Architecture & Engineering: 1 Million Homes

UNIVERSAL MODULAR BUILDING

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Tutors

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Two fundamental challenges in the built environment



1. There is a large and long lasting need for new homes.

- In the Netherlands, we need **1.000.000 new homes by 2030.**

- Globally, we need **2.000.000.000 new homes by 2100.**



2. There is a drastic and urgent need for reduced pollution from the building industry.

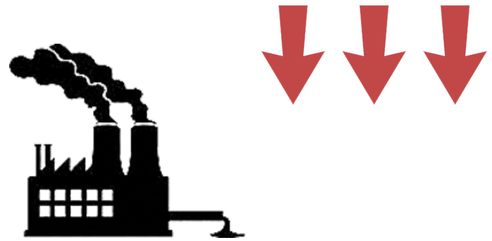
- The building industry currently causes around 50% of man-made climate change.[1]

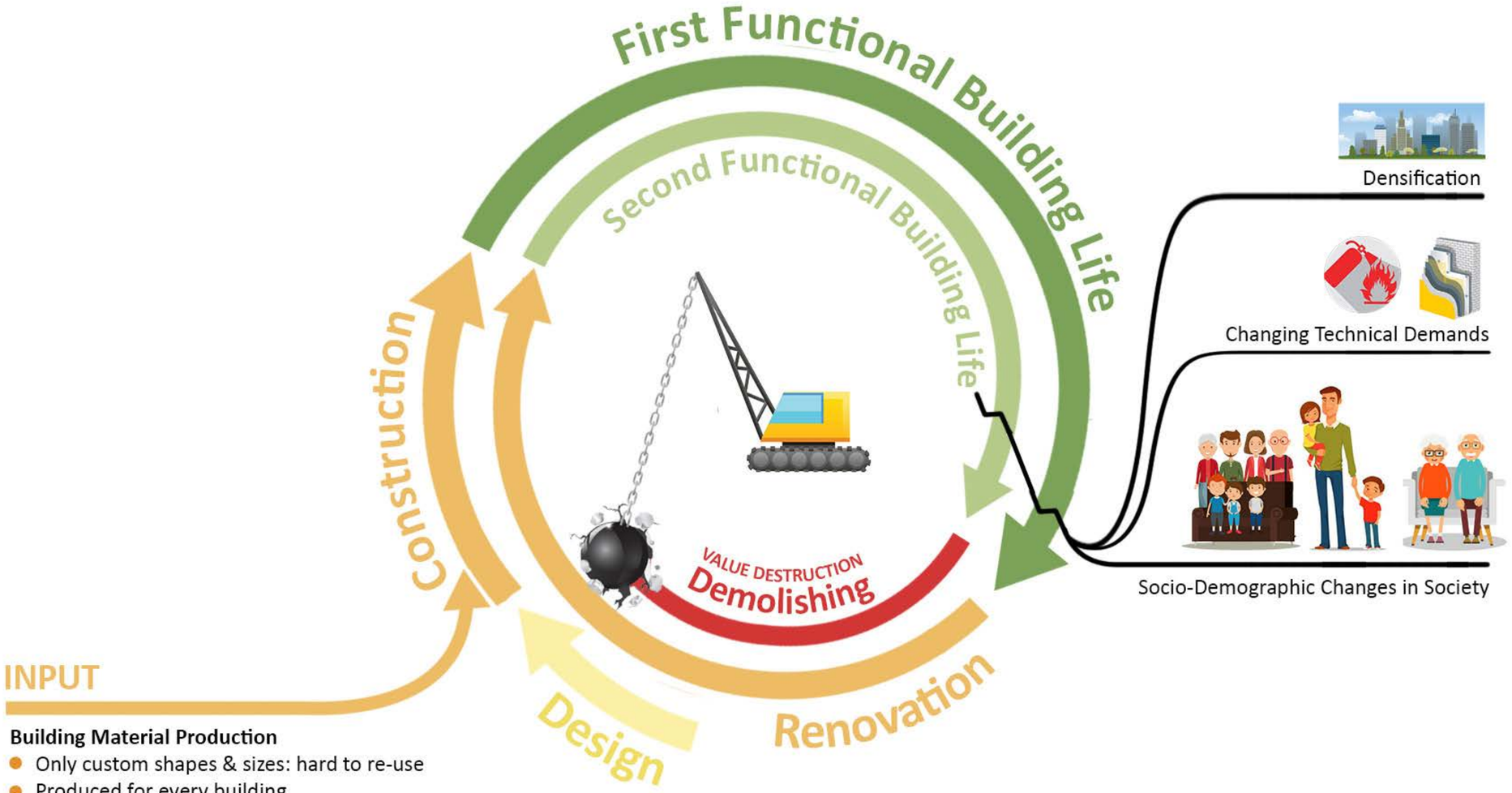
- Concrete and steel production together are responsible for 15% of global anthropogenic CO2 emissions.[2]

1 **https://www.worldgbc.org/sites/default/files/UNEP%20188_GABC_en%20%28web%29.pdfttt**

2 https://www.researchgate.net/publication/302061863_Long-term_model-based_projections_of_energy_use_and_CO2_emissions_from_the_global_steel_and_cement_industries






First Functional Building Life
Second Functional Building Life
Construction
Design
Renovation
VALUE DESTRUCTION
Demolishing
Densification
Changing Technical Demands
Socio-Demographic Changes in Society
INPUT
Building Material Production
Only custom shapes & sizes: hard to re-use
Produced for every building
Polluting materials chosen for economic reasons
Non-adaptable

Opportunity 1: Engineered Wood

CLT



Glu-lam



LVL

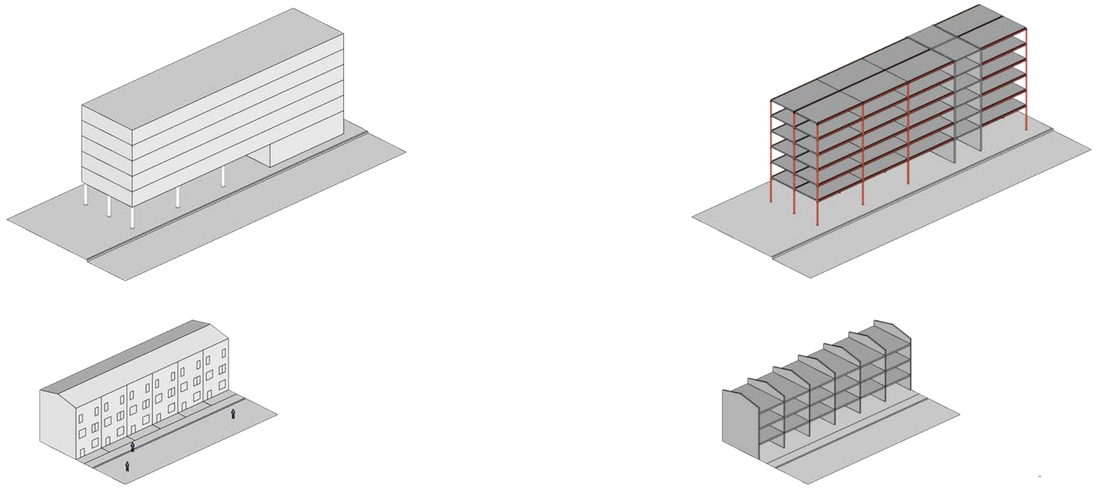


- Strong & Lightweight

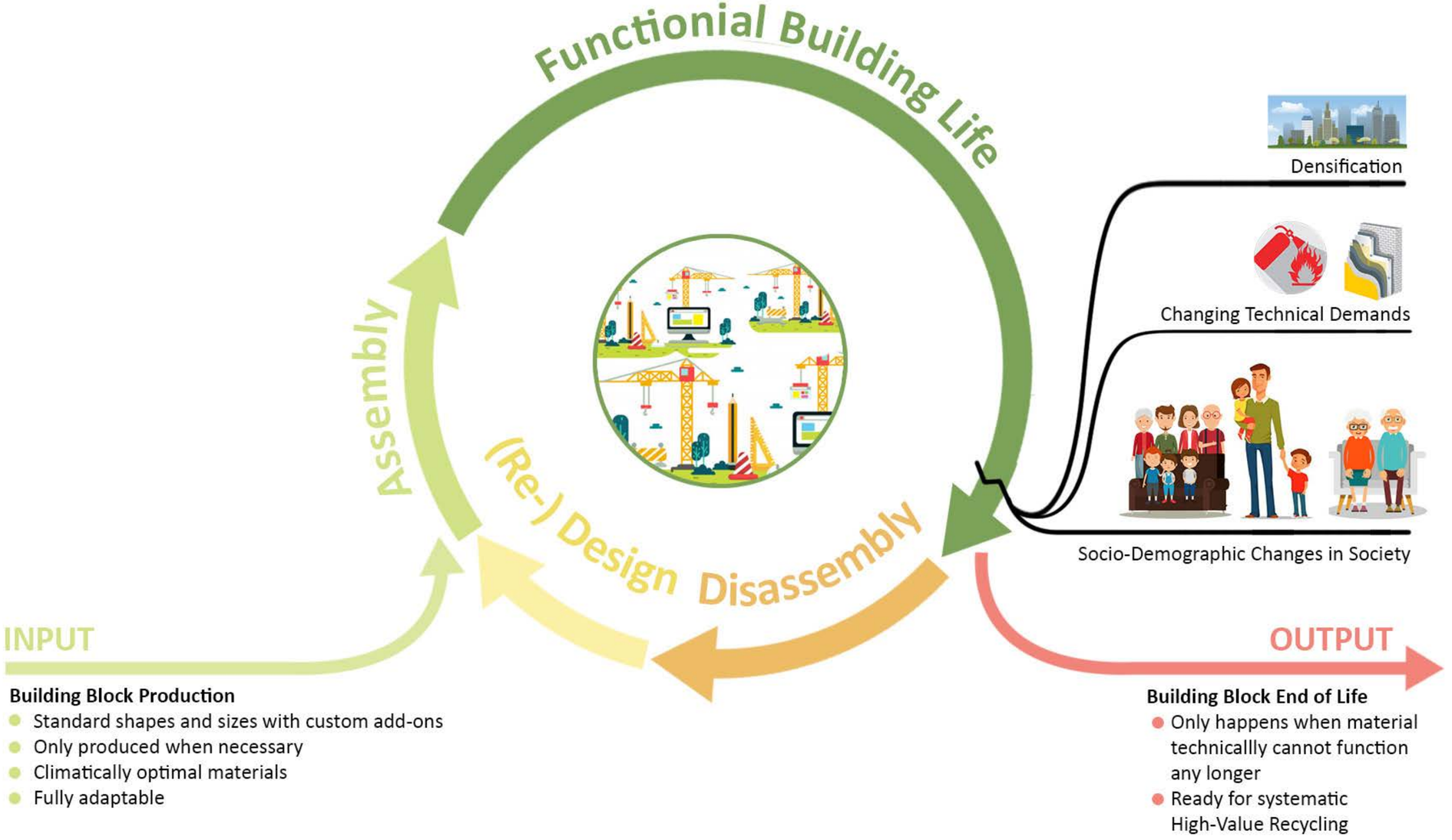
- Climate-friendly production (low emissions & wood absorbs CO^2 during growth

- High workability (CnC milling, high precision, automated production)

Opportunity 2: ‘Low-hanging fruit’

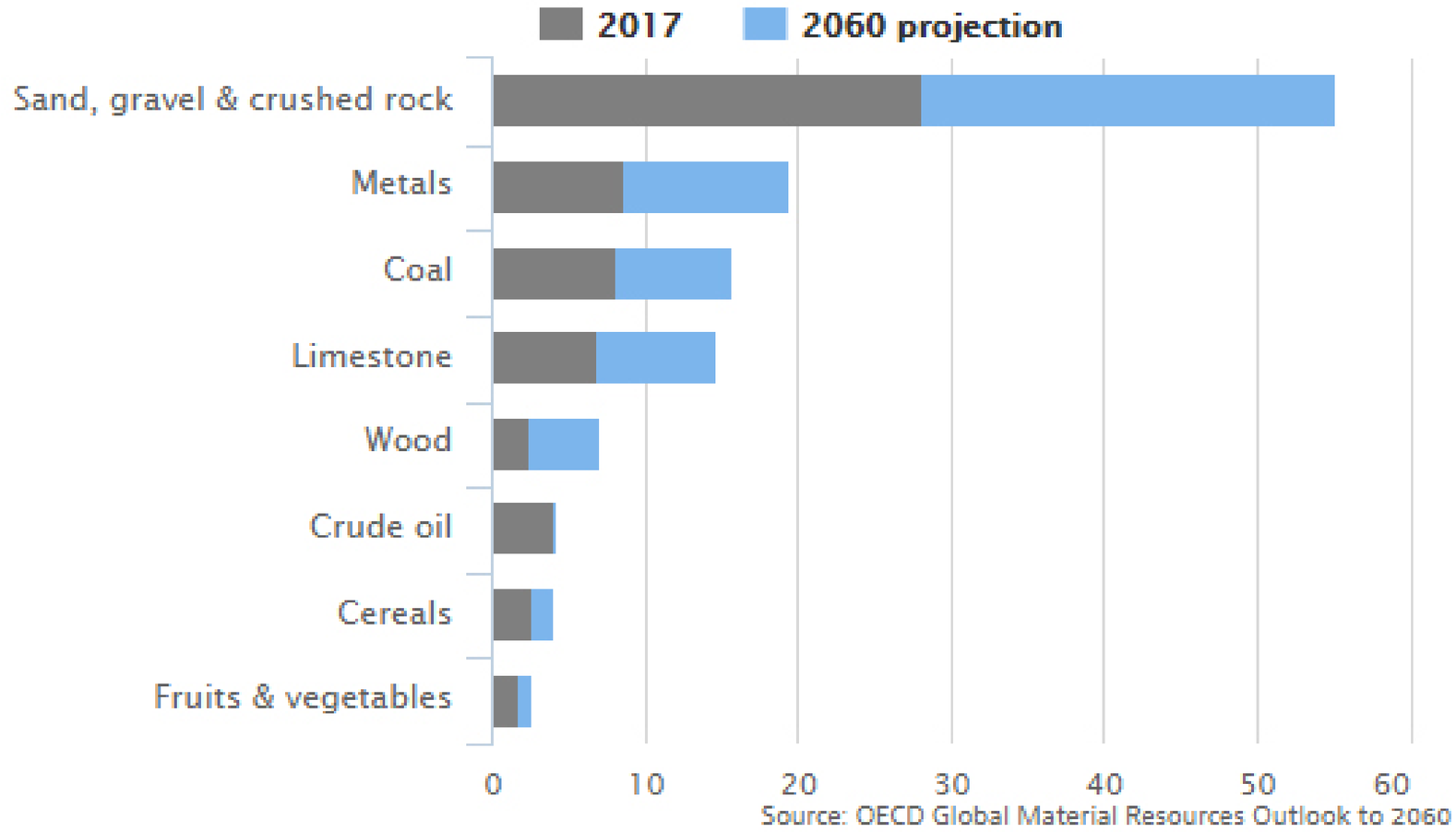


Most buildings we make have very simple structures that could easily be made out of a system of some kind.


Functional Building Life
Assembly
(Re-) Design
Disassembly
Densification
Changing Technical Demands
Socio-Demographic Changes in Society
INPUT
Building Block Production
Standard shapes and sizes with custom add-ons
Only produced when necessary
Climatically optimal materials
Fully adaptable
OUTPUT
Building Block End of Life
Only happens when material technicallly cannot function any longer
Ready for systematic High-Value Recycling

Construction materials dominate resource consumption

Consumption in gigatonnes



Source: OECD Global Material Resources Outlook to 2060

The Design Assignment

1. Design a Modular Reusable Building System prototype.

- Disassemblable
- Flexible in life (e.g. changable inner walls)
-Allows freedom of design
- Useable in conjction with ‘normal’, custom building elements
- Engineered wood as main body

2. Use system to design two buildings in drastically different contexts

- Show the system can adapt to different climates, architectural cultures and local problems.
- Chosen locations are Amsterdam, the Netherlands and Jakarta, Indonesia

Cornerstones

1. System elements are directly reusable

- assembly
- damage
- transport
- storage
- etc..

1. Fill in product context profile & pairwise comparison to determine category weights

Pairwise Comparison Chart (PCC)	Tool Complexity	Workspace Accesibility	Product placement/removal	Labour intensiveness	Connectivity	Damage	Functional Reusability	End of cycle potential	Transport and storage	Required operator qualifications	Rating score	Percentual score
Tool Complexity		5	1/2	4	1/2	6	1/2	1/7	1/7	1/4	17,0	7,8%
Workspace Accesibility	1/5		1/3	1/4	1/5	3	1/5	1/7	1/7	1/5	4,7	2,1%
Product placement/removal	2	3		6	3	7	3	1/3	3	5	32,3	14,8%
Labour intensiveness	1/4	4	1/6		1/5	3	1/6	1/7	1/6	1/5	8,3	3,8%
Connectivity	2	5	1/3	5		6	1/3	1/5	1/4	2	21,1	9,7%
Damage	1/6	1/3	1/7	1/3	1/6		1/7	1/7	1/7	1/4	1,8	0,8%
Functional Reusability	2	5	1/3	6	3	7		1/5	1/5	2	25,7	11,8%
End of cycle Potential	7	7	3	7	5	7	5		2	5	48,0	22,0%
Transport and storage	7	7	1/3	6	4	7	5	1/2		3	39,8	18,2%
Required operator qualifications	4	5	1/5	5	1/2	4	1/2	1/5	1/3		19,7	9,0%

2. Fill in scoring tables for different categories and sub-categories (e.g. (dis)assembly, reusability in new designs)

Tool Complexity (Assembly)	Rating
Tools are not required; task is accomplished by hand	9
Common hand tools are required	(7)
Power tools are required	6
Special tools are required	5
Significant time delay	-2
Special care/techniques are needed	-1

Workspace accessibility	Rating
Mounting can be done with hardly any space required (< 5 cm)	9
Mounting requires some space for hands or small hand tools (< 20 cm)	7
Mounting requires significant space for hand or powered tools	(5)
Special care/tools/techniques are needed	-1
Blind assembly/disassembly	-1
Significant time delay	(-1)
One product have to be removed to access the area	-1
Multiple products have to be removed to access the area	-2

3. Combine all scores and weigh according to pairwise comparison

	Factor	%	Perfect example Rating	Perfect example Score	Product 1 R	Product 1 S	Product 2 R	Product 2 S	Product 3 R	Product 3 S	Product 4 R	Product 4 S	Product 5 R	Product 5 S	Product 6 R	Product 6 S
Tool Complexity	17,0	7,8%	9	153,3	9	153	9	153	8	136	8	136	8	136	8	136
Number of fastener types	17,0		9	153,3	9	153	9	153	7	119	7	119	7	119	7	119
Workspace Accesibility	4,7	2,1%	9	42,0	9	42	9	42	7	33	7	33	7	33	7	33
Product placement/removal	32,3	14,8%	9	291,0	9	291	9	291	7	226	7	226	7	226	7	226
Labour intensiveness	8,3	3,8%	9	74,6	9	75	8	66	9	75	9	75	9	75	9	75
Connectivity	21,1	9,7%	9	190,1	9	190	9	190	9	190	9	190	9	190	9	190
Damage	1,8	0,8%	9	16,4	8	15	8	15	8	15	8	15	8	15	8	15
Functional Reusability	25,7	11,8%	9	231,6	7	180	7	180	7	180	7	180	7	180	7	180
End of cycle potential	48,0	22,0%	9	432,0	1	48	1	48	1	48	4	192	4	192	4	192
Transport and storage	39,8	18,2%	9	358,5	9	359	9	359	9	359	9	359	9	359	9	359
Required operator qualifications	19,7	9,0%	9	177,6	9	178	9	178	9	178	9	178	9	178	9	178
Space needed				2120,4		###		###		###		###		###		###
			Maximum Score	100		79,4		79,0		73,5		80,3		80,3		80,3

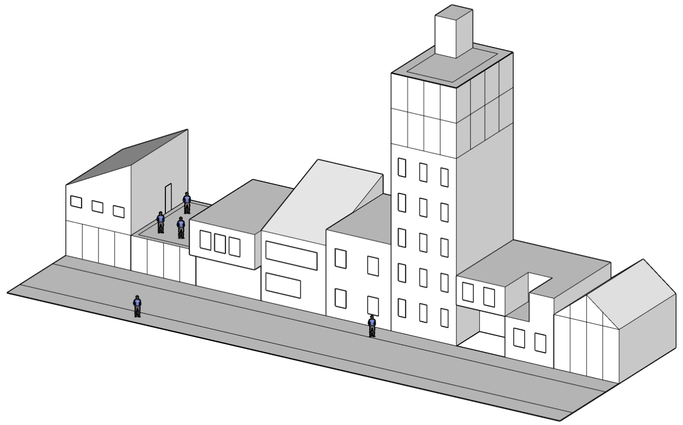
4. Compare final- and sub-scores to gain insight about the product's reusability

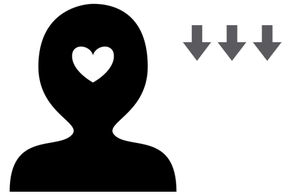
Cornerstones:

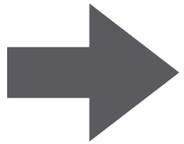
1. System elements are directly reusable

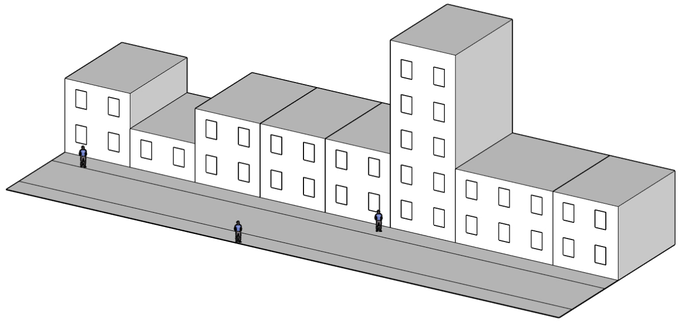
- assembly
- damage
- transport
- storage
- etc..

2. System must give user FREEDOM OF DESIGN









- Loss of identity
- Loss of sense of belonging
- Uninspiring / Depressing





Cornerstones

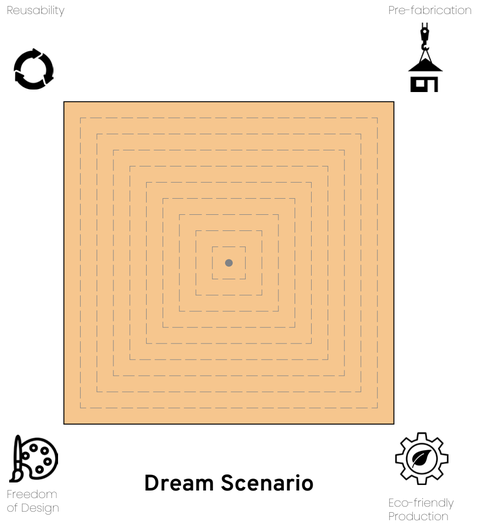
1. System elements are directly reusable

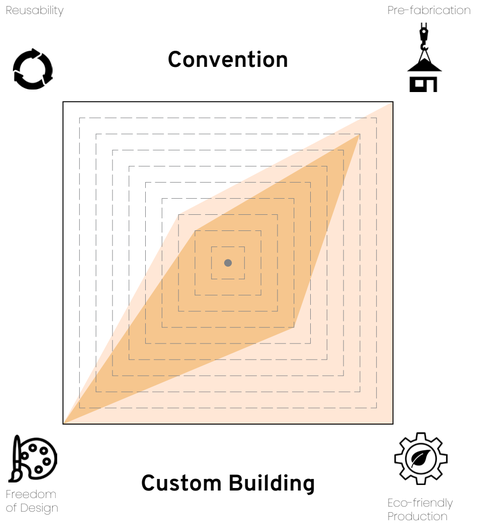
- assembly
- damage
- transport
- storage
- etc..

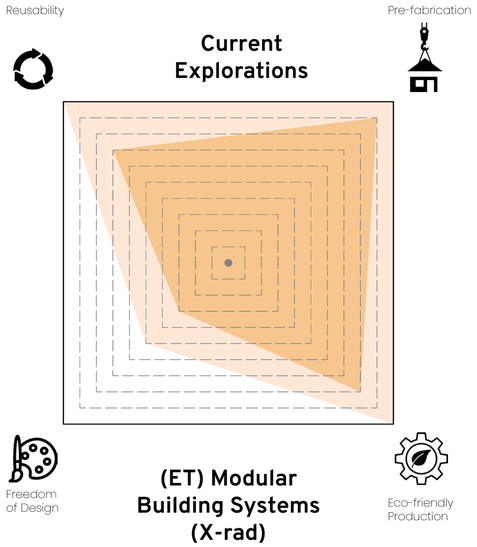
2. System must have Freedom of Design

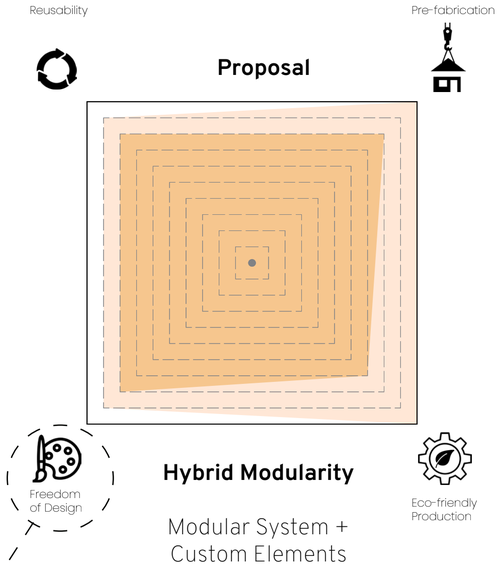
3. Climate-friendly production (WOOD!)

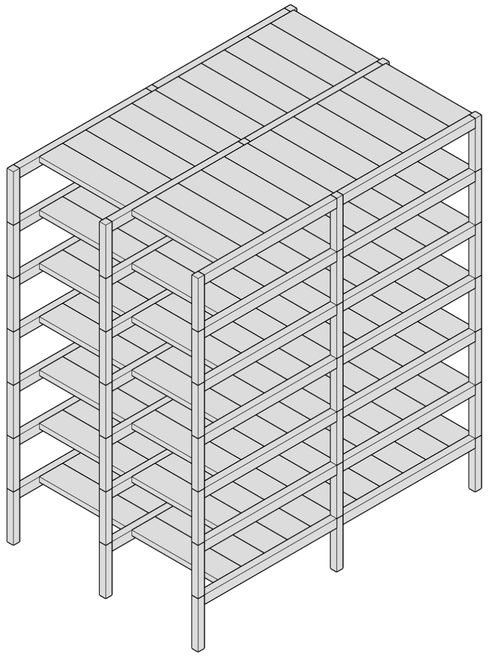
4. Prefabrication (efficiency, digital & smart production)


Reusability
Pre-fabrication
Freedom of Design
Eco-friendly Production
Dream Scenario

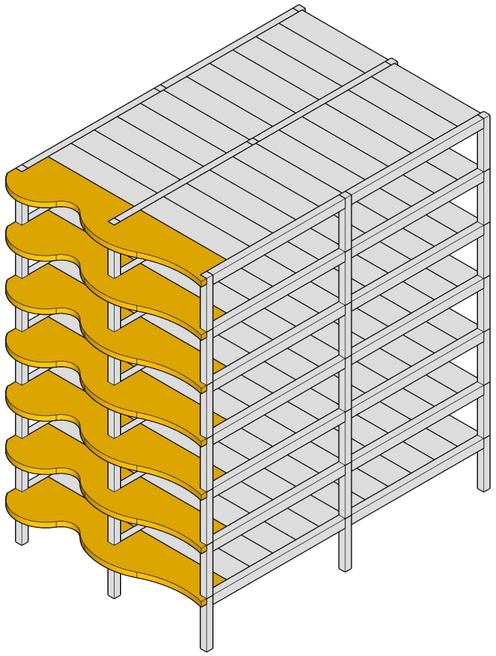

Reusability
Convention
Pre-fabrication
Freedom of Design
Eco-friendly Production
Custom Building


Reusability
Current Explorations
Pre-fabrication
Freedom of Design
(ET) Modular Building Systems (X-rad)
Eco-friendly Production

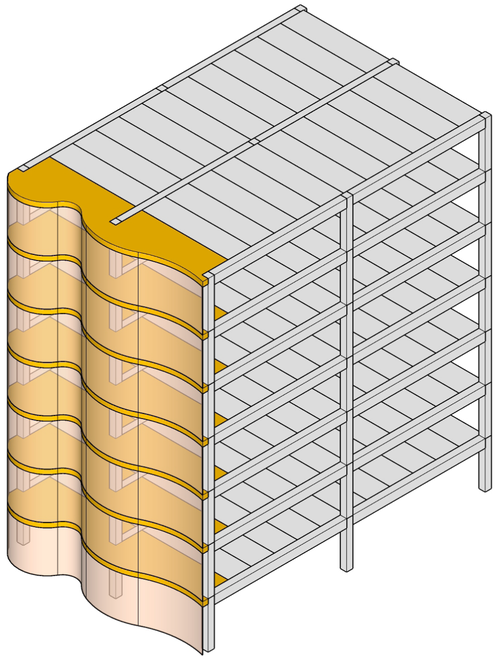

Reusability
Proposal
Pre-fabrication
Freedom of Design
Hybrid Modularity
Modular System + Custom Elements
Eco-friendly Production
Essential for Mass Market Adaptation & Significant Impact!



Core of building made
entirely out of system elements



Small amount of custom additions



Final result that is demountable and for
the most part directly reusable

SYSTEM DESIGN

System design: Existing Solutions

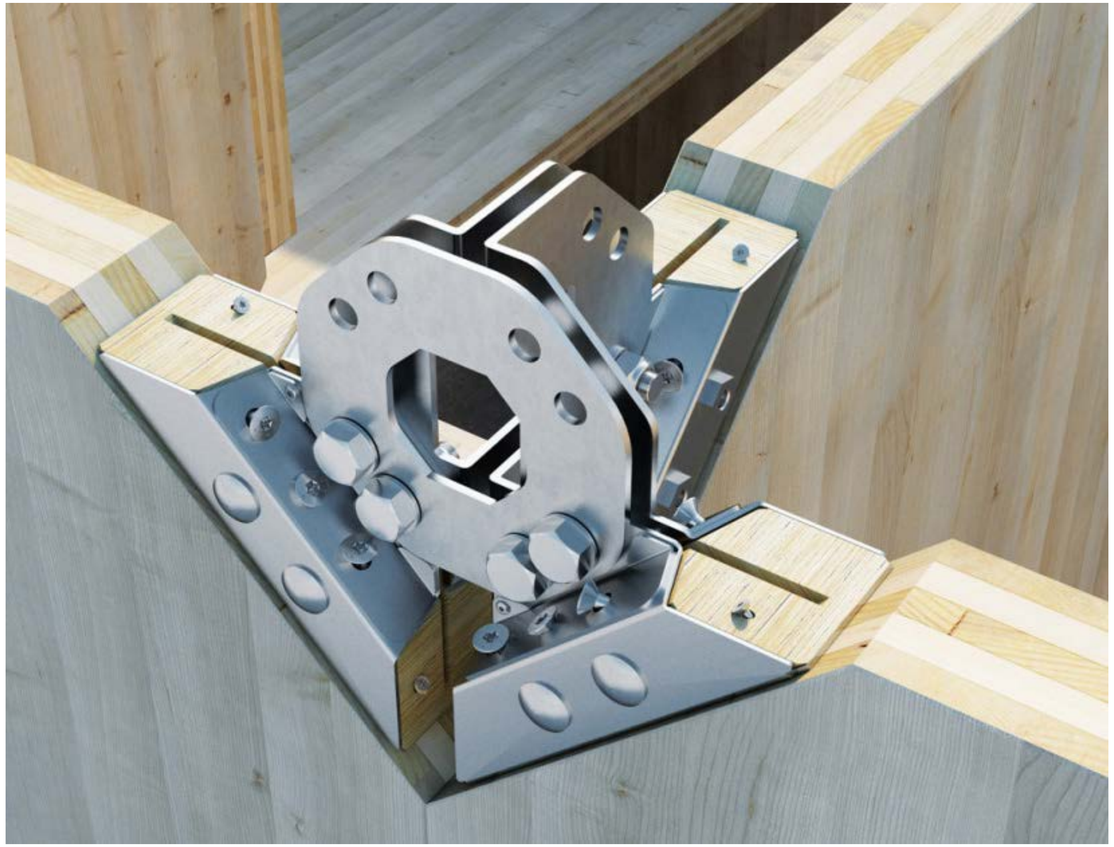


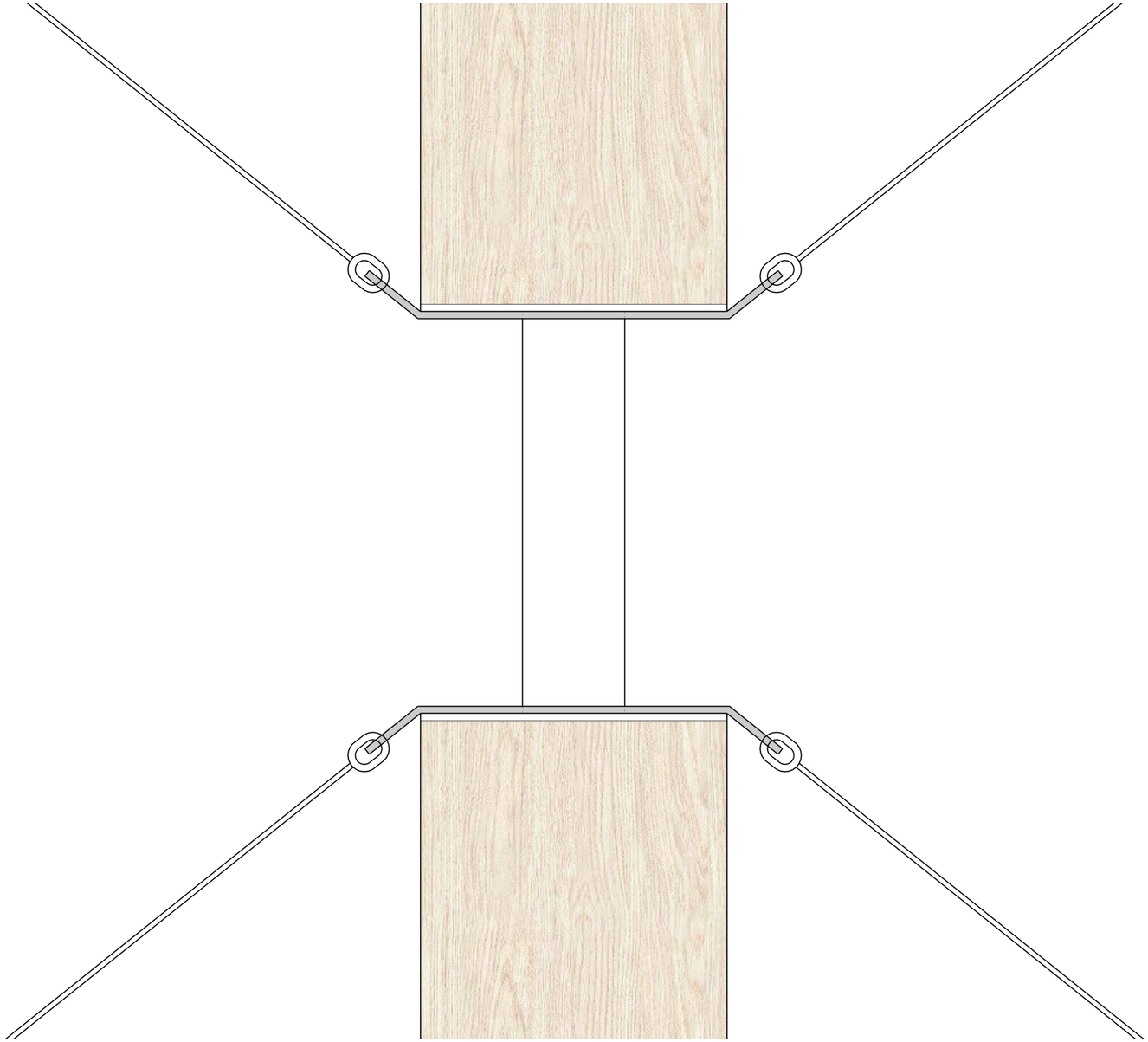


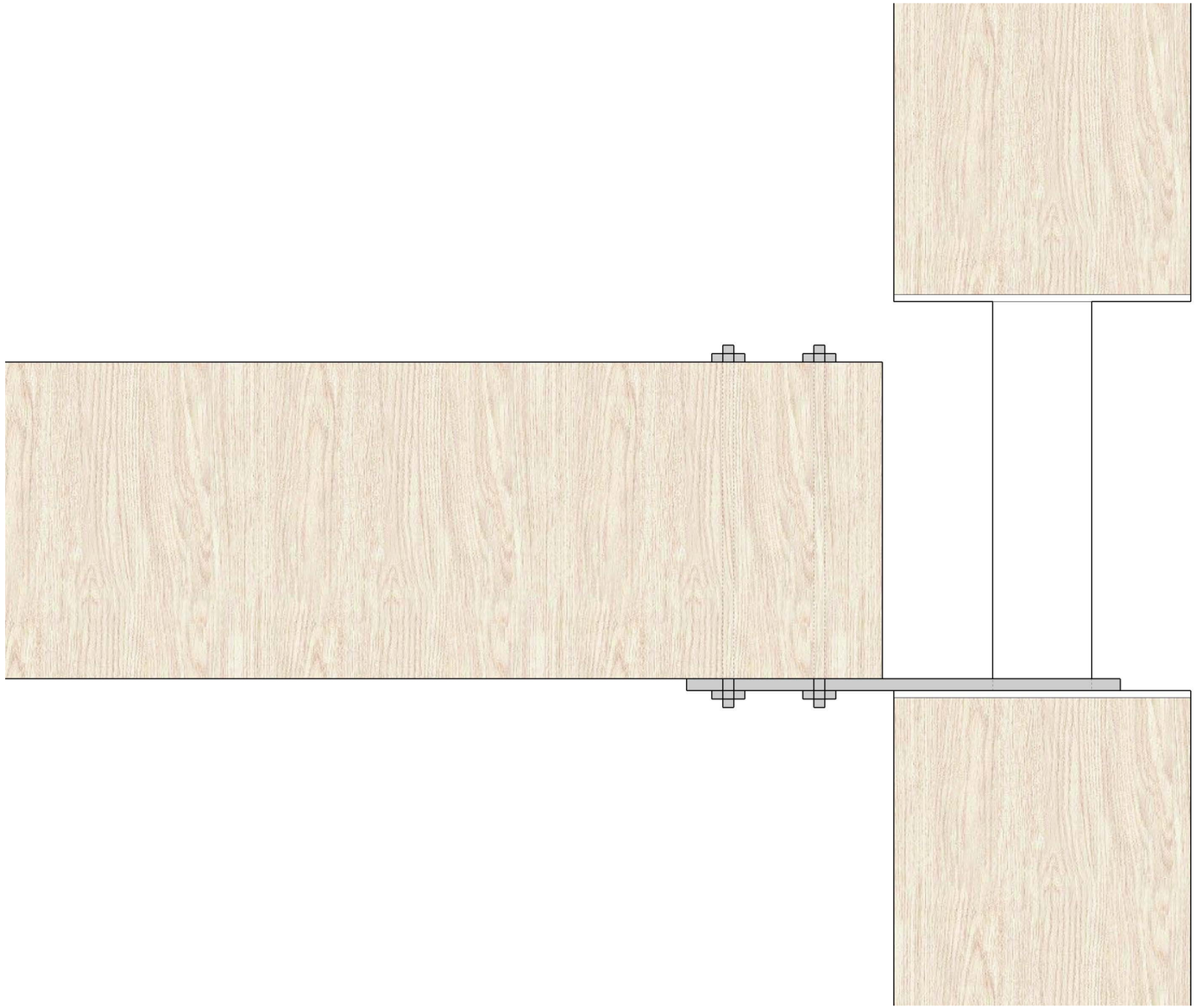


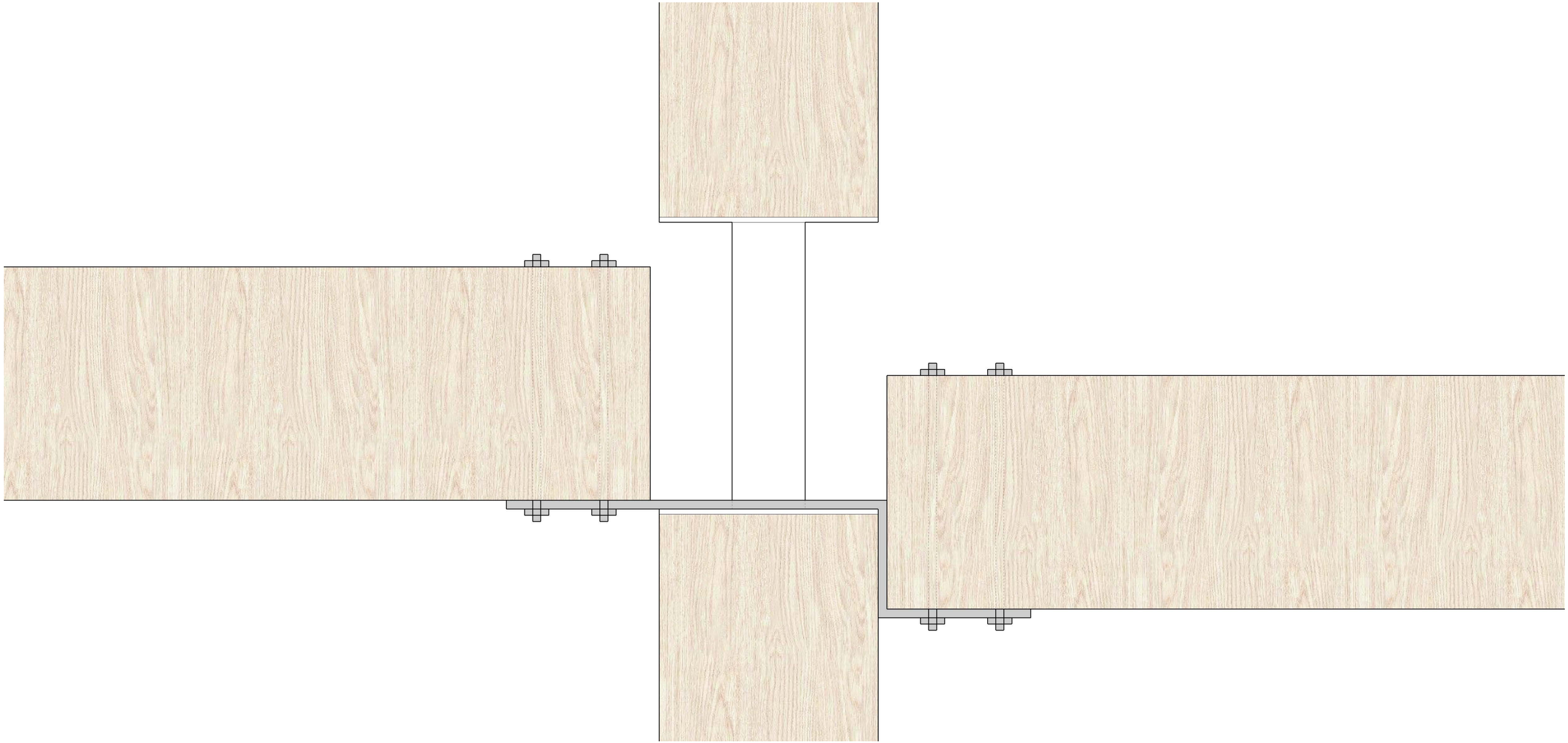


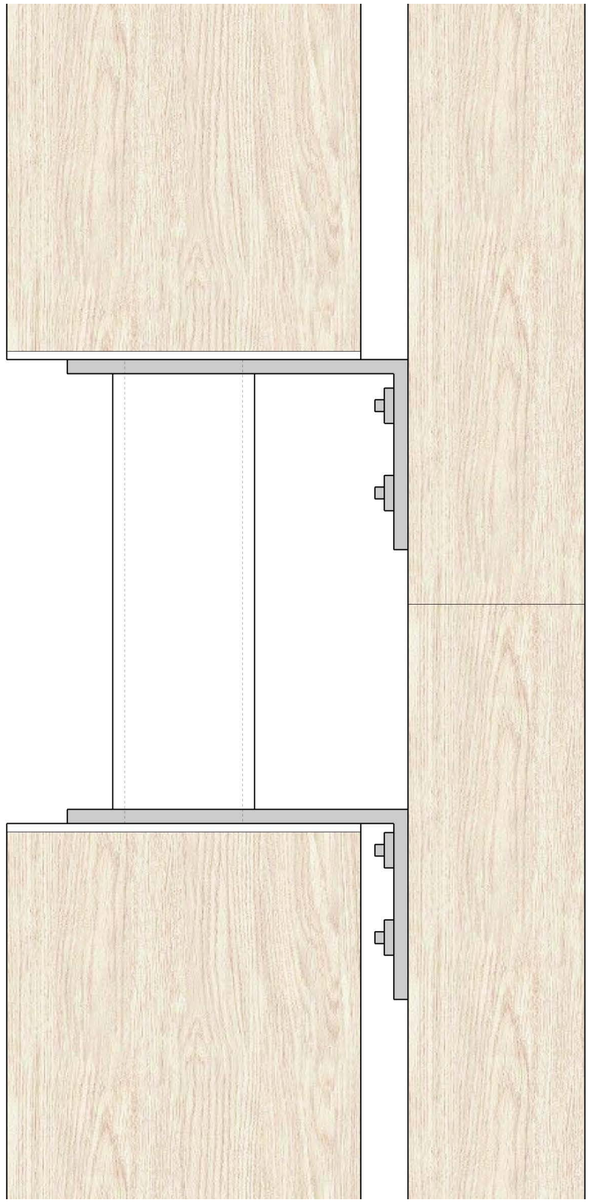
X-rad system by ROTHOBLAAS

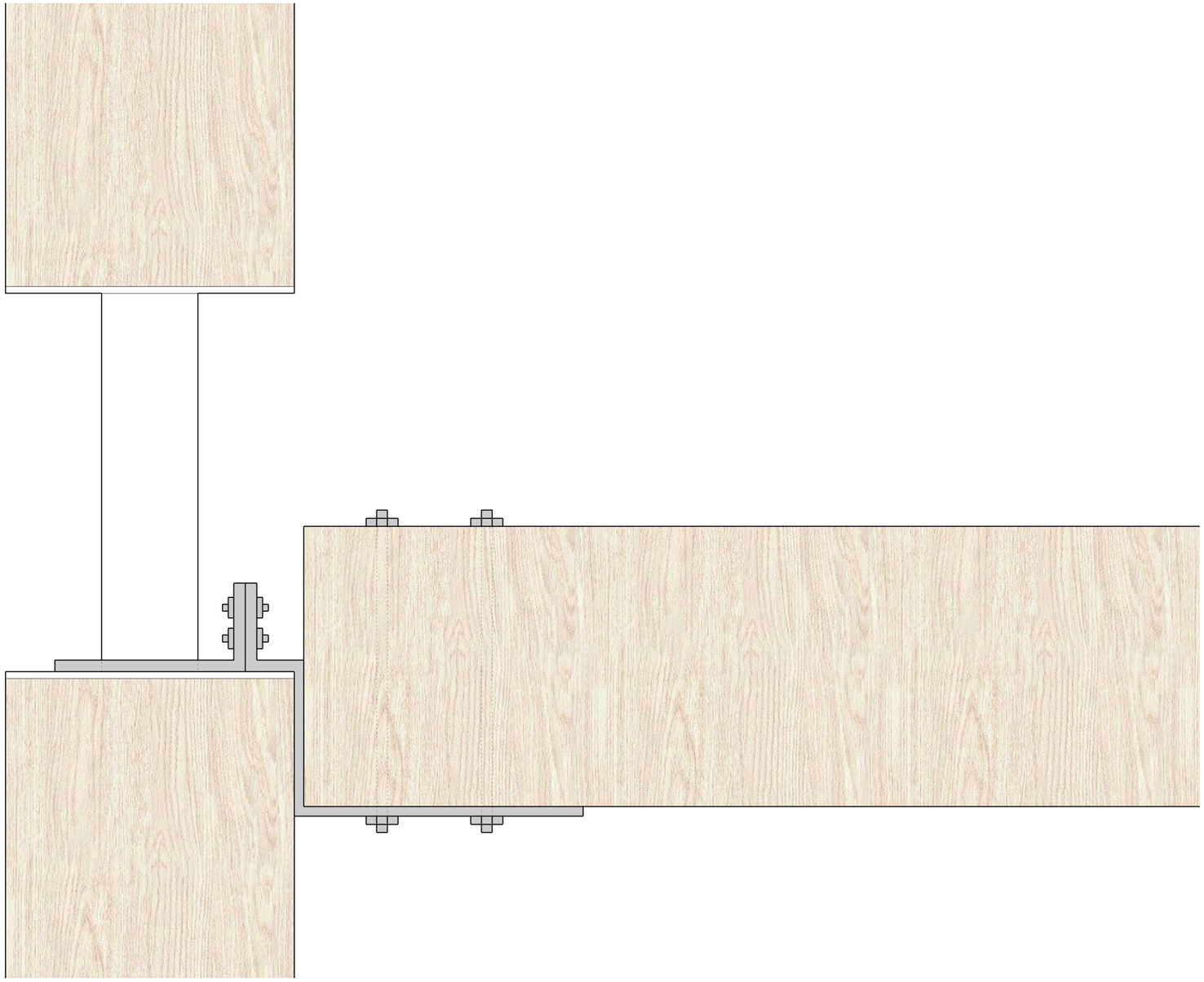


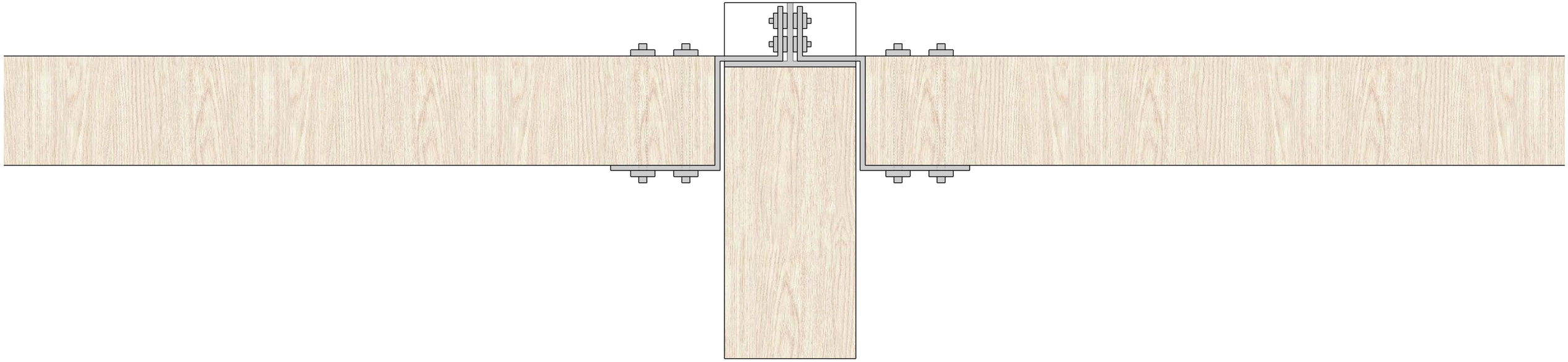


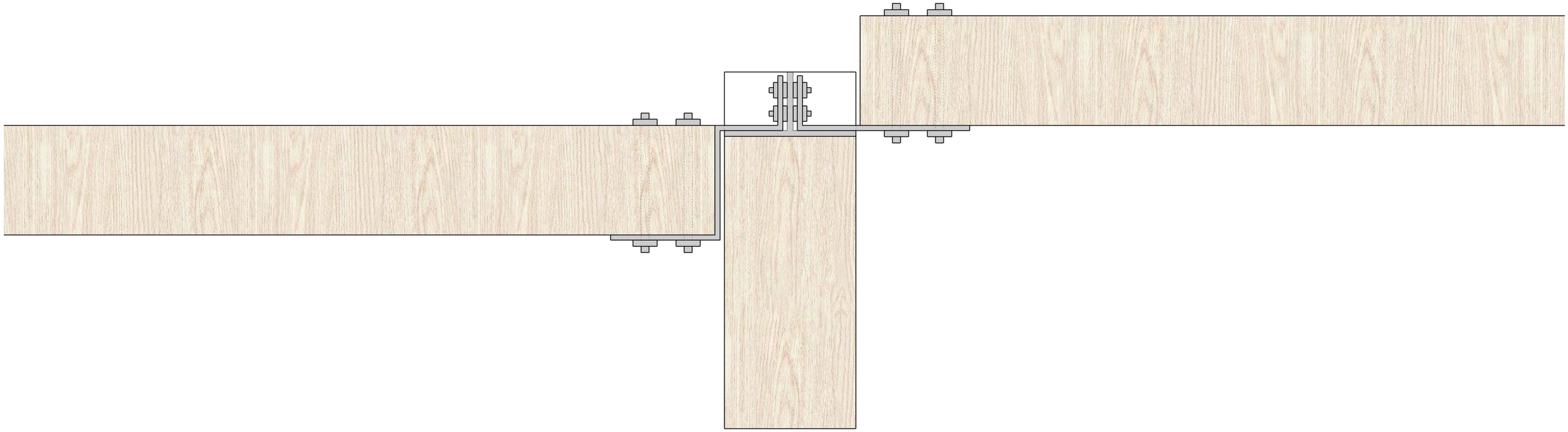


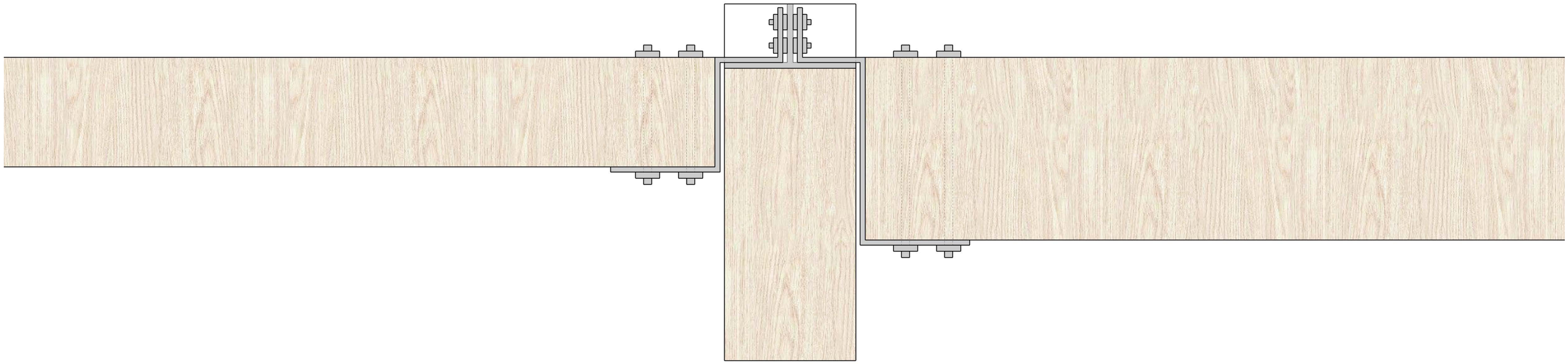


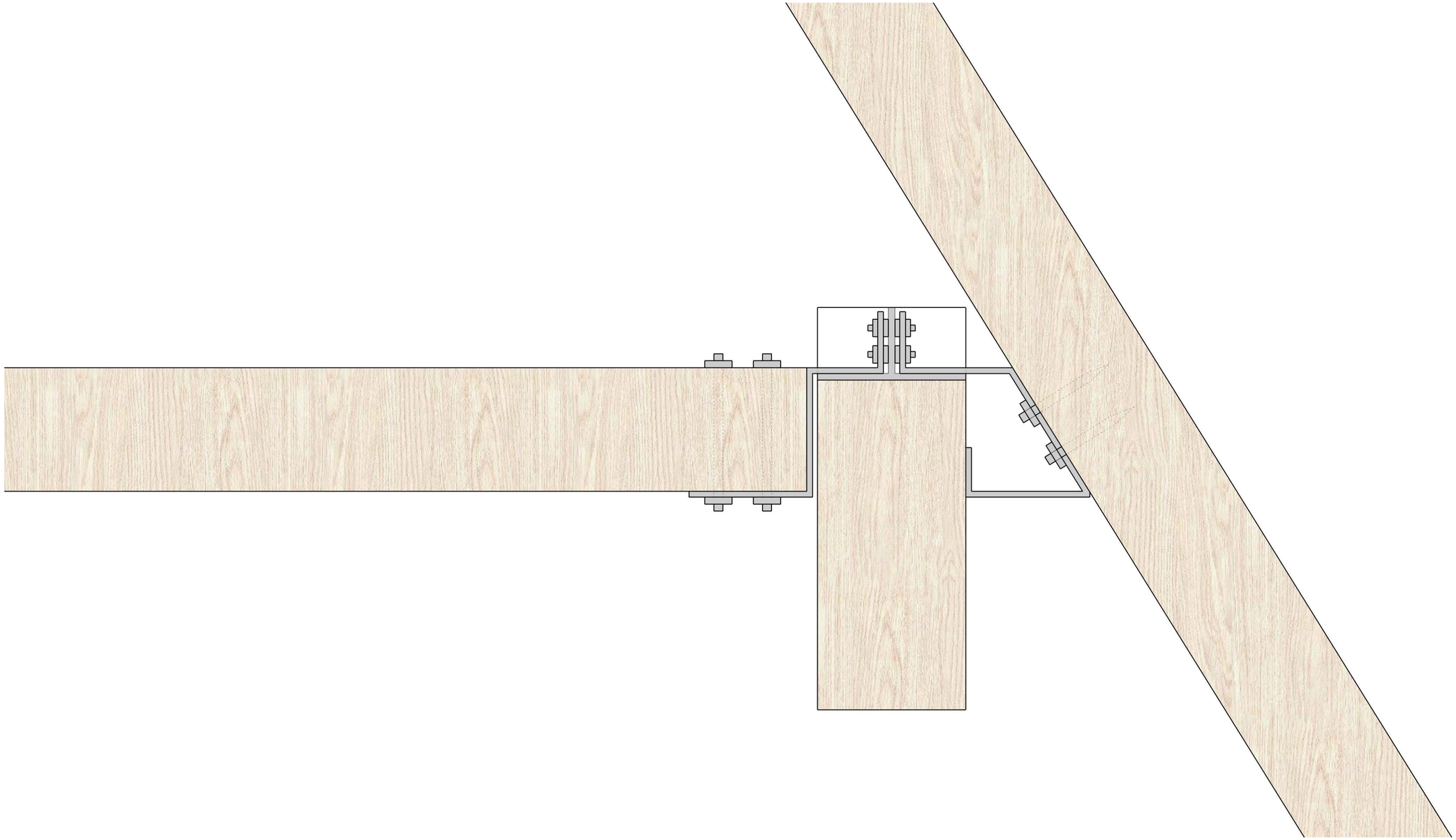


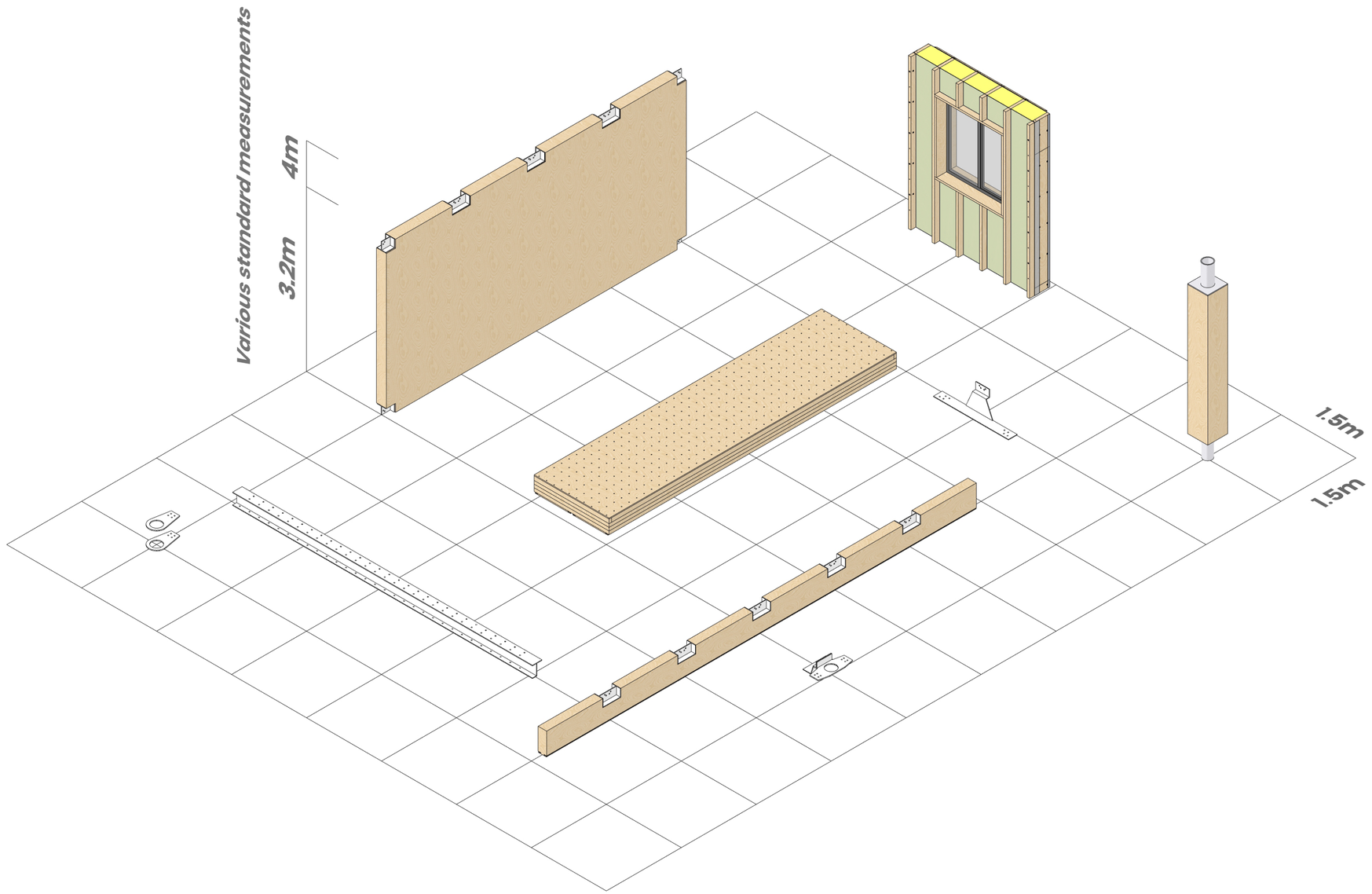


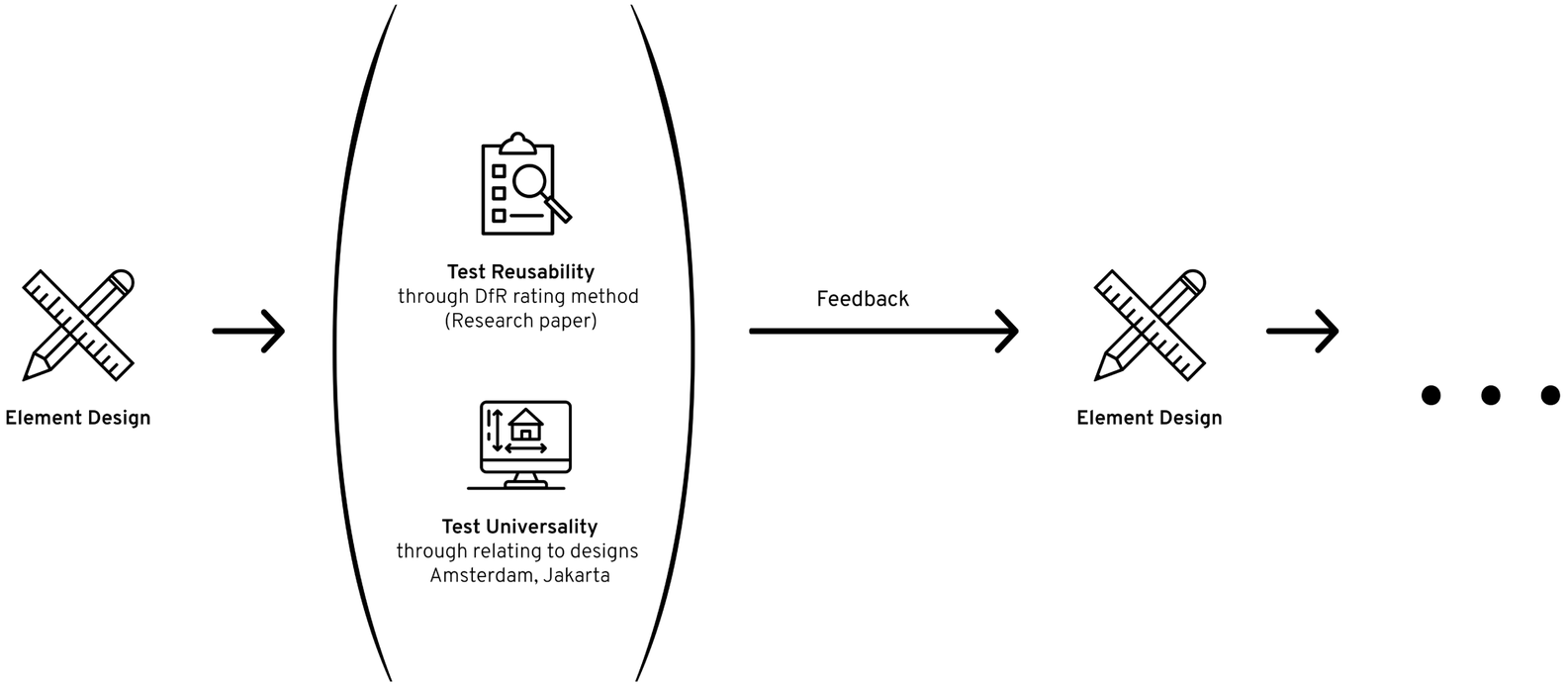


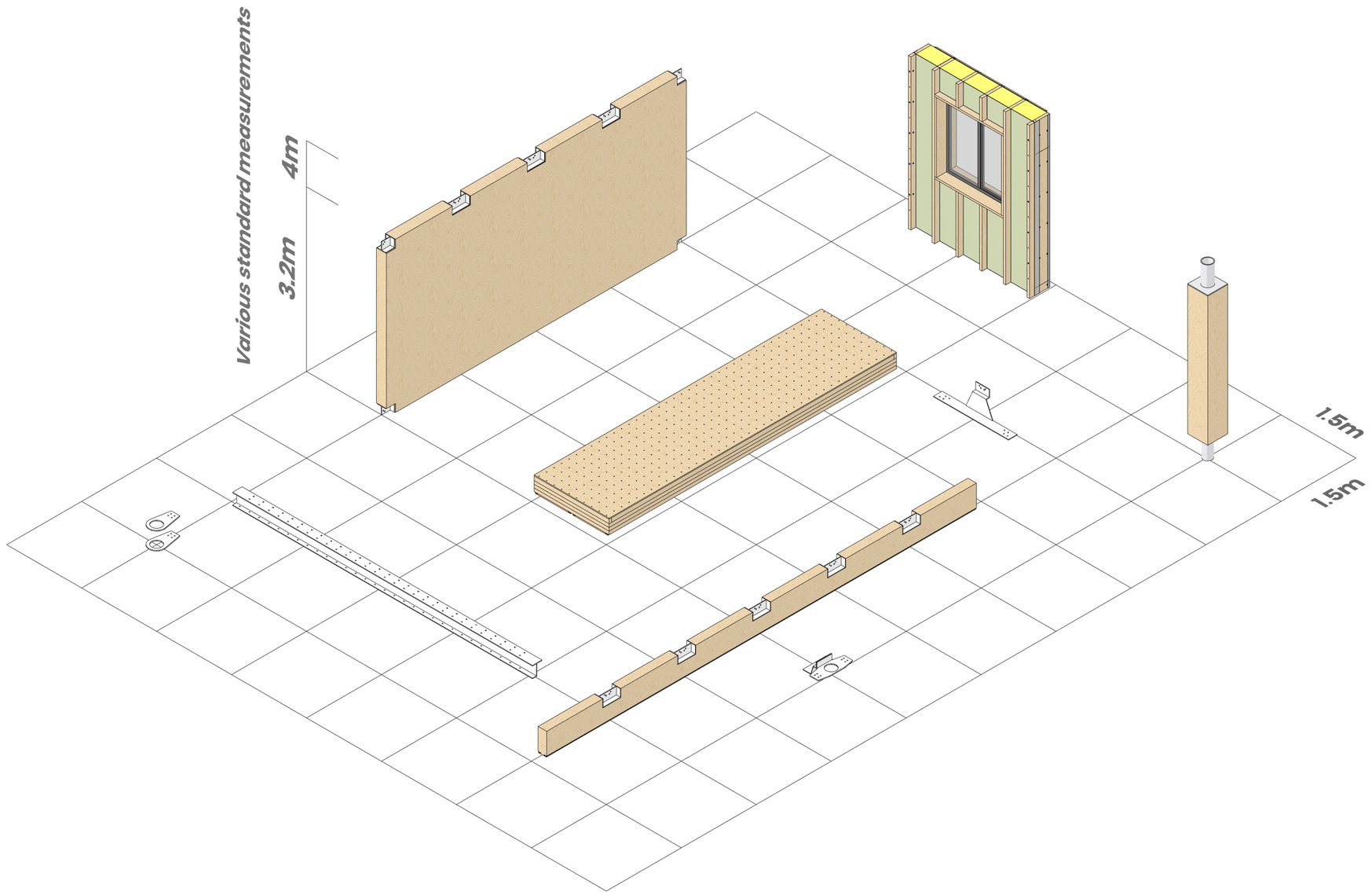







Various standard measurements
3.2m
4m
1.5m
1.5m


Element Design
Test Reusability
through DfR rating method
(Research paper)
Test Universality
through relating to designs
Amsterdam, Jakarta
Feedback
Element Design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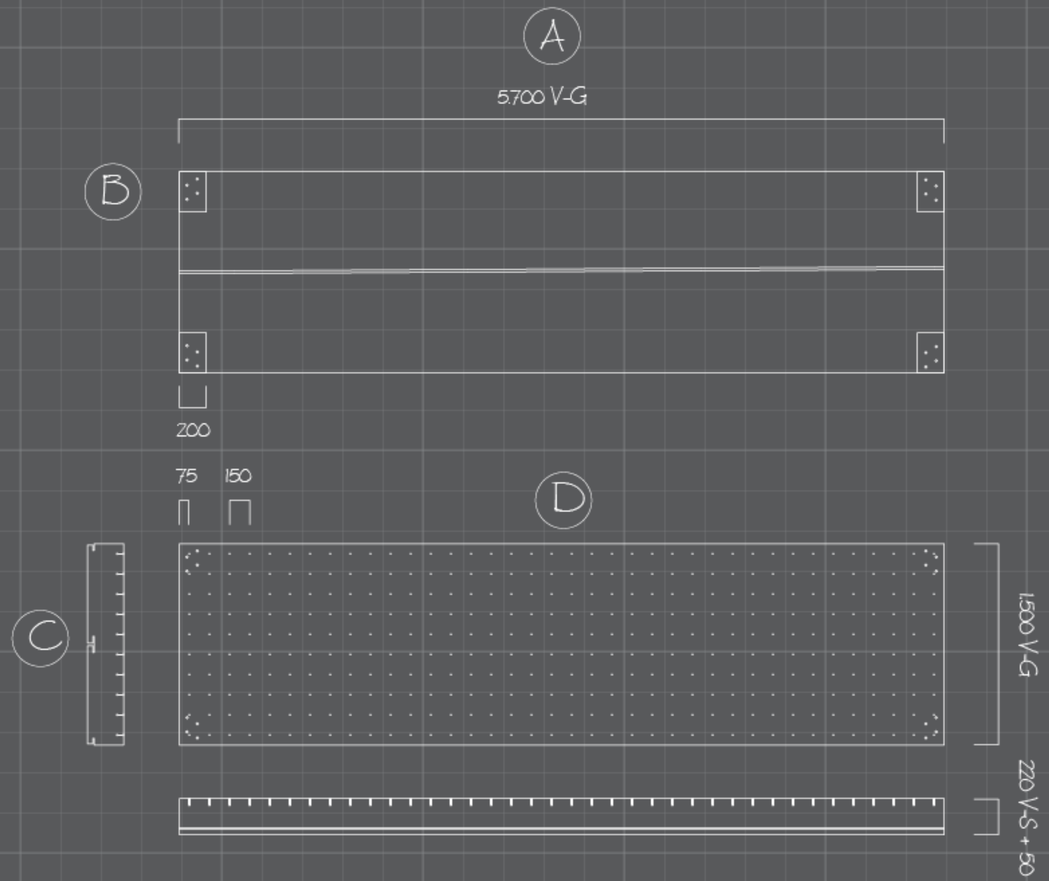
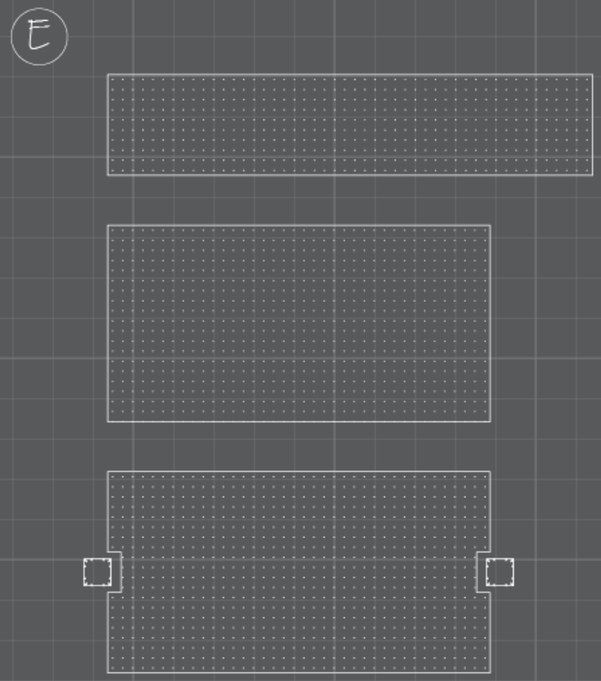




FLOOR ELEMENT

A

VARIABLES
The floor elements have three variables. The first variable is the span, which varies according to standard grid units of 1500 mm (V-G).

The second variable is the width, which also varies according to V-G.

The third variable is the thickness, which varies according to a number of standard measurements (V-S) based on both span and load. In this case the thickness is 220+50, with 220 mm of the thickness being loadbearing and the bottom 50 mm facilitating attachment points.

B

PRIMARY ATTACHMENT POINTS
At the bottom side, each corner has milled-in space where the steel interfaces are placed to connect the floors to walls or beams.

These interfaces can vary in height to either heighten or lower the floor elements as required for the design.

C

SECONDARY ATTACHMENT POINTS
Similar to the beam elements, the floor elements have a bottom layer of 50 mm non-loadbearing CLT with milled-in slits and pre-drilled holes.

These serve as attachment points for add-ons that can fulfill a variaty and multiplicity of functions: sound insulation, fire proofing, electrics, ventilation and lowered ceiling (additionalheight).

D

SECONDARY ATTACHMENT POINTS
On the top side, the floor elements have pre-drilled holes according to a simple grid of 150 x 150 mm.

These holes serve as the attachment points for both floor add-ons (extra height, sound insulation, weight) and the 'footprints' of walls.

These elements are connected via friction-fit steel pins to be completely remountable.

E

VARIANTS
Depicted a several variants of the floor element, differing in width and span.

Notable is the bottom variant, which has double width and spacing in the middle for columns in the system grid. This variant makes use of the property of CLT where it can bear loads in both perpendicular directions, and only needs to be secured at the corners.

A

Topside Add-on (PRE-FAB)
Additional Height, Weight, Sound insulation. Variable according to building needs. Pre-drilled holes as attachment points for wall foot-prints.

B

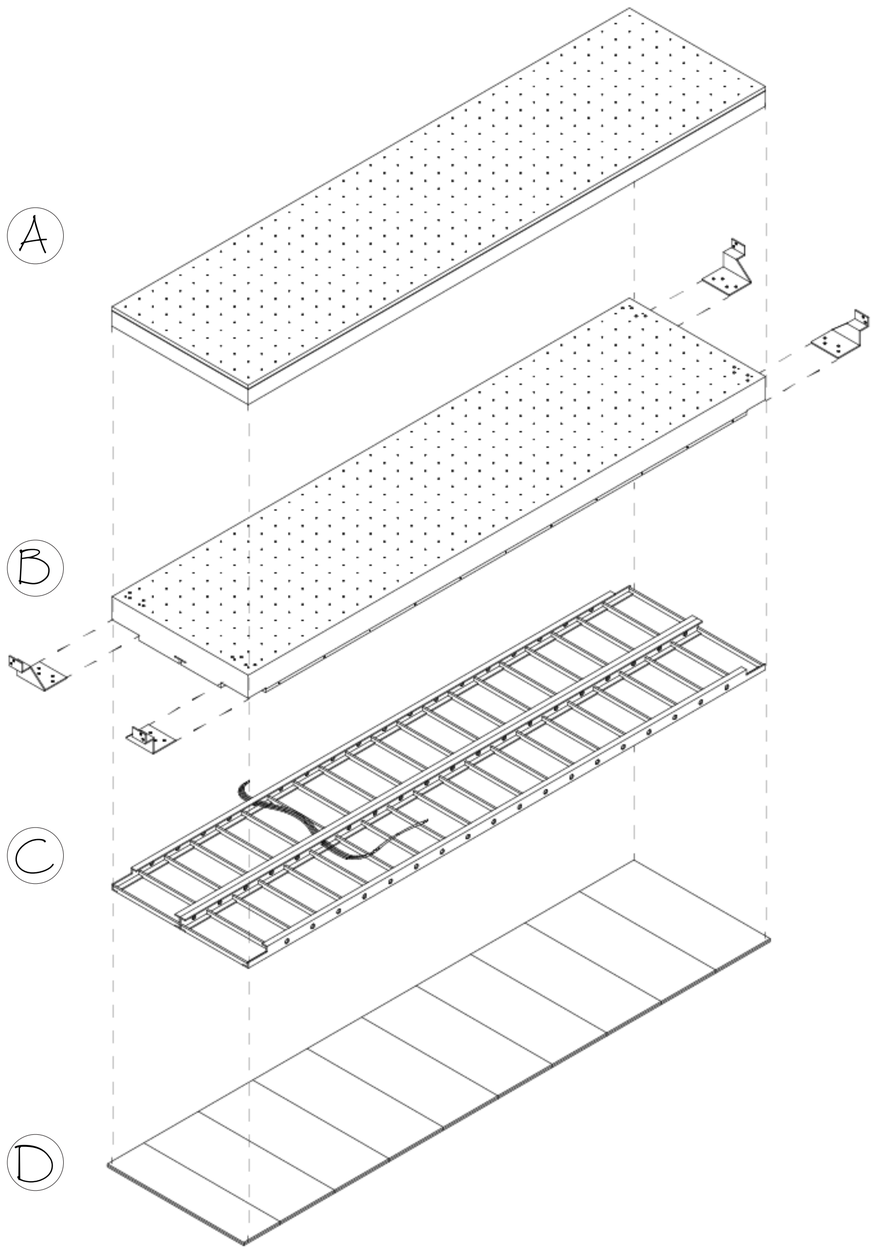
Floor Element (PRE-FAB)
According to blueprint.

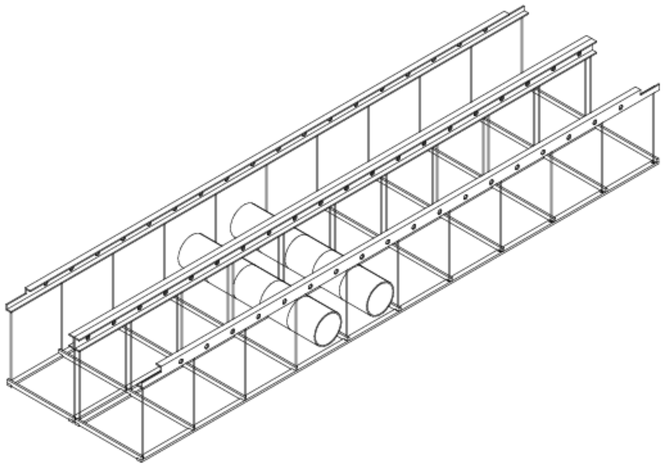
C

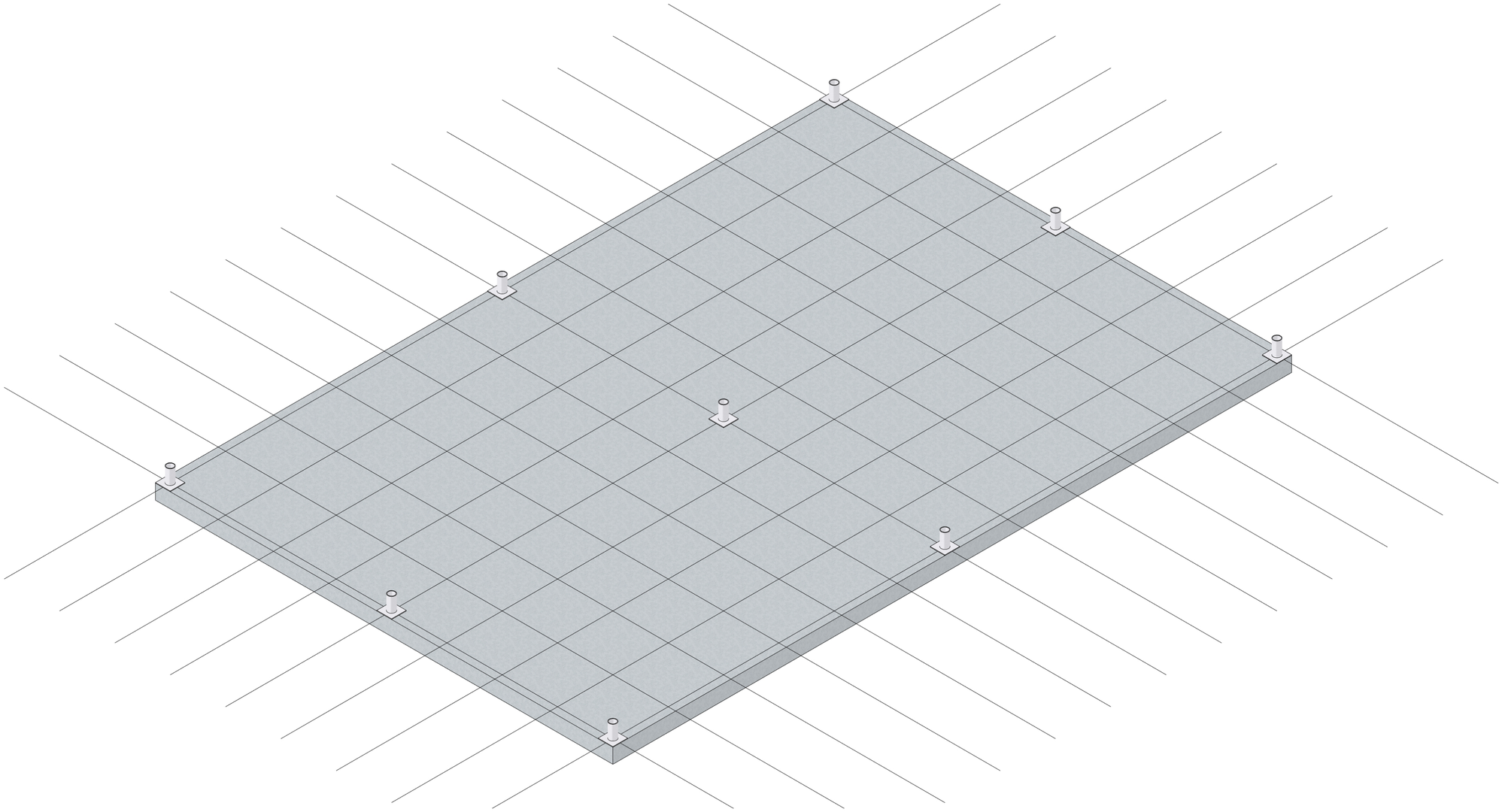
Bottomside Add-on (PRE-FAB)
Additional height, sound insulation, electrics and installations. Slid unto the bottom of the floor element and secured with horizontal friction fit pins.

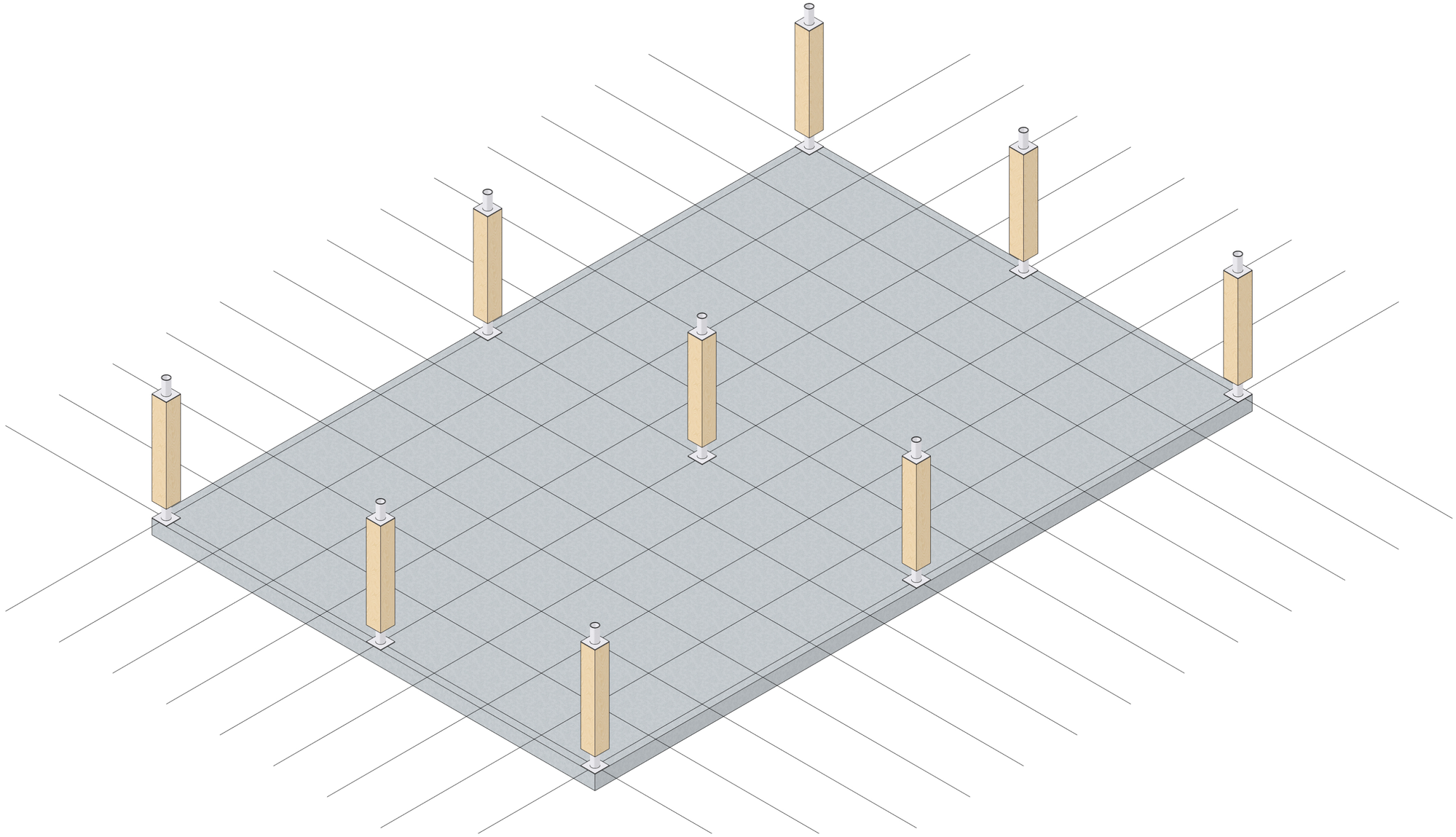
D

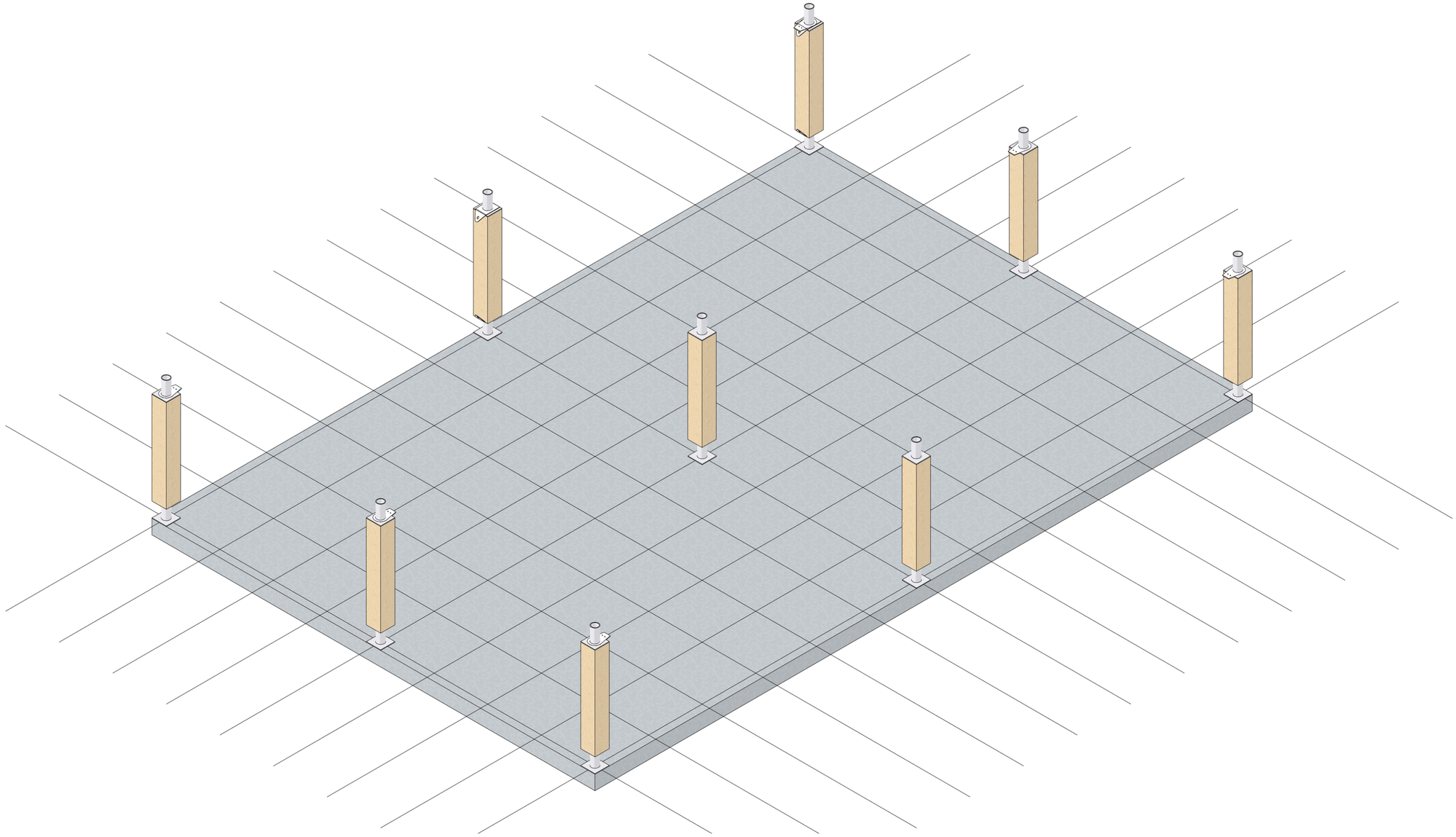
Ceiling Finish
Fire-proofing. Finish. Added on-site. Variable.

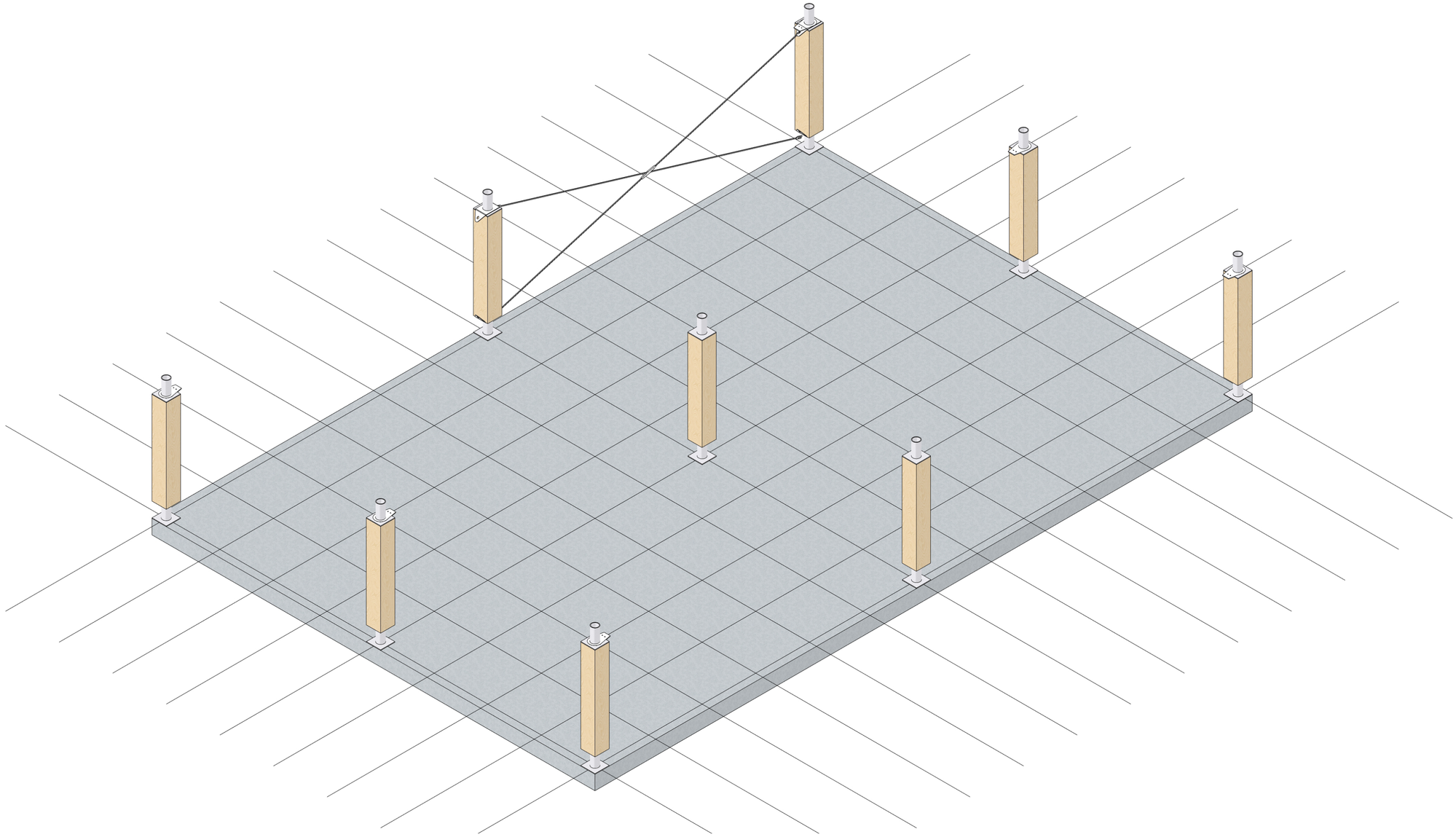


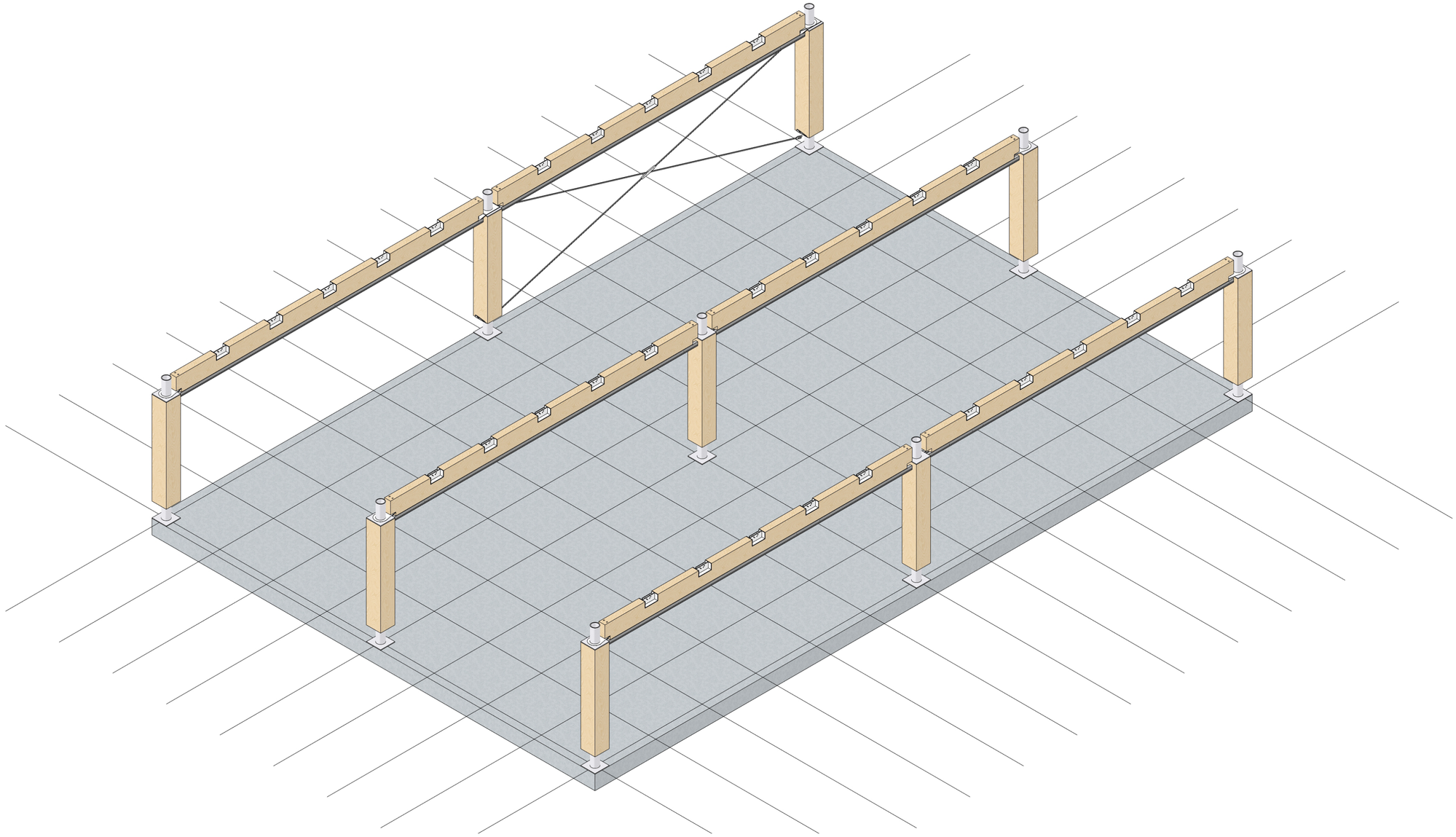


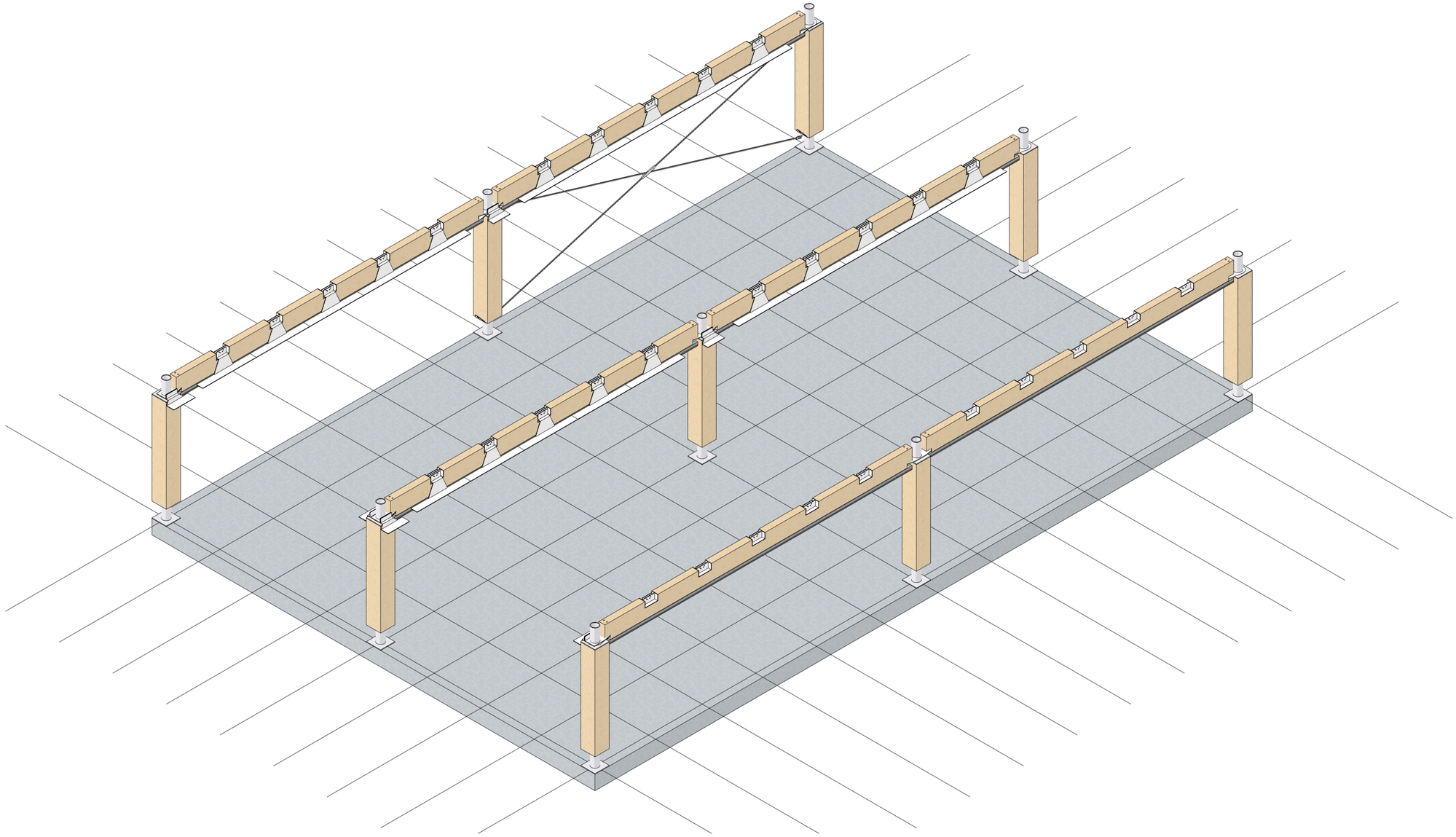


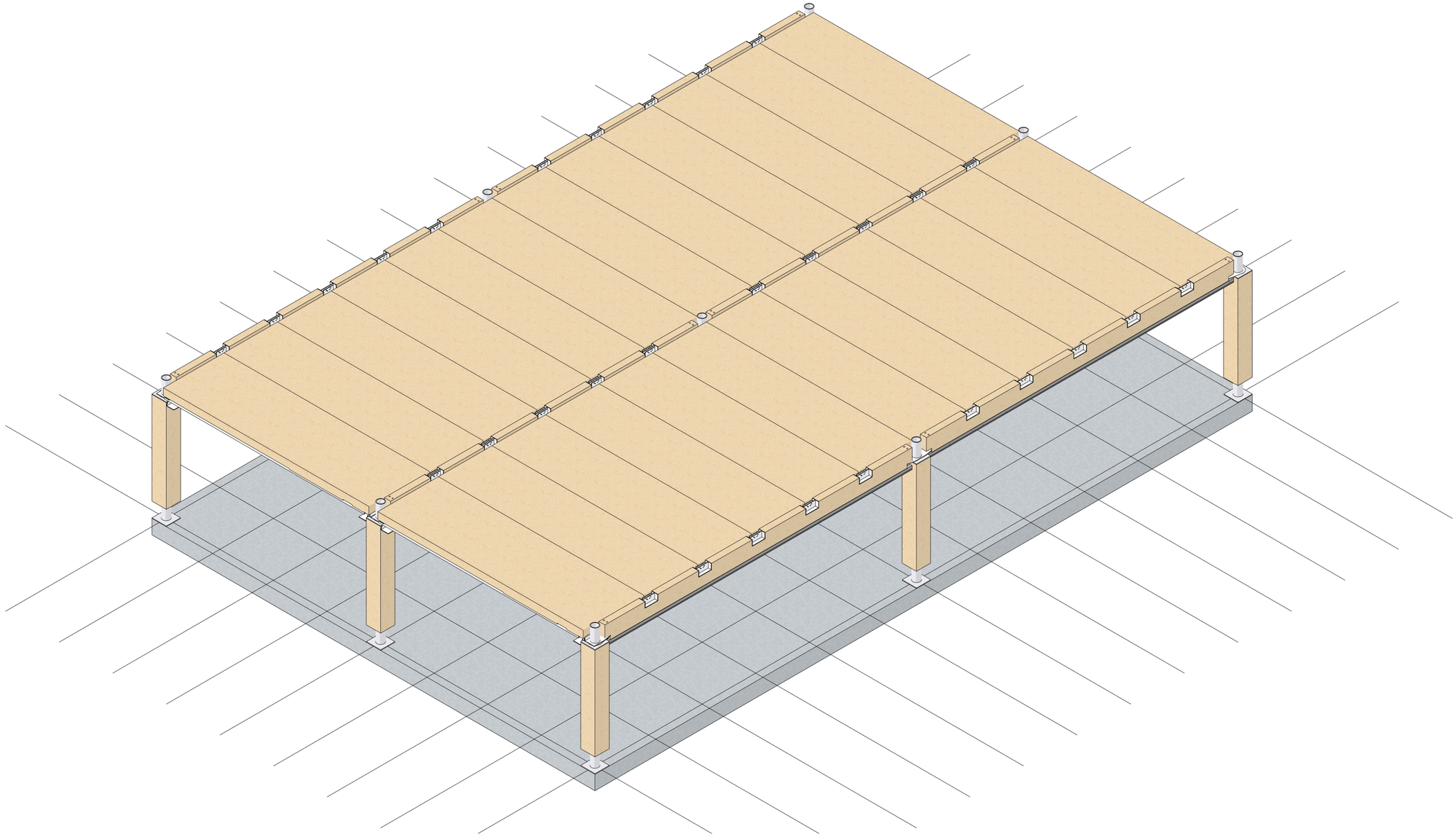


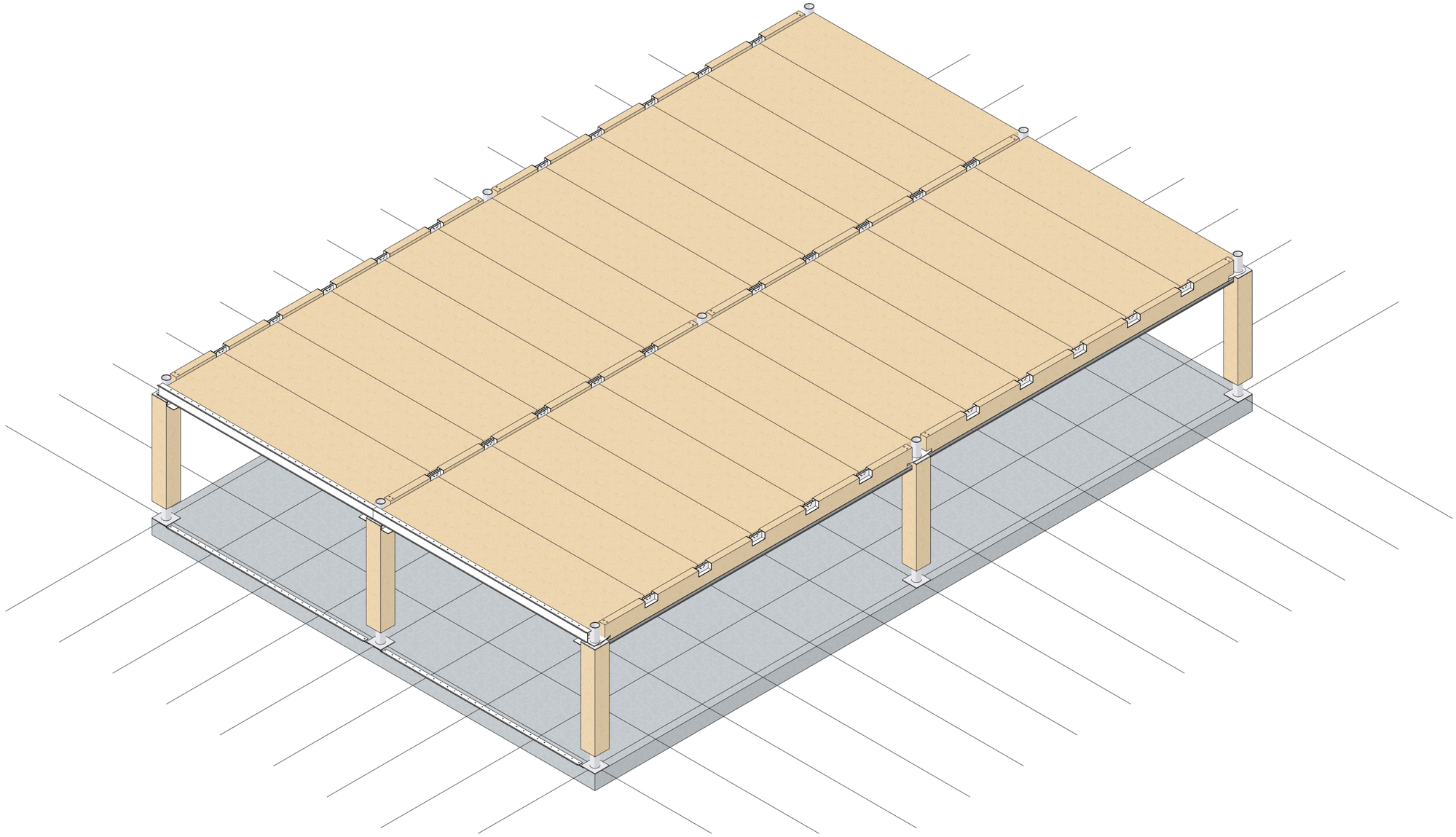


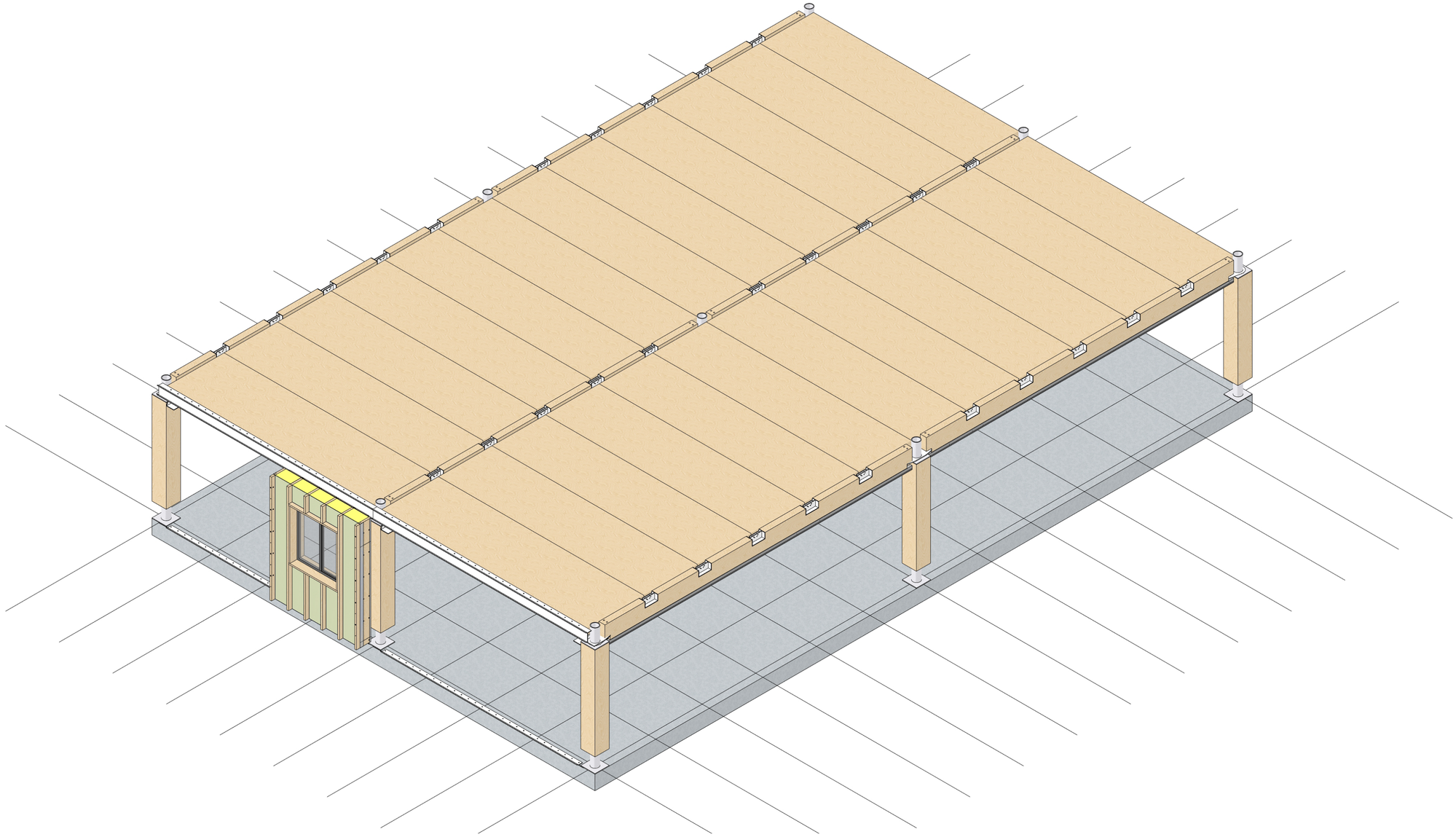


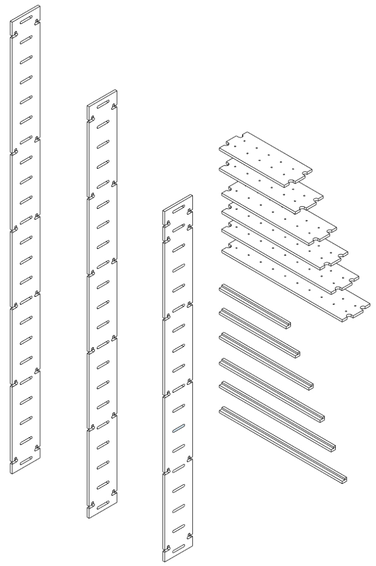


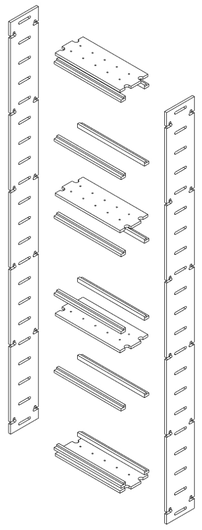


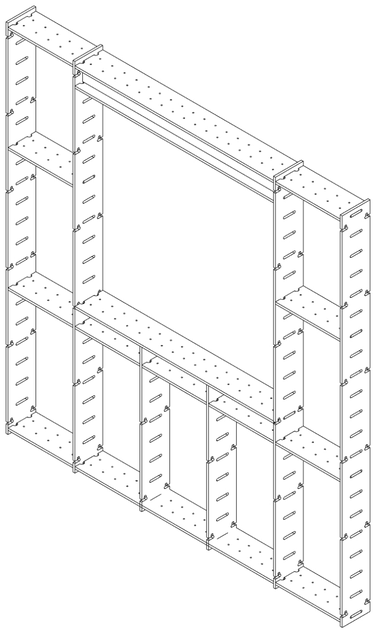


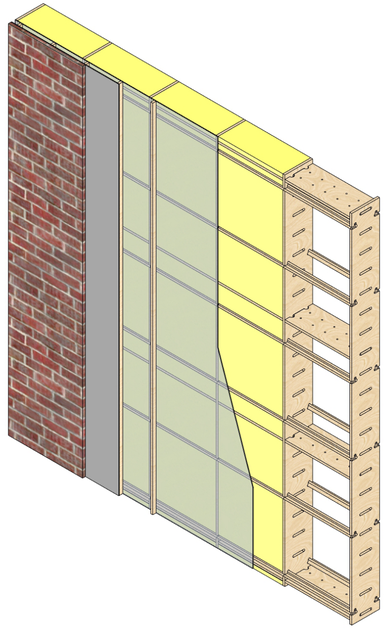


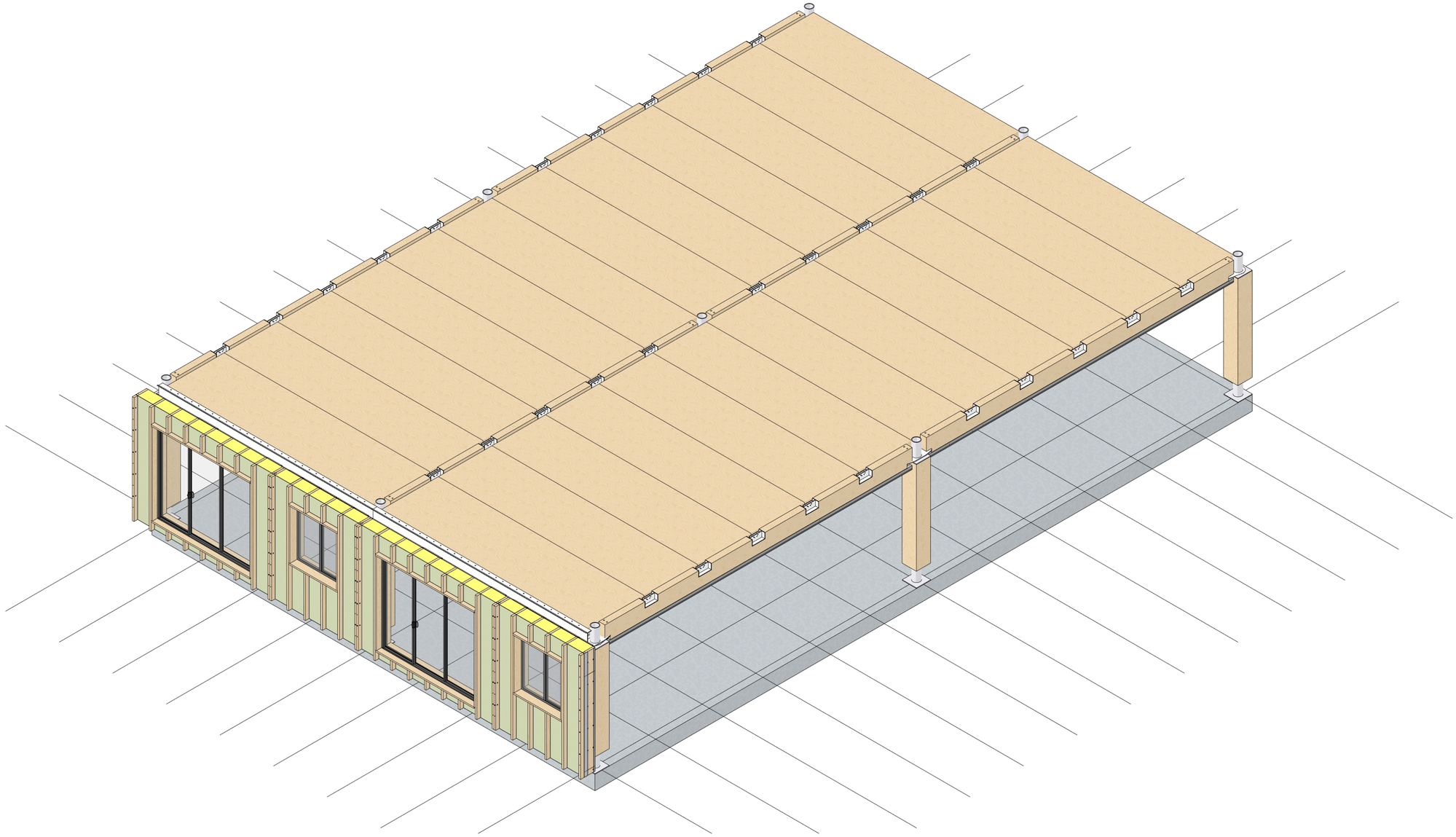


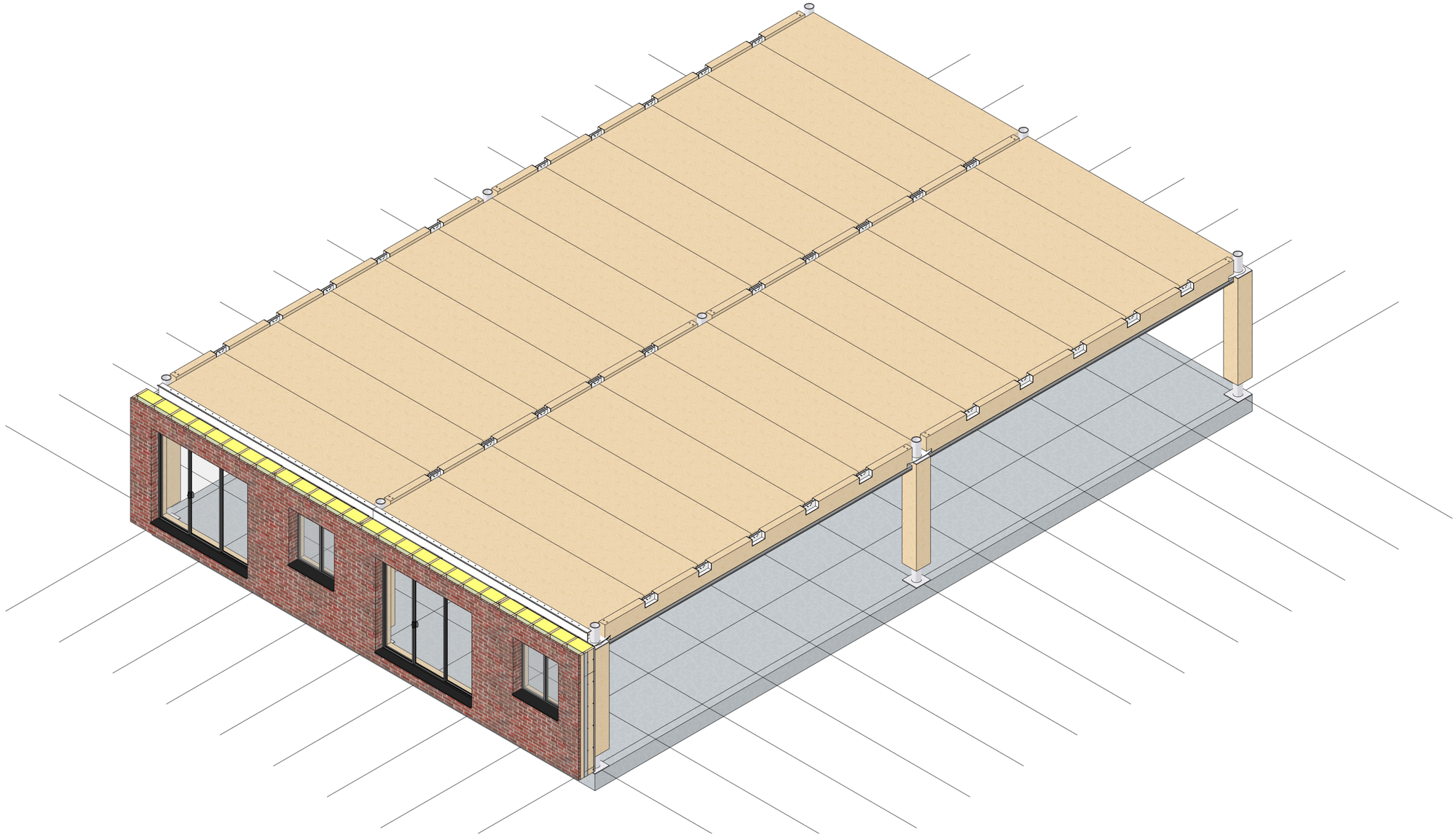


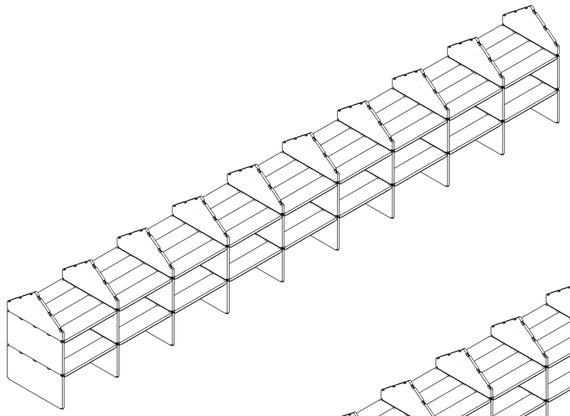


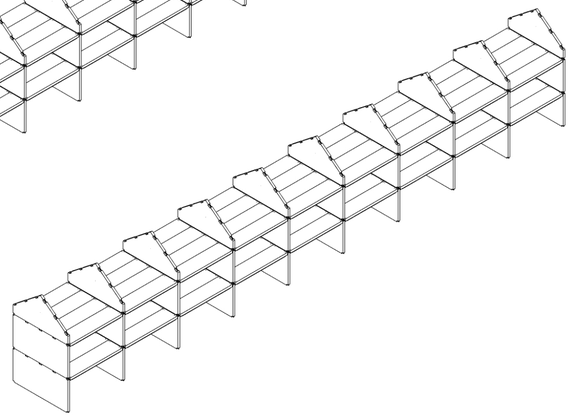


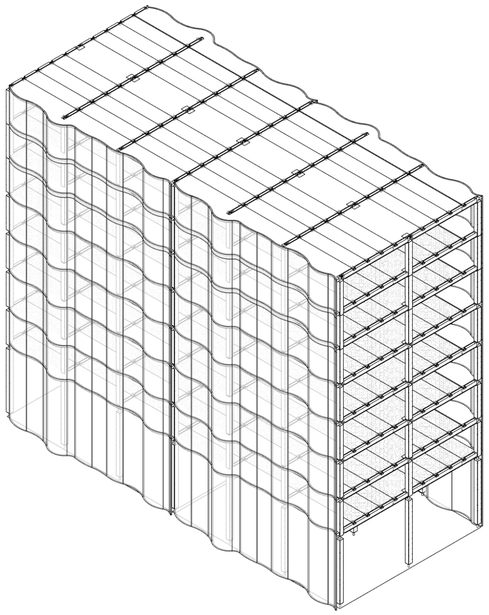


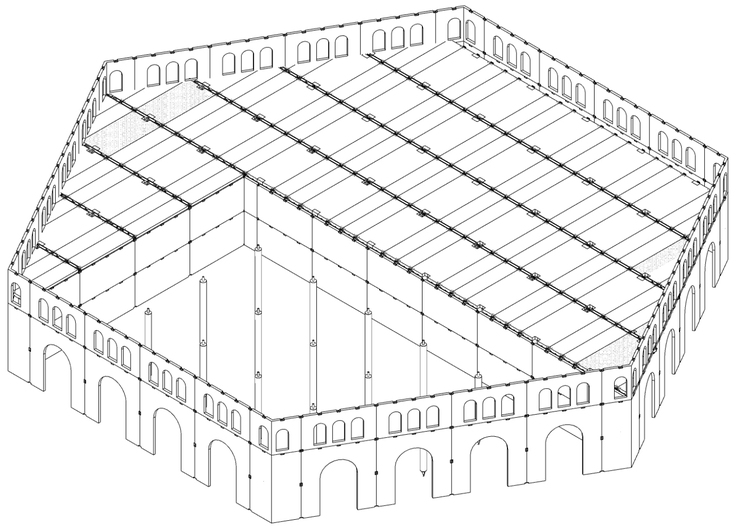


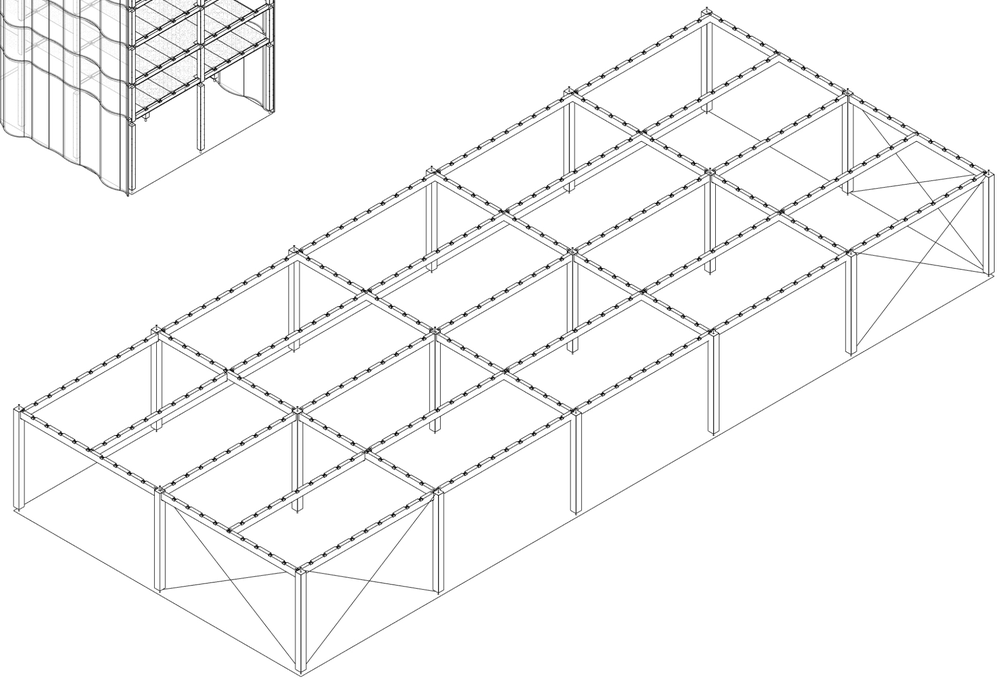












DESIGN SHOWCASES



PRIMARY SHOWCASE

THE NETHERLANDS,
AMSTERDAM,
NIEUW WEST,
OSDORPPLEIN.



SECONDARY SHOWCASE

INDONESIA,
JAKARTA,
CENKARENG,
RAWA BUAYA.



Locational differences:

1. Climate
2. Architectural culture
3. Local problems
4. Future developments



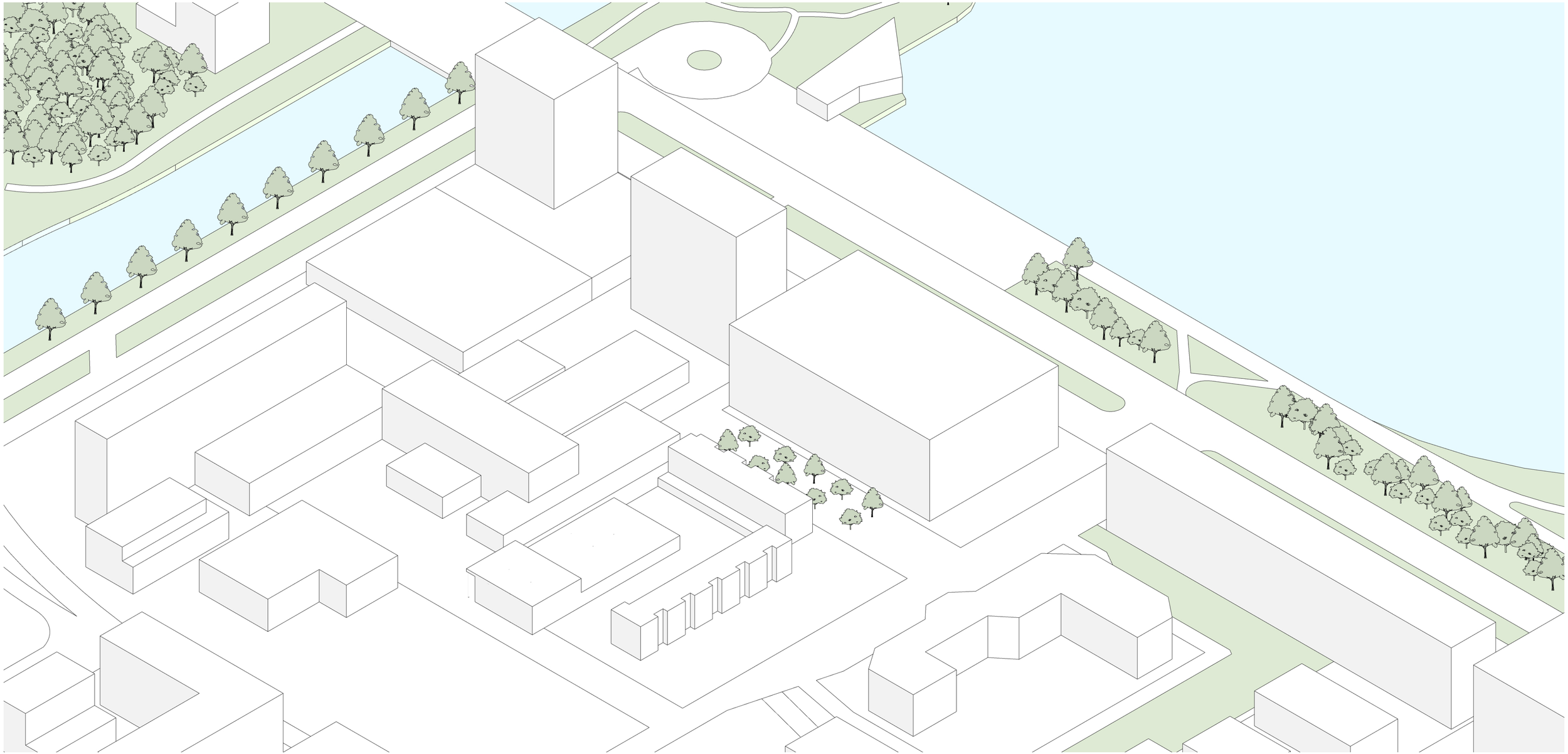
AMSTERDAM

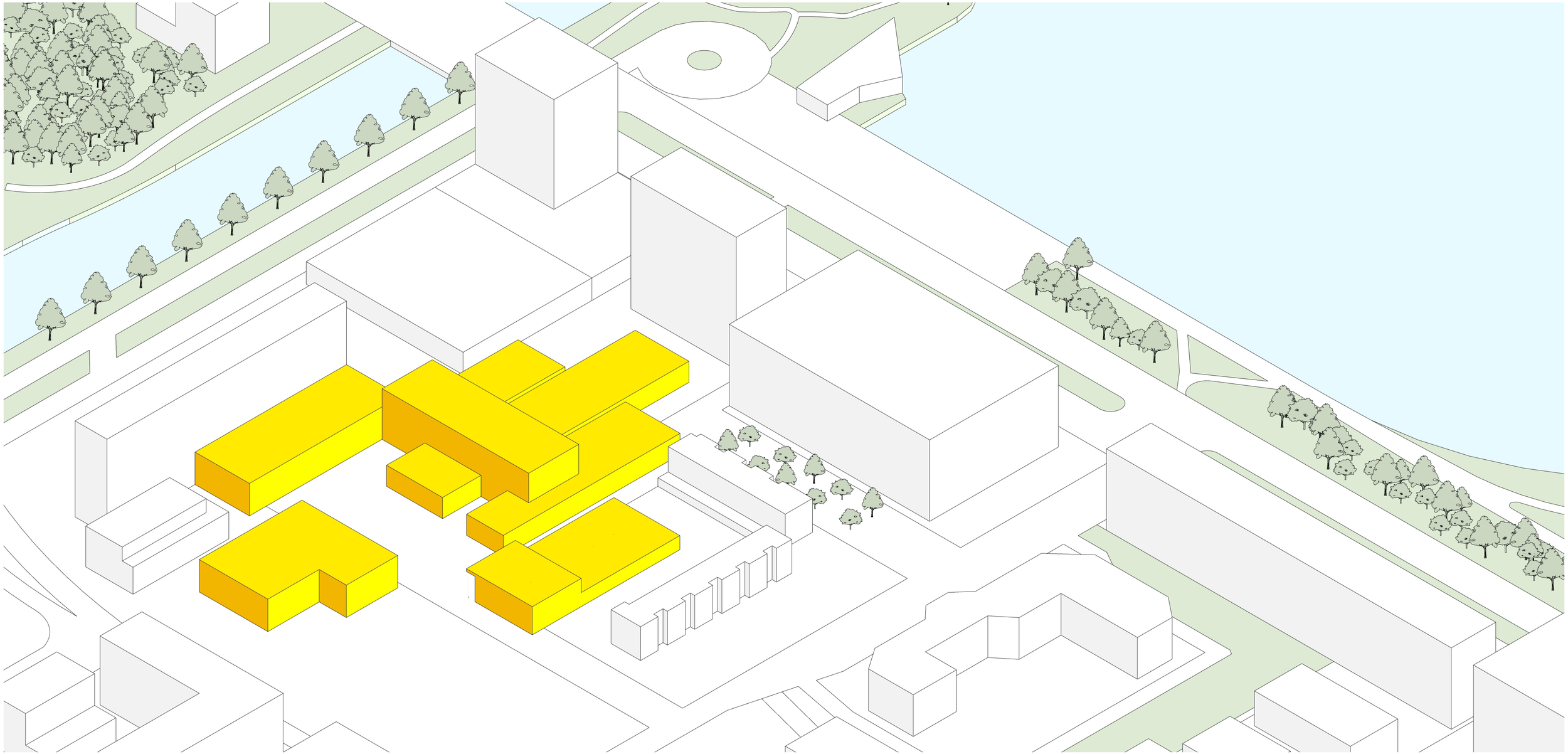
Local challenge: Dutch housing crisis, lack of affordable and fitting home, especially for starters

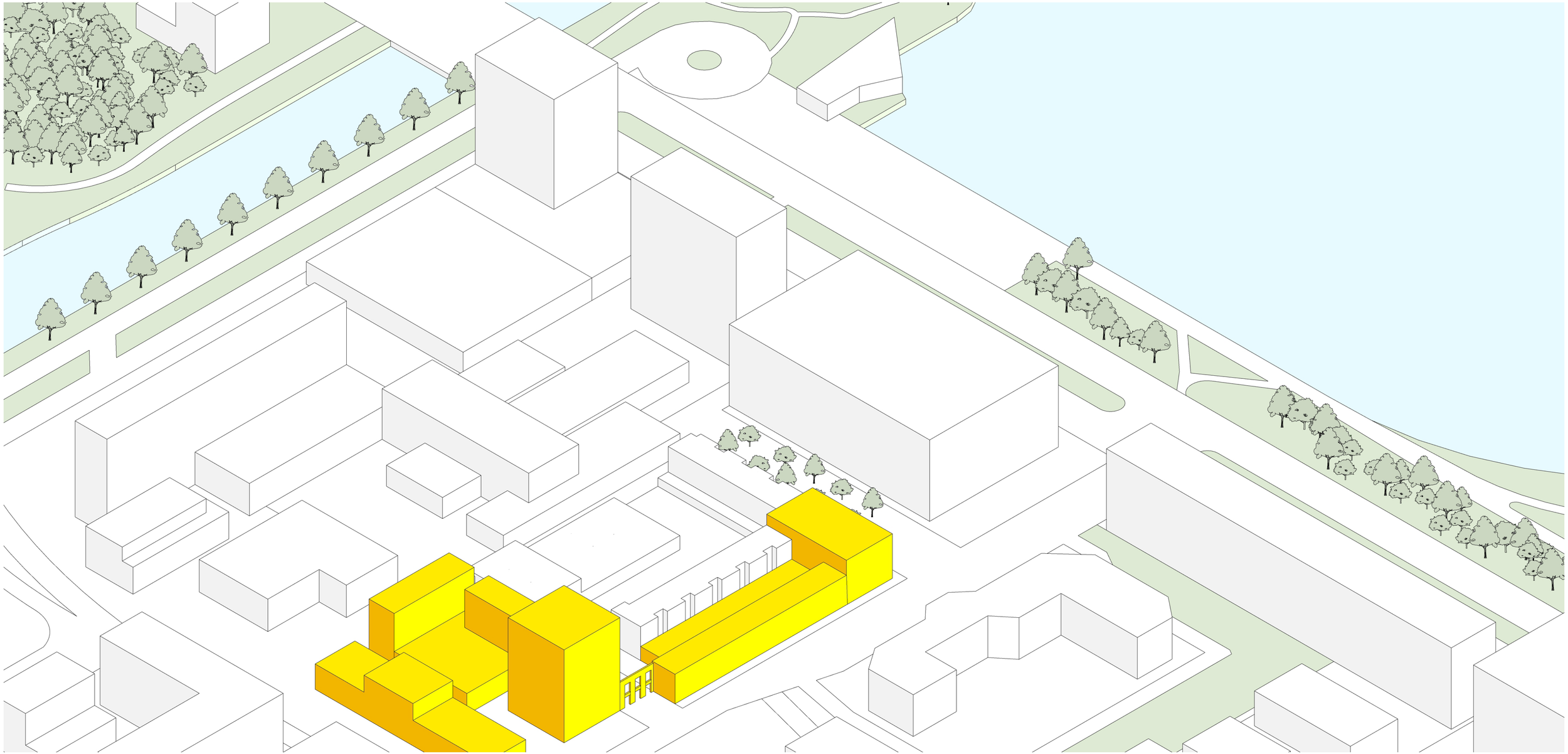
Target Group: Starters & Starting families

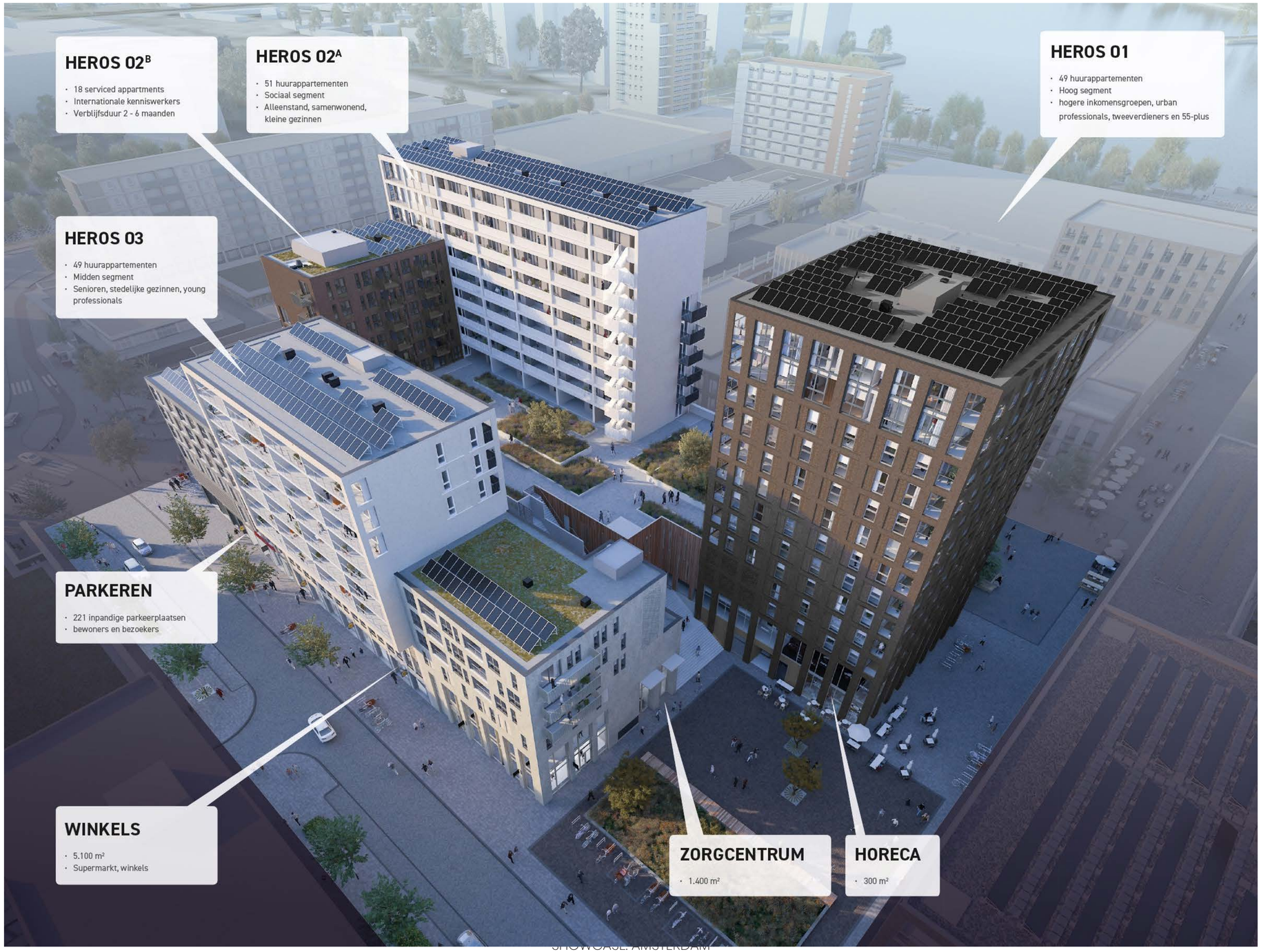




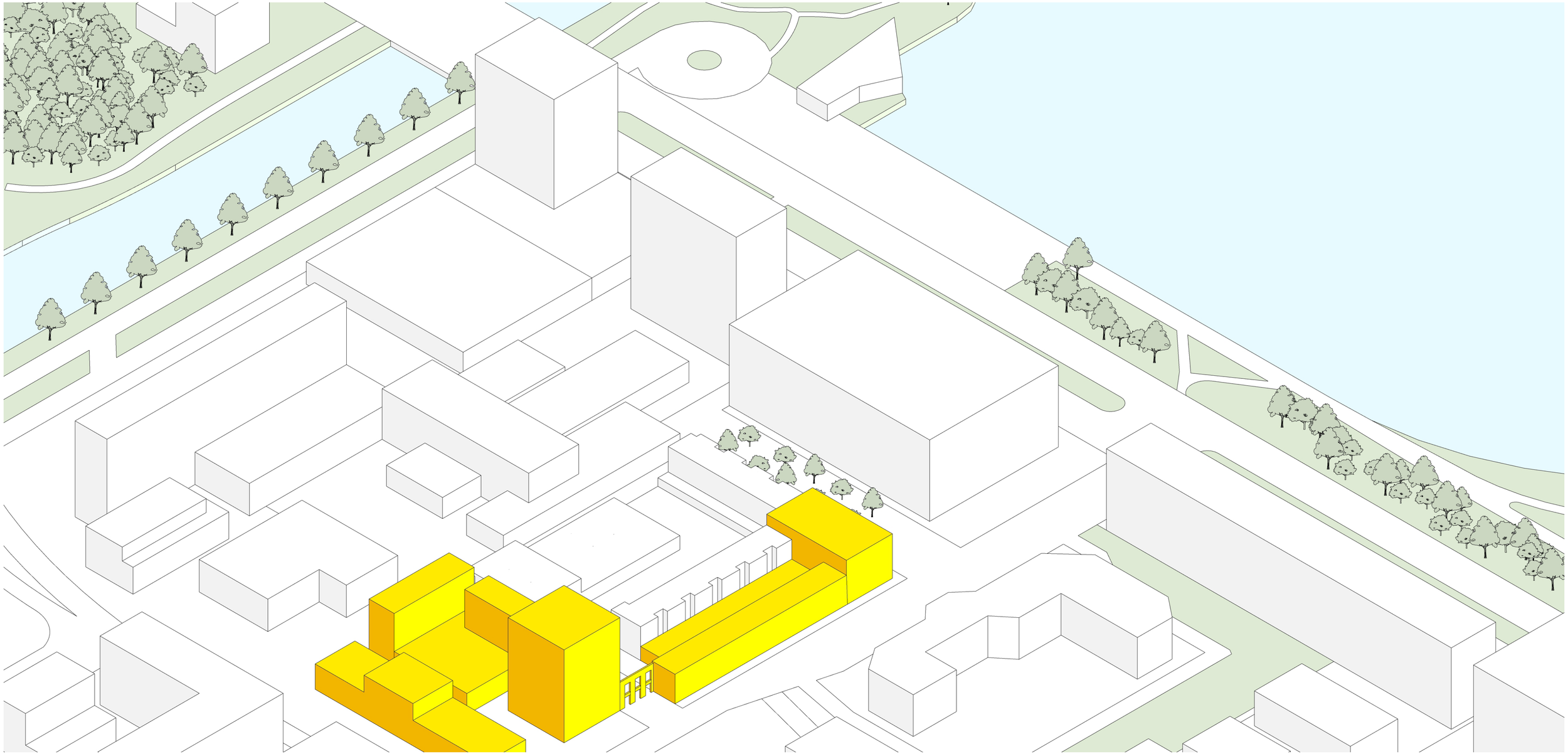


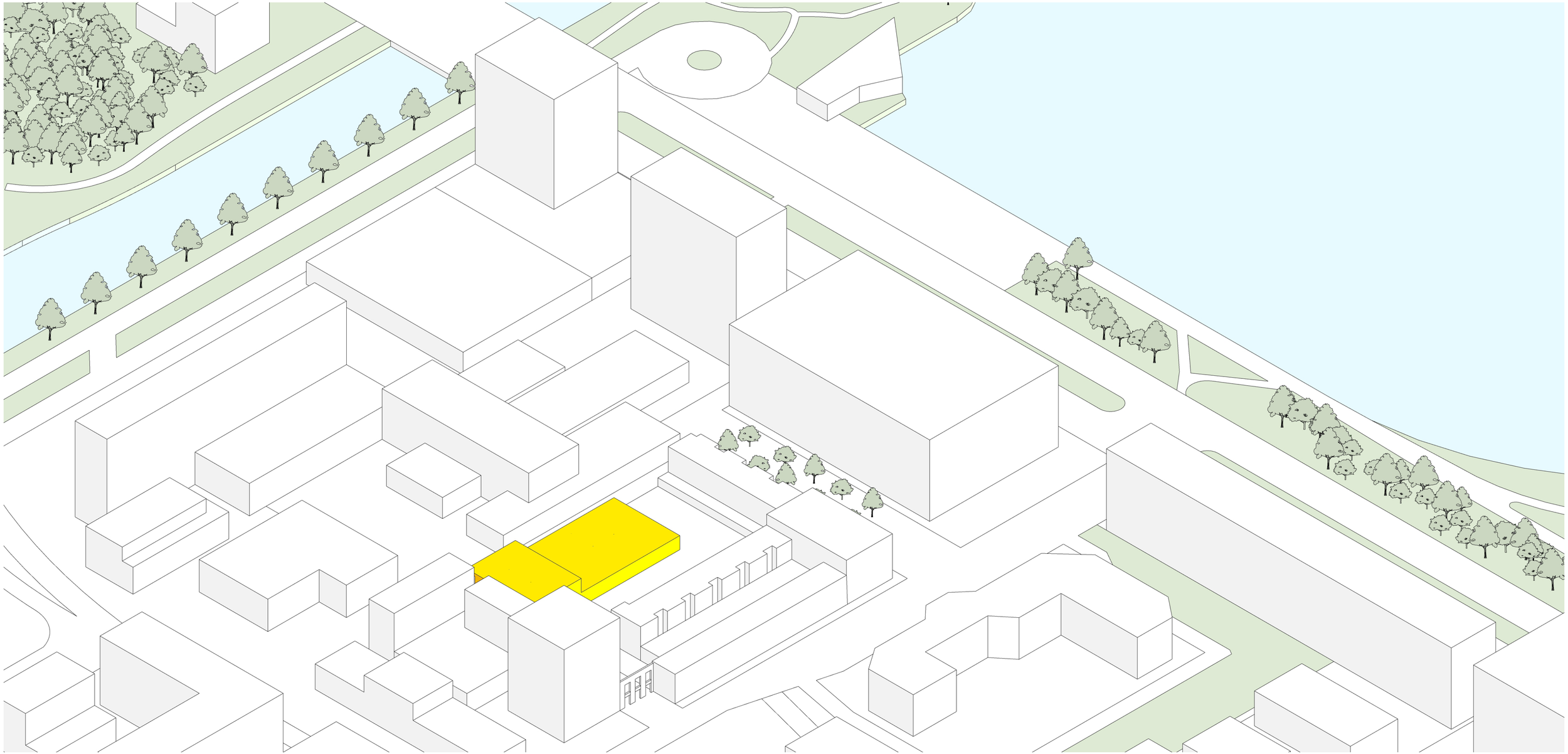




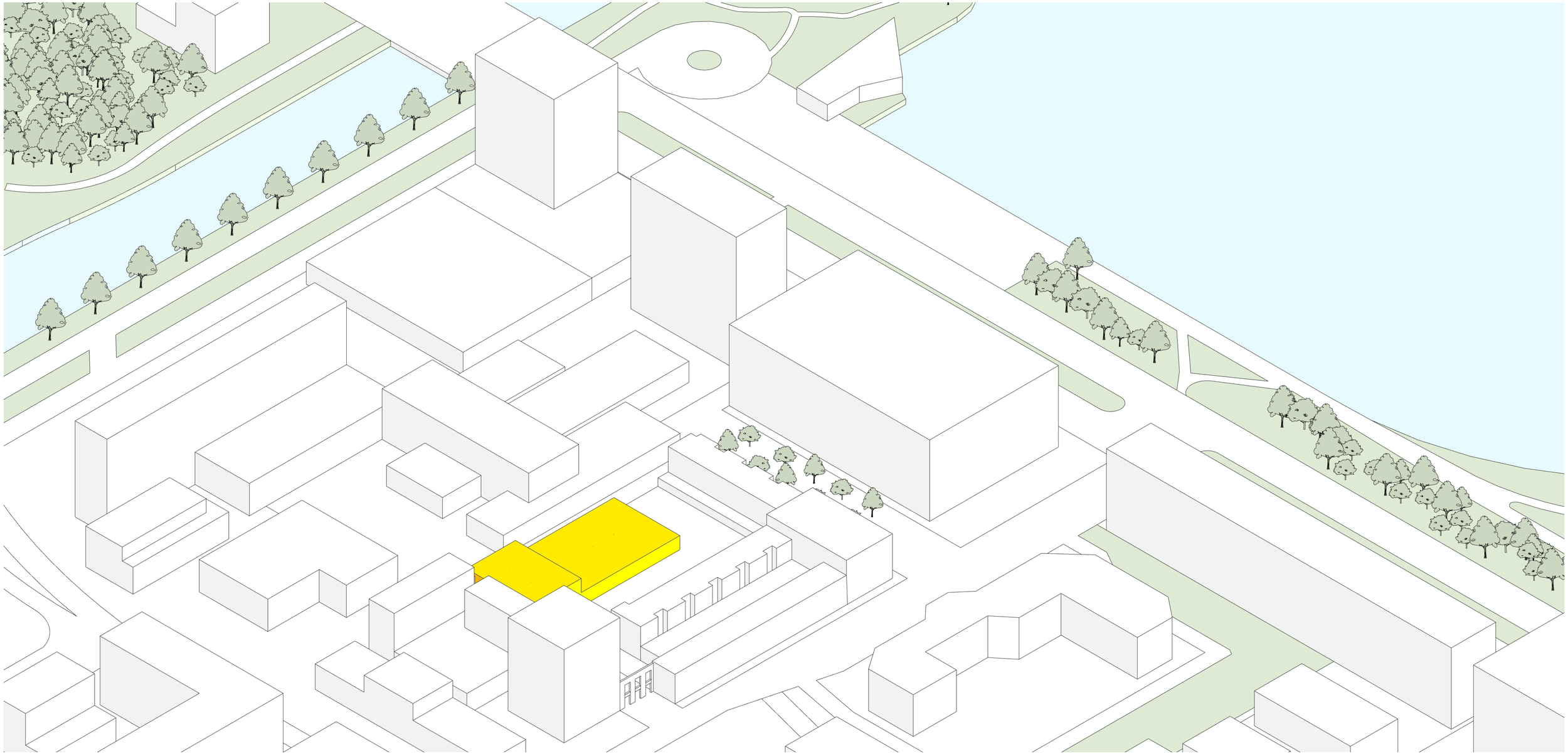

HEROS 02B
· 18 serviced appartments
· Internationale kenniswerkers
· Verblijfsduur 2 - 6 maanden
HEROS 02A
· 51 huurappartementen
· Sociaal segment
· Alleenstand, samenwonend, kleine gezinnen
HEROS 01
· 49 huurappartementen
· Hoog segment
· hogere inkomensgroepen, urban professionals, tweeverdieners en 55-plus
HEROS 03
· 49 huurappartementen
· Midden segment
· Senioren, stedelijke gezinnen, young professionals
PARKEREN
· 221 inpandige parkeerplaatsen
· bewoners en bezoekers
WINKELS
· 5.100 m²
· Supermarkt, winkels
ZORGCENTRUM
· 1.400 m²
HORECA
· 300 m²

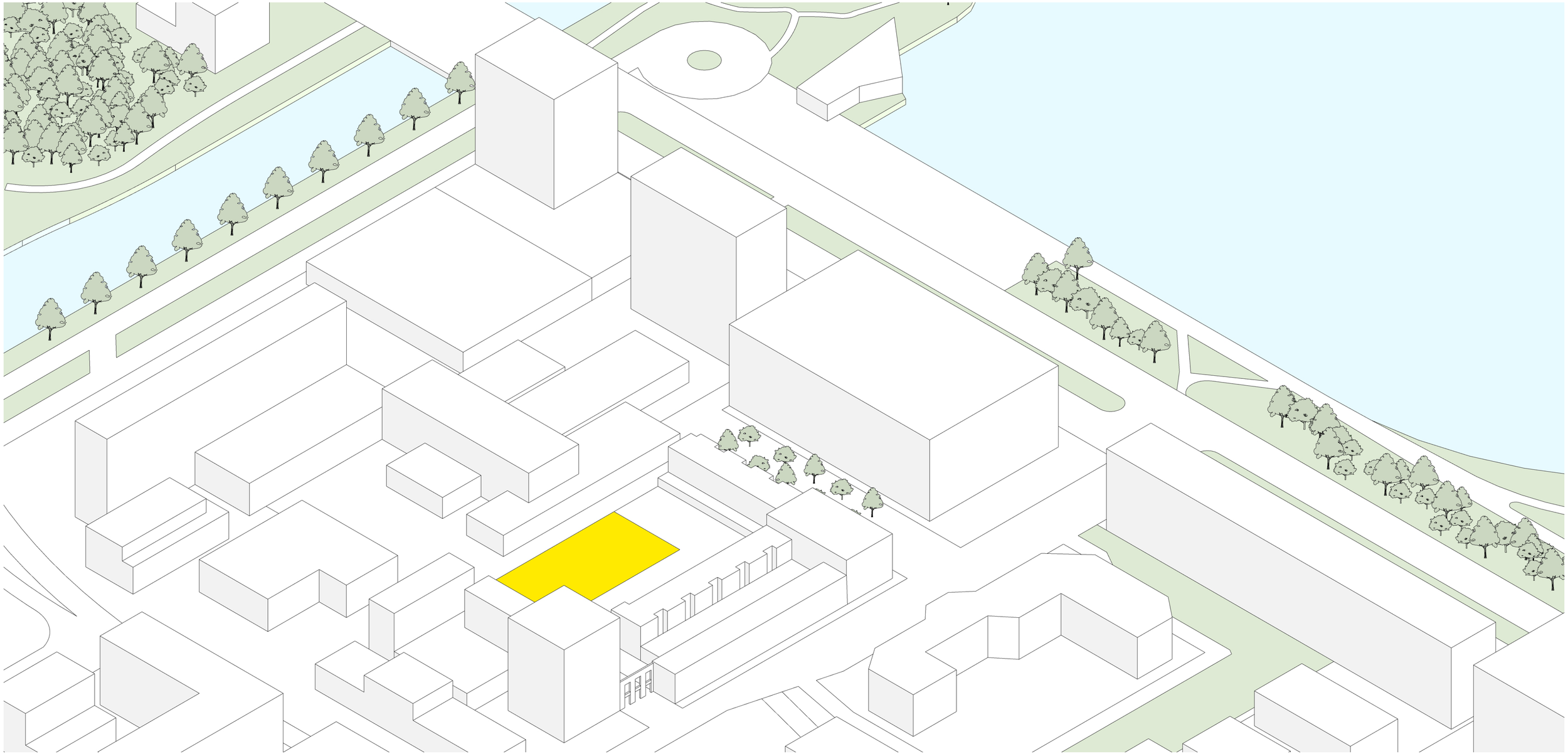


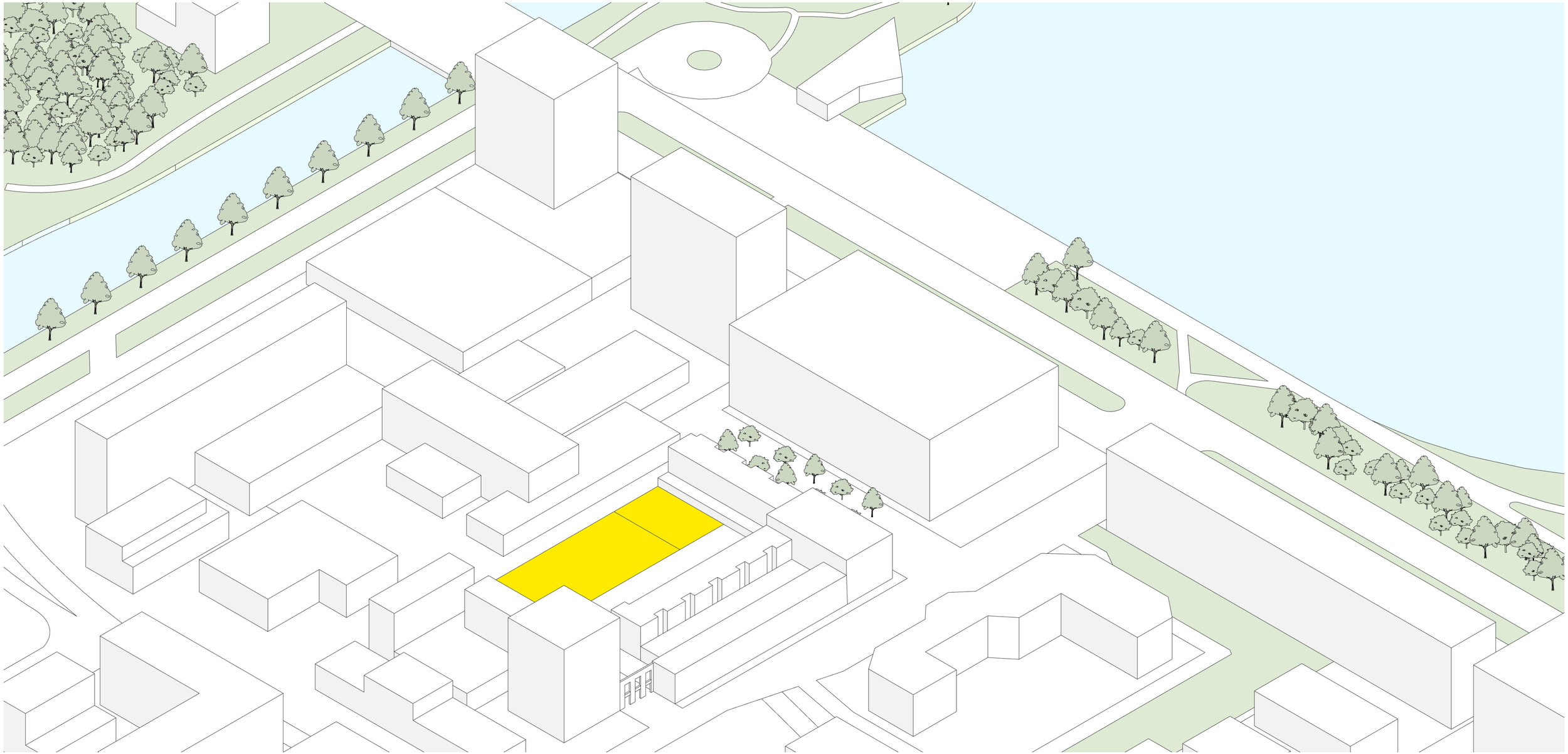


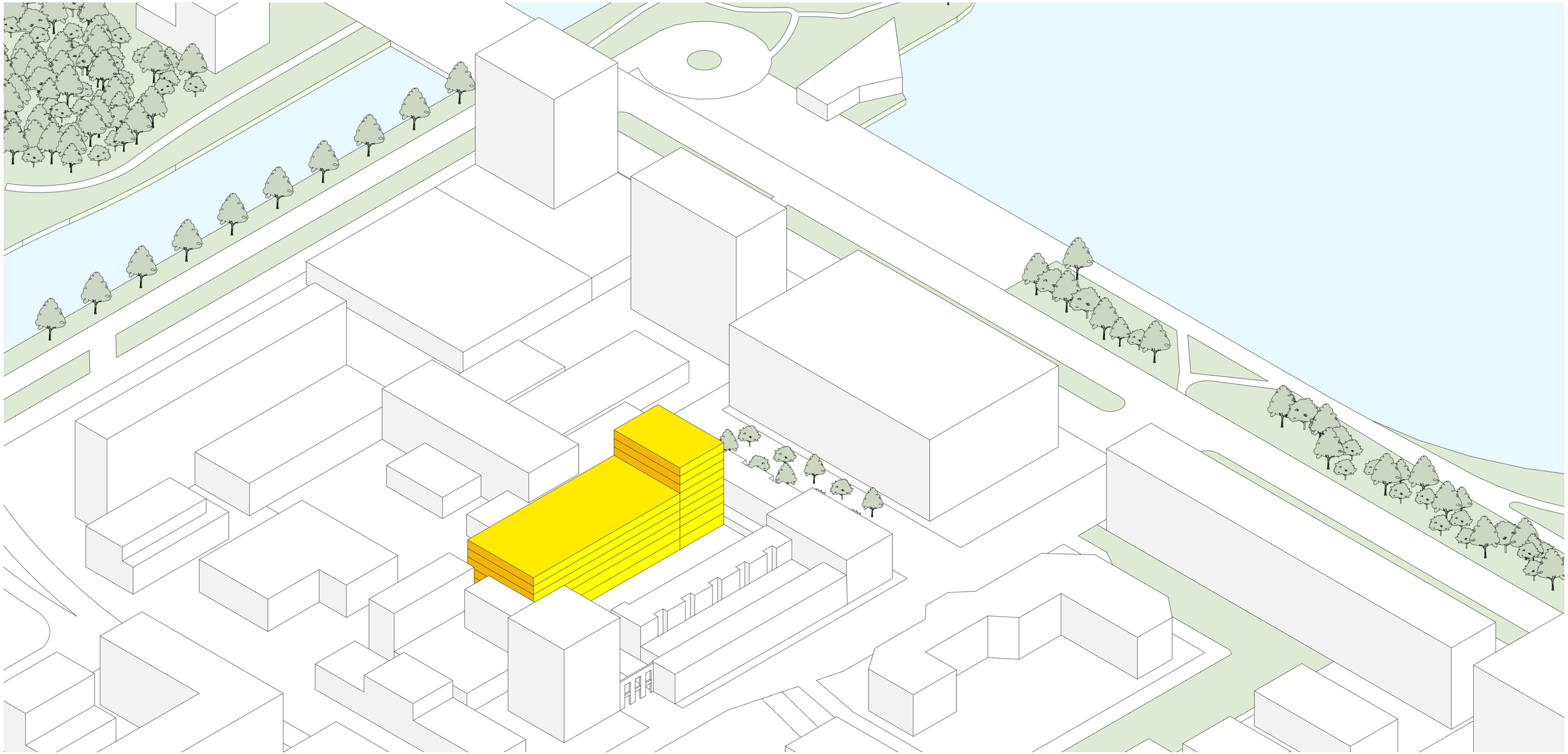


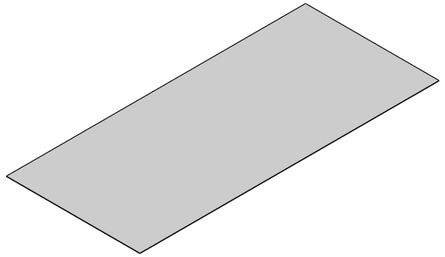

C&A
ACTION
ACTION
C&A
PINK DIAMOND



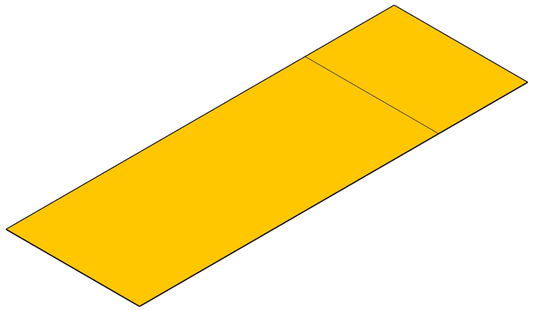




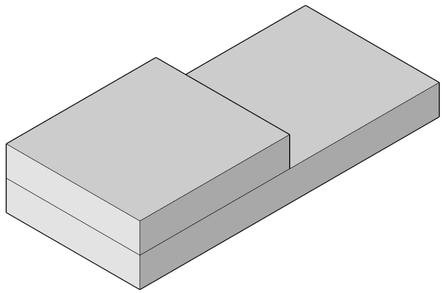




Old Footprint: 1.500 m²

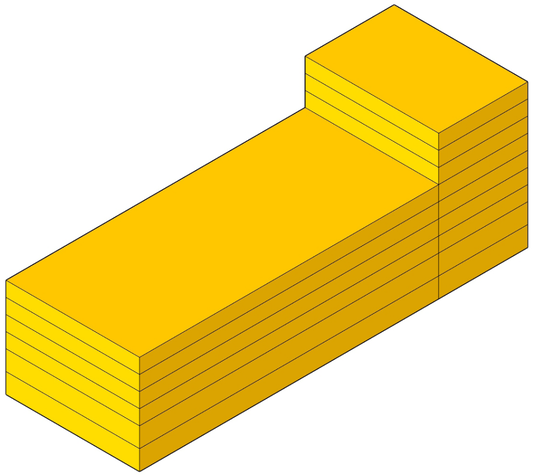


New Footprint: 2.000 m²



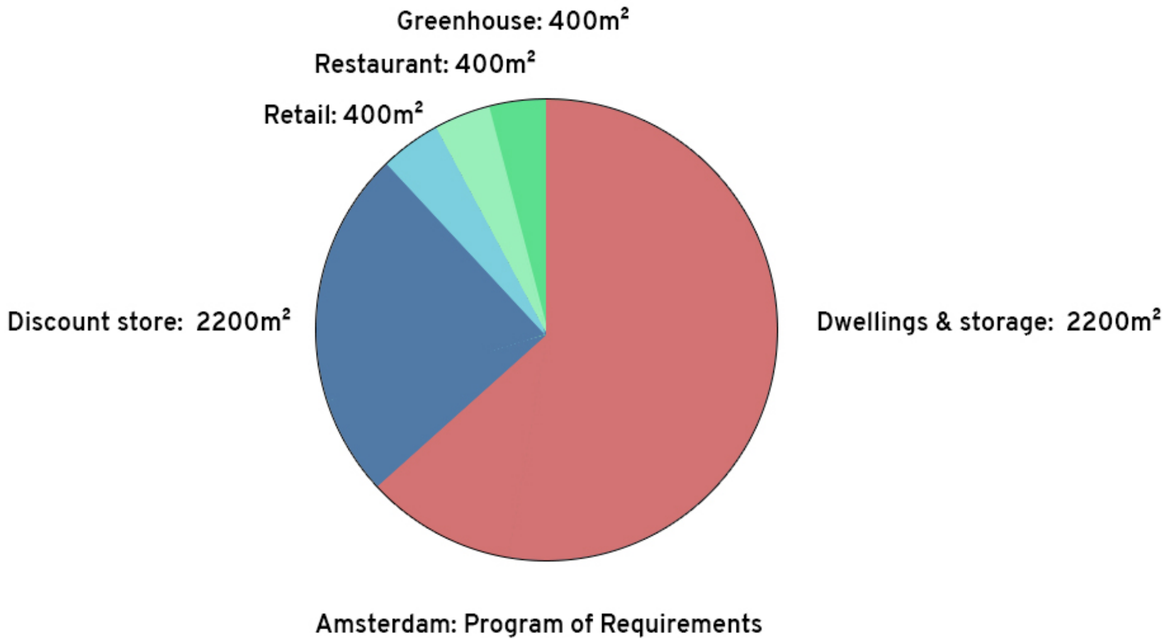
Old floor space: ~2.200 m²

- Heavyweight concrete construction
- Two double height floors

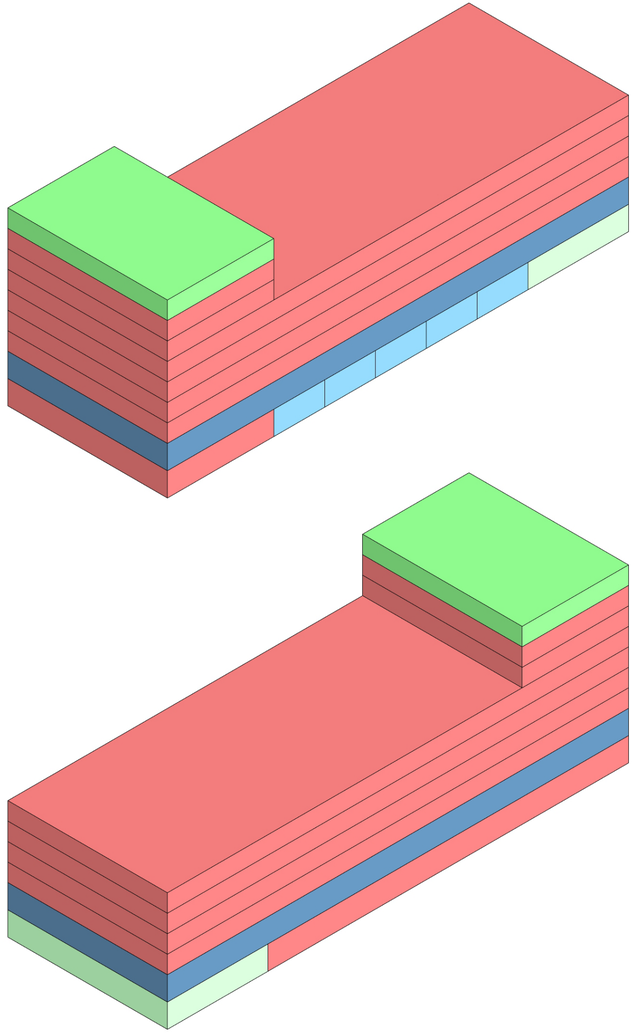


New floor space: max ~13.500 m²

- Lightweight wooden construction
- Six floors on old foundation, nine on new foundation

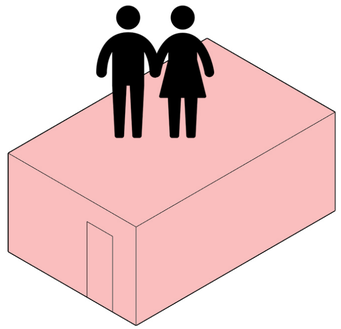


Amsterdam: Program of Requirements



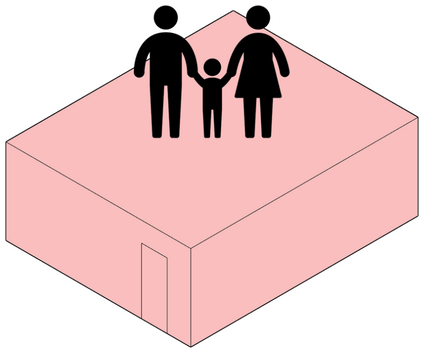
Type A

Couple
30 - 40m²



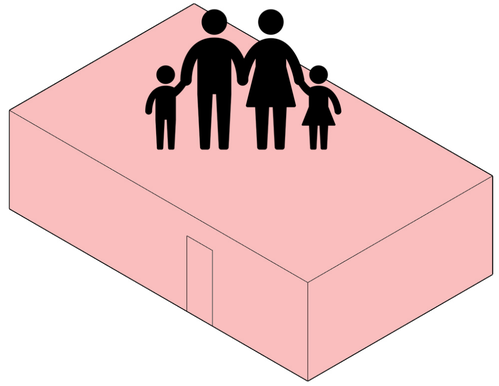
Type B

3-person household
55- 60 m²



Type C

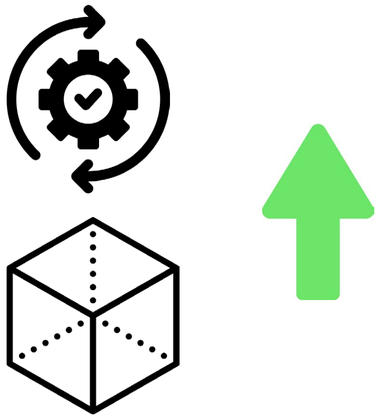
4-person household
70 - 75 m²





Loss of individual (spatial) value on dwelling scale

- Smaller dwellings
- Fewer possibilities for social interactions, events, leasure, in private dwelling



Maximize efficiency available space

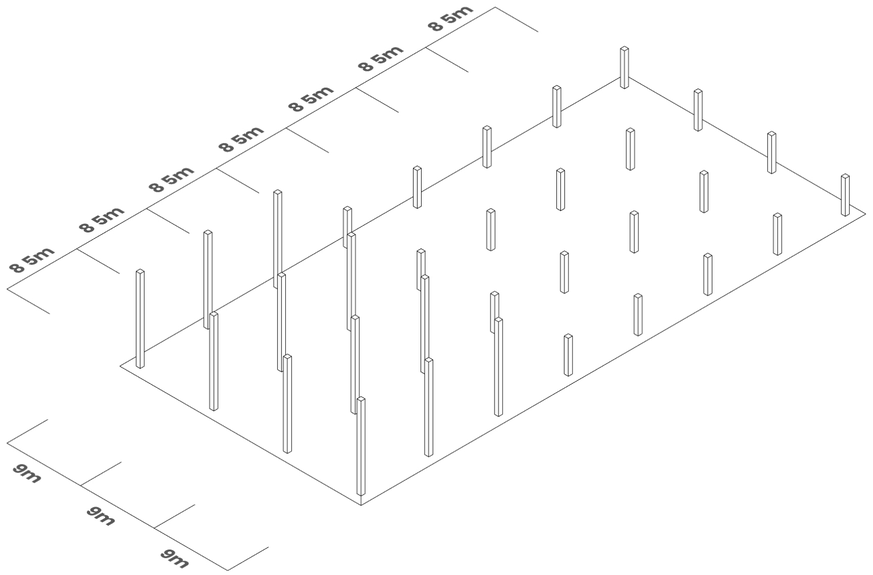
- Remove dedicated circulation space
- Integrate storage
- Maximize feeling of spatiousness



Opportunity: Introduce community (spatial) value on building scale

- Bring back lost values in shared environment.
- Sharing saves money & brings people together
- Encourages feeling of community & social interaction

BUILDING DESIGN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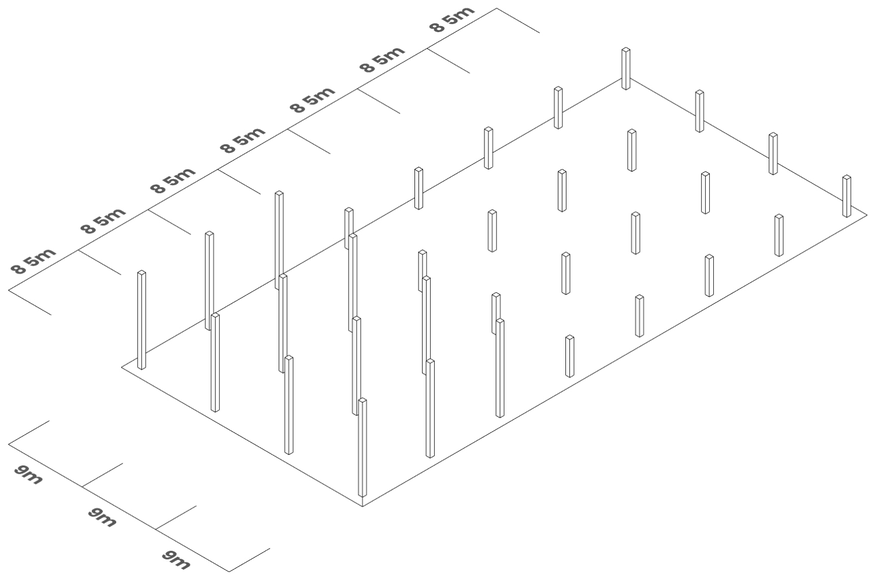
CHALLENGE 1: DEALING WITH THE EXISTING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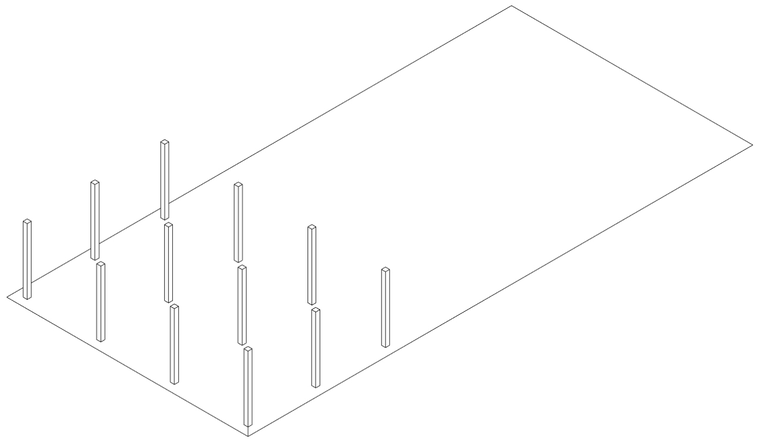

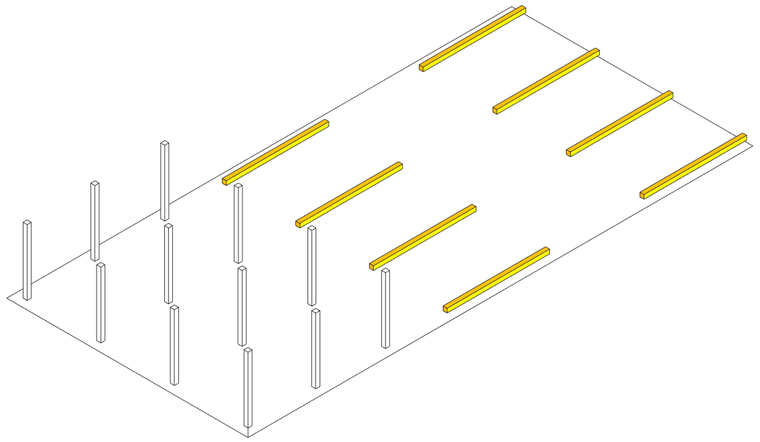

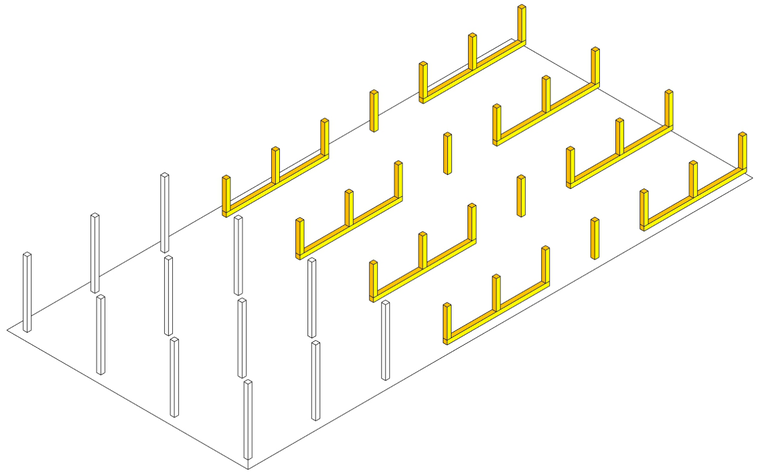

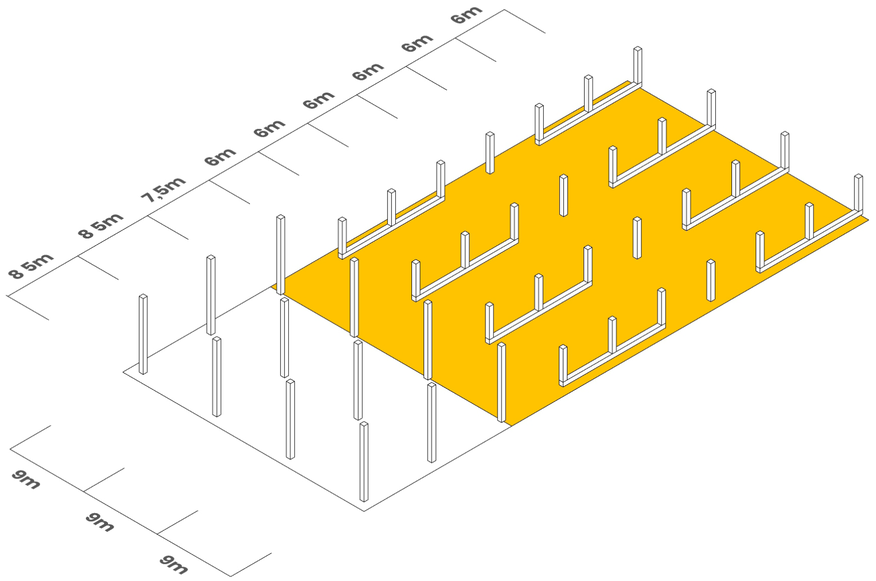
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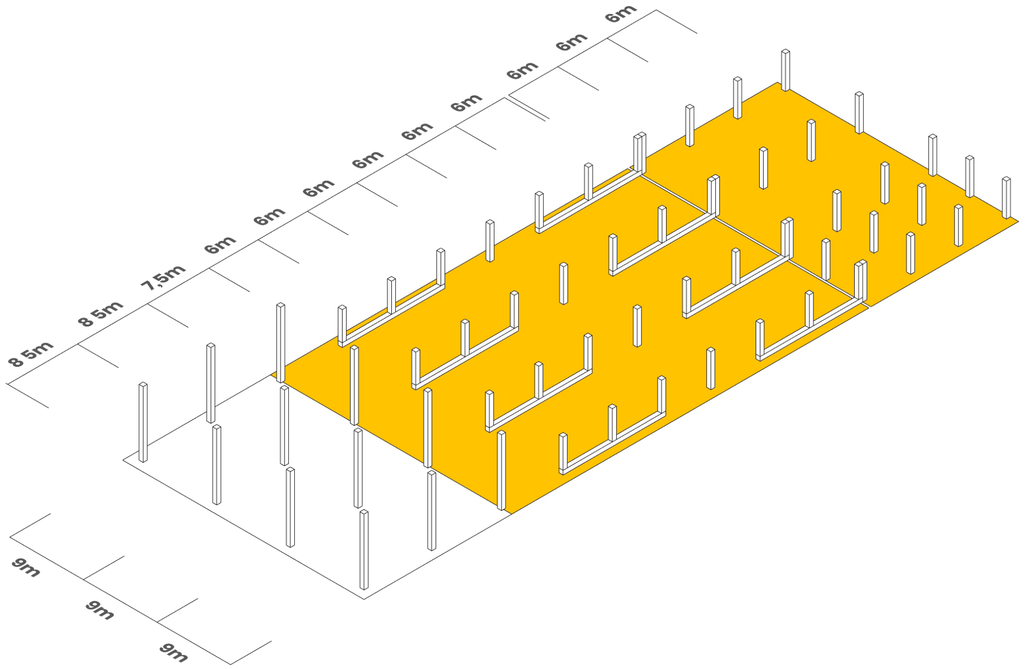
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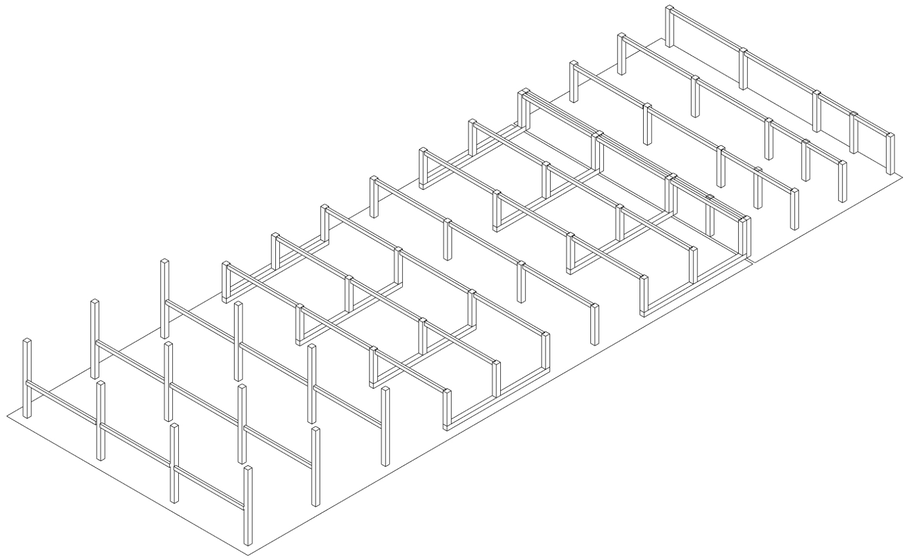

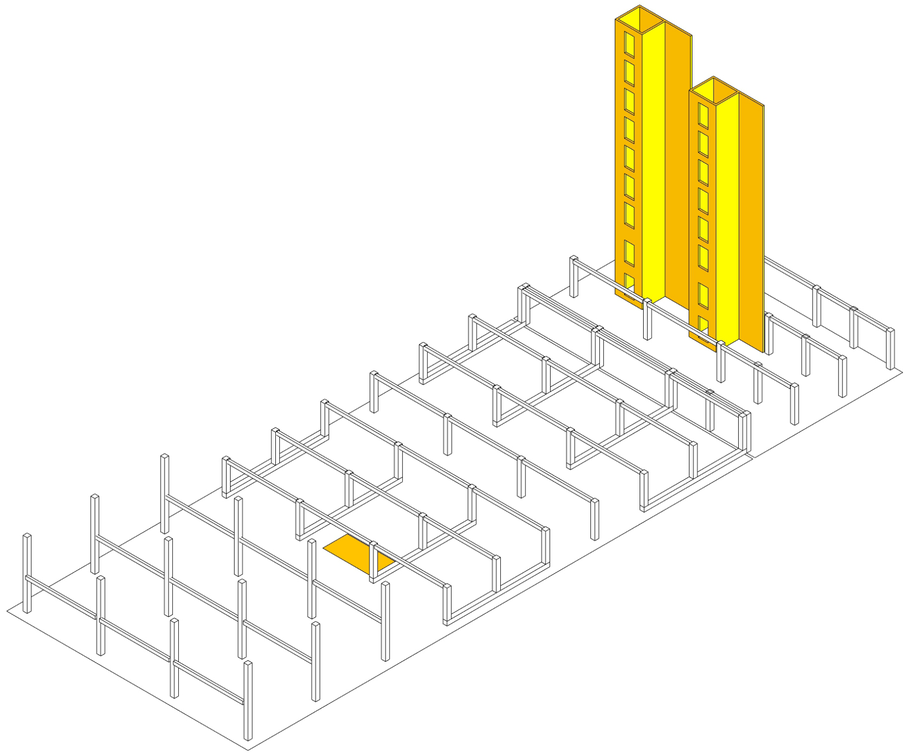

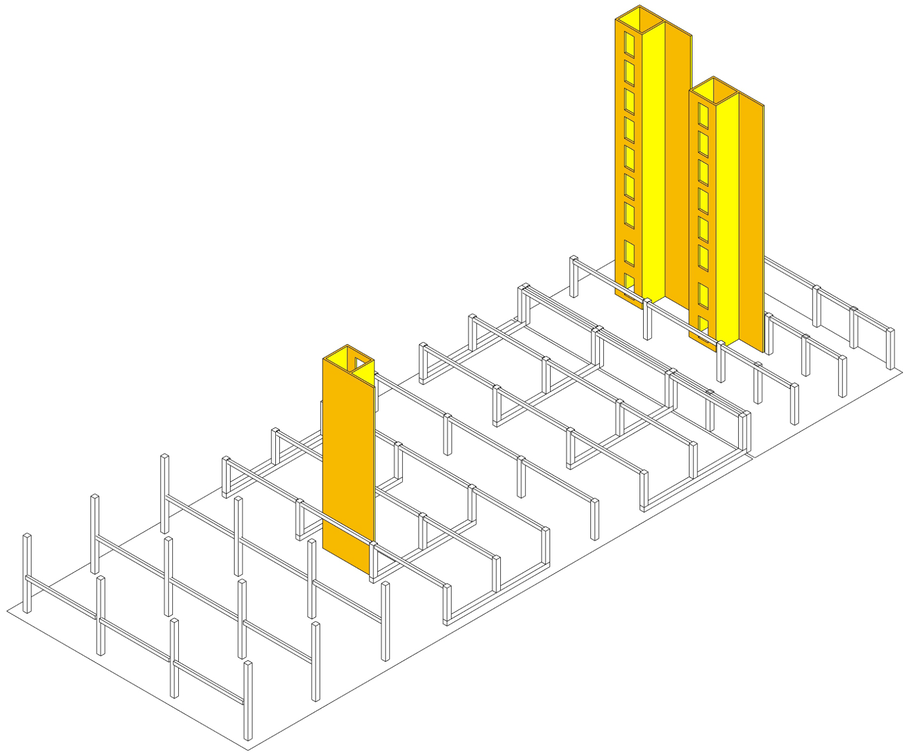

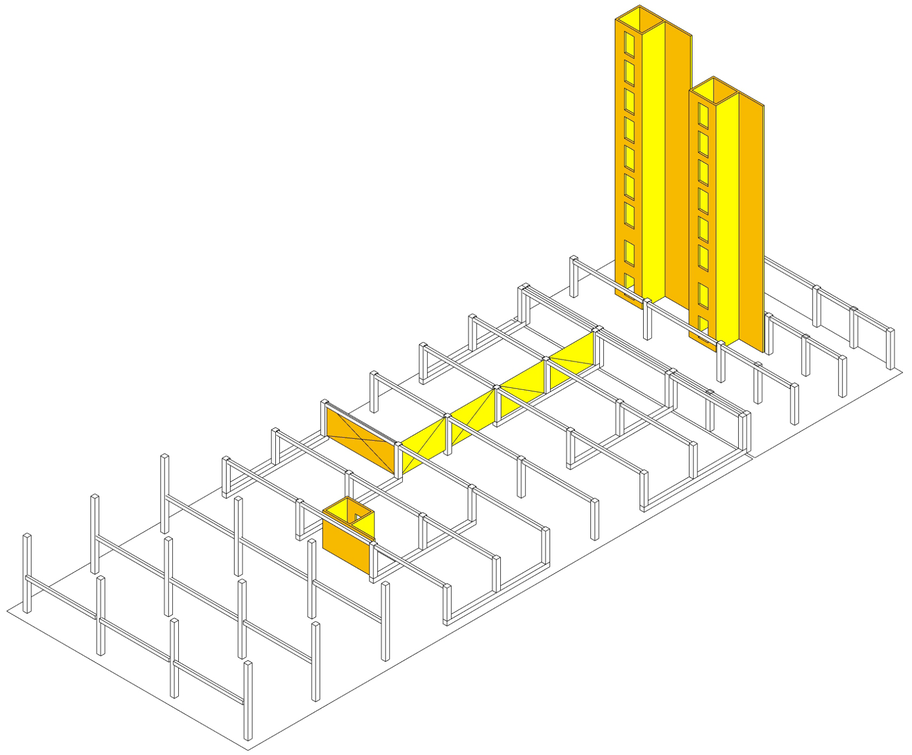

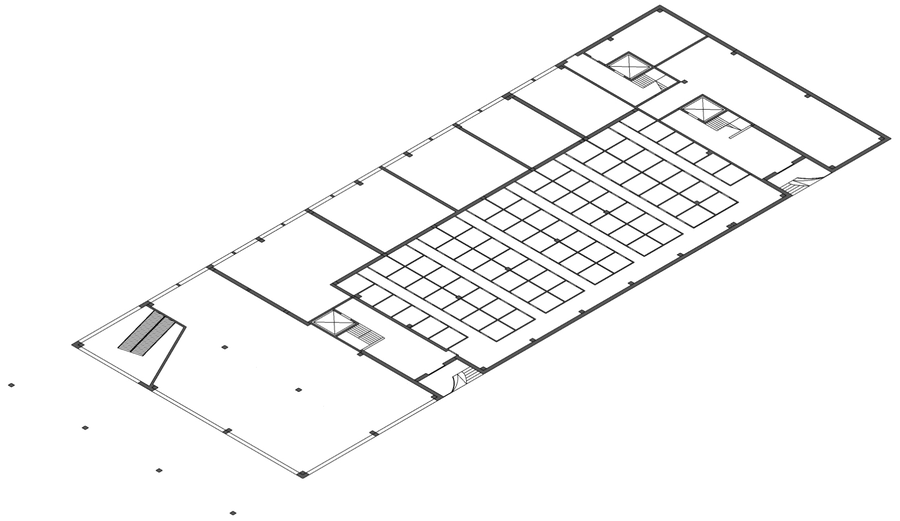

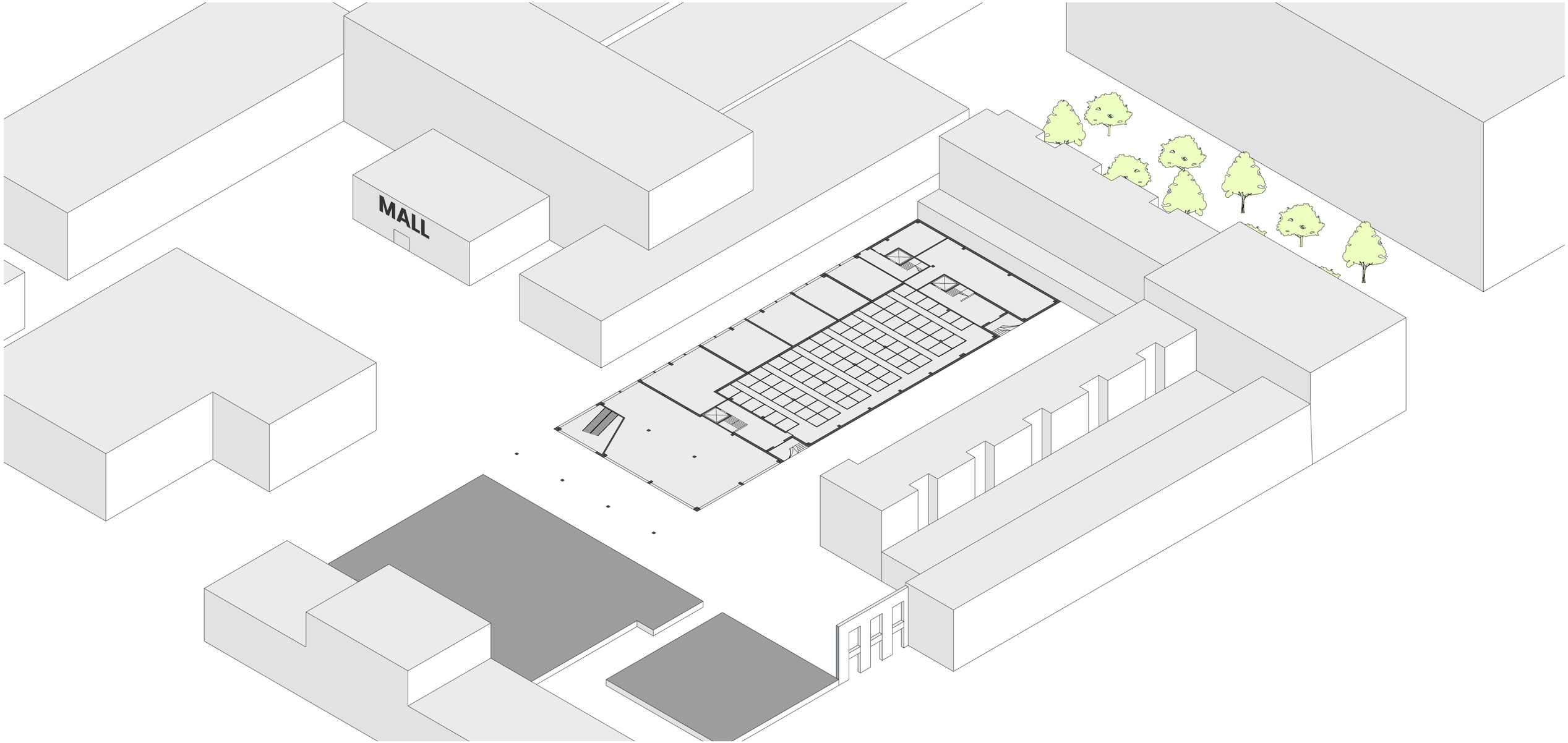
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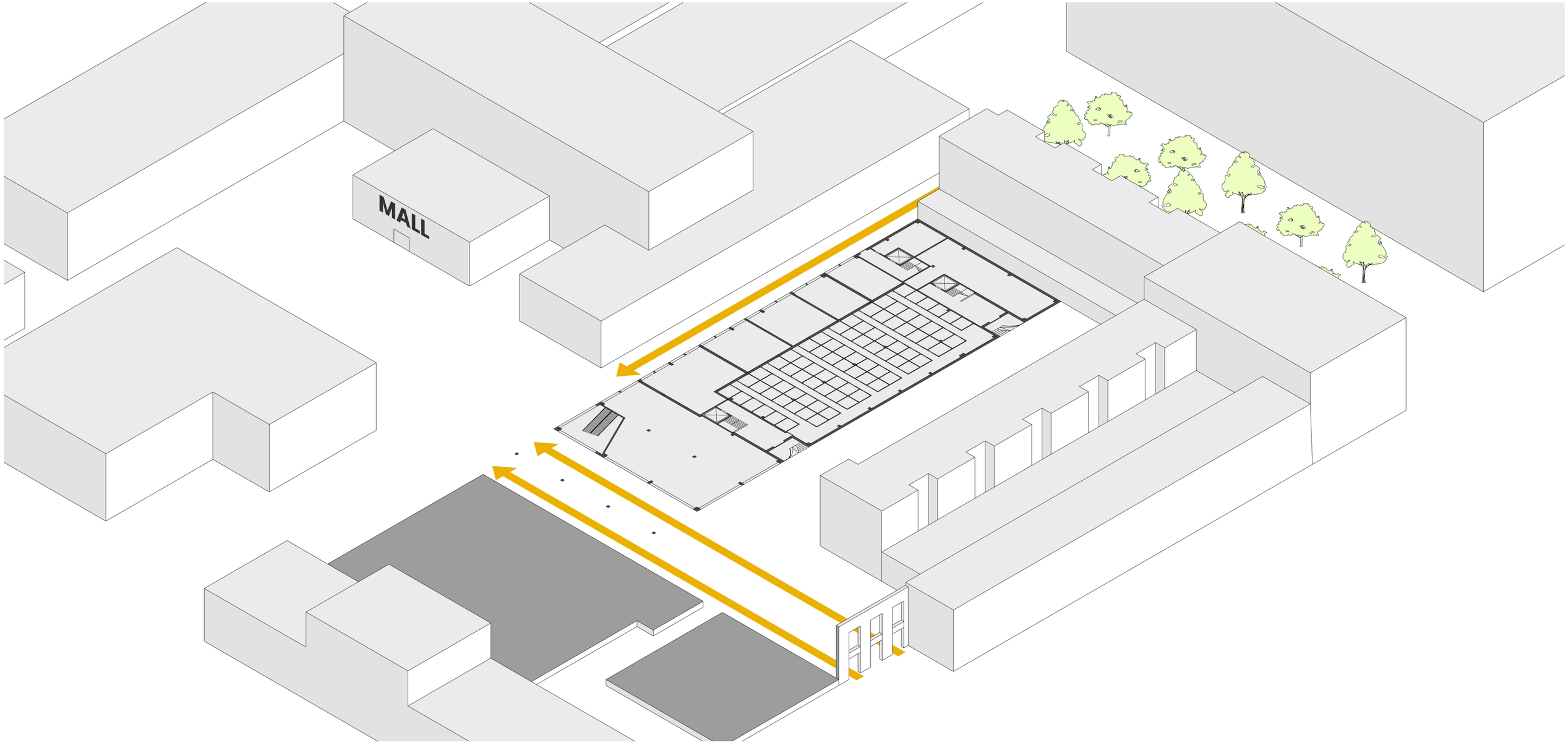
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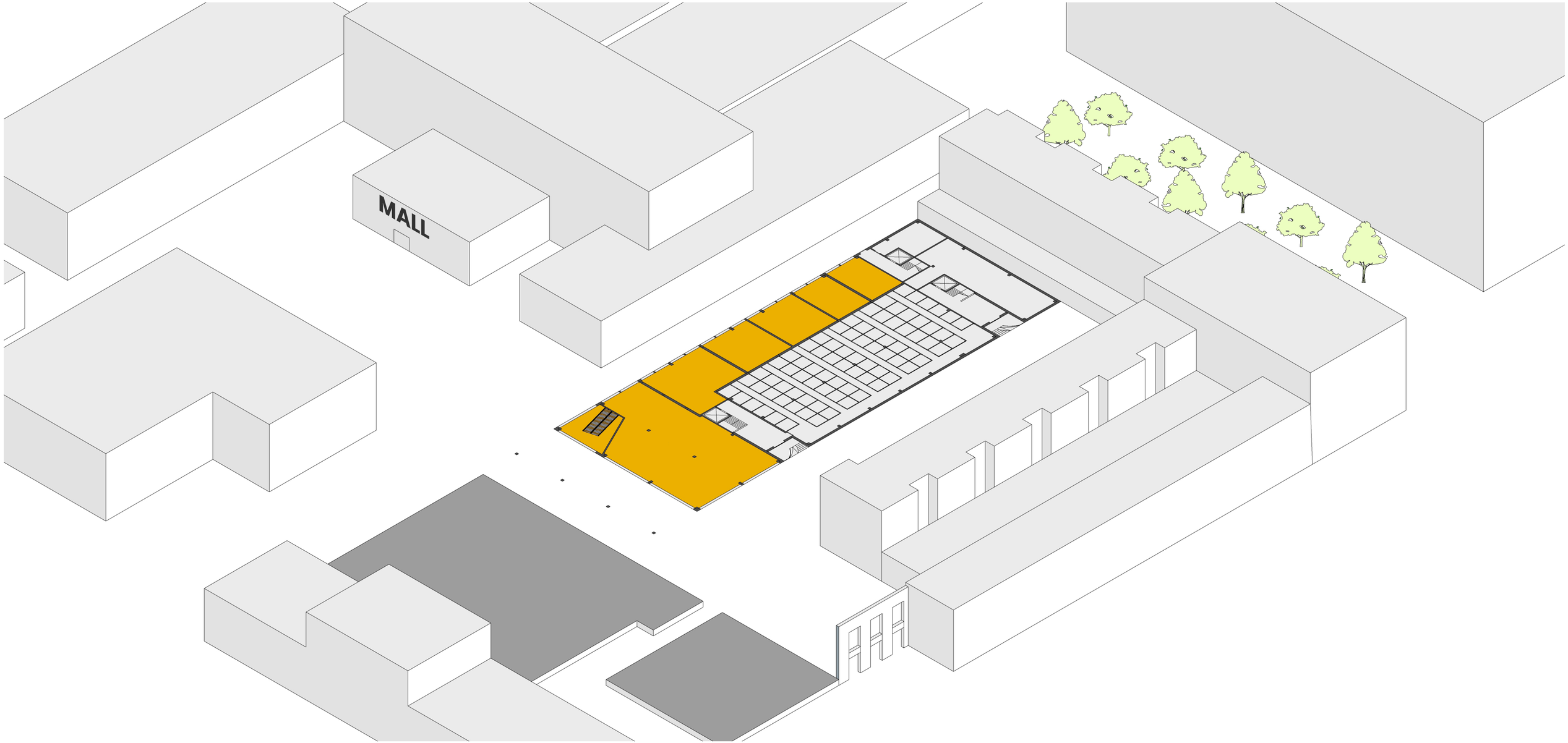
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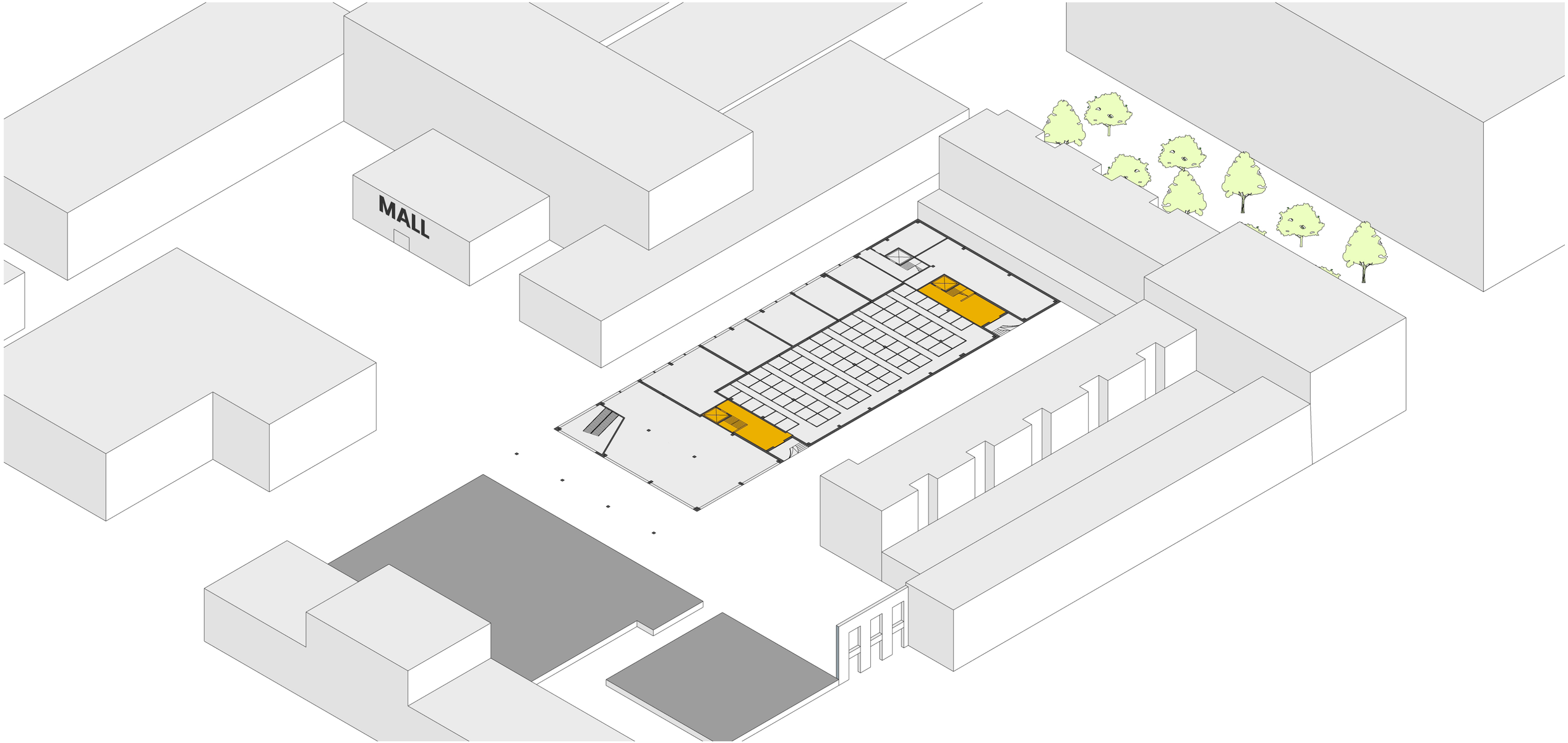
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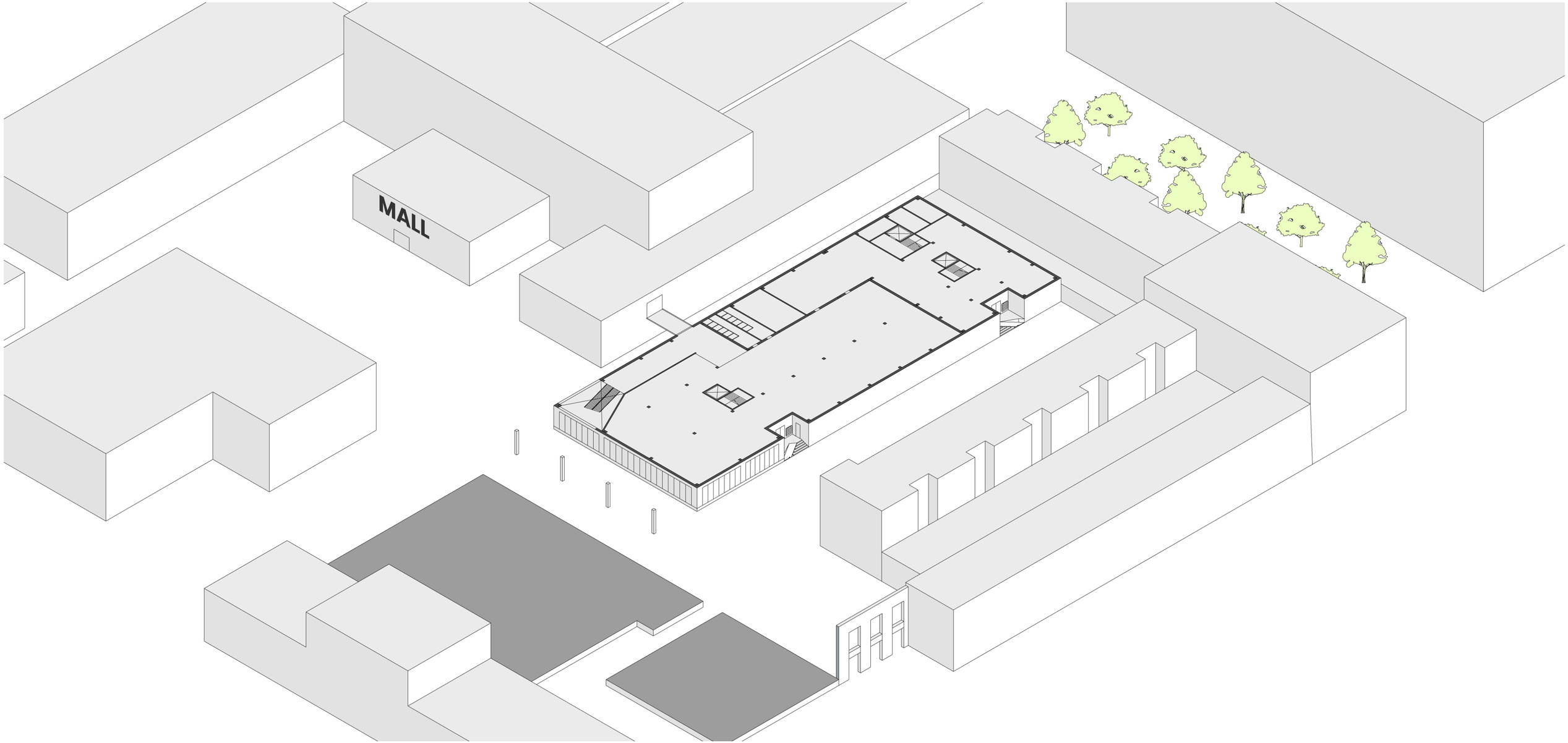
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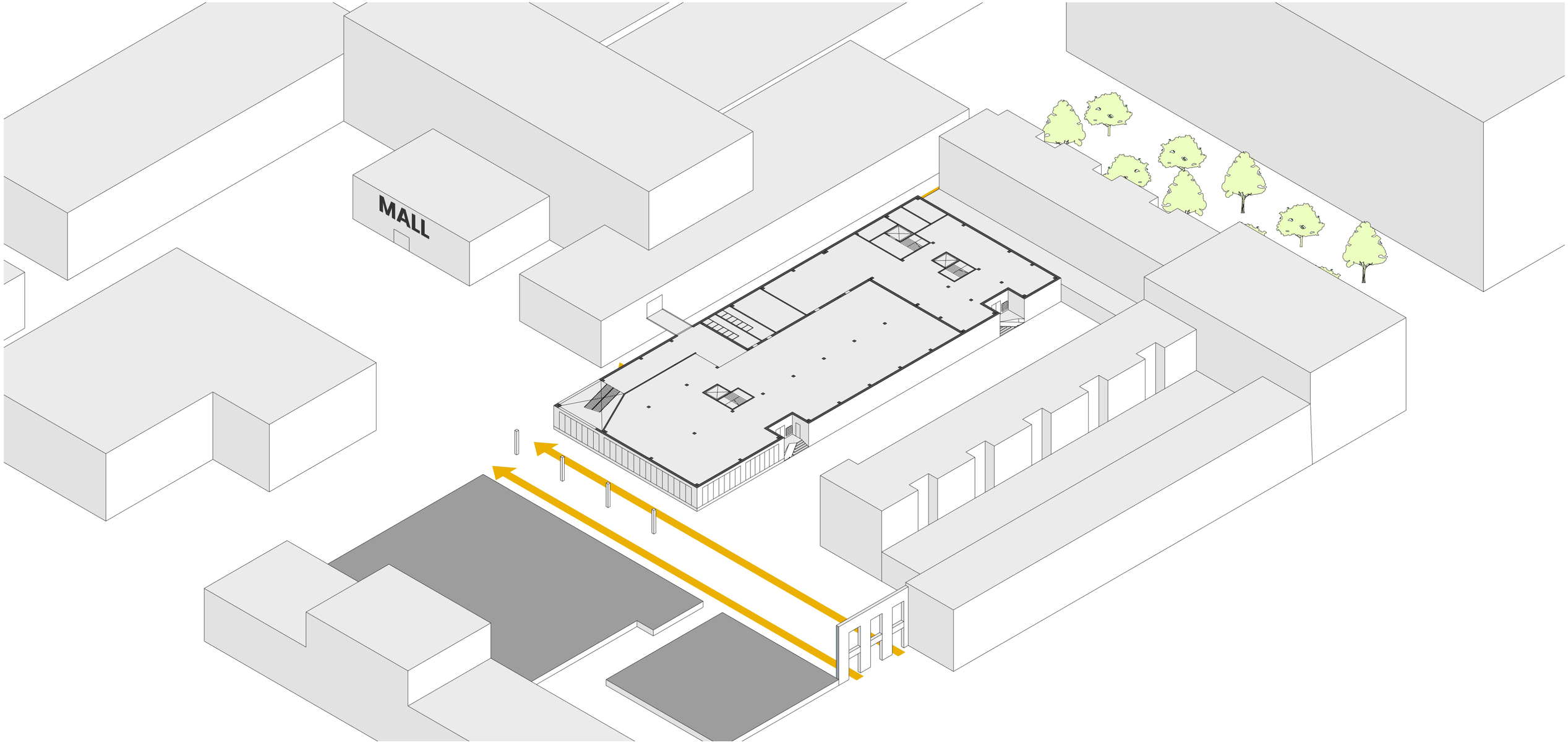
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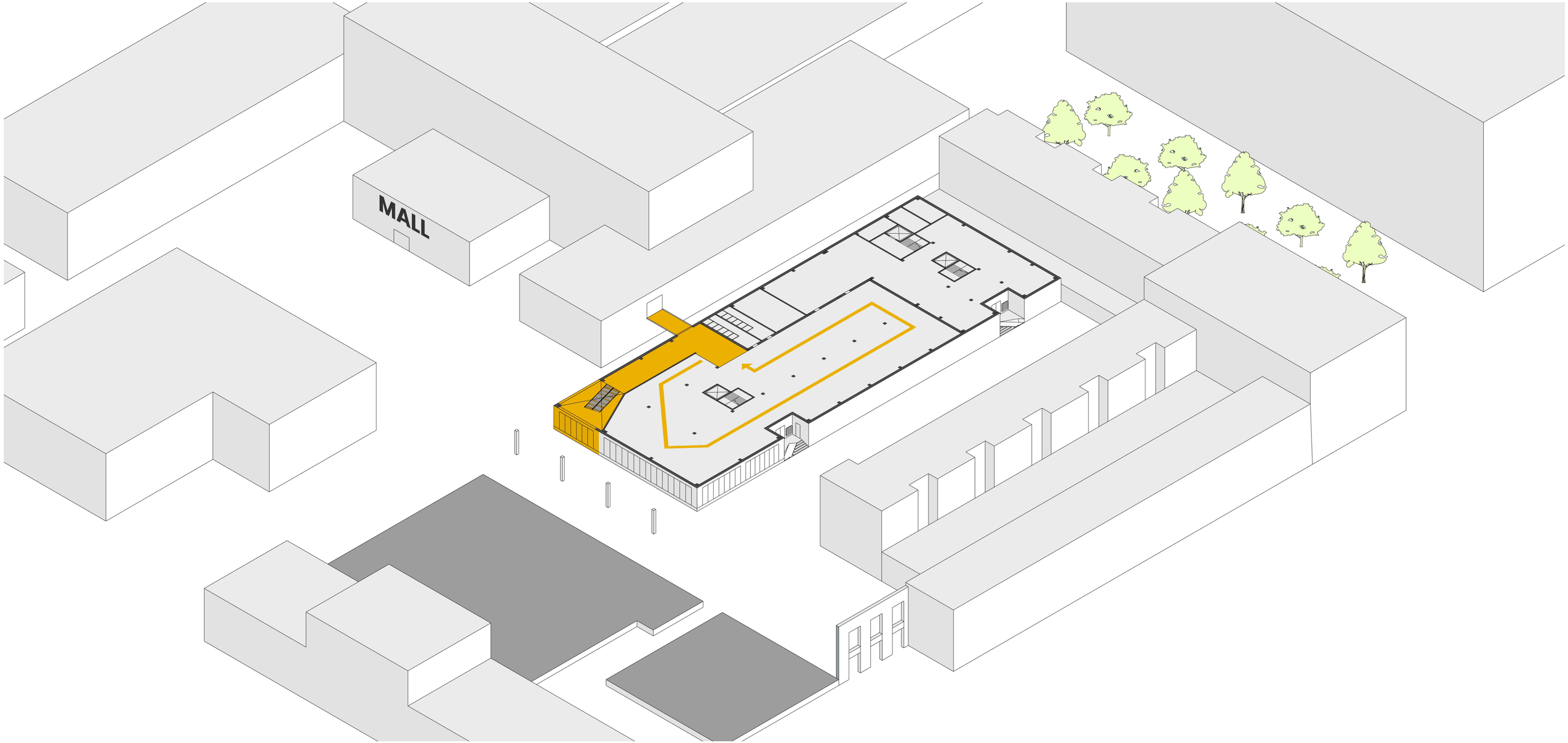
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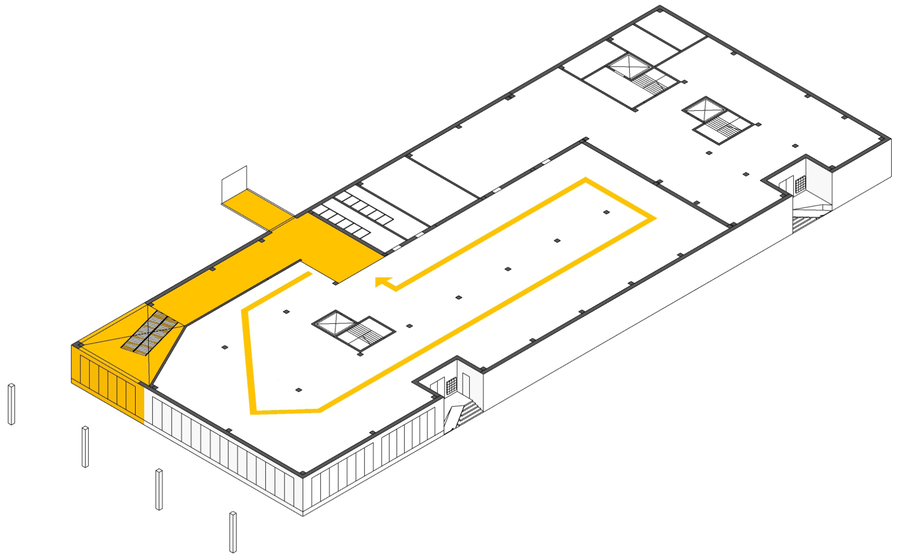

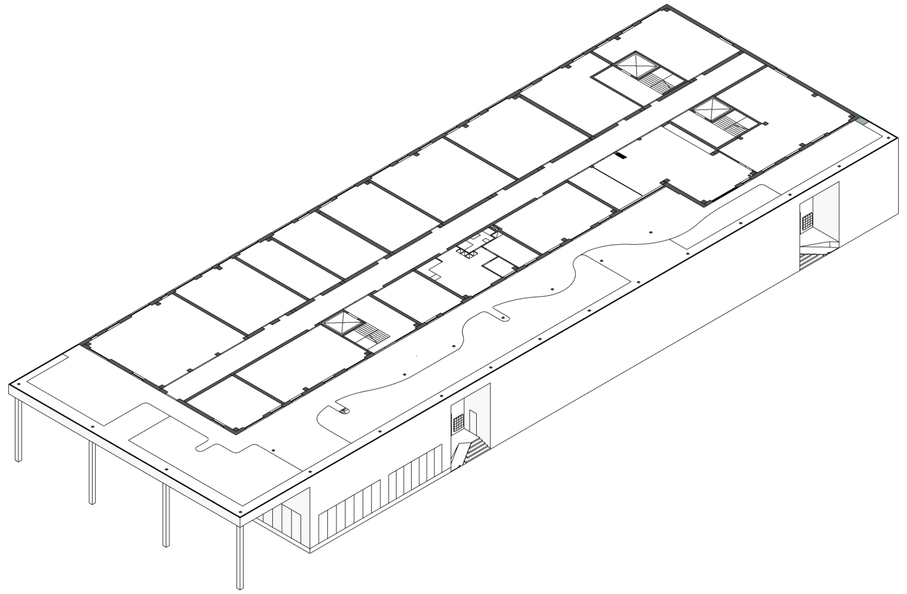

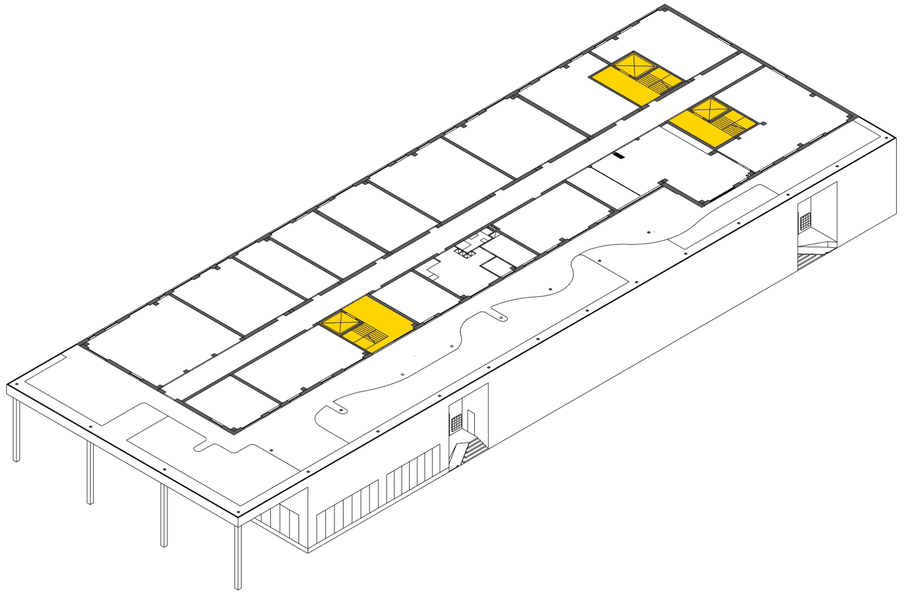

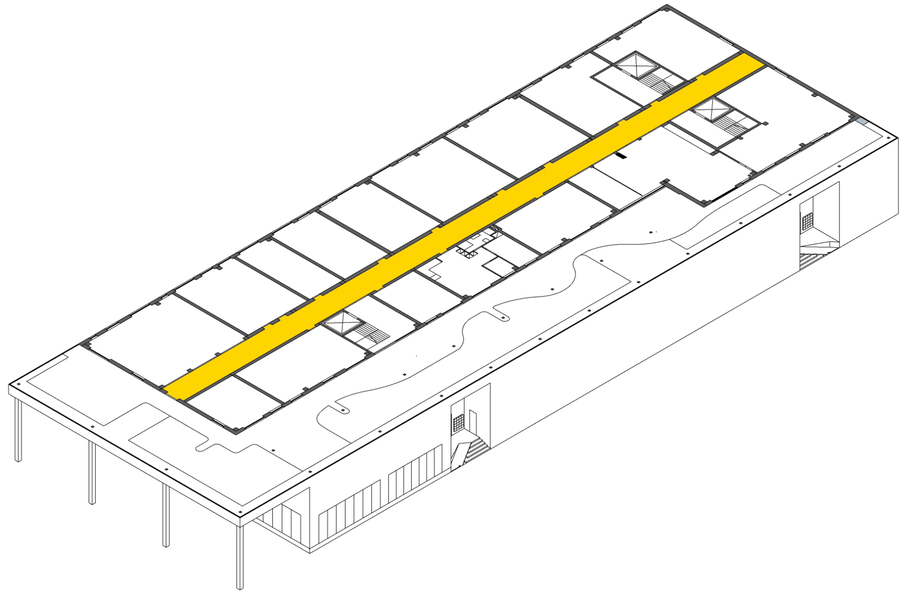

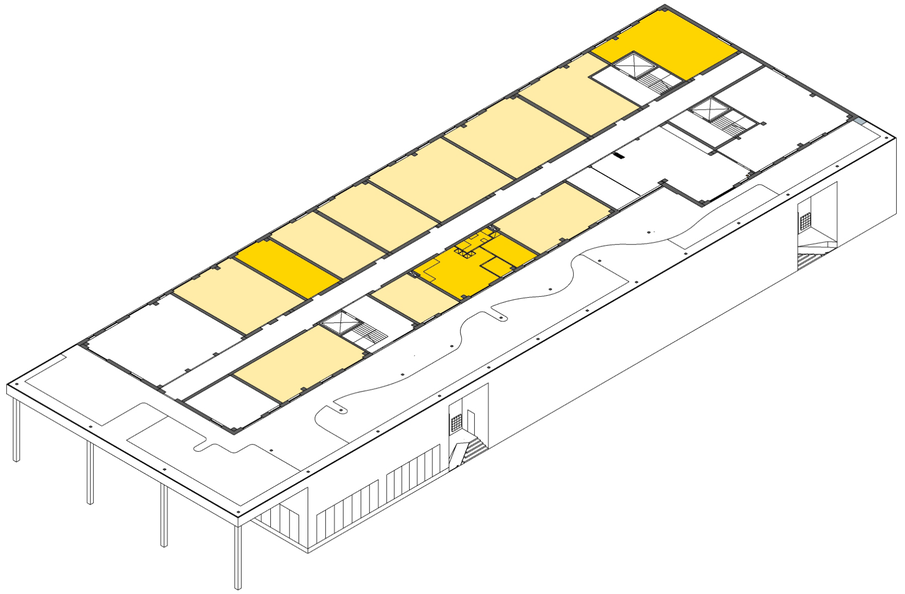







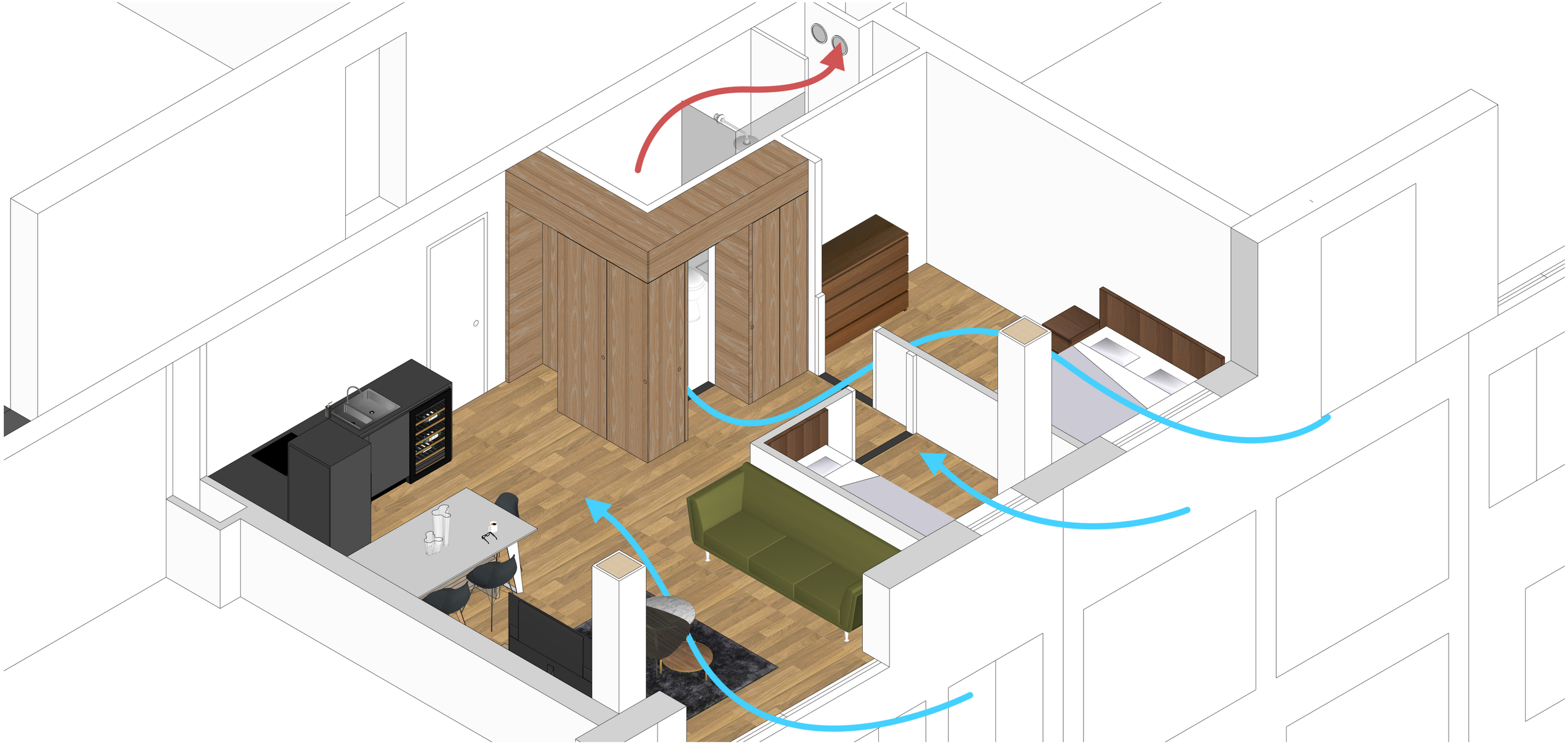

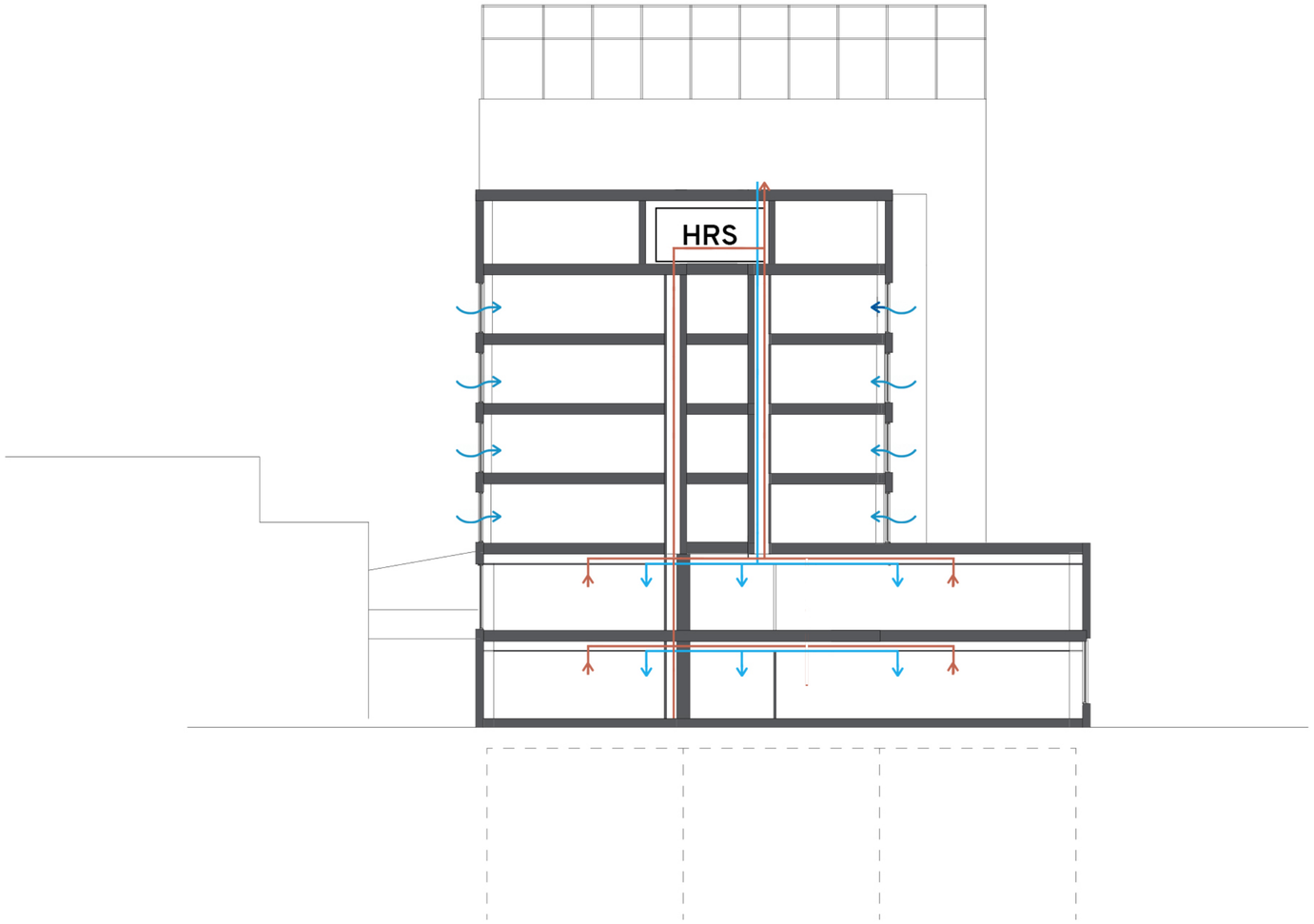
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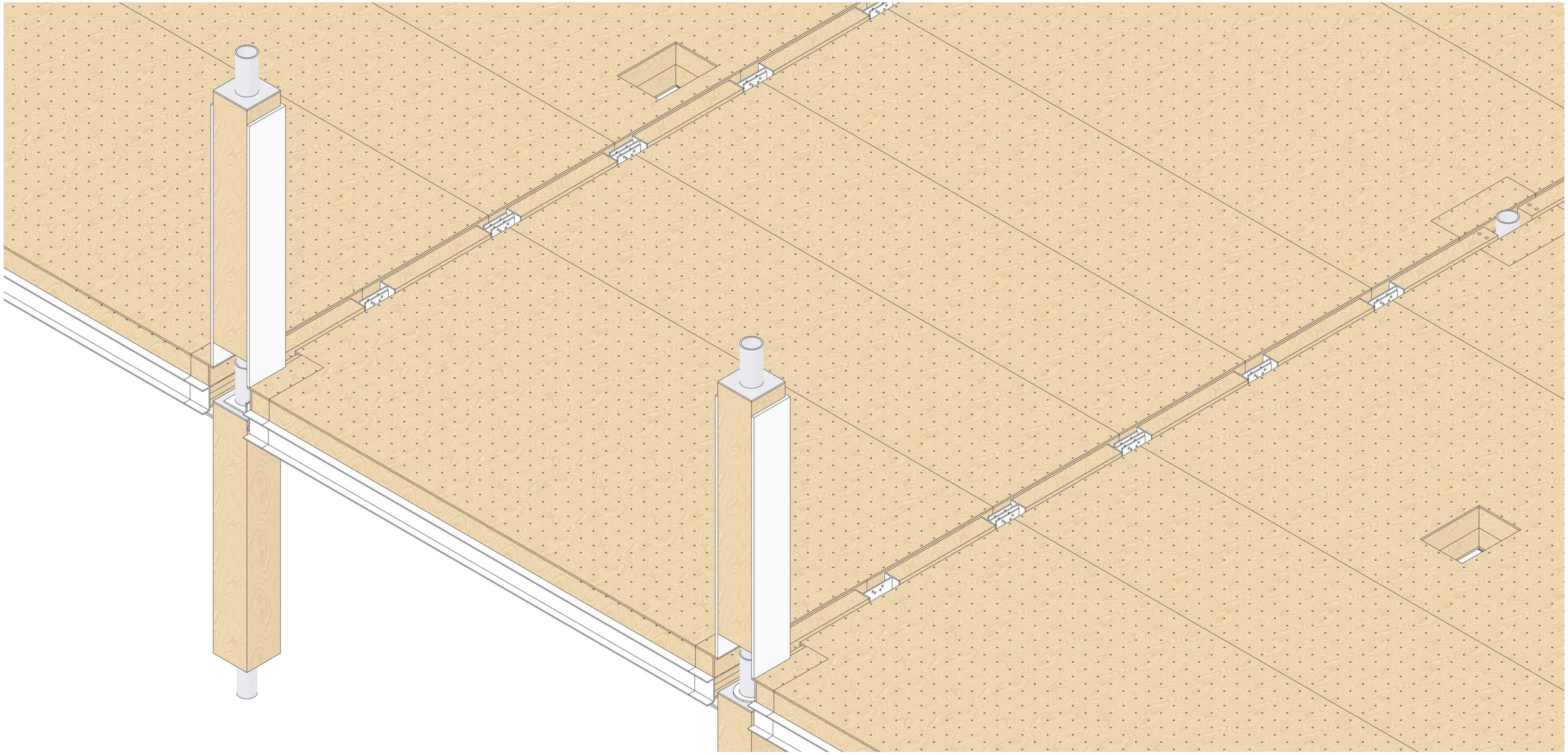
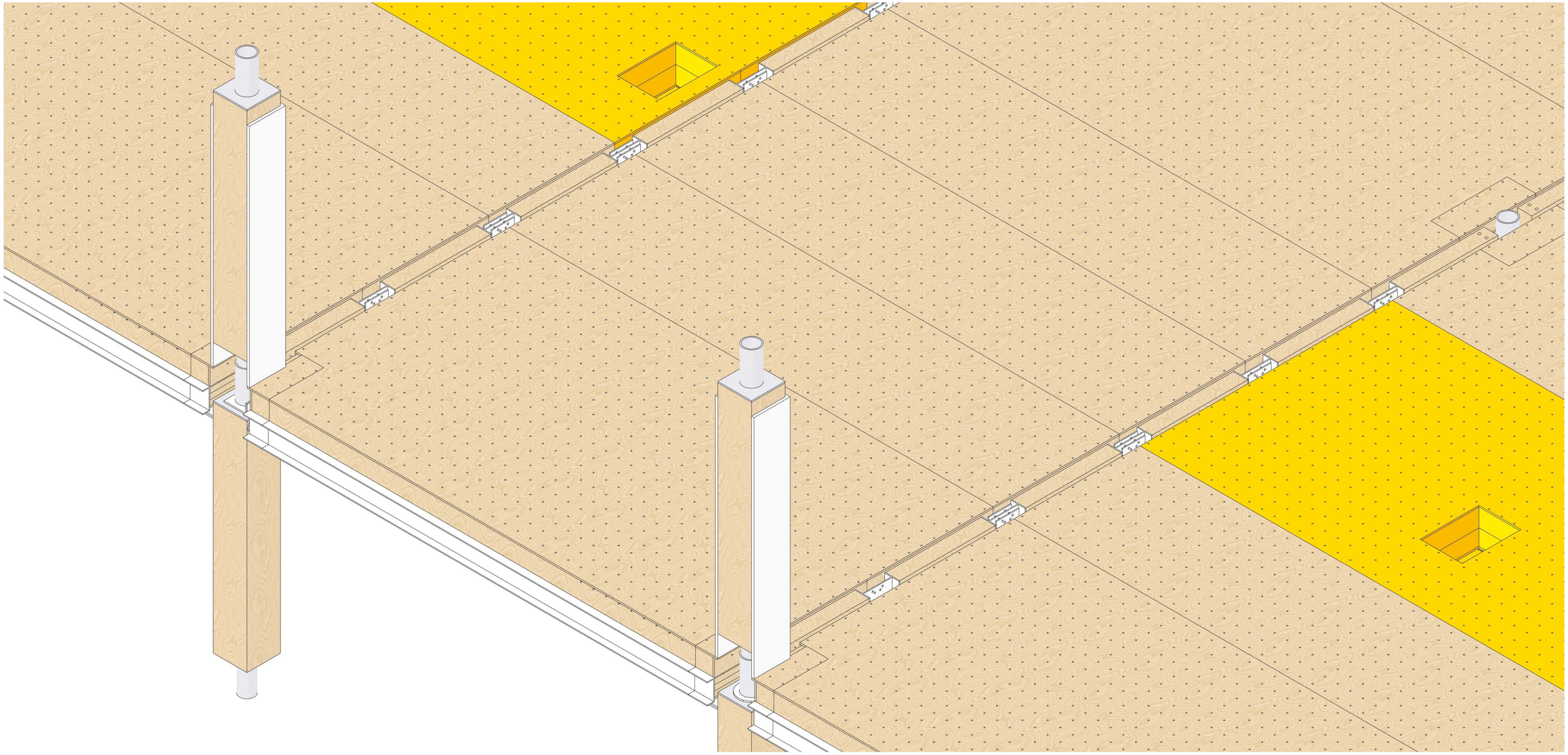
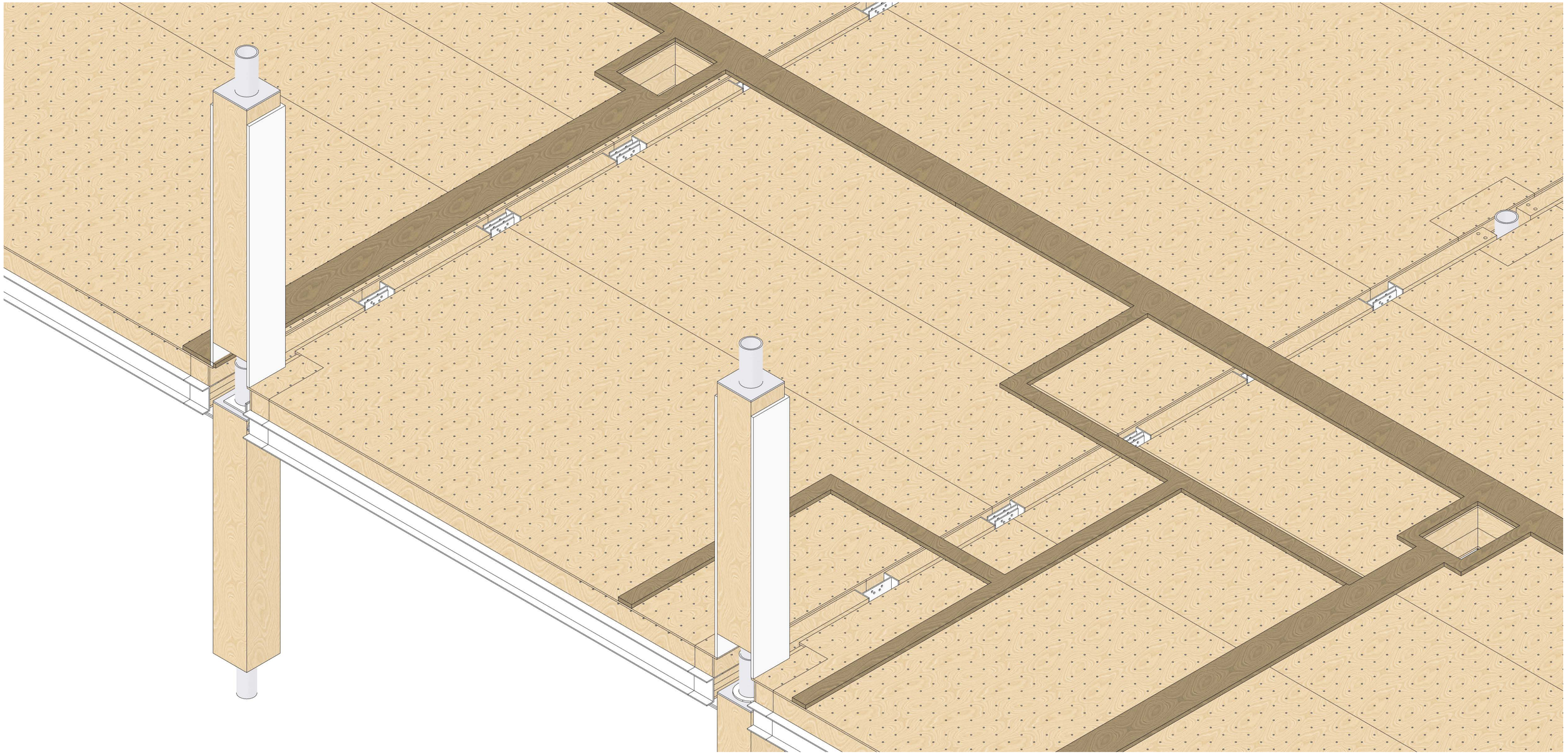
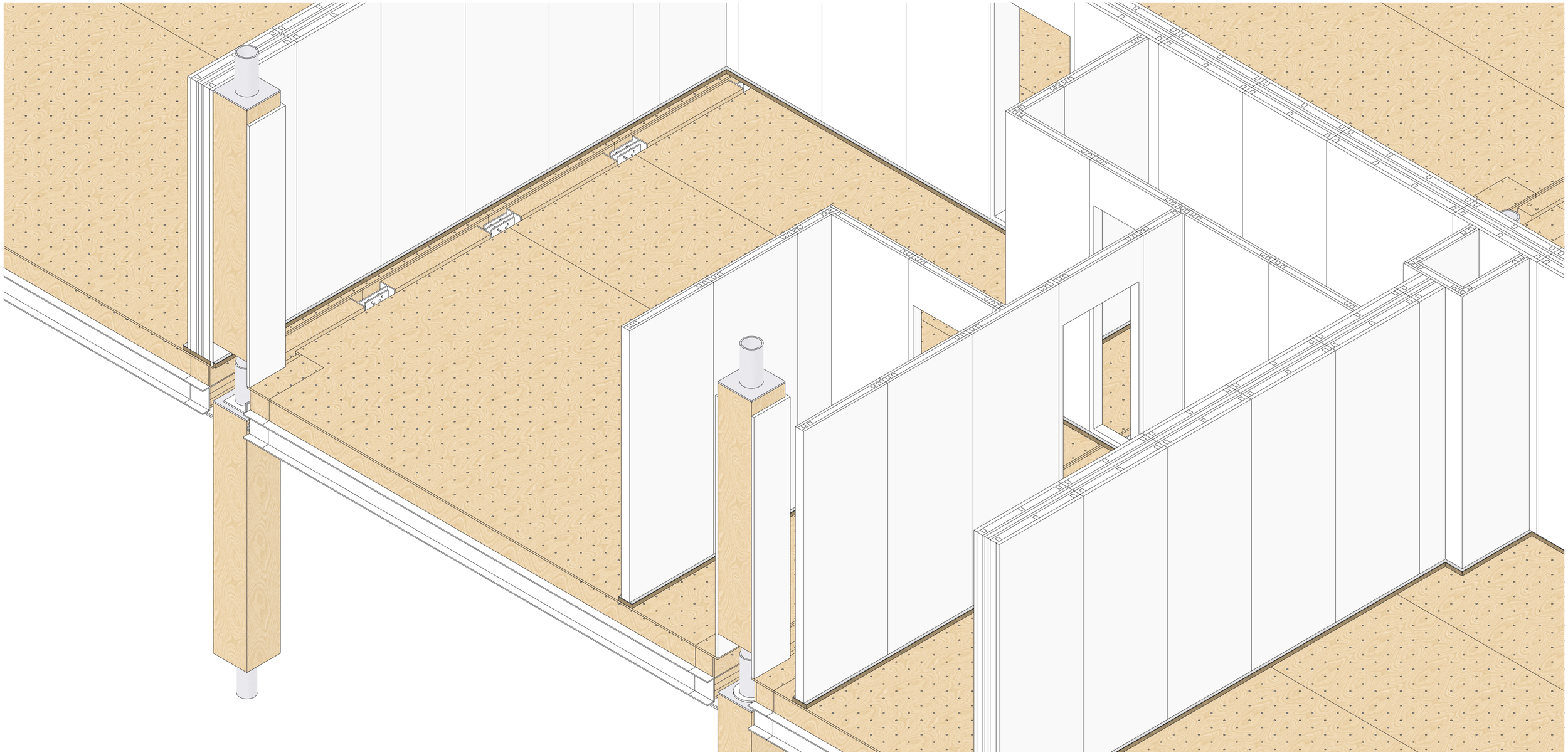
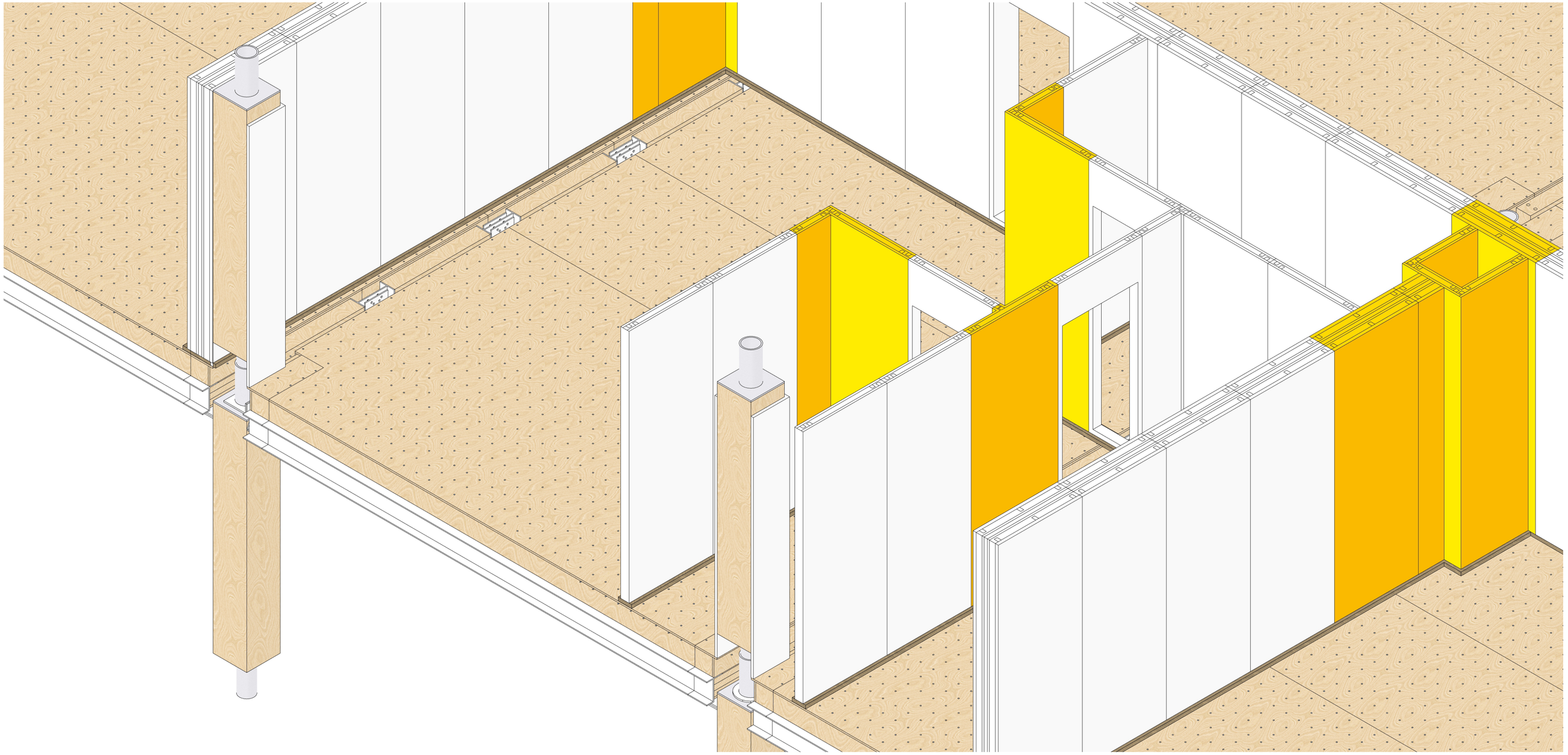
CHALLENGE 2: FREELY PLANNABLE FLOOR PLANS





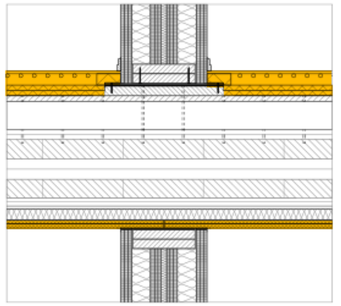




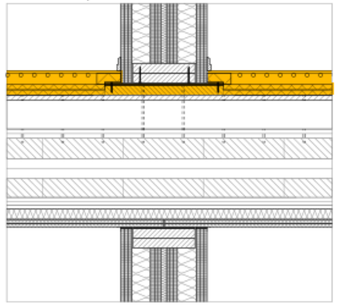


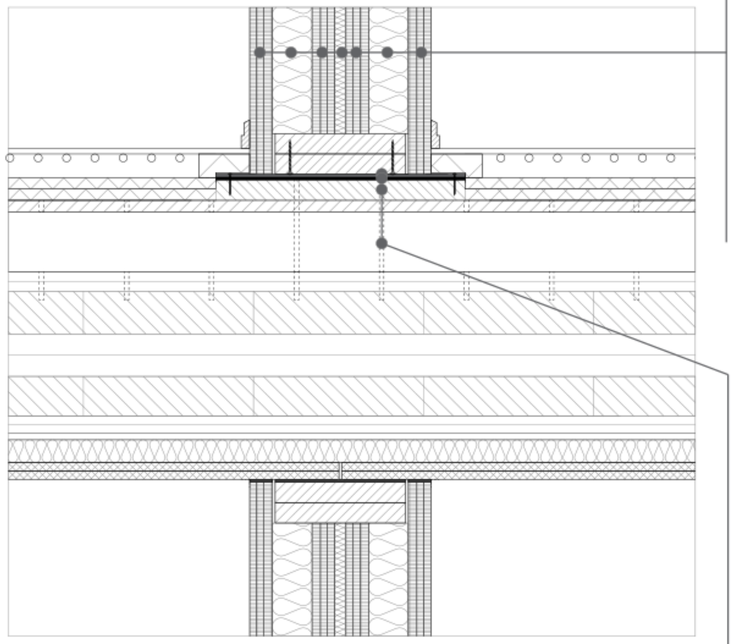
DETAIL G

PREFAB / ON-SITE



SYSTEM / CUSTOM





GFRP 3x 12,5 mm
Outer layer used as functional finish layer

Studs / Rockwool, 80m
Sound insulation

GFRP 3x 12,5 mm

Rockwool 20 mm
Decoupling layer
Sound insulation

GFRP 3x 12,5 mm

Studs / Rockwool, 80m
Sound insulation

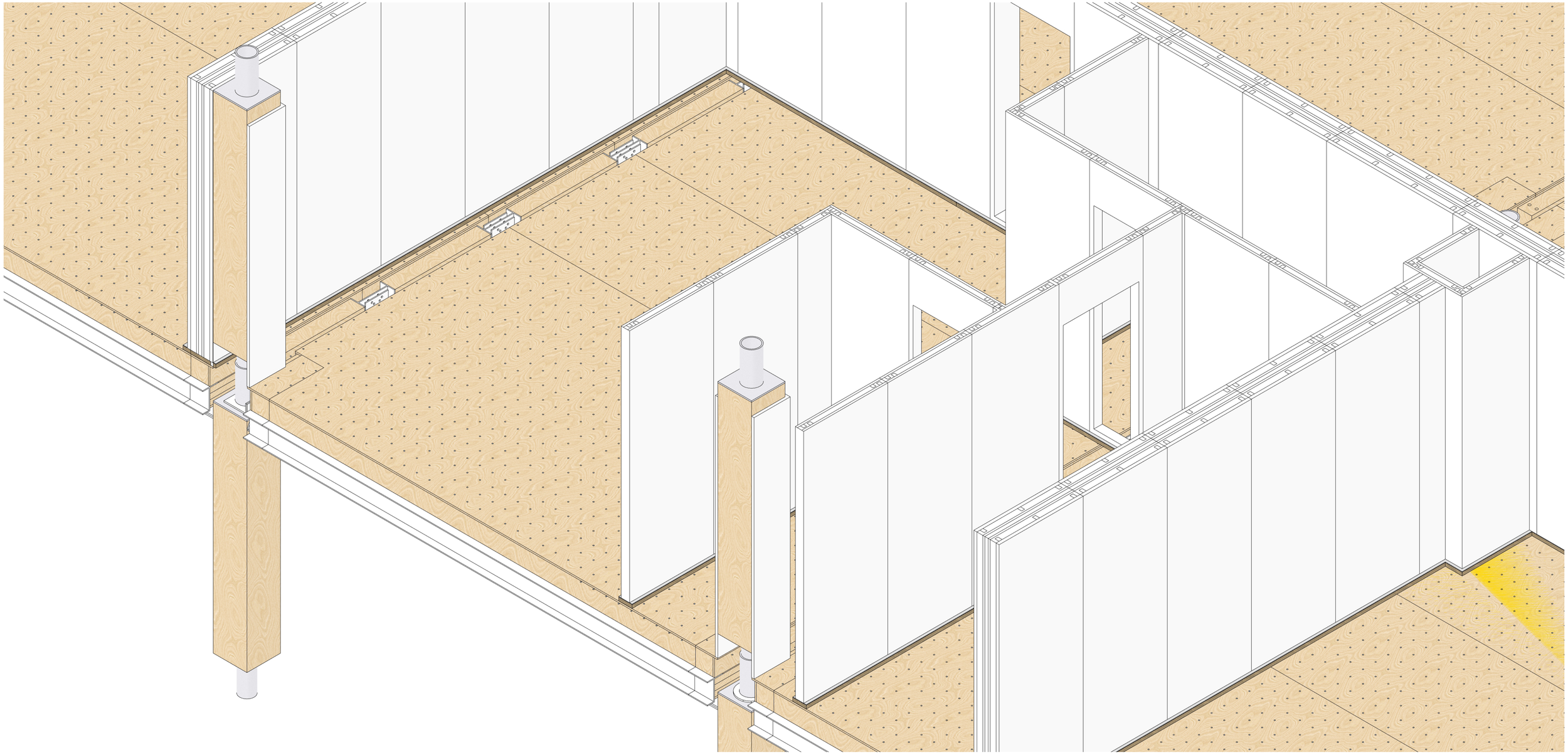
GFRP 3x 12,5 mm

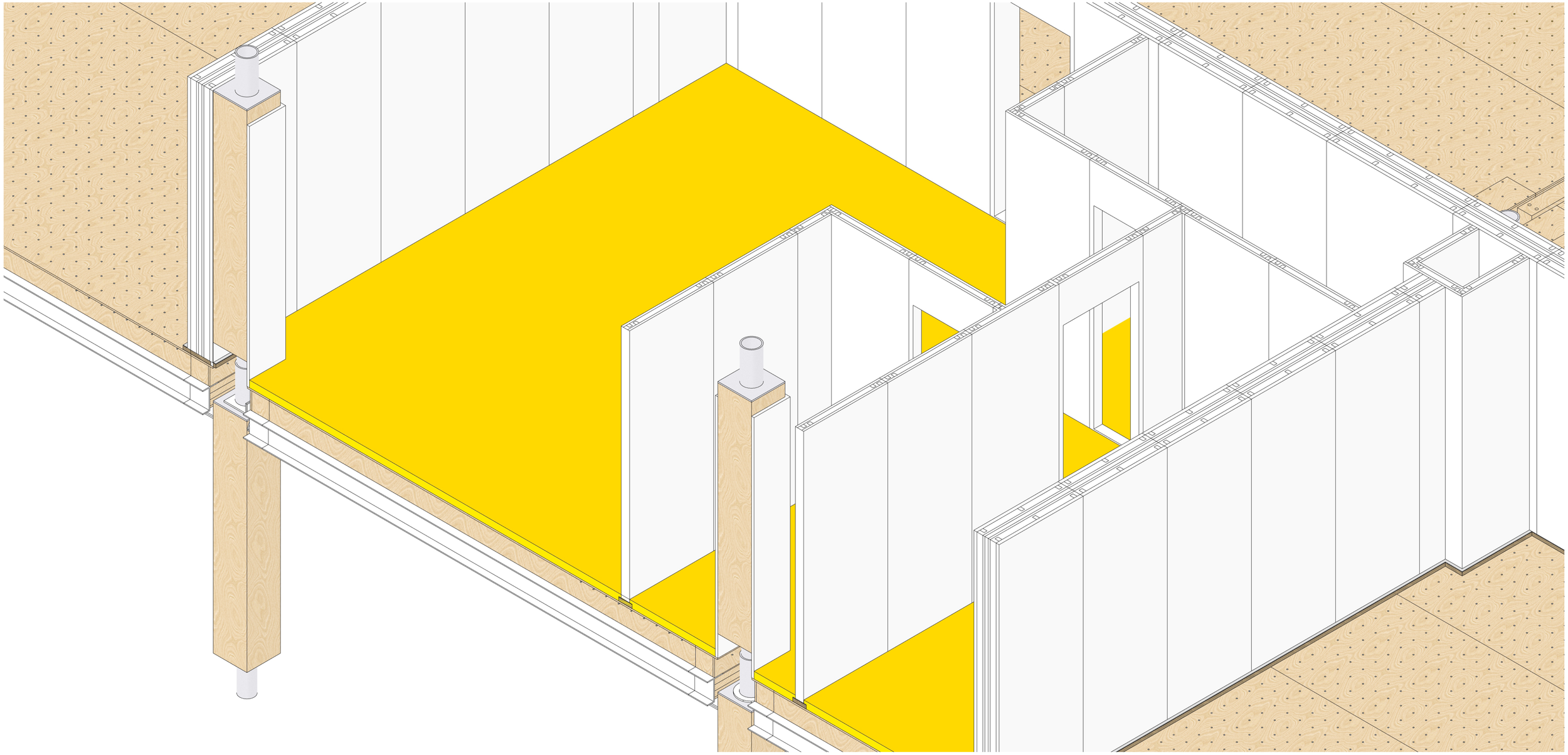
Interior wall connecting foot
Thin steel plate integrated on the bottom of pre-fab interior wall elements. Connects to pre-fab floor via disposable wooden interface

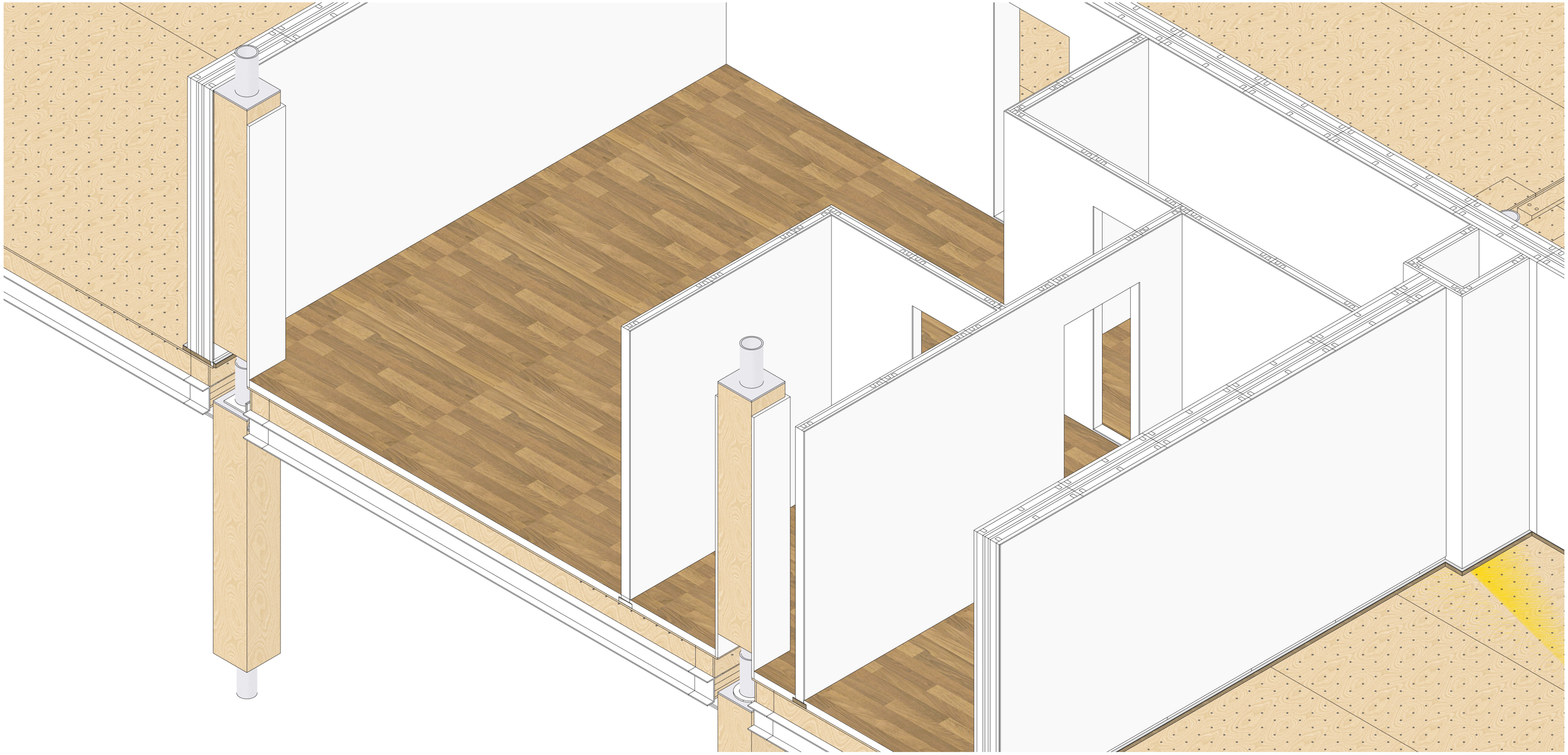
Elastomer Joint
Decoupling element between wall and floor

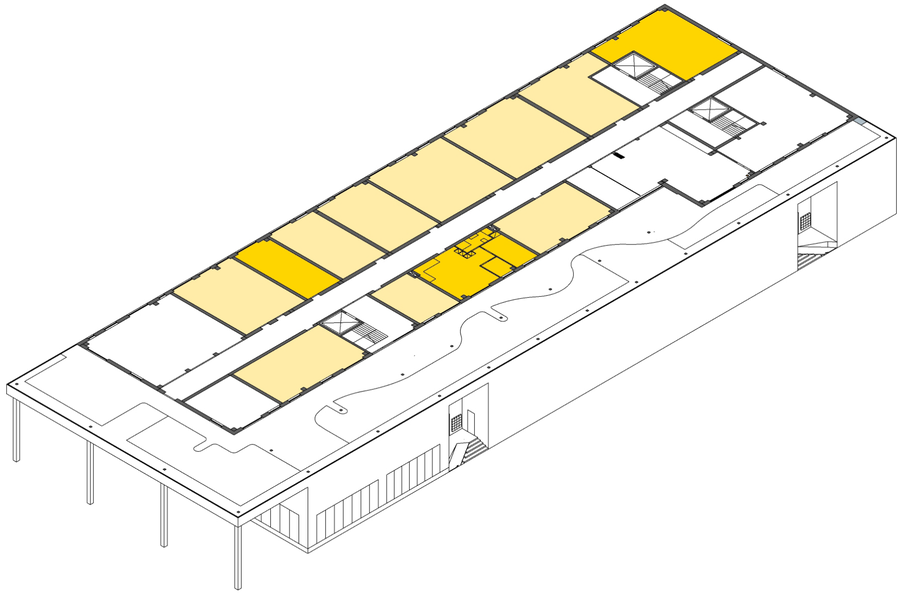
Interior wall wooden footprint / interface
Custom-measured wooden footprint that forms the disposable / non-reusable connecting element between system wall and system floor elements. Attached to floor via steel friction-fit pins. Attached to wall via simple screws.

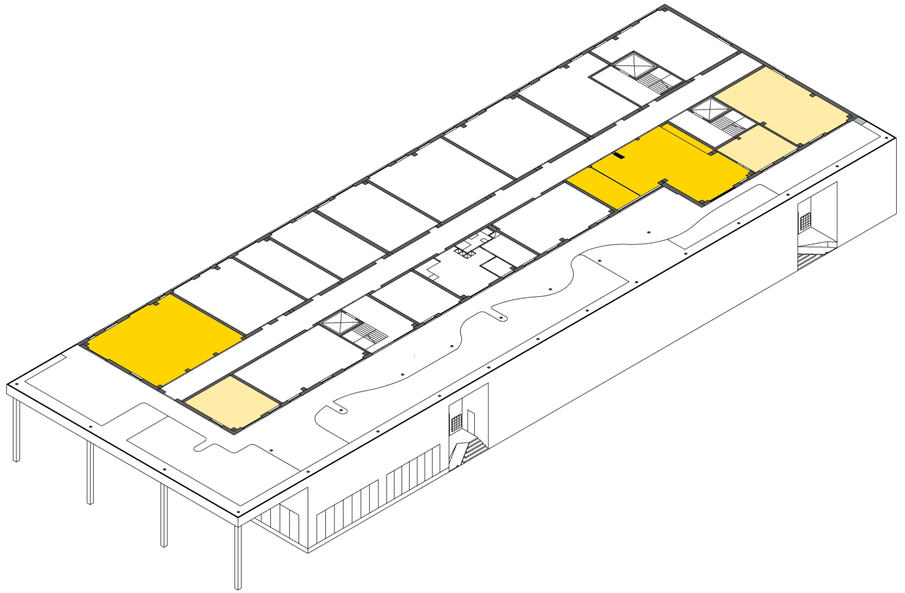
Steel pins
Friction-fit / demountable connection between wooden footprint and floor element. Goes through infill layer into CLT floor element.

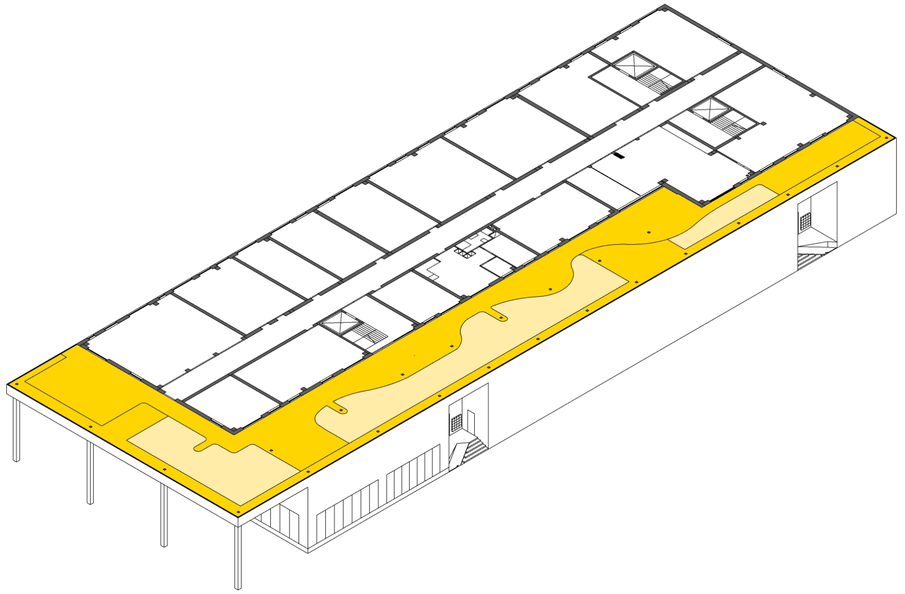


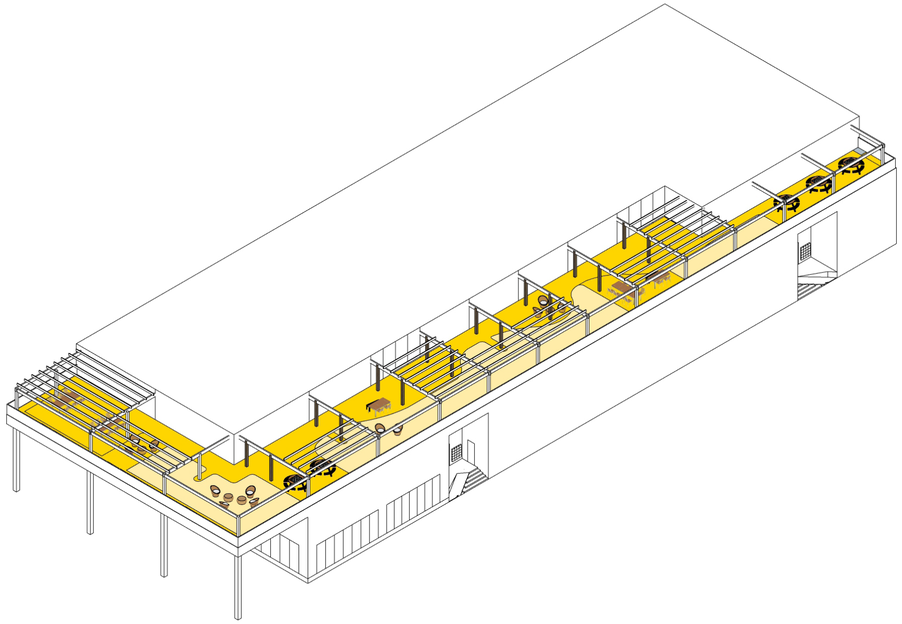




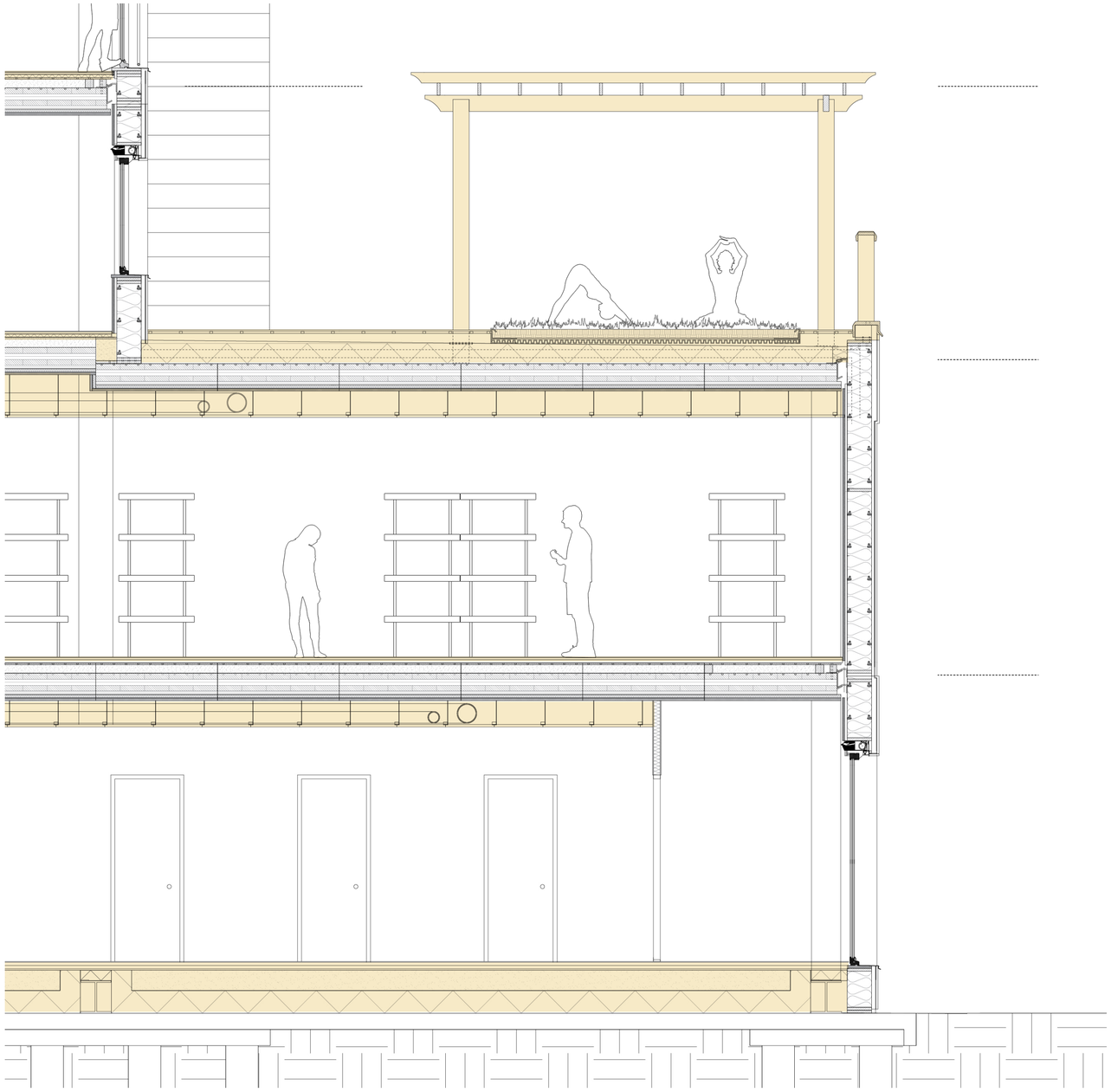




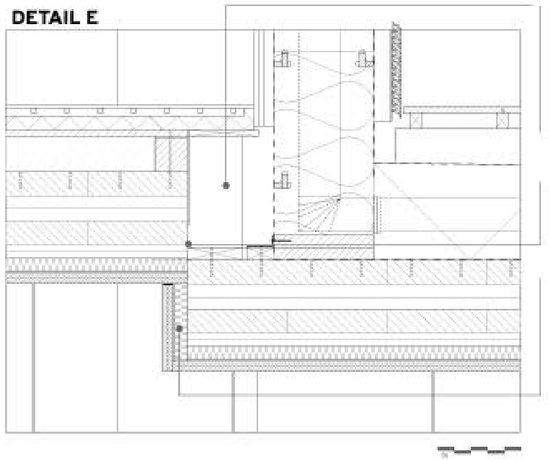




CHALLENGE 3: LEVEL DIFFERENCE & CUSTOM ELEMENTS



DETAIL E

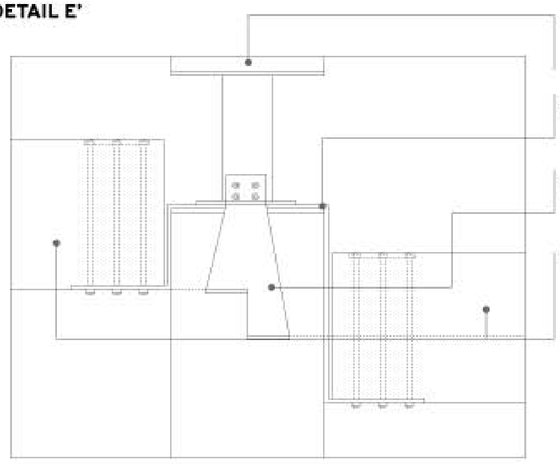


Extra large custom floor edge closer
Constructed with simple wood frame construction.
Custom measurements to accomodate floor level difference.
Space for pipes and cables.

Floor level difference
Facilitates level transition between dwellings and roof terrace
See Detail E'

Custom ceiling add-on
Placed at the level difference, bottom floor elements have special custom ceiling add-ons (Fire protection, sound insulation) that provide full encapsulation of constructive elements.

DETAIL E'



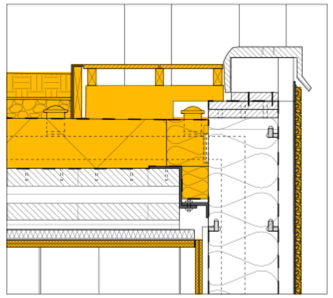
Standard Glu-LamPost
450x450x3200 mm
Integrated tubular steel interfaces at top and bottom side to connect elements.

Custom Post-Beam Steel Interface
Executed as a single element with two different height levels for beams.
Slid over topside of post interfaces before new constructive layer is added.

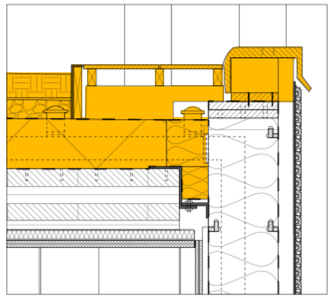
Custom Post-Floor Steel Interface
Executed as a single element with two different height levels for floors.
Attached to post interface

Standard Glu-Lam Beams
(<)9000 mm span, 500 mm height (450+50)
Attached to steel interfaces with 6 remountable bolts.

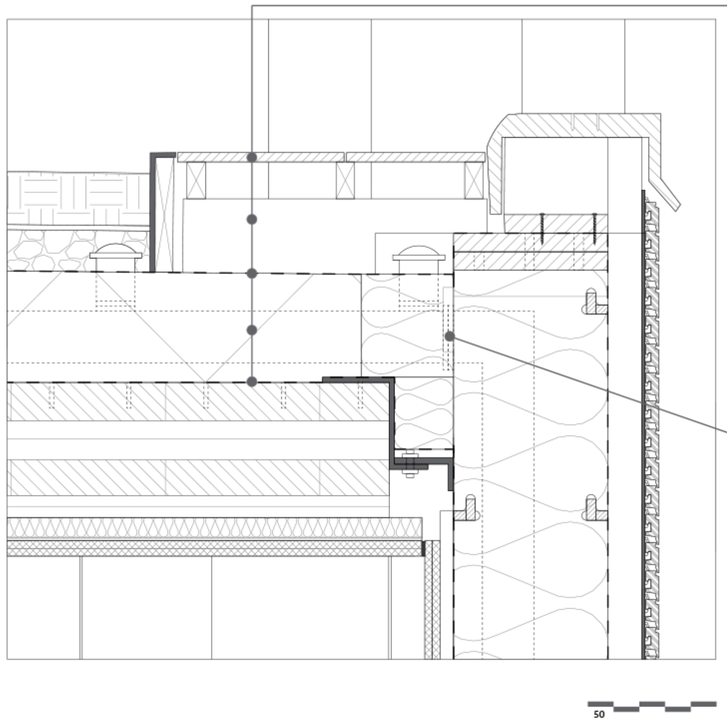
PREFAB / ON-SITE



SYSTEM / CUSTOM

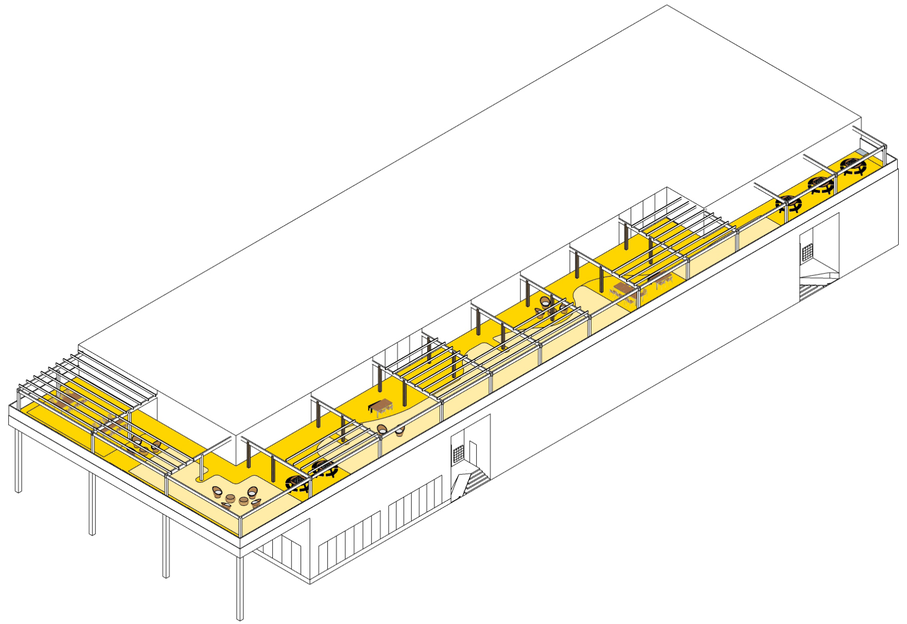


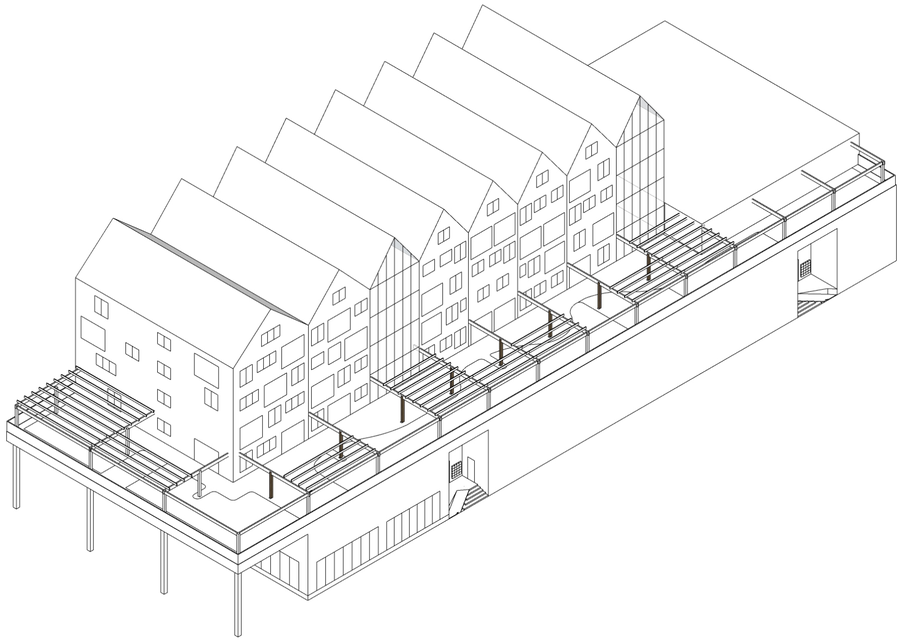
DETAIL D

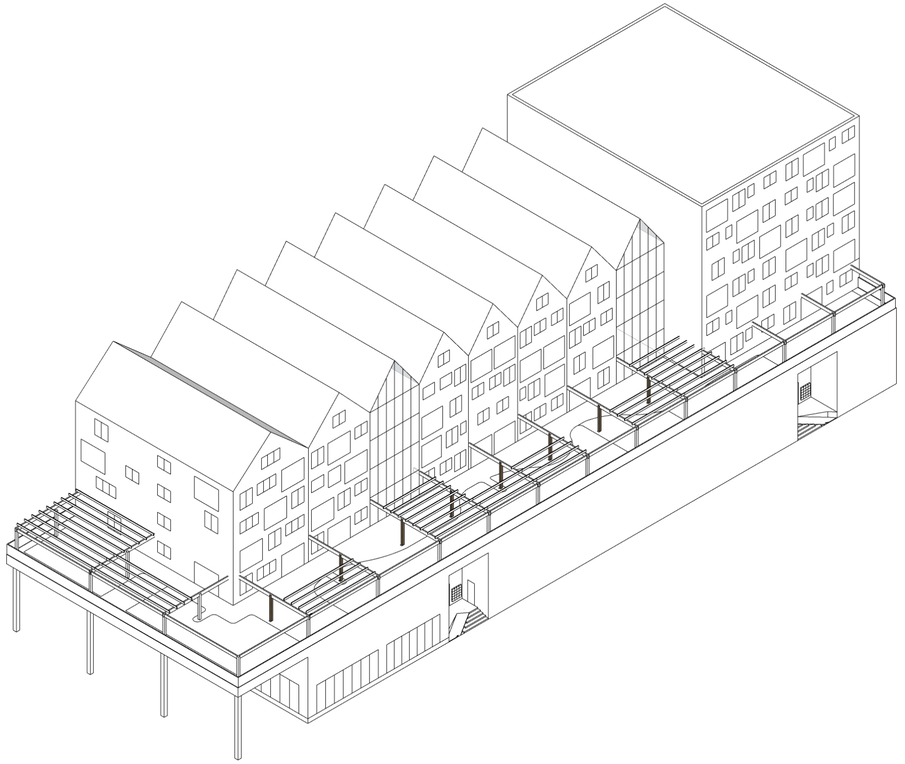


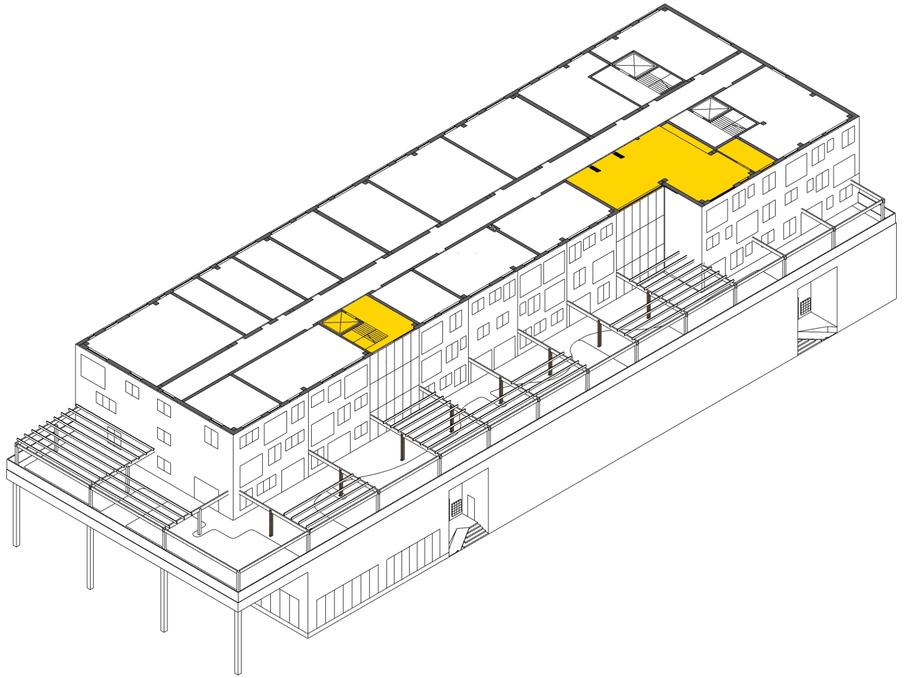
Terrace finish, wooden deck, 18mm
Wood frame, 100 + 40mm
Constructive element
opening at facade side to allow water to flow to drainage points
Waterproof membrane
Thermal Insulation (EPS), 250mm
10/1000 height gradient to facilitate water drainage
Water drainage integrated in layer
Seperate closed-off water drainage for green roof segments
Vapor barrier

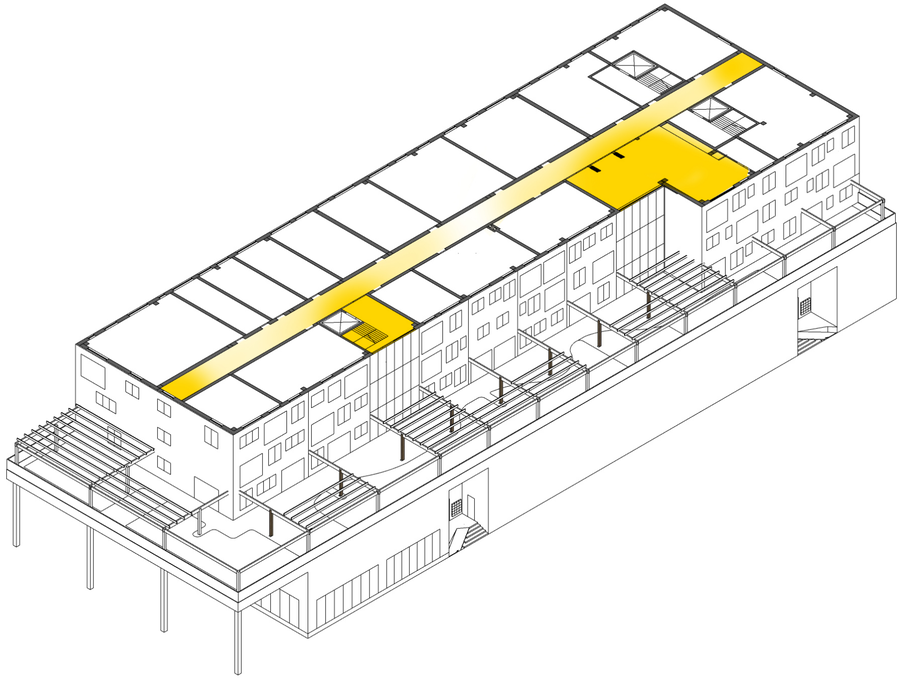
Downspout coupling point
Downspout is integrated in pre-fab facade elements, extended to roof/terrace on-site









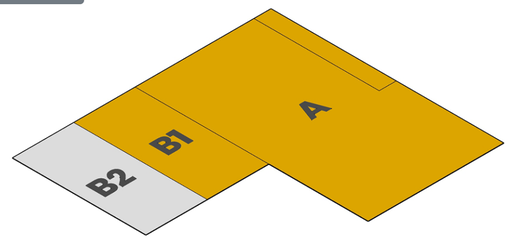






FLOOR 03

SPACE 1



Give your event a name!...

FROM

12:30
12:45
13:00

TO

14:15
14:30
14:45

TO

BIRTHDAY PARTY
DINNER
OTHER...

If it is an open event,give the community a short description! ...

UPCOMING COMMUNITY EVENTS

Saturday 13:00 - 17:00 F03 SPACE 1



TAMAR'S BIRTHDAY PARTY!!
ALL KIDS INVITED! :D

Ages 8-11, baking cookies for lunch!

12

Sunday 20:00 - 24:00 F03 SPACE 1



BOARD GAME NIGHT Edition 23!
Catan, Monopoly, Risk. Usual rules.
No more cheating, brandon! :p
Different floor this time!

5

PAST WEEK

Sunday 20:00 - 24:00 F01 SPACE 3



BOARD GAME NIGHT edition 22
This week: only risk! Bring your best game!!

9



Evan Raaphorst
BRANDON CHEATED FOR SURE!!



Brandon Bekker
Great game guys, close one :^)

Sunday 20:00 - 24:00 F03 SPACE 1



BOARD GAME NIGHT edition 21
This week: only risk! Bring your best game!!

9



Evan Raaphorst
BRANDON CHEATED FOR SURE!!



Brandon Bekker
Great game guys, close one :^)

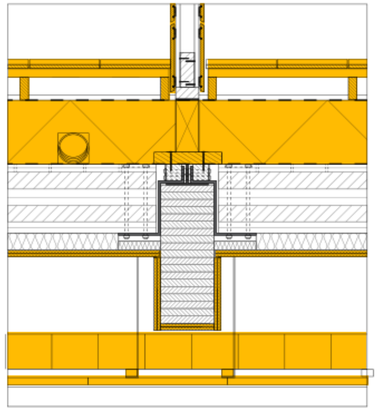




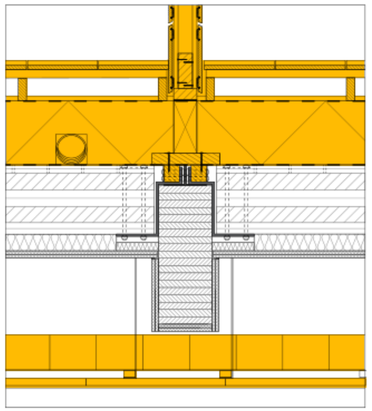


CHALLENGE 4: CUSTOM STRUCTURE

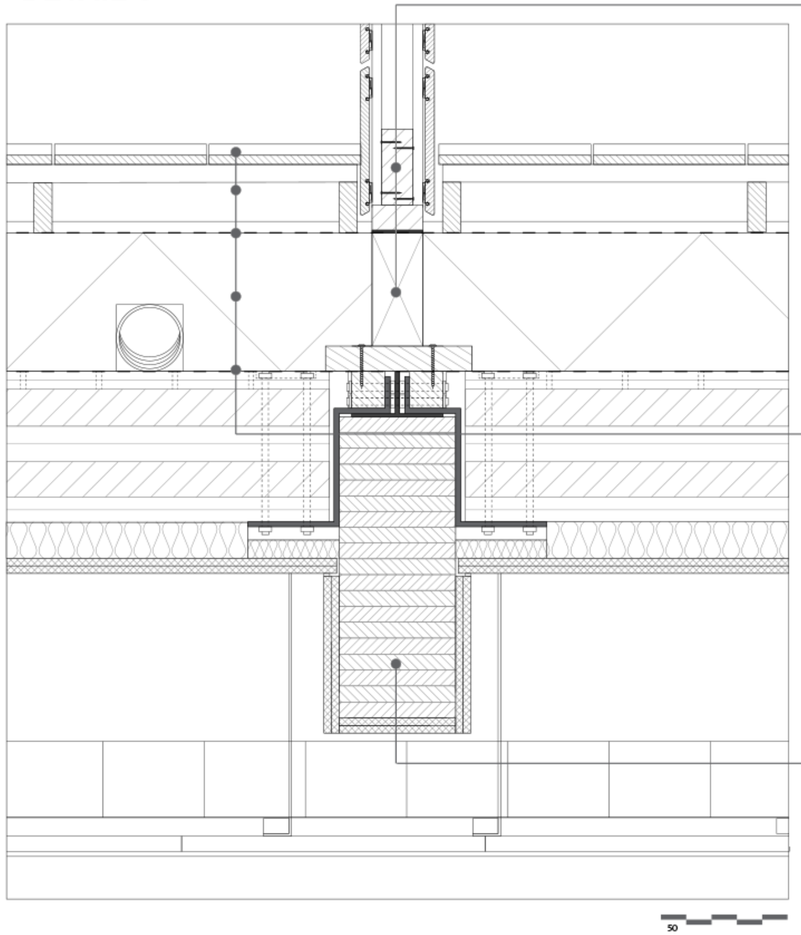
PREFAB / ON-SITE



SYSTEM / CUSTOM



DETAIL C

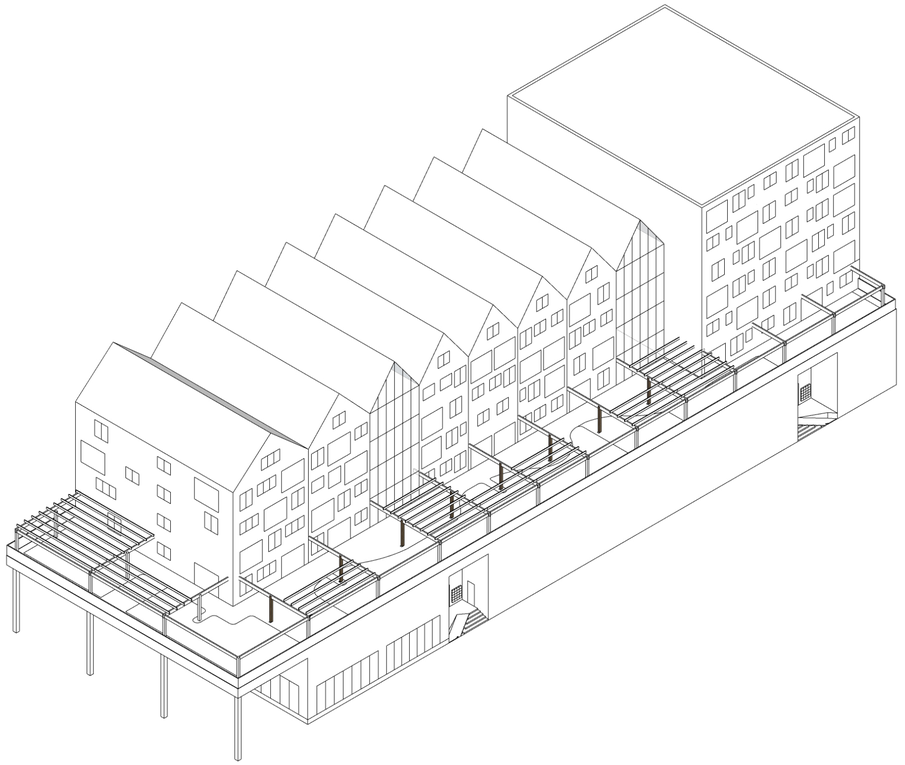


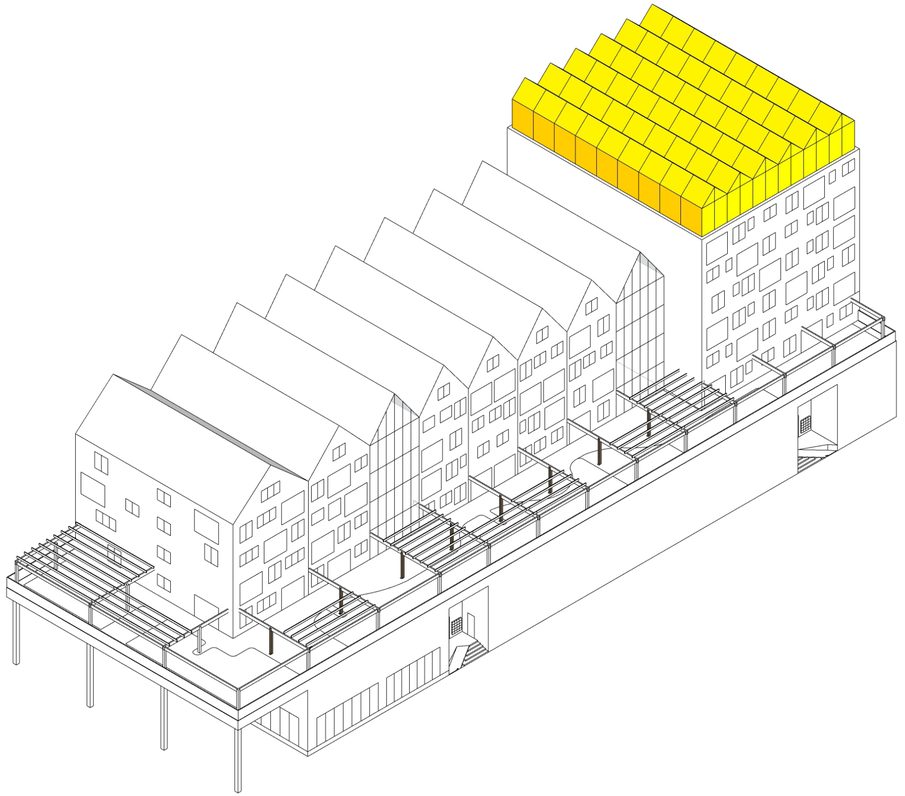
Wood frame construction
Balcony-bearing construction
Custom element
Finished with Derako demountable wood facade system
Anchored to facade for stability

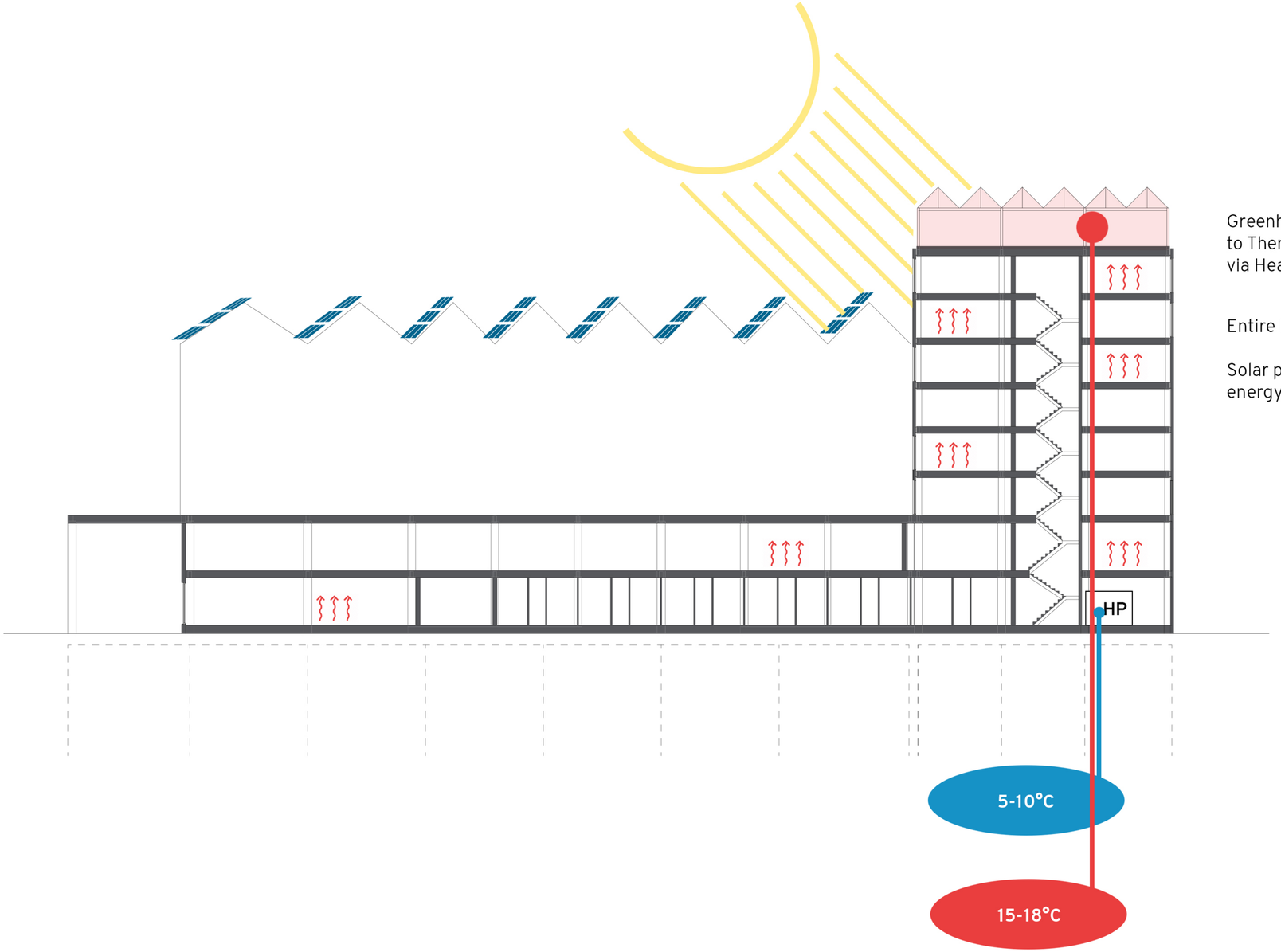
Wooden Interface construction
Custom wooden construction
Connects custom balcony construction to building system standard beam
Constructed on-site

Terrace finish, wooden deck, 18mm
Wood frame, 100 + 40mm
Constructive element
Lower frame aligned with insulation height gradient to allow water drainage
Waterproof membrane
Thermal Insulation (EPS), 250mm
10/1000 height gradient to facilitate water drainage
Water drainage integrated in layer
Vapor barrier

Glu-lam 9m System beam
Standard system element
Thicker Variant compared to beams that do not bear balcony load







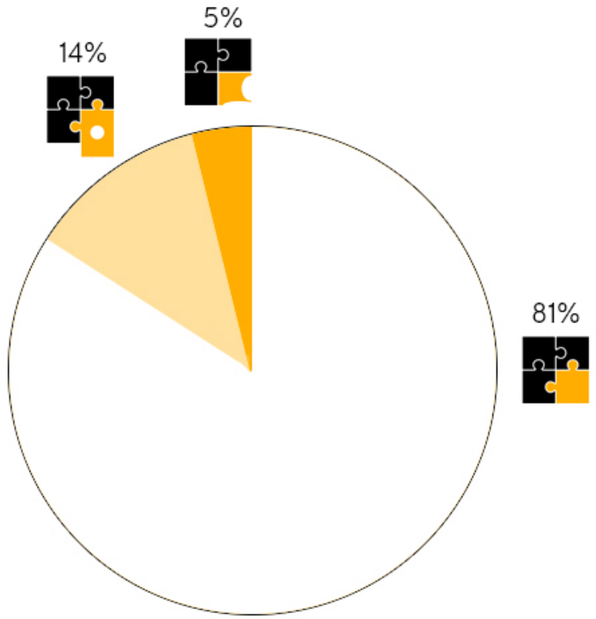
Greenhous Residual heat contributes to Thermal Energy Storage System via Heat pump

Entire building makes use of floor heating

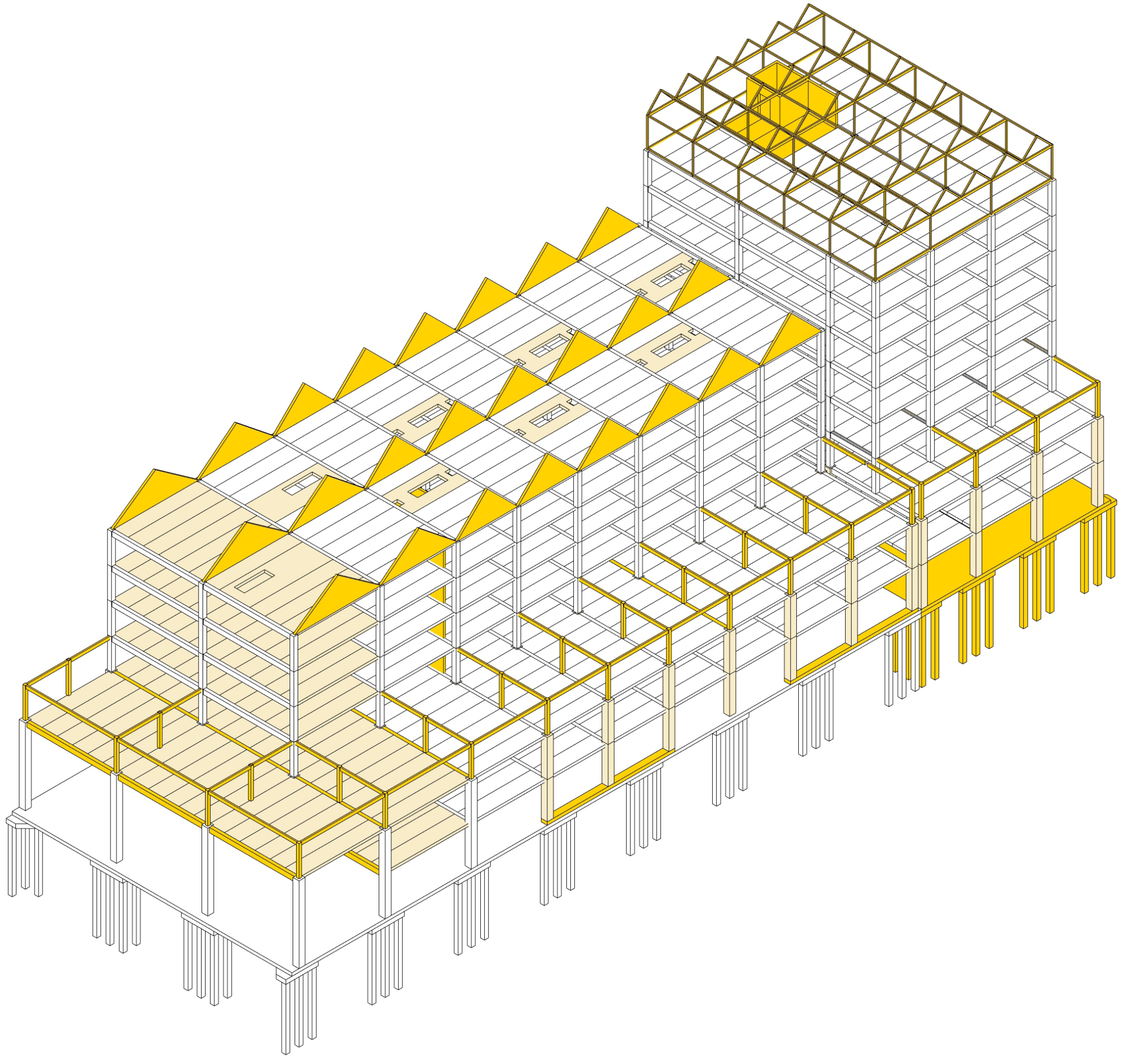
Solar panels on south-western roof side to generate energy


45

MODULARITY ANALYSIS

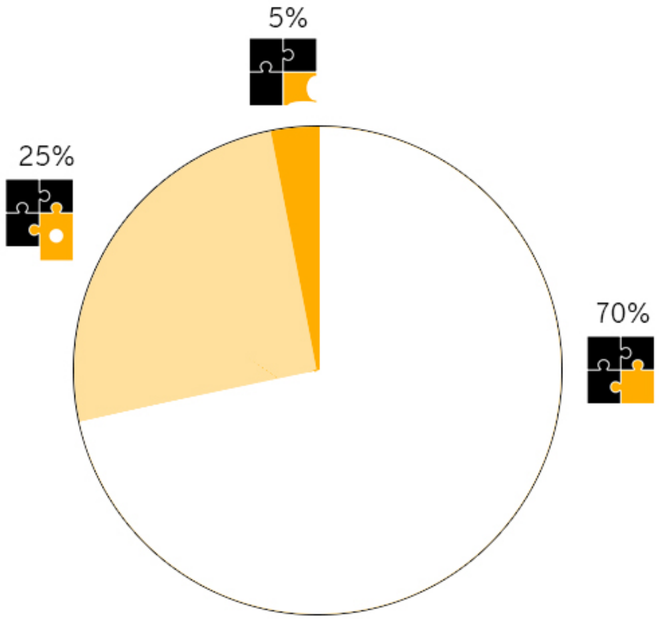


Amsterdam: Construction

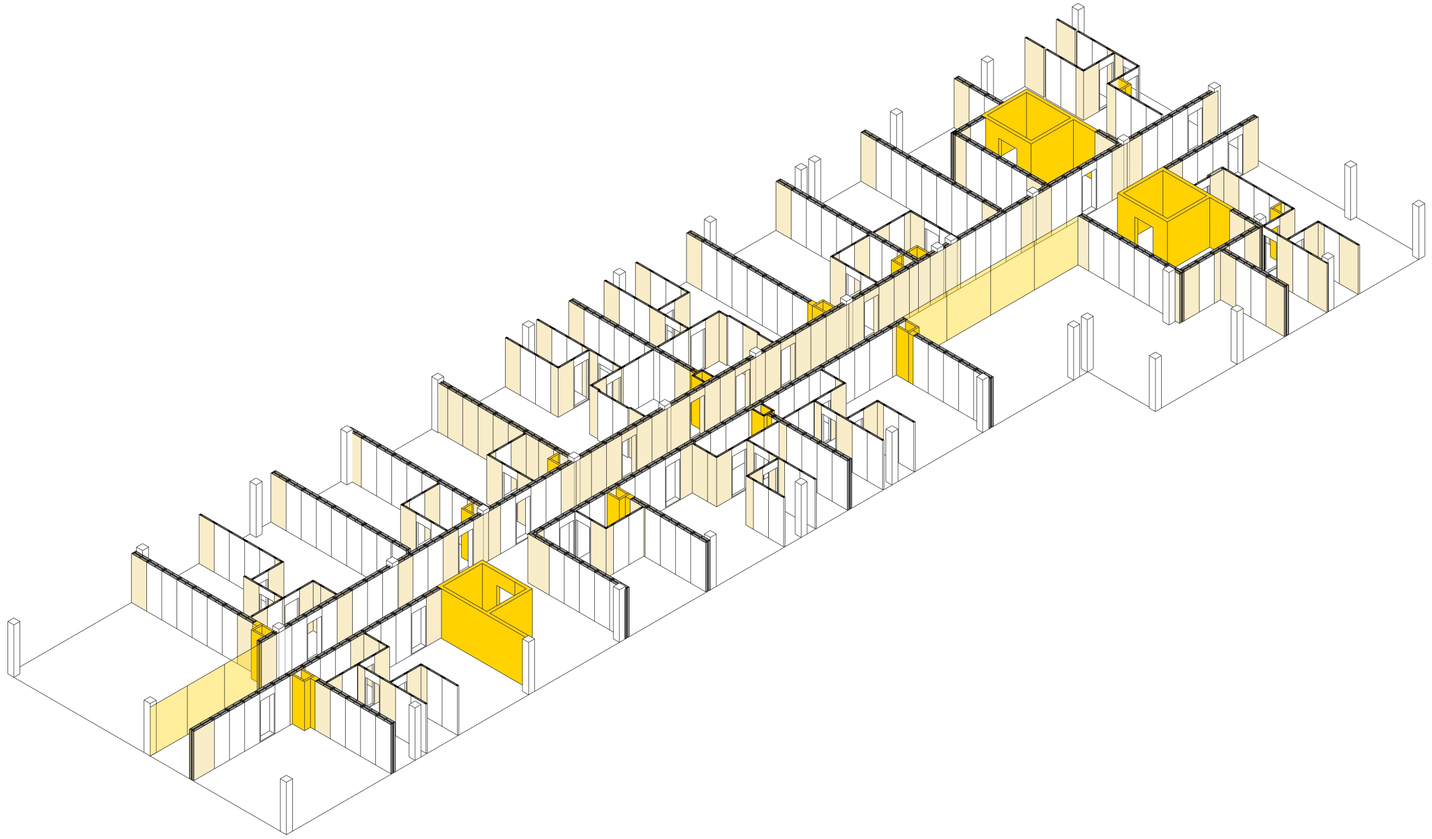


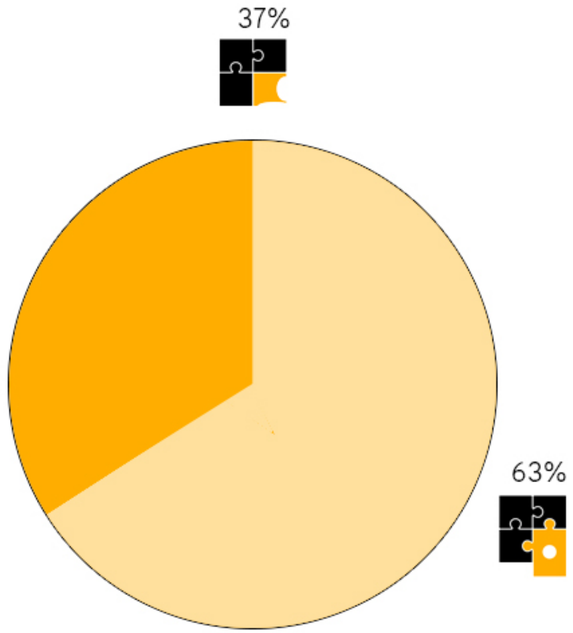
EXCLUDING

Foundation
Concrete elevator cores
Pergola construction
Greenhouse construction

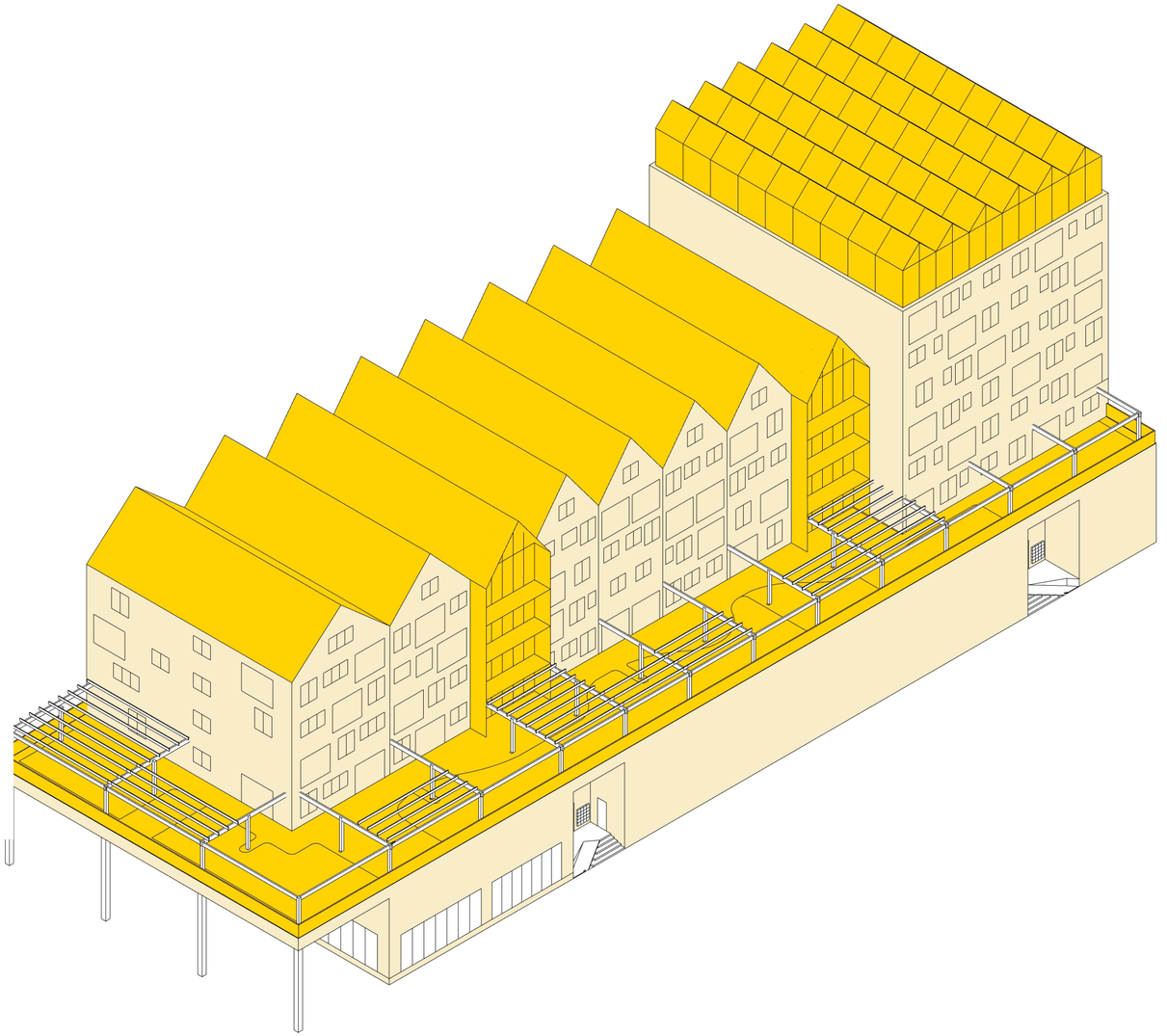


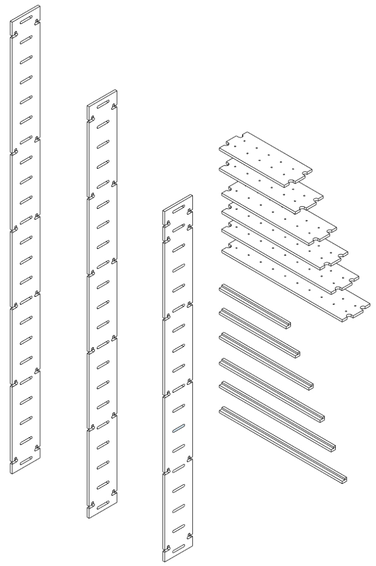
Amsterdam: Interior Walls

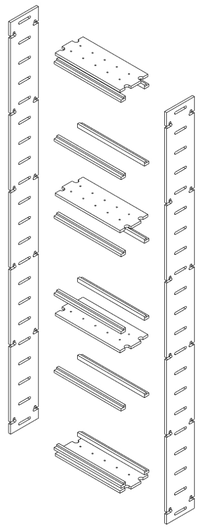


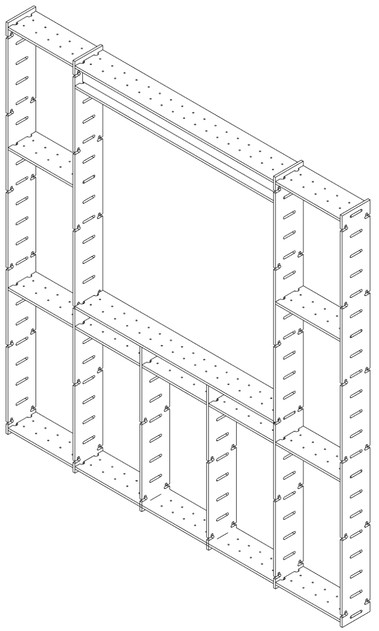


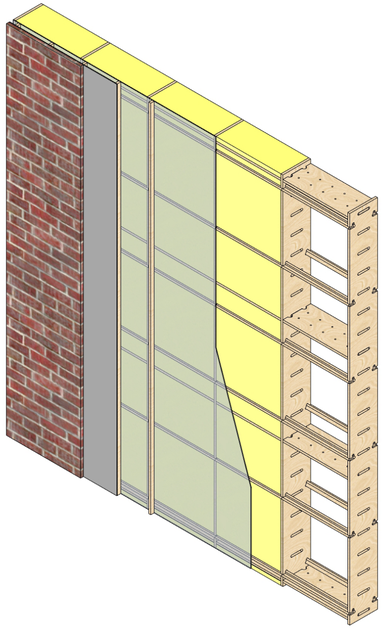
Amsterdam: Building Envelope

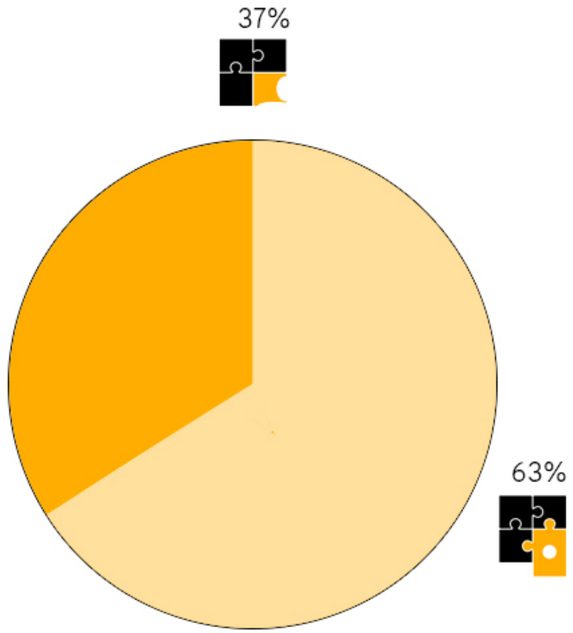




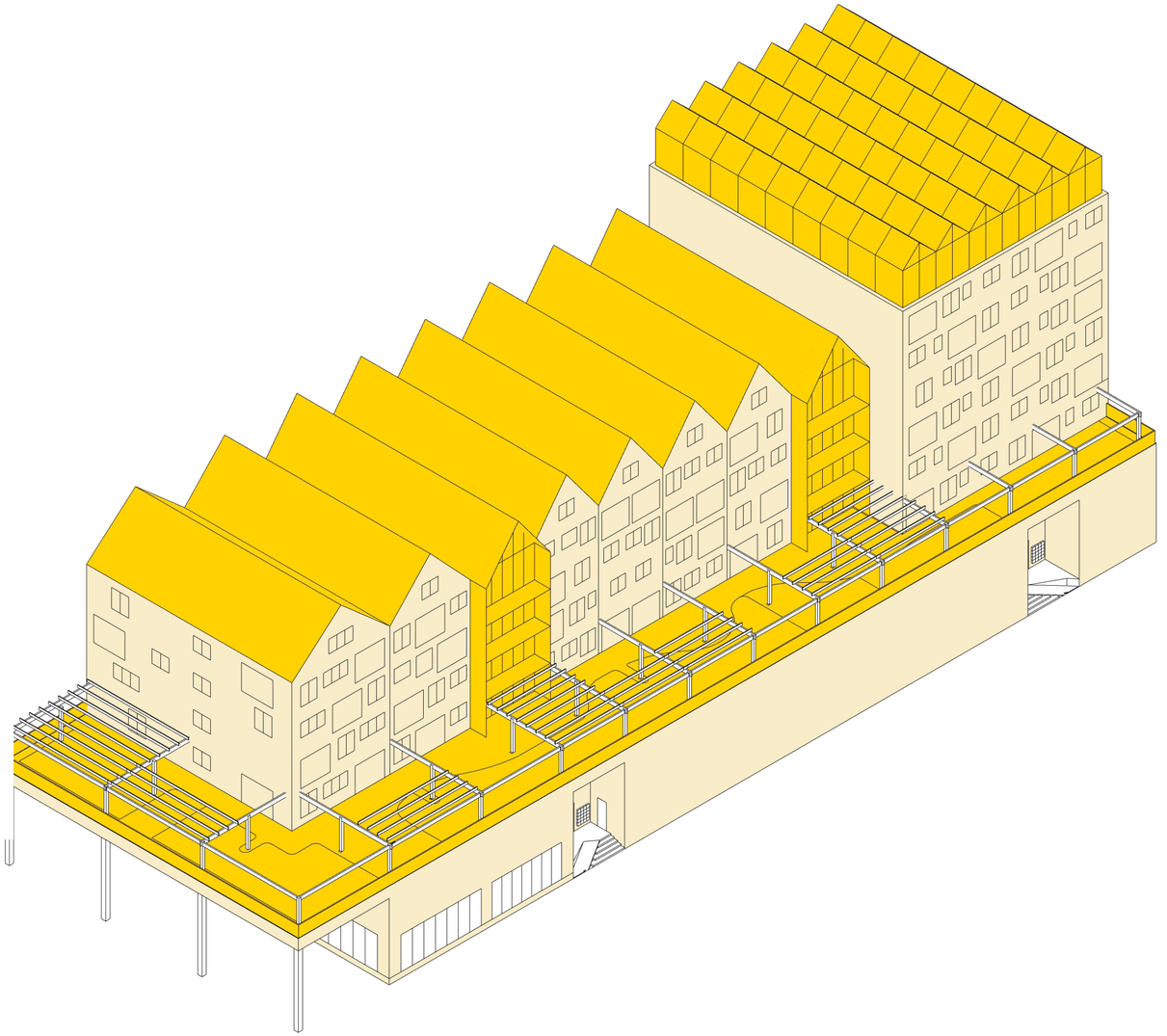








Amsterdam: Building Envelope



JAKARTA

Local challenge: City flooding in 20 - 30 years, but big demand for housing

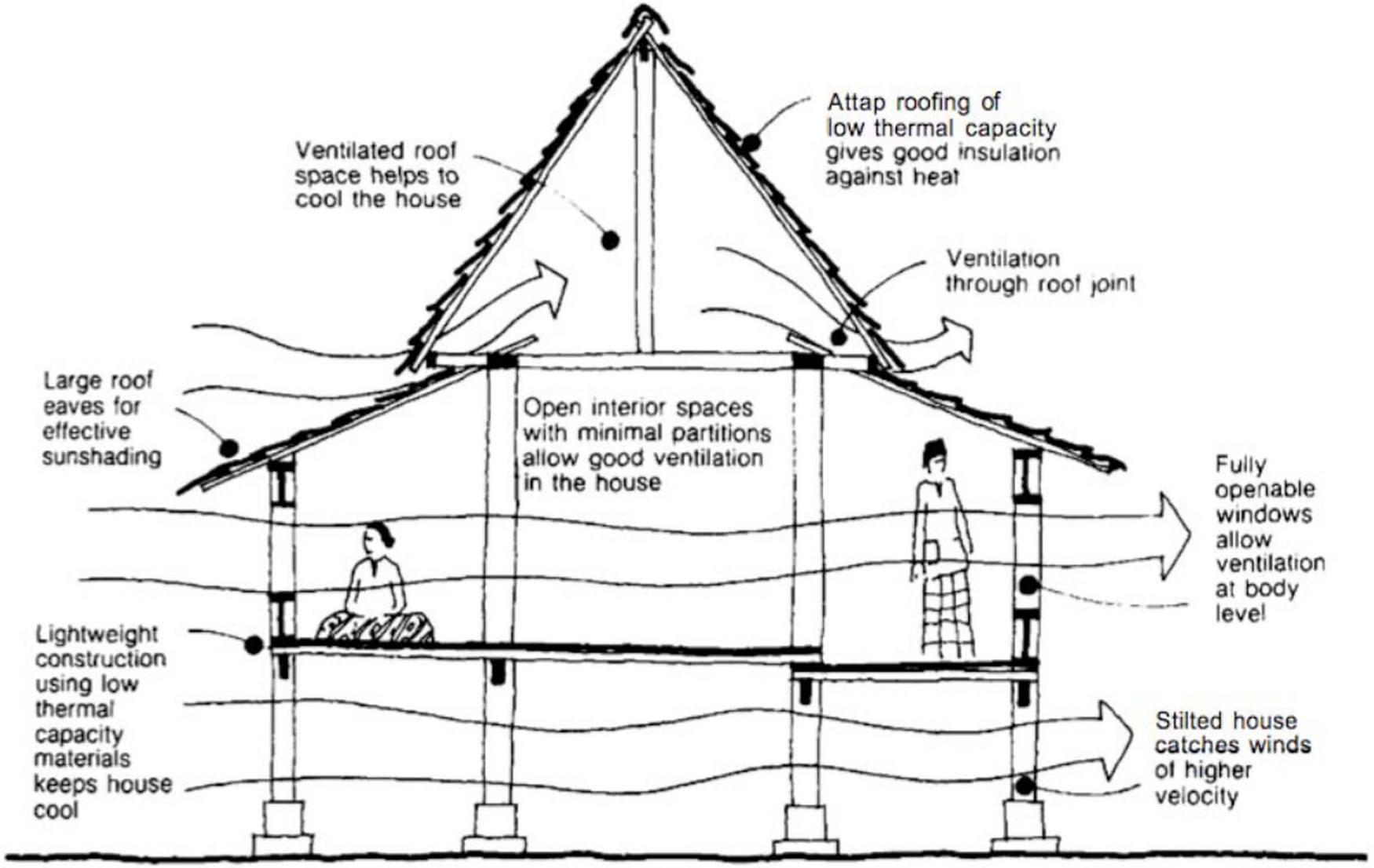
Target Group: Former rural migrants

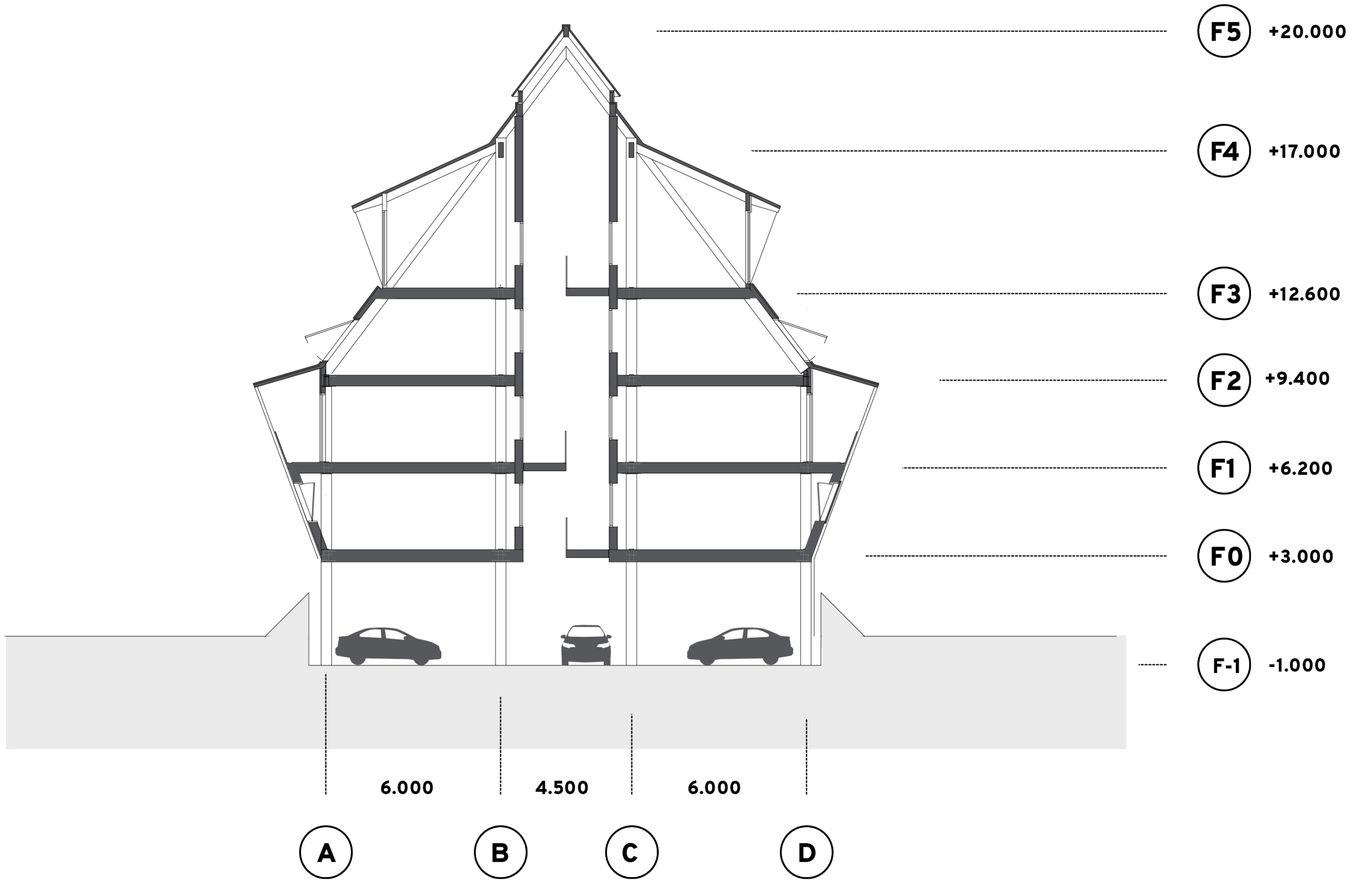


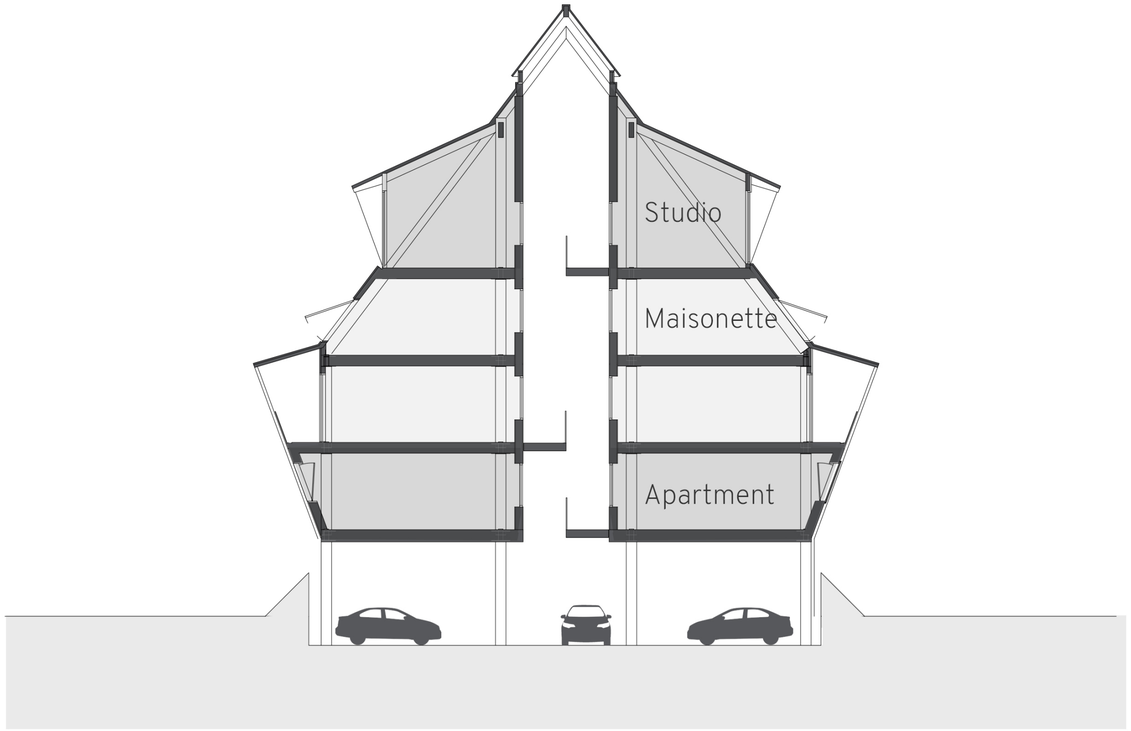


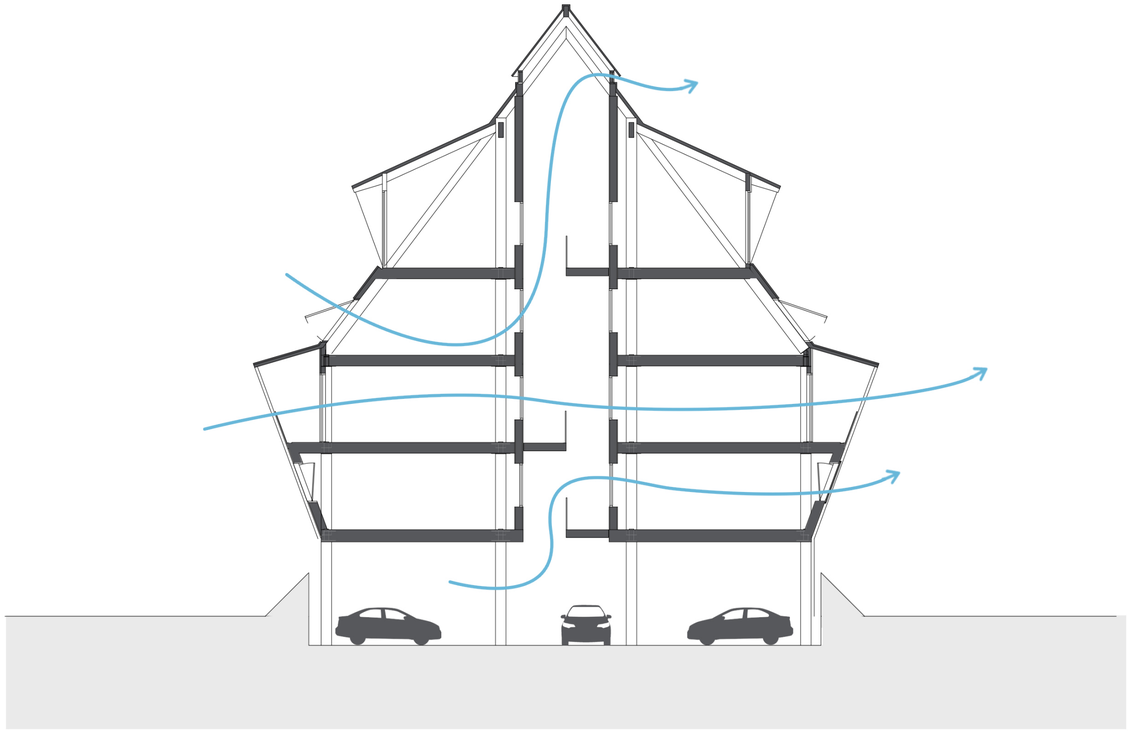


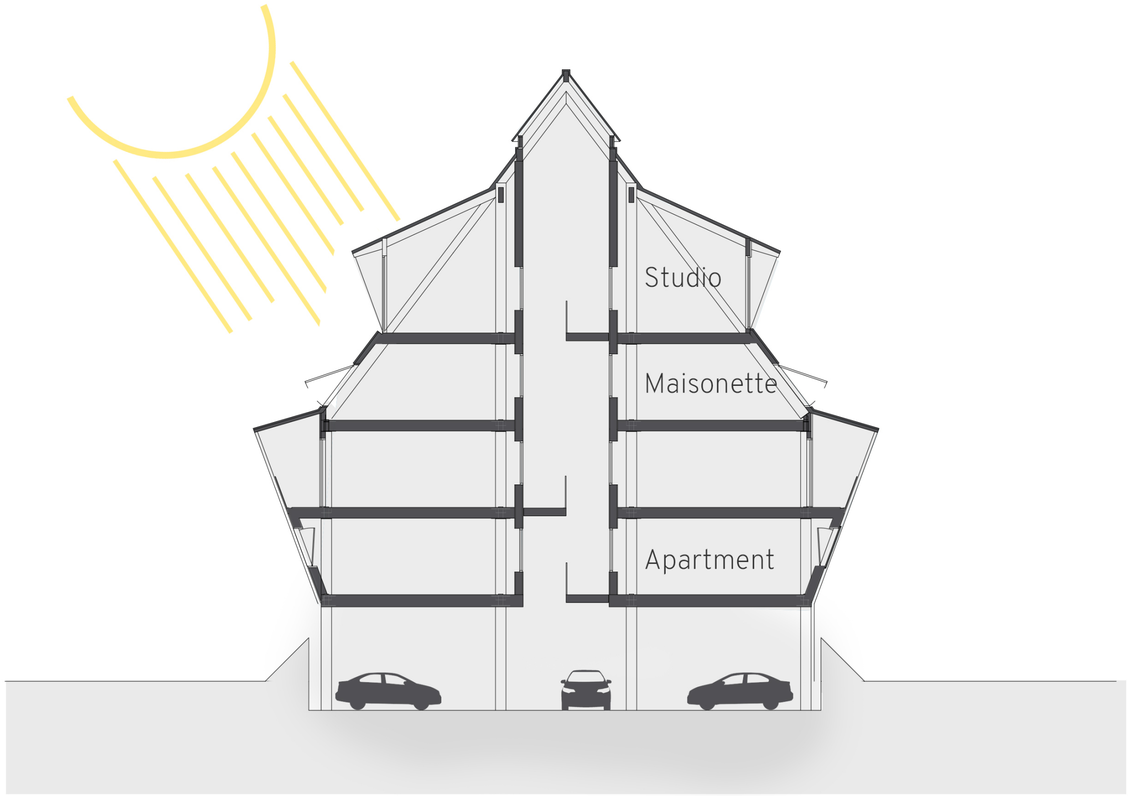


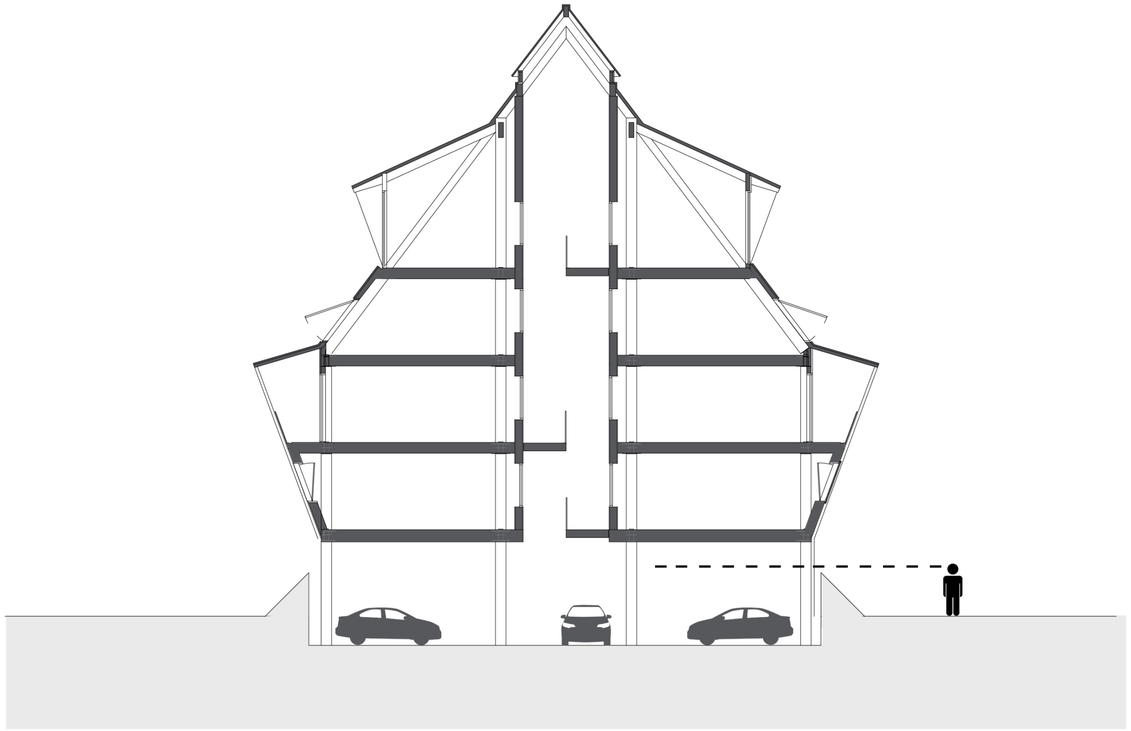

Attap roofing of low thermal capacity gives good insulation against heat
Ventilated roof space helps to cool the house
Ventilation through roof joint
Large roof eaves for effective sunshading
Open interior spaces with minimal partitions allow good ventilation in the house
Fully openable windows allow ventilation at body level
Lightweight construction using low thermal capacity materials keeps house cool
Stilted house catches winds of higher velocity

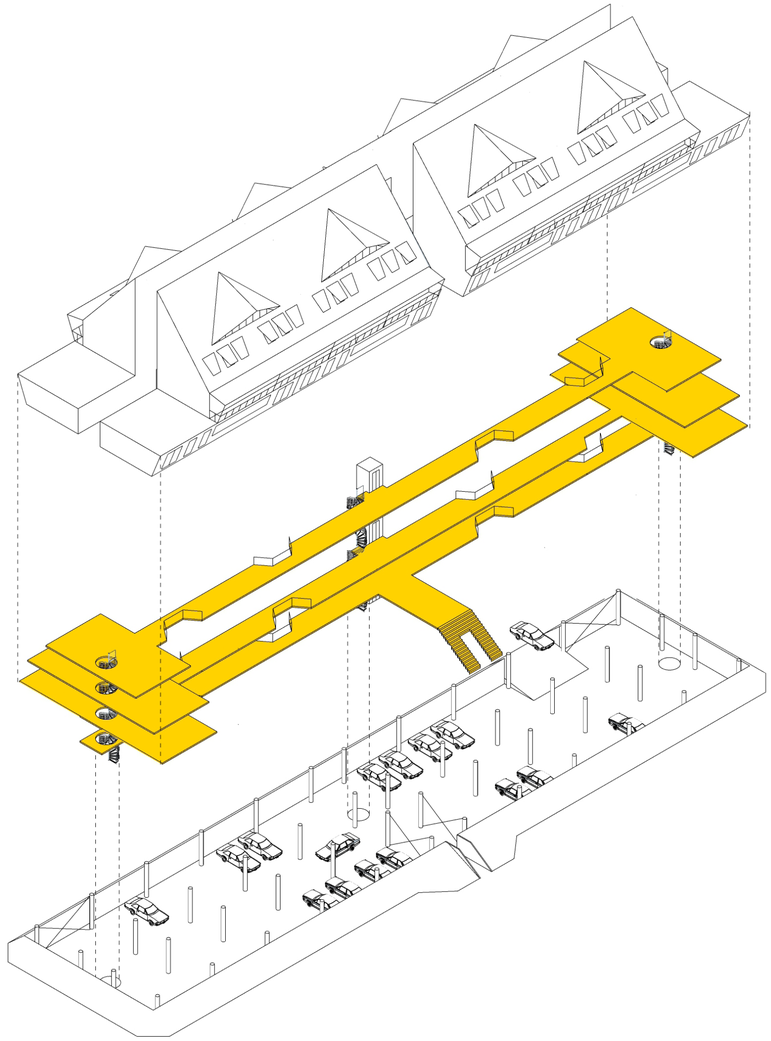

F5 +20.000
F4 +17.000
F3 +12.600
F2 +9.400
F1 +6.200
F0 +3.000
F-1 -1.000
6.000
4.500
6.000
A
B
C
D

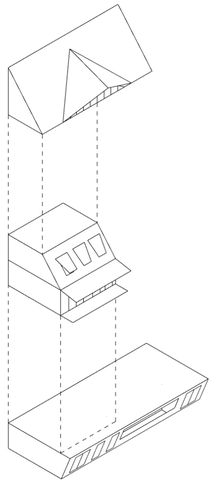

Studio
Maisonette
Apartment

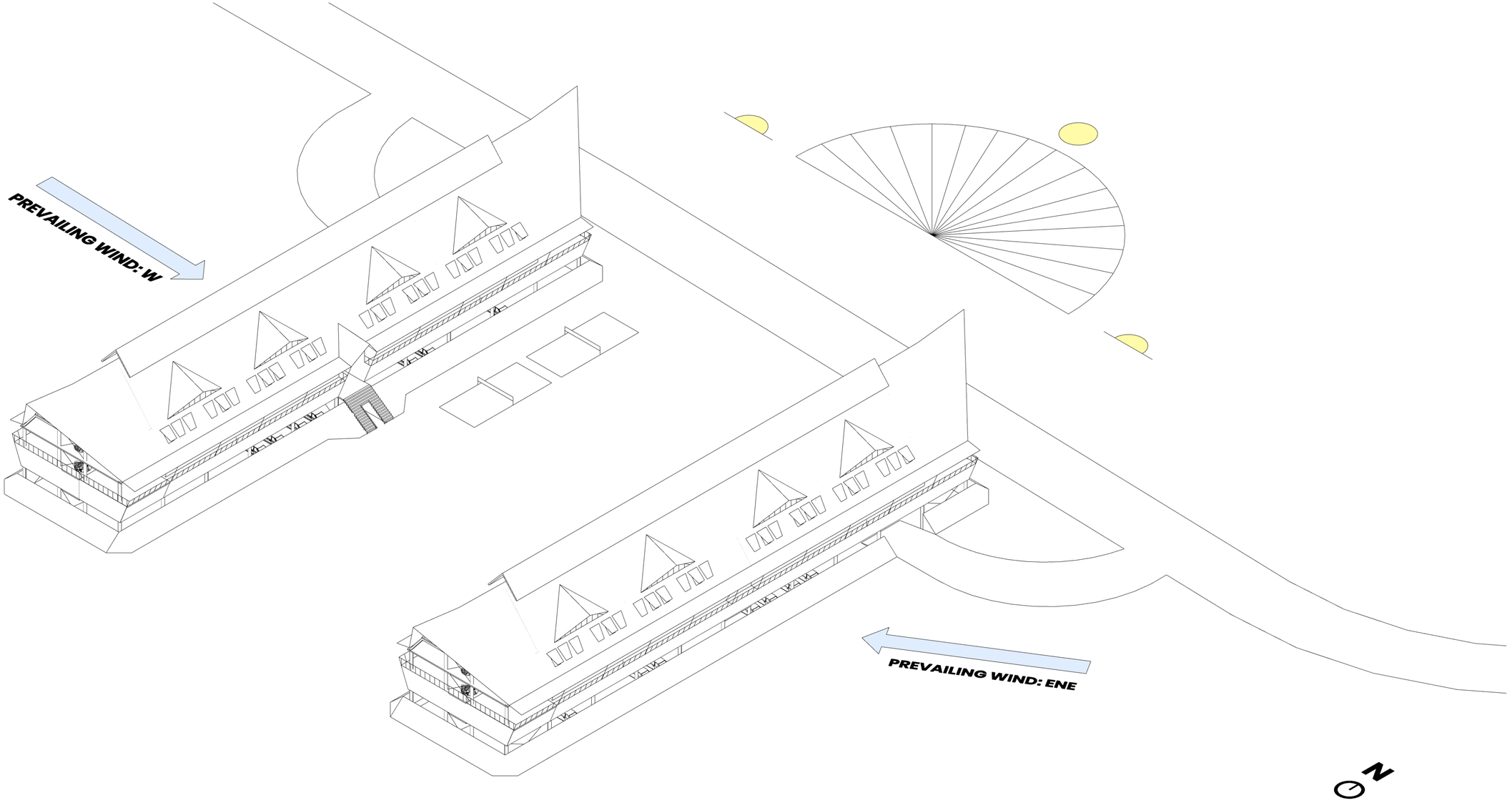



Studio
Maisonette
Apartment



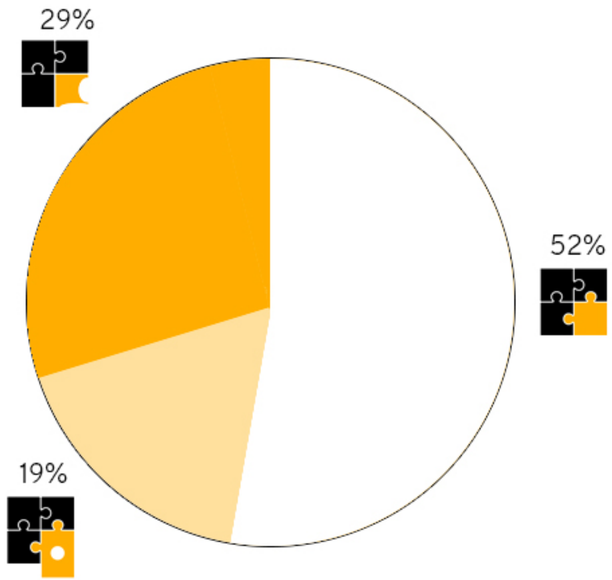




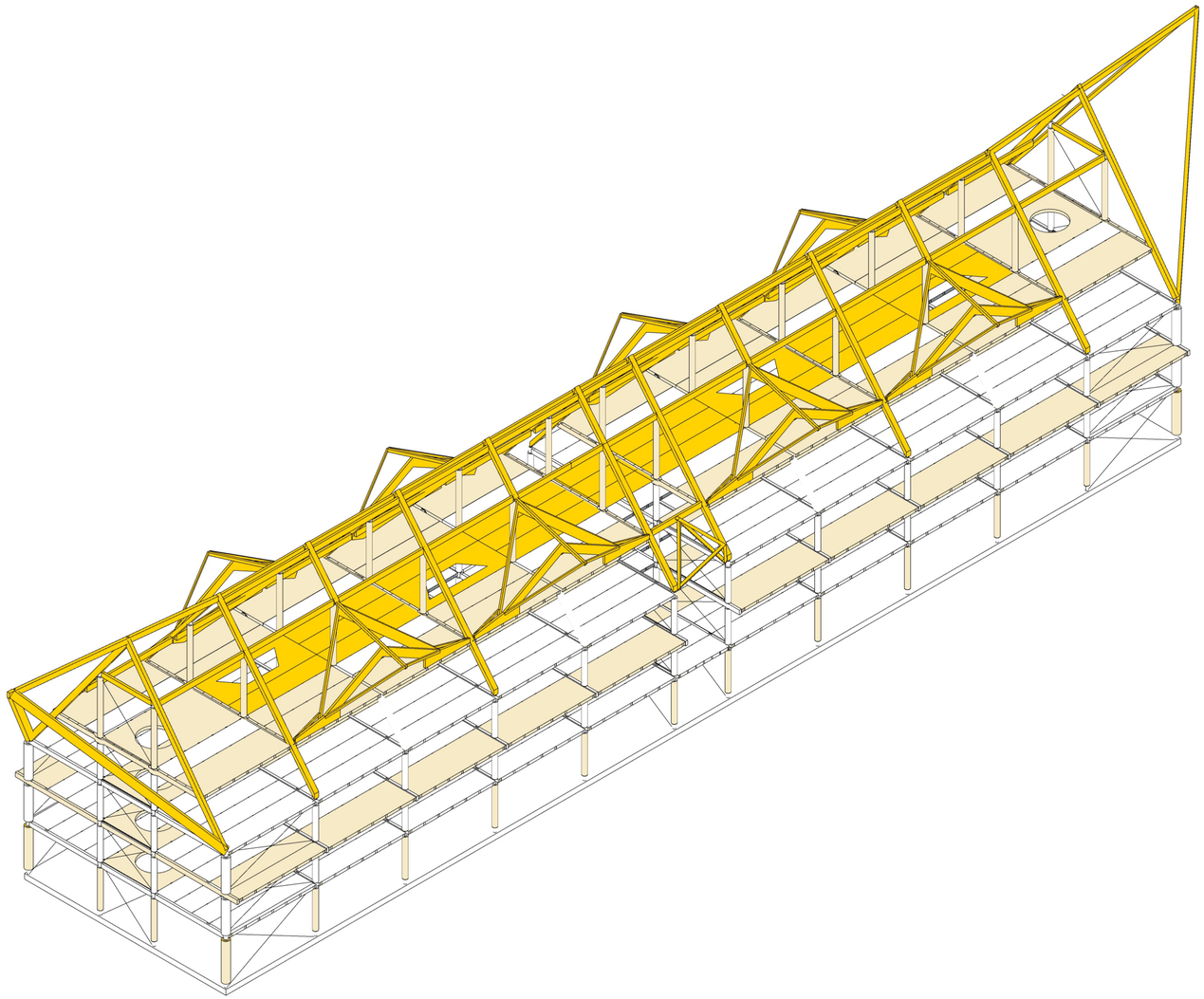

PREVAILING WIND: W
PREVAILING WIND: ENE
N



MODULARITY ANALYSIS

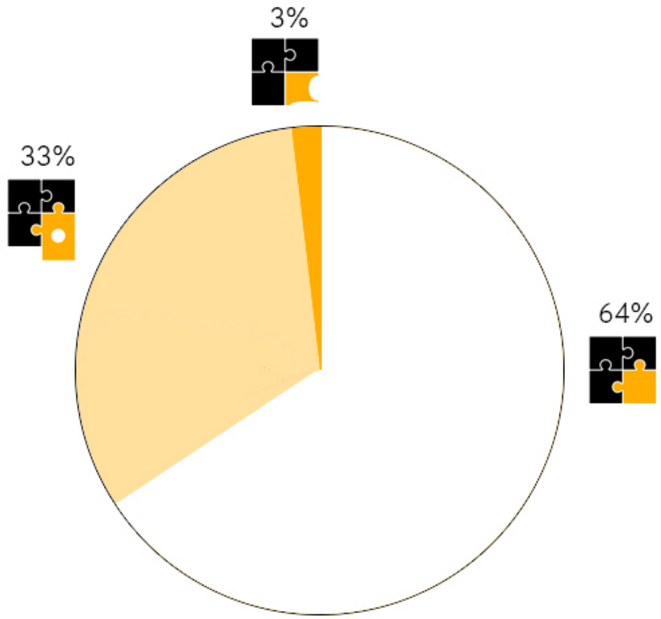


Jakarta: Construction

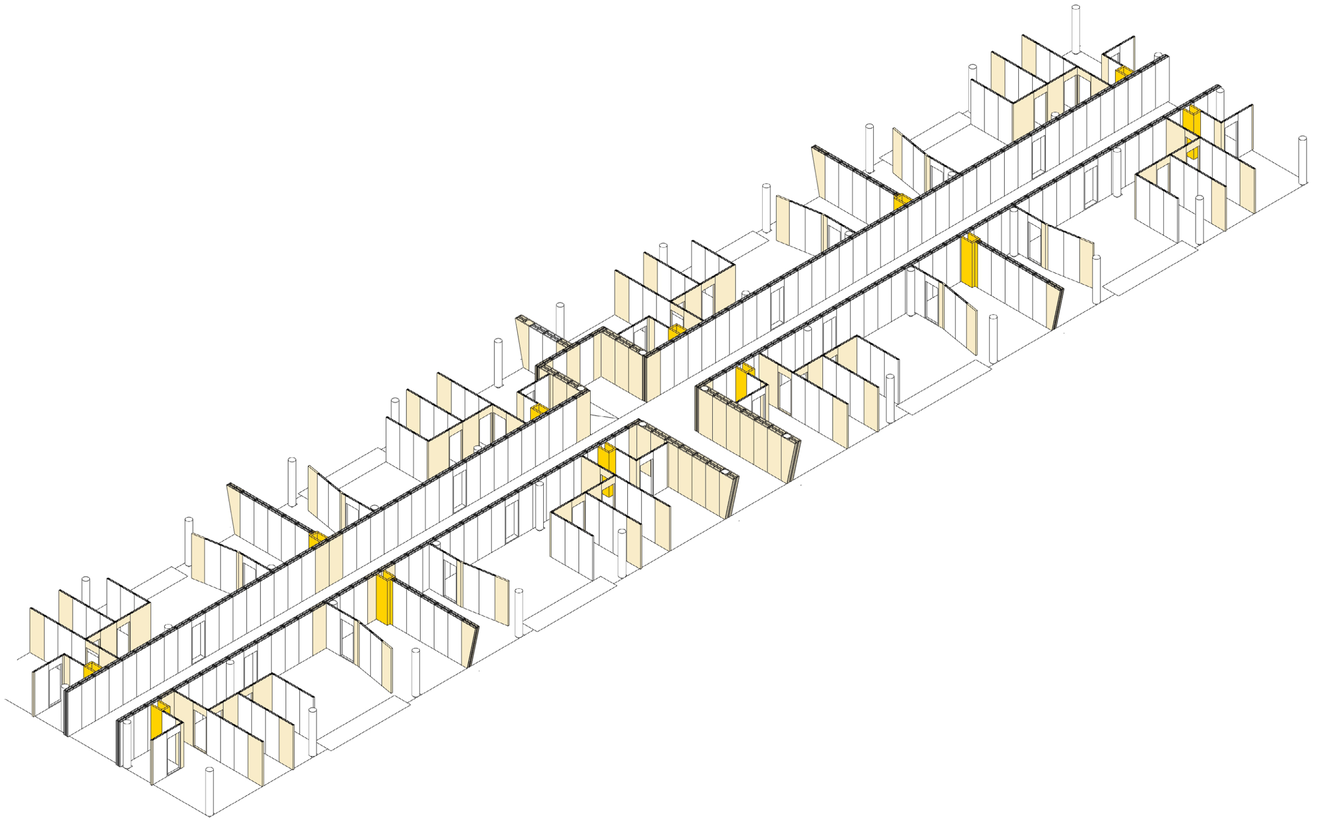


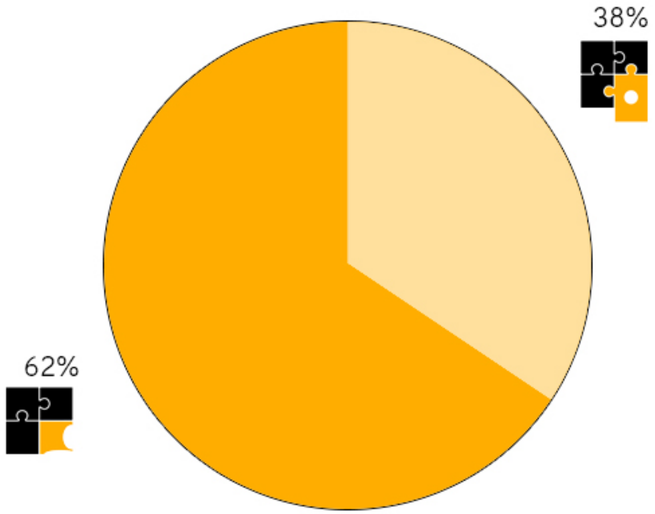
EXCLUDING

Foundation
Elevator

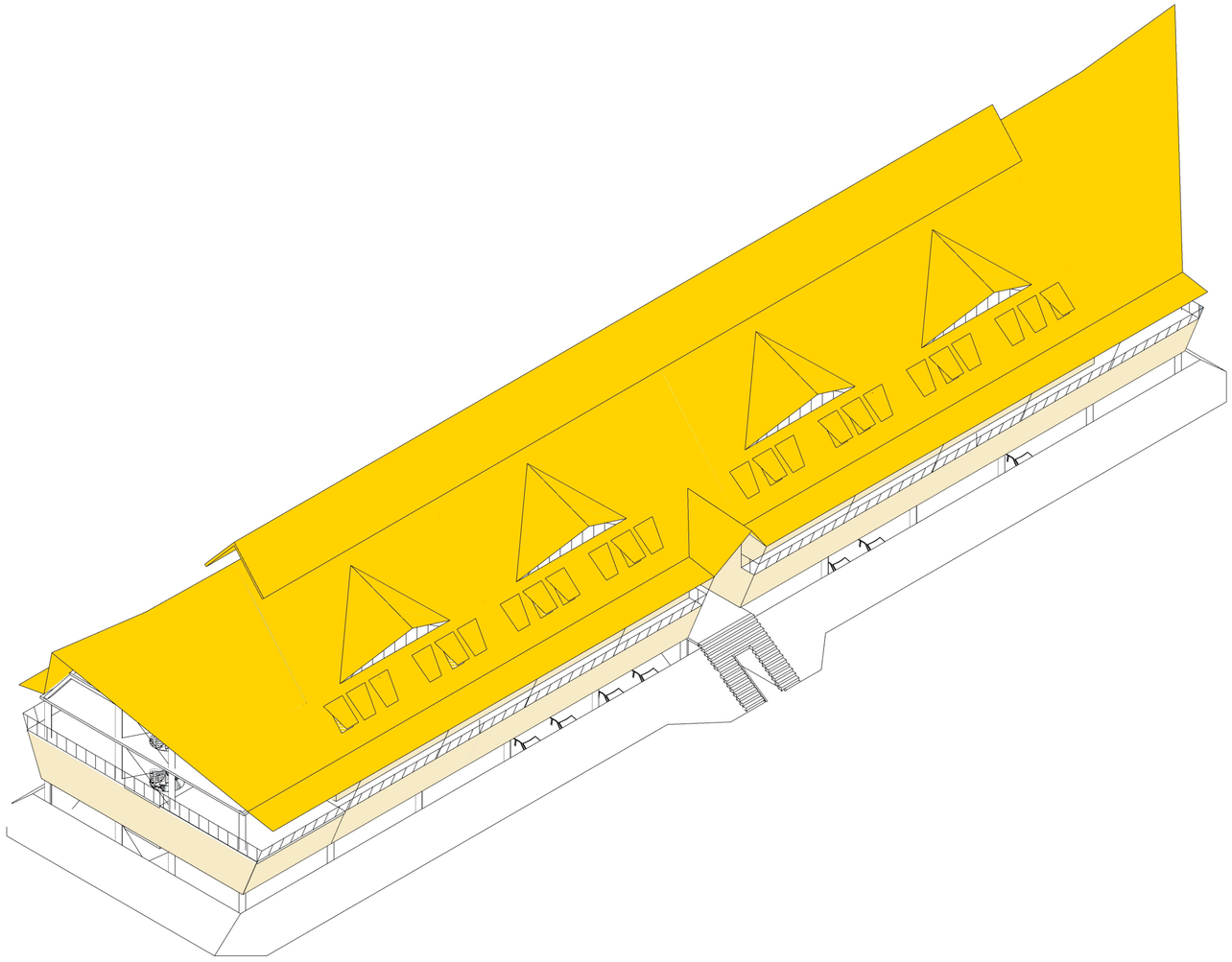


Jakarta: Interior Walls

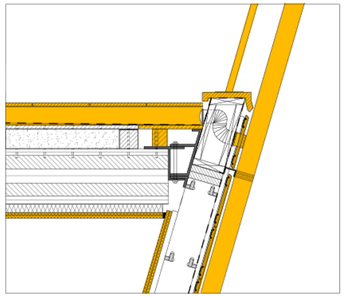




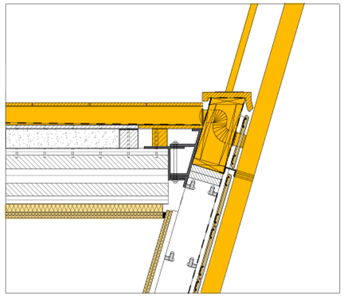
Jakarta: Building Envelope



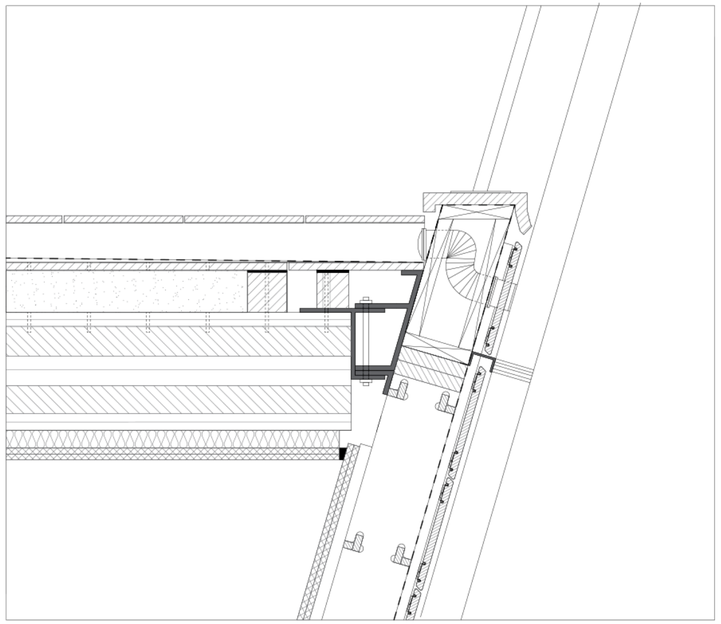
PREFAB / ON-SITE



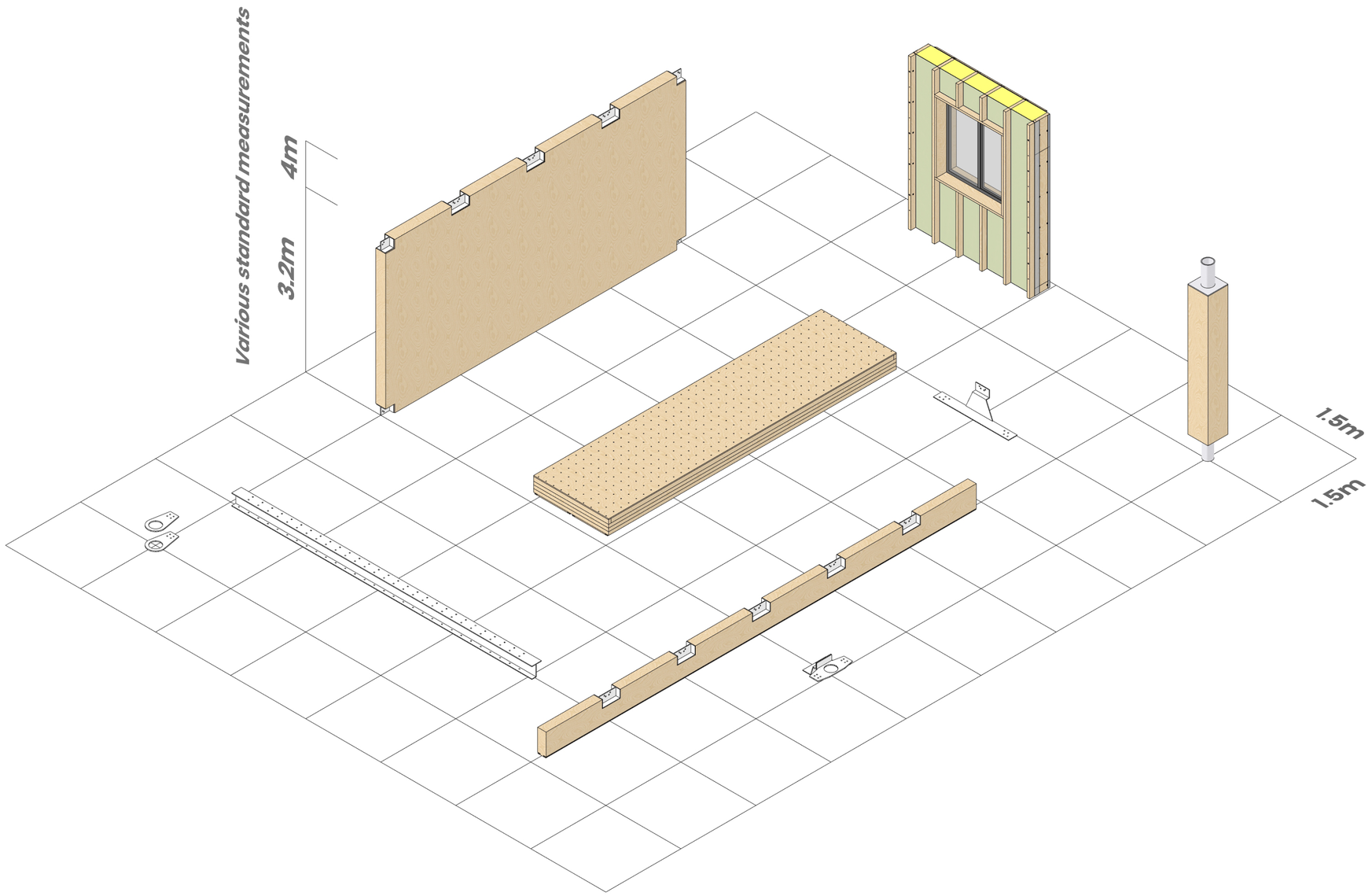
SYSTEM / CUSTOM



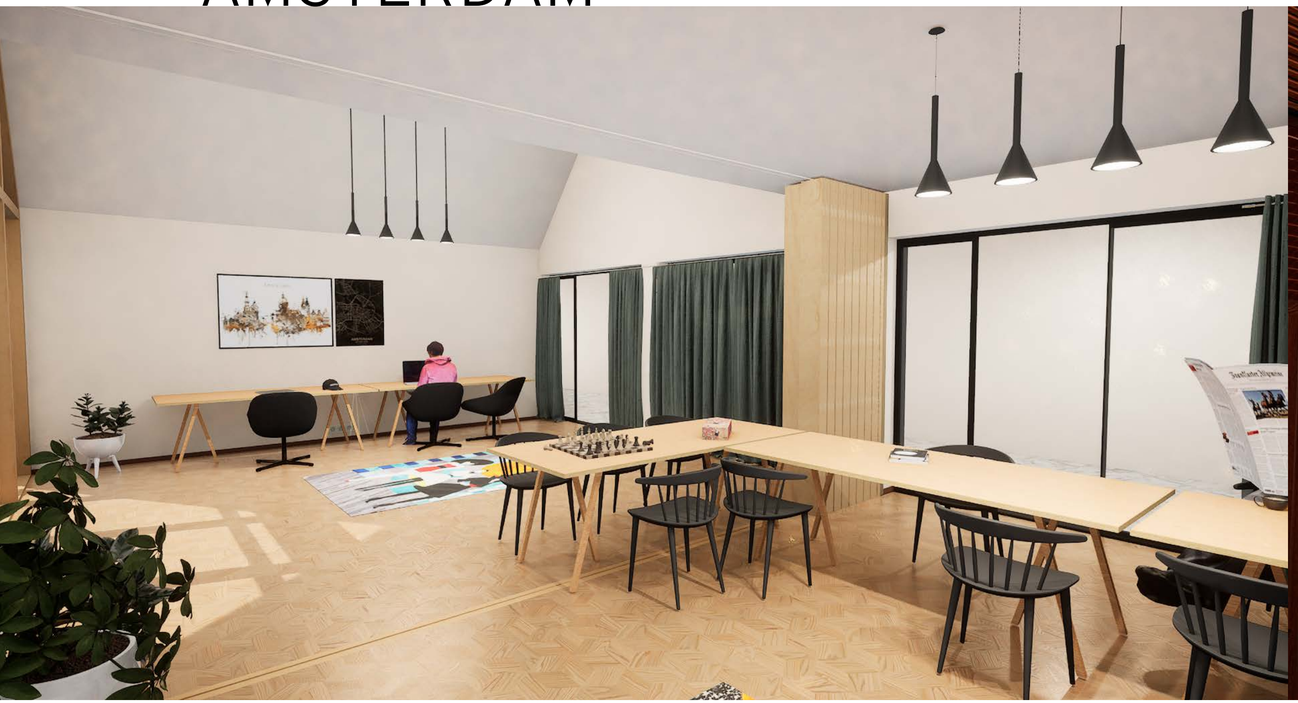
Jakarta Balcony Joint



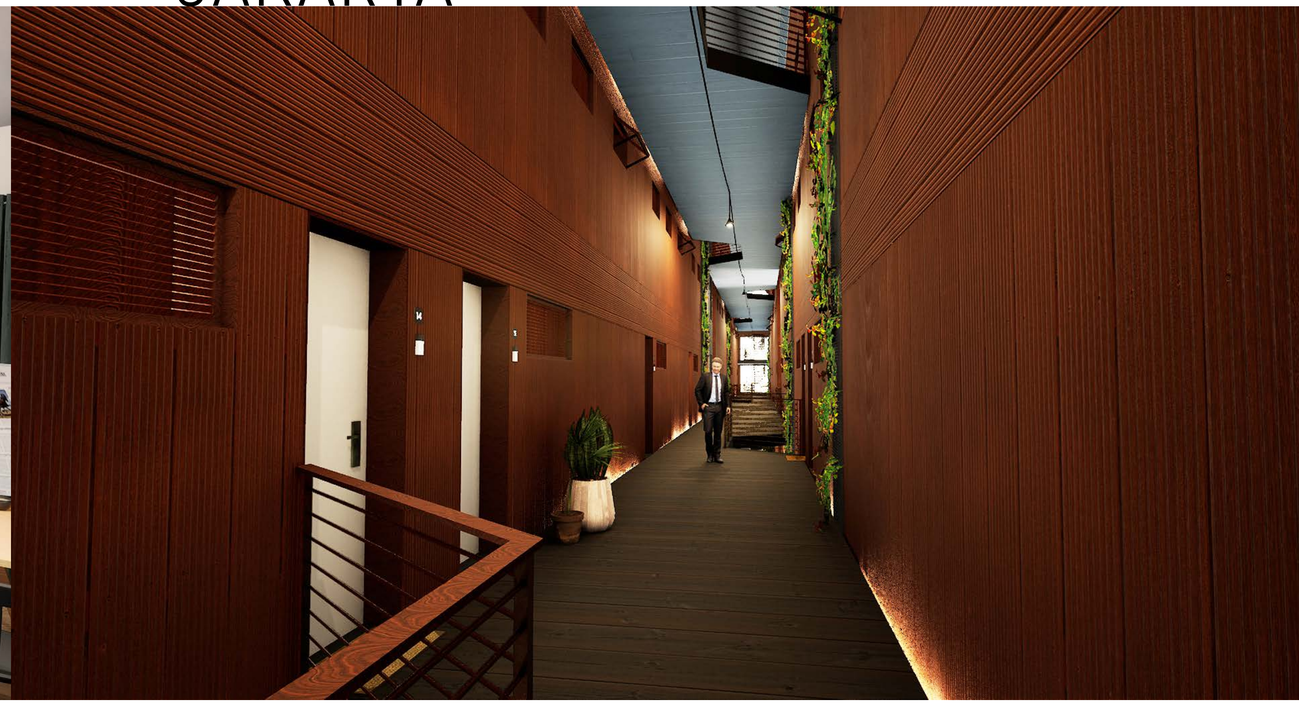
CONCLUSION

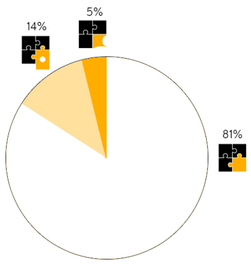

Various standard measurements
3.2m
4m
1.5m
1.5m

AMSTERDAM

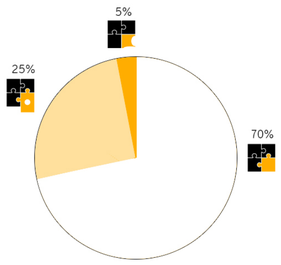


JAKARTA

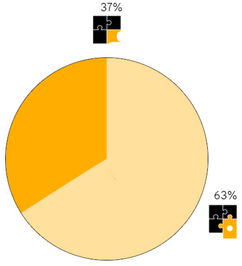




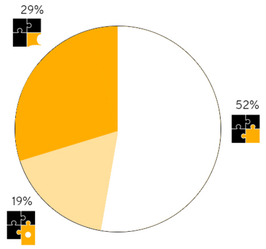
Amsterdam: Construction



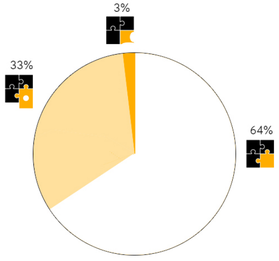
Amsterdam: Interior Walls



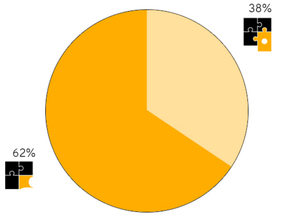
Amsterdam: Building Envelope



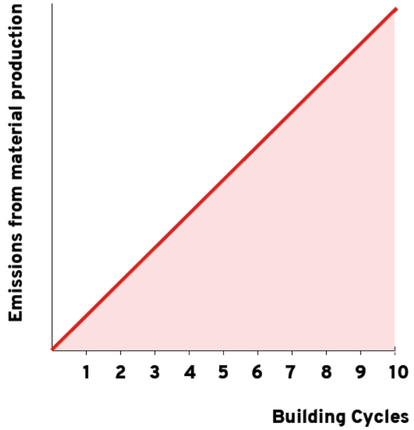
Jakarta: Construction

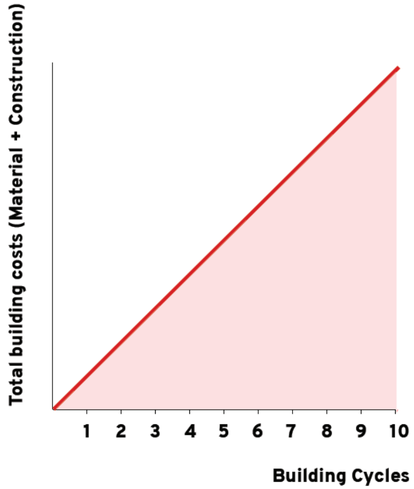


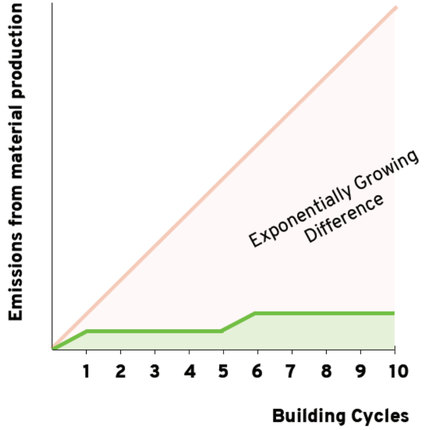
Jakarta: Interior Walls

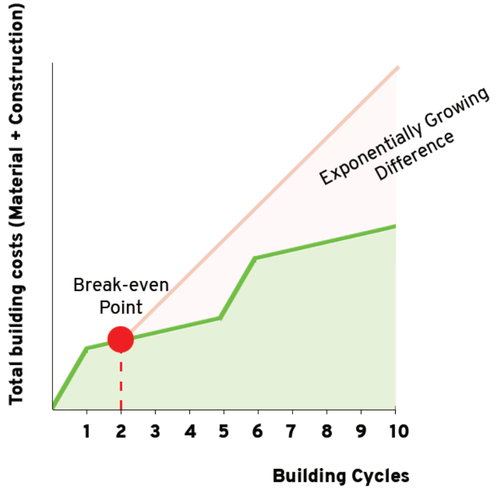


Jakarta: Building Envelope









- Lower average pollution during production (wood > concrete/steel)

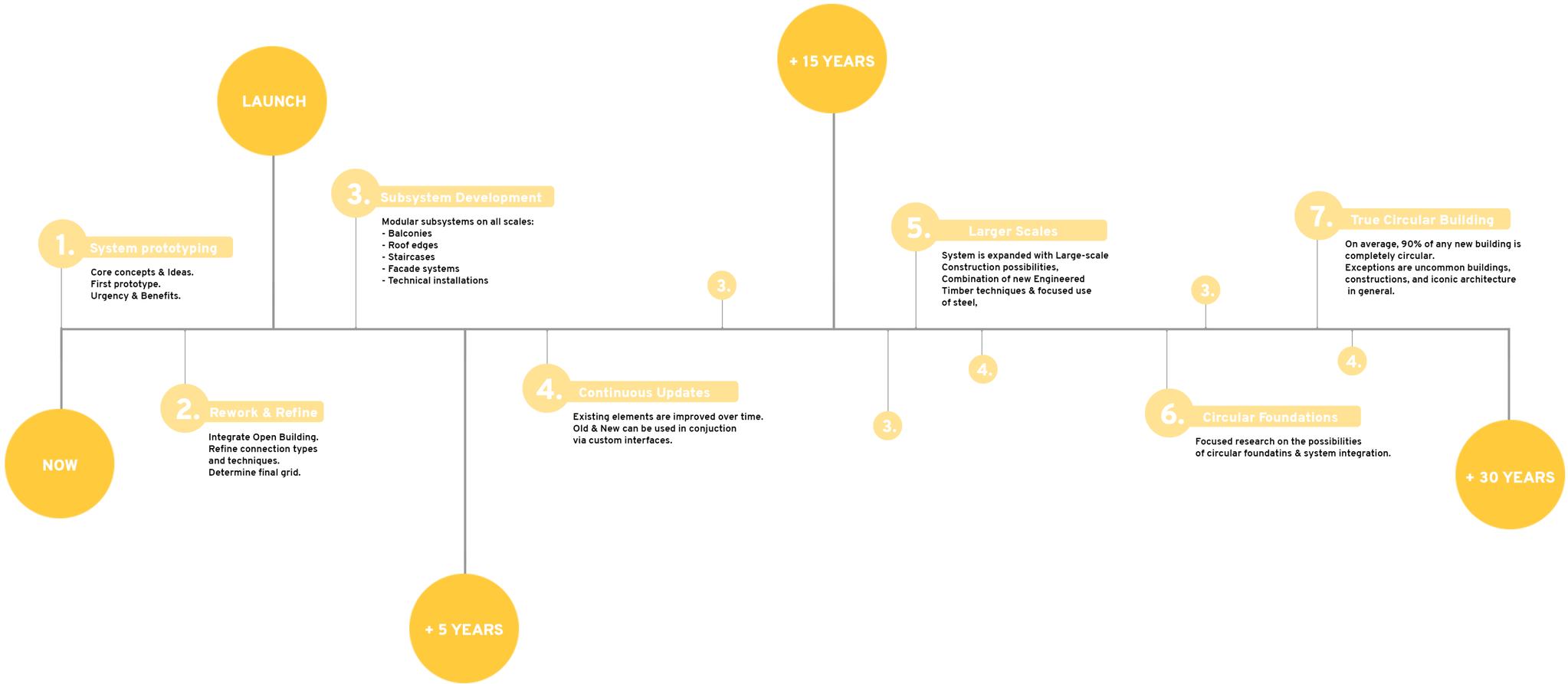
- Only have additional production when elements reach End of Life

- Vast and exponentially growing reduction of emissions over time

- Production more expensive (more complex elements)

- Lineair costs to harvest materials

- Exponentially growing profit over time, breaking even at the second building cycle


NOW
1.
System prototyping
Core concepts & Ideas.
First prototype.
Urgency & Benefits.
LAUNCH
2.
Rework & Refine
Integrate Open Building.
Refine connection types
and techniques.
Determine final grid.
+ 5 YEARS
3.
Subsystem Development
Modular subsystems on all scales:
- Balconies
- Roof edges
- Staircases
- Facade systems
- Technical installations
3.
4.
Continuous Updates
Existing elements are improved over time.
Old & New can be used in conjuction
via custom interfaces.
+ 15 YEARS
3.
4.
5.
Larger Scales
System is expanded with Large-scale
Construction possibilities,
Combination of new Engineered
Timber techniques & focused use
of steel,
3.
6.
Circular Foundations
Focused research on the possibilities
of circular foundatins & system integration.
4.
7.
True Circular Building
On average, 90% of any new building is
completely circular.
Exceptions are uncommon buildings,
constructions, and iconic architecture
in general.
+ 30 YEARS



SOURCE: https://www.archdaily.com/904271/can-future-cities-be-timber-cities-googles-sidewalk-labs-asks-the-experts/5bcdab91f197cc4e40000204-can-future-cities-be-timber-cities-googles-sidewalk-labs-asks-the-experts-image



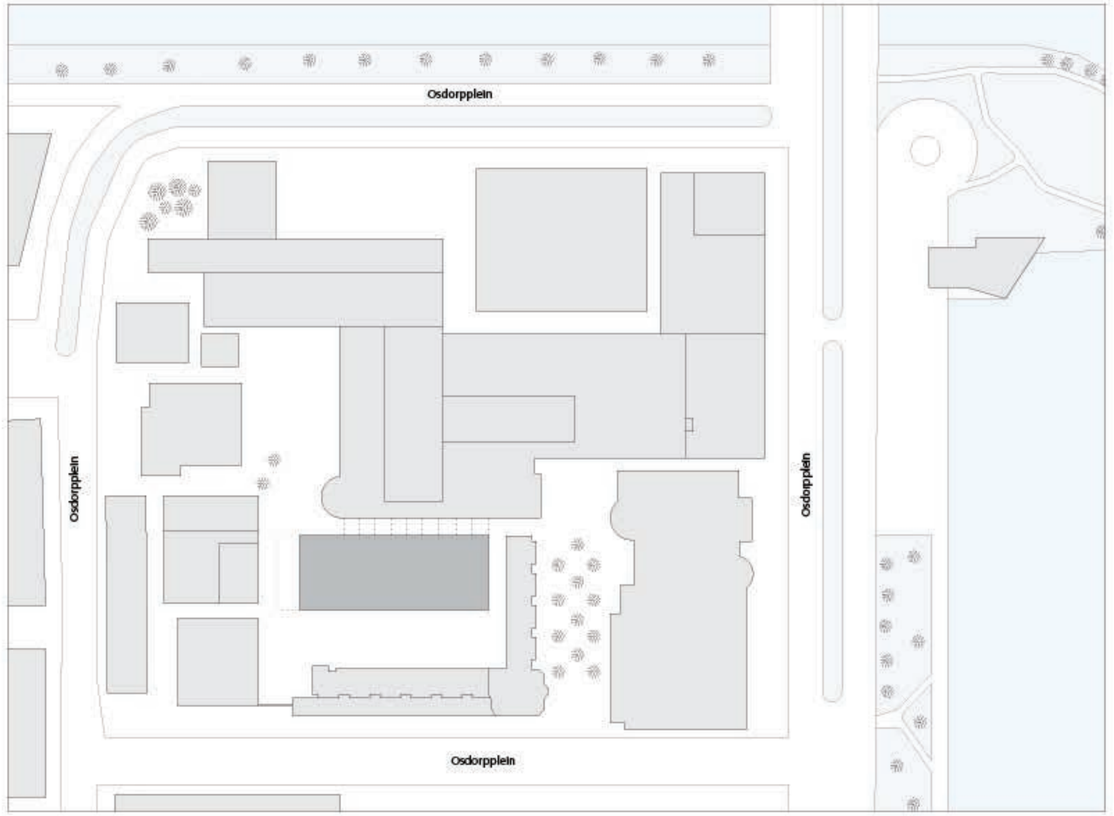
SOURCE: hhttps://www.theglobeandmail.com/arts/art-and-architecture/article-cab[illegible]build-the-future-of-wood-well-see/



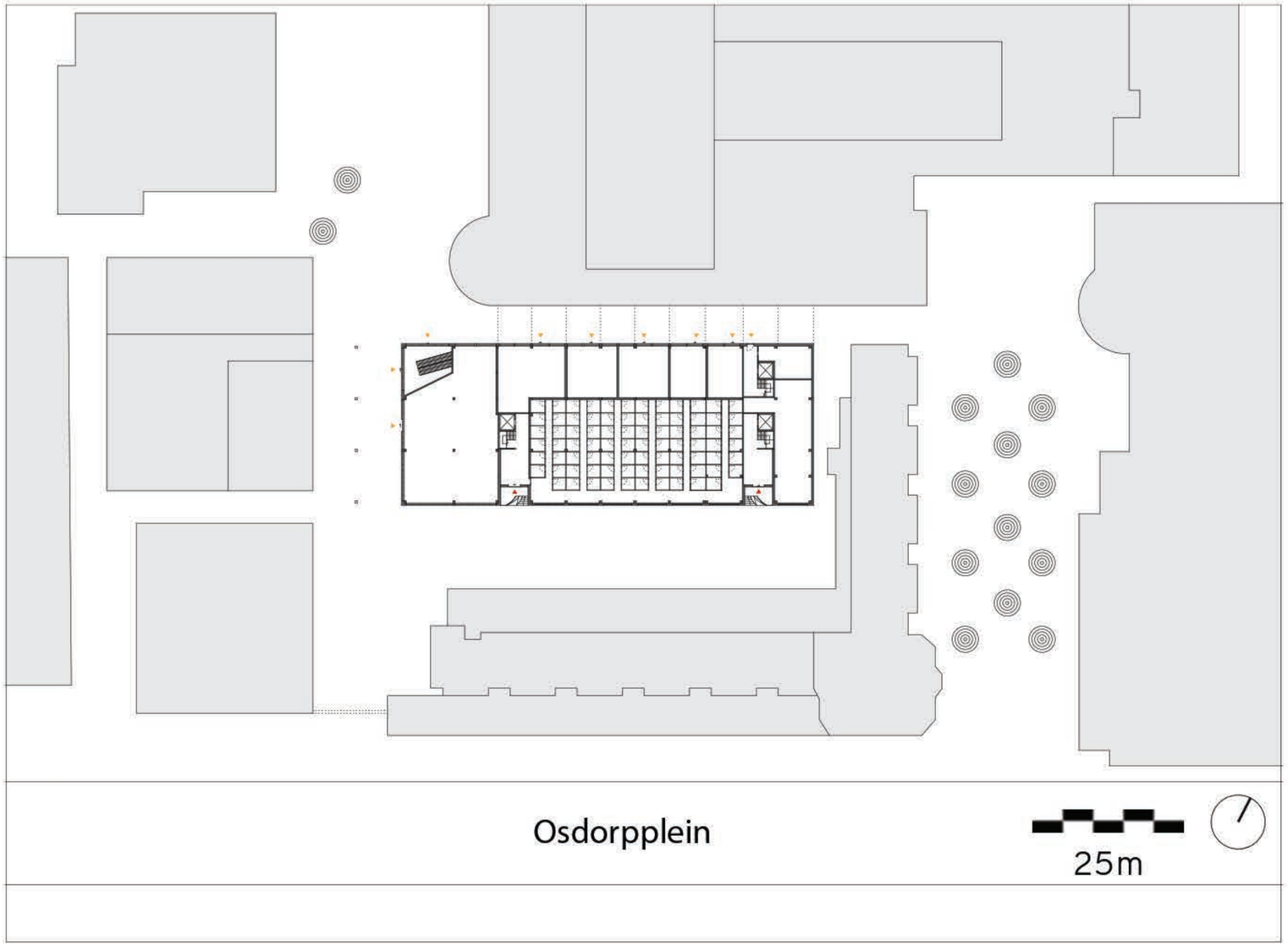
SOURCE: https://www.phaidon.com/agenda/architecture/articles/2018/january/04/could-wood-be-the-future-of-urban-architecture/

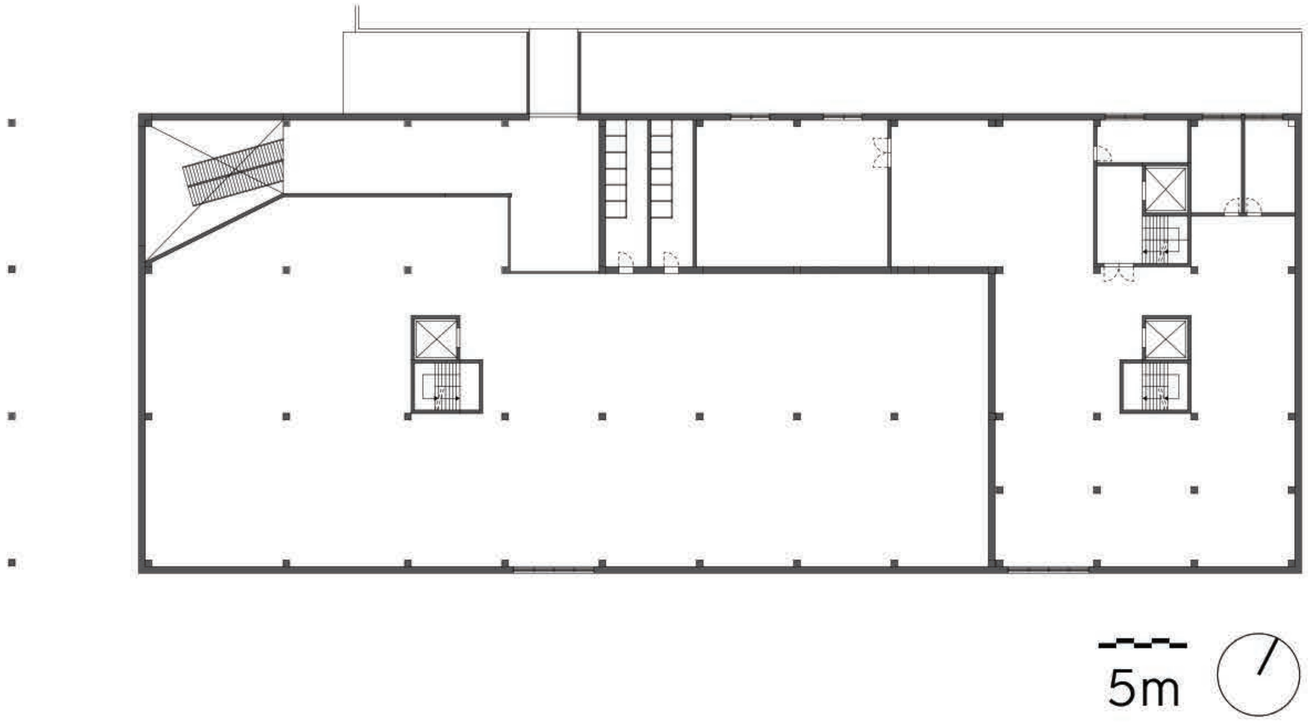
BOOKLET

SITUATION & FLOOR PLANS



25m Situational plan


Osdorpplein
25m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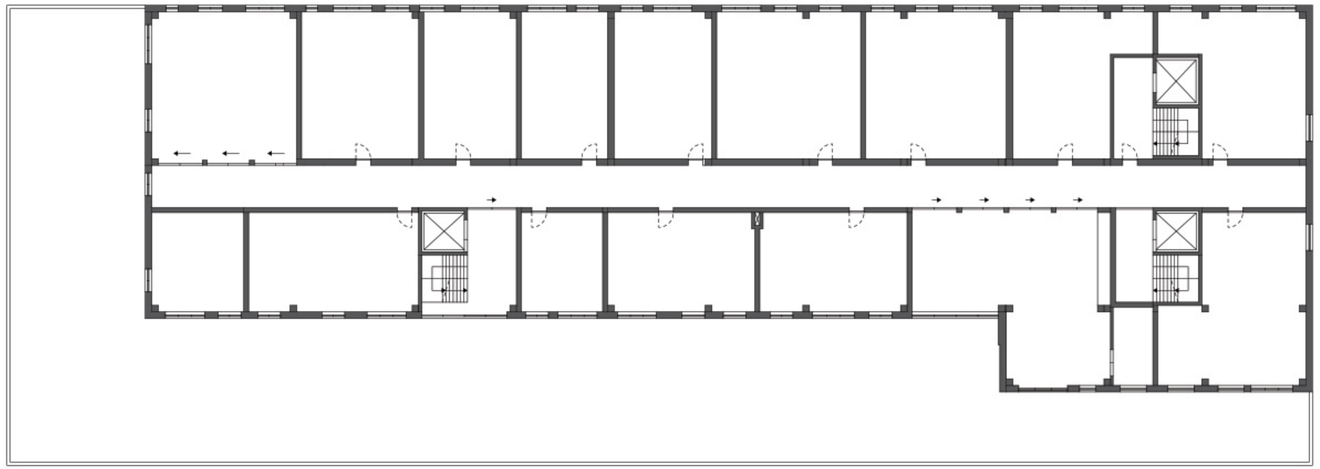
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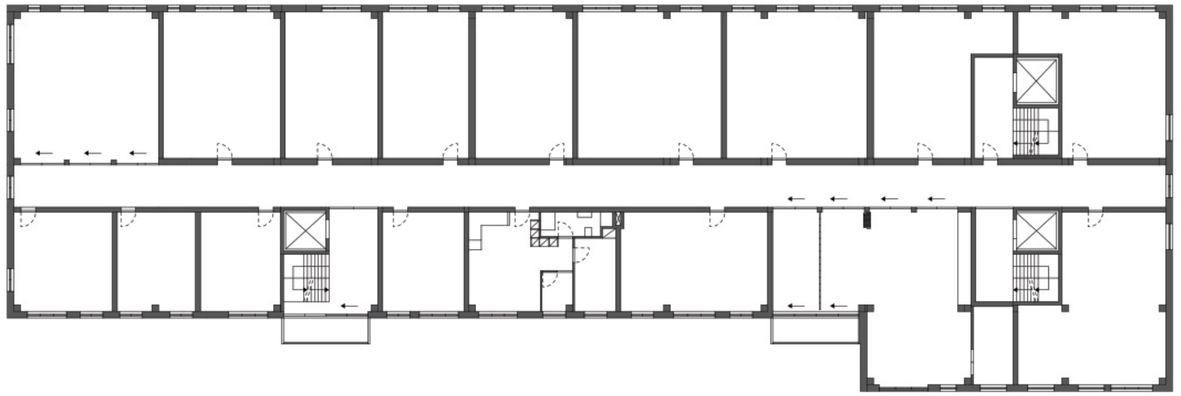
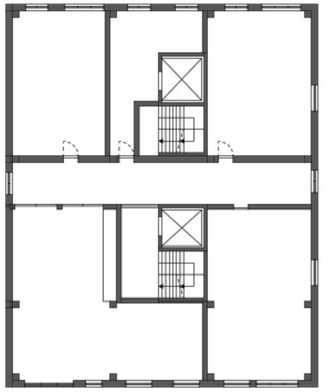



5m

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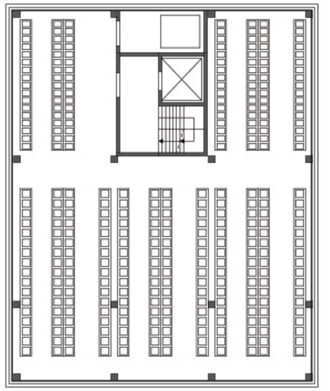
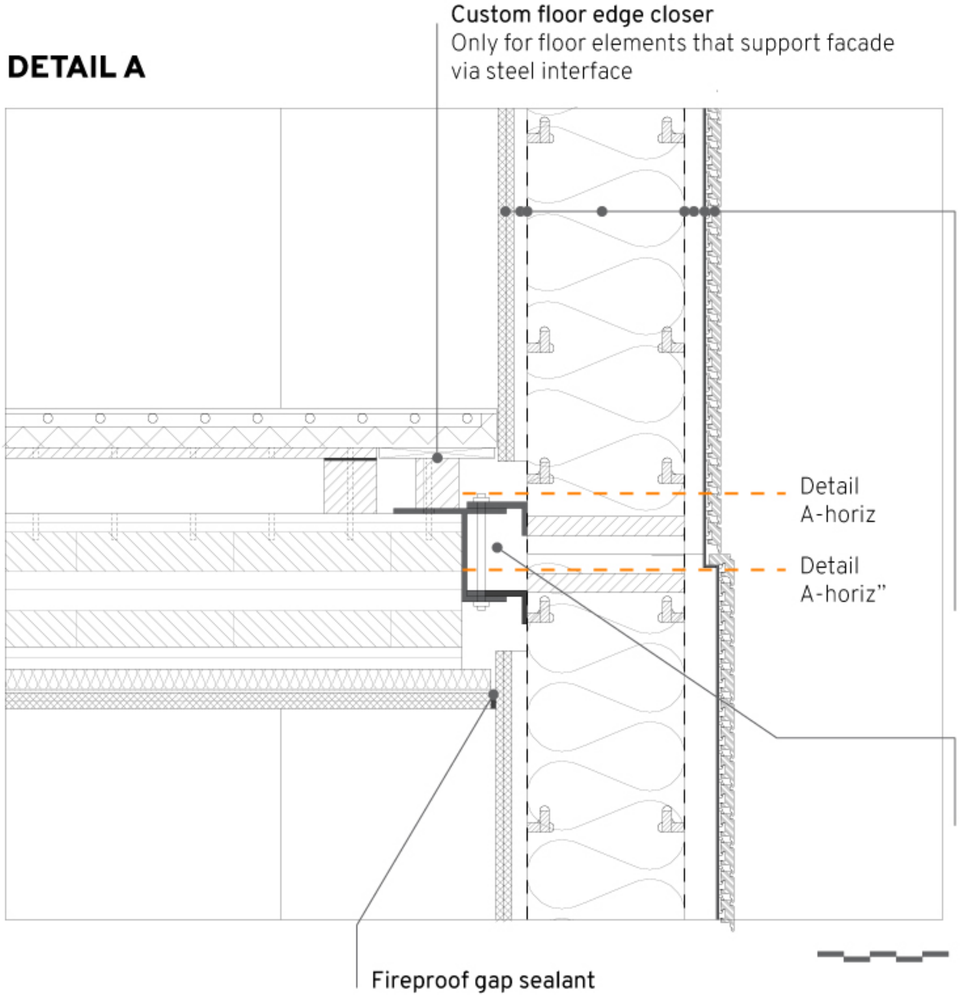



5m

DETAILS

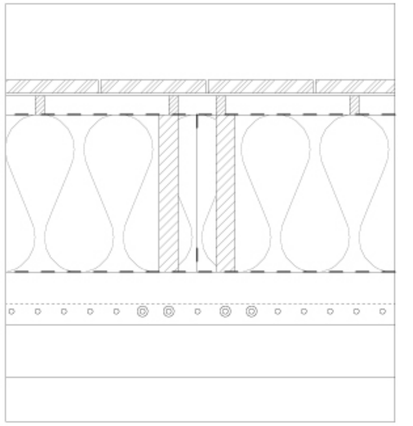
DETAIL A



Stucco, finishing layer, 2mm
Gypsum fibre board 2x, 30mm
Fire protection
Functional finishing layer
Vapor barrier
Rockwool, 300mm
Thermal insulation
Sound insulation for exterior sound
Waterproof membrane
Ventilated cavity, 35mm
Aberson A-brick system: metal sheet , 5mm
protrusions to attach brick faces
Aberson A-brick system: brick faces, 25mm
demountable ceramicfacade system

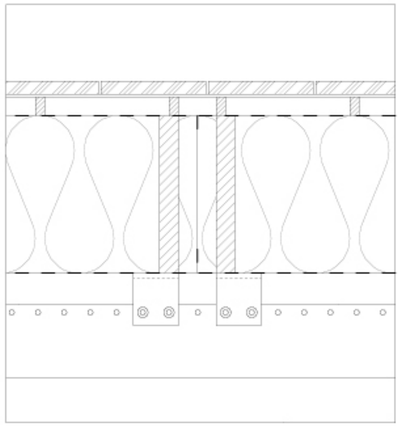
Floor-Facade Connection
Vertical space is provided to ease appliance of vapor barrier, see details A & A'

DETAIL A-Horiz



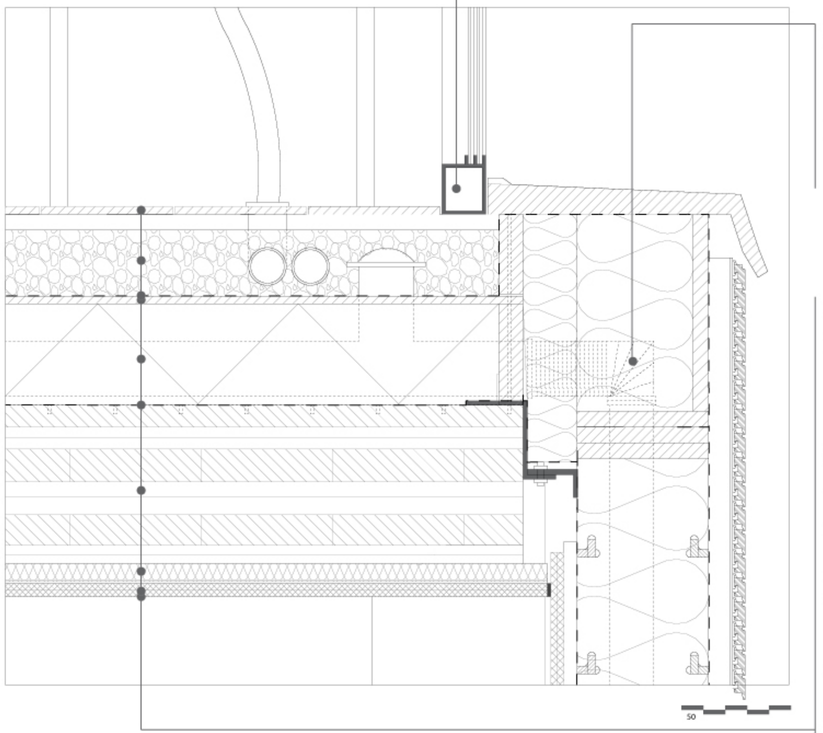
Floor-Facade interface
At the top side of the facade elements, the interface spreads the entire width to provide freedom of placement and strong construction. Attached with steel bolts, easily disas-semblable.

DETAIL A-Horiz'



Floor-Facade interface
At the bottom side of the facade elements, the interfaces don't spread the entire width and provide space to seal the seams between seperate elements on-site.

DETAIL B



Lightweight steel frame
Greenhouse construction
Attached to construction with method comparable to detail X

Custom roof edge construction
Non-system roof edge, wood frame construction
Attached to facade elements via disposable wooden interfaces

Downspout coupling piece
Custom piece to couple the pre-fab water drainage from roof and facade elements

Greenhouse flooring, wooden deck, 18mm

Gravel, 150mm
Water drainage
Extra weight for construction
Sound insulation
Integrated water system for greenhouse units

Waterproof membrane

Timber, 18mm | PREFAB
Roof construction topping layer

Thermal Insulation (EPS), 250mm | PREFAB
Water drainage integrated

Vapor barrier | PREFAB

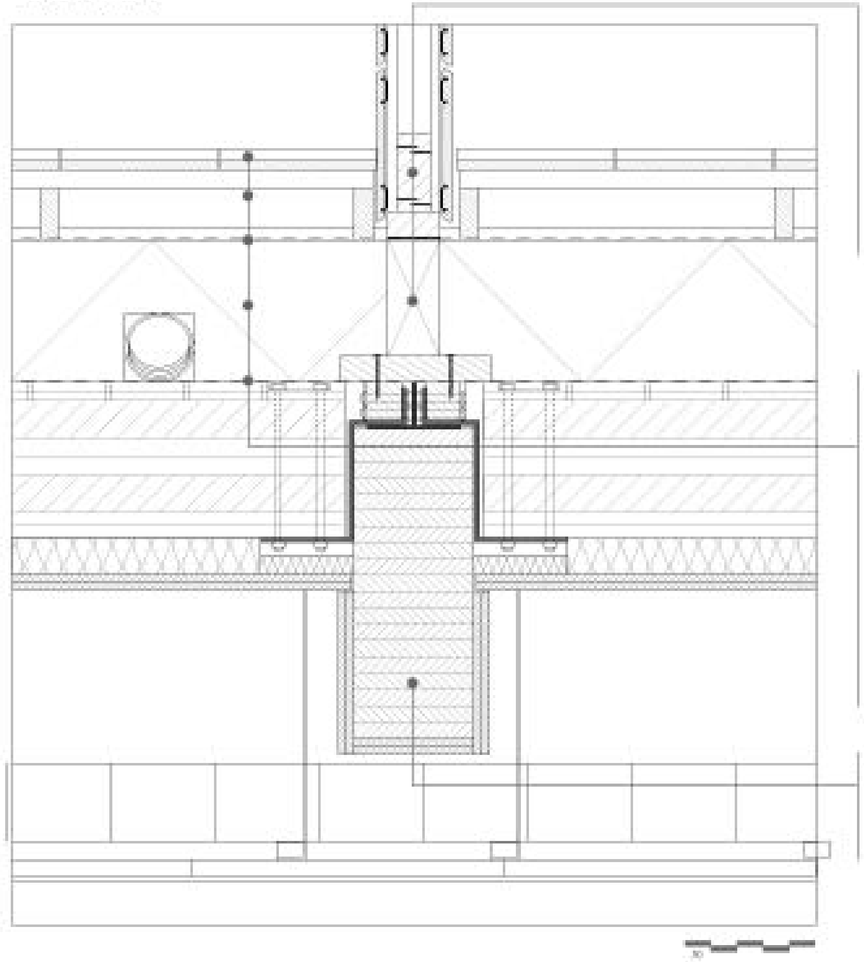
CLT, 360mm
Constructive element
Extra thickness to bear load of greenhouse

Rockwool, 40mm
Additional sound insulation

Gympsum fibre board double layer, 30mm
Fire protection
Functional finishing layer

Stucco, 2mm
Finish

DETAIL C



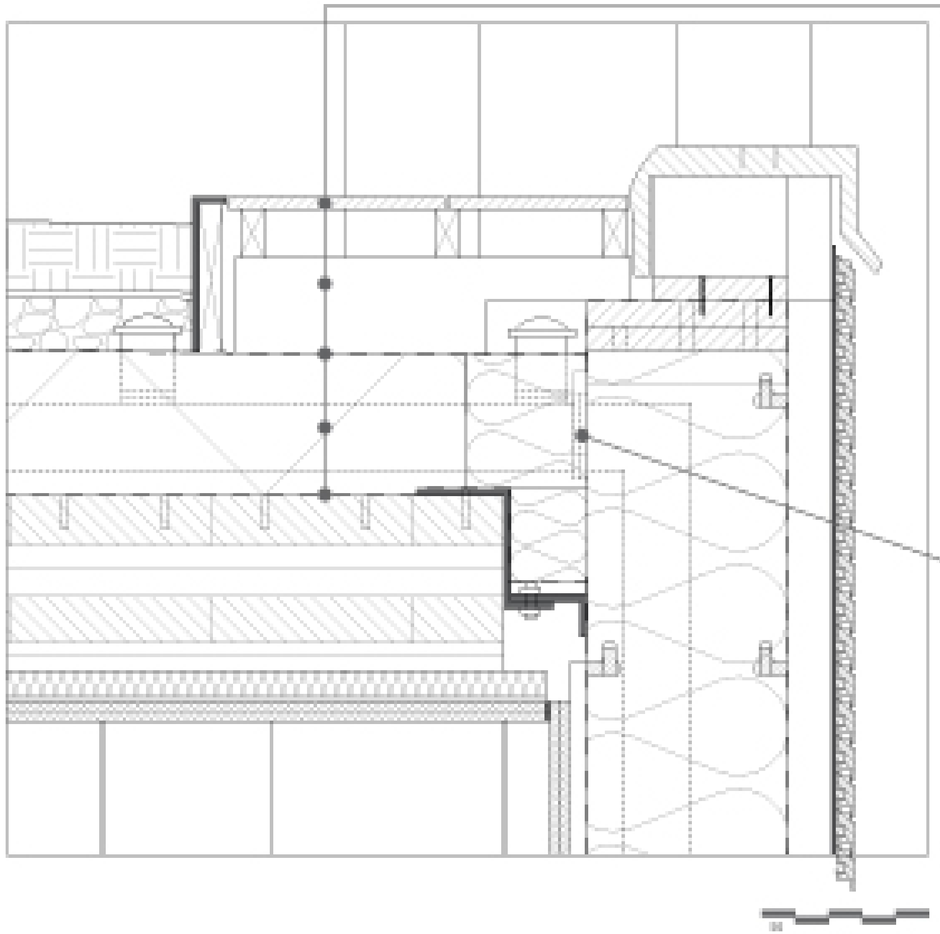
Wood frame construction
Balcony-bearing construction
Custom element
Finished with Derako demountable wood facade system

Wooden Interface construction
Custom wooden construction
Connects custom balcony construction to building system standard beam
Constructed on-site

Terrace finish, wooden deck, 18mm
Wood frame, 100 + 40mm
Constructive element
Lower frame aligned with insulation height gradient to allow water drainage
Waterproof membrane
Thermal Insulation (EPS), 250mm
10/1000 height gradient to facilitate water drainage
Water drainage integrated in layer
Vapor barrier

Glu-lam 9m System beam
Standard system element
Thicker Variant compared to beams that do not bear balcony load

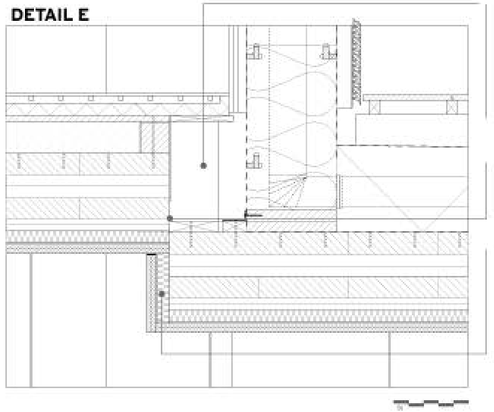
DETAIL D



Terrace finish, wooden deck, 18mm
Wood frame, 100 + 40mm
Constructive element
opening at facade side to allow water to flow to drainage points
Waterproof membrane
Thermal insulation (EPS), 250mm
10/1000 height gradient to facilitate water drainage
Water drainage integrated in layer
Seperate closed-off water drainage for green roof segments
Vapor barrier

Downspout coupling point
Downspout is integrated in pre-fab facade elements, extended to roof/terrace on-site

DETAIL E

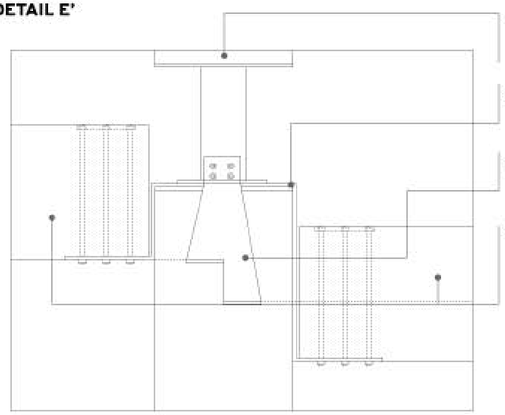


Extra large custom floor edge closer
Constructed with simple wood frame construction.
Custom measurements to accomodate floor level difference.
Space for pipes and cables.

Floor level difference
Facilitates level transition between dwellings and roof terrace
See Detail E'

Custom ceiling add-on
Placed at the level difference, bottom floor elements have special custom ceiling add-ons (Fire protection, sound insulation) that provide full encapsulation of constructive elements.

DETAIL E'



Standard Glu-LamPost
450x450x3200 mm
Integrated tubular steel interfaces at top and bottom side to connect elements.

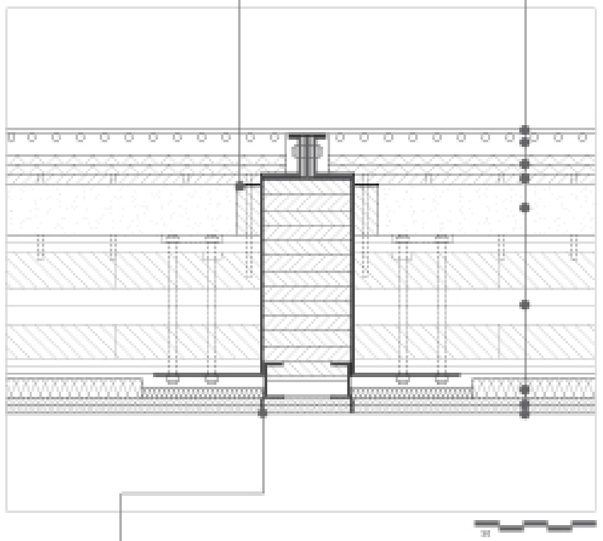
Custom Post-Beam Steel Interface
Executed as a single element with two different height levels for beams.
Slid over topside of post interfaces before new constructive layer is added.

Custom Post-Floor Steel Interface
Executed as a single element with two different height levels for floors.
Attached to post interface

Standard Glu-Lam Beams
(<)9000 mm span, 500 mm height (450+50)
Attached to steel interfaces with 6 remountable bolts.

DETAIL F

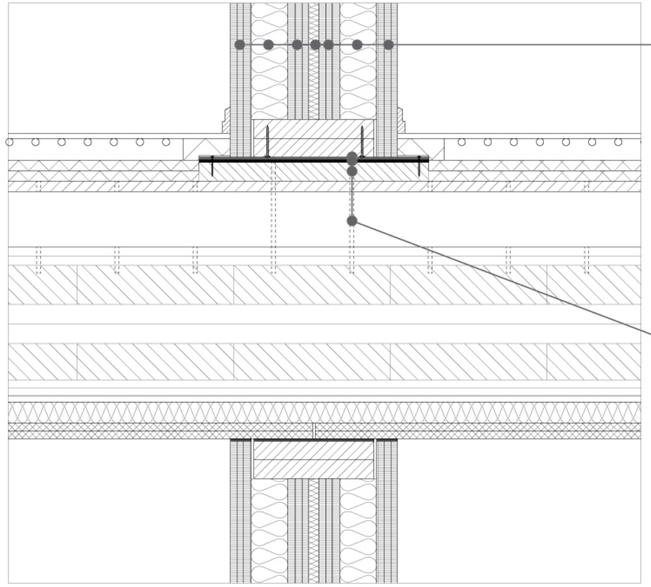
Elastomer bearing
Decouples top layer from supporting timber elements to ensure sound insulative properties of honeycomb cardboard layer.



Fire protective gap sealant
Closes gaps of pre-fab beam and floor element's fire protective layers.

Floor Finish, 10mm
Variable material
Dry floor heating screed, 35 mm
Easily disassemblable
Insulating Foam, 40 mm
To optimize underfloor heating
Hardboard, 18mm
Top layer of Pre-fab floor elements
Pre-drilled holes with grid of 150 mm x 150 mm that allow easily disassemblable connections
Honeycomb cardboard + infill, 100mm
Additional constructive weight
Sound insulation
Height padding
CLT Slab, 35+220+35 mm
Dwelling variant
35 mm extra material on top and bottom as utilitary layers
Top :Pre-drilled holes with grid of 150 mm x 150 mm that
Bottom: Milled grooves to allow slide-on ceiling add-ons
Ceiling Add-on - Frame, 50 mm
Wood frame attached to aluminium frames
Ceiling Add-on - Rockwool, 40 mm
Additional sound insulation
Ceiling Add-on - Gypsum Fibre Board Double layer, 30 mm
Fire protection
Functional finishing layer (drilling small holes in ceiling, walls without damaging core element)
Stucco
Finish

DETAIL G



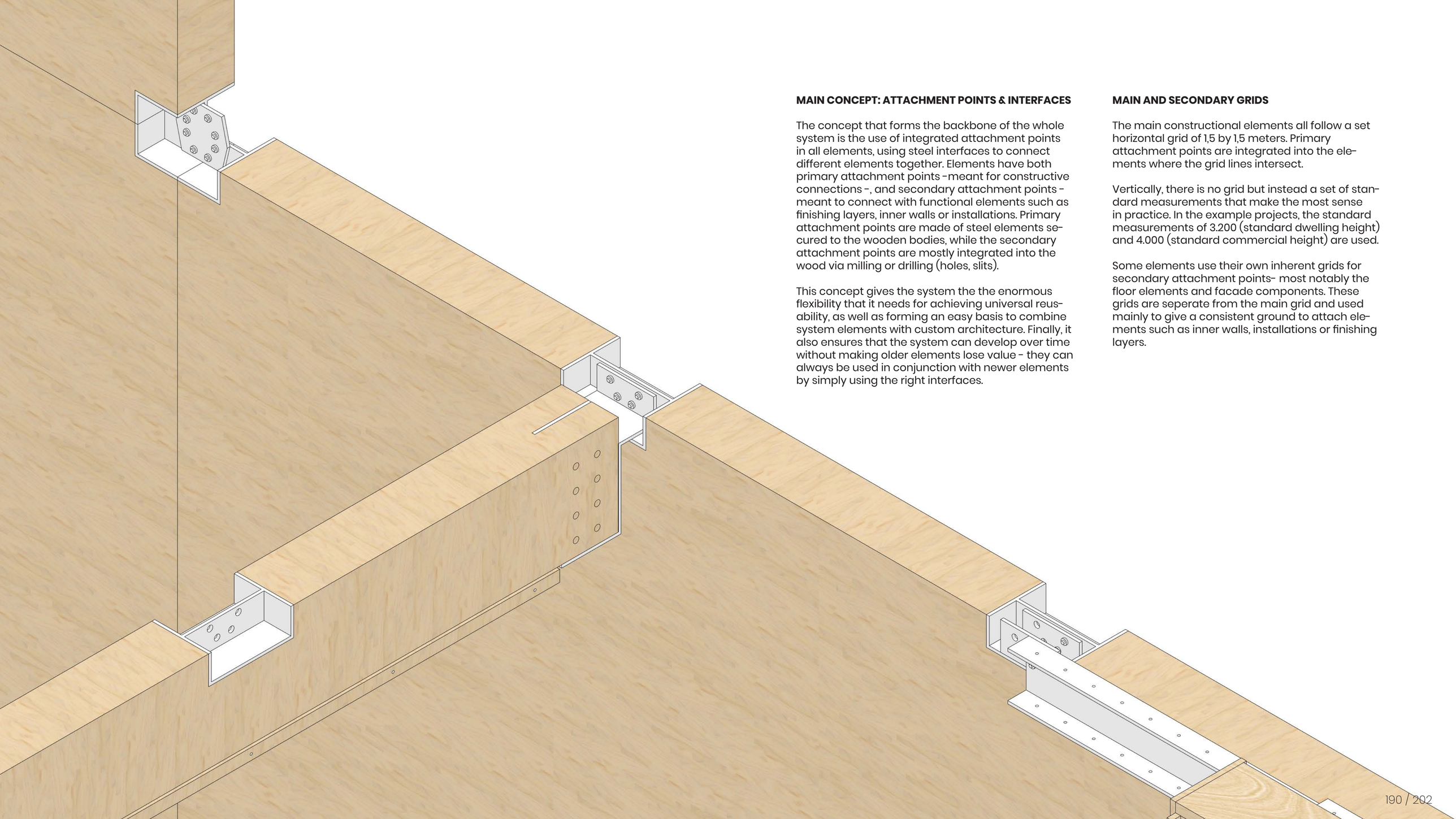
GFRP 3x 12,5 mm
Outer layer used as functional finish layer
Studs / Rockwool, 80m
Sound insulation
GFRP 3x 12,5 mm
Rockwool 20 mm
Decoupling layer
Sound insulation
GFRP 3x 12,5 mm
Studs / Rockwool, 80m
Sound insulation
GFRP 3x 12,5 mm

Interior wall connecting foot
Thin steel plate integrated on the bottom of pre-fab interior wall elements. Connects to pre-fab floor via disposable wooden interface
Elastomer Joint
Decoupling element between wall and floor
Interior wall wooden footprint / interface
Custom-measured wooden footprint that forms the disposable / non-reusable connecting element between system wall and system floor elements. Attached to floor via steel friction-fit pins. Attached to wall via simple screws.
Steel pins
Friction-fit / demountable connection between wooden footprint and floor element. Goes through infill layer into CLT floor element.

FACADE FRAGMENT


Greenhouse
Dwellings
Discount store
Dwelling storage / retail / restaurant
HP +34.900
F9 +30.400
F8 +27.200
F4 +14.400
F3 +11.200
F2 +8.000
F1 +4.000
7
6.000
8

SYSTEM GUIDE AND DETAILING



MAIN CONCEPT: ATTACHMENT POINTS & INTERFACES

The concept that forms the backbone of the whole system is the use of integrated attachment points in all elements, using steel interfaces to connect different elements together. Elements have both primary attachment points -meant for constructive connections -, and secondary attachment points - meant to connect with functional elements such as finishing layers, inner walls or installations. Primary attachment points are made of steel elements secured to the wooden bodies, while the secondary attachment points are mostly integrated into the wood via milling or drilling (holes, slits).

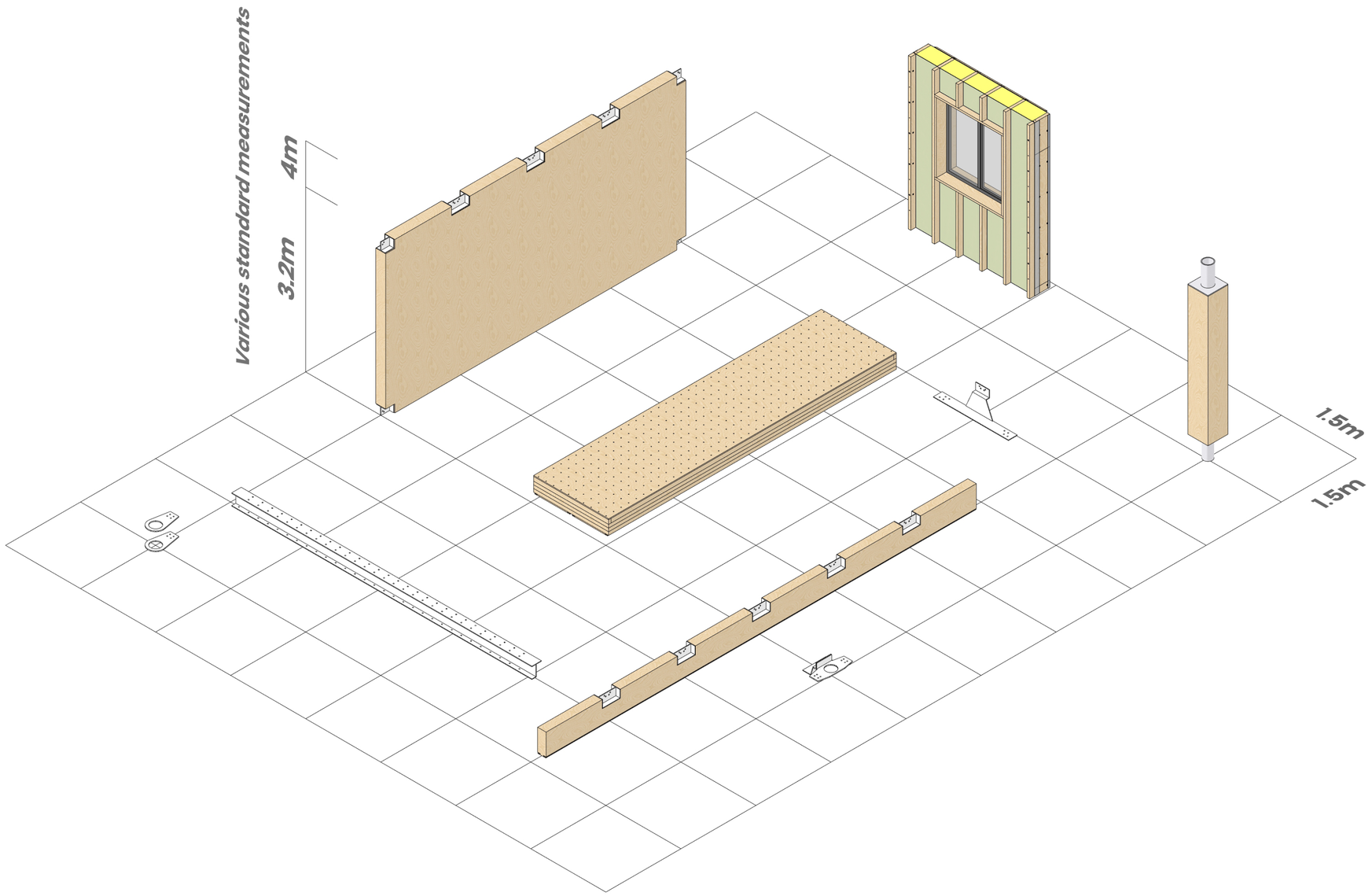
This concept gives the system the the enormous flexibility that it needs for achieving universal reusability, as well as forming an easy basis to combine system elements with custom architecture. Finally, it also ensures that the system can develop over time without making older elements lose value - they can always be used in conjunction with newer elements by simply using the right interfaces.

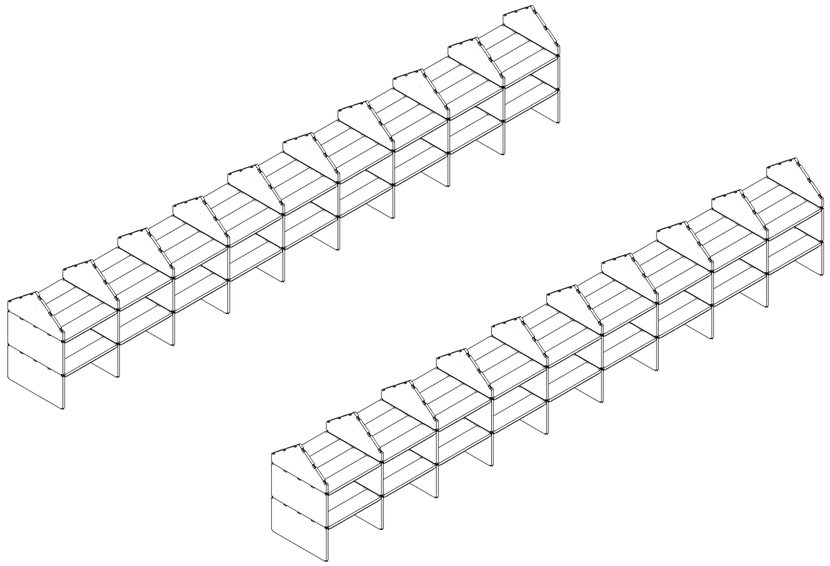
MAIN AND SECONDARY GRIDS

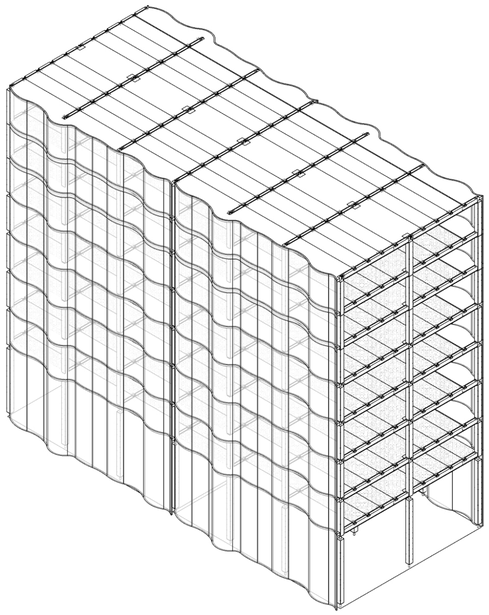
The main constructional elements all follow a set horizontal grid of 1,5 by 1,5 meters. Primary attachment points are integrated into the elements where the grid lines intersect.

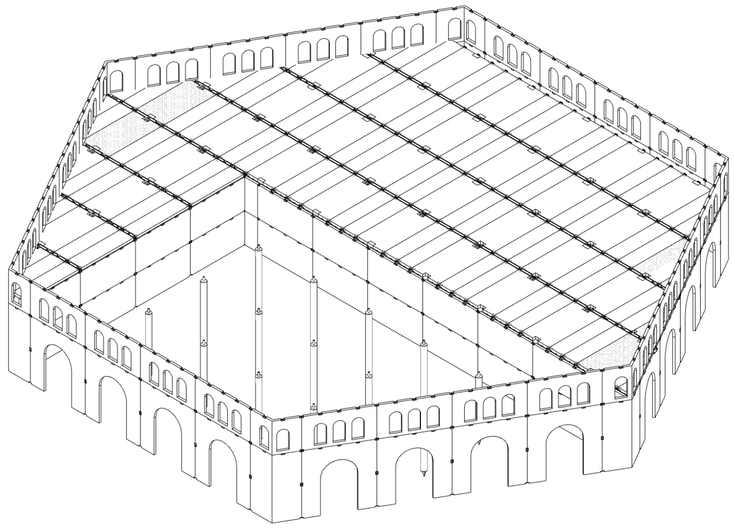
Vertically, there is no grid but instead a set of standard measurements that make the most sense in practice. In the example projects, the standard measurements of 3.200 (standard dwelling height) and 4.000 (standard commercial height) are used.

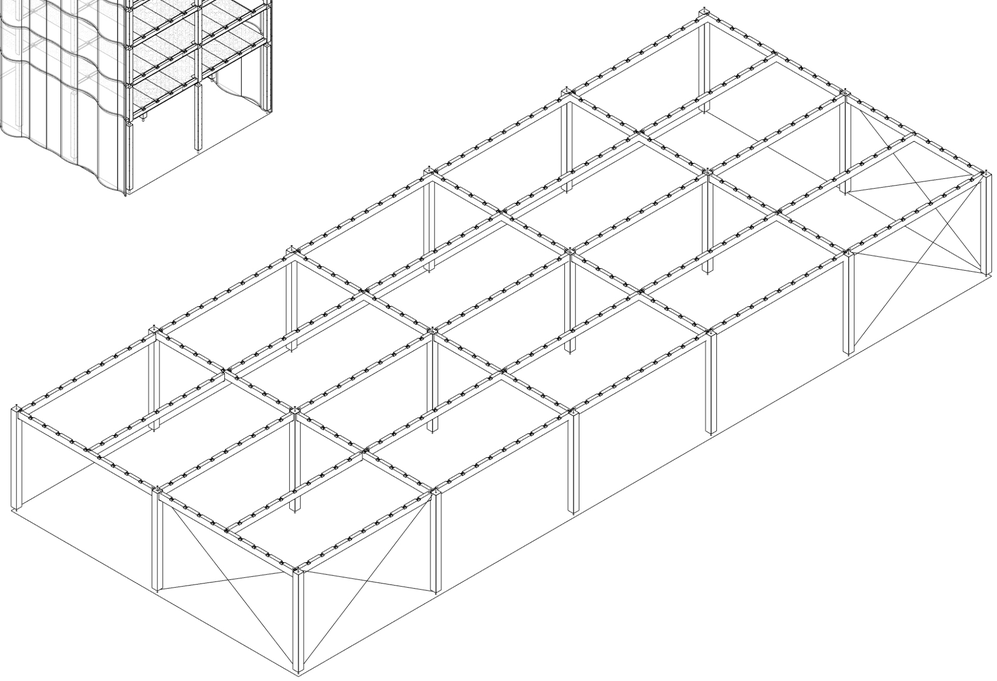
Some elements use their own inherent grids for secondary attachment points- most notably the floor elements and facade components. These grids are seperate from the main grid and used mainly to give a consistent ground to attach elements such as inner walls, installations or finishing layers.


Various standard measurements
3.2m
4m
1.5m
1.5m



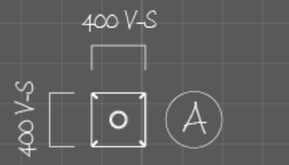


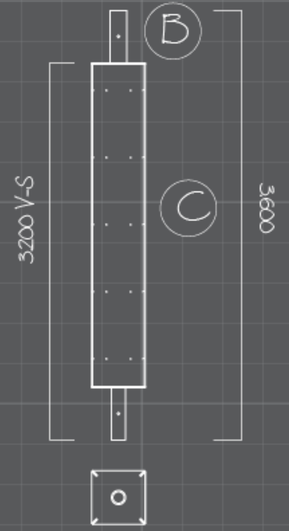


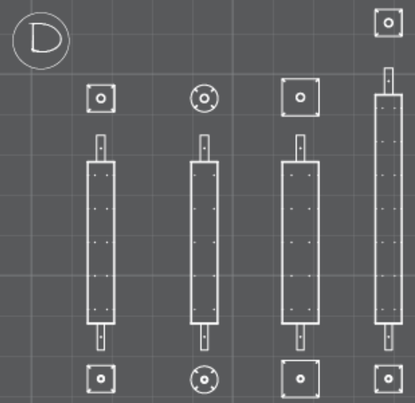


DIVERSITY OF STRUCTURE AND SPACE
With the inherent flexibility of the interfaces and the combination of wall elements, columns and beams, a large variety of different structures and spaces can be made using the building system.

Depicted are a typical row house structure, an office building with double height plinth and a custom curved glass facade, a hexagon-shaped building with colosseum-like custom facade, and a simple structure for a large event hall.







COLUMN ELEMENT

A **VARIABLES**
The column elements have two different variables. The first variable is the dimensions of the section, in the shown case 400 x 400. Standard models are available in steps of 100 mm .

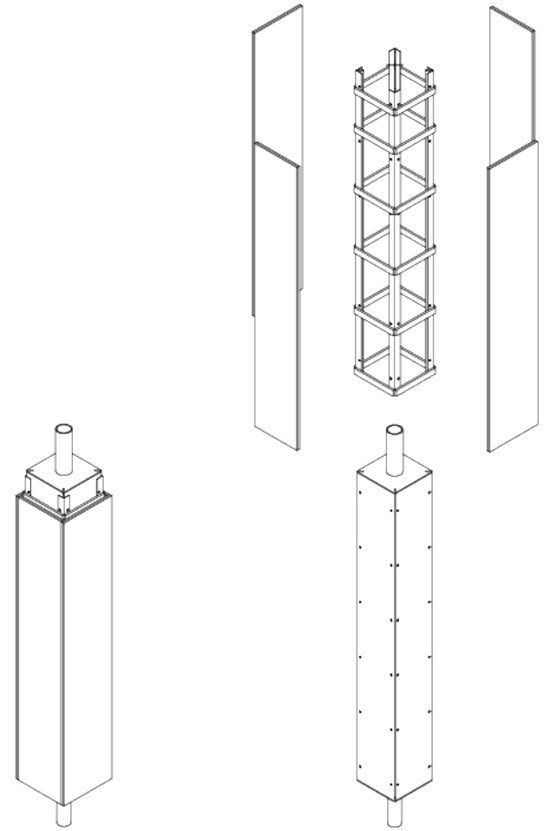
The second variable is the height, which also varies according to a number of standard measurements, in this case based on the standard floor height of 3.200. The totaal height is this number increased by 400, as the collumns slid inside of each other.

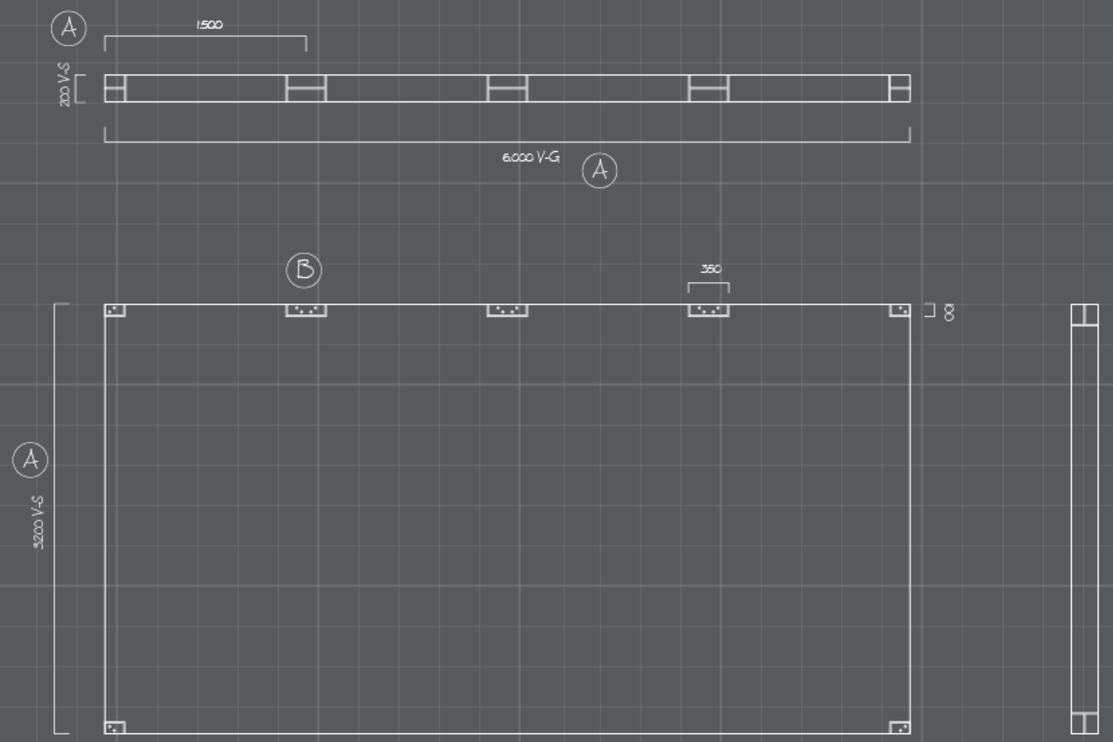
B **PRIMARY ATTACHMENT POINTS**
Steel elements form the primary attachment points at both extremes of the columns.

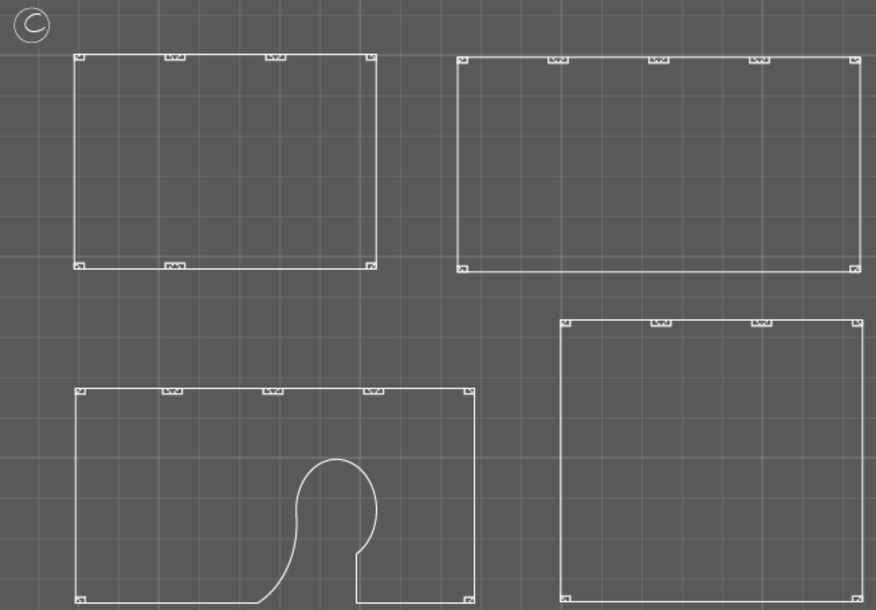
C **SECONDARY ATTACHMENT POINTS**
Each collumns has slits milled into the wood at the corners to facilitate the demountable attachment of a finishing layer.

Holes drilled at a regular interval serve to pin the attachment in place vertically with friction fit metal pins.

D **VARIANTS**
The column elements vary according to several factors. Height, sectional dimensions, and shape.







WALL ELEMENT

A

VARIABLES
The wall elements have three different variables. The first variable is the width, which is variable according to the standard Grid (V-G).

The second variant is the thickness, which varies according to a set of standard options (V-S).

The last variable is the height, which also varies according to a set of standard options (V-S). The standard used for dwelling type buildings is 3.200

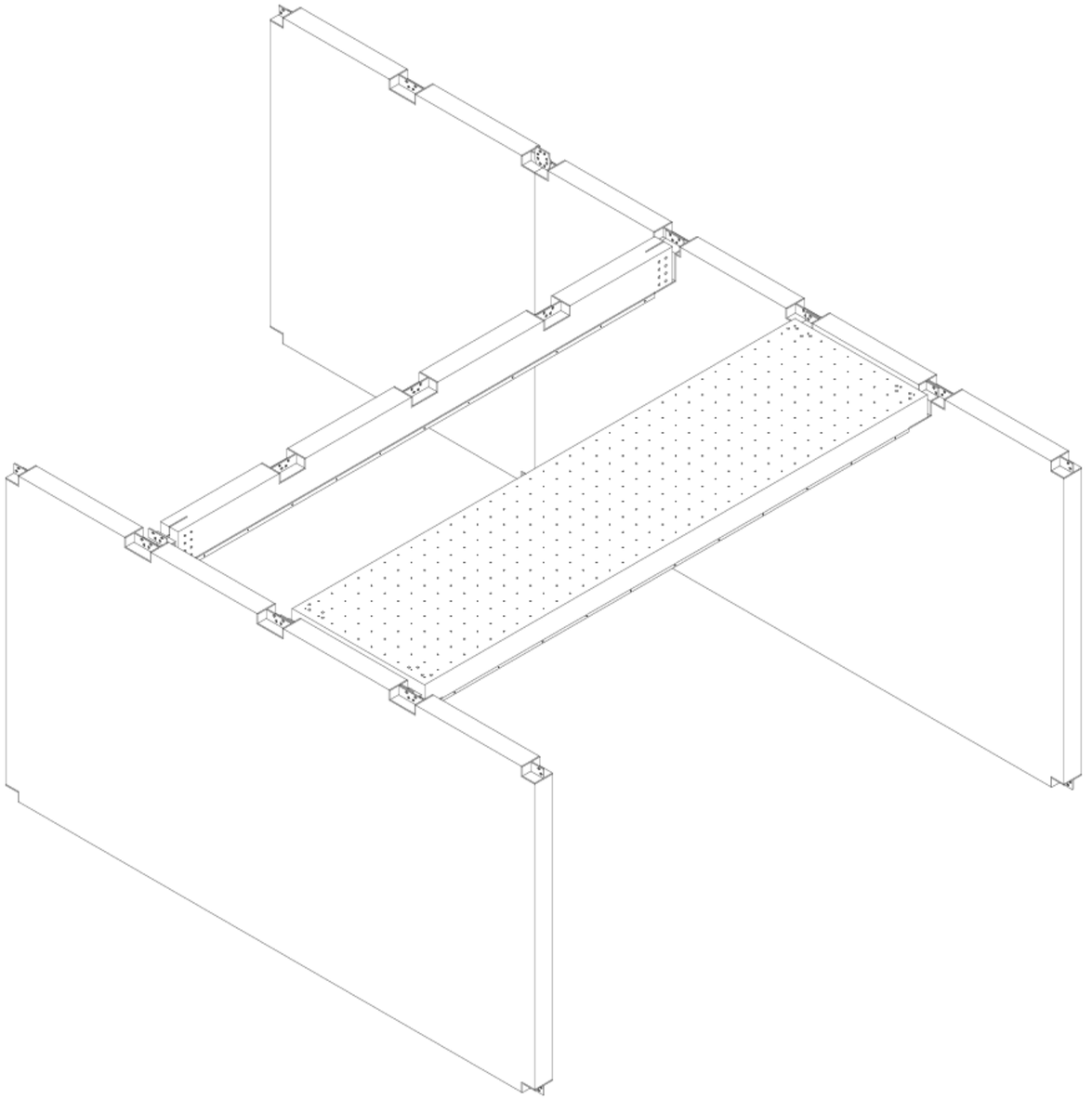
B

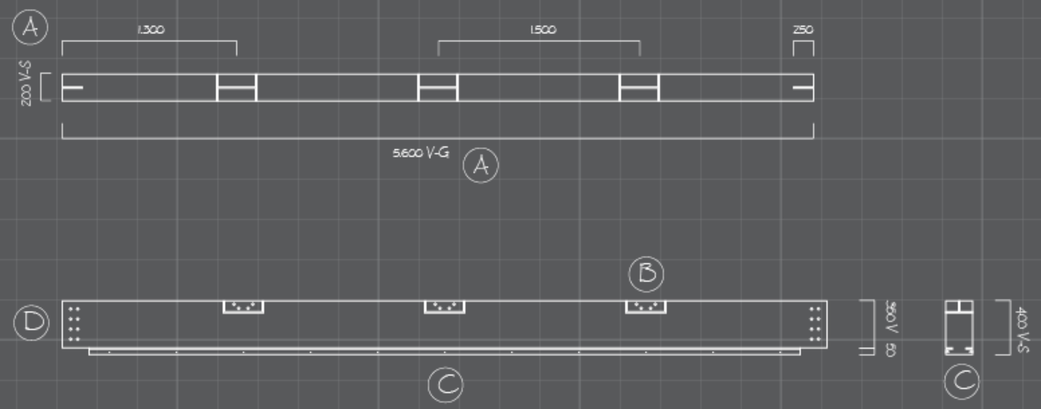
PRIMARY ATTACHMENT POINTS
Steel attachment points are attached to the CLT body at a regular interval of 1.500 (Grid Unit). These steel elements are attached using multple long screws. They serve as the backbone for the system, as they allow elements to be connected to theoretically any other element, using a variety of standard or custom interfaces.

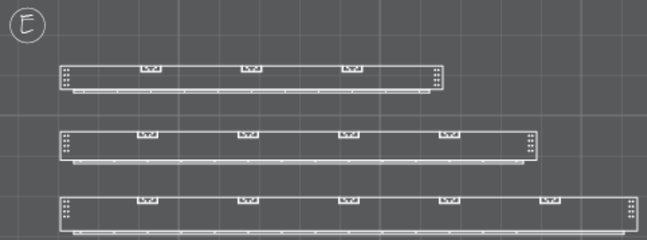
At the bottom side they are only located at the corner, meant to secure the wall element itself. On the top side, they are placed at every grid unit to faciltiate attachment to beams, floors or facade elements.

C

VARIANTS
Depicted are several variants of wall elements, including a custom variant with a custom shape milled out. Elements like these can be easily remanufactured into standard elements reducing its size.







BEAM ELEMENT

A

VARIABLES
The beam elements have three variables. The first variable is the span, which varies in cre-ments of the standard 1.500 mm grid unit.

The second variable is the thickness, which varies according to a number of standard measure-ments, based on the load the beam needs to bear.

The third variable is the height, which varies ac-cording to a number of a standard measure-ments, based on both the required load and the

B

PRIMARY ATTACHMENT POINTS
Steel attachment points are attached to the CLT body at a regular interval of 1.500 (Grid Unit). These steel elements are attached using multple long screws.They serve as the backbone for the system, as they allow elements to be connected to theoretically any other element, using a variety of standard or custom interfaces.

C

SECONDARY ATTACHMENT POINTS
The bottom fo the beam elements have a layer of 50 mm non-loadbearing Glu-Lam, with slits milled to serve as attach-ment points for ceiling add-ons.

These addons are slid on the bottom of the beams and secured in place hori-zontally with friction fit steel pins placed in pre-drilled holes in the side.

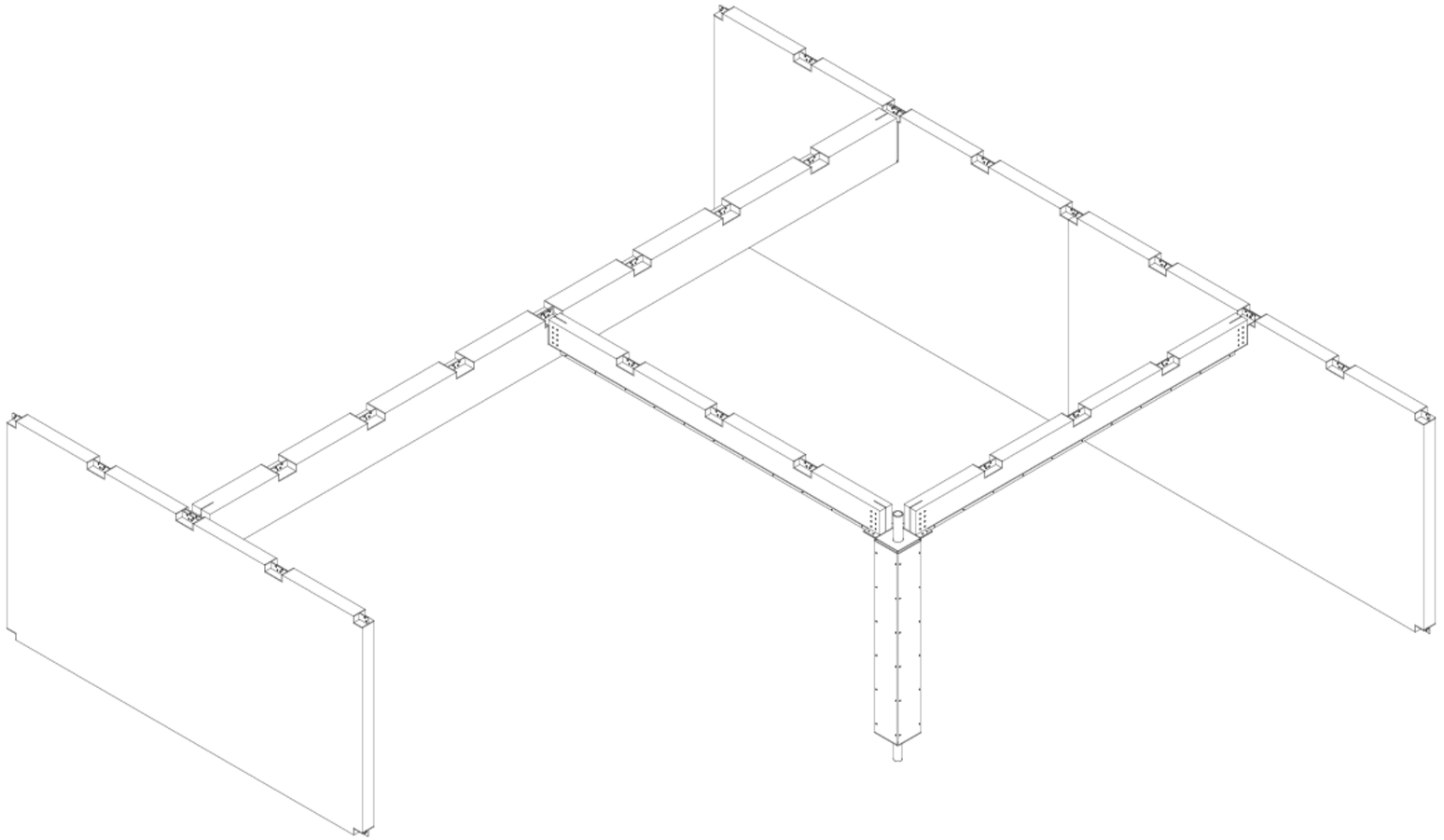
D

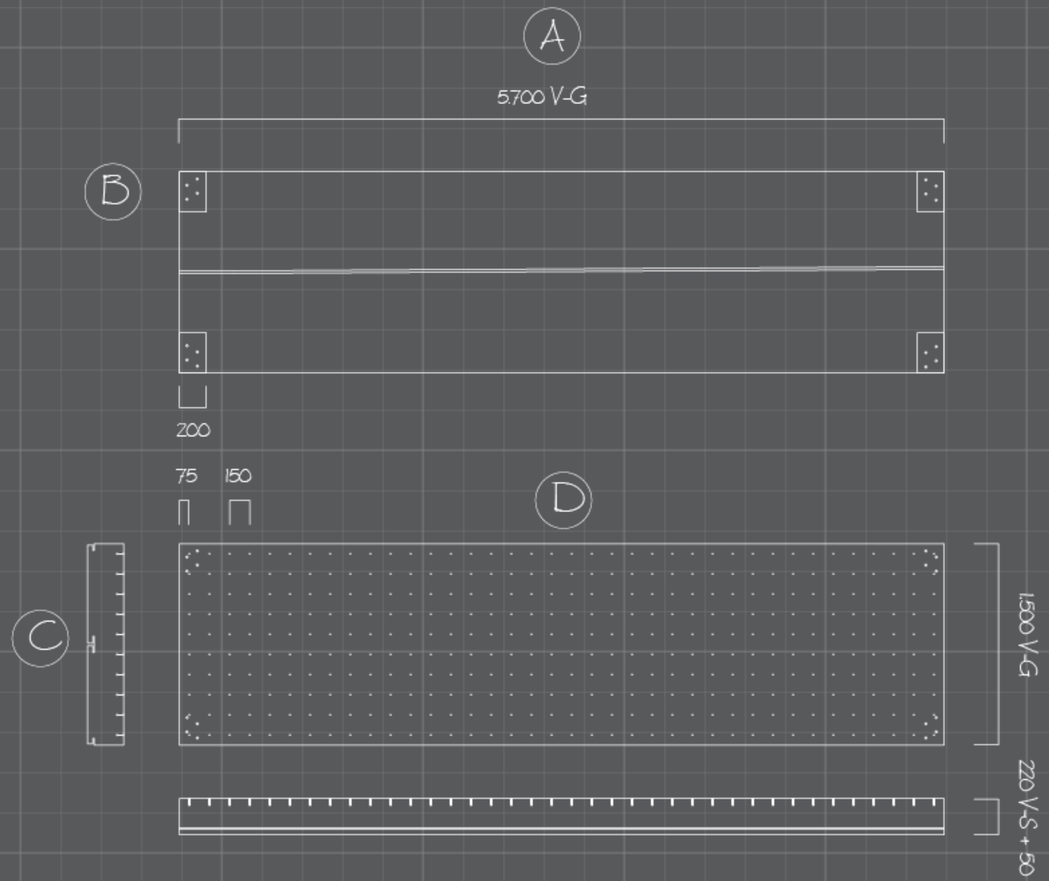
PRIMARY ATTACHMENT POINTS
At both extremes the beams have eight pre-drilled holes as well as a vertical slit milled into the Glu-Lam.

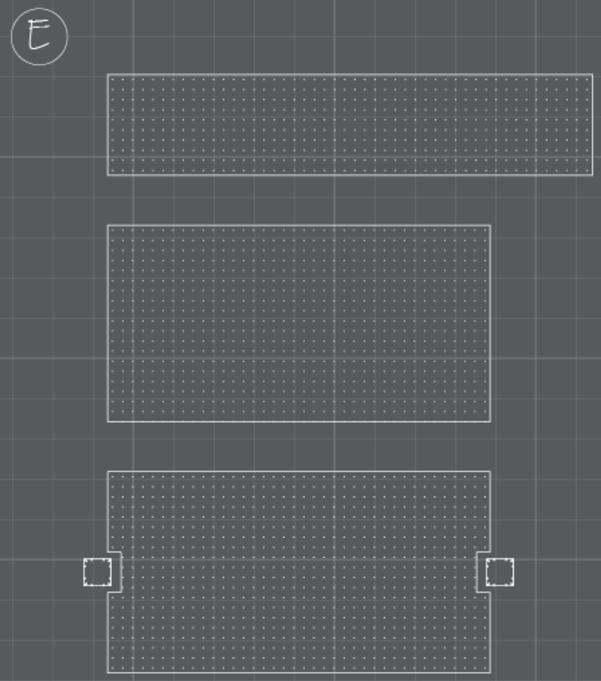
A variety of steel interfaces can be attached to this part of the beam, to attach it to different el-ements such as walls, columns or even other beams.

E

VARIANTS
A depiction of several variants of beams, vary-ing in span, height and thickness.







FLOOR ELEMENT

A

VARIABLES
The floor elements have three variables. The first variable is the span, which varies according to standard grid units of 1500 mm (V-G).

The second variable is the width, which also varies according to V-G.

The third variable is the thickness, which varies according to a number of standard measurements (V-S) based on both span and load. In this case the thickness is 220+50, with 220 mm of the thickness being loadbearing and the bottom 50 mm facilitating attachment points.

B

PRIMARY ATTACHMENT POINTS
At the bottom side, each corner has milled-in space where the steel interfaces are placed to connect the floors to walls or beams.

These interfaces can vary in height to either heighten or lower the floor elements as required for the design.

C

SECONDARY ATTACHMENT POINTS
Similar to the beam elements, the floor elements have a bottom layer of 50 mm non-loadbearing CLT with milled-in slits and pre-drilled holes.

These serve as attachment points for add-ons that can fulfill a variaty and multiplicity of functions: sound insulation, fire proofing, electrics, ventilation and lowered ceiling (additionalheight).

D

SECONDARY ATTACHMENT POINTS
On the top side, the floor elements have pre-drilled holes according to a simple grid of 150 x 150 mm.

These holes serve as the attachment points for both floor add-ons (extra height, sound insulation, weight) and the 'footprints' of walls.

These elements are connected via friction-fit steel pins to be completely remountable.

E

VARIANTS
Depicted a several variants of the floor element, differing in width and span.

Notable is the bottom variant, which has double width and spacing in the middle for columns in the system grid. This variant makes use of the property of CLT where it can bear loads in both perpendicular directions, and only needs to be secured at the corners.

A

Topside Add-on (PRE-FAB)
Additional Height, Weight, Sound insulation. Variable according to building needs. Pre-drilled holes as attachment points for wall foot-prints.

B

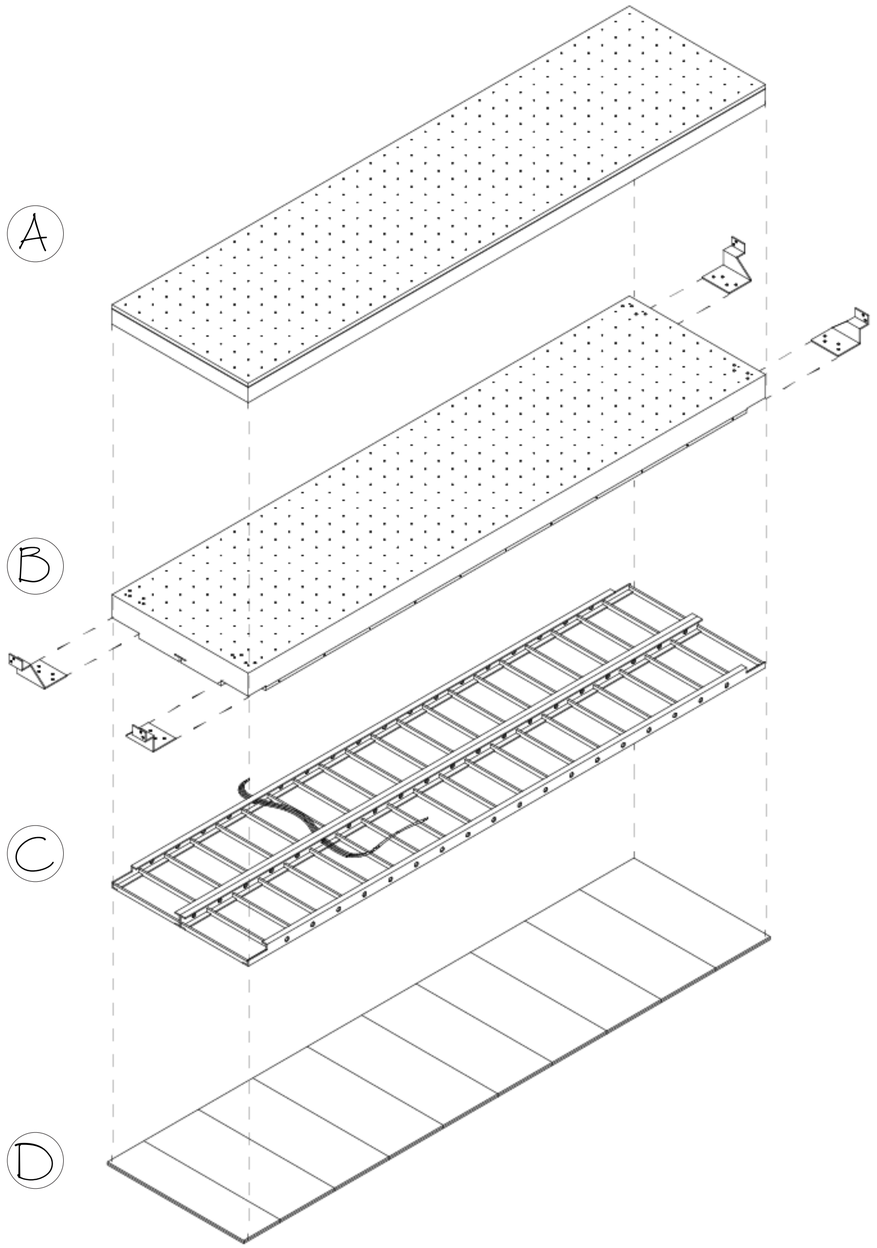
Floor Element (PRE-FAB)
According to blueprint.

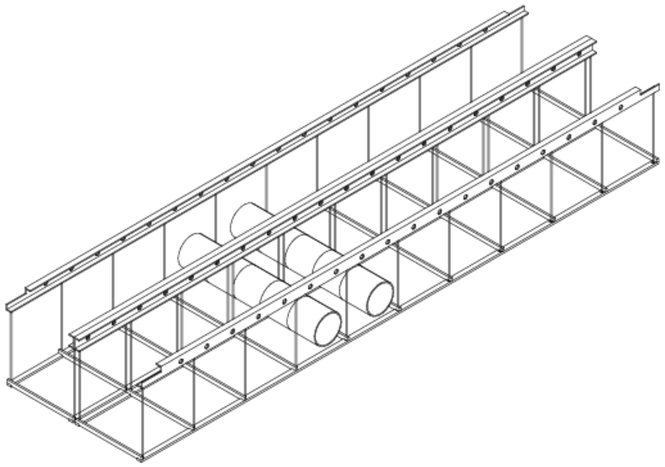
C

Bottomside Add-on (PRE-FAB)
Additional height, sound insulation, electrics and installations. Slid unto the bottom of the floor element and secured with horizontal friction fit pins.

D

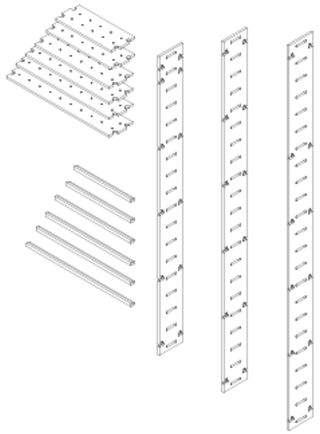
Ceiling Finish
Fire-proofing. Finish. Added on-site. Variable.

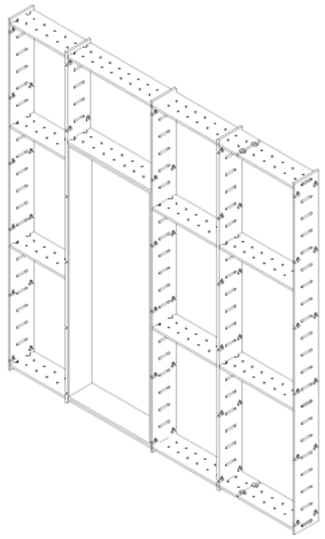




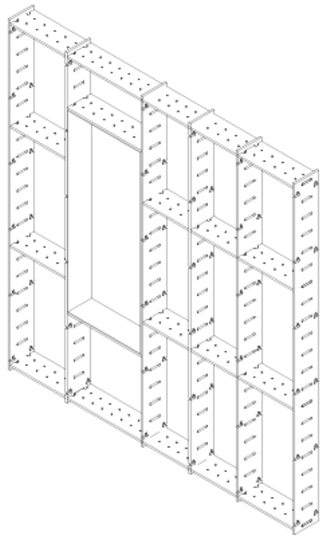
FACADE ELEMENTS

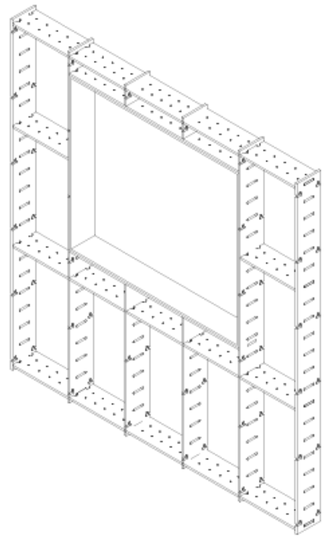
A





B





A

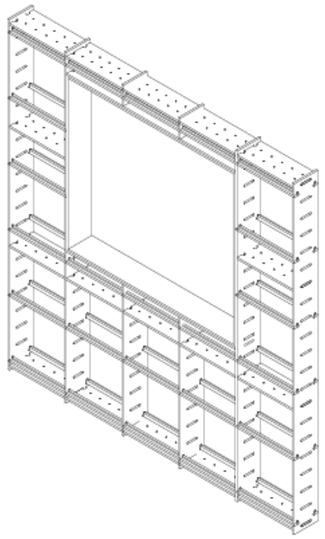
Facade elements are composed of standardized wooden milled elements with a grid of 100 mm. The main horizontal and vertical elements are demountable and reusable without any damage. Disposable lats are used to secure elements such as interfaces or Finish lats in non-reusable manner (screws).

The main elements have pre-drilled holes in a simple grid to allow the attachment of window and door frames in a demountable way via pins.

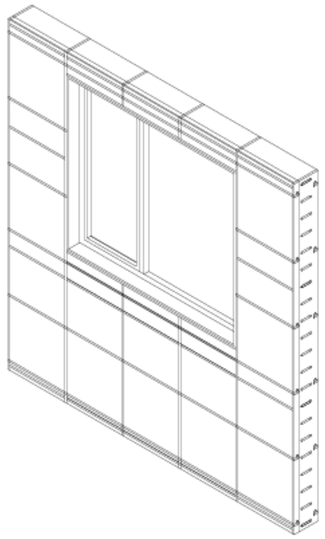
B

The elements can be configured in an almost infinite number of ways to facilitate rectangular facade openiongs of almost any size. Window and door frames are are are attached in a remountable way but are themselves disposable - windows and doors are attached to these frames with regular attachment methods such as screws.

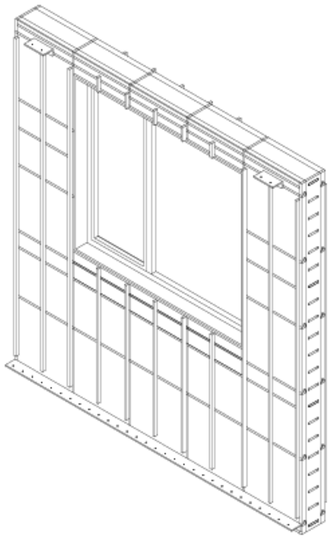
C



D



E



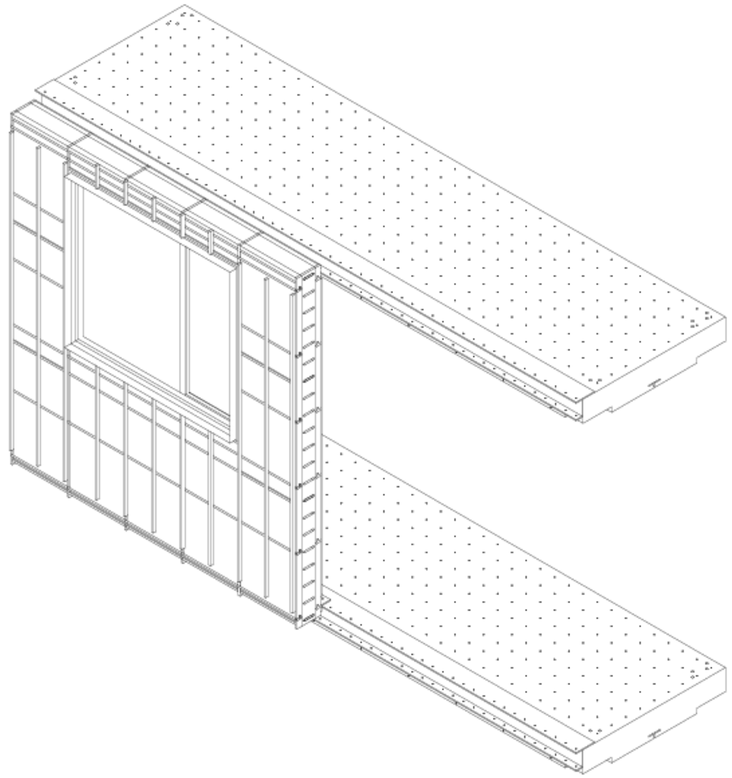
C A standard frame with lats attached.

D Insulation, windows and foils (dampopen and waterproofing respectively on the interior and exterior sides) are added. Insulation is naturally demountable and reusable.

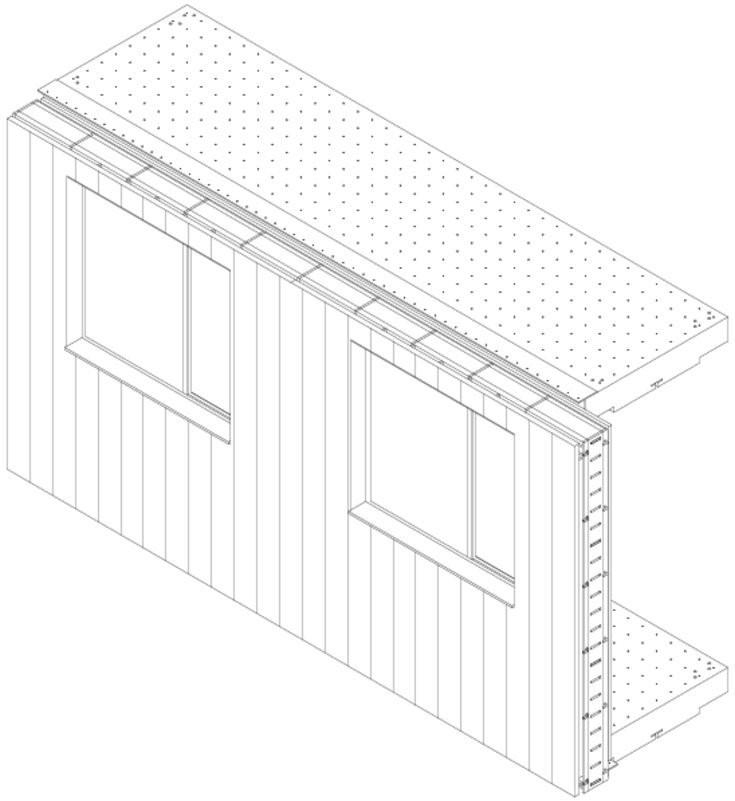
E Finish lats are added on both the exterior and interior sides. Finishing layers are attached to these on-site with regular attachment methods such as screws. The lats are disposed after lifecycles.

Horizontal steel interfaces are added at the top and bottom sides of the interior to facilitate attachment of the facade elements to floors, beams and walls.

F



G



F

At this stage the elements are ready to be transported to the building site and attached to the main structure. In this case they are attached to interfaces on standard floor elements. Gaps and foils are sealed off with sealing tape on both the exterior and interior. The elements are designed to reserve space for this.

G

As the last step, finishing layers are added on the interior and exterior sides. Because the Finish lats are disposable, in principle anything can be attached to these elements as finishing layer, as long as the lats can bear its load. In the two example projects, existing remountable systems for wooden planks and a ceramic facade are used.

After the building life cycle has ended, the finishing layers (interior and exterior) can be removed, and the element can demounted as a whole. It can then be either directly reused as is in a similar design or transported to the factory to be reconfigured in a new shape.