

Preparing for a modular retrofit future of walk-up apartments with the use of computational design

Pim Brueren 4658752
Faculty of Architecture & the Built Environment
Delft University of Technology

Design tutor: Anne Snijders
Research tutor: Serdar Asut
Building Technology tutor: Marcel Bilow
Examiner: Andre Mulder





1. Introduction

Incentives & goals

2. Research

Background, set up, results & conclusions

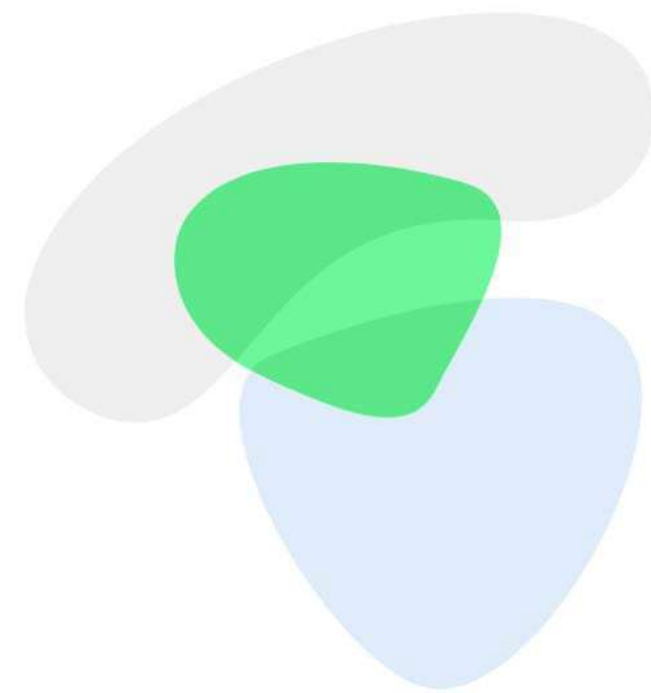
3. Design

Programme, masterplan & architecture

1. Project Introduction

Context, Problem
statement, Objective &
Questions

1. Project Introduction



National Energy and Climate Plan

1. Project Introduction

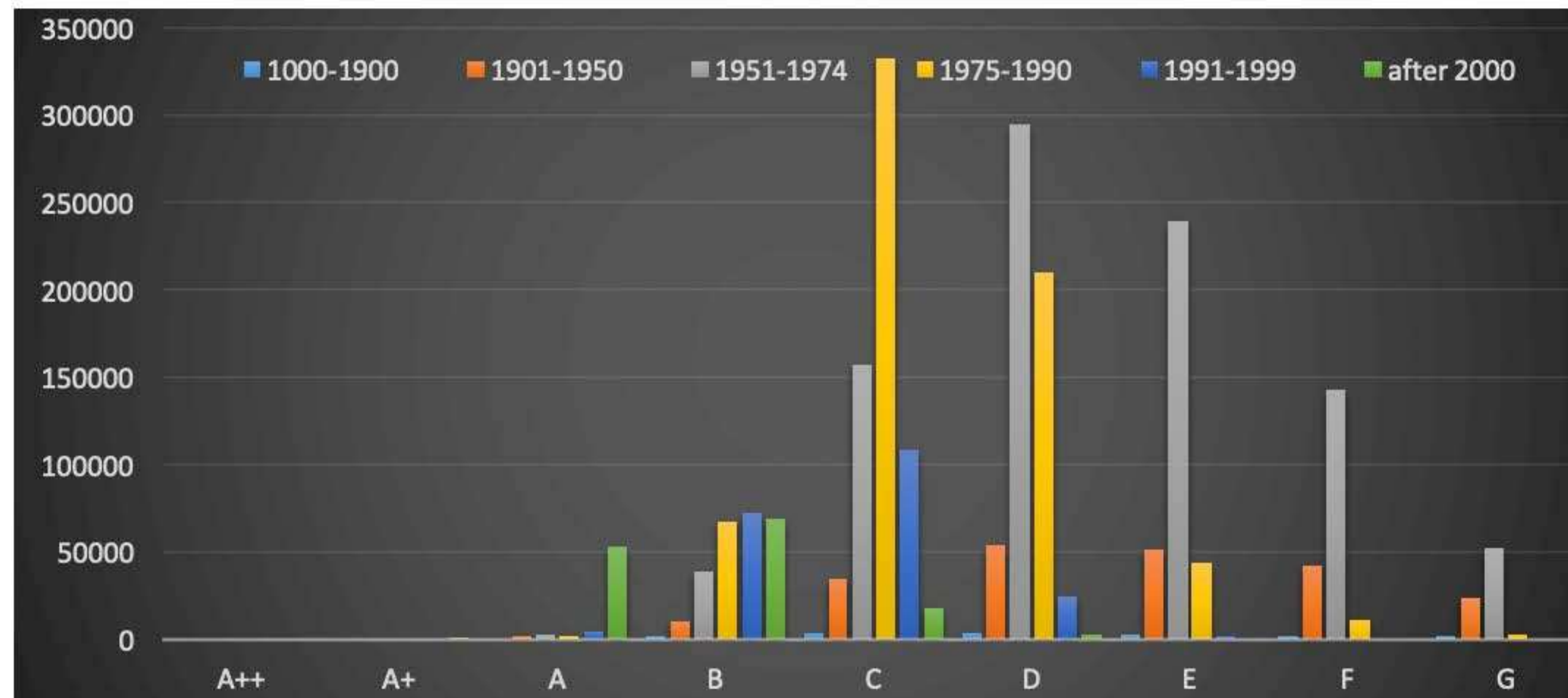


Figure 2. Energy labels of residential building stock (AgentschapNL, 2011). The majority of dwellings of the post-war period score label D or lower.

1. Project Introduction



1. Project Introduction



1. Project Introduction



1. Project Introduction

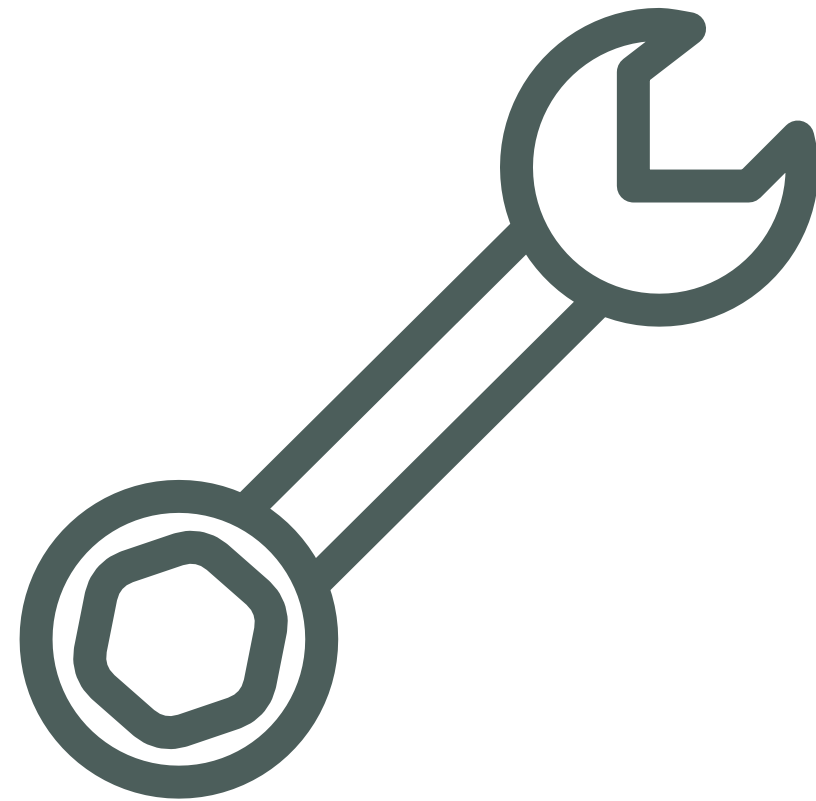
How can the renovation process of walk-up apartments be improved by using modular facade components generated by computational design?

1. Project Introduction

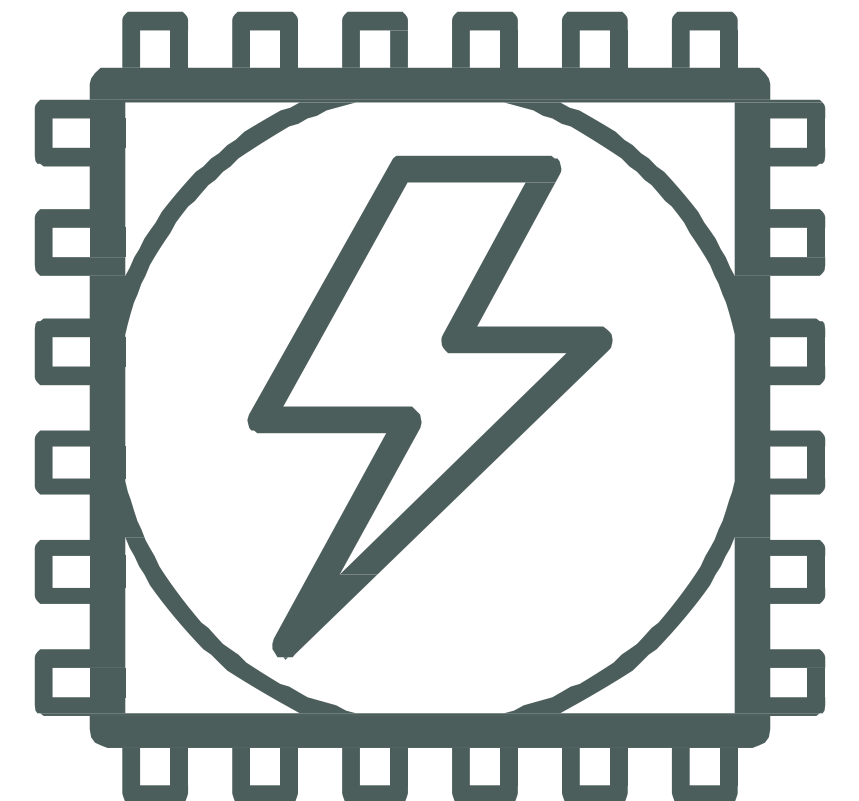
Typologie



Modularity and Modular parts



Computational design



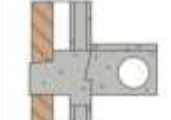
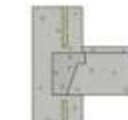
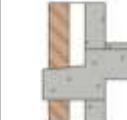
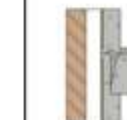
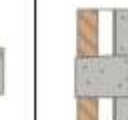
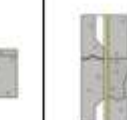


2. Research

Set up, Results &
Conclusions

2. Research

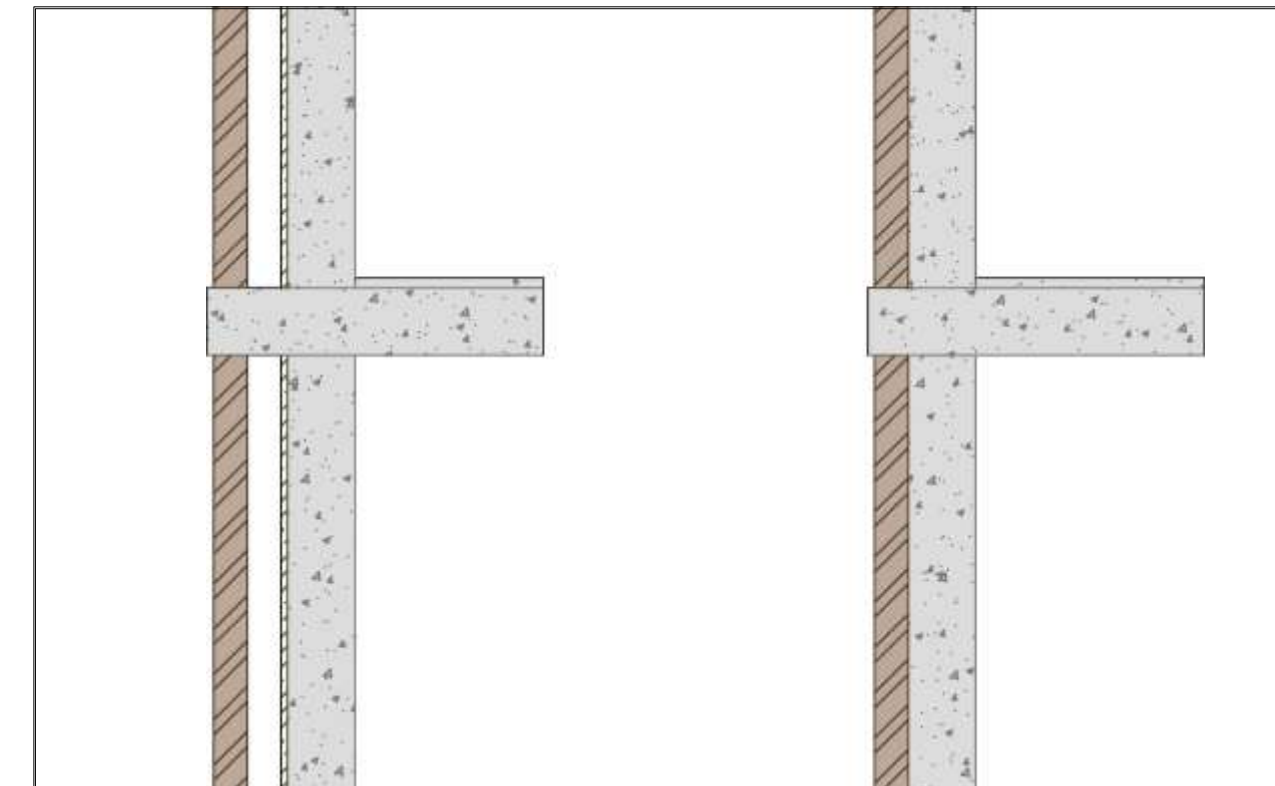
1. Which different typologies for walk-up apartments from inter/post-war are constructed and usable for modular facade retrofitting?

System	MUWI	Pronto	Coignet	RBM	BMB (Baksteen Montage Bouw)	Korrelbeton	VAM	Rottinghuis	Wilma	Welschen
Figure										
Amount of housing	36685 houses	17812 houses	31378 Houses	32292 Houses	+/- 30000 houses	15322 houses	14000 houses	17000 houses	12579 houses	5602 Houses
Percentage of total housing	11%	5%	9%	9%	9%	4%	4%	5%	3%	1%
Type of housing	53% porch 46% gallery 1% rest	32% Single Family house 62% porch 4% gallery 2% rest	Single family house 25% porch Gallery	Single family house porch gallery	Porch Gallery	75% porch 25 % single family house	Porch	50% porch 50% gallery	Single family house porch gallery	Single family house Porch
Construction technics System recognizability	Hollow light concrete blocks filled with gravel concrete	Stack construction, two-man blocks that are laid in half-brick bond, core of gravel concrete	Concrete is the basic material for load-bearing reinforced walls and floors	RBM 1 = setting and casting RBM 2 = casting construction, the walls are first poured using steel molds	Whole or half story height prefab concrete wall elements	Standardized wooden formwork and poured concrete with a granular aggregate	Element construction, light concrete prefabricated wall elements the floor is placed and the cavities are poured together	Element construction, medium-rise buildings, prefabricated concrete walls and floors, facade is masonry	Casting construction, formwork method with steel for the walls	Cast building facades, floors and skeleton entirely of concrete
Floor construction technics	Floors are made of prestressed concrete beams with filler blocks	system floor / sandwich floor	reinforced concrete floor and poured with wall anchors	wooden table placed on which the floor is poured, when cured wooden table is lifted out of the building	masonry floor slabs	slab floors (do not belong to the granular concrete system)	floor finish was still necessary, prefab floor elements	prefab floor plate	Floors wooden formwork where concrete is poured	floor plates were made separately on the construction site
Demolishment	<5% demolished	5-7 % demolished	>50% demolished	Unknown	<5% demolished	high demolition schedule	5-20% demolished	Unknown	Unknown	high demolition schedule
Floor plans	different types of floor plans 2 - 5 rooms apartments	4 - 5 - 6 Rooms Apartments	standardized 4 rooms apartments (Is experienced as unpleasant)	standardized 4 rooms apartments	5 - 6 Rooms Apartments	4 - 5 Rooms Apartments	2 and 4 Rooms Apartments	6 and 7 Room Apartments	7 Room apartments	4 - 5 Rooms Apartments
Improvement / renovation costs	improvement sum 60,400 total renovation 125,000	Improvement sum 94,000 total renovation 124,000	Unknown	Unknown	Improvement sum 61,220 Total renovation Unknown	Improvement sum 50000 -70000 total renovation Unknown	Unknown	Improvement sum 90000 euro Total renovation Unknown	Improvement sum 35,000 -115,000 Total renovation Unknown	Improvement sum 42,700 Total renovation Unknown
Wall characteristics	cavity wall innovation between 1954-1959	3cm thick insulation	2-2.5 centimeters thick polystyrene insulation	air cavity	cavity + 1cm polystyrene	plaster layer 1955 brick cladding 1962 cavity construction	different finish type	masonry front cover	-	-
Notes for renovation	Renovations seems to work		several structural problems, gray appearance, poor finish, demolition within 30 years	not a fixed size, which means that the RBM comes in different appearances and there is no typical recognizable appearance	houses of reasonable size, therefore also good to tackle on the inside	sober appearance	many possibilities with merging 3 to 2 apartments per floor	chance of improvement due to floor plan mainly at gallery		currently renovation project in Rotterdam, sporadic neighborhoods only exist
Standardization needed for tool	floor plan and standard sizes	floor plan and standard sizes	floor plan and standard sizes		floor plan and standard sizes	floor plan and standard sizes	floor plan and standard sizes	floor plan and standard sizes	floor plan and standard sizes	floor plan and standard sizes
Detailing										
Useable for retrofitting	Good	Good	Bad	Bad	Good	neutral	Good	Good	Good	neutral

2. Research

System	Korrelbeton
Amount of housing	15322 houses
Percentage of total housing	4%
Type of housing	75% porch 25 % single family house
Construction technics System recognizability	Standardized wooden formwork and poured concrete with a granular aggregate
Floor construction technics	slab floors (do not belong to the granular concrete system)
Demolishment	high demolition schedule

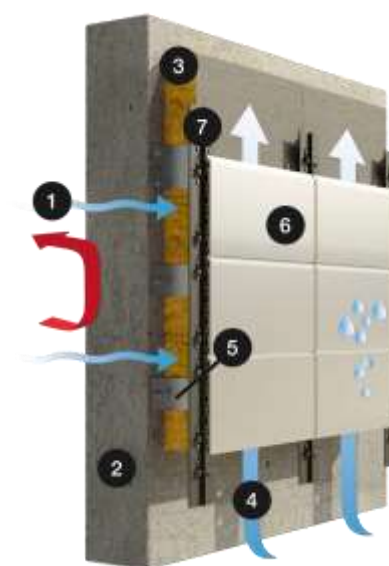
Floor plans	4 – 5 Rooms Apartments
Improvement / renovation costs	Improvement sum 50000 - 70000 total renovation Unknown
Wall characteristics	plaster layer 1955 brick cladding 1962 cavity construction
Notes for renovation	sober appearance
Standardization needed for tool	floor plan and standard sizes
Detailing	
Useable for retrofitting	Good/Neutral



2. Research

2. What are the existing renovation techniques for walk-up apartments?

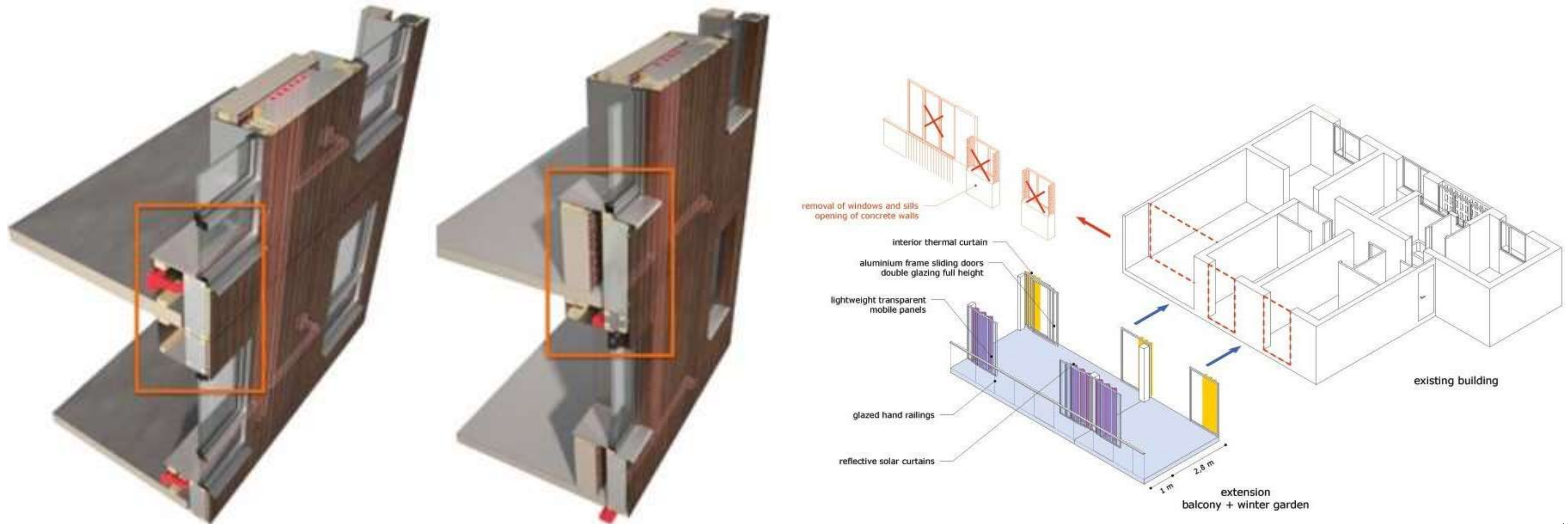
- External composite insulation system (ETICS)—traditional measure, in which insulation panels are mounted manually on site and are covered with plaster.
- Rear ventilated façade system—a manually procedure done on site consisting of insulation brought up between laths and fixed with a mounting system, being covered with different claddings.
- Partly prefabricated façade system—a prefabricated substructure with blown in insulation with an exterior cladding which is also prefabricated or is installed on site.
- Prefabricated module system—fully prefabricated panels, assembled in a factory, transported and mounted on site.



2. Research

2. What are the existing renovation techniques for walk-up apartments?

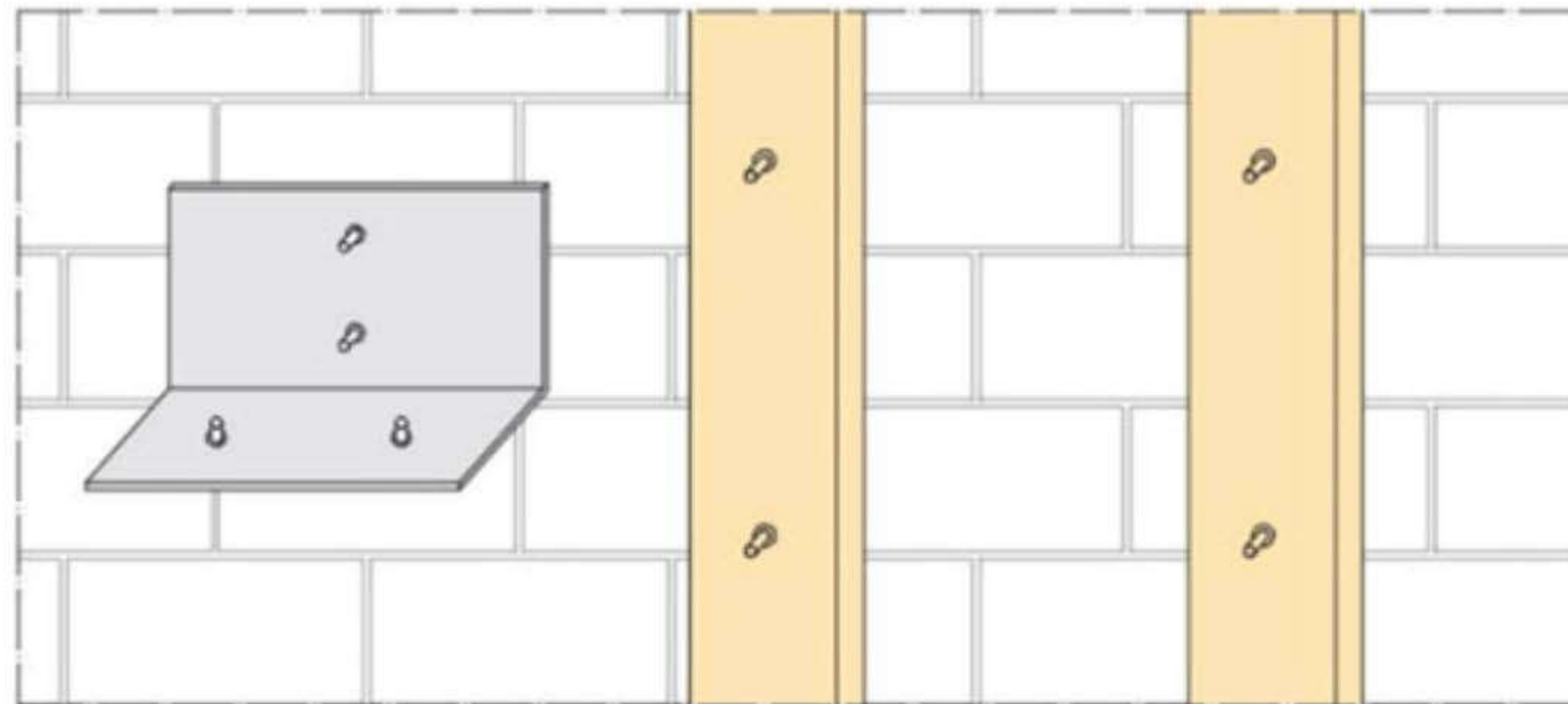
- Prefabricated module system—fully prefabricated panels, assembled in a factory, transported and mounted on site



2. Research

4. How are modular facade systems attached to the existing buildings?

1. Directly connected to the existing façade with the use of (metal) anchors where vertical brackets are mounted. The brackets or hot-tip galvanized steel corner brackets support the prefabricated wooden panels.
2. Wooden vertical/horizontal structure is attached to the old façade, where the gaps are filled with ventilations ducks and insulation material. After which prefabricated panels are attached to the wooden beams, the windows are removed from the inside ones finished.
3. Separate (column) structure where the prefabricated panels are stacked. (Metal anchor are attached to ensure that the panels stay in their dedicated place.)



2. Research

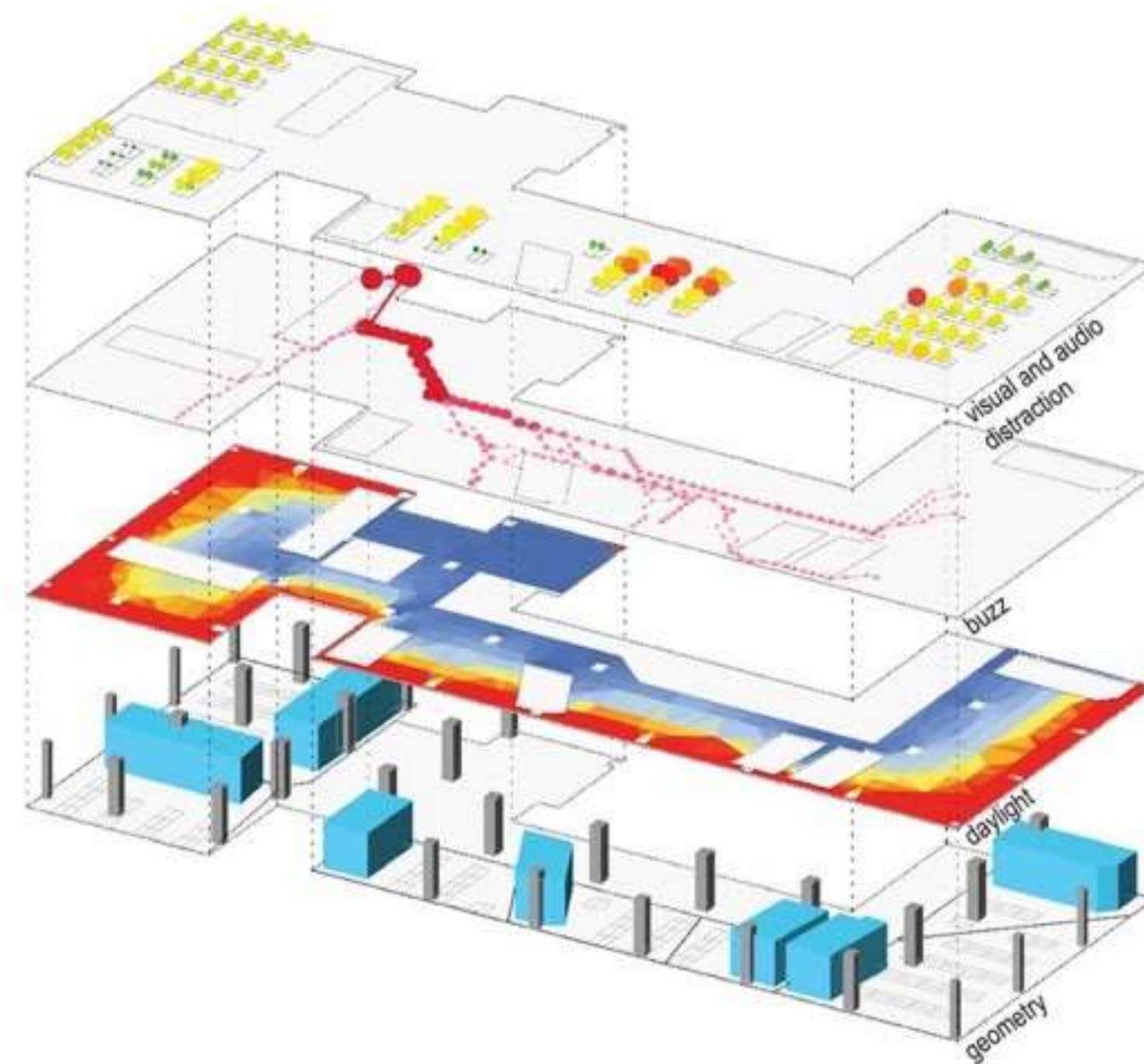
5. Are there existing projects in which computational design methods are used for retrofitting of existing buildings?



<https://www.autodesk.co.jp/solutions/bim/mep>

2. Research

6. How can computational design method help for a generative renovation design for walk-up apartments?



1. geometry
2. daylight
3. routing
4. visual and audio distraction
5. facade elements

generative design principles (Marc K. Howe, 2017)

2. Research

Conclusions and other findings





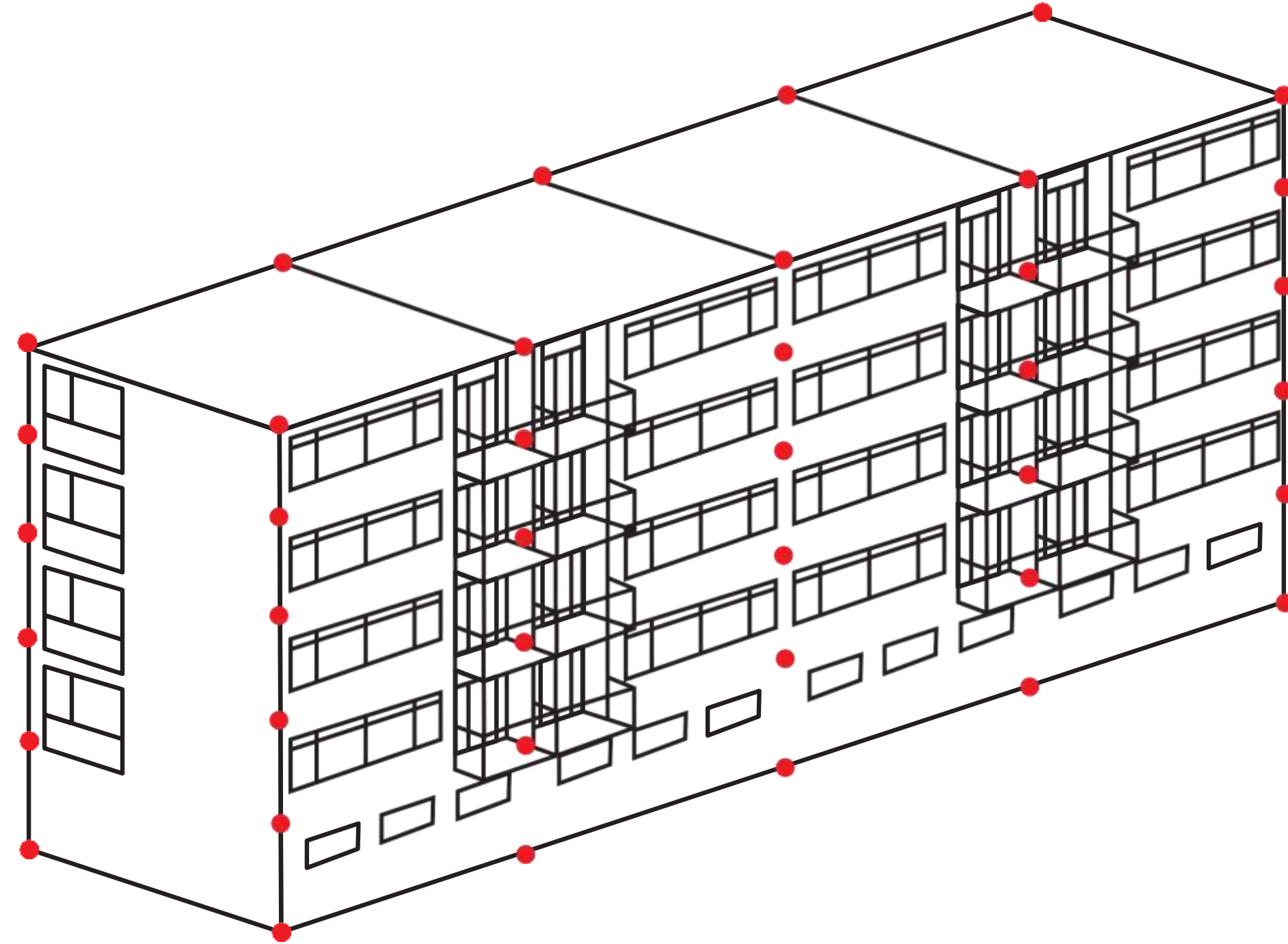
3. Design

Context, Programme,
Masterplan &
Architectuur

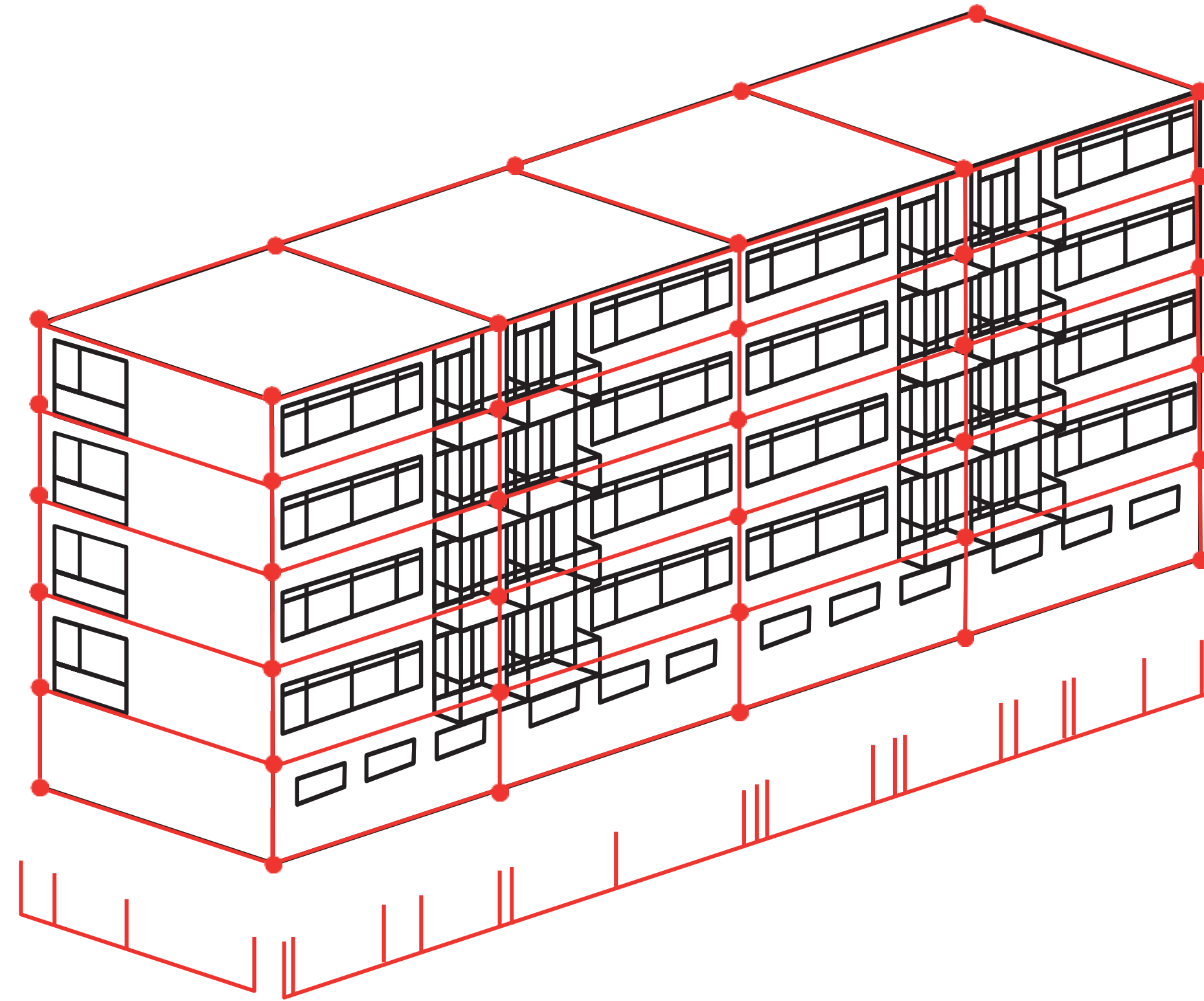
3. Design



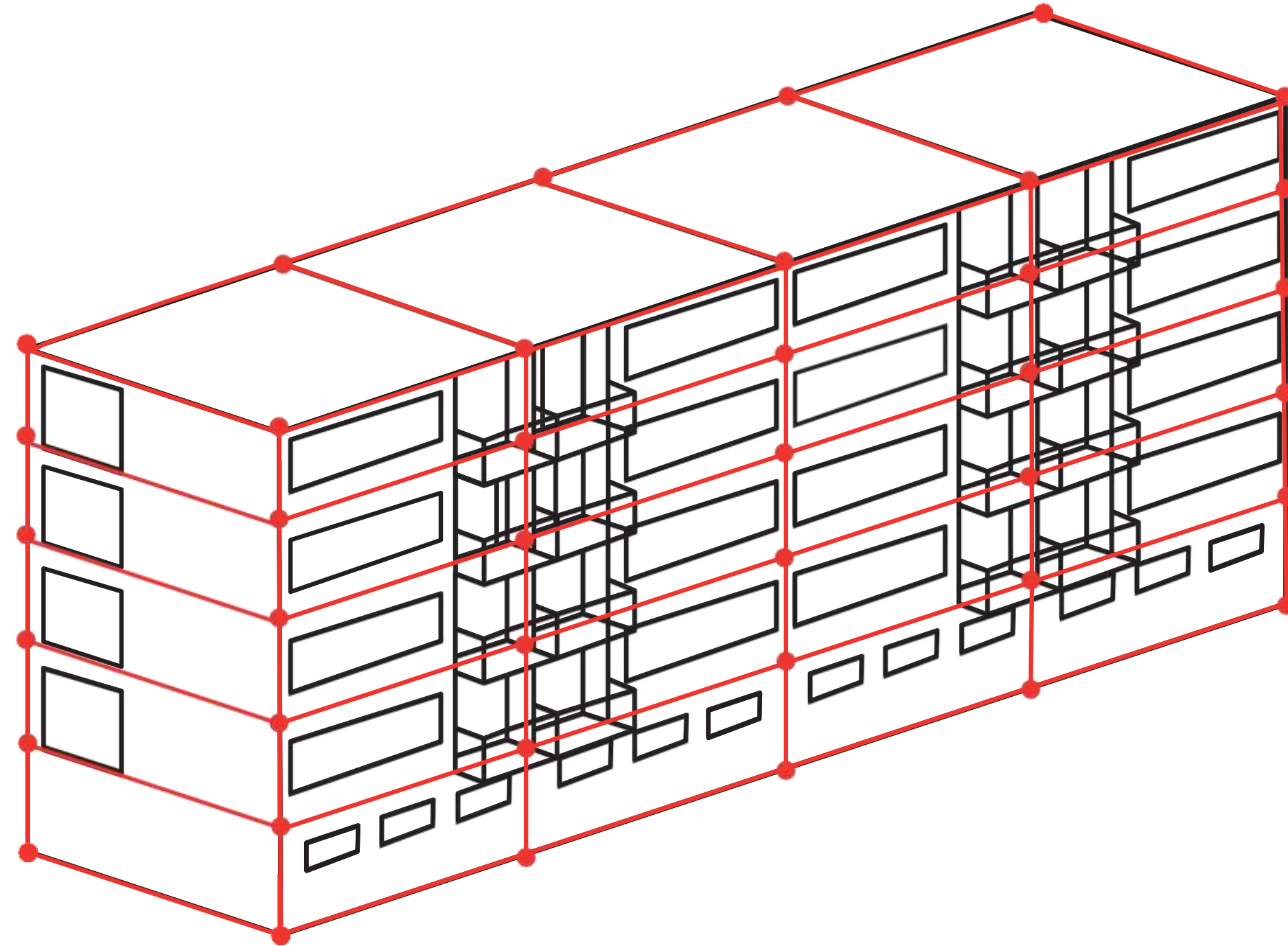
3. Design



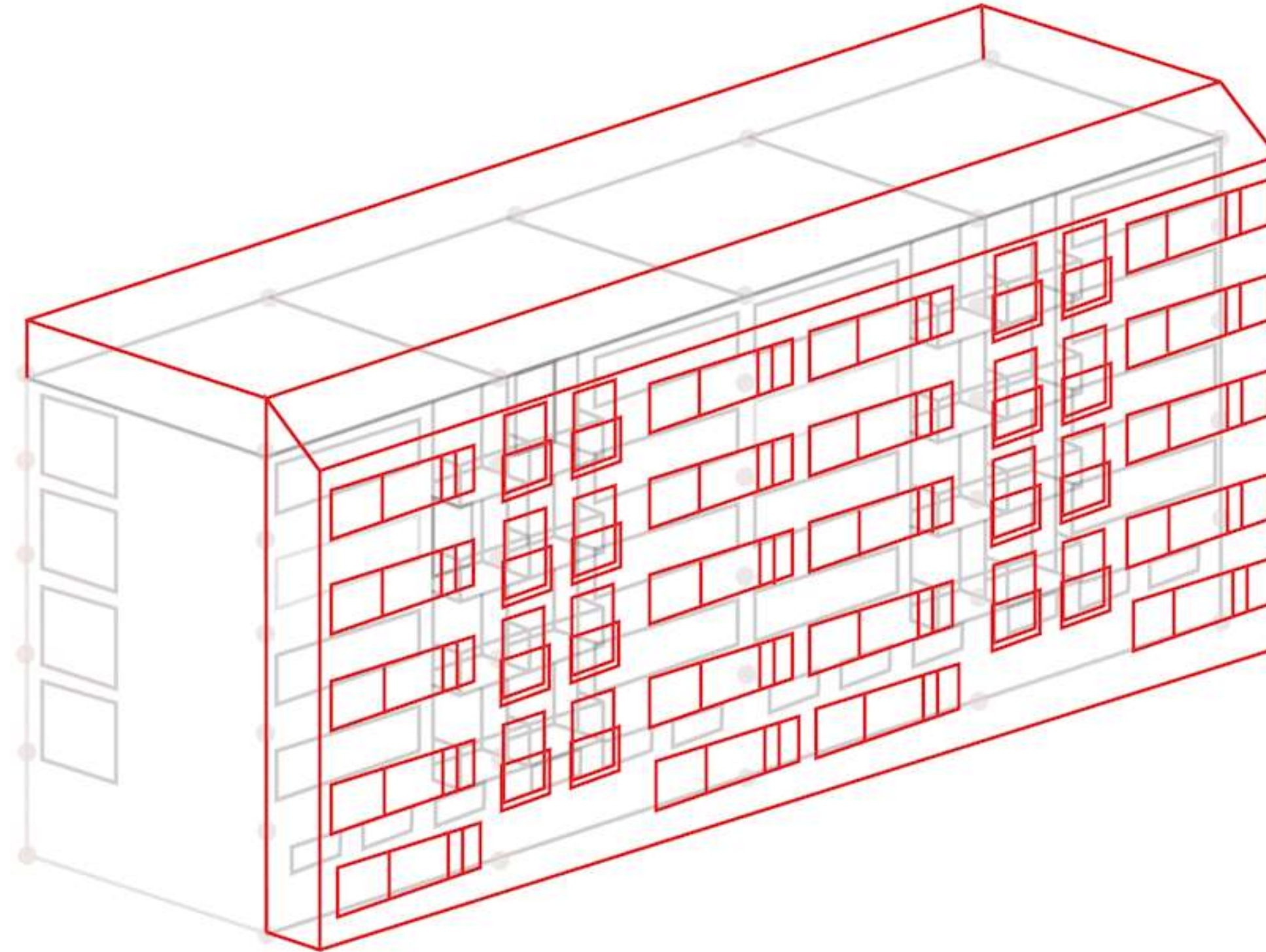
3. Design



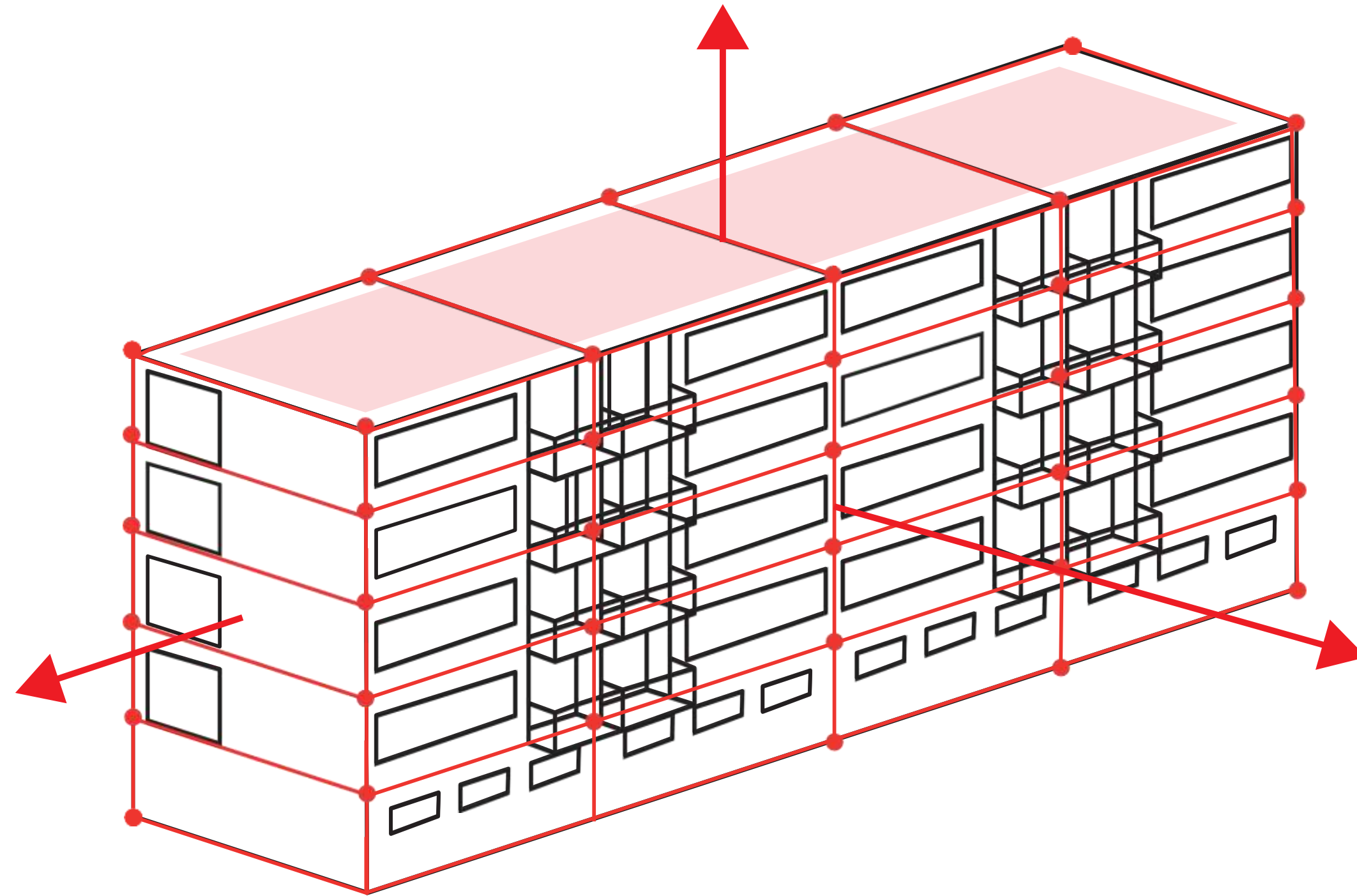
3. Design



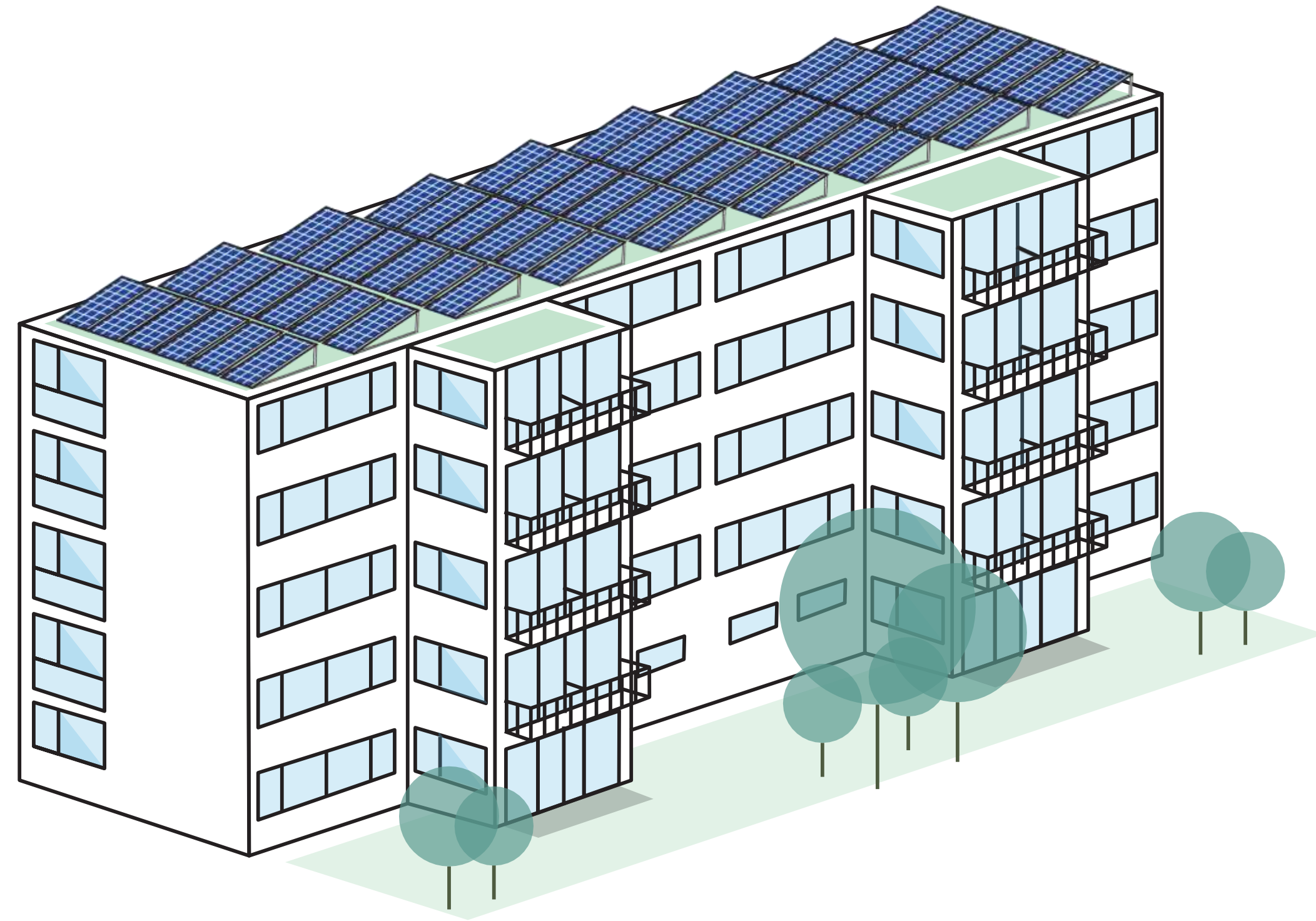
3. Design



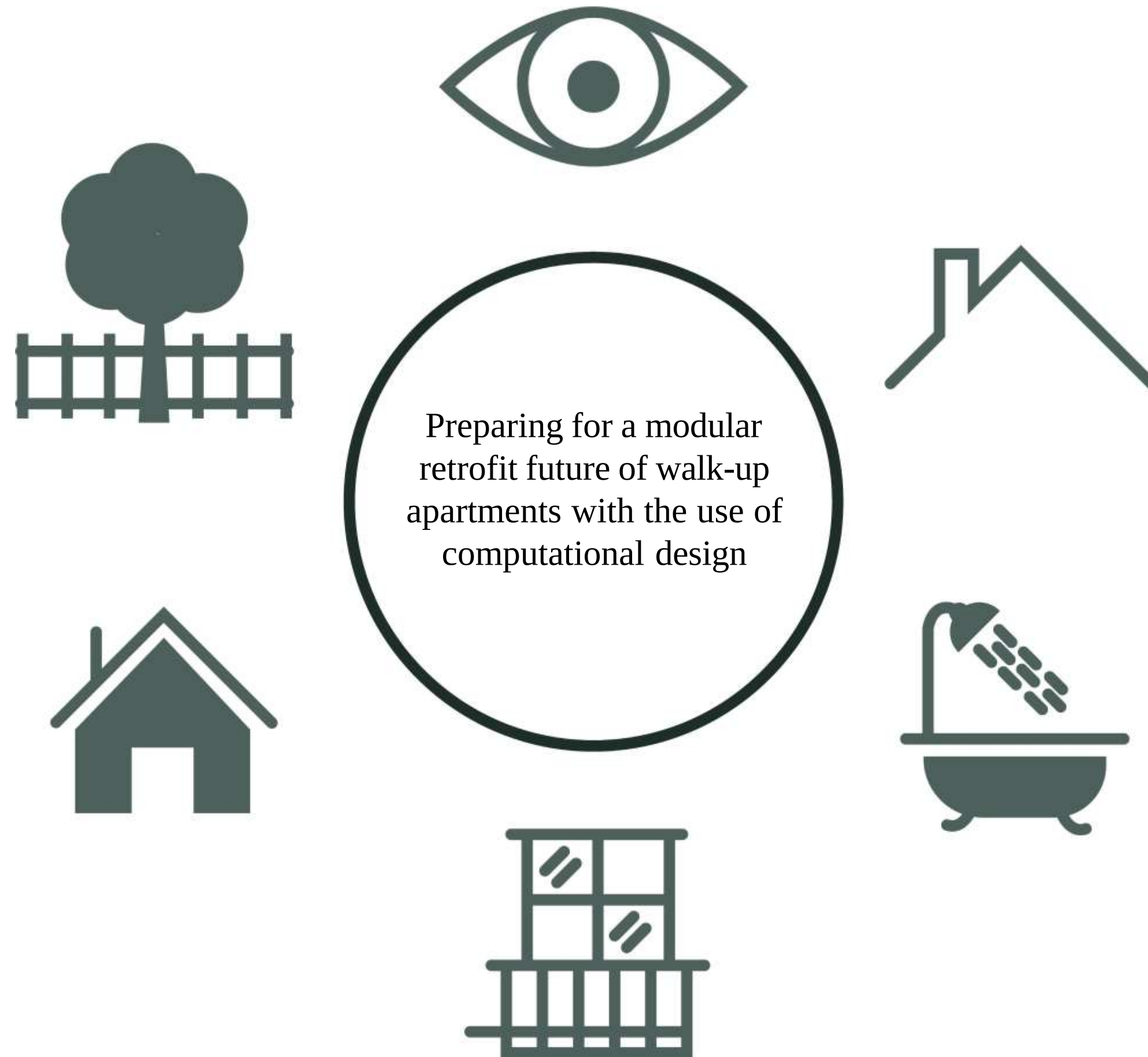
3. Design



3. Design



3. Design



3. Design



3. Design



3. Design



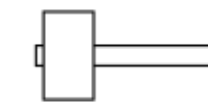
3. Design



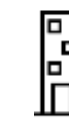
15385 inhabitants



10303 addresses



7916 built 1950-1970



48% 4-layer walk-up
apartment



22% 7-layer walk-up
apartment



63% lease apartments

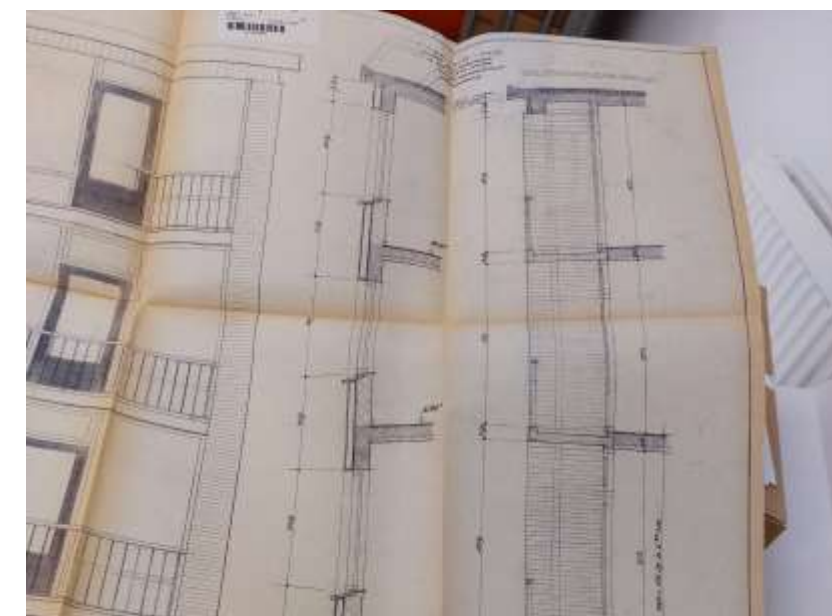
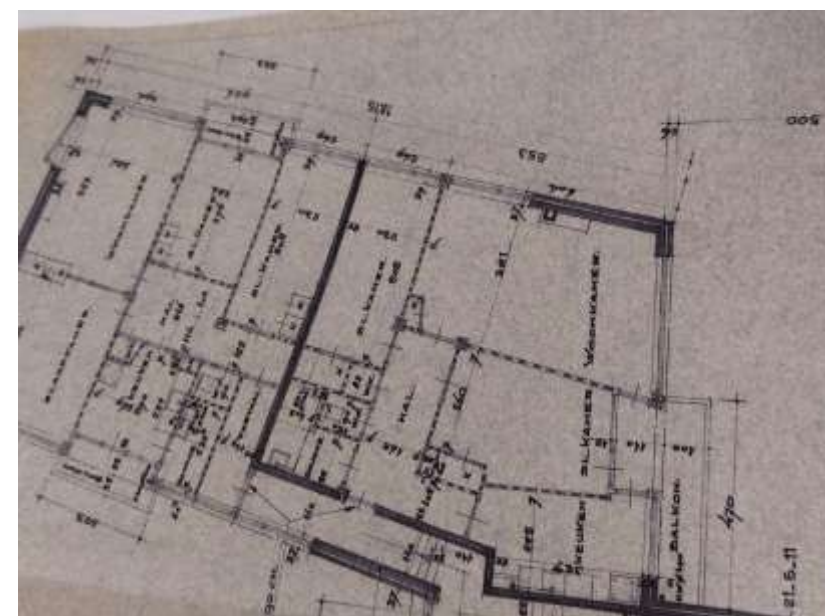
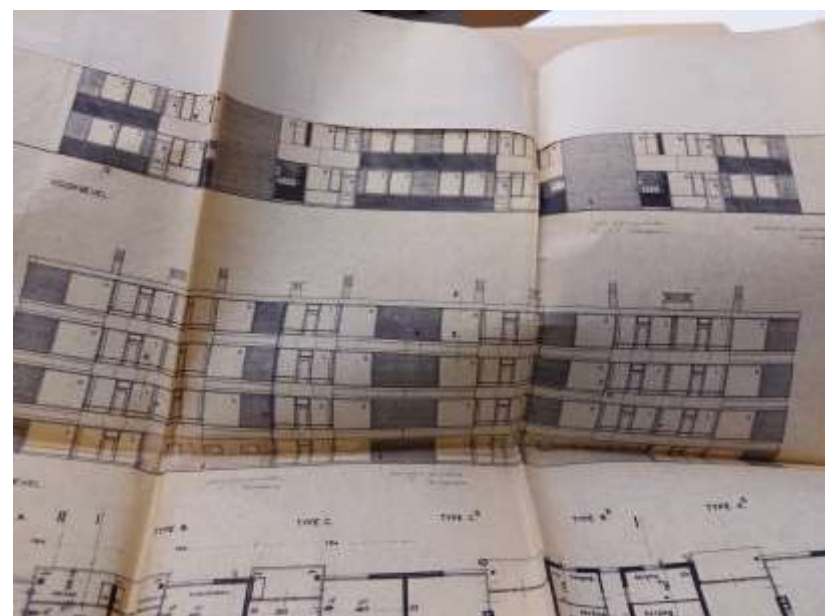
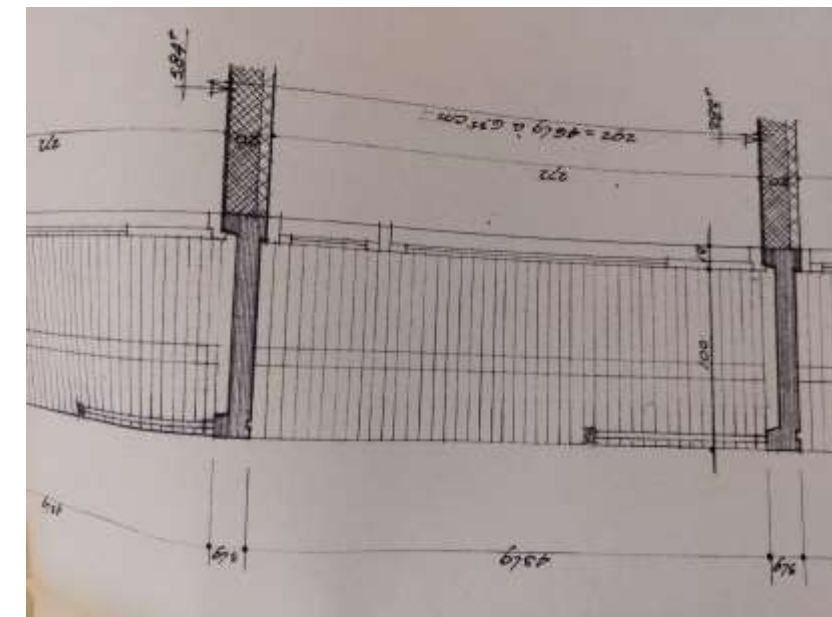
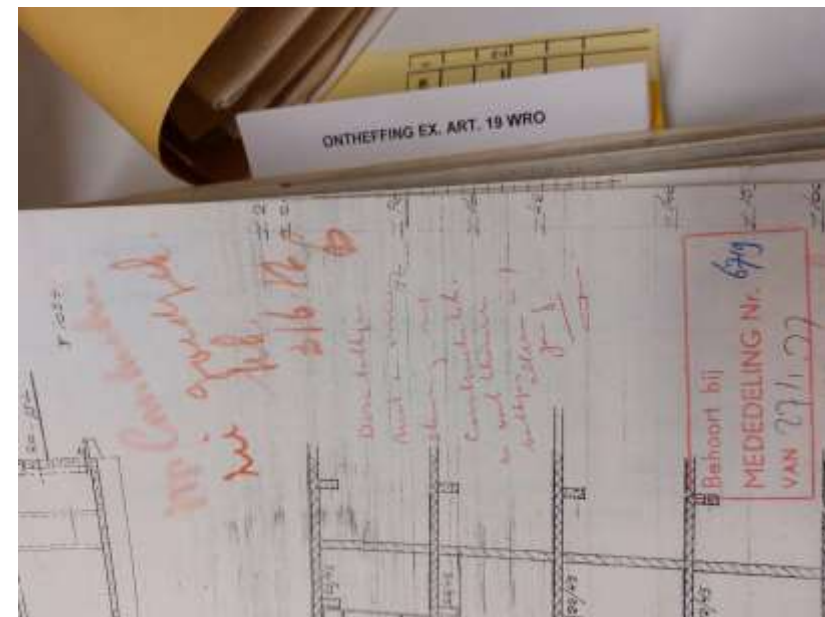
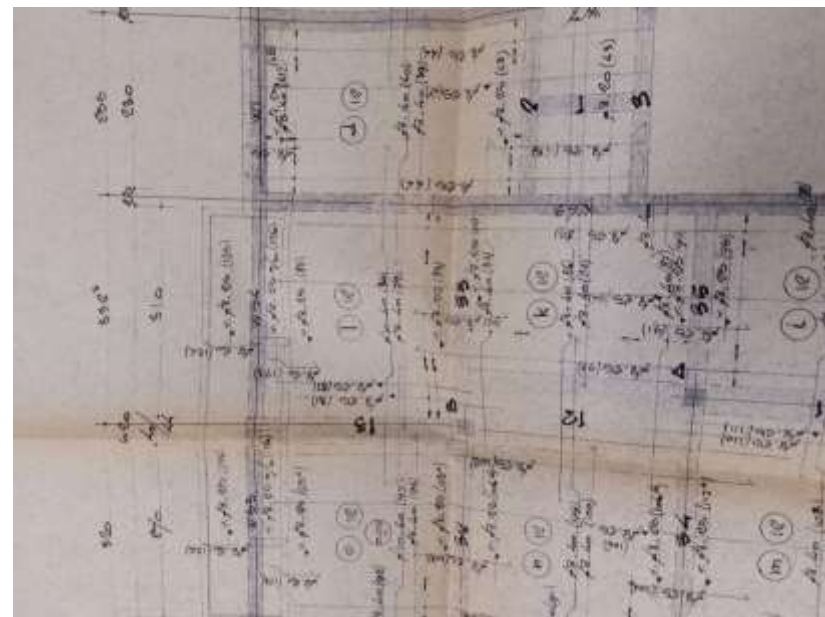
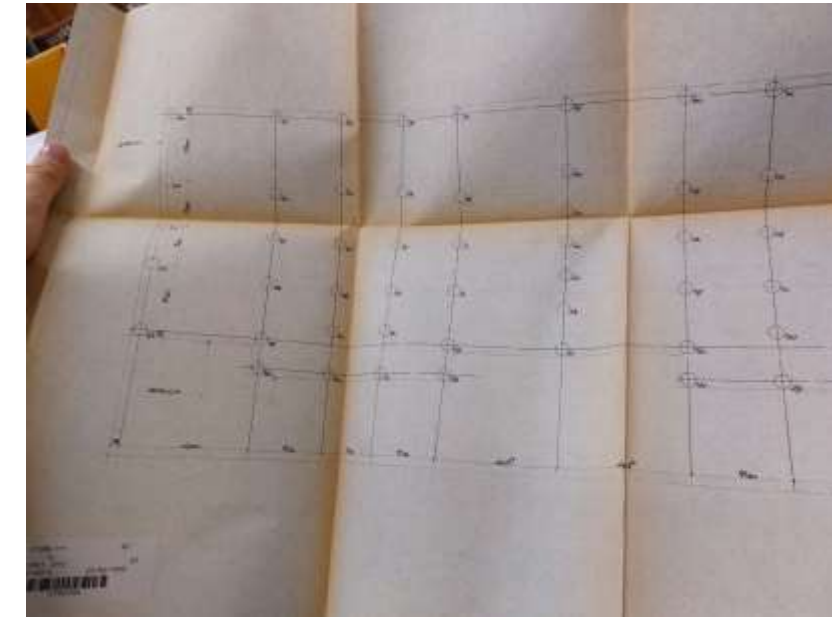
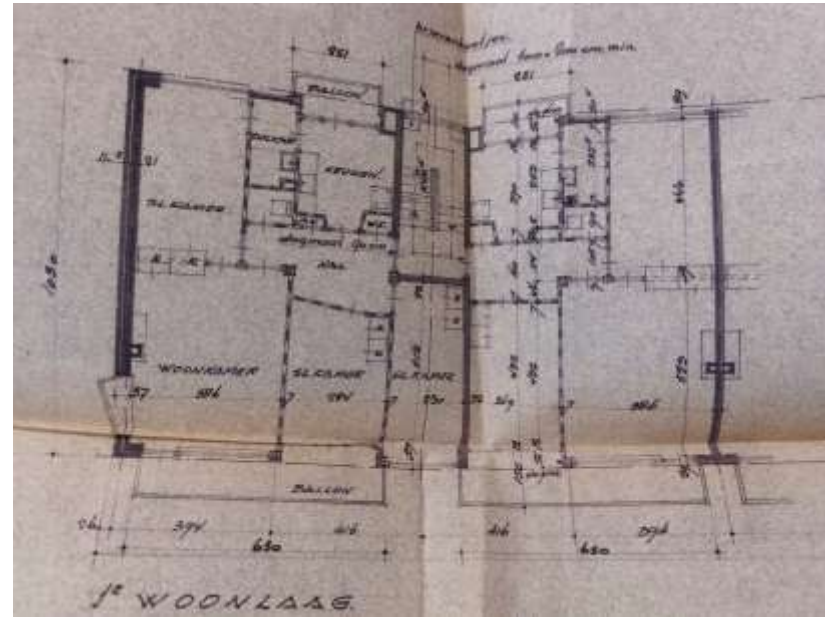


allotments

3. Design



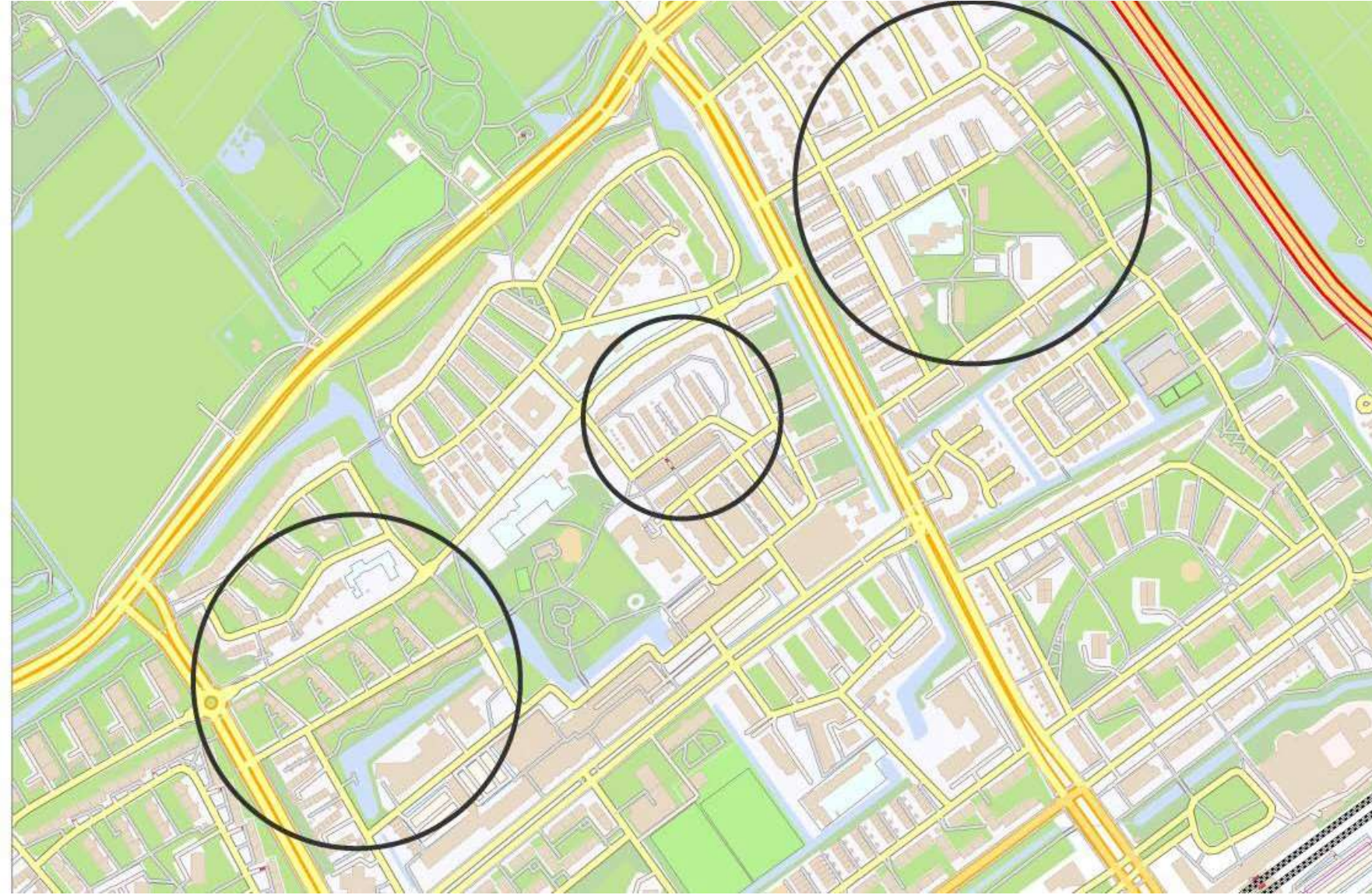
3. Design



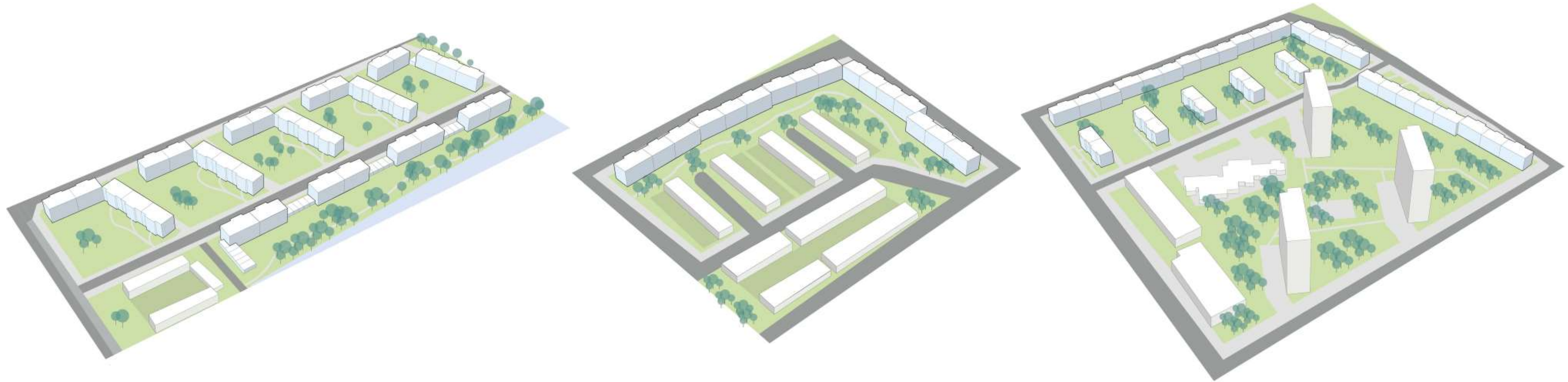
3. Design



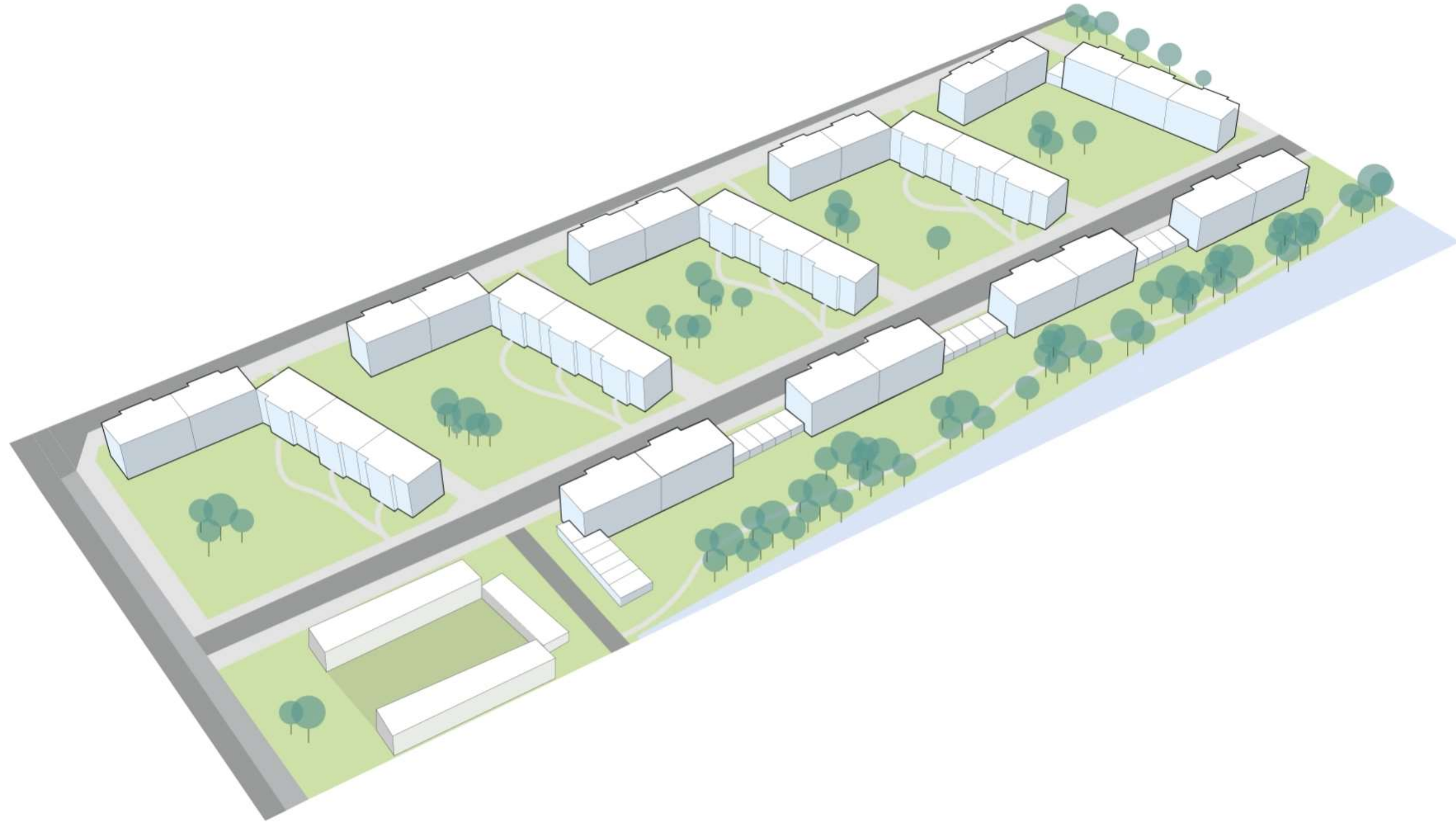
3. Design



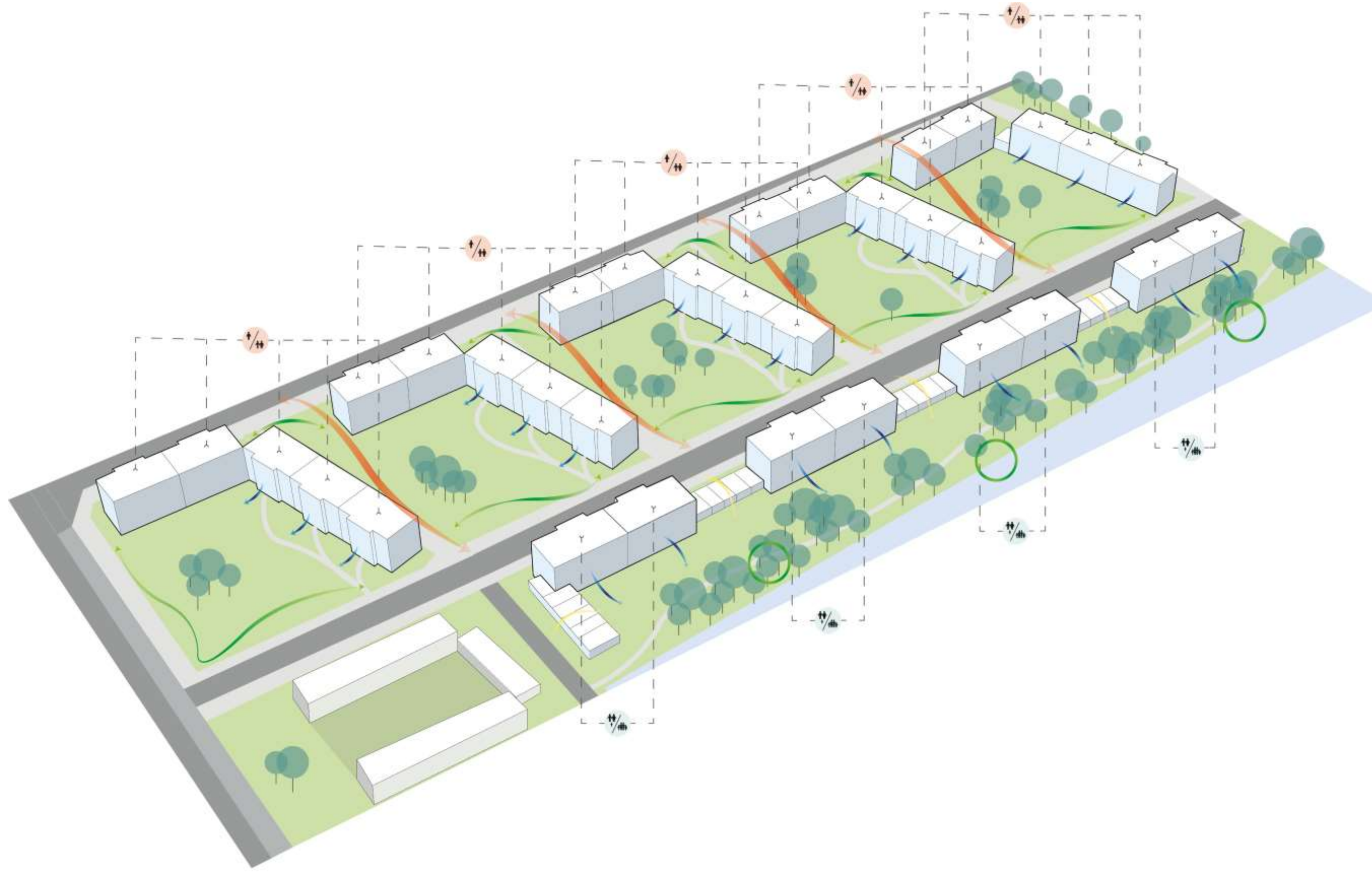
3. Design



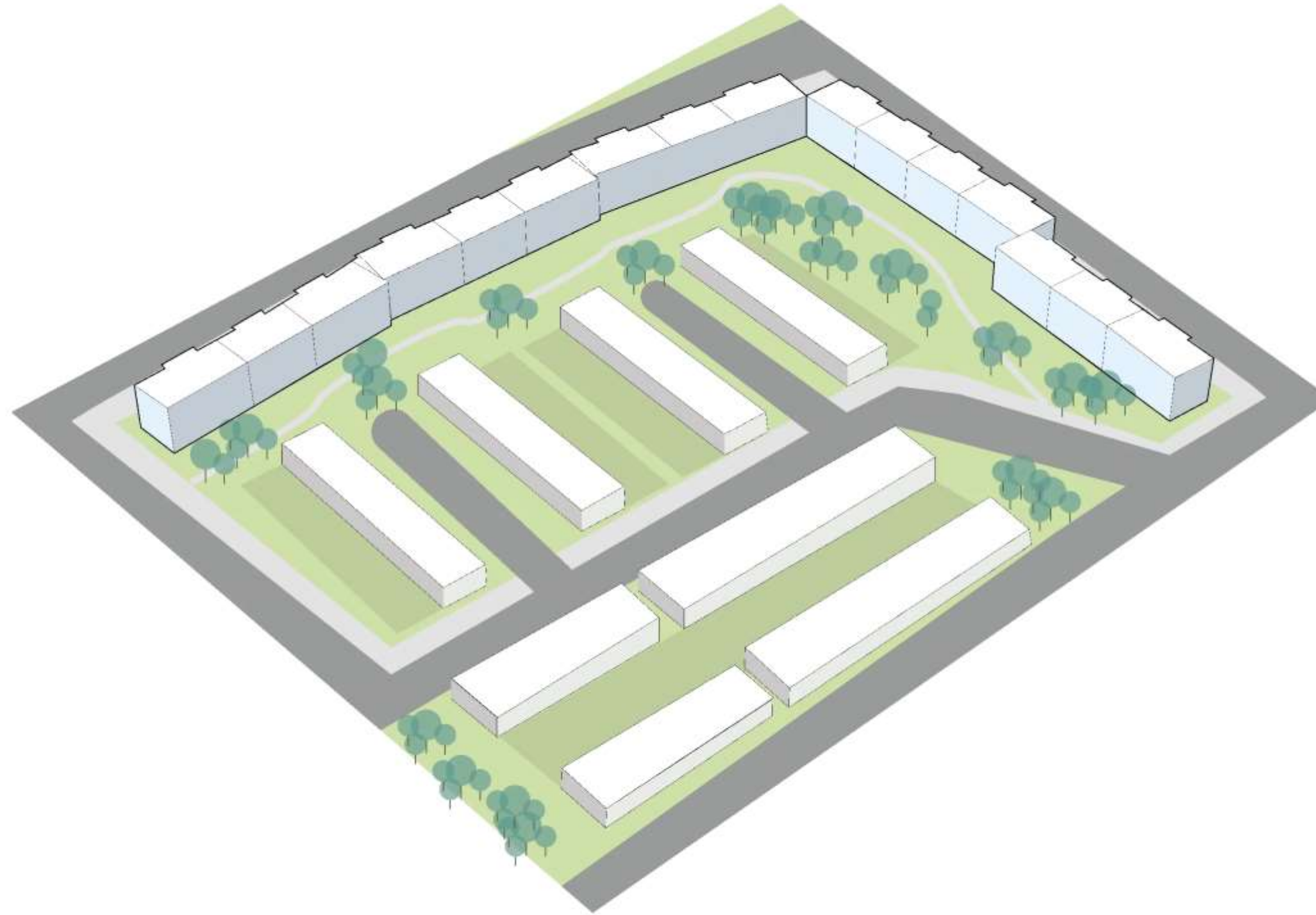
3. Design



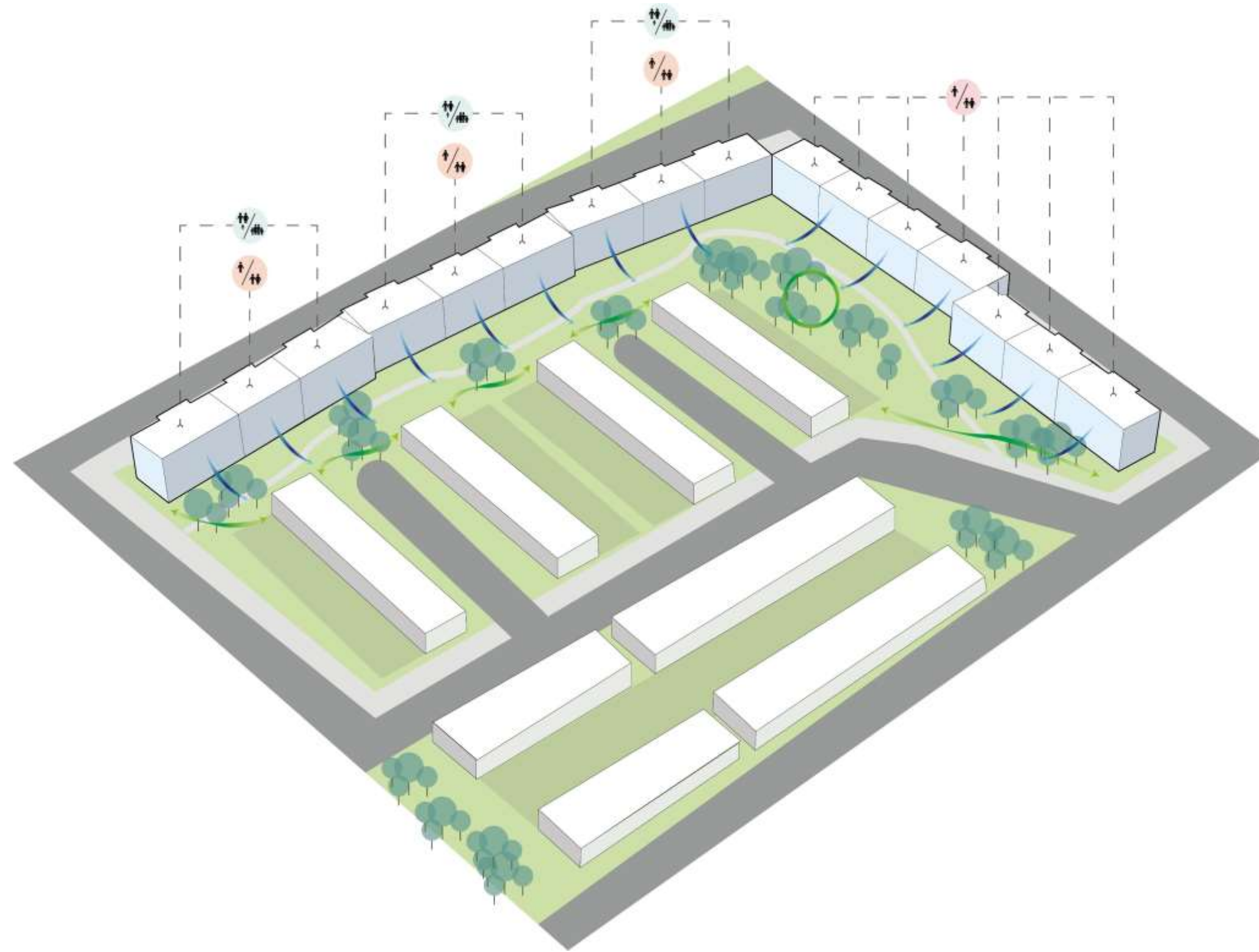
3. Design



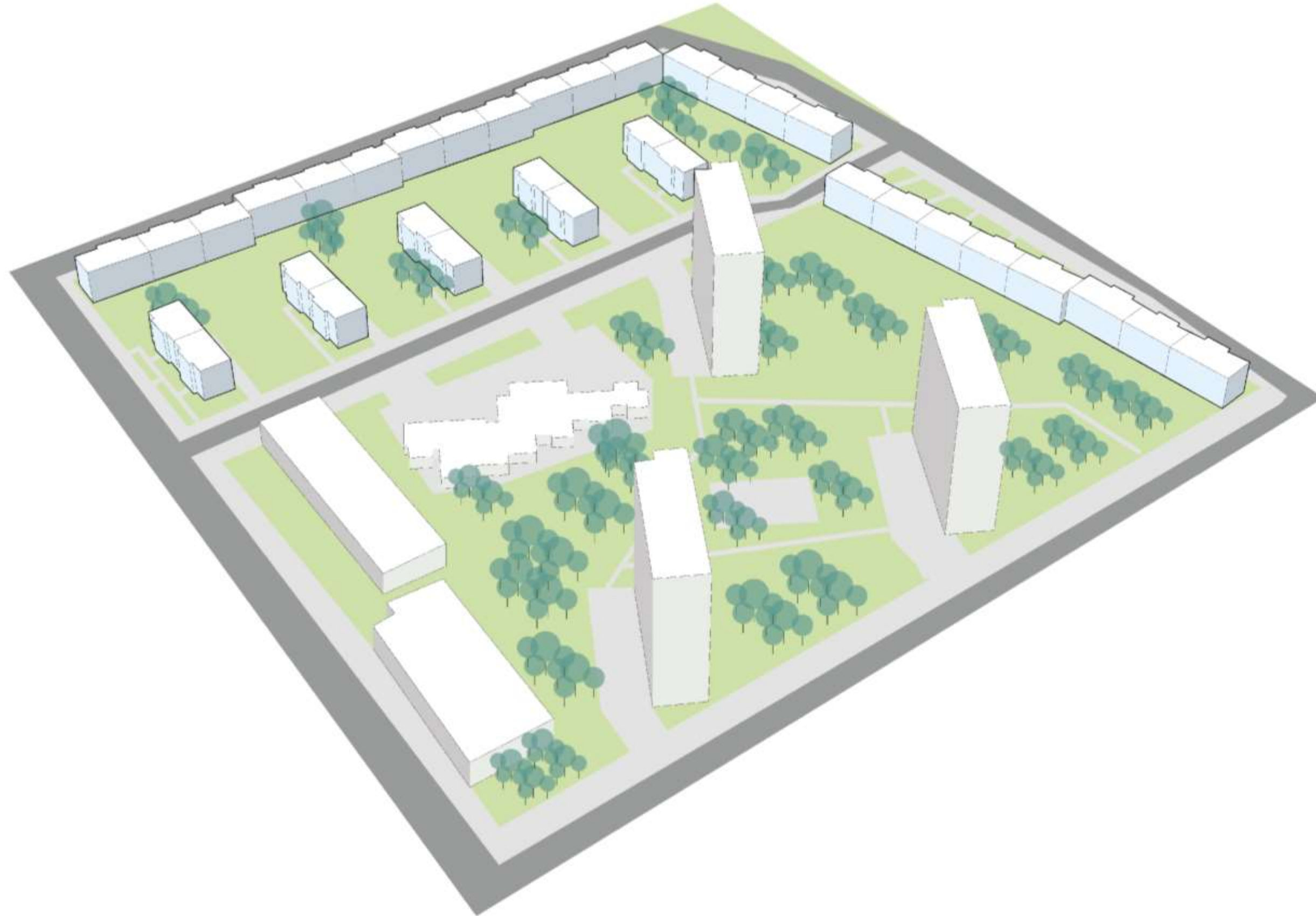
3. Design



3. Design



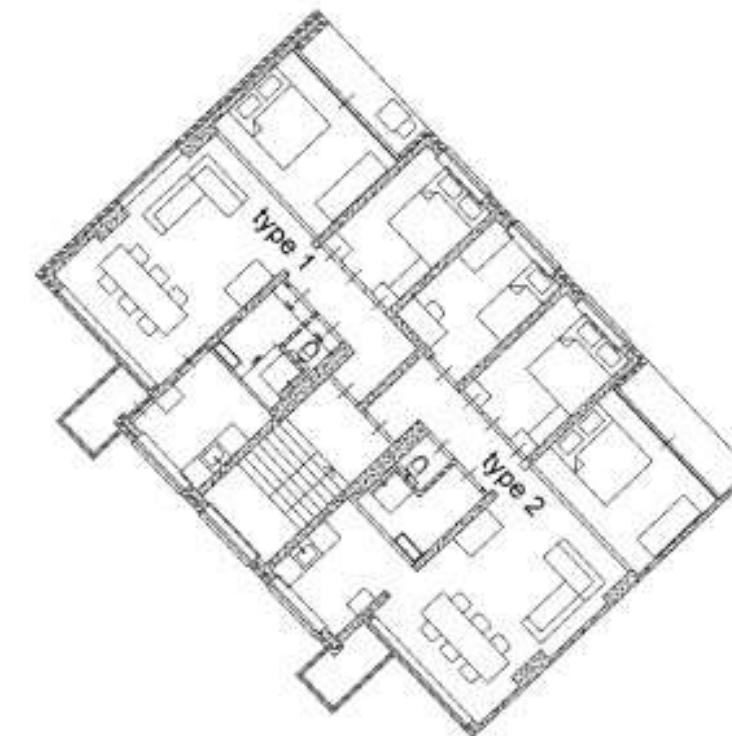
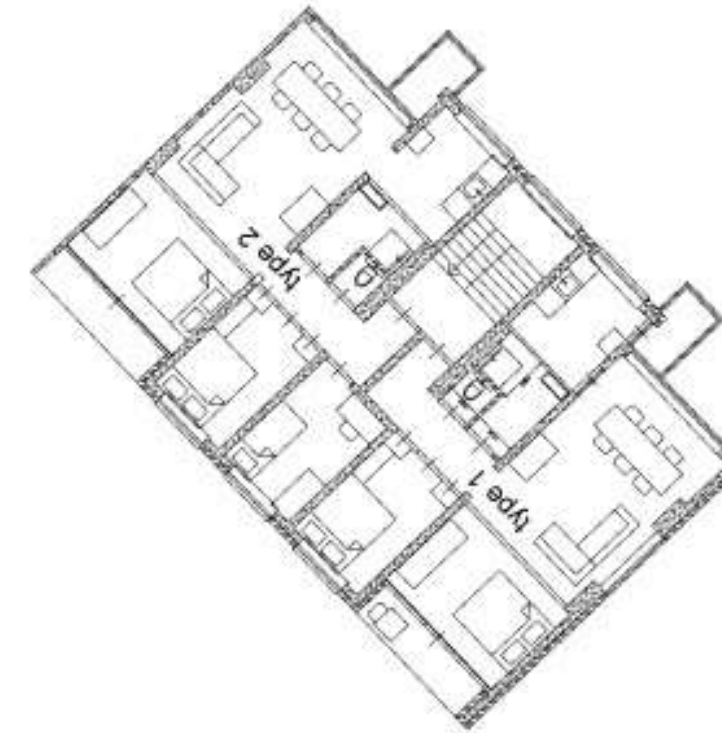
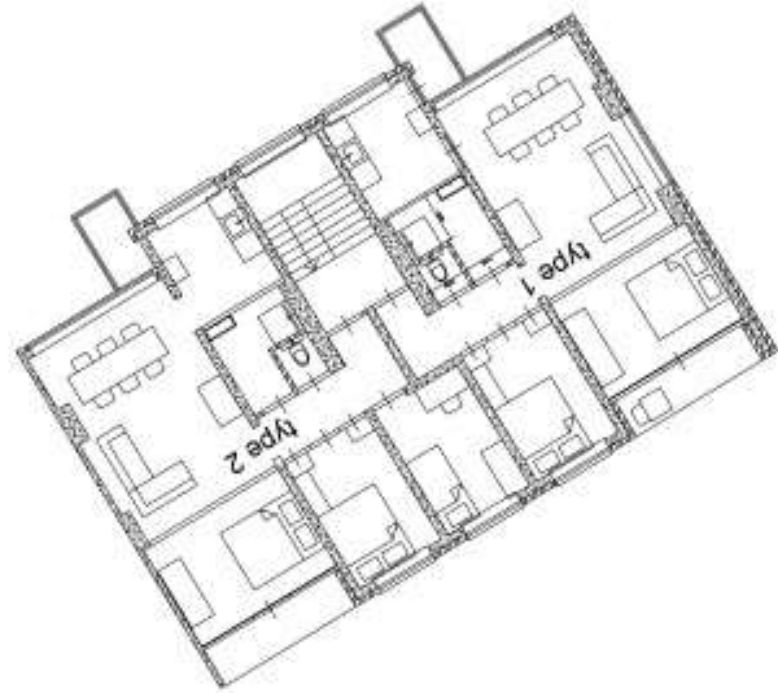
3. Design



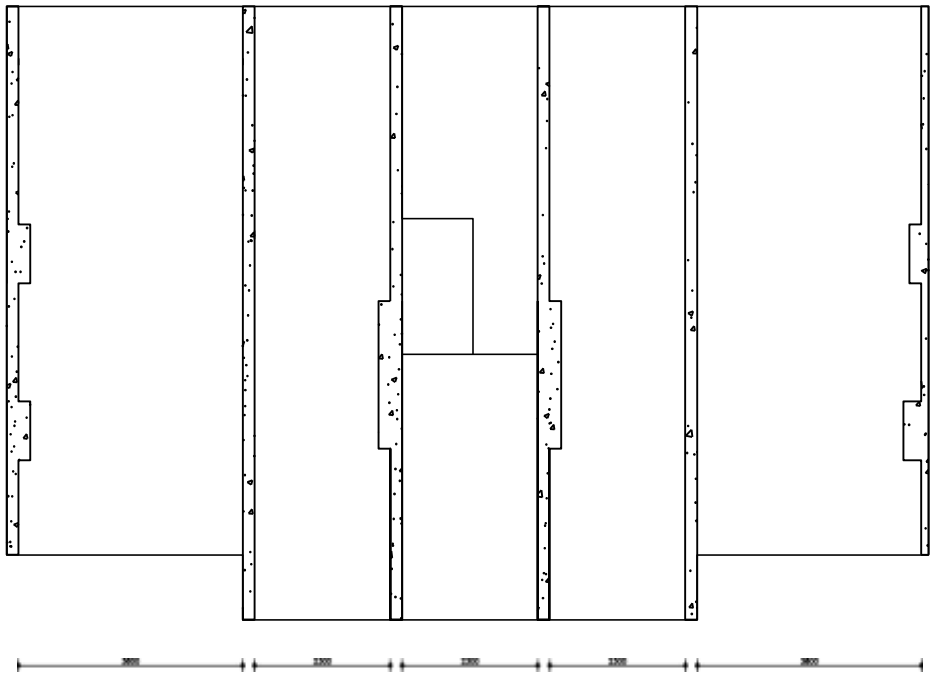
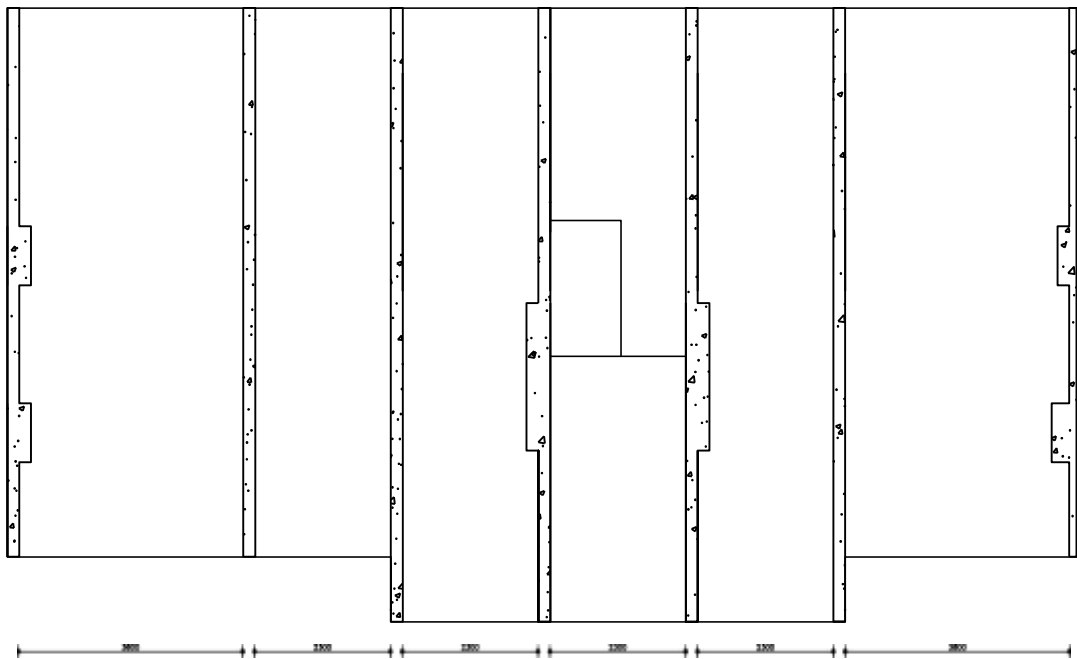
3. Design



3. Design

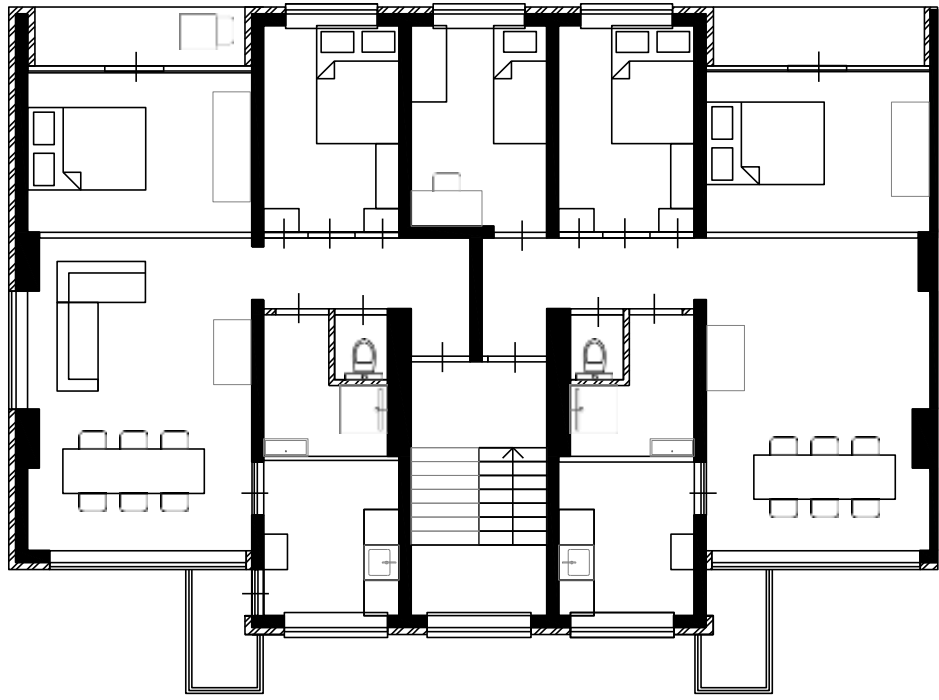


3. Design



type 3
78.3 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

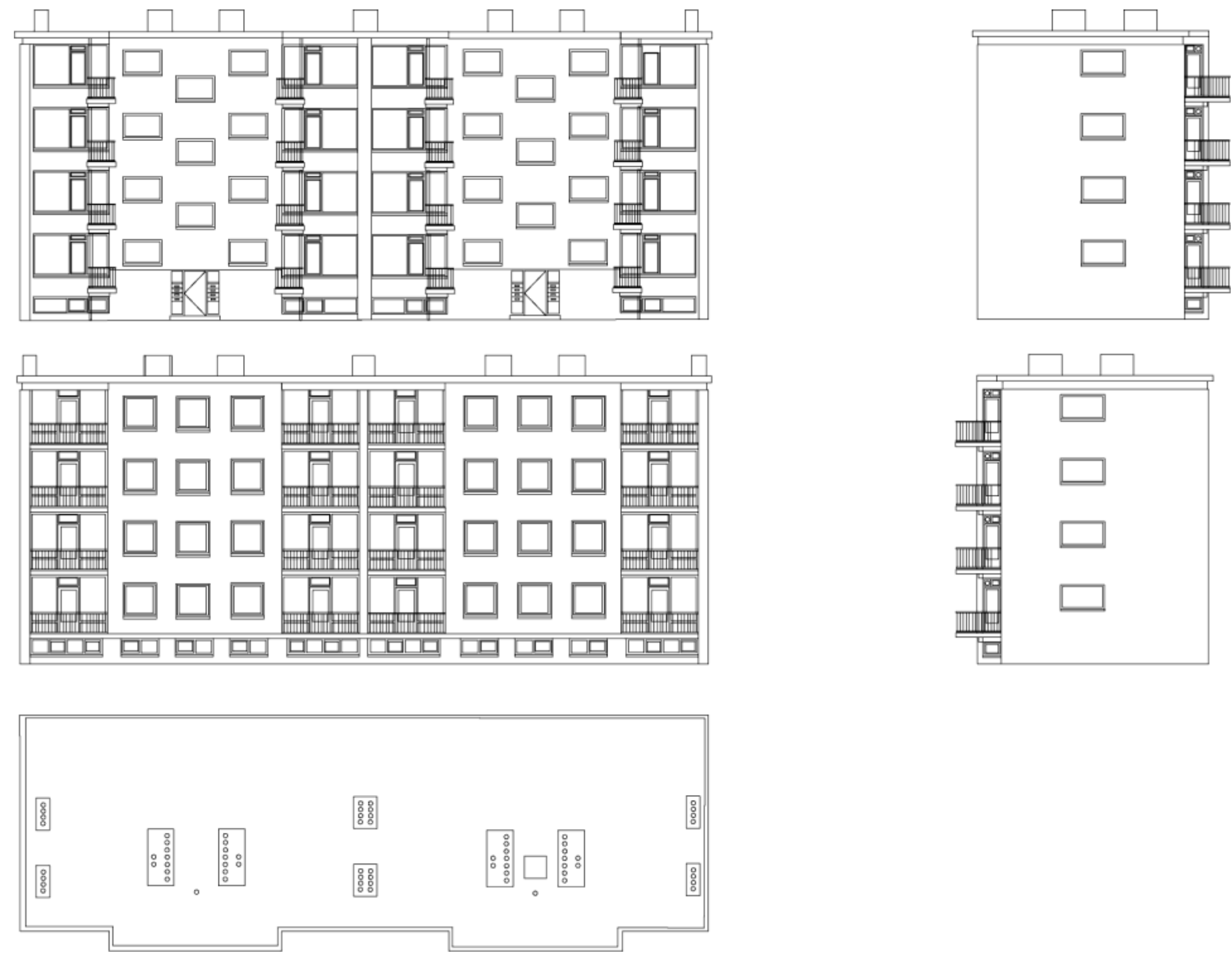
type 2
66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia



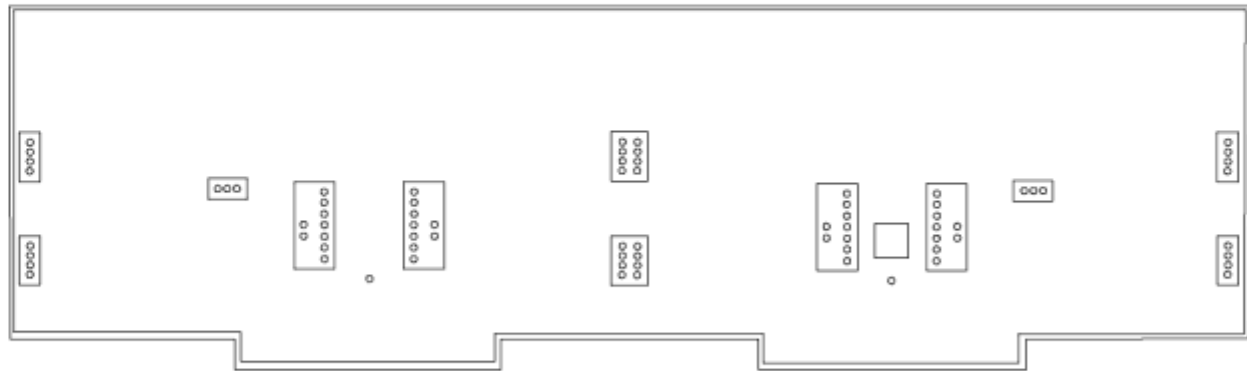
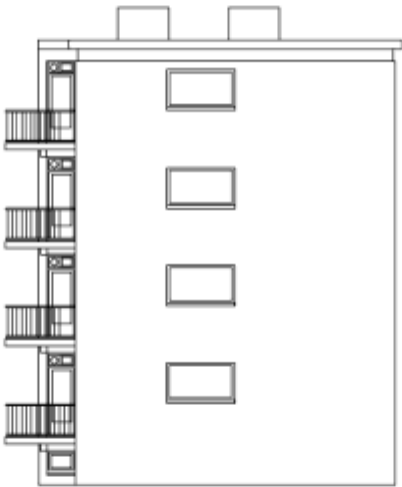
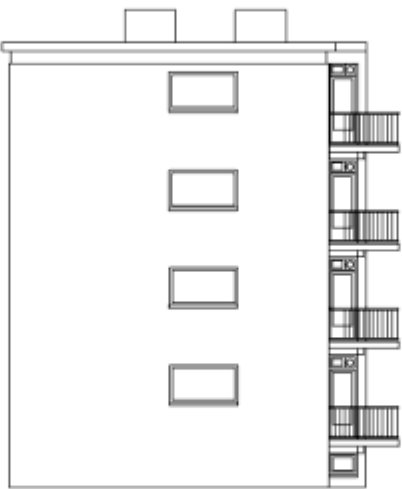
type 1
56.8 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

type 2
66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

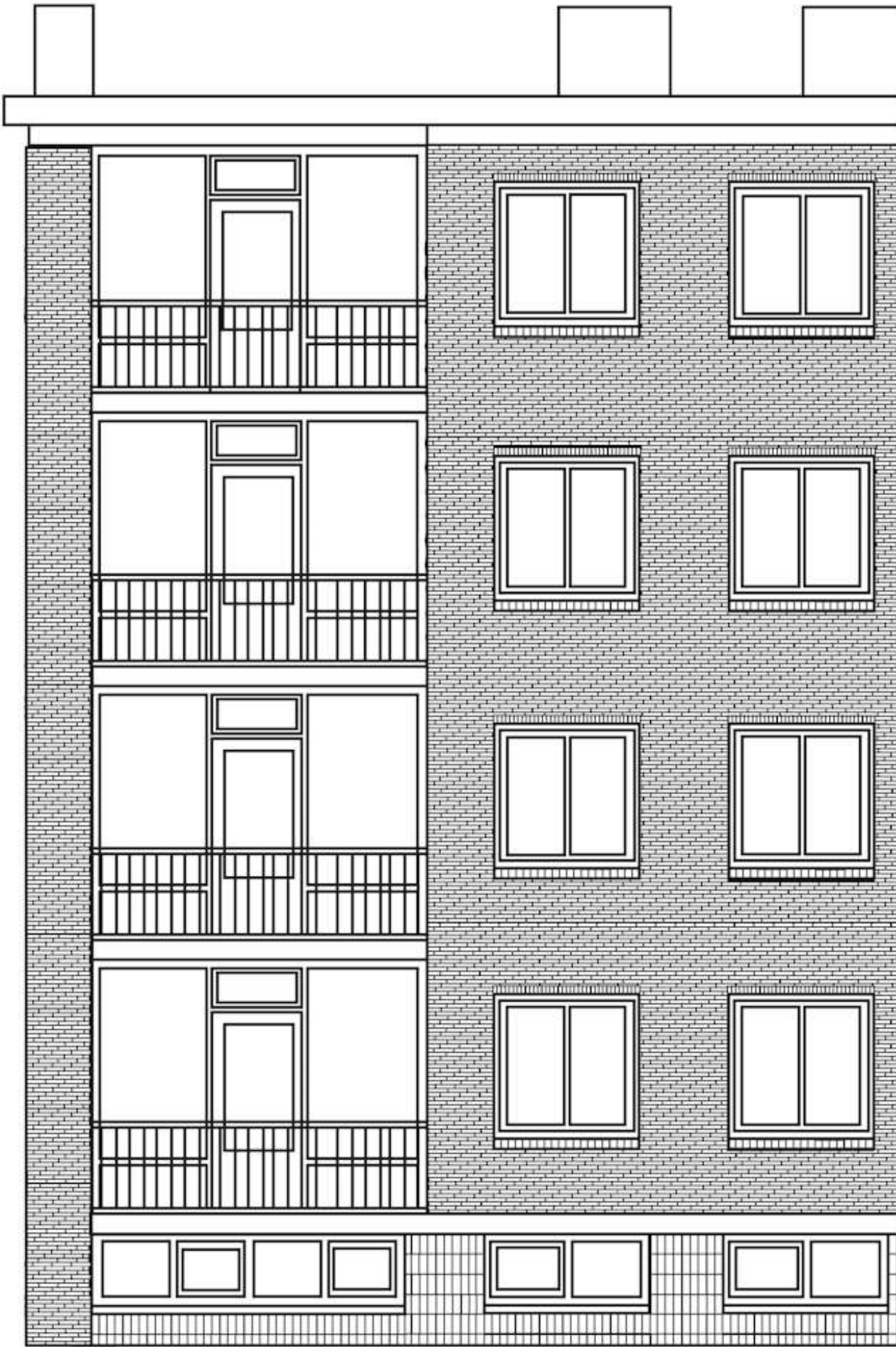
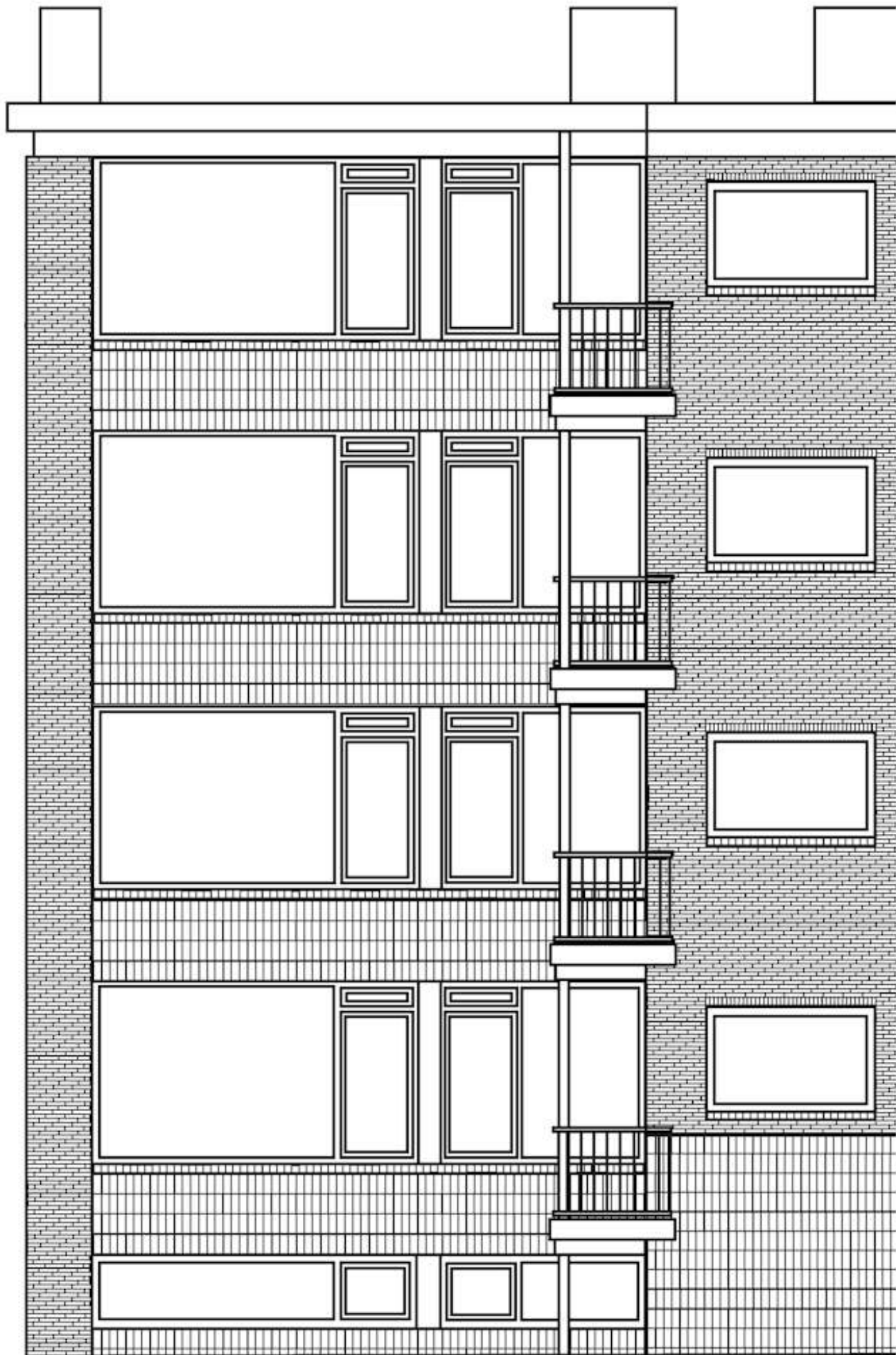
3. Design



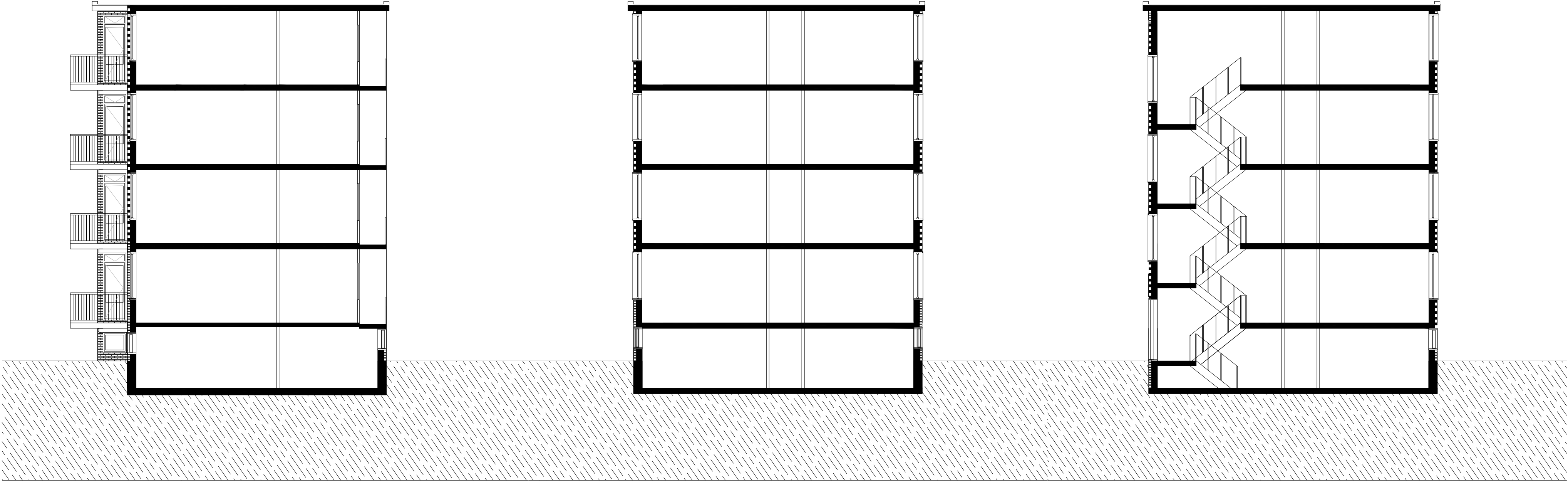
3. Design



3. Design



3. Design



3. Design



3. Design



Type 1

56.8 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

Type 2

66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia



Type 3

78.3 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

Type 2

66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

3. Design

Preperations



Connection facade elements



Changing floor plan



3. Design

Preperations



Connection facade elements

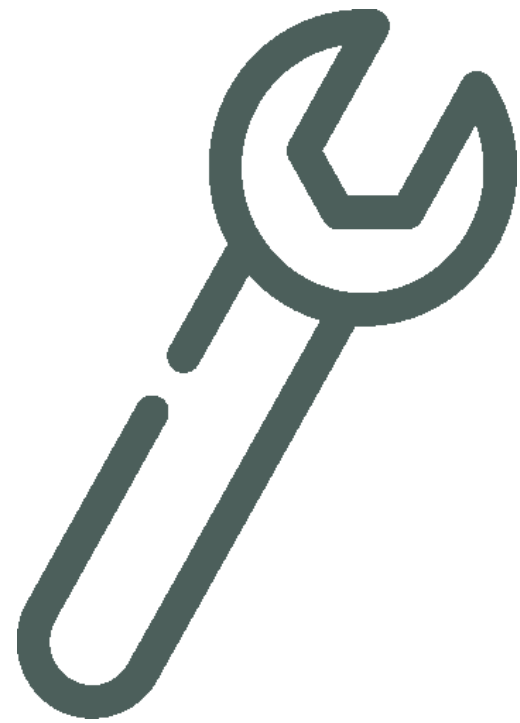


Changing floor plan



3. Design

Preperations



Connection facade elements



Changing floor plan



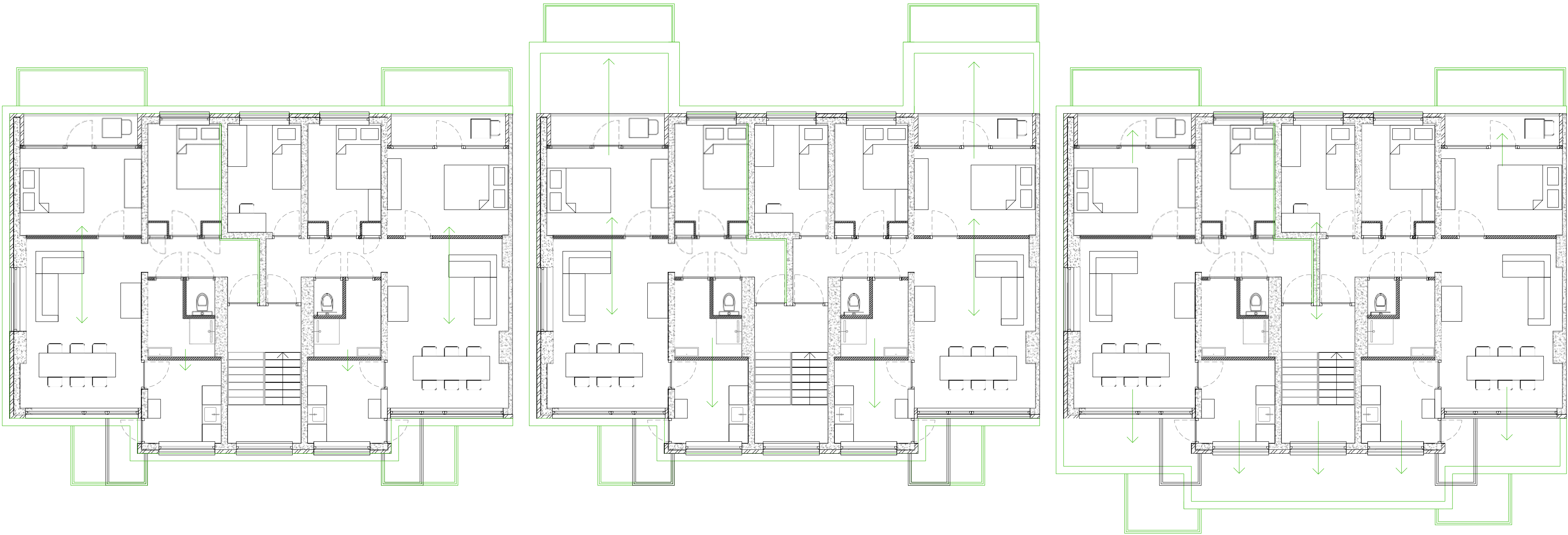
3. Design



Type 1
56.8 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

Type 2
66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

3. Design



Type 1.1
60.4 m2 Living
7.4 m2 Balcony

Type 2.1
70 m2 Living
7.4 m2 Balcony

Type 1.2
67.9 m2 Living
7.4 m2 Balcony

Type 2.2
77.5 m2 Living
7.4 m2 Balcony

Type 1.3
75.9 m2 Living
8.8 m2 Balcony

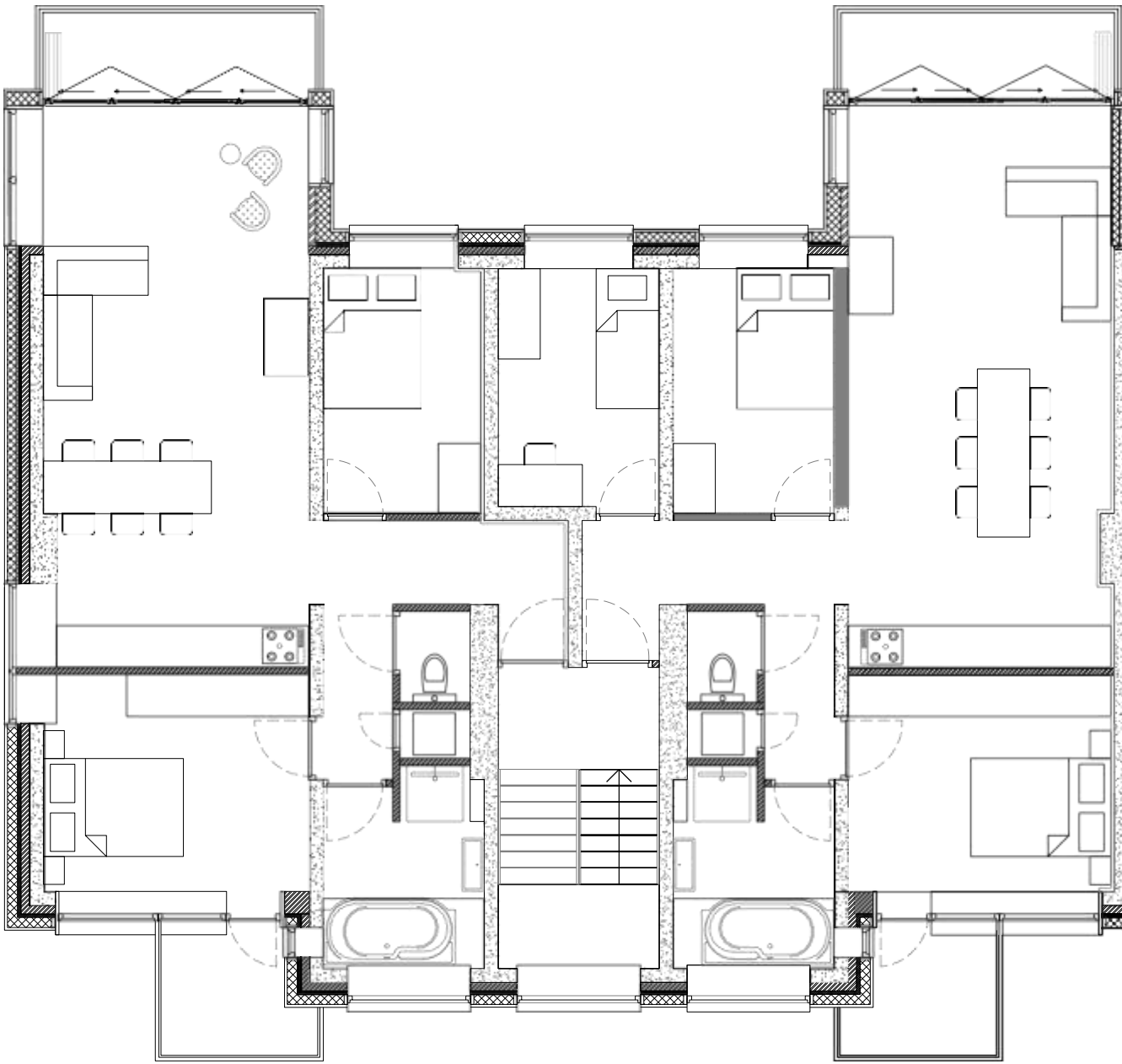
Type 2.3
78.9 m2 Living
8.8 m2 Balcony

3. Design



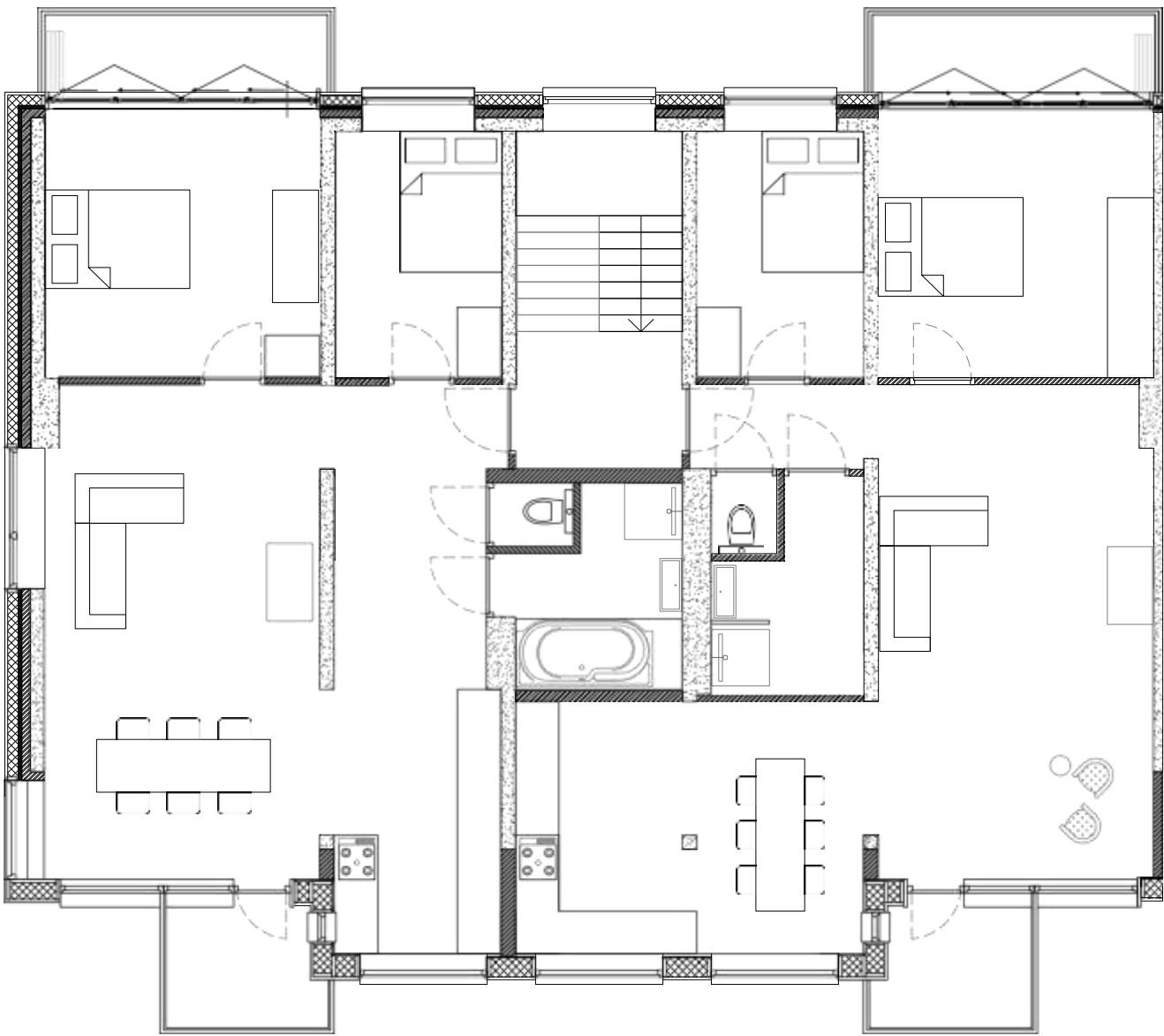
Type 1.1
60.4 m2 Living
7.4 m2 Balcony

Type 2.1
70 m2 Living
7.4 m2 Balcony



Type 1.2
67.9 m2 Living
7.4 m2 Balcony

Type 2.2
77.5 m2 Living
7.4 m2 Balcony



Type 1.3
75.9 m2 Living
8.8 m2 Balcony

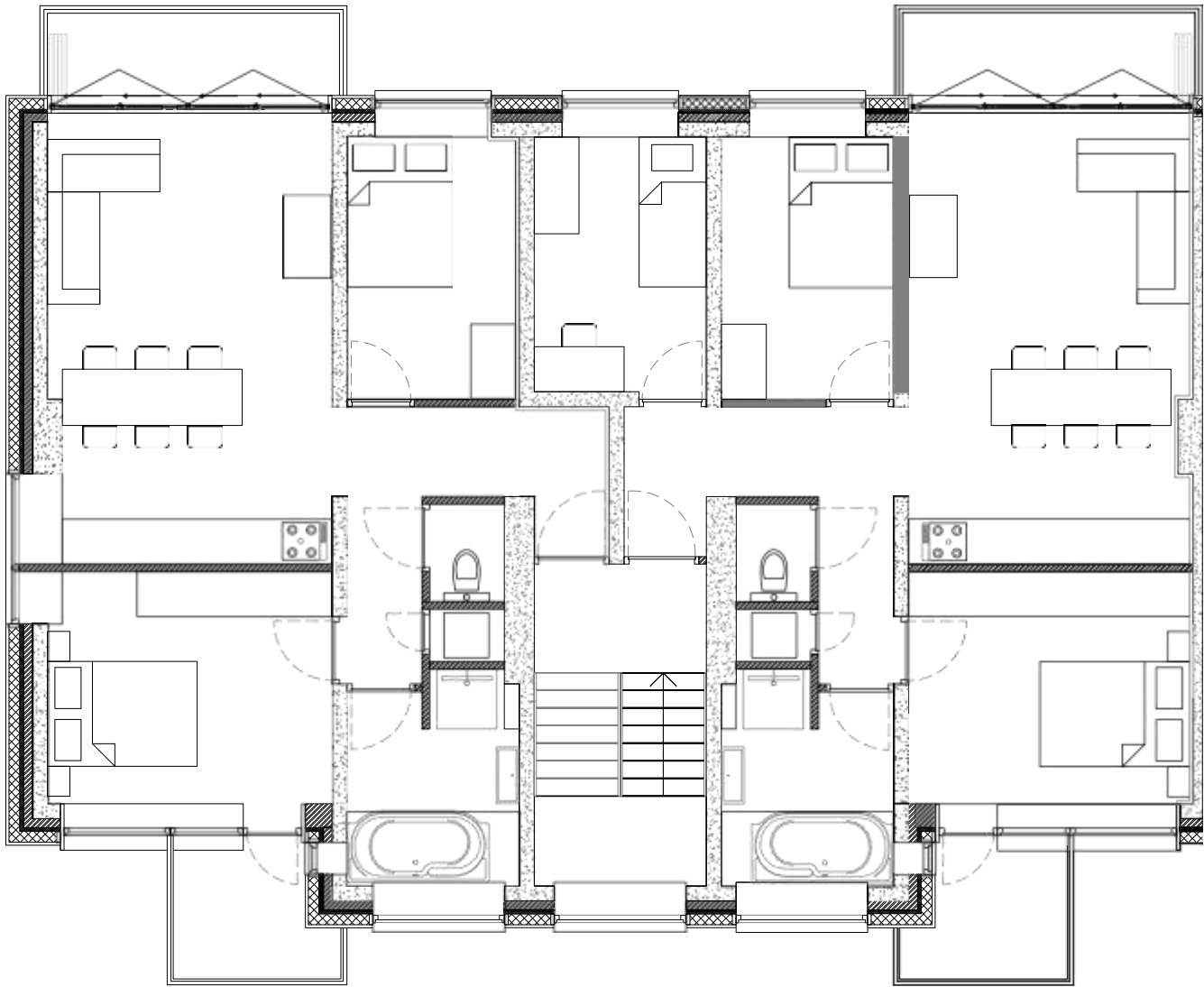
Type 2.3
78.9 m2 Living
8.8 m2 Balcony

3. Design



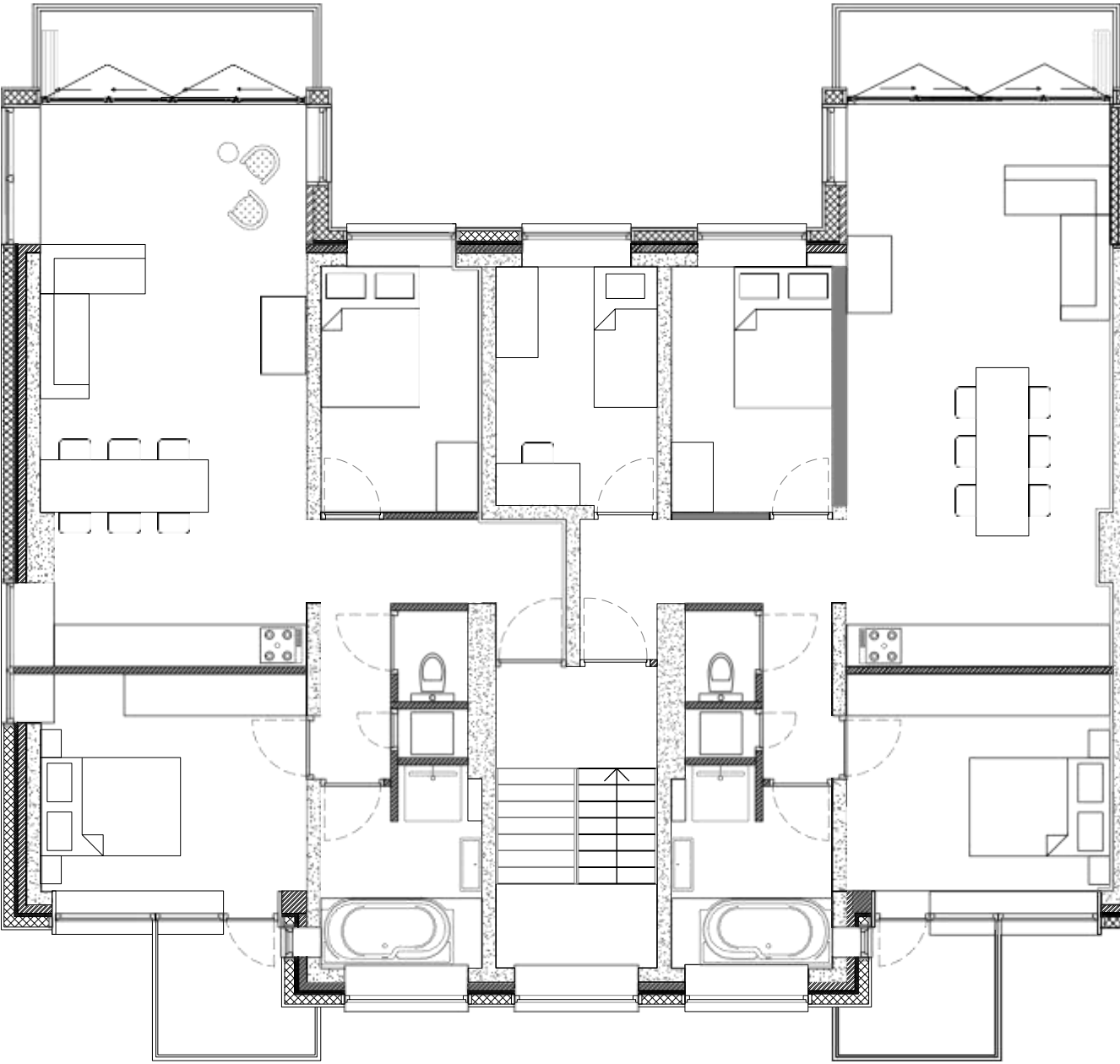
Type 1
56.8 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

Type 2
66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia



Type 1.1
60.4 m2 Living
7.4 m2 Balcony

Type 2.1
70 m2 Living
7.4 m2 Balcony



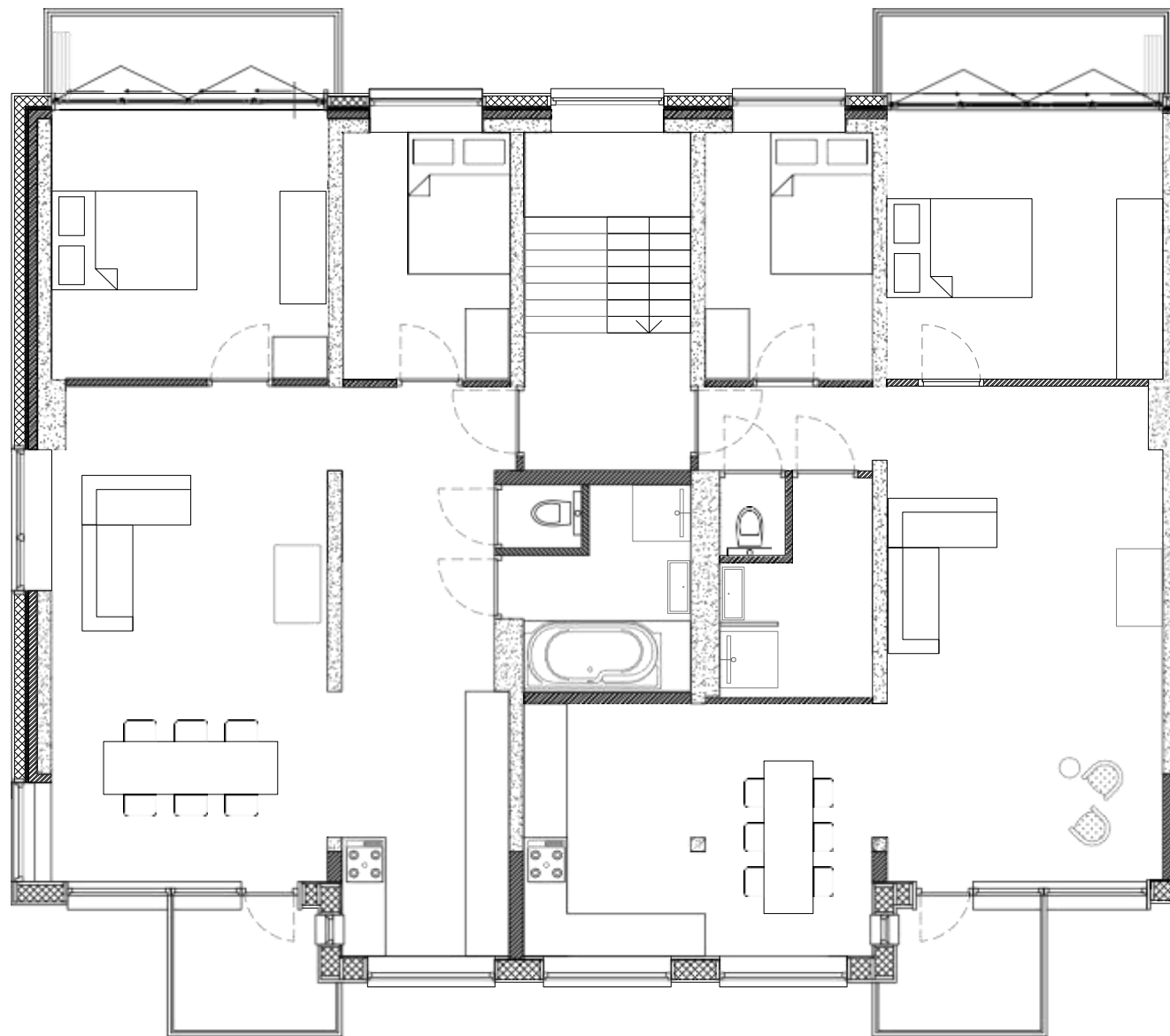
Type 1.2
67.9 m2 Living
7.4 m2 Balcony

Type 2.2
77.5 m2 Living
7.4 m2 Balcony

3. Design



Type 1	Type 2
56.8 m2 Living	66.4 m2 Living
2.3 m2 Balcony	2.3 m2 Balcony
3.6 m2 Logia	3.6 m2 Logia



Type 1.3	Type 2.3
75.9 m2 Living	78.9 m2 Living
8.8 m2 Balcony	8.8 m2 Balcony

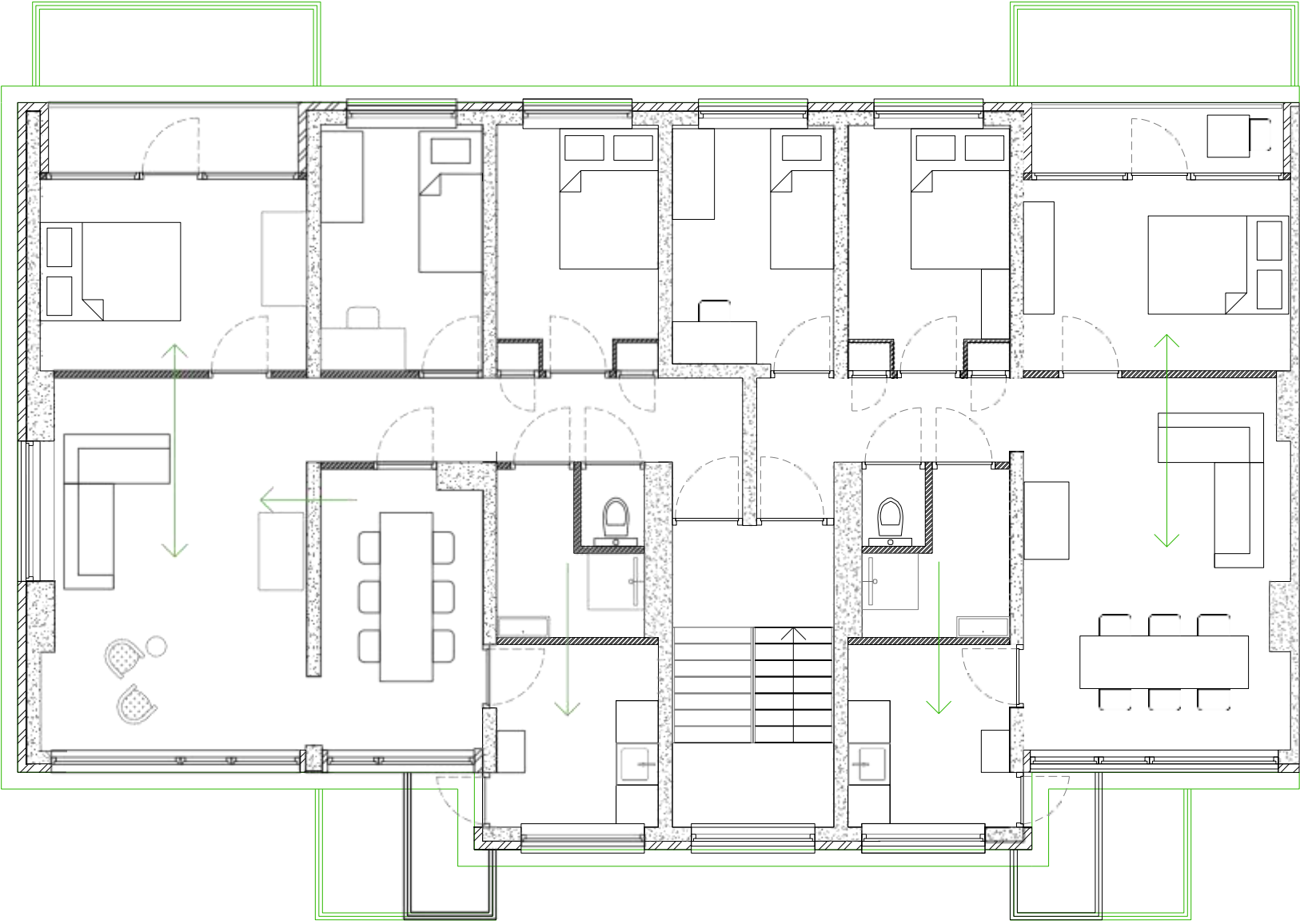
3. Design



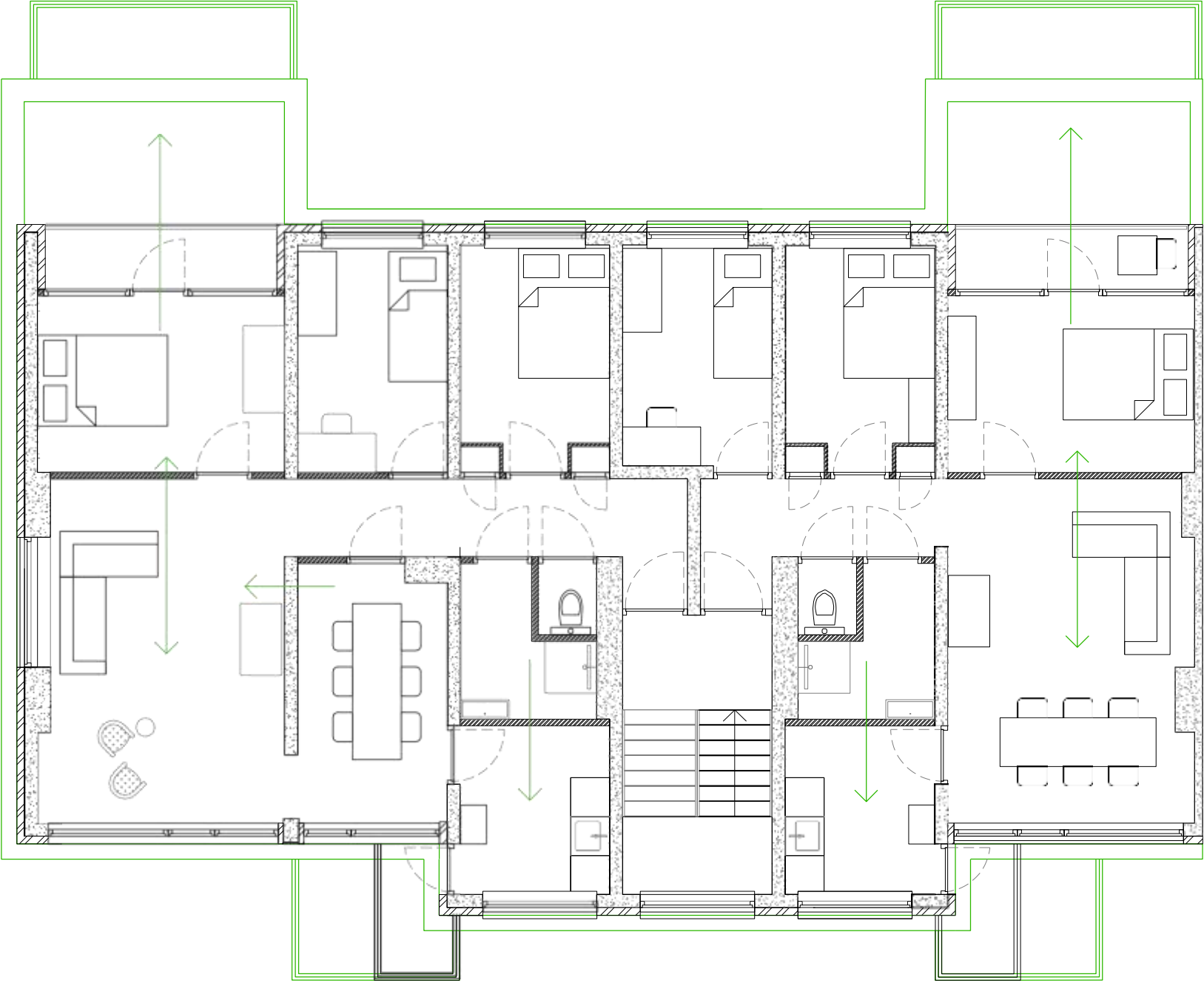
Type 3
78.3 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

Type 2
66.4 m2 Living
2.3 m2 Balcony
3.6 m2 Logia

3. Design

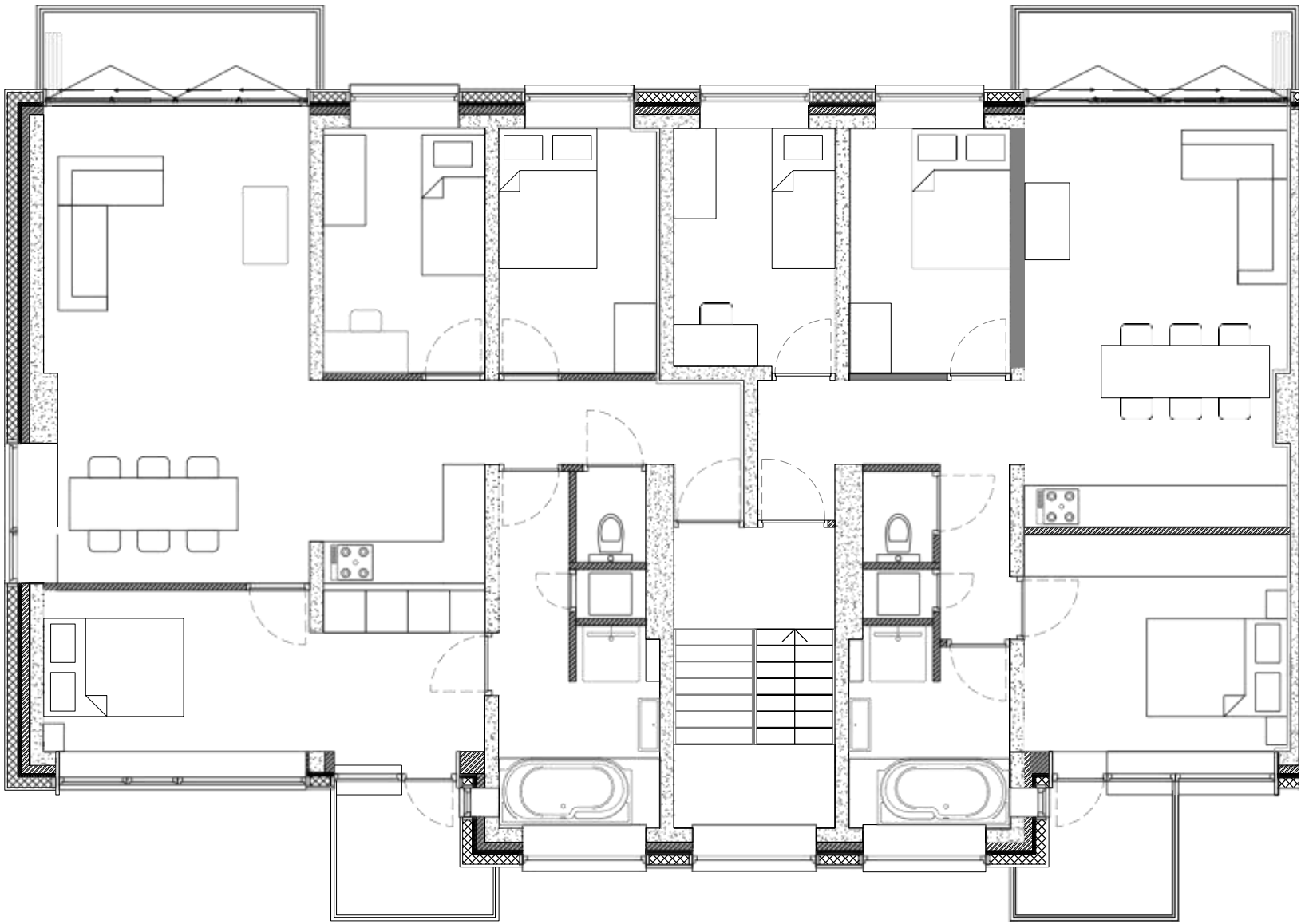


Type 3.1	Type 2.1
81.9 m2 Living	70 m2 Living
7.4 m2 Balcony	7.4 m2 Balcony



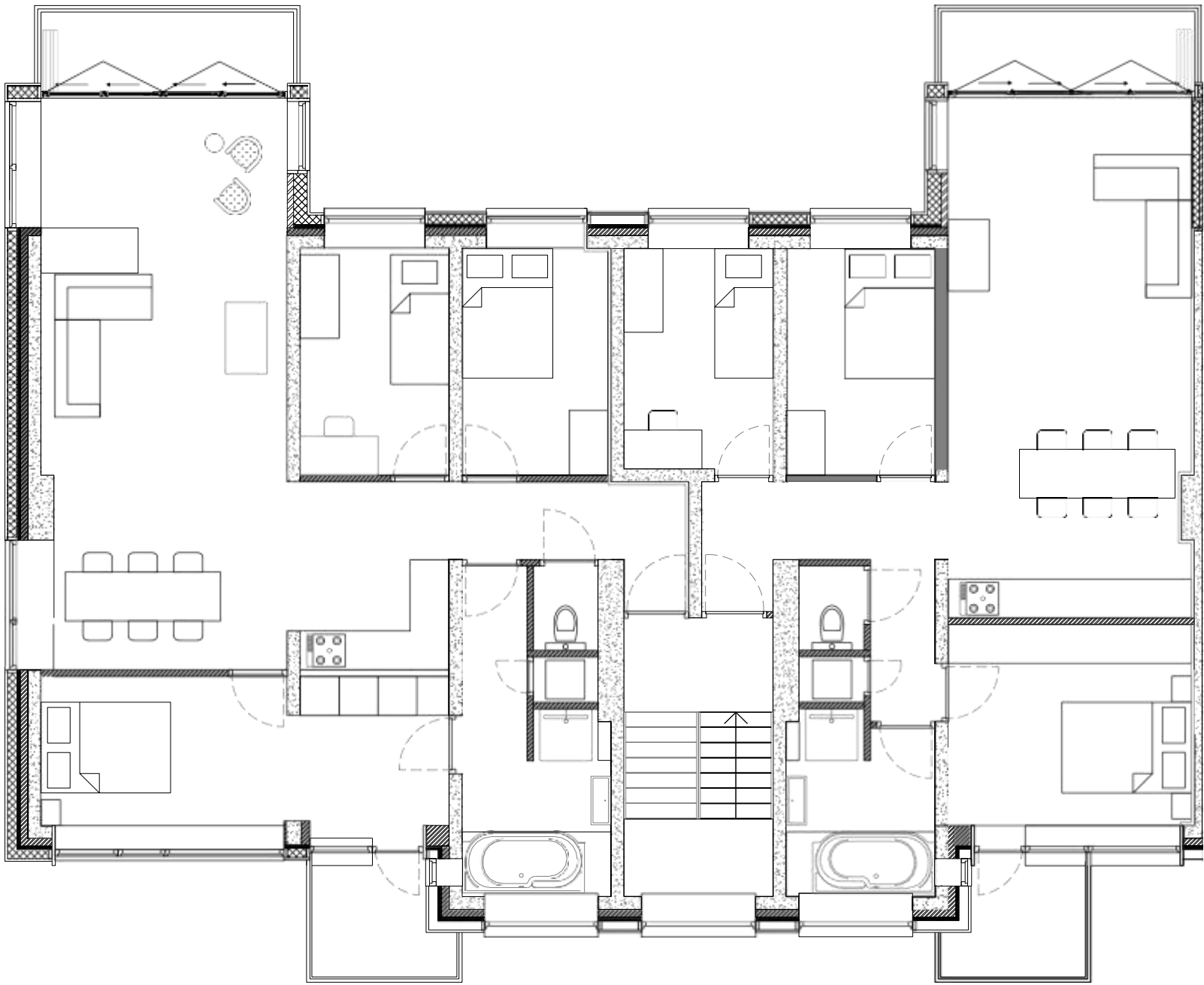
Type 3.2	Type 2.2
89.4 m2 Living	77.5 m2 Living
7.4 m2 Balcony	7.4 m2 Balcony

3. Design



Type 3.1
81.9 m2 Living
7.4 m2 Balcony

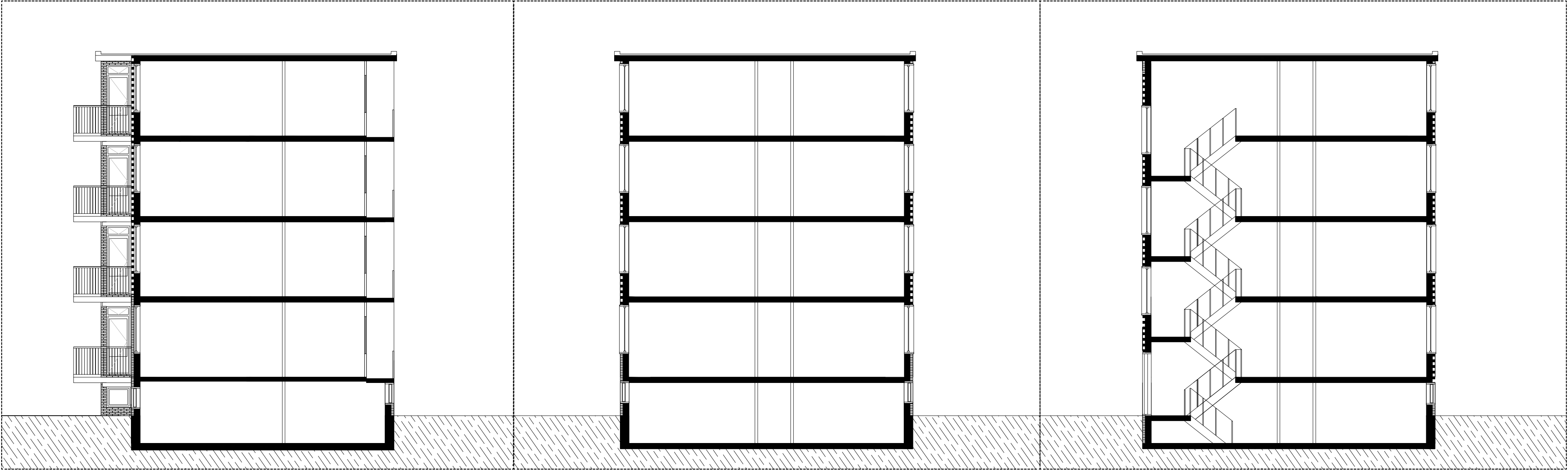
Type 2.1
70 m2 Living
7.4 m2 Balcony



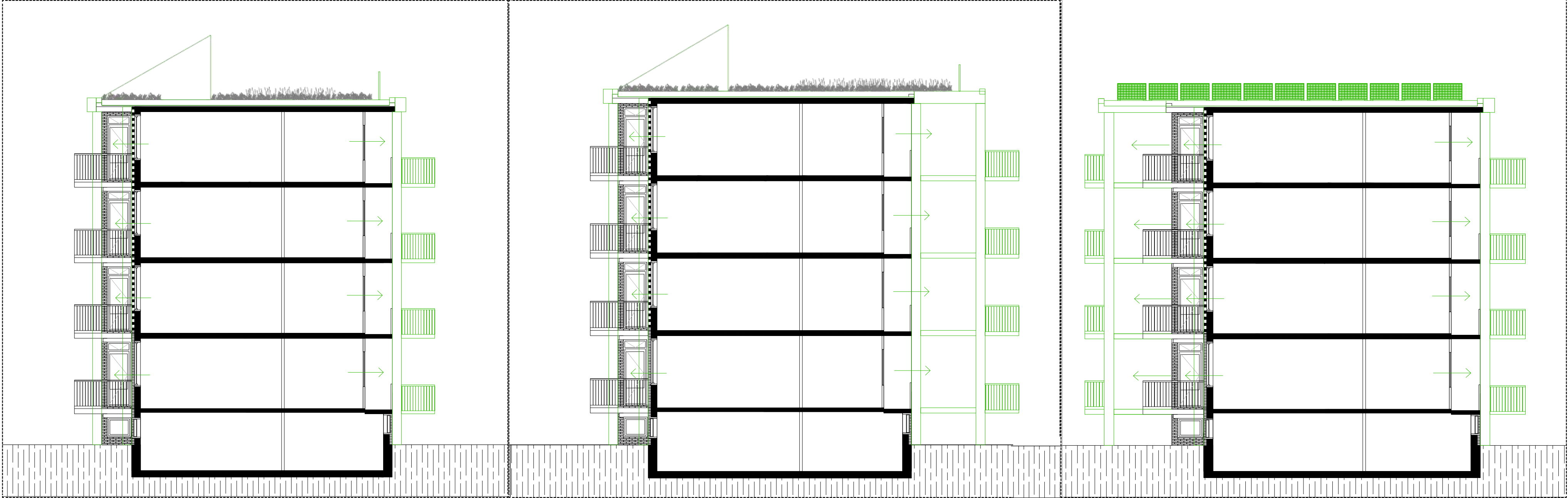
Type 3.2
89.4 m2 Living
7.4 m2 Balcony

Type 2.2
77.5 m2 Living
7.4 m2 Balcony

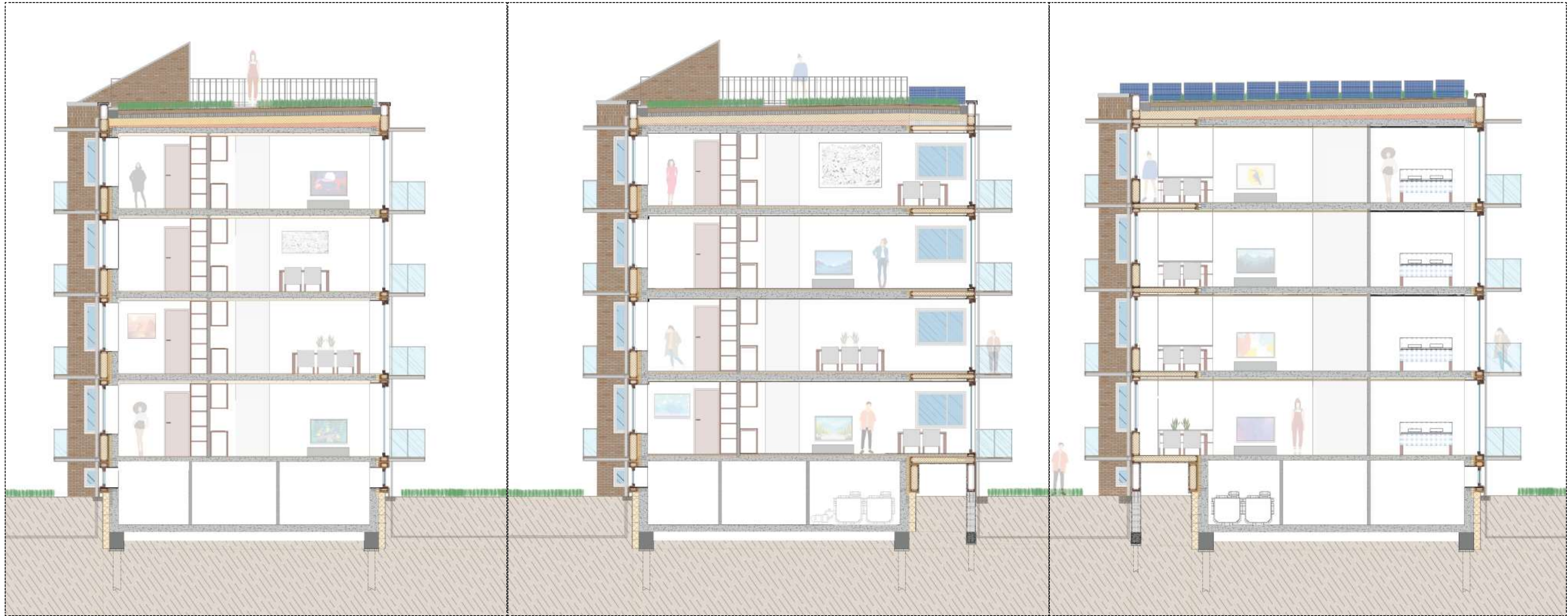
3. Design



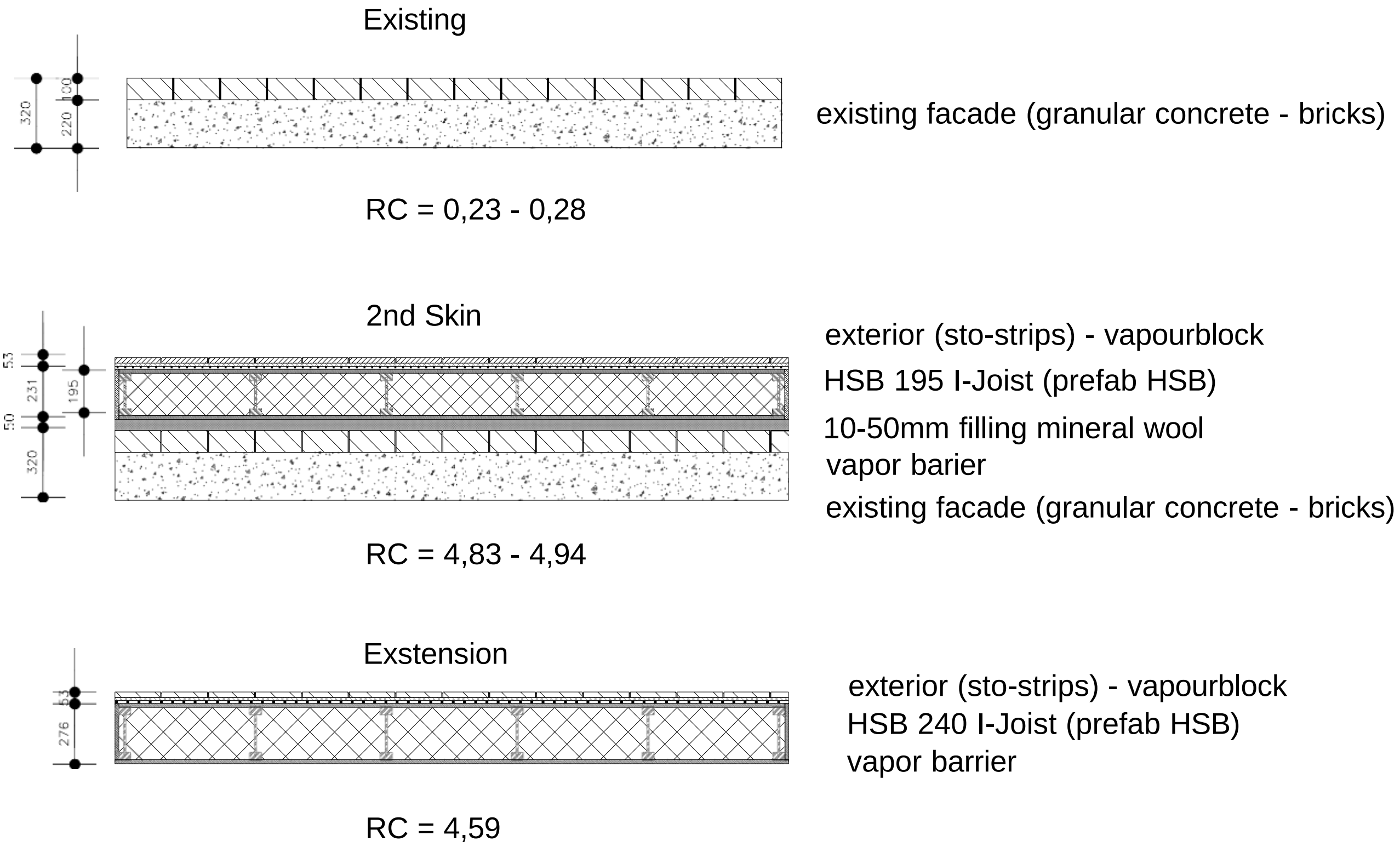
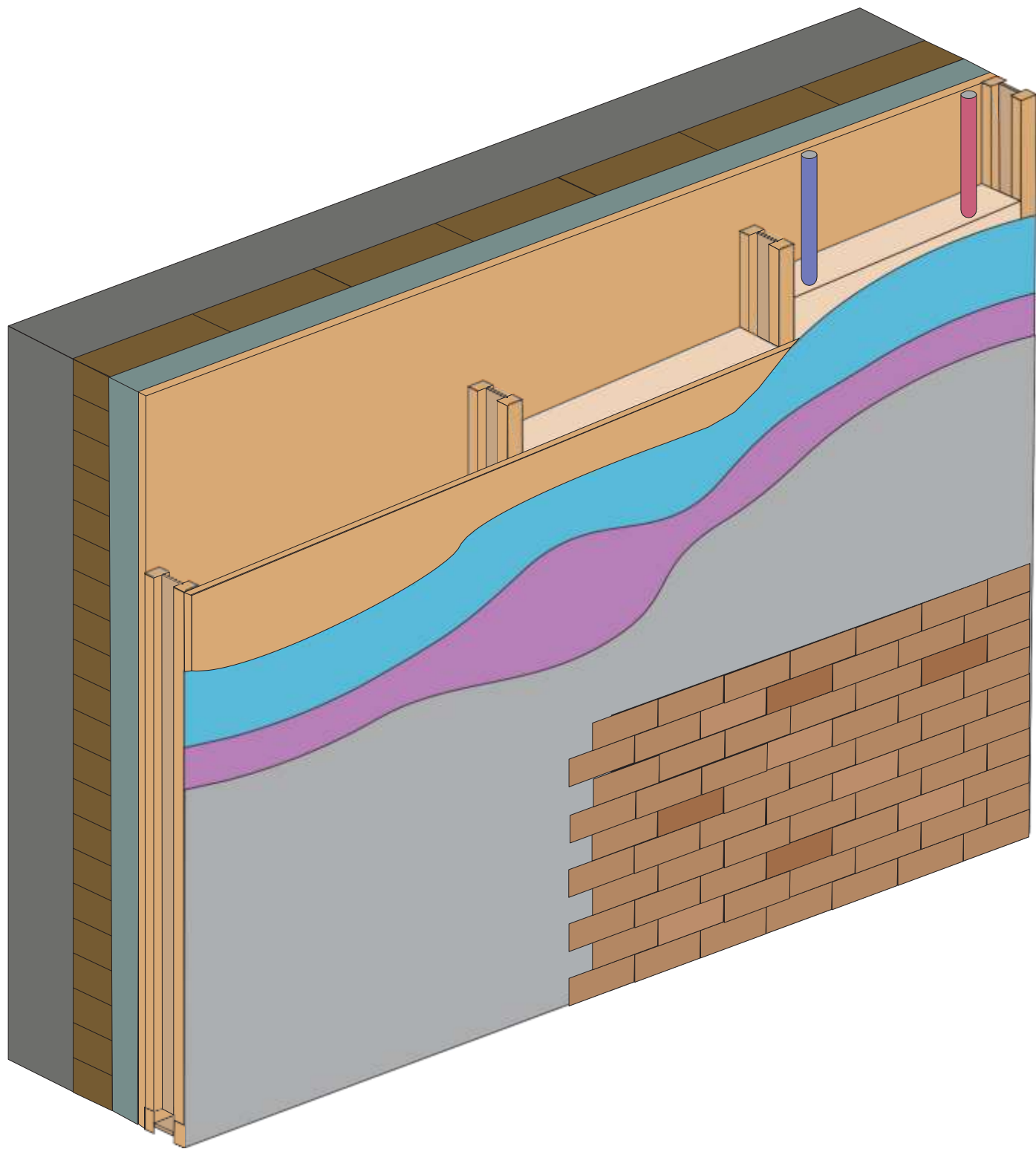
3. Design



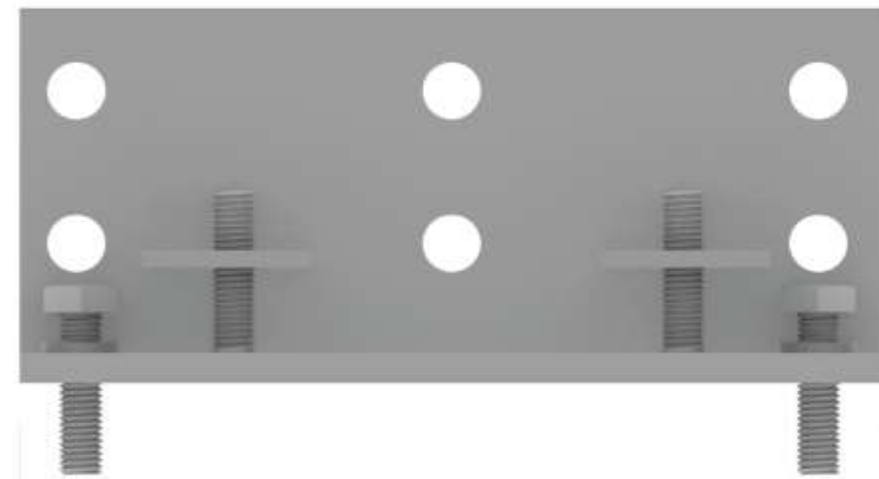
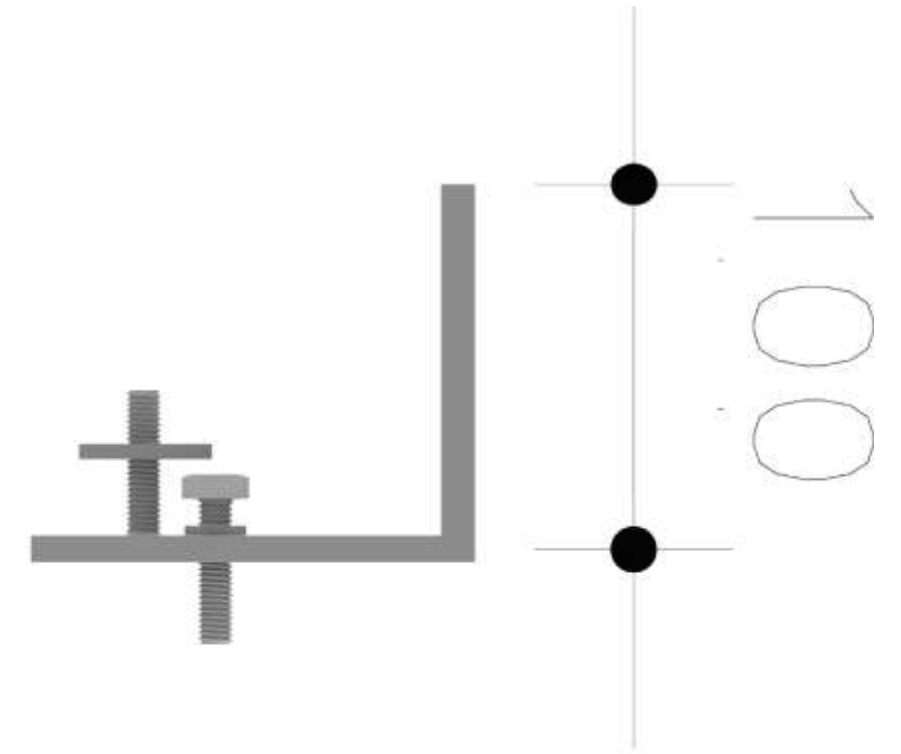
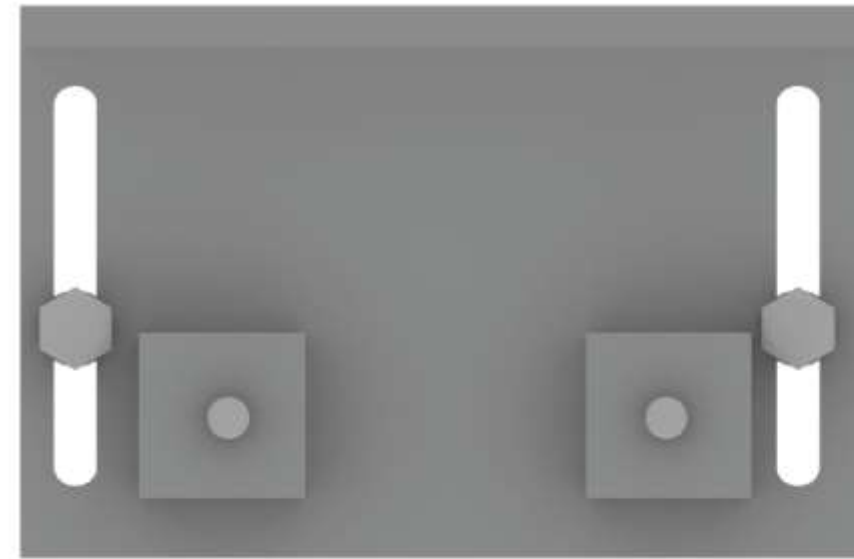
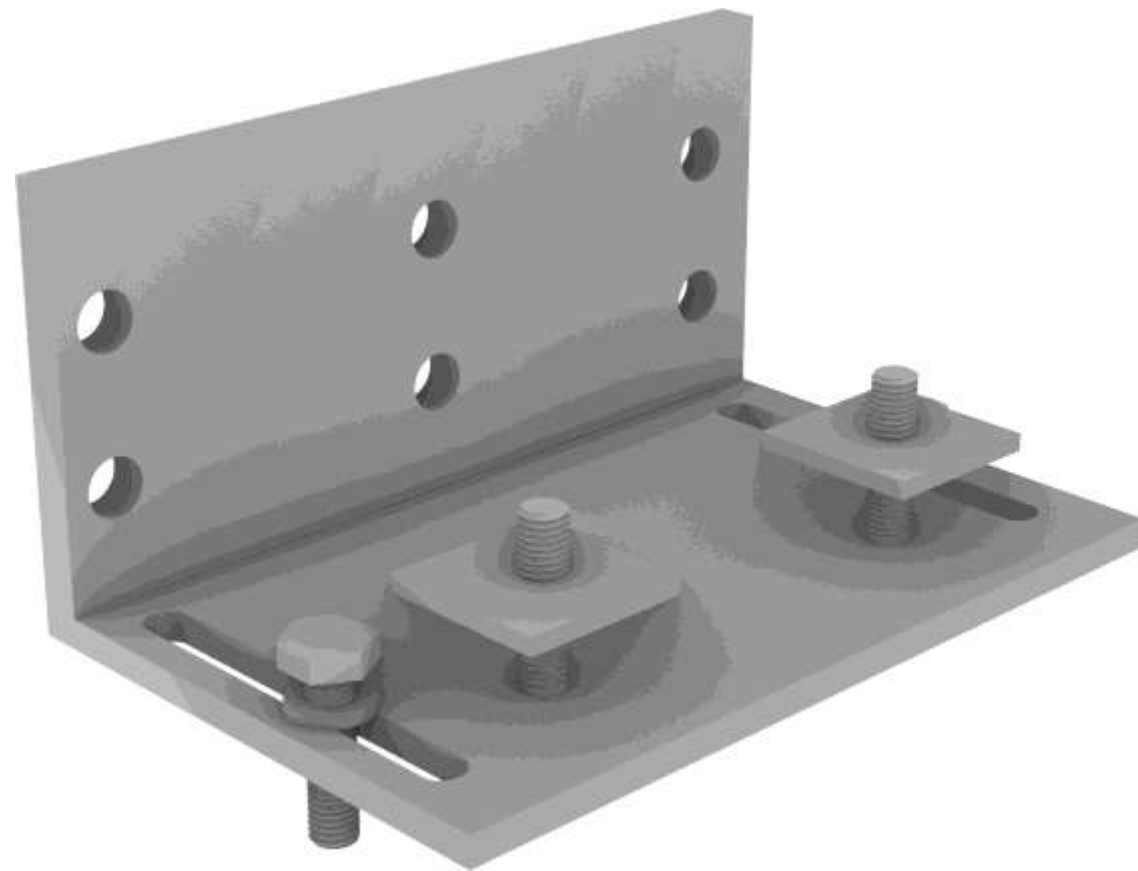
3. Design



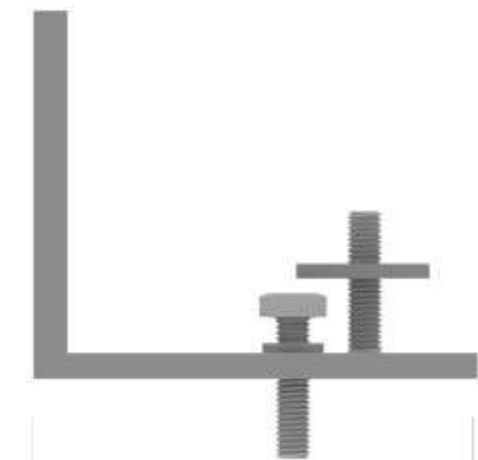
3. Design



3. Design

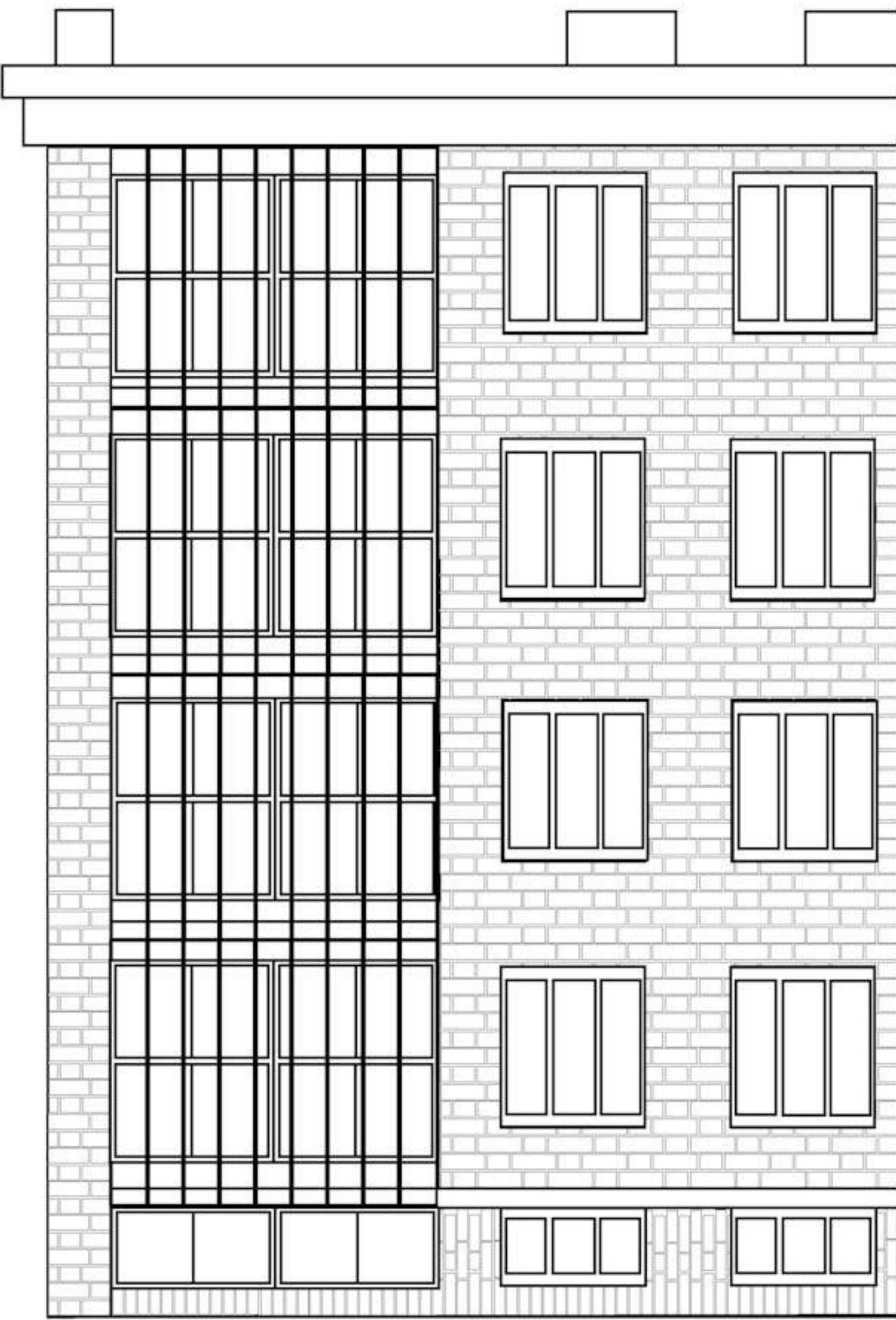


200

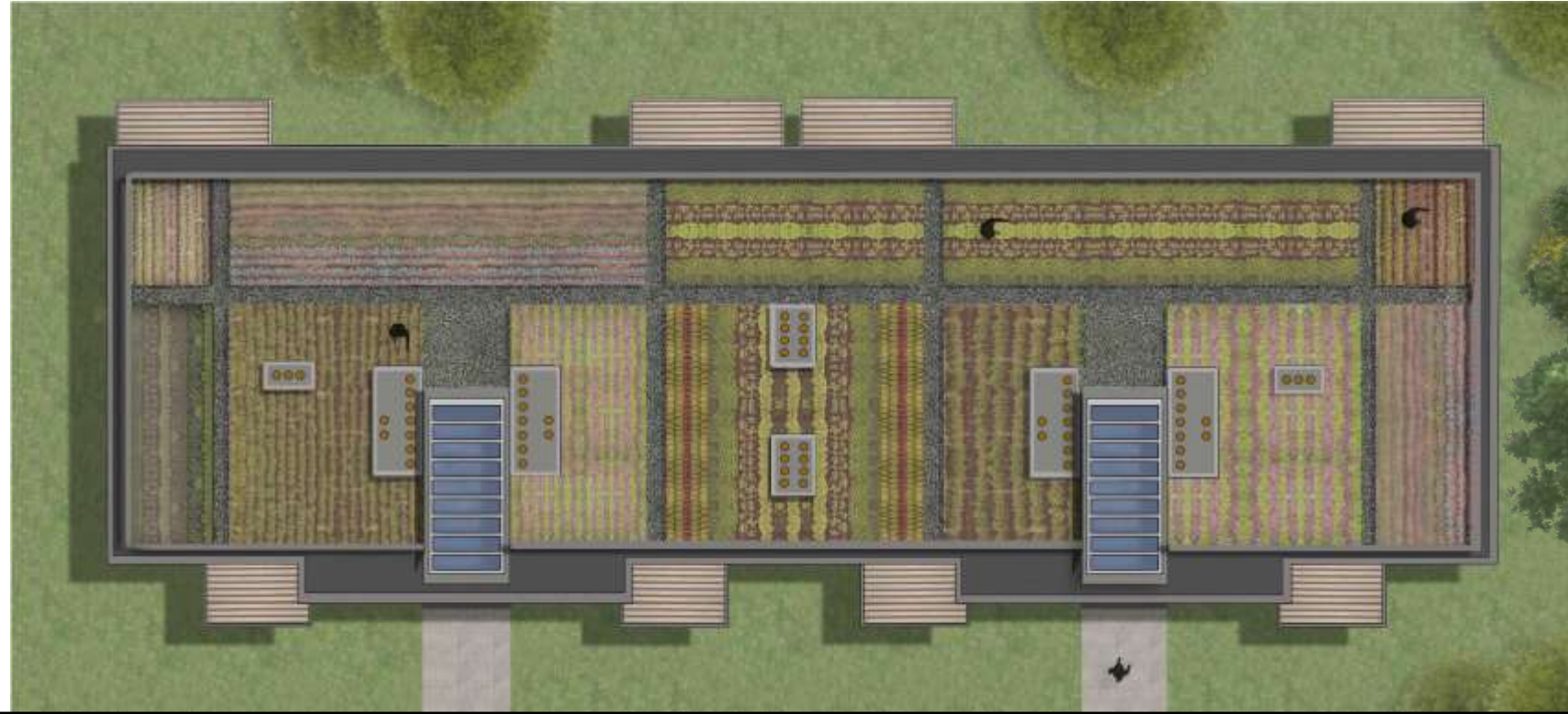


130

3. Design



3. Design



3. Design



3. Design



3. Design



3. Design



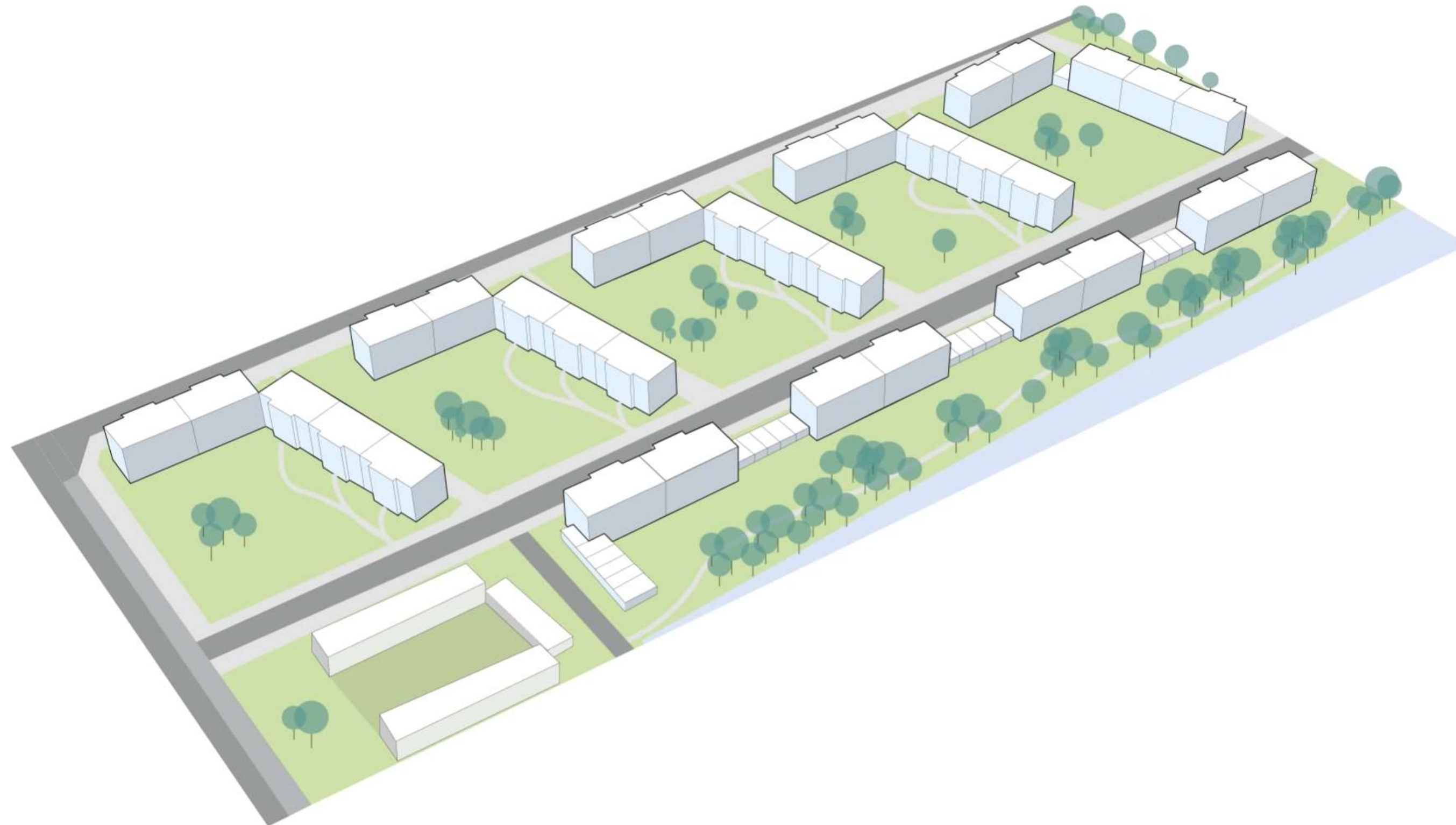




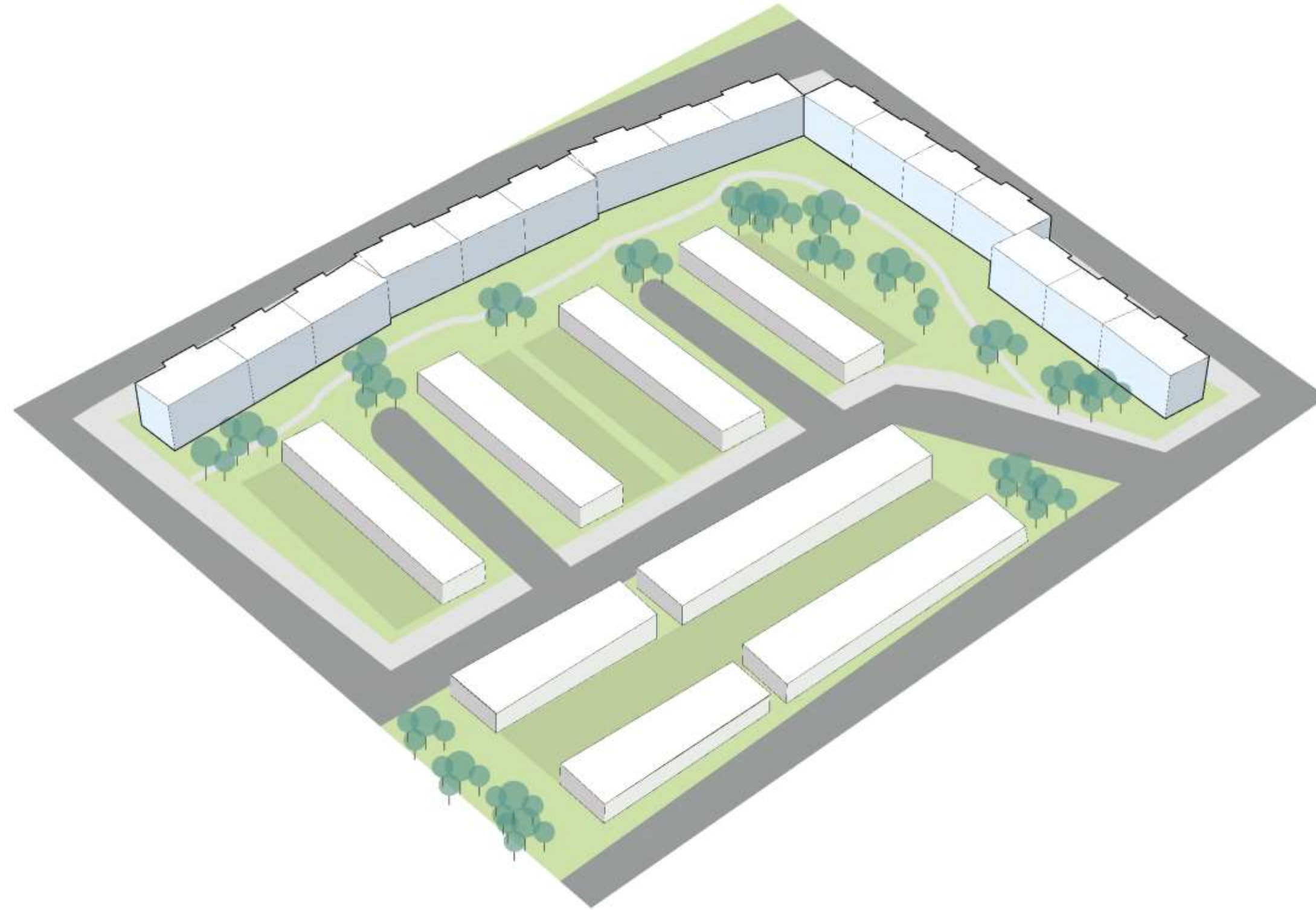




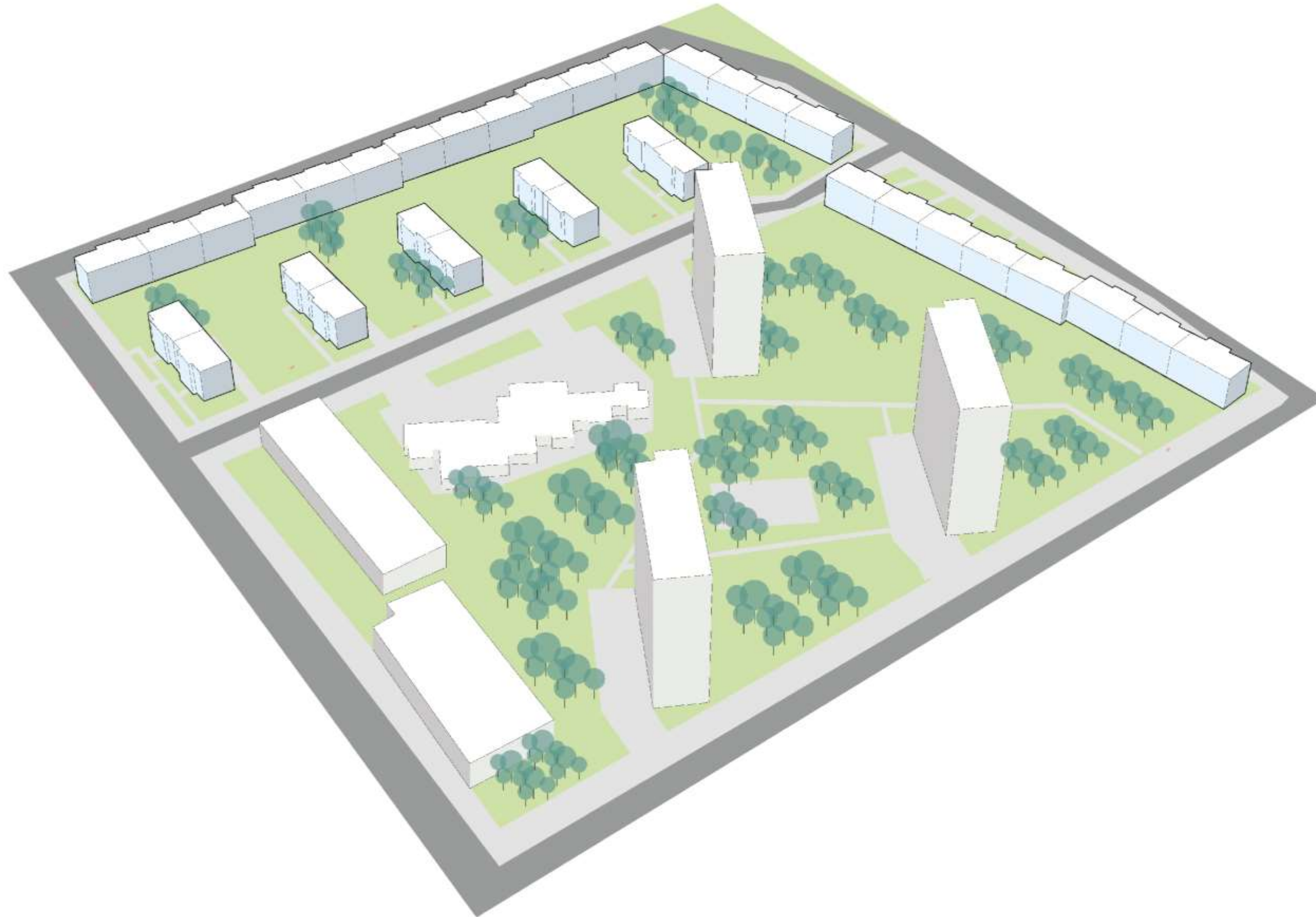
3. Design



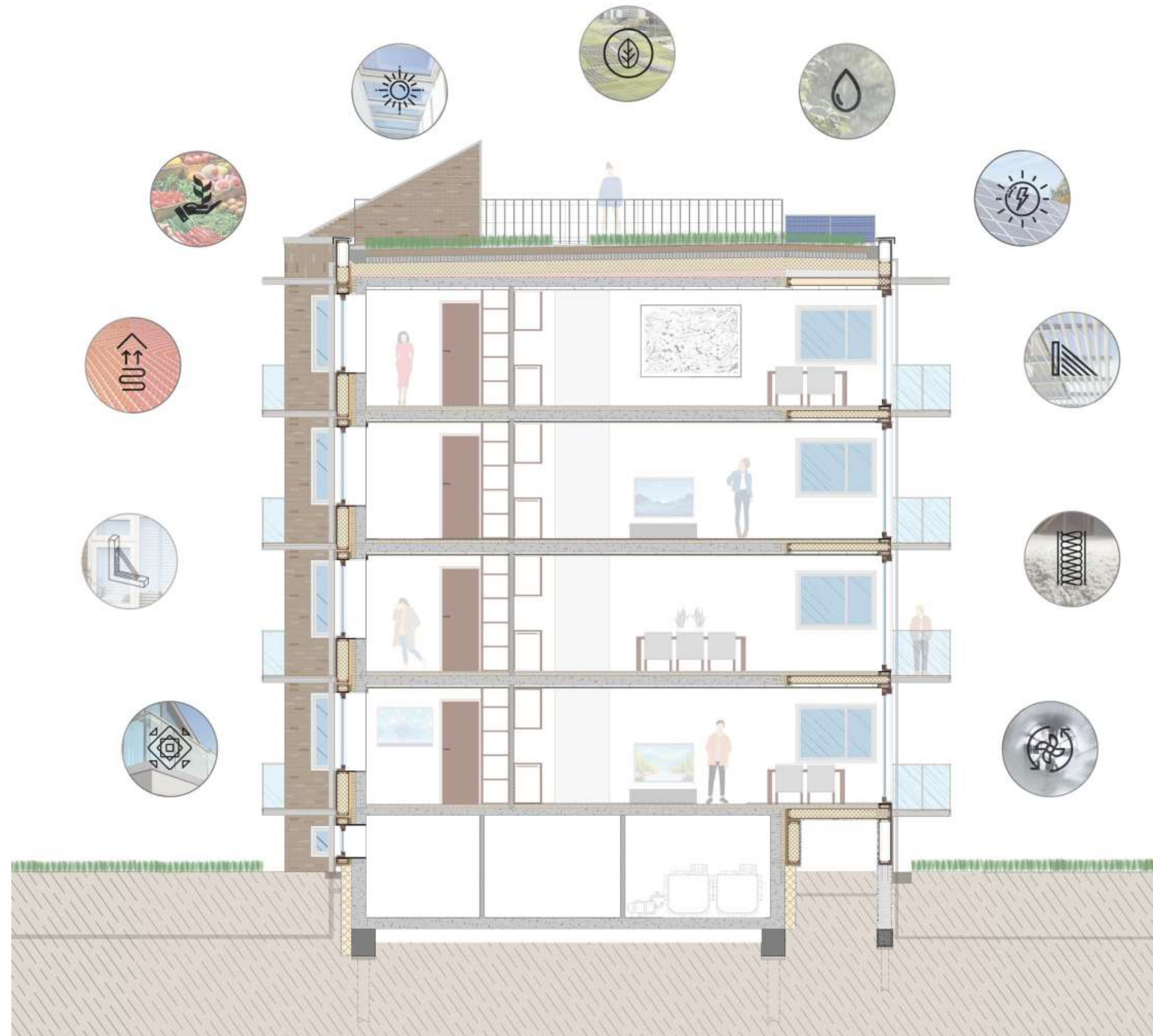
3. Design



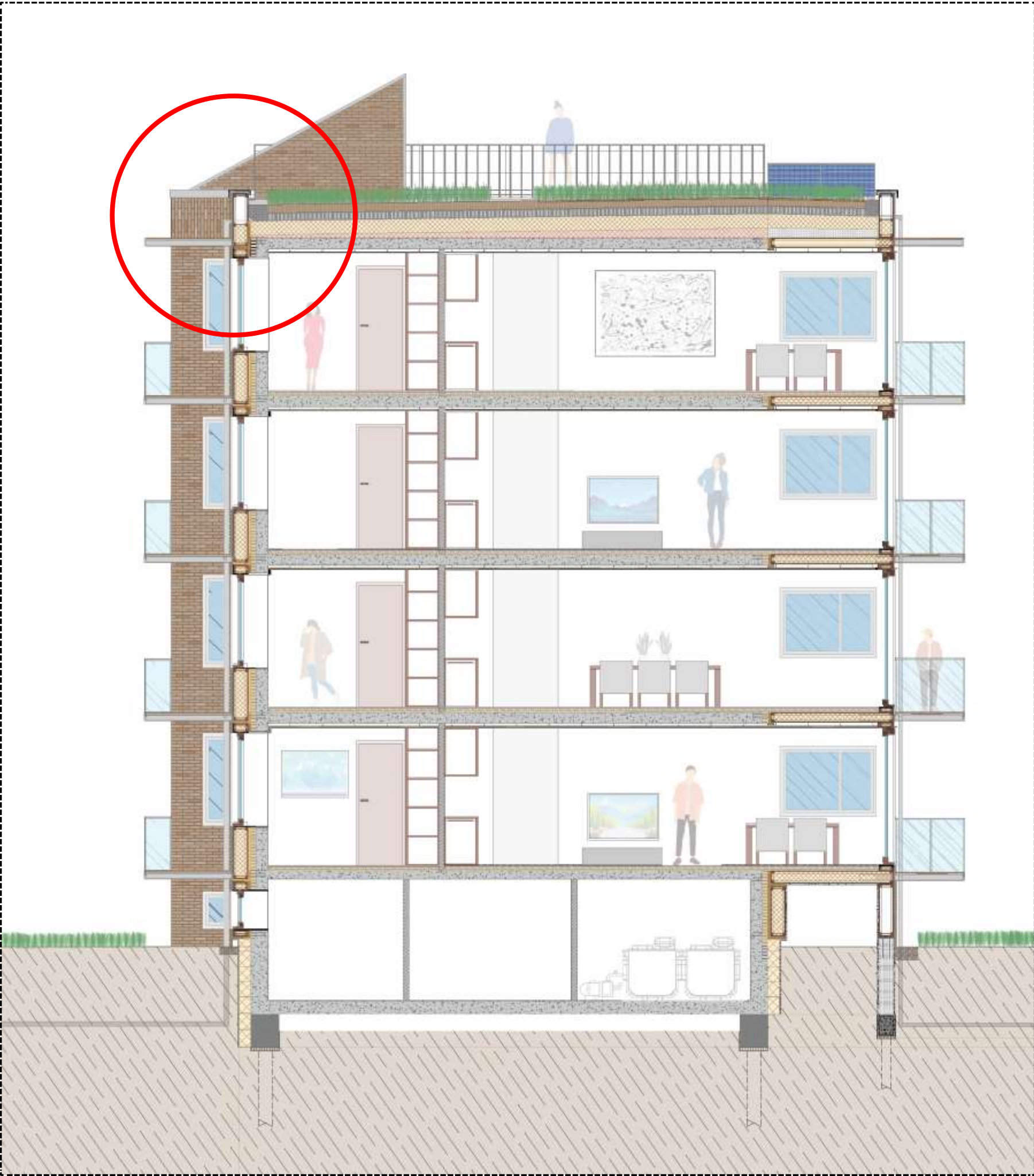
3. Design



3. Design



3. Design

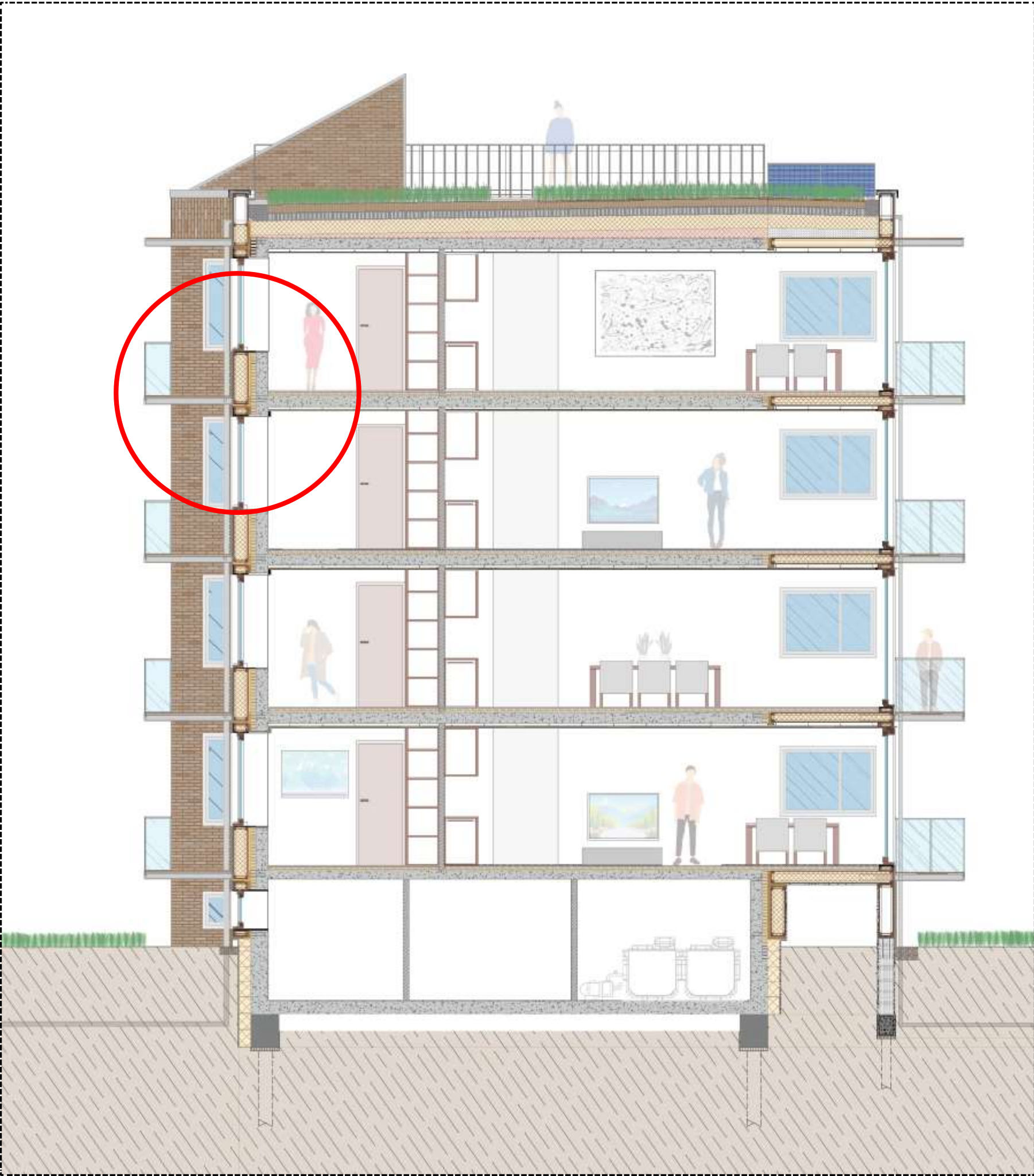


- 2 Sublime window frame tilt / turn window Natura Clad Classic 92 System
- 3 I Joist 195 prefab frame
- 4 50 mm light mineral wool
- 5 Steel bracket L (connection rooftoppanel)
- 6 steel self-clamping bolts 150 - 200 mm
- 7 Existing Granular concrete
- 8 MDF wooden frame
- 9 Glips 12.5mm
- 10 Rockwool steenwol 100mm
- 11 Existing roof pitch
- 12 Gutex Thermoflex houtvezelisolatie 220mm

- 14 Waterentliebox 200mm
- 15 Substraatlaag 200mm
- 16 Sedum + lage vegetatie
- 17 Roof molding aluminum
- 18 Roof railing
- 19 glue and grout for sto strips
- 20 Semi-rigid mineral wool slab with special wind barrier facing
- 21 OSB 18MM
- 22 Pebble eaves
- 23 Gutter Aluminium
- 24 Steel balcony bracket connected to I Joist

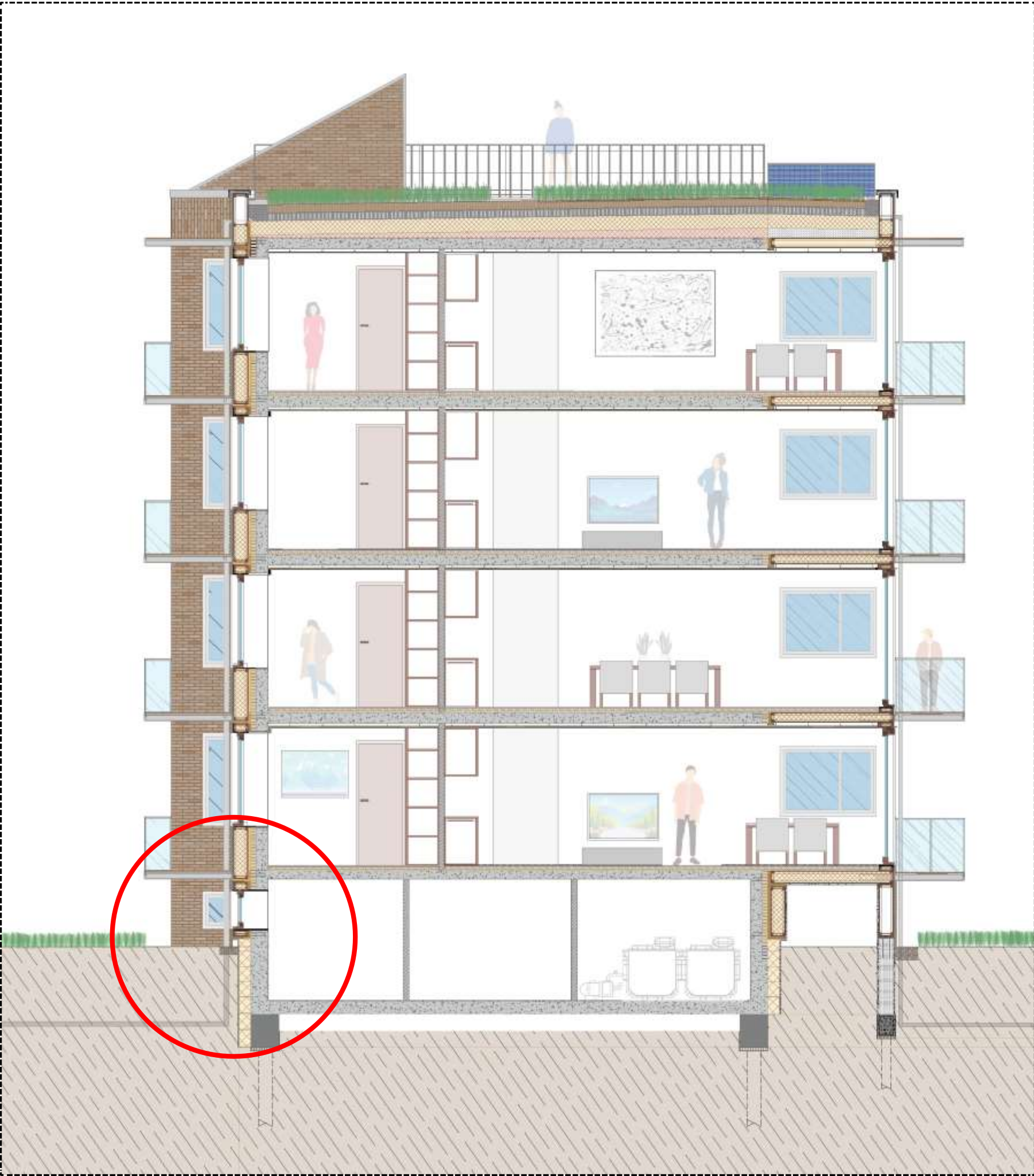
- 26 Rain Gutter
- 27 Wooden Slats
- 28 Steel I profile
- 29 Pavaflex, wood fiber insulation
- 30 Solarlux combine glass folding tire (aluminium/wood)
- 31 Existing Bricks
- 32 Stone strips
- 33 Steel bracket
- 34 Glass hardened balcony panels
- 35 raised floor with floor insulation
- 36 I Joist floor filled with cellulose insulation

3. Design



- | | | | | | |
|----|---|----|---|--|--|
| 2 | Sublime window frame tilt / turn window Natura Clad Classic 92 System | 14 | Waterentliebox 200mm | 26 | Rain Gutter |
| 3 | I Joist 195 prefab frame | 15 | Substraatlaag 200mm | 27 | Wooden Slats |
| 4 | 50 mm light mineral wool | 16 | Sedum + lage vegetatie | 28 | Steel I profile |
| 5 | Steel bracket L (connection rooftoppanel) | 17 | Roof molding aluminum | 29 | Pavaflex, wood fiber insulation |
| 6 | steel self-clamping bolts 150 - 200 mm | 18 | Roof railing | 30 | Solarlux combine glass folding tire (aluminium/wood) |
| 7 | Existing Granular concrete | 19 | glue and grout for sto strips | 31 | Existing Bricks |
| 8 | MDF wooden frame | 20 | Semi-rigid mineral wool slab with special wind barrier facing | 32 | Stone strips |
| 9 | Gips 12.5mm | 21 | Semi-rigid mineral wool slab with special wind barrier facing | 33 | Steel bracket |
| 10 | Rockwool steenwol 100mm | 22 | OSB 18MM | 34 | Glass hardened balcony panels |
| 11 | Existing roof pitch | 23 | Pebble eaves | 35 | raised floor with floor insulation |
| 12 | Gutex Thermoflex houtvezelisolatie 220mm | 24 | Gutter Aluminium | 36 | I Joist floor filled with cellulose insulation |
| | | | 25 | Steel balcony bracket connected to I Joist | |

3. Design

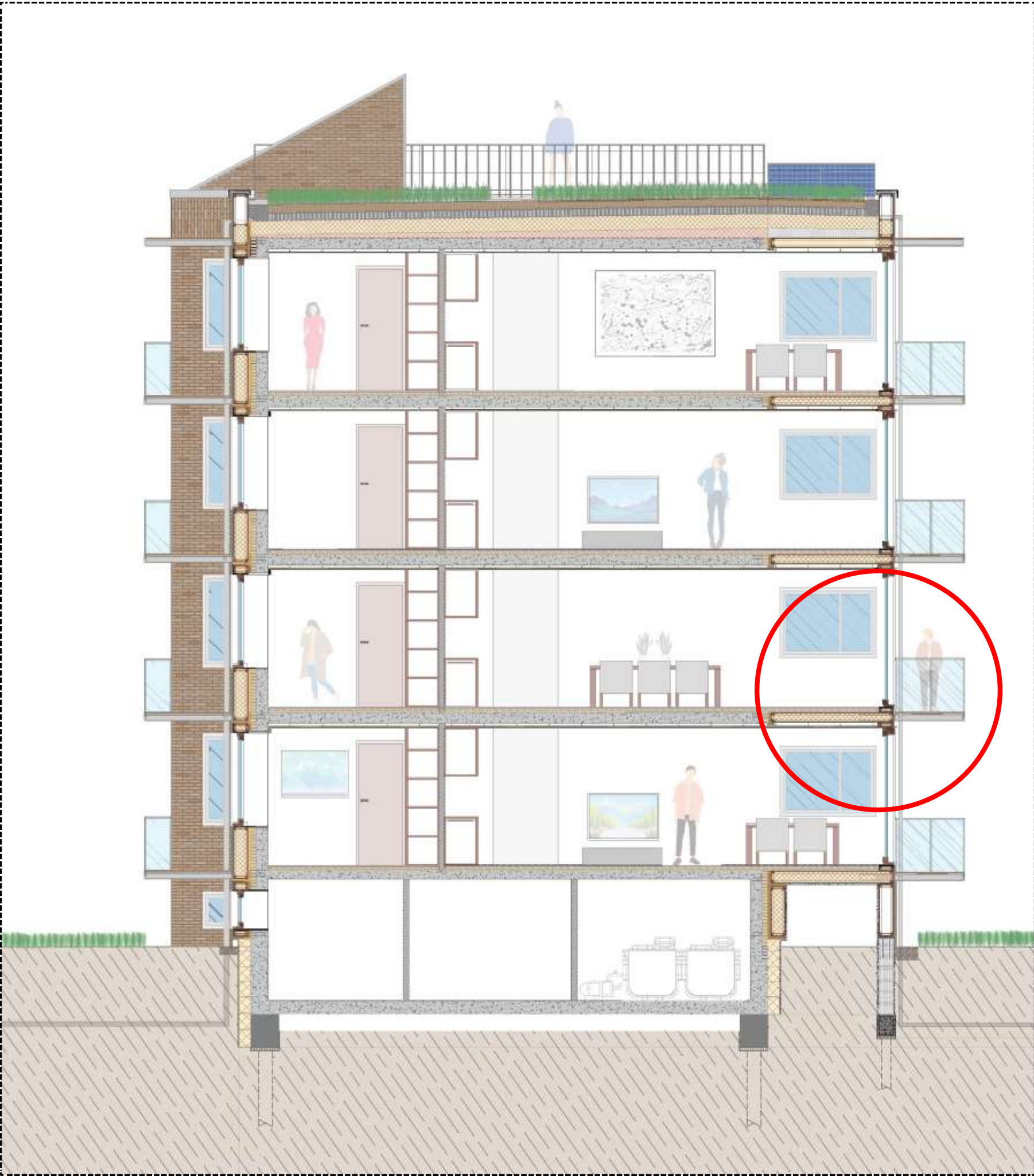


- 2 Sublime window frame tilt / turn window Natura Clad Classic 92 System
- 3 I Joist 195 prefab frame
- 4 50 mm light mineral wool
- 5 Steel bracket L (connection rooftoppanel)
- 6 steel self-clamping bolts 150 - 200 mm
- 7 Existing Granular concrete
- 8 MDF wooden frame
- 9 Gips 12.5mm
- 10 Rockwool steenwol 100mm
- 11 Existing roof pitch
- 12 Gutex Thermoflex houtvezelisolatie 220mm

- 14 Waterentliebox 200mm
- 15 Substraatlaag 200mm
- 16 Sedum + lage vegetatie
- 17 Roof molding aluminum
- 18 Roof railing
- 19 glue and grout for sto strips
- 20 Semi-rigid mineral wool slab with special wind barrier facing
- 21 OSB 18MM
- 22 Pebble eaves
- 23 Gutter Aluminium
- 24 Steel balcony bracket connected to I Joist

- 26 Rain Gutter
- 27 Wooden Slats
- 28 Steel I profile
- 29 Pavaflex, wood fiber insulation
- 30 Solarlux combine glass folding tire (aluminium/wood)
- 31 Existing Bricks
- 32 Stone strips
- 33 Steel bracket
- 34 Glass hardened balcony panels
- 35 raised floor with floor insulation
- 36 I Joist floor filled with cellulose insulation

3. Design

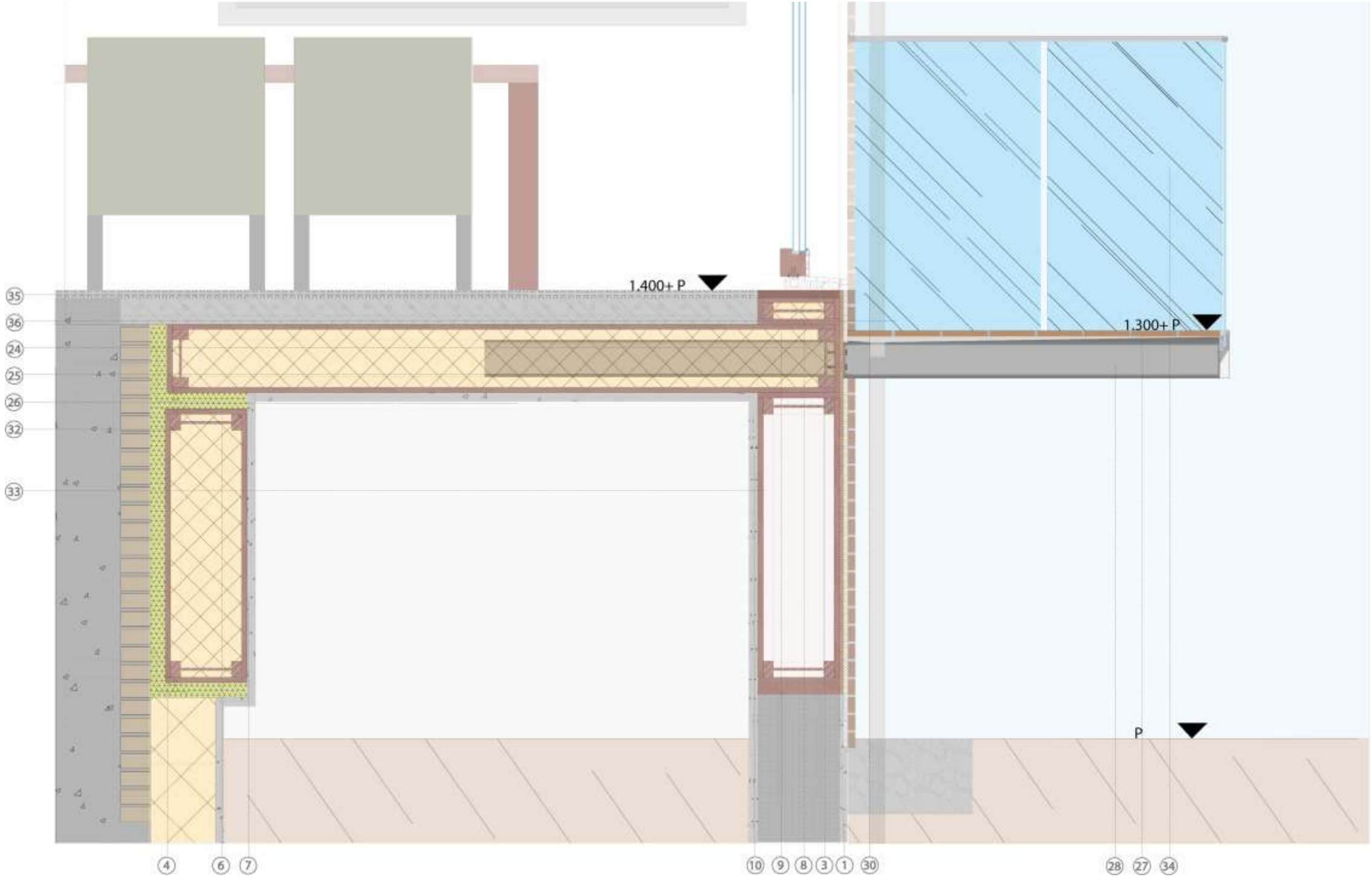
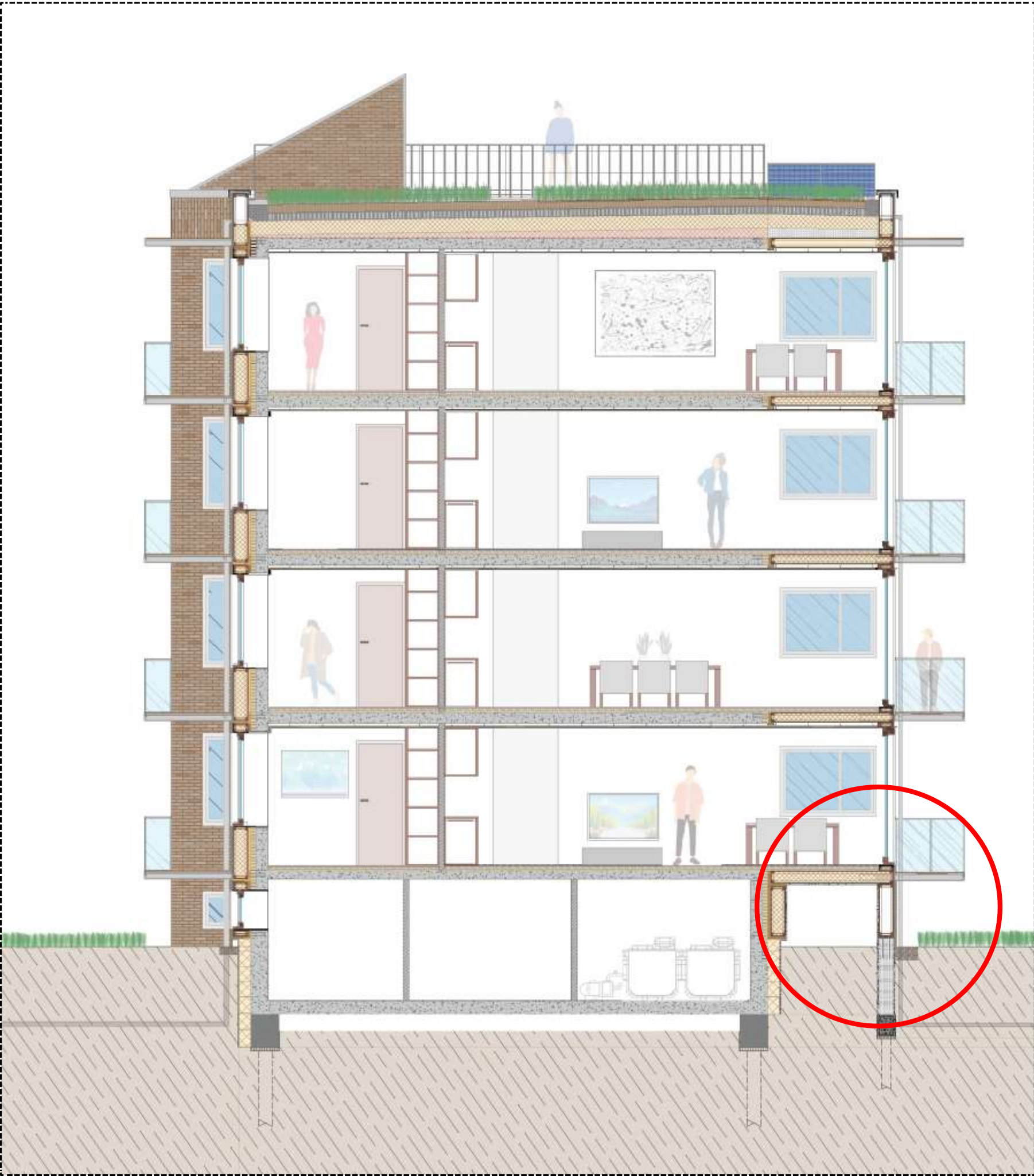


- 2 Sublime window frame tilt / turn window Natura Clad Classic 92 System
- 3 I Joist 195 prefab frame
- 4 50 mm light mineral wool
- 5 Steel bracket L (connection rooftoppanel)
- 6 steel self-clamping bolts 150 - 200 mm
- 7 Existing Granular concrete
- 8 MDF wooden frame
- 9 Glips 12.5mm
- 10 Rockwool steenwol 100mm
- 11 Existing roof pitch
- 12 Gutex Thermoflex houtvezelisolatie 220mm

- 14 Waterentliebox 200mm
- 15 Substraatlaag 200mm
- 16 Sedum + lage vegetatie
- 17 Roof molding aluminum
- 18 Roof railing
- 19 glue and grout for sto strips
- 20 Semi-rigid mineral wool slab with special wind barrier facing
- 21 OSB 18MM
- 22 Pebble eaves
- 23 Gutter Aluminium
- 24 Steel balcony bracket connected to I Joist

- 26 Rain Gutter
- 27 Wooden Slats
- 28 Steel I profile
- 29 Pavaflex, wood fiber insulation
- 30 Solarlux combine glass folding tire (aluminium/wood)
- 31 Existing Bricks
- 32 Stone strips
- 33 Steel bracket
- 34 Glass hardened balcony panels
- 35 raised floor with floor insulation
- 36 I Joist floor filled with cellulose insulation

3. Design

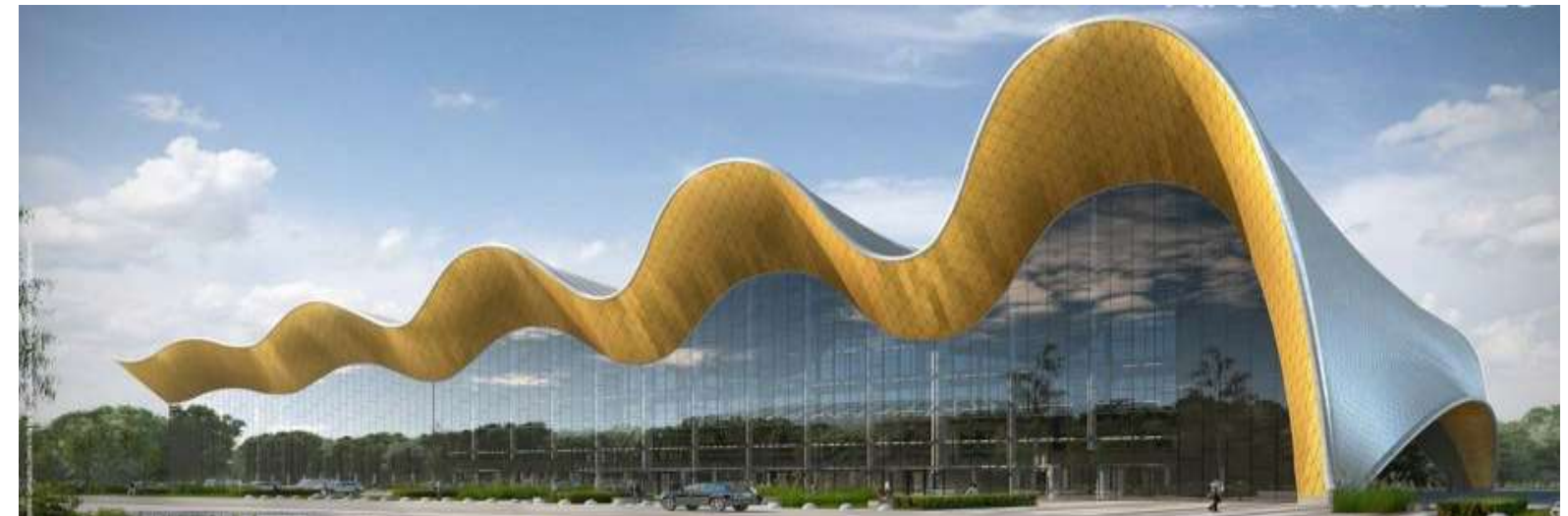
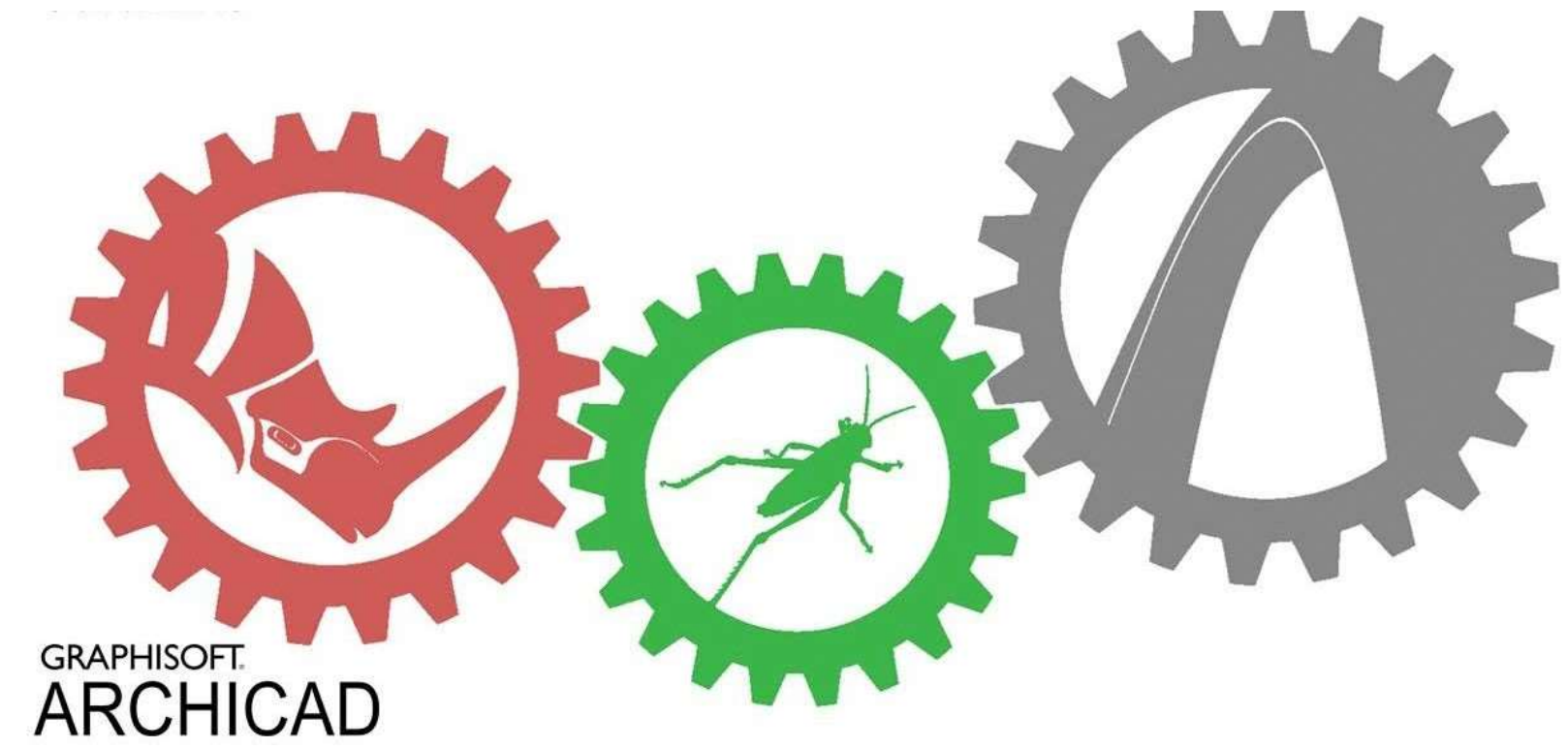
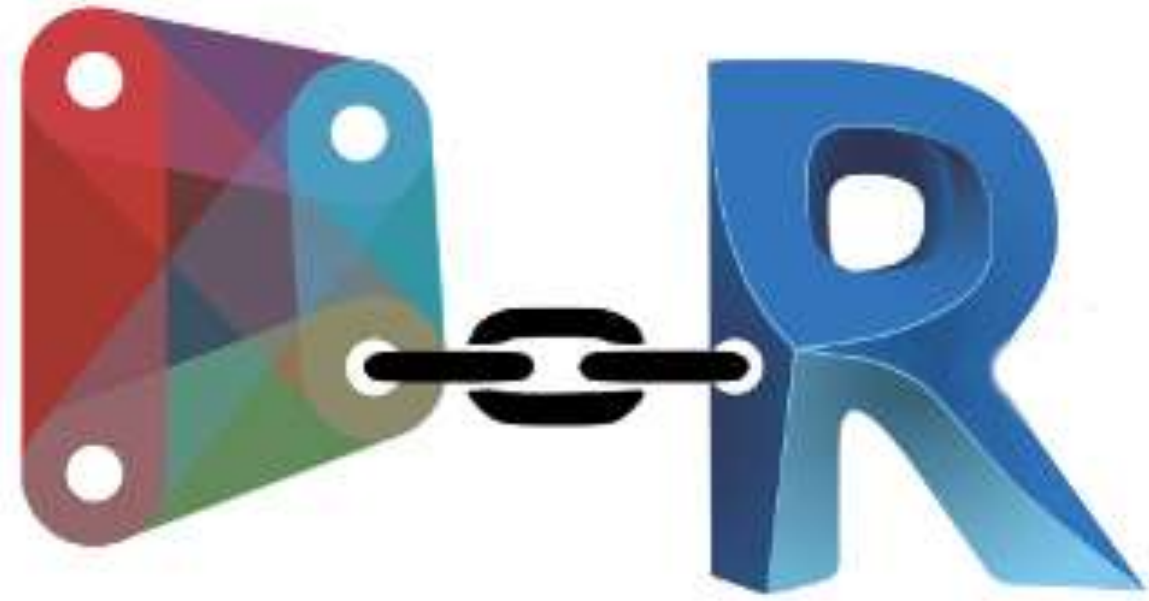


- 2 Sublime window frame tilt / turn window Natura Clad Classic 92 System
- 3 I Joist 195 prefab frame
- 4 50 mm light mineral wool
- 5 Steel bracket L (connection rooftoppanel)
- 6 steel self-clamping bolts 150 - 200 mm
- 7 Existing Granular concrete
- 8 MDF wooden frame
- 9 Gips 12.5mm
- 10 Rockwool steenwol 100mm
- 11 Existing roof pitch
- 12 Gutex Thermoflex houtvezelisolatie 220mm

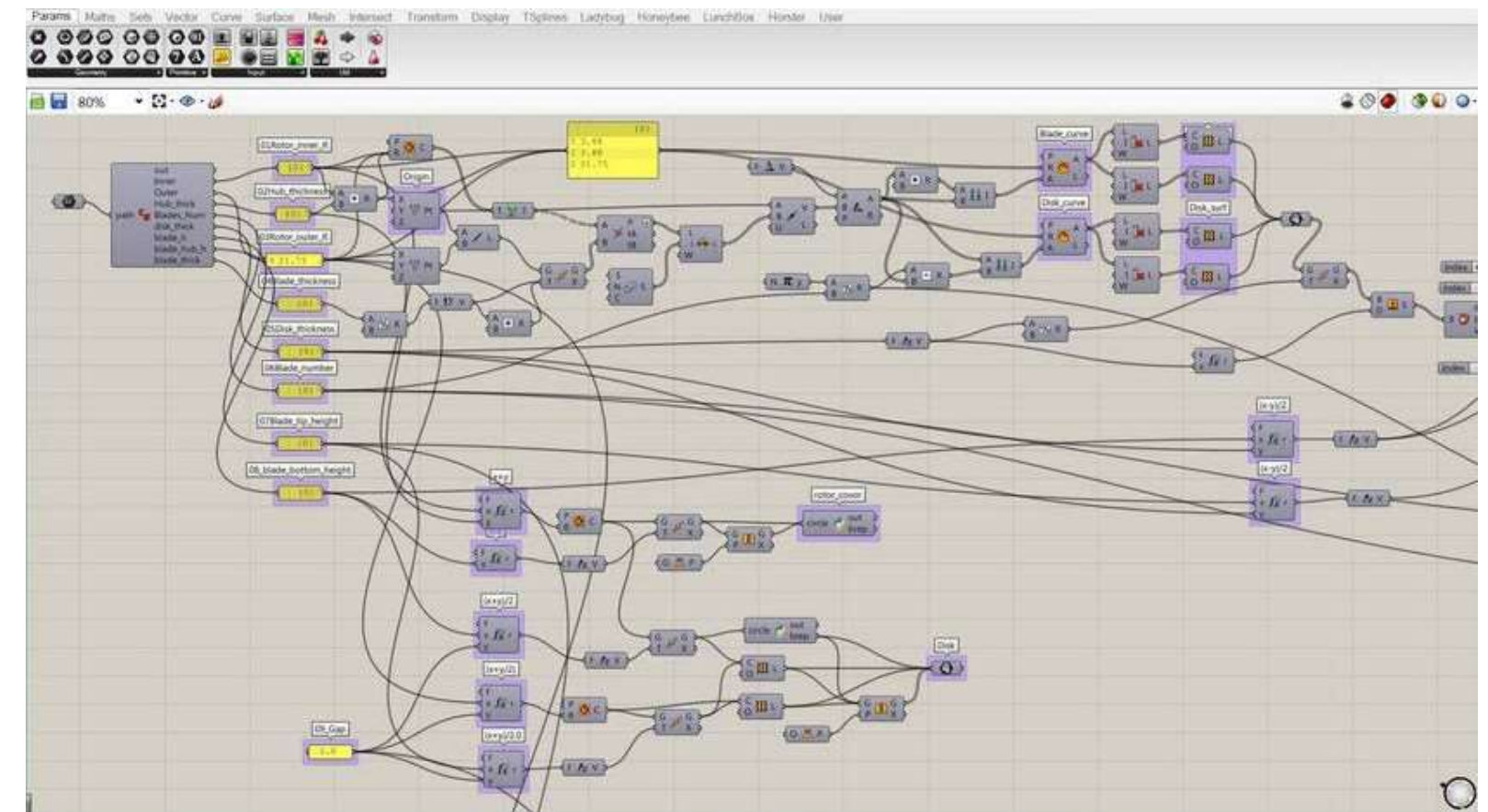
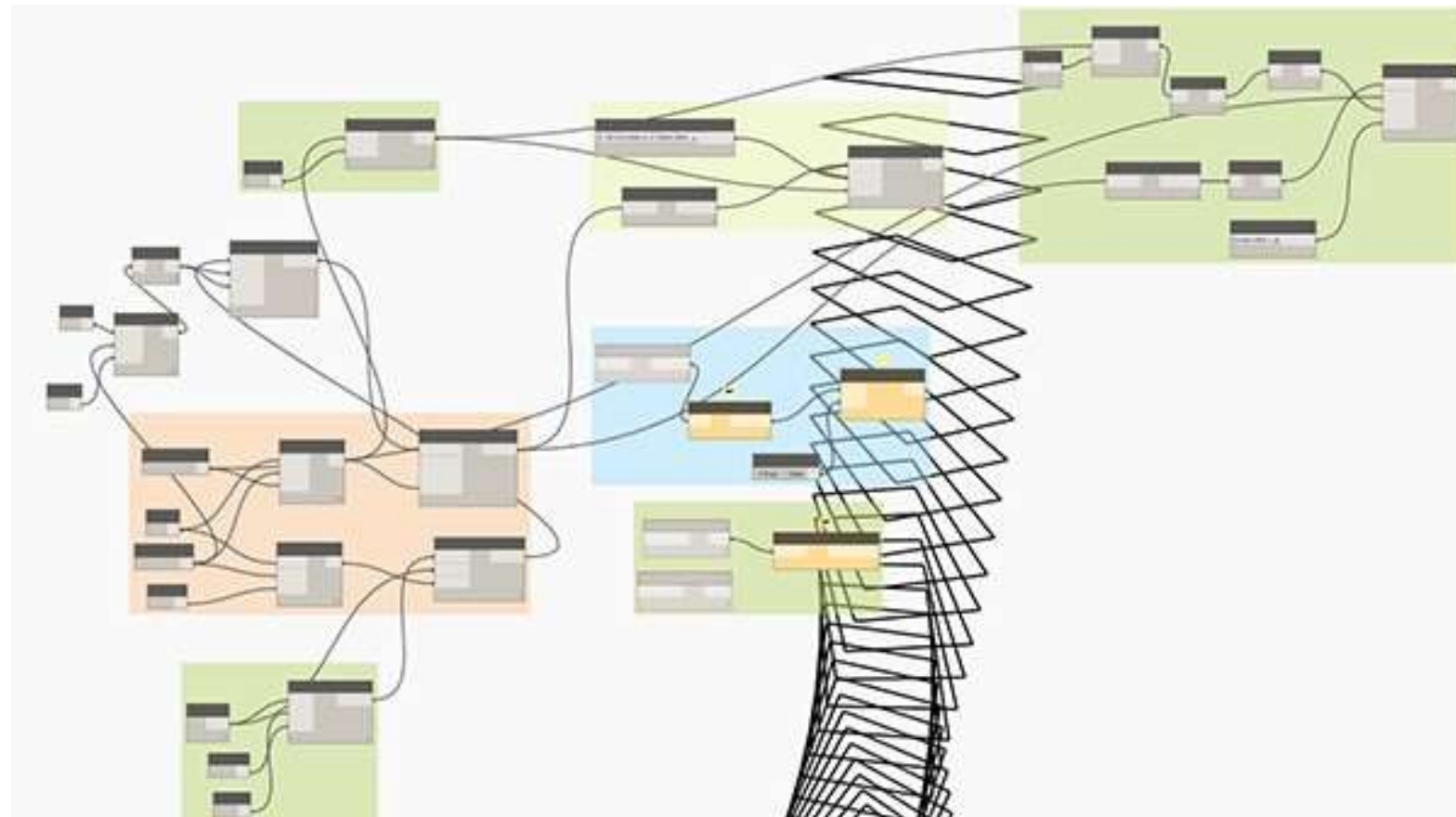
- 14 Waterentriebbox 200mm
- 15 Substraatlaag 200mm
- 16 Sedum + lage vegetatie
- 17 Roof molding aluminum
- 18 Roof railing
- 19 glue and grout for sto strips
- 20 Semi-rigid mineral wool slab with special wind barrier facing
- 21 OSB 18MM
- 22 Pebble eaves
- 23 Gutter Aluminium
- 24 Steel balcony bracket connected to I Joist

- 26 Rain Gutter
- 27 Wooden Slats
- 28 Steel I profile
- 29 Pavaflex, wood fiber insulation
- 30 Solarlux combine glass folding tire (aluminium/wood)
- 31 Existing Bricks
- 32 Stone strips
- 33 Steel bracket
- 34 Glass hardened balcony panels
- 35 raised floor with floor insulation
- 36 I Joist floor filled with cellulose insulation

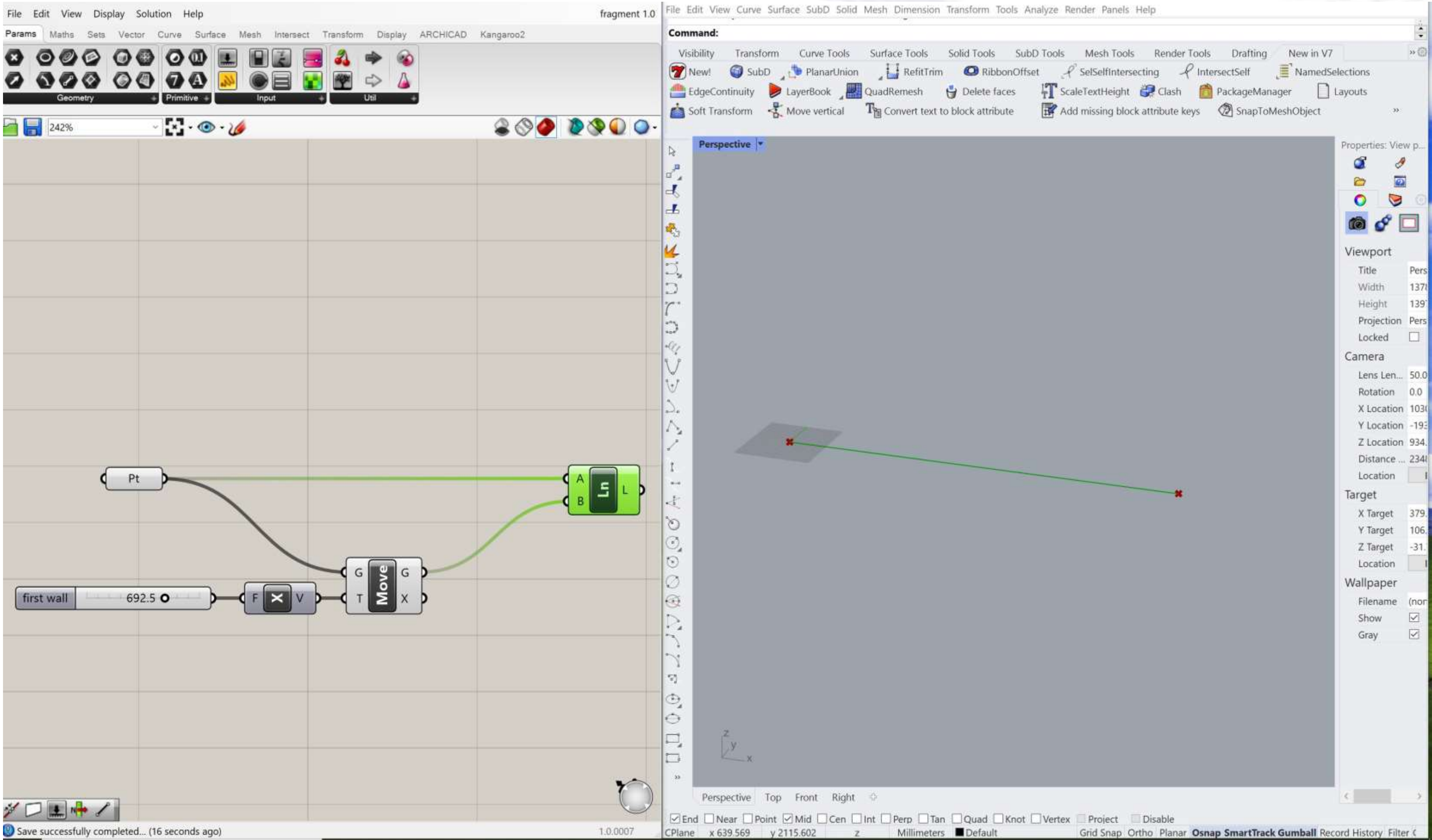
3. Design



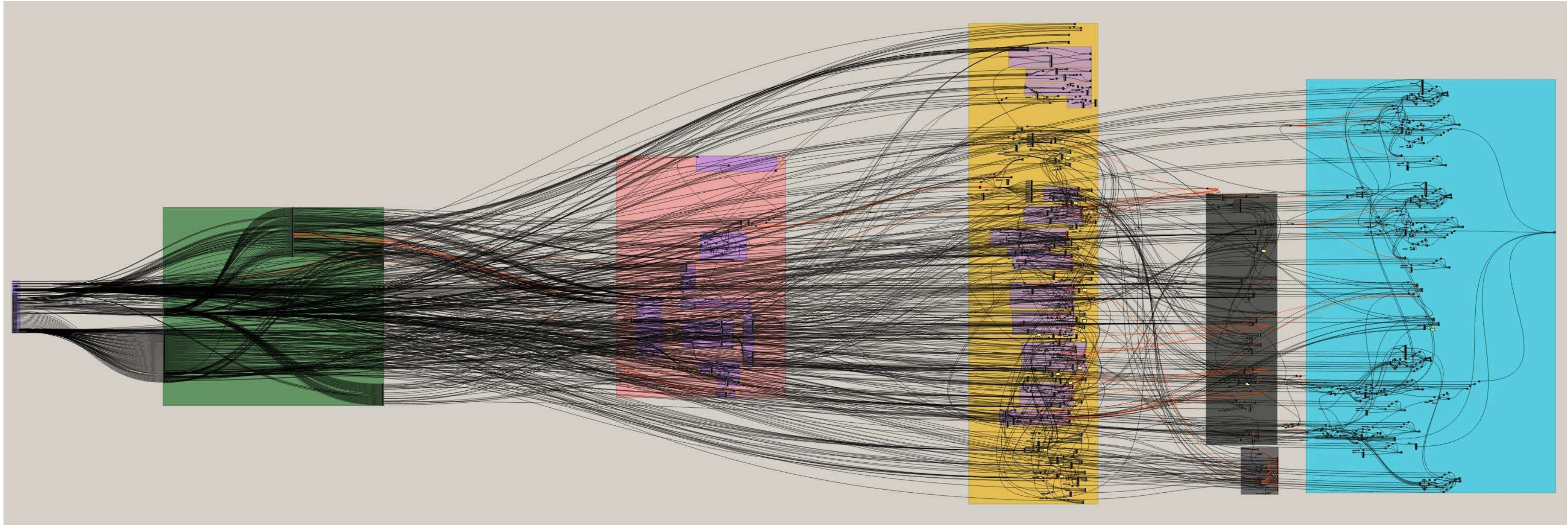
3. Design



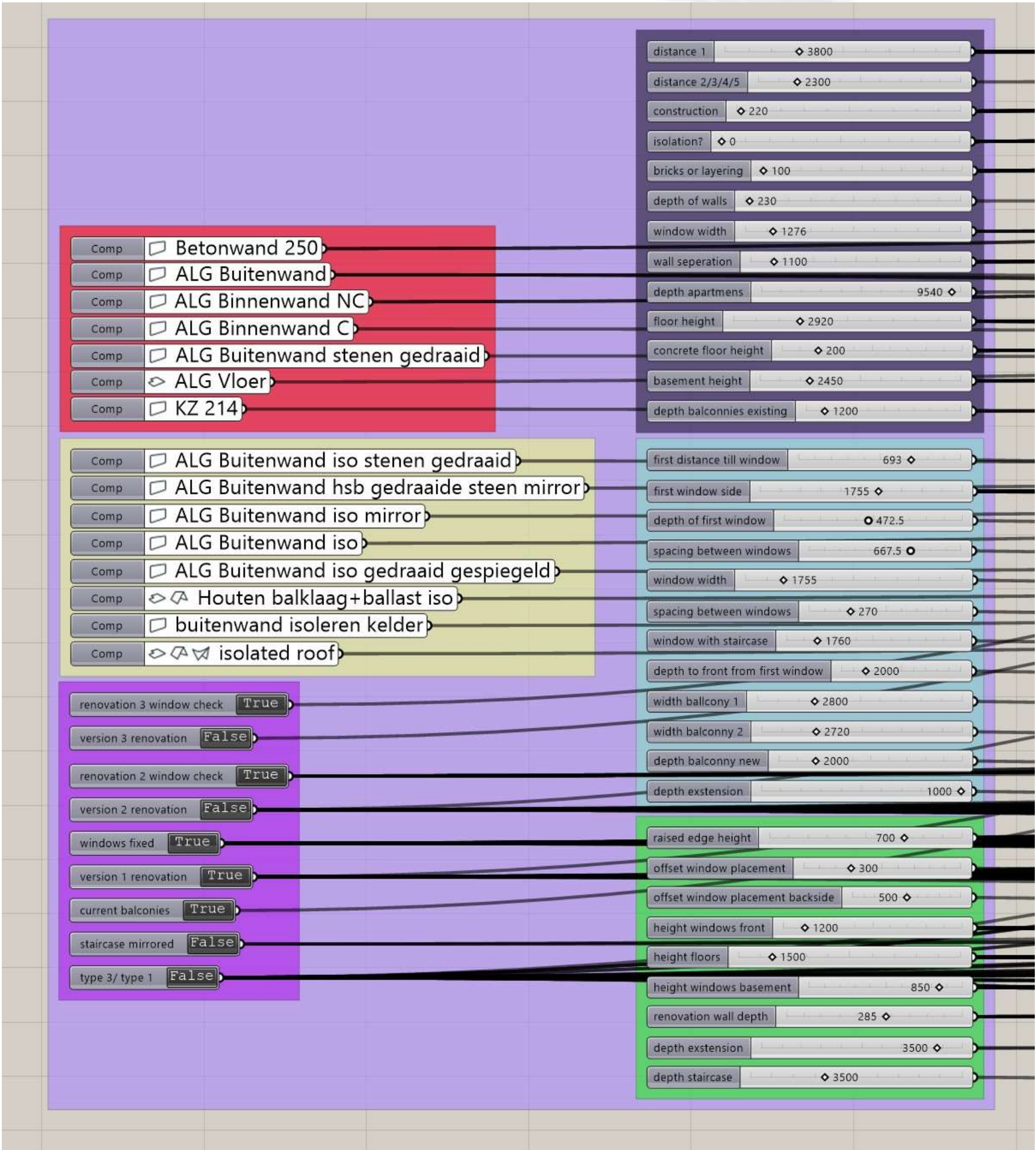
3. Design



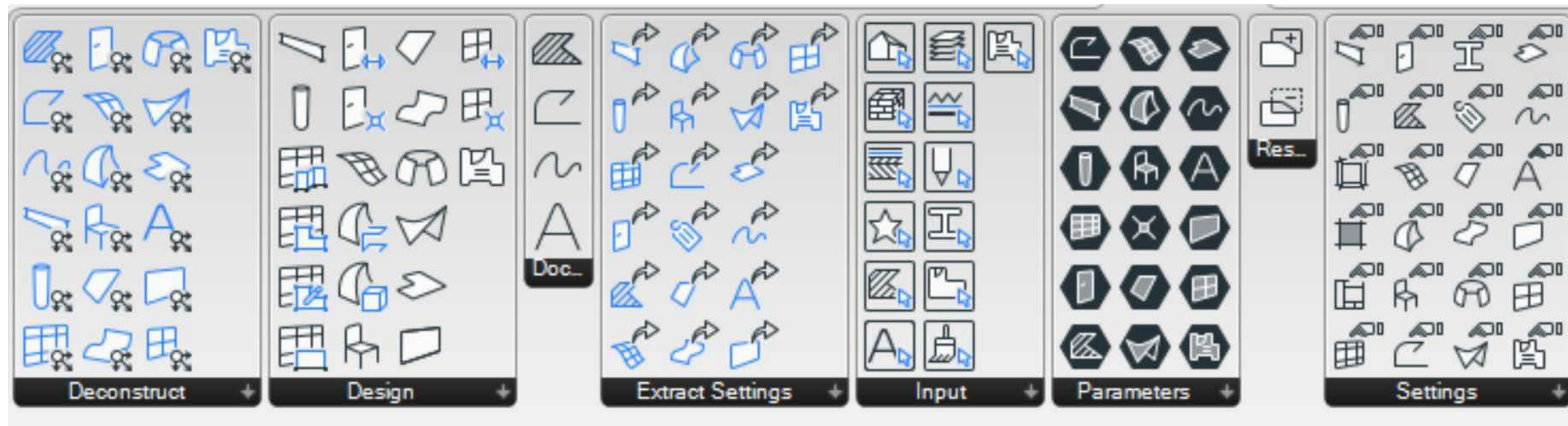
3. Design



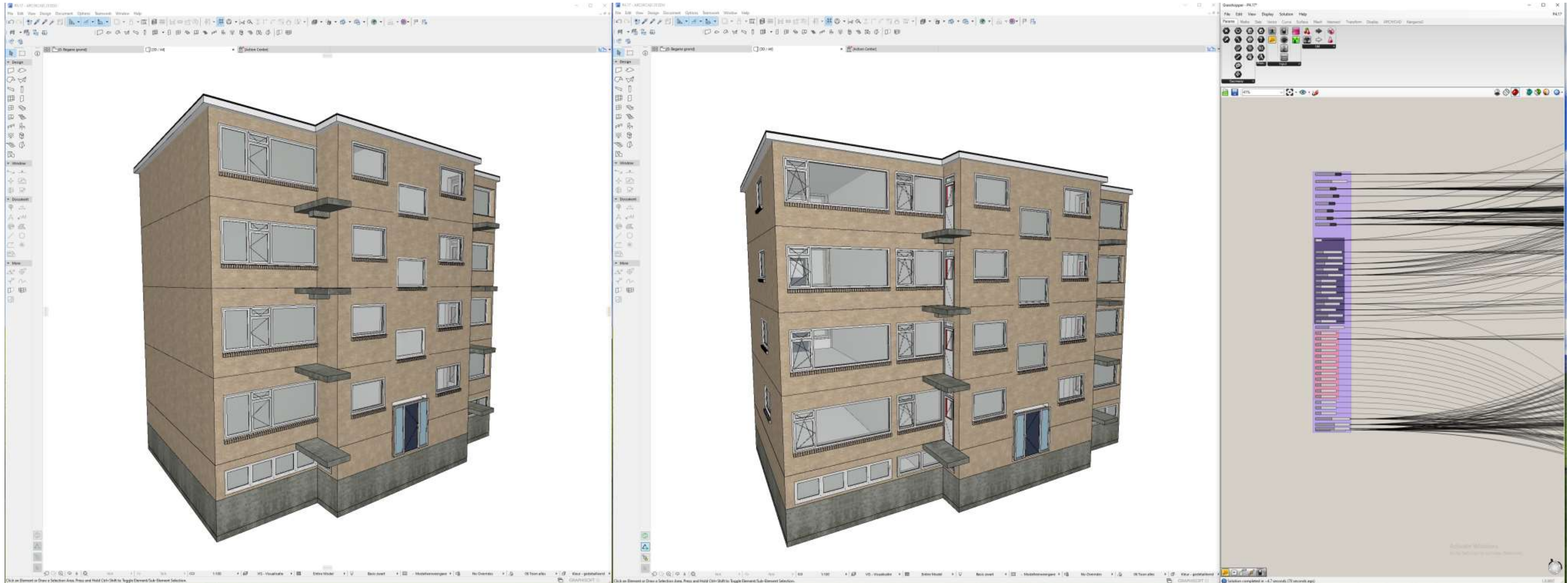
3. Design



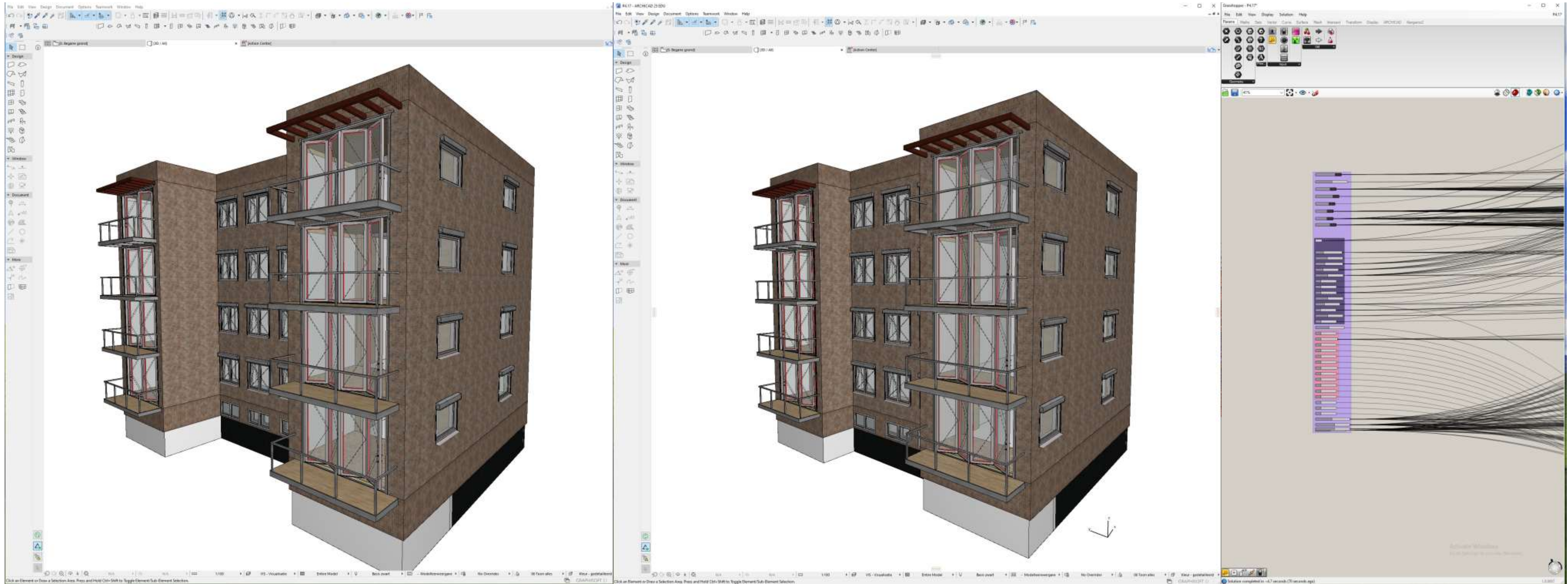
3. Design



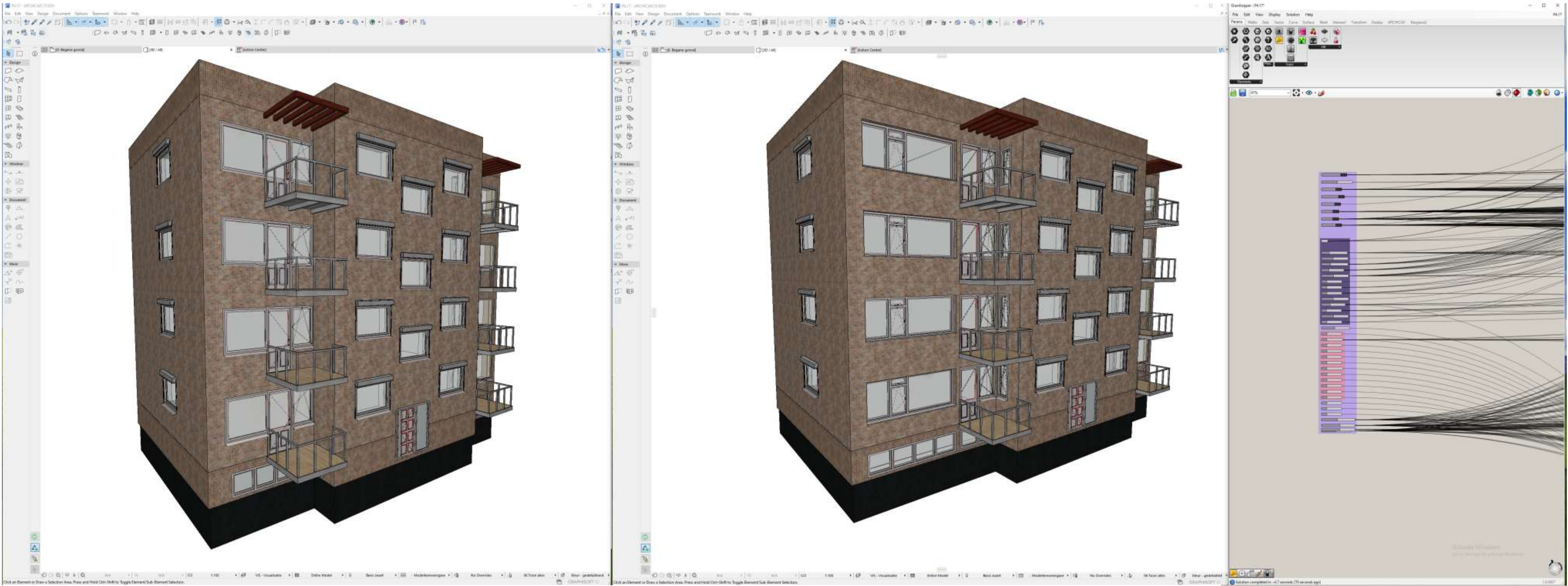
3. Design



3. Design



3. Design



3. Design



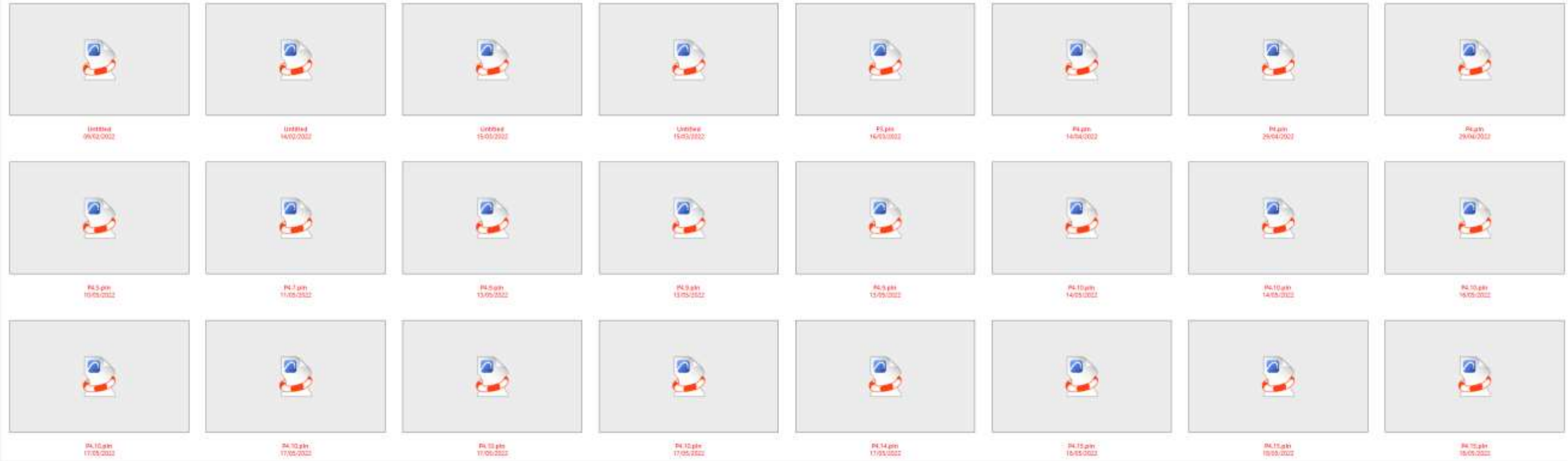
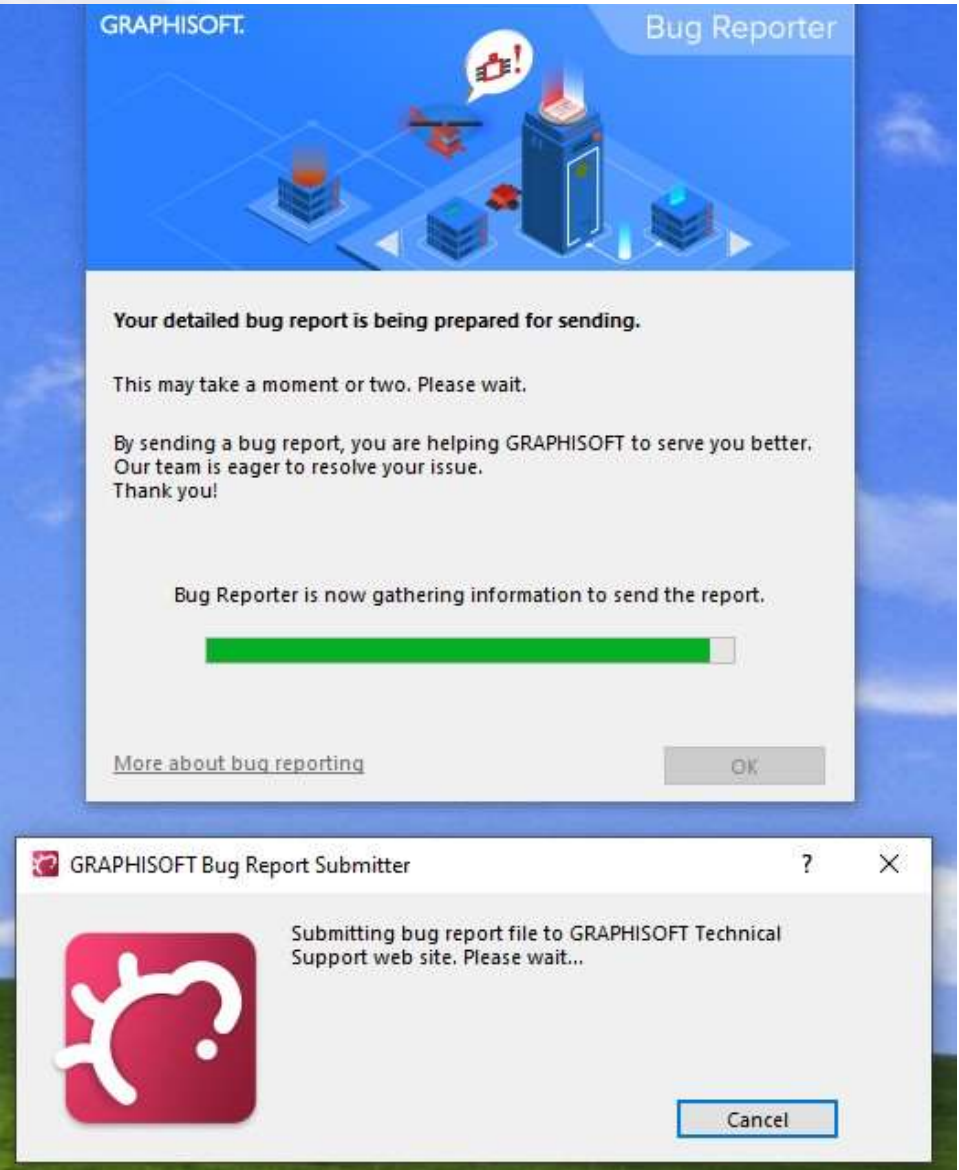
	Story Name / Viewpoint Name	Element type	Building Material/Composite/Profile Name	Section Pen	Thickness/Size	Thickness/Size	Surface Area	Surface Area	Surface Area	Surface Area	Surface Area	Surface Area	Surface Area	Surface Area	Surface Area	Surface Area	Volume	Volume	Volume	Volume
1	Begane grond	WALL	brick strips (3)	-1	81,0		8,87	9,42	1,55								0,72			
1	Begane grond	WALL	iso i joist	-1	220,0		8,96	8,96	1,25								1,89			
1	Begane grond	WALL	OSB 18	-1	18,0		9,34	9,34	0,34								0,17			
29	Begane grond	COLUMN	Profiel I hout	-1	235,0	235,0					10,71							0,07		
2	Begane grond	WINDOW	305 Loofhout (01)	3	2.100,0	0,0						0,00							0,00	
1	Begane grond	WINDOW	305 Loofhout (01)	3	2.100,0	64,0						25,74							0,31	
2	Begane grond	WINDOW	305 Loofhout (01)	3	3.350,0	0,0						0,00							0,00	
1	Begane grond	WINDOW	305 Loofhout (01)	3	3.350,0	64,0						37,39							0,42	
4	Begane grond	BEAM	Profiel I hout	-1	65,0								0,00	0,69	2,09	2,11	0,02			0,03
1	Begane grond	BEAM	Profiel I hout lat eronder	-1	74,2								0,01	0,49	2,75	2,46	0,01			0,03
1	Begane grond	BEAM	Profiel I hout lat eronder mirror	-1	75,0								0,02	0,49	2,46	2,75	0,01			0,03
							27,17	27,72	3,14	10,71	63,13	0,03	1,67	7,30	7,31	0,04	2,78	0,07	0,73	0,10



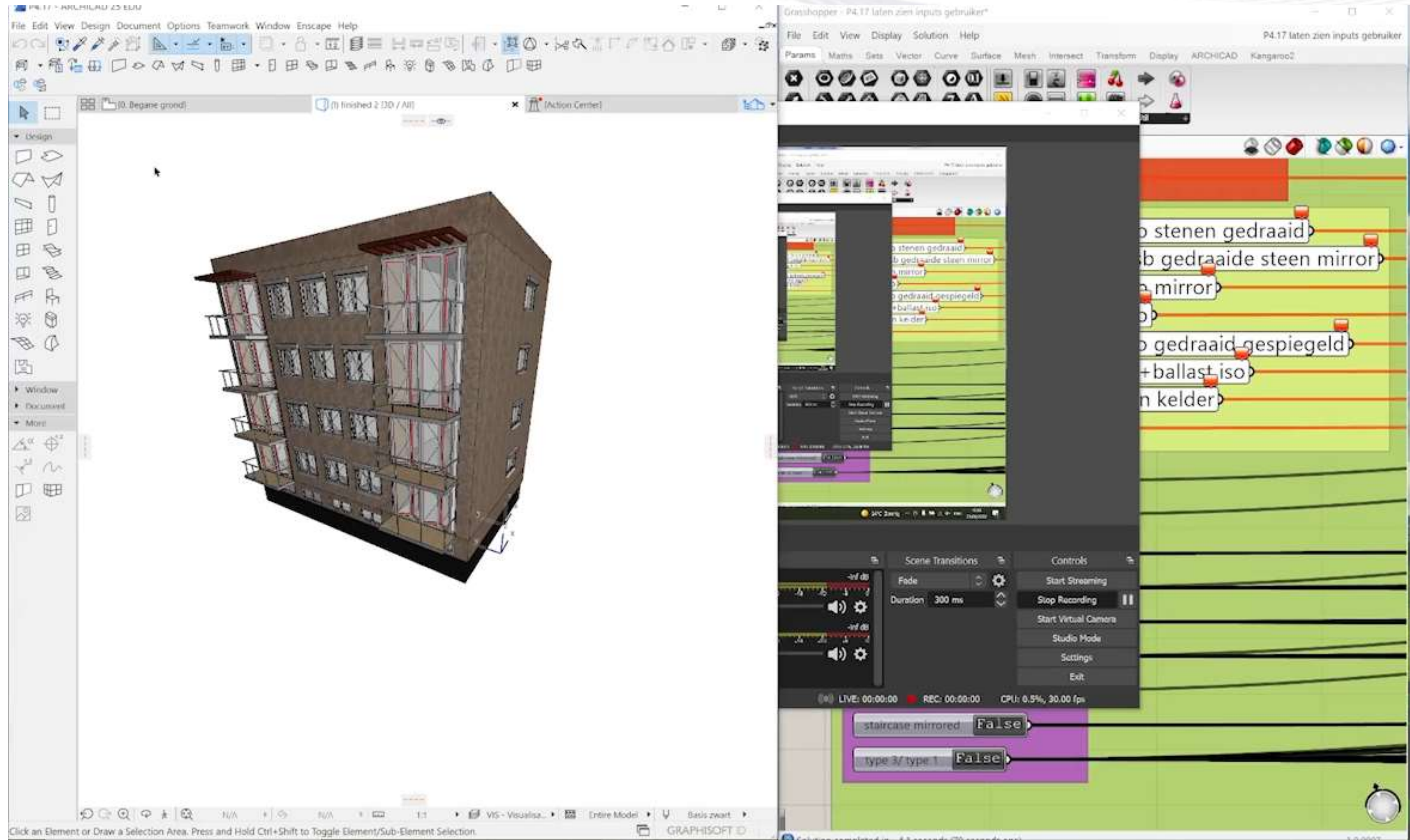
3. Design



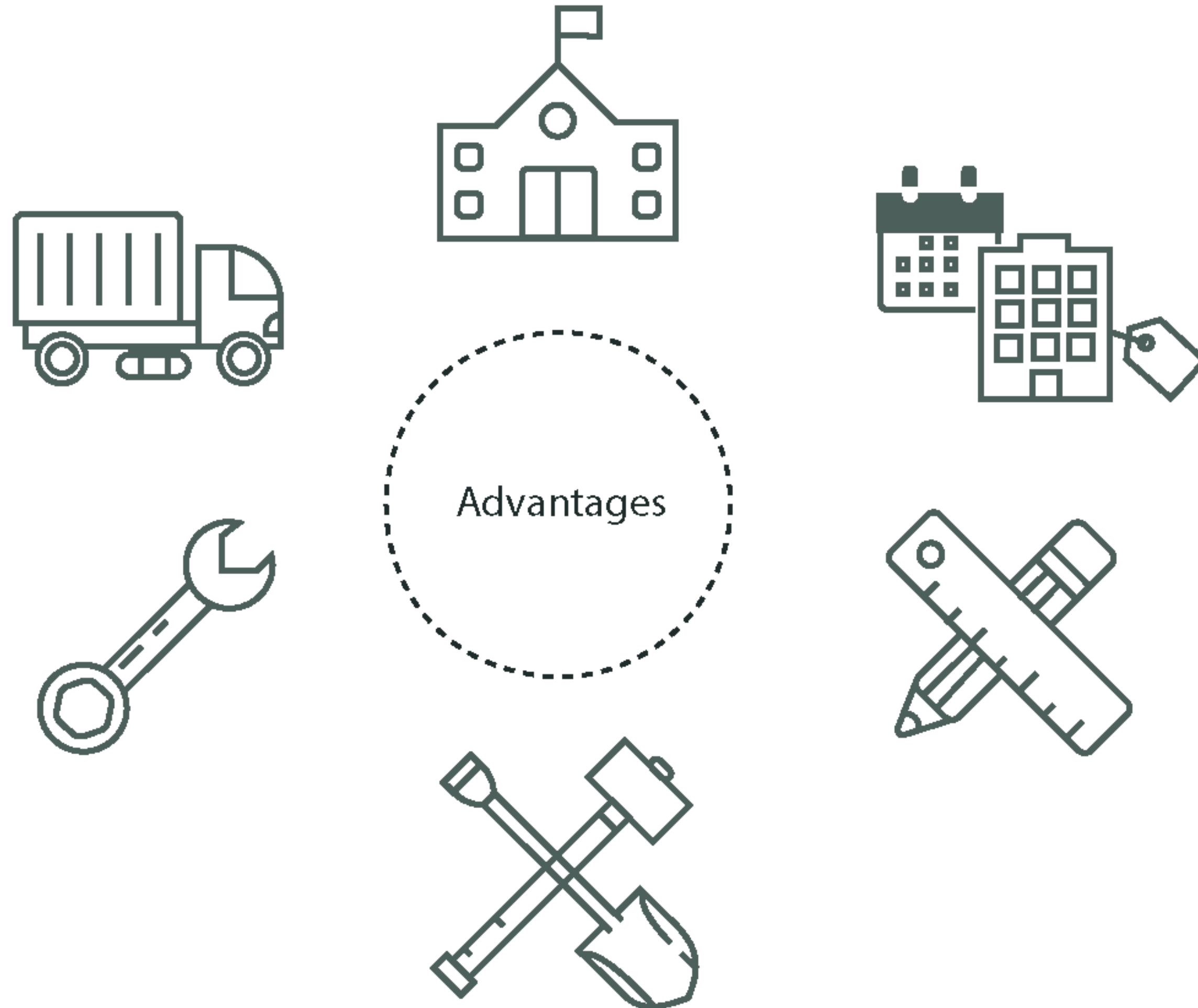
3. Design



3. Design



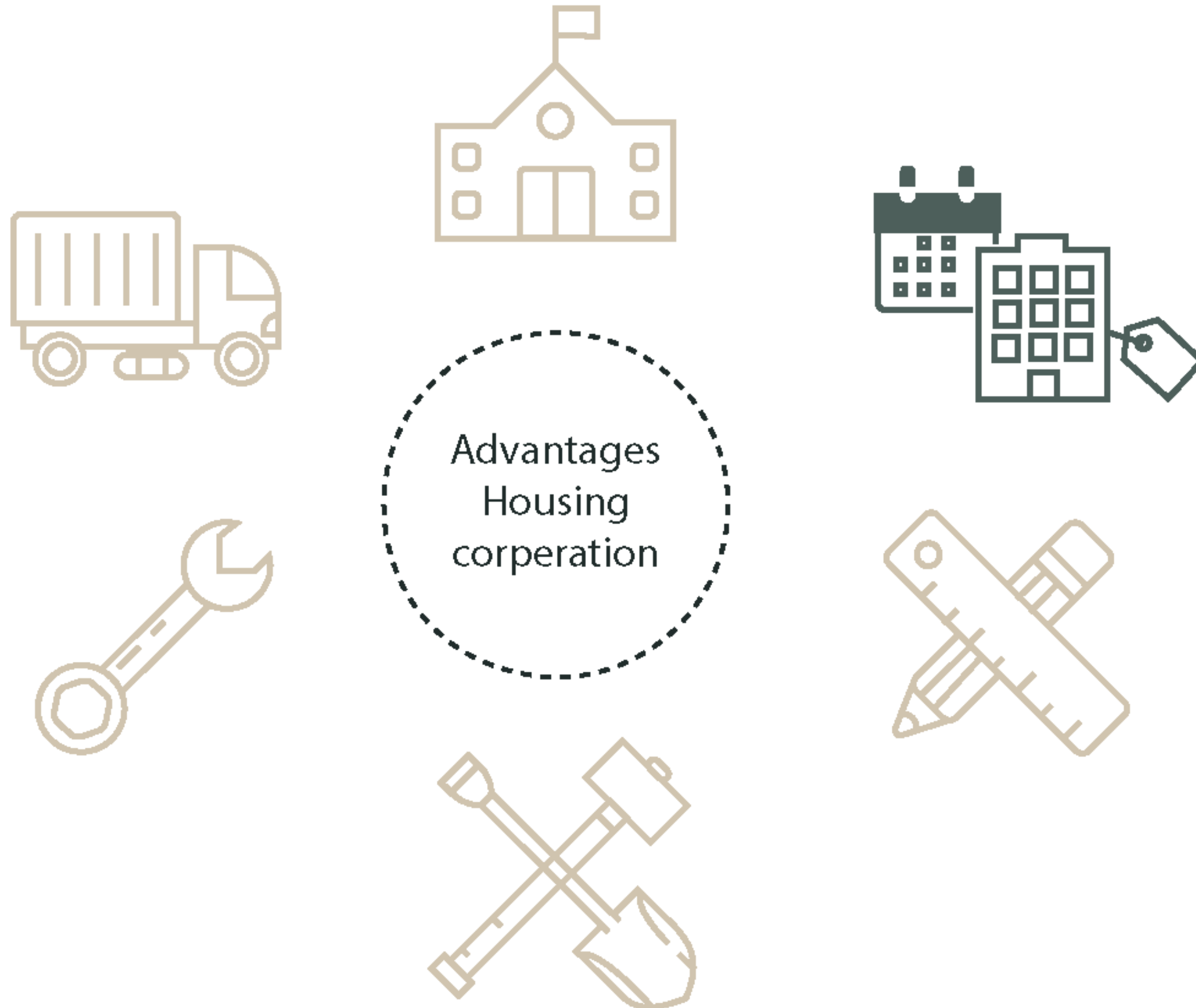
3. Design



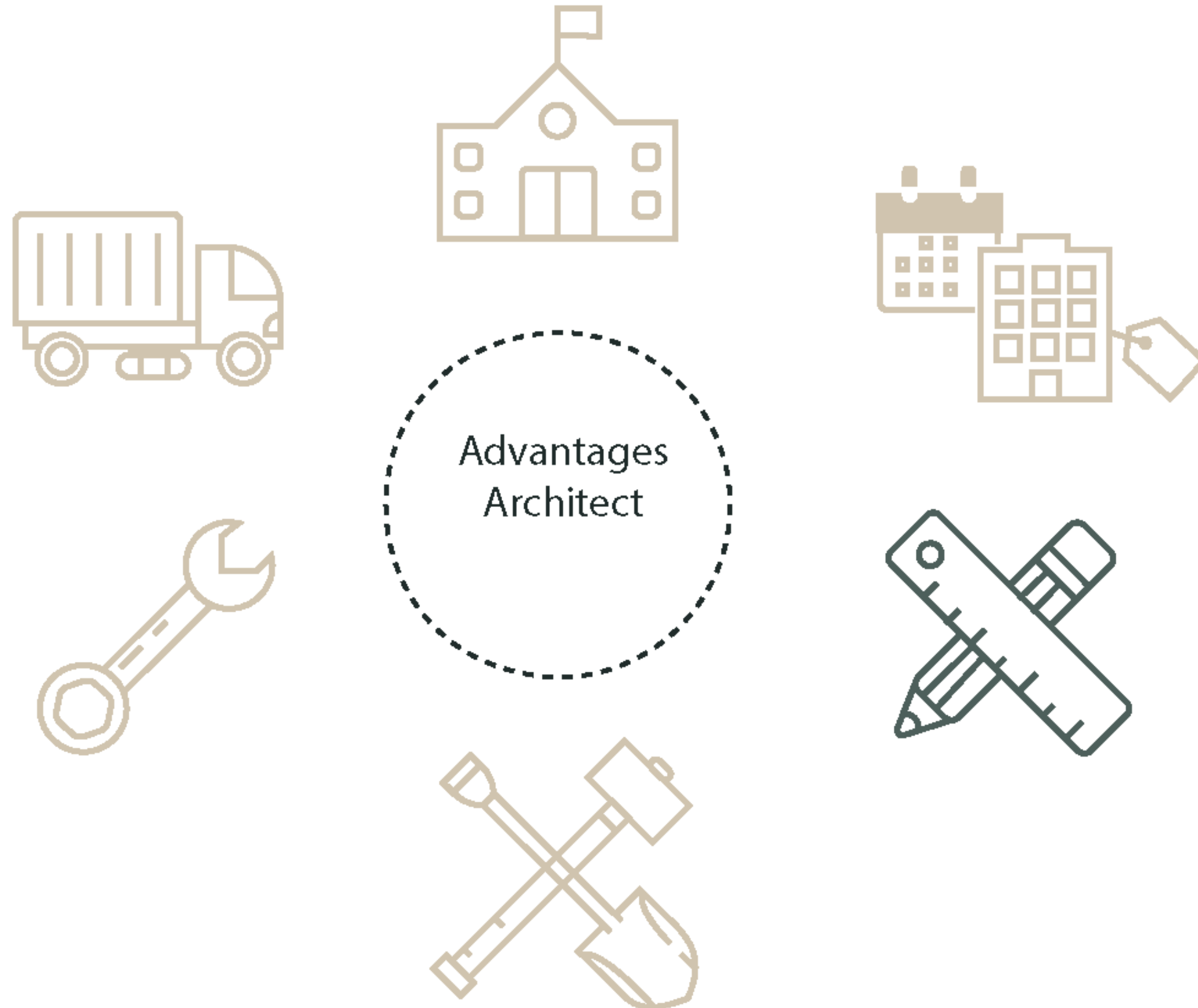
3. Design



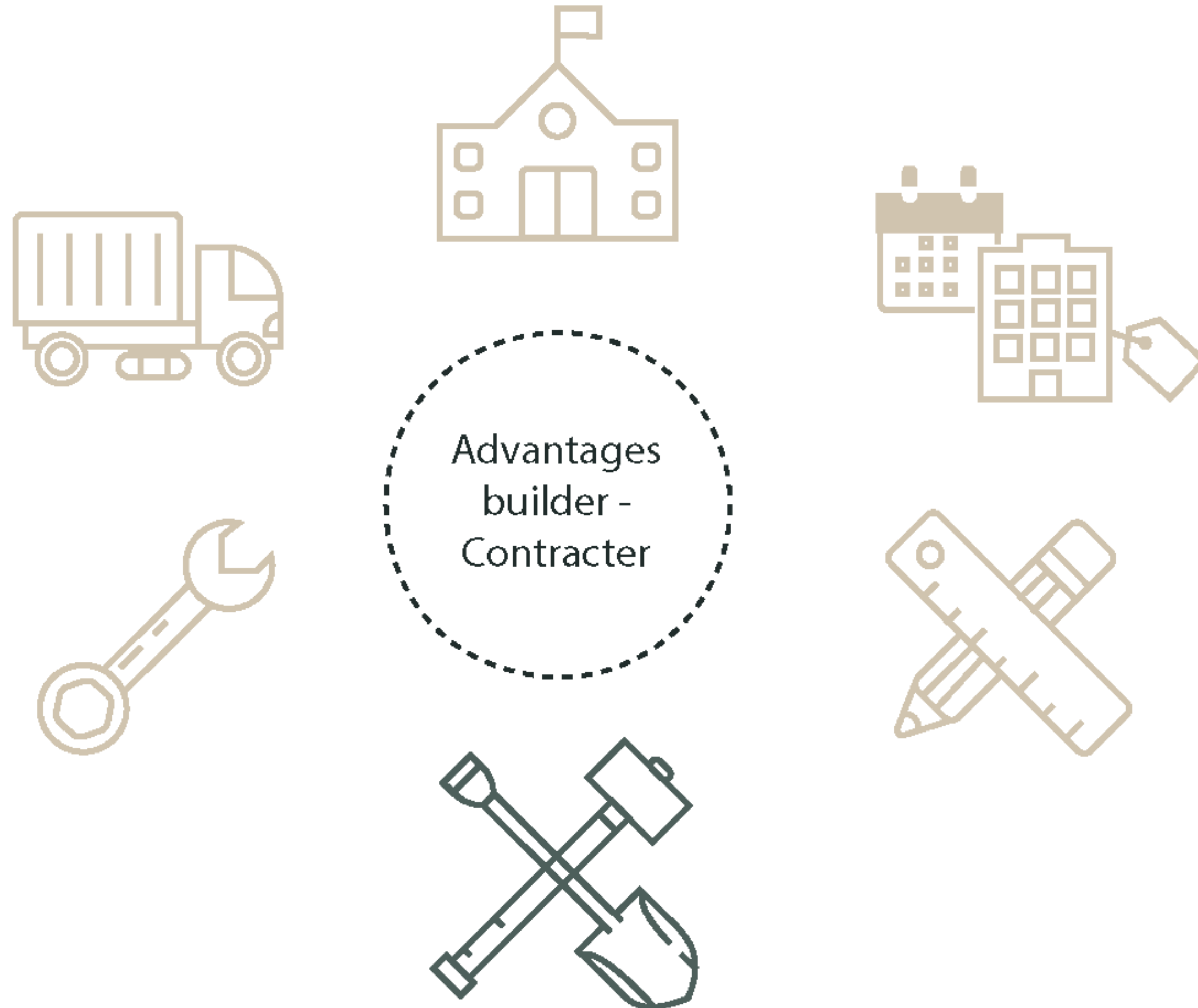
3. Design



3. Design



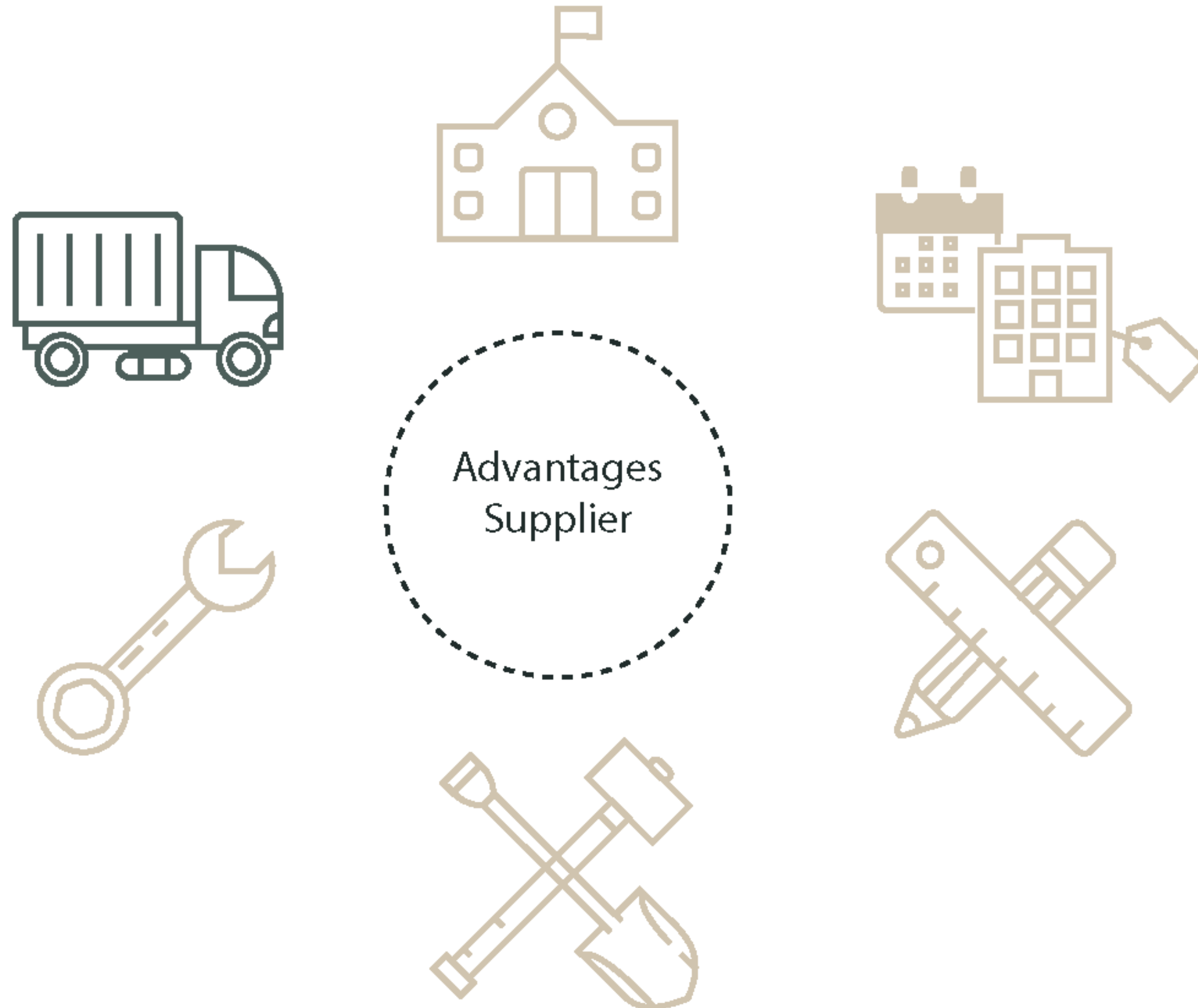
3. Design



3. Design



3. Design



3. Design

