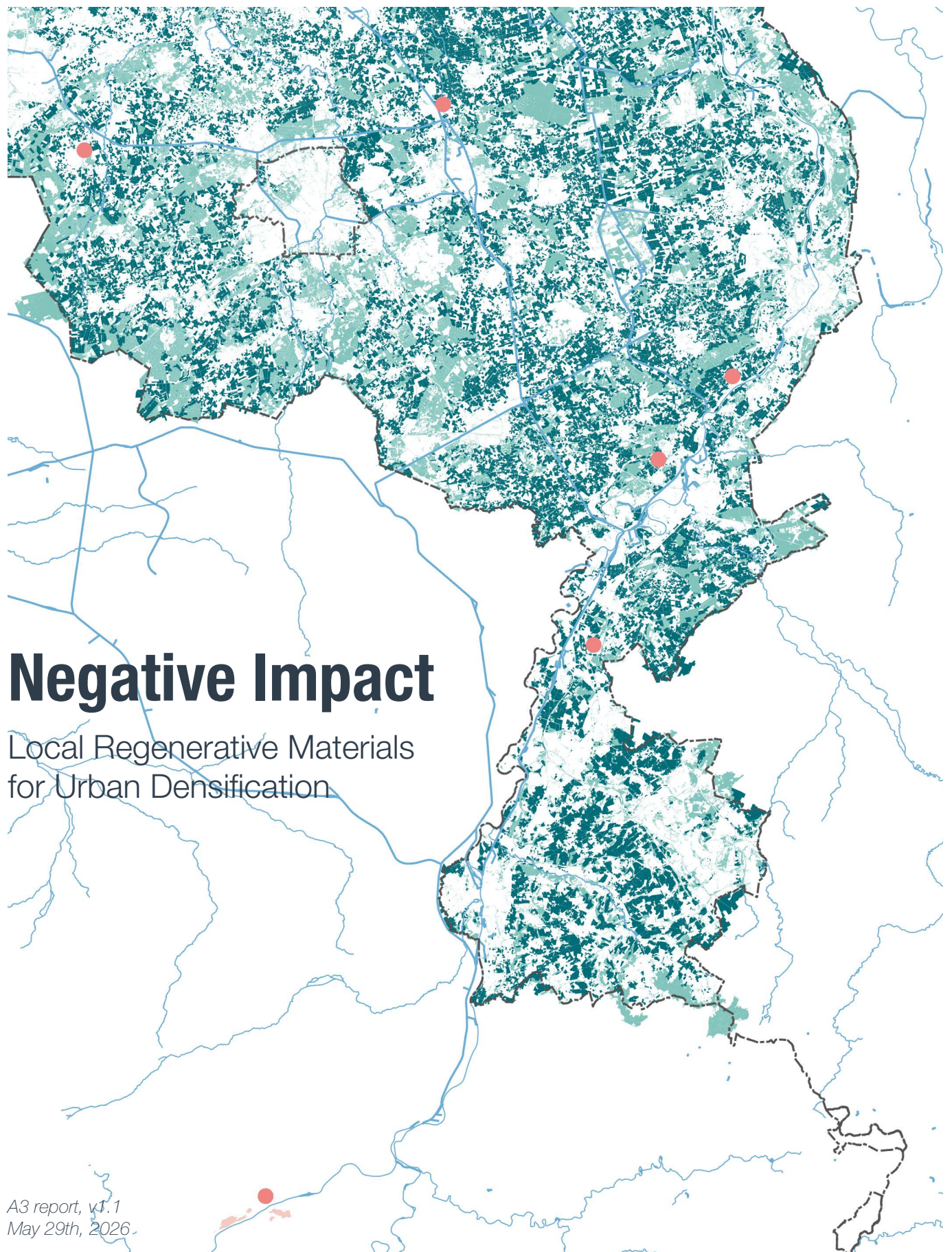




Negative Impact

Local Regenerative Materials
for Urban Densification

A3 report, v1.1
May 29th, 2026

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AE graduation
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Abstract

This project explores how local regenerative materials, mainly hemp-lime and timber, can be used for sustainable urban densification. It starts from the environmental impact of mainstream construction processes and the housing crisis. Also, the potential of underused urban areas with local identity is a key theme. In many projects, materials are sourced all over the world and buildings are constructed on a “tabula rasa”, while local resources, techniques and overlooked urban qualities can lead to characteristic projects.

The project is situated in the Eindhoven region with in particular the Schellensfabriek. It studies how local regenerative materials can be sourced, distributed and fabricated in modular 3D systems made for housing. Key methods are mapping and prototyping. The local characteristics shape the boundary of this modular system.

The modules are made for a housing concept which allows for polyvalent and adaptative use of space, made for 1 to 2 person households with a focus on social interaction through gradual privacy and collective spaces. This housing concept is applied to underused urban “tabula scripta” sites using a repeatable design method. It carefully considers existing qualities, architectural but also social, cultural and more. The modular concept is applied to the Schellensfabriek and complemented by a project specific design part, which reacts to the site’s rich history as a textile factory.

The result aims to show that local regenerative materials can be a sustainable alternative to mainstream practices, but also that it can lead to an architecture that enhances local qualities.

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Part A

Introduction

Context and reason

By 2026, 75% of Europeans reside in urban areas. Rapid urbanisation and climate change impact have and will further increase pressure on European cities (EC, 2025). The Dutch housing market faces a shortage of 396.000; Eindhoven alone requires 40.000 houses towards 2040 (NOS, 2025; Gemeente Eindhoven, n.d.).

At the same time, construction accounts for 34% of global CO₂ emissions. A significant share of these emissions is related to the use of materials like cement, steel and aluminium, at 18%, while material extraction is projected at a 60% rise by 2060 (UNEP, 2050). Not only extraction and production but also transport contributes to these emissions. The planet-wide distribution of these materials is often untraceable and unquantifiable. (Ibanez and Ferrer, 2026) Usual road freight emits 5x more CO₂ and embodies 6x more energy than for instance river freight (European Parliament, 2022; Vinci, 2024).

Contrarily, local potential is often overlooked. 54% of Dutch landuse is agricultural. A transition from kettle to biobased building material production holds great potential for sustainable material supply, solving the nitrogen crisis and decreasing international dependence caused by material scarcity (CBS, 2025; UNEP, 2025). It has however struggled to take off because of underdeveloped value-chains (VPRO Tegenlicht, 2024; Volkshuis-vesting Nederland, 2023).

Besides local material potential, 17.8 million m² of existing floor space is vacant, equivalent to the city of Utrecht. These buildings, including for instance industrial real estate, offer great transformation potential that remains largely underused (Koot, 2025; Remøy et al., 2025). Also, the existing housing stock is unsuited for today's needs, with 72% of households being single or double-person (NOS, 2025).

Problem statement

While there is a widespread shortage of affordable housing, many current construction practices are unsustainable and not future-proof. Material sourcing, distribution and production uses polluting and energy intensive strategies while local regenerative material strategies and water-based transport are often overlooked.

Design assignment

The challenge lies in designing with materials that are locally available and regenerative. The characteristics of the materials, but also the production techniques and distribution strategies define the boundary of the project. Moreover, integrating these materials in an existing site asks for alternative approaches compared to new constructions.

Relevance

Architectural Quality and Scalability

Modern architecture is very much globalised. A site is bulldozed, materials are imported from around the world. The local identity of urban areas is under pressure. Local strategies for material sourcing and enhancing existing qualities is an opportunity to counter this movement towards one look fits all.

Knowledge production

Recent global events have shown how resource reliance on global players can affect Europe. Europe is too dependent on large global powers for its resources. Self-sufficiency can prove to be crucial for the EU's global position in the coming decades. Circular strategies are very important to reach this.



Europeans that live in cities

40.000

Houses needed in Eindhoven towards 2040



Dutch households consisting of 1 or 2 persons

17.800.000

Dutch vacant floor space in m2

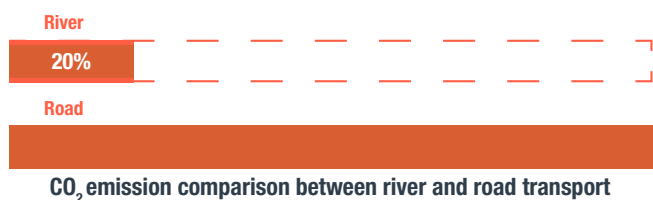
F1. Pressure on cities and housing crisis in the EU, the Netherlands and Eindhoven. (Author, 2025)



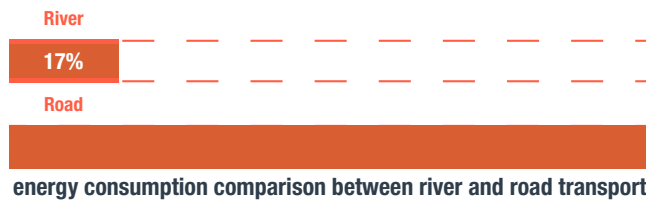
global CO₂ emissions related to buildings



of which are related to cement, steel and aluminium



CO₂ emission comparison between river and road transport



energy consumption comparison between river and road transport



share of agriculture in Dutch landuse



share of agriculture in Dutch N₂O emissions

F2. Climate crisis; emissions, transport and landuse. (Author, 2025)

Objective and motivation

Architectural and technical ambitions

The goal is to demonstrate how a local material culture drives sustainable architecture which enhances local qualities. The architecture should be rooted in its place through its material palette and the reinterpretation of places with local identity.

The technical ambition is to develop an industrialised building system built primarily from local, regenerative materials. It serves as the basis for a modular, spatially adaptive social housing concept for one- to two-person households. The concept is applied to activate underused urban “tabula scripta” sites. In the context of Eindhoven and this project specifically the concept is focussed on (partially) vacant industrial complexes as these are present all across the city and representative for Eindhoven’s identity. Boundaries are shaped by the locally available materials, fabrication techniques, and logistical strategies.

Personal interest

Throughout my life I have always been fascinated by different cultures and local identity. This is what makes each place unique. From playing children between Dutch row housing, to the culinary hotspots in San Sebastian’s Parte Vieja and middle-eastern Souqs in narrow medinas. They all have their own identity. To work with what is available in a region is an opportunity to create an architecture of local identity and sustainable, future-proof cities.

Also, growing up on the coast I have always been drawn to water. It fascinates me how oceans, seas, rivers and canals can be the backbone of entire regions and drive practices in all sorts of forms. I believe waterways can contribute to solving the climate crisis in many ways.

Research and design questions

Main question

How can local regenerative materials be applied to sustainably densify underused urban sites in an industrialised modular way while enhancing local identity?

Sub-questions

What local regenerative materials are available in the regio and how can they be sourced, processed and transported to urban sites in a sustainable value-chain?

How can the housing concept be shaped by the local boundaries, answer to current and future societal needs and be modularly applied?

How can local, regenerative materials be fabricated into components for the modular housing concept, within the boundaries of the sustainable value-chain?

How can a replicable spatial strategy enhance local qualities of underused urban “tabula scripta” sites and facilitate sustainable densification?

How can the housing concept and spatial strategy be applied to the architectural transformation of the Schellensfabriek?



F3. Urban situatio. 1:25.000. (Author, 2026)

Scope

Location

The main location for the architectural design is the Schellensfabriek in Eindhoven. It is considered as characteristic for Eindhoven's industrial and creative makers' identity.

The region is defined by the waterways that connect the city to its surroundings and thus material source. The main sources are surrounding farmlands, forests and the limestone region.

Program

The program consists of adaptive housing for 1 to 2 person households, combined with local makers and interwoven public spaces.

The material and architectural strategies are meant to be replicable to various underused urban "tabula scripta" sites across the city of Eindhoven and further.

The regional strategy is meant to be replicable to various cities that have their own material source opportunities, waterways and characteristic architectural typologies.



F4. Urban situation (Google Earth, 2026)

Part B

Approach

Methods

Sub question 1 - Local regenerative materials

What local regenerative materials are available in the regio and how can they be sourced, processed and transported to urban sites in a sustainable value-chain?

This question answers what local regenerative materials and production techniques are available and where, and what current applications exist. Also, the logistical system from source to site is considered on sketch level.

Desk research, an exhibition visit and mapping are combined.

Sources include a graduation report (Boon, 2025), professional articles, exhibitions and podcasts (Building Balance, n.d.; Houtblad, 2025; Bouzas and Salgueiro, 2026; Material District, 2026; VPRO, 2023; Staatsbosbeheer, n.d.), supplier information and open-source GIS data (OpenStreetMap, 2026).

The output is a regional harvesting map with sources, production facilities, and waterways and an urban system map. Furthermore, this phase results in a material catalogue with properties.

Sub question 2 - Housing concept

How can the housing concept be shaped by the local boundaries, answer to current and future societal needs and be modularly applied?

This question results in a prototype for the individual housing unit, including a stacking and linking strategy. It is a design exploration. An analysis of references and studies, including the available materials informs the process of sketch and maquette prototyping. A sketch climate principle is made to ensure integrated design.

Sources are co-housing concepts (de Beun, 2023; MVRDV, 2025), a previous study assignment for industrialised production in architecture (Muller, 2025) and a reference project (bosch.capdeferro, 2020).

The outcome is a housing concept at detail level of the individual dwelling, which informs SQ3 and is applied in SQ5.

Sub question 3 - Building components

How can local, regenerative materials be fabricated into components for the modular housing concept, within the boundaries of the sustainable value-chain?

This phase utilises the product development methodology established by Mac-Lean (2018). First, building components required for the site-specific program are mapped using Brand's shearing layers and the housing concept. These components are analysed based on boundary conditions (e.g. fire safety), performance indicators (e.g. R-value) and vision indicators (e.g. aesthetics).

Then, for each building component, the raw crops and half-fabricates from the material catalogue that are applicable are combined into concepts.

Finally, the most significant concepts are physically prototyped into a 1:1 model.

Sub question 4 - Spatial strategy transformation

How can a replicable spatial strategy enhance local qualities of underused urban “tabula scripta” sites and facilitate sustainable densification?

This question results in a replicable strategy for transforming underused urban “tabula scripta” sites in a sustainable way. It is a design exploration which informs the research.

Sketch exploration, a site visit and 3D prototyping iteratively result in the strategy. Afterwards, it is applied to the Schellensfabriek to validate its usefulness.

Sketching, Sketchup 2026, 3Dbagviewer and Google Earth are tools used in this phase.

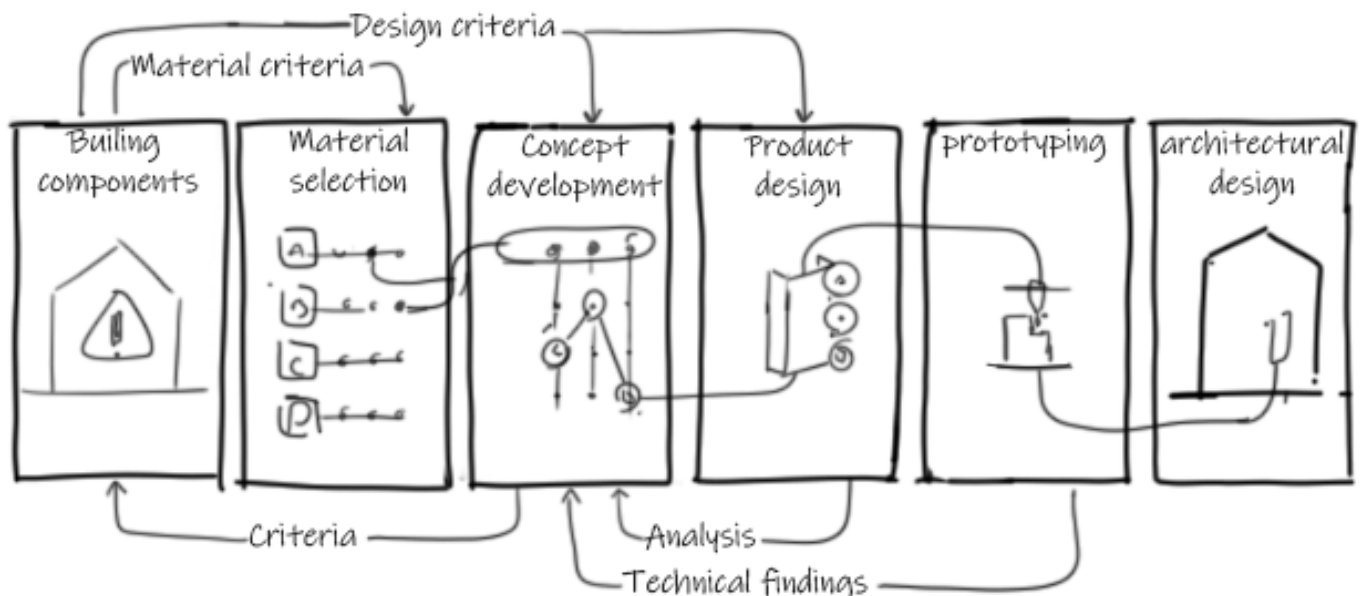
Sub question 5 - Architectural case study

How can the housing concept and spatial strategy be applied to the architectural transformation of the Schellensfabriek?

Finally, the results of SQ1-4 are integrated in an architectural design in which the Schellensfabriek is transformed. Methods include desk research, visual analysis, site visit, informal talks, prototyping of negative space, sketch variants, sketch maquettes, mass variants.

Among the techniques and tools used are Sketchup 2026, Archicad 2029, Adobe Creative Cloud 2026, Autodesk Forma.

The sources include the municipal vision (Gemeente Eindhoven, 2023), existing design visions (Atelier van Berlo, 2018; Schellenskwartier, n.d.), various architectural case studies, but also existing BIM models for drawings and dimensions.



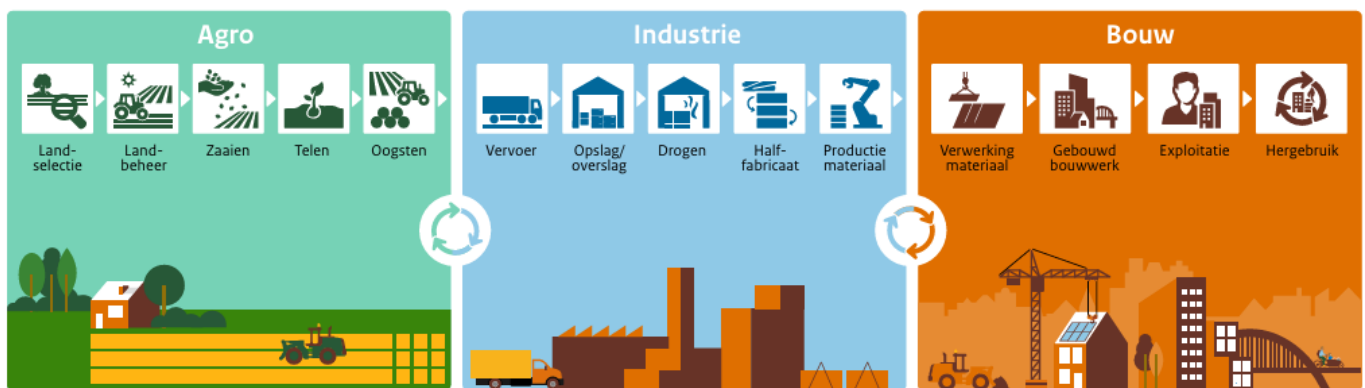
F5. Product development methodology based on Mac-Lean (2018)

Theoretical framework

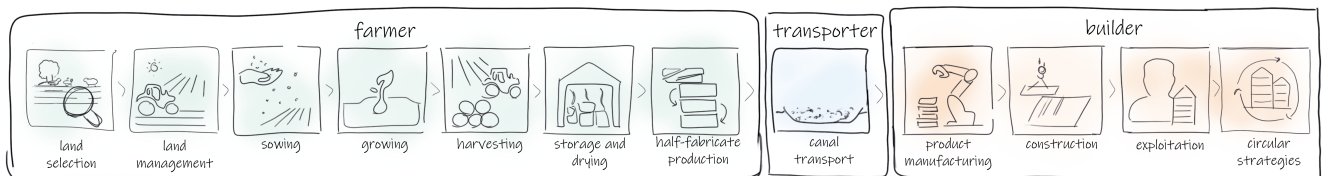
Regional value-chain

VPRO Tegenlicht (2024) and the Nationale Aanpak Biobased Bouwen (NABB) (Volkshuisvesting Nederland, 2023) highlight that while the potential for “farm-to-building” regional value-chains is high, the market is struggling to take off, due to a lack of robust value-chains. Builders are uninformed or hesitant because of technical uncertainties and costs, farmers face investment risks and long-term uncertainty. To address this, the Central Government and initiatives like Building Balance are upscaling regional chains up to 1.000 ha or 1.500 football fields. Eindhoven’s Zuidoost-Brabant currently grows 160 ha of wheat, flax, hemp and sorghum (Building Balance, n.d.).

The typical model for regional “farm-to-building” value chains, according to Volkshuisvesting Nederland (2023), is shown in figure 17. However, a key theoretical shift is the move toward decentralised production. By storing, drying and producing half-fabricates on-farm, value remains with the farmer, transport movements are minimised, and agricultural rest-products are recycled locally. (Volkshuisvesting Nederland, 2023) A decentralised value-chain would look like figure 18. An industrial hub in an urban industrial area could facilitate storage of half-fabricates and capacity for manufacturing to building products, supported by optimised waterfronts.



F6. The biobased production chain between farmer, transporter and builder. (Volkshuisvesting Nederland, 2023)

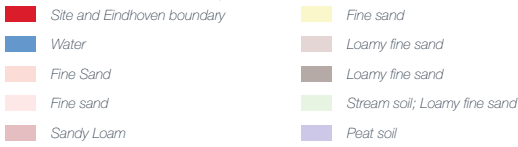
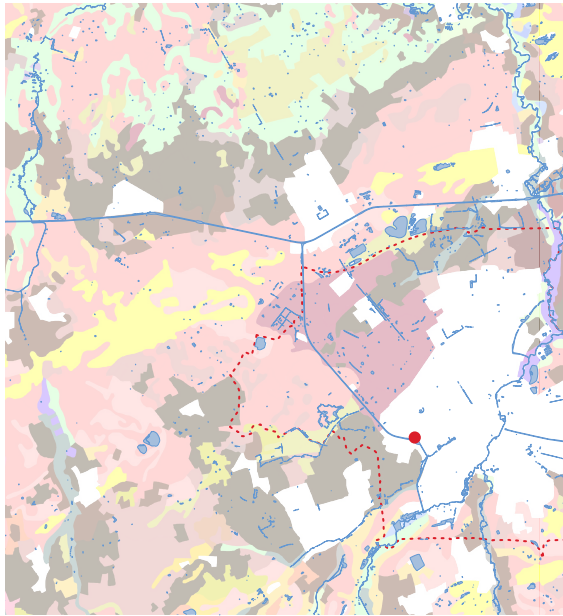


F7. Decentralised regional value chain (Author, 2025; based on: Volkshuisvesting Nederland, 2023)

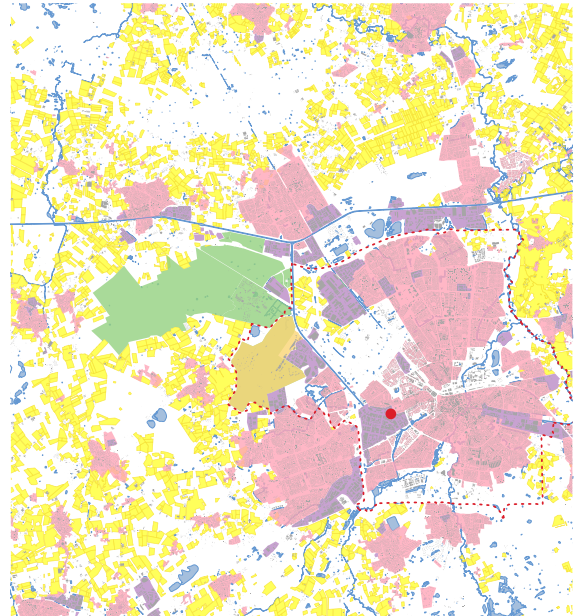
Abiotic conditions, mapping and suitable crops

By mapping the region the logistical potential and boundary conditions for (future) suitable crops become clear. The maps show that the urban industrial area is well-connected to the region by following the Beatrixkanaal downstream. The abiotic map shows that the soil can be characterised as mainly sandy. An exception can be found around the Dommel, in peat soil. (Klimaat-effectatlas, n.d.). The cultural map shows an interesting landscape that is mainly characterised by the amount of farms. Also the military district and airport come to attention. When the farms are projected over the landscape it can be seen that they are mostly located on sandy soil, which gives a boundary condition for crops. Climate risks include high ground water and longer droughts. Crops need to be resistant. The Klimaat-effectatlas gives future climatic risks for the area, being extreme and prolonged rainfall and agricultural drought damage. Crops should be suited to these boundary conditions to ensure farmers’ long-term safety.

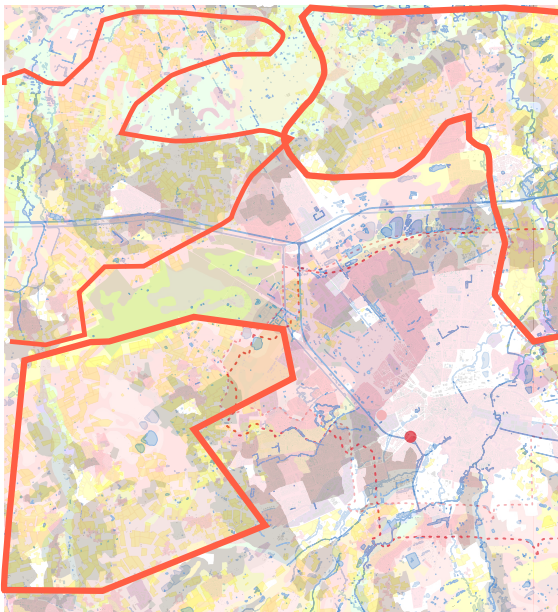
The crops that remain after applying these boundary conditions are listed in figure 12. While all these crops have high potential, there are differences in application. Miscanthus, Silphi and Sorghum are mainly used as blow-in insulation and as non-structural boards. Bamboo has higher investment cost and time. The most high potential crop is hemp, as it is used in various applications such as hemp-lime composites and suited to local conditions. The only property that is



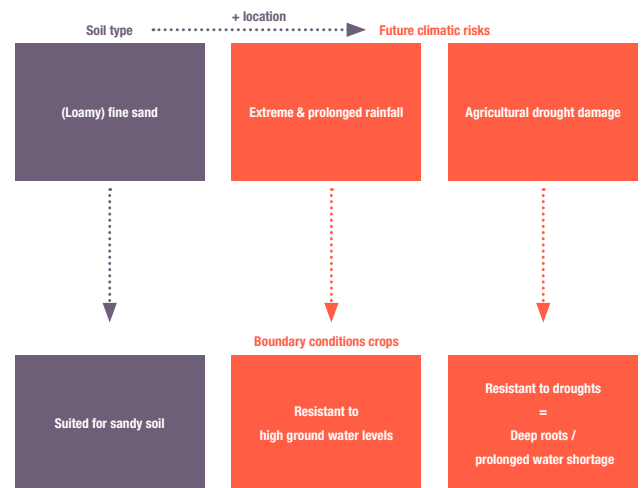
F8. The abiotic system. (Author, 2025)



F9. The cultural system. (Author, 2025)



F10. Farms overlayed on soil type. (Author, 2025)



F11. Soil and climate change dictate boundary conditions for crops. (Author, 2025; based on: Klimaateffectatlas, 2025)

Miscanthus

Silphi



Sorghum

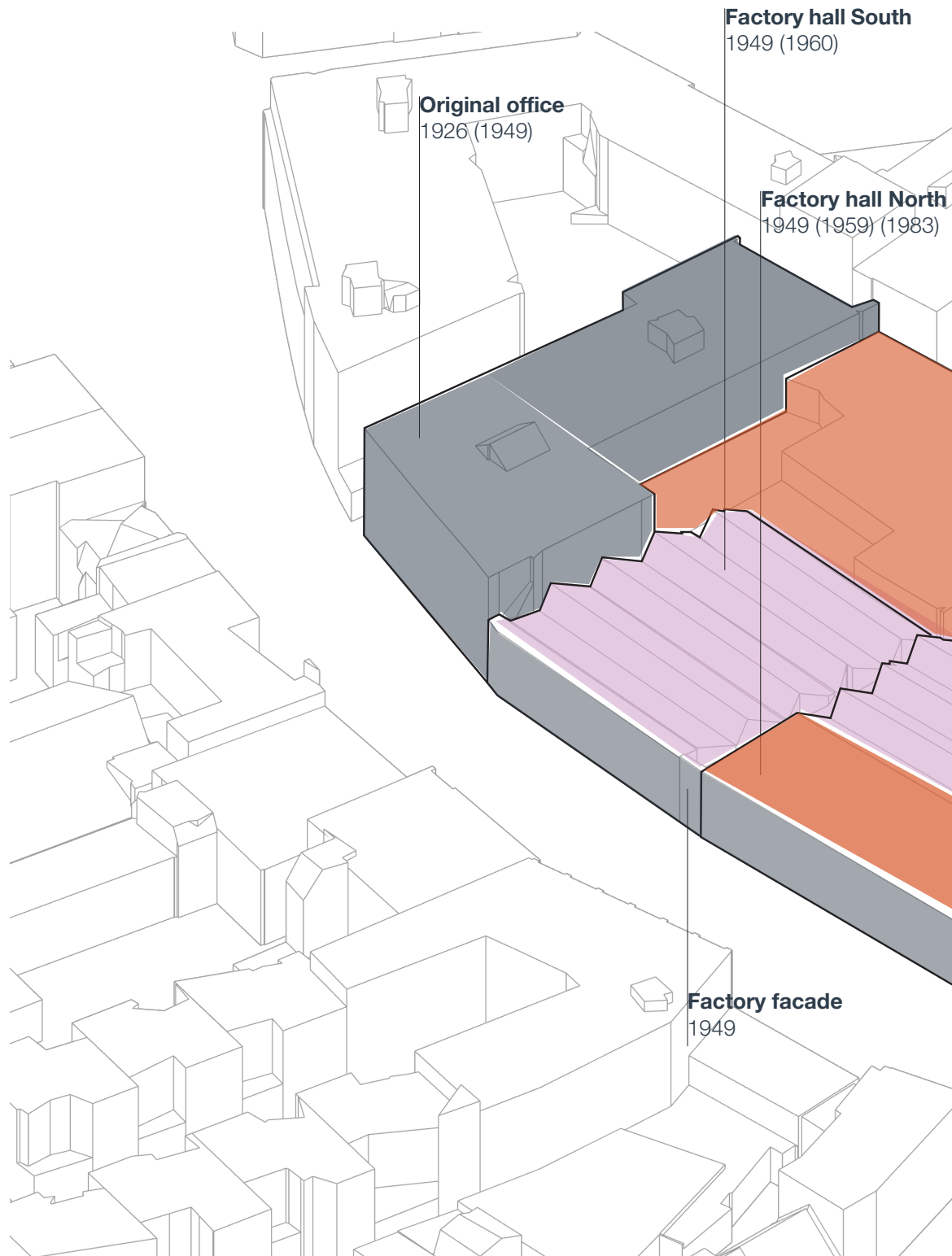


Hemp

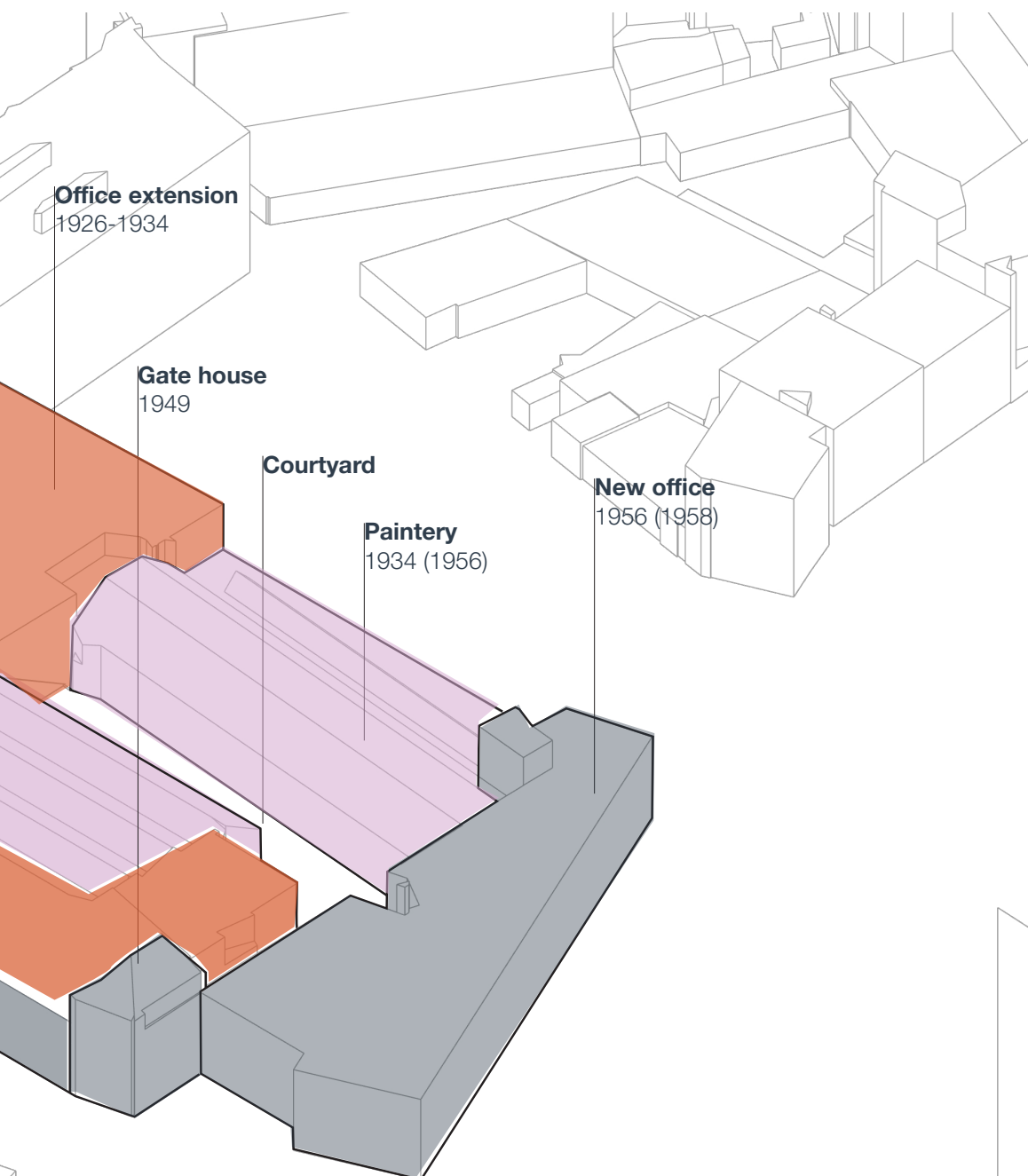
Bamboo

F12. Suitable and high potential crops to regional system. (Author, 2026)

The Schellensfabriek is a former textile factory which was active in the 20th century. It consists of two office buildings, both extended with factory halls, a younger office extension and a paintery. The original office building and factorywall are listed. While large parts have been vacant for years, the complex has high cultural value as there are multiple local makers involved as current users: 100Watt cafe and brewery, Lucifer Coffee Roasters, Studio Sander Mulder, CoCosmos and an unidentified atelier. The halls are used as exhibition space for the Dutch Design Week. The complex has high architectural value and is located on the Dommel. Figure 13 shows the different building parts with a picture collage of

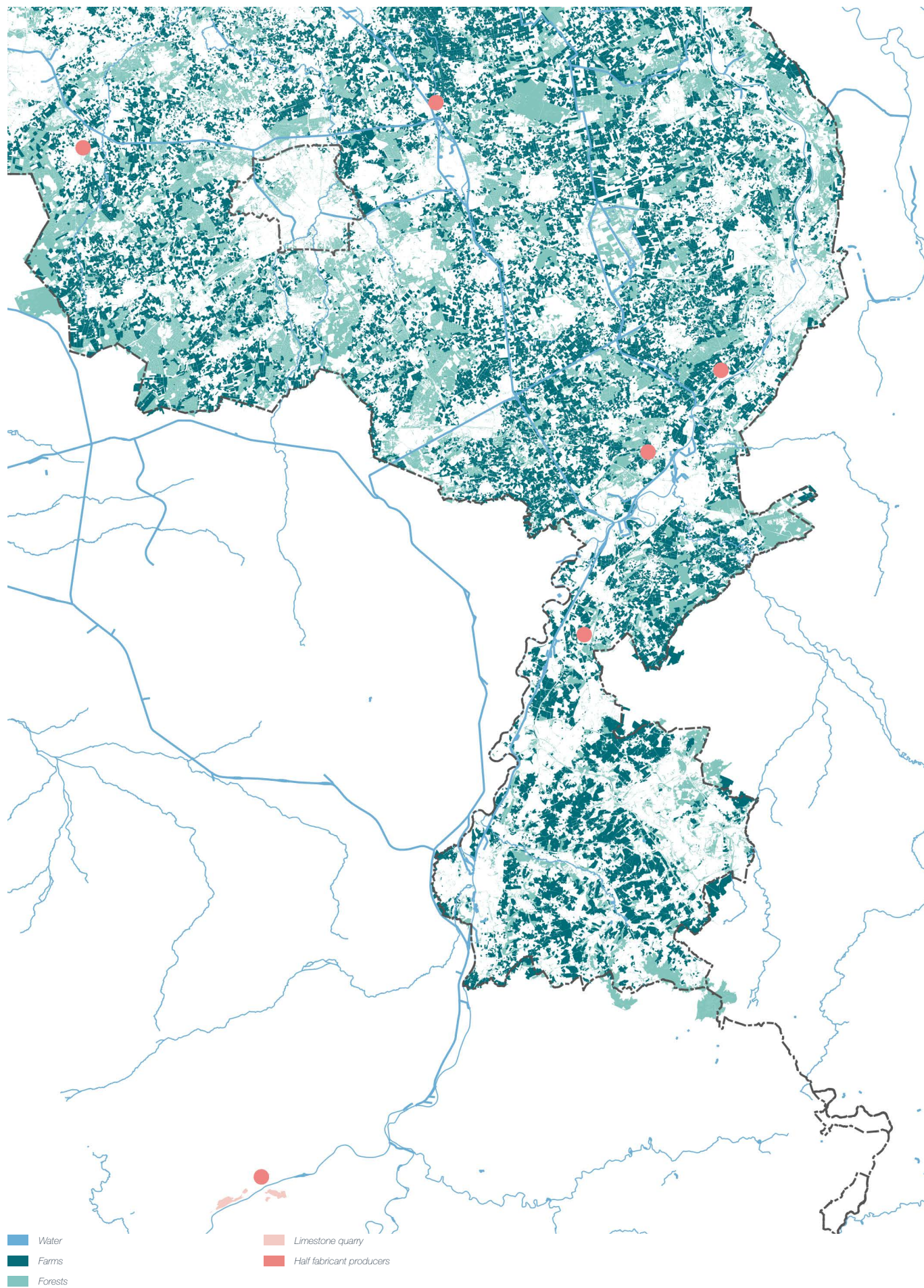


F14. Schellensfabriek analysis. (Author, 2026)



Part C

Results



F15. Regional harvesting map. (Author, 1:500.000)

SQ1; Local regenerative materials

What local regenerative materials are available in the regio and how can they be sourced, processed and transported to urban sites in a sustainable value-chain?

F15 shows the regional map. The light green spots are the farmlands, the darker green the forests. The beige shows the limestone quarry. The waterways connect the sources to the city. Along the way, the different producers can be seen, being sawmills and a factory for laminated timber. F16 shows the urban system. The purple spots are the industrial buildings in Eindhoven. This gives an idea of the spread of industrial buildings across city. The Schellensfabriek is marked in red and a fictional location for the industrial hub in blue. The building components are fabricated in the industrial hub and transported to various sites via light electric vehicles.

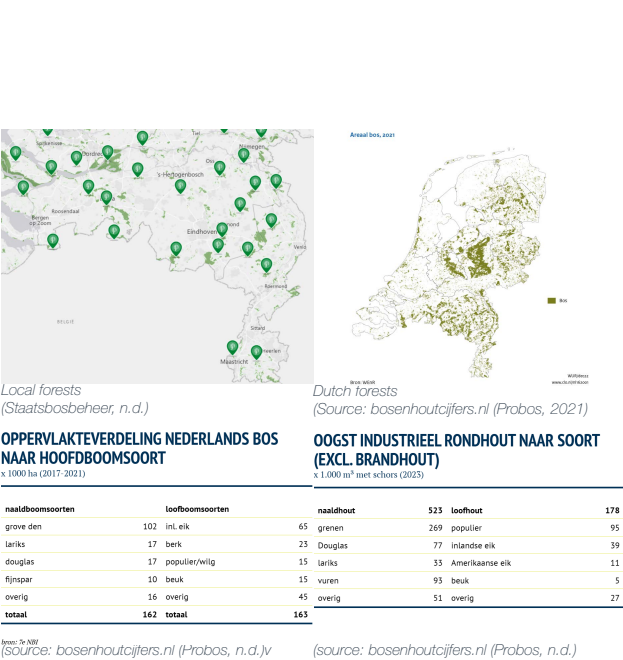


F16. Urban system. (Author, 1:50.000)

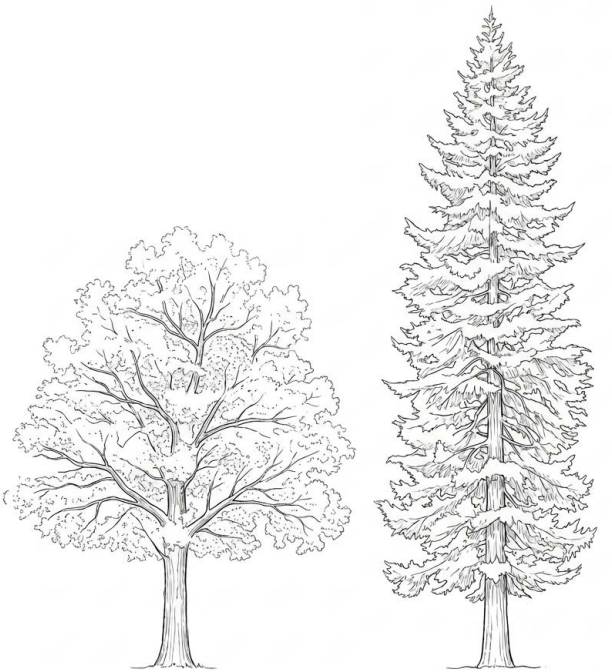
● Schellensfabriek ● Industrial hub ● Industrial buildings

The building system is a combination between a timber structure and hempcrete infill, complemented with possible other materials for finishing like lime plaster or biocomposites such as coffee waste tiles or pressed fibre boards. The timber structure is made from local timber. Currently, 8% of Dutch construction wood is sourced in the Netherlands. This can be scaled up through more high-value use of the sawn timber. (Houtblad, 2025). The available species are highly dependent on what species are harvested at a particular moment. Sustainable forestry includes a variety in species to battle monoculture. This means that in the near future, there will be a higher variety in the available species to designers and builders. It is the designers task to use the property of the species in a design and work with what is available. At the time of research, Douglas Fir and American Oak are being harvested in Leenderbos and Groote Heide. It can be assumed that these species will be available more often in the future as they are highly represented in the area. Also, they represent coniferous and deciduous wood. These are the two species considered in this project.

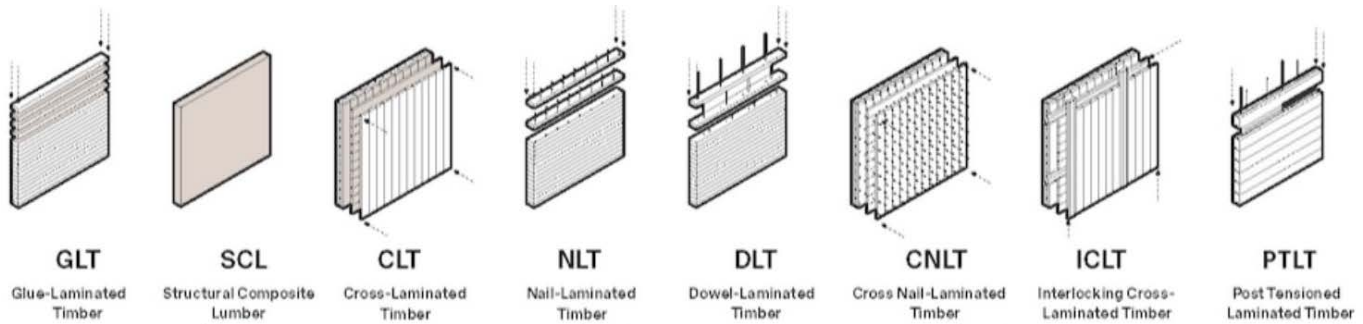
The available techniques for timber construction are imporant to consider. If for instance LVL, CLT or GLT are used, the materials need an extra stop at a lamination factory. Figure 19 shows various timber construction methods. The constraints of this project lead towards a more low-tech technique of for instance NLT, DLT. The buckling factor is crucial for a bearing column, thus DLT with a combination of structural Douglas timber and Oak dowels is chosen. The hempcrete frames are constructed in the same way with a bridle joint at all corners.



F17. Timber data (Staatsbosbeheer, n.d.; bosenhoutcijfers.nl; Probos, 2021; Probos, n.d.)



F18. American Oak and Douglas Fir (AI created, Gemini NanoBanana2)



F19. Timber construction methods. (Internalities, 2026)

Hempcrete is a combination of industrial hemp shivs and a lime binder. It can function as a monolithic facade or inner wall system. It regulates indoor climate and has good properties. It also has high aesthetic potential, including color variation through natural pigments. Figure 20 shows different construction techniques.

Hempcrete properties based on Boon (2025):

Statistics

91 kg CO₂eq in one m³ hempcrete
 50-80% energy use reduction in hemp structures
 22 tonnes of co₂ absorbed by 1 ha. of industrial hemp (Cannabis Sativa L)

Construction methods

spraying, forming into blocks, insulation infill (cavity walls), cast in-situ (exposed facades)

Physical properties

- air cavity (60-90% is pores) for insulation
- dampopen, but must be airtight.
- highly hygroscopic
- must not be subjected to large amounts of water
- in situ hempcrete lambda-value between 0.06 and 0.18 W/mK, for a density ranging from 200 to 800 kg/m³
- phase shift up to 16 hours depending on mixture
- self-supportive, non load-bearing
- binder, ratio binder-hemp, orientation and size shivs strongly affect performance
- highly flexible under pressure, deform without breaking
- good sound absorption
- limited sound insulation (200 mm can achieve 22-32 dB unfinished, 39-40 dB finished)
- fire resistance classified as B-s1, d0 ; limited fire contribution, low smoke, no flaming droplets
- good durability to salt, mould and insects

Thickness monolithic building components [mm]

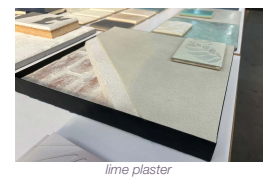
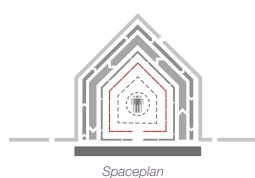
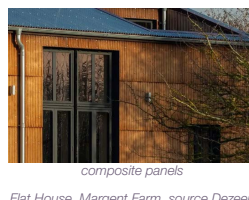
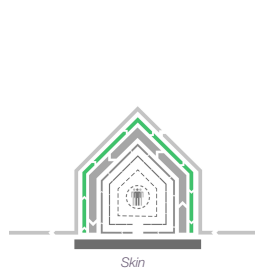
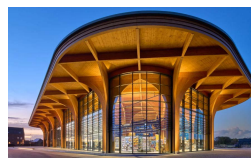
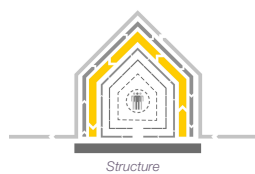
(R_{roof}=6,0 ; R_{gevel}=4,7 ; R_{vloer} = 3,7)

Roof	360-1080
Facade	282-846
Floor	220-660

Proposed mix

- dry density	275 kg/m ³
- B/H ratio	1.09
- Thermal conductivity	0.078 Wm/K
(thickness roof 468mm, wall 366mm, floor 289mm)	
- Hemp mass per m ³	131.6 kg
- Binder mass per m ³	143.4 kg
- Functional unit FU	0.366*3.0=1,098 m ³
(one m stretch of wall excl. support structure)	
- Mass per FU	302 kg

source: Monolith (Boon, 2025)



F20. Material Catalogue. (Author, 2026; De Zwarte Hond, n.d.; Kontextur, 2025; Boon, 2025; Levy, 2020; Ebginge, 2024)

SQ2; Housing concept

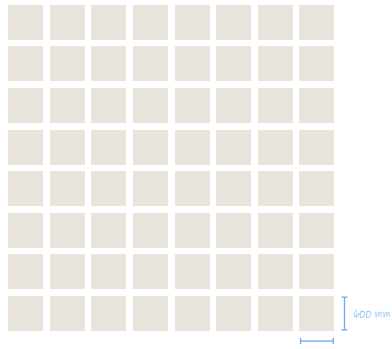
How can the housing concept be shaped by the local boundaries, answer to current and future societal needs and be modularly applied?

The housing concept is based on standard sizes for timber and hempcrete components with a grid of 600 mm (1). It follows a reinterpreted structuring to the classic gallery flat (2). By rotating the houses, social spaces emerge in the form of a collective living gallery and connected balconies. The living gallery sees a gradual privacy from collective walkway to semi-private corner. The balconies are designed so that there is more private space (3).

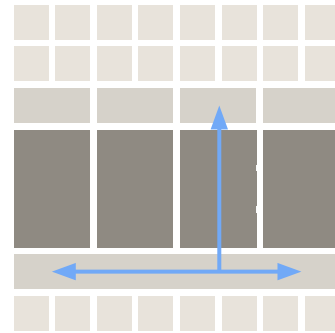
The concept floor plan of the dwelling is inspired by the 6x6 block (bosch.capdeferro, 2020). It is divided in 6 blocks. The middle blocks are the kitchen and sanitary unit, the others can be anything the user would like. This allows for adaptivity and different types of people in 1 or 2 person configurations, even a starting family (4). A full house is around 60 m², a studio 40 m². An individual ? room is 10.8 m², a double one is thus 21.6 m². The sanitary and kitchen are designed in a way that linking and stacking is possible. This also makes it possible to make lofts (5). The infill could be anything desired (6). In other projects the gallery and rotation system can be reinterpreted in different ways.

The climate concept is designed to aim for a reduction of energy use and a passively managed climate as much as possible. Orientation, seasonal optimised shading, cross-ventilation, thermal and moisture buffering are considered.

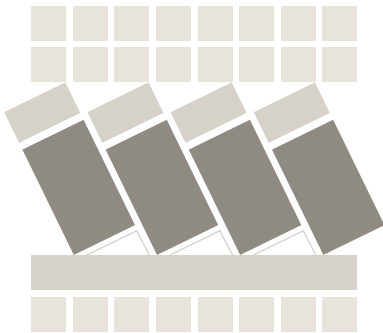
The housing concept is considered modular, it can be applied different forms in different projects. Each project has a project specific part. In this case this is mainly the reused buildings, public space, plinth, cores, galleries, balconies and roofs.



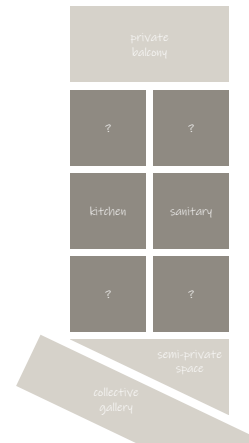
1. grid based on standard timber sizes



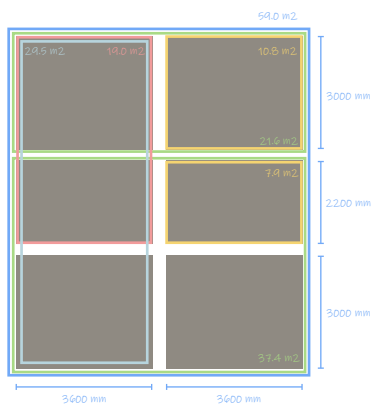
2. gallery housing principle



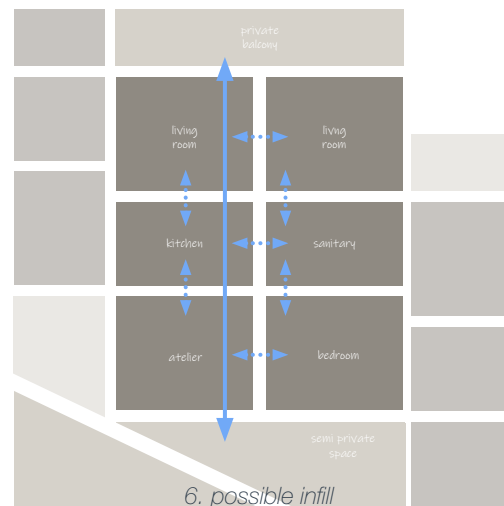
3. rotate



4. dwelling concept



5. dimensioning for 1p/2p household



6. possible infill

SQ3; Building components

How can local, regenerative materials be fabricated into components for the modular housing concept, within the boundaries of the sustainable value-chain?

Product development method

The product development method starts from design criteria, which are derived from the project vision. These criteria are ordered in a hierarchy of importance by a dual pairing matrix. Design concepts are made for each building component. The best ones are integrated in the building system. The focus scale is 1:20. The design vision is described using the Architectural Engineering studio triangle of context, program, technology. One extra pillar is added, being expression.

Context The components are developed for application in transformations of vacant industrial sites in urban areas, in this case particular the Schellensfabriek.

Technology The components are made from as much local regenerative materials as deemed possible, being mainly hemp and timber. The building system is a structure/infill system. The priority lies on materials sourced from the direct farm landscapes around the city. The components must fit the logistical system, transport via waterways and last-mile light electric truck. Also, they should fit the making system, decentralised production of half-fabricates, integrated modular prefabrication in industrial hub and light/clean mounting on-site.

Program The components are primarily used to make the adaptive 1 to 2 person housing concept. The housing program is complemented by local maker spaces on street level. The site features a spine of outdoor, public spaces in which visitors meet makers and residents.

Expression The local regenerative materials are communicated through the design. The making process is visible in the components. The new architecture is complementary to and enhances the qualities of the Schellensfabriek. New volumes should “overgrow” the factory.

Design criteria derived from the design vision

Context:

- (C1) Adaptivity to different vacant industrial sites

Technology:

- (T1) Usage degree of local regenerative materials (hemp prioritised)

- (T2) Suitability to logistical system

- (T3) Suitability to making system

Program:

- (P1) Suitability to housing concept

Expression:

- (E1) Readability local regenerative materials

- (E2) Readability making process

- (E3) Complementarity to Schellensfabriek

- (E4) Degree of overgrow aesthetic

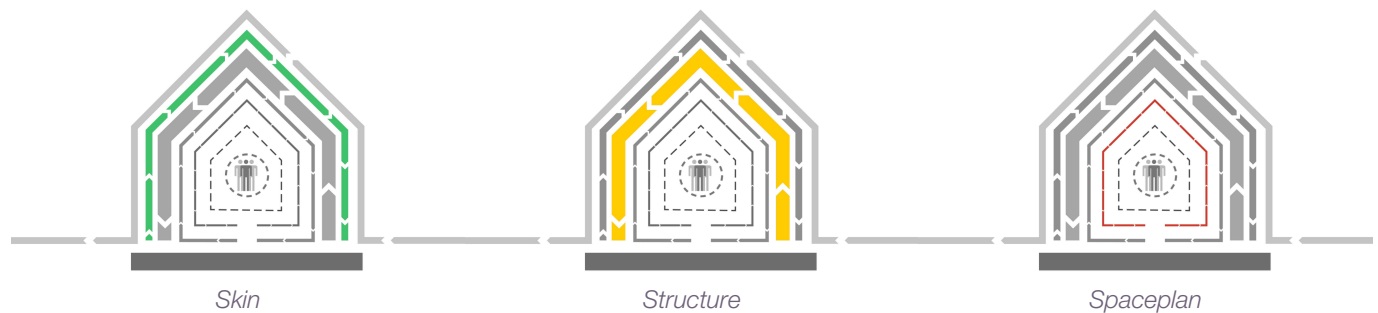
	C1	T1	T2	T3	P1	E1	E2	E3	E4	
C1		0	0	0	0	0	1	0	1	2
T1	1		1	1	1	1	1	1	1	8
T2	1	0		0	0	0	1	1	1	4
T3	1	0	1		0	1	1	1	1	6
P1	1	0	1	1		0	1	1	1	6
E1	1	0	1	0	1		1	1	1	6
E2	0	0	0	0	0	0		0	0	0
E3	1	0	0	0	0	0	1		0	2
E4	0	0	0	0	0	0	1	1		2

F22. Priority by dual pairing matrix. (Author, 2026)

The design criteria are prioritised in the dual pairing matrix. Two criteria are compared, the winner gets 1, the loser 0. In the end all points are counted to see hierarchy of importance. The ranking is as follows:

- 8 - Usage degree of local regenerative materials (hemp prioritised)
- 6 - Readability local regenerative materials
- 6 - Suitability to housing concept
- 6 - Suitability to making system
- 4 - Suitability to logistical system
- 2 - Complementary to Schellensfabriek
- 2 - Adaptive to different vacant industrial sites
- 2 - Degree of overgrow aesthetic
- 0 - Readability making process

The criteria are used to remind of the priorities in each design choice. Not each design aspect is scored individually for all choices as this is very time consuming and seen as too mathematical for a design process.



F23. Layers of Brand (RoosRos, n.d.)

Building component concept development

The layers of Brand are the basis for the building component development. The layers structure, skin and spaceplan are considered. The following building components are considered, ordered by hierarchical importance from large to small.

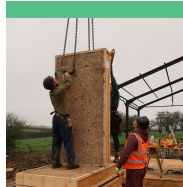
- Skin - facade
- Structural system (building scale)
- Spaceplan - dividing wall
- Spaceplan - dividing floor
- Spaceplan - partition wall
- Structure - external circulation
- Skin - roof
- Skin - ground floor
- Structure - foundation

The variants for the different building components can be seen in the matrix. With in mind the criteria, each variation is scored green (good), yellow (doubt) or red (negative). In the next phase the different green or yellow variants could be combined to figure out the building system on a 1:20 scale. This will inform the prototype and of course the building design and detail scale. The process is iteratively, if the system does not work, other variants are created.

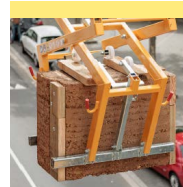
skin
facade



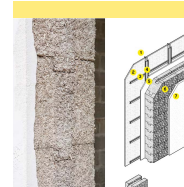
hempcrete + water-
roofing



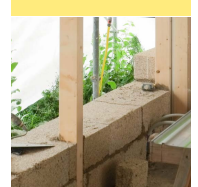
Prefab frames



Prefab post-
supported blocks



Interlocking blocks



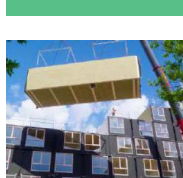
Masonry blocks

All options are considered to need extra water protection from the outside, this is done by adding lime render. The thickness of monolithic hempcrete for thermal insulation is 366mm. (Material Cultures, 2023; Boon, T., 2025 from: Déchelette Architecture, n.d.; Pierre Chevet Sports Hall, source: Lemoal Lemoal; ©Raphael Hähni, Lepold Strobl - Jens Knöpfel Architekten; collective.and, 2025)

structure
building scale



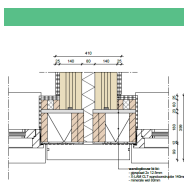
laminated core+floors
+ glulam post/beam



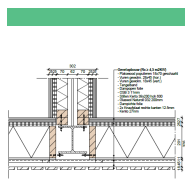
3D laminated
modules

3d modules are considered most fitting for the concept. They are fabricated off-site and easily transported. The modular character fits well. (Urban Climate Architects and MAATworks, 2026))

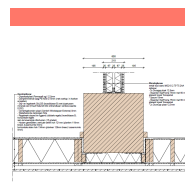
spaceplan
dividing wall



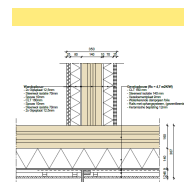
3D modules



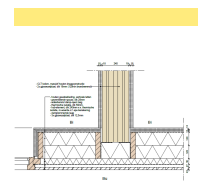
detached frames



infill wall



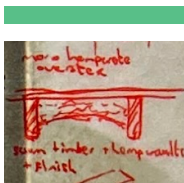
stud walls



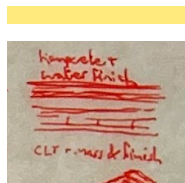
overdimension

Walls need to be detached for acoustic properties. Timber frames filled with hempcrete, as part of the 3D module fit best. They can be finished in different ways and formed in sculptural ways. (Urban Climate Architects and MAATworks, 2026)

spaceplan
dividing floor /
ceiling



timber frame/clt floor
+ hemp-lime ceiling



CLT floor + subfloor,
visible ceiling

Hempcrete needs to be on the surface with only a damp-open finish at maximum. This creates the regulating environment. Also, it can be made in a sculptural way.

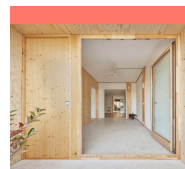
spaceplan
partition wall



prefab hemp-lime
blocks



timber frame +
hemp-lime blocks



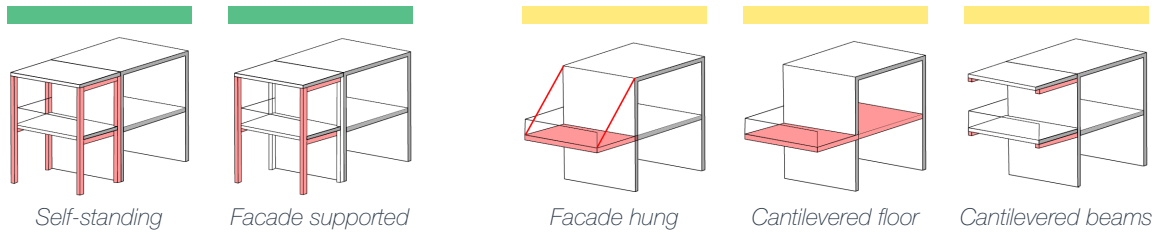
large openable door



sliding doors

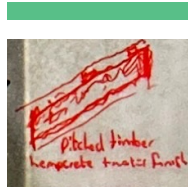
Blocks can be prefabricated and mounted on-site. In case of 3D modules, timber framing would be possible. However, the modules would need to be made in the industrial hub. Sliding doors can be used for the adaptive, openable parts. (bosch.capdeferro, 2020)

structure
external circulation



All structures are considered using sawn American Oak. Stability elements may be integrated in the facade supported structure. Most likely, the structure would need to be standing on its own at least largely due to the large spans. It is connected to the modules for stability in the long direction. (Urban Climate Architects and MAATworks, 2026)

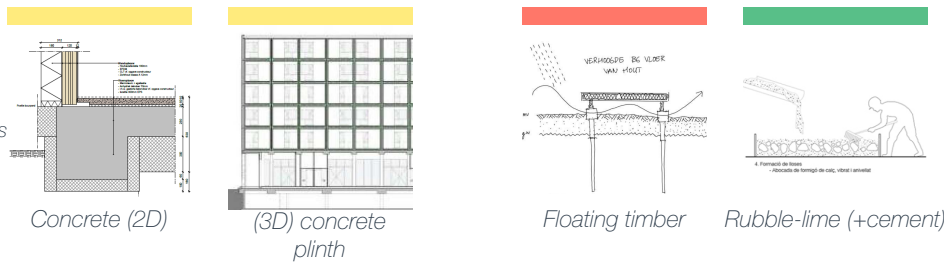
skin
roof



pitched timber framing
+ hemp-lime infill

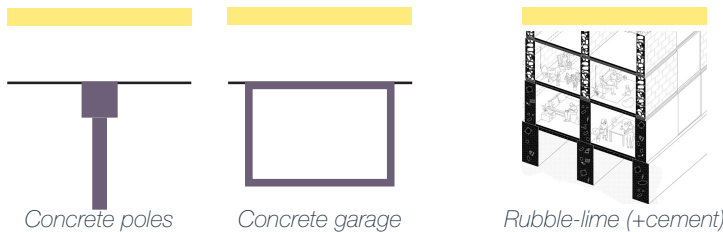
The thickness of a hempcrete element only for thermal purposes is 468mm. Waterproofing is essential and is considered by adding materials.

skin
ground floor
(Urban Climate Architects
and MAATworks, 2026;
De Koning, D., 2026)



Although ecologically interesting, the floating floor would not suit maker spaces. Timber and especially hempcrete need to be protected from water. Concrete would work but are not really suited to the projects environmental ambitions. The rubble lime would be well suited. (H Architectes, n.d.)

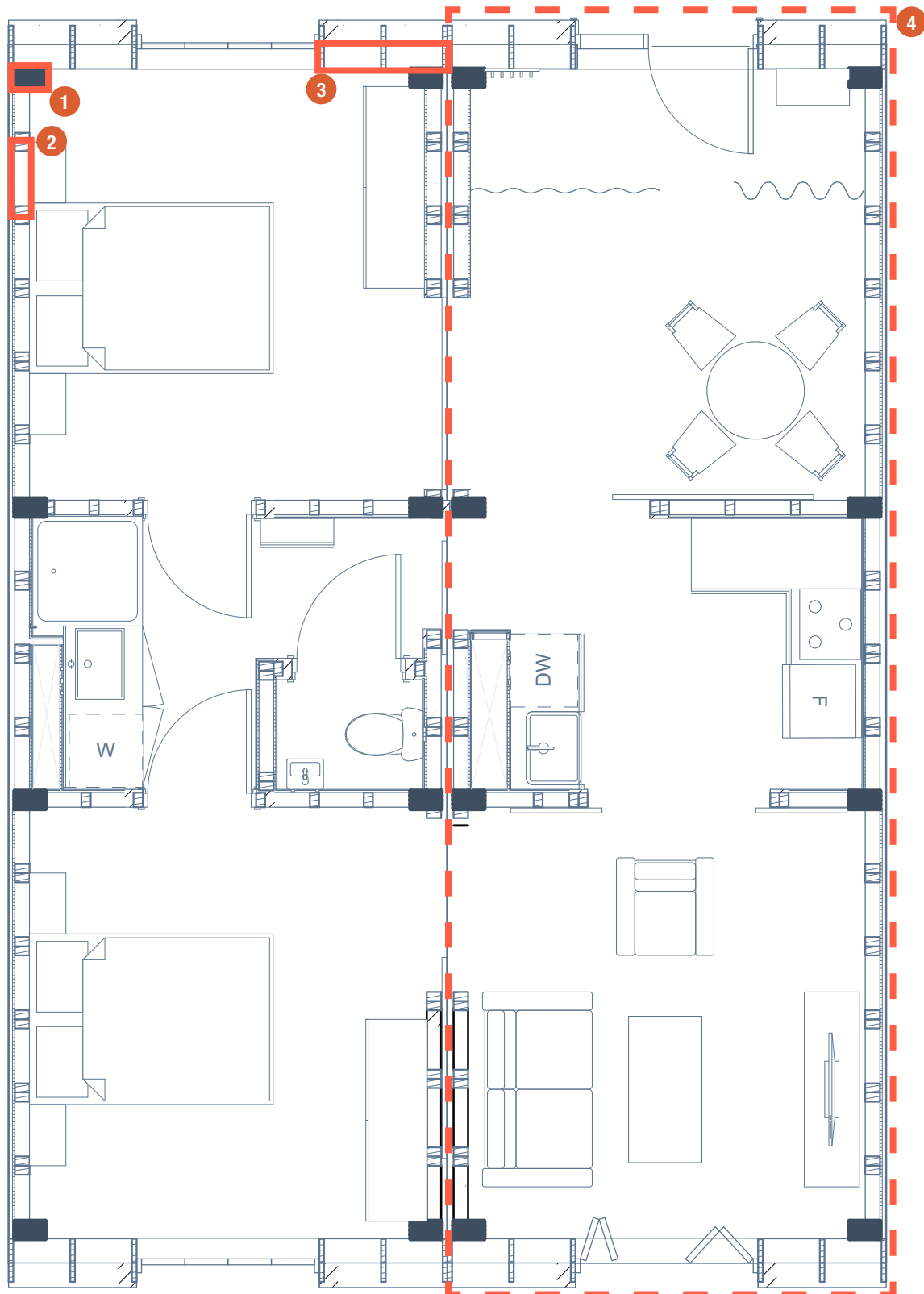
structure
foundation



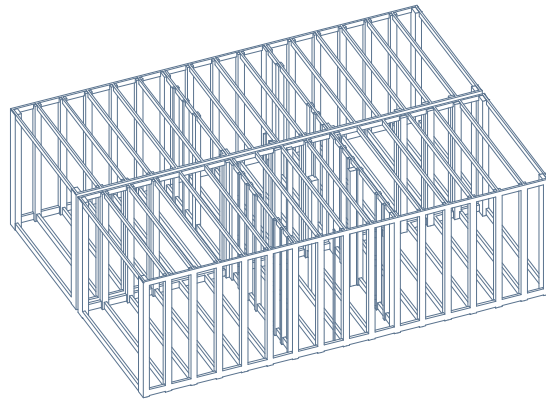
As foundation, concrete is inevitable. Careful consideration is required to not damage the existing building. The rubble lime would be perfect but unsure if it has the properties for this typology. (H Architectes, n.d.)

Module (4) and components

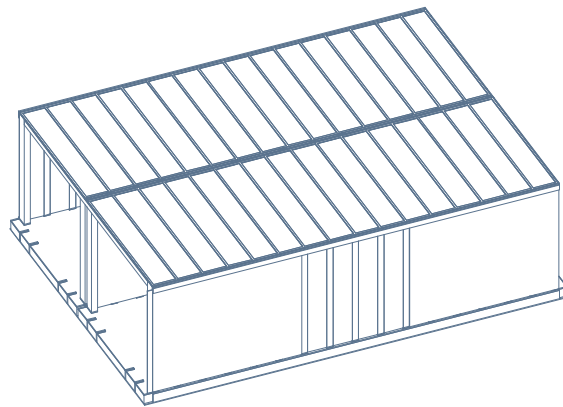
The main structural elements in the floor plan are the DLT columns made of 4 36x250 mm sawn douglas columns and oak dowels. (1) The partition is a sawn timber frame made of 75x120 mm sawn timber members, connected by bridle joints with oak dowels. For stability, these elements are connected with 18 mm ecoboards. The infill is hemp-lime mix finished with lime render. (2) The facade elements are made of 38x200 mm sawn douglas columns, filled with the hemp-lime mix. (3)



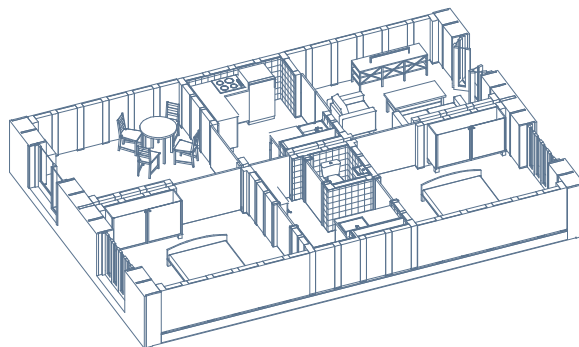
F25. Floor plan base module (1:50; author, 2026))



F26. Structure only, excluding ecoboard stability members. (1:50 scaled to 1:100; author, 2026)



F27. Structure and infill, excluding facade. (1:50 scaled to 1:100; author, 2026)



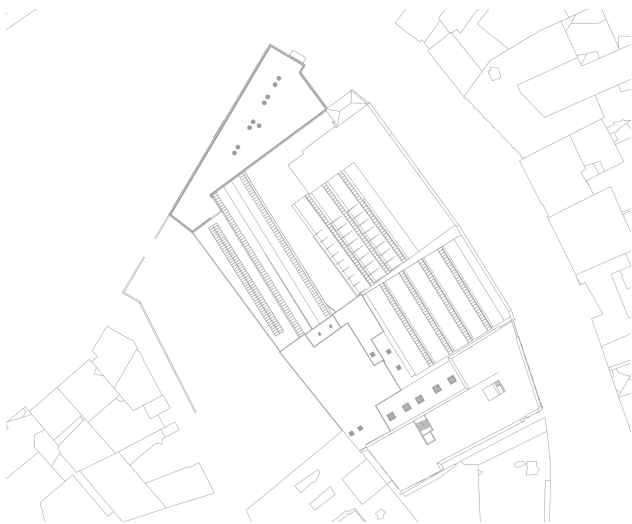
F28. Full module, cut at 1100 mm height. (1:50 scaled to 1:100; author, 2026)

SQ4; Spatial strategy transformation

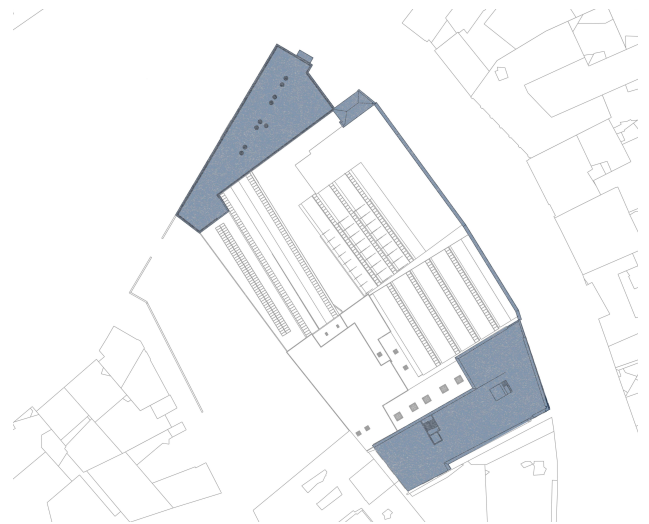
How can a replicable spatial strategy enhance local qualities of underused urban “tabula scripta” sites and facilitate sustainable densification?

To enhance local qualities and identity of underused sites like the Schellensfabriek, this project introduces the concept of negative space as replicable design strategy. The goal is to open up the building and strengthen existing qualities by taking away parts to reinterpret the current ensemble, rather than bulldozing and building entirely new. Industrial sites are characterised by large open spaces and a patchwork of building parts, often unsuitable for housing due to little light and inconvenient dimensions. Not all parts have equal quality. By taking away certain parts, the most valuable parts get the space they need.

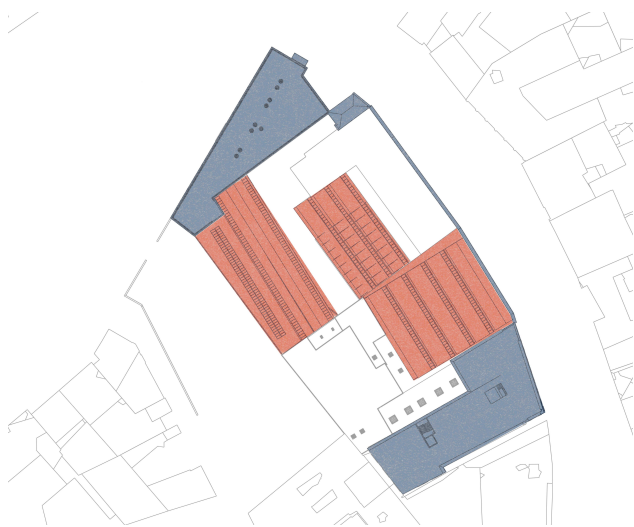
A few steps can be repeated for various vacant complexes. First, an in-depth analysis is required. Not only architectural, but also social, cultural and contextual qualities are considered. This determines the parts that are preserved, reinterpreted or taken away. Then, the positive space is sketched. This space is open and permeable to give room to the preserved building parts. In this case, the existing hall structure forms the positive space which is reinterpreted as an outdoor public square for cultural purposes. The square opens the complex up diagonally and faces it towards the Dommel and the city. Lastly, when positive space is inverted, as in a photograph, the negative space appears. Negative space is the footprint for possible new building volumes. It is the starting point of an iterative process in which the modular is complemented by project-specific that weave the project together. Depending on the choices there are multiple outcomes. The strategy can therefore be used as a replicable method to redesign various “tabula scripta” sites, in a way that enhances local qualities and facilitates sustainable urban densification.



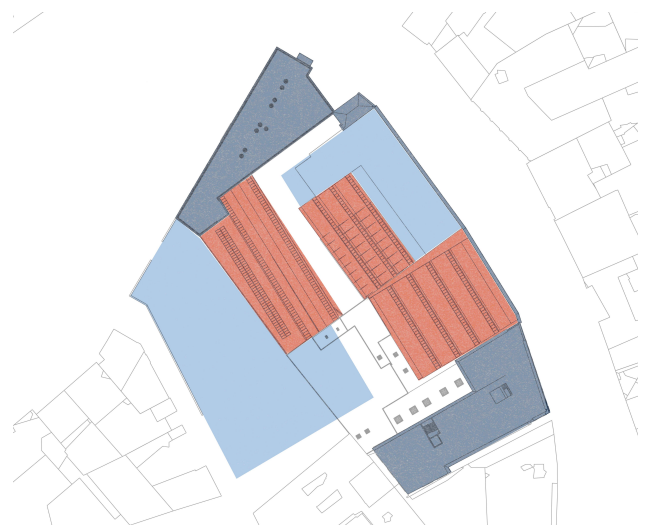
F29. Base situation. (author, 2026)



F30. Existing qualities. (author, 2026)



F31. Positive space. (author, 2026)



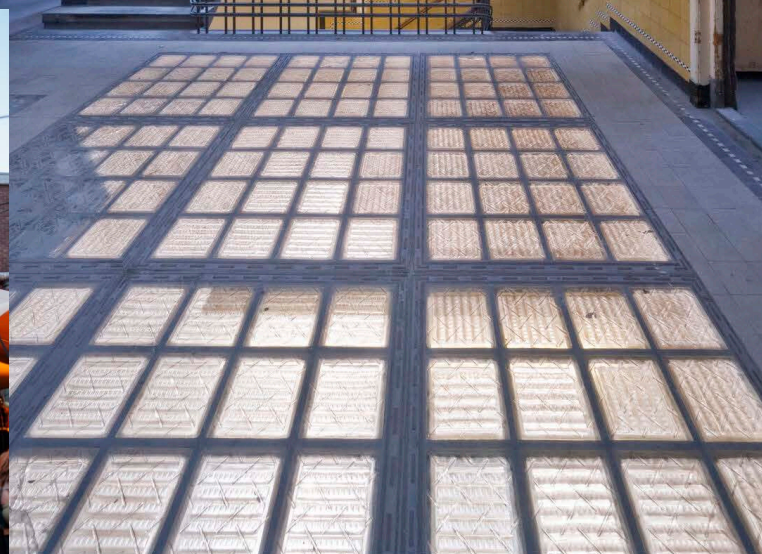
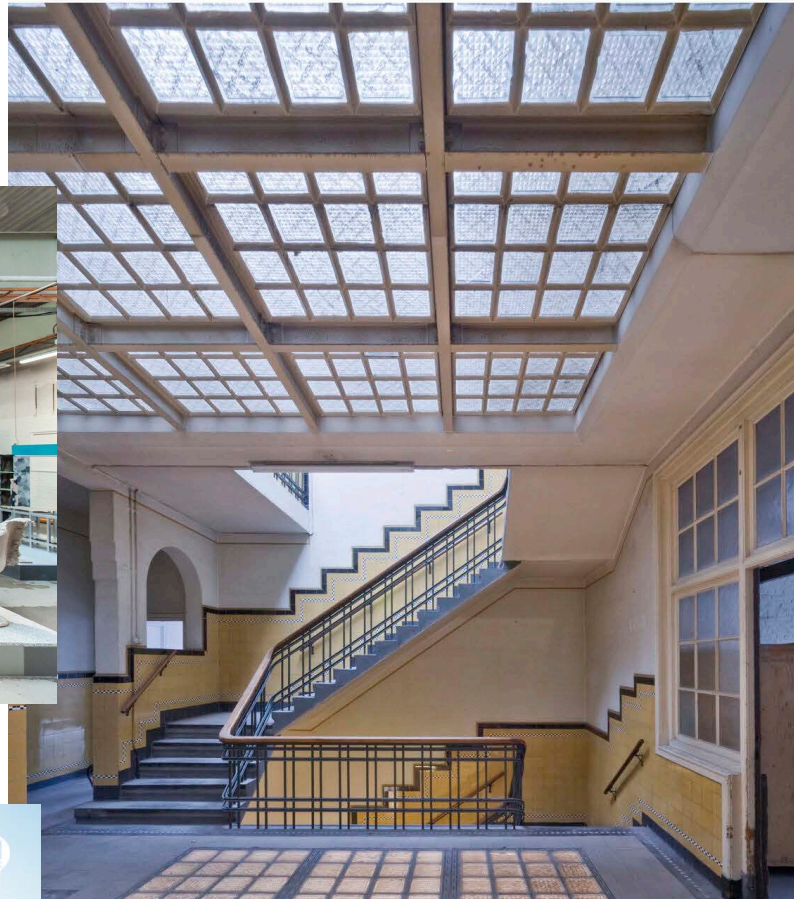
F32. Negative space. (author, 2026)

SQ5; Architectural case study

How can the housing concept and spatial strategy be applied to the architectural transformation of the Schellensfabriek?

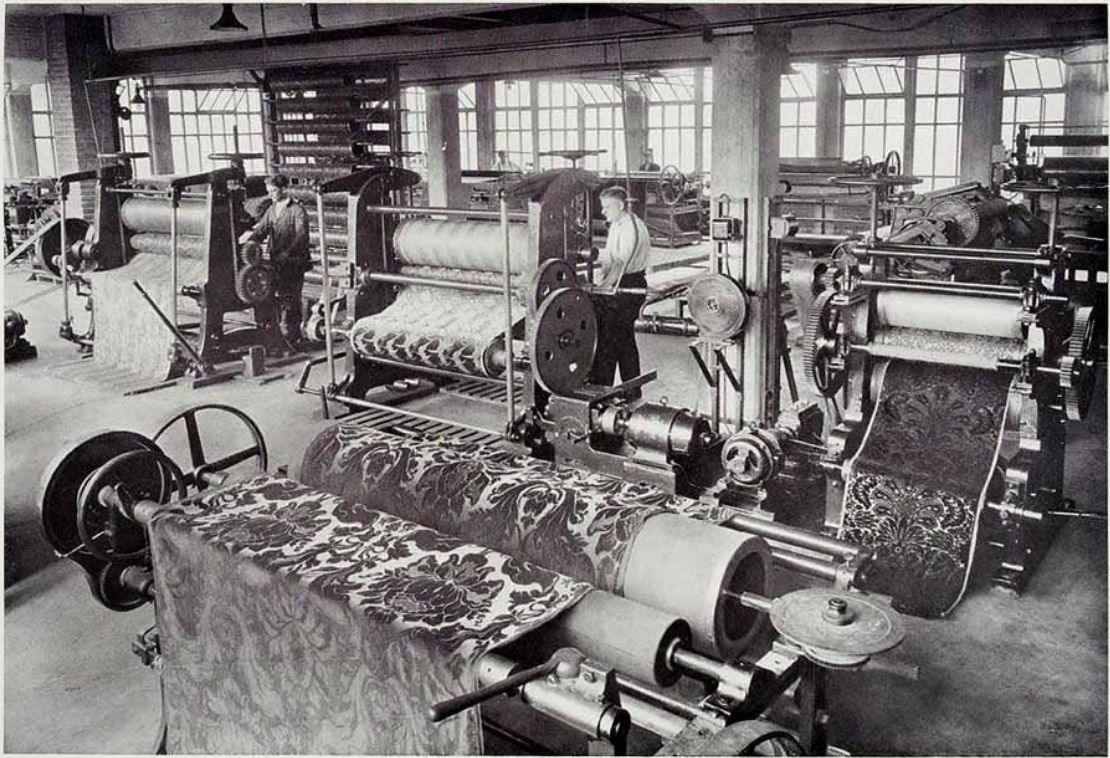
In this part, the design process is explained, **the full drawing set in full scale can be found in appendix B.**

The Schellensfabriek has a rich history as a textile factory, which made linnen and coton. This history is reflected in to-day's practices by the various local designers and makers that house in parts of the complex. This identity is valued in the and integrated in the project-specific design elements. Architecturally, the office buildings and steel hall structure are core of the design.



schellens fabriek ein
© photo : norbert v

N.V. EINDHOVENSCHE TRUIJPFABRIEKEN SCHELLENS & MARTO - EINDHOVEN (HOLLAND)



SCHEERDERIJ-PERSERIJ



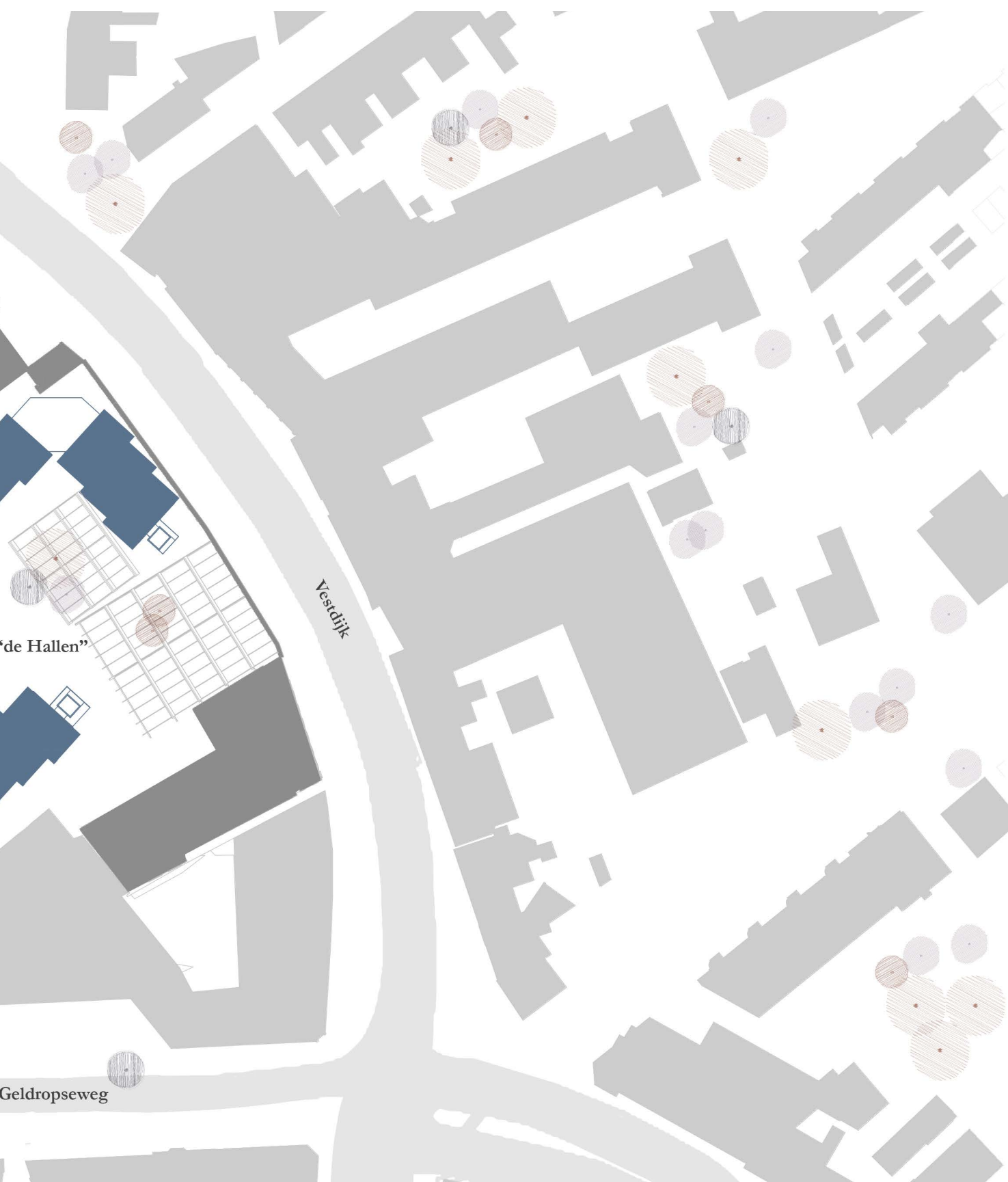
F34. Schellens then. (Brabant Cultureel, 2017; BERNs architectuur, n.d.)

Site plan

The starting point for the design is the negative space footprint. After prototyping different forms this leads to the following site plan.



F35. Site plan (1:1000)

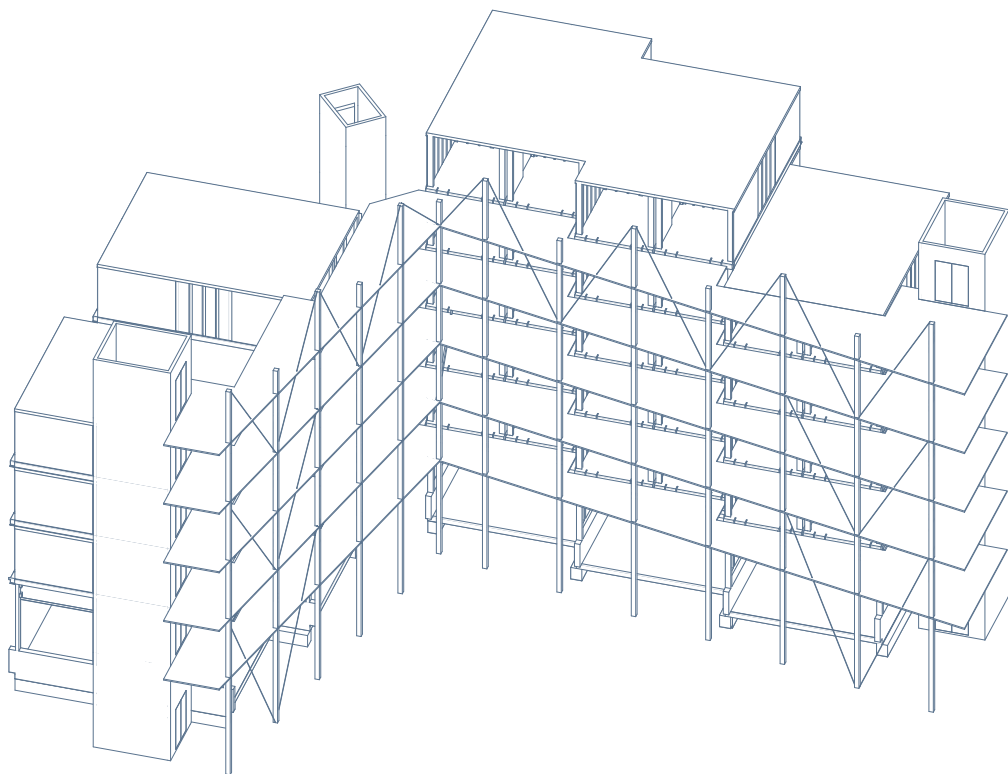


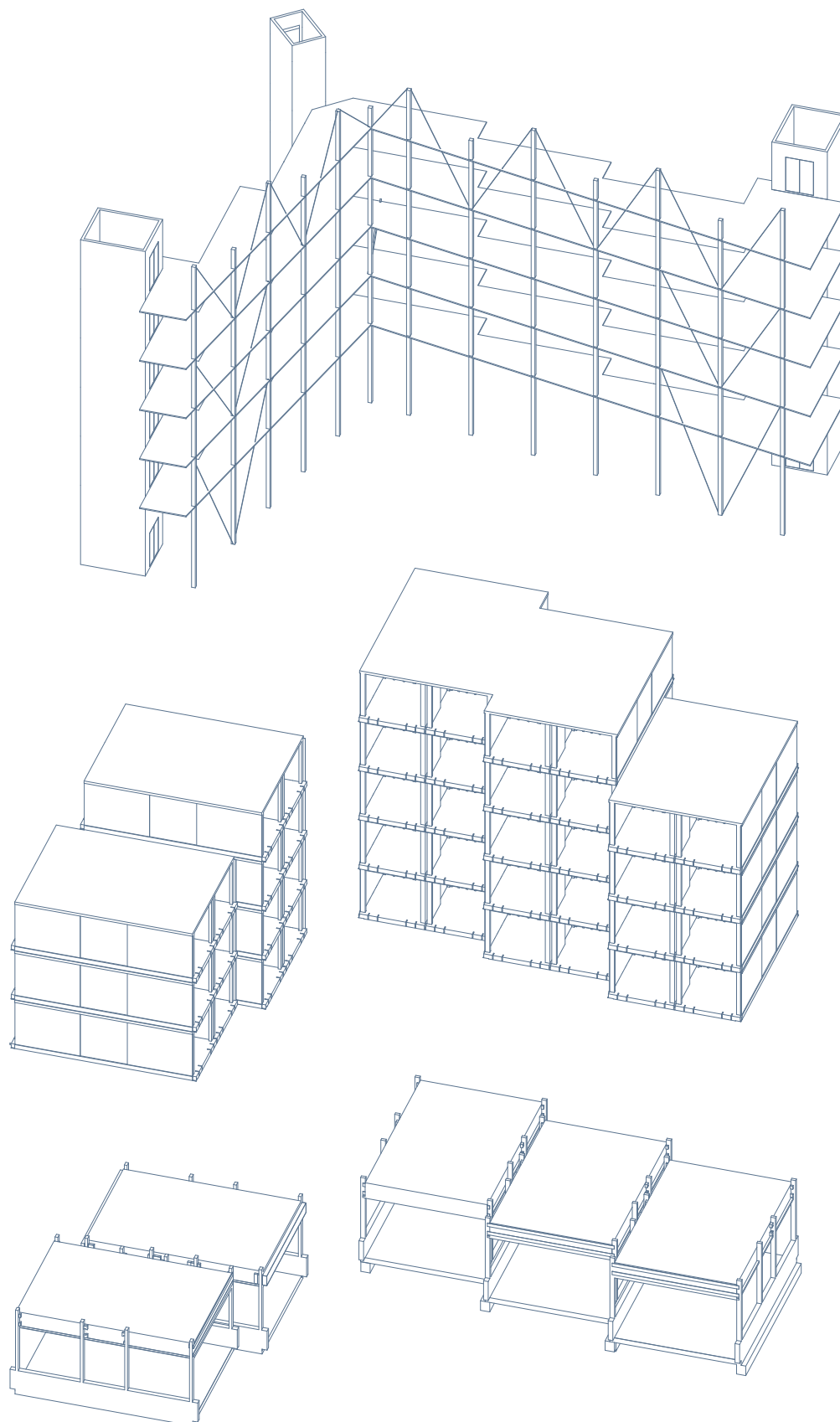
Modular fit-in

The modules are rotated and linked in a sawtooth form. This is a reinterpretation of the gallery typology and results in social galleries with semi-private nooks. These nooks are polyvalent and invite for individual expression. The orientation of the houses also forms the basis for the industrial form language of the modules.



F37 .Floor plan 4th story (1:200 scaled to 1:300)





Stability
Concrete cores
Diagonal bracing

Gallery floors
Ecoboard
18 mm
Sawn oak beams (longitudinal)
80x150 mm
Sawn oak beams (transverse)
80x150 mm
Sawn oak columns
h 500 mm
Concrete footing
h 500 mm

Ceiling
Ecoboard 18 mm
Sawn douglas beams 45x120 mm

Stability walls and unit core
Ecoboard 18 mm

Columns
Sawn douglas columns 36x250 mm

Floor
Sawn douglas beams 63x160 mm
Ecoboard 18 mm

Ceiling
Double layer ecoboard (cross-NLT)
4x18 mm
Sawn douglas beam
100x250 mm
Sawn douglas truss
h 720 mm

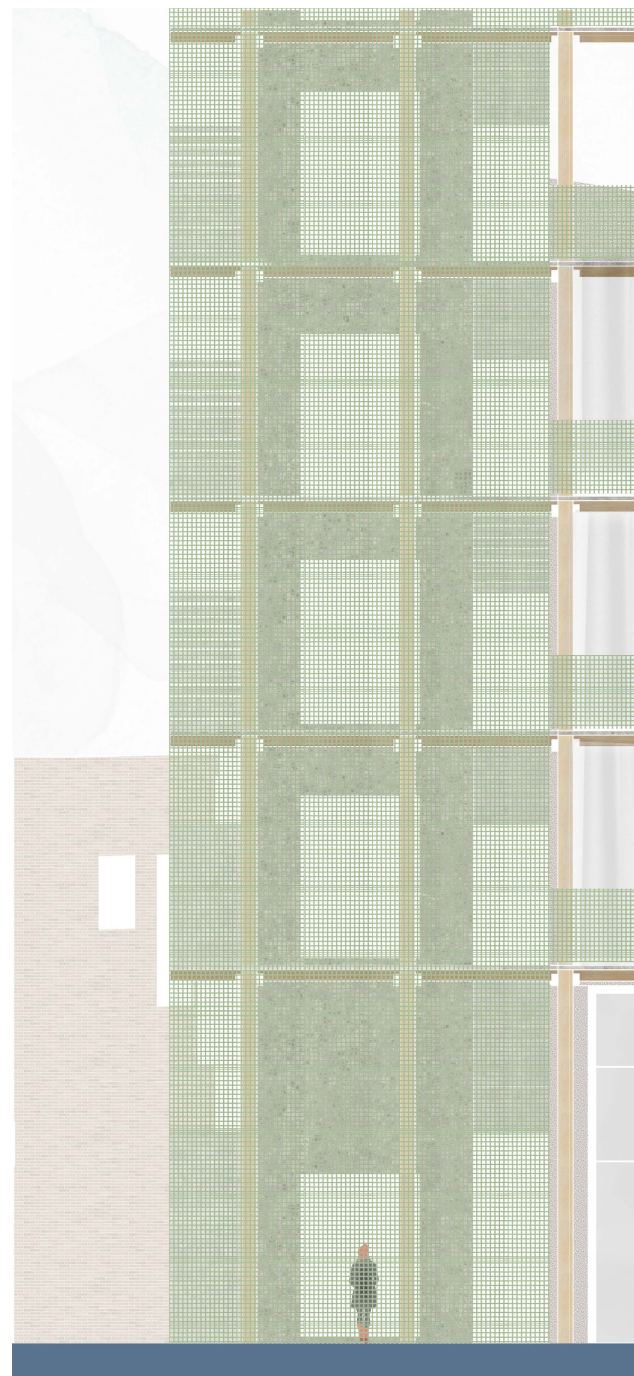
Walls
Douglas columns
150x250 mm
Concrete base walls
250x500 mm

Floor
Reused brick-lime terrazo
Concrete foundation

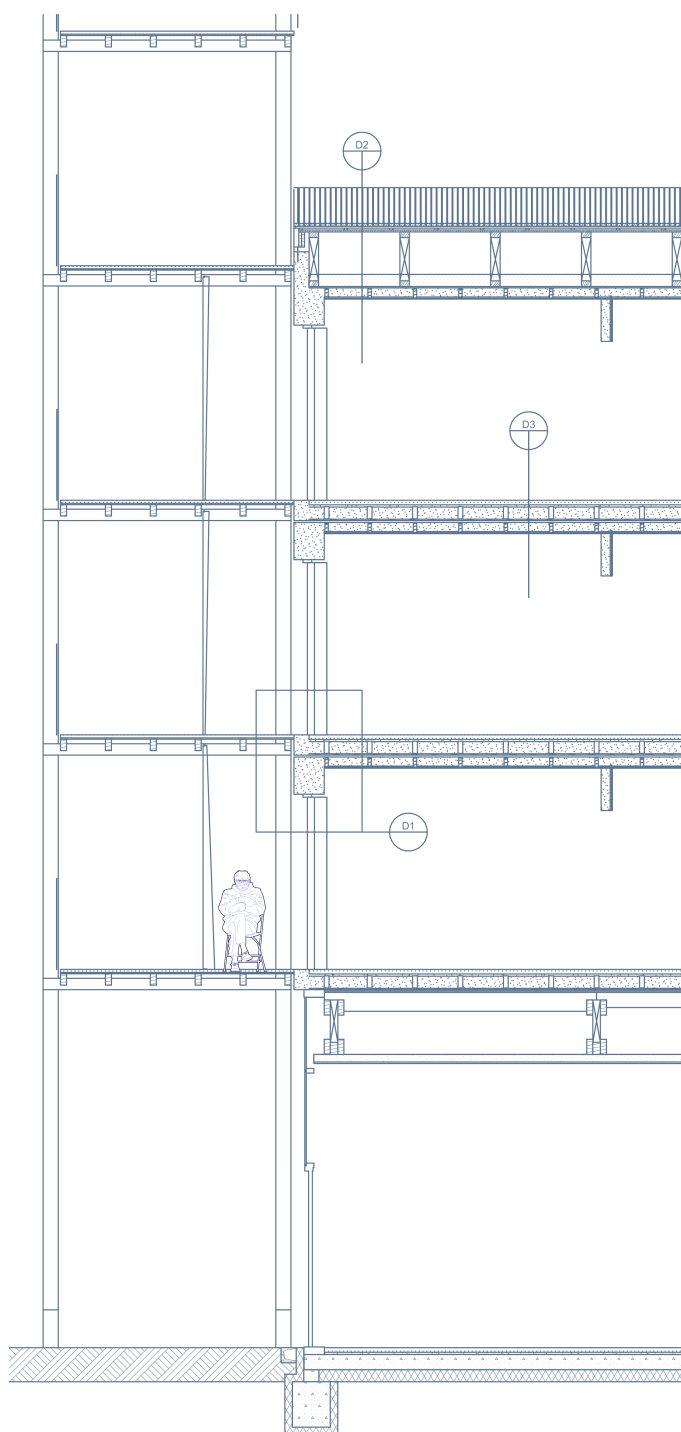
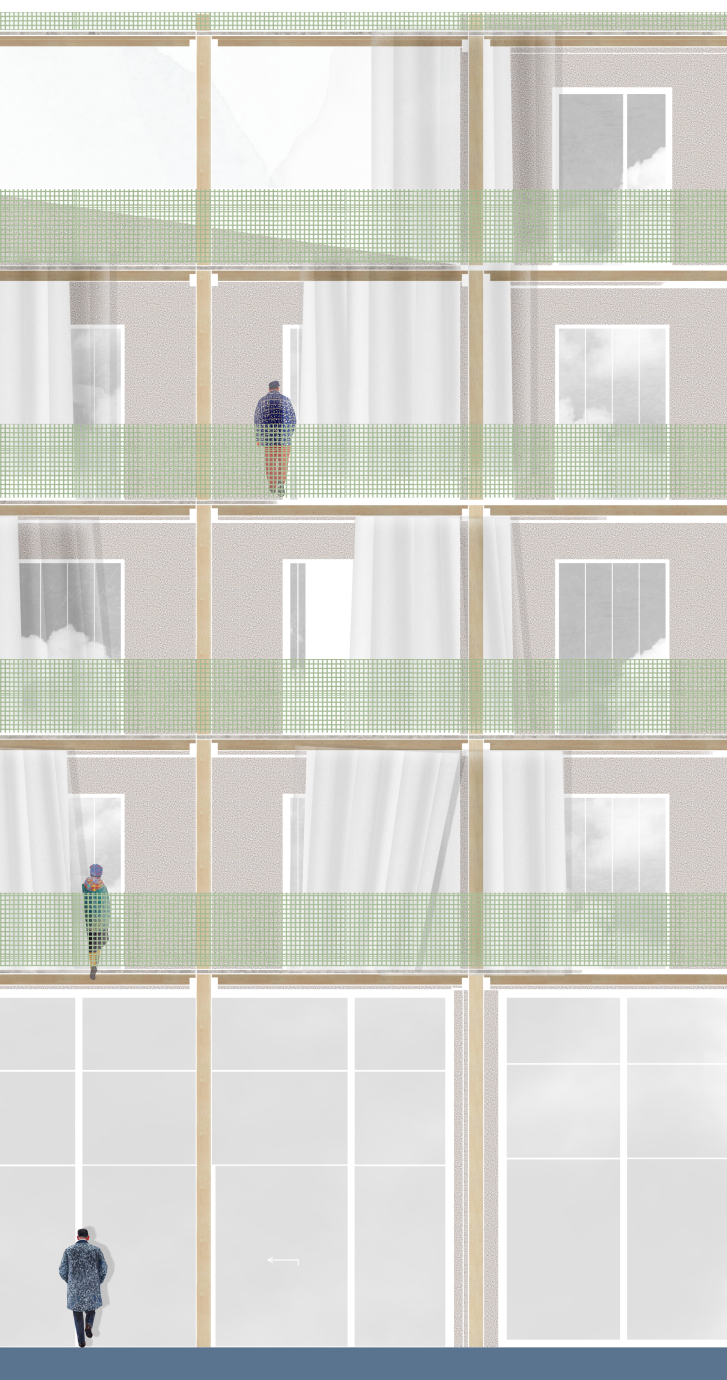
F36. Construction, modules highlighted. (1:200 scaled to 1:400)

Project-specific design concept

The modular sawtooth ensembles form the basis of the design and are complemented by a project-specific approach. The design can be seen as a layered concept. The modules and maker spaces are almost monolith industrial towers, which reflects the hemp-lime material and is strengthened by its aesthetic. The roof has a strong industrial form language. This first layer is wrapped in a transparent and natural textile like layer in the galleries and balconies. The curtains give the facades a changing appearance. The cores, roofs and gallery fences are coloured in the same tints as the hall structure and stand out. These elements are the thread that bind the project together.



F38. Fragment elevation and section. (1:50 scaled down)



Bird's eye isometric

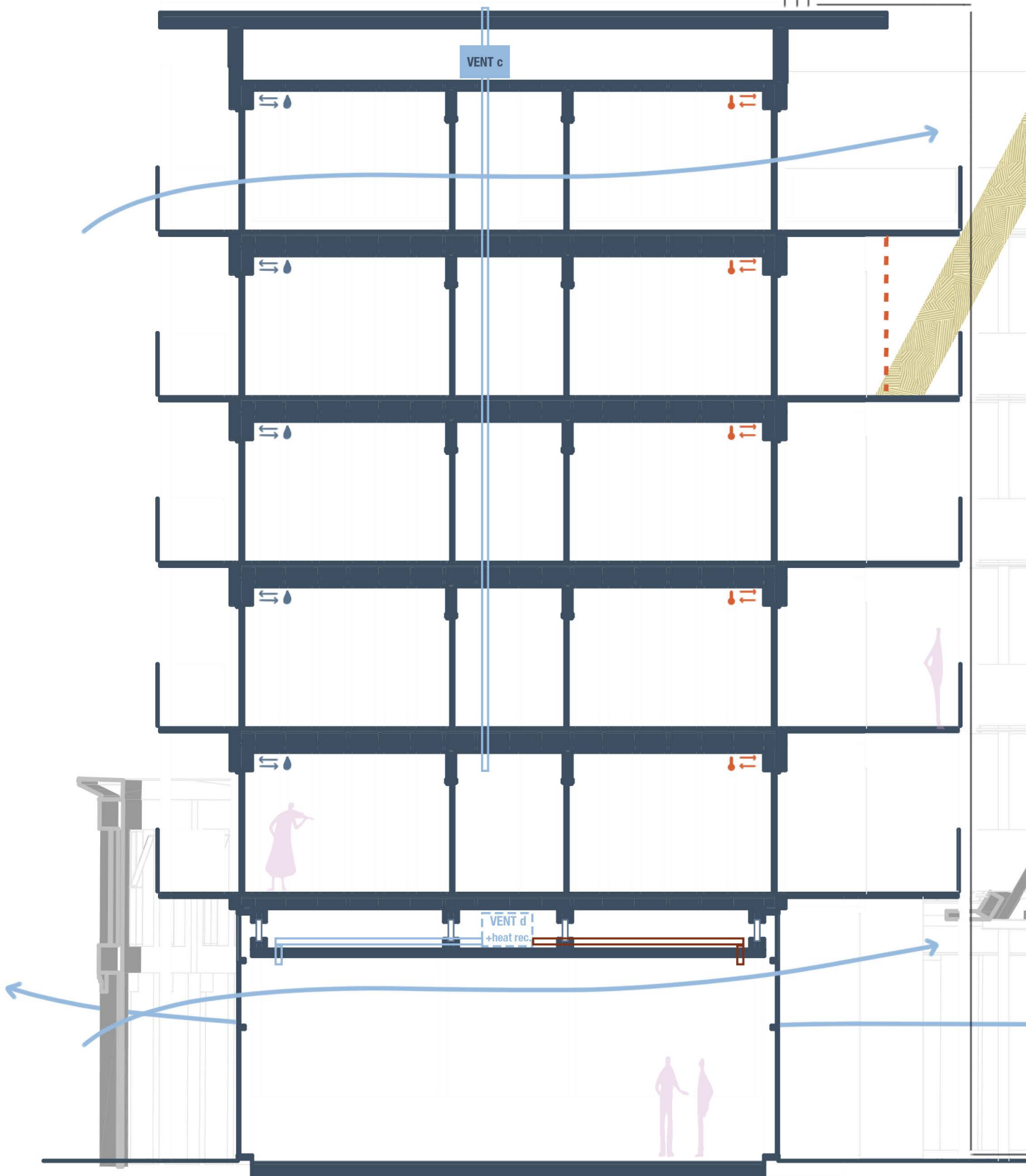


F39. Isometric collage. (1:500)



Passive and self-regulating climate

The hemp-lime elements have great regulating properties. The thermal inertia is up to 12 hours, which steadies out indoor temperature and kitchen zone. The overhangs are larger on the south side, due to the width of the social galleries, textile is used as extra dynamic pv-panels on the roofs of the existing buildings, which are currently not used. On complex level, the diagonal public space allows building volumes. In the mornings and late afternoons the sun is allowed in.

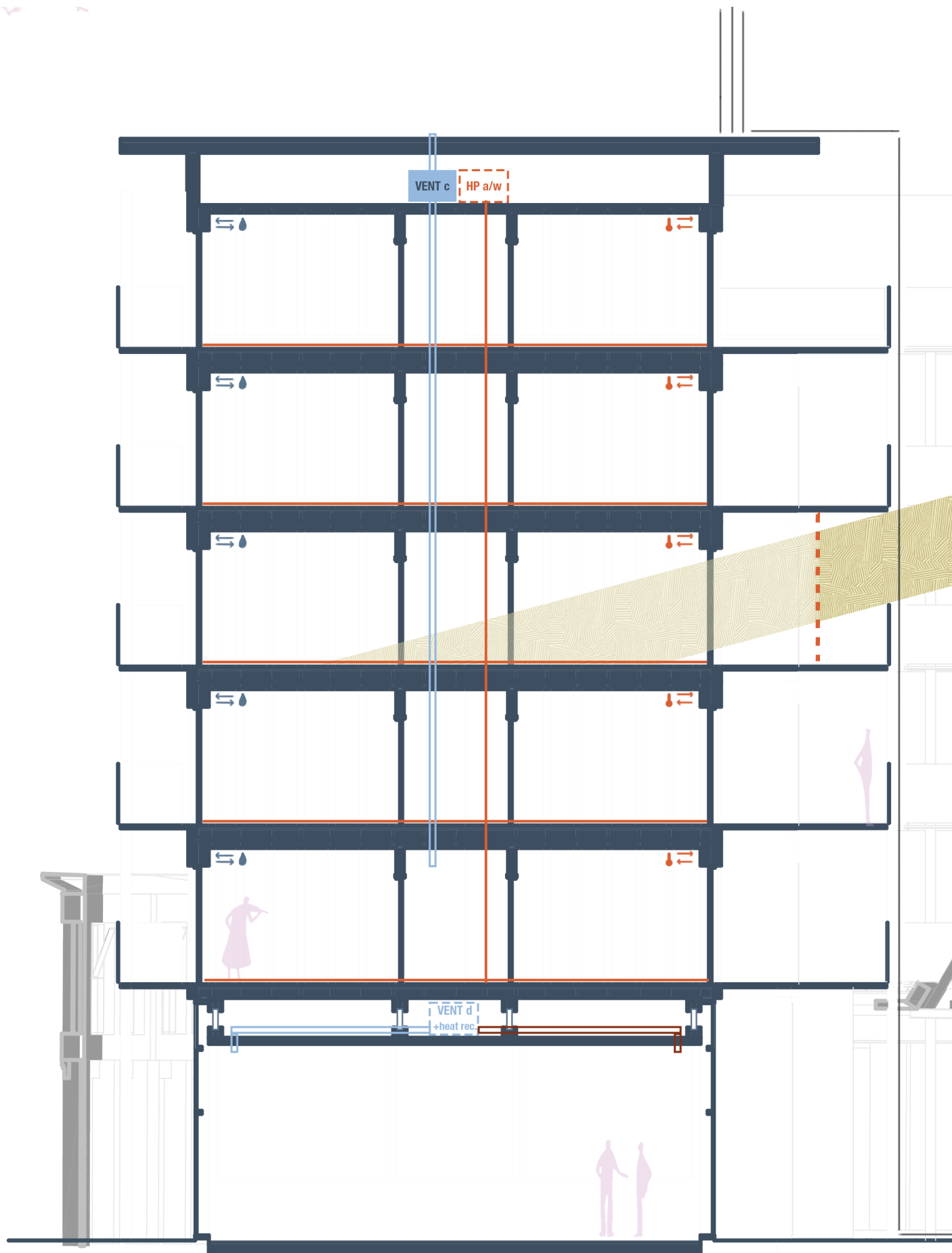


F40. Climate section summer. (1:100)

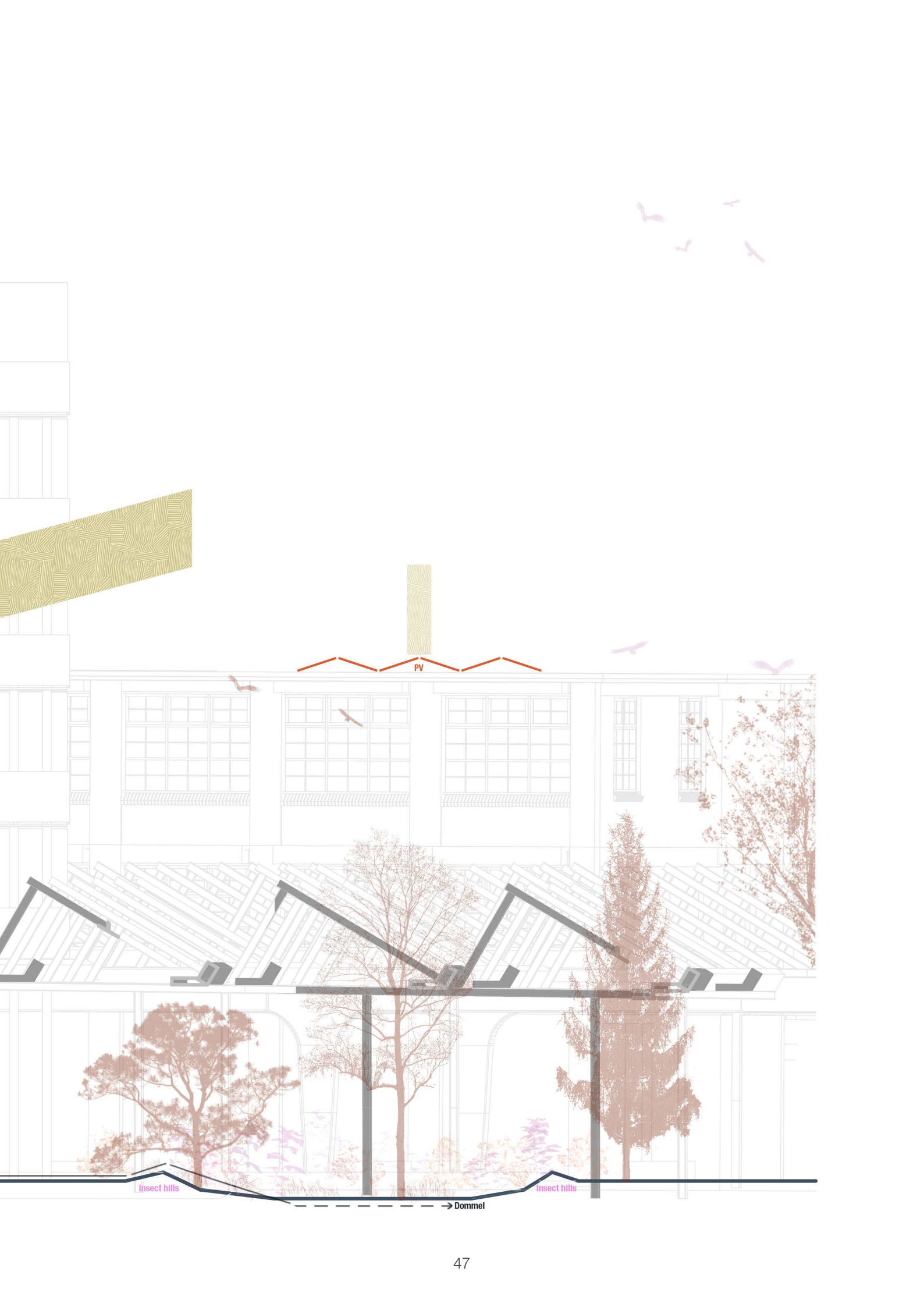
ture, as well as controls humidity. The dwellings are designed for cross-ventilation, additioned with mechanical extraction in sanitary mic shading. Heating is facilitated by central air-heat pumps, connected to low temperature floor heating. Electricity is generated by for cross ventilation, with green for extra shading. The square is shaded in the hottest parts of the day due to the form of the new



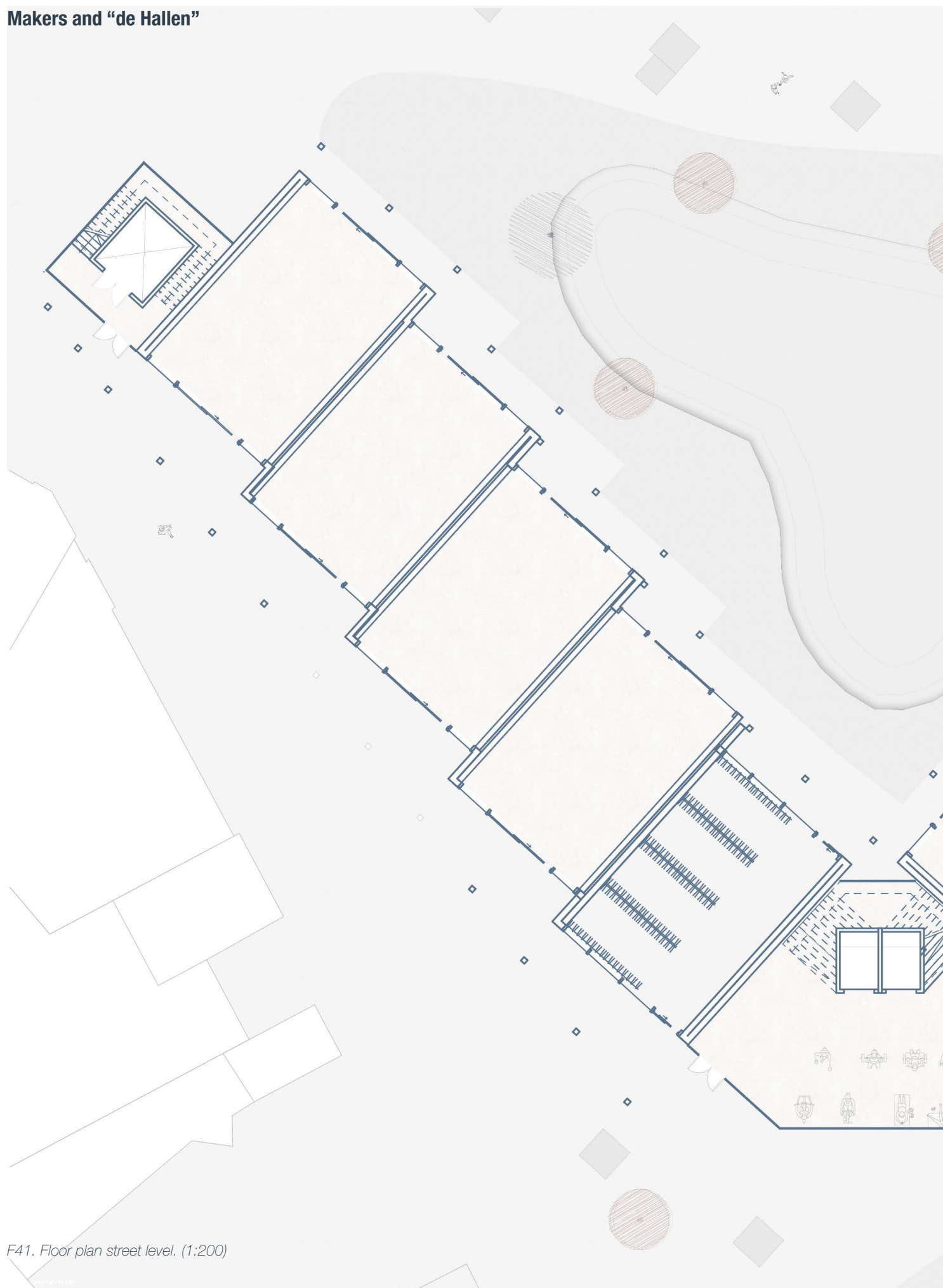
Passive and self-regulating climate



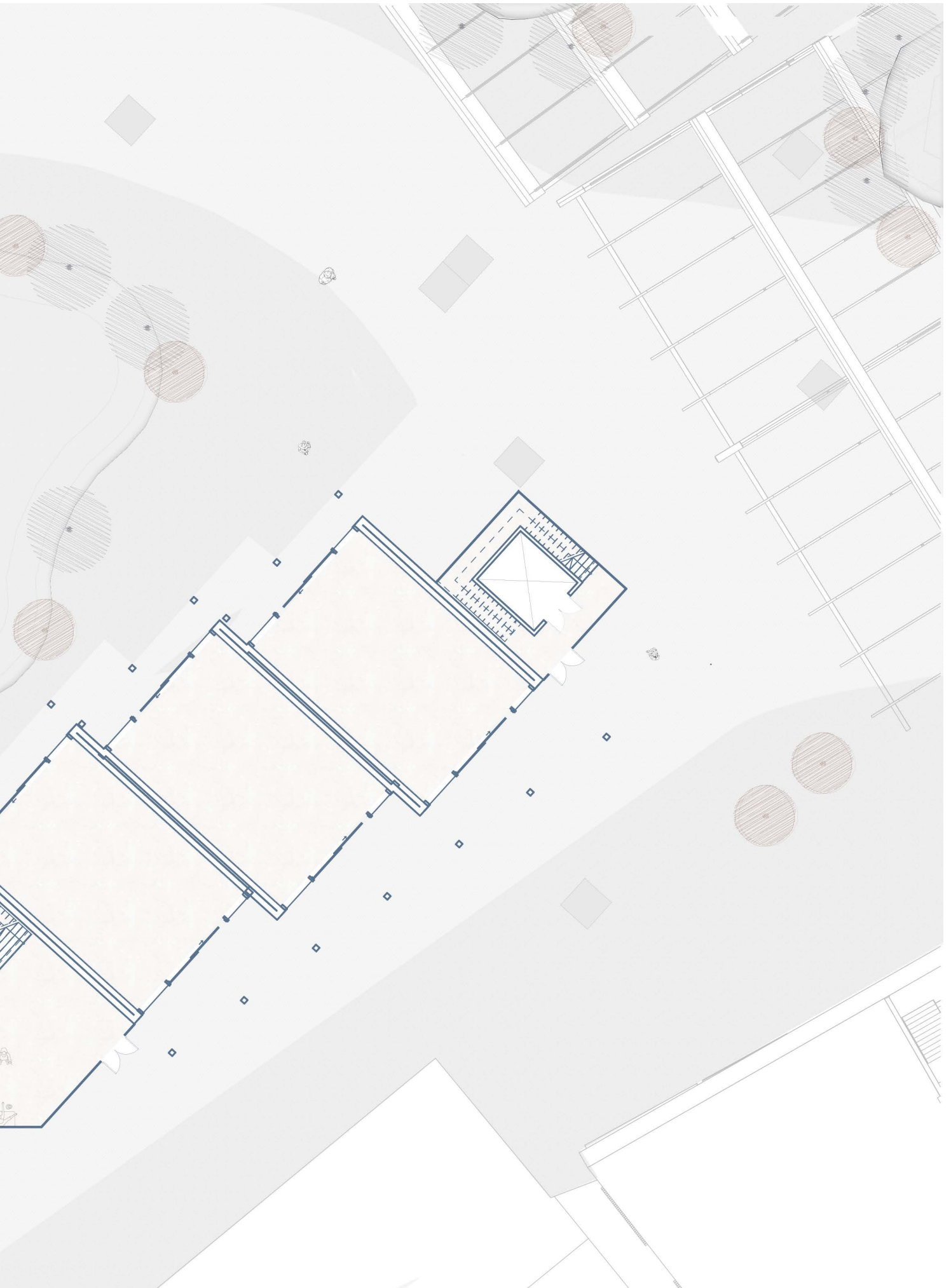
F40. Climate section winter. (1:100)



Makers and “de Hallen”

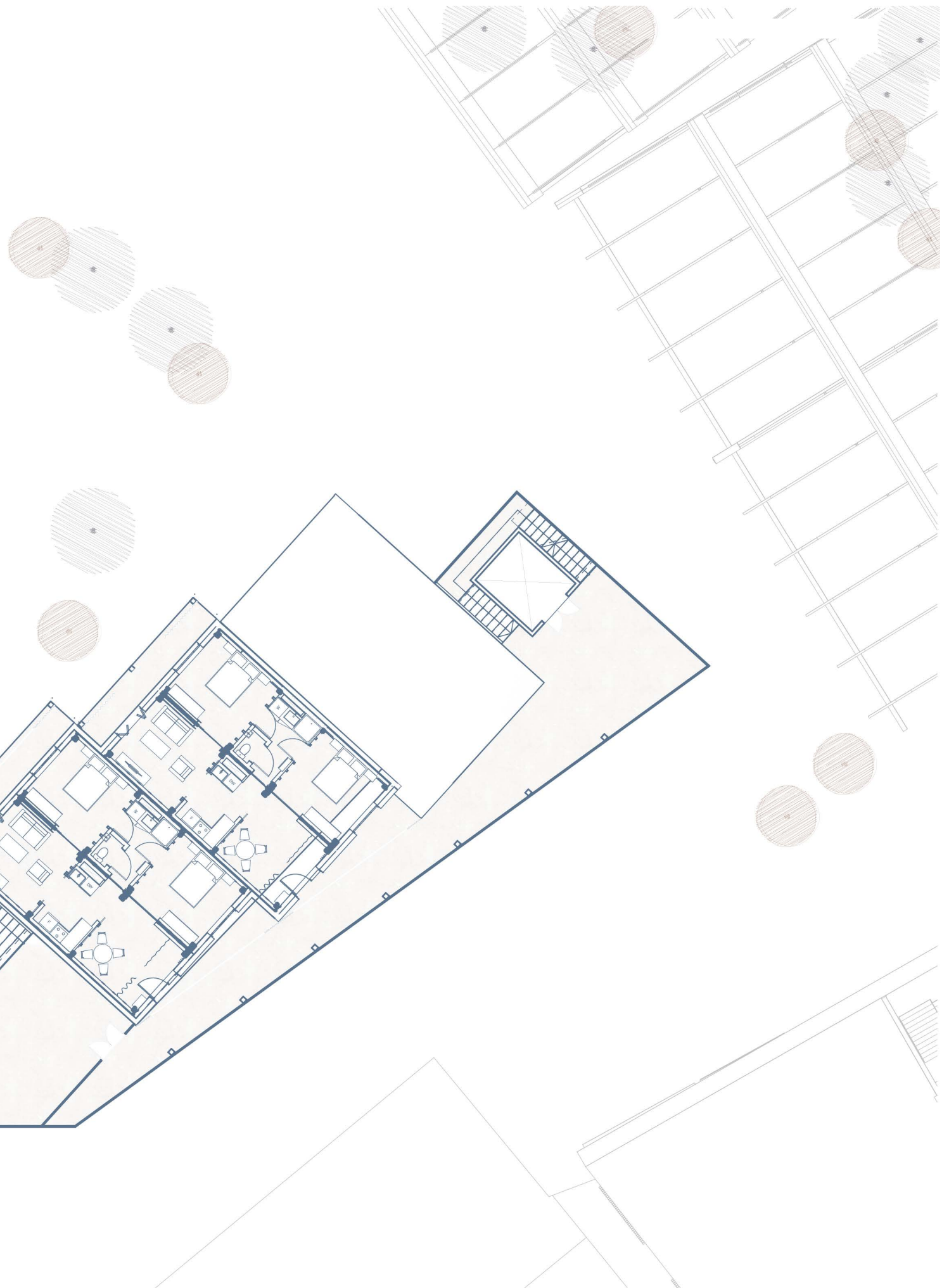


F41. Floor plan street level. (1:200)



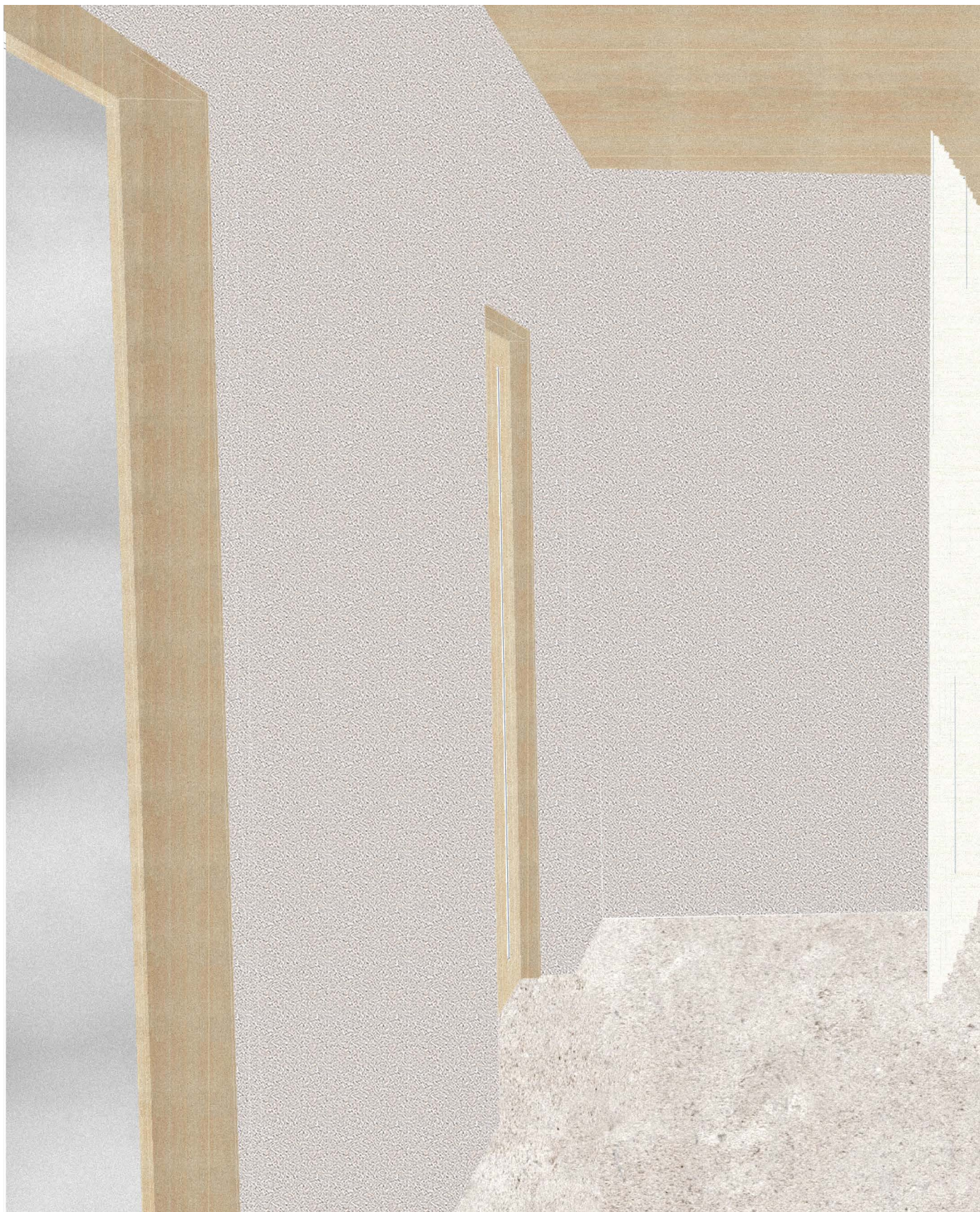


F44. Floor plan 4th story, apartments. (1:200)



Social gallery

The gallery view shows the effect of the sawtooth pattern and textile layer. The nooks can be more private or opened up, depending on social preference or climatic situation.



F45. Visual social gallery.



Materiality

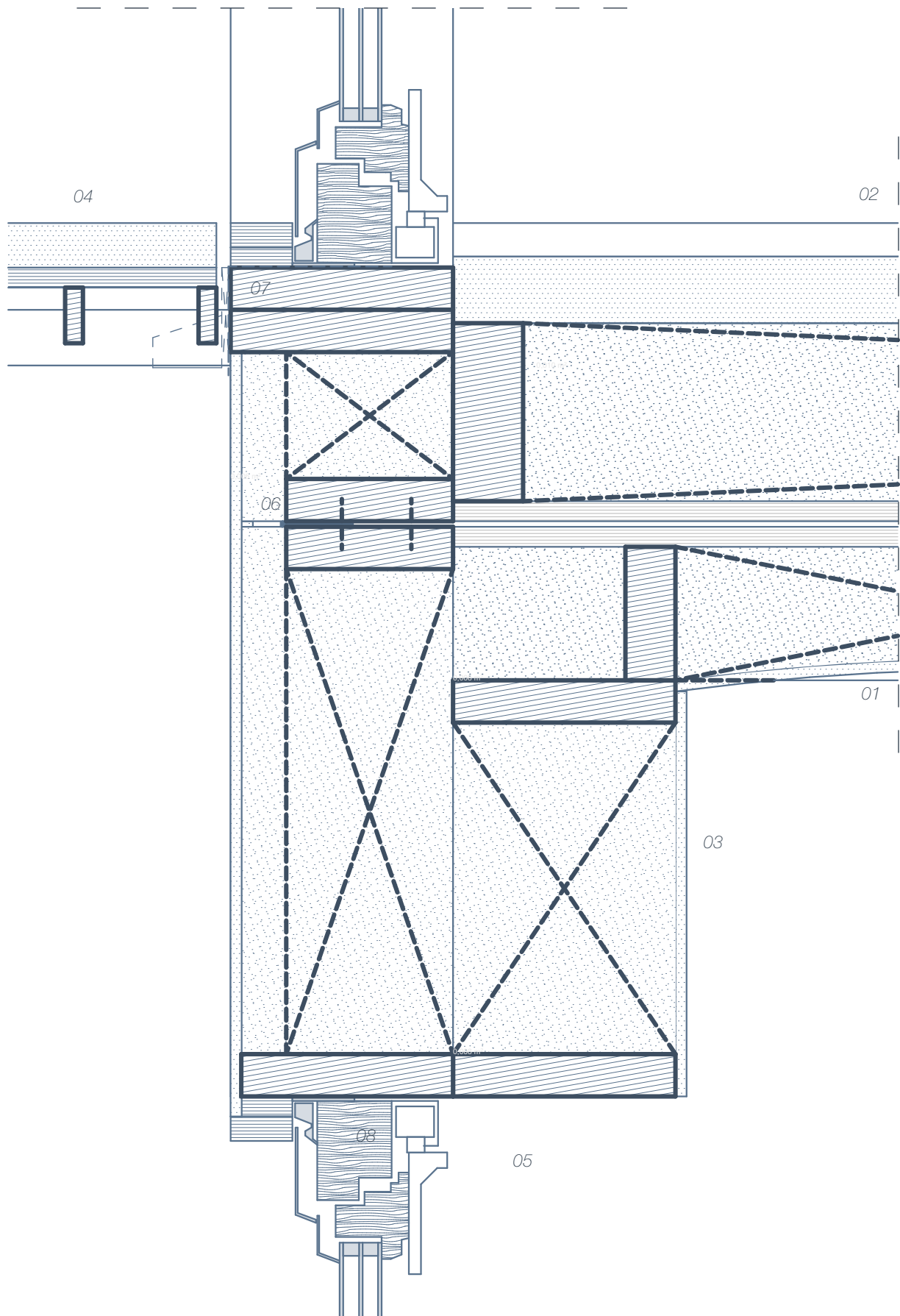
The interior visualisation shows the atmosphere and a possible interpretation of the ? space inside the dwellings, Hempcrete, timber and textile create a light and natural atmosphere.



F46. Visual interior.



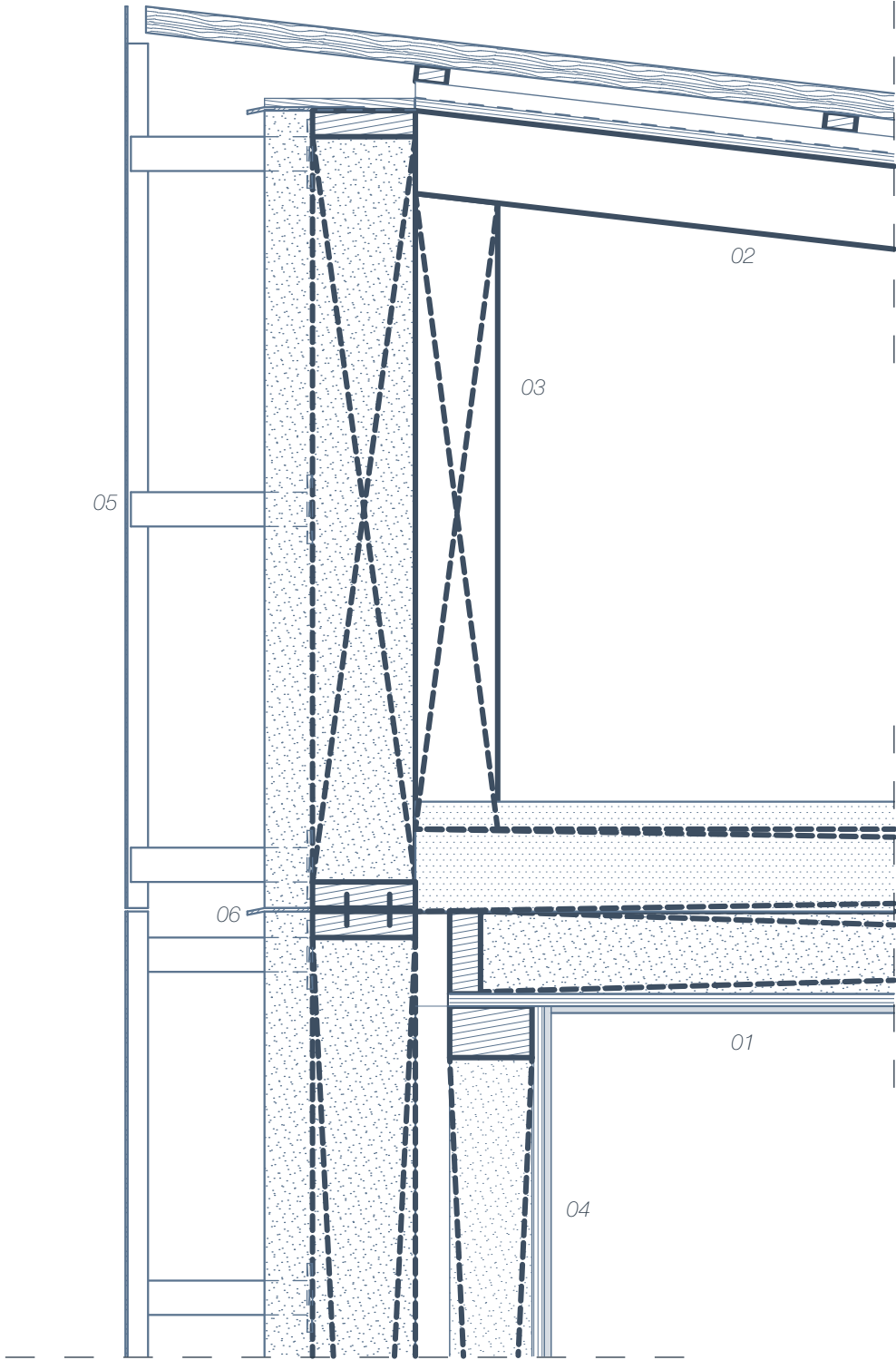
(V) gallery and modules



F48. Detail (V) module facade and gallery connection. (1:5)

01	ecoboard sawn douglas hemp-lime lime render	18 mm 45x120 mm 100/120 mm 10 mm
02	finish lime-sand (floor heating) sawn douglas hemp-lime ecoboard	25 mm 80 mm 63x160 mm 160 mm 18 mm
03	lime render sawn douglas hemp-lime sawn douglas hemp-lime lime render	20 mm 45x150 mm 200 mm 45x200 mm 200 mm 10 mm
04	lime-sand ecoboard sawn douglas (l) sawn douglas (t)	60 mm 18 mm 50x150 mm 50x150 mm
05	folding door	
06	hemp mat + lime	
07	waterproof membrane	
08	bifold oak door	

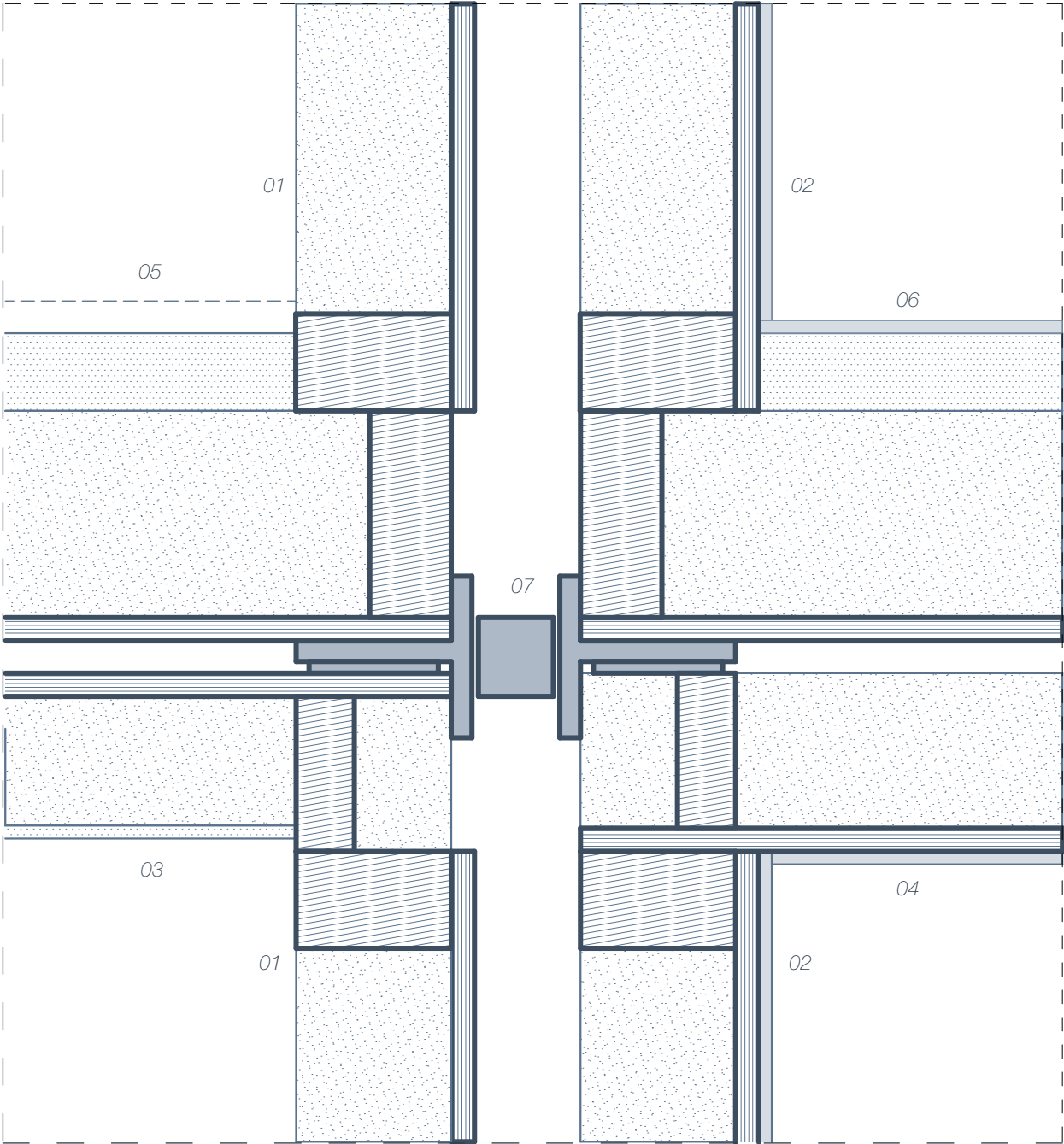
(V) high and dry



F50. Detail (V) roof. (1:5)

01	<i>hemp-lime</i>	160 mm
	<i>sawn douglas</i>	75x120 mm
	<i>hemp-lime</i>	120 mm
	<i>sawn douglas</i>	45x120 mm
	<i>lime render</i>	10 mm
	<i>Lucifer coffee tiles</i>	8 mm
02	<i>oak</i>	38x60 mm
	<i>timber</i>	45x25 mm
	<i>timber</i>	45x25 mm
	<i>water membrane</i>	2 mm
	<i>ecoboard</i>	18 mm
	<i>sawn douglas</i>	75x120 mm
03	<i>lime render</i>	20 mm
	<i>hemp-lime</i>	200 mm
	<i>sawn douglas</i>	38x150 mm
	<i>sawn douglas</i>	75x120 mm
04	<i>lime render</i>	20 mm
	<i>sawn douglas</i>	45x150 mm
	<i>hemp-lime</i>	200 mm
	<i>air cavity</i>	50 mm
	<i>sawn douglas</i>	75x120 mm
	<i>hemp-lime</i>	120 mm
	<i>ecoboard</i>	18 mm
	<i>Lucifer coffee tiles</i>	8 mm
05	<i>steel mesh fence</i>	2 mm
	<i>aluminium beams</i>	30x30 mm
	<i>aluminium brackets</i>	50x8(T) mm
06	<i>steel plate</i>	4 mm

(V) module joint



F49. Detail (V) module connection. (1:5)

01	sawn douglas hemp-lime ecoboard	75x120 mm 120 mm 18 mm
02	sawn douglas hemp-lime ecoboard Lucifer coffee tiles	75x120 mm 120 mm 18 mm 8 mm
03	ecoboard sawn douglas hemp-lime lime render	18 mm 45x120 mm 100/120 mm 10 mm
04	air cavity (mounting) sawn douglas hemp-lime ecoboard Lucifer coffee tiles	25 mm 45x120 mm 120 mm 18 mm 8 mm
05	finish lime-sand (floor heating) hemp-lime sawn douglas ecoboard	25 mm 60 mm 160 mm 63x160 mm 18 mm
06	lime render lime-sand (floor heating) hemp-lime sawn douglas ecoboard	20 mm 60 mm 160 mm 63x160 mm 18 mm
07	steel 3d module joint (acoustically detached)	

Part D

Conclusion and Discussion

Conclusion

SQ1; Local regenerative materials

What local regenerative materials are available in the regio and how can they be sourced, processed and transported to urban sites in a sustainable value-chain?

The region around Eindhoven holds large potential for an agricultural shift towards building materials. Crops like miscanthus, silphie and especially hemp have properties that are suited to architectural usage. It is key for designers and architects to include material innovation in their designs. Crops have widespread applications from insulation to boards and furniture. However, the structural capacity for multistory buildings is missing. Natural complementary materials like lime are used to make multi-purpose building materials like hempcrete. When applied in multistory buildings the potential for local wood as structural material is high. Designers should pay attention to local circumstances and shift to a material-driven design approach. The waterways can connect urban industry to the hinterlands and facilitate a water-based logistical system for half-fabricates like sawn timber, hemp shives and lime. These half-fabricates can be manufactured into industrialised building components in a hub, which are transported to various sites via light electric vehicles. It is crucial for designers to be aware of the boundaries of this system and use it in their designs.

SQ2; Housing concept

How can the housing concept be shaped by the local boundaries, answer to current and future societal needs and be modularly applied?

The modular housing concept is based on standard sizes of half-fabricates and dimensioned with logistical boundaries in mind. Dwellings are designed for 1 to 2 person households, with the capability of taking on different forms. In this way, the houses can be made for many different people and households. It is thus adaptive in the design phase, but also in use. The core, sanitary and kitchen zones, is repetitive and can be linked and stacked in multiple ways. The two, three or four ? zones around it are polyvalent. They can be interpreted in many different ways and allow for various room types and orientations.

SQ3; Building components

How can local, regenerative materials be fabricated into components for the modular housing concept, within the boundaries of the sustainable value-chain?

Hemp, lime, douglas- and oak timber are combined into a 3d module made of different components with the same principle. The module is made of timber frames, filled with hempcrete in various sizes. It is complemented with ecoboard for stability, lime render for finishes and lime-sand floors. Sawn douglas timber members are joined by using the Dowel Laminated Timber technique and bridle joints for the frames. The hempcrete is casted in these timber frames and can be sculptured in for instance vault forms. A module is made of an entire floor frame, heavy DLT columns, infill partition walls and a ceiling frame to form a stable entity. Two modules are combined to form one dwelling. The surfaces are designed to be left visible but can also be covered with various finishes.

SQ4; Spatial strategy transformation

How can a replicable spatial strategy enhance local qualities of underused urban "tabula scripta" sites and facilitate sustainable densification?

The project seeks to enhance local qualities and identities. For this, the concept of negative space is introduced. First, the complex is analysed deeply to identify existing qualities. Not only architectural, but also social, cultural and so on. Then, the key building parts or elements are chosen to reuse or reinterpret. To open the complex up and to enhance the key elements, the positive space is sketched. This space is open, permeable and becomes the heart of the complex. When the positive space is inverted, one finds the negative space. Which is the footprint of possible new building volumes. The footprint is the starting point of an iterative design process which considers the entire complex and surroundings. This concept can be repeated and is a starting point for the redesign of various underused "tabula scripta" sites.

How can the housing concept and spatial strategy be applied to the architectural transformation of the Schellensfabriek?

The negative space forms the starting point for the architectural design in which the modules are integrated. Within this space, the modules are rotated and linked in a sawtooth pattern, resulting in social galleries with semi-private nooks. The composition of the modules is shaped by reacting to the direct surroundings, which inform the height of the stacked modules. This produces two stepped volumes in an L-shape. Together they form the base layer of the design, characterised by an industrial form language and a monolithic appearance due to the hempcrete façades. Together with the original and later office buildings, the two new volumes complete the built ensemble of the Schellensfabriek site. The modules are placed on a raised plinth of maker spaces. The project-specific part of the design consists of this heightened plinth of makers, various cores, galleries, balconies and roofs. The aesthetic of the building is composed of multiple layers. The first layer is the industrial form language of the modules, roofs and maker spaces, which is strengthened by a monolithic aesthetic. This also clearly communicates the material language. The second layer responds to the textile factory context by wrapping the monoliths in light textile layer with transparent and dynamic aesthetic. Timber and lime make this layer light and breathable, to counterbalance the heavier base behind. The complex is tied together by various transparent cores in a recognisable color. This signature colour continues from the cores up the end walls and roofs to emphasise the industrial form, and weaves through the galleries in the form of light mesh fences. At the heart of the project, the existing hall structures are used to shape “de Hallen”: a central composition of public space that opens up the complex diagonally toward the Dommel and the city. De Hallen have room for culture, exhibitions, performance, skating, making and more. In this way, the Schellensfabriek is faced towards the city and opens up for local culture to take over.

Implications and recommendations

In this project I aim to contribute to a shift away from mainstream, linear construction practices. Defining the boundaries of a project by regenerative resources that are locally available is in my view a good strategy towards solving the climate-related issues connected to the construction sector. Moreover, it can be the basis of an architecture that is rooted in place and thus counter the generalisation of modern era architecture. This approach also considers dependency on large global players and finite material resources as a major threat to Europe and other parts of the world.

Also, I strongly believe that the proposed housing concept can contribute towards solving the housing crisis while considering social issues. It is crucial that regenerative and industrialised construction come together, but that it does not lead to repetitiveness and loss of individual character, as many of the industrialised projects from the 20th century have led to. Social spaces and encounters should be an important design aspect in every housing project, especially in a world that is moving away from collectiveness and more towards isolation.

Along the way I became very inspired by all the different people working on these topics, from farmers to designers and policy makers. It would strengthen all the innovations if these worlds come together more and see each others initiatives.

Reflection

Looking back at this project I have learned a lot again. Being a graduation project I expected to be able to integrate all my fascinations and make it a special final project which would reflect me as an architect. However, as experienced before, having too many interest does not strengthen a design. Rather, a strong concept with clear focus helps towards a special project. I think this wide view has led me to good places but has also complicated my process in some periods.

Furthermore, I tend to make safe choices when I am in tight areas, such as in a lack of time. While this helps towards finishing a project I would have liked to take some more bold design decisions. In the end, the project will always be there if the work is put in, but this boldness can make it stand out.

All in all I have learned a lot from my research and am happy with the final result of my design. I enjoyed working in this studio a lot due to the culture and people.

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F2. Climate crisis; emissions, transport and landuse. (author, 2026)

F3. Urban situation Schellensfabriek. 1:25.000. (author, 2026)

F4. Urban situation Schellensfabriek (Google Earth, 2026)

F5. Product development methodology based on Mac-Lean (2018).

F6. The biobased production chain between farmer, transporter and builder. (Volkshuisvesting Nederland, 2023)

F7. Decentralised regional value chain (Author, 2025; based on: Volkshuisvesting Nederland, 2023)

F8. The abiotic system. (author, 2025)

F9. The cultural system. (author, 2025)

F10. Farms overlayed on soil type. (author, 2025)

F11. Soil and climate change dictate boundary conditions for crops. (Author, 2025; based on: Klimaateffectatlas, 2025)

F12. Suitable and high potential crops to regional system. (Author, 2026)

F13. Schellensfabriek visuals. (Author, 2026) (Wikimedia Commons, © Rosemoon); (ed, 2021, © Jean Pierre Reijnen) (DDW, 2025, © SintLucas) (100Watt instagram) (Flickr, M3nn0, 2009) (prenc0, 2014) (Berns, n.d.) (StudioBoot.nl, n.d.) (Isola Design Agenda DDW, 2025) (Ijsselid, 2014) (© Norbert van Onna) (FOAM architecten)

F14. Schellensfabriek analysis. (Author, 2026)

F15. Regional harvesting map. (Author, 1:500.000)

F16. Urban system. (Author, 1:50.000)

F17. Timber data (Staatsbosbeheer, n.d.; bosenhoutcijfers.nl; Probos, 2021; Probos, n.d.)

F18. American Oak and Douglas Fir (AI created, Gemini NanoBanana2)

F19. Timber construction methods. (Internalities, 2026)

F20. Material Catalogue. (Author, 2026; De Zwarte Hond, n.d.; Kontextur, 2025; Boon, 2025; Levy, 2020; Ebbinge, 2024)

F21. Diagrams housing concept. (Author, 2026)

F22. Priority by dual pairing matrix. (Author, 2026)

F23. Layers of Brand (RoosRos, n.d.)

F24. Building component development variants. (Author, 2026)

F25. Floor plan base module (1:50; author, 2026))

F26. Structure only, excluding ecoboard stability members. (1:50 scaled to 1:100; author, 2026)

F27. Structure and infill, excluding facade. (1:50 scaled to 1:100; author, 2026)

F28. Full module, cut at 1100 mm heigth. (1:50 scaled to 1:100; author, 2026)

F29. Base situation. (author, 2026)

F30. Existing qualities. (author, 2026)

F31. Positive space. (author, 2026)

F32. Negative space. (author, 2026)

F33. Schellens today (Isola Design, 2025; 100watt cafe, n.d.; van Onna, 2025)

F34. Schellens then. (Brabant Cultureel, 2017; BERNS architectuur, n.d.)

F35. Site plan (1:1000)

F36. Construction, modules highlighted. (1:200 scaled to 1:400)

F37. Floor plan 4th story (1:200 scaled to 1:300)

F38. Fragment elevation and section. (1:20 scaled down)

F39. Isometric collage.

F40. Climate section. (1:100)

F41. Floor plan street level. (1:200)

F42. Visual "de Hallen".

F43. Visual entrance to the building.

F44. Floor plan 4th story, apartments. (1:200)

F45. Visual social gallery.

F46. Visual interior.

F47. 3D detail timber structure gallery.

F48. Detail (V) module facade and gallery connection. (1:5)

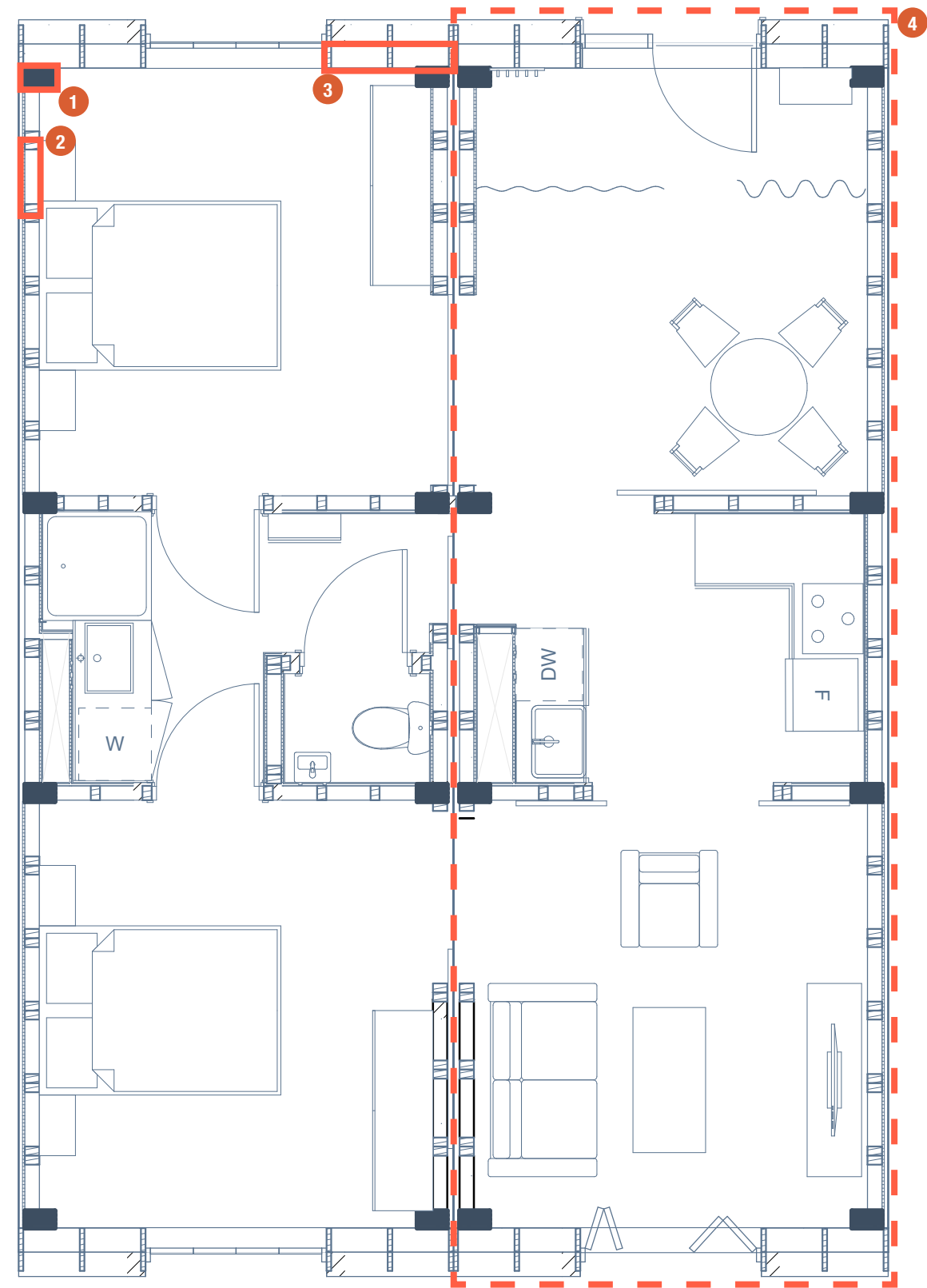
F49. Detail (V) module connection. (1:5)

F50. Detail (V) roof. (1:5)

Appendix B

Full scale drawing set

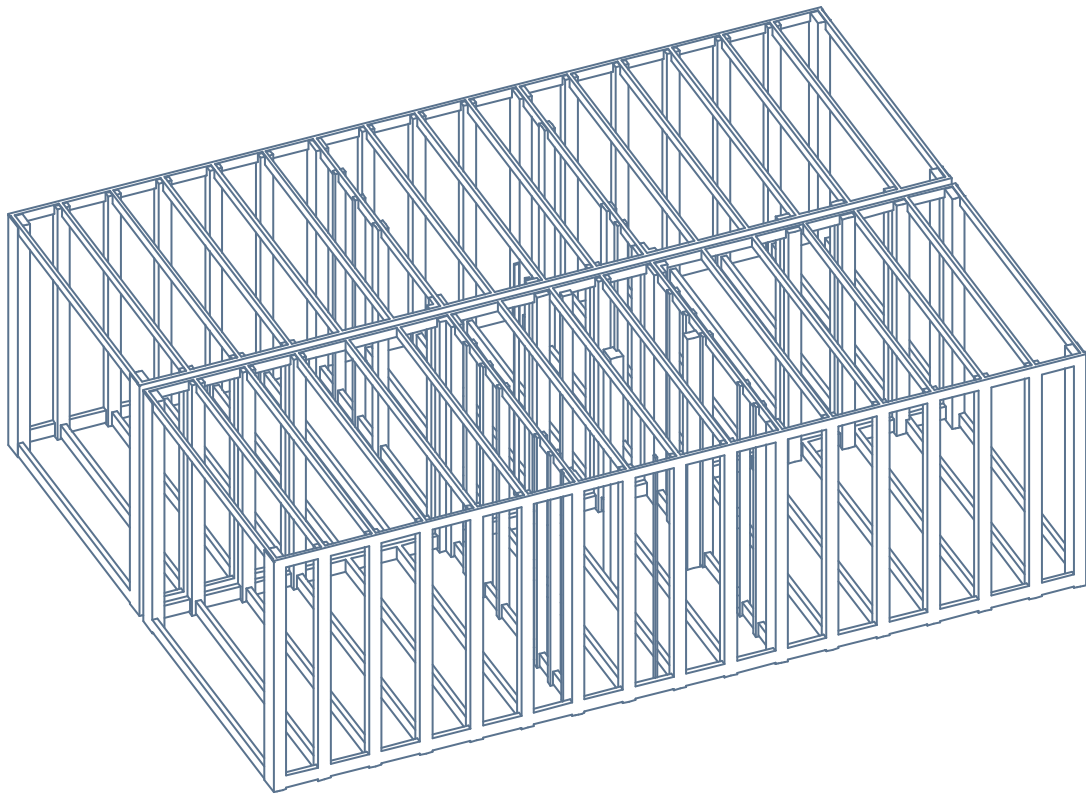
The module



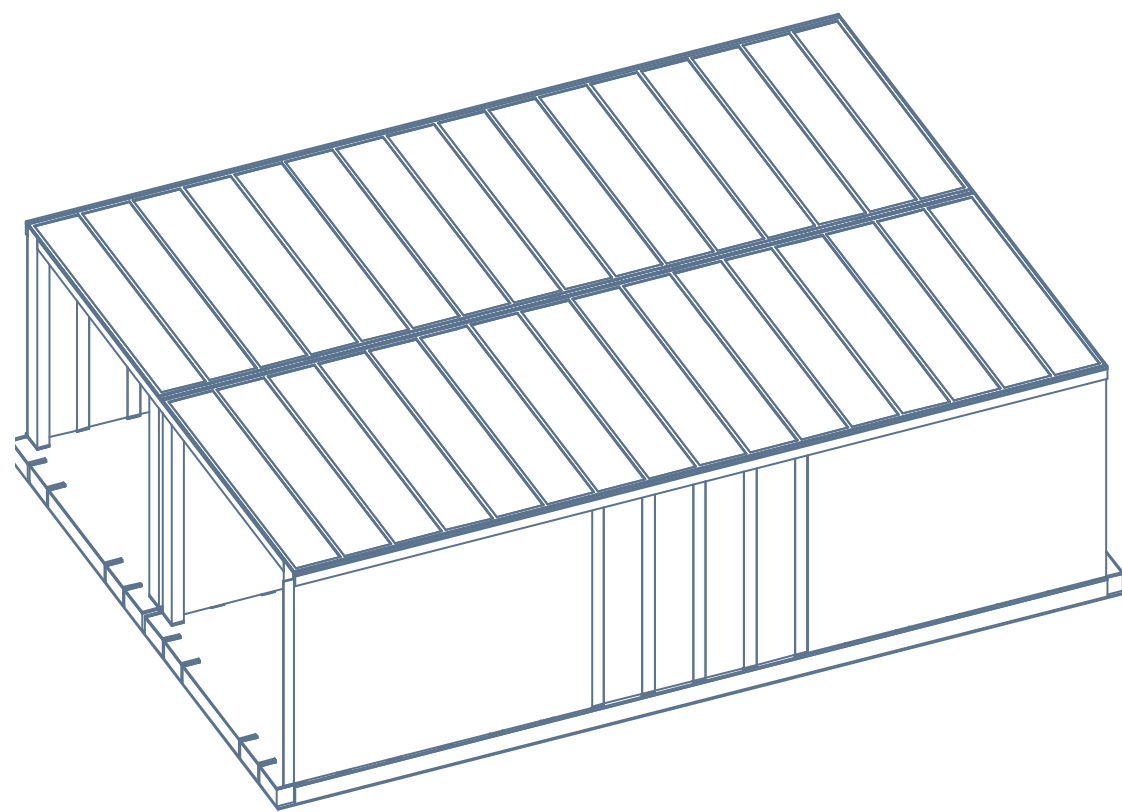
F25. Floor plan base module (1:50)

Module (4) and components

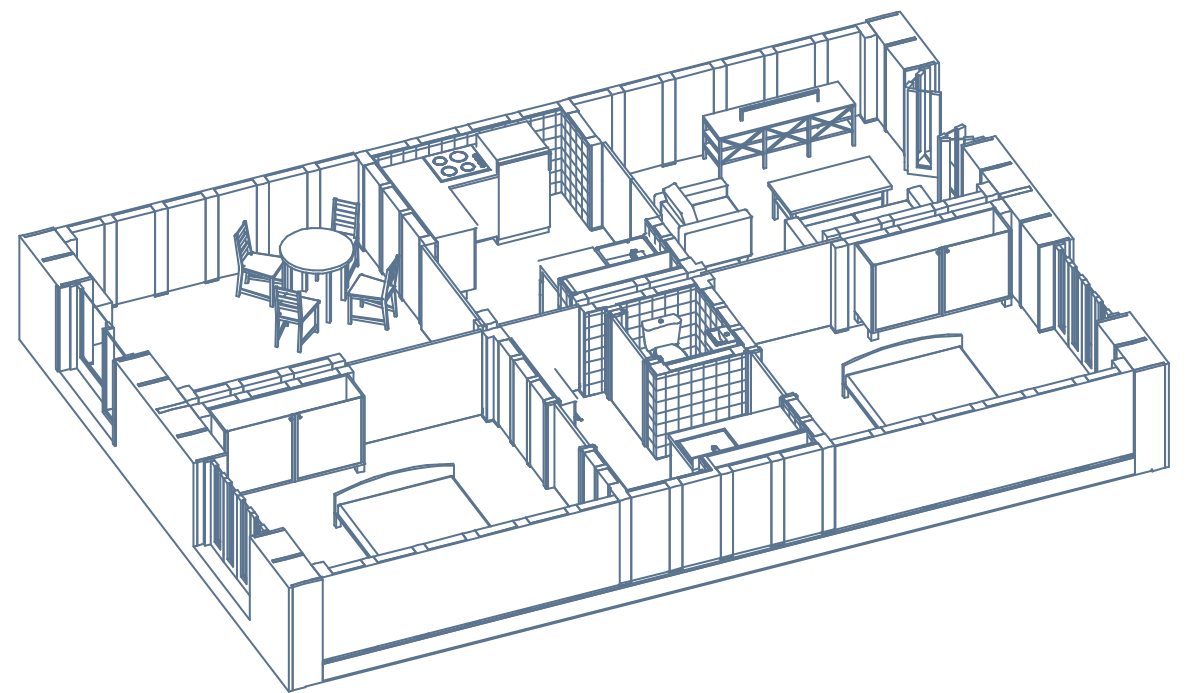
The main structural elements in the floor plan are the DLT columns made of 4 36x250 mm sawn douglas columns and oak dowels. (1) The partition is a sawn timber frame made of 75x120 mm sawn timber members, connected by bridle joints with oak dowels. For stability, these elements are connected with 18 mm ecoboards. The infill is hemp-lime mix finished with lime render. (2) The facade elements are made of 38x200 mm sawn douglas columns, filled with the hemp-lime mix. (3)



F26. Structure only, excluding ecoboard stability members. (1:50)



F27. Structure and infill, excluding facade. (1:50)



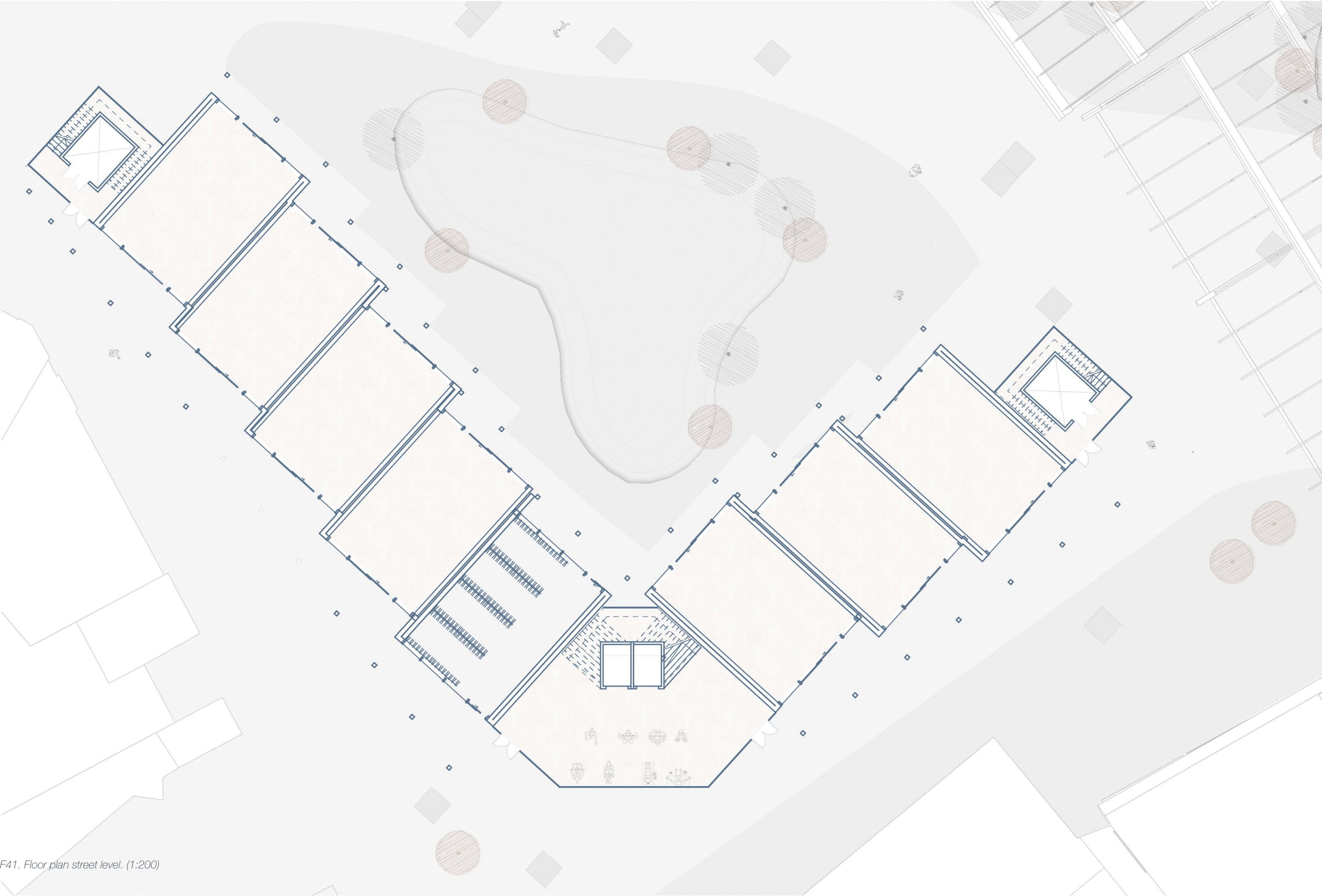
F28. Full module, cut at 1100 mm heighth. (1:50)



F35. Site plan (1:1000)

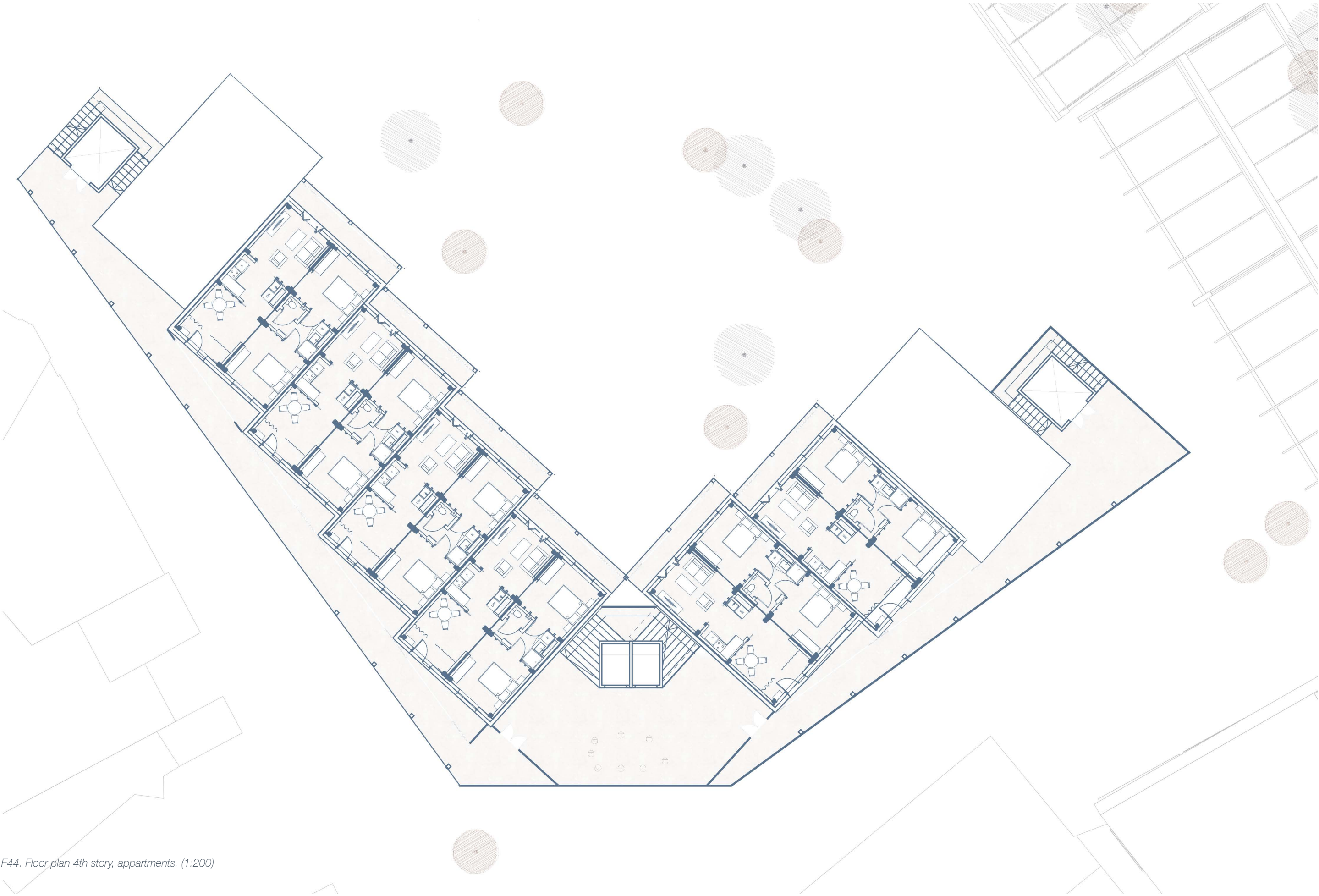


Street level, makers and public square



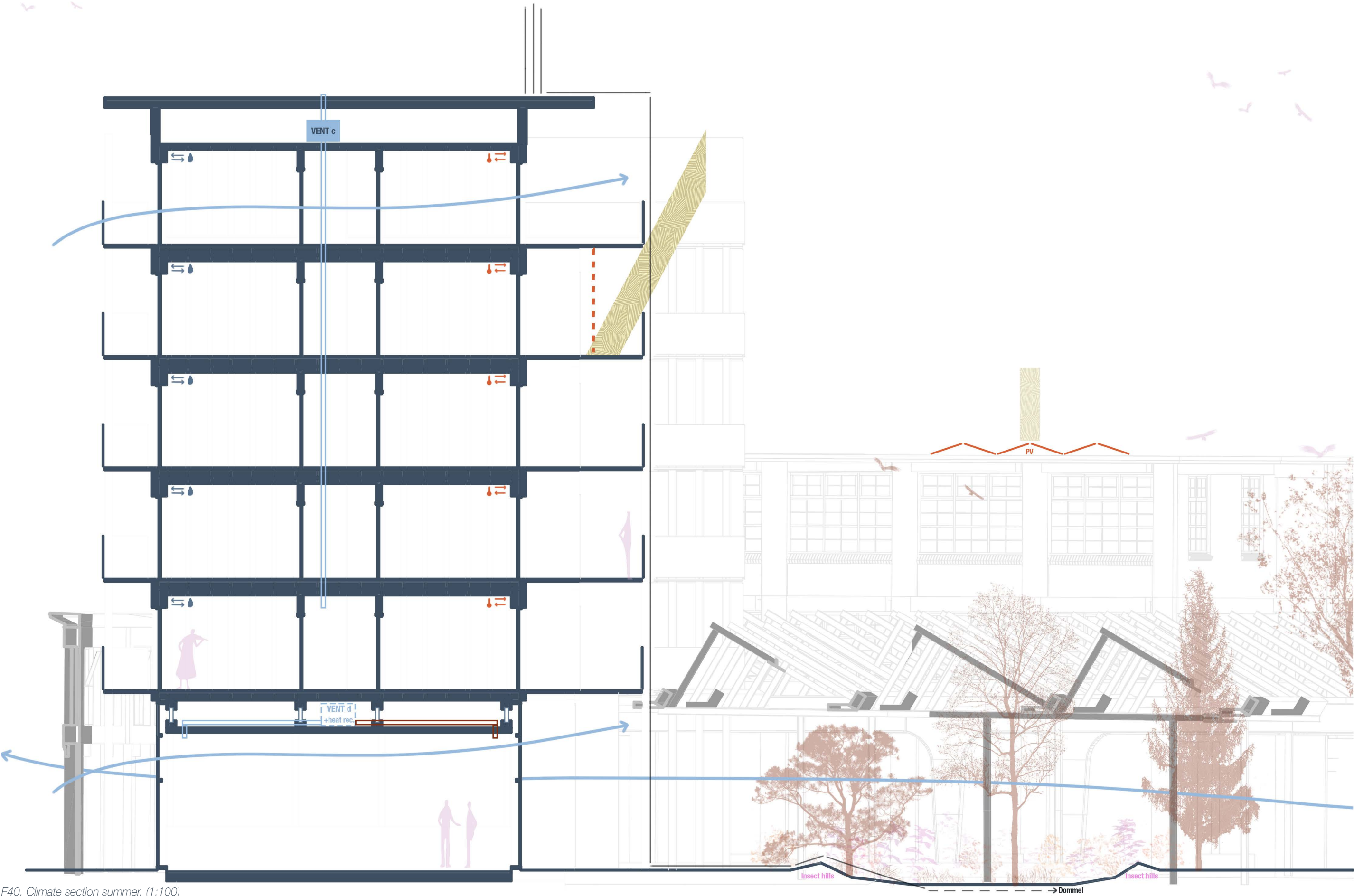
F41. Floor plan street level. (1:200)

4th level, apartments



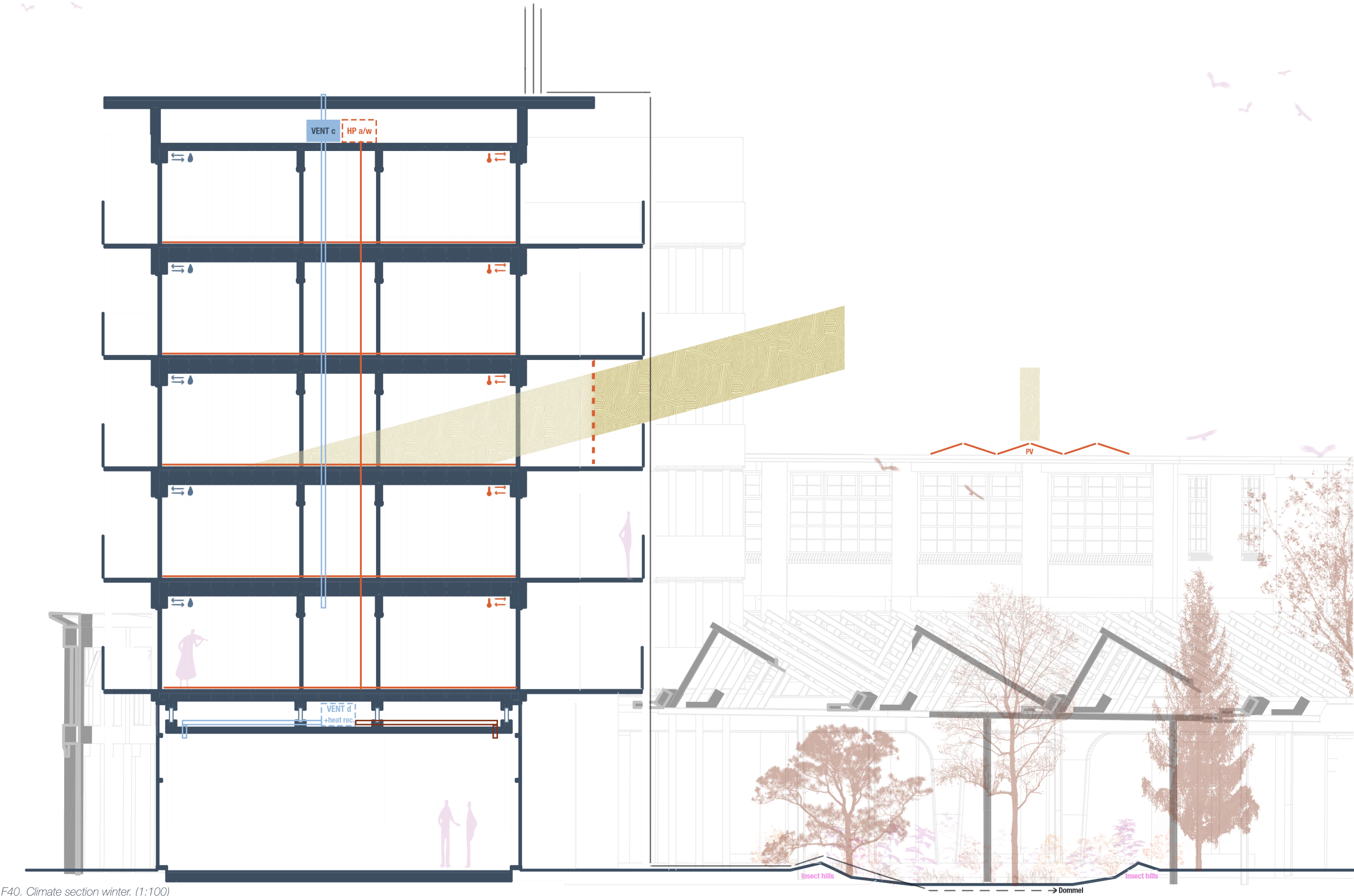
F44. Floor plan 4th story, apartments. (1:200)

Climate section summer



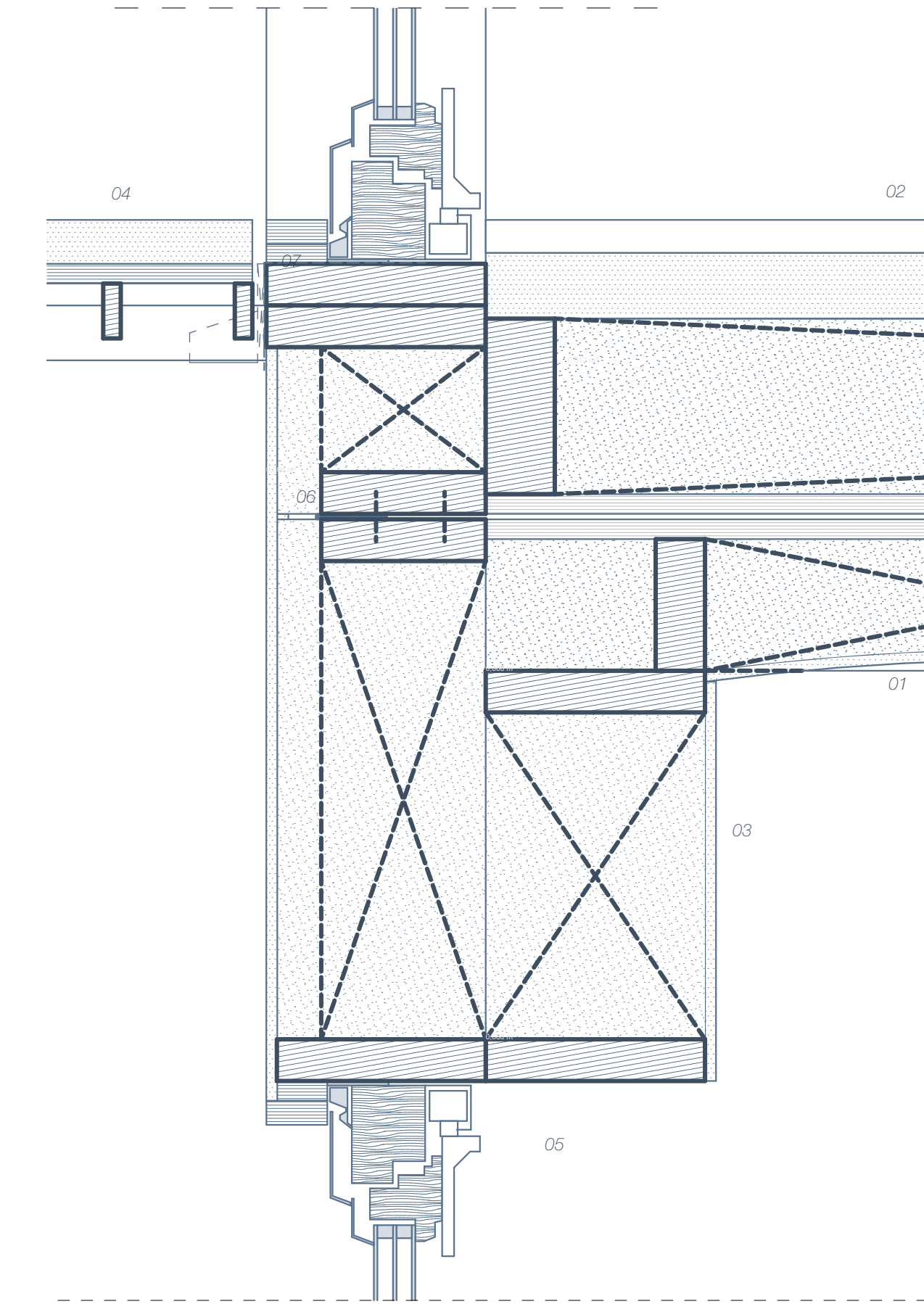
F40. Climate section summer. (1:100)

Climate section winter



F40. Climate section winter. (1:100)

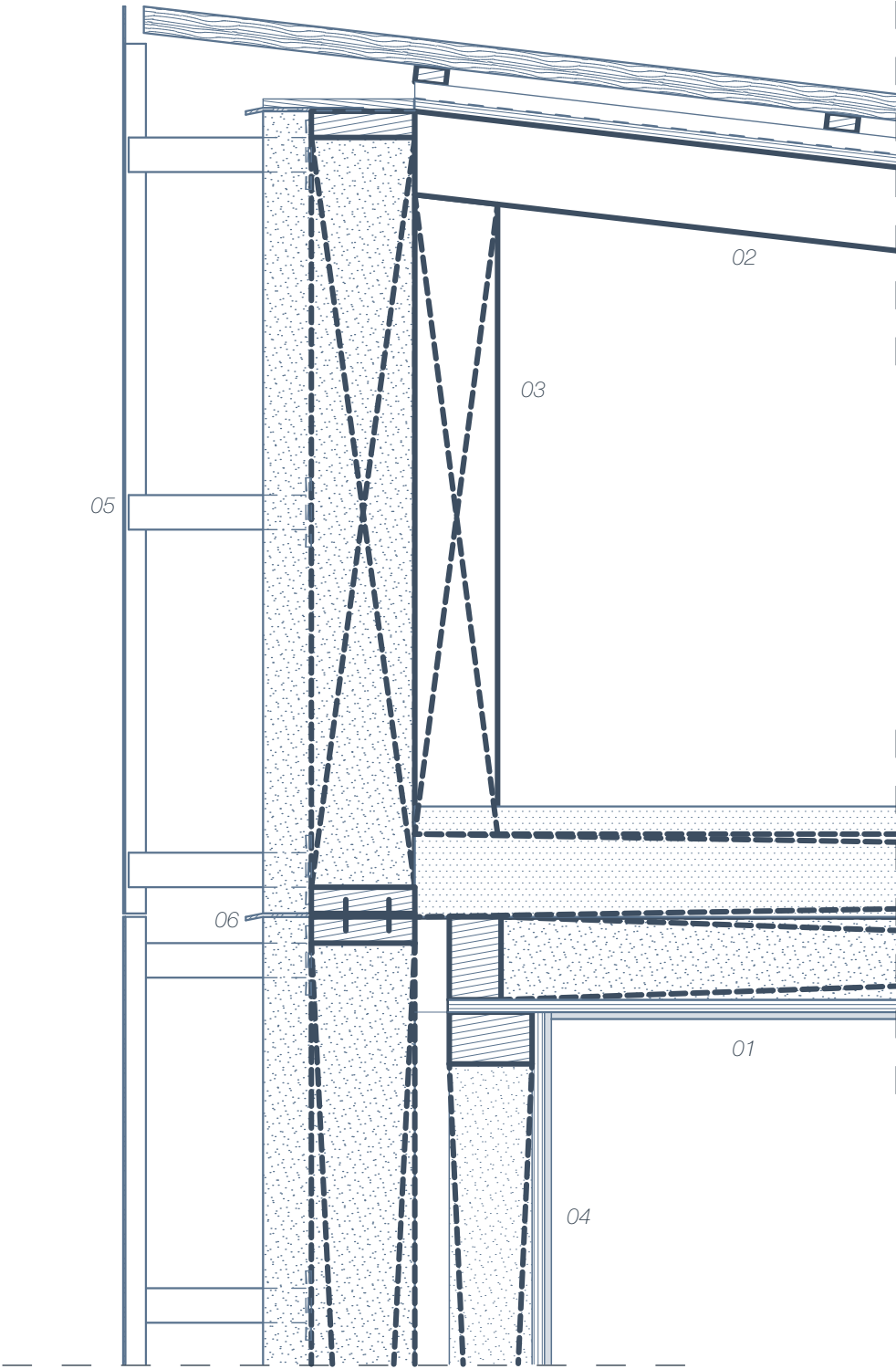
(V) gallery and modules



- 01 ecoboard 18 mm
sawn douglas XX mm
hemp-lime 100/120 mm
lime render 10 mm
- 02 finish 25 mm
lime-sand (floor heating) 80 mm
sawn douglas 63x160 mm
hemp-lime 160 mm
ecoboard 18 mm
- 03 lime render 20 mm
sawn douglas 45x150 mm
hemp-lime 200 mm
sawn douglas 45x200 mm
hemp-lime 200 mm
lime render 10 mm
- 04 lime-sand 60 mm
ecoboard 18 mm
sawn douglas (l) 50x150 mm
sawn douglas (t) 50x150 mm
- 05 folding door
- 06 hemp mat + lime
- 07 waterproof membrane
- 08 bifold oak door

F48. Detail (V) module facade and gallery connection. (1:5)

(V) high and dry



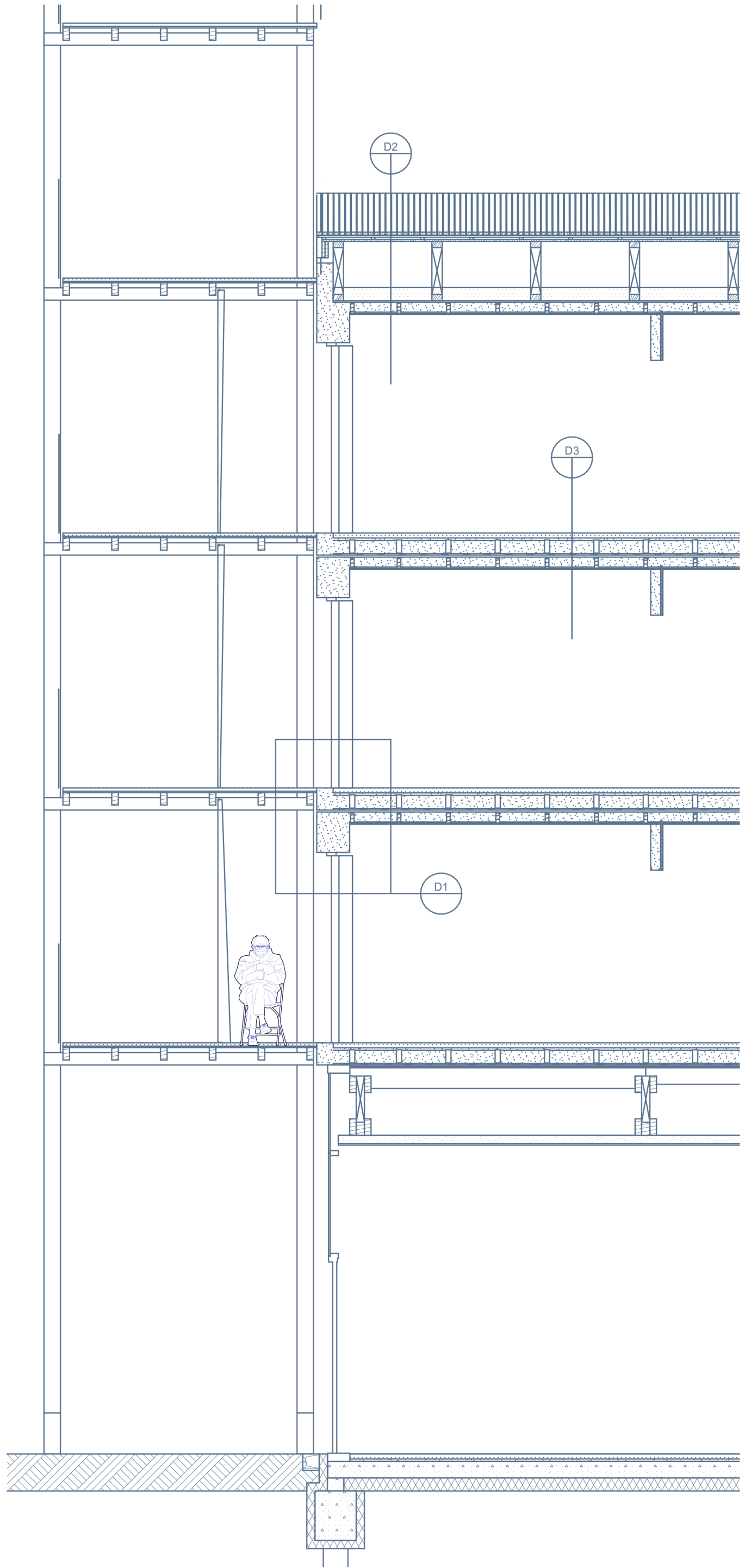
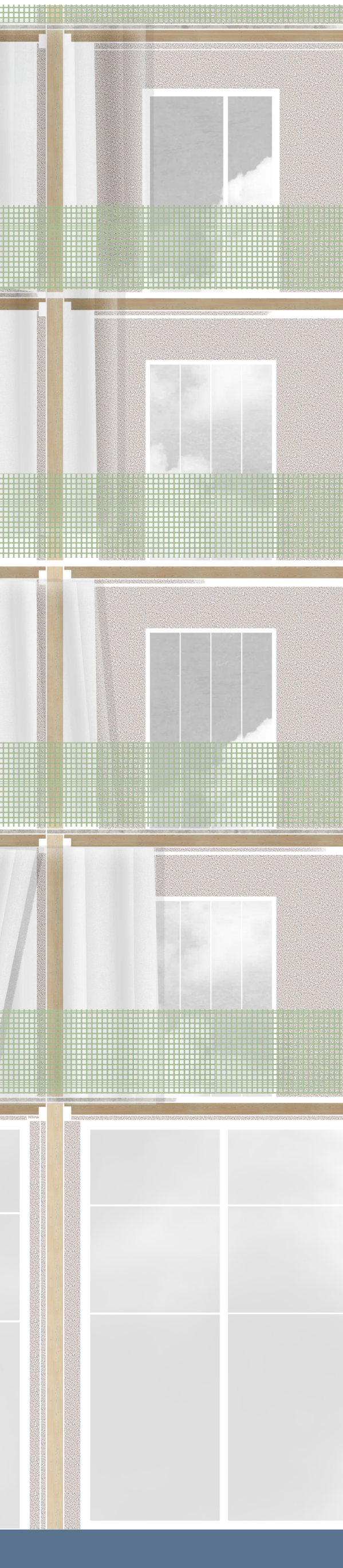
01	hemp-lime sawn douglas hemp-lime sawn douglas lime render Lucifer coffee tiles	160 mm 75x120 mm 120 mm 45x120 mm 10 mm 8 mm
02	oak timber timber water membrane ecoboard sawn douglas	38x60 mm 45x25 mm 45x25 mm 2 mm 18 mm 75x120 mm
03	lime render hemp-lime sawn douglas sawn douglas	20 mm 200 mm 38x150 mm 75x120 mm
04	lime render sawn douglas hemp-lime air cavity sawn douglas hemp-lime ecoboard Lucifer coffee tiles	20 mm 45x150 mm 200 mm 50 mm 75x120 mm 120 mm 18 mm 8 mm
05	steel mesh fence aluminium beams aluminium brackets	2 mm 30x30 mm 50x8(T) mm
06	steel plate	4 mm

F50. Detail (V) roof. (1:5)

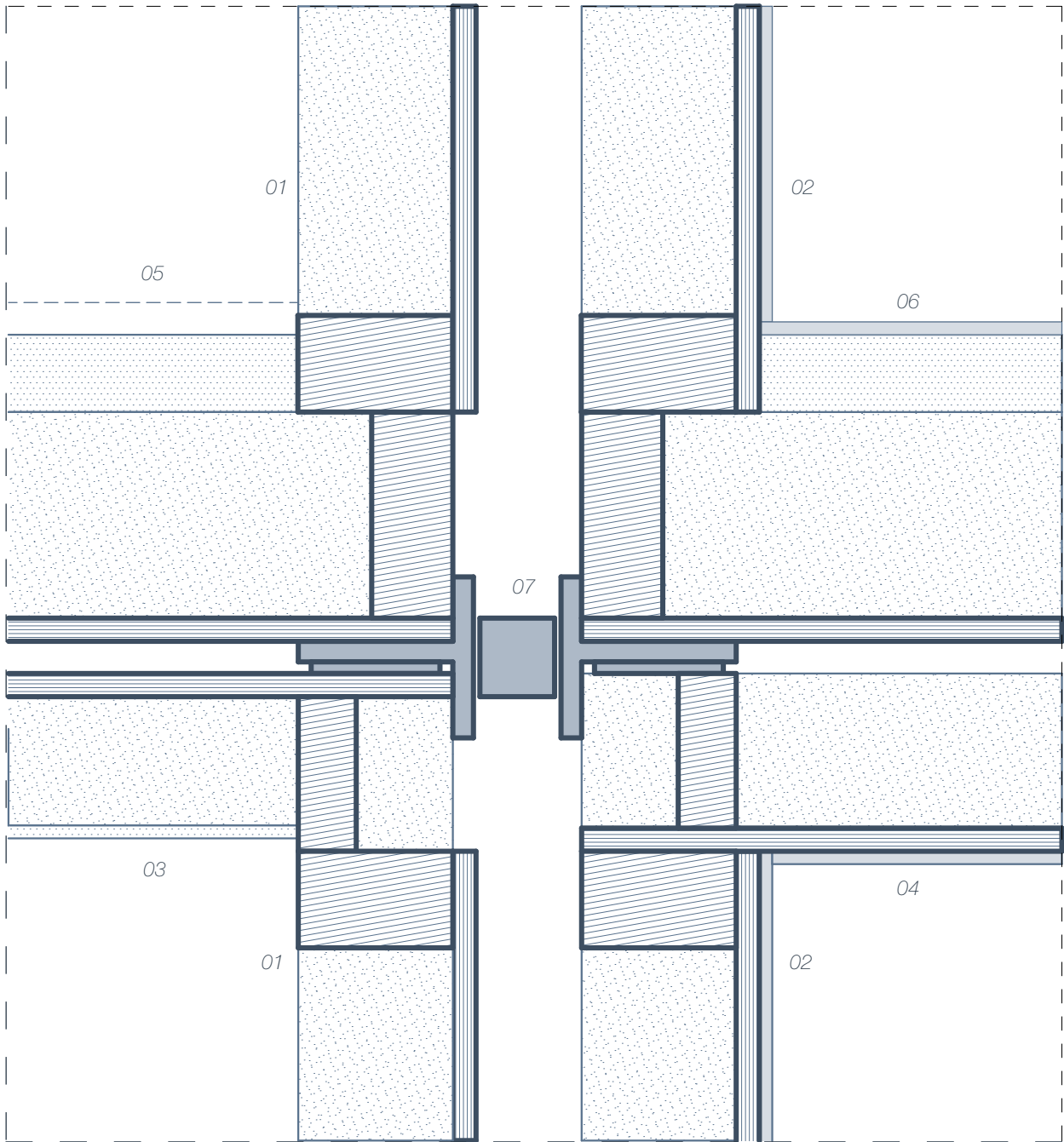
Fragment and elevation



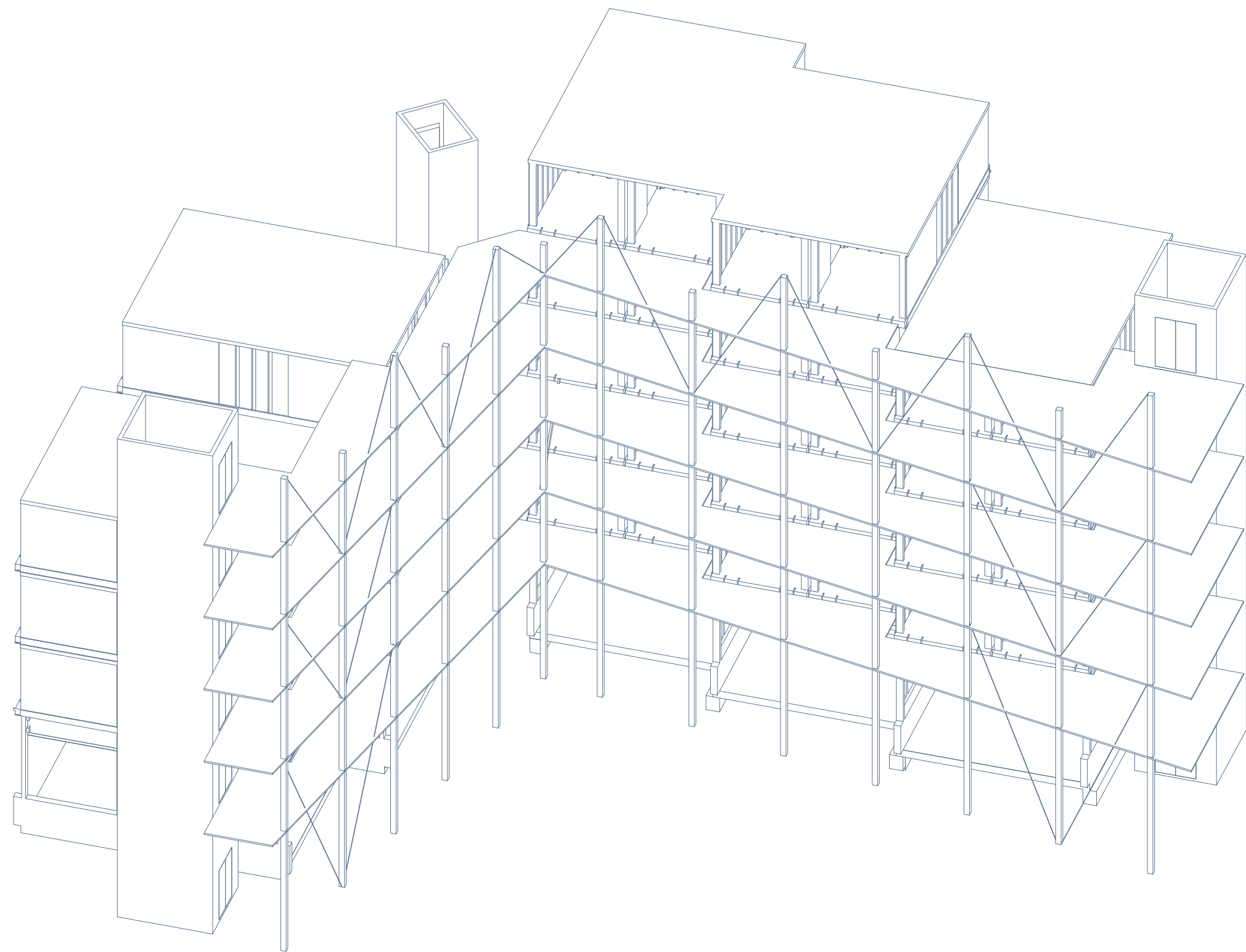
F38. Fragment elevation and section. (1:50 scaled down)

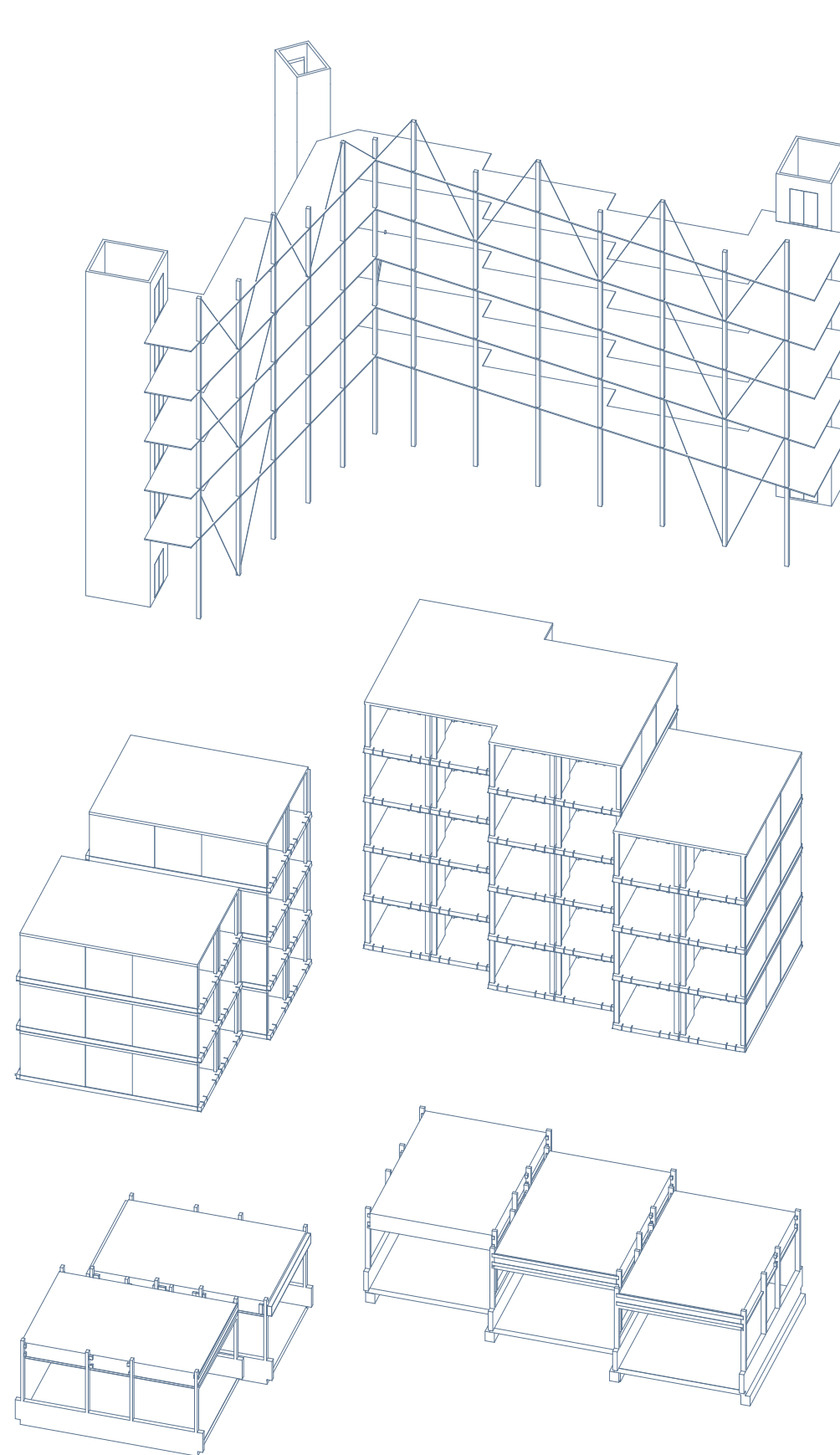


(V) module joint



01	sawn douglas hemp-lime ecoboard	75x120 mm 120 mm 18 mm
02	sawn douglas hemp-lime ecoboard Lucifer coffee tiles	75x120 mm 120 mm 18 mm 8 mm
03	ecoboard sawn douglas hemp-lime lime render	18 mm 45x120 mm 100/120 mm 10 mm
04	air cavity (mounting) sawn douglas hemp-lime ecoboard Lucifer coffee tiles	25 mm 45x120 mm 120 mm 18 mm 8 mm
05	finish lime-sand (floor heating) hemp-lime sawn douglas ecoboard	25 mm 60 mm 160 mm 63x160 mm 18 mm
06	lime render lime-sand (floor heating) hemp-lime sawn douglas ecoboard	20 mm 60 mm 160 mm 63x160 mm 18 mm
07	steel 3d module joint (acoustically detached)	





Stability
Concrete cores
Diagonal bracing

Gallery floors
Ecoboard
18 mm
Sawn oak beams (longitudinal)
80x150 mm
Sawn oak beams (transverse)
80x150 mm
Sawn oak columns
h 500 mm
Concrete footing
h 500 mm

Ceiling
Ecoboard 18 mm
Sawn douglas beams 45x120 mm

Stability walls and unit core
Ecoboard 18 mm

Columns
Sawn douglas columns 36x250 mm

Floor
Sawn douglas beams 63x160 mm
Ecoboard 18 mm

Ceiling
Double layer ecoboard (cross-NLT)
4x18 mm
Sawn douglas beam
100x250 mm
Sawn douglas truss
h 720 mm

Walls
Douglas columns
150x250 mm
Concrete base walls
250x500 mm

Floor
Reused brick-lime terrazo
Concrete foundation



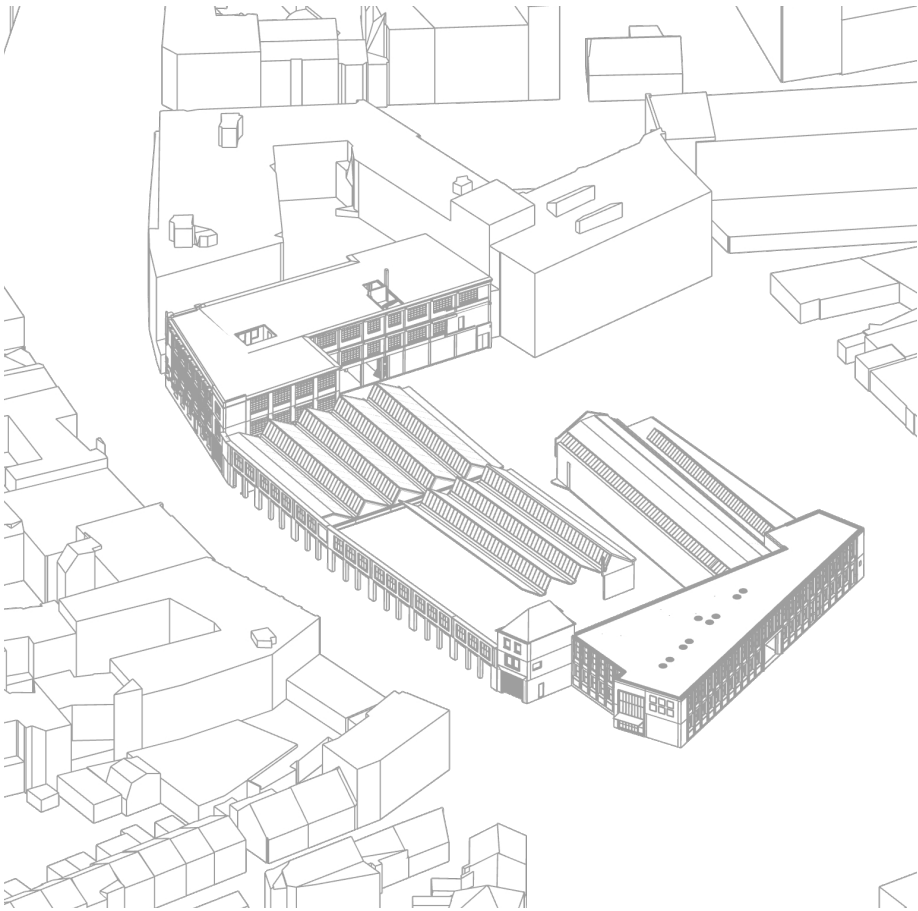
interior polyvalent space



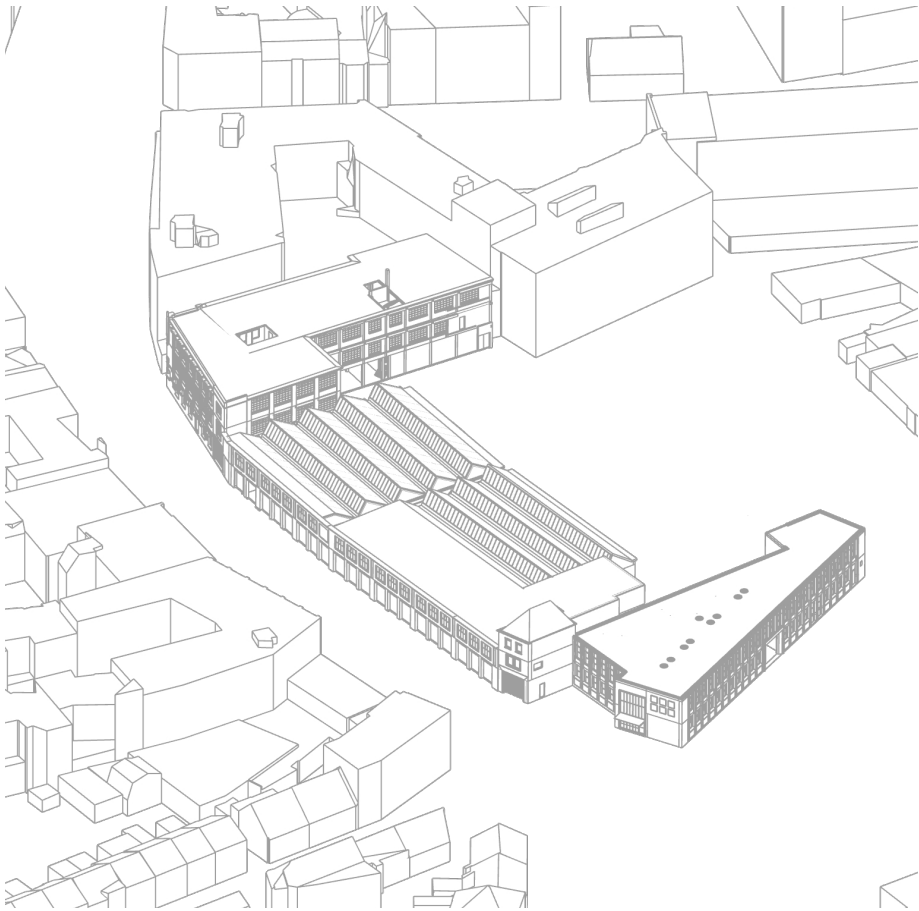
Appendix C

Sketch and presentation maquettes

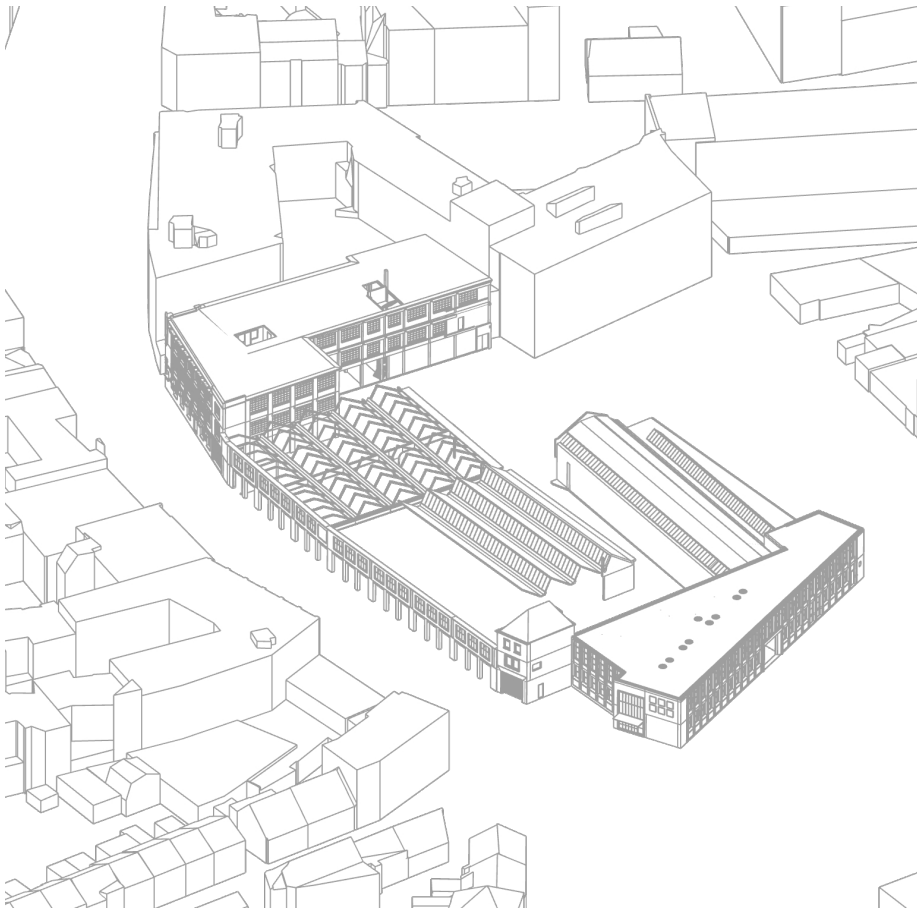
Prototype negative space (1:500)



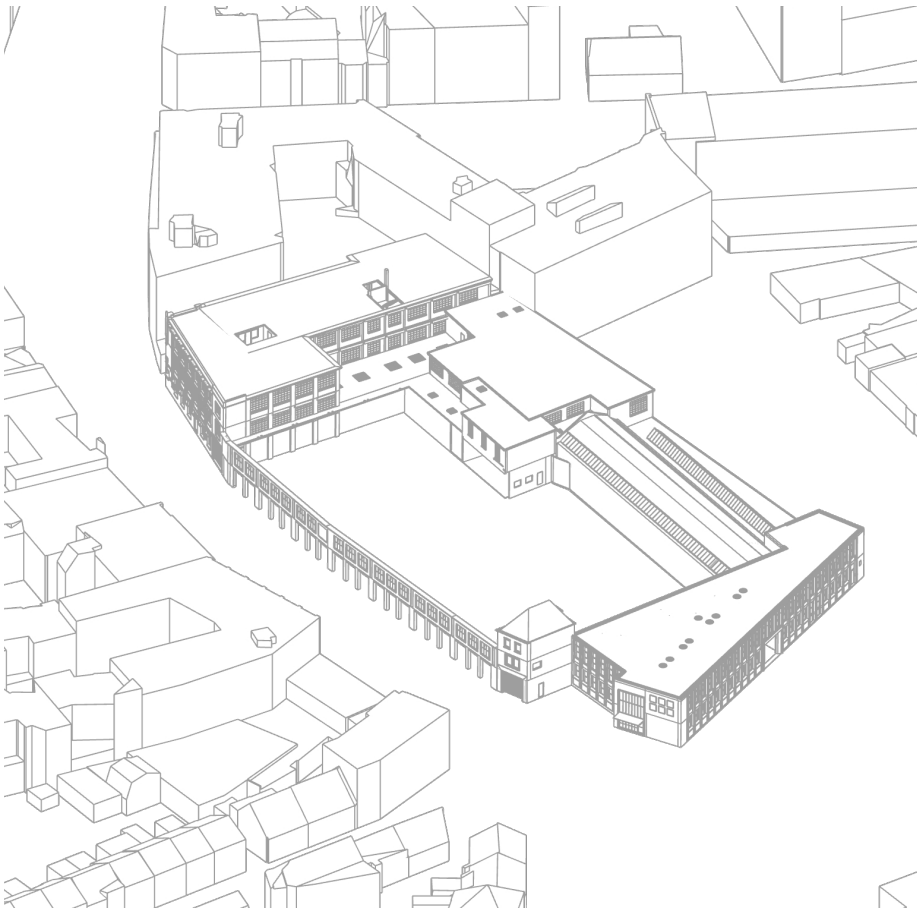
1. open hallen & ververij



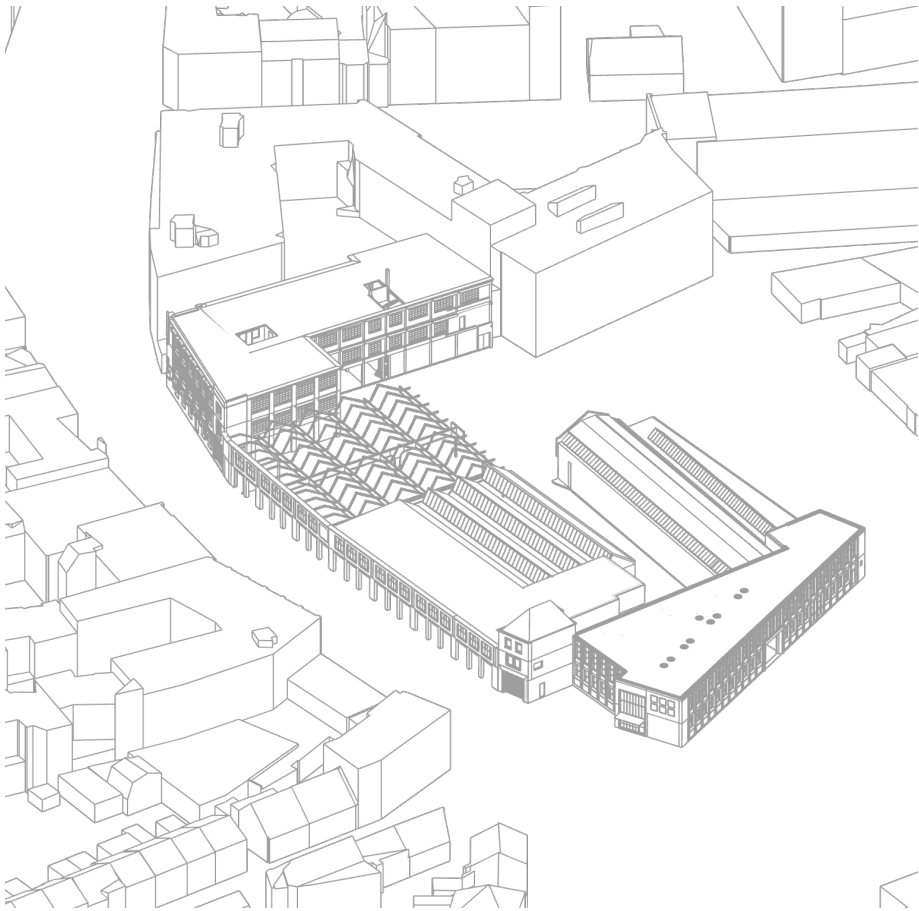
2. schellenshallen en dommelplein



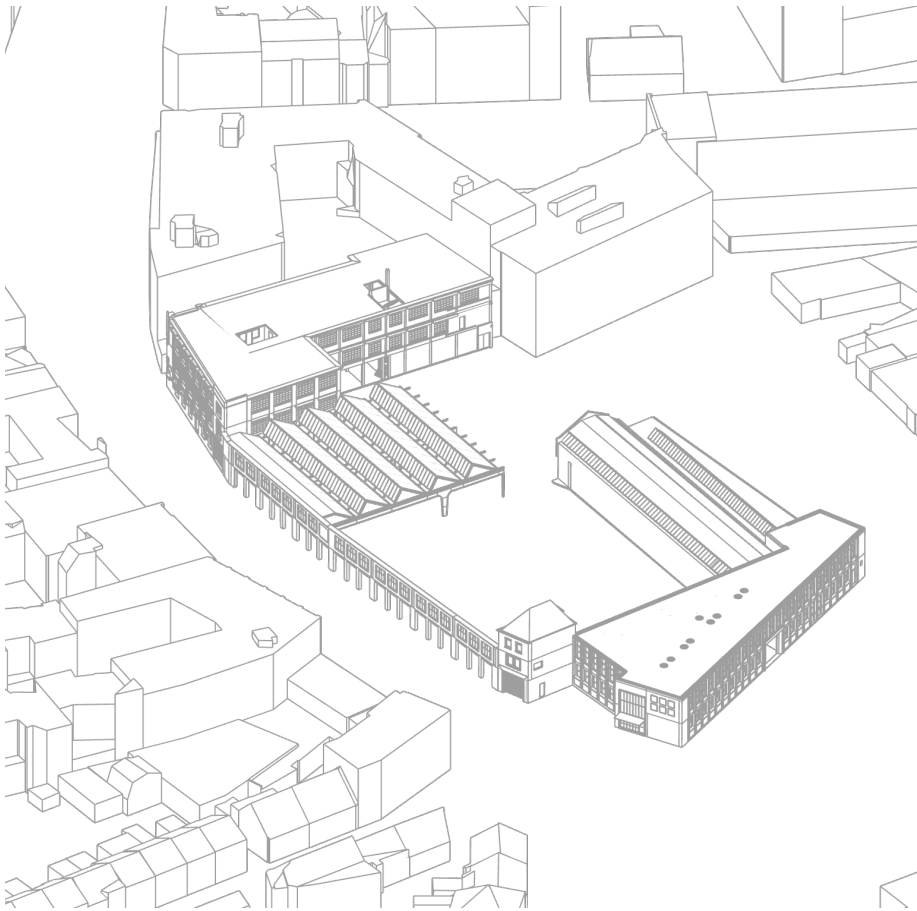
3. makers noord - skaters zuid



4. schellenshof

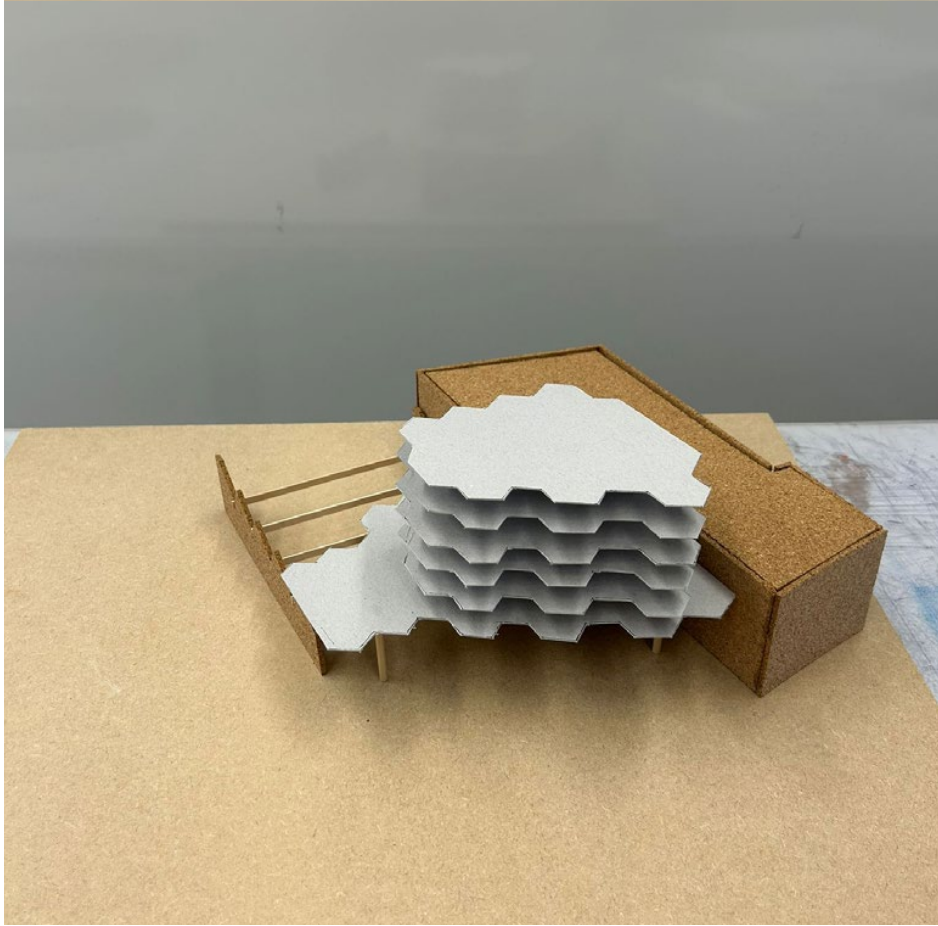
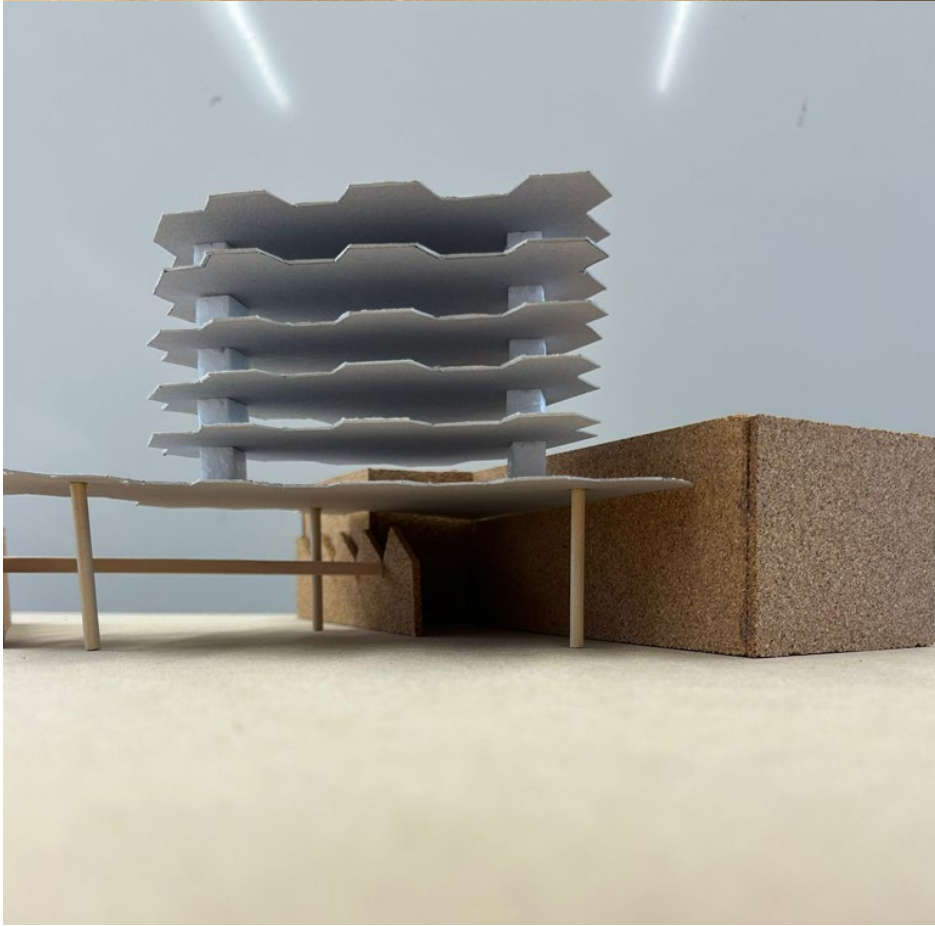
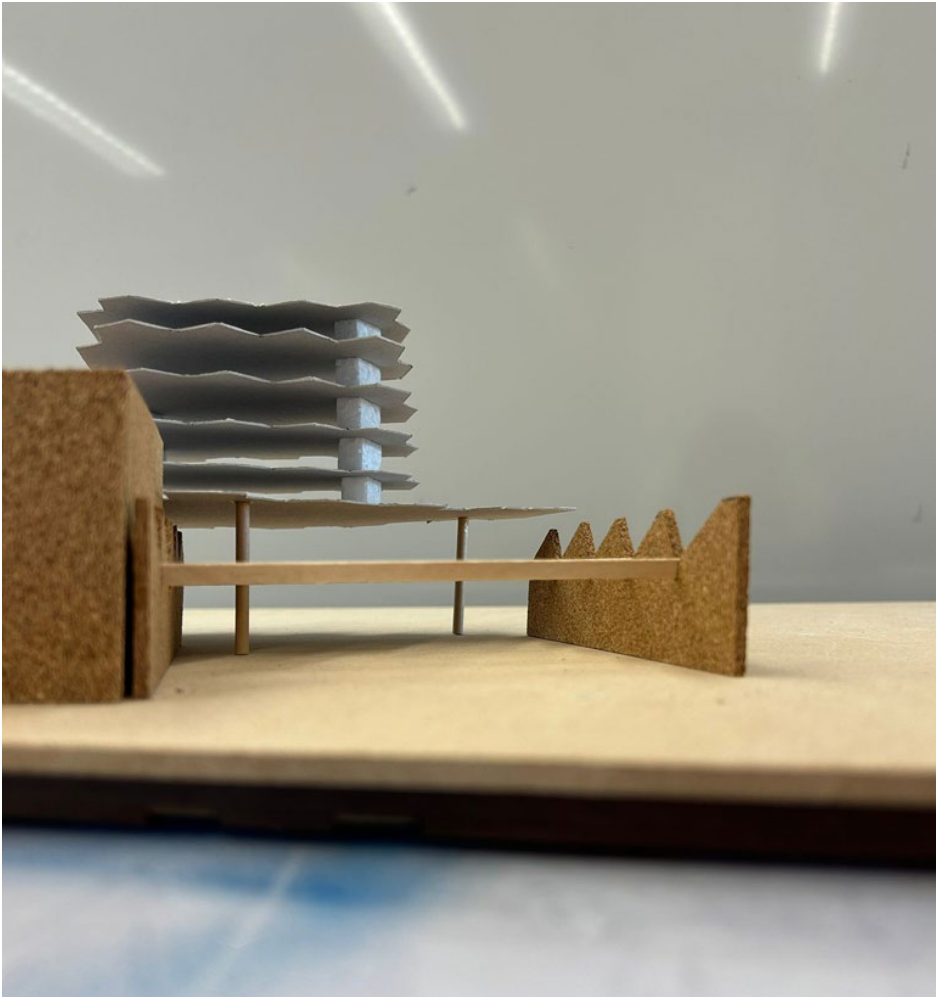
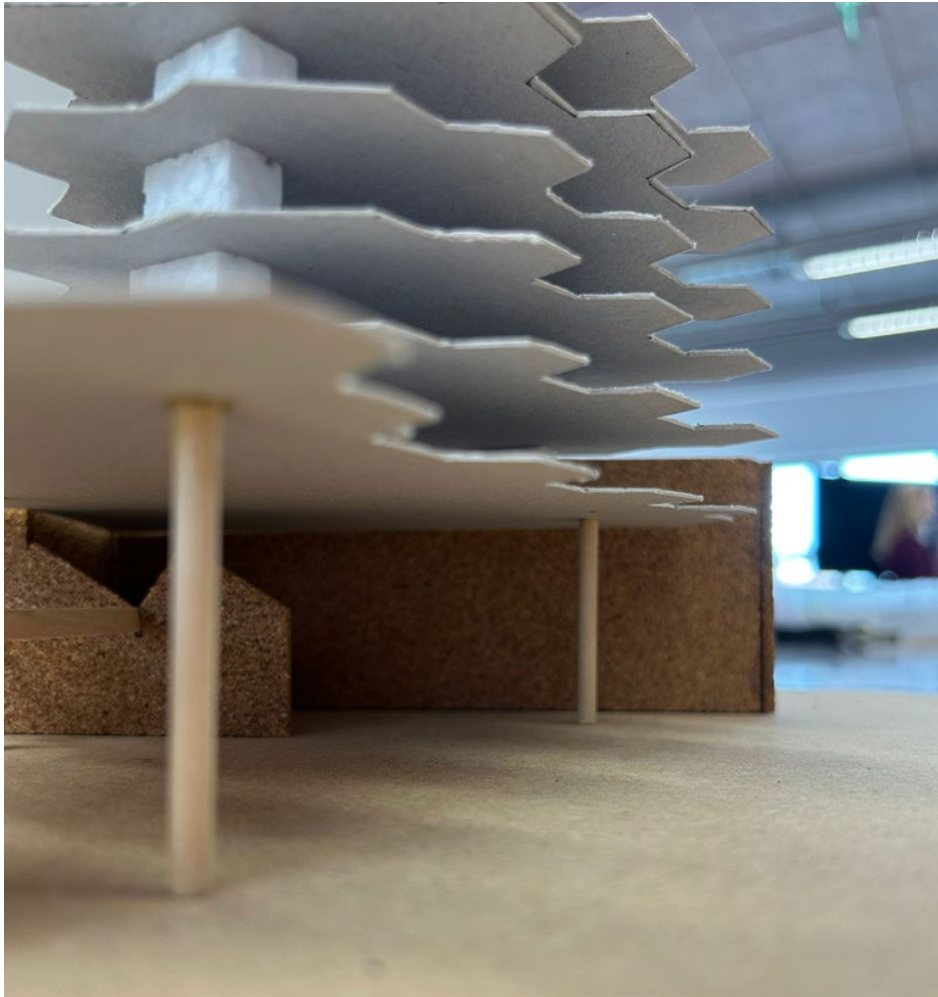


5. makersstraat en open plein

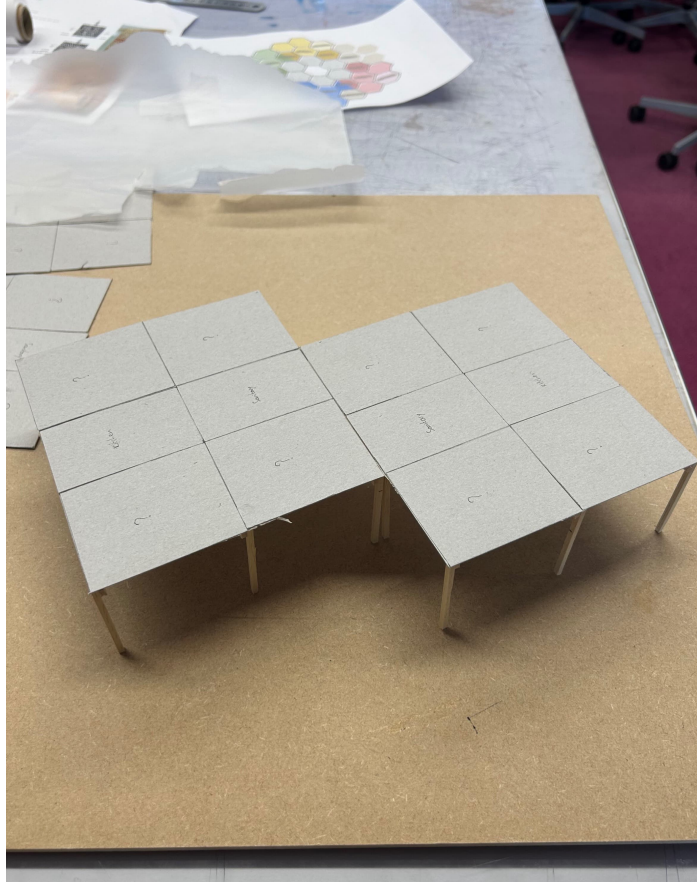
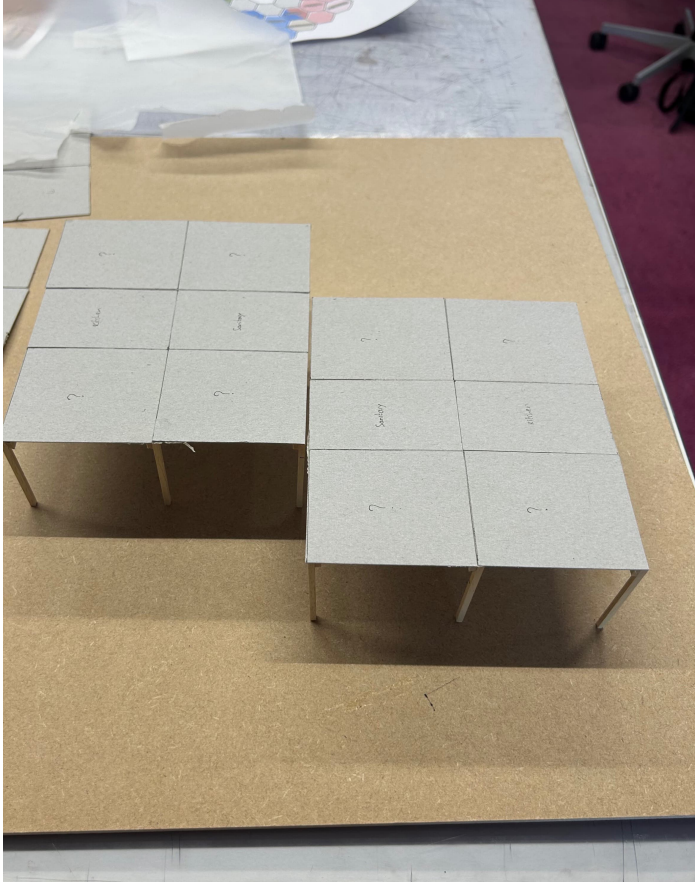
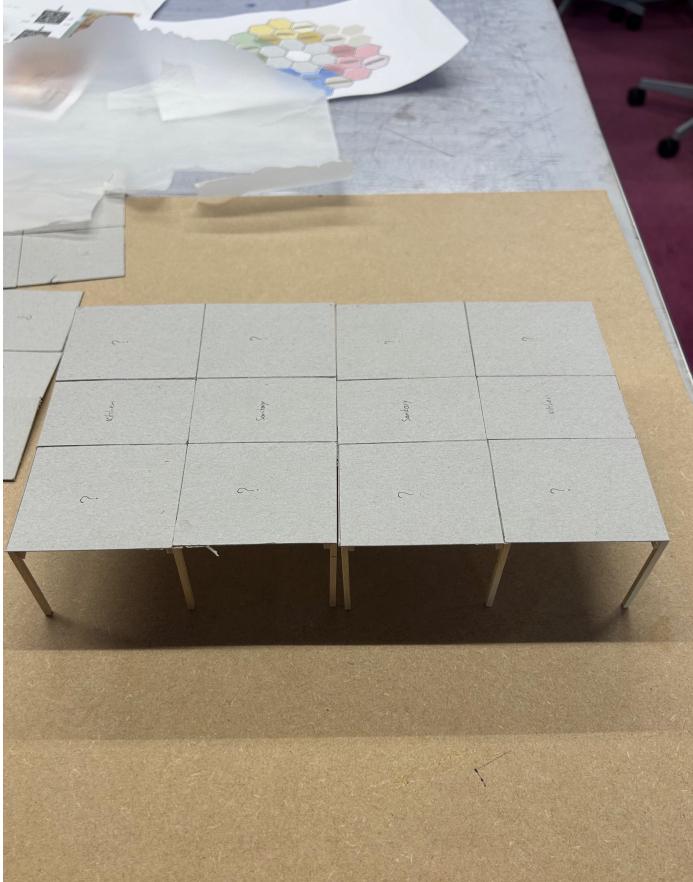
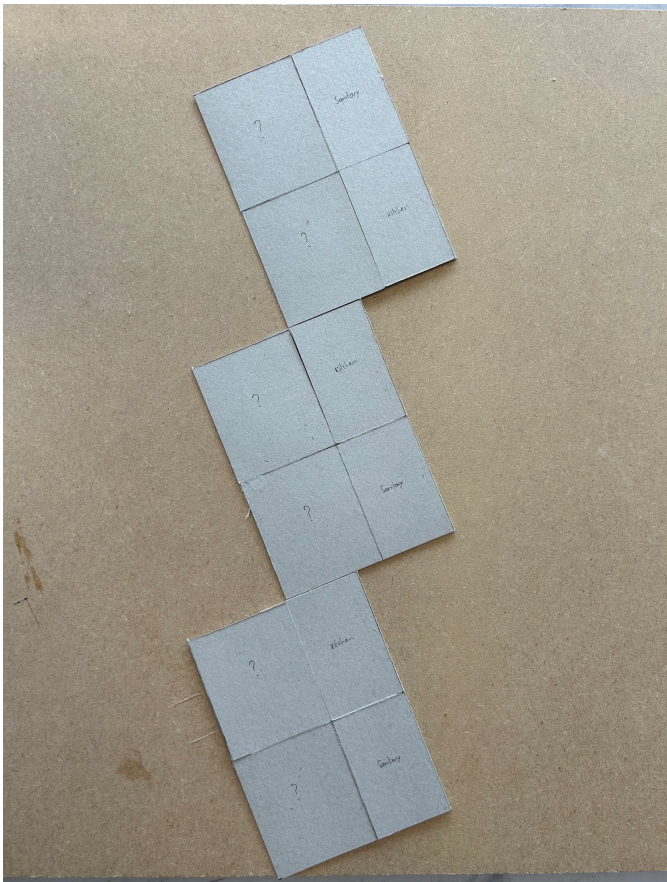
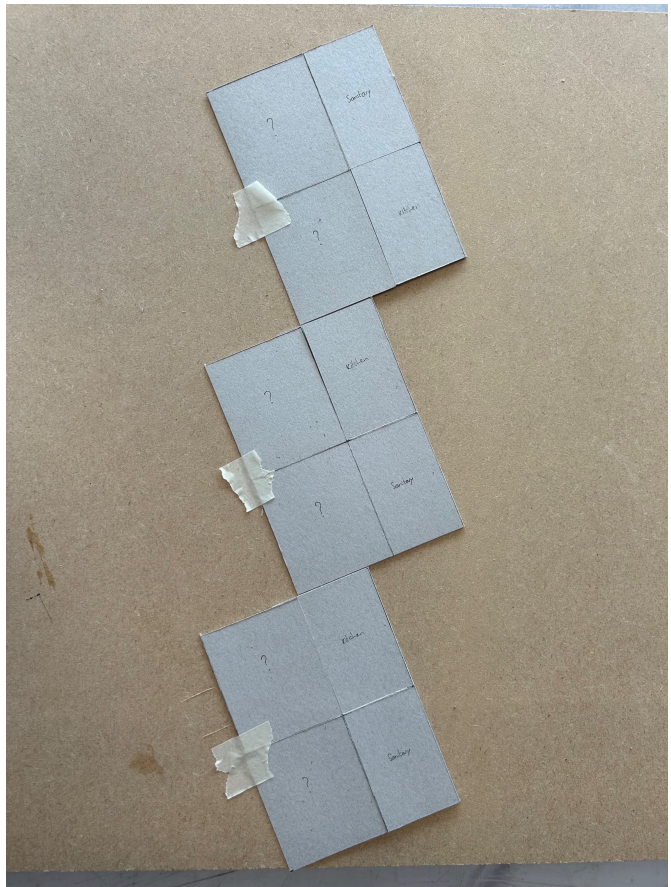
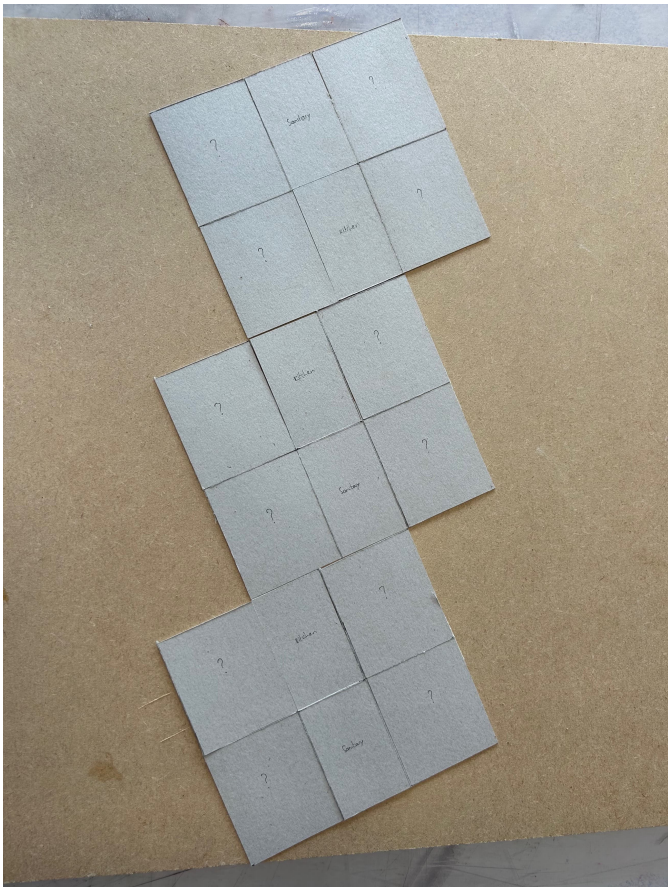
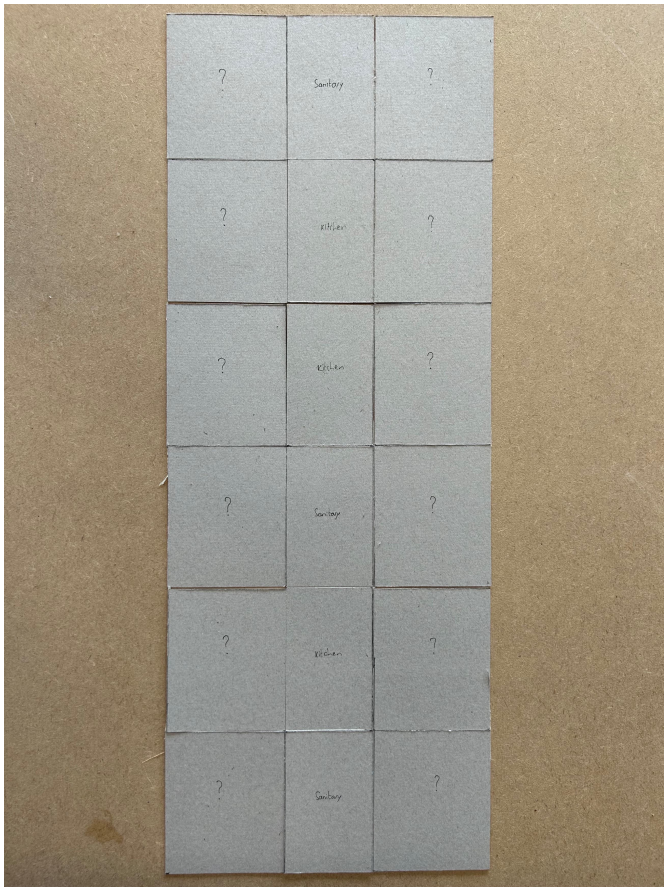
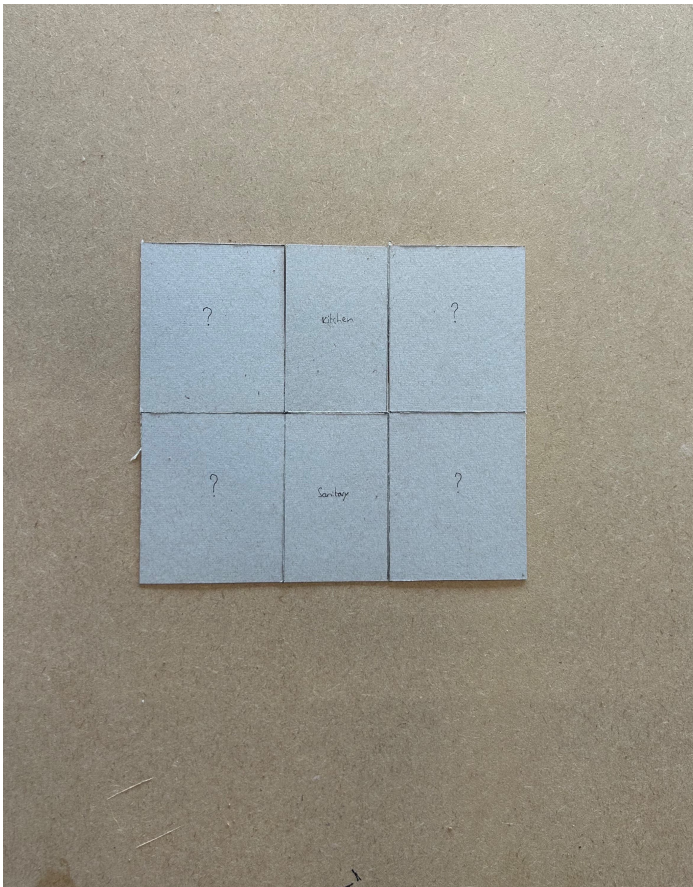


6. diagonale pleinen

Prototype hexagon grid (1:200)



Prototype housing concept, base dwelling (1:50)



Prototype base module (1:20)



Appendix D

Data management checklist

DATA MANAGEMENT CHECKLIST

Instruction

This checklist is relevant for all graduation projects of the Master AUBS. The form is intended to highlight common aspects of graduation projects that require particular attention with regard to planning the research and data management. Relevant information and supplementary sources regarding each question are provided below each question.

With this checklist, the faculty wants to avoid that students unexpectedly find themselves in complex and stressful situations, in which ethical or privacy matters and/or other laws and regulations become an issue. In projects involving humans, certain types of data processing increase the risks to the human participants: planning such projects requires additional evaluations and advice from university staff before ethical approval can be received and the project can begin. In the case of a graduation project, obtaining additional advice or permits may delay the project with an extra education period or semester. To avoid this, it is recommended that students set up a graduation project with a low level of risk. Therefore, all students have to check their risk, by completing this checklist before their A1.

The first section of the checklist (A) should be completed by all students, together with their supervisor, during the planning of the graduation project, before the A1. It does not need to be submitted to anyone for review or approval. Please consider questions 1 to 3 carefully in relation to the intended graduation project, and answer with 'yes' or 'no'.

The second section of the checklist (B) should only be completed if the graduation project involves working with data from human participants. In that case, the student and their supervisor must apply for and receive ethical approval from the [Human Research Ethics Committee](#) (HREC) before the project can begin (see the paragraph 'Explanation and follow-up' after the questions). The student can submit the application to the HREC, but the supervisor is responsible for making sure that the project is compliant with relevant privacy regulations and ethical policies.

Section A. General considerations	yes	no
1. Is the graduation project conducted as part of an internship (at a company), or as part of a research project at TU Delft? If a student's graduation project is conducted at a company or as part of a research project at the university, questions of data ownership and intellectual property rights need to be addressed in a written graduation or internship agreement before the project begins. Students and their supervisor should consult the Intellectual Property Rights of Students webpage. Additional information can also be found in the Extended Personal Research Data Workflow.		✓
2. Does the project involve conducting (part of) the research outside the Netherlands? Students who intend to travel abroad (even to other EU countries) for study, exchange, research, internship, or graduation project purposes need to follow the Travel Safety Protocol. This includes attending a mandatory Travel Safety Training Session: see the Disclaimer.		✓
3. Will the research involve processing data from humans, such as running a survey, conducting interviews or workshops, collecting data through social media or internet forums, or re-using existing datasets about humans provided by a third party? (If 'yes', see follow-up questions 4 to 13 in Checklist B.) Students who work with data from human participants must complete the next section and apply for and receive ethical approval from the Human Research Ethics Committee (HREC) before conducting the research.		✓

Section B. Extended risk factors (only if question 3 has been answered with 'yes'.)	yes	no
4. Will the project involve participants who may be considered vulnerable, such as the elderly, refugees or asylum seekers, ethnic minorities, patients, or people with disabilities? Participants who may suffer very adverse consequences (for instance, due to discrimination) if their personal data became publicly available can be considered vulnerable.		✓
5. Will the project involve participants who cannot themselves give informed consent for taking part in the project, but for whom consent must be obtained from a legal guardian? Participants who cannot give informed consent can include, for instance, children or participants with intellectual disabilities, mental disorders, or dementia. Such participants are also considered vulnerable in the context of the General Data Protection Regulation (GDPR).		✓
6. Will the project involve processing any of the special categories of personal data below? - Race - Ethnicity - Criminal offence data - Political opinion - Union membership - Religious or philosophical beliefs - Sex life and/or sexual orientation - Health data (including measurements such as heart rate) - Biometric or genetic data (including fingerprints, iris scanning, facial recognition) The General Data Protection Regulation (GDPR) defines a stricter rules for processing special categories of personal data. If it is necessary to process these data in a project, it is it is important to provide additional safeguards.		✓
7. Will the project involve processing personal data that could be considered sensitive, such as the ones listed below? - Information about a person's income, debts, or other payments - Information about a person's (un-)employment status - Information about a person's performance at school or work - Information about relationship problems or (gambling) addiction - Information about poverty, domestic violence, or youth welfare/social work involvement Some types of personal data are considered sensitive, because they can have a high impact on the privacy of the data subject if other persons gain access to these data. Sensitive personal data should only be processed if necessary: in such cases, additional safeguards need to be put in place.		✓
8. Will the project involve processing video-recordings, or photographs of participants? TU Delft considers photographic and video-materials of research participants to be sensitive personal data. If such data need to be processed, additional safeguards must be put in place.		✓

Section B. Extended risk factors (only if question 3 has been answered with 'yes'.)	yes	no
9. Will the project involve sharing or transferring personal data between multiple partners or collaborating organisations involved, such as between TU Delft and an internship company? According to privacy law, sharing personal data between organisations requires a privacy agreement to be in place: setting this up takes time, and requires support from additional university staff. Furthermore, personal data sharing can potentially expose research participants to different types of risks: these risks must be considered in the ethical application.		✓
10. Will the project involve deception, or covert observation of participants? In some types of research, obtaining informed consent for processing participants' personal data is not an option: for instance, if the research involves deception, or the research is covert (conducted without participants knowing about it). In such situations, the steps to mitigate risks to participants are important, and an alternative legal basis for processing the participant's data needs to be established with the help of additional support staff.		✓
11. Will the project involve working with social media data? Social media data are personal data, but since it is usually not possible to ask for informed consent for processing social media data, another legal basis for processing the participant's data needs to be established. Processing of social media data also involves legal considerations related to terms of use of data from third-party platforms: therefore, research with social media data requires expert support on privacy, ethics, and legal matters.		✓
12. Will the project involve using learning algorithms or other AI to analyse, combine, or otherwise process data from participants? The use of AI in research involves many considerations in terms of data protection, ethics, security, and intellectual property: for more information, see TU Delft's Instructions for use of Generative AI.		✓
13. Will the project involve participants who are based in a country or countries outside of the EU? Students affiliated with TU Delft must comply with Dutch and EU regulations of personal data processing (GDPR). Furthermore, the student and their supervisor must make sure that the research complies with local (privacy) legislations of any foreign destinations. Additional support from an external (local) expert may be required.		✓

Explanation and follow-up

If you have answered 'no' to all questions 4 to 13, your project is likely to be considered low or minimal-risk: see the paragraph 'Projects with minimal or low-risk' on the next page.

If you have answered 'yes' to one or more of the questions 4 to 13, your research likely involves extended or high risks to participants, according to the [General Data Protection Regulation](#) (GDPR) and TU Delft's privacy and ethical policies: for information regarding such projects, see the paragraph 'Projects with extended or high-risk' on the next pages.

Projects with minimal or low-risk

If you have answered 'no' to questions 4 to 13, your project is likely to be considered low-risk. This does not mean that the project involves no risks at all, but suggests that these risks can likely be addressed by the student and supervisor in the application to the [Human Research Ethics Committee](#) (HREC) within the timeline for a graduation project and without need for additional support.

Compiling the HREC application:

An application to the HREC generally involves a Data Management Plan (DMP), a risk-identification and mitigation checklist, and informed consent materials. Master's students at ABE who intend to compile a HREC application are advised to make use of the following support documents:

- the [student guide](#)
- the [Example Data Management Plan](#) for MSc projects

The graduation supervisor is [responsible](#) for the student's project and ethical application, and must provide support for compiling the HREC application documents.

Additional support

For low-risk student graduation projects, compiling of the HREC application documents should be done by the student in consultation with the supervisor. The Faculty Data Steward can be contacted for individual questions at datasteward-BK@tudelft.nl; however, the Data Steward does not provide detailed feedback on student DMPs for low-risk HREC applications.

Additional resources

The HREC has guides available for [completing the checklist](#) and for compiling [informed consent materials](#). Additionally, the [Guide to the Extended Personal Research Data Workflow](#) has been created to help researchers and students who work with human participants comply with both GDPR principles and TU Delft's policies on Data Management and Human Research Ethics.

Timeline

Minimal or low-risk HREC applications are generally processed faster than extended or high-risk applications (see the paragraph below). Nevertheless, the initial evaluation by the HREC usually takes approximately 2 weeks, and may take longer during busy periods or holiday: see the [HREC website](#) for up-to-date information. Additionally, the application may require revisions before final approval is granted. If you do not receive an initial response about your ethical application after 4 weeks from the time of submission, you may follow up with the HREC to enquire about an update.

Projects with extended or high-risk

If you have answered 'yes' to one or more of questions 4 to 13, there are potential increased risks related to how data from human participants will be processed in your project. These risks will need to be addressed in consultation with the Data Steward and other relevant support staff before submitting the ethical application to the [Human Research Ethics Committee](#) (HREC).

Compiling the HREC application

An application to the HREC generally involves a Data Management Plan (DMP), a risk-identification and mitigation checklist, and informed consent materials. Master's students at ABE who intend to compile a HREC application are advised to make use of the following support documents:

- the [Ethical Approval & Data Management Planning Student Information](#)
- the [Example Data Management Plan](#) for MSc projects

The graduation supervisor is [responsible](#) for the student's project and ethical application, and must provide support for compiling the HREC application documents.

Additional support

Once the DMP has been compiled and reviewed by the supervisor, feedback should be requested from the Data Steward via DMPonline. After this, any other necessary support staff will need to be contacted. Crucially, if the project involves one or multiple ways of personal data processing that could result in high-risk to the participants according to the GDPR, the TU Delft Privacy Team must be consulted to establish whether or not a [Data Protection Impact Assessment](#) (DPIA) is required.

Additional resources

The HREC has guides available for [completing the checklist](#) and for compiling [informed consent materials](#). Additionally, the [Guide to the Extended Personal Research Data Workflow](#) has been created to help researchers and students who work with human participants comply with both GDPR principles and TU Delft's policies on Data Management and Human Research Ethics.

Timeline

It can take a long time to compile a complete research plan and HREC application for projects involving extended risks. DMP feedback from the Data Steward usually takes around 2 weeks, but can take longer during busy periods or holidays. Receiving additional support from other staff, such as the Privacy Team, can take anywhere from a few days to multiple weeks, depending on the project and capacity of university staff. If a DPIA is deemed necessary, it can take anywhere from 4 weeks to several months.

It is important to note that advice from the Privacy Team or other support staff, as well as any additional documents (such as necessary contracts, or a DPIA, if needed) must be in place before the application is submitted to the HREC. The initial evaluation by the HREC can be processed in 2 weeks, but may take longer during busy periods or holidays: see the [HREC website](#) for up-to-date information. Additionally, the application may require revisions before final approval is granted. If you do not receive an initial response about your ethical application after 4 weeks from the time of submission, you may follow up with the HREC to enquire about an update.

Considering the limited time available for students conducting their graduation projects, students working with data from human participants are strongly advised to prioritise low-risk research projects. If a student project necessitates processing data in ways that are considered extended or high-risk, both student and supervisor need to be aware of the extended processing times involved in obtaining ethical approval and beginning the graduation project.