“Change is needed rapidly and because of that our processes, material, economic system and building norms need to be adjusted. **Everything around construction and urban development is up for debate.**”

- Anders Lendager, Architect

M+M4H
REUSE IN ARCHITECTURE

A study about how urban mining and building material waste could be used in future-proof architecture with data-driven design as a tool.

P5

15 JANUARI 2024

BRITT LIGTHART

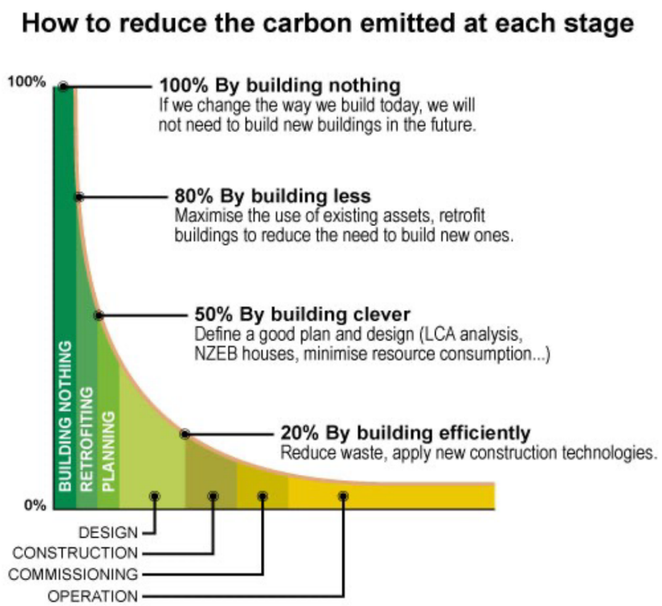
Architectural Engineering Studio

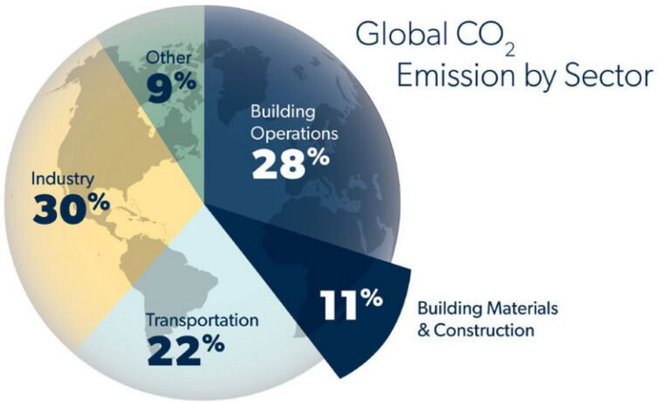
Design Tutor: Mo Smit // Building Technology Tutor: Paddy Tomesen // Research Tutor: Dafne Swank

Context

1. General problem statement
2. Research objective
3. Design + Research question
4. Methodology
5. Research findings
    a. Megastores
    b. Design tool
    c. Architectural implementation
6. Design objective
7. Approach design
8. Programme of requirements
9. Design

General problem statement





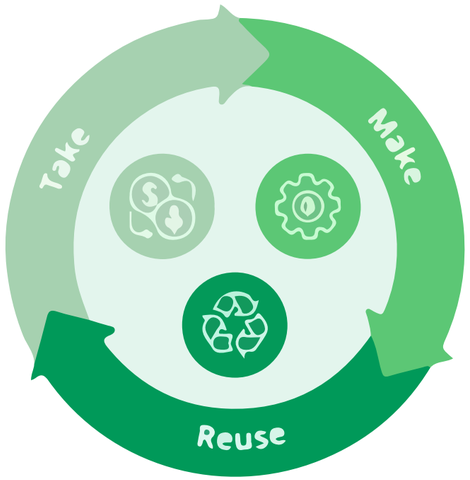
https://www.openaccessgovernment.org/environmental-impact-construction/144144/
https://sabmagazine.com/design-practice-buildings-as-a-climate-change-solution/

PARIS PROOF

DGBC

Linear Economy

Circular Economy



NOS Nieuws • Zaterdag 15 juli 2023, 08:30 •
Aangepast zaterdag 15 juli 2023, 09:29

Gebouwen vaker duurzaam gesloopt, meer tweedehands bouwmaterialen op de markt

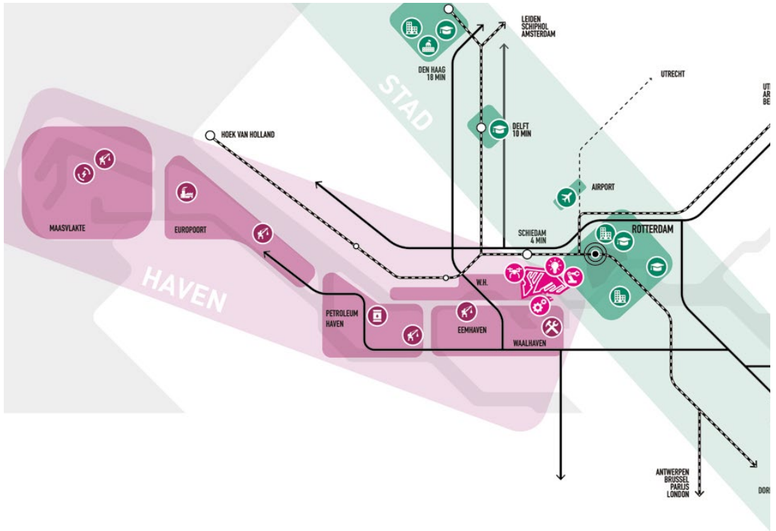
Rising population in cities
Rotterdam 86.000 home seekers

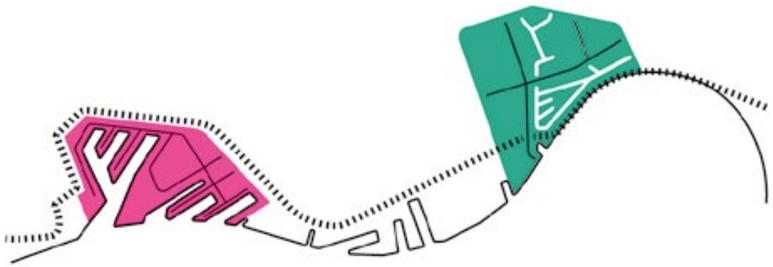
Solution: Build, build, build!

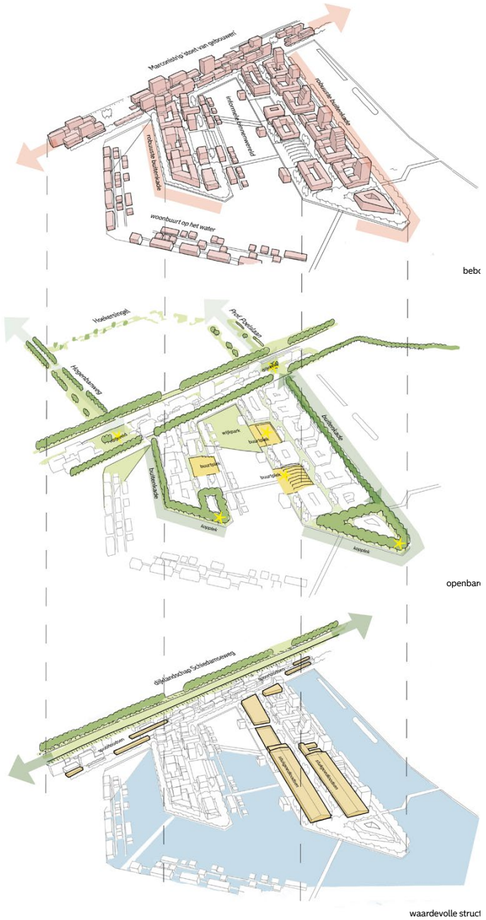
https://openrotterdam.nl/woningtekort-niet-opgelost-door-nieuwe-plannen-kabinet-minder-kans-op-huur-2/#:~:text=Er%20is%20een%20groot%20woningtekort,flink%20ingegrepen%20in%20de%20woningmarkt.

Merwehaven


Masterplan Merwehaven


STAD
HAVEN
LEIDEN
SCHIPHOL
AMSTERDAM
DEN HAAG
10 MIN
UTRECHT
DELFT
10 MIN
HOEK VAN HOLLAND
AIRPORT
MAASVLAKTE
EUROPOORT
SCHIEDAM
4 MIN
ROTTERDAM
N.M.
PETROLEUM
HAVEN
EEMHAVEN
WAALHAVEN
ANTWERPEN
BRUSSEL
PARIJS
LONDON




bebo
openban
waardevolle struct

‘Meten is weten’

ECI

Environmental
Cost
Indicators

LCA

Life
Cycle
Analyses

$C0_2$

Embodied
Carbon

Paris Proof grenswaarden	materiaalgebonden kg CO_2-eq. per m^2			
	2021	2030	2040	2050
Woning (eengezinswoning)	200	126	75	45
Woning (meergezinswoning)	220	139	83	50
Kantoor	250	158	94	56
Retail vastgoed	260	164	98	59
Industrie[5]	240	151	91	54

Circular Building

"A circular building is a building that is developed, **used and reused without unnecessary depletion of resources**, environmental pollution and degradation of ecosystems. It is built in an economically sound manner and contributes to the well-being of people and the biosphere. Here and there, now and later. **Technical elements are demountable and reusable** and biological elements can be returned to their biological cycle."

- Framework Voor Circulaire Gebouwen - Nieuwbouw - Dutch Green Building Council

Thematic Research Focus

Research objective

The objective of this research is to develop **a method for designing with reused building materials by employing a data-driven approach.**

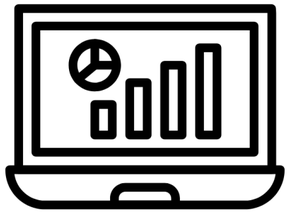
This involves identifying the necessary information to enable the reuse of materials, evaluating the factors that affect the reuse potential, and **creating a data-driven design tool** using Microsoft Excel to assist in making deposition decisions for sustainable reuse.

Additionally, the research seeks to derive **design principles** from case studies of architectural projects that successfully used reclaimed materials, providing a comprehensive overview of considerations and guidelines for reuse in architectural design.

Research question

What data-driven design method is needed for a design tool with reclaimed materials to make deposition decisions for a new circular building?

Data-Driven



Making actions measurable

Setting parameters and constraints to a objective

Data-Driven Design Tool

Input: data + instructions + parameters + constrains
Output: controlled data

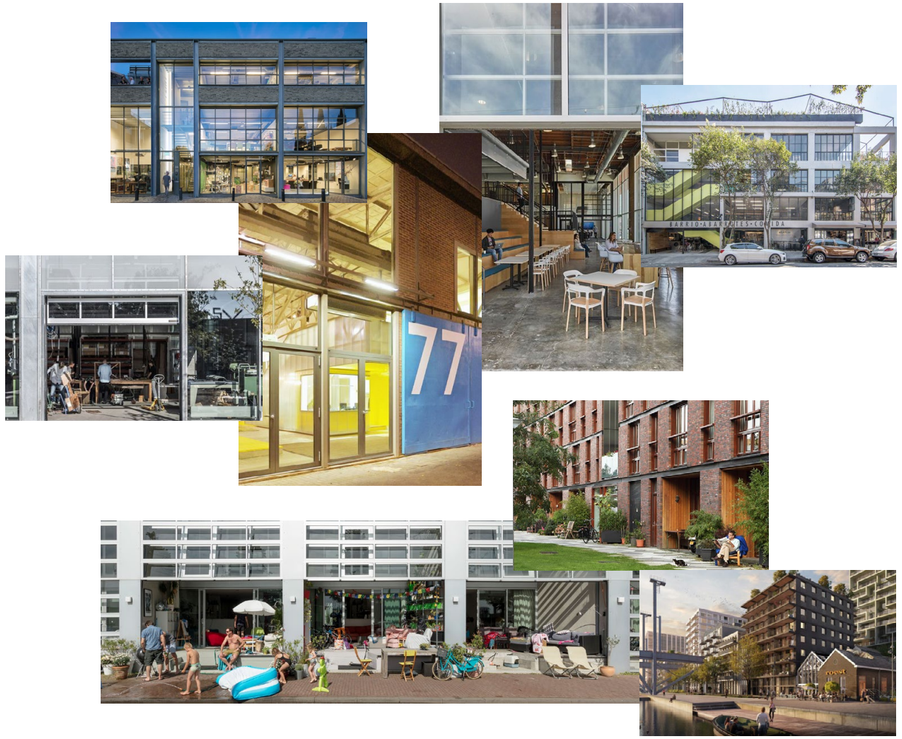
Guiding

When your design is guided by the results of the model, it is data-driven. This allows you to make informed design decisions based on data.

Objective context

1. The masterplan for Merwehaven in Rotterdam focuses on a unique living in an innovative Makers-district.

2. The building design is in line with the ambitions of the masterplan ‘Merwehaven’. However the design is not necessarily a 1-to-1 fit to the urban design and the function map in the masterplan.

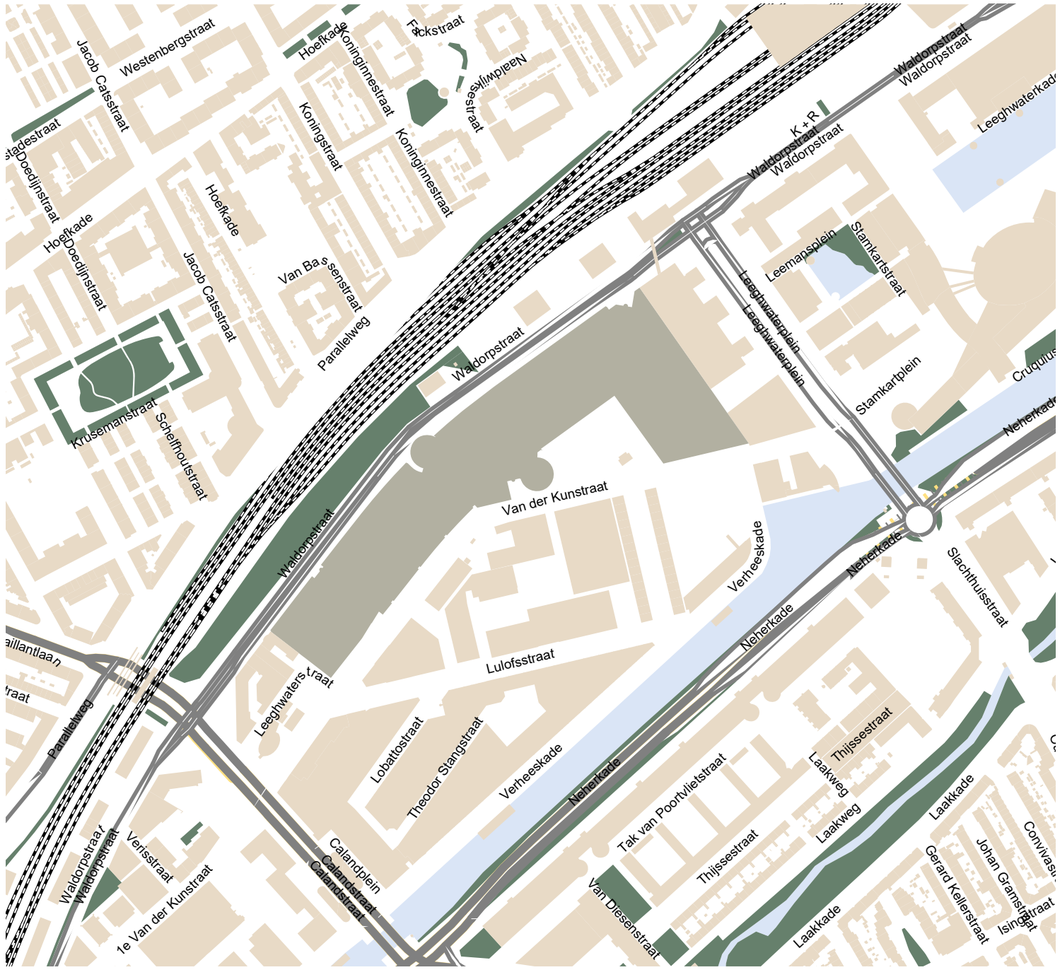


Design question

How can an circular multilevel building in the Merwehaven, Rotterdam, take shape for a mixed target group with a design approach where reclaimed materials and reuse practices play a leading role?

Thematic Research Focus

Megastores & Merwehaven



scale 1:5000


ENTREE
SWISS SENS
OUTLET
MONTEL
LET OP!


BIG BAZAR
Pasta Gilde

Methodology

A

"Project overstijgend onderzoek"

Circulairity
Reusability
Building Technology

Data-Driven Design Tool
Data Management

1

Material

Reusability Factors
Dimensions
Availability
Performance
(Technical) Lifespan
Disassembly
Toxicity
Maintenance

2

Logistics

Transport

3

Architectural Implementation

Bau-büro in situ
K.118

Popma Ter Steege Architects
Biopartners 5

Lendager Group
Resource Rows/Upcycle Studios

B

"Project Specifiek onderzoek"

Case Study:

Megastores Material Reuse

Circulair Building on the Merwehaven

1

Material

Reusability Factors
Dimensions
Availability
Performance
(Technical) Lifespan
Disassembly
Toxicity
Maintenance

2

Logistics

Transport

3

Architectural Implementation

P5?

1. What information and methods are needed to facilitate the reuse of building materials to extend the life cycle?

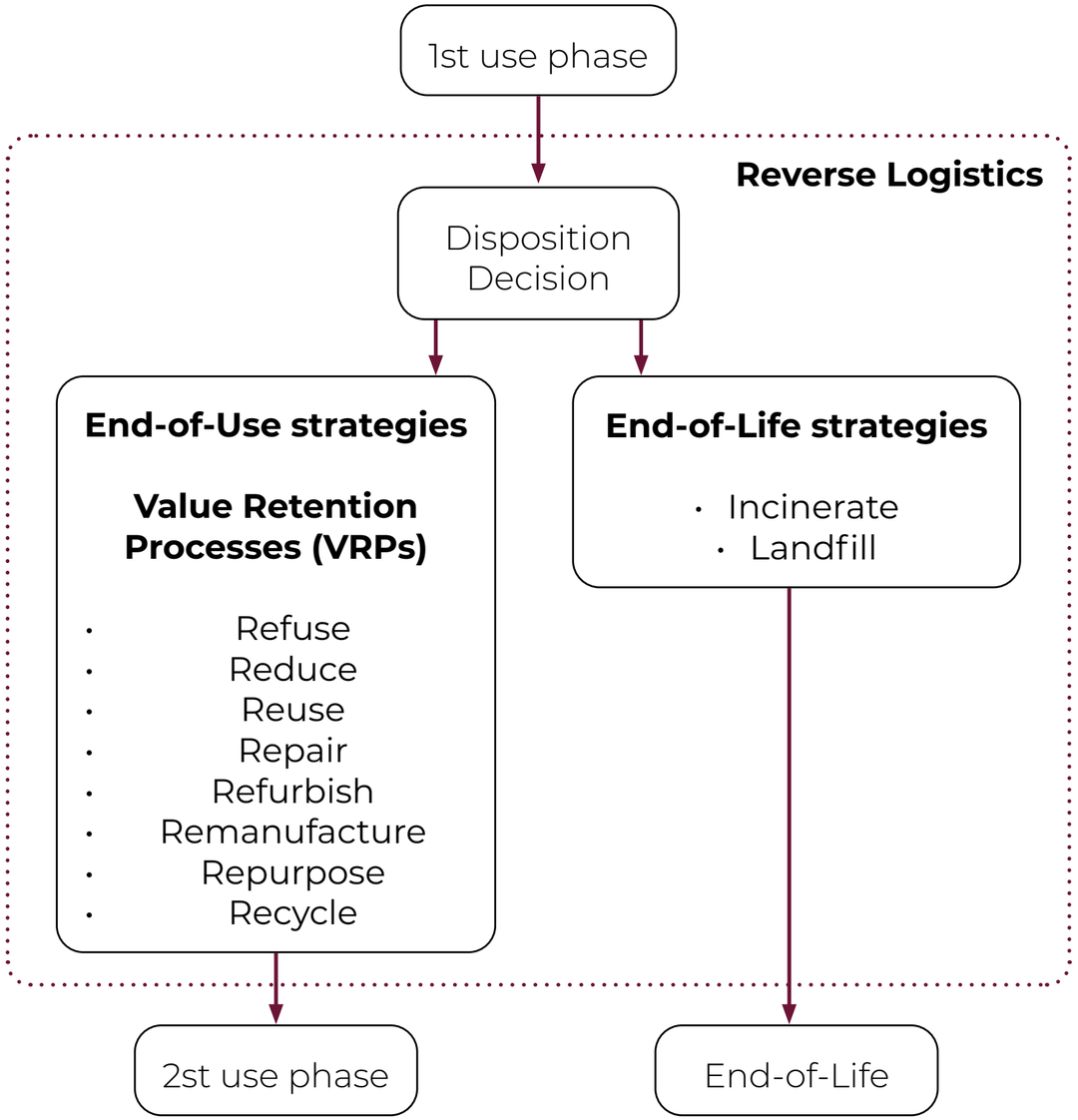
2. How to make the reuse potential measurable to develop a design tool?

3. What constraints does a new circular residential building impose on implementing reclaimed materials into design?

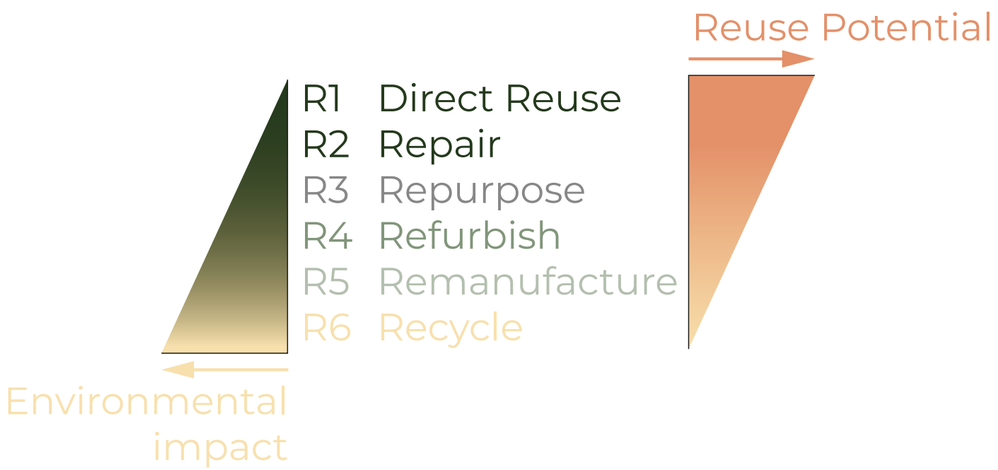
4. What can we learn from architectural projects with reclaimed materials implemented in their design?

5. When availability defines the form of your design, how does it influence your design process?

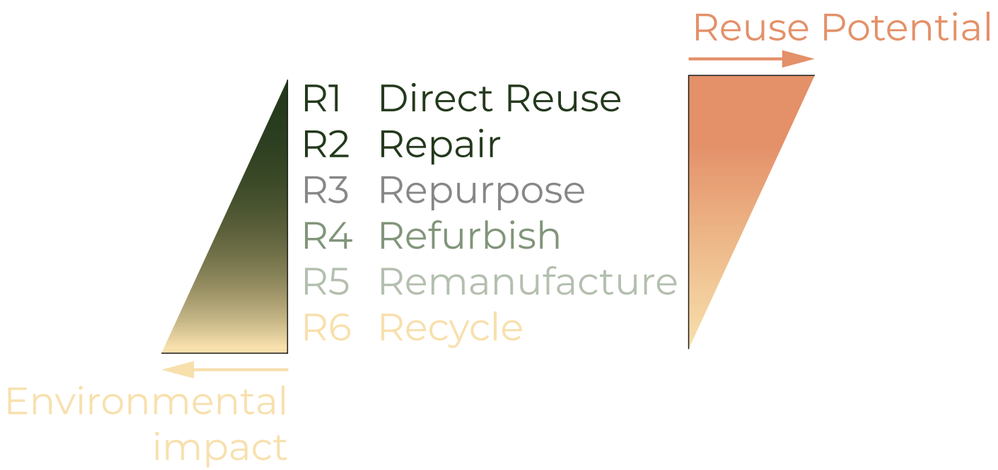
Research findings


1st use phase
Reverse Logistics
Disposition Decision
End-of-Use strategies
Value Retention Processes (VRPs)
Refuse
Reduce
Reuse
Repair
Refurbish
Remanufacture
Repurpose
Recycle
End-of-Life strategies
Incinerate
Landfill
2st use phase
End-of-Life

R-strategies



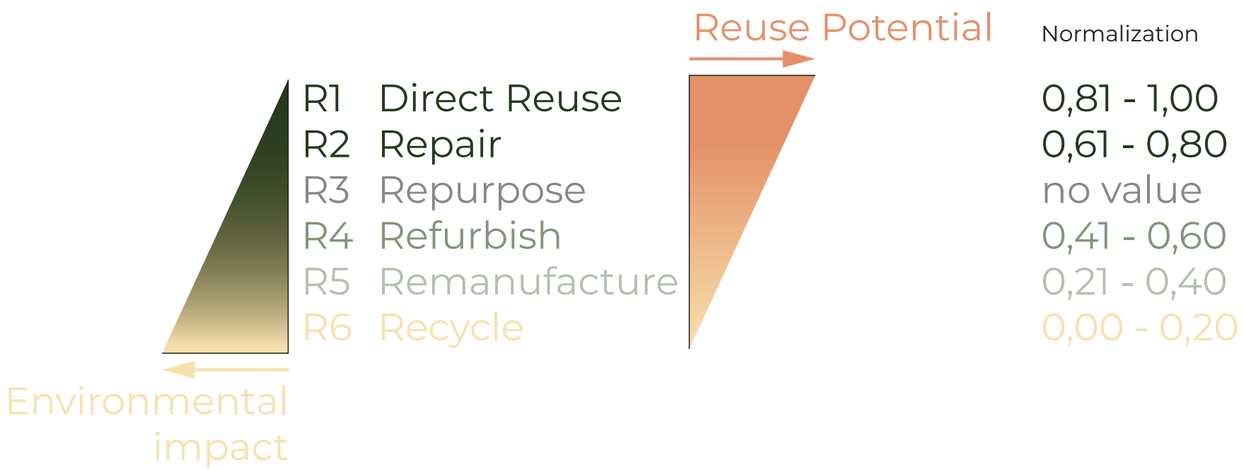
R-strategies



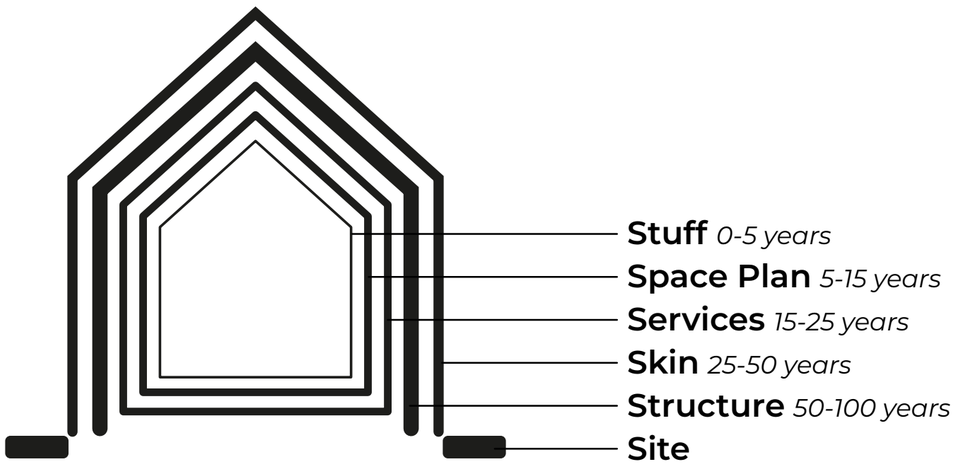
Value Retention Process

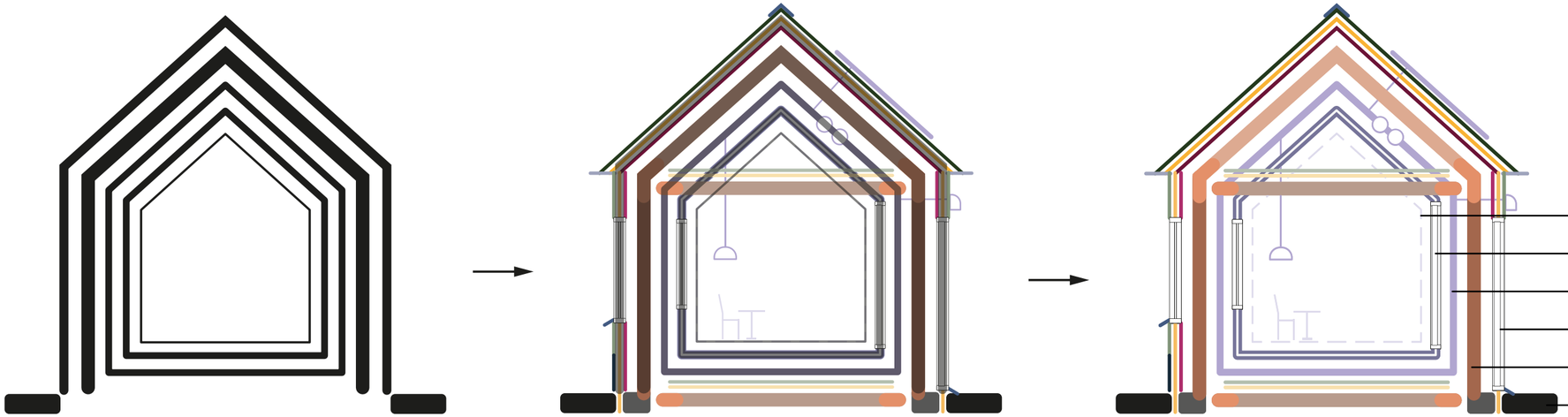
Only cleaning
E.g. painting
Other function, breaking down into smaller parts
Replace or repair parts
Take apart completely, replace/repair parts, reassemble
Return to original raw materials and make new product

R-strategies



Building layers





Stuff *0-5 years*

Space Plan *5-15 years*
- interior wall systems
- doors
- window frames

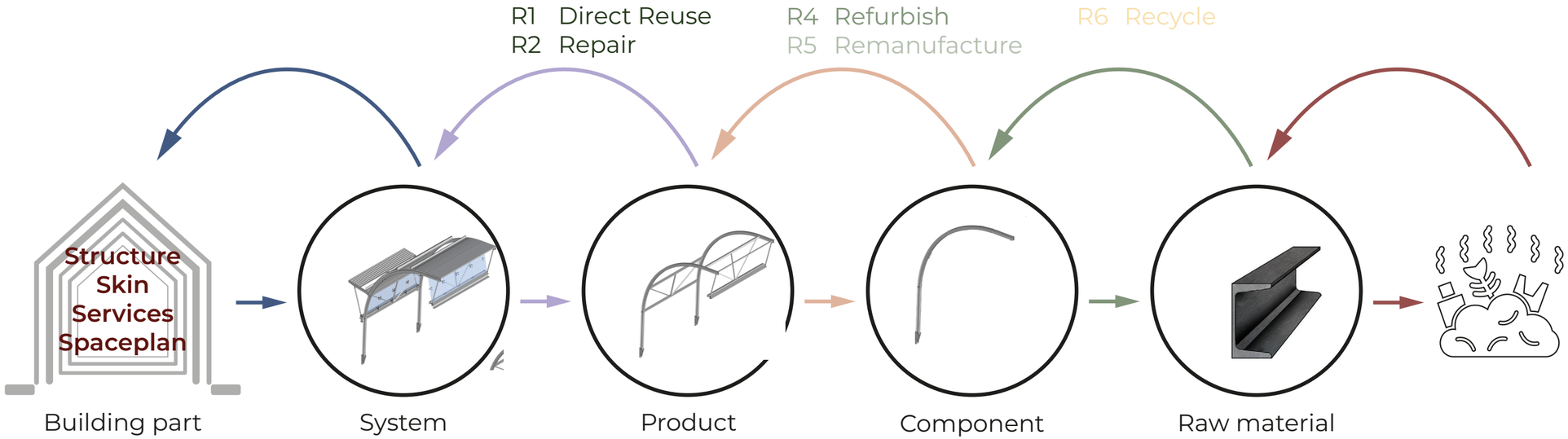
Services *15-25 years*
- climate systems
- electricity
- pipes
- lighting

Skin *25-50 years*
- facade systems
- facade cladding
- insulation
- bearing inner wall
- bearing inner roof
- roof cladding
- sealing profiles

Structure *50-100 years*
- beams
- columns
- connections
- floors
- bearing walls

Site

Scales

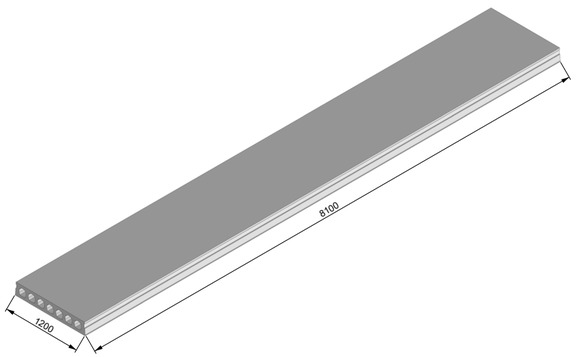

R1 Direct Reuse
R2 Repair
R4 Refurbish
R5 Remanufacture
R6 Recycle
Structure
Skin
Services
Spaceplan
Building part
System
Product
Component
Raw material

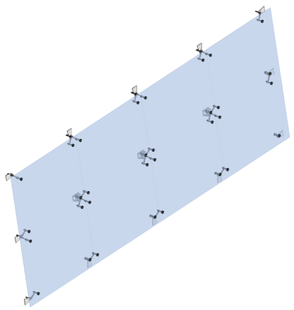
Tool 1/5

Bill of Material				
	Code	**Item name**	Photo	Shearing layer
Building part	1			
System	2			
Product	3a			
	3b			
	3c			
Component	4a			
	4b			
	4c			
Raw Material	5a			
	5b			
	5c			

Shearing Layer
Stuff (0-5 years)
Space Plan (5-15 years)
Services (15-25 years)
Structures (50-100 years)
Skin (25-50 years)
Site

Case study Megastores & Merwehaven 1/5





Bill of Material

	Code	Item name	Photo	Shearing layer
Building part	1.1	Floors		Structures (50-100 years)
System	1.2	Floor packet		Structures (50-100 years)
Product	1.3a	Precast hollow core slabs		Structures (50-100 years)
	1.3b	50 mm Anhydrietvloer		Structures (50-100 years)
	1.3c	Finishing		Space Plan (5-15 years)
Raw Material	1.5a	Concrete		
	1.5b	Concrete and gypsum mix		
	1.5c	Reinforcement steel		

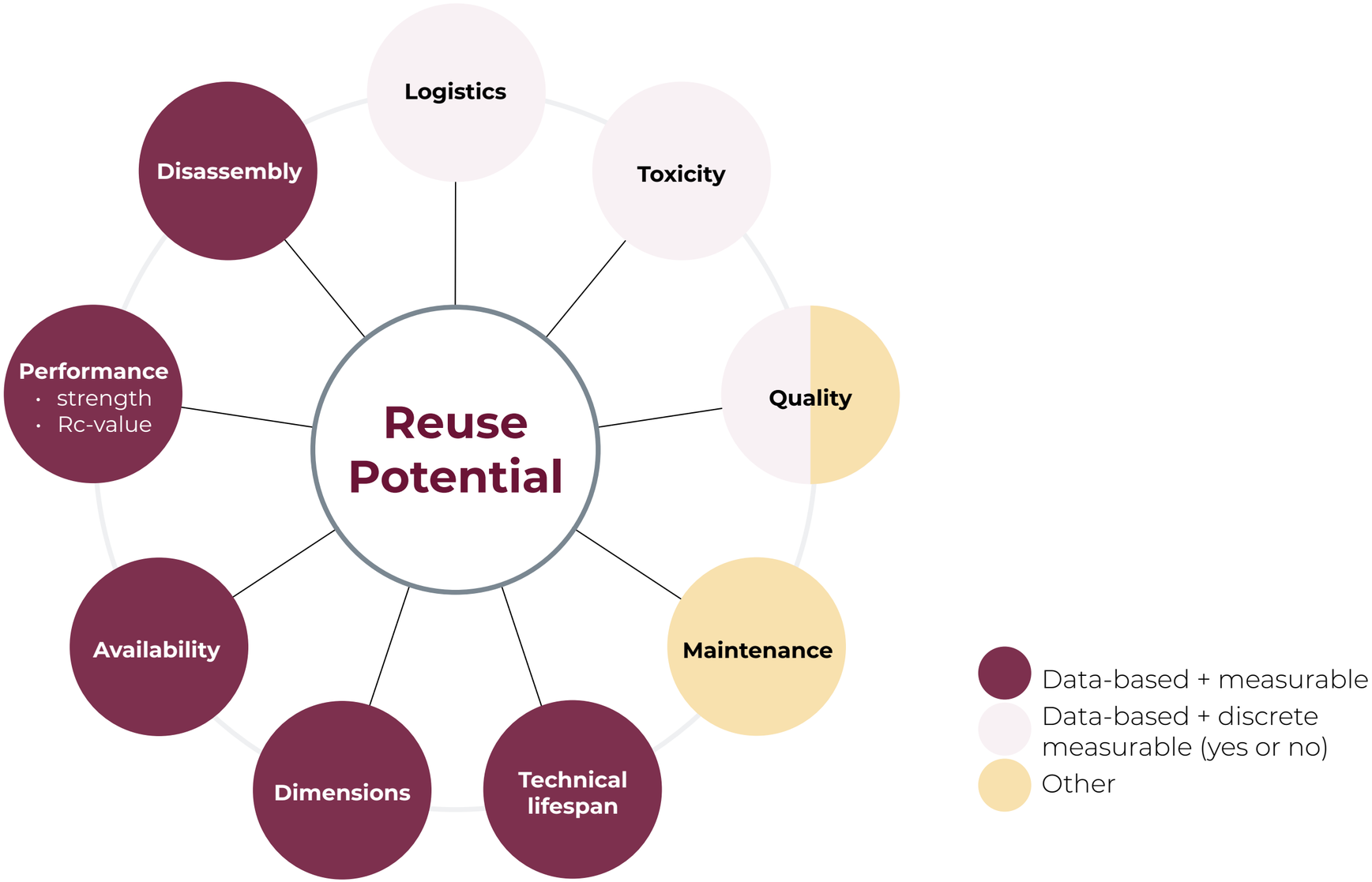
Bill of Material

	Code	Item name	Photo	Shearing layer
Building part	2.1	Roof		Skin (25-50 years)
System	2.2	Loadbearing construction		Structures (50-100 years)
Product	2.3a	Steel beam square		Structures (50-100 years)
	2.3b	Steel beam I		Structures (50-100 years)
	2.3c	Steel pipe		Structures (50-100 years)
Component	2.4a	Pin + bolts		
	2.4b	Hanger curtain wall		
	2.4c	Profile connections		
Raw Material	2.5a	Steel		

Bill of Material

	Code	Item name	Photo	Shearing layer
Building part	2.1	Facade		Skin (25-50 years)
System	2.2	Curtain wall spider		Skin (25-50 years)
Product	2.3a	Glass panel		Skin (25-50 years)
	2.3b	Spider connections		Skin (25-50 years)
Component	2.4a	Pin + bolts		
	2.4b	Spider 2 knots		
	2.4c	Spider 4 knots		
	2.4d	Plate		
Raw Material	2.5a	Aluminium		
	2.5b	Glass		
	2.5c	Foil		

Criteria


Logistics
Toxicity
Quality
Maintenance
Technical lifespan
Dimensions
Availability
Performance
• strength
• Rc-value
Disassembly
Reuse Potential
Data-based + measurable
Data-based + discrete measurable (yes or no)
Other

Tool 2/5

Bill of Material				
	Code	Item name	Photo	Shearing layer
Building part	1			
System	2			
Product	3a			
	3b			
	3c			
Component	4a			
	4b			
	4c			
Raw Material	5a			
	5b			
	5c			

Measurements					Availability
Height (mm)	Width (mm)	Thickness (mm)	Weight (gram)	Volume (m^3)	Amount
				0	
				0	
				0	
				0	
				0	
				0	
				0	
				0	
				0	
				0	

Performance					
Strength	Strength aim	RP value	Rc-value	Rc-value aim	RP value
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1

Logistics	
Building close to waterway ?	Transport options

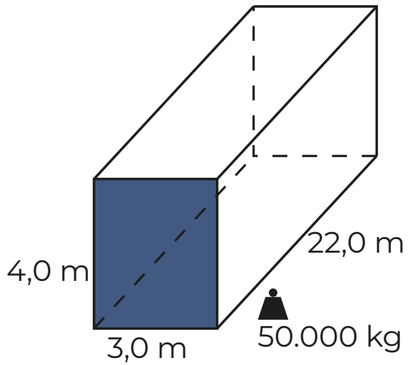
Supplier				
Brand	Age (End-of-use) (months)	Technical lifespan End-of-life (months)	Estimated remaining lifespan	RP value
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Disassembly index										
(Tv) Type joint		Accessibility link (ToV)		Intersections (DK)		Edging (RO)		Disassembly index	LIcn = losmaakbaarheidsindex van de connectie van product of element n:	LIcn = losmaakbaarheidsindex van de samenstelling van element n:
								0	0	0
								0	0	0
								0	0	0
								0	0	0
								0	0	0
								0	0	0
								0	0	0
								0	0	0
								0	0	0
								0	0	0

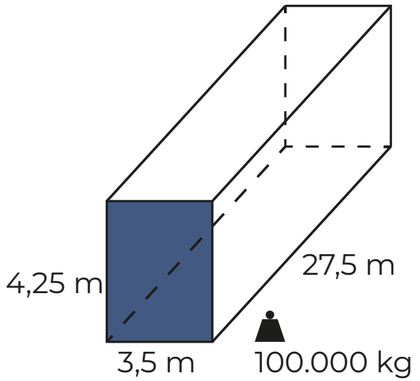
Toxicity	
Toxicity range	index toxicity

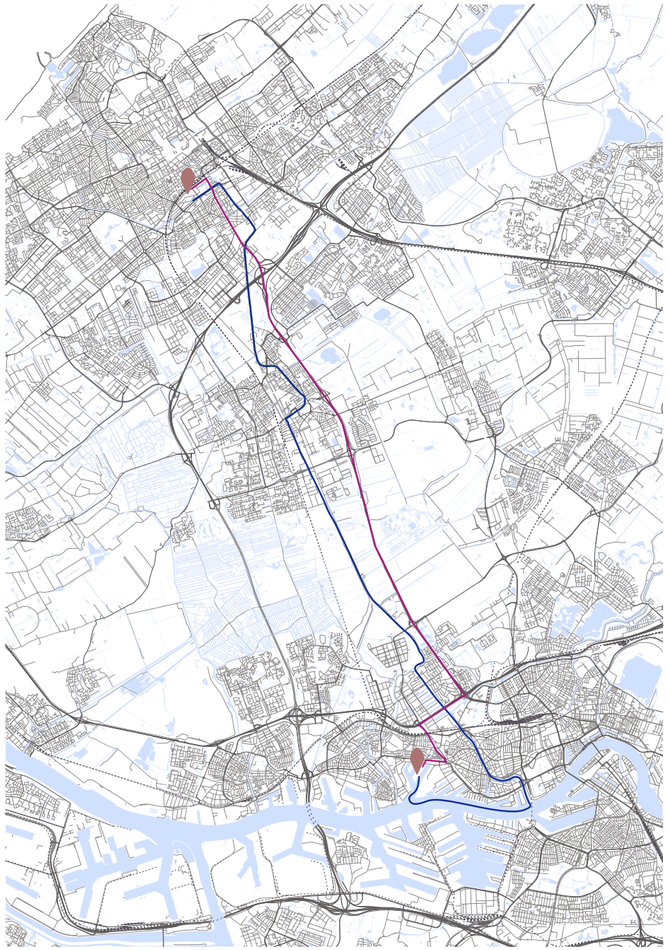
Logistics

Normal transportation



Specific transportation





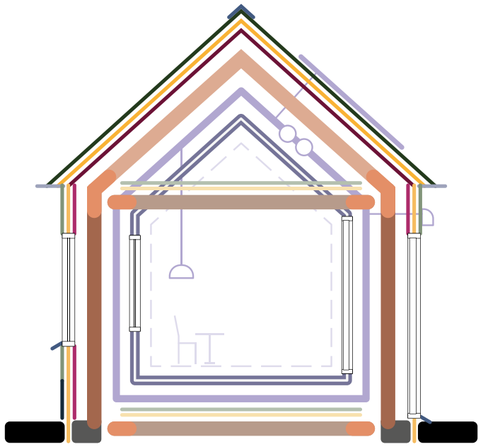
shipping route
driving route

CEMT-Class II
length: 50-55 m.
width: 6,6 m.
401-650 tonnes
carrying capacity

Tool 3/5

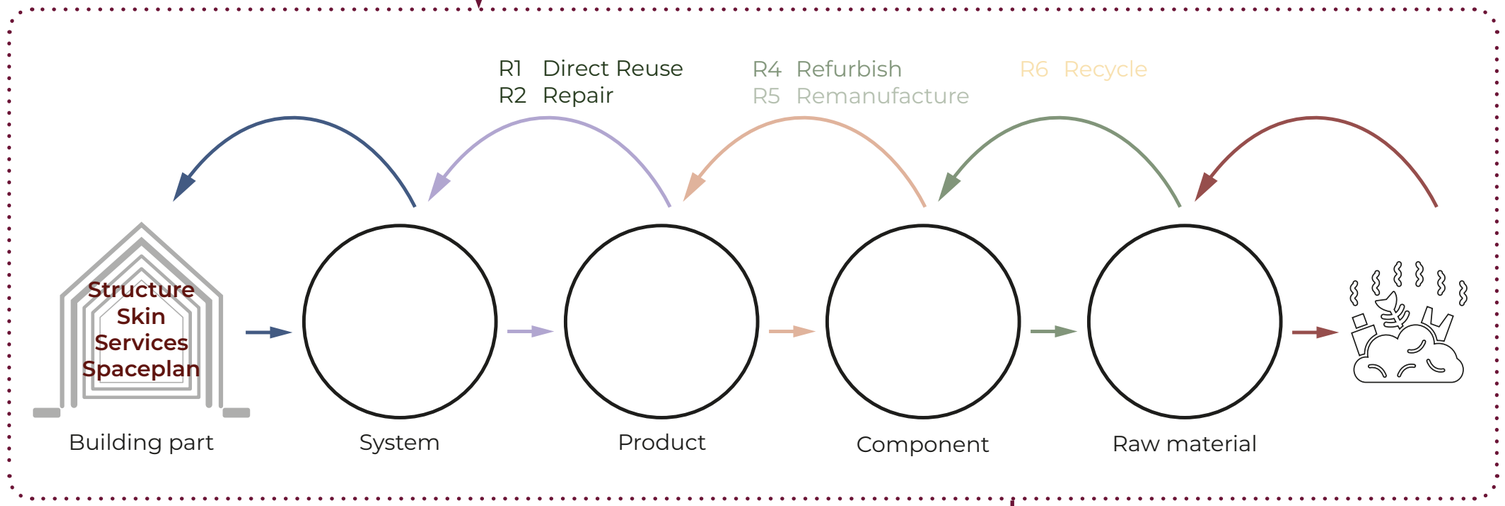
Bill of Material					Measurements					Availability	Performance					Logistics	
	Code	Item name	Photo	Shearing layer	Height (mm)	Width (mm)	Thickness (mm)	Weight (gram)	Volume (m^3)	Amount	Strength			Rc-value		Building close to waterway ?	Transport options
Building part	1								0								
System	2								0								
Product	3a								0								
	3b								0								
	3c								0								
Component	4a								0								
	4b								0								
	4c								0								
Raw Material	5a								0								
	5b								0								
	5c								0								

Supplier					Disassembly index											Toxicity	
Brand	Age (End-of-use) (months)	Technical lifespan End-of-life (months)			(Tv) Type joint		Accessibility link (ToV)		Intersections (DK)		Edging (RO)		Disassembly index	LIcn = losmaakbaarheidsindex van de connectie van product of element n:	LIcn = losmaakbaarheidsindex van de samenstelling van element n:	Toxicity range	index toxicity
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		
													0	0	0		



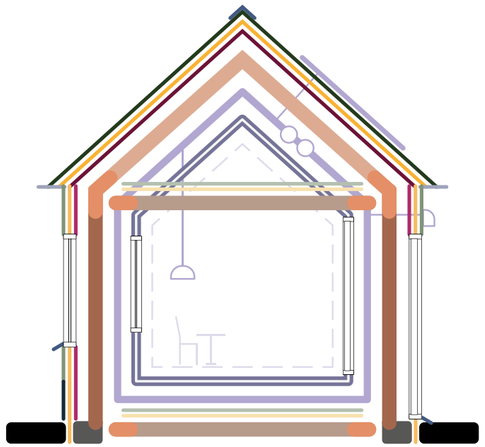
User traces
Old building codes
Degradation of material
One-of-a-kind products
Designed for specific function

1st use phase

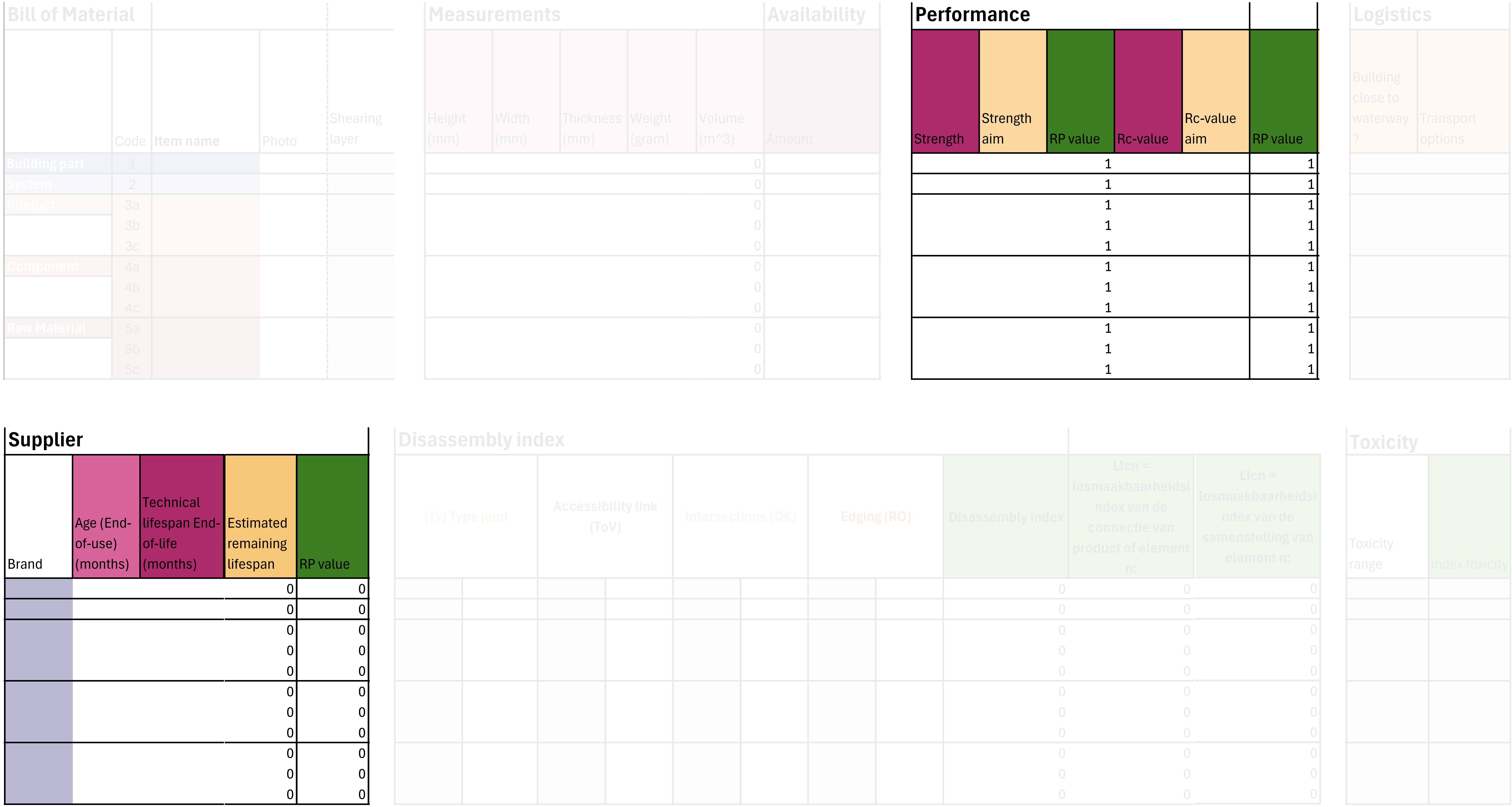


2st use phase

Aesthetics
New building codes
Design for disassembly
Different function



Tool 4/5



Bill of Material

	Code	Item name	Photo	Shearing layer
Building part	1			
System	2			
Product	3a			
	3b			
	3c			
Component	4a			
	4b			
	4c			
Raw Material	5a			
	5b			
	5c			

Measurements

Height (mm)	Width (mm)	Thickness (mm)	Weight (gram)	Volume (m^3)
				0
				0
				0
				0
				0
				0
				0
				0
				0
				0
				0

Availability

Amount

Performance

Strength	Strength aim	RP value	Rc-value	Rc-value aim	RP value
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1
		1			1

Logistics

Building close to waterway ?	Transport options

Supplier

Brand	Age (End-of-use) (months)	Technical lifespan End-of-life (months)	Estimated remaining lifespan	RP value
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Disassembly index

(Tv) Type joint	Accessibility link (ToV)	Intersections (DK)	Edging (RO)	Disassembly index	LIcn = losmaakbaarheidsindex van de connectie van product of element n:	LIcn = losmaakbaarheidsindex van de samenstelling van element n:
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0
				0	0	0

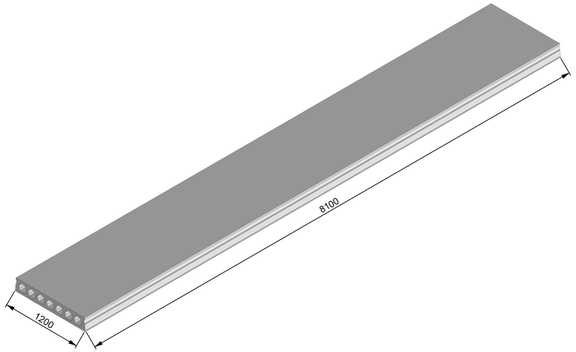
Toxicity

Toxicity range	index toxicity

Tool 5/5

Reuse Potential				Bill of Material				
RP-	RP		RP+		Code	Item name	Photo	Shearing layer
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle	Building part	1			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle	System	2			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle	Product	3a			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle		3b			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle		3c			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle	Component	4a			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle		4b			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle		4c			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle	Raw Material	5a			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle		5b			
R4 Refurbi	0,33	R5 Remanufacture	R6 Recycle		5c			

Case study: Results Reuse Potential Material Megastores to Merwehaven

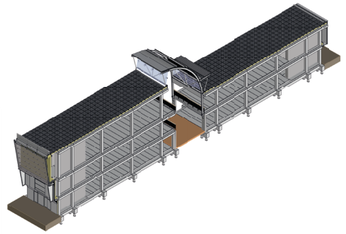


Reuse Potential				Bill of Material		
RP-	RP		RP+		Code	Item name
R2 Repair	0,54	R4 Refurbish	R5 Remanufacture	Building part	1.1	Floors
R2 Repair	0,54	R4 Refurbish	R5 Remanufacture	System	1.2	Floor packet
R1 Direct u	0,75	R2 Repair	R4 Refurbish	Product	1.3a	Precast hollow core slabs
R4 Refurbi	0,39	R5 Remanufacture	R6 Recycle		1.3b	50 mm Anhydrietvloer
R1 Direct u	0,75	R2 Repair	R4 Refurbish		1.3c	Finishing
R2 Repair	0,57	R4 Refurbish	R5 Remanufacture	Raw Material	1.5a	Concrete
R2 Repair	0,50	R4 Refurbish	R5 Remanufacture		1.5b	Concrete and gypsum mix
R2 Repair	0,57	R4 Refurbish	R5 Remanufacture		1.5c	Reinforcement steel

Bill of Material

Project: Megastores

Location: Van der Kunstraat 123, 2521 CD Den Haag
Building year: 2000
Function: Commercial and public building (shopping mall)



R1	Direct Reuse
R2	Repair
R3	Repurpose
R4	Refurbish
R5	Remanufacture
R6	Recycle

Environmental impact

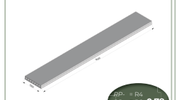
Reuse Potential

Normalization
0,81 - 1,00
0,61 - 0,80
no value
0,41 - 0,60
0,21 - 0,40
0,00 - 0,20

Design Potential: Low / Medium / High

Structure

Floor



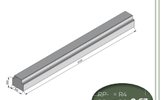
RP = R2 0,78 (RPn = R1)

DP High

Measurements
Height: 8100 mm
Width: 1200 mm
Thickness: 200 mm
Weight [kg/m²]: 1450
Volume [m³]: 19
150 per grid

Availability
Performance
Estimated remaining lifespan: 76
Disassembly
Type joint (TJ_): D1 - Cementitious joint
Accessibility link (AL_): D4 - Accessible
Connection: DI_{conn} = 0,16
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,27
Deconstruction method: Concrete saw
Quality: Damaged borders

Beam



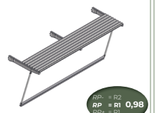
RP = R4 0,63 (RPn = R1)

DP High

Measurements
Height: 660 mm
Width: 800mm
Thickness: 800mm
Weight [kg/m²]: 420
Volume [m³]: 4,2
25 per grid

Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D1 - Cementitious joint
Accessibility link (AL_): D4 - Accessible
Connection: DI_{conn} = 0,16
Intersections (INT_): D4 - Occasional crossing
Edging (EDG_): D4 - Overlapping
Composition: DI_{comp} = 0,4
Product Disassembly Index: DI_{prod} = 0,22
Deconstruction method: Concrete saw
Quality: Damaged borders

Sun shading structure



RP = R2 0,98 (RPn = R1)

DP Medium

Measurements
Height: 3900 mm
Width: 8100 mm
Thickness: 7965 mm
Weight [kg/m²]: 1,5
Volume [m³]: 93
2 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

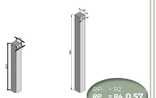
Roof

RP = R1 0,83 (RPn = R1)

DP Low

Measurements
Height: 19240 mm
Width: 14360 mm
Thickness: 8100 mm
Weight [kg/m²]: -
Volume [m³]: -
Rc = 2,5
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Column



RP = R4 0,57 (RPn = R5)

DP High

Measurements
Height: 3640, 5860mm
Width: 450 mm
Thickness: 450 mm
Weight [kg/m²]: 2420
Volume [m³]: 1,17
25 per grid
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D1 - Cementitious joint
Accessibility link (AL_): D3 - Not accessible
Connection: DI_{conn} = 0,1
Intersections (INT_): 1 - No intersections
Edging (EDG_): D2 - Closed
Composition: DI_{comp} = 0,18
Product Disassembly Index: DI_{prod} = 0,12
Deconstruction method: Concrete saw
Quality: Scratches

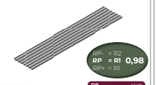
Beam

RP = R1 0,98 (RPn = R1)

DP High

Measurements
Height: 8100 mm
Width: 300 mm
Thickness: 330 mm
Weight [kg/m²]: 7140
Volume [m³]: 0,07
3 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Untouched

Corrugated sheet



RP = R2 0,98 (RPn = R1)

DP High

Measurements
Height: 3640 mm
Width: 4050 mm
Thickness: 105 mm
Weight [kg/m²]: 7140
Volume [m³]: 13400
2 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

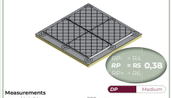
Structure glass system

RP = R1 0,98 (RPn = R1)

DP Medium

Measurements
Height: 3500 mm
Width: 8100 mm
Thickness: 250mm
Weight [kg/m²]: 7140
Volume [m³]: -
2 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Floorsystem Strijland

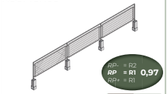


RP = R5 0,38 (RPn = R6)

DP Medium

Measurements
Height: 920 mm
Width: 920 mm
Thickness: 190 mm
Weight [kg/m²]: 2420
Volume [m³]: 0,36
621 per grid
Availability: Rc=2,5
Performance
Estimated remaining lifespan: 1 year
Disassembly
Type joint (TJ_): D1 - Adhesive bonding
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,18
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 0,1
Product Disassembly Index: DI_{prod} = 0,3
Deconstruction method: Dismantling
Quality: Mixed

Roof fence

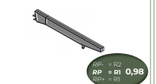


RP = R1 0,97 (RPn = R1)

DP Medium

Measurements
Height: 1970 mm
Width: 8100 mm
Thickness: 200 mm
Weight [kg/m²]: -
Volume [m³]: -
2 per grid
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Beam

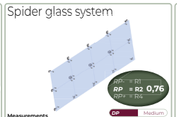


RP = R2 0,98 (RPn = R1)

DP High

Measurements
Height: 2966 mm
Width: 135 mm
Thickness: 302 mm
Weight [kg/m²]: 7140
Volume [m³]: 0,02
3 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Spider glass system

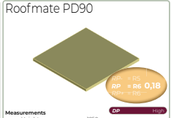


RP = R1 0,76 (RPn = R4)

DP Medium

Measurements
Height: 7320 mm
Width: 8100 mm
Thickness: 300 mm
Weight [kg/m²]: -
Volume [m³]: -
2 per grid
Availability: Rc = 2,5
Performance
Estimated remaining lifespan: 16-26 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Roofmate PD90

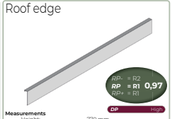


RP = R6 0,18 (RPn = R6)

DP High

Measurements
Height: 1250 mm
Width: 600 mm
Thickness: 80 mm
Weight [kg/m²]: 2,6
Volume [m³]: 0,06
80,5 m² per grid
Availability: Rc=2,5
Performance
Estimated remaining lifespan: 1 year
Disassembly
Type joint (TJ_): D1 - Adhesive bonding
Accessibility link (AL_): D3 - Not accessible
Connection: DI_{conn} = 0,1
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,38
Deconstruction method: Cutting
Quality: Soft material

Roof edge



RP = R1 0,97 (RPn = R1)

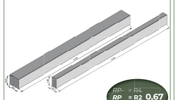
DP High

Measurements
Height: 770 mm
Width: 190 mm
Thickness: 3 mm
Weight [kg/m²]: -
Volume [m³]: -
2 per grid
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Structure

Foundation

Foundation beam



RP = R4 0,67 (RPn = R2)

DP High

Measurements
Height: 660, 300 mm
Width: 660, 600 mm
Thickness: 660, 600 mm
Weight [kg/m²]: 2420
Volume [m³]: 3,4 + 1,4
2 + 4 per grid
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D1 - Cementitious joint
Accessibility link (AL_): D3 - Not accessible
Connection: DI_{conn} = 0,1
Intersections (INT_): D4 - Occasional crossing
Edging (EDG_): D4 - Overlapping
Composition: DI_{comp} = 0,4
Product Disassembly Index: DI_{prod} = 0,36
Deconstruction method: Concrete saw
Quality: Untouched

Pad foundation

RP = R5 0,33 (RPn = R5)

DP High

Measurements
Height: 1000 mm
Width: 2000 mm
Thickness: 700 mm
Weight [kg/m²]: 2420
Volume [m³]: 1,4
24 per grid
Availability
Performance
Estimated remaining lifespan: 76
Disassembly
Type joint (TJ_): D1 - Cementitious joint
Accessibility link (AL_): D3 - Not accessible
Connection: DI_{conn} = 0,1
Intersections (INT_): D1 - Full integration
Edging (EDG_): D2 - Closed
Composition: DI_{comp} = 0,3
Product Disassembly Index: DI_{prod} = 0,3
Deconstruction method: Demolish
Quality: Untouched

Roof passage

Steel structure

RP = R2 0,98 (RPn = R1)

DP Medium

Measurements
Height: 19240 mm
Width: 4060 mm
Thickness: 8100 mm
Weight [kg/m²]: 7140
Volume [m³]: -
1 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

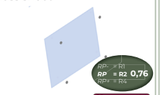
Arche beam passage

RP = R2 0,98 (RPn = R1)

DP High

Measurements
Height: 19240 mm
Width: 4060 mm
Thickness: 100 mm
Weight [kg/m²]: 7140
Volume [m³]: 0,07
2 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Glass sheet



RP = R1 0,76 (RPn = R2)

DP High

Measurements
Height: 1550 mm
Width: 2005 mm
Thickness: 8 mm
Weight [kg/m²]: 0,03
Volume [m³]: 16 per grid
Availability: Rc = 2,5
Performance
Estimated remaining lifespan: 16-26 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

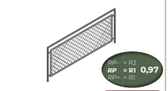
APP roof covering

RP = R6 0,18 (RPn = R6)

DP High

Measurements
Height: 8100 mm
Width: 8100 mm
Thickness: 10 mm
Weight [kg/m²]: 12
Volume [m³]: 6,5
80,5 m² per grid
Availability: UV and heat resistant
Performance: 0
Estimated remaining lifespan
Disassembly
Type joint (TJ_): D1 - Adhesive bonding
Accessibility link (AL_): D3 - Not accessible
Connection: DI_{conn} = 0,1
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 0,1
Product Disassembly Index: DI_{prod} = 0,38
Deconstruction method: Cutting
Quality: Damaged

Fence

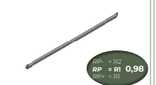


RP = R1 0,97 (RPn = R1)

DP High

Measurements
Height: 1200 mm
Width: 2700 mm
Thickness: 52 mm
Weight [kg/m²]: -
Volume [m³]: -
6 per grid
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

HEA160



RP = R1 0,98 (RPn = R1)

DP High

Measurements
Height: 8100 mm
Width: 160 mm
Thickness: 160 mm
Weight [kg/m²]: 7140
Volume [m³]: 0,02
1 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

Beam

RP = R2 0,98 (RPn = R1)

DP High

Measurements
Height: 3300 mm
Width: 120 mm
Thickness: 120 mm
Weight [kg/m²]: 7140
Volume [m³]: 0,149
4 per grid
Availability: 5235
Performance
Estimated remaining lifespan: 76 year
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering

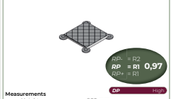
Spider joint

RP = R1 0,90 (RPn = R1)

DP High

Measurements
Height: 300 mm
Width: 300 mm
Thickness: 200 mm for 11 mm glass
Weight [kg/m²]: 0,018
Volume [m³]: 1 pin 8, 2 pins 16, 4 pins 6
Availability: 5235
Performance
Estimated remaining lifespan: 26-years
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): D2 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Weathering outside

Tiles + tensioning elements

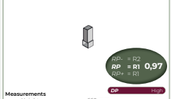


RP = R2 0,97 (RPn = R1)

DP High

Measurements
Height: 900 mm
Width: 900 mm
Thickness: 80 mm
Weight [kg/m²]: 2400
Volume [m³]: 0,0648
621 per grid
Availability: suitable for car parks
Performance: 100+ years
Estimated remaining lifespan
Disassembly
Type joint (TJ_): 1 - Loose (no fixing material)
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 1,0
Intersections (INT_): 1 - No intersections
Edging (EDG_): D1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 1,0
Deconstruction method: Lifting
Quality: Dirty

Pedestal eaves and fence

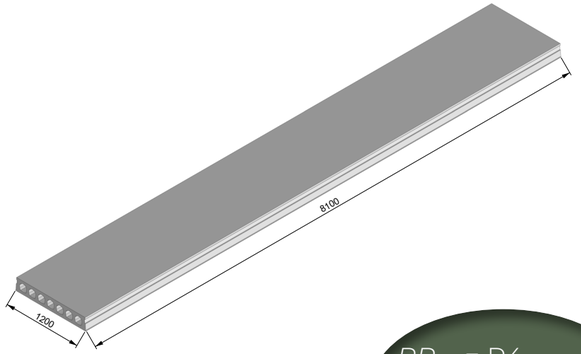


RP = R2 0,97 (RPn = R1)

DP High

Measurements
Height: 660 mm
Width: 165 mm
Thickness: 165 mm
Weight [kg/m²]: -
Volume [m³]: -
6 per grid
Availability
Performance
Estimated remaining lifespan: 76 years
Disassembly
Type joint (TJ_): D8 - Bolt and nut connection
Accessibility link (AL_): 1 - Freely accessible
Connection: DI_{conn} = 0,88
Intersections (INT_): 1 - No intersections
Edging (EDG_): 1 - Open
Composition: DI_{comp} = 1,0
Product Disassembly Index: DI_{prod} = 0,94
Deconstruction method: Dismantling
Quality: Untouched

Floor



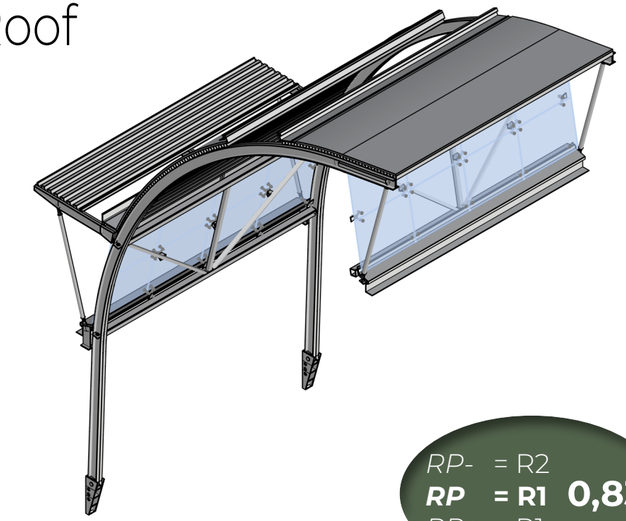
RP- = R4
RP = R2 0,78
RP+ = R1

DP High

Measurements

Height:	8100 mm
Width:	1200 mm
Thickness:	200 mm
Weight [kg/m³]	2420
Volume [m³]	1,9
Availability:	150 per grid
Performance:	...
Estimated remaining lifespan:	76
Disassembly	
Type joint (TJ_n):	0,1 - Cementitious joint
Accessibility link (AL_n):	0,4 - Accessible
Connection	$DI_{conn.n}$ = 0,16
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,27
Deconstruction method:	Concrete saw
Quality:	Damaged borders

Roof



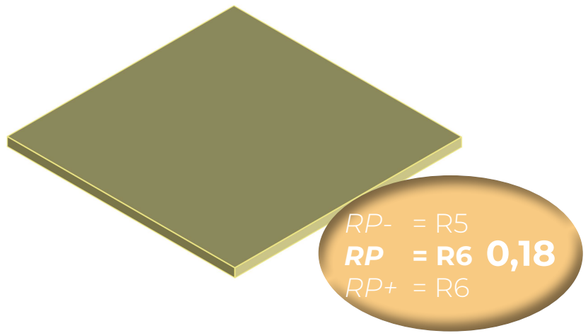
RP- = R2
RP = R1 0,83
RP+ = R1

DP Low

Measurements

Height:	19240 mm
Width:	14160 mm
Thickness:	8100 mm
Weight [kg/m³]	...
Volume [m³]	...
Availability:	...
Performance:	Rc = 2,5
Estimated remaining lifespan:	76 years
Disassembly	
Type joint (TJ_n):	0,8 - Bolt and nut connection
Accessibility link (AL_n):	1 - Freely accessible
Connection	$DI_{conn.n}$ = 0,88
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,94
Deconstruction method:	Dismantling
Quality:	Weathering

Roofmate PD90



RP- = R5
RP = R6 0,18
RP+ = R6

DP High

Measurements

Height:	1250 mm
Width:	600 mm
Thickness:	80 mm
Weight [kg/m²]	2,6
Volume [m³]	0,06
Availability:	803,5 m² per grid
Performance:	Rc=2,5
Estimated remaining lifespan:	1 year
Disassembly	
Type joint (TJ_n):	0,1 - Adhesive bonding
Accessibility link (AL_n):	0,1 - Not accessible
Connection	$DI_{conn.n}$ = 0,1
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,18
Deconstruction method:	Cutting
Quality:	Soft material

Reuse Potential

Disposition Decision

Design Potential

Reuse Potential

Disposition Decision

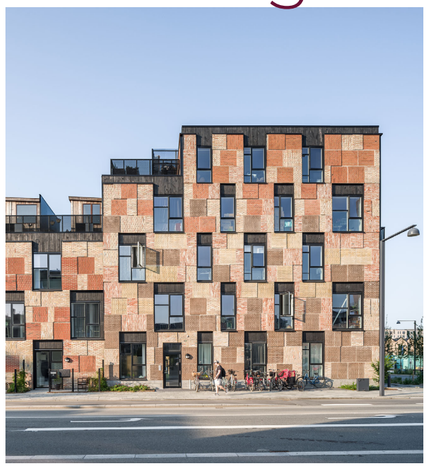
Design Potential

Architectural implementation

K.118

Biopartner5

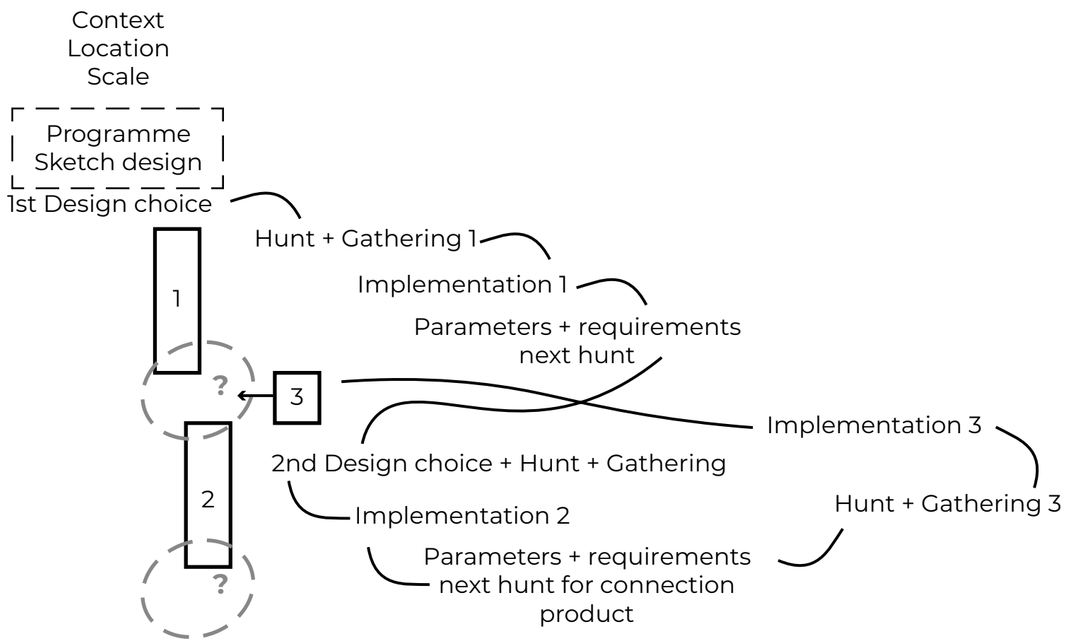
Lendager



design processes

Integration of reuse within their designs

objectives related to reuse


Context
Location
Scale
Programme
Sketch design
1st Design choice
Hunt + Gathering 1
Implementation 1
Parameters + requirements
next hunt
1
?
3
Implementation 3
2nd Design choice + Hunt + Gathering
2
Implementation 2
Hunt + Gathering 3
Parameters + requirements
next hunt for connection
product
?

Objective technical design

1. Reuse first!

2. Minimal 20% reuse, 40% renewable, 40% most sustainable supplier

3. Finding optimal match for reclaimed materials architecturally and functionally

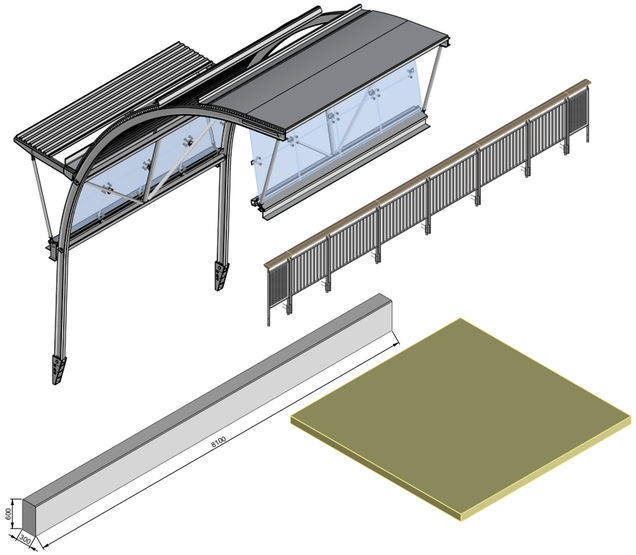
4. “Scars” may been seen

5. Disassembly and replaceability

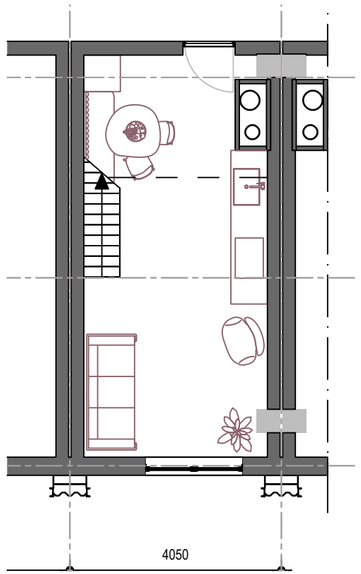
Design approach

Material-driven design

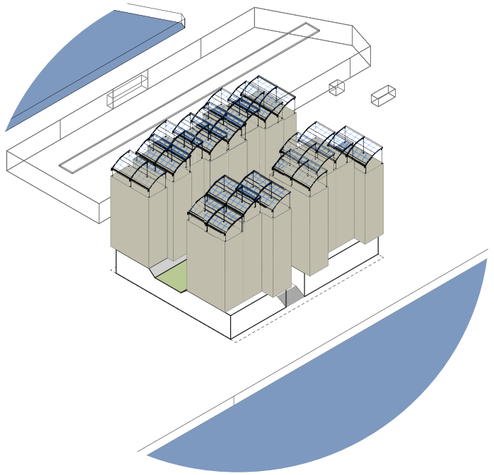
Material



Architecture



Urban

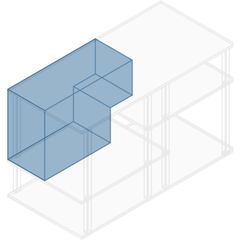


Programme of requirements

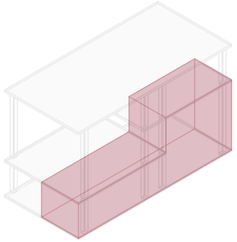
Makers Places

Public Spaces

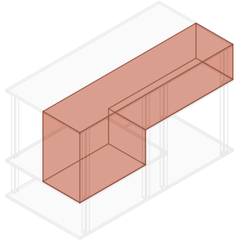
Housing



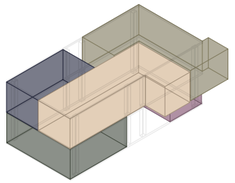
Studio

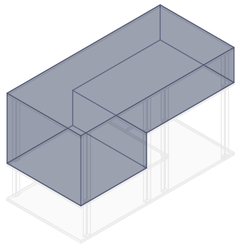


1,5 person apartment

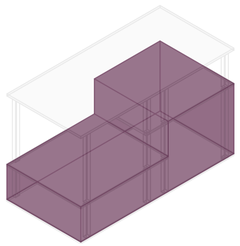


1,5 person apartment

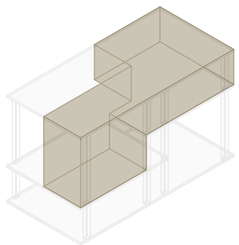




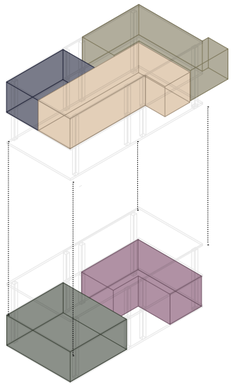
Family apartment



Family apartment



Family apartment



Shared housing with 3 sub-dwellings

Collective

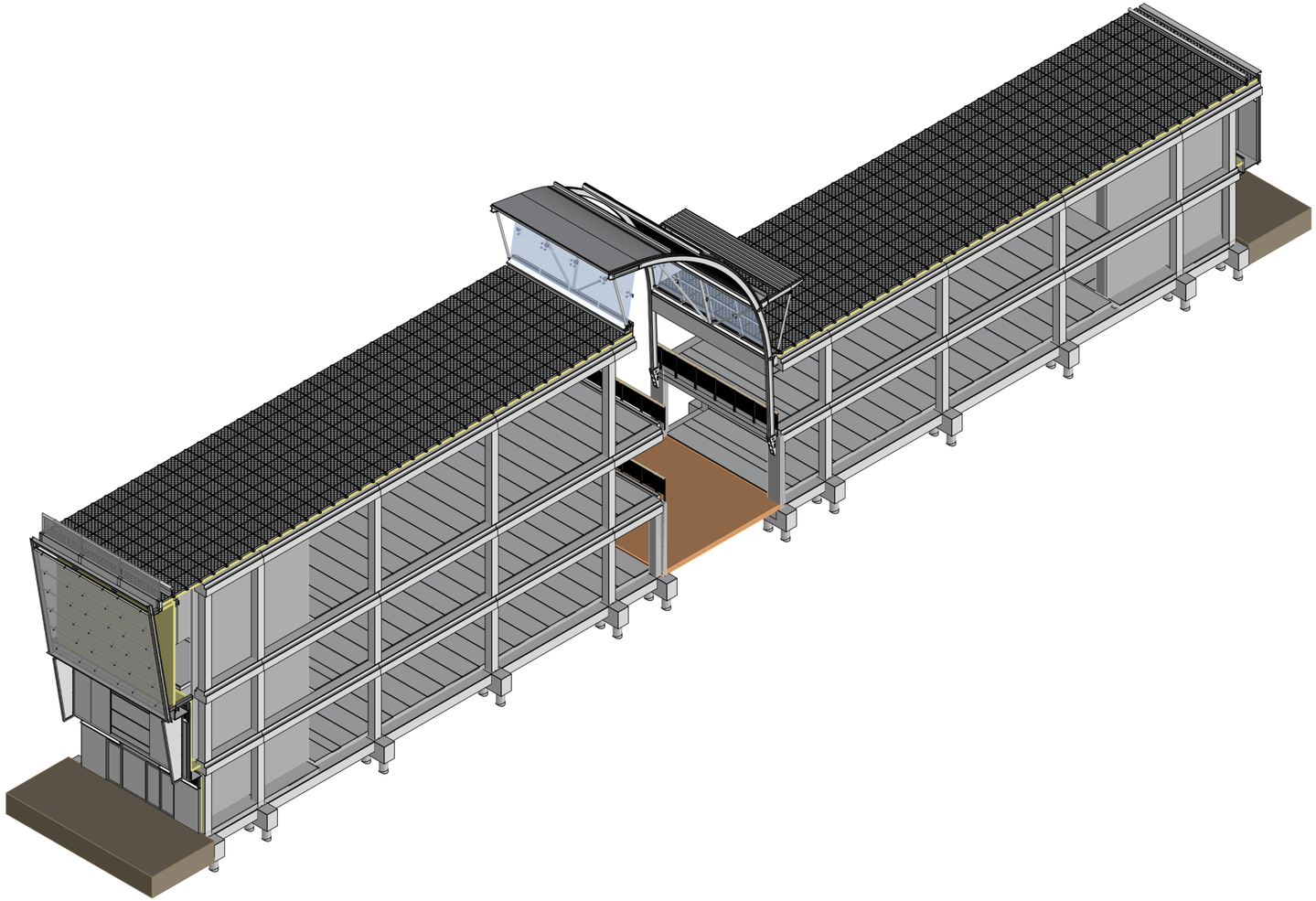
Roof garden

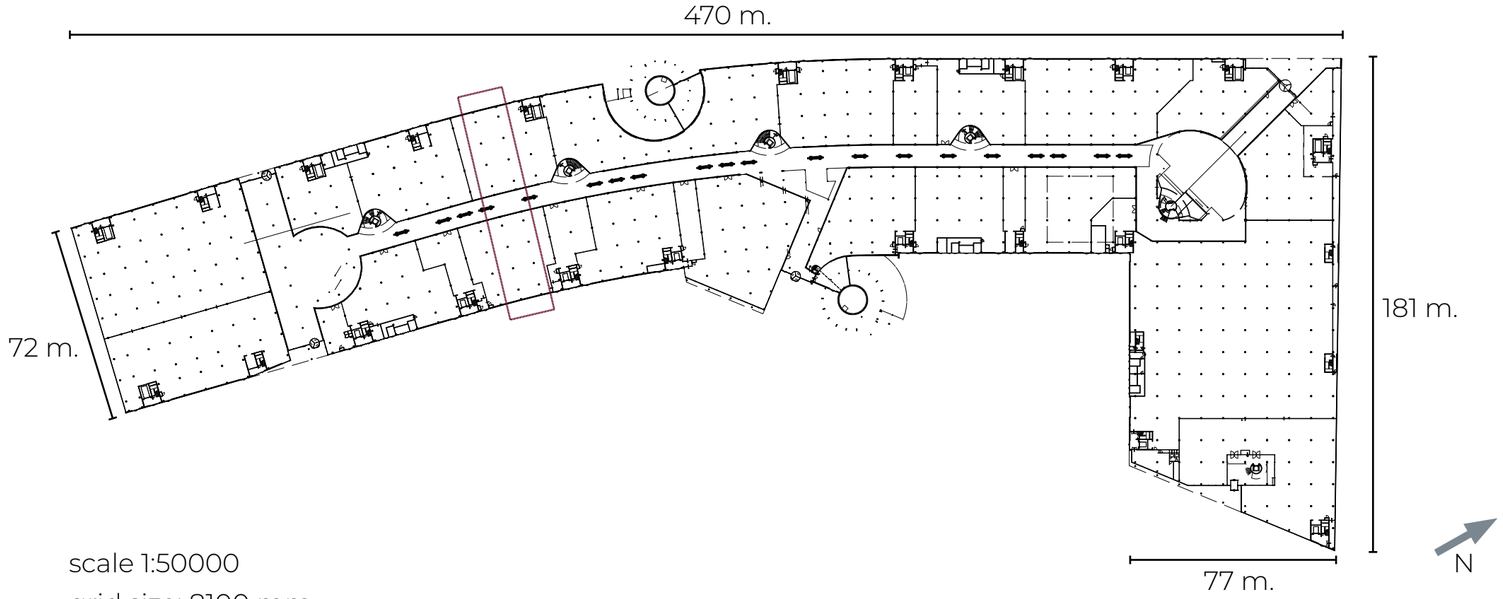
Inner garden

Bicycle parking

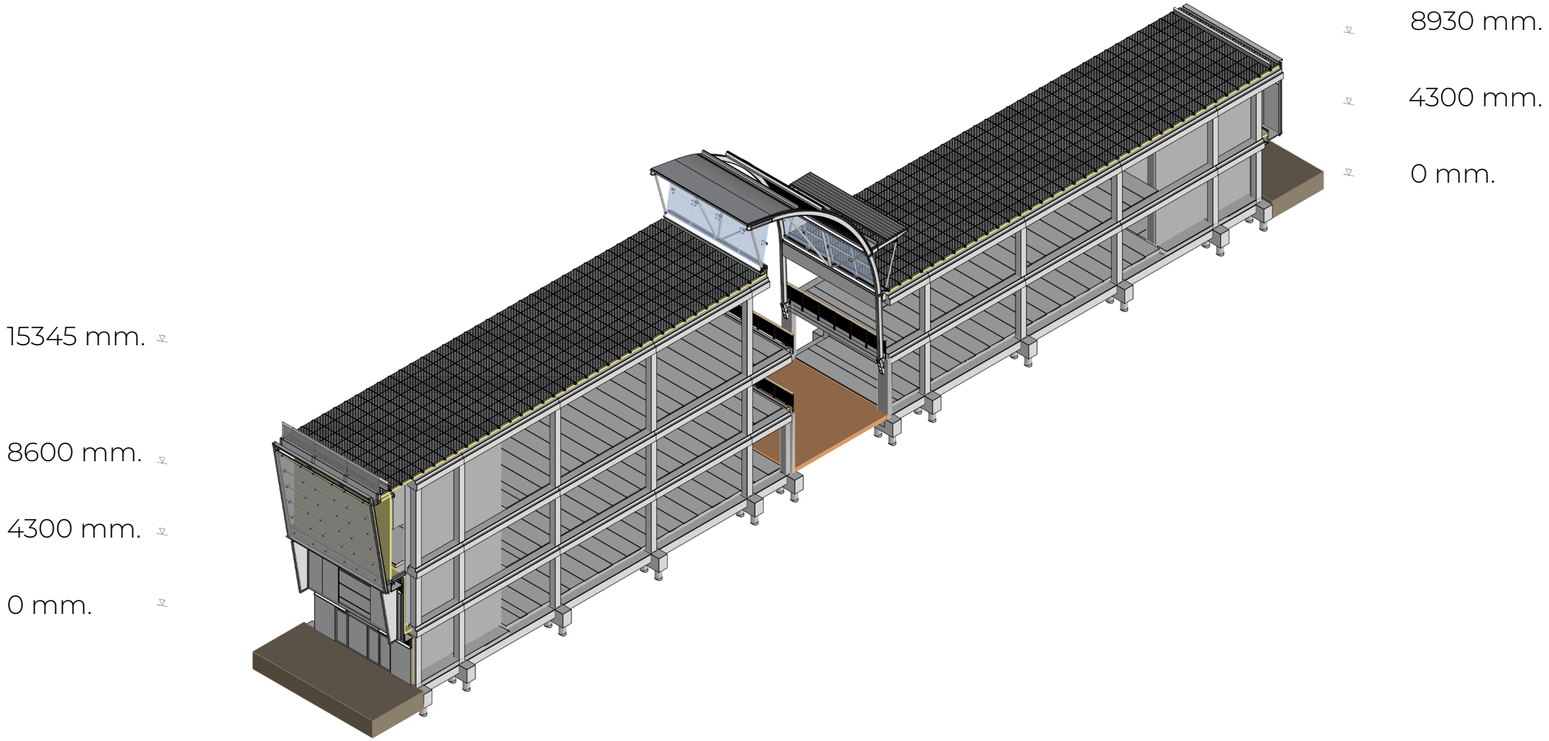
Waste sorting

Design

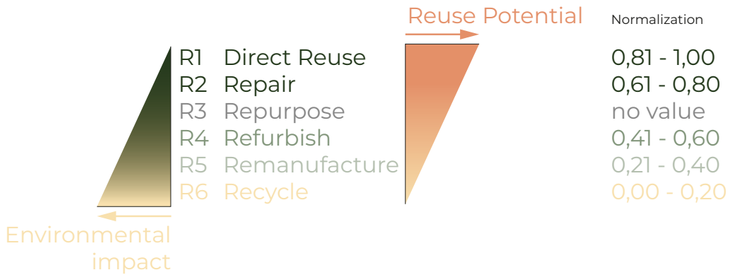




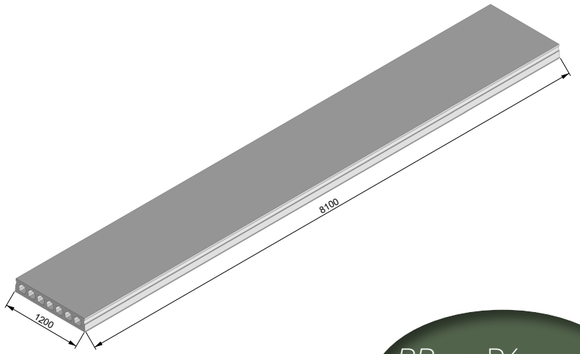
scale 1:50000
grid size: 8100 mm.



STEP 1: MATERIALS WITH BIGGEST IMPACT



Floor

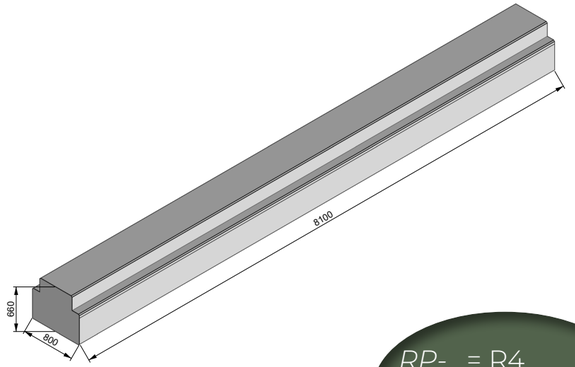


RP- = R4
RP **= R2 0,78**
RP+ = R1

Measurements

Height:	8100 mm
Width:	1200 mm
Thickness:	200 mm
Weight [kg/m³]	2420
Volume [m³]	1,9
Availability:	150 per grid
Performance:	...
Estimated remaining lifespan:	76
Disassembly	
Type joint (TJ_n):	0,1 - Cementitious joint
Accessibility link (AL_n):	0,4 - Accessible
Connection	$DI_{conn.n}$ = 0,16
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,27
Deconstruction method:	Concrete saw
Quality:	Damaged borders

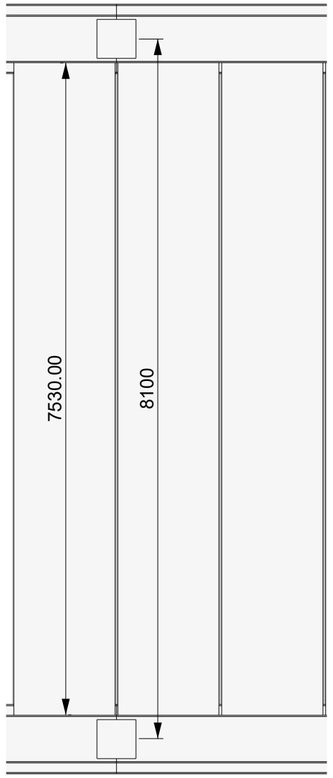
Beam

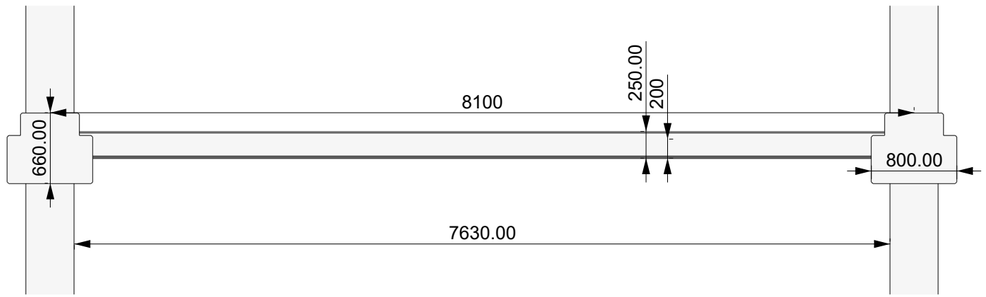


RP- = R4
RP **= R2 0,63**
RP+ = R1

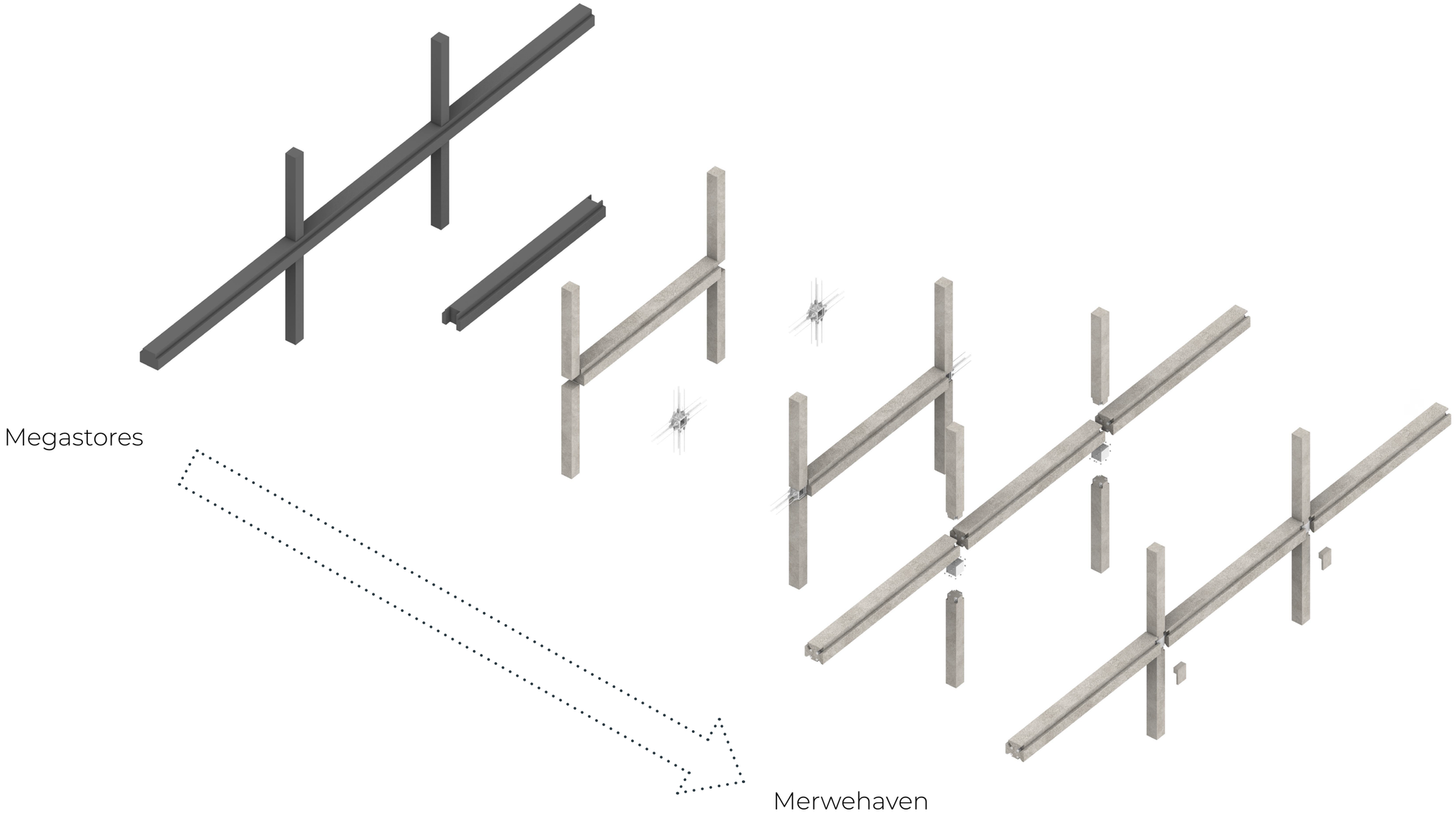
Measurements

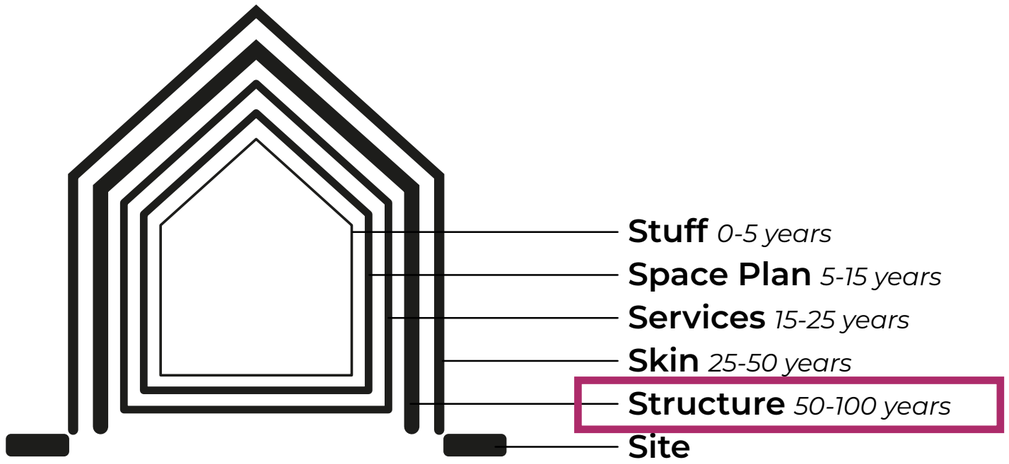
Height:	660 mm
Width:	800mm
Thickness:	8100mm
Weight [kg/m³]	2420
Volume [m³]	4,2
Availability:	25 per grid
Performance:	...
Estimated remaining lifespan:	76 years
Disassembly	
Type joint (TJ_n):	0,1 - Cementitious joint
Accessibility link (AL_n):	0,4 - Accessible
Connection	$DI_{conn.n}$ = 0,16
Intersections (INT_n)	0,4 - Occasional crossing
Edging (EDG_n)	0,4 - Overlapping
Composition	$DI_{comp.n}$ = 0,4
Product Disassembly Index	$DI_{prod.n}$ = 0,22
Deconstruction method:	Concrete saw
Quality:	Damaged borders

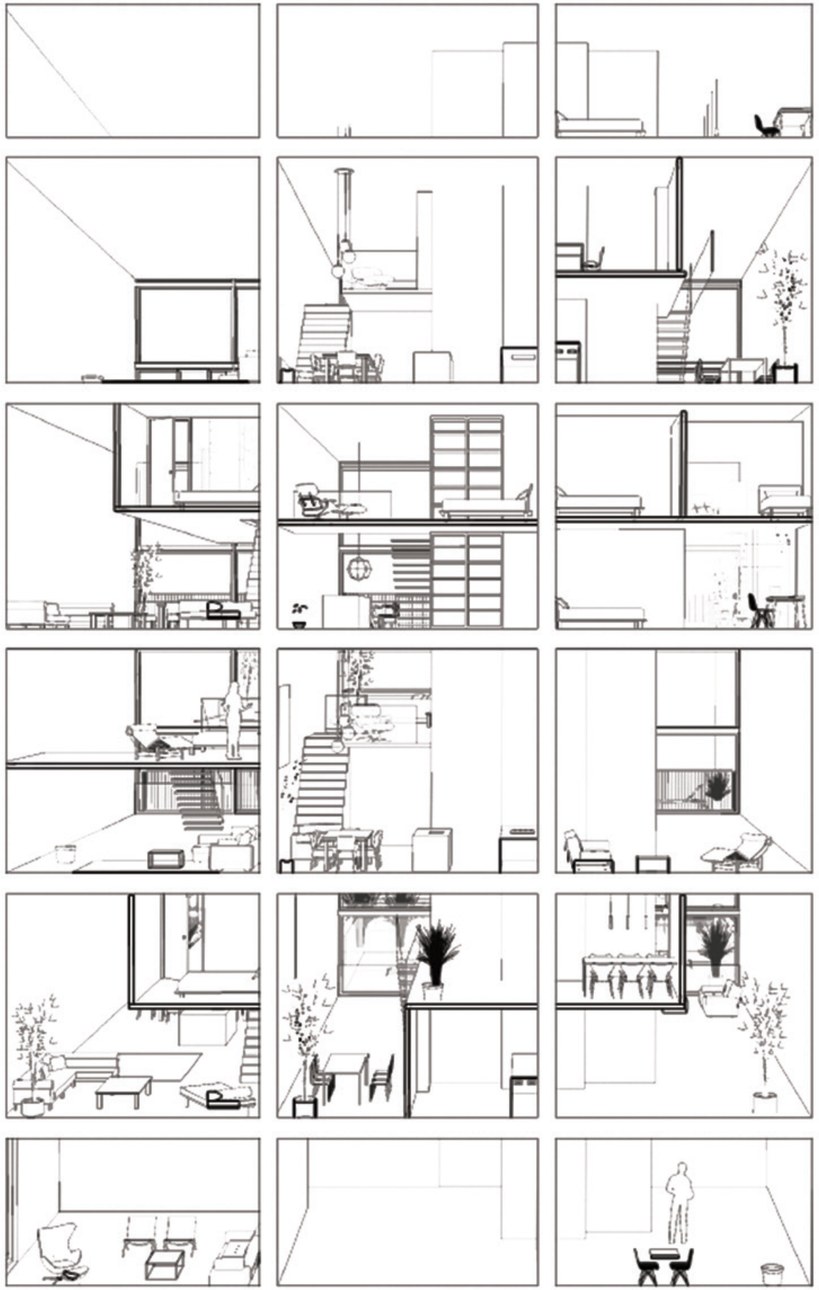

7530.00
8100


8100
250.00
200
660.00
800.00
7630.00

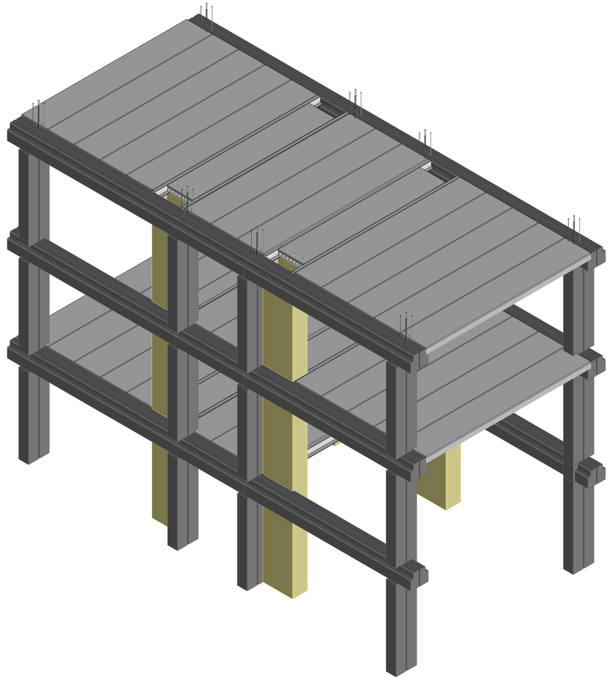
Remanufacture: Demountable concrete system

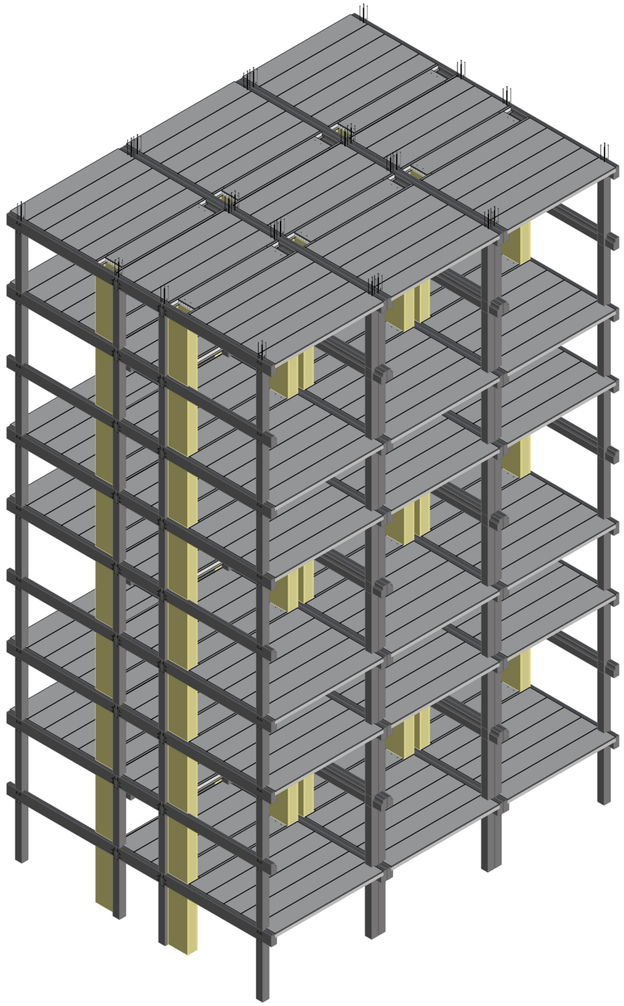




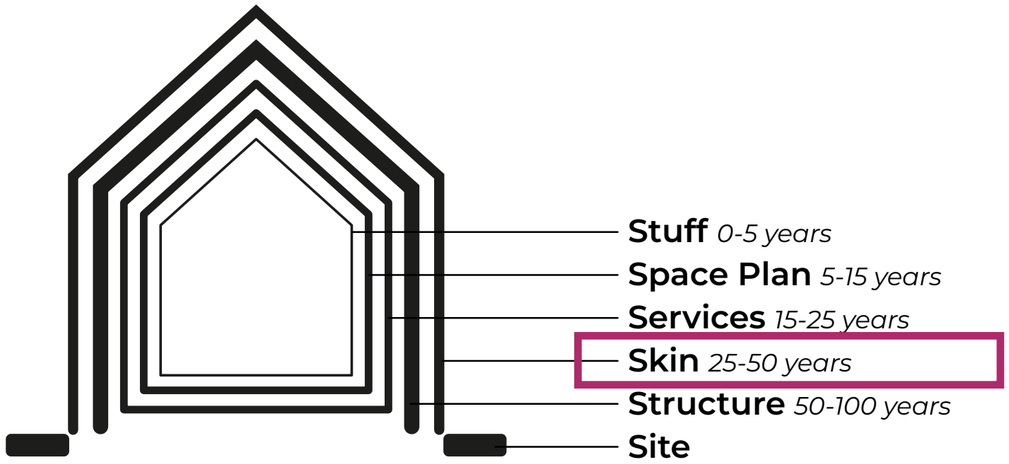


Conceptual Cross Section, Superlofts, Amsterdam, Mark Koehler Architects

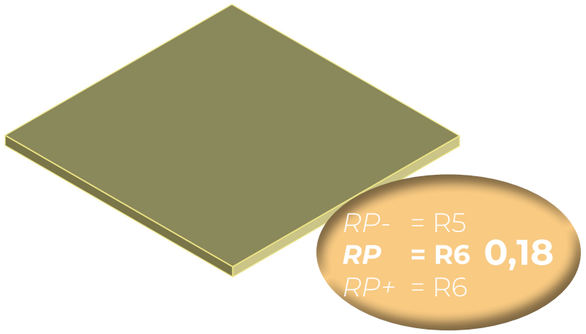




STEP 2:
REUSE POTENTIAL FOR RESIDENTIAL BUILDING



Roofmate PD90

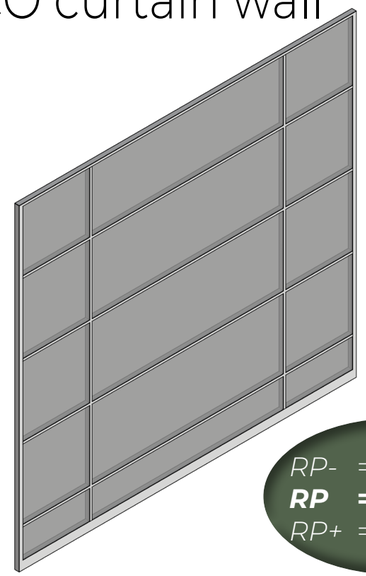


DP High

Measurements

Height:	1250 mm
Width:	600 mm
Thickness:	80 mm
Weight [kg/m²]	2,6
Volume [m³]	0,06
Availability:	803,5 m² per grid
Performance:	Rc=2,5
Estimated remaining lifespan:	1 year
Disassembly	
Type joint (TJ_n):	0,1 - Adhesive bonding
Accessibility link (AL_n):	0,1 - Not accessible
Connection	$DI_{conn.n}$ = 0,1
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,18
Deconstruction method:	Cutting
Quality:	Soft material

SCHUCO curtain wall

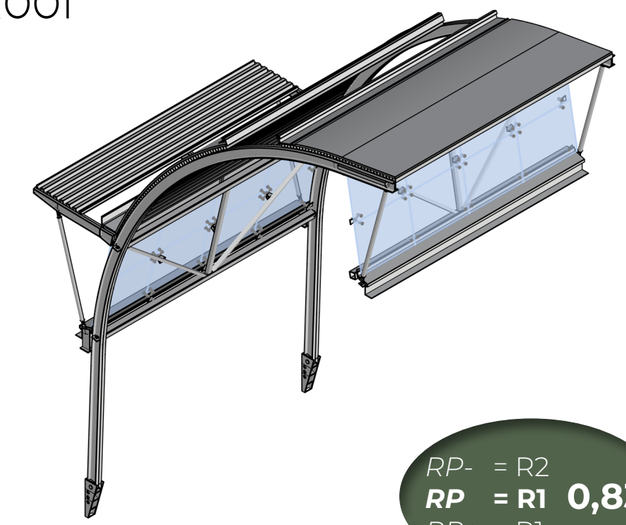


DP Low

Measurements

Height:	3760, 4350, 7190 mm
Width:	2618, 4700, 8100 mm
Thickness:	98, 173, 194 mm
Weight [kg/m²]	20-50
Volume [m³]	...
Availability:	8, 10, 21
Performance:	Rc=2,5
Estimated remaining lifespan:	16-26 years
Disassembly	
Type joint (TJ_n):	0,8 - Screw joint
Accessibility link (AL_n):	1 - Freely accessible
Connection	$DI_{conn.n}$ = 0,88
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,94
Deconstruction method:	Dismantling
Quality:	Scratches

Roof



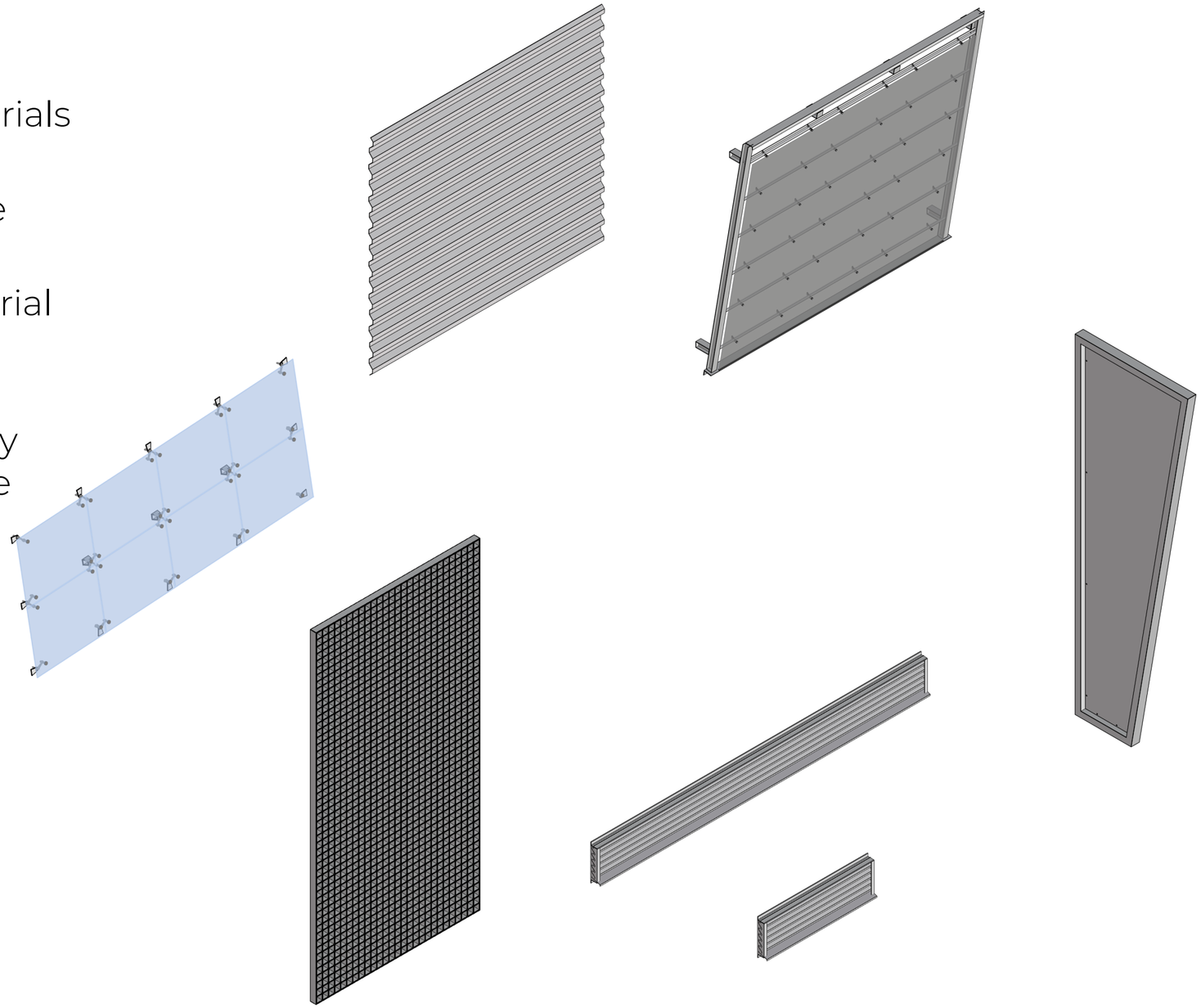
DP Low

Measurements

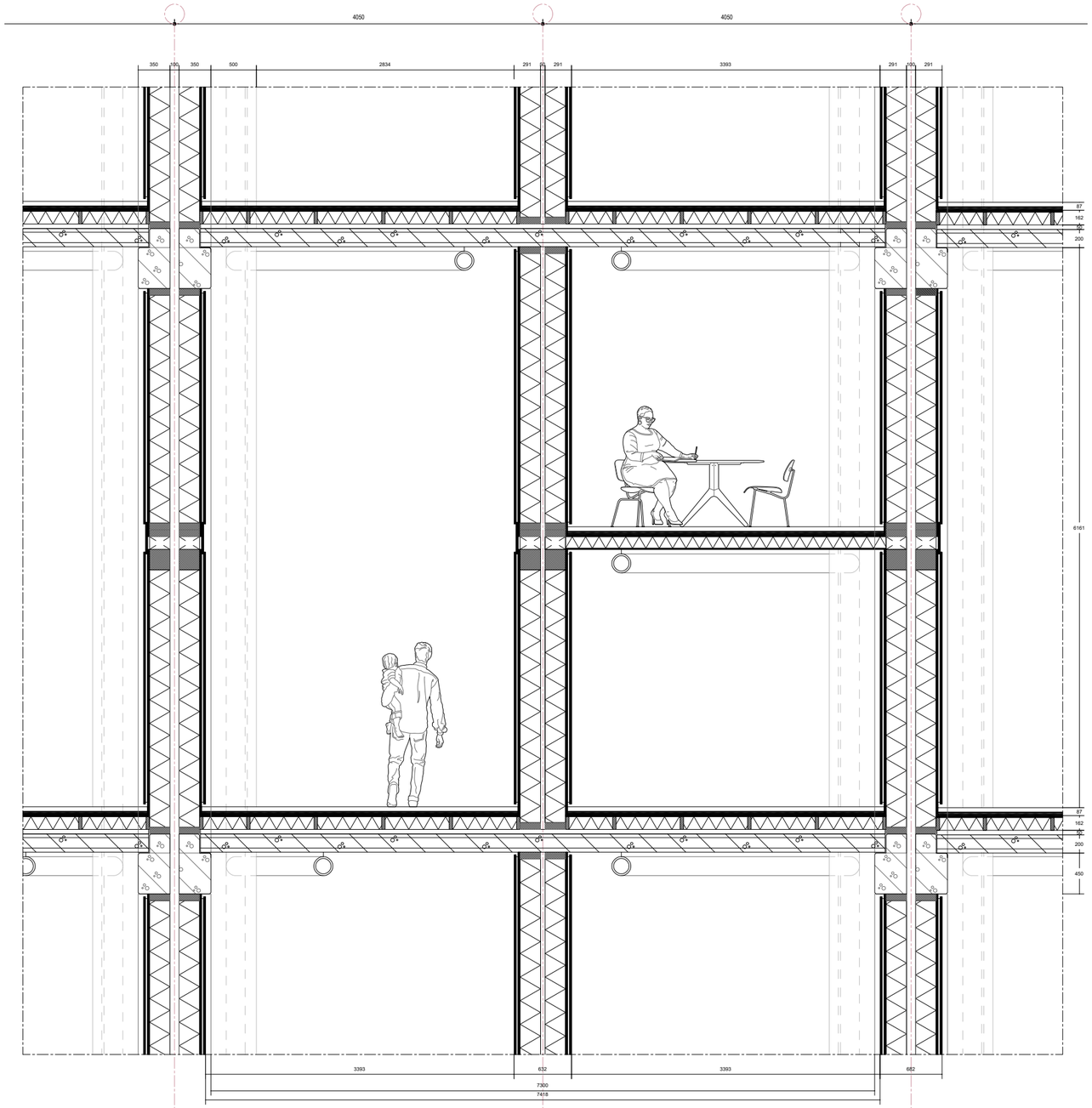
Height:	19240 mm
Width:	14160 mm
Thickness:	8100 mm
Weight [kg/m³]	...
Volume [m³]	...
Availability:	...
Performance:	Rc = 2,5
Estimated remaining lifespan:	76 years
Disassembly	
Type joint (TJ_n):	0,8 - Bolt and nut connection
Accessibility link (AL_n):	1 - Freely accessible
Connection	$DI_{conn.n}$ = 0,88
Intersections (INT_n)	1 - No intersections
Edging (EDG_n)	1 - Open
Composition	$DI_{comp.n}$ = 1,0
Product Disassembly Index	$DI_{prod.n}$ = 0,94
Deconstruction method:	Dismantling
Quality:	Weathering

Potentials:

- Longlasting materials
- Low maintenance
- Easthetics: Industrial material
- High dissassembly index = high reuse potential

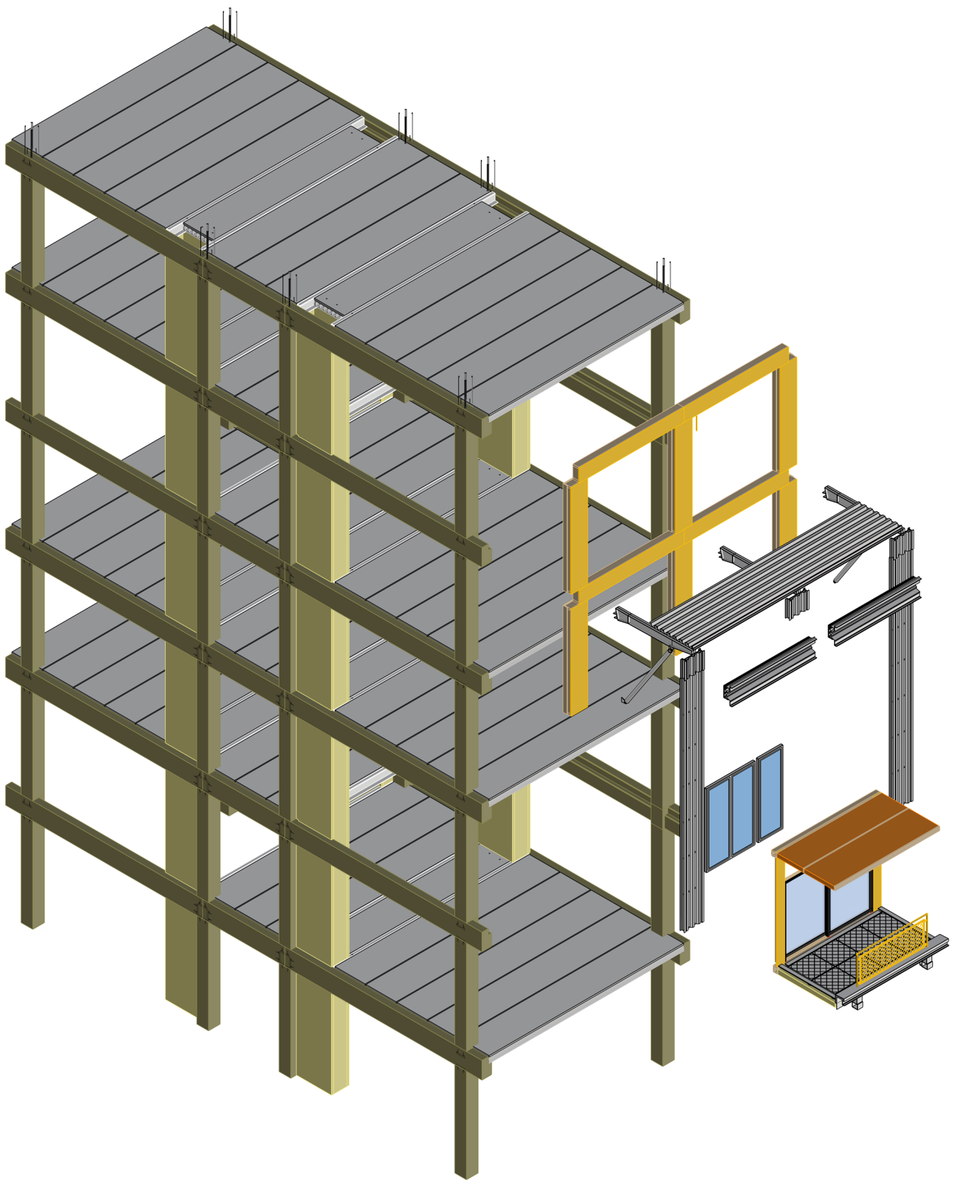


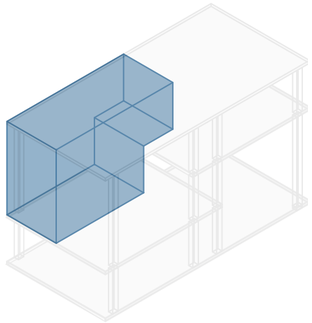
“Create a home out of timber”



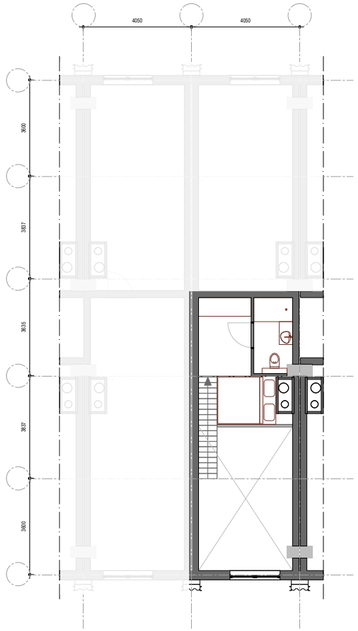
STEP 3: FUTURE-PROOF THROUGH FLEXIBILITY

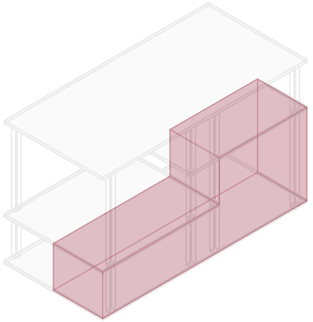
Plug-and-play system



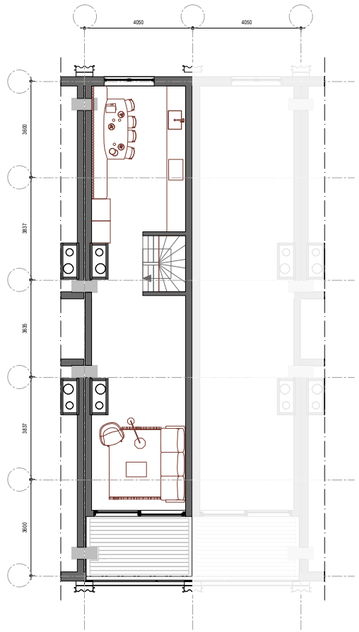


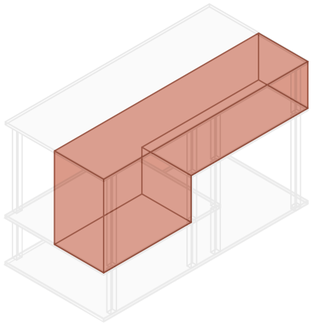
Studio



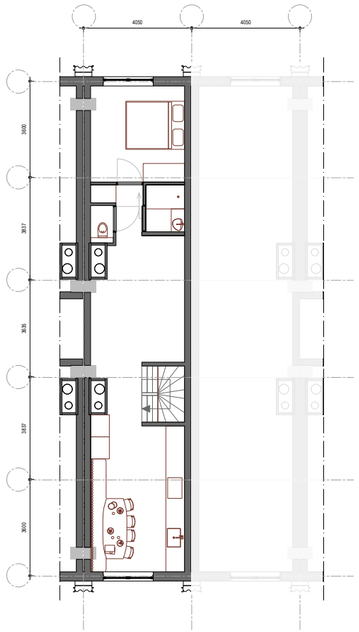


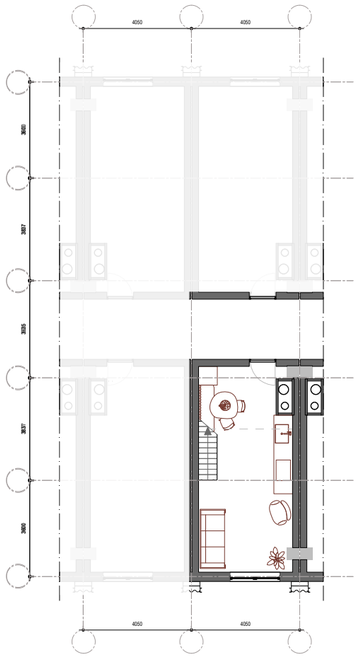
1,5 person appartment

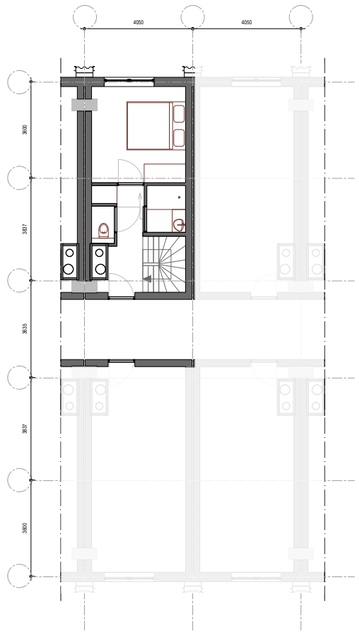


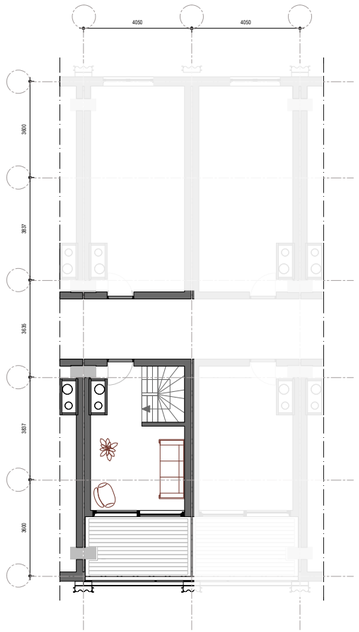


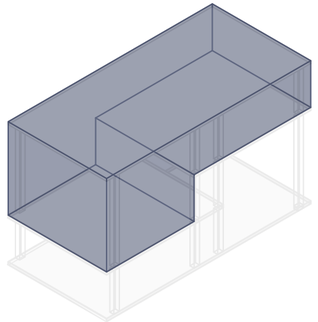
1,5 person appartment



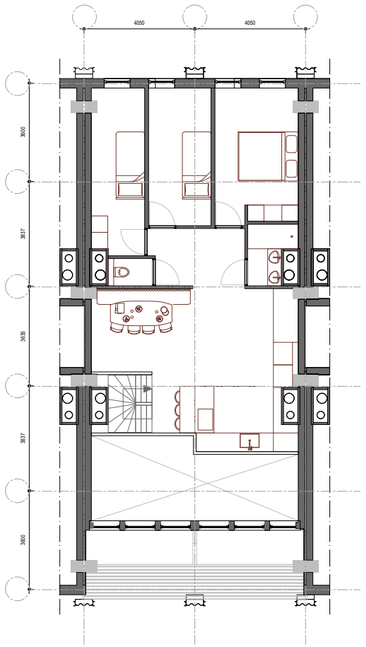


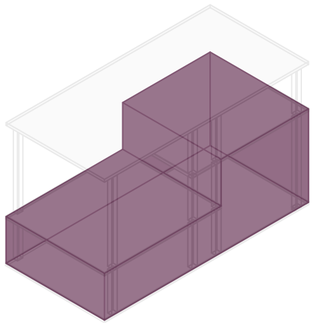






Family appartment





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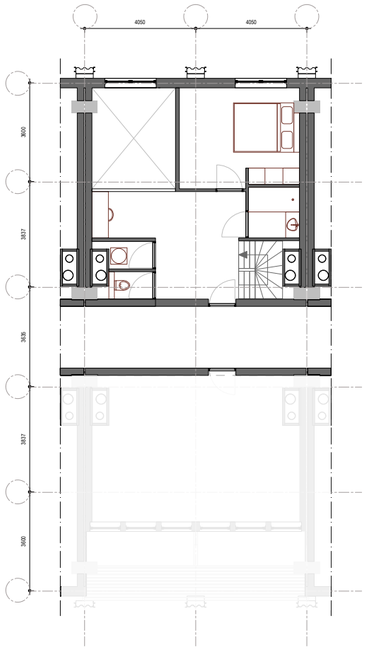

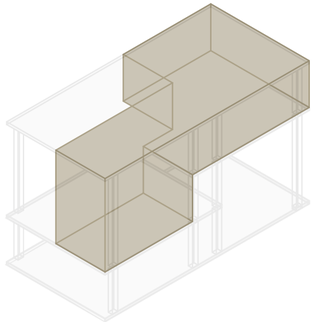

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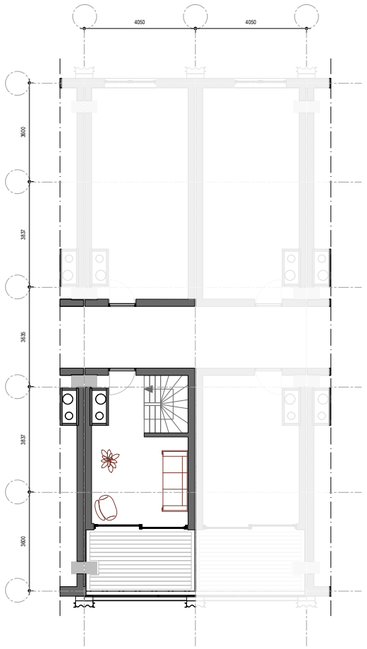
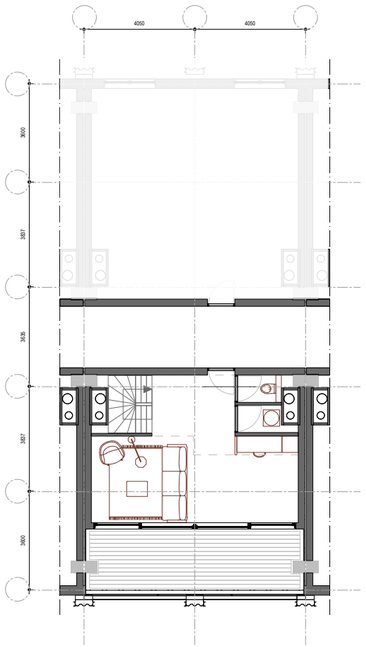
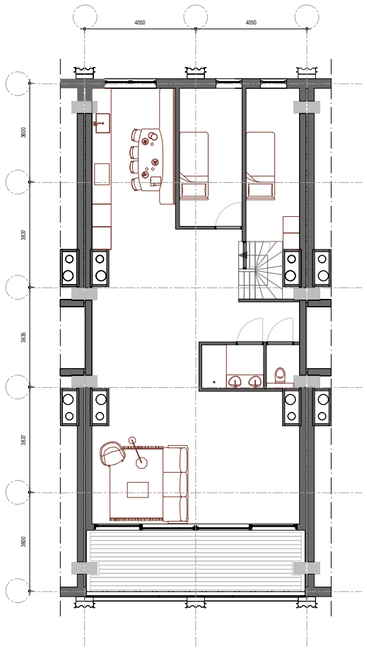
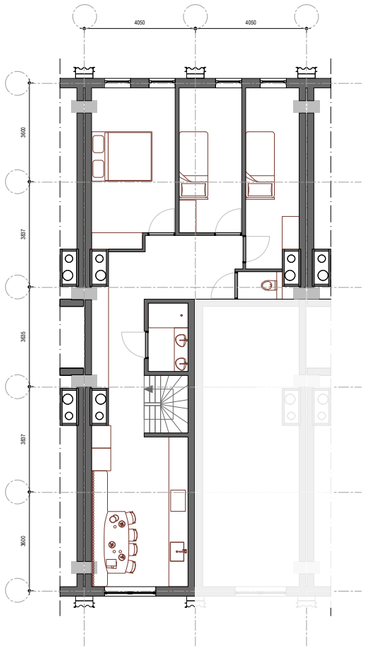
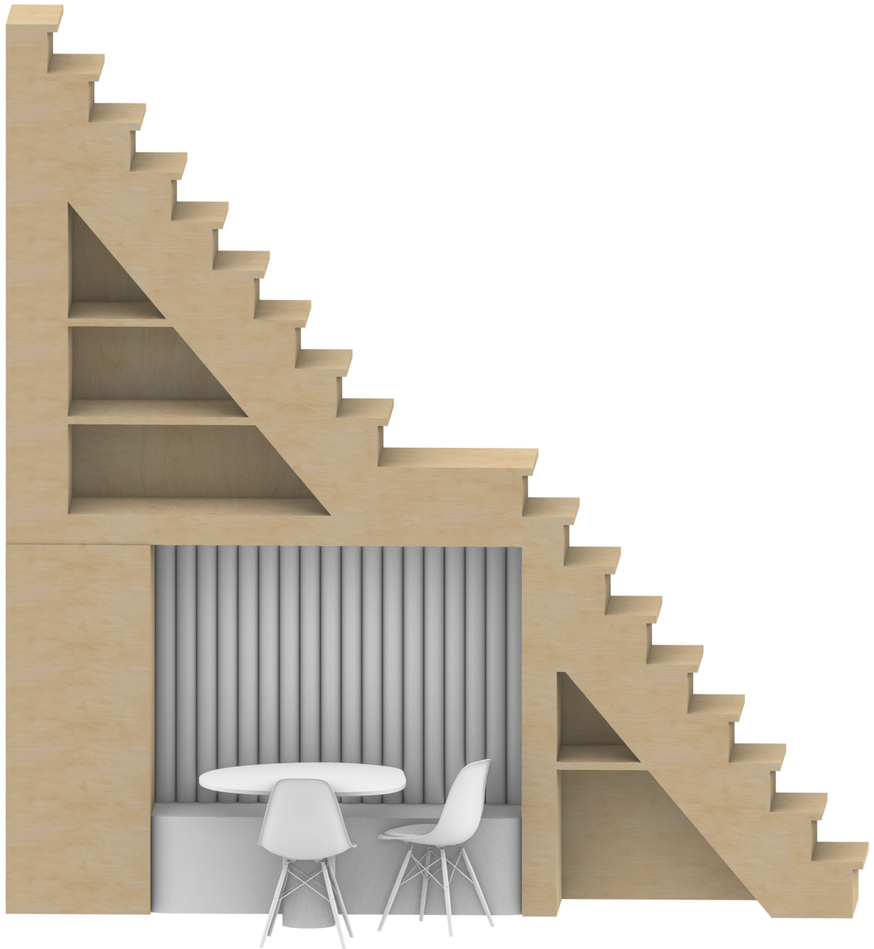
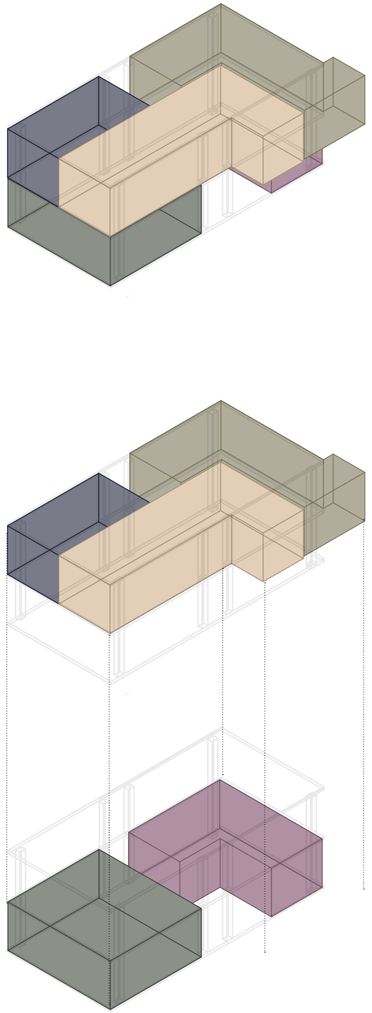


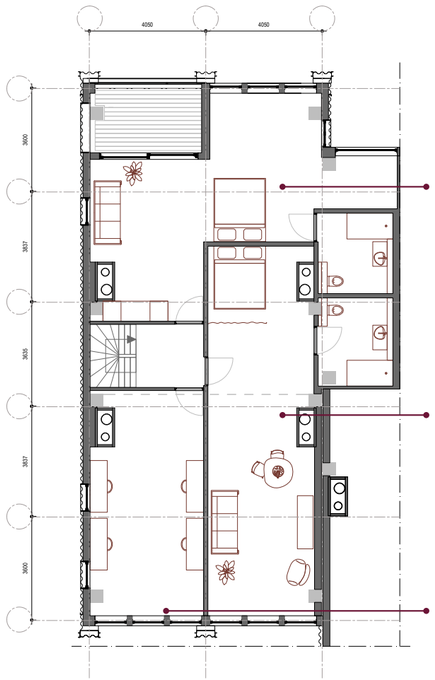








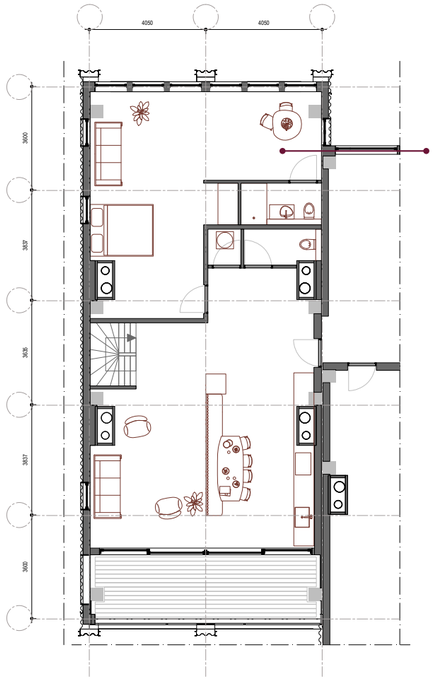




Sub-dwelling 1

Sub-dwelling 2

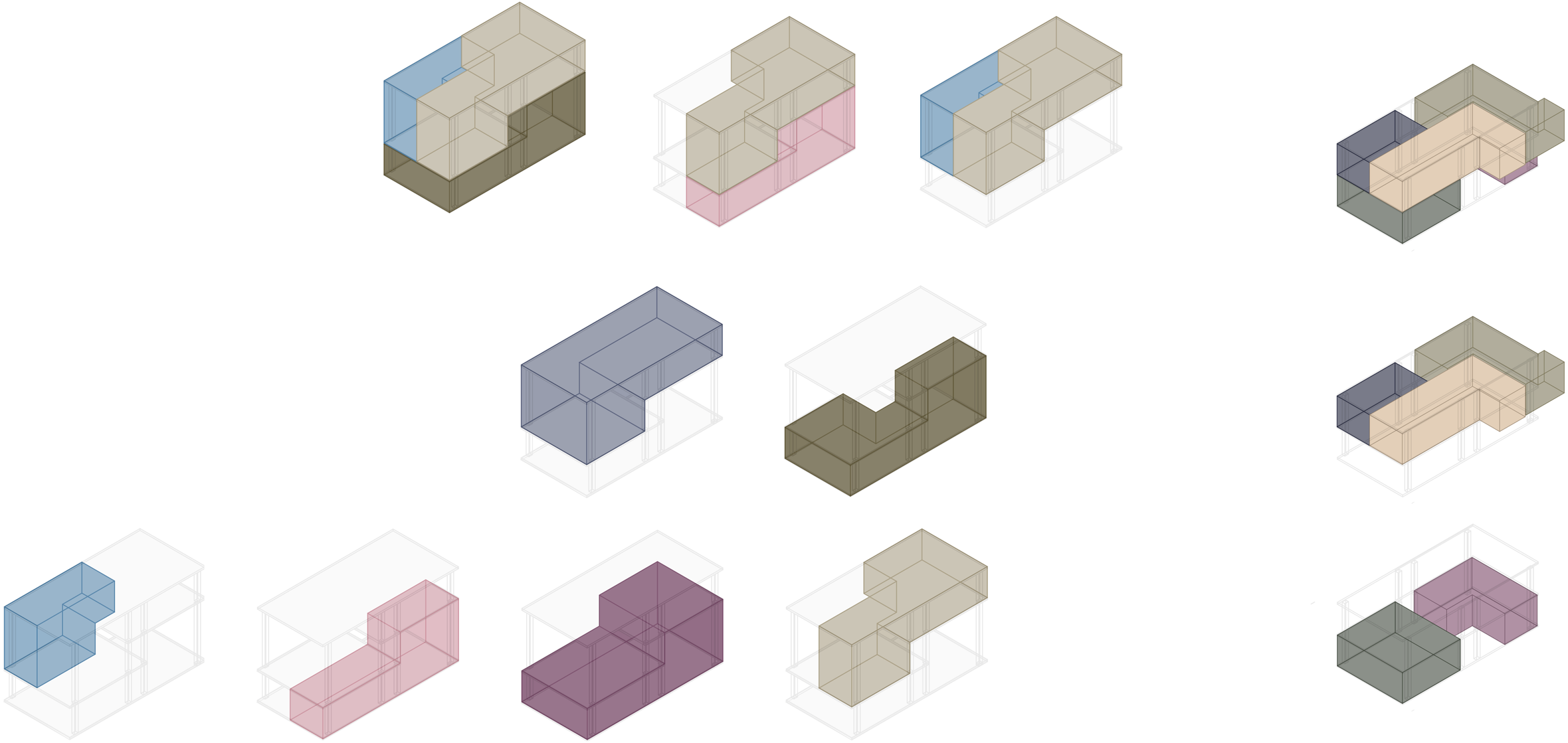
Office space

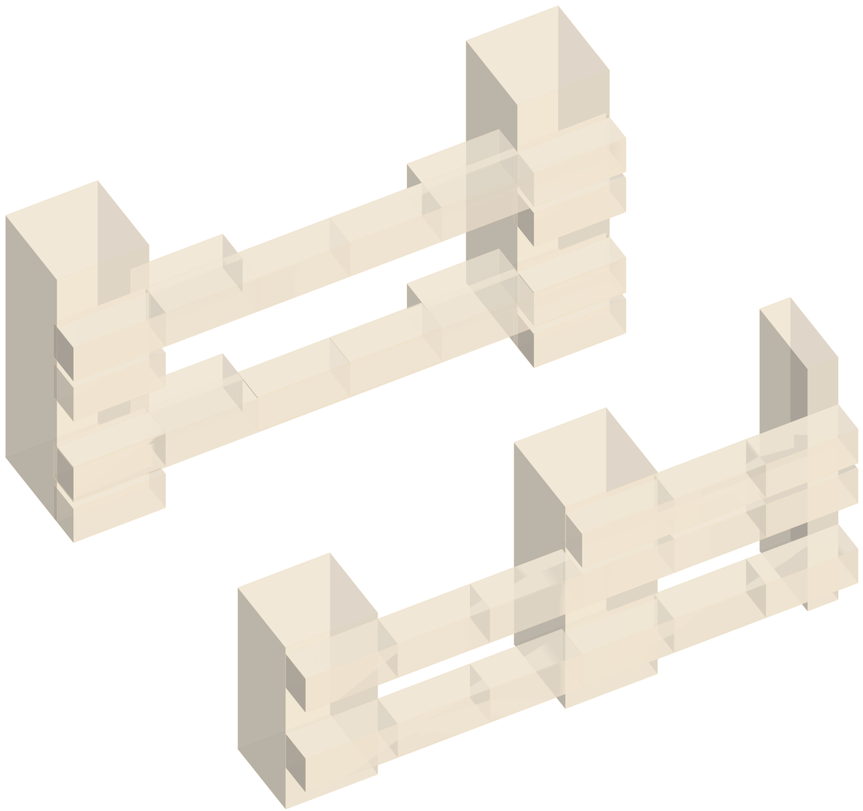


Sub-dwelling 3

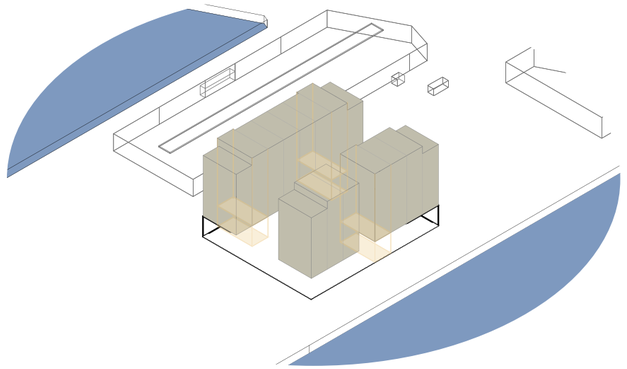
Livingroom

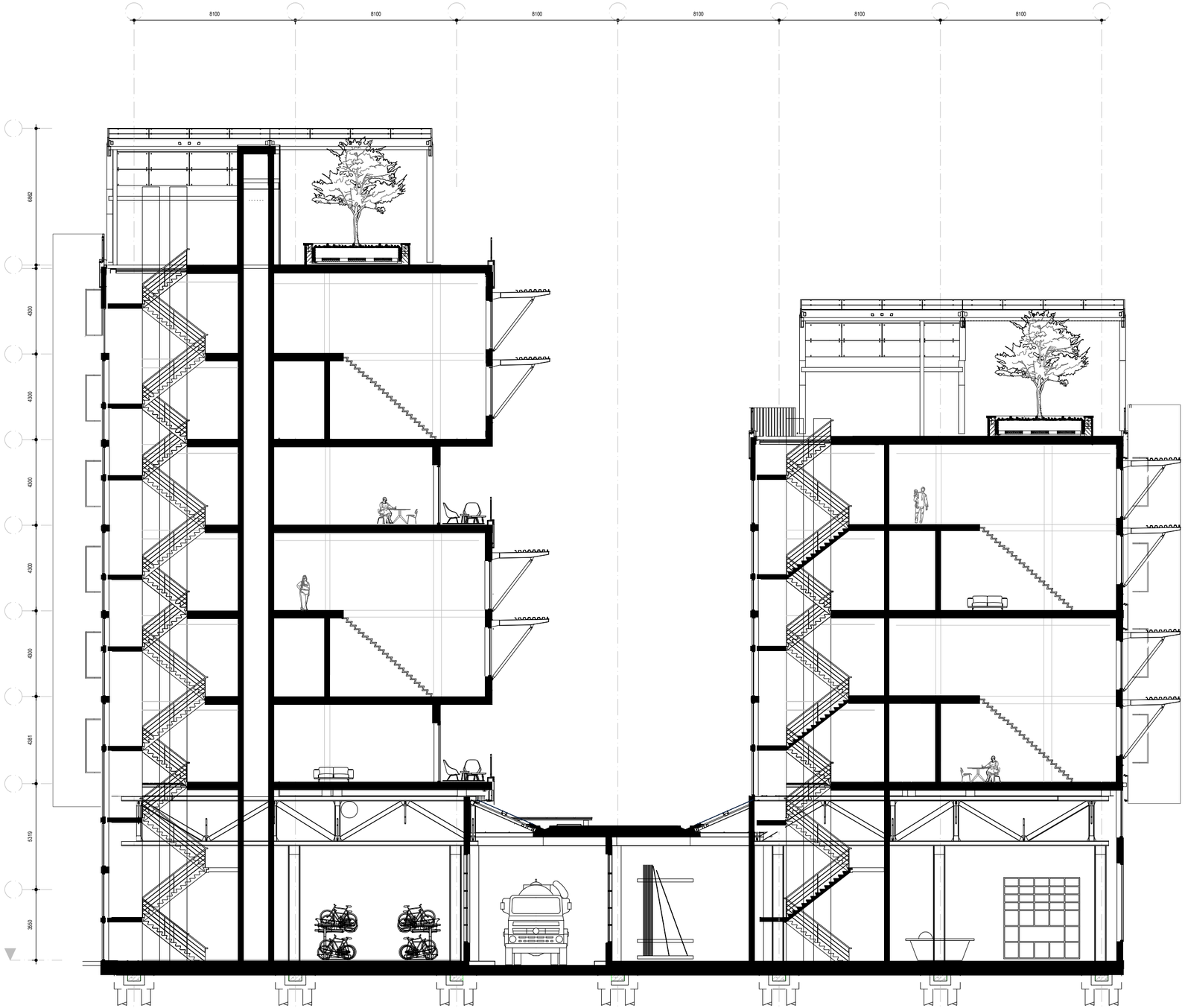
Flexibility



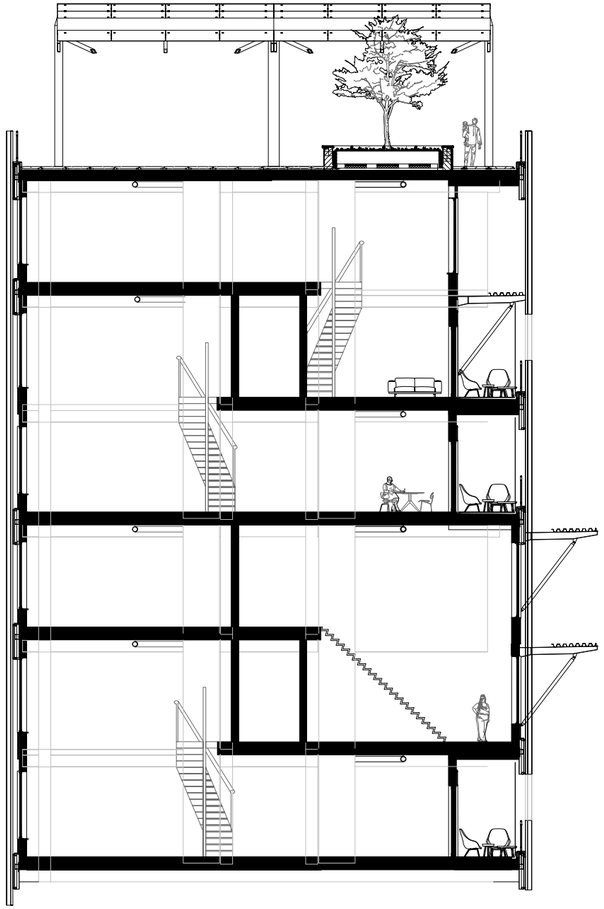


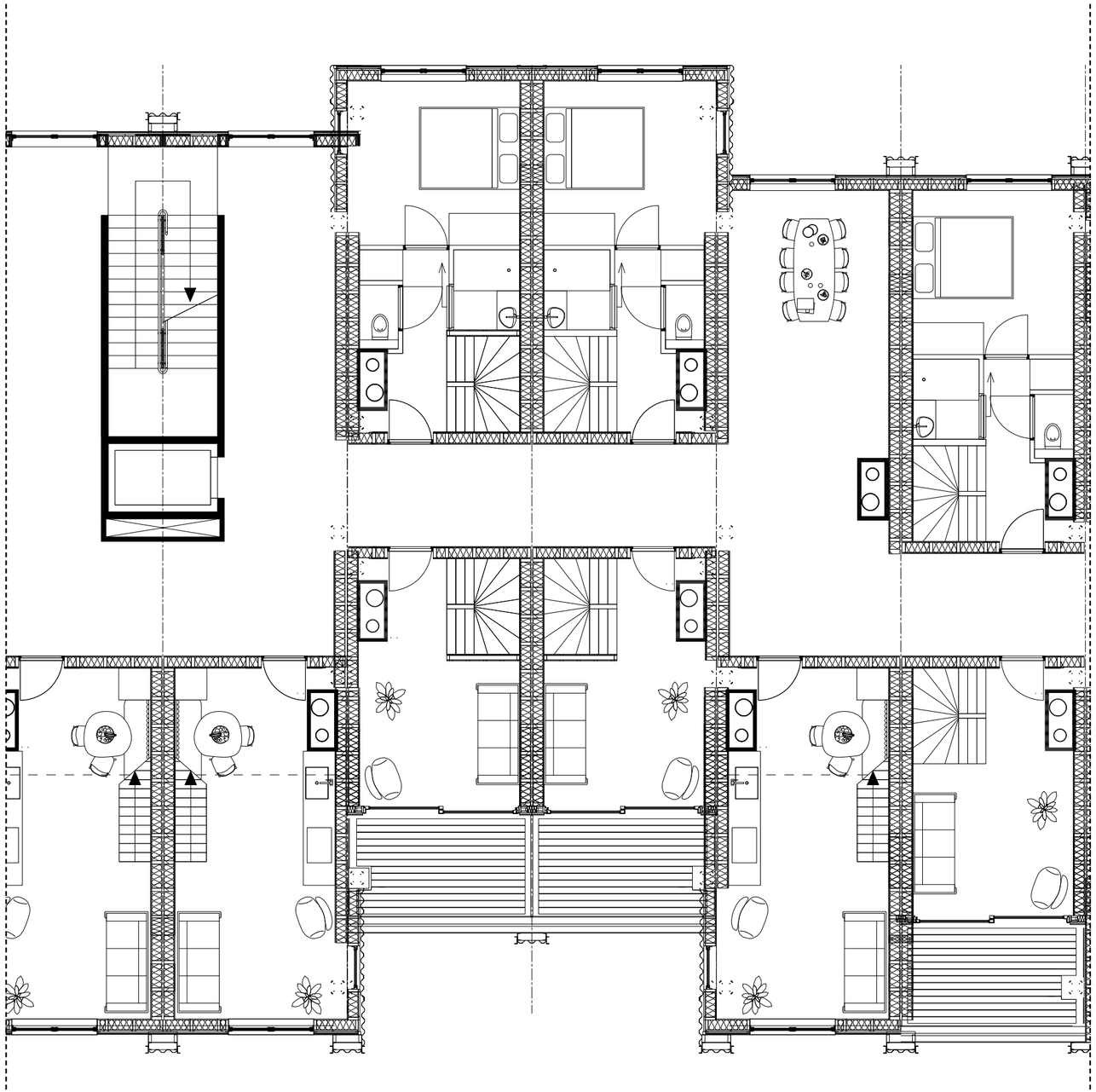
Circulation

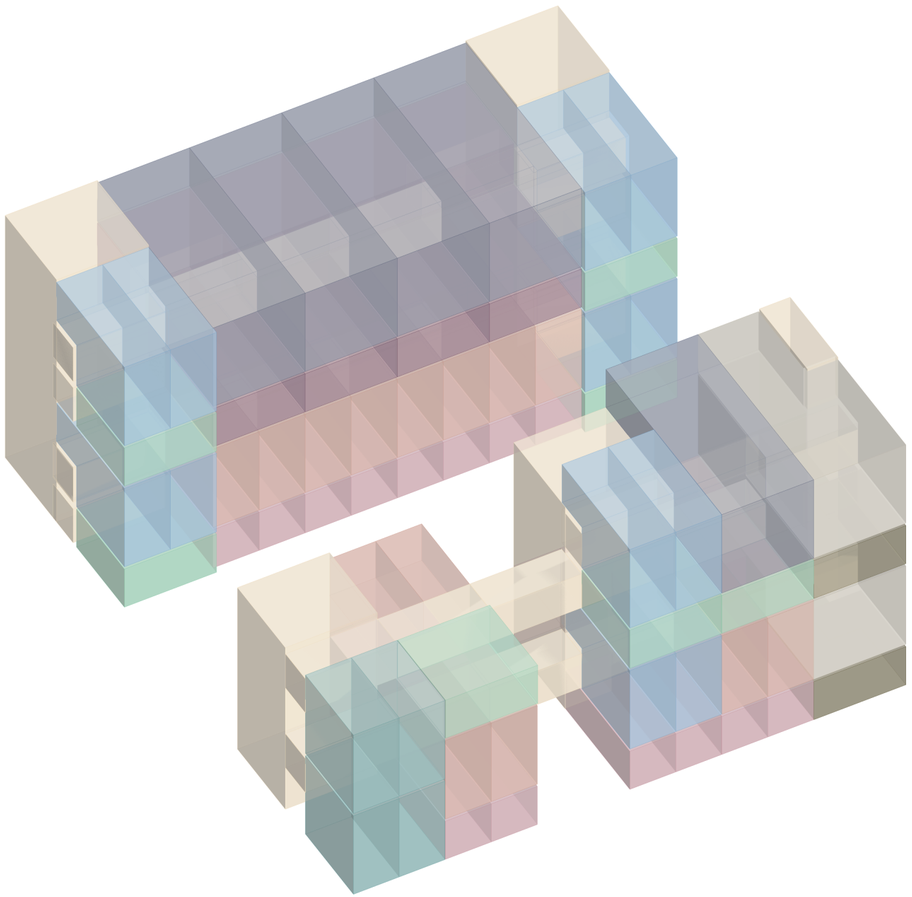


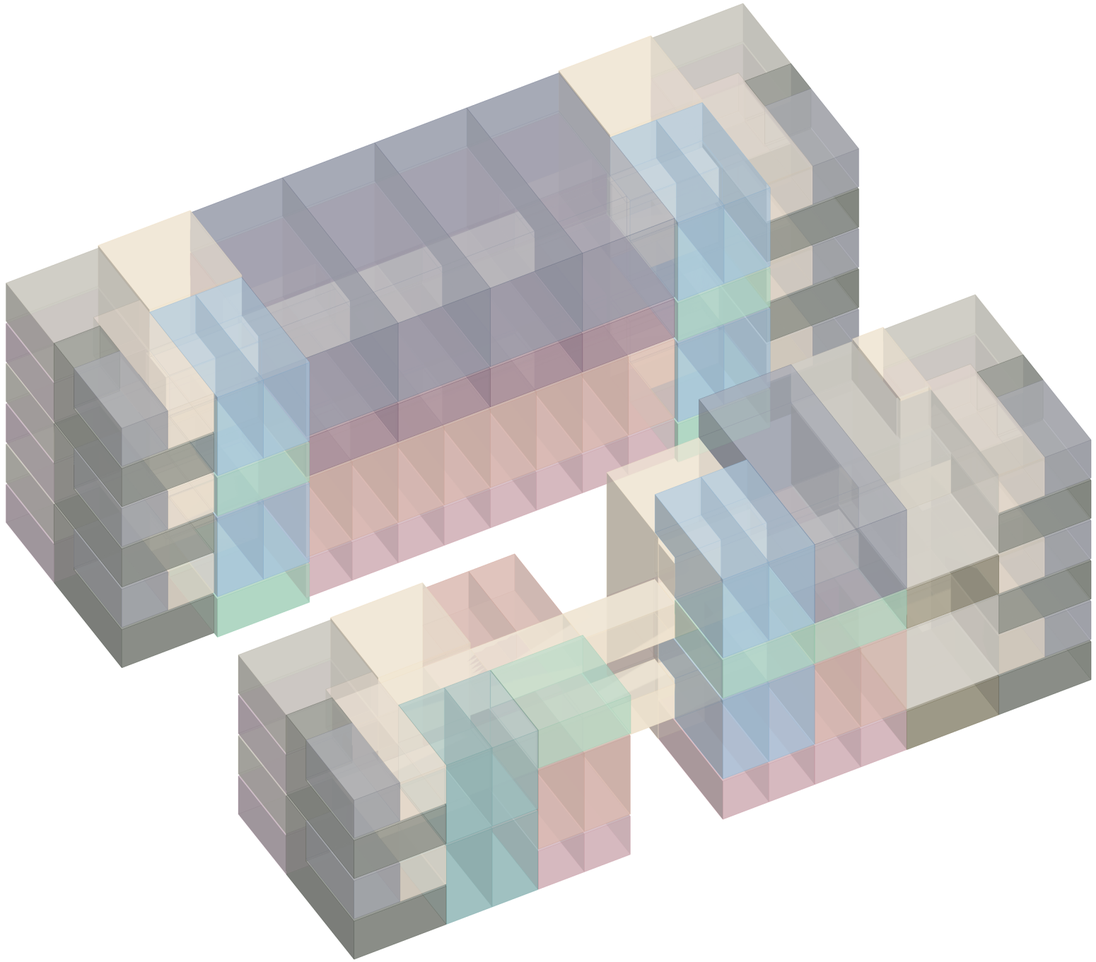


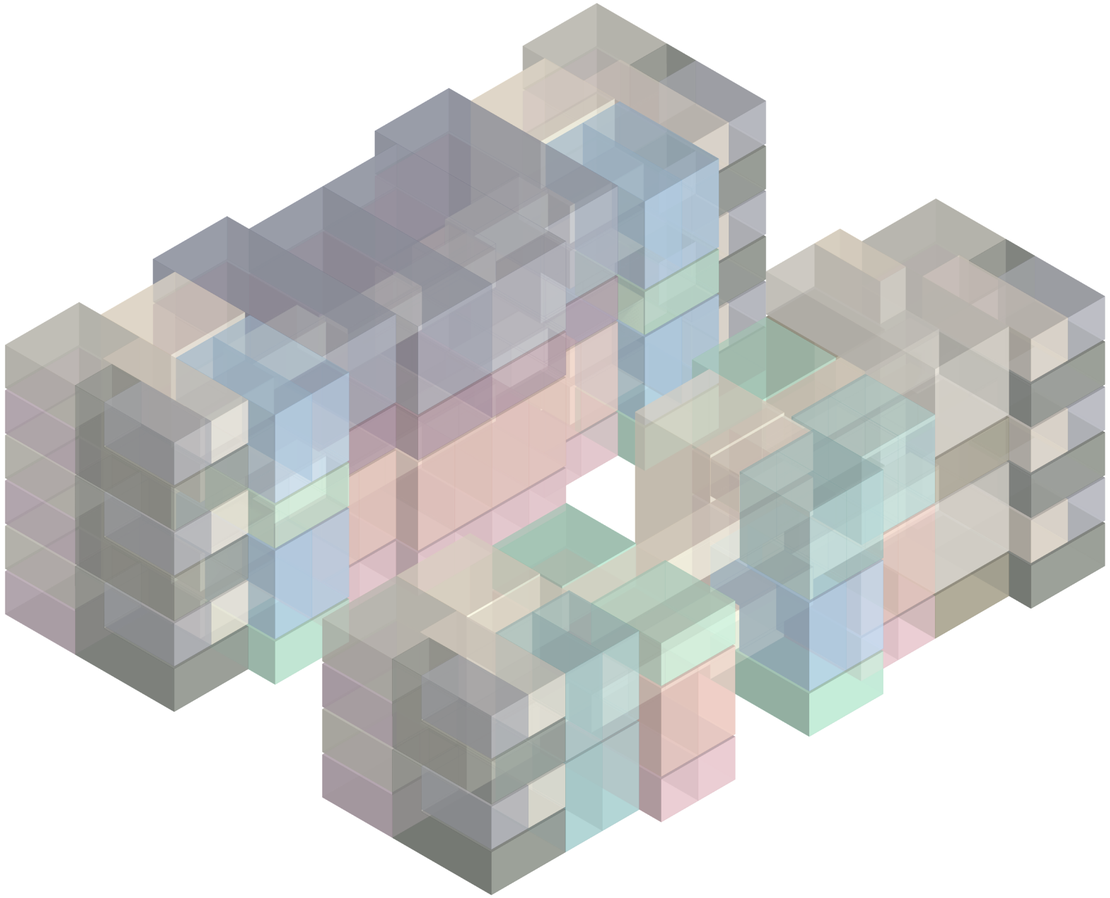
Circulation

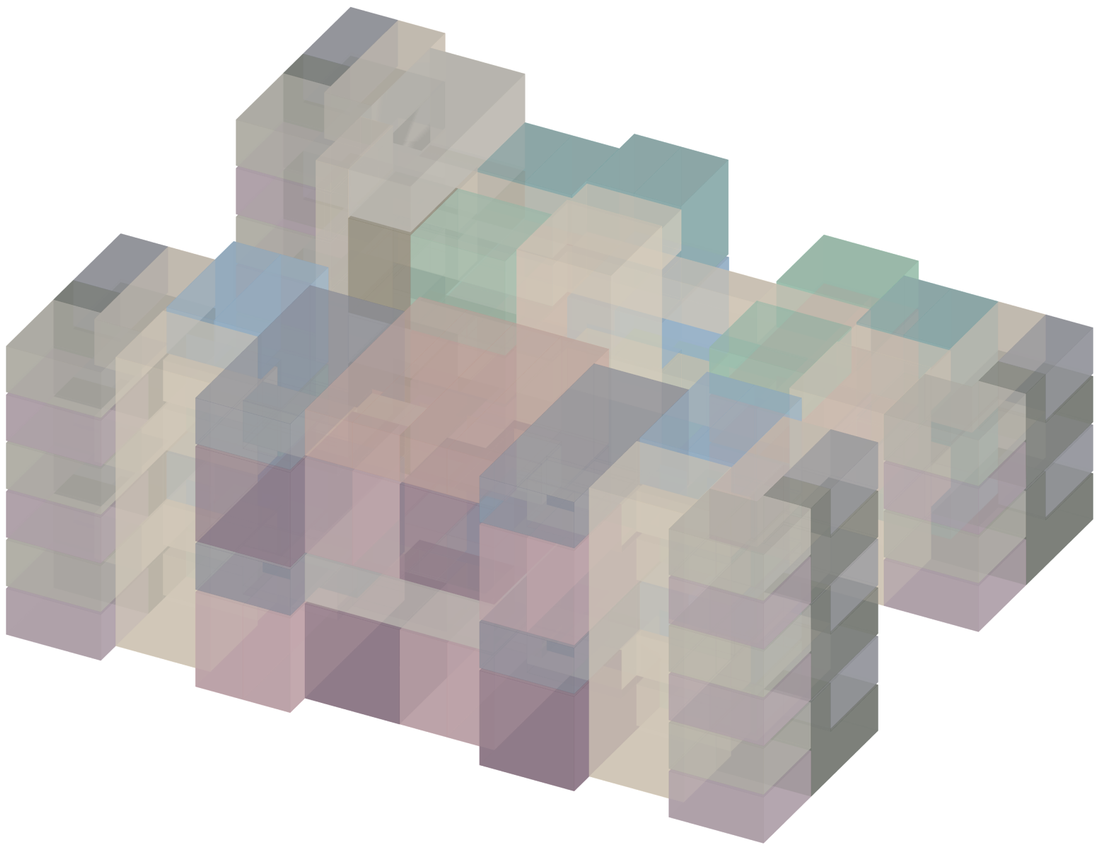




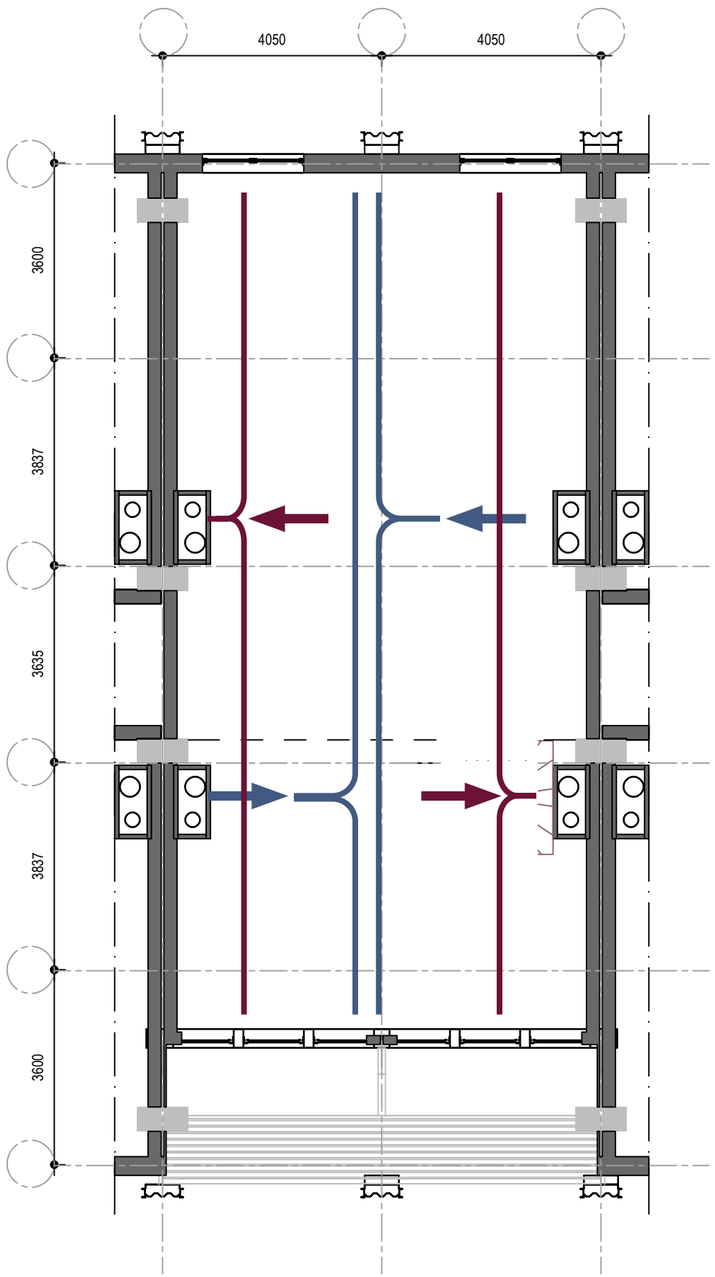






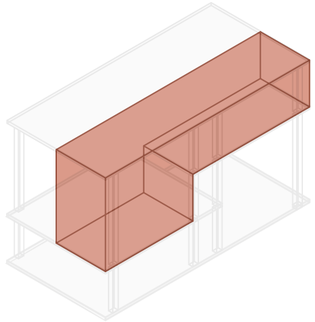


Shafts

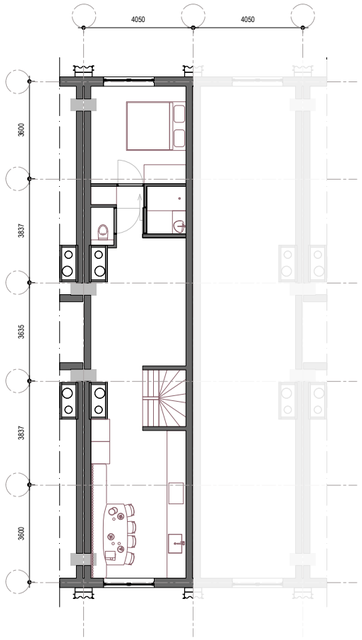


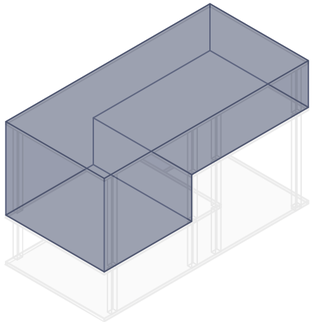
Climate regulation

	Winter	Autumn	Spring	Summer
Heating	Low temperature floor heating Extra heating by air (WTW)	Low temperature floor heating Extra heating by air (WTW)	Low temperature floor heating	
Cooling	-	-	Cooling by air (WTW)	Cooling with floorsystem Cooling by air (WTW)
Ventilation	Type D Mechanical Climate system with WTW central in climate room in plinth			
Sun shading	Inside dwellings as option to block the low sunrays (in for example offices)	Inside dwellings as option to block the low sunrays (in for example offices)	2 options: 1. Windows get a steel awning fixed to façade 2. façade is set back in loggia	2 options: 1. Windows get a steel awning fixed to façade 2. façade is set back in loggia
Energy efficienty	WTW system Pre-heated air by airduct in the ground Heat pump (on the water for the whole district)	Solar enery Heat pump (on the water for the whole district)	Solar energy	Solar energy

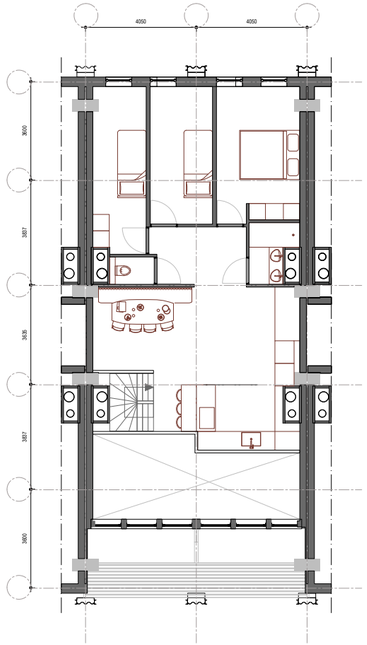


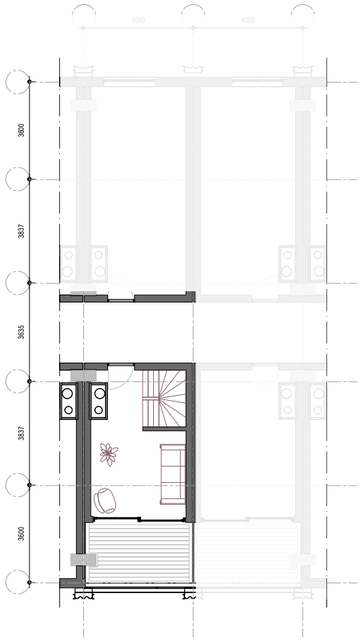
1,5 person appartment

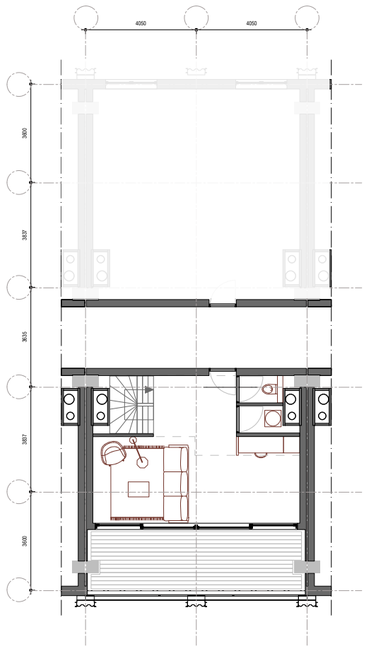




Family appartment

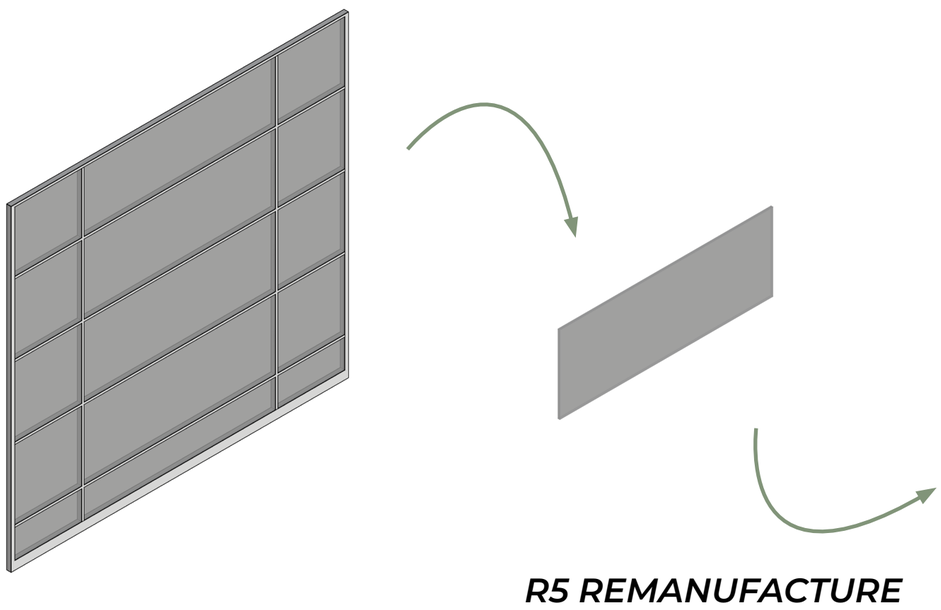


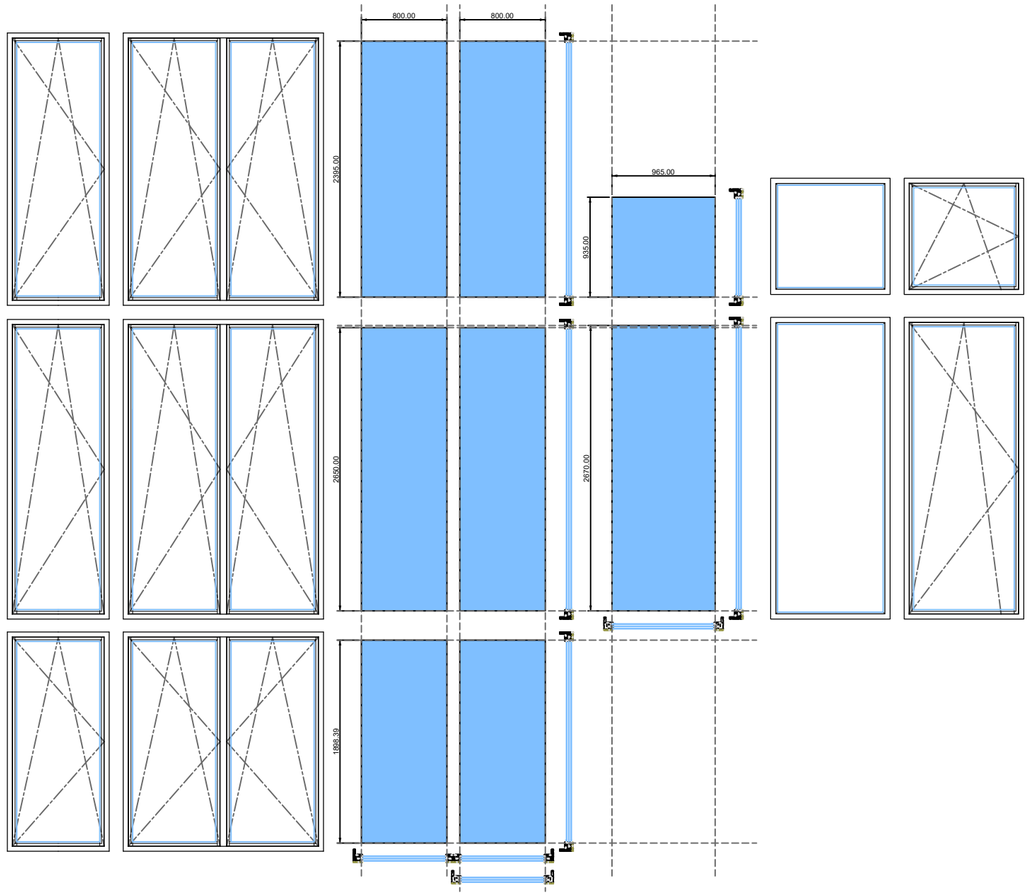




OTHER REUSE STRATEGIES

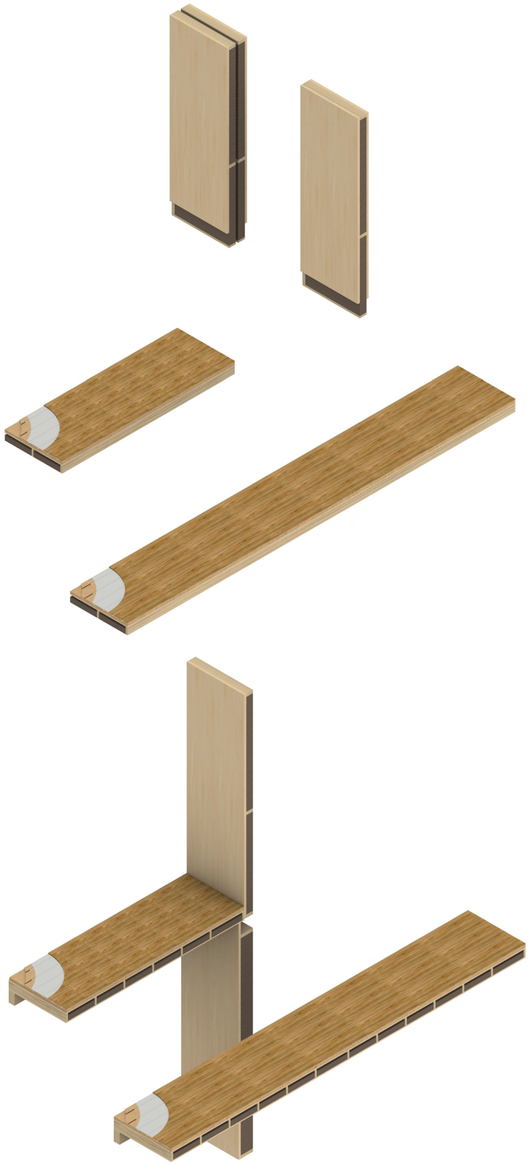
STEP 3:
INCREASE CIRCULARITY WITH DESIGN IN EARLY STAGE





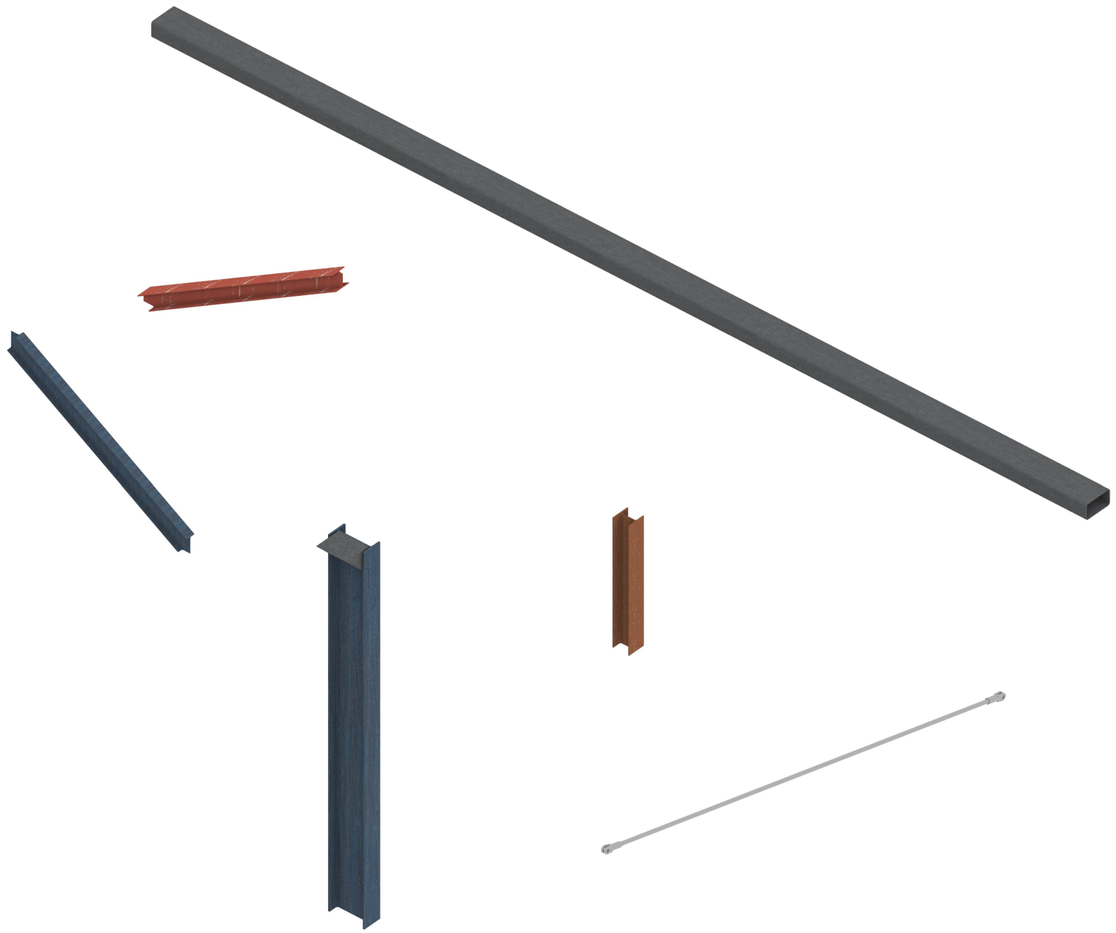
Biobased Materials

Standard dimensions
(600 or 1200 mm width)



+

Donor Steel



Fragment - Dwelling loft
scale 1:40

Fragment - Dwelling loft
scale 1:40

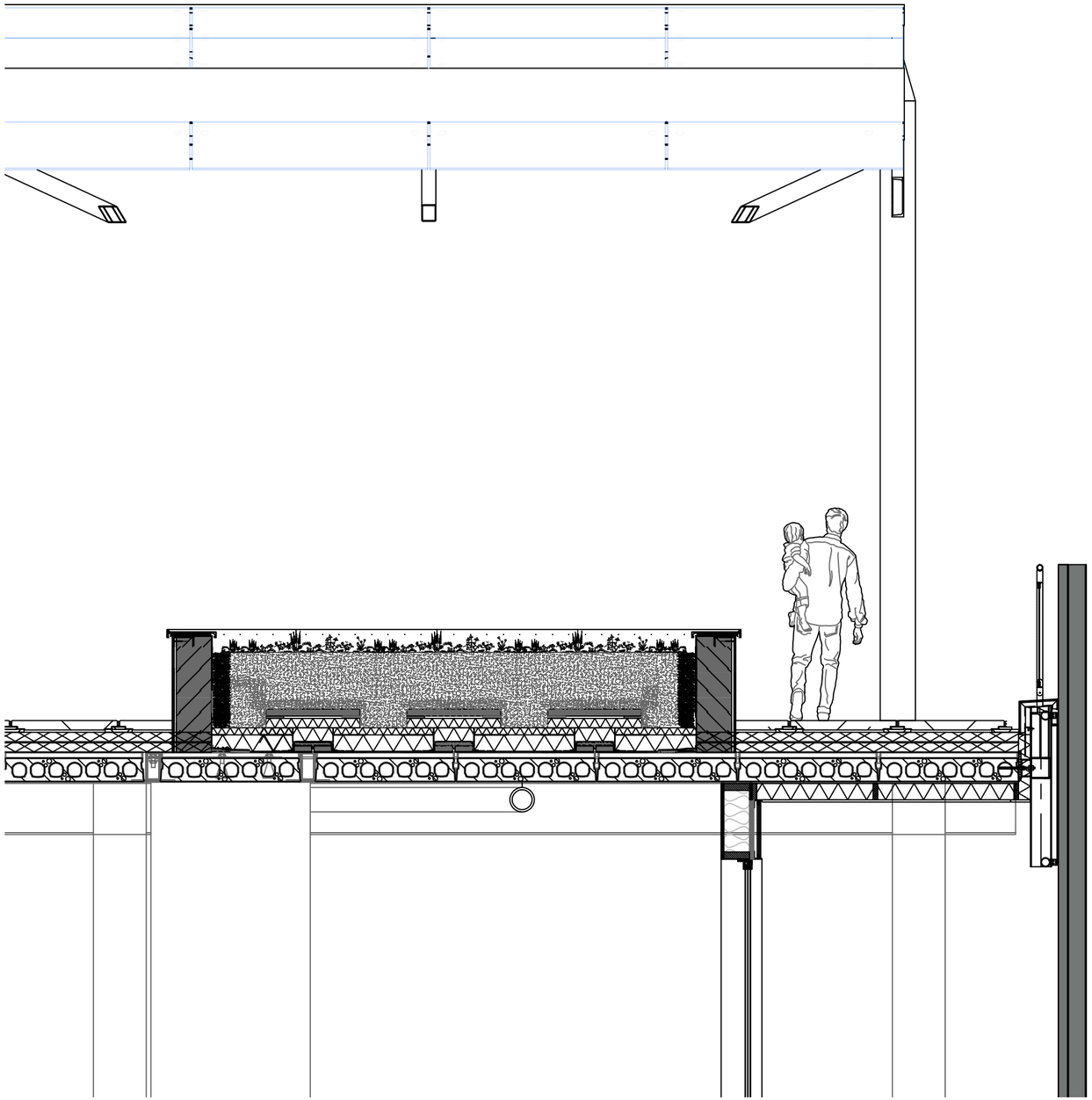
Roof garden

Facade dwellings

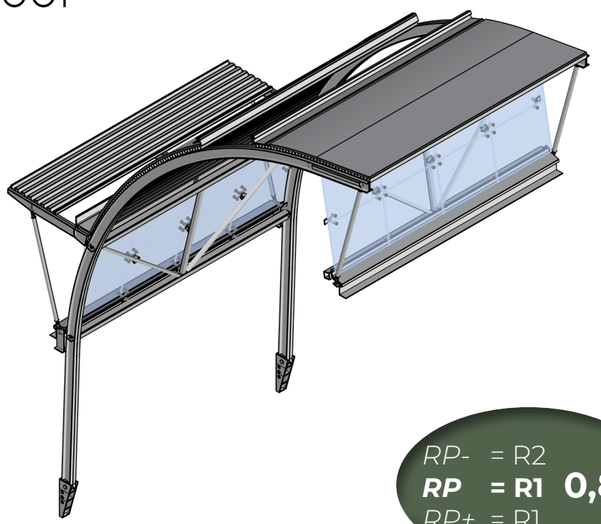
Circulation

“Super plinth” concept

Urban configurations



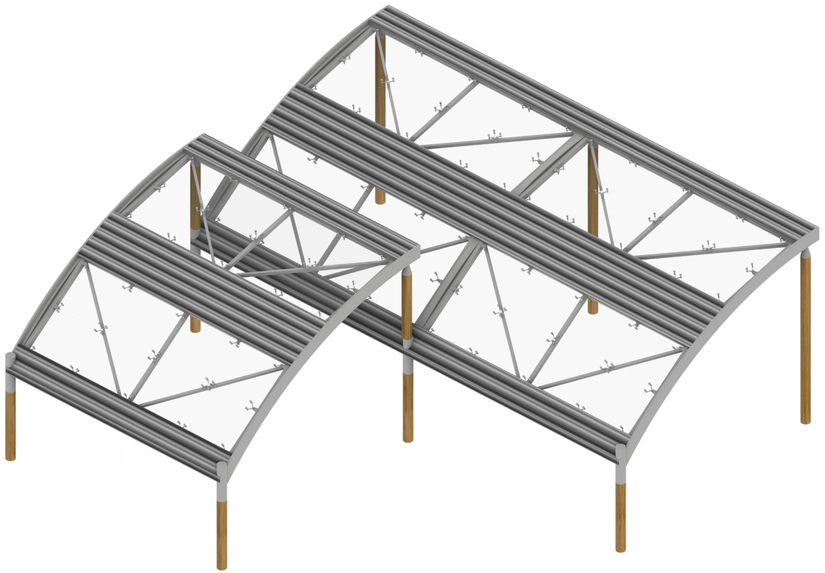
Roof

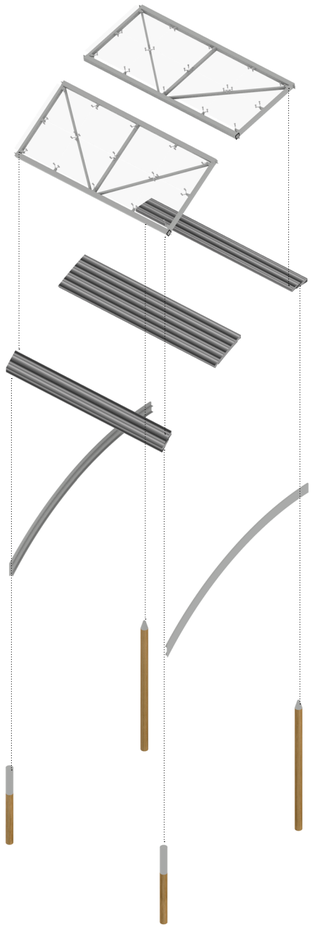


RP- = R2
RP = R1 0,83
RP+ = R1

DP Low

R3 REPURPOSE

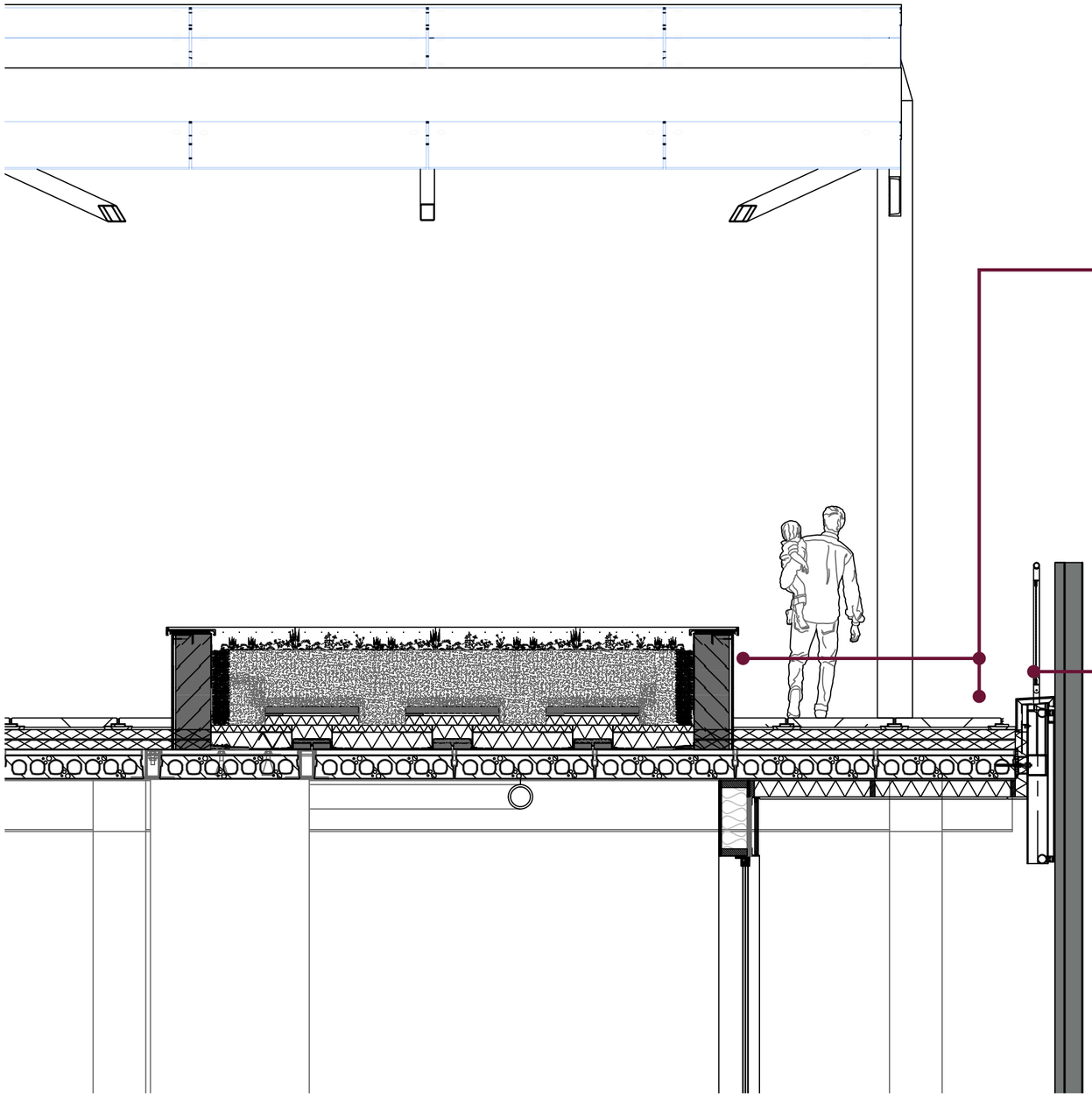




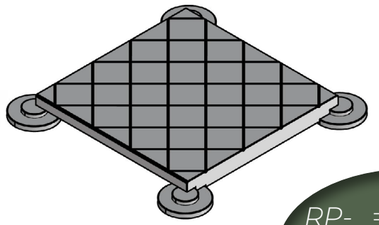
Space for solar panels

Creating covered outdoor spaces

Urban vegetable garden on roof



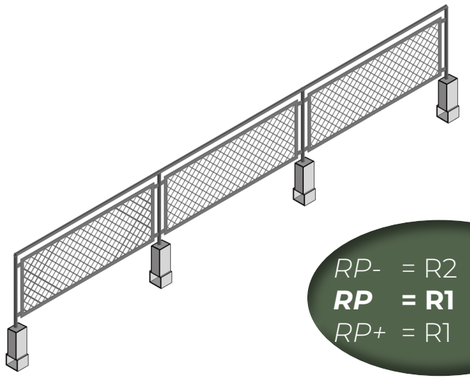
Tiles + tensioning elements



RP- = R2
RP **= R1** **0,97**
RP+ = R1

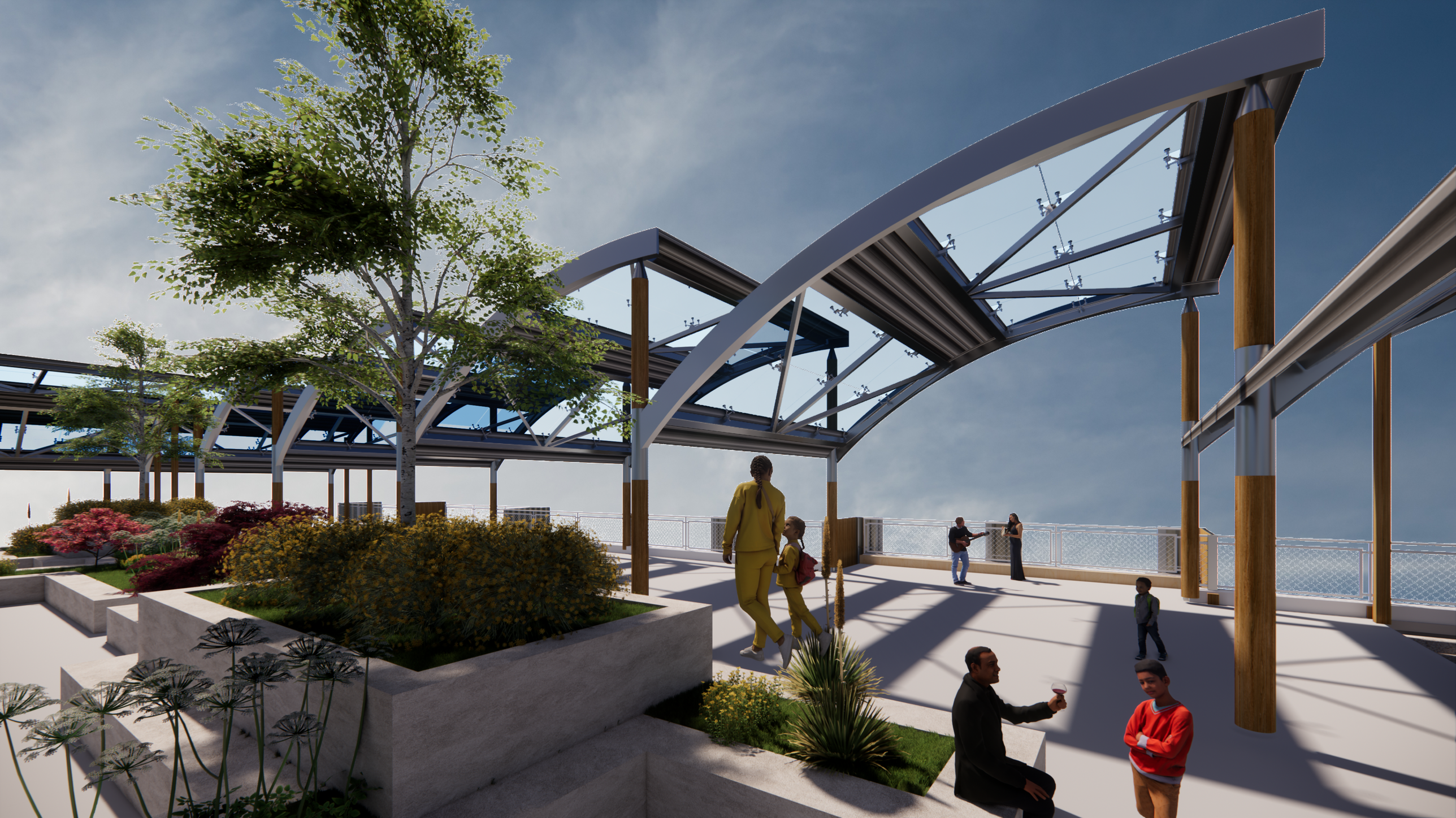
DP High

Roof fence

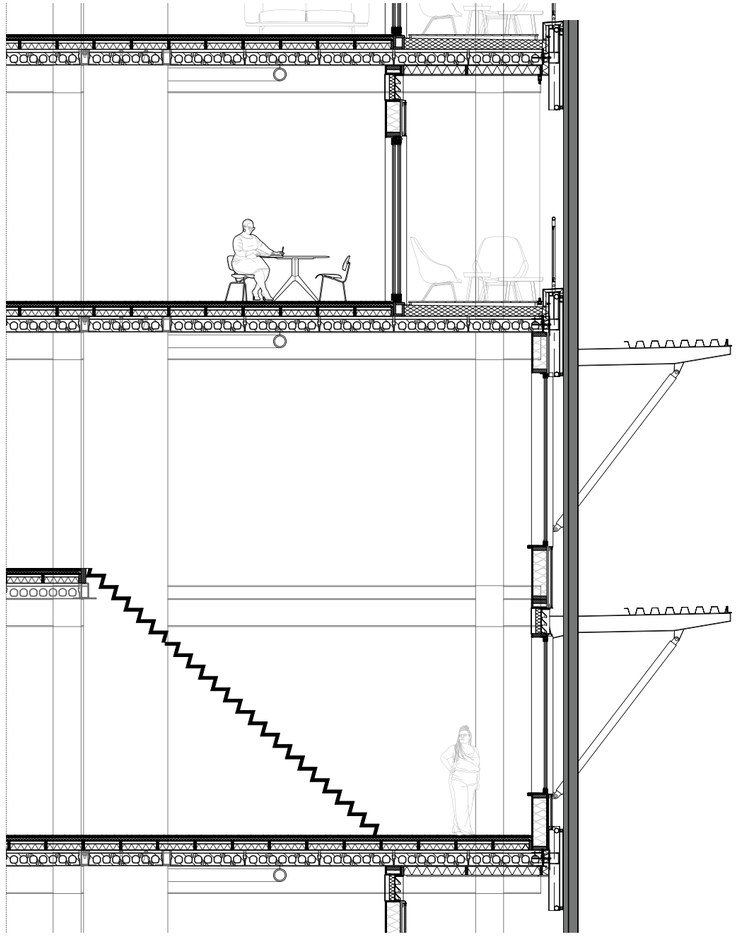


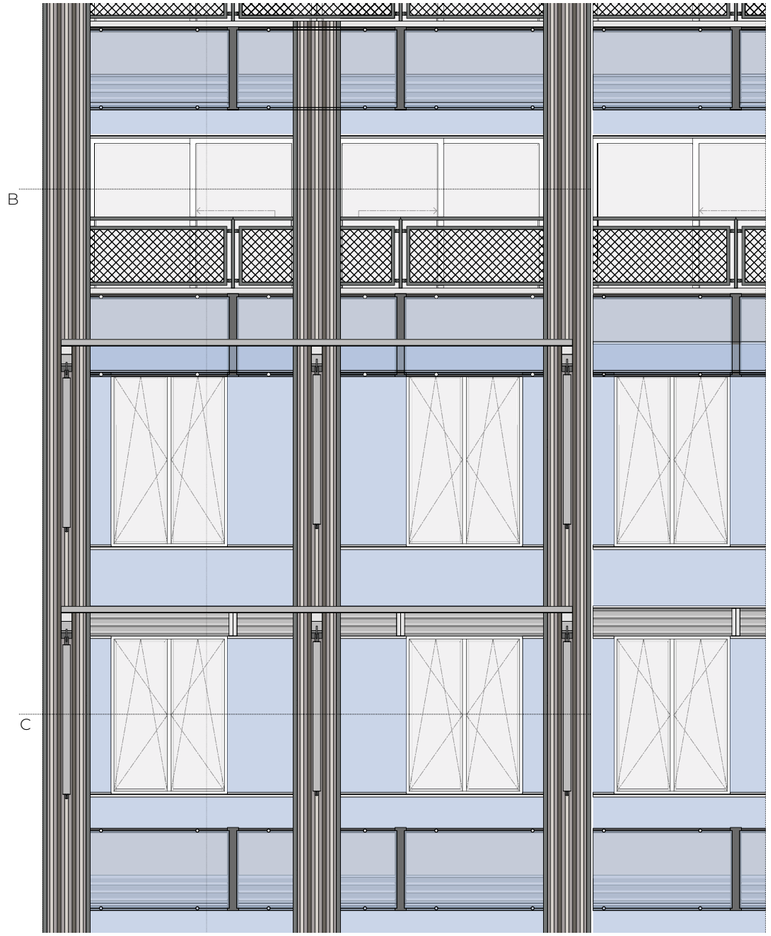
RP- = R2
RP **= R1** **0,97**
RP+ = R1

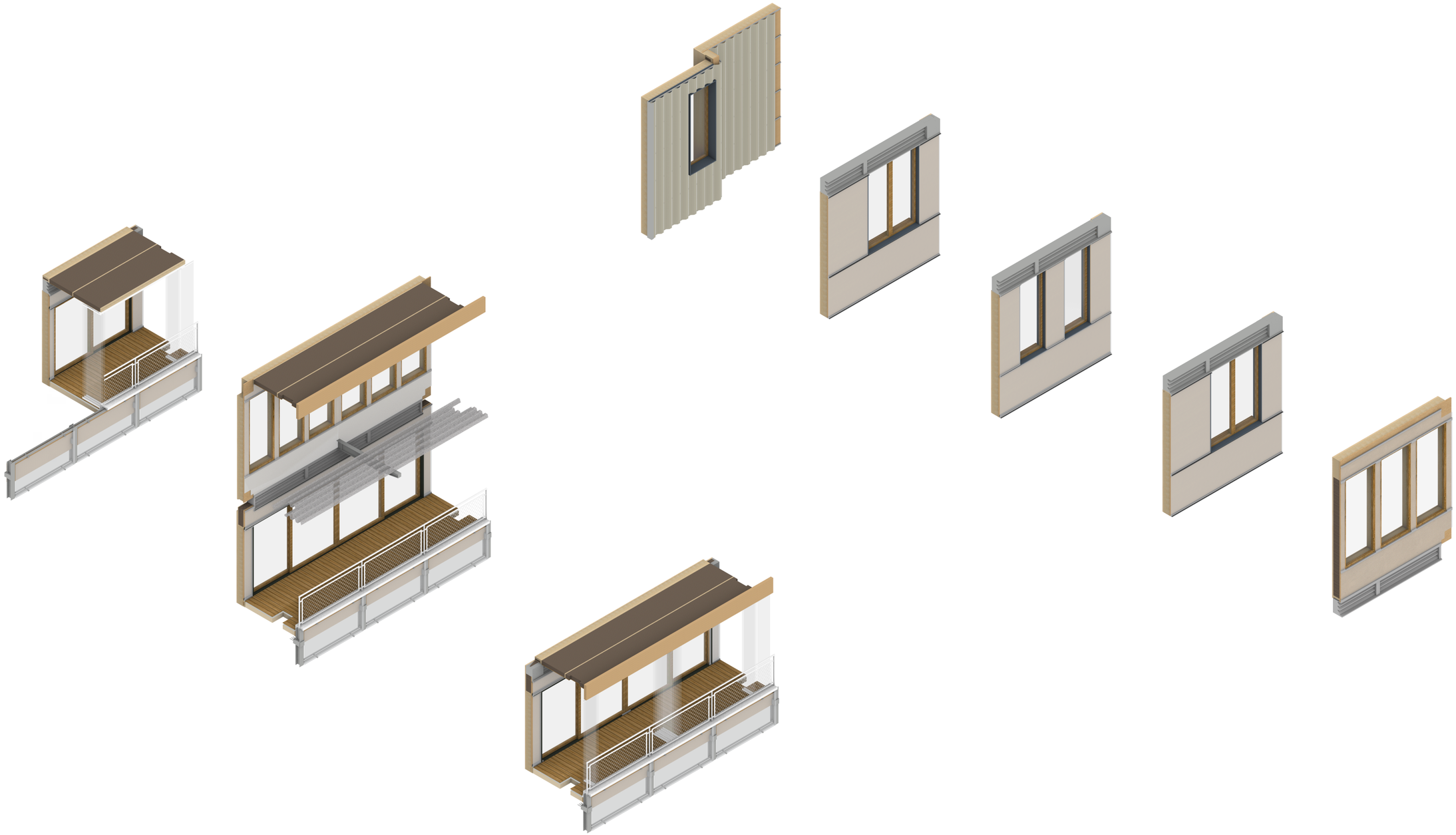
DP Medium

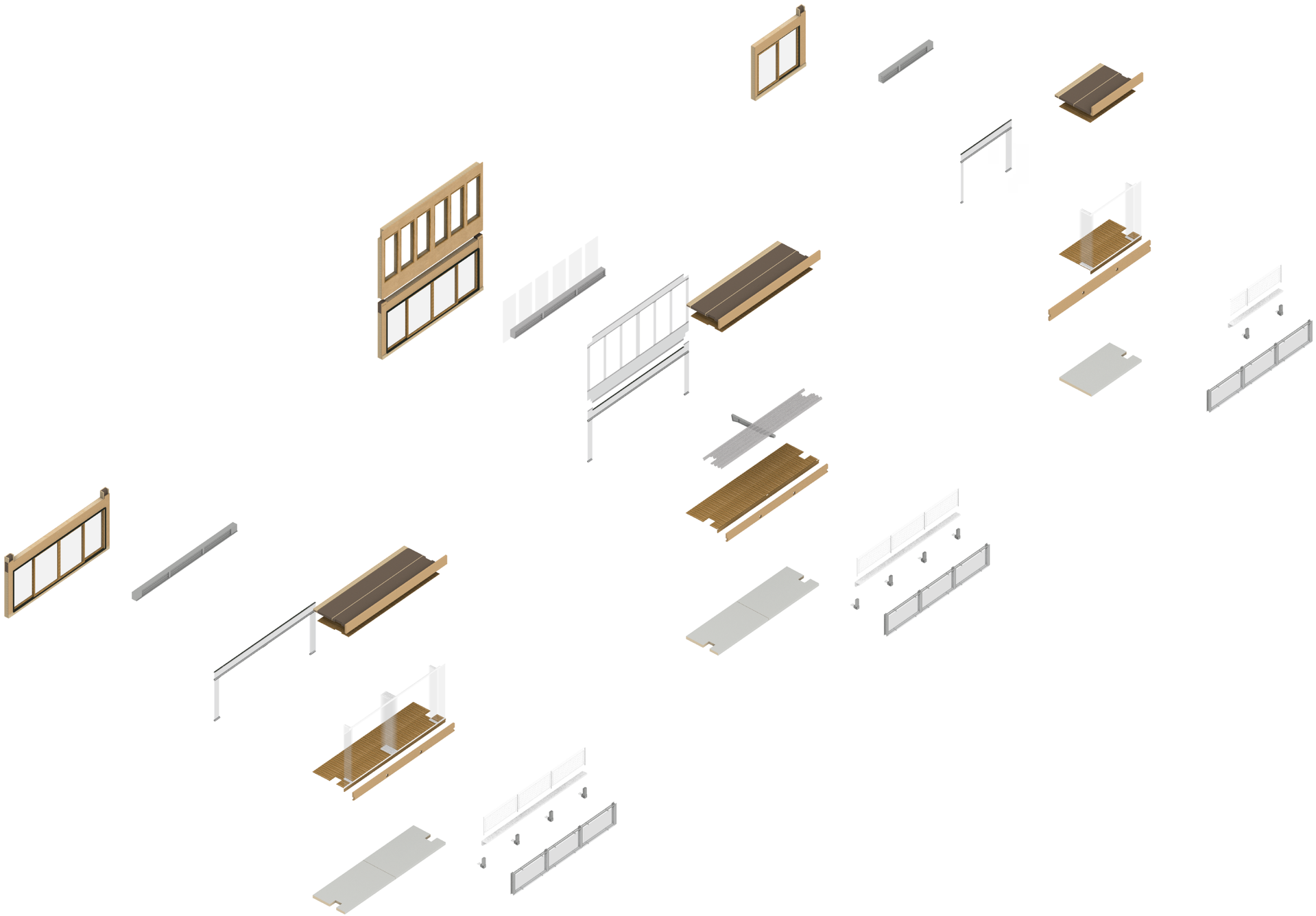


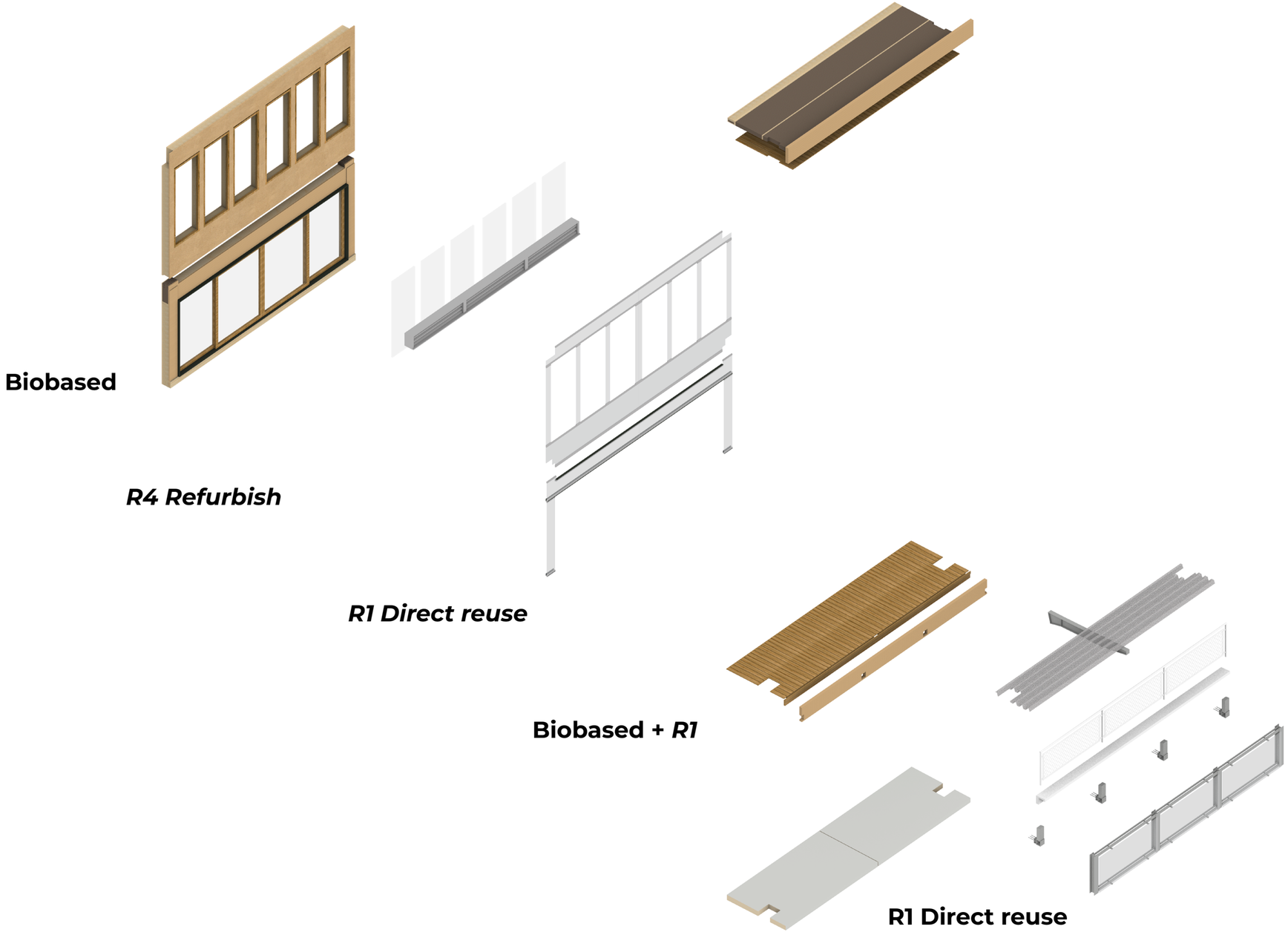
Facade dwellings










Biobased
R4 Refurbish
R1 Direct reuse
Biobased + R1
R1 Direct reuse


8100
8100
8100
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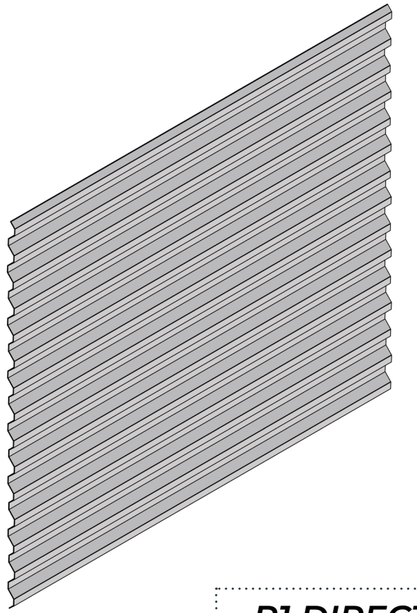
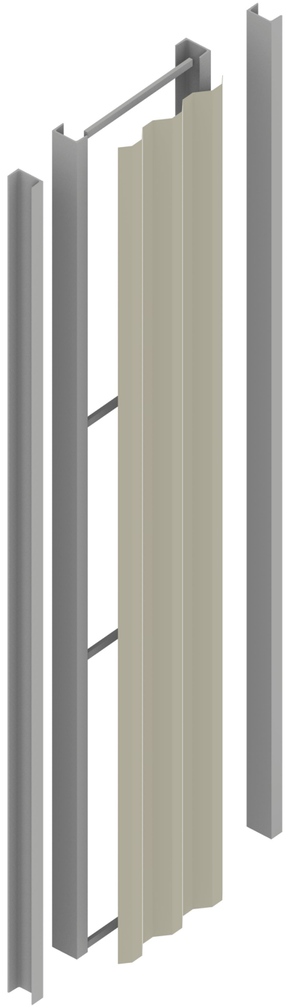
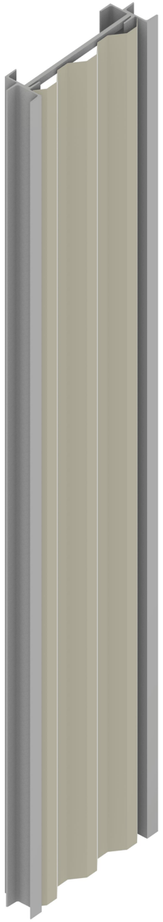
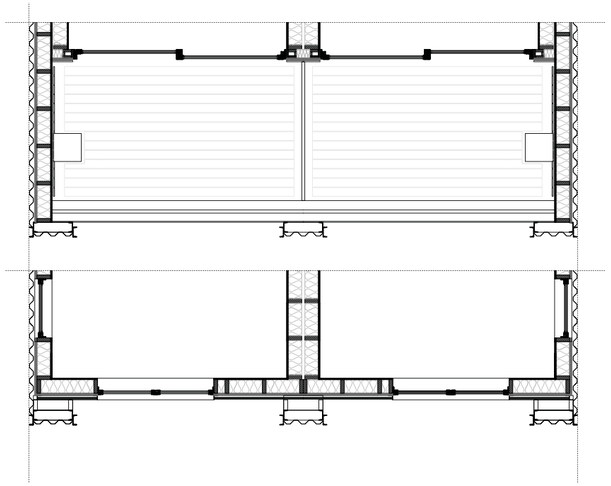
8100
8100
6862
4300
4300
4300
4300
4300
4381
5319
3550

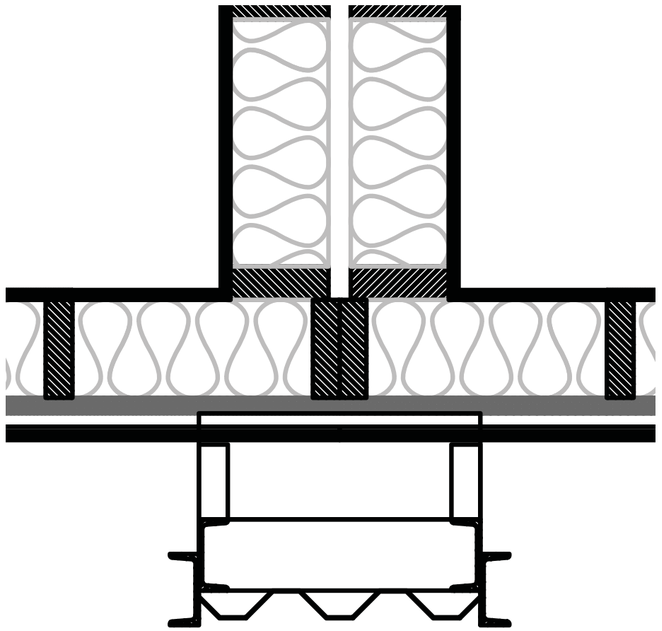


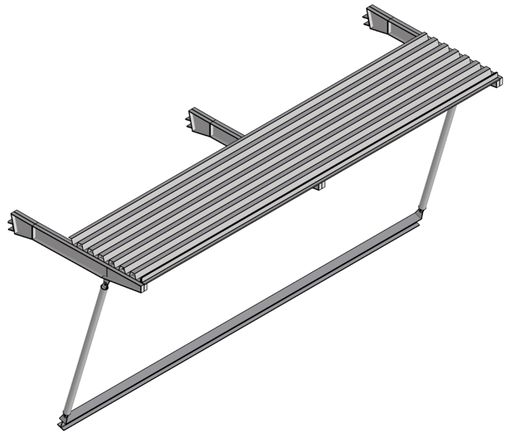
R1 DIRECT REUSE



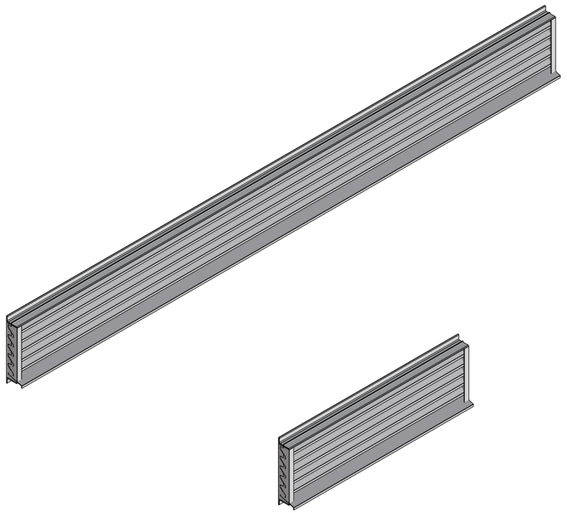








R1 DIRECT REUSE



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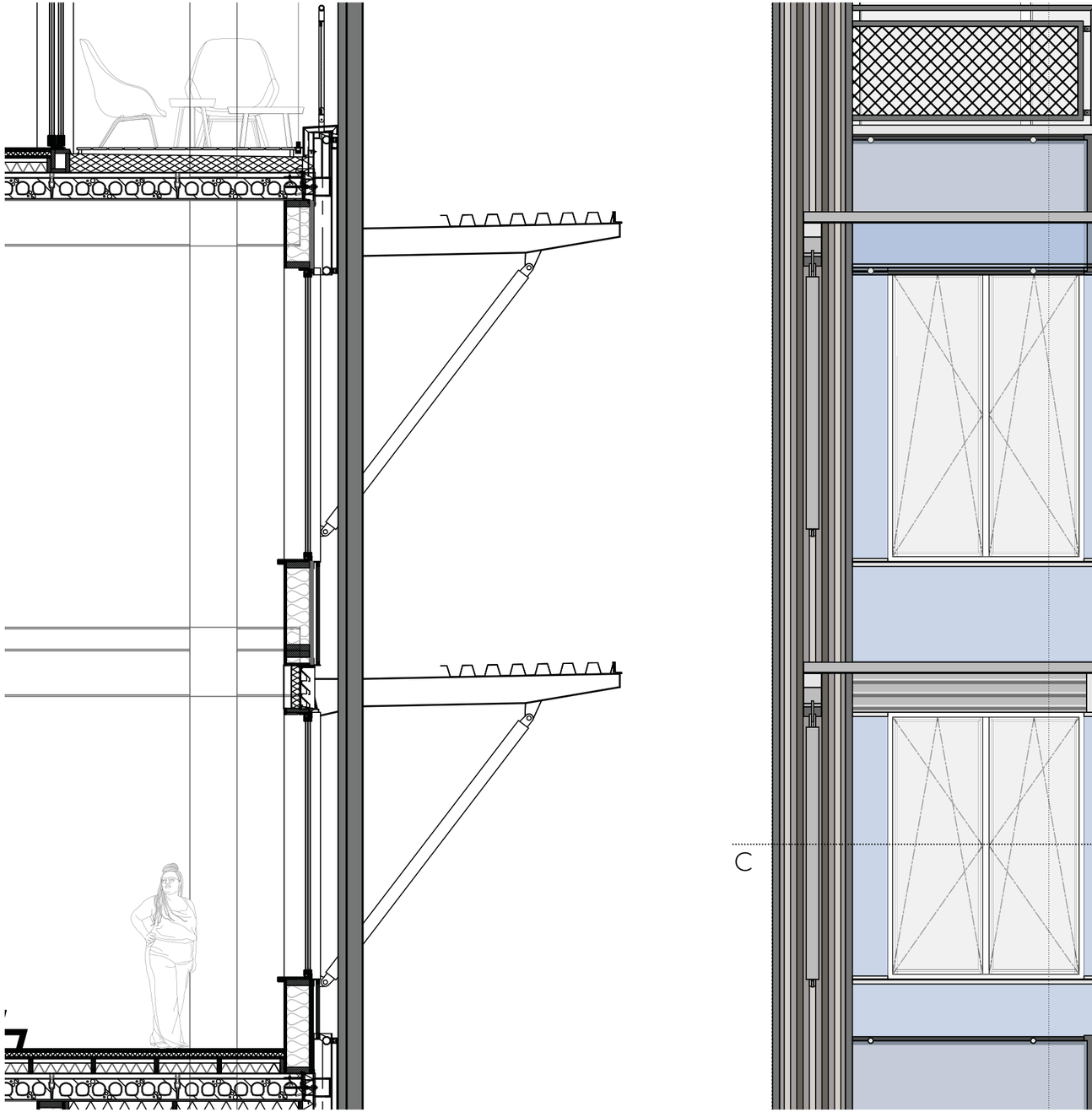

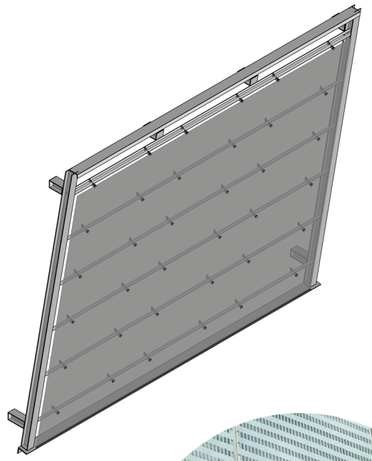

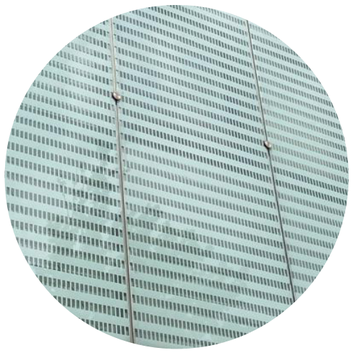

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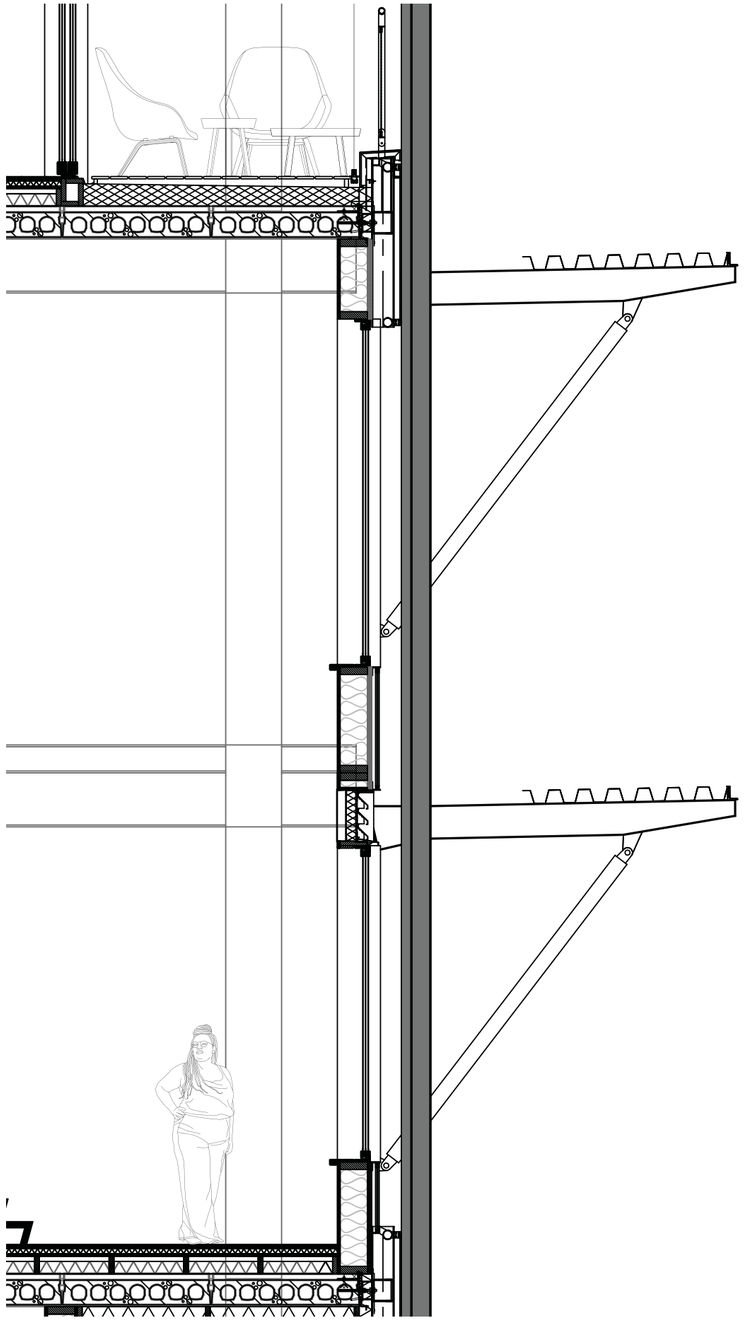
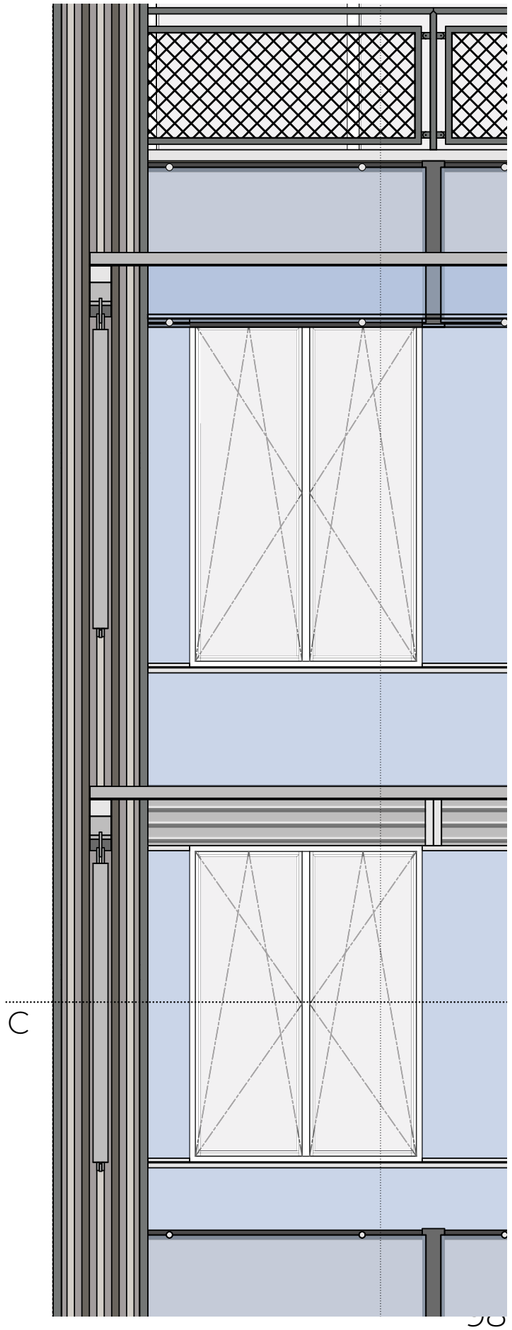
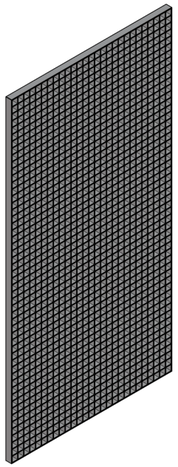
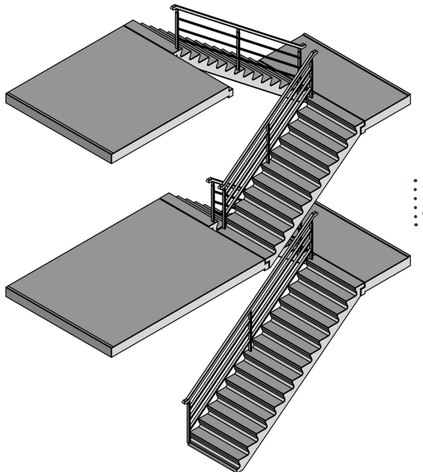




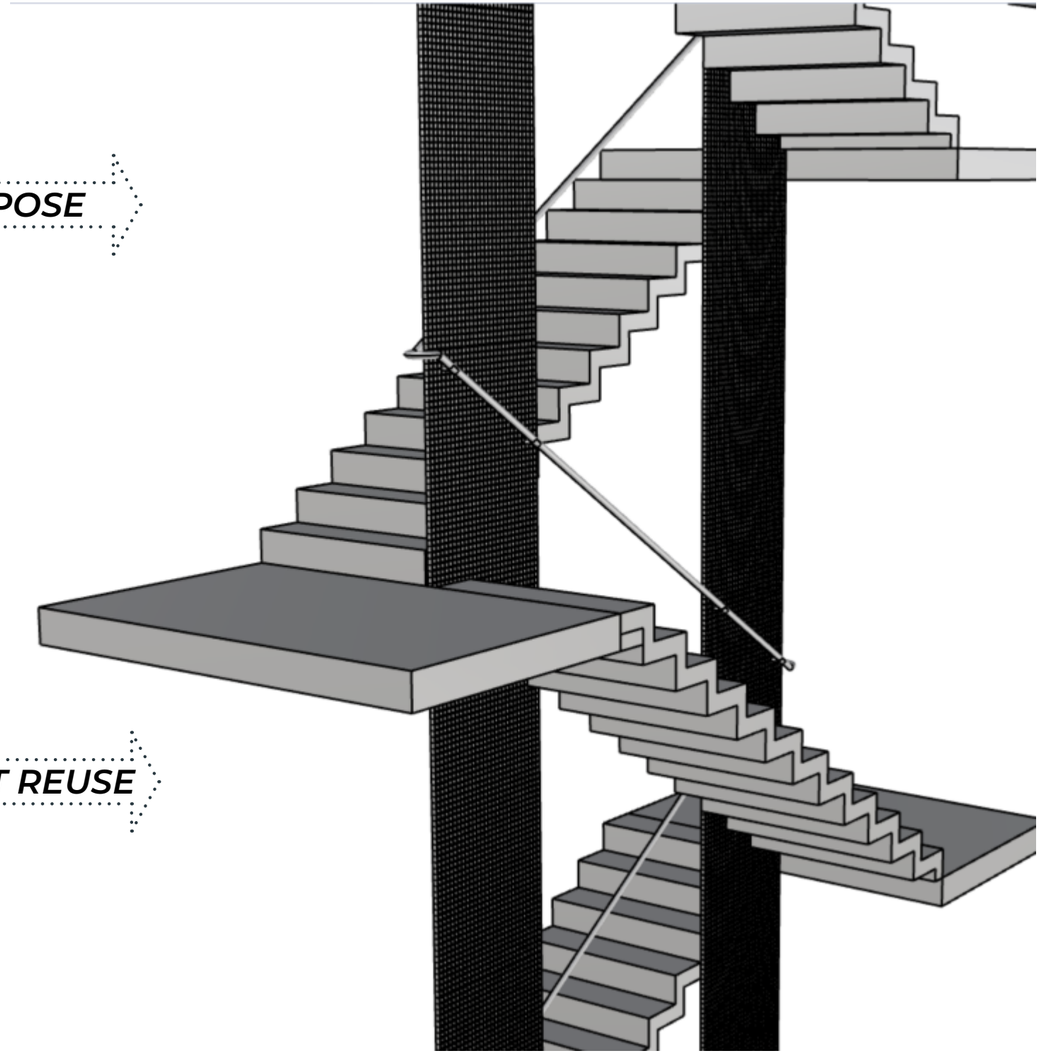
Circulation



R3 REPURPOSE

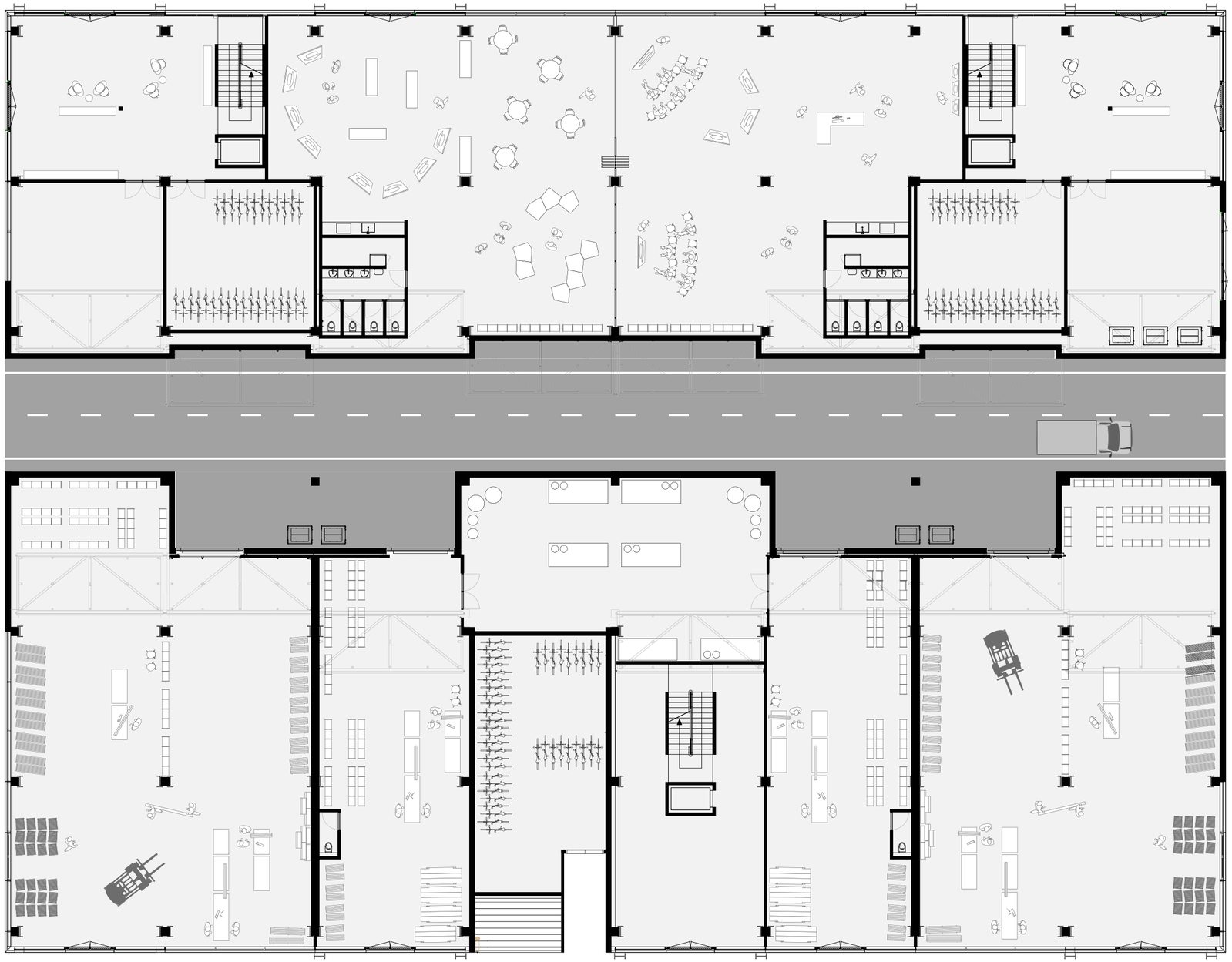


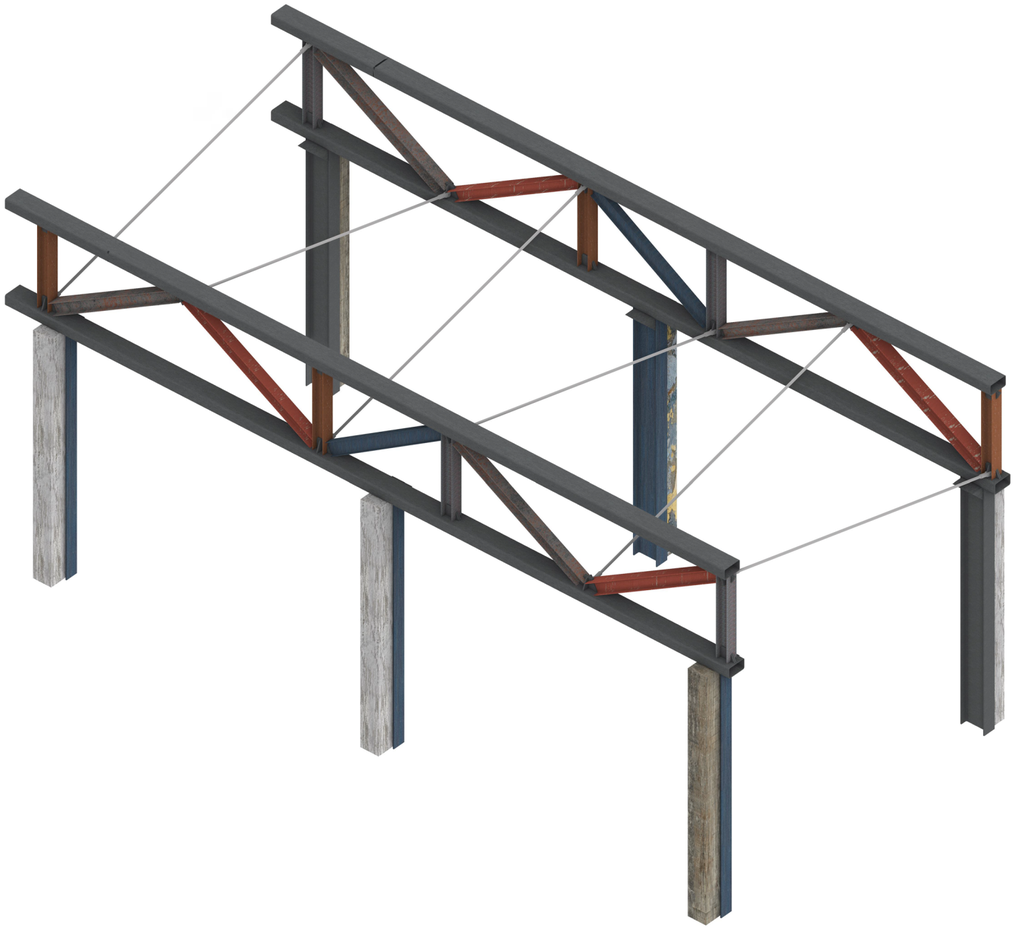
R1 DIRECT REUSE



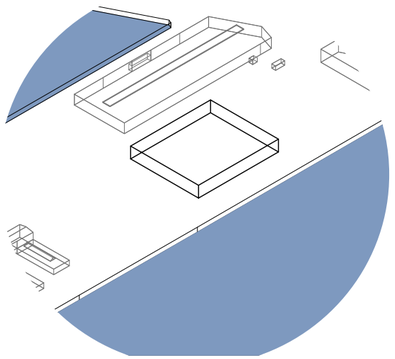
“Super Plinth”

Makers District

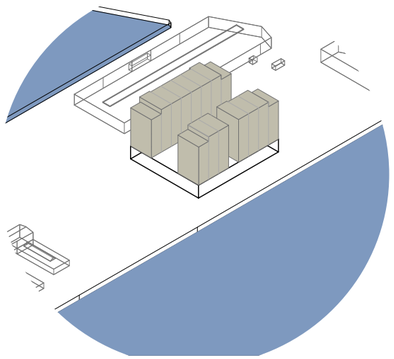




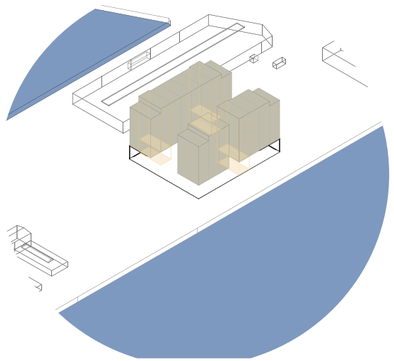
Urban Configuration



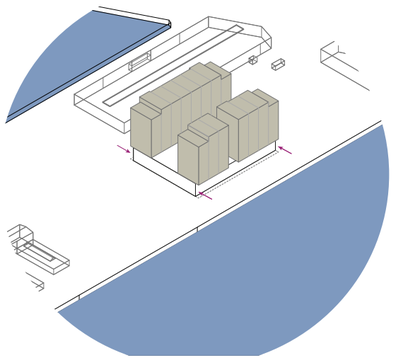
Building area Merwehaven master plan
Plinth same height as surrounding buildings



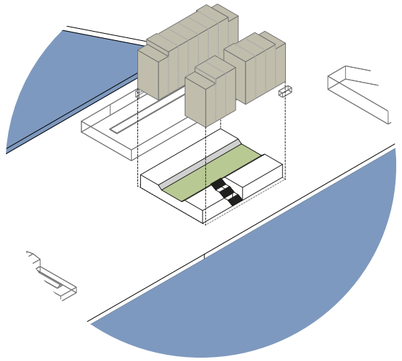
Top-up dwelling



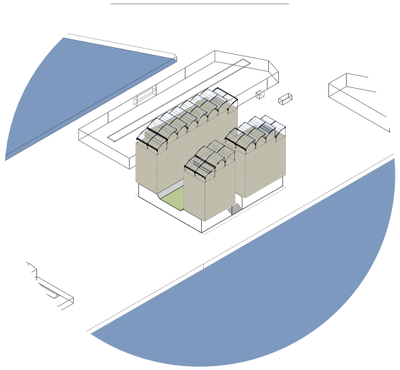
Enclosure via portico with social lobby



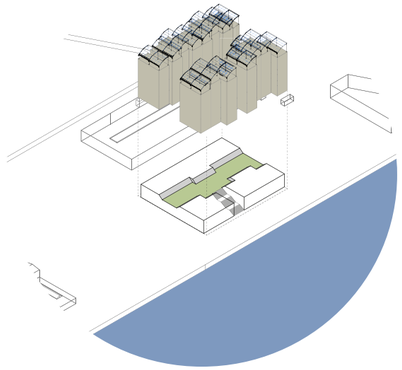
Set-back plinth



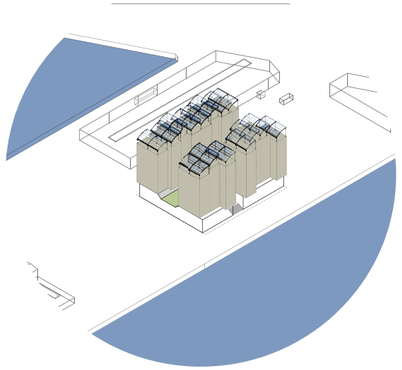
Innergarden



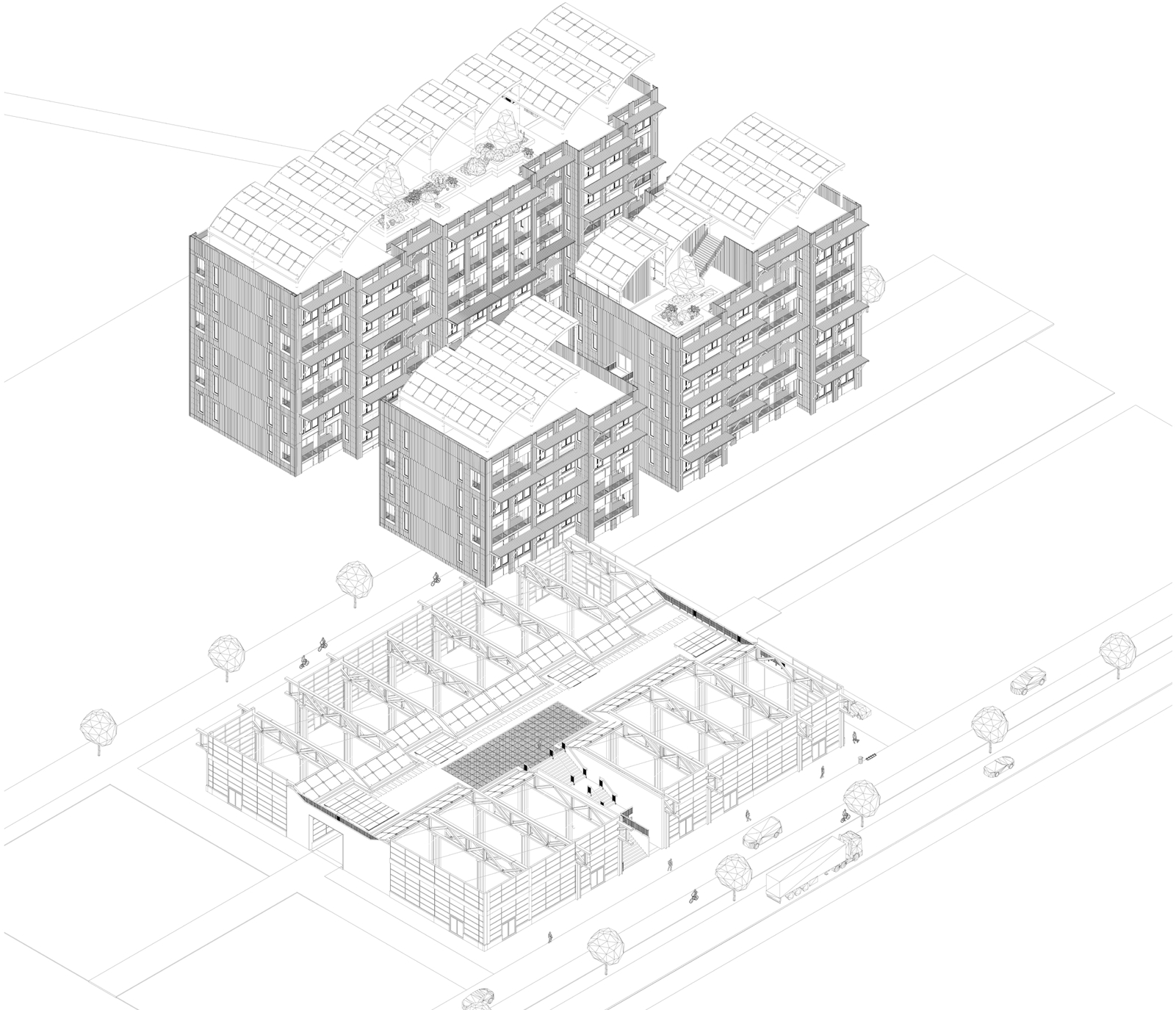
Covered outdoor spaces on roof terraces



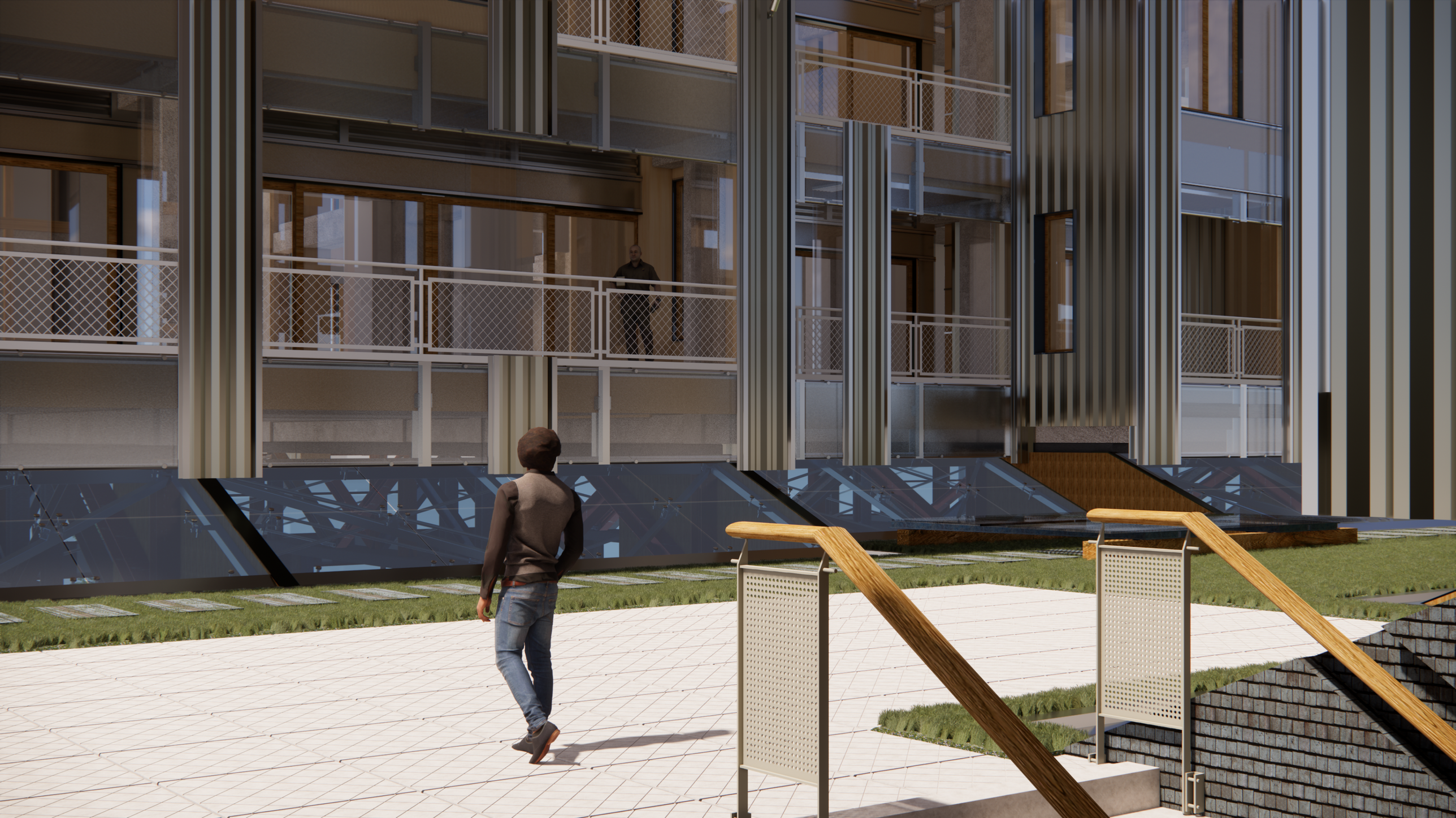
Distord

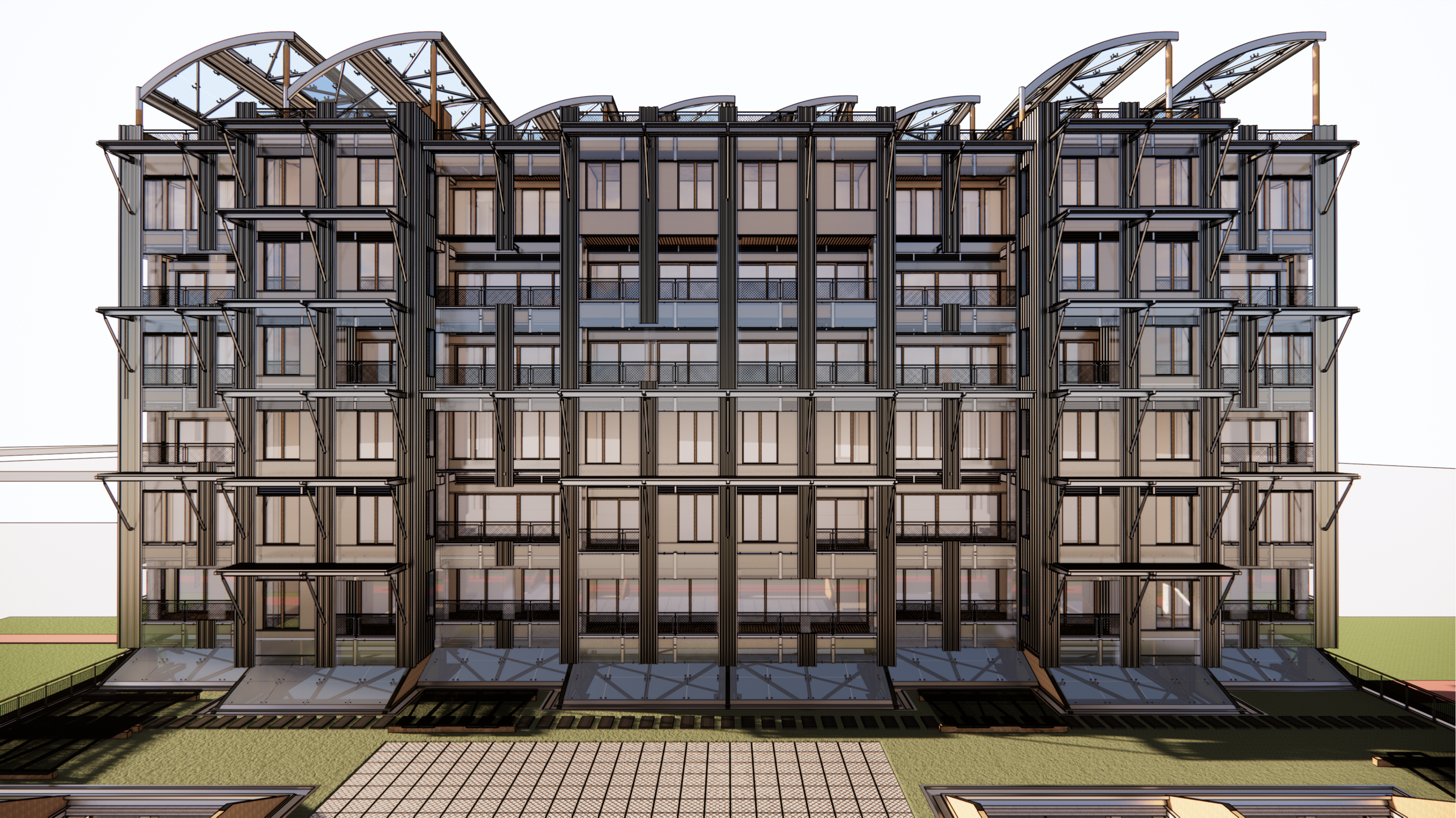


Urban configuration




INTERNATIONAL
LOGISTICS





45% reused

40% biobased

15% most sustainable supplier

M+M4H

A FUTURE-PROOF CIRCULAR LIVE-WORK BUILDING

QUESTIONS?