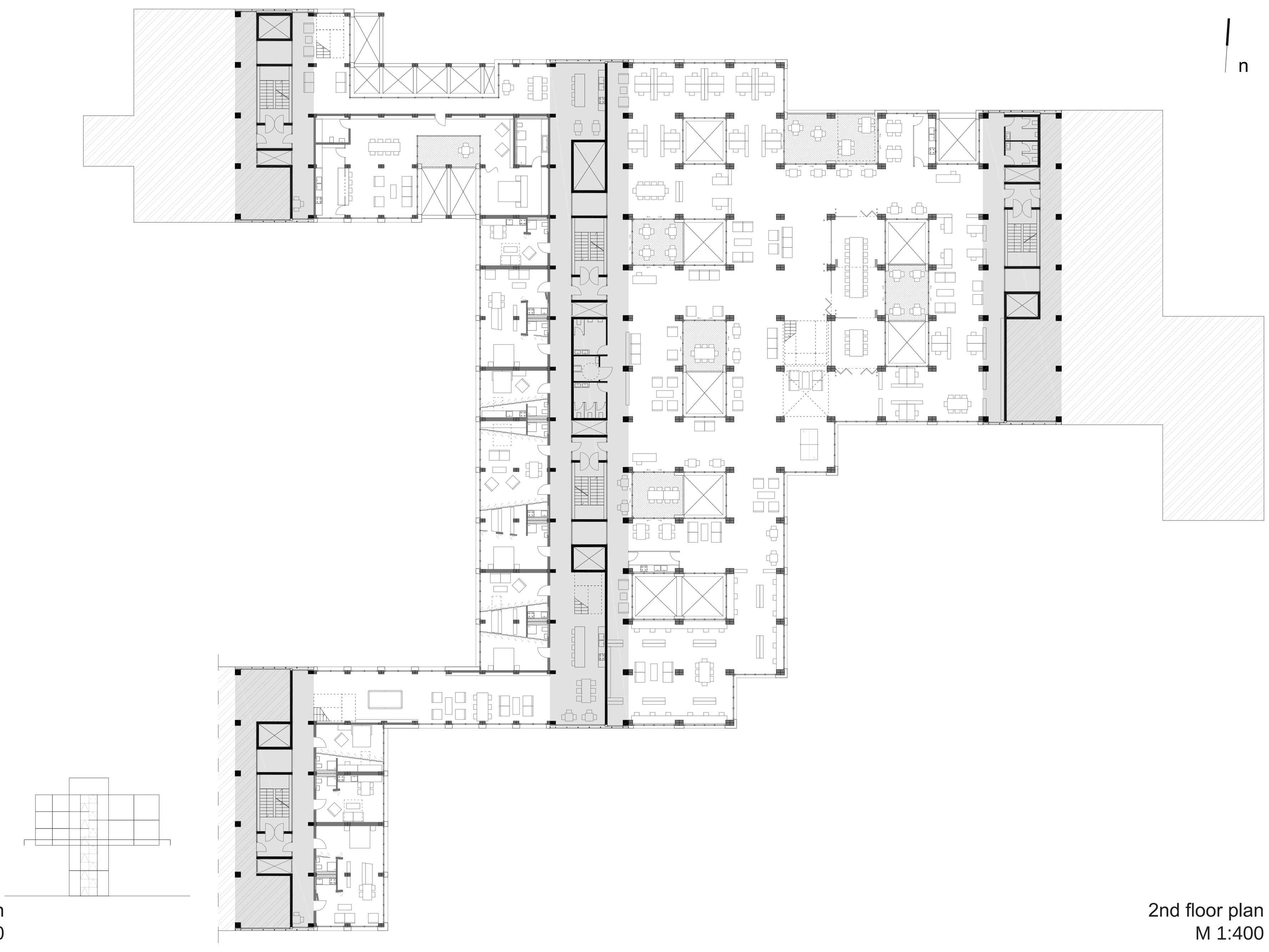
site plan, ground floor
M 1:1000



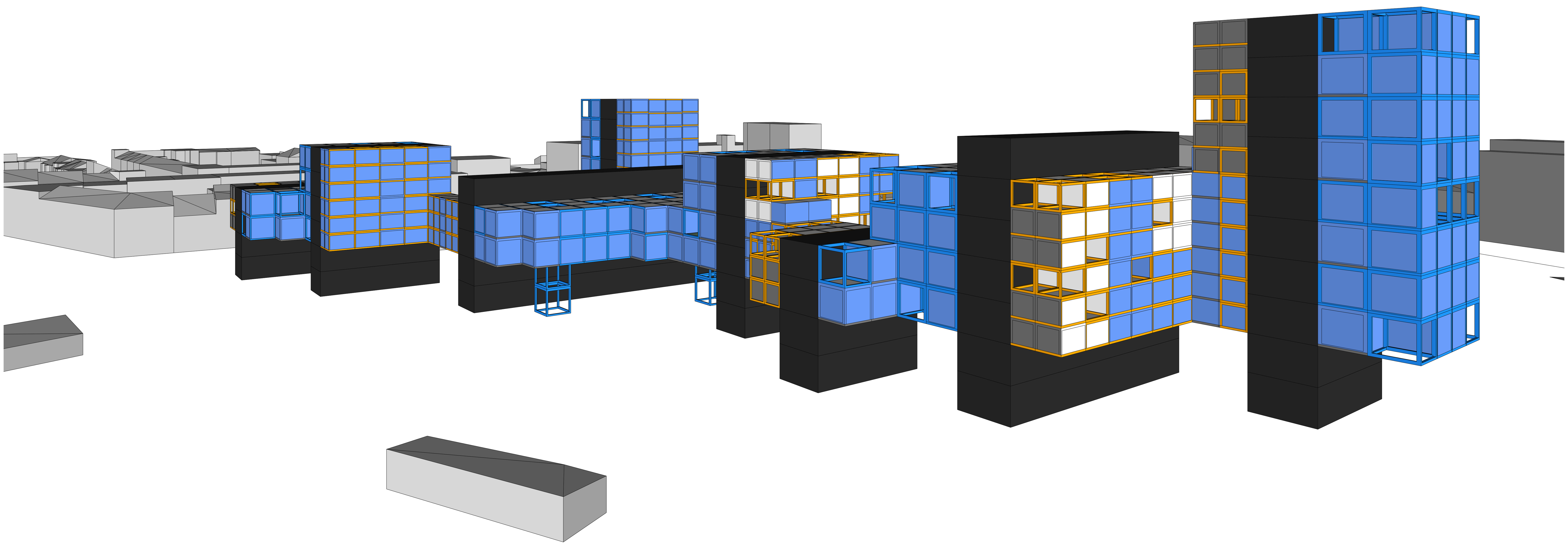
longitudinal section through core
M 1:400



west elevation
M 1:400



2nd floor plan
M 1:400



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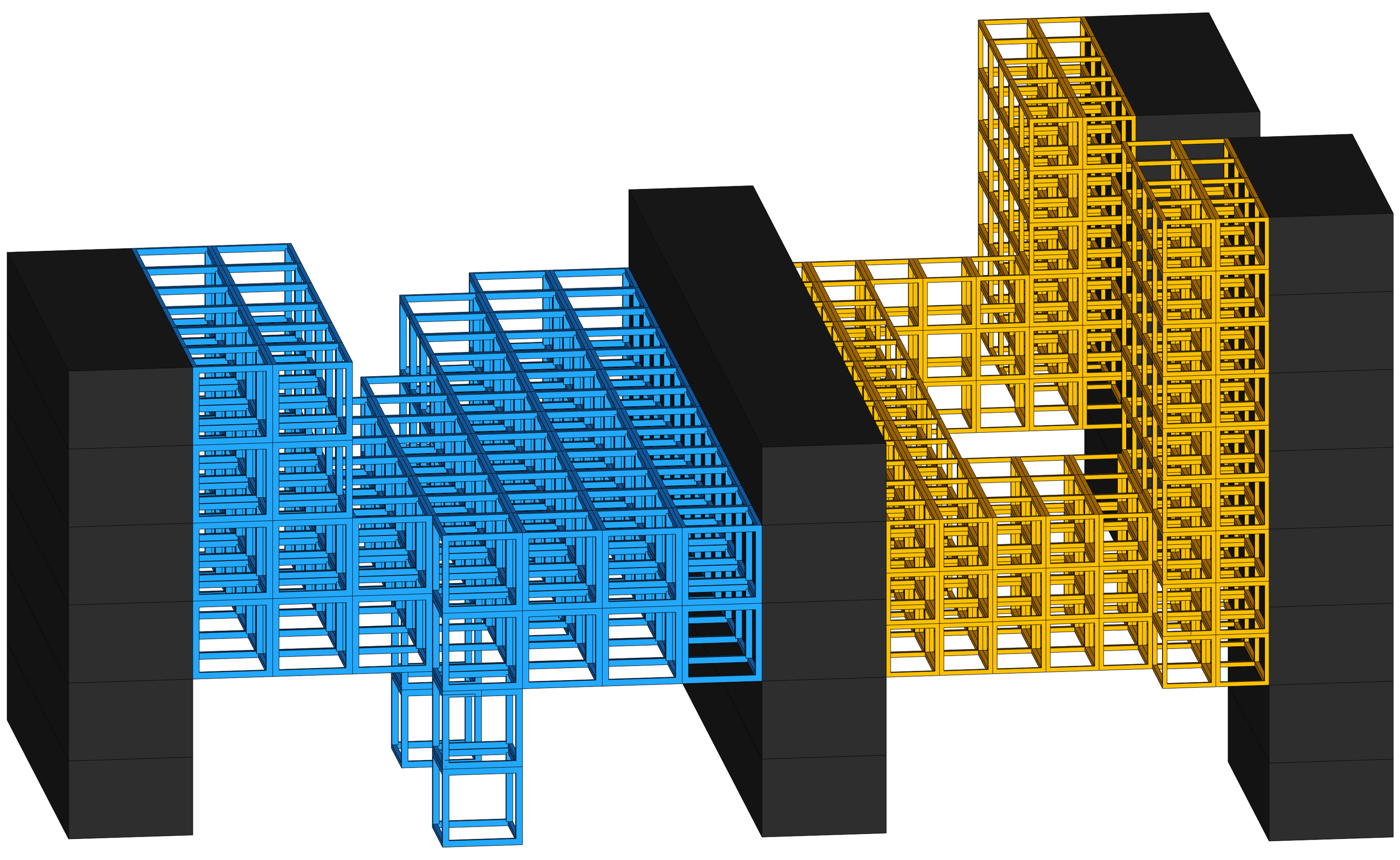
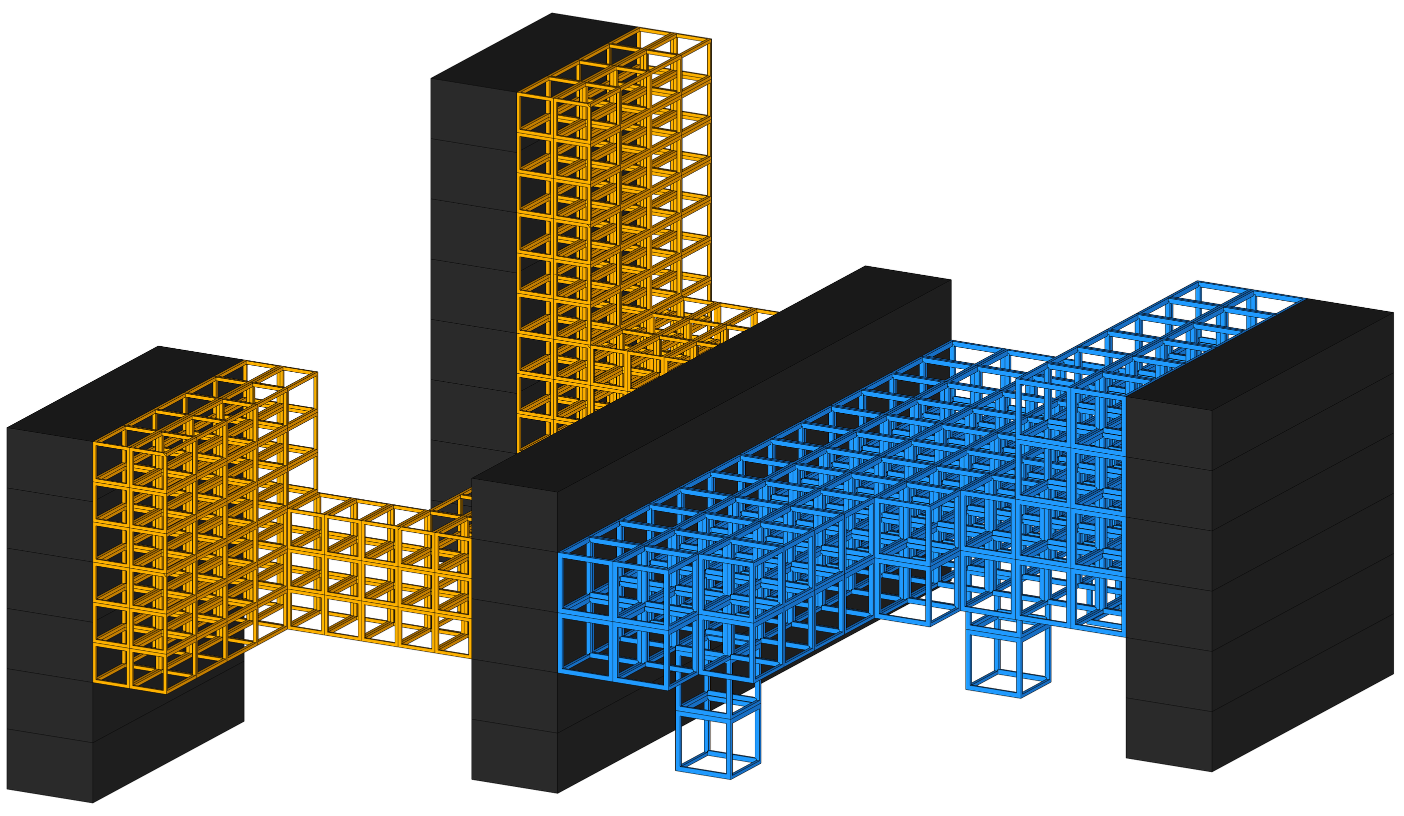




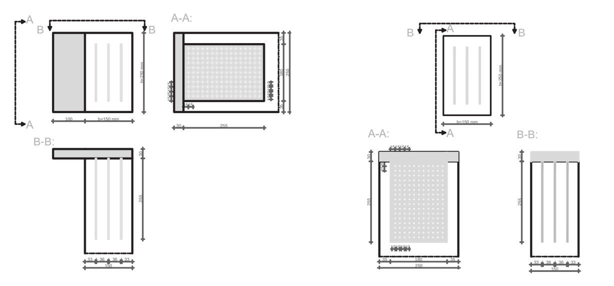
1. Structure:
Structure is divided on two parts; living and work space, which are connected with the concrete core.
Both parts are made of cubic shaped modules, composed of glue laminated timber elements, each having CLT floor panel.
The difference between modules in whose two parts is in dimensions of modules and their cross sections.
Those cubic modules are made in factory, delivered and connected on the construction site.

2. Load analysis
Dead load: self-weight of glue laminated elements and CLT panels
Non-structural elements: interior equipment, insulation, etc.
Live load

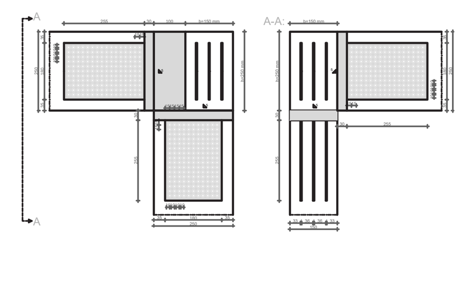
Load inducted by environment: Snow $s = s_k \cdot \mu_i \cdot C_e \cdot C_t$
Relevant design situations:
ULS: 1,35G + 1,5S
SLS: 1,0G + 1,0S

3. Static calculations
Construction is designed in Autodesk Robot as a 3D model, due to high number of nodes and main elements, and calculations of CLT panels were made in Stora Enso Calculatis software to determine design which can meet conditions of ULS and SLS, vibrations in particular being the most problematic condition.

Combinations type	Name	Analysis type	Combination
4 (C)	(SW)*1.35+(Us)*1,5+(Sn)*0.90	Linear Combination	ULS
5 (C)	(SW+Us)*1.00+Sn*0.60	Linear Combination	SLS

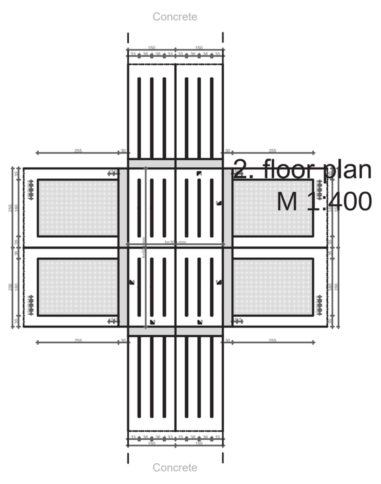


timber to metal connection
adhesive connection using perforated steel plates

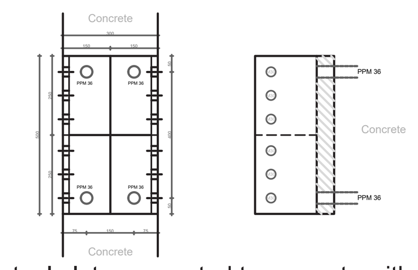


connection in the node of one timber cube module

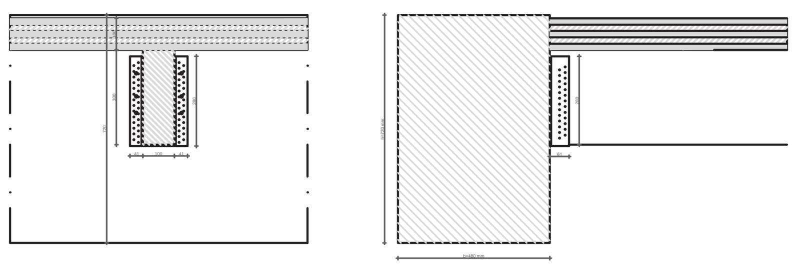
2. floor plan
M 1:400



connection in the node of four timber cube modules



steel plate connected to concrete with anchors and bolts



ribbed CLT plate and beam connection (metal hanger)

4. Verification of the main structural elements

The structure consists of beams and columns. The connection between them is fixed.

To design those elements and get the proper cross sections we made tests for:

1.1. Shear capacity

$$\tau_{v,d} = 1,5 \cdot \frac{V_d}{A_b} \leq f_{v,d}$$

1.2. Tension parallel to the grains

$$\sigma_{t,0,d} = \frac{F_{t,0,d}}{A_{netto}} \leq f_{t,0,d}$$

1.3. Tension perpendicular to the grains

$$\sigma_{t,90,d} = \frac{F_{t,d}}{A_b} \leq f_{t,90,d}$$

1.4. Compression perpendicular to the grains

$$\sigma_{c,90,d} = \frac{F_{c,d}}{A_b} \leq k_{c,90} \cdot f_{c,90,d}$$

1.5. Bending with torsional buckling + Compression parallel to the grains with buckling

$$\left(\frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}}\right) + \left(\frac{\sigma_{m,y,d}}{k_{crit,y} \cdot f_{m,y,d}}\right) \leq 1,0$$

$$\left(\frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}}\right) + \left(k_m \cdot \frac{\sigma_{m,y,d}}{k_{crit,y} \cdot f_{m,y,d}}\right) \leq 1,0$$

1.6. SLS

Results for the SLS have been compared with limitation values, taking into consideration deformation factor k_{def}.

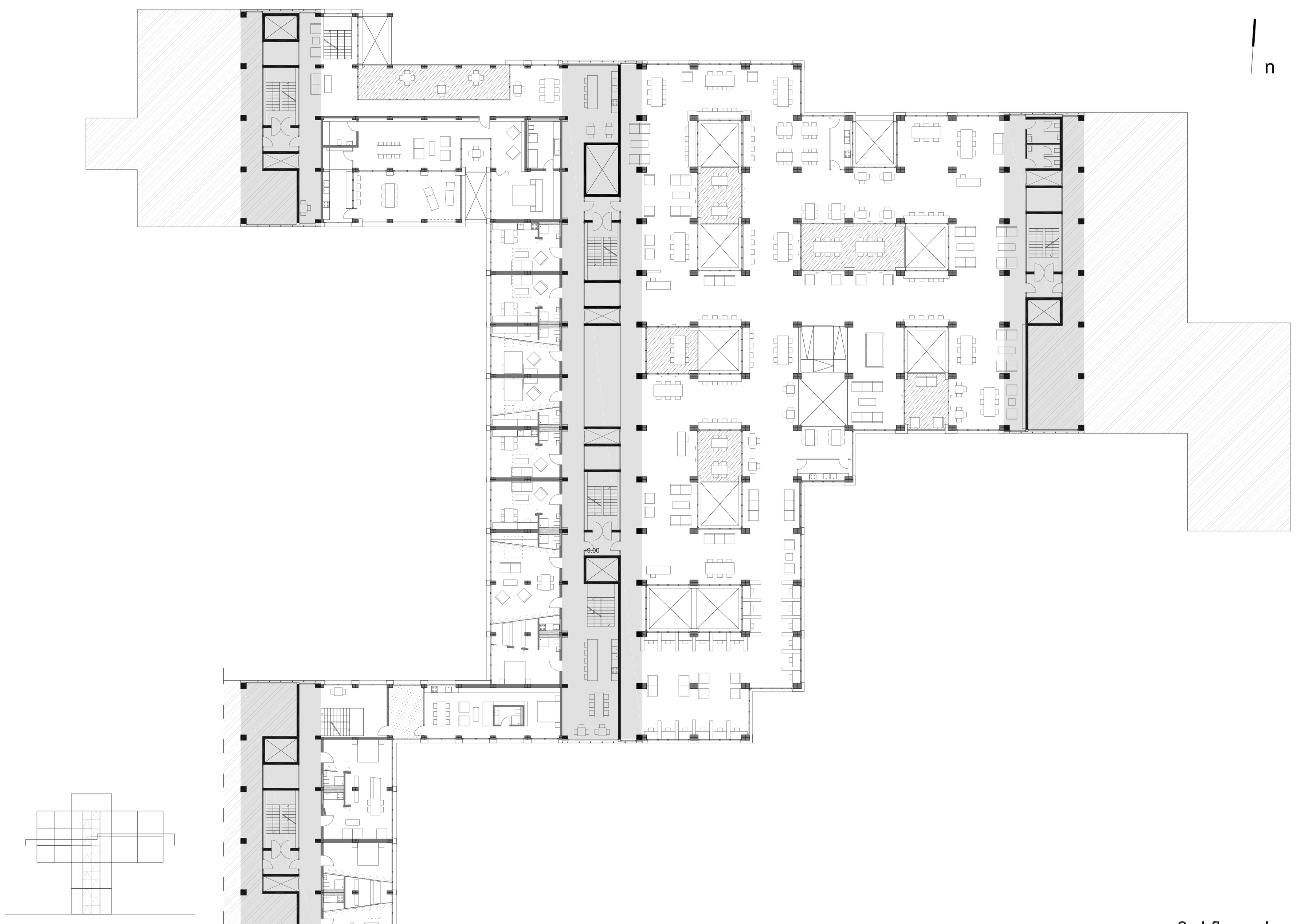
$$u^{Gk}{}_{fin,y} = u^{Gk}_{inst,y} \cdot (1 + k_{def,G})$$

$$u^{Qk}{}_{fin,y} = u^{Qk}_{inst,y} \cdot (1 + k_{def,Q})$$

$$u_{net,fin} = u^{Gk}{}_{fin,y} + u^{Qk}{}_{fin,y}$$

$$u_{net,fin} < L / 250$$

$$u_{2,inst} = u^{Qk}{}_{inst} < L / 300$$



3rd floor plan
M 1:400

south elevation
M 1:400

5. Connections

In order to make our construction as rigid as possible, and to confirm assumption of fixed connections between beams and columns, as well as their connection to concrete core, we used new system of adhesive connection using perforated steel plates. The innovative connection consists of two component adhesive system along with the standardized steel connection geometry.

The basic idea behind this is to design in steel and at the same time build with timber. The connection is design to produce steel failure in the range of ultimate load, and in that respect the ultimate performance of the connection depends on the plastic performance of the steel component in this innovative coupling system.

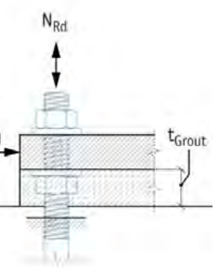
$$V_{Ed} < R_{v,d} = \sigma_{V,epoxyd} \cdot A_{tot} = \sigma_{V,epoxyd} \cdot n_{sides} \cdot A_1$$

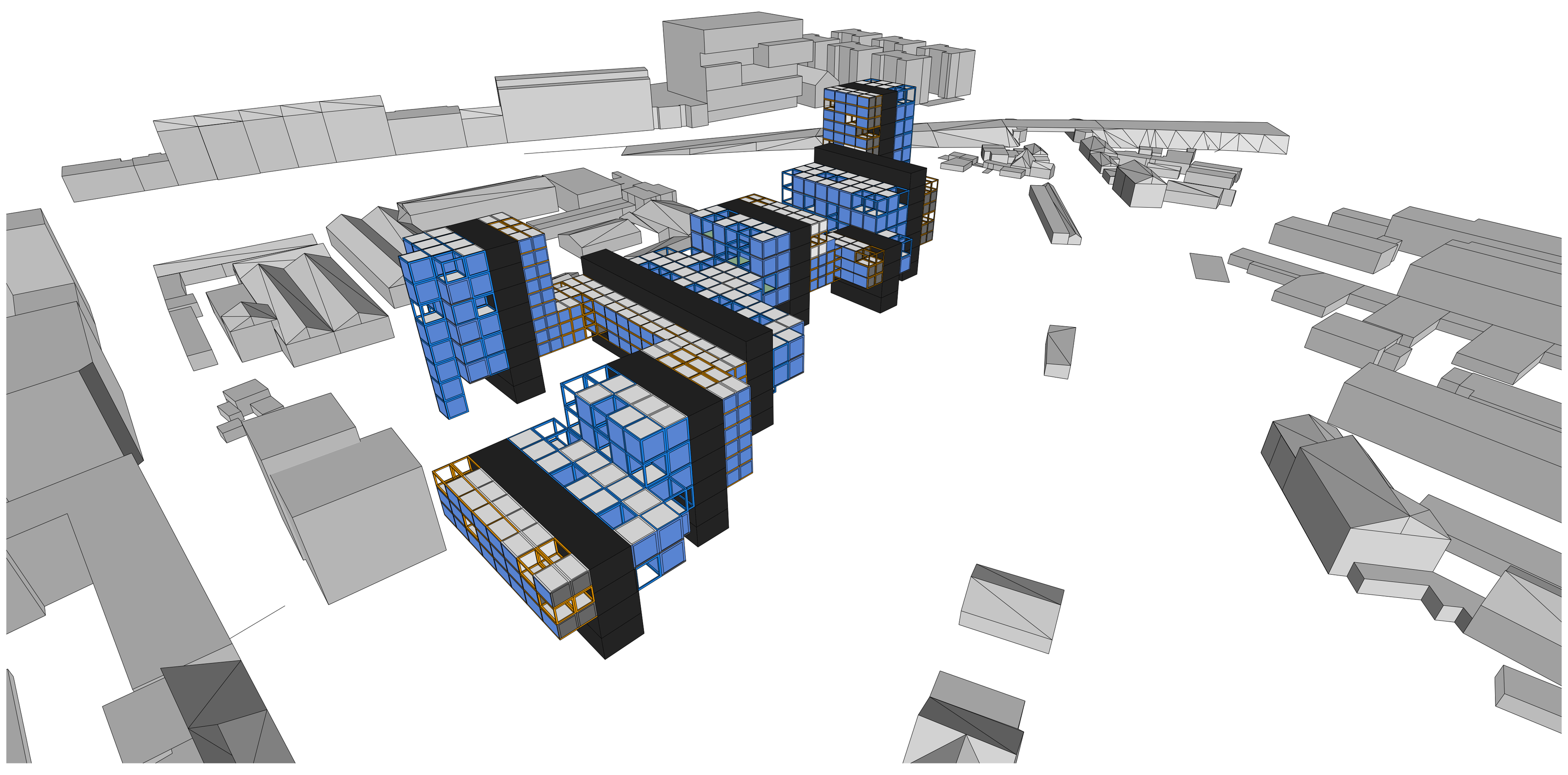
Steel to steel connection between plates is accomplished by welding on the construction site.

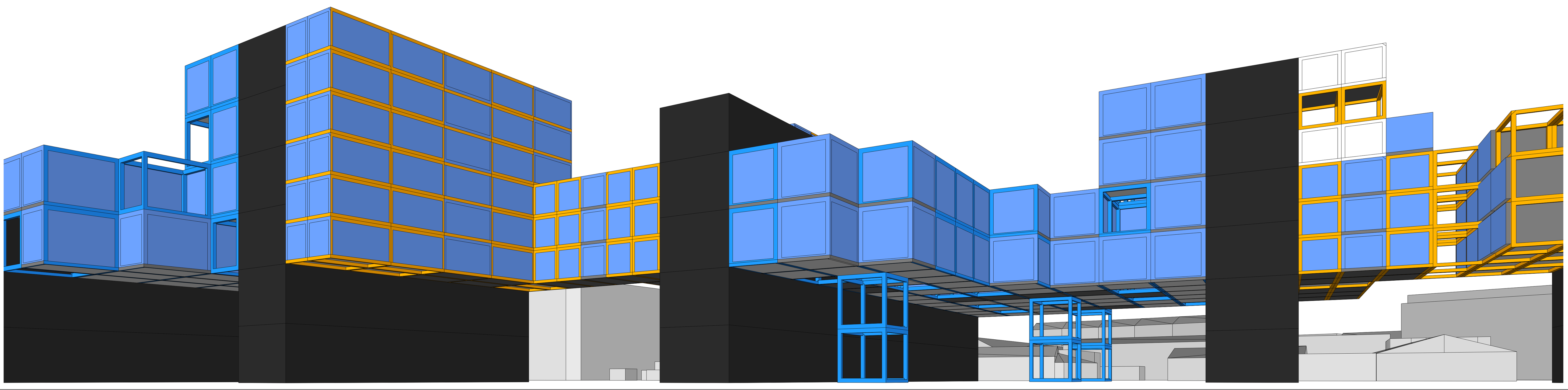
$$F_{w,Rk} = \frac{f_u}{\sqrt{3} \cdot \beta_w} \cdot a \cdot L \qquad \frac{F_{w,Rk}}{\gamma_{Mb}} > N_{Ed}$$

Concrete to steel connection is realized with steel plate connected with high load capacity anchors, and then the metal plates of the timber structure are welded, and at the same time, bolted to the steel plate connected to the concrete core.

	N_{Rd} (ETAG 001)	V_{Rd} (EN 1993-1-8) Final Stage	$V_{Rd,0}$ (EN 1993-1-8) Erection Stage	t_{Grout}
	[kN]	[kN]	[kN]	[mm]
PPM 30	299	89	53	50
PPM 36	436	130	88	55
PPM 39	521	155	104	60
PPM 45	697	207	144	65
PPM 52	938	219	215	70
PPM 60	1260	225	225	80







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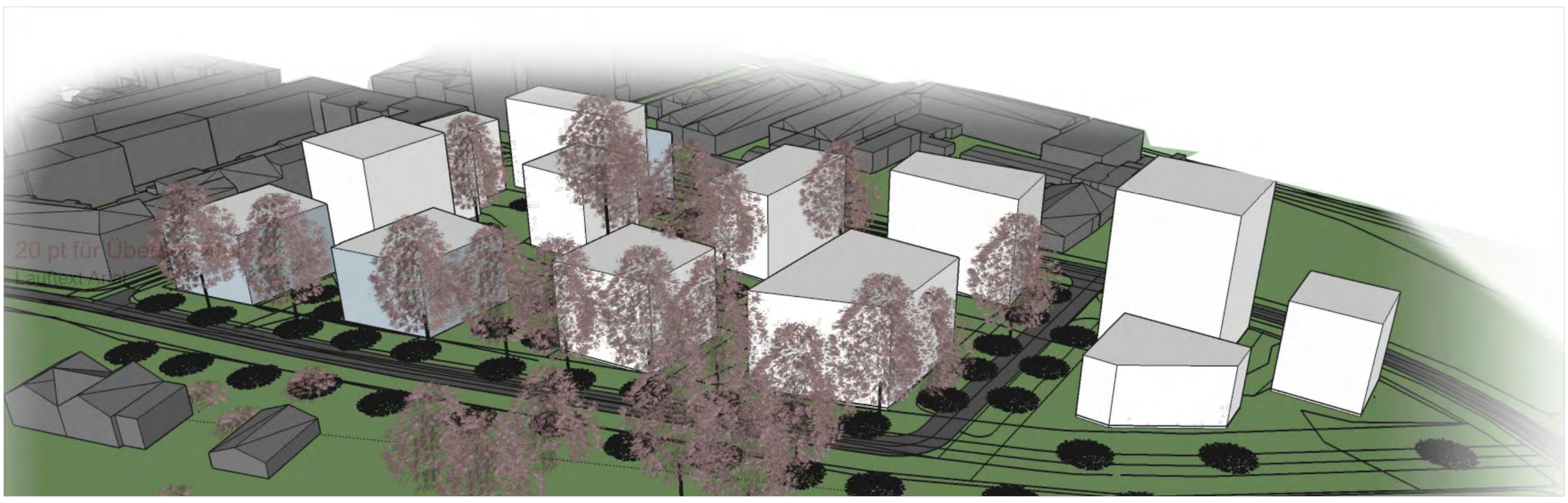
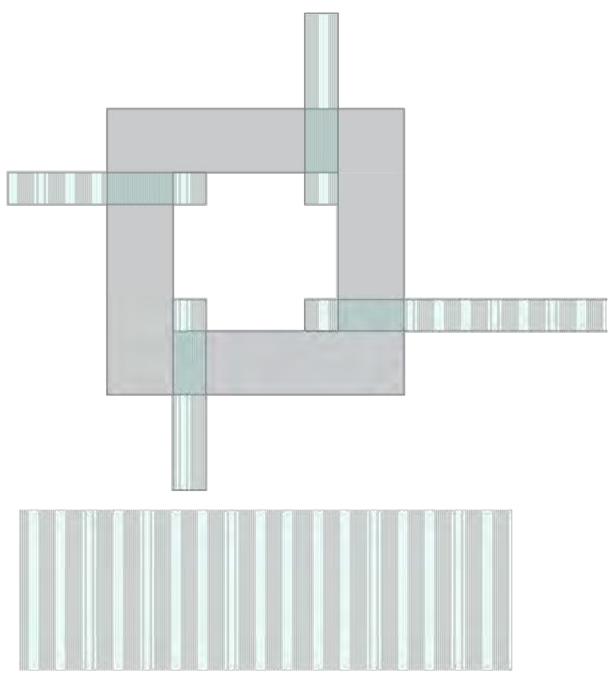
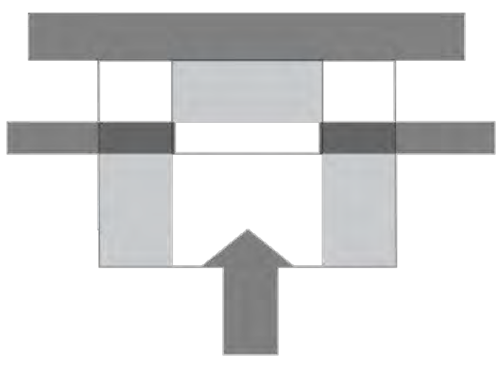
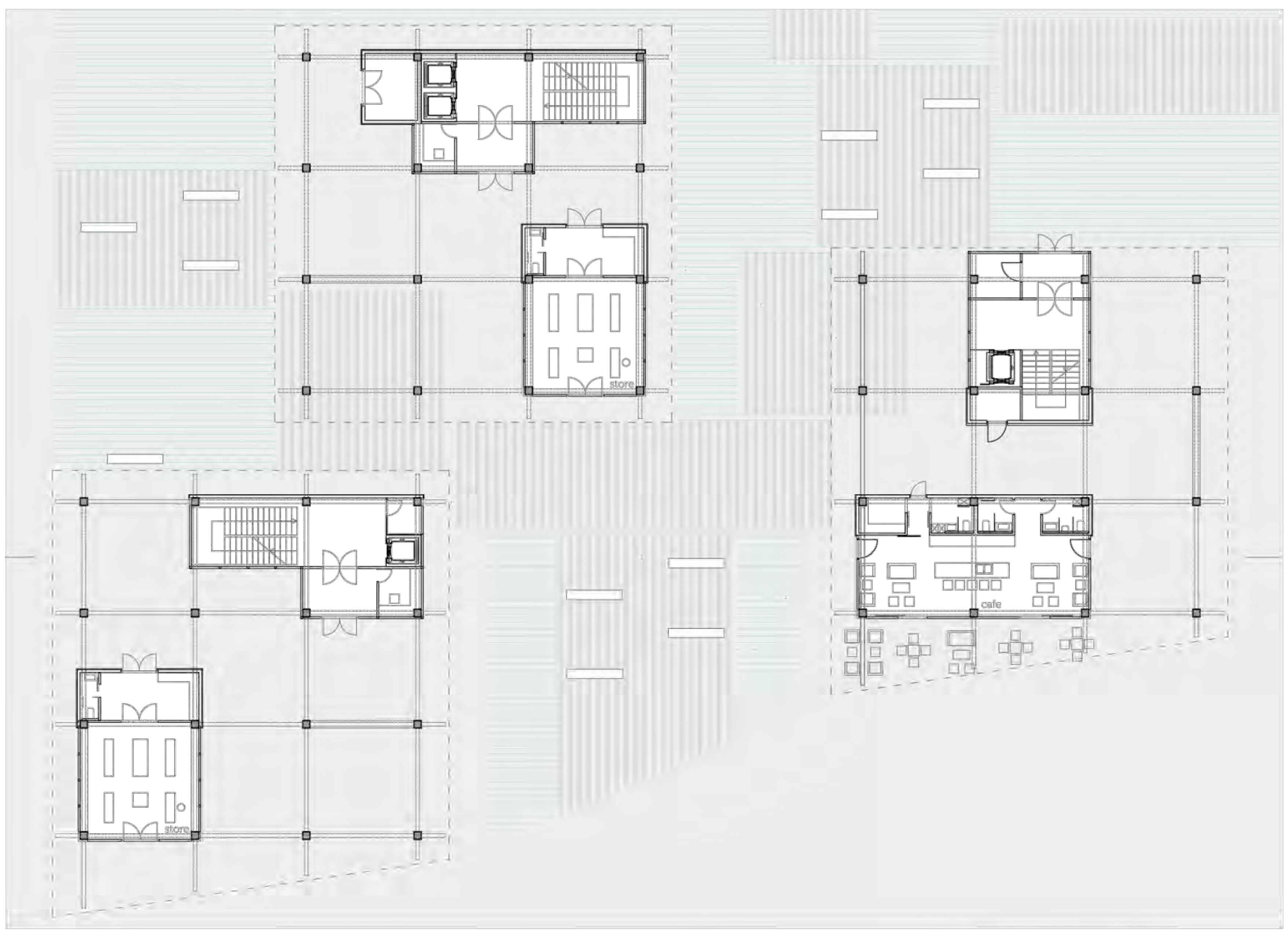
Maja Benkovic, Faculty of Architecture, University of Zagreb
Marin Ribic, Faculty of Civil Engineering, University of Zagreb

URBAN PLANING AND DESIGN - MIXED USE AREA
OFFICE AND RESIDENTIAL BUILDINGS









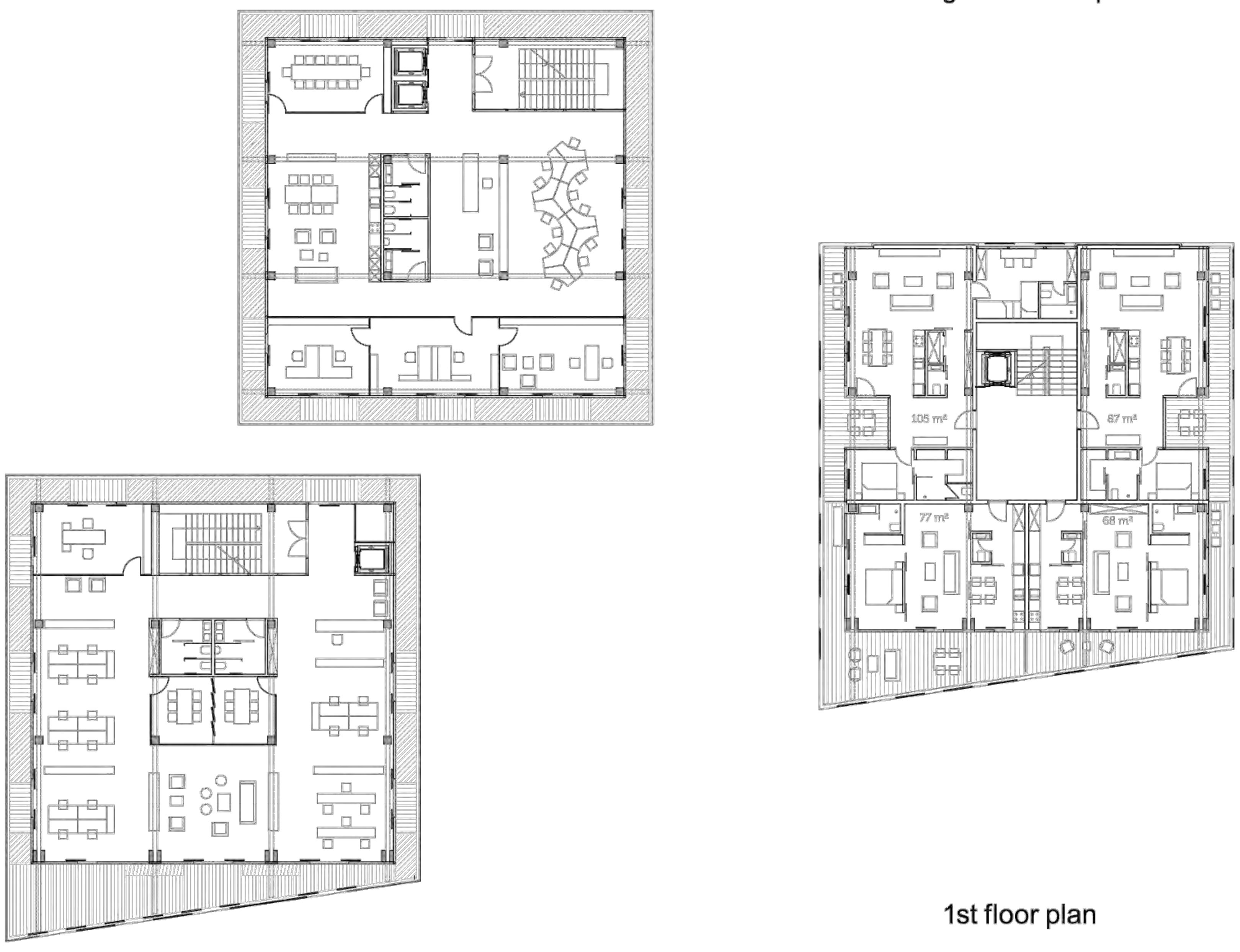
ground floor plan

CONCEPT

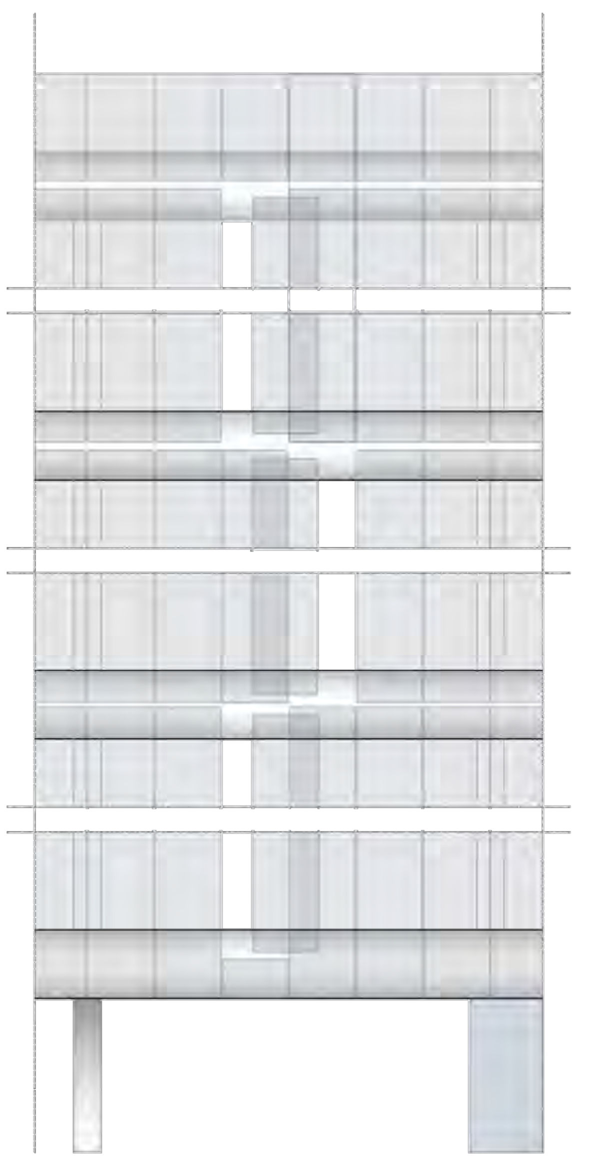
breaking city block by opening passages
open space ground floor is always available for use
organic form of green areas breaks formal shape of the buildings

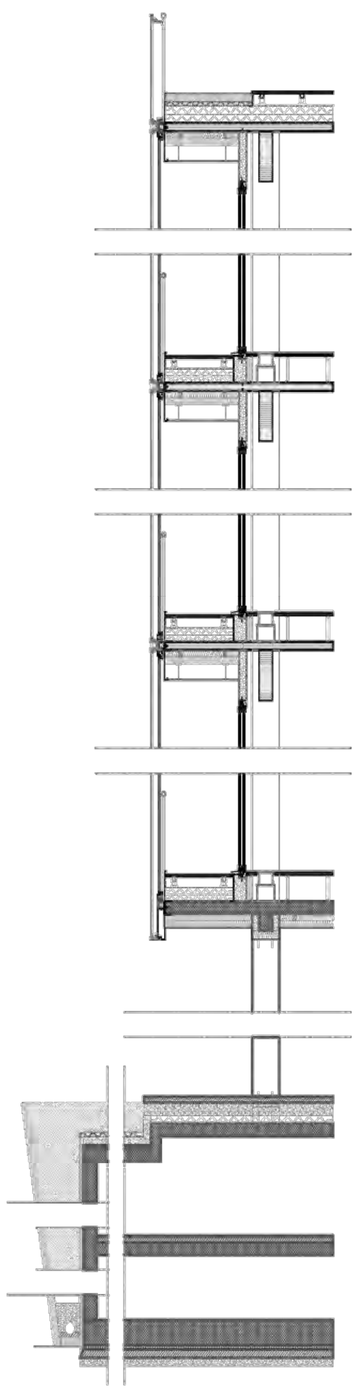
OFFICE AND RESIDENTIAL BUILDING
creating service passages on the north side of the loft
opening courtyard to the park creating new square

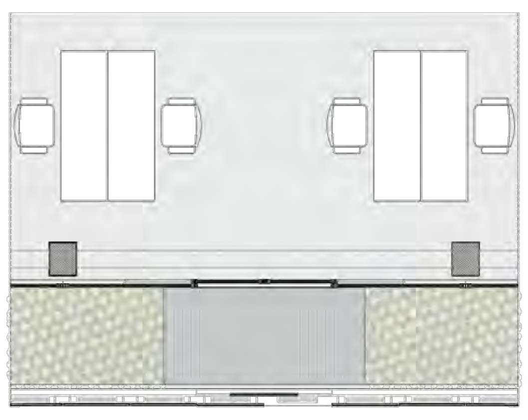
double skin facade used for better and economic use of the building
- transluscent solar panels, green plants for better microclimate conditions

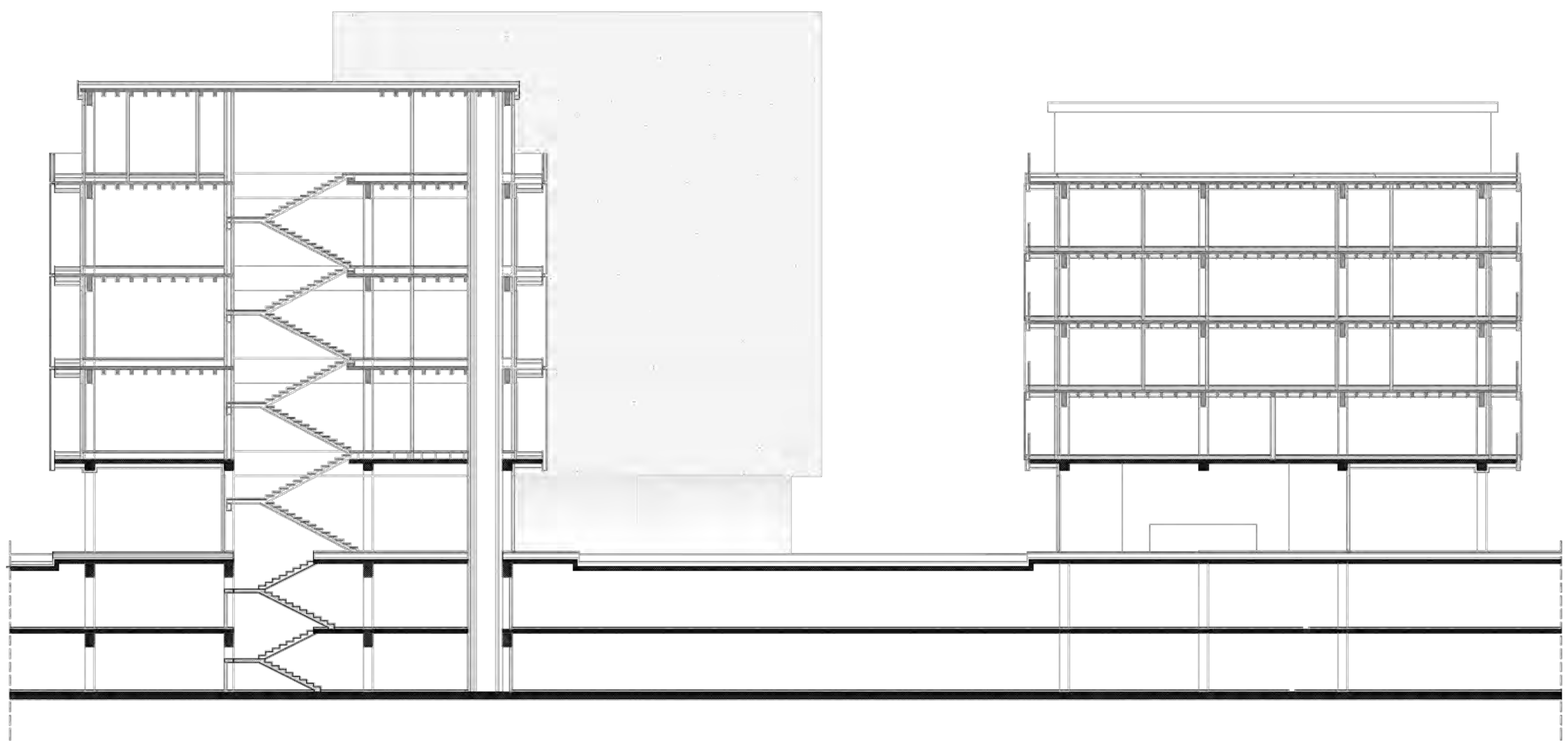


1st floor plan









section

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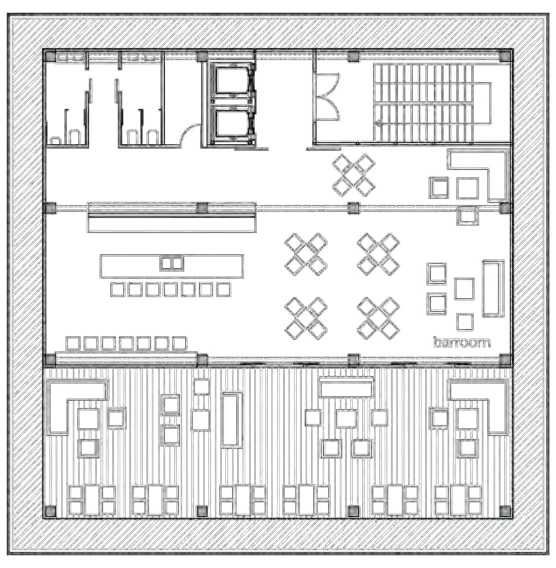
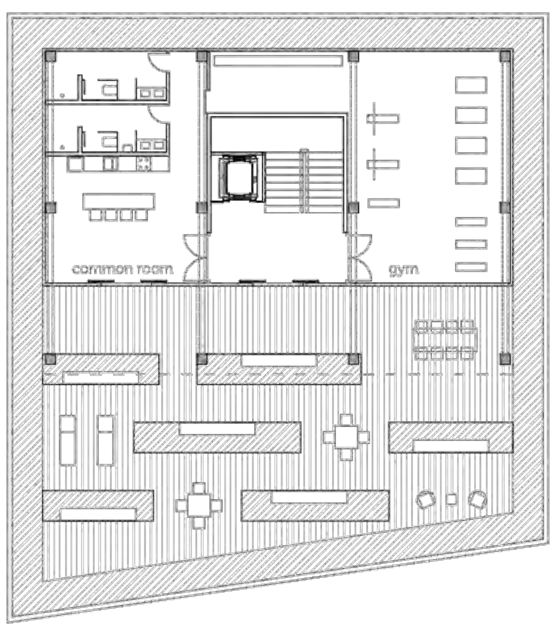
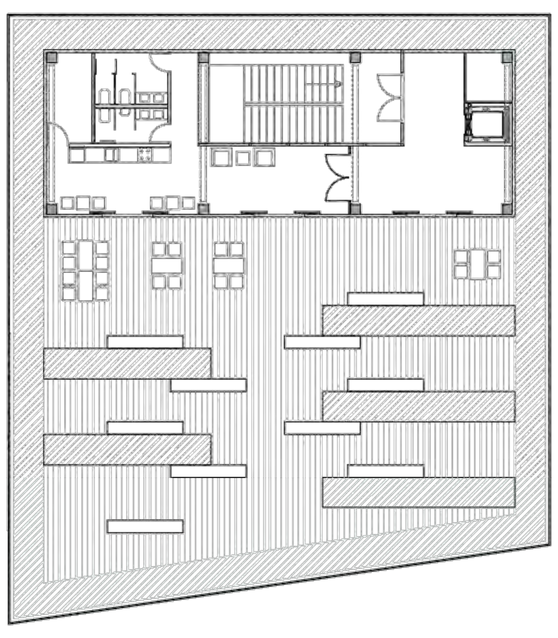






roof plan

CONSTRUCTION

TECHNICAL DATA OF RESIDENTAL AND OFFICE BUILDINGS

Project of both office buildings and residental building is completely accurate to the newest Eurocode norms.
EN 1990:2002+A1:2005, Eurocode 0 - Basis of structural design
EN 1991-1-1:2002, Eurocode 1 - Actions on structures
EN 1992-1-1:2004, Eurocode 2 - Design of concrete structures
EN 1993-1-3:2006, Eurocode 3 - Design of steel structures
EN 1995-1-1:2004, Eurocode 5 - Design of timber structures

Load analysis includes self weight, live load, snow and wind. Snow and wind are designed according to croatian national annex (NA), which gives certain loads on buildings. In case of snow that is 150 kg/m2, and speed of wind is 25m/s. Imposed loads varies from structure to structure, in office building is 200kg/m2 and in residental building 150kg/m2.

All imposed loads on cantilevers are 250kg/m2, and projected fire resistance is R60.

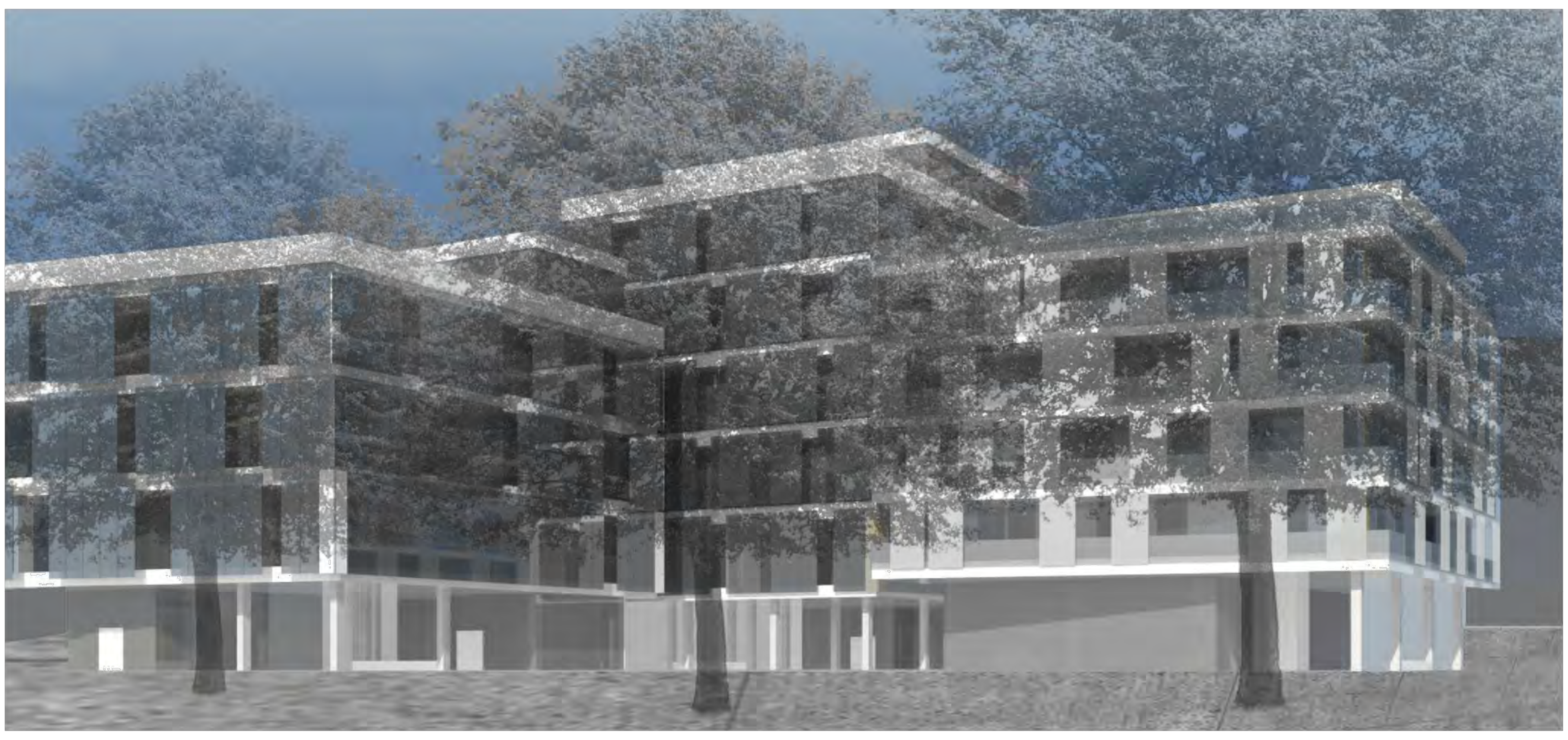
Materials used in buildings:
o C35/45, for concrete slab, beams and columns
o S355, for steel bracing system
o GL36h, for timber columns, beams and ribbed floor

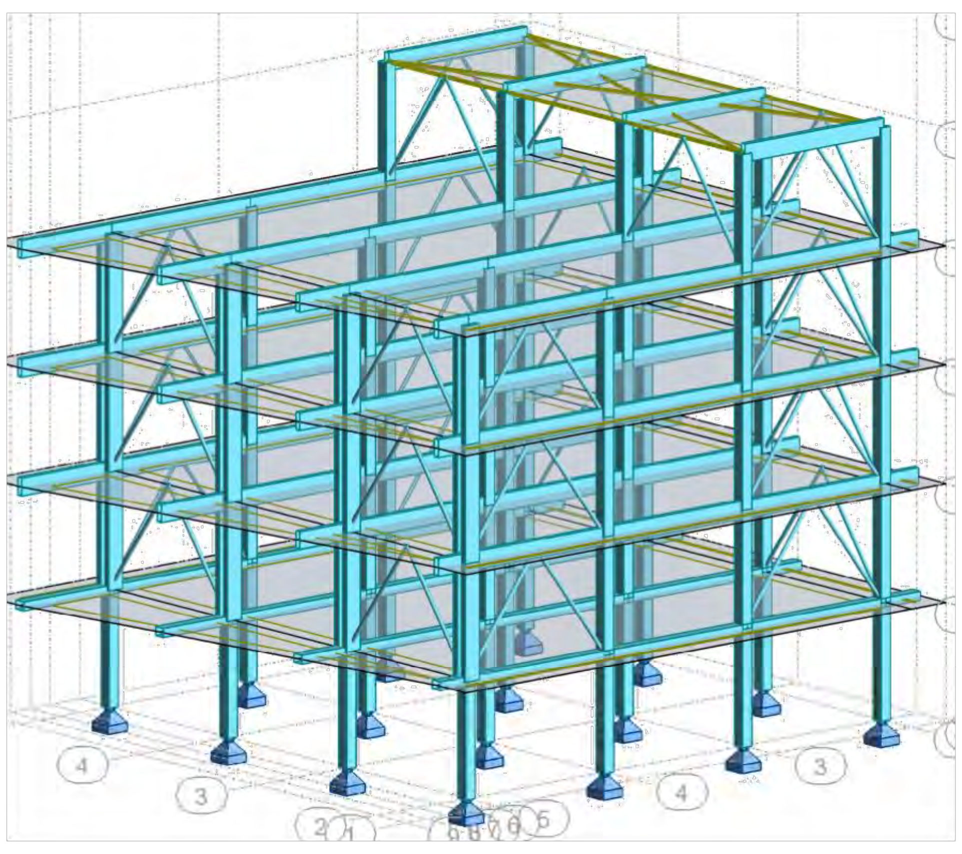
Resistance of elements in structures are calculated in Autodesk Robot Structural Analysis 3D Structure Model, for OFF1, OFF2, RES

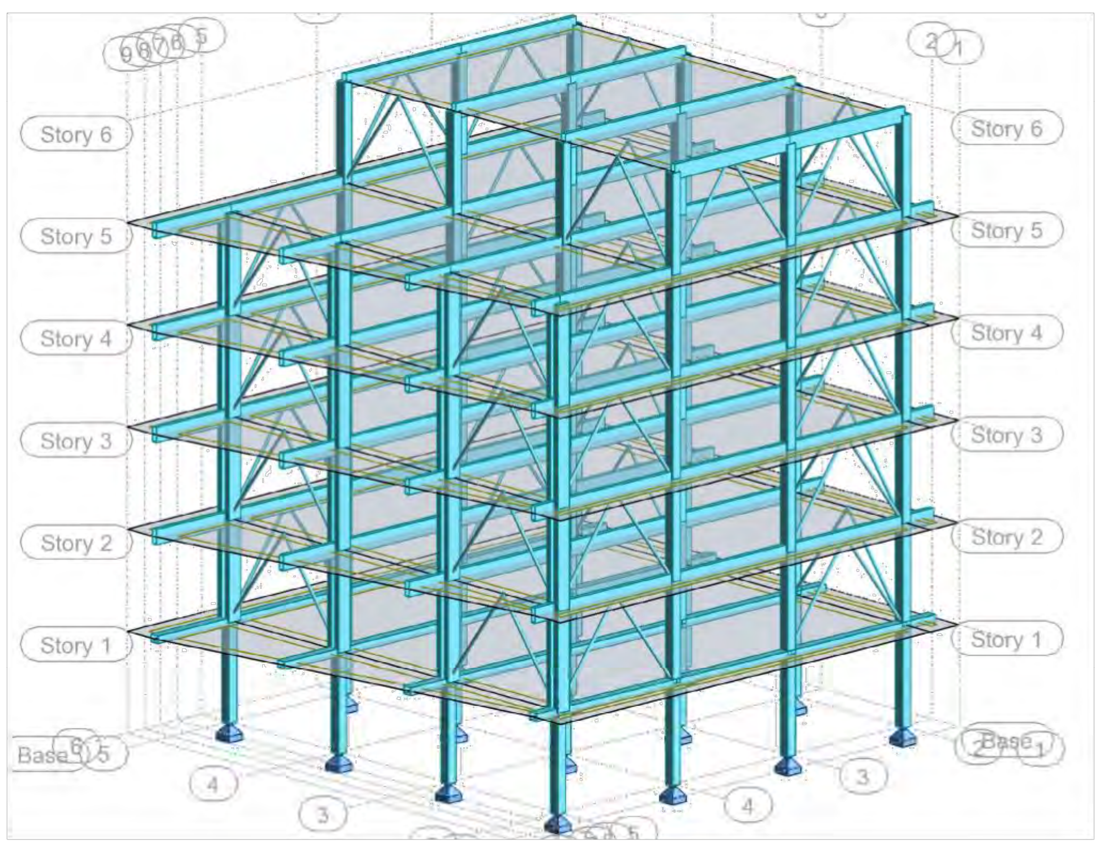
According to ULS, elements are dimensioned on maximum normal and shear stresses. Maximum normal stresses appear only in columns, while maximum shear stresses appear in beams and slabs. Referring to SLS, all deformations are below their limit state.

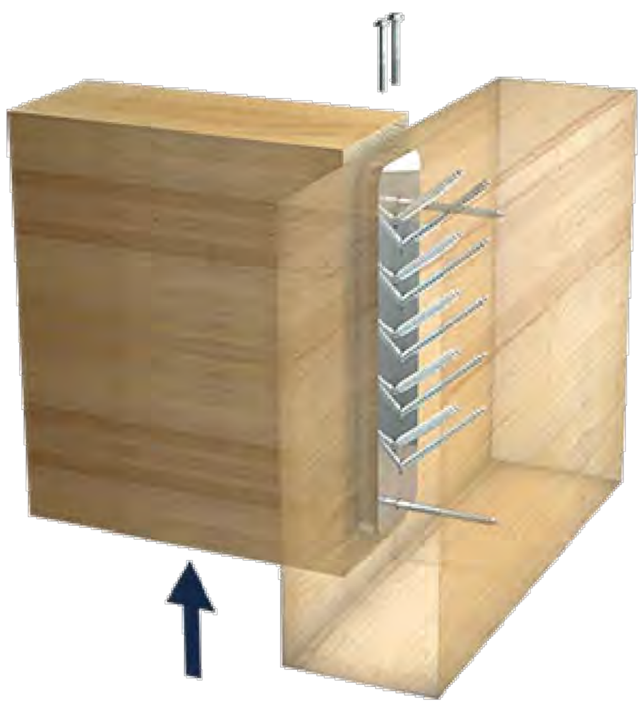
BUILDING PHASES
First phase of building consists only of concrete elements, which are poured monolithically into sheetings with reinforcement. It starts with excavation of 6.30m deep hole intended for subterranean garage on two levels. Poured foundation slab is 30cm thick, dimension of columns are 40x40cm, and beam 40x60cm.
Concrete elements are also placed on the ground floor to maximize material performance in capacity of bearing forces in both diretions what enables open concept ground floor without bracing system.
Second phase is mounting timber structure starting on level one, and hoisting to different heights of OFF1, OFF2, and RES. Bracing system is applied to all levels above ground floor with elements CHS 139,7x6,0.

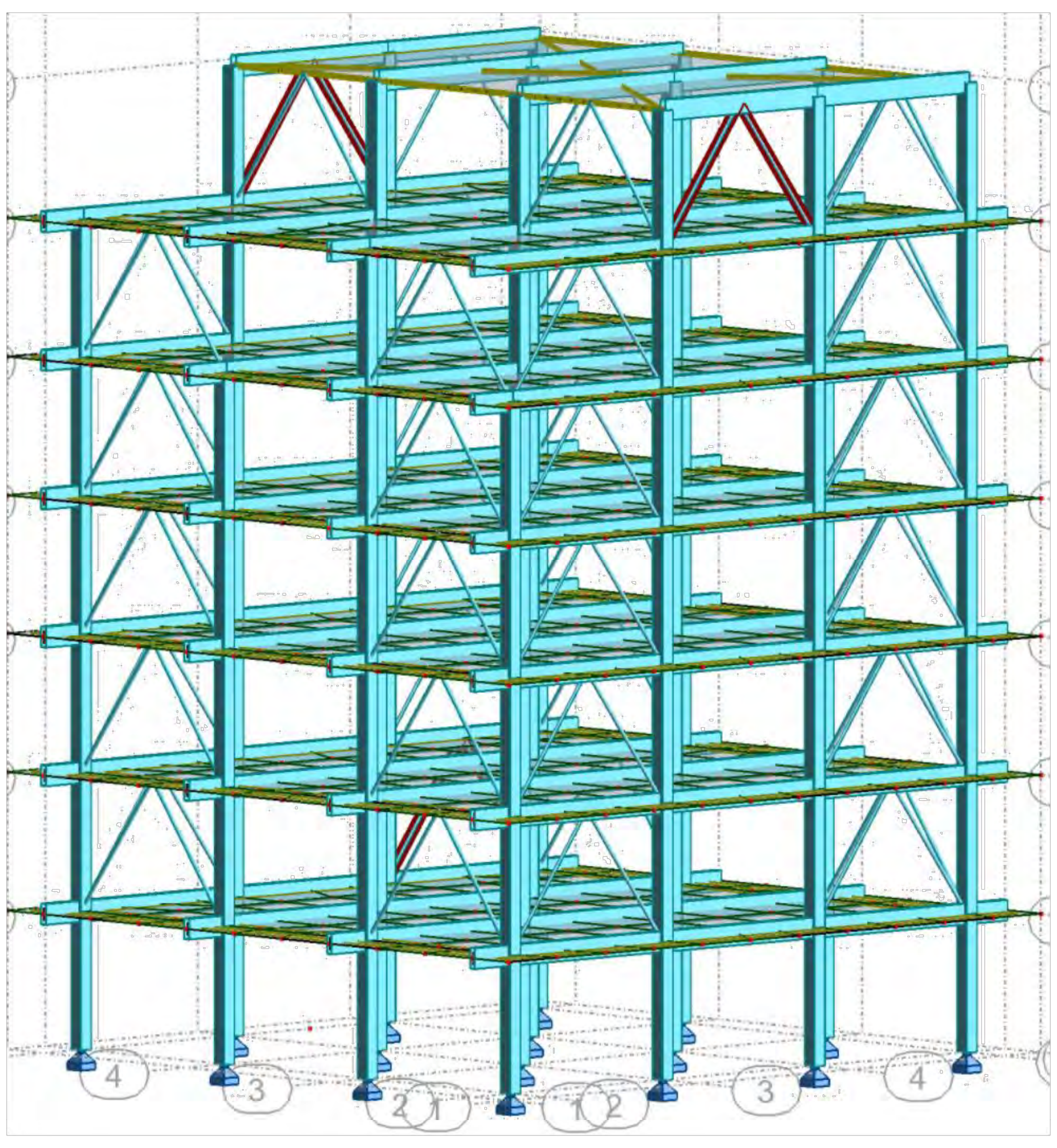
Dimensions for columns are 40x40cm with exception of two-part columns 20x60cm needed for cantilever stability. Connection between column and beam is performed with sherpa connector , and metal hangers with internal wing between ribbed floor and beam.

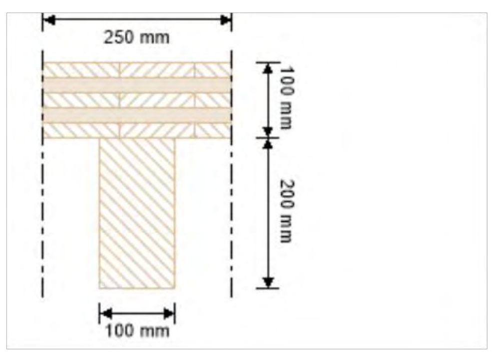












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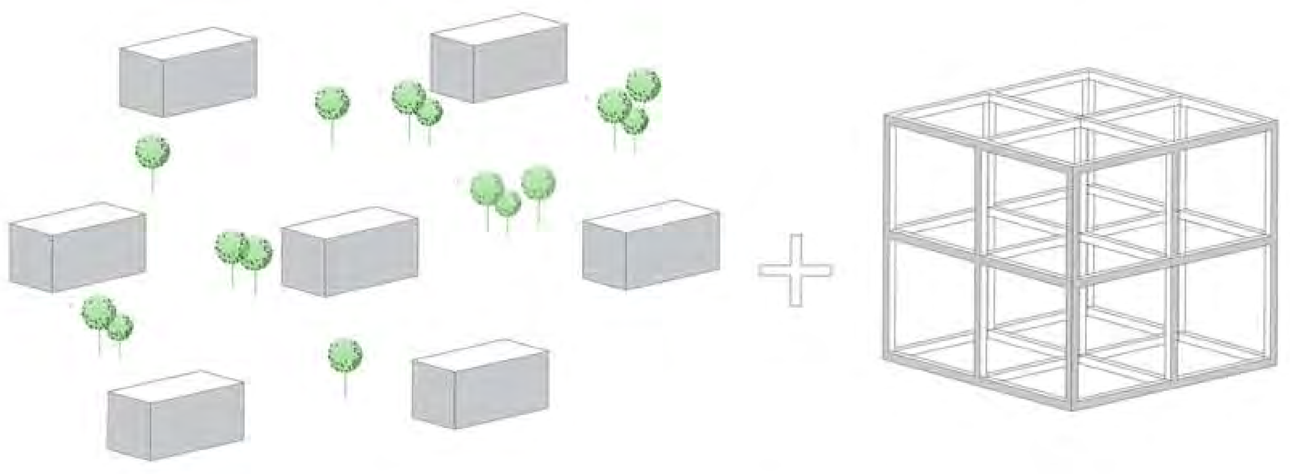
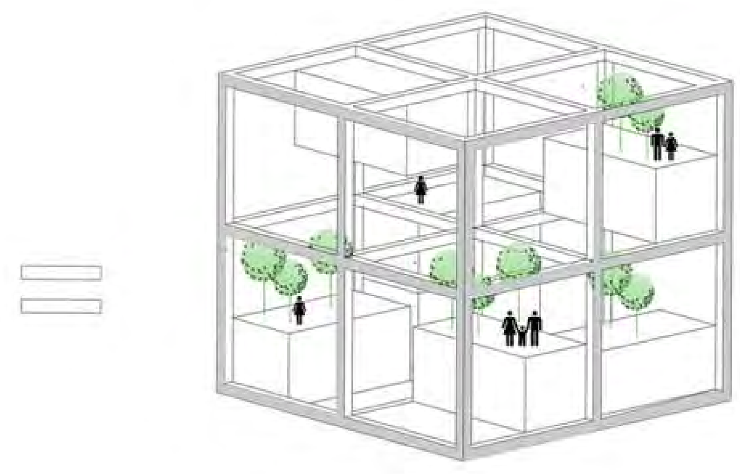
Hybrid architecture_residental+office

SMALL SCALE COMUNITIES

MEGASTRUCTURE - GRID





HOUSING MEGASTRUCTURE

Location: downtown Zagreb
Site area 3500 m2
Building area: 9600 m2
Purpose: residental-public

Main idea was to create an urban space which provides its habitants to live a simple suburban life while living in the city centre. Every house has its own terrace and a garden, as well as a good connection to the vertical comunucations. On first two floors, there are offices that areorganised in a way to simplify everyday work tasks.

Ground floor is public, and consists of a restaurant and a gym. The view outside is always towards vegetation.

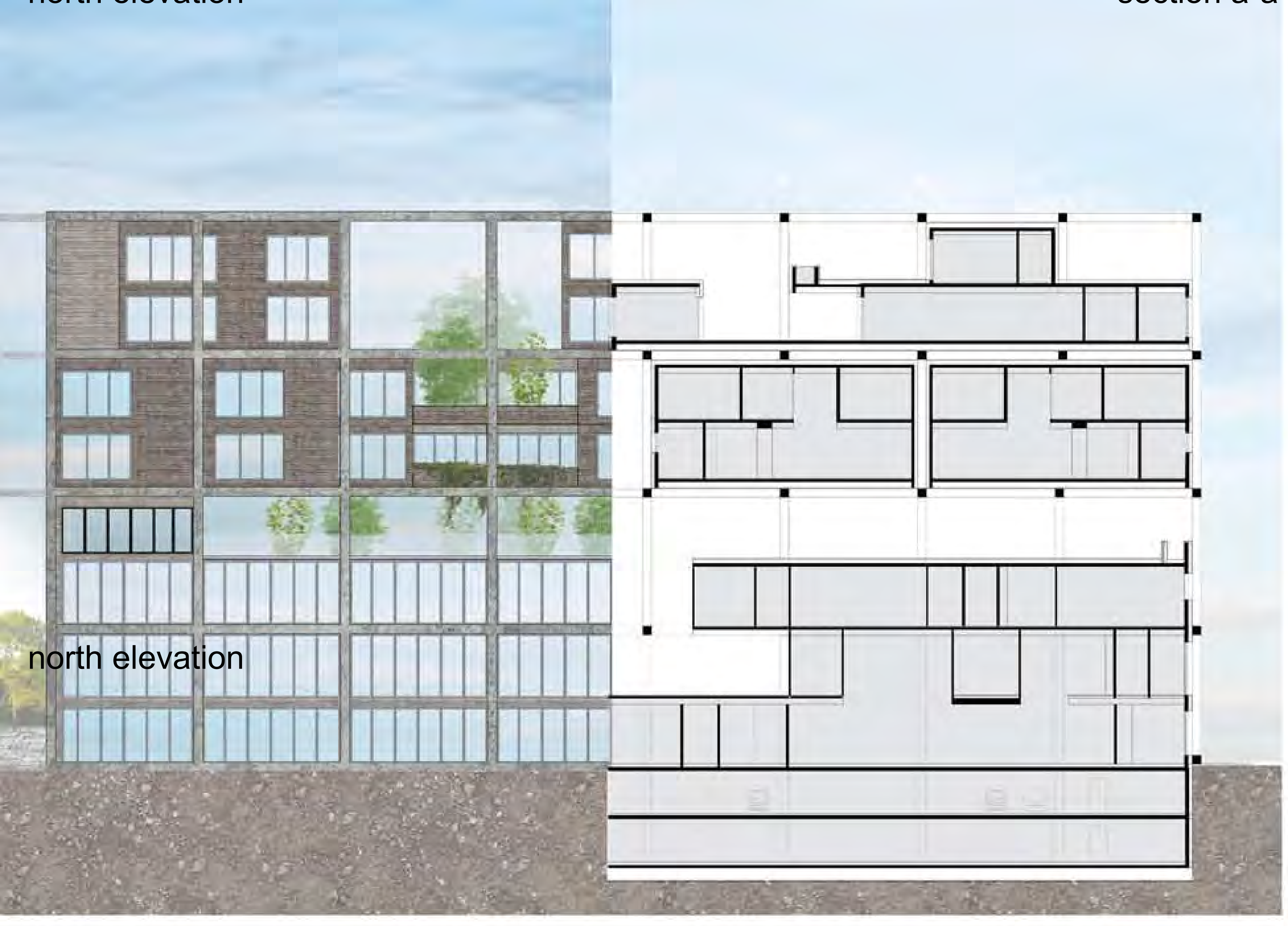
ground floor

office floor

residental floor

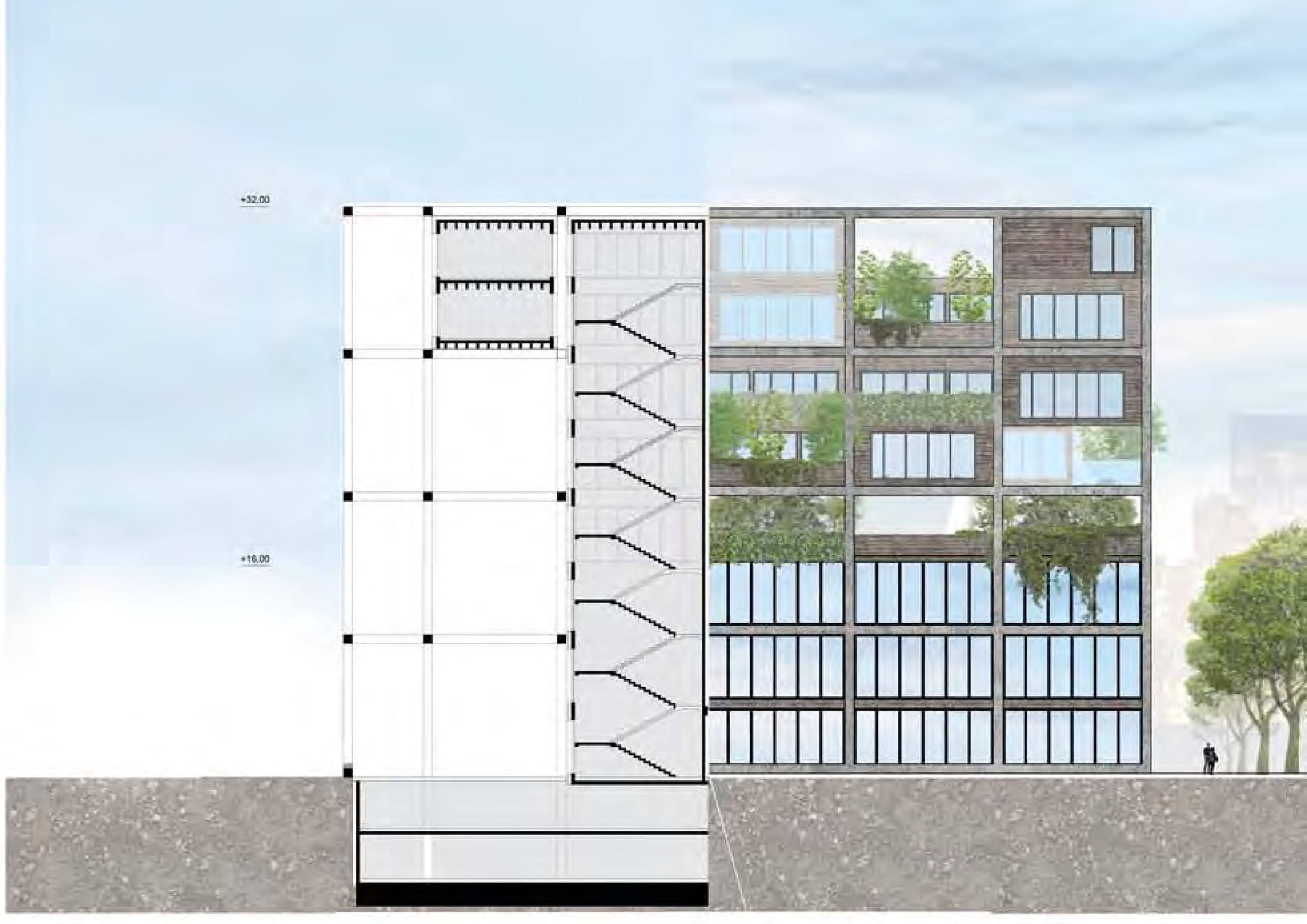
north elevation

section a-a



section 1-1

west elevation

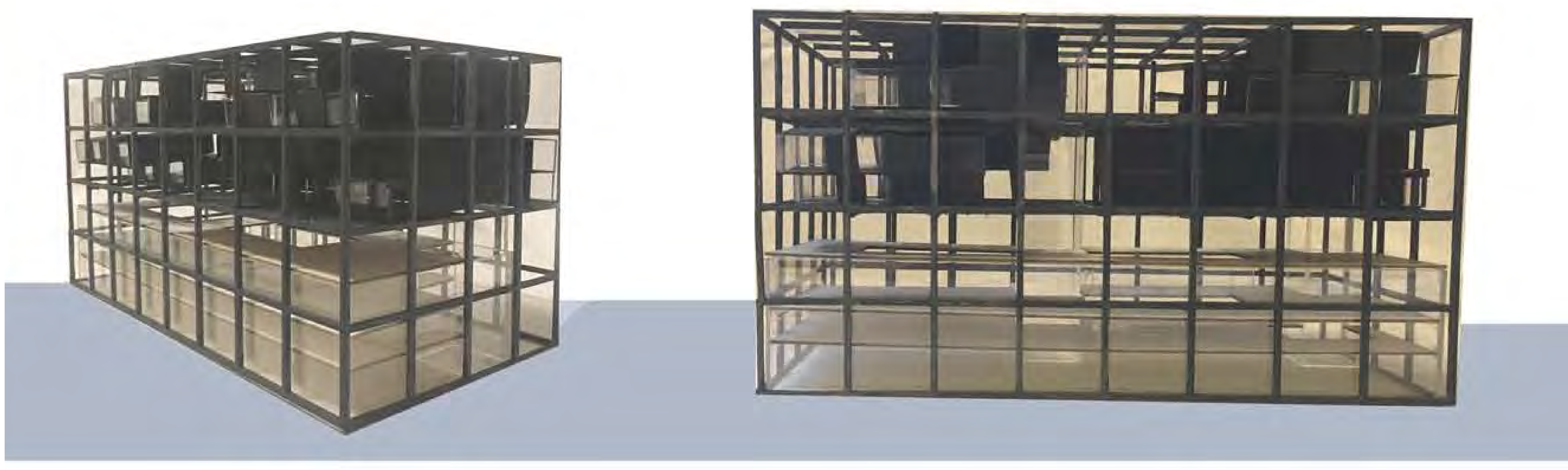


east elevation

south elevation

3D model

scale model



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TEHNICAL DATA

<u>Load analysis</u>

Dead load:self weight of elements includes by static calculations: g

Non structural elements and installations: $\Delta g = 0,3 kN/m^2$

Live load: office: $q_o = 2,5 kN/m^2$

living area: $q_l = 1,5 kN/m^2$

Loads included by environment: Snow: $s = s_k \cdot C_e \cdot C_t \cdot \mu$

$s = 1,25 \cdot 1 \cdot 1 \cdot 0,8 = 1,0 kN/m^2$

Wind

The wind is taken into account by pushing up pressure (1.2) on the objects with open lower slabs.

$q_p(z) = C_e(z) \cdot q_b$

$q_p(z) = 1,8 \cdot 0,39$

$q_p(z) = 0,70 kN/m^2$

$w = c_{pi} \cdot q_p(z)$

$w = 1,2 \cdot 0,70$

$w = 0,84 kN/m^2$

Relevant design situations:

ULS: $1,35 \cdot G + 1,5 \cdot Q + 1,5 \cdot 0,5 \cdot S \rightarrow top\ floor$

$1,35 \cdot G + 1,5 \cdot Q \rightarrow other\ floors$

SLS: $1,0 \cdot G + 1,5 \cdot S$

<u>Structure</u>

Construction is made of concrete grid with mesh 8x8x8 meters.

Vertical load:On first,fifth and sevnth floor CLT panels is lean on secondary beams in GLT span of 8 m.Beams transmit load on the concrete columns

On second,forth and sixth floor we have concrete beams in grid mesh.

All the floors are made of CLT panels except third,which is made of concrete because of higher load and mosture of green layer thickness 20 cm.

Columns as a vertical support member is subjected to compressive load and internal moment due to the action of wind

Last four storeys are for living and transmit of vertical loads are similar these in lower floors.

Lateral load: The floor (CLT beams and panels) transfer lateral load to the rigid concrete frame.

Objects are made in situ with only CLT material:Panels and walls. In some places where exist continuity in vertical direction CLT panels are used as ceeling in under and slab in upper house in the same time.

Calculations for Ultimate limit state and Serviceability limit state is runned by Storaenso Calculatis in order to determinate design and material properties for ceeling,slabs and walls.

Other construction elements like concrete grid,secondary GLT beams and itc. are hand-by calculated and checked in Scia Engeenier 2016

Columns: most loaded column calculation is applied to the all columns

<u>compressive strength</u>

$N_{Ed} = 1,35 \cdot G + 1,5 \cdot Q + 1,5 \cdot 0,7 \cdot \Delta Q + 1,5 \cdot S$

$N_{Ed} = 1,35 \cdot 570,0 + 1,5 \cdot 864,0 + 1,5 \cdot 0,7 \cdot 180 + 1,5 \cdot 64$

$N_{Ed} = 2350,5 kN$

$A_{s,req} = \frac{N_{Ed} - A_c \cdot f_{cd}}{f_{yd} - f_{cd}} < 0 \rightarrow min\ earthquake\ requestment$

$A_{s,req} = 8\Phi 16 \rightarrow longitudinal\ reinforcement$

$\Phi 8/18 \rightarrow clamps$

Beams: most loaded beam calculation is applied to the all beams

To design beams and get the proper mesaurments for them we had to project uniform load from panels (ULS combination) into the linear load on simply supported beams.Loads are taken from Storaenso Calculatis.

a) Rectangle cross section 50x50 cm

$q_{Ed} = 1,35 \cdot G + 1,5 \cdot Q + 1,5 \cdot 0,5 \cdot S$

$q_{Ed} = 1,35 \cdot (6,25 + 3 \cdot 1,31) + 1,5 \cdot 20 + 1,5 \cdot 0,5 \cdot 8$

$q_{Ed} = 45,6 kN$

$M_{Ed} = \frac{45,6 \cdot 8^2}{8} = 361,3 kNm$

$choosen: 5\Phi 25$

$\Phi 8/20 \rightarrow clamps$

b) T- cross section $b_w / b_f = 50x370$ cm

$q_{Ed} = 1,35 \cdot G + 1,5 \cdot Q$

$q_{Ed} = 1,35 \cdot (6,25 + 30 + 22,5) + 1,5 \cdot 20$

$q_{Ed} = 105,0 kN/m$

$M_{Ed} = 861 kNm$

$choosen: 7\Phi 28$

$\Phi 10/20 \rightarrow clamps$

GLT beam (in office-most loaded)

Bending with torsional buckling

$beam: b/h = 22/60 cm$

$material: GL36h \rightarrow f_{m,k} = 36 N/mm^2$

$k_{mod} = 0,9$

$\gamma_M = 1,3$

$f_{m,d} = k_{mod} \cdot f_{m,k} / \gamma_M = 0,9 \cdot 36 / 1,3 = 24,92 N/mm^2$

$q_{Ed} = 1,35 \cdot (g + \Delta g) + 1,5 \cdot q$

$q_{Ed} = 1,35 \cdot (1,31 + 2,4) + 1,5 \cdot 20$

$q_{Ed} = 35,13 kN/m$

$M_{Ed} = \frac{q_{Ed} \cdot L^2}{8} = \frac{35,13 \cdot 8^2}{8} = 281,04 kNm$

$l_{ef} = 8000 mm, h = 600 mm, b = 220 mm$

$\frac{l_{ef} \cdot h}{b^2} = \frac{8000 \cdot 600}{220^2} = 99,17 < 120 \rightarrow k_m = 1$

$\sigma_{m,y,d} = \frac{M_{Ed}}{W} = \frac{281,04 \cdot 12}{0,22 \cdot 0,6^3} = 21,29 N/mm^2 < f_{m,d} = 24,92 N/mm^2$

Shear

$beam: b/h = 22/60 cm$

$material: GL36h \rightarrow f_{v,k} = 3,5 N/mm^2$

$k_{mod} = 0,9$

$\gamma_M = 1,3$

$f_{v,d} = k_{mod} \cdot f_{m,d} / \gamma_M = 0,9 \cdot 3,5 / 1,3 = 2,42 N/mm^2$

$q_{Ed} = 1,35 \cdot (g + \Delta g) + 1,5 \cdot q$

$q_{Ed} = 1,35 \cdot (1,31 + 2,4) + 1,5 \cdot 20$

$q_{Ed} = 35,13 kN/m$

$M_{Ed} = \frac{q_{Ed} \cdot L^2}{8} = \frac{35,13 \cdot 8^2}{8} = 281,04 kNm$

$\tau_{v,d} = 1,5 \cdot \frac{q_{Ed} \cdot L}{2 \cdot A} = \frac{35,13 \cdot 8000}{2 \cdot 220 \cdot 600} = 1,59 N/mm^2 < f_{v,d} = 2,42 N/mm^2$

Results for the ULS

Plate:Storaenso Calculatis

GLT beam:

$u_{fin}^G = u_{inst}^G \cdot (1 + k_{def,G})$

$u_{fin}^Q = u_{inst}^Q \cdot (1 + k_{def,Q})$

$u_{net,fin}^G = u_{fin}^G + u_{fin}^Q$

$u_{inst}^Q = 20 mm < L/300 = 26,67 mm$

$u_{net,fin}^G = 32 < L/200 = 40 mm$

Deflections have been got in Scia Engineer 2016

<u>Details</u>

Secondary beam-column connection

Connection of the column and beams will be made by concealed beam hanger with holes

shear

$F_{v,Rk} = 40,5 kN (1\ bolt)$

$F_{v,Rd} = \frac{F_{v,Rk} \cdot 3}{\gamma_M} = \frac{40,5 \cdot 3}{1,25} = 97,2 kN$

$V_{Ed} = 74,0 kN < F_{v,Rd} = 97,2 kN$

welds strength

S275

$F_{w,Rk} = 165,0 kN \rightarrow weld\ thickness\ 5 mm, length\ 113 mm$

$F_{w,Rd} = \frac{F_{w,Rk} \cdot 3}{\gamma_M} = \frac{165,0}{1,25} = 132,0 kN$

$V_{Ed} = 74,0 kN < F_{w,Rd} = 132,0 kN$

$V_{Ed} = 162,53 kN$

$R_d = \frac{R_k \cdot k_{mod}}{\gamma_M} = \frac{202,2 \cdot 0,9}{1,3} = 163,8 kN$

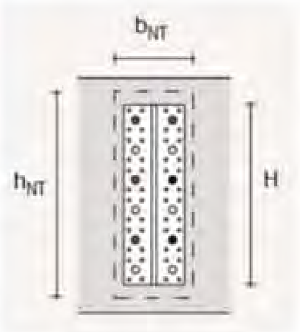
$V_{Ed} < R_d$

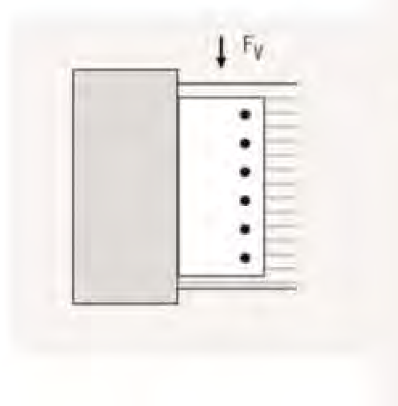
$H = 576 mm$

$h_{NT} = 624 mm$

$b_{NT} = 160 mm$

$dowels\ STA\ \Phi 16x160$





Secondary beam-column(external)

$q_{Ed} = 1,35 \cdot (g + \Delta g) + 1,5 \cdot q$

$q_{Ed} = 1,35 \cdot (1,31 + 1,2) + 1,5 \cdot 10$

$q_{Ed} = 18,51 kN/m$

$V_{Ed} = \frac{q_{Ed} \cdot L}{2} = \frac{18,51 \cdot 8}{2} = 74,0 kN$

For this detail is used metal plate thickness 20 mm anchored in column with high qualitiy bolts(8.8;⌀12 mm)

Plate-beam(core) connection

$V_{Ed} = 1,35 \cdot (G + \Delta G) + 1,5 \cdot Q$

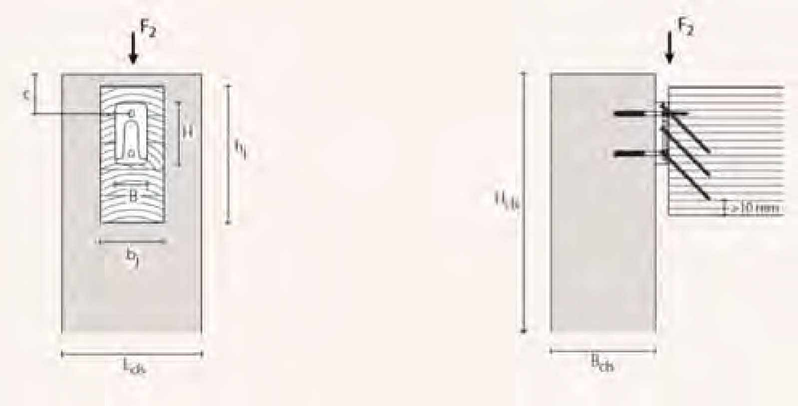
$V_{Ed} = 1,35 \cdot (0,28 + 2,08) + 1,5 \cdot 4$

$V_{Ed} = 9,18 kN$

$R_k = 17,34 kN$

$R_d = R_k \cdot \frac{k_{mod}}{1,3} = 17,34 \cdot \frac{0,9}{1,3} = 11,93 kN$

$V_{Ed} < R_d$



Connection of the plate and concrete core or beam

$type: UVC60115$

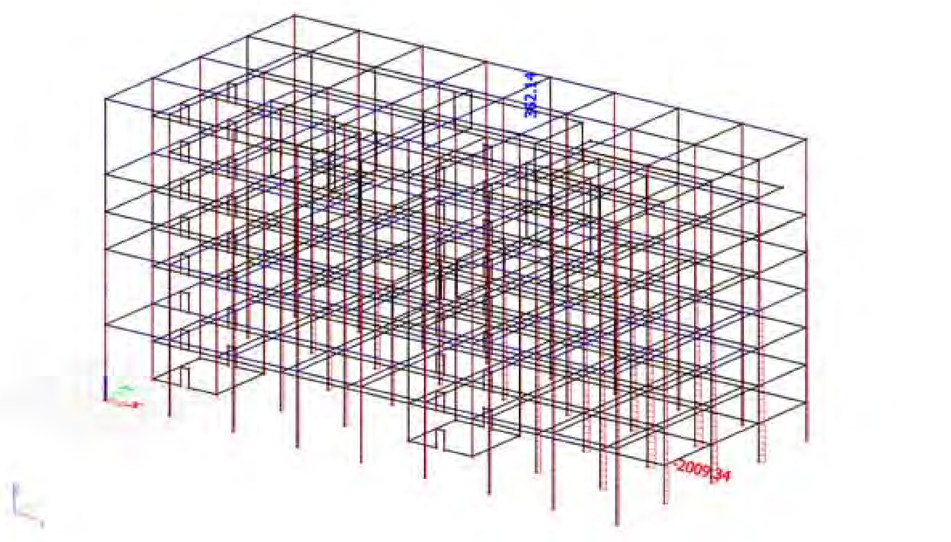
$fasteners\ holes\ \Phi 12$

$\Phi x L [mm]$

$SKS\ CE\ \Phi 10x100$

$BxHxs [mm] = 60x115x24 \rightarrow concrete$

$b_{j,MIN}; h_{j,MIN} [mm] = 80; 180 \rightarrow wooden\ secondary\ beam(rib)$



Model in Scia Engineer 2016-ULS

Master class

international and interdisciplinary workshop

Densification of the city districts with CLT modular elements

www.wooddays.eu

Students – authors: Petra Alić, architecture; Stipe Vuković, civil engineering

TU Graz

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University of Zagreb

Prof. Dr. Vlatka Rajčić, Faculty of Civil Engineering

Doc. Ivica Plavec, Faculty of Architecture

Prof. Dr. Sanja Filep, Faculty of Architecture

pro:Holz Austria

Marin Bencic, Faculty of Architecture, University of Zagreb
Matej Kramaric, Faculty of Civil Engineering, University of Zagreb
Petar Marovic, Faculty of Civil Engineering, University of Zagreb

city trees

Story behind the project

The site of the project is on the middle-west side of Zagreb. If you watch the building tipology our site is on the edge of the urban block buildings. From that point i started my idea. First I extracted main parts wich make a urban block. First we have a commercial groundfloor, and offices or flats are on the upper floors. Also in the protected core we have gardens or green spaces. Those facts were mine startpoins. I wanted to make a 21th century block not a modest one. So I opened up my block and gave it a free polyline form. That polyline makes 2 squares for the users and 1 backyard for all the services. I did change the tickness of the building itself given it slimmer a ticker spaces depending on their use. I stacked up on 4 mainpoints more floors and let the groundfloors stay just on 2 elevations. The towers are in differnte shapes, but the whole complex is streched between 2 high towers. The lower one has 12 elevations and the taller one has 16.

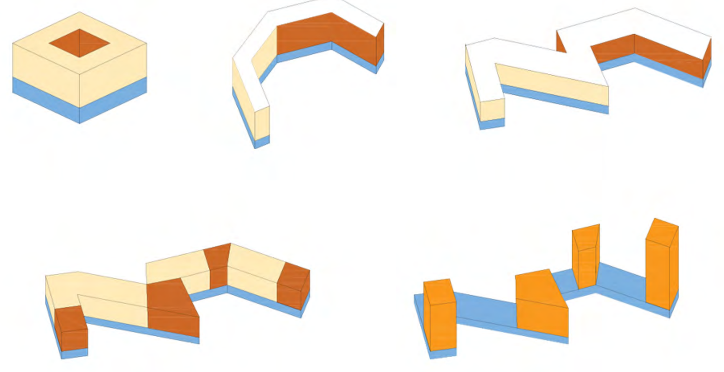
Groundfloors are commercial. On start we little caffe, after that theres a lobby and a congres auditory followed by a shopping mall. On the north side we a courtyard for sports and on the end stands a supermarket. The towers itself are mostly offices but they got luxury flat wich are chaging their usage for every tower

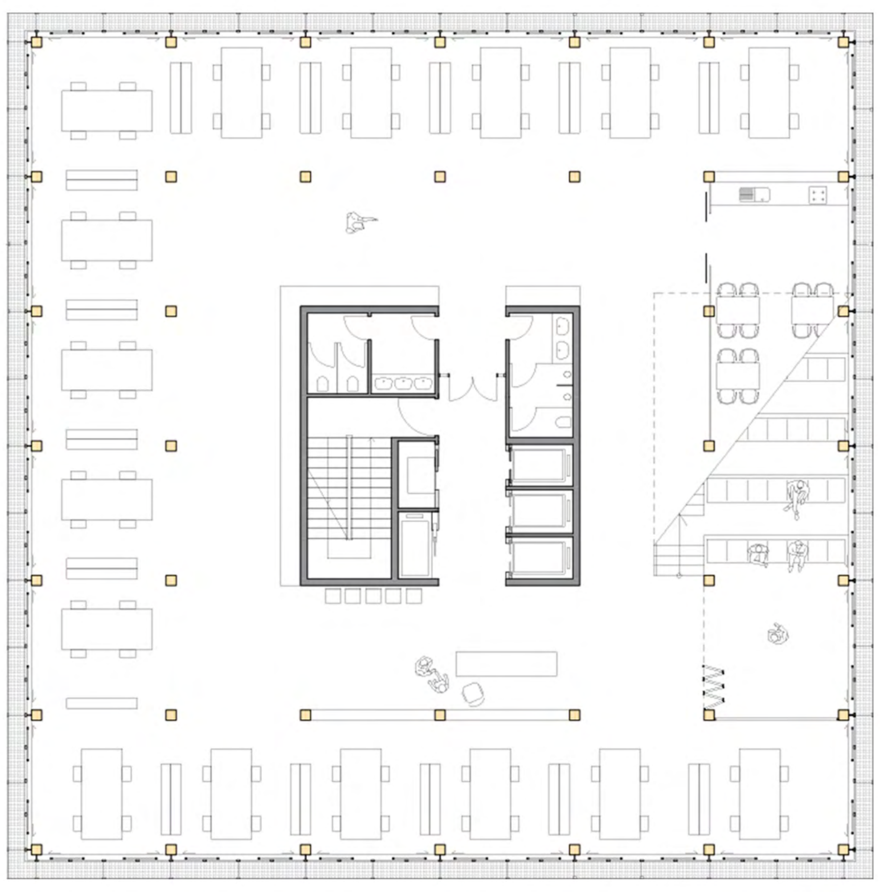
On the lower rooftops we have a green space wich is avaible to anyone and also gives a connection between all towers on a differnte level. They purpose is to return garndens wich we lost opening up the block

The tower wich I developed has 12 storeys and is 24 by 24 meters. First 2 floors are build from concrete and got a caffe and aconfres auditory. They height is 5 m. The next 10 storeys are made out of CLT with a concrete core 8 by 8 metes and a height of 4 m. 8 storeys are offices. Becuse of the skelet system the offices are very flexible, and I made varities on duplex and simplex offices.
The duplex offices are much more seperated and got a strick hierarchy of workes. They also got a staircase wich can be used for teambuilding speaches or just relaxing.

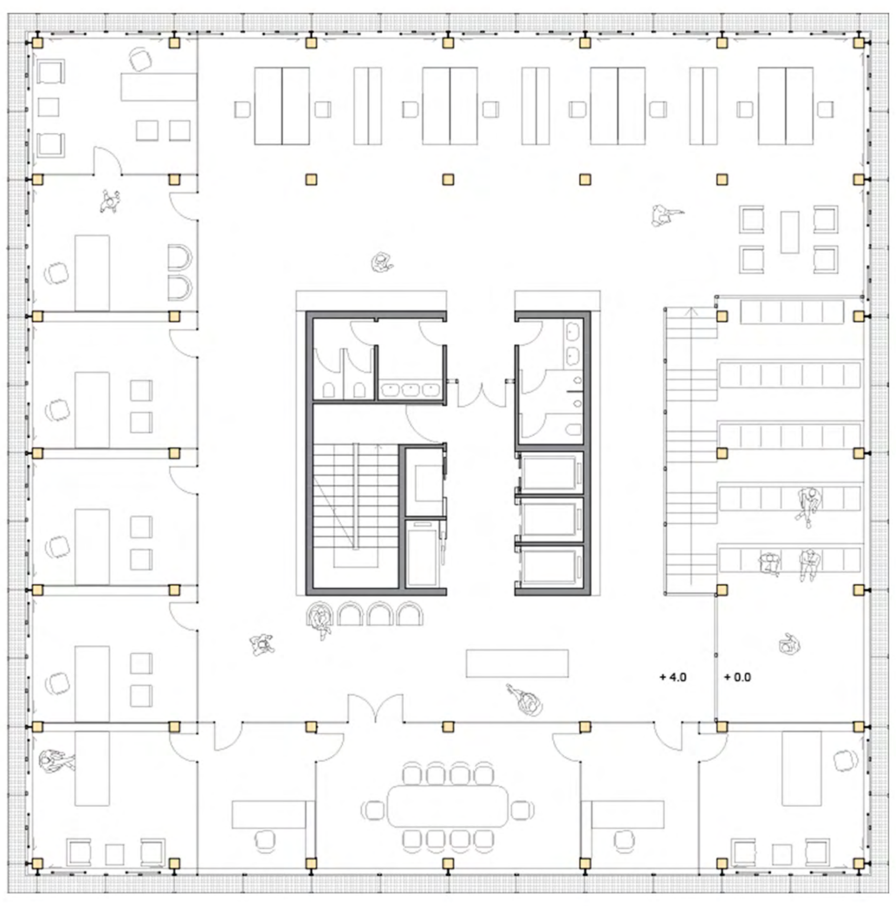
SITUATION M 1:1000

KONCEPT

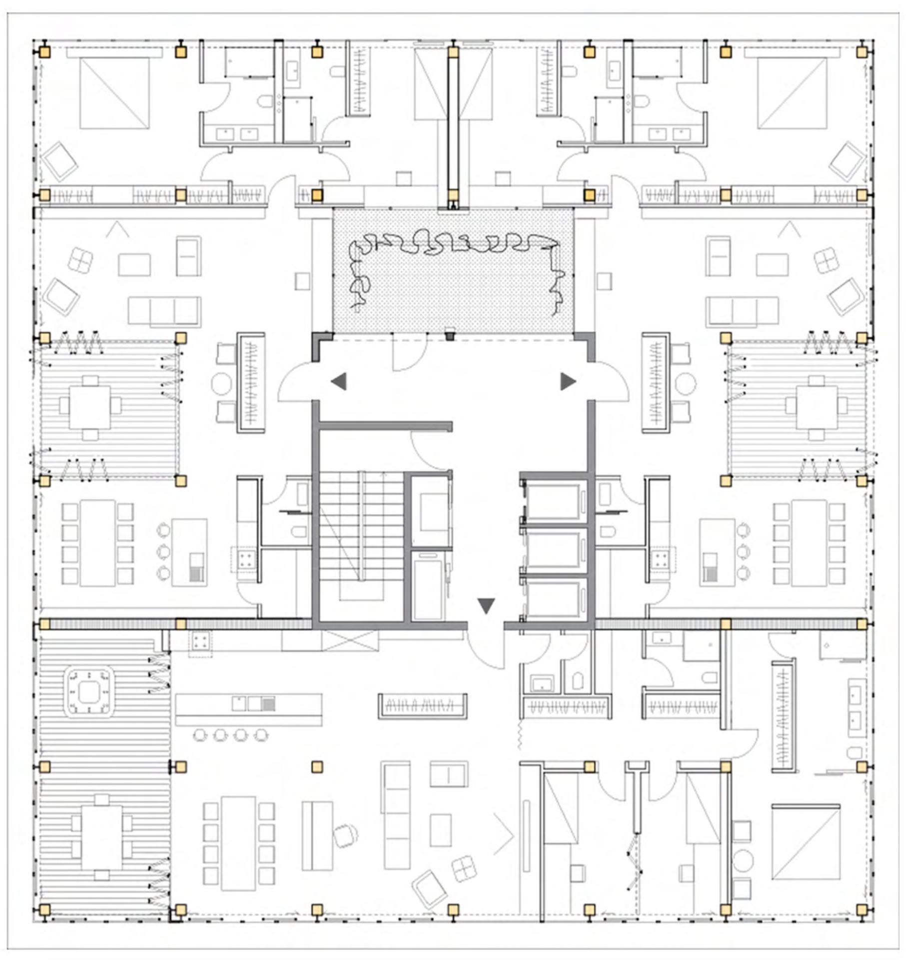




OFFICE PLANS M 1:100 OFFICE INTERIOR



OFFICE PLANS M 1:100 FLAT INTERIOR



PLAN OF FLATS M:100 3D by night

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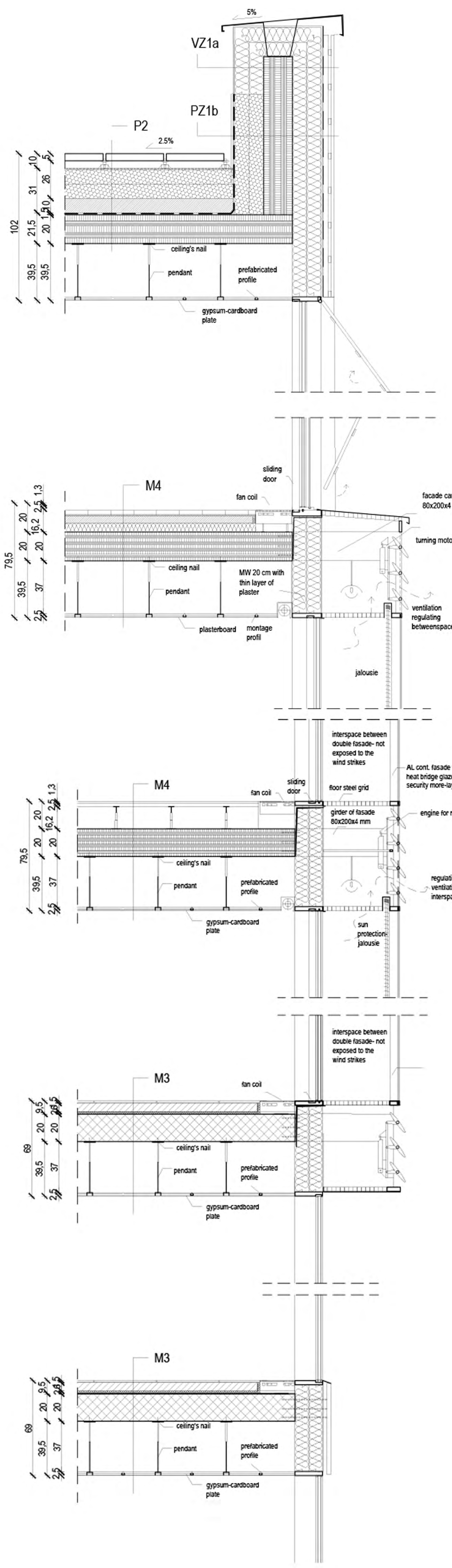
Detal and contruction information
1:100



VZ1a- roof fence

-thin-layered plaster 1 cm
-hard plates MW 2x10 cm 20 cm
-CLT 18 cm
-hard plates MW 2x10 cm 20 cm
-rain's barrage 0,1cm
-ventilated layer 4 cm
-cross-setted up timber revetment 4 cm

P2- flat roof

-stone's plate 5 cm
-girder's of diffirent heights 5 cm
- layer for filtering water 5 cm
-cork tape 1 cm
-T.I. XPS 20 cm

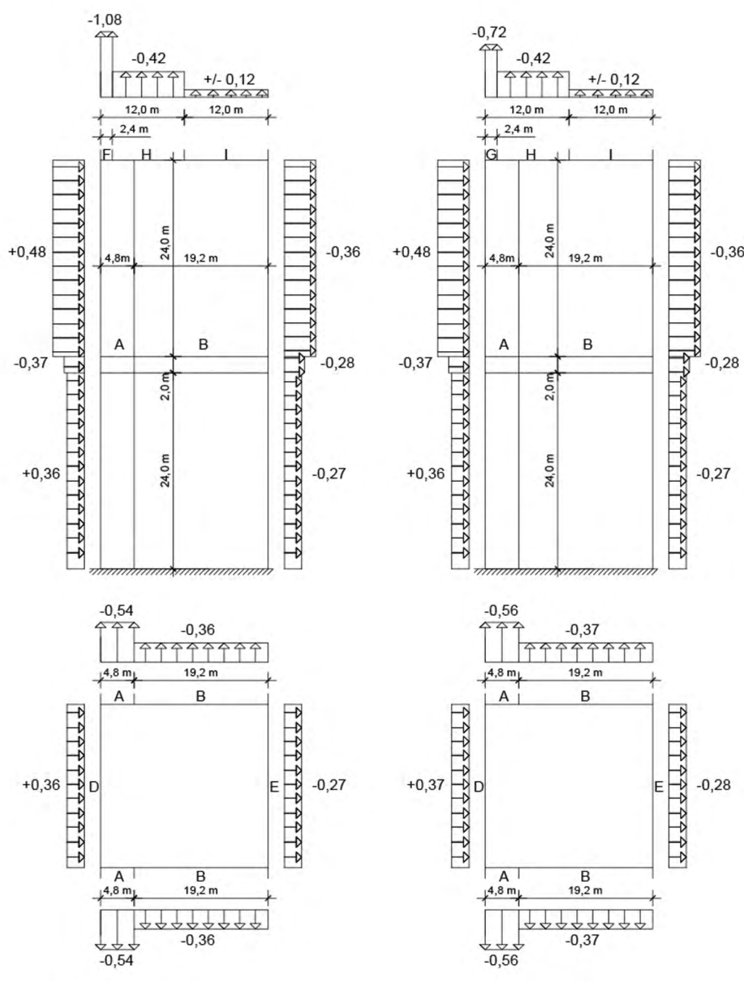
M3- floor construction CLT 79,5

-floor plasterboard cement boards(1,3+2,5) 3,8 cm
- computer floor with carrier 16,2 cm
-cross lamineted timber plate 20,0 cm
-low ceiling with carriers 37,0 cm
-plasterboard for low ceiling

ANALYSIS OF LOADS

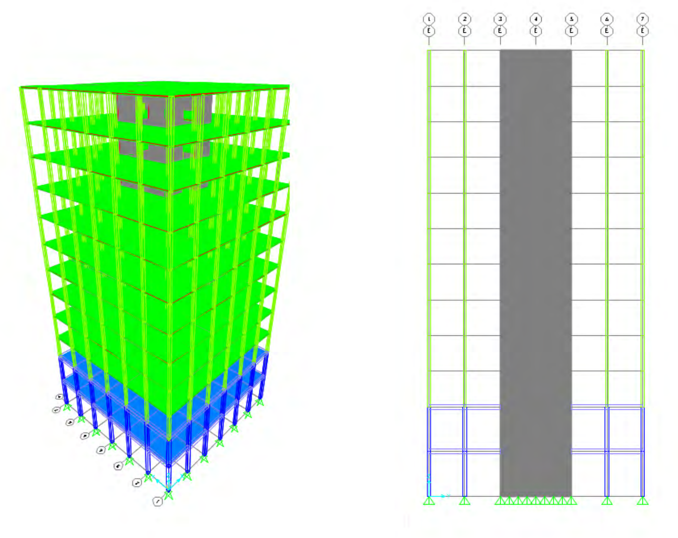
PERMAMENT LOADS
- Self weight software
- Instalations 0,20 kN/m²
- Glass 0,20 kN/m²

IMPOSED LOADS
- Impervious flat roof 0,75 kN/m²
- Residential space 2,00 kN/m²
- Business space 2,50



3D MODEL

- Made in 2 softwares: SAP2000 v19 and SCIA ENGINEER 2017
- Similar results were recieved
- Bigger results were used (SAP2000 v19)
- Forces we calculated for most loaded 2D frame coincide with 3D
- Aspiration for as realistic as possible model, used 2 materials (timber, concrete), created concrete core with all its parts (walls and opens)
- Seismic load also included in static calculation (not applicable)
- Whole static calculation followed advisories of EC 1, 2, 3, 5 and 8



COLUMNS

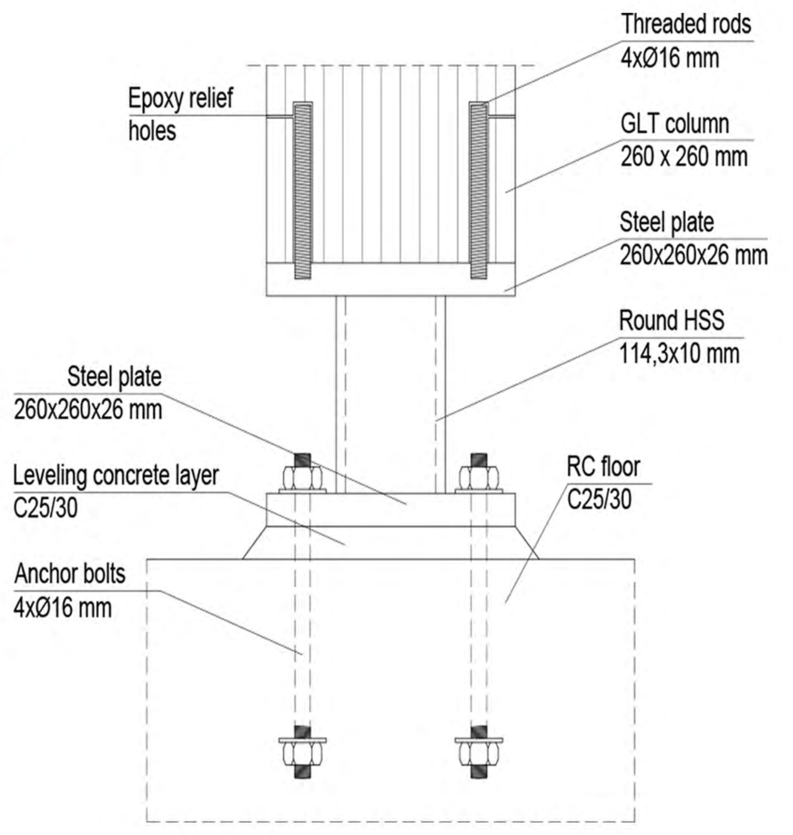
- Max. axial force in timber column 768,0 kN
- Quality of wood (chosen) GL28h
- Dimensions of cross section (chosen) 26x26 cm
- Max. length of buckling 4,0 m
- Usability of chosen cross section 83 %

PLATES

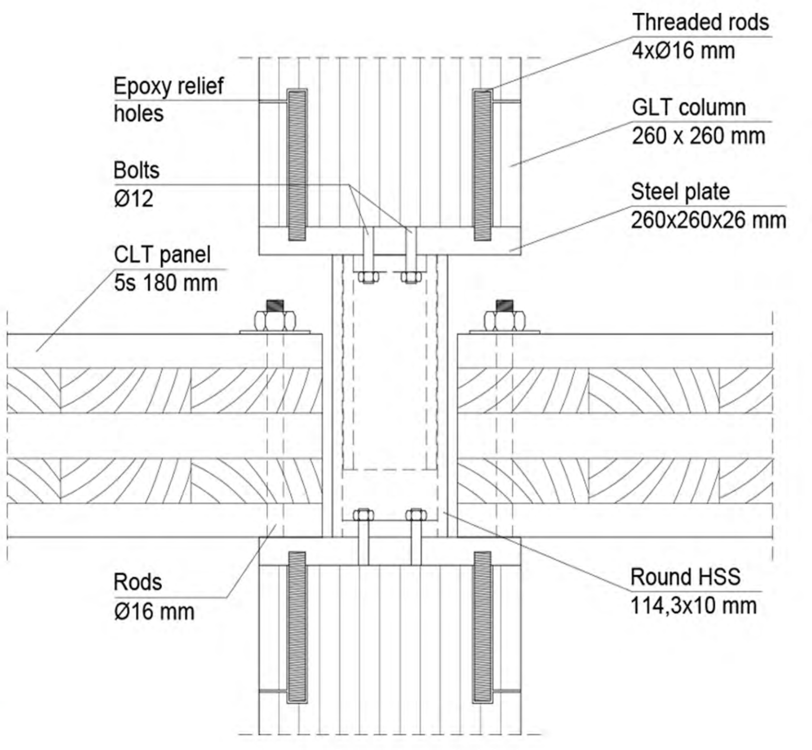
* CLT Designer was used to calculate CLT plates.

- Span in x direction 4,0 m
- Span in y direction 4,0 m
- Thickness of plates 18,0 cm

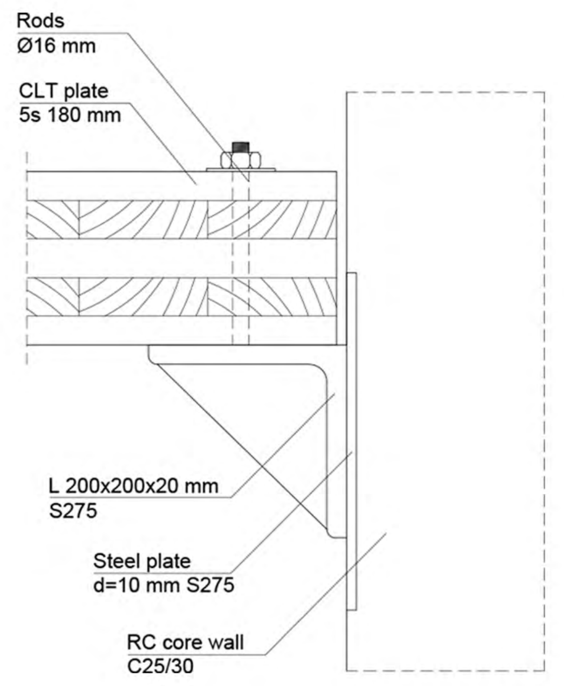
Layer composition
- First layer thick. 30 mm, C24-KLH
- Second layer thick. 40 mm, C24-KLH
- Third layer thick. 40 mm, C24-KLH
- Fourth layer thick. 40 mm, C24-KLH
- Fifth layer thick. 30 mm, C24-KLH



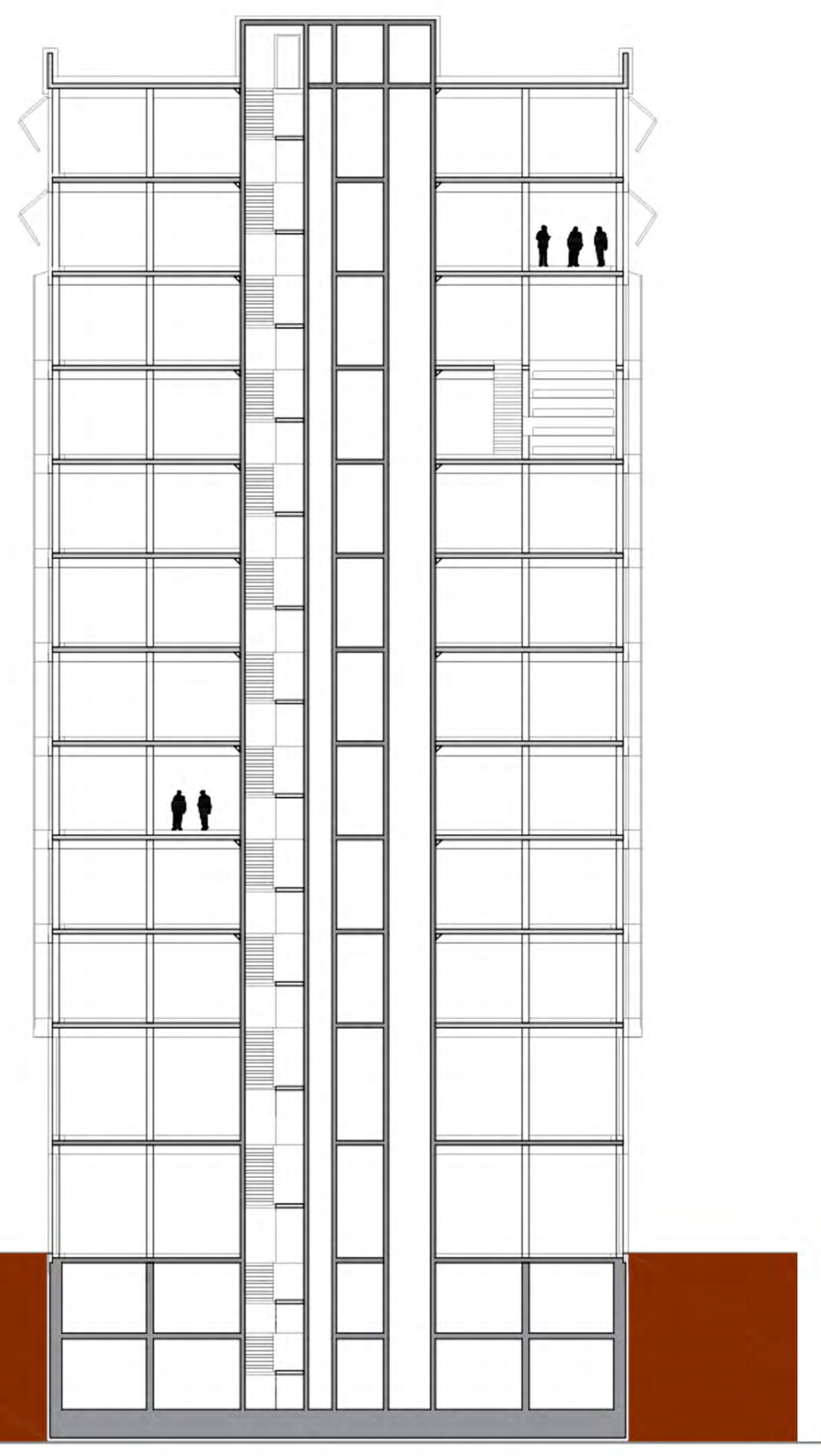
Steel connection- column to column and column to CLT plate- gives very good answers on seismic load



Connection between concrete core and CLT plate- very simple and often used



Facade and section 1:200



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Dina Baranic, Faculty of Architecture, University of Zagreb
Jakov Oreb, Faculty of Civil Engineering, University of Zagreb

OFFICE + RESIDENTIAL BUILDING
Zagreb

SITE PLAN

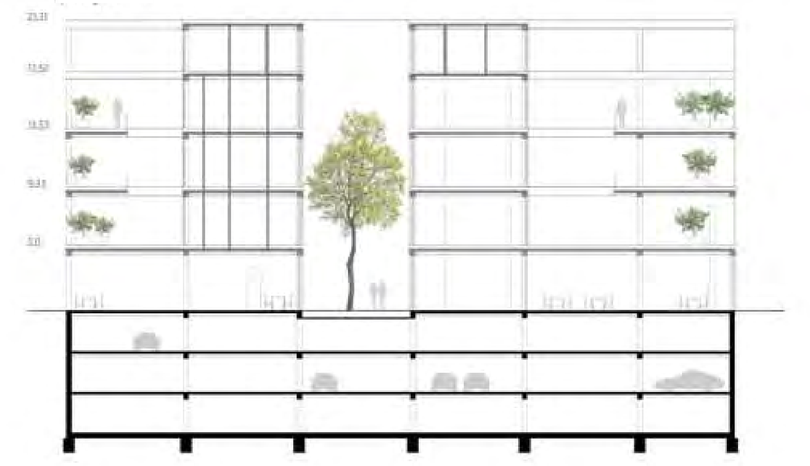
Urban structure of Zagreb - urban blocks - linear forms
-gradation
-connecting diverse parts

CONCEPT

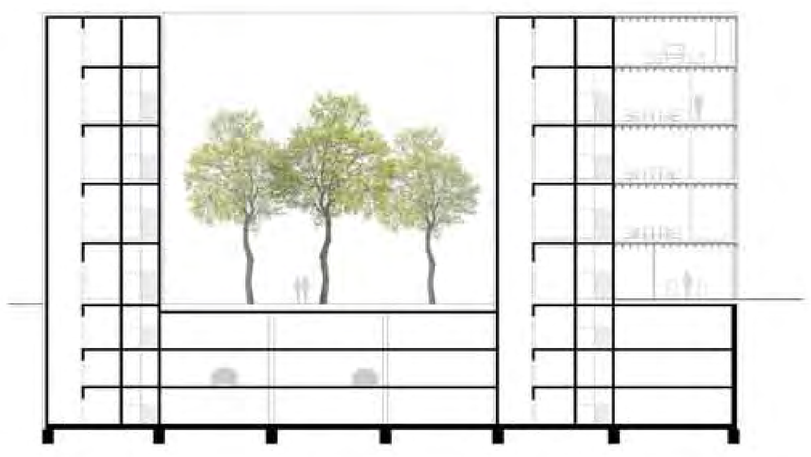
GROUND FLOOR

SECOND FLOOR

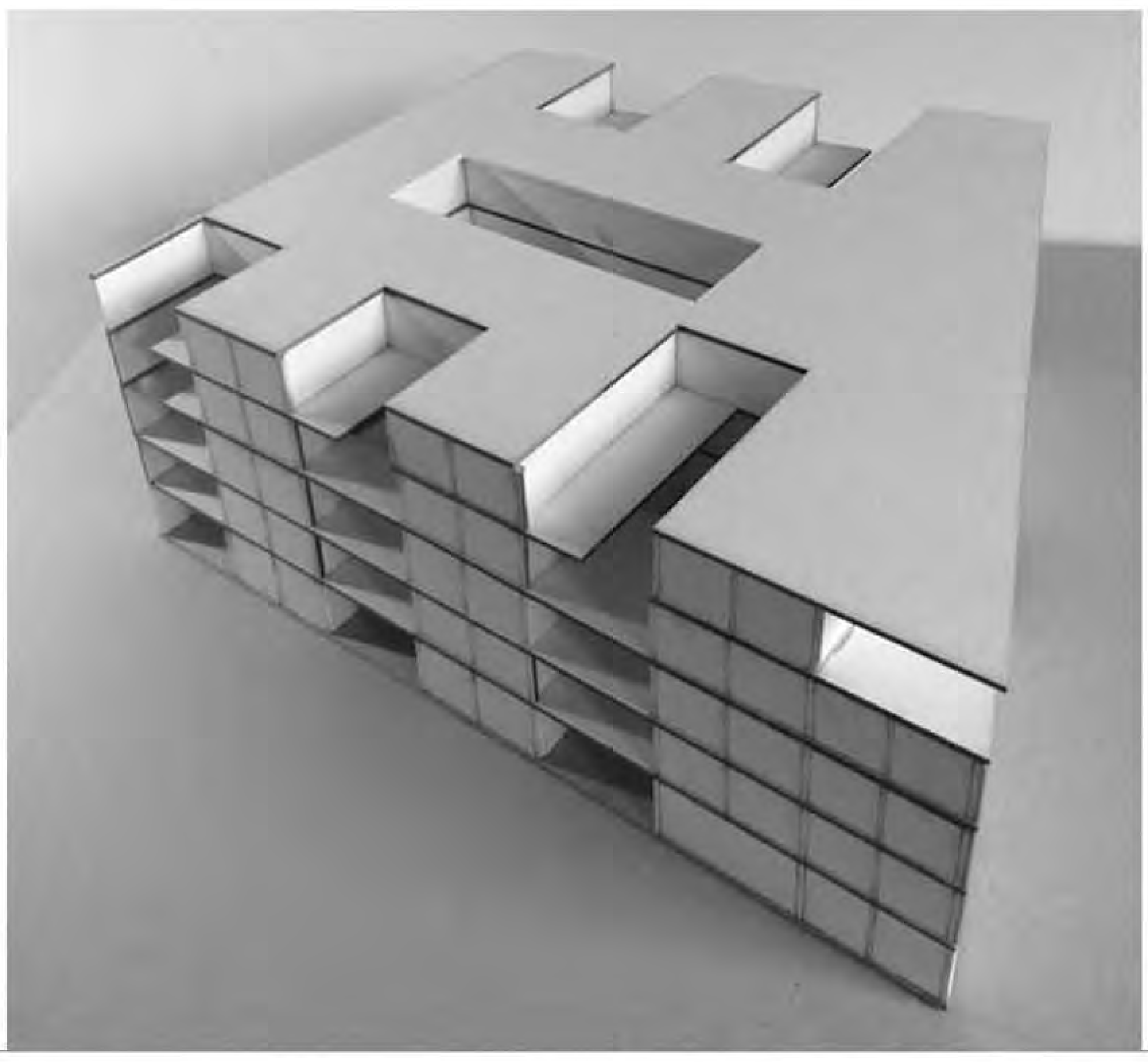
RESIDENTIAL



SECTION 1-1



SECTION 2-2



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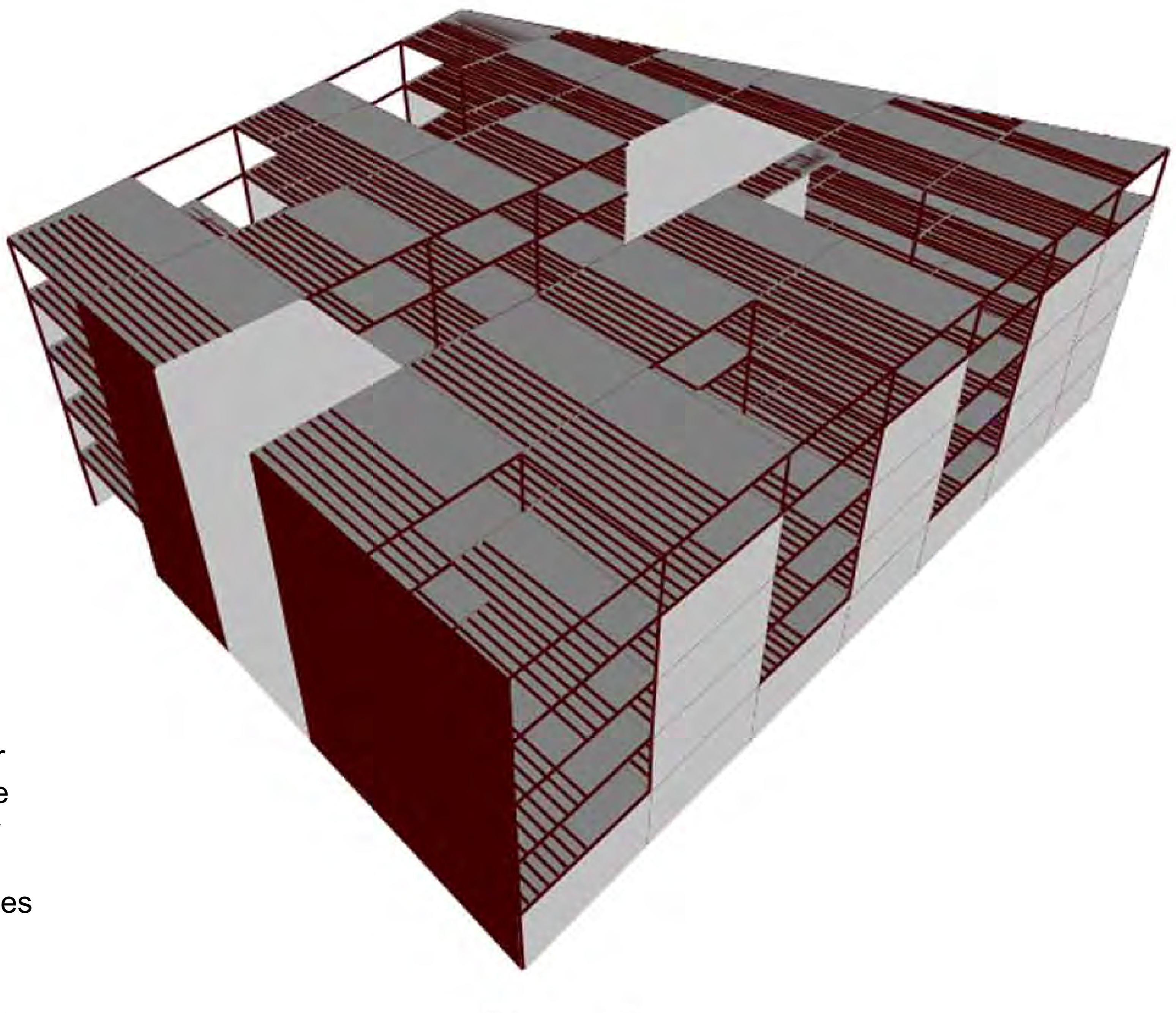
OFFICE + RESIDENTIAL BUILDING
Zagreb



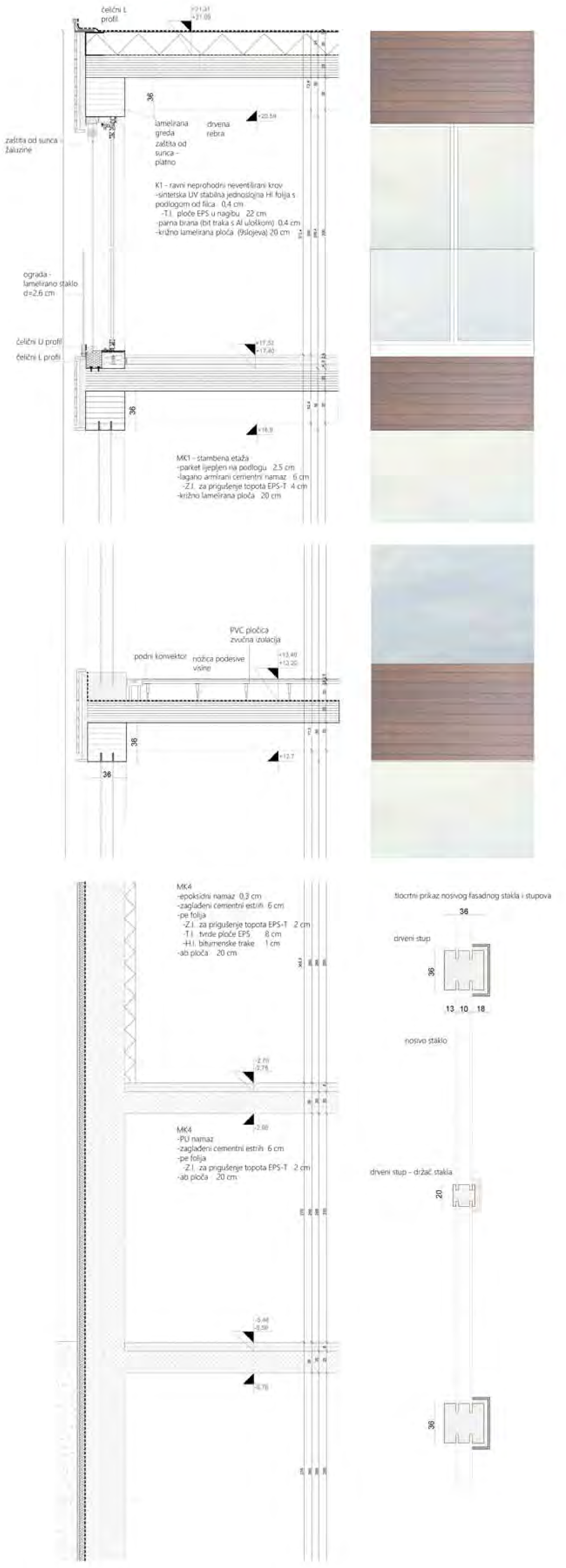
Building is located in Zagreb, Croatia.
All Calculations, including claculation of internal forces, bending moments, and dimensioning of all elements of timber construction has been caried ou in acordance with Eurocode apliying influences of the following loads :

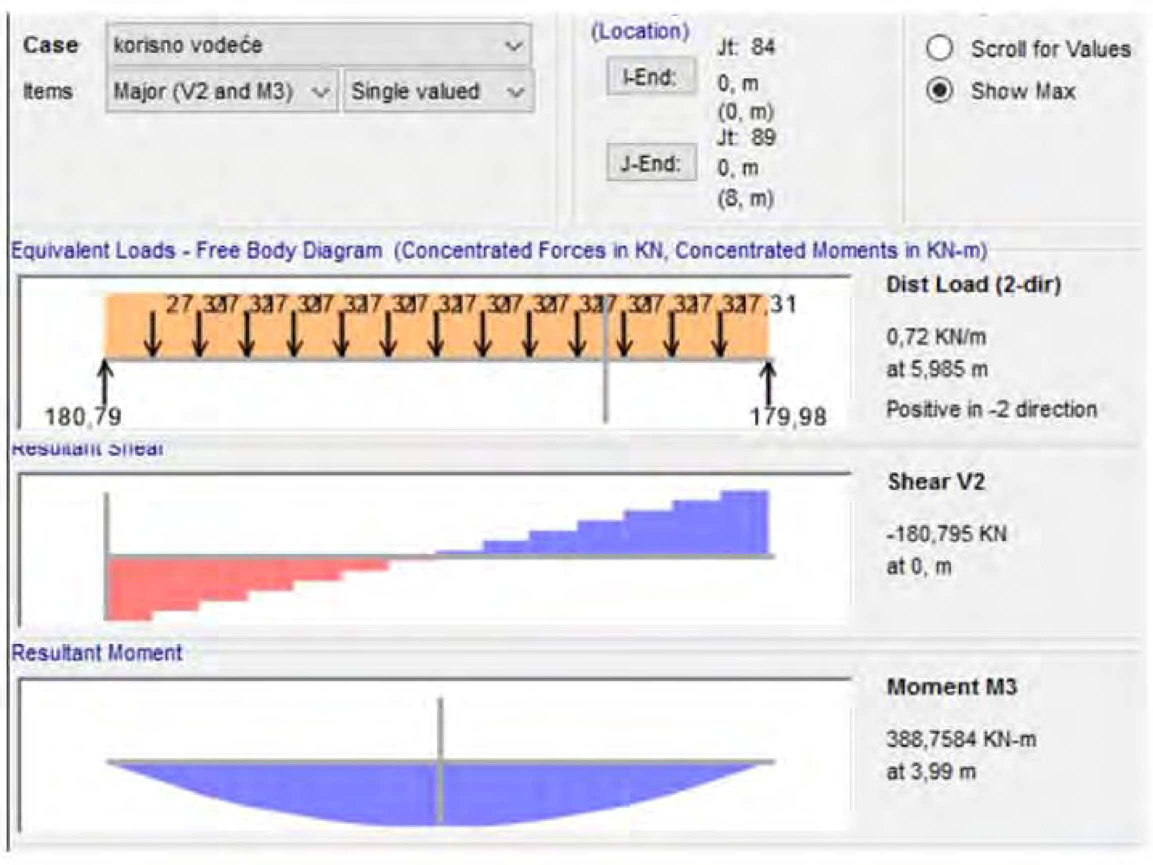
Dead load: self weight of elements,included in static calculations.
Non structural elements and fixed services: electrical equipment, heating, ventilation, ect.
Live loads
Loads caused by environment: snow
Snow estimate model
wind
Load combinations:
ULS
SLS
Seismic design situation

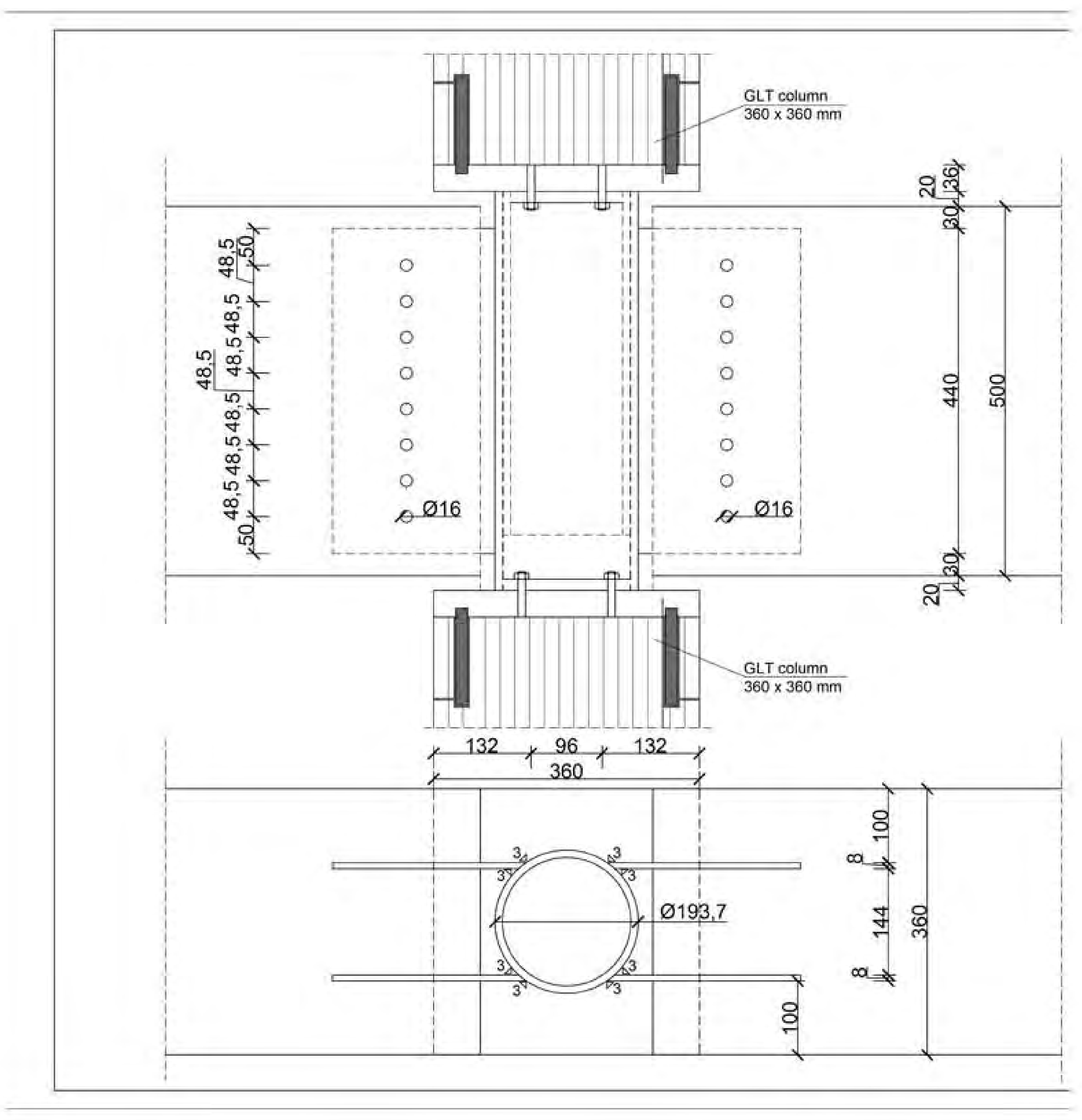
VERTICAL LOAD
Ribbed CLT panels are used as roof system and they transmit the applied loads to their supports, beams, 36/50 cm in the middle of the building and 36/40 cm on the fasade of the building. The beam transfer load horizontally along their length to it s vertical support where the loads are resolved into vertical forces. Column 36/36 cm, as a vertical support member is subjected to compressive load and vertical moment, due to the action of wind and earhquake. As a last member of this load bearing system it finishes the load pass by transferring it to the foundations.

LATERAL LOAD
Horizontal seismic load, as a dominant lateral force, is carried by rigid concrete core (20 cm core thickness) which is placed symmetrically to prevent torsion effects. Approximately 92% of seismic load will be taken by concrete core and 8% will be taken by CLT walls and LLD columns. Load bearing glass will carry the wind load. It will be also used as a frame bracing system . Calculations for ultimate limit state and serviceability limit state have been preformed by „CLT Stora Enso", in order to determine design and material properties for roof panel, and it fulfilled the KHL plates thickness of 200 mm and LLD ribs cross section dimensions 200/300 mm. Full results can be found in the report.
To design the beam and to get it s proper dimensions we had to transfer the uniform plane loads from ribs (ULS combination) into the concentrated load as simply supported beams.
To design them we made tests for bending in the middle and shear at the supports.

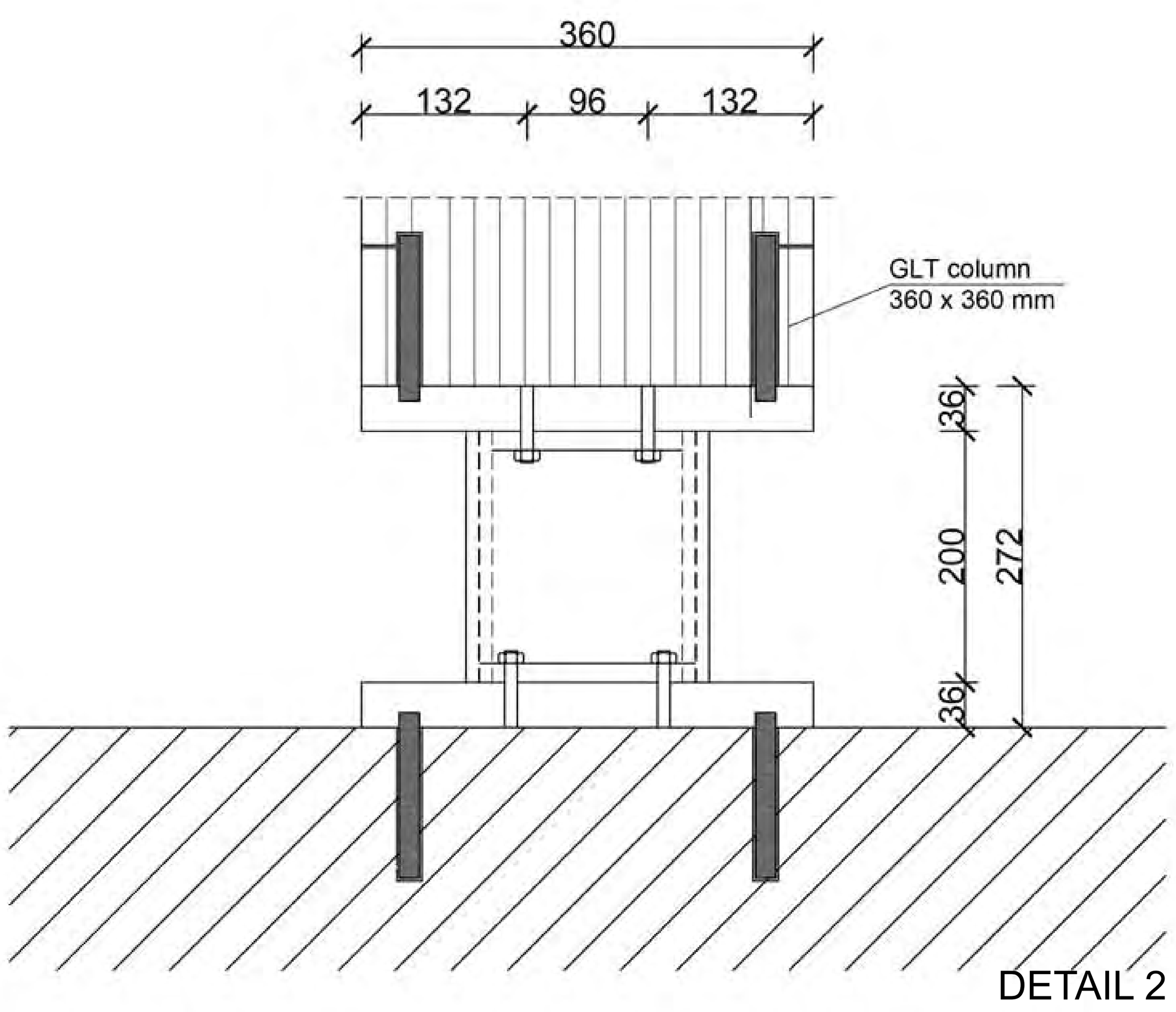
We avoided high compresion stresses for beams (aproximately 13,5 MPa) by carrying out the characteristic manual details of the column extension, and because of the relatively large shear force in the beam, I decided to use a pressed steel sheet with a thickness of 8 mm with the thorns, 16 mm diameter.
The pressed plate will weld to the steel tubes of the column extension joint.







DETAIL 1



DETAIL 2

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pro:Holz
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Antonija Balic, Faculty of Architecture, University of Zagreb
Natali Kolega, Faculty of Civil Engineering, University of Zagreb
Filip Knezevic, Faculty of Civil Engineering, University of Zagreb

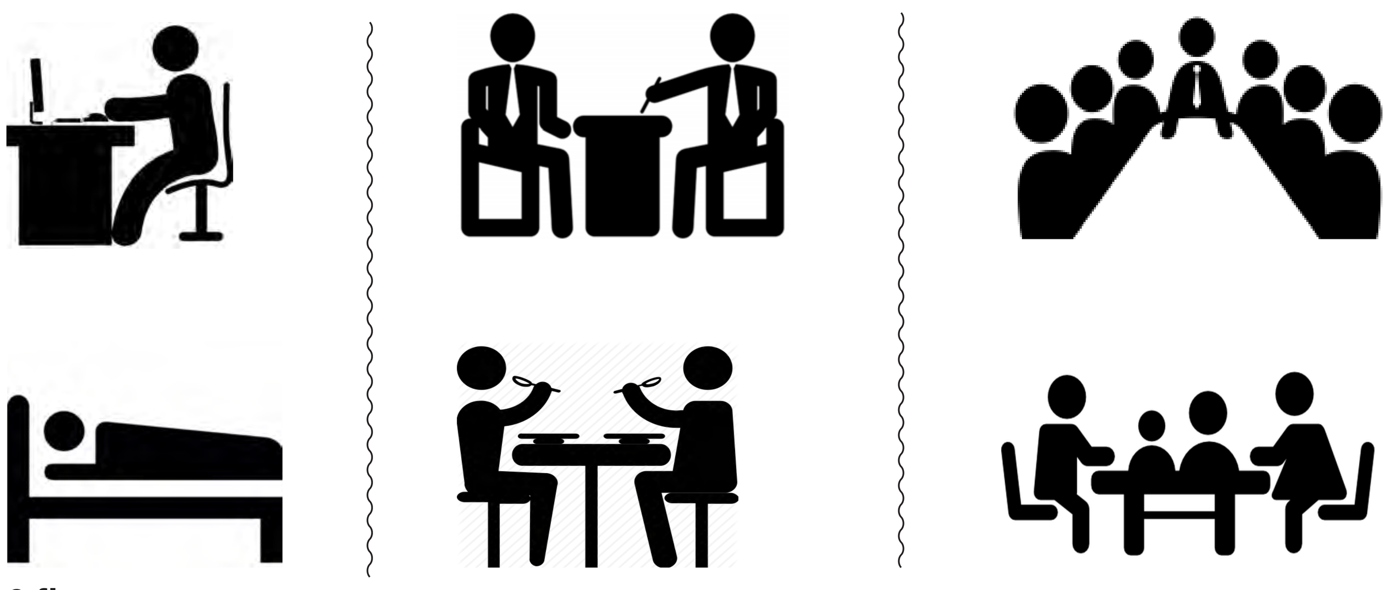
Hybrid building Trešnjevka

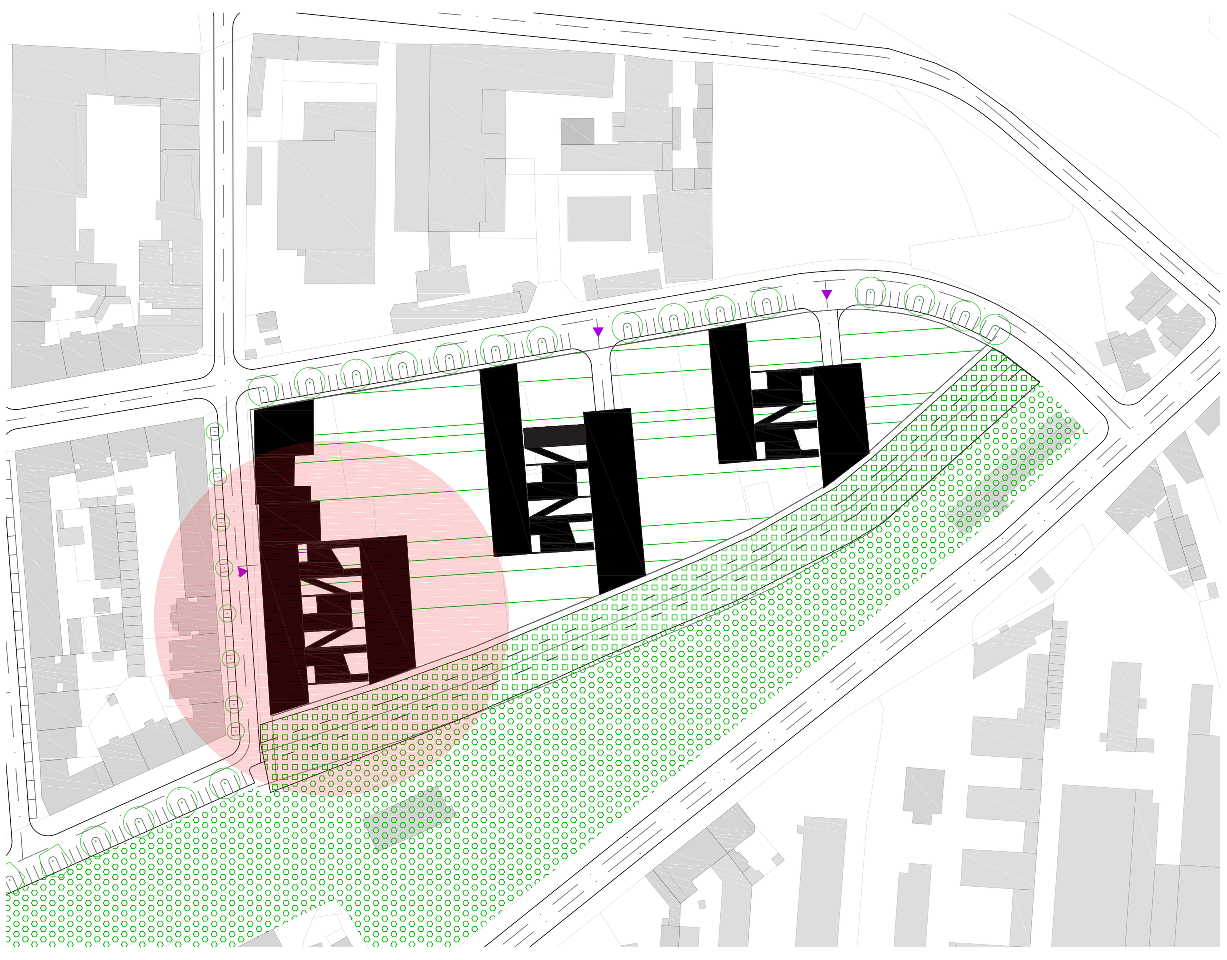
urban concept: fading of an urban block

building concept: co-working + co-living

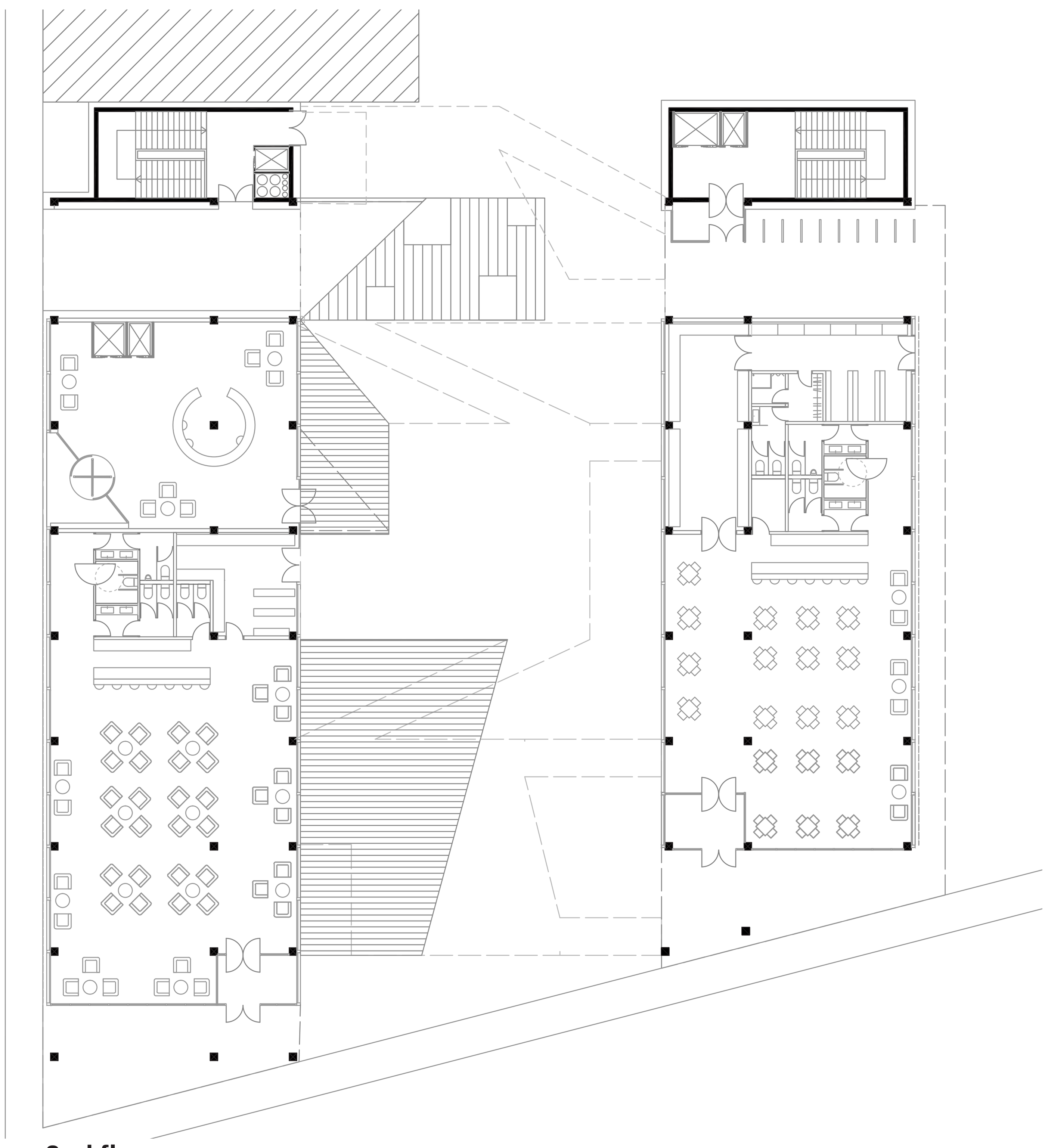
idea: bringing young working and frequently moving people together

way to do: create gradation of private to public zones of living/working

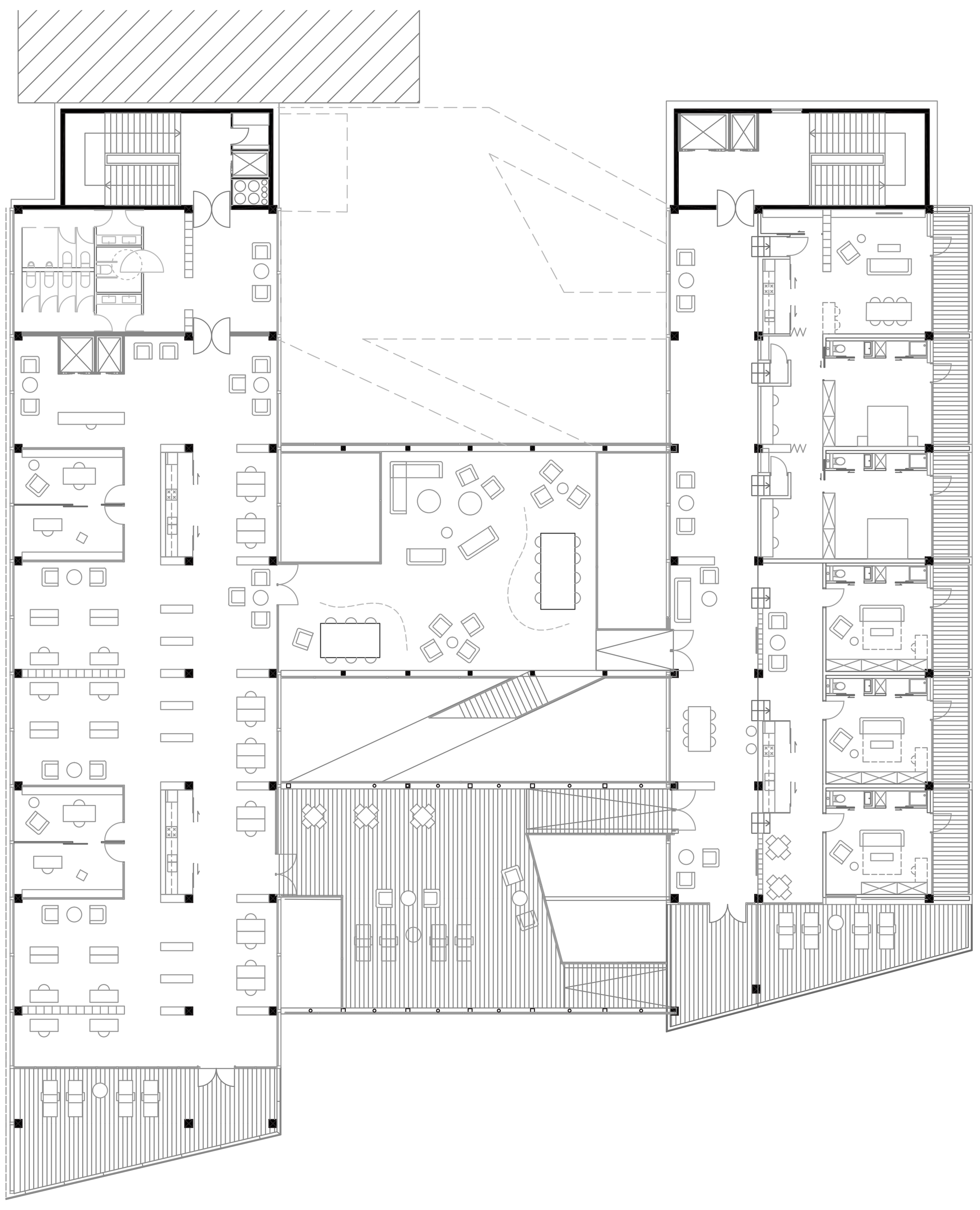




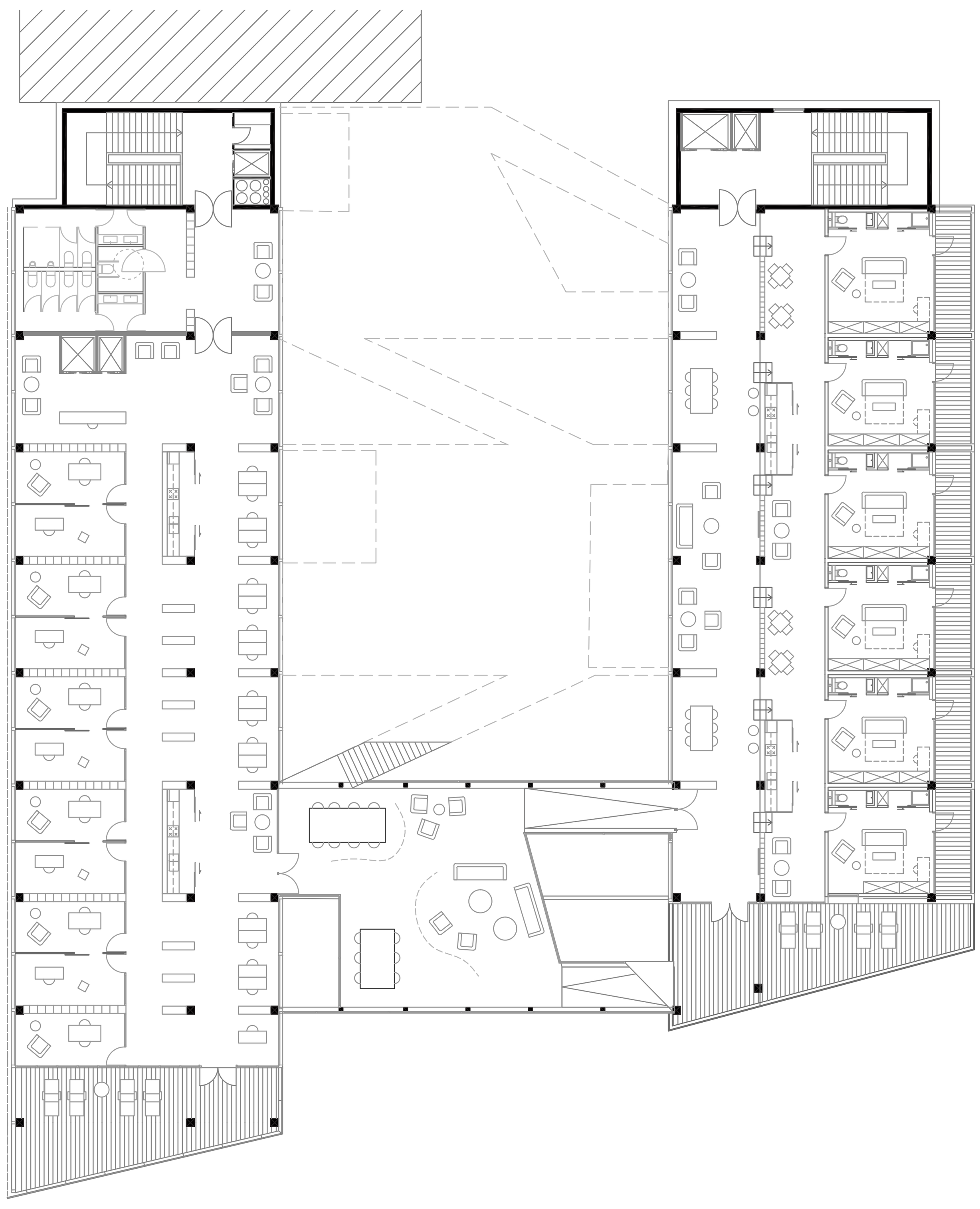
0 floor



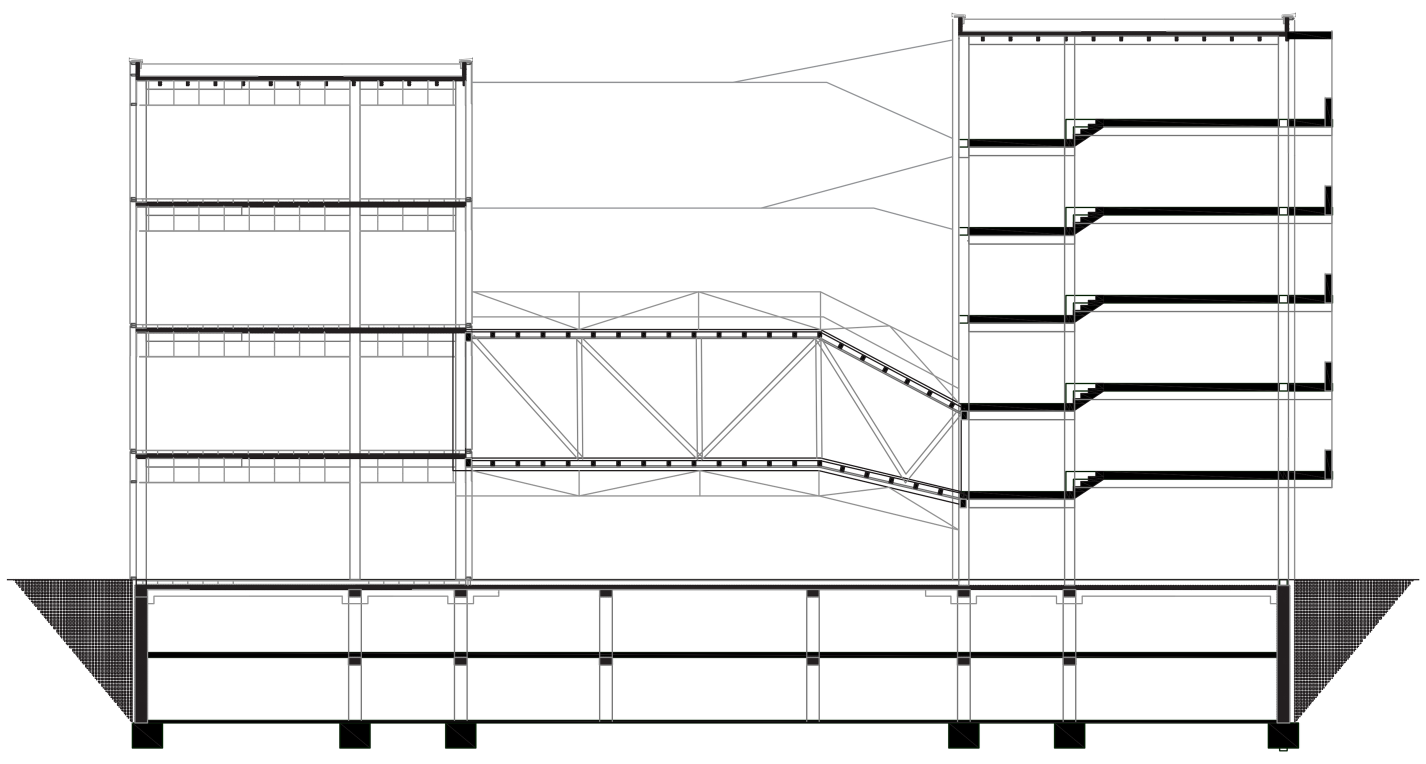
1st floor

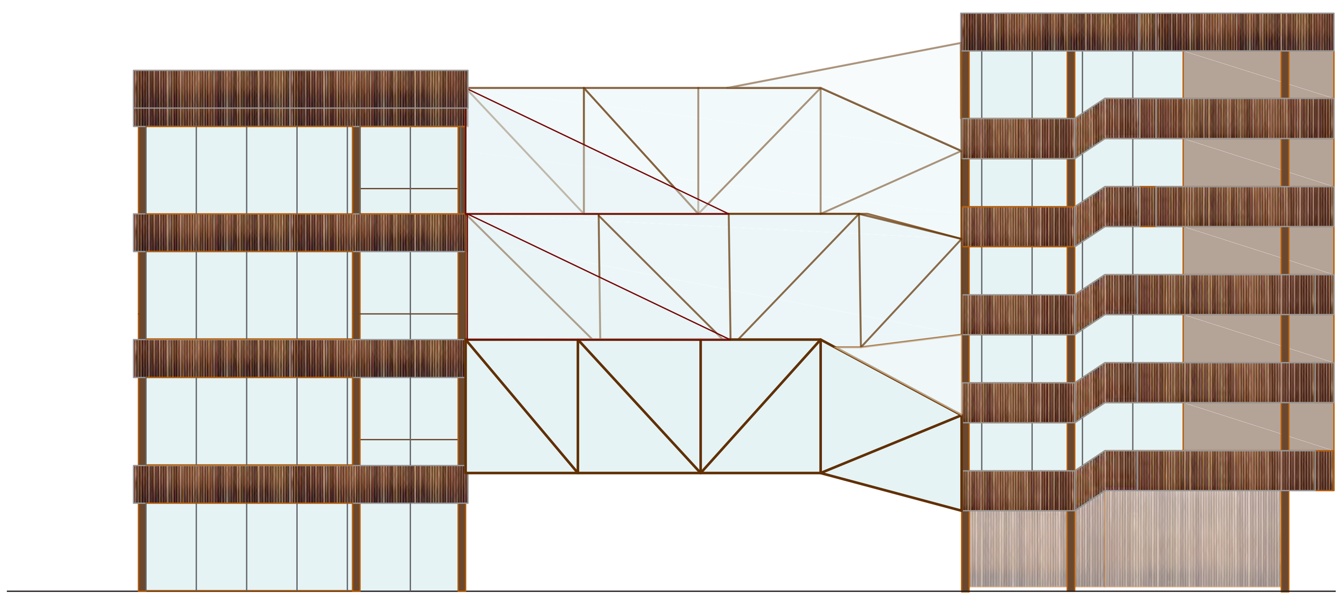


2nd floor

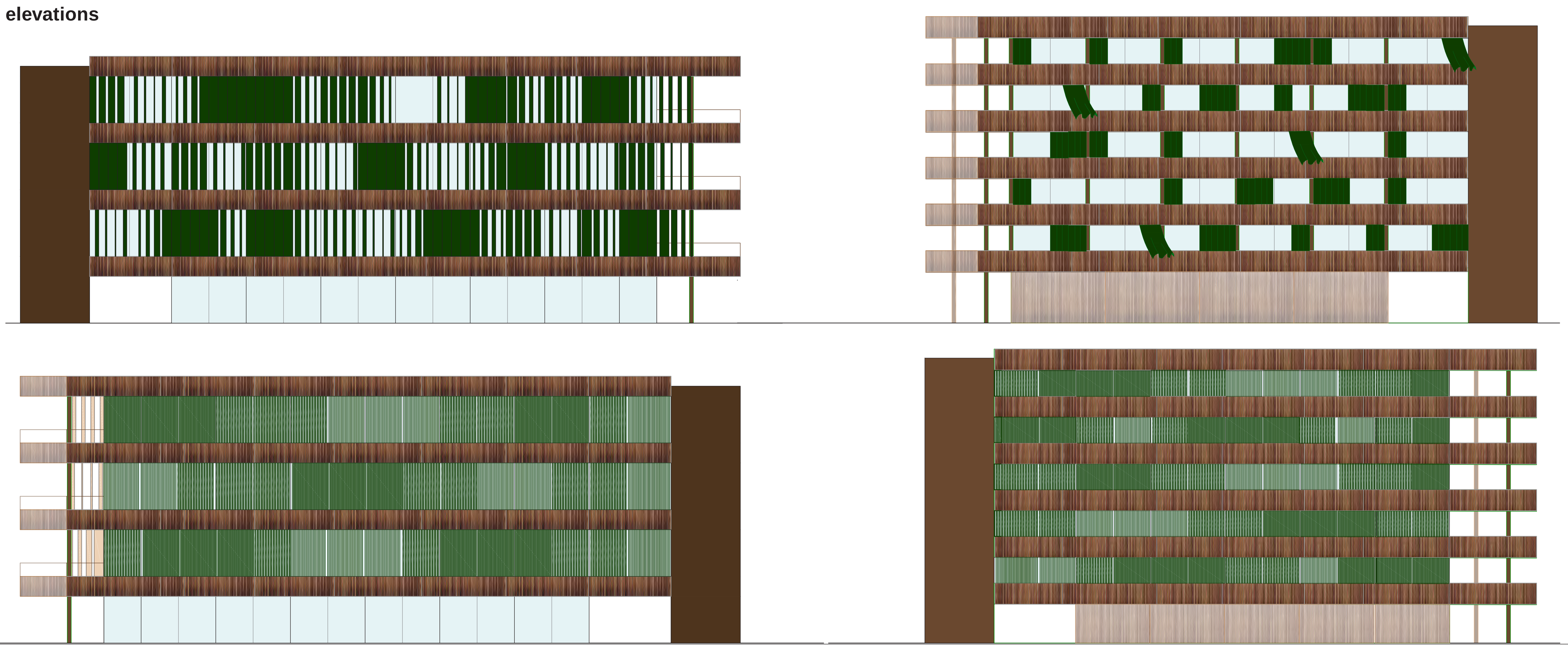


cross section





elevations



Master class

international and interdisciplinary workshop

Densification of the city districts with CLT modular elements

www.wooddays.eu

Students – authors:

Antonija Balić, architecture; Natali Kolega, Filip Knežević, civil engineering

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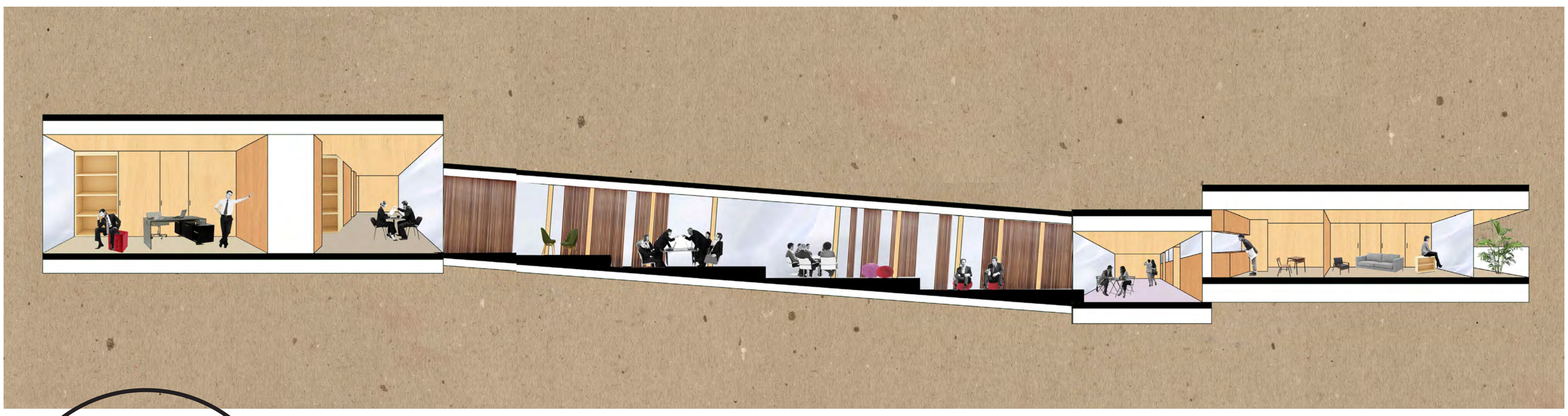
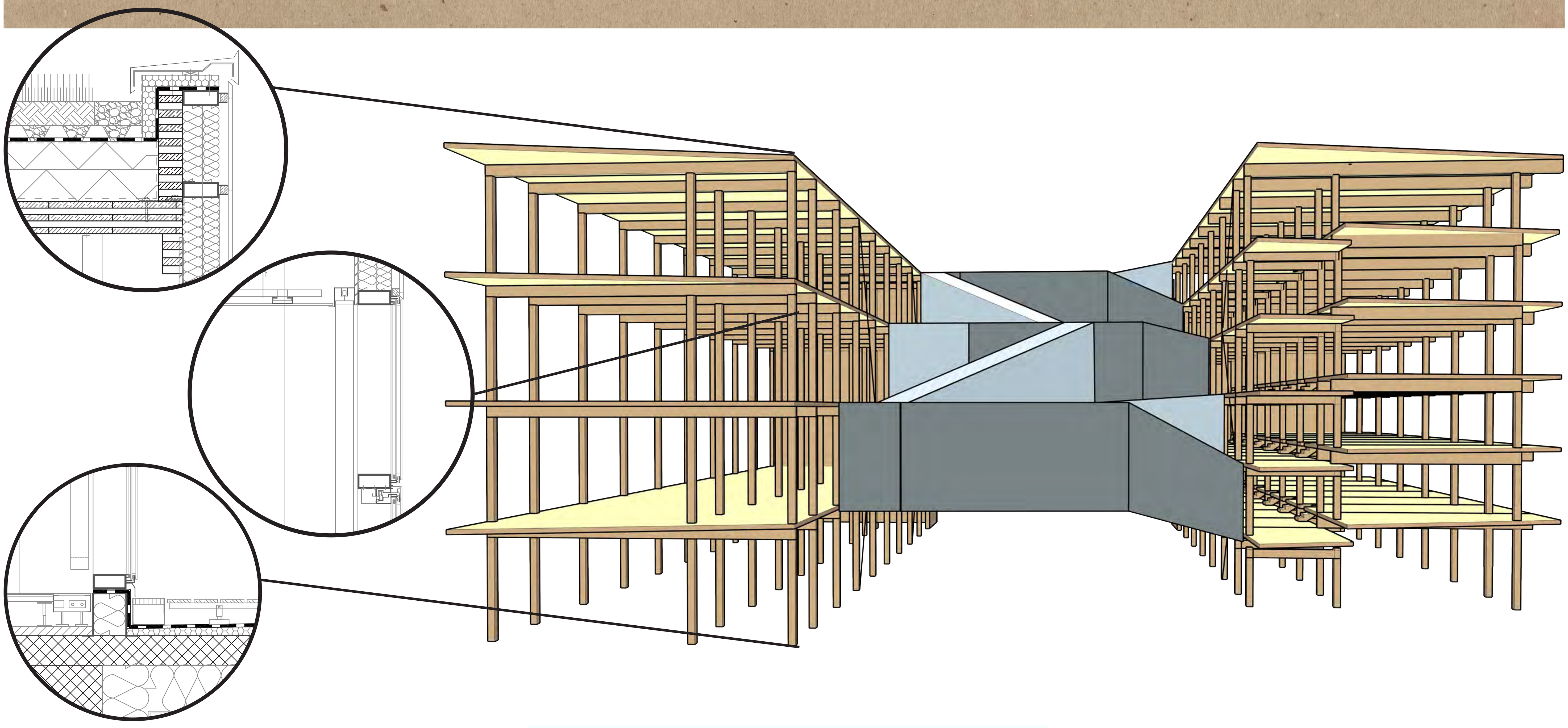




TEHNICAL DATA

<u>Load analyis</u>
Dead Load: self load of elements included by static calculations
Non structural elements and fixed services: heating, ventilating, facade, ect.
Green roof load on top of building and platform load on construcion A and B
Live load: loads inducted by enviroment -snow
- wind

Relevant design situation:
USL: 1,35G+1,5S
SLS:1,0G+1,0S

1. STRUCTURE (A & B)

Construction is made of CLT panels suported by beams which transfer a load action to columns. (Skeletal building system)
Vertical load: CLT panels are used as roof system and they transmit load the aplied load to their suports which are beams. Beams are suported between columns. Beams transfer loads horizontally along their lenth to the suports where the loads are resolved into vertical forces.
Columns as a vertical elemnts are subjected compressive load and internal moment due to wind load, they transfer all the loads into foundation.
Lateral load: the floor (CLT elements) ,the bracings and the CLT walls transfer lateral load over columns into foundations.

Calculations for Ultimate limit state and Serviceability limit state runne by Stora Enso in order to define design and material properties for roof pannel.
The roof plate, thickness 160mm with ribbs 100x200mm/100cm.
The ceiling plate, thickness 180mm. Full resoults can be found in the report.

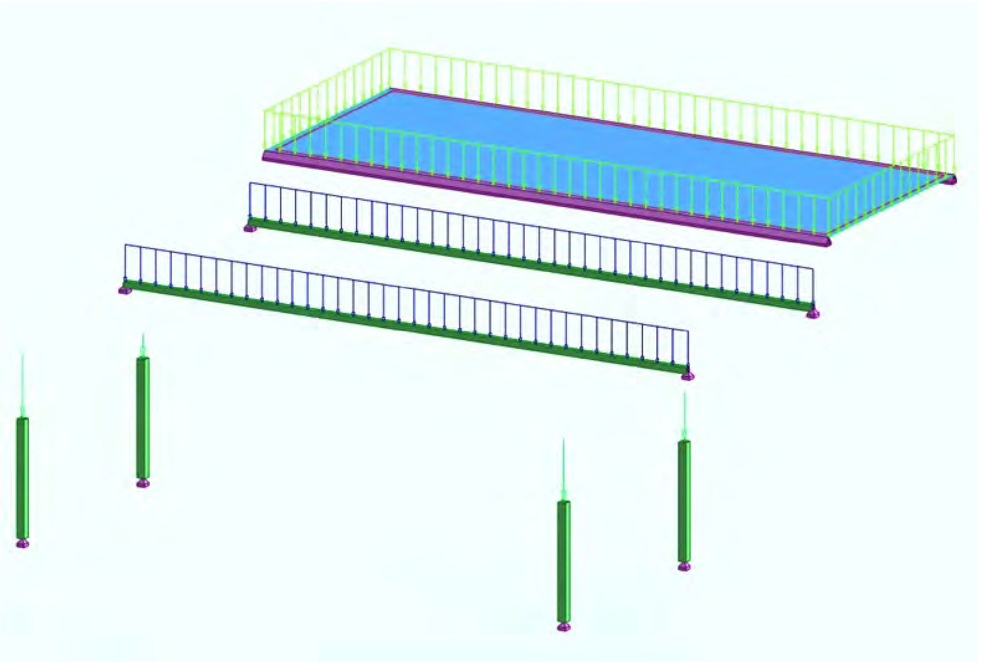
To design the beams all the loads from the plates should be transfer equally to the simply supported beams as plate's supports (USL combination).
Tests:
-Shear $\tau_{v,d} \leq k_v \cdot f_{v,d}$
-Lateral buckling $\sigma_{m,y,d} \leq k_{crit,y} \cdot f_{m,y,d}$
-Longitudinal pressure buckling $\sigma_{c,0,d} < k_{c,y} \cdot f_{c,0,d}$
-Interaction of Lateral buckling & Longitudinal pressure buckling $\frac{\sigma_{c,0,d}}{k_{c,y} \cdot f_{c,0,d}} + \frac{\sigma_{m,y,d}}{k_{crit} \cdot f_{m,y,d}} \leq 1$

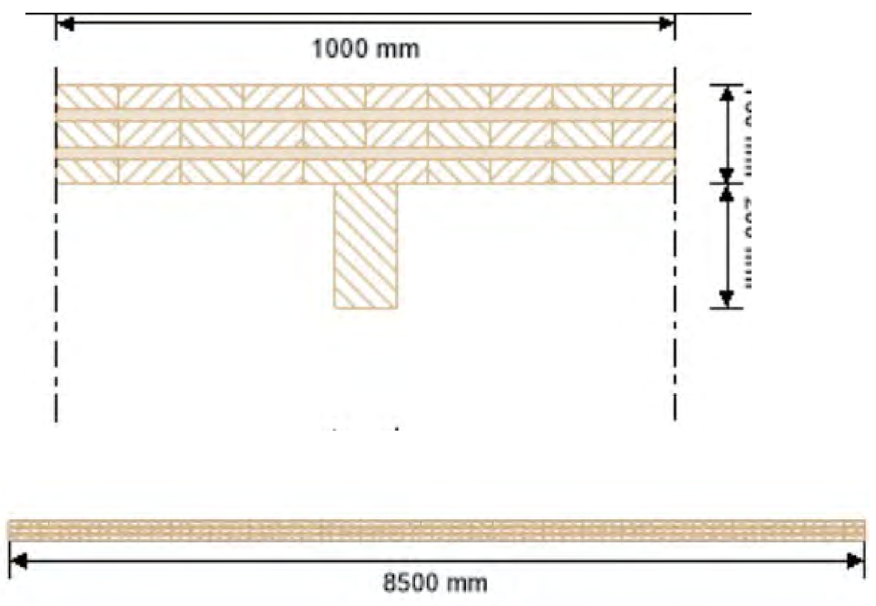
Test for columns design were:
-Longitudinal pressure buckling
$\sigma_{c,0,d} < k_{c,y} \cdot f_{c,0,d}$

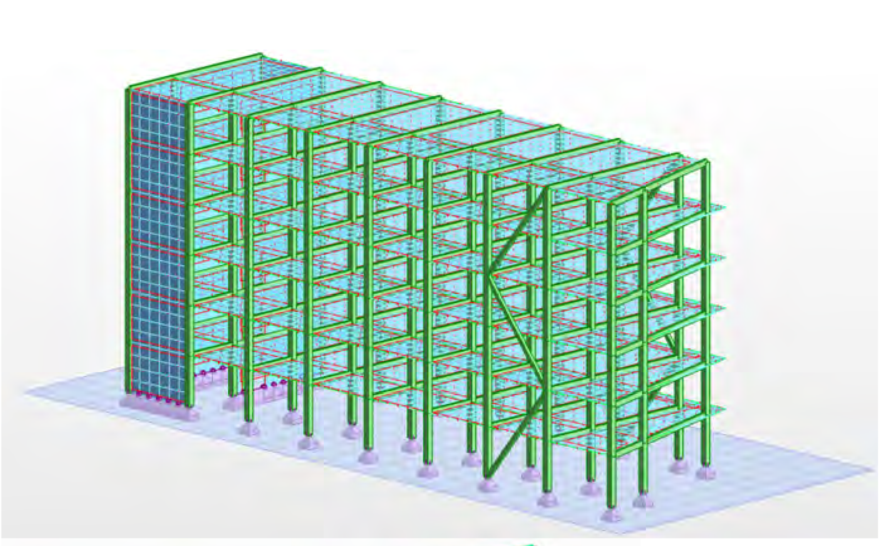
The construction is designed in ROBOT Autodesk as a 3D Model.

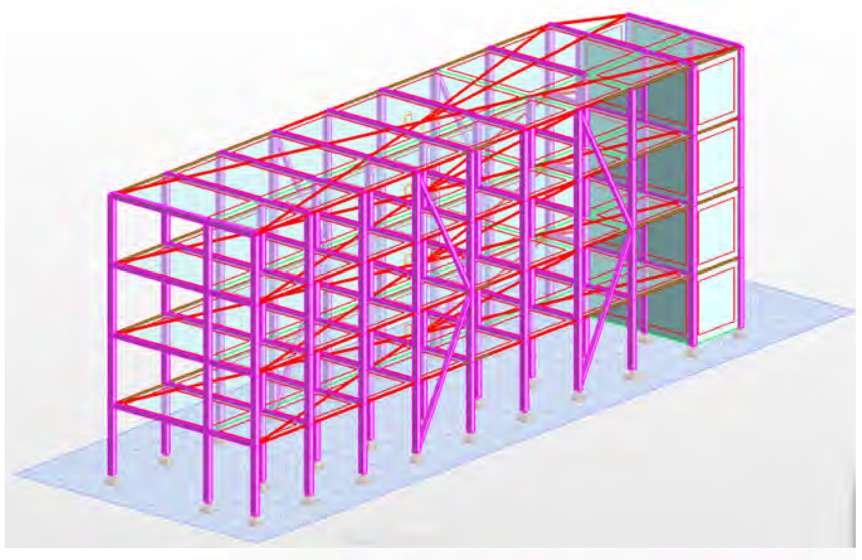
2. STRUCTURE (C)

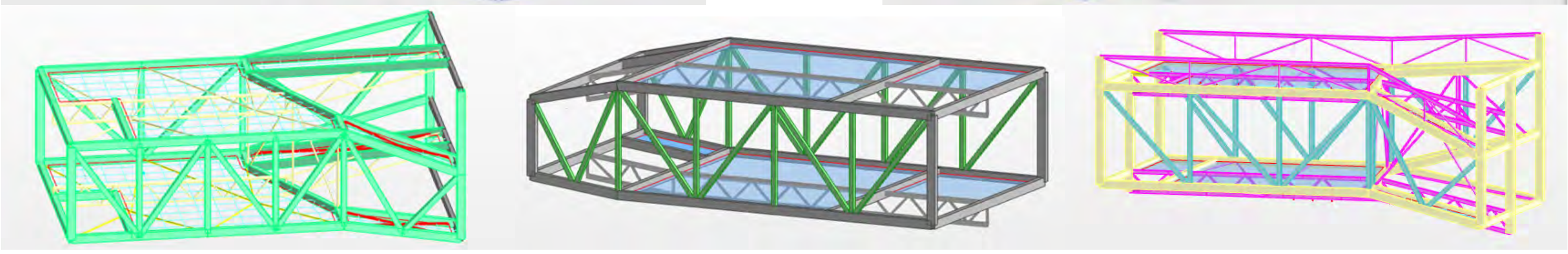
C structure is platform made of steel and timber elements forming grid.
Main longitudinal elements are 5m high timber grid on sides (two elemnts 11,2m devided) and in the middle of them, under the floor panel with ribbs there is another longitudinal steel grid 0,8m high.
Vertical load is transfered from the panel on the main grid, and then over the grid's elements to the supports where the platform is conected to the main construction. In order to enable the conection between steel grid and main

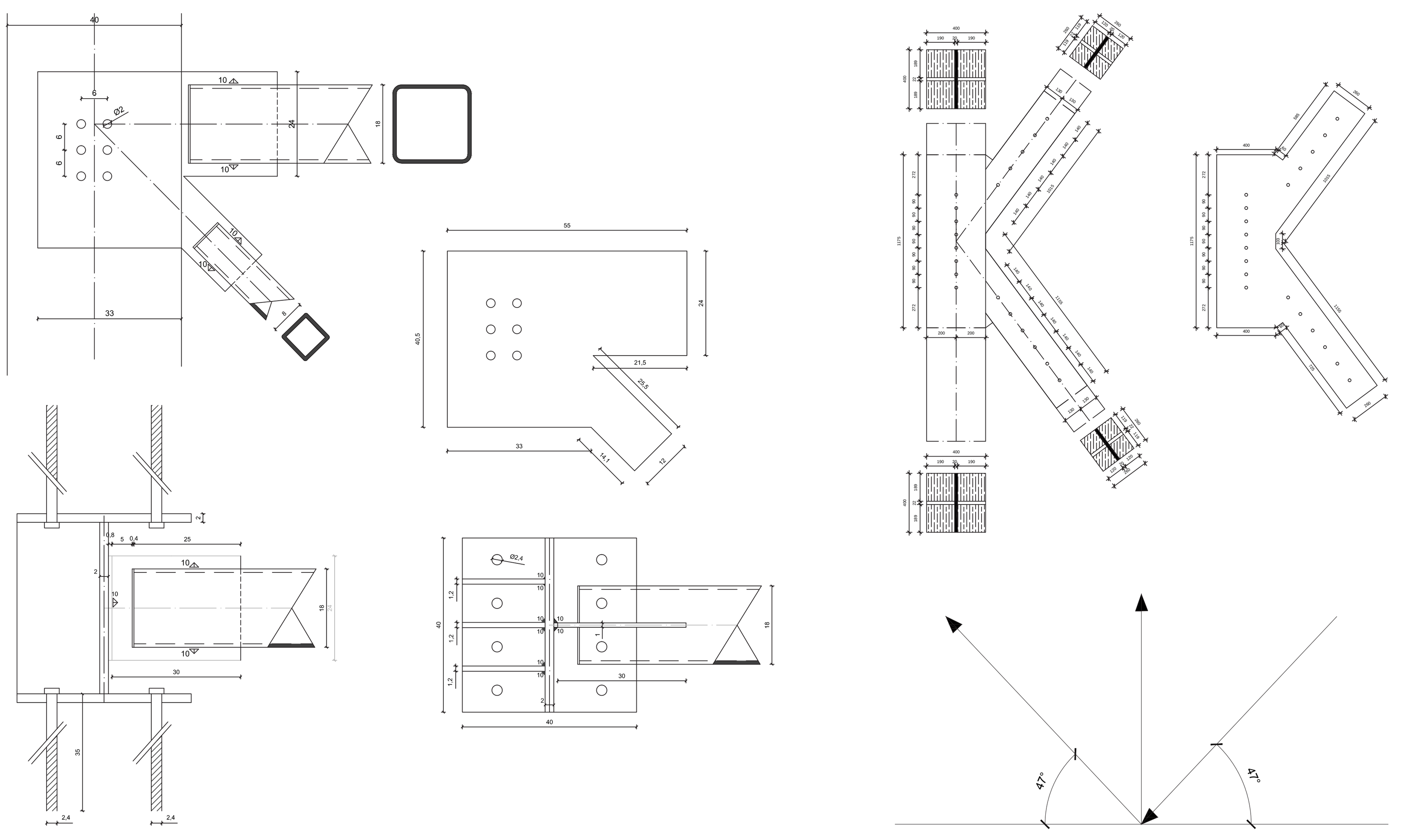


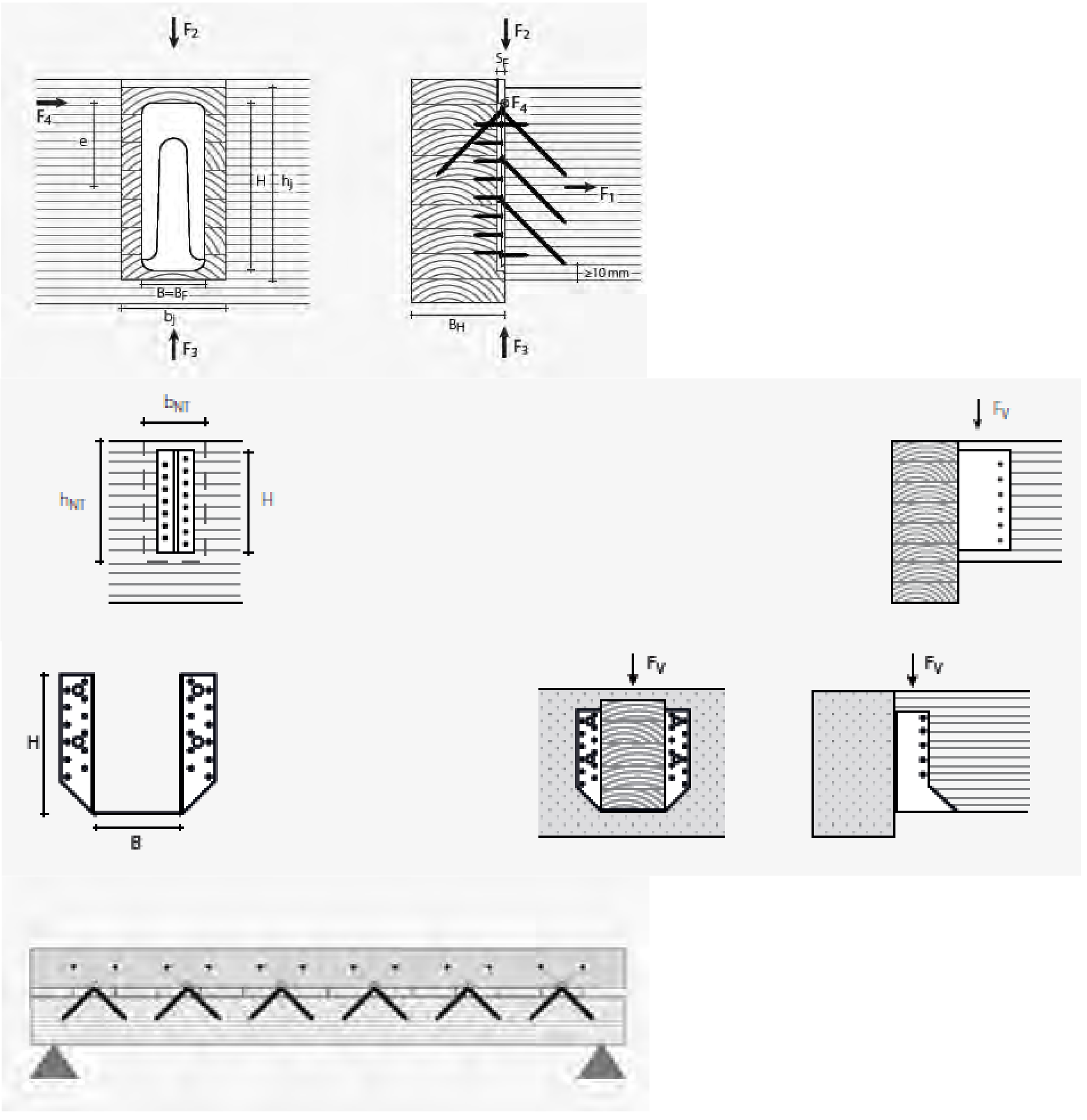


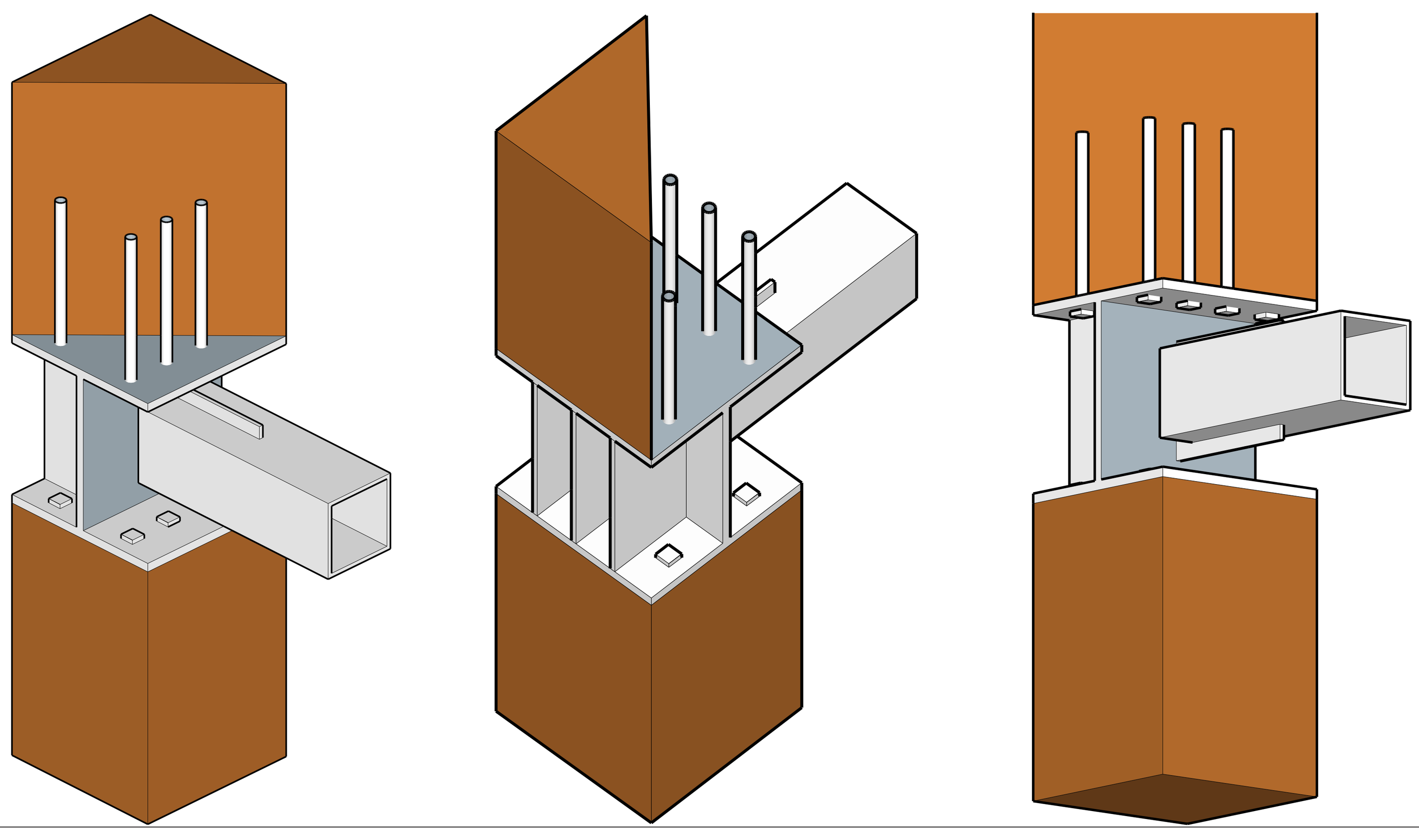


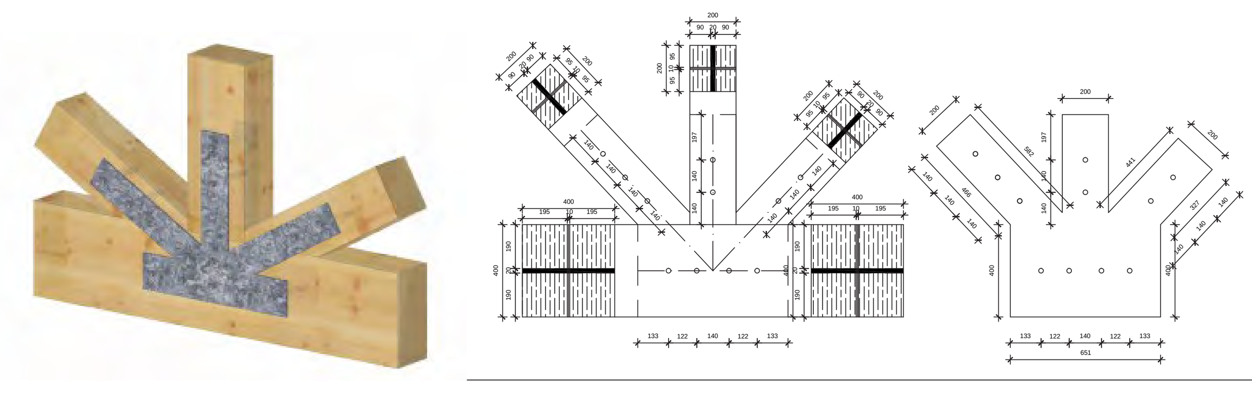












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